VSC7428-12 Datasheet
11-Port L2 Ethernet Switch with 8 Integrated 10/100 Cu PHYs and Embedded MIPS CPU

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1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 4.1

Revision 4.1 of this datasheet was published in April 2019. The following is a summary of the changes implemented in the datasheet:

- Frame Arrival section was updated. For more information, see Frame Arrival, page 8.
- MIIM Interface in Slave Mode section was updated with a note. For more information, see MIIM Interface in Slave Mode, page 165.
- VeriPHY™ Cable Diagnostics section was updated. For more information, see VeriPHY Cable Diagnostics, page 42.
- VeriPHY control registers were deleted. For more information, see PHY:PHY_EXT1, page 610.
- Design considerations were added to address issues with 1588 out-of-sync and copper ports. For more information, see Design Considerations, page 688.

1.2 Revision 4.0

Revision 4.0 of this datasheet was published in September 2014. This was the first production-level publication of the document.

2 Introduction

This document consists of descriptions and specifications for both functional and physical aspects of the VSC7428-12 device. It is intended for system designers and software developers.

In addition to the datasheet, Vitesse maintains an extensive part-specific library of support and collateral materials that you may find useful in developing your own product. Depending upon the Vitesse device, this library may include:

- Application notes that provide detailed descriptions of the use of the particular Vitesse product to solve real-world problems
- White papers published by industry experts that provide ancillary and background information useful in developing products that take full advantage of Vitesse product designs and capabilities
- User guides that describe specific techniques for interfacing to the particular Vitesse products
- Reference designs showing the Vitesse device built in to applications in ways intended to exploit its relative strengths
- Software Development Kits with sample commands and scripts
- Presentations highlighting the operational features and specifications of the devices to assist in developing your own product road map
- Input/Output Buffer Information specification (IBIS) models to help you create and support the interfaces available on the particular Vitesse product

Visit and register as a user on the Vitesse Web site to keep abreast of the latest innovations from research and development teams and the most current product and application documentation. The address of the Vitesse Web site is www.vitesse.com.

2.1 Register Notation

This datasheet uses the following general register notation:

<TARGET>:<REGISTER_GROUP>:<REGISTER>.<FIELD>

<REGISTER_GROUP> is not always present. In that case, the following notation is used:

<TARGET>::<REGISTER>.<FIELD>

When a register group does exist, it is always prepended with a target in the notation.

In sections where only one register is discussed, or the target (and register group) is known from the context, the <TARGET>:<REGISTER_GROUP>: may be omitted for brevity, and uses the following notation:

<REGISTER>.<FIELD>

Also, when a register contains only one field, the .<FIELD> is not included in the notation.

2.2 Standard References

This document uses the following industry references.

Table 1 • **Referenced Documents**

Document	Title	Revision
IEEE		
IEEE 802.1ad	802.1Q Amendment 4: Provider Bridges	-2005
IEEE P802.1ag	802.1Q Amendment 5: Connectivity Fault Management (CFM)	Evolving
IEEE 802.1D	Media Access Control (MAC) Bridges	-2004
IEEE 802.1Q	Virtual Bridged Local Area Networks	-2005

Table 1 • **Referenced Documents**

IEEE 802.3	Local and metropolitan area networks — Specific requirements Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications	-2008
IEEE 802.3az	Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Amendment: Media Access Control Parameters, Physical Layers and Management Parameters for Energy-Efficient Ethernet	-2010
IEEE 1588	Precision Clock Synchronization Protocol for Networked Measurement and Control Systems	-2008
MEF		
MEF-9	Abstract Test Suite for Ethernet Services at the UNI	October 2004
MEF-10.1	Ethernet Services Attributes Phase 2	November 2006
MEF-14	Abstract Test Suite for Traffic Management Phase 1	November 2005
MEF-16	Ethernet Local Management Interface (E-LMI)	January 2006
ITU-T		
Y.1731	OAM Functions and Mechanisms for Ethernet Based Networks	5/22/2006
G.8261	Timing and Synchronization Aspects in Packet Networks	12/14/2006
IETF		
RFC-2236	Internet Group Management Protocol, Version 2 (IGMPv2)	November 1997
RFC-2710	Multicast Listener Discovery for IPv6 (MLDv1)	October 1999
RFC-2819	Remote Network Monitoring (RMON) MIB	May 2000
RFC-2863	The Interfaces Group MIB	June 2000
RFC-3376	Internet Group Management Protocol, Version 3 (IGMPv3)	October 2002
RFC-3635	Definitions of Managed Objects for Ethernet-like Interface Types	September 2003
Other		
ENG-46158	Cisco Serial GMII (SGMII) Specification	1.7
JESD79	DDR2 SDRAM Specification	2B

2.3 Terms and Abbreviations

The following terms and abbreviations are used throughout this document.

Table 2 • **Terms and Abbreviations**

Term	Explanation
ACL	Access Control List
ASP	Vitesse Arrival Service Point (see SP).
CFM	IEEE Connectivity Fault Management.
DEI	IEEE Drop Eligible Indicator.
DP	Drop Precedence
DSP	Vitesse Departure Service Point (see SP).
E-LMI	MEF Ethernet Local Management Interface.
EPL, EVPL	MEF Ethernet Private Line, Ethernet Virtual Private Line service.
EP-LAN, EVP-LAN	MEF Ethernet Private LAN, Ethernet Virtual Private LAN service.
EP-TREE, EVP-TREE	MEF Ethernet Private TREE, Ethernet Virtual Private TREE service.
EVC	MEF Ethernet Virtual Connection.
PAG	Policy association group. Used to map many services to a shared security Policy.
PB	IEEE 802.1AD Provider Bridging (also known as “Q-in-Q”).
PCP	IEEE Priority Code Point interpretation of Ethernet Priority (also known as 802.1p) bits.
SP	Vitesse Service Point. A reference point inside the CE Switch where service policy is applied. Service policy includes policing, statistics, tagging/encapsulation, QoS, and connectivity.
VCAP-II	Vitesse Content Aware Processor, TCAM-based classification and security.
VID	IEEE VLAN Identifier.
Classified VLAN	The final VLAN ID classification of a frame used in the forwarding process. The classified VLAN is the result of basic and advanced classification.
Basic VLAN	The VLAN ID returned by the basic classification. A basic VLAN is assigned to every frame as a default classified VLAN if no more advanced VLAN classification is carried out on the frame.

3 Product Overview

The VSC7428-12 is an 11-port Layer 2 Ethernet switch with eight fully integrated copper PHYs and an embedded MIPS CPU. It supports the following interfaces.

- 8 x 10/100M copper PHY
- 1 x 1G SGMII
- 2 × 2.5G SGMII

The VSC7428-12 provides a rich set of Carrier Ethernet switching features such as queue-based Ethernet services, provider bridging, protection switching, and synchronous Ethernet. Advanced TCAM-based VLAN and QoS processing enables delivery of differentiated services with per-service SLA guarantees. Security is assured through frame processing using a TCAM-based Vitesse Content Aware Processor (VCAP-II). In addition, VSC7428-12 contains a powerful 416 MHz CPU enabling full management of the switch.

VSC7428-12 is part of the Caracal™ family of Carrier Ethernet switches, which are pin-compatible and provide port counts ranging from 11 to 26 Ethernet ports. In addition to the VSC7428-12 device, the Caracal family includes the following products.

- VSC7428-02 Caracal-1™: 11 ports supporting:
  8 x 1G copper PHY
  9 x 1G SGMII
  2 × 2.5G SGMII
- VSC7429-02 Caracal-2™: 11 ports supporting:
  12 x 1G copper PHY
  10 x 1G SGMII
  2 × 2.5G SGMII

Note: 1000BASE-TX or QSGMII is supported only on the VSC7428-02 and VSC7429-02 devices. References in this document to these modes do not apply to the VSC7428-12 device.

3.1 General Features

- All 1G Ethernet ports are tri-speed 10/100/1000 Mbps ports
- All 2.5G Ethernet ports are quad-speed 10/100/1000/2500 Mbps ports
- Integrated Fast Ethernet copper transceivers are compliant with IEEE 802.3ab and support Vitesse ActiPHY™ link down power savings and PerfectReach™ smart cable reach algorithm
- SGMII ports support both 100-BASE-FX and 1000-BASE-X-SERDES
- Four megabits of integrated shared packet memory
- Fully nonblocking wire-speed switching performance for all frame sizes
- Eight priorities and eight queues per port
- Dual leaky bucket policing per queue and per port
- DWRR scheduler/shaper per queue and per port with a mix of strict and weighted queues
- 256 TCAM-based egress tagging entries
- Up to 256 TCAM-based classification entries for Quality of Service (QoS) and VLAN membership
- Up to 512 host identity entries for source IP guarding
- 256 TCAM-based security enforcement entries
- L1 Synchronous Ethernet
- L2 IEEE 1588-2008 Precision Time Protocol (IEEE 1588) with hardware-based timestamping for one-step or two-step clocks
- Energy Efficient Ethernet (IEEE 802.3az) is supported by both the switch core and the internal Fast Ethernet copper PHYs
- Audio/Video bridging (AVB) with support for time-synchronized, low-latency audio and video streaming services
- VCore-III CPU system with integrated 416 MHz MIPS 24KEc™ CPU with MMU and DDR2 SDRAM controller

3.1.1 Layer-2 Switching

- 8,192 MAC addresses

- 4,096 VLANs (IEEE 802.1Q)
- Push/pop/translate up to two VLAN tags; translation on ingress and/or on egress
- TCAM-based VLAN classification and translation with pattern matching against Layer 2 through Layer 4 information such as MAC addresses, VLAN tag header, EtherType, DSCP, IP addresses, and TCP/UDP ports and ranges
- Up to 256 QoS and VLAN TCAM entries
- 256 VLAN egress tagging TCAM entries
- Link aggregation (IEEE 802.3ad)
- Link aggregation traffic distribution is programmable and based on Layer 2 through Layer 4 information
- Wire-speed hardware-based learning and CPU-based learning configurable per port
- Independent and shared VLAN learning
- Provider Bridging (VLAN Q-in-Q) support (IEEE 802.1ad)
- Rapid Spanning Tree Protocol support (IEEE 802.1w)
- Multiple Spanning Tree Protocol support (IEEE 802.1s)
- Jumbo frame support up to 9.6 kilobytes with programmable MTU per port

3.1.2 Multicast

- 8K L2 multicast group addresses with 64 port masks
- 8K IPv4/IPv6 multicast groups
- Internet Group Management Protocol version 2 (IGMPv2) support
- Internet Group Management Protocol version 3 (IGMPv3) support with source specific multicast forwarding
- Multicast Listener Discovery (MLDv1) support
- Multicast Listener Discovery (MLDv2) support with source specific forwarding (32-bit LSB of SIP used for indexing source IP address)

3.1.3 Carrier Ethernet

- Provider Bridge (Q-in-Q) switch

  8K MACs, 4K VLANs
- Per queue MEF E-LINE or per port MEF E-LAN, E-TREE Service Points

  Per port per queue Dual Leaky Bucket Service Policers with PCP or DSCP remarking per Service Point

  Statistics and Tagging options per Service Point
- OAM hardware for generating CCM messages, CCM checking is done by software

  Software for OAM and protection switching
- L1 Synchronous Ethernet
- L2 IEEE 1588 timestamping hardware, with one-step and two-step clock support
- Enhanced Carrier Ethernet software API

3.1.4 Quality of Service

- Eight QoS queues per port with strict or deficit weighted round-robin scheduling (DWRR)
- TCAM-based QoS classification with pattern matching against Layer 2 through Layer 4 information
- 256 QoS and VLAN TCAM entries
- DSCP translation, both ingress and/or egress
- DSCP remarking based on QoS class and drop precedence level
- VLAN (PCP, DEI, and VID) translation, both ingress and egress
- PCP and DEI remarking based on QoS class and drop precedence level
- Per-queue and per-port policing and shaping, programmable in steps of 100 kbps
- Per-flow policing through TCAM-based pattern matching, up to 256 policers
- Full-duplex flow control (IEEE 802.3X) and half-duplex backpressure, symmetric and asymmetric

3.1.5 Security

- Vitesse Content Aware Processor (VCAP-II) packet filtering engine using ACLs for ingress and egress packet inspection:
  256 security VCAP entries

  Up to 256 shared VCAP rate policers with rate measurements in frames per second or bits per second

  Eight shared range checkers supporting ranges based on TCP/UDP port numbers, DSCP values, and VLAN identifiers

  VCAP match patterns supporting generic MAC, ARP, IPv4, and IPv6 protocols

  VCAP actions including permit/deny, police, count, CPU-copy, and mirror

  Special support for IP fragments, UDP/TCP port ranges, and ARP sanity check

  Extensive CPU DoS prevention by VCAP rate policers and hit-me-once functions

  Surveillance functions supported by 32-bit VCAP counters
- Generic storm controllers for flooded broadcast, flooded multicast, and flooded unicast traffic
- Selectable CPU queues for segregation of CPU redirected traffic, with 8 queues supported
- Per-port, per-address registration for snooping of reserved IEEE MAC addresses (BPDU, GARP, CCM/Link trace)
- Port-based and MAC-based access control (IEEE 802.1X)
- Per-port CPU-based learning with option for secure CPU-based learning
- Per-port ingress and egress mirroring
- Mirroring per VLAN and per VCAP match

3.1.6 Management

- MIPS 24KEc™ CPU system with memory management unit (MMU), and 32 kilobytes of instruction cache (I-cache) and 32 kilobytes of data cache (D-cache)
- CPU frame extraction (eight queues) and injection (two queues) through DMA, which enables efficient data transfer between Ethernet ports and CPU
- EJTAG debug interface
- Eight-bit DDR2 SDRAM interface
- Thirty-two pin-shared general-purpose I/Os
- Eight-bit parallel slave interface through GPIOs
- Serial LED controller controlling up to 32 ports with four LEDs each
- Serial GPIO controller
- PHY management controller
- Per-port 32-bit counter set with support for the RMON statistics group (RFC 2819) and SNMP interfaces group (RFC 2863)

3.2 Applications

VSC7428-12 targets the Customer Premise Equipment (CPE) or Provider Edge (PE) equipment. It can be used to implement the access functions in these boxes.

VSC7428-12 provides the required set of UNI features in a cost-effective manner:

- Map Customer frame formats into Provider frame formats

  Classify frames and map to appropriate QoS profiles

  Apply Provider Bridge (Q-in-Q) encapsulations
- Meter the customer traffic and ensure that the customer Service Level Agreement (SLA) is met

  Police using MEF-defined Dual Leaky Bucket algorithm

Mark frames as Committed (Green) or Discard Eligible (Yellow)

Provide correct QoS treatment (traffic management)

Provide traffic statistics per customer in a manner consistent with the SLA

- Enable end-to-end Service OAM by the customer, if allowed
- Implement the service as defined by the SLA

E-LINE for point-point or backhaul services

E-LAN for multipoint/bridged services

E-TREE for video distribution or backhaul services

- Enable management and protection schemes as required by the Provider

Link Aggregation or other port protection schemes if used for access

OAM at the Operator and Service Provider levels for remote management, fault diagnosis, and protection switching

- Supports network timing and synchronization requirements as required
- Synchronous Ethernet and IEEE 1588 functionality

3.3 Related Products

VSC7460 Jaguar-1: 24× 1G + 4× 10G Carrier Ethernet switch

VSC7462 Lynx-1: 12× 1G + 2× 10G Carrier Ethernet switch

Both Jaguar-1 and Lynx-1 provide comprehensive service and transport support for networks based on Provider Bridge.

Jaguar-1 and Lynx-1 are suitable for access devices as well as first level of aggregation within the provider network. Compared to Caracal-1, Jaguar-1 and LynX-1 offer greater scale and these additional capabilities:

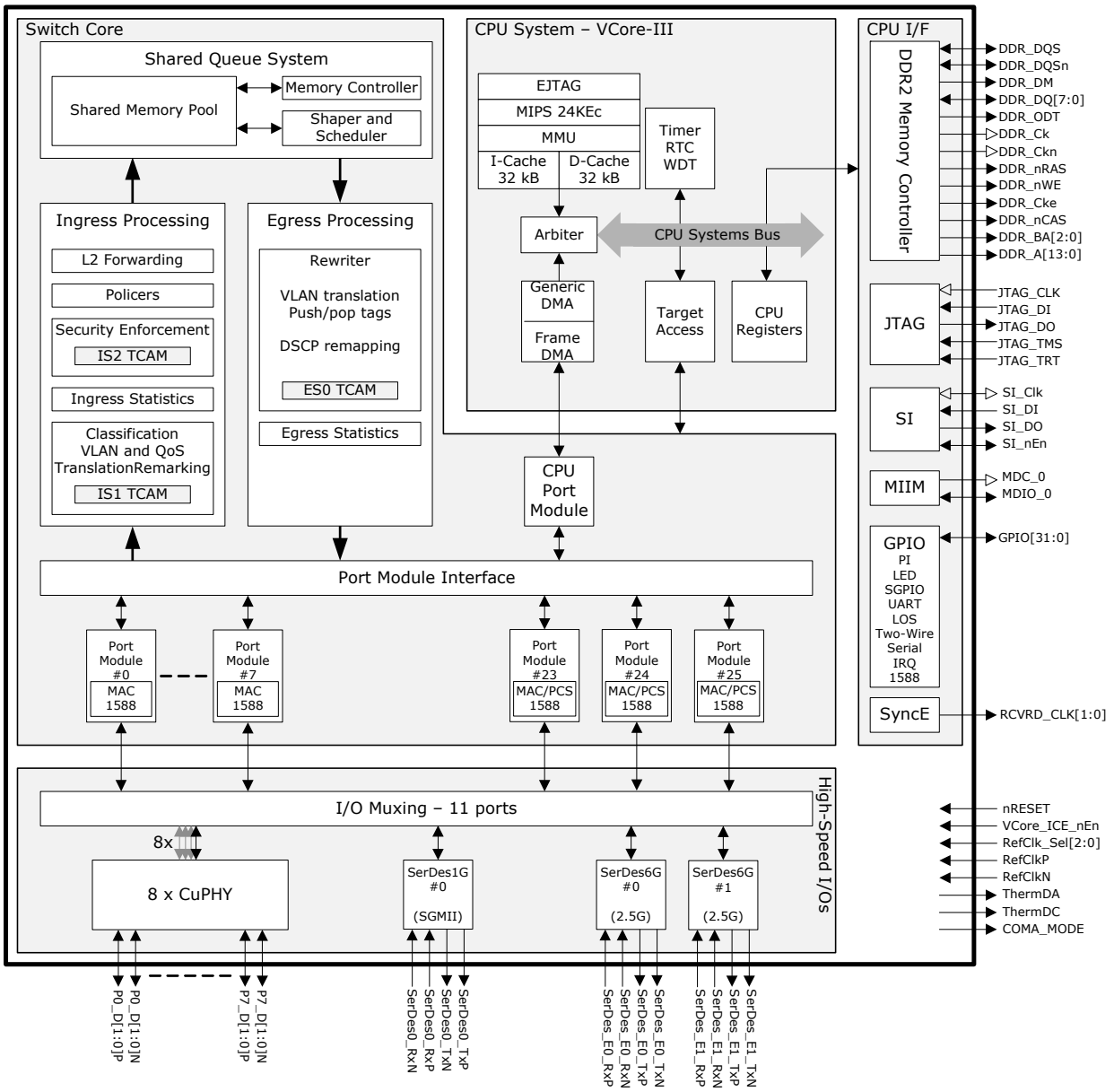
- Higher bandwidth support through 10 GbE ports
- Traffic engineering and protection schemes
- Ability to aggregate services already conditioned by other access gear while also offering new services directly. Support for 4,096 dedicated services.
- Participation in Ethernet aggregation topologies such as meshes and rings.

3.4 Functional Overview

This section provides an overview all major blocks and functions involved in the bridging operation in the same order as a frame traverses through the device. It also outlines other major functionality of the device such as the CPU port module, the CPU system, and CPU interfaces.

The following illustrations show the block diagram for the VSC7428-12 device.

Figure 1 • **Block Diagram**



For more information about the I/O muxing and the mapping from switch core port modules to external I/Os, see Port Module Numbering and Macro Connections, page 16.

3.4.1 Frame Arrival

The Ethernet interfaces receive incoming frames and forward these to the port modules. Supported interfaces include Fast Ethernet copper transceivers, SGMII, and SerDes.

The integrated low-power, Fast Ethernet copper transceivers support full duplex operation at 10/100 Mbps and half-duplex operation at 10/100 Mbps. The key PHY features are:

- Low power consumption in all modes through ActiPHY™ link down power savings, PerfectReach™ smart cable reach algorithm, and IEEE 802.3az Energy Efficient Ethernet idle power savings.
- VeriPHY® cable diagnostics suite provides extensive network cable operating conditions and status.

There are two programmable direct drive LEDs per port and adjustable brightness levels via register controls with bi-color LED support using both LED pins. The device also feature a serial LED controller interface for driving LED pins on both internal and external PHYs.

The 1G SGMII and 2.5G SGMII ports support both 100BASE-X and 1000BASE-X-SERDES.

Each port module contains a Media Access Controller (MAC) that performs a full suite of checks, such as VLAN Tag-aware frame size checking, frame check sequence (FCS) checking, and pause frame identification.

Each port module connecting to a SerDes macro contains a Physical Coding Sublayer (PCS) which perform 8 bits/10 bits encoding, auto-negotiation of link speed and duplex mode, and monitoring of the link status.

Full-duplex is supported for all speeds, and half-duplex is supported for 10 Mbps and 100 Mbps. Symmetric and asymmetric pause flow control are both supported.

All Ethernet ports support Energy Efficient Ethernet (EEE) according to IEEE 802.3az. The shared queue system is capable of controlling the operating states, active or low-power, of the PCS or the internal PHYs. Both the PCS and PHYs understand the line signaling as required for EEE. This includes signaling of active, sleep, quiet, refresh, and wake.

3.4.2 Basic and Advanced Frame Classification

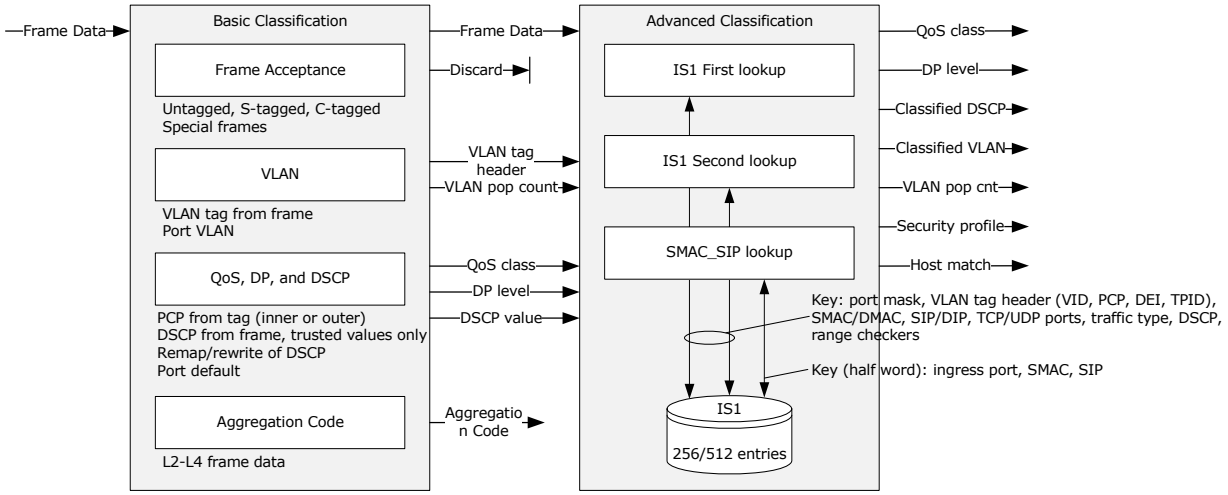
Each frame is sent to the ingress processing module for classification to a VLAN, classification to a Quality of Service (QoS) class, policing, drop precedence marking, collecting statistics, security enforcement, and Layer-2 forwarding.

The classification is a combination of a basic classification using configurable logic and more advanced classification using a TCAM.

The classification engine can understand up to two VLAN tags and can look for Layer-3 and Layer-4 information behind two VLAN tags. If frames are triple tagged, the higher-layer protocol information is not extracted.

The following illustration shows the basic and advanced frame classification.

Figure 2 • **Basic and Advanced Frame Classification**



The basic and advanced classification classifies each frame to a VLAN, a QoS class, a drop precedence (DP) level, DSCP value, and an aggregation code. The basic classification also performs a general frame acceptance check. The output from the basic classification may be overwritten or changed by the more intelligent advanced classification using the IS1 TCAM.

Frame Acceptance The frame acceptance filter checks for valid combinations of VLAN tags against the ingress port's VLAN acceptance filter where it is possible to configure rules for accepting untagged, priority-tagged, C-tagged, and S-tagged frames. In addition, the filter also enables discarding of frames with illegal MAC addresses (for instance null MAC address or multicast source MAC address).

VLAN Every incoming frame is classified to a VLAN by the basic VLAN classification. This is based on the VLAN in the frame, or if the frame is untagged or the ingress port is VLAN unaware, it is based on the

ingress port's default VLAN. A VLAN classification includes the whole TCI (PCP, DEI, and VID) and also the TPID (C-tag or S-tag).

For double-tagged frames, it is selectable whether the inner or the outer tag is used.

The device can recognize S-tagged frames with the standard TPID (0x88A8) or S-tagged frames using a custom programmable value. One custom value is supported by the device.

QoS, DP, and DSCP Each frame is classified to a Quality of Service (QoS) class and a drop precedence level (frame color). The QoS class and DP level are used throughout the device for providing queuing, scheduling, and congestion control guarantees to the frame according to what is configured for that specific QoS class and color.

The QoS class and DP level in the basic classification are assigned based on the class of service information in the frame's VLAN tags (PCP and DEI) and/or the DSCP values from the IP header. Both IPv4 and IPv6 are supported. If the frame is non-IP or untagged, the port's default QoS class and DP level are used.

The DSCP values can be remapped before being used for QoS. This is done using a common table mapping the incoming DSCP to a new value. Remapping is enabled per port. In addition, for each DSCP value, it is possible to specify whether the value is trusted for QoS purposes.

Each IP frame is also classified to an internal DSCP value. By default, this value is taken from the IP header but it may be remapped using the common DSCP mapping table or rewritten based on the assigned QoS class. The classified DSCP value may be written into the frame at egress – this is programmable in the rewriter.

Aggregation Code Finally, the basic classification calculates an aggregation code, which is used to select between ports that are member of a link aggregation group. The aggregation code is based on selected Layer-2 through Layer-4 information, such as MAC addresses, IP addresses, IPv6 flow label, and TCP/UDP port numbers. The aggregation code ensures that frames belonging to the same conversation are using the same physical ports in a link aggregation group.

Advanced Classification

Following the basic classification, Layer-2 and Layer-4 information is extracted from each frame and matched against a TCAM, IS1, with any mix of up to 256 complex entries (QoS and VLAN) or up to 512 simple entries (host identity check).

The TCAM embeds powerful protocol awareness for well-known protocols such as LLC, SNAP, ARP, IPv4, IPv6, and UDP/TCP. For each frame, three keys are generated and matched against the TCAM. The first two matches are QoS and VLAN relevant, and the last match is a host identity check validating that the frame contains a valid combination of source MAC address and source IP address.

The actions associated with each entry (programmed into the TCAM action RAM) for the first two matches include the ability to overwrite or translate the classified VLAN, overwrite the priority code point (PCP) or the drop eligibility indicator (DEI), overwrite the QoS class and DP level, or overwrite the DSCP value. Each of these actions is enabled individually.

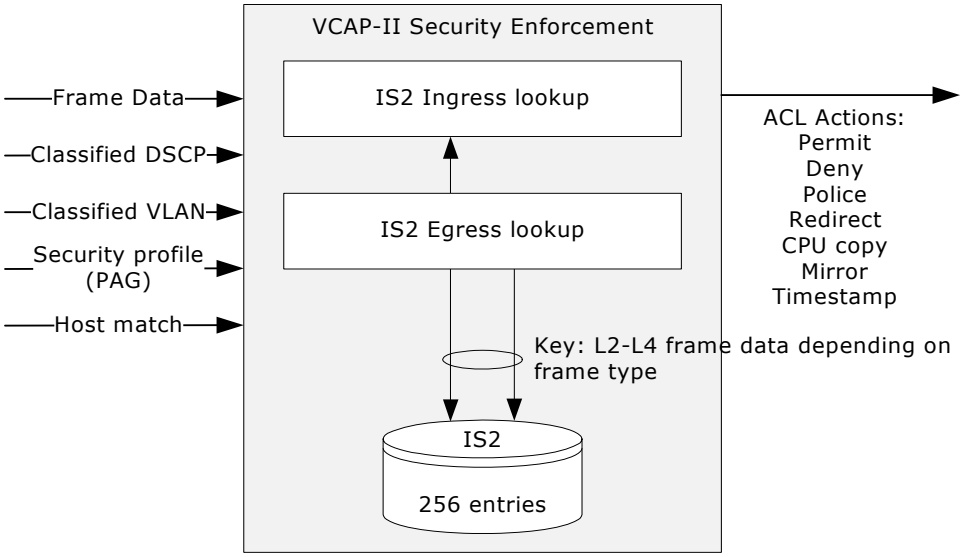
In addition, a policy association group (PAG) is assigned to the frame. The PAG identifies a security profile to which the frame belongs. The PAG is used in the succeeding security frame processor, IS2, to select which access control lists to apply to the frame. The PAG enables creating efficient ACLs that only are applicable to frames with the same PAG.

The host identity validation results in a flag being passed on to the security frame processor IS2 where associated actions such as permit/deny can be programmed.

3.4.3 VCAP-II Vitesse Content Aware Processor

All frames are inspected by the VCAP-II IS2 before they are passed on to the Layer-2 forwarding.

Figure 3 • **VCAP-II Security Enforcement**



The VCAP uses a TCAM-based frame processor enabling implementation of a rich set of security features. The flexible VCAP engine supports wire-speed frame inspection based on Layer 2-4 frame information, including the ability to perform longest prefix matching and identifying port ranges. The action associated with each VCAP entry (programmed into the VCAP action RAM) includes the ability to do frame filtering, rate limitation, snooping, redirection, mirroring, and accounting. Even though the VCAP is located in the ingress path of the device, it possesses both ingress and egress capabilities.

The VCAP embeds powerful protocol awareness for well-known protocols such as LLC, SNAP, ARP, IPv4, IPv6, and UDP/TCP.

3.4.4 Policing

Each frame is subject to a number of different policing operations. The device features a pool of 256 programmable policers. Each frame can trigger three policers from the pool. The pool of policers is split into the followings groups:

- Queue policers: Ingress port number and QoS class determine which policer to use.
- Port policers: Ingress port number determines which policer to use.
- VCAP-II IS2 policers: IS2 action can point to any of the policers in the pool.

It is programmable per port whether to use a port policer or use the queue policers. Policers not used by the port or the queues are available as VCAP-II IS2 policers. It is also programmable whether the policers are working in serial or in parallel.

Each policer is a MEF-compliant dual leaky bucket policer supporting both color-blind and color-aware operation. The initial frame color is derived from the drop precedence level from the frame classification. For color-aware operation, a coupling mode is configurable for each policer.

Using these policers ensures Service Level Agreement (SLA) compliance. The outcome of this policing operation is to mark each accepted frame as in-profile (Green) or out-of-profile (Yellow). Yellow frames are treated as excess or Discard-Eligible and Green frames are committed. Frames that exceed the Yellow/Excess limits are discarded (Red).

Each frame is counted in associated statistics reflecting the ingress port, the QoS class, and the frame's color (green, yellow, red). The statistics can count bytes or frames.

Finally, the analyzer contains a group of storm control policers that are capable of policing various kinds of flooding traffic as well as CPU directed learn traffic. These policers are global policers working on all frames received by the switch.

All policers can measure frame rates or bit rates.

3.4.5 Layer-2 Forwarding

After the policers, the Layer-2 forwarding block (the analyzer) handles all fundamental bridging operations and maintains the associated MAC table, the VLAN table, and the aggregation table. The device implement an 8K MAC table and a 4K VLAN table.

The main task of the analyzer is to determine the destination port set of each frame. This forwarding decision is based on various information such as the frame's ingress port, source MAC address, destination MAC address, and the VLAN identifier, as well as the frame's VCAP action, mirroring, and the destination port's link aggregation configuration.

The switch performs Layer-2 forwarding of frames. For unicast and Layer-2 multicast frames, this means forwarding based on the destination MAC address and the VLAN. For IPv4 multicast frames, the switch performs Layer-2 forwarding, but based on Layer-3 information, such as the source IP address. The latter enables source-specific IPv4 multicast forwarding (IGMPv3).

The following describes some of the contributions to the Layer-2 forwarding:

- VLAN classification VLAN-based forward filtering include source port filtering, destination port filtering, VLAN mirroring, asymmetric VLANs, and so on.
- Security enforcement The security decision made by the VCAP-II can, for example, redirect the frame to the CPU based on some abnormality detection filters.
- MAC addresses Destination and source MAC address lookups in the MAC table determine if a frame is a learn frame, a flood frame, a multicast frame, or a unicast frame.
- Learning By default, the device performs wire-speed learning on all ports. However, certain ports could be configured with secure learning enabled, where an incoming frame with unknown source MAC address is classified as a "learn frame" and is redirected to the CPU. The CPU performs the learning decision and also decides whether the frame is forwarded.

  Learning can also be disabled. In that case, it does not matter if the source MAC address is in the MAC table.
- Link aggregation A frame targeted at a link aggregate is further processed to determine which of the link aggregate group ports the frame must be forwarded to.
- Mirroring Mirror probes may be set up in different places in the forwarding path for monitoring purposes. As part of a mirror a copy of the frame is sent either to the CPU or to another port.

3.4.6 Shared Queue System and Egress Scheduler

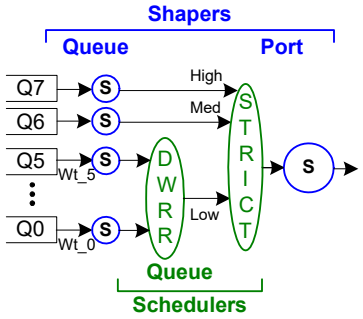
The analyzer provides the destination port set of a frame to the shared queue system. It is the queue system's task to control the frame forwarding to all destination ports.

The shared queue system embeds 4Mbits of memory that can be shared between all queues and ports. The queue system implements egress queues per priority per ingress port. The sharing of resources between queues and ports is controlled by an extensive set of thresholds.

The overall frame latency through the switch is low due to the shared queue system only storing the frame once.

Each egress port implements a scheduler and shapers as shown in the following illustration. Per egress port, the scheduler sees the outcome of aggregating the egress queues (one per ingress port per Qos class) into eight queues, one queue per QoS class. The aggregation is done in a round-robin fashion per QoS class serving all ingress ports equally.

Figure 4 • **Egress Scheduler and Shaper**



When transmitting frames from the shared queue system out on an egress port, frames are scheduled within the port using one of two methods:

- Strict priority – frames with the highest priority are always transmitted before frames with lower priority.
- Deficit Weighted Round Robin (DWRR) – queues 6 and 7 are always strict, and queues 0 through 5 are weighted. Each queue sets a weight ranging from 0 to 31.

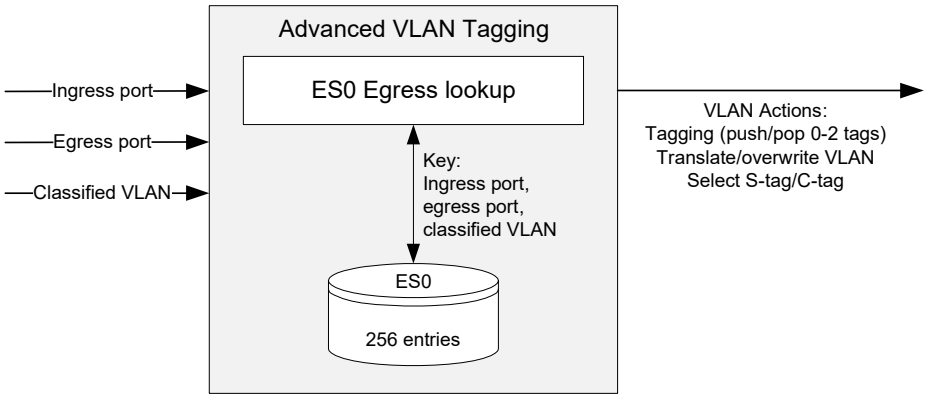
In addition, each egress port implements shapers, one per egress queue and one per port.

3.4.7 Rewriter and Frame Departure

Before transmitting the frame on the egress line, the rewriter can modify selected fields in the frame, such as VLAN tags, DSCP value, and FCS.

The rewriter controls the final VLAN tagging of frames based on the classified VLAN, the VLAN pop count, and egress-determined VLAN actions. The egress VLAN actions are by default given by the egress port settings. These include normal VLAN operations such as pushing a VLAN tag, untagging for specific VLANs, and simple translations of DEI and PCP.

Figure 5 • **Advanced VLAN Tagging**



By using the egress TCAM, ES0, much more advanced VLAN tagging operations can be achieved. ES0 enables pushing up to two VLAN tags and allows for a flexible translation of the VLAN tag header. The key into ES0 is the combination of the ingress port, the egress port, and the classified VLAN tag header.

The PCP and DEI bits in the VLAN tag are subject to remarking based on translating the classified tag header or by using the classified QoS value and the frame's drop precedence level from ingress.

In addition, the DSCP value in IP frames can be updated using the classified DSCP value and the frame's drop precedence level from ingress. The DSCP value can be remapped at egress before writing it into the frame.

Finally, the rewriter updates the FCS if the frame was modified before the frame is transmitted.

The egress port module controls the flow control exchange of pause frames with a neighboring device when the interconnection link operates in full-duplex flow control mode. When the connected device

triggers flow control through transmission of a pause frame, the MAC stops the egress scheduler's forwarding of frames out of the port. Traffic then builds up in the queue system but sufficient queuing is available to ensure wire speed lossless operation.

In half-duplex operation, the port module's egress path responds to back pressure generation from a connected device by collision detection and frame retransmission.

3.4.8 CPU Port Module

The CPU port module contains eight CPU extraction queues and two CPU injection queues. These queues provide an interface for exchanging frames between the internal CPU system and the switch core. An external CPU using the serial interface can also inject and extract frames to and from the switch core by using the CPU port module. Additionally, any Ethernet interface on the device can be used for extracting and injecting frames.

The switch core can intercept a variety of different frame types and copy or redirect these to the CPU extraction queues. The classifier can identify a set of well-known frames such as IEEE reserved destination MAC addresses (BPDUs, GARPs, CCM/Link trace), as well as IP-specific frames (IGMP, MLD). The security TCAM, IS2, provides another very flexible way of intercepting all kinds of frames, for instance specific OAM frames, ARP frames or explicit applications based on TCP/UDP port numbers. In addition, frames can be intercepted based on the MAC table, the VLAN table, or the learning process.

Whenever a frame is copied or redirected to the CPU, a CPU extraction queue number is associated with the frame and used by the CPU port module when enqueuing the frame into the 8 CPU extraction queues. The CPU extraction queue number is programmable for every interception option in the switch core.

3.4.9 Synchronous Ethernet and Precision Time Protocol

VSC7428-12 supports Layer-1 ITU-T G.8261 Synchronous Ethernet and Layer-2 IEEE 1588 Precision Time Protocol for synchronizing network timing throughout a network.

Synchronous Ethernet allows for the transfer of network timing from one reference to all network elements. In Caracal, each port can recover its ingress clock and output the recovered clock to one of two output pins. Two pins are available for redundancy. External circuitry can then generate a stable reference clock input used for egress and core logic timing in Caracal.

The Precision Time Protocol (PTP) allows for the network-wide synchronization of precise time of day. It is also possible to derive network timing. PTP can operate with a one-step clock or a two-step clock. For one-step clocks, a frame's residence time is calculated and stamped into the frame at departure. For two-step clocks, a frame's residence time is simply recorded and provided to the CPU for further processing. The CPU can then initiate a follow-up message with the recorded timing.

3.4.10 CPU System and Interfaces

The device features a VCore-III CPU system containing a powerful 416 MHz MIPS 24KEc™ CPU. It is suitable for lightly managed and fully managed applications.

VCore-III includes a general-purpose direct memory access engine (GPDMA) that also supports frame-based direct memory access (FMDA) operations. The FMDA offloads the CPU when injecting and extracting frames to and from the switch core. VCore-III boots up from a serial flash and uses DDR2 SDRAM for memory, in addition to its built-in 32 kilobytes of instruction cache and 32 kilobytes of data cache. An external debugger can be attached to the EJTAG interface.

In addition to the integrated processor, the CPU system permits the attachment of an external CPU. For configuration of switch register, an external CPU can use either a serial interface or an MII Management interface. For frame transfers, the external CPU has the option of using the serial interface, an MII Management interface, or an SGMII port.

The device includes a GPIO interface with 32 individually configurable pins. Through the GPIOs, various interfaces are supported by the device:

- Two-wire serial interface (two GPIO pins)
- Eight-bit parallel interface (sixteen GPIO pins)
- UART (two GPIO pins)

- External interrupts (two interrupt pins)
- Serial GPIO (SGPIO) and LED interface (four GPIO pins)
- Fan controller with speed input and pulse-width-modulated output (two GPIO pins)
- MII Management slave interface for accessing switch registers from an external CPU (two GPIO pins)
- Direct drive LEDs (two pins per internal PHY)
- IEEE 1588 pin with a programmable synchronized 1588 clock

The Serial GPIO and LED interface can be used specifically for driving external LEDs for the internal and external copper PHYs or for serializing external interrupts. For instance link down events from external PHYs, before being input to the device.

Finally, the device has two MII management controllers; one for the internal PHYs and one connected to the MIIM interface for controlling external PHYs.

4 Functional Descriptions

This section provides detailed information about the functional aspects of the VSC7428-12 Carrier Ethernet switch device, available configurations, operational features, and testing functionality.

4.1 Port Modules

The port modules contain the following functional blocks:

- MAC
- PCS (ports connecting to a high-speed I/O SerDes macro)

Ports connecting to one of the integrated Fast Ethernet copper transceivers do not have a PCS.

4.1.1 Port Module Numbering and Macro Connections

The port modules connect to the interface macros. The interface macros can be of three types:

- Internal Fast Ethernet copper PHY
- SERDES6G macro
- SERDES1G macro

The interface macros connect to the external interface pins. For more information about the SerDes macros and integrated copper transceivers, see SERDES1G, page 23, SERDES6G, page 27, and Copper Transceivers, page 33. Which switch core port module connected to which interface macro depends on the internal configuration.

The following table lists the mapping from the switch core port modules to the interface macros. Note that switch core port modules 8 through 22 are not used for this device.

When programming registers depending on port numbers, the switch core port module number must always be used. Examples of this are when accessing port module registers (PORT::), using port masks in system or analyzer registers (SYS::, ANA::), or programming VCAP entries with port number information or port masks.

The number next to the interface macro type (for example, “1” in cell SERDES6G, 1) indicates either the macro number or the internal PHY number that must be used when addressing the macros and PHYs for programming.

Table 3 • **Port Mapping from Switch Core Port Module to Interface Macros**

Switch Core Port Module	Interface Macro
0 – 7	CuPHY, 0-7
8 – 22	Not used
23	SERDES1G, 0
24	SERDES6G, 1
25	SERDES6G, 0
26	CPU port

4.1.2 MAC

This section provides information about the high-level functionality and the configuration options of the Media Access Controller (MAC) that is used in each of the port modules.

The MAC supports the following speeds and duplex modes:

- PHY ports support 10/100 Mbps in full-duplex mode and 10/100 Mbps in half-duplex mode.
- SERDES1G port support 10/100/1000 Mbps in full-duplex mode and 10/100 Mbps in half-duplex mode.

- SERDES6G ports support 10/100/1000/2500 Mbps in full-duplex mode and 10/100 Mbps in half-duplex mode. The device must operate in switch mode 1. The DEVCPU_GCB::MISC_CFG.SW_MODE bit controls the switch mode.

The following table lists the registers associated with configuring the MAC.

Table 4 • **MAC Configuration Registers**

Register	Description	Replication
CLOCK_CFG	Reset and speed configuration	Per port
DEV_IF_CFG	Interface Configuration (ports 10 and 11)	
MAC_ENA_CFG	Enabling of Rx and Tx data paths	Per port
MAC_MODE_CFG	Port mode configuration	Per port
MAC_MAXLEN_CFG	Maximum length configuration	Per port
MAC_TAGS_CFG	VLAN tag length configuration	Per port
MAC_ADV_CHK_CFG	Type length configuration	Per port
MAC_IFG_CFG	Interframe gap configuration	Per port
MAC_HDX_CFG	Half-duplex configuration	Per port
MAC_FC_CFG	Flow control configuration	Per port
MAC_FC_MAC_LOW_CFG	LSB of SMAC used in pause frames	Per port
MAC_FC_MAC_HIGH_CFG	MSB of SMAC used in pause frames	Per port
MAC_STICKY	Sticky bit recordings	Per port

4.1.2.1 Resets

There are a number of resets in the port module. All of the resets can be set and cleared simultaneously. By default, all blocks are in the reset state. With reference to register CLOCK_CFG, the resets are:

- MAC_RX_RST — Reset of the MAC receiver
- MAC_TX_RST — Reset of the MAC transmitter
- PORT_RST — Reset of the ingress and egress queues
- PHY_RST — Reset of the integrated PHY (only present for port modules connecting to a PHY)
- PCS_RX_RST — Reset of the PCS decoder (only present for port modules connecting to a SerDes macro)
- PCS_TX_RST — Reset of the PCS encoder (only present for port modules connecting to a SerDes macro)

When changing the MAC configuration, the port must go through a reset cycle. This is done by writing register CLOCK_CFG twice. On the first write, the reset bits are set. On the second write, the reset bits are cleared. Bits that are not reset bits in CLOCK_CFG must keep their new value for both writes.

For more information about resetting a port, see Port Reset Procedure, page 189.

4.1.2.2 Port Mode Configuration

The MAC provides a number of handles for configuring the port mode. With reference to the MAC_MODE_CFG, MAC_IFG_CFG, and MAC_ENA_CFG registers, the handles are:

- Duplex mode (FDX_ENA). Half or full duplex.
- Data sampling (GIGA_MODE_ENA). Must be 1 in 1 Gbps and 2.5 Gbps and 0 in 10 Mbps and 100 Mbps.
- Enabling transmission and reception of frames (TX_ENA/RX_ENA). Clearing RX_ENA stops the reception of frames and further frames are discarded. An ongoing frame reception is interrupted. Clearing TX_ENA stops the dequeuing of frames from the egress queues, which means that frames are held back in the egress queues. An ongoing frame transmission is completed.
- Tx to Tx inter-frame gap (TX_IFG).

For ports connecting to an internal PHY, the link speed is determined by the PHY. For other ports, the link speed is configured using CLOCK_CFG.LINK_SPEED with the following options:

- Link speed (CLOCK_CFG.LINK_SPEED)
  Ports 23, 24, and 25: 1 Gbps (125 MHz clock)

  Ports 24 and 25: 1 Gbps or 2.5 Gbps (125 MHz or 312.5 MHz clock). The actual clock frequency depends on the SerDes configuration.

  All ports: 100 Mbps (25 MHz clock)

  All ports: 10 Mbps (2.5 MHz clock)

4.1.2.3 Half-Duplex Mode

A number of special configuration options are available for half-duplex (HDX) mode:

- **Seed for back-off randomizer** Field MAC_HDX_CFG.SEED seeds the randomizer used by the backoff algorithm. Use MAC_HDX_CFG.SEED_LOAD to load a new seed value.
- **Backoff after excessive collision** Field MAC_HDX_CFG.WEXC_DIS determines whether the MAC backs off after an excessive collision has occurred. If set, backoff is disabled after excessive collisions.
- **Retransmission of frame after excessive collision** Field MAC_HDX_CFG.RETRY_AFTER_EXC_COL_ENA determines if the MAC retransmits frames after an excessive collision has occurred. If set, a frame is not dropped after excessive collisions, but the backoff sequence is restarted. Although this is a violation of IEEE 802.3, it is useful in non-dropping half-duplex flow control operation.
- **Late collision timing** Field MAC_HDX_CFG.LATE_COL_POS adjusts the border between a collision and a late collision in steps of 1 byte. According to IEEE 802.3, section 21.3, this border is permitted to be on data byte 56 (counting frame data from 1); that is, a frame experiencing a collision on data byte 55 is always retransmitted, but it is never retransmitted when the collision is on byte 57. For each higher LATE_COL_POS value, the border is moved 1 byte higher.
- **Rx-to-Tx inter-frame gap** The sum of MAC_IFG_CFG.RX_IFG1 and MAC_IFG_CFG.RX_IFG2 establishes the time for the Rx-to-Tx inter-frame gap. RX_IFG1 is the first part of half-duplex Rx-to-Tx inter-frame gap. Within RX_IFG1, this timing is restarted if carrier sense (CRS) has multiple high-low transitions (due to noise). RX_IFG2 is the second part of half-duplex Rx-to-Tx inter-frame gap. Within RX_IFG2, transitions on CRS are ignored.

When enabling a port for half-duplex mode, the switch core must also be enabled (SYS::FRONT_PORT_MODE.HDX_MODE).

4.1.2.4 Frame and Type/Length Check

The MAC supports frame lengths of up to 16 kilobytes. The maximum length accepted by the MAC is configurable in MAC_MACLEN_CFG.MAX_LEN.

The MAC allows tagged frames to be 4 bytes longer and double-tagged frames to be 8 bytes longer than the specified maximum length (MAC_TAGS_CFG.VLAN_LEN_AWR_ENA). The MAC must be configured to look for VLAN tags. By default, EtherType 0x8100 identifies a VLAN tag. In addition, a custom EtherType can be configured in MAC_TAGS_CFG.TAG_ID. The MAC can be configured to look for none, one, or two tags (MAC_TAG_CFG.VLAN_AWR_ENA, MAC_TAG_CFG.VLAN_DBL_AWR_ENA).

The type/length check (MAC_ADV_CHK_CFG.LEN_DROP_ENA) causes the MAC to discard frames with type/length errors (in-range and out-of-range errors).

4.1.2.5 Flow Control

In full-duplex mode, the MAC provides independent support for transmission of pause frames and reaction to incoming pause frames. This allows for asymmetric flow control configurations.

The MAC obeys received pause frames (MAC_FC_CFG.RX_FC_ENA) by pausing the egress traffic according to the timer values specified in the pause frames.

The transmission of pause frames is triggered by assertion of a flow control condition in the ingress queues caused by a queue filling exceeding a watermark. For more information, see Shared Queue

System, page 103. The MAC handles the formatting and transmission of the pause frame. The following configuration options are available:

- Transmission of pause frames (MAC_CFG_CFG.TX_FC_ENA).
- Pause timer value used in transmitted pause frames (MAC_FC_CFG.PAUSE_VAL_CFG).
- Flow control cancellation when the ingress queues de-assert the flow control condition by transmission of a pause frame with timer value 0 (MAC_FC_CFG.ZERO_PAUSE_ENA).
- Source MAC address used in transmitted pause frames (MAC_FC_MAC_HIGH_CFG, MAC_FC_MAC_LOW_CFG).

The MAC has the option to discard incoming frames when the remote link partner is not obeying the pause frames transmitted by the MAC. The MAC discards an incoming frame if a Start-of-Frame is seen after the pause frame was transmitted. It is configurable how long reaction time is given to the link partner (MAC_FC_CFG.FC_LATENCY_CFG). The benefit of this approach is that the queue system is not risking being overloaded with frames due to a non-complying link partner.

In half-duplex mode, the MAC does not react to received pause frames. If the flow control condition is asserted by the ingress queues, the industry-standard backpressure mechanism is used. Together with the ability to retransmit frames after excessive collisions (MAC_HDX_CFG.RETRY_AFTER_EXC_COL_ENA), this enables non-dropping half-duplex flow control.

4.1.2.6 Frame Aging

The following table lists the registers associated with frame aging.

Table 5 • **Frame Aging Configuration Registers**

Register	Description	Replication
SYS::FRM_AGING	Frame aging time	None
REW::PORT_CFG.AGE_DIS	Disable frame aging	Per port

The MAC supports frame aging where frames are discarded if a maximum transit delay through the switch is exceeded. All frames, including CPU-injected frames, are subject to aging. The transit delay is time from when a frame is fully received until that frame is scheduled for transmission through the egress MAC. The maximum allowed transit delay is configured in SYS::FRM_AGING.

Frame aging can be disabled per port (REW::PORT_CFG.AGE_DIS).

Discarded frames due to frame aging are counted in the c_tx_aged counter.

4.1.3 PCS

This section provides information about the Physical Coding Sublayer (PCS) block, where the auto-negotiation process establishes mode of operation for a link. The PCS supports both SGMII mode and two SerDes modes, 1000BASE-X and 100BASE-FX.

The PCS block is only available in port modules 23 through 25.

The following table lists the registers associated with PCS.

Table 6 • **PCS Configuration Registers**

Registers	Description	Replication
PCS1G_CFG	PCS configuration	Per PCS
PCS1G_MODE_CFG	PCS mode configuration	Per PCS
PCS1G_SD_CFG	Signal detect configuration	Per PCS
PCS1G_ANEG_CFG	Configuration of the PCS auto-negotiation process	Per PCS
PCS1G_ANEG_NP_CFG	Auto-negotiation next page configuration	Per PCS

Table 6 • **PCS Configuration Registers *(continued)***

Registers	Description	Replication
PCS1G_LB_CFG	Loop-back configuration	Per PCS
PCS1G_ANEG_STATUS	Status signaling of the PCS auto-negotiation process	Per PCS
PCS1G_ANEG_NP_STATUS	Status signaling of the PCS auto-negotiation next page process	Per PCS
PCS1G_LINK_STATUS	Link status	Per PCS
PCS1G_LINK_DOWN_CNT	Link down counter	Per PCS
PCS1G_STICKY	Sticky bit register	Per PCS

The PCS is enabled in PCS1G_CFG.PCS_ENA and supports both SGMII and 1000BASE-X SERDES mode (PCS_MODE_CFG.SGMII_MODE_ENA), as well as 100-BASE-FX. For information about enabling 100BASE-FX, see **100BASE-FX**, page 22.

The PCS also supports the IEEE 802.3, Clause 66 unidirectional mode, where the transmission of data is independent of the state of the receive link (PCS_MODE_CFG.UNIDIR_MODE_ENA).

4.1.3.1 Auto-Negotiation

Auto-negotiation is enabled in PCS1G_ANEG_CFG.ANEG_ENA. To restart the auto-negotiation process, PCS1G_ANEG_CFG.ANEG_RESTART_ONE_SHOT must be set.

In SGMII mode (PCS_MODE_CFG.SGMII_MODE_ENA=1), matching the duplex mode with the link partner must be ignored (PCS1G_ANEG_CFG.SW_RESOLVE_ENA). Otherwise, the link is kept down when the auto-negotiation process fails.

The advertised word for the auto-negotiation process (base page) is configured in PCS1G_ANEG_CFG.ADV_ABILITY. The next page information is configured in PCS1G_ANEG_NP_CFG.NP_TX.

When the auto-negotiation state machine has exchanged base page abilities, the PCS1G_ANEG_STATUS.PAGE_RX_STICKY is asserted indicating that the link partner's abilities were received (PCS1G_ANEG_STATUS.LP_ADV_ABILITY).

If next page information is exchanged, PAGE_RX_STICKY must be cleared, next page abilities must be written to PCS1G_ANEG_NP_CFG.NP_TX, and PCS1G_ANEG_NP_CFG.NP_LOADED_ONE_SHOT must be set. When the auto-negotiation state machine has exchanged the next page abilities, the PCS1G_ANEG_STATUS.PAGE_RX_STICKY is asserted again, indicating that the link partner's next page abilities were received (PCS1G_ANEG_STATUS.LP_NP_RX). Additional exchanges of next page information are possible using the same procedure.

After the last next page is received, the auto-negotiation state machine enters the IDLE_DETECT state and the PCS1G_ANEG_STATUS.PR bit is set indicating that ability information exchange (base page and possible next pages) is finished and software can now resolve priority. Appropriate actions, such as Rx or Tx reset, or auto-negotiation restart, can then be taken, based on the negotiated abilities. The LINK_OK state is reached one link timer period later.

When the auto-negotiation process reaches the LINK_OK state, PCS1G_ANEG_STATUS.ANEG_COMPLETE is asserted.

4.1.3.2 Link Surveillance

The current link status can be observed through PCS1G_LINK_STATUS.LINK_STATUS. The LINK_STATUS is defined as either the PCS synchronization state or as bit 15 of PCS1G_ANEG_STATUS.LP_ADV_ABILTY, which carries information about the link status of the attached PHY in SGMII mode.

Link down is defined as the auto-negotiation state machine being in neither the AN_DISABLE_LINK_OK state nor the LINK_OK state for one link timer period. If a link down event occurs,

PCS1G_STICKY.LINK_DOWN_STICKY is set, and PCS1G_LINK_DOWN_CNT is incremented. In SGMII mode, the link timer period is 1.6 ms; in SerDes mode, the link timer period is 10 ms.

The PCS synchronization state can be observed through PCS1G_LINK_STATUS.SYNC_STATUS. Synchronization is lost when the PCS is not able to recover and decode data received from the attached serial link.

4.1.3.3 Signal Detect

The PCS can be enabled to react to loss of signal through signal detect (PCS1G_SD_CFG.SD_ENA). At loss of signal, the PCS Rx state machine is restarted, and frame reception stops. If signal detect is disabled, no action is taken upon loss of signal. The polarity of signal detect is configurable in PCS1G_SD_CFG.SD_POL.

The source of signal detect is selected in PCS1G_SD_CFG.SD_SEL to either the SerDes PMA or the PMD receiver. If the SerDes PMA is used as source, the SerDes macro provides the signal detect. If the PMD receiver is used as source, signal detect is sampled externally through one of the GPIO pins. For more information about the configuration of the GPIOs and signal detect, see GPIO Controller, page 176.

PCS1G_LINK_STATUS.SIGNAL_DETECT contains the current value of the signal detect input.

4.1.3.4 Tx Loopback

For debug purposes, the Tx data path in the PCS can be looped back into the Rx data path. This feature is enabled through PCS1G_LB_CFG.TBI_HOST_LB_ENA.

4.1.3.5 Test Patterns

The following table lists the registers associated with configuring test patterns.

Table 7 • **Test Pattern Registers**

Registers	Description	Replication
PCS1G_TSTPAT_MODE_CFG	Test pattern configuration	Per PSC
PCS1G_TSTPAT_MODE_STATUS	Test pattern status	Per PCS

PCS1G_TSTPAT_MODE_CFG.JTP_SEL overwrites normal operation of the PCS and enables generation of jitter test patterns for debugging. The jitter test patterns are defined in IEEE 802.3, Annex 36A, and the following patterns are supported:

- High frequency test pattern
- Low frequency test pattern
- Mixed frequency test pattern
- Continuous random test pattern with long frames
- Continuous random test pattern with short frames

PCS1G_TSTPAT_MODE_STATUS register holds information about error and lock conditions while running the jitter test patterns.

4.1.3.6 Low Power Idle

The following table lists the registers associated with low power idle (LPI).

Table 8 • **Low Power Idle Registers**

Registers	Description	Replication
PCS1G_LPI_CFG	Configuration of the PCS Low Power Idle process	Per PSC
PCS1G_LPI_WAKE_ERROR_CNT	Error counter	Per PCS
PCS1G_LPI_STATUS	Low Power Idle status	Per PCS

The PCS supports Energy Efficient Ethernet (EEE) as defined by IEEE 802.3az. The PCS converts Low Power Idle (LPI) encoding between the MAC and the serial interface transparently. In addition, the PCS

provides control signals allowing to stop data transmission in the SerDes macro. During low power idles the serial transmitter in the SerDes macro can be powered down, only interrupted periodically while transmitting refresh information, which allows the receiver to notice that the link is still up but in power down mode.

For more information about powering down the serial transmitter in the SerDes macros, see SERDES1G, page 23 or SERDES6G, page 27.

It is not necessary to enable the PCS for EEE, because it is controlled indirectly by the shared queue system. It is possible, however, to manually force the PCS into the low power idle mode through PCS1G_LPI_CFG.TX_ASSERT_LPIDLE. During LPI mode, the PCS constantly encodes low power idle with periodical refreshes. For more information about EEE, see Energy Efficient Ethernet, page 110.

The current low power idle state can be observed through PCS1G_LPI_STATUS for both receiver and transmitter:

- RX_LPI_MODE: Set if the receiver is in low power idle mode.
- RX_QUIET: Set if the receiver is in the Quiet state of the low power idle mode. If cleared while RX_LPI_MODE is set, the receiver is in the refresh state of the low power idle mode.

The same is observable for the transmitter through TX_LPI_MODE and TX_QUIET.

If an LPI symbol is received, the RX_LPI_EVENT_STICKY bit is set, and if an LPI symbol is transmitted, the TX_LPI_EVENT_STICKY bit is set. These events are sticky.

The PCS1G_LPI_WAKE_ERROR_CNT wake-up error counter increments when the receiver detects a signal and the PCS is not synchronized. This can happen when the transmitter fails to observe the wake-up time or if the receiver is not able to synchronize in time.

4.1.3.7 100BASE-FX

The following table lists the registers associated with 100BASE-FX configuration.

Table 9 • **100BASE-FX Registers**

Registers	Description	Replication
PCS_FX100_CFG	Configuration of the PCS 100BASE-FX mode	Per PSC
PCS_FX100_STATUS	Status of the PCS 100BASE-FX mode	Per PCS

The PCS supports a 100BASE-FX mode in addition to the SGMII and 1000BASE-X SerDes modes. The 100BASE-FX mode uses 4-bit/5-bit coding as specified in IEEE 802.3 Clause 24 for fiber connections. The 100BASE-FX mode is enabled through PCS_FX100_CFG.PCS_ENA, which masks out all PCS1G related registers.

The following options are available:

Far-End Fault facility In 100BASE-FX, the PCS supports the optional Far-End Fault facility. Both Far-End Fault generation (PCS_FX100_CFG.FEF_GEN_ENA) and Far-End Fault Detection (PCS_FX100_CFG.FEF_CHK_ENA) are supported. An Far-End Fault incident is recorded in PCS_FX100_STATUS.FEF_FOUND.

Signal Detect 100BASE-FX has a similar signal detect scheme to the SGMII and SerDes modes. For 100BASE-FX, PCS_FX100_CFG.SD_ENA enables signal detect, PCS_FX100_CFG.SD_POL controls the polarity, and PCS_FX100_CFG.SD_SEL selects the input source. The current status of the signal detect input can be observed through PCS_FX100_STATUS.SIGNAL_DETECT. For more information about signal detect, see **Signal Detect**, page 21.

Link Surveillance The PCS synchronization status can be observed through PCS_FX100_STATUS.SYNC_STATUS. When synchronization is lost, the link breaks and PCS_FX100_STATUS.SYNC_LOST_STICKY is set. The PCS continuously tries to recover the link.

Unidirectional mode 100BASE-FX has a similar unidirectional mode as SGMII and SerDes modes. PCS_FX100_CFG.UNIDIR_MODE_ENA enables unidirectional mode.

4.2 SERDES1G

SERDES1G is a high-speed SerDes interface that operates at 1 Gbps (SGMII/SerDes) and 100 Mbps (100BASE-FX). The 100BASE-FX mode is supported by oversampling.

The following table lists the registers associated with SERDES1G.

Table 10 • **SERDES1G Registers**

Registers	Description	Replication
SERDES1G_COMMON_CFG	Common configuration	Per SerDes
SERDES1G_DES_CFG	Deserializer configuration	Per SerDes
SERDES1G_IB_CFG	Input buffer configuration	Per SerDes
SERDES1G_SER_CFG	Serializer configuration	Per SerDes
SERDES1G_OB_CFG	Output buffer configuration	Per SerDes
SERDES1G_PLL_CFG	PLL configuration	Per SerDes
SERDES1G_MISC_CFG	Miscellaneous configuration	Per SerDes

For increased performance in specific application environments, SERDES1G supports the following:

- Programmable loop-bandwidth and phase regulation of deserializer
- Input buffer signal detect/loss of signal (LOS) options
- Input buffer with equalization
- Programmable output buffer features, including:

  De-emphasis

  Amplitude drive levels

  Slew rate control

  Idle mode
- Synchronous Ethernet support
- Loopbacks for system test

4.2.1 SERDES1G Basic Configuration

The SERDES1G is enabled in SERDES1G_COMMON_CFG.ENA_LANE. By default, the SERDES1G is held in reset and must be released before the interface is active. This is done through SERDES1G_COMMON_CFG.SYS_RST and SERDES1G_MISC_CFG.LANE_RST.

4.2.1.1 SERDES1G PLL Frequency Configuration

To operate the SERDES1G block at 1.25 GHz (corresponding to 1 Gbps data rate), configure the internal macro PLL as follows:

1. Configure SERDES1G_PLL_CFG.PLL_FSM_CTRL_DATA to 200.
2. Set SYS_RST = 0 (active) and PLL_FSM_ENA = 0 (inactive).
3. Set SYS_RST = 1 (deactive) and PLL_FSM_ENA = 1 (active).

4.2.2 SERDES1G Loopback Modes

The SERDES1G interface supports two different loopback modes for testing and debugging data paths: equipment loopback and facility loopback.

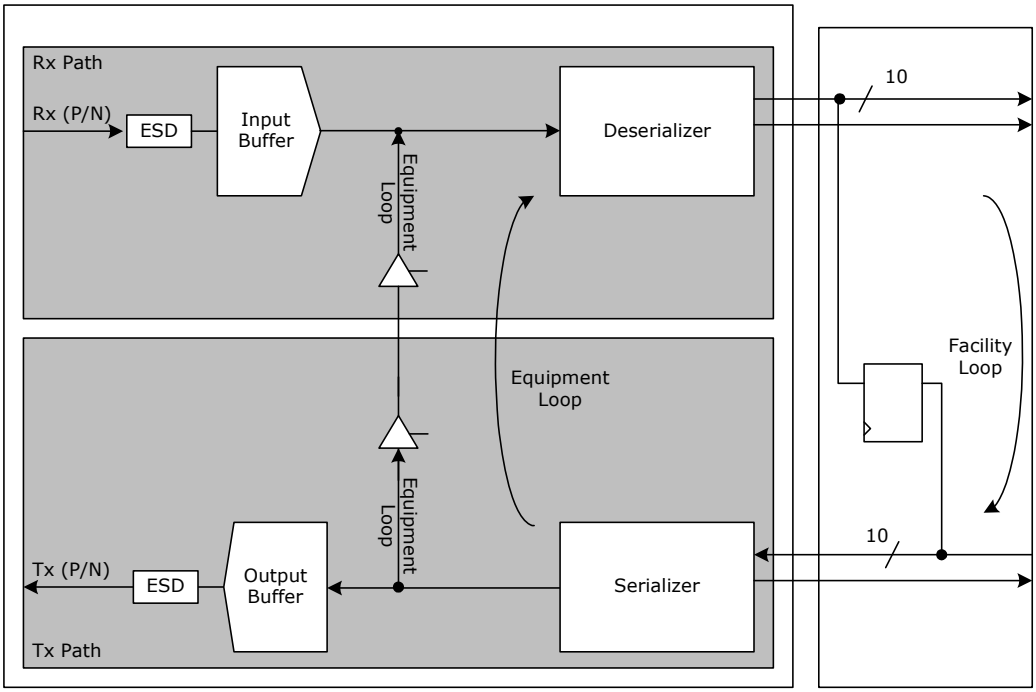
Equipment loopback (SERDES1G_COMMON_CFG.ENA_ELOOP) Data is looped back from serializer output to deserializer input, and the receive clock is recovered. The equipment loopback includes all transmit and receive functions, except for the input and output buffers. The Tx data can still be observed on the output.

Facility loopback (SERDES1G_COMMON_CFG.ENA_FLOOP) The clock and parallel data output from deserializer are looped back to the serializer interface. Incoming serial data passes through the input buffer, the CDR, the deserializer, back to the serializer, and finally out through the output buffer.

Only one of the loopbacks can be enabled at the same time.

The following illustration shows the loopback paths.

Figure 6 • **SERDES1G Loopback Modes**



4.2.3 Synchronous Ethernet

The SERDES1G block can recover the clock from the received data and apply the clock to one of the two recovered clock output pins (SERDES1G_COMMON_CFG.RECO_SEL_A and SERDES1G_COMMON_CFG.RECO_SEL_B). Note that only one macro should drive a recovered clock output pin at the same time. In addition, it is possible to squelch the recovered clock if the associated PCS cannot detect valid data (SERDES1G_COMMON_CFG.SE_AUTO_SQUELCH_A_ENA and SERDES1G_COMMON_CFG.SE_AUTO_SQUELCH_B_ENA). For more information about synchronous Ethernet, see Layer-1 Timing, page 123.

4.2.4 SERDES1G Deserializer Configuration

The SERDES1G block includes digital control logic that interacts with the analog modules within the block and compensates for the frequency offset between the received data and the internal high-speed reference clock. To gain high jitter performance, the phase regulation is a PI-type regulator, whose proportional (P) and integrative (I) characteristics can be independently configured.

The integrative part of the phase regulation loop is configured in SERDES1G_DES_CFG.DES_PHS_CTRL. The limits of the integrator are programmable, allowing different settings for the integrative regulation while guaranteeing that the proportional part still is stronger than the integrative part. Integrative regulation compensates frequency modulation from DC up to cut-off frequency. Frequencies above the cut-off frequency are compensated by the proportional part.

The time constant of the integrator is controlled independently of the proportional regulation by SERDES1G_DES_CFG.DES_BW_HYST. The DES_BW_HYST register field is programmable in a range from 3 to 7. The lower the configuration setting, the smaller the time-constant of the integrative regulation. For normal operation, configure DES_BW_HYST to 5.

The cut-off-frequency is calculated to:

fco = 1/(2 × PI × 128 × PLL period × 32 × 2^(DES_BW_HYST + 1 – DES_BW_ANA))

PLL period = 1/(data rate)

The integrative regulator can compensate a static frequency offset within the programmed limits down to a remaining frequency error of below 4 ppm. In steady state, the integrator toggles between two values around the exact value, and the proportional part of the phase regulation takes care of the remaining phase error.

After a device reset, the phase regulation may be 180° out of phase compared to the incoming data, resulting in a deadlock condition at the sampling stage of the deserializer. To prevent this situation, the SERDES1G provides a 180° deadlock protection mechanism (SERDES1G_DES_CFG.DES_MBTR_CTRL). If the deadlock protection mechanism is enabled, a small frequency offset is applied to the phase regulation loop. The offset is sufficient to move the sampling point out of the 180° deadlock region, while at the same time, small enough to allow the regulation loop to compensate when the sample point is within the data eye.

The loop bandwidth for the proportional part of the phase regulation loop is controlled by configuring SERDES1G_DES_CFG.DES_BW_ANA.

The fastest loop bandwidth setting (lowest configuration value) results in a loop bandwidth that is equal to the maximum frequency offset compensation capability. For improved jitter performance, use a setting with sufficient margin to track the expected frequency offset rather than using the maximum frequency offset. For example, if a 100 ppm offset is expected, use a setting that is four times higher than the offset. For more information about possible bandwidth selections, see Table 511, page 414.

The following table provides the limits for the frequency offset compensation. The values are theoretical limits for input signals without jitter, because the actual frequency offset compensation capability is dependent on the toggle rate of the input data and the input jitter. Only applicable configuration values are listed.

Table 11 • **SERDES1G Loop Bandwidth**

DES_BW_ANA	Limits
4	1953 ppm
5	977 ppm
6	488 ppm
7	244 ppm

4.2.5 SERDES1G Serializer Configuration

The serializer provides the ability to align the phase of the internal clock and data to a selected source (SERDES1G_SER_CFG.SER_ENALI). The phase align logic is used when SERDES1G operates in the facility loopback mode.

4.2.6 SERDES1G Input Buffer Configuration

The SERDES1G input buffer supports configuration options for:

- 100BASE-FX mode support
- Signal detection, threshold configurable
- Configurable equalization including corner frequency configuration for the equalization filter
- DC voltage offset compensation
- Configurable common-mode voltage (CMV) termination
- Selectable hysteresis, configurable hysteresis levels

When the SerDes interface operates in 100BASE-FX mode, the input buffer of the SERDES1G macro must also be configured for 100BASE-FX (SERDES1G_IB_CFG.IB_FX100_ENA).

The input buffer provides an option to configure the threshold level of the signal detect circuit to adapt to different input amplitudes. The signal detect circuit can be configured by SERDES1G_IB_CFG.IB_ENA_DETLEV and SERDES1G_IB_CFG.IB_DET_LEV.

The SERDES1G block offers options to compensate for channel loss. Degraded signals can be equalized, and the corner frequency of the equalization filter can be adapted to the channel behavior. The equalization settings are configured by SERDES1G_IB_CFG.IB_EQ_GAIN and SERDES1G_IB_CFG.IB_CORNER_FREQ.

The SERDES1G block compensates for possible DC-offset that can distort the received input signal by enabling SERDES1G_IB_CFG.IB_ENA_OFFSET_COMP during normal reception.

The common-mode voltage (CMV) input termination can be set to either an internal reference voltage or to V_{DD_A}. To allow external DC-coupling of the input buffer to an output buffer, set the CMV input termination to the internal reference voltage, with internal DC-coupling disabled. SERDES1G_IB_CFG.IB_ENA_DC_COUPLING controls internal DC-coupling, and SERDES1G_IB_CFG.IB_ENA_CMV_TERM controls CMV input termination. The following modes are defined by CMV input termination and DC-coupling:

- SGMII compliant mode with external AC coupling (IB_ENA_DC_COUPLING =0, IB_ENA_CMV_TERM = 1)
- Vitesse-mode with external DC-coupling to another Vitesse output buffer, which can operate DC-coupled to the input buffer (IB_ENA_DC_COUPLING = 0, IB_ENA_CMV_TERM = 0)
- 100BASE-FX low frequency mode (IB_ENA_DC_COUPLING = 1, IB_ENA_CMV_TERM = 1)

The SERDES1G macro supports input hysteresis, which is required for some standards (SGMII). The hysteresis function is enabled by SERDES1G_IB_CFG.IB_ENA_HYST, and hysteresis levels are defined by SERDES1G_IB_CFG.IB_HYST_LEV.

Note: Hysteresis and DC offset compensation cannot be enabled at the same time. For more information, see Table 512, page 415.

4.2.7 SERDES1G Output Buffer Configuration

The SERDEDS1G output buffer supports configuration options for:

- Configurable amplitude settings
- Configurable slew rate control
- 3 dB de-emphasis selectable
- Idle mode

The output amplitude of the output buffer is controlled by SERDES1G_OB_CFG.OB_AMP_CTRL. It can be adjusted in 50 mV steps from 0.4 V to 1.1 V peak-to-peak differential. The output amplitude also depends on the output buffer's supply voltage. For more information about dependencies between the maximum achievable output amplitude and the output buffer's supply voltage, see Table 830, page 630.

The slew rate is adjustable using SERDES1G_OB_CFG.OB_SLP.

The output buffer supports a fixed 3 dB de-emphasis (SERDES1G_SER_CFG.SER_DEEMPH).

The output buffer supports an idle mode (SERDES1G_SER_CFG.SER_IDLE), which results in an differential peak-to-peak output swing of less than 30 mV.

4.2.8 SERDES1G Clock and Data Recovery (CDR) in 100BASE-FX

To enable clock and data recovery when operating SERDES1G in 100BASE-FX mode, set the following register fields:

- SERDES1G_MISC_CFG.DES_100FX_CPMD_ENA = 1
- SERDES1G_IB_CFG.IB_FX100_ENA = 1
- SERDES1G_DES_CFG.DES_CPMD_SEL = 2

4.2.9 SERDES1G Energy Efficient Ethernet

The SERDES1G supports Energy Efficient Ethernet as defined in IEEE 802.3az. To enable the low power modes, SERDES1G_MISC_CFG.TX_LPI_MODE_ENA and

SERDES1G_MISC_CFG.RX_LPI_MODE_ENA must be set. At this point, the attached PCS takes full control over the high-speed output and input buffer activity.

4.2.10 SERDES1G Data Inversion

The data streams in the transmit and the receive direction can be inverted using SERDES1G_MISC_CFG.TX_DATA_INV_ENA and SERDES1G_MISC_CFG.RX_DATA_INV_ENA. This effectively allows for swapping the P and N lines of the high-speed serial link.

4.3 SERDES6G

The SERDES6G is a high-speed SerDes interface that operates at 100 Mbps (100BASE-FX), 1 Gbps (SGMII/SerDes), and 2.5 Gbps (SGMII). The 100BASE-FX mode is supported by oversampling.

The following table lists the registers associated with SERDES6G.

Table 12 • **SERDES6G Registers**

Registers	Description	Replication
SERDES6G_COMMON_CFG	Common configuration	Per SerDes
SERDES6G_DES_CFG	Deserializer configuration	Per SerDes
SERDES6G_IB_CFG	Input buffer configuration	Per SerDes
SERDES6G_IB_CFG1	Input buffer configuration	Per SerDes
SERDES6G_SER_CFG	Serializer configuration	Per SerDes
SERDES6G_OB_CFG	Output buffer configuration	Per SerDes
SERDES6G_OB_CFG1	Output buffer configuration	Per SerDes
SERDES6G_PLL_CFG	PLL configuration	Per SerDes
SERDES6G_MISC_CFG	Miscellaneous configuration	Per SerDes

For increased performance in specific application environments, SERDES6G supports the following:

- Baud rate support, configurable from 1 Gbps to 4 G, for quarter, half, and full rate modes
- Programmable loop bandwidth and phase regulation for the deserializer
- Configurable input buffer features such as signal detect/loss of signal (LOS) options
- Configurable output buffer features, such as programmable de-emphasis, amplitude drive levels, and slew rate control
- Synchronous Ethernet support
- Loopbacks for system test

4.3.1 SERDES6G Basic Configuration

The SERDES6G is enabled in SERDES6G_COMMON_CFG.ENA_LANE. By default, the SERDES6G is held in reset and must be released before the interface is active. This is done through SERDES6G_COMMON_CFG.SYS_RST and SERDES6G_MISC_CFG.LANE_RST.

4.3.1.1 SERDES6G Parallel Interface Configuration

The SERDES6 block includes a parallel data interface, which can operate in two different modes. It must be set according to the mode of operation (SERDES6G_COMMON_CFG.IF_MODE). For 100 Mbps, 1 Gbps, and 2.5 Gbps operation, the 10-bit mode is used.

4.3.1.2 SERDES6G PLL Frequency Configuration

To operate the SERDES6G block at the correct frequency, configure the internal macro as follows. The PLL calibration is enabled through SERDES6G_PLL_CFG.PLL_FSM_ENA.

1. Configure SERDES6G_PLL_CFG.PLL_FSM_CTRL_DATA in accordance with data rates listed in the following two tables.
2. Set SYS_RST = 0 (active) and PLL_FSM_ENA = 0 (inactive).

3. Set SYS_RST = 1 (deactive) and PLL_FSM_ENA = 1 (active).

Table 13 • **PLL Configuration**

Mode	SERDES6G_PLL_CFG.PLL_FSM_CTRL_DATA
SGMII/SerDes, 1 Gbps data	60
SGMII, 2.5 Gbps data	48

4.3.1.3 SERDES6G Frequency Configuration

The following table lists the range of data rates that are supported by SERDES6G.

Table 14 • **SERDES6 Frequency Configuration Registers**

Configuration	SGMII/SerDes 1 Gbps	SGMII 2.5 Gbps
SERDES6G_PLL_CFG.PLL_ROT_FRQ	0	1
SERDES6G_PLL_CFG.PLL_ROT_DIR	1	0
SERDES6G_PLL_CFG.PLL_ENA_ROT	0	1
SERDES6G_COMMON_CFG.QRATE	1	0
SERDES6G_COMMON_CFG.HRATE	0	1

4.3.2 SERDES6G Loopback Modes

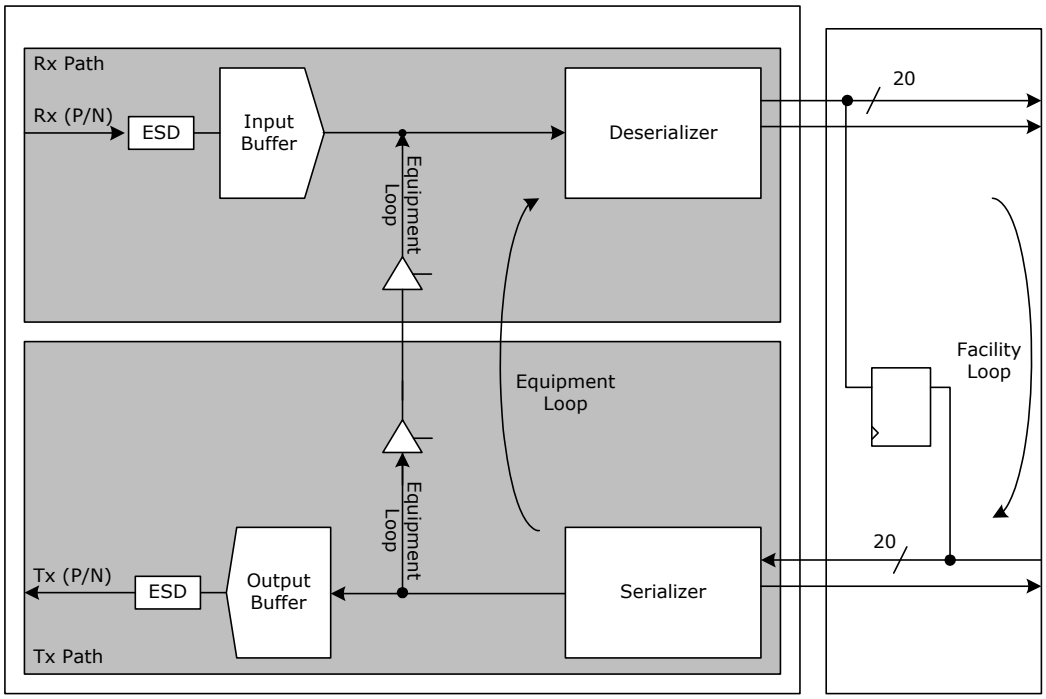
The SERDES6G interface supports two different loopback modes for testing and debugging data paths: equipment loopback and facility loopback.

Equipment loopback (SERDES6G_COMMON_CFG.ENA_ELOOP) Data is looped back from serializer output to the deserializer input, and the receive clock is recovered. The equipment loopback includes all transmit and receive functions, except for the input and output buffers. The Tx data can still be observed on the output.

Facility loopback (SERDES6G_COMMON_CFG.ENA_FLOOP) The clock and parallel data output from deserializer are looped back to the serializer interface. Incoming serial data passes through the input buffer, the CDR, the deserializer, back to the serializer, and finally out through the output buffer.

Only one of the loopbacks can be enabled at the same time.

The following illustration shows the loopback paths for the SERDESG6.



4.3.3 Synchronous Ethernet

The SERDES6G macro can recover the clock from the received data and apply the clock to one of the two recovered clock output pins (SERDES6G_COMMON_CFG.RECO_SEL_A and SERDES6G_COMMON_CFG.RECO_SEL_B). Note that only one macro should drive a recovered clock output pin at the same time. In addition, it is possible to squelch the recovered clock if the associated PCS cannot detect valid data (SERDES6G_COMMON_CFG.SE_AUTO_SQUELCH_A_ENA and SERDES6G_COMMON_CFG.SE_AUTO_SQUELCH_B_ENA). For more information about Synchronous Ethernet, see Layer-1 Timing, page 123.

4.3.4 SERDES6G Deserializer Configuration

The SERDES6G block includes digital control logic that interacts with the analog modules within the block and compensates for the frequency offset between the received data and the internal high-speed reference clock. To gain high jitter performance, the phase regulation is a PI-type regulator, whose proportional (P) and integrative (I) characteristics can be independently configured.

The integrative part of the phase regulation loop is configured in SERDES6G_DES_CFG.DES_PHS_CTRL. The limits of the integrator are programmable, allowing different settings for the integrative regulation while guaranteeing that the proportional part still is stronger than the integrative part. Integrative regulation compensates frequency modulation from DC up to cut-off frequency. Frequencies above the cut-off frequency are compensated by the proportional part.

The DES_BW_HYST register field controls the time constant of the integrator independently of the proportional regulator. The range of DES_BW_HYST is programmable as follows:

- Full rate mode = 3 to 7
- Half-rate mode = 2 to 7
- Quarter-rate mode = 1 to 7

The lower the configuration setting, the smaller the time-constant of the integrative regulation. For normal operation, configure DES_BW_HYST to 5.

The cut-off-frequency is calculated to:

fco = 1/(2 × PI × 128 × PLL period × 32 × 2^(DES_BW_HYST + 1 – DES_BW_ANA))

PLL period = 1/(*n* × data rate)

where, *n* = 1 (full rate mode), 2 (half-mode) or 4 (quarter-rate mode)

The integrative regulator can compensate a static frequency offset within the programmed limits down to a remaining frequency error of below 4 ppm. In steady state, the integrator toggles between two values around the exact value, and the proportional part of the phase regulation takes care of the remaining phase error.

After a device reset, the phase regulation may be 180° out of phase compared to the incoming data, resulting in a deadlock condition at the sampling stage of the deserializer. To prevent this situation, the SERDES6G provides a 180° deadlock protection mechanism (SERDES6G_DES_CFG.DES_MBTR_CTRL). If the deadlock protection mechanism is enabled, a small frequency offset is applied to the phase regulation loop. The offset is sufficient to move the sampling point out of the 180° deadlock region, while at the same time, small enough to allow the regulation loop to compensate when the sample point is within the data eye.

The loop bandwidth for the proportional part of the phase regulation loop is controlled by configuring SERDES6G_DES_CFG.DES_BW_ANA.

The fastest loop bandwidth setting (lowest configuration value) results in a loop bandwidth that is equal to the maximum frequency offset compensation capability. For improved jitter performance, use a setting with sufficient margin to track the expected frequency offset rather than using the maximum frequency offset. For example, if a 100 ppm offset is expected, use a setting that is four times higher than the offset. For more information about possible bandwidth selections, see Table 512, page 415 and Table 524, page 423.

The following table provides the limits for the frequency offset compensation. The values are theoretical limits for input signals without jitter, because the actual frequency offset compensation capability is dependent on the toggle rate of the input data and the input jitter. Note that only applicable configuration values are listed. HRATE and QRATE are the configuration settings of SERDES6G_COMMON_CFG.HRATE and SERDES6G_COMMON_CFG.QRATE.

Table 15 • **SERDES6G Loop Bandwidth**

DES_BW_ANA	Limits when HRATE = 0 QRATE = 0	Limits when HRATE = 1 QRATE = 0	Limits when HRATE = 0 QRATE = 1
2			1953 ppm
3		1953 ppm	977 ppm
4	1953 ppm	977 ppm	488 ppm
5	977 ppm	488 ppm	244 ppm
6	488 ppm	244 ppm	122 ppm
7	244 ppm	122 ppm	61 ppm

4.3.5 SERDES6G Serializer Configuration

The serializer provides the ability to align the phase of the internal clock and data to a selected source (SERDES6G_SER_CFG.SER_ENALI). The phase align logic is used when SERDES6G operates in the facility loopback mode.

4.3.6 SERDES6G Input Buffer Configuration

The SERDES6G input buffer supports configuration options for:

- Automatic input voltage offset compensation
- Loss of signal detection

The input buffer is normally AC-coupled and therefore the common-mode termination is switched off (SERDES6G_IB_CFG1.IB_CTERM_ENA). In order to support type-2 loads (DC-coupling at 1.0 V termination voltage) according to the OIF CEI specifications, common-mode termination must be enabled.

The sensitivity of the level detect circuit can be adapted to the input signal's characteristics (amplitude and noise). The threshold value for the level detect circuit is set in SERDES6G_IB_CFG.IB_VBCOM. The default value is suitable for normal operation.

When the SerDes interface operates in 100BASE-FX mode, the input buffer of the SERDES6G macro must also be configured for 100BASE-FX (SERDES6G_IB_CFG.IB_FX100_ENA).

During test or reception of low data rate signals (for example, 100BASE-FX), the DC-offset compensation must be disabled. For all other modes, the DC-offset compensation must be enabled for optimized performance. DC-offset compensation is controlled by SERDES6G_IB_CFG1.IB_ENA_OFFSAC and SERDES6G_IB_CFG1.IB_ENA_OFFSDC.

4.3.7 SERDES6G Output Buffer Configuration

The SERDEDS6G output buffer supports the following configuration options:

- Amplitude control
- De-emphasis and output polarity inversion
- Slew rate control
- Skew adjustment
- Idle mode

The maximum output amplitude of the output buffer depends on the output buffer's supply voltage. For interface standards requiring higher output amplitudes (backplane application or interface to optical modules, for example), the output buffer can be supplied from a 1.2 V instead of a 1.0 V supply. By default, the output buffer is configured for 1.2 V mode, because enabling the 1.0 V mode when supplied from 1.2 V must be avoided. The supply mode is configured by SERDES6G_OB_CFG.OB_ENA1V_MODE.

The output buffer supports a four-tap pre-emphasis realized by one pre-cursor, the center tap, and two post cursors. The pre-cursor coefficient, C0, is configured by SERDES6G_SER_CFG.OB_PREC. C0 is a 5-bit value, with the most significant bit defining the polarity. The lower 4-bit value is hereby defined as B0. The first post-cursor coefficient, C2, is configured by SERDES6G_OB_CFG.OB_POST0. C2 is a 6-bit value, with the most significant bit defining the polarity. The lower 5-bit value is hereby defined as B2. The second post-cursor coefficient, C3, is configured by SERDES6G_SER_CFG.OB_POST1. C3 is 5-bit value, with the most significant bit defining the polarity. The lower 4-bit value is hereby defined as B3. The center-tap coefficient, C1, is a 6-bit value. Its polarity can be programmed by SERDES6G_OB_CFG.OB_POL, which is defined as p1. For normal operation SERDES6G_OB_CFG.OB_POL must be set to 1. The value of the 6 bits forming C1 is calculated by the following equation.

Equation 1: C1: (64 – (B0 + B2 + B3)) × p1

The output amplitude is programmed by SERDES6G_OB_CFG1.OB_LEV, which is a 6-bit value. This value is internally increased by 64 and defines the amplitude coefficient K. The range of K is therefore 64 to 127. The differential peak-peak output swing is given by 8.75 mV × K. The maximum peak-peak output swing depends on the data stream and can be calculated to:

Equation 2: $H(Z) = 4.375\ mVpp \times K \times (C0 \times z^{1} + C1 \times z^{0} + C2 \times z^{-1} + C3 \times z^{-2})/64$

with z^{n} denoting the current bits of the data pattern defining the amplitude of Z. The output amplitude also depends on the output buffer's supply voltage. For more information about the dependencies between the maximum achievable output amplitude and the output buffer's supply voltage, see Table 828, page 629.

The configuration bits are summarized in the following table.

Table 16 • **De-Emphasis and Amplitude Configuration**

Configuration	Value	Description
OB_PREC	Signed 5-bit value	Pre-cursor setting C0 Range is –15 to 15

Table 16 • **De-Emphasis and Amplitude Configuration *(continued)***

Configuration	Value	Description
OB_POST0	Signed 6-bit value	First post-cursor setting C2 Range is –31 to 31
OB_POST1	Signed 5-bit value	Second post-cursor setting C3 Range is –15 to 15
OB_LEV	Unsigned 6-bit value	Amplitude coefficient, K = OB_LEV + 64 Range is 0 to 63
OB_POL	0 1	Non-inverting mode Inverting mode

The output buffer provides additional options to configure its behavior. These options are:

- Idle mode:
  Enabling idle mode (SERDES6G_OB_CFG.OB_IDLE) results in a remaining voltage of less than 30 mV at the buffers differential outputs.
- Slew Rate:
  Slew rate can be controlled by two configuration settings. SERDES6G_OB_CFG.OB_SR_H provides coarse adjustments whereas SERDES6G_OB_CFG.OB_SR provides fine adjustments.
- Skew control:
  In 1 Gbps SGMII mode, skew adjustment is controlled by SERDES6G_OB_CFG1.OB_ENA_CAS. Skew control is not applicable to other modes.

4.3.8 SERDES6G Clock and Data Recovery (CDR) in 100BASE-FX

To enable clock and data recovery when operating SERDES6G in 100BASE-FX mode, set the following register fields:

- SERDES6G_MISC_CFG.DES_100FX_CPMD_ENA = 1
- SERDES6G_IB_CFG.IB_FX100_ENA = 1
- SERDES6G_DES_CFG.DES_CPMD_SEL = 2

4.3.9 SERDES6G Energy Efficient Ethernet

The SERDES6G block supports Energy Efficient Ethernet as defined in IEEE 802.3az. To enable the low power modes, set SERDES6G_MISC_CFG.TX_LPI_MODE_ENA and SERDES6G_MISC_CFG.RX_LPI_MODE_ENA. At this point, the attached PCS takes full control over the high-speed output and input buffer activity.

4.3.10 SERDES6G Data Inversion

The data streams in the transmit and the receive direction can be inverted using SERDES6G_MISC_CFG.TX_DATA_INV_ENA and SERDES6G_MISC_CFG.RX_DATA_INV_ENA. This effectively allows for swapping the P and N lines of the high-speed serial link.

4.3.11 SERDES6G Signal Detection Enhancements

Signal detect information from the SERDES6G macro is normally directly passed to the attached PCS. It is possible to enable a hysteresis such that the signal detect condition must be active or inactive for a certain time before it is signaled to the attached PCS.

The signal detect assertion time (the time signal detect must be active before the information is passed to a PCS) is programmable in SERDES6G_DIG_CFG.SIGDET_AST. The signal detect de-assertion time (the time signal detect must be inactive before the information is passed to a PCS) is programmable in SERDES6G_DIG_CFG.SIGDET_DST.

4.3.12 SERDES6G High-Speed I/O Configuration Bus

The high-speed SerDes macros are configured using the high-speed I/O configuration bus (MCB), which is a serial bus connecting the configuration register set with all the SerDes macros. The HSIO::MCB_SERDES1G_ADDR_CFG register is used for SERDES1G macros and

HSIO::MCB_SERDES6G_ADDR_CFG register is used for SERDES6G macros. The configuration busses are used for both writing to and reading from the macros.

The SERDES6G macros are programmed as follows:

- Program the configuration registers for the SERDES6G macro. For more information about configuration options, see SERDES6G, page 27.
- Transfer the configuration from the configuration registers to one or more SerDes macros by writing the address of the macro (MCB_SERDES6G_ADDR_CFG.SERDES6G_ADDR) and initiating the write access (MCB_SERDES6G_ADDR_CFG.SERDES6G_WR_ONE_SHOT).
- The SerDes macro address is a mask with one bit per macro so that one or more macros can be programmed at the same time.
- The MCB_SERDES6G_ADDR_CFG.SERDES6G_WR_ONE_SHOT are automatically cleared when the writing is done.

The configuration and status information in the SERDES6G macros can be read as follows:

- Transfer the configuration and status from one or more SerDes macros to the configuration registers by writing the address of the macro (MCB_SERDES6G_ADDR_CFG.SERDES6G_ADDR) and initiating the read access (MCB_SERDES6G_ADDR_CFG.SERDES6G_RD_ONE_SHOT).
- The SerDes macro address is a mask with one bit per macro so that configuration and status information from one or more macros can be read at the same time. When reading from more than one macro, the results from each macro are OR'ed together.
- The MCB_SERDES6G_ADDR_CFG.SERDES6G_RD_ONE_SHOT are automatically cleared when the reading is done.

The SERDES1G macros are programmed similarly to the SERDES6G macros, except that MCB_SERDES1G_ADDR_CFG must be used for register access. For more information about configuration options, see SERDES1G, page 23.

4.4 Copper Transceivers

The VSC7428-12 device includes eight low-power Fast Ethernet transceivers, numbered 0 through 7.

This section describes the high-level functionality and operation of the built-in transceivers. The integration is kept as close to multi-chip PHY and switch designs as possible. This allows a fast path for software already running in a similar distributed design while still benefiting from the cost savings provided by the integration.

4.4.1 Register Access

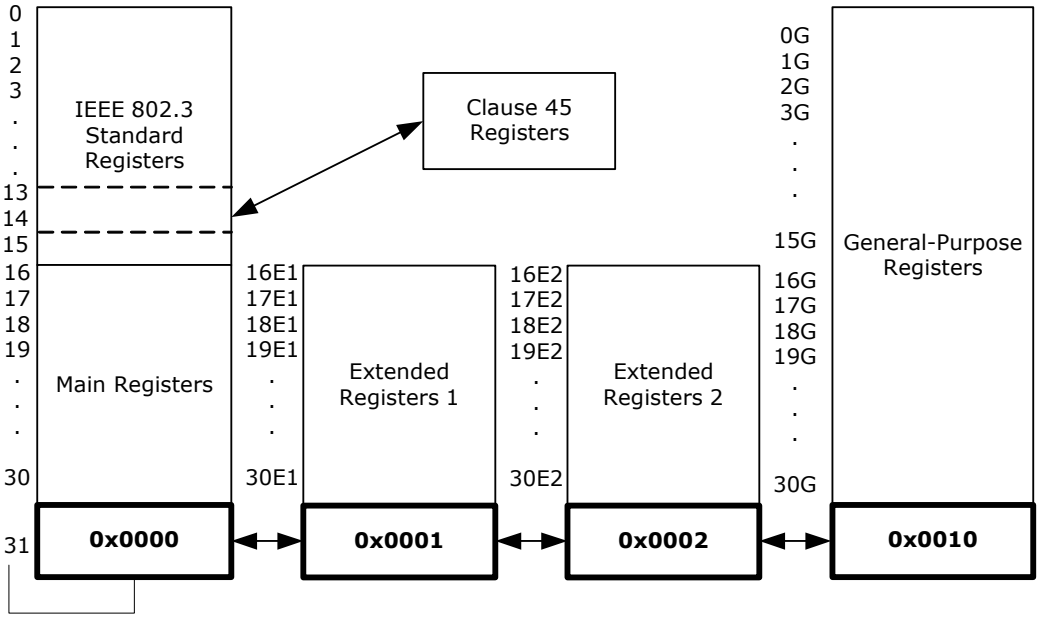
The registers of the integrated transceivers are not placed in the memory map of the switch, but are attached instead to the built-in MII management controller 0 of the device. As a result, PHY registers are accessed indirectly through the switch registers. For more information, see MII Management Controller, page 174.

In addition to providing the IEEE 802.3 specified 16 MII Standard Set registers, the PHYs contain an extended set of registers that provide additional functionality. The following types of registers are supported.

- IEEE Clause 22 device registers with addresses from 0 to 31
- Two pages of extended registers with addresses from 16E1 through 30E1 and 16E2 through 30E2
- General-purpose registers with addresses from 0G to 30G
- IEEE Clause 45 device registers accessible through the Clause 22 registers 13 and 14 to support IEEE 802.3az Energy Efficient Ethernet registers

The memory mapping is controlled through PHY_MEMORY_PAGE_ACCESS::PAGE_ACCESS_CFG. The following illustration shows the relationship between the device registers and their address spaces.

Figure 7 • **Register Space Layout**



4.4.1.1 Broadcast Write

The PHYs can be configured to accept MII PHY register write operations regardless of the destination address of these writes. This is enabled in PHY_CTRL_STAT_EXT::BROADCAST_WRITE_ENA. This enabling allows similar configurations to be sent quickly to multiple PHYs without having to do repeated MII PHY write operations. This feature applies only to writes; MII PHY register read operations are still interpreted with “correct” address.

4.4.1.2 Register Reset

The PHY can be reset through software. This is enabled in PHY_CTRL::SOFTWARE_RESET_ENA. Enabling this field initiates a software reset of the PHY. Fields that are not described as sticky are returned to their default values. Fields that are described as sticky are only returned to defaults if sticky-reset is disabled through PHY_CTRL_STAT_EXT::STICKY_RESET_ENA. Otherwise, they retain their values from prior to the software reset. A hardware reset always brings all PHY registers back to their default values.

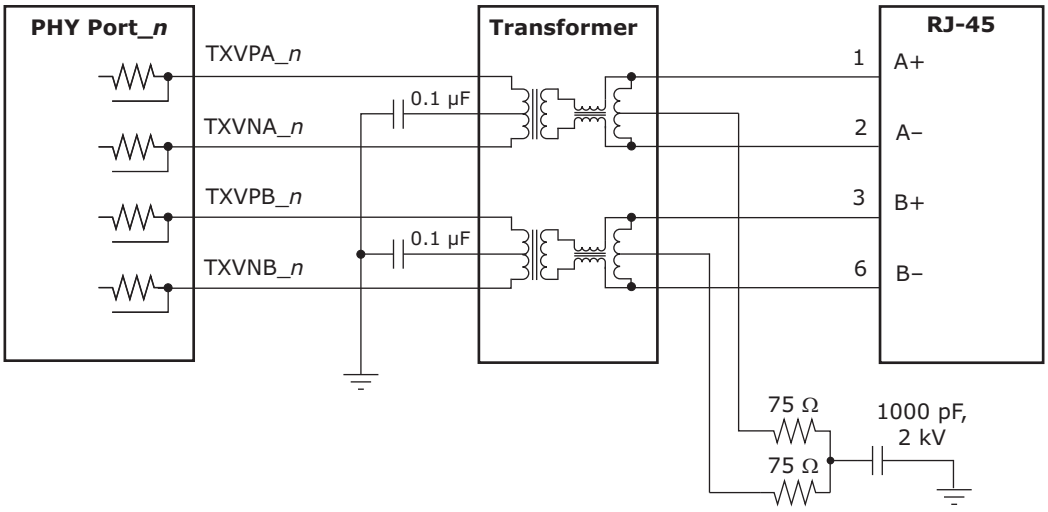
4.4.2 Cat5 Twisted Pair Media Interface

The twisted pair interfaces are compliant with IEEE 802.3-2008 and IEEE 802.3az for Energy Efficient Ethernet.

4.4.2.1 Voltage-Mode Line Driver

Unlike many other Fast Ethernet PHYs, this PHY uses a patented voltage-mode line driver that allows it to fully integrate the series termination resistors (required to connect the PHY’s Cat5 interface to an external 1:1 transformer). Also, the interface does not require placement of an external voltage on the center tap of the magnetic. The following illustration shows the connections.

Figure 8 • **Cat5 Media Interface**



4.4.2.2 Cat5 Autonegotiation and Parallel Detection

The integrated transceivers support twisted pair autonegotiation as defined by clause 28 of the IEEE 802.3-2008. The autonegotiation process evaluates the advertised capabilities of the local PHY and its link partner to determine the best possible operating mode. In particular, auto-negotiation can determine speed and duplex configuration. Auto-negotiation also allows the device to communicate with the link partner (through the optional “next pages”) to set attributes that may not otherwise be defined by the IEEE standard.

If the Cat5 link partner does not support auto negotiation, the device automatically uses parallel detection to select the appropriate link speed.

Auto-negotiation can be disabled by clearing PHY_CTRL.AUTONEG_ENA. If auto-negotiation is disabled, the state of the SPEED_SEL_MSB_CFG, SPEED_SEL_LSB_CFG, and DUPLEX_MODE_CFG fields in the PHY_CTRL register determine the device operating speed and duplex mode.

4.4.2.3 Automatic Crossover and Polarity Detection

For trouble-free configuration and management of Ethernet links, the integrated transceivers include a robust automatic crossover detection feature for all speeds on the twisted-pair interface (10BASE-T and 100BASE-T). Known as HP Auto-MDIX, the function is fully compliant with clause 40 of the IEEE 802.3-2002.

Additionally, the device detects and corrects polarity errors on all MDI pairs—a useful capability that exceeds the requirements of the standard.

Both HP Auto-MDIX detection and polarity correction are enabled in the device by default. You can change the default settings using fields POL_INV_DIS and PAIR_SWAP_DIS in the PHY_BYPASS_CTRL register. Status bits for each of these functions are located in register PHY_AUX_CTRL_STAT.

The integrated transceivers can be configured to perform HP Auto-MDIX, even when auto-negotiation is disabled (PHY_CTRL.AUTONEG_ENA = 0) and the link is forced into 10/100 speeds. To enable the HP Auto-MDIX feature, set PHY_BYPASS_CTRL.FORCED_SPEED_AUTO_MDIX_DIS to 0.

The HP Auto-MDIX algorithm successfully detects, corrects, and operates with any of the MDI wiring pair combinations listed in the following table.

Table 17 • **Supported MDI Pair Combinations**

RJ-45 Pin Pairings		
1, 2	**3, 6**	**Mode**
A	B	Normal MDI
B	A	Normal MDI-X

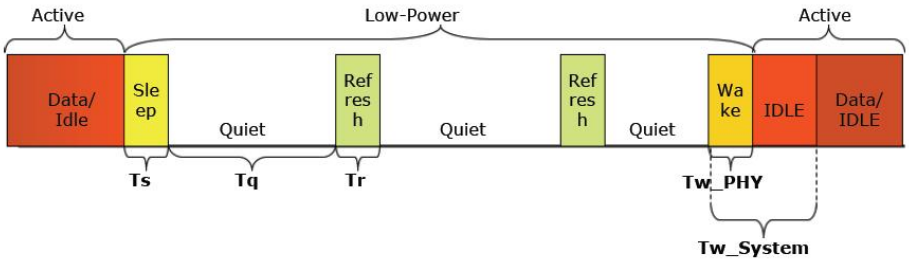
4.4.2.4 Manual MDI/MDI-X Setting

As an alternative to HP Auto-MDIX detection, the PHY can be forced to be MDI or MDI-X using PHY_EXT_MODE_CTRL.FORCE_MDI_CROSSOVER_ENA. Setting this field to 10 forces MDI, and setting 11 forces MDI-X. Leaving the bits 00 enables the MDI/MDI-X setting to be based on FORCED_SPEED_AUTO_MDIX_DIS and PAIR_SWAP_DIS in the register PHY_BYPASS_CTRL.

4.4.2.5 Energy Efficient Ethernet

The integrated transceivers support IEEE 802.3az Energy Efficient Ethernet (EEE) currently in development. This new standard provides a method for reducing power consumption on an Ethernet link during times of low use. It uses Low Power Idles (LPI) to achieve this objective.

Figure 9 • **Energy Efficient Ethernet**



Term	Description
Sleep Time (Ts)	**Duration PHY sends Sleep symbols before going Quiet.**
Quiet Duration (Tq)	**Duration PHY remains Quiet before it must wake for Refresh period.**
Refresh Duration (Tr)	**Duration PHY sends Refresh symbols for timing recovery and coefficient synchronization.**
PHY Wake Time (Tw_PHY)	**Duration PHY takes to resume to Active state after decision to Wake.**
System Wake Time (Tw_System)	**Wait period where no data is transmitted to give the receiving system time to wake up.**

Using LPI, the usage model for the link is to transmit data as fast as possible and then return to a low power idle state. Energy is saved on the link by cycling between active and low power idle states. Power is reduced during LPI by turning off unused circuits and, using this method, energy use scales with bandwidth utilization.

The transceivers use LPI to optimize power dissipation in 100BASE-TX operation. In addition, IEEE 802.3az defines a 10BASE-Te mode that reduces transmit signal amplitude from 5 V to approximately 3.3 V, peak-to-peak. This mode reduces power consumption in 10 Mbps link speed and can fully interoperate with legacy 10BASE-T compliant PHYs over 100 m Cat5 cable or better.

To configure the transceivers in 10BASE-Te mode, set PHY_EEE_CTRL.EEE_LPI_RX_100BTX_DIS to 1 for each port. Additional Energy Efficient Ethernet features are controlled through Clause 45 registers as defined in Clause 45 registers to Support Energy Efficient Ethernet.

4.4.3 LED Interface

The device outputs two LED signals per port, LED0 and LED1, through direct-drive signal outputs. The polarity of the LED outputs is programmable and can be changed through PHY_EEE_CTRL.INV_LED_POL_ENA. The default polarity is active low.

The device also has a serial LED interface if more than two LEDs per port are required. For more information, see Serial GPIO Controller, page 178.

4.4.3.1 LED Modes

Each direct-drive LED pin can be configured to display different status information that can be selected by setting the LED mode in register PHY_LED_MODE_SEL. The modes listed in the following table are equivalent to the setting used in PHY_LED_MODE_SEL to configure each LED pin. The default LED state is active low and can be changed by modifying the value in PHY_EEE_CTRL.INV_LED_POL_ENA. The blink/pulse-stretch is dependent on the LED behavior settings in PHY_LED_BEHAVIOR_CTRL.

Table 18 • **LED Modes**

Mode	Function Name	LED State and Description
0	Link/Activity	1: No link in any speed on any media interface. 0: Valid link at any speed on any media interface. Blink or pulse-stretch: Valid link at any speed on any media interface with activity present.
1	Link1000/Activity	1: No link in 1000BASE-X. 0: Valid 1000BASE-X. Blink or pulse-stretch: Valid 1000BASE-X link with activity present.
2	Link100/Activity	1: No link in 100BASE-TX or 100BASE-FX. 0: Valid 100BASE-TX or 100BASE-FX. Blink or pulse-stretch: Valid 100BASE-TX or 100BASE-FX link with activity present.
3	Link10/Activity	1: No link in 10BASE-T. 0: Valid 10BASE-T link. Blink or pulse-stretch: Valid 10BASE-T link with activity present.
4	Link100/1000/Activity	1: No link in 100BASE-TX, 100BASE-FX, or 1000BASE-X. 0: Valid 100BASE-TX, 100BASE-FX, or 1000BASE-X link. Blink or pulse-stretch: Valid 100BASE-TX, 100BASE-FX, or 1000BASE-X link with activity present.
5	Link10/1000/Activity	1: No link in 10BASE-T or 1000BASE-X. 0: Valid 10BASE-T or 1000BASE-X link. Blink or pulse-stretch: Valid 10BASE-T or 1000BASE-X link with activity present.
6	Link10/100/Activity	1: No link in 10BASE-T, 100BASE-FX, or 100BASE-TX. 0: Valid 10BASE-T, 100BASE-FX, or 100BASE-TX, link. Blink or pulse-stretch: Valid 10BASE-T, 100BASE-FX, or 100BASE-TX link with activity present.
7	Reserved	Reserved.
8	Duplex/Collision	1: Link established in half-duplex mode, or no link established. 0: Link established in full-duplex mode. Blink or pulse-stretch: Link established in half-duplex mode but collisions are present.
9	Collision	1: No collision detected. Blink or pulse-stretch: Collision detected.

Table 18 • **LED Modes *(continued)***

Mode	Function Name	LED State and Description
10	Activity	1: No activity present. Blink or pulse-stretch: Activity present.
11	Reserved	Reserved.
12	Auto-Negotiation Fault	1: No autonegotiation fault present. 0: Autonegotiation fault occurred.
13	Reserved.	Reserved.
14	Force LED Off	1: De-asserts the LED
15	Force LED On	0: Asserts the LED

4.4.3.2 LED Behavior

Several LED behaviors can be programmed into the PHYs. Use the settings in registers PHY_LED_BEHAVIOR_CTRL and PHY_EXT_MODE_CTRL to program the following LED behaviors.

LED Combine (LEDx_COMBINE_DIS) Enables an LED to display the status for a combination of primary and secondary modes. This can be enabled or disabled for each LED pin. For example, a copper link running in 100BASE-T mode and activity present can be displayed with one LED by configuring an LED pin to Link100/Activity mode. The LED asserts when linked to a 100BASE-T partner and also blinks or performs pulse-stretch when activity is either transmitted by the PHY or received by the link partner. When disabled, the LED combine feature only provides status of the selected primary function. In this example, only Link100 asserts the LED, and the secondary mode, activity, does not display if the combined feature is disabled.

LED Blink or Pulse-Stretch (LEDx_PULSE_STRETCH_ENA) This behavior is used for activity and collision indication. This can be uniquely configured for each LED pin. Activity and collision events can occur randomly and intermittently throughout the link-up period. Blink is a 50% duty cycle oscillation of asserting and de-asserting an LED pin. Pulse-stretch guarantees that an LED is asserted and de-asserted for a specific period of time when activity is either present or not present. These rates can also be configured using a register setting.

Rate of LED Blink or Pulse-Stretch (BLINK_RATE_CFG) This behavior controls the LED blink rate or pulse-stretch length when blink/pulse-stretch is enabled on an LED pin. The blink rate, which alternates between a high and low voltage level at a 50% duty cycle, can be set to 2.5 Hz, 5 Hz, 10 Hz, or 20 Hz. For pulse-stretch, the rate can be set to 50 ms, 100 ms, 200 ms, or 400 ms. The blink rate selection for PHY0 globally sets the rate used for all LED pins on all PHY ports.

LED Pulsing Enable (PULSING_ENA) To provide additional power savings, the LEDs (when asserted) can be pulsed at 5 kHz, 20% duty cycle.

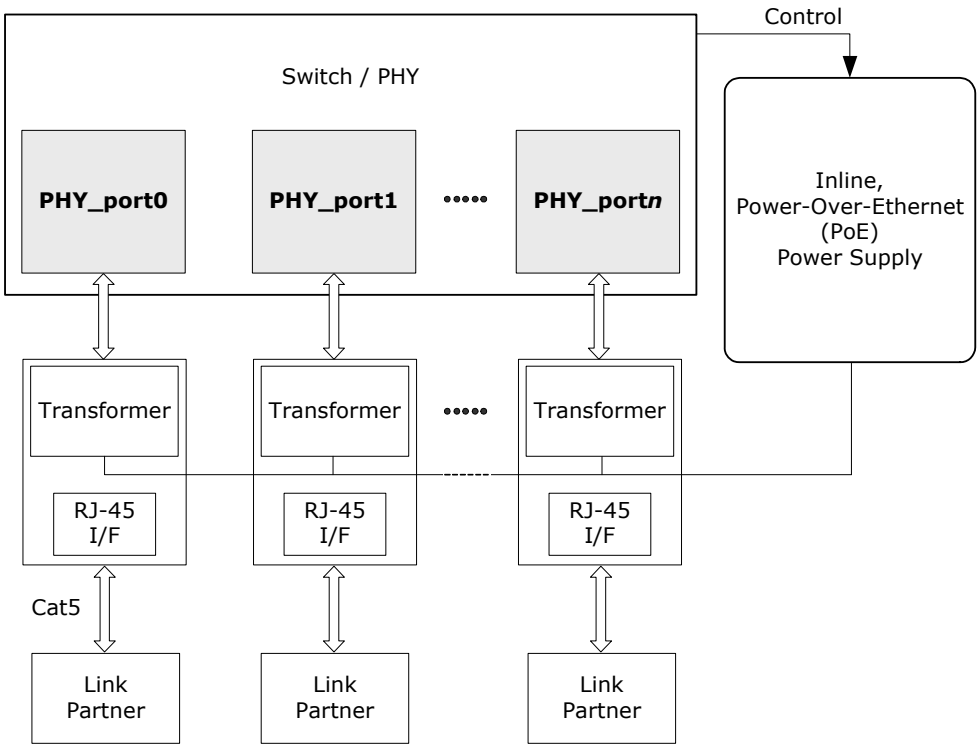
LED Blink After Reset (LED_BLINK_SUPPRESS) The LEDs blink for one second after power-up and after any time all resets are de-asserted.

4.4.4 Ethernet Inline Powered Devices

The integrated transceivers can detect legacy inline powered devices in Ethernet network applications. The inline powered detection capability can be part of a system that allows for IP-phone and other devices, such as wireless access points, to receive power directly from their Ethernet cable, similar to office digital phones receiving power from a Private Branch Exchange (PBX) office switch over the telephone cabling. This can eliminate the need of an external power supply for an IP-phone. It also enables the inline powered device to remain active during a power outage (assuming the Ethernet switch is connected to an uninterrupted power supply, battery, back-up power generator, or some other uninterruptable power source).

The following illustration shows an example of this type of application.

Figure 10 • **Inline Powered Ethernet Switch**



The following procedure describes the process that an Ethernet switch must perform to process inline power requests made by a link partner (LP); that is, in turn, capable of receiving inline power.

1. Enable the inline powered device detection mode on each transceiver using its serial management interface. Set PHY_CTRL_EXT4.INLINE_POW_DET_ENA to 1.
2. Ensure that the Auto-Negotiation Enable bit (register 0.12) is also set to 1. In the application, the device sends a special Fast Link Pulse (FLP) signal to the LP. Reading PHY_CTRL_EXT4.INLINE_POW_DET_STAT returns 00 during the search for devices that require Power-over-Ethernet (PoE).
3. The transceiver monitors its inputs for the FLP signal looped back by the LP. An LP capable of receiving PoE loops back the FLP pulses when the LP is in a powered-down state. This is reported when PHY_CTRL_EXT4.INLINE_POW_DET_STAT reads back 01. If an LP device does not loop back the FLP after a specific time, PHY_CTRL_EXT4.INLINE_POW_DET_STAT automatically resets to 10.
4. If the transceiver reports that the LP needs PoE, the Ethernet switch must enable inline power on this port, externally of the PHY.
5. The PHY automatically disables inline powered device detection if PHY_CTRL_EXT4.INLINE_POW_DET_STAT automatically resets to 10, and then automatically changes to its normal auto-negotiation process. A link is then auto-negotiated and established when the link status bit is set (PHY_STAT.LINK_STAT is set to 1).
6. In the event of a link failure (indicated when PHY_STAT.LINK_STAT reads 0), the inline power must be disabled to the inline powered device external to the PHY. The transceiver disables its normal auto-negotiation process and re-enables its inline powered device detection mode.

4.4.5 IEEE 802.3af PoE Support

The integrated transceivers are also compatible with switch designs intended for use in systems that supply power to Data Terminal Equipment (DTE) by means of the MDI or twisted pair cable, as described in clause 33 of the IEEE 802.3af.

4.4.6 ActiPHY™ Power Management

In addition to the IEEE-specified power-down control bit (PHY_CTRL.POWER_DOWN_ENA), the device also includes an ActiPHY power management mode for each PHY. The ActiPHY mode enables support for power-sensitive applications. It uses a signal detect function that monitors the media interface for the presence of a link to determine when to automatically power-down the PHY. The PHY "wakes up" at a programmable interval and attempts to wake-up the link partner PHY by sending a burst of FLP over copper media.

The ActiPHY power management mode in the integrated transceivers is enabled on a per-port basis during normal operation at any time by setting PHY_AUX_CTRL_STAT.ACTIPHY_ENA to 1.

Three operating states are possible when ActiPHY mode is enabled:

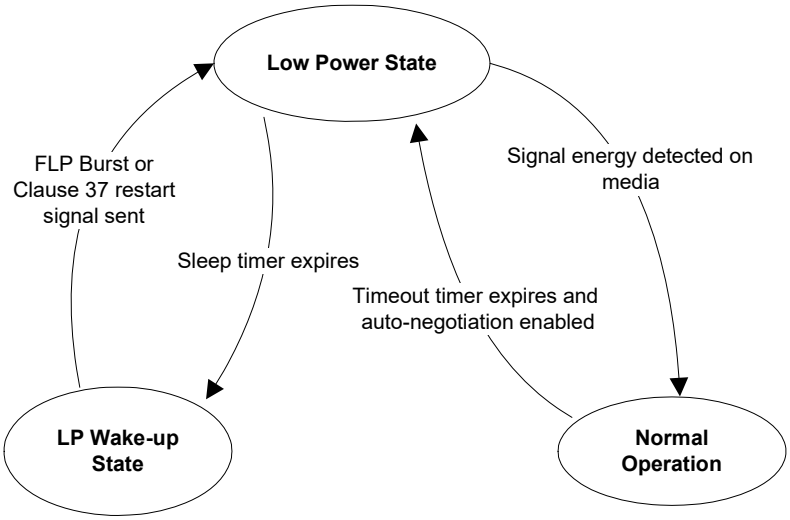
- Low power state
- LP wake-up state
- Normal operating state (link up state)

The PHY switches between the low power state and the LP wake-up state at a programmable rate (the default is two seconds) until signal energy is detected on the media interface pins. When signal energy is detected, the PHY enters the normal operating state. If the PHY is in its normal operating state and the link fails, the PHY returns to the low power state after the expiration of the link status time-out timer. After reset, the PHY enters the low power state.

When auto-negotiation is enabled in the PHY, the ActiPHY state machine operates as described. If auto-negotiation is disabled and the link is forced to use 10BT or 100BTX modes while the PHY is in its low power state, the PHY continues to transition between the low power and LP wake-up states until signal energy is detected on the media pins. At that time, the PHY transitions to the normal operating state and stays in that state even when the link is dropped. If auto-negotiation is disabled while the PHY is in the normal operation state, the PHY stays in that state when the link is dropped and does not transition back to the low power state.

The following illustration shows the relationship between ActiPHY states and timers.

Figure 11 • **ActiPHY State Diagram**



4.4.6.1 Low Power State

All major digital blocks are powered down in the lower power state.

In this state, the PHY monitors the media interface pins for signal energy. The PHY comes out of low power state and transitions to the normal operating state when signal energy is detected on the media. This happens when the PHY is connected to one of the following:

- Auto-negotiation capable link partner
- Another PHY in enhanced ActiPHY LP wake-up state

In the absence of signal energy on the media pins, the PHY transitions from the low power state to the LP wake-up state periodically based on the programmable sleep timer (PHY_CTRL_EXT3.ACTIPHY_SLEEP_TIMER). The actual sleep time duration is random, from –80 ms to +60 ms, to avoid two linked PHYs in ActiPHY mode entering a lock-up state during operation.

After sending signal energy on the relevant media, the PHY returns to the low power state.

4.4.6.2 Link Partner Wake-up State

In the link partner wake-up state, the PHY attempts to wake up the link partner. Up to three complete FLP bursts are sent on alternating pairs A and B of the Cat5 media for a duration based on the wake-up timer, which is set using register bits 20E1.12:11.

After sending signal energy on the relevant media, the PHY returns to the low power state.

4.4.6.3 Normal Operating State

In normal operation, the PHY establishes a link with a link partner. When the media is unplugged or the link partner is powered down, the PHY waits for the duration of the programmable link status time-out timer, which is set using ACTIPHY_LINK_TIMER_MSB_CFG and ACTIPHY_LINK_TIMER_LSB_CFG in the PHY_AUX_CTRL_STAT register. It then enters the low power state.

4.4.7 Testing Features

The integrated transceivers include several testing features designed to facilitate performing system-level debugging.

4.4.7.1 Ethernet Packet Generator (EPG)

The Ethernet Packet Generator (EPG) can be used at each of the 10/100 speed settings for copper Cat5 media to isolate problems between the MAC and the PHY, or between a local PHY and its remote link partner. Enabling the EPG feature effectively disables all MAC interface transmit pins and selects the EPG as the source for all data transmitted onto the twisted pair interface.

Important The EPG is intended for use with laboratory or in-system testing equipment only. Do not use the EPG testing feature when the PHY is connected to a live network.

To use the EPG feature, set PHY_1000BT_EPG2.EPG_ENA to 1.

When PHY_1000BT_EPG2.EPG_RUN_ENA is set to 1, the PHY begins transmitting Ethernet packets based on the settings in the PHY_1000BT_EPG1 and PHY_1000BT_EPG2 registers. These registers set:

- Source and destination addresses for each packet
- Packet size
- Inter-packet gap
- FCS state
- Transmit duration
- Payload pattern

If PHY_1000BT_EPG1.TRANSMIT_DURATION_CFG is set to 0, PHY_1000BT_EPG1.EPG_RUN_ENA is cleared automatically after 30,000,000 packets are transmitted.

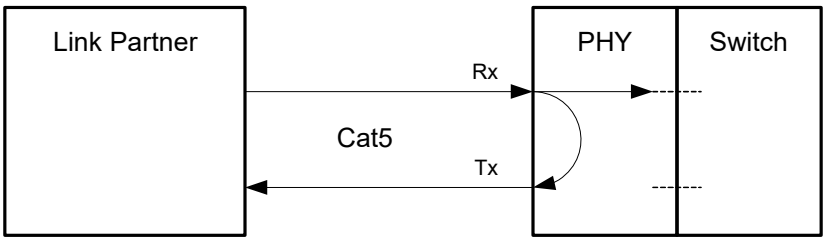
4.4.7.2 CRC Counters

Two separate CRC counters are available in the PHY: a 14-bit good CRC counter available through PHY_CRC_GOOD_CNT.CRC_GOOD_PKT_CNT and a separate 8-bit bad CRC counter in PHY_CTRL_EXT4.CRC_1000BT_CNT.

4.4.7.3 Far-End Loopback

The far-end loopback testing feature is enabled by setting PHY_CTRL_EXT1.FAR_END_LOOPBACK_ENA to 1. When enabled, it forces incoming data from a link partner on the current media interface, into the MAC interface of the PHY, to be re-transmitted back to the link partner on the media interface as shown in the following illustration. The incoming data also appears on the receive data pins of the MAC interface. Data present on the transmit data pins of the MAC interface is ignored when using this testing feature.

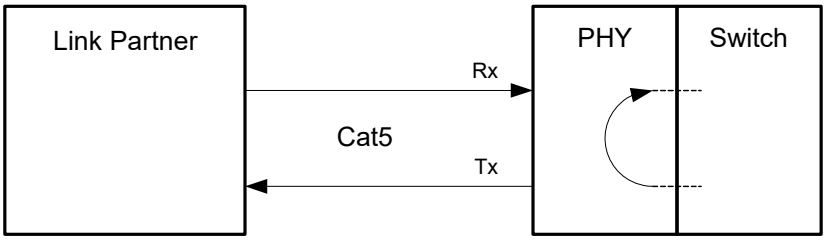
Figure 12 • **Far-End Loopback Diagram**



4.4.7.4 Near-End Loopback

When the near-end loopback testing feature is enabled (by setting PHY_CTRL.LOOPBACK_ENA to 1), data on the transmit data pins (TXD) is looped back in the PCS block, onto the device receive data pins (RXD), as shown in the following illustration. When using this testing feature, no data is transmitted over the network.

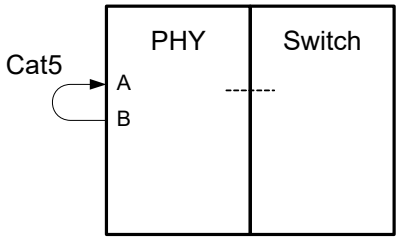
Figure 13 • **Near-End Loopback Diagram**



4.4.7.5 Connector Loopback

The connector loopback testing feature allows the twisted pair interface to be looped back externally. When using the connector loopback feature, the PHY must be connected to a loopback connector or a loopback cable. Pair A must be connected to pair B, and pair C to pair D, as shown in the following illustration. The connector loopback feature functions at all available interface speeds.

Figure 14 • **Connector Loopback Diagram**



When using the connector loopback testing feature, the device auto-negotiation, speed, and duplex configuration is set using device registers 0, 4, and 9.

4.4.8 VeriPHY Cable Diagnostics

The integrated transceivers include a comprehensive suite of cable diagnostic functions that are available through the onboard processor. These functions enable cable operating conditions and status to be accessed and checked. The VeriPHY suite has the ability to identify the cable length and operating conditions and to isolate common faults that can occur on the Cat5 twisted pair cabling.

For the functional details of the VeriPHY suite and operating instructions, see ENT-AN0125, *PHY, Integrated PHY-Switch VeriPHY - Cable Diagnostics Feature* Application Note.

4.5 Statistics

The following table lists the registers for the statistics module.

Table 19 • **Counter Registers**

Register	Description	Replication
SYS::STAT:CNT	Data register for reading port counters	Per counter per port
SYS::STAT_CFG.STAT_CLEAR_SHOT	Clears port counters	
SYS::STAT_CFG.STAT_CLEAR_PORT	Selects which port's counters to clear	
SYS::STAT_CFG.TX_GREEN_CNT_MODE SYS::STAT_CFG.TX_YELLOW_CNT_MODE	Controls whether to counts bytes or frames for Tx priority counters	
SYS::STAT_CFG.DROP_GREEN_CNT_MODE SYS::STAT_CFG.DROP_YELLOW_CNT_MODE	Controls whether to counts bytes or frames for drop priority counters	
ANA::AGENCTRL.GREEN_COUNT_MODE ANA::AGENCTRL.YELLOW_COUNT_MODE ANA::AGENCTRL.RED_COUNT_MODE	Controls whether to counts bytes or frames for Rx priority counters	

All counters for all ports are sharing a common statistics block with directly addressable counters. Each counter is 32 bits wide, which is large enough to ensure a wrap-around time longer than 13 seconds.

Each switch core port has 43 Rx counters, 18 FIFO drop counters, and 31 Tx counters.

The following table defines the per-port available Rx counters and lists the counter's base address in the common statistics block.

Table 20 • **Rx Counters in the Statistics Block**

Type	Short Name	Base Address	Description
Rx	c_rx_oct	0x000	Received octets in good and bad frames.
Rx	c_rx_uc	0x001	Number of good unicasts.
Rx	c_rx_mc	0x002	Number of good multicasts.
Rx	c_rx_bc	0x003	Number of good broadcasts.
Rx	c_rx_short	0x004	Number of short frames with valid CRC (<64 bytes).
Rx	c_rx_frag	0x005	Number of short frames with invalid CRC (<64 bytes).
Rx	c_rx_jabber	0x006	Number of long frames with invalid CRC (according to MAXLEN.MAX_LENGTH).
Rx	c_rx_crc	0x007	Number of CRC errors, alignment errors and RX_ER events.
Rx	c_rx_sz_64	0x008	Number of 64-byte frames in good and bad frames.
Rx	c_rx_sz_65_127	0x009	Number of 65-127-byte frames in good and bad frames.
Rx	c_rx_sz_128_255	0x00A	Number of 128-255-byte frames in good and bad frames.
Rx	c_rx_sz_256_511	0x00B	Number of 256-511-byte frames in good and bad frames.

Table 20 • **Rx Counters in the Statistics Block *(continued)***

Type	Short Name	Base Address	Description
Rx	c_rx_sz_512_1023	0x00C	Number of 512-1023-byte frames in good and bad frames.
Rx	c_rx_sz_1024_1526	0x00D	Number of 1024-1526-byte frames in good and bad frames.
Rx	c_rx_sz_jumbo	0x00E	Number of 1527-MAXLEN.MAX_LENGTH-byte frames in good and bad frames.
Rx	c_rx_pause	0x00F	Number of received pause frames.
Rx	c_rx_control	0x010	Number of MAC control frames received.
Rx	c_rx_long	0x011	Number of long frames with valid CRC (according to MAXLEN.MAX_LENGTH).
Rx	c_rx_cat_drop	0x012	Number of frames dropped due to classifier rules.
Rx	c_rx_red_prio_0	0x013	Number of received frames classified to QoS class 0 and discarded by a policer.
Rx	c_rx_red_prio_1	0x014	Number of received frames classified to QoS class 1 and discarded by a policer.
Rx	c_rx_red_prio_2	0x015	Number of received frames classified to QoS class 2 and discarded by a policer.
Rx	c_rx_red_prio_3	0x016	Number of received frames classified to QoS class 3 and discarded by a policer.
Rx	c_rx_red_prio_4	0x017	Number of received frames classified to QoS class 4 and discarded by a policer
Rx	c_rx_red_prio_5	0x018	Number of received frames classified to QoS class 5 and discarded by a policer.
Rx	c_rx_red_prio_6	0x019	Number of received frames classified to QoS class 6 and discarded by a policer.
Rx	c_rx_red_prio_7	0x02A	Number of received frames classified to QoS class 7 and discarded by a policer.
Rx	c_rx_yellow_prio_0	0x01C	Number of received frames classified to QoS class 0 and marked yellowby a policer
Rx	c_rx_yellow_prio_1	0x01D	Number of received frames classified to QoS class 1 and marked yellow by a policer
Rx	c_rx_yellow_prio_2	0x01E	Number of received frames classified to QoS class 2 and marked yellow by a policer
Rx	c_rx_yellow_prio_3	0x01F	Number of received frames classified to QoS class 3 and marked yellow by a policer
Rx	c_rx_yellow_prio_4	0x020	Number of received frames classified to QoS class 4 and marked yellow by a policer
Rx	c_rx_yellow_prio_5	0x021	Number of received frames classified to QoS class 5 and marked yellow by a policer
Rx	c_rx_yellow_prio_6	0x022	Number of received frames classified to QoS class 6 and marked yellow by a policer
Rx	c_rx_yellow_prio_7	0x023	Number of received frames classified to QoS class 7 and marked yellow by a policer
Rx	c_rx_green_prio_0	0x024	Number of received frames classified to QoS class 0 and marked green by a policer.
Rx	c_rx_green_prio_1	0x025	Number of received frames classified to QoS class 1 and marked green by a policer.

Table 20 • **Rx Counters in the Statistics Block *(continued)***

Type	Short Name	Base Address	Description
Rx	c_rx_green_prio_2	0x026	Number of received frames classified to QoS class 2 and marked green by a policer.
Rx	c_rx_green_prio_3	0x027	Number of received frames classified to QoS class 3 and marked green by a policer.
Rx	c_rx_green_prio_4	0x028	Number of received frames classified to QoS class 4 and marked green by a policer.
Rx	c_rx_green_prio_5	0x029	Number of received frames classified to QoS class 5 and marked green by a policer.
Rx	c_rx_green_prio_6	0x02A	Number of received frames classified to QoS class 6 and marked green by a policer.
Rx	c_rx_green_prio_7	0x02B	Number of received frames classified to QoS class 7 and marked green by a policer.

The following table defines the per-port available FIFO drop counters and lists the counter address.

Table 21 • **FIFO Drop Counters in the Statistics Block**

Type	Short Name	Base Address	Description
Drop	c_dr_local	0xC00	Number of frames discarded due to no destinations.
Drop	c_dr_tail	0xC01	Number of frames discarded due to no more memory in the queue system (tail drop).
Drop	c_dr_yellow_prio_0	0xC02	Number of FIFO discarded frames classified to QoS class 0 with DP level 1
Drop	c_dr_yellow_prio_1	0xC03	Number of FIFO discarded frames classified to QoS class 1 with DP level 1
Drop	c_dr_yellow_prio_2	0xC04	Number of FIFO discarded frames classified to QoS class 2 with DP level 1
Drop	c_dr_yellow_prio_3	0xC05	Number of FIFO discarded frames classified to QoS class 3 with DP level 1
Drop	c_dr_yellow_prio_4	0xC06	Number of FIFO discarded frames classified to QoS class 4 with DP level 1
Drop	c_dr_yellow_prio_5	0xC07	Number of FIFO discarded frames classified to QoS class 5 with DP level 1
Drop	c_dr_yellow_prio_6	0xC08	Number of FIFO discarded frames classified to QoS class 6 with DP level 1
Drop	c_dr_yellow_prio_7	0xC09	Number of FIFO discarded frames classified to QoS class 7 with DP level 1
Drop	c_dr_green_prio_0	0xC0A	Number of FIFO discarded frames classified to QoS class 0 with DP level 0.
Drop	c_dr_green_prio_1	0xC0B	Number of FIFO discarded frames classified to QoS class 1 with DP level 0.
Drop	c_dr_green_prio_2	0xC0C	Number of FIFO discarded frames classified to QoS class 2 with DP level 0.
Drop	c_dr_green_prio_3	0xC0D	Number of FIFO discarded frames classified to QoS class 3 with DP level 0.
Drop	c_dr_green_prio_4	0xC0E	Number of FIFO discarded frames classified to QoS class 4 with DP level 0.

Table 21 • **FIFO Drop Counters in the Statistics Block *(continued)***

Type	Short Name	Base Address	Description
Drop	c_dr_green_prio_5	0xC0F	Number of FIFO discarded frames classified to QoS class 5 with DP level 0
Drop	c_dr_green_prio_6	0xC10	Number of FIFO discarded frames classified to QoS class 6 with DP level 0.
Drop	c_dr_green_prio_7	0xC11	Number of FIFO discarded frames classified to QoS class 7 with DP level 0.

The following table defines the per-port available Tx counters and lists the counter address.

Table 22 • **Tx Counters in the Statistics Block**

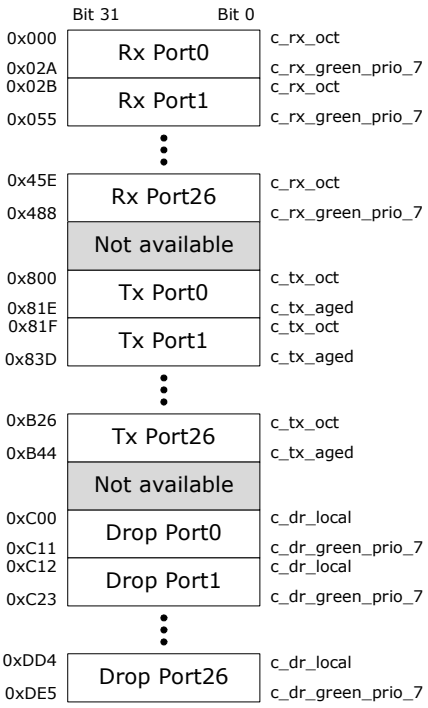
Type	Short Name	Base Address	Description
Tx	c_tx_oct	0x800	Transmitted octets in good and bad frames.
Tx	c_tx_uc	0x801	Number of good unicasts.
Tx	c_tx_mc	0x802	Number of good multicasts.
Tx	c_tx_bc	0x803	Number of good broadcasts.
Tx	c_tx_col	0x804	Number of transmitted frames experiencing a collision. An excessive collided frame gives 16 counts.
Tx	c_txdrop	0x805	Number of frames dropped due to excessive collisions or late collisions.
Tx	c_txpause	0x806	Number of transmitted pause frames in 1 Gbps full-duplex. Transmitted pause frames in 10/100 Mbps full-duplex are not counted.
Tx	c_tx_sz_64	0x807	Number of 64-byte frames in good and bad frames.
Tx	c_tx_sz_65_127	0x808	Number of 65-127-byte frames in good and bad frames.
Tx	c_tx_sz_128_255	0x809	Number of 128-255-byte frames in good and bad frames.
Tx	c_tx_sz_256_511	0x80A	Number of 256-511-byte frames in good and bad frames.
Tx	c_tx_sz_512_1023	0x80B	Number of 512-1023-byte frames in good and bad frames.
Tx	c_tx_sz_1024_1526	0x80C	Number of 1024-1526-byte frames in good and bad frames.
Tx	c_tx_sz_jumbo	0x80D	Number of 1527-MAXLEN.MAX_LENGTH-byte frames in good and bad frames.
Tx	c_tx_yellow_prio_0	0x80E	Number of transmitted frames classified to QoS class 0 with DP level 1.
Tx	c_tx_yellow_prio_1	0x80F	Number of transmitted frames classified to QoS class 1 with DP level 1.
Tx	c_tx_yellow_prio_2	0x810	Number of transmitted frames classified to QoS class 2 with DP level 1.
Tx	c_tx_yellow_prio_3	0x811	Number of transmitted frames classified to QoS class 3 with DP level 1.
Tx	c_tx_yellow_prio_4	0x812	Number of transmitted frames classified to QoS class 4 with DP level 1.

Table 22 • **Tx Counters in the Statistics Block *(continued)***

Type	Short Name	Base Address	Description
Tx	c_tx_yellow_prio_5	0x813	Number of transmitted frames classified to QoS class 5 with DP level 1.
Tx	c_tx_yellow_prio_6	0x814	Number of transmitted frames classified to QoS class 6 with DP level 1.
Tx	c_tx_yellow_prio_7	0x815	Number of transmitted frames classified to QoS class 7 with DP level 1.
Tx	c_tx_green_prio_0	0x816	Number of transmitted frames classified to QoS class 0 with DP level 0.
Tx	c_tx_green_prio_1	0x817	Number of transmitted frames classified to QoS class 1 with DP level 0.
Tx	c_tx_green_prio_2	0x818	Number of transmitted frames classified to QoS class 2 with DP level 0.
Tx	c_tx_green_prio_3	0x819	Number of transmitted frames classified to QoS class 3 with DP level 0.
Tx	c_tx_green_prio_4	0x81A	Number of transmitted frames classified to QoS class 4 with DP level 0.
Tx	c_tx_green_prio_5	0x81B	Number of transmitted frames classified to QoS class 5 with DP level 0.
Tx	c_tx_green_prio_6	0x81C	Number of transmitted frames classified to QoS class 6 with DP level 0.
Tx	c_tx_green_prio_7	0x81D	Number of transmitted frames classified to QoS class 7 with DP level 0.
Tx	c_tx_aged	0x81E	Number of frames dropped due to frame aging.

The counters are placed in a directly addressable RAM as shown in the following illustration.

Figure 15 • **Counter Layout**



The reading of a counter uses direct addressing. The following shows the address to use when reading a given counter for a port:

- Rx counter: Rx counter's base address + 43*port
- Tx counter: Tx counter's base address + 31*port
- Drop counter: Drop counter's base address + 18*port

For information about Rx counter base addresses, see Table 20, page 43. For information about Tx counter base addresses, see Table 22, page 46. For information about drop counter base addresses, see Table 21, page 45.

Writing to register STAT_CFG.STAT_CLEAR_SHOT clears all associated counters in the port module specified in STAT_CFG.STAT_CLEAR_PORT.

It is possible to select whether to count frames or bytes for the following specific counters:

- The Rx priority counters (c_rx_red_prio_*, c_rx_yellow_prio_*, c_rx_green_prio_*, where x is 0 through 7).
- The Tx priority counters (c_tx_yellow_prio_*, c_tx_green_prio_*, where x is 0 through 7).
- The Drop priority counters (c_dr_yellow_prio_*, c_dr_green_prio_*, where x is 0 through 7).

The Rx priority counters are programmed through ANA::AGENCTRL, and the Tx and drop priority counters are programmed through SYS::STAT_CFG. When counting bytes, the frame length excluding inter frame gap and preamble is counted.

For testing purposes, all counters are both readable and writable. All counters wrap around to 0 when reaching the maximum.

For more information about how the counters map to relevant MIBs, see Port Counters, page 190.

4.6 Classifier

The switch core includes a common classifier, which determines a number of properties affecting the forwarding of each frame through the switch. These properties are:

- Frame acceptance filtering – Drop illegal frame types.
- QoS classification – Assign one of eight QoS classes to the frame.
- Drop precedence (DP) classification - Assign one of two drop precedence levels to the frame.
- DSCP classification - Assign one of 64 DSCP values to the frame.
- VLAN classification – Extract tag information from the frame or use the port VLAN.
- Link aggregation code generation – Generate the link aggregation code.
- CPU forwarding determination – Determine CPU Forwarding and CPU extraction queue number

The outcome of the classifier is the basic classification result, which can be overruled by more intelligent frame processing in the VCAP-II IS1. For more information, see VCAP-II, page 57.

4.6.1 General Data Extraction Setup

This section provides information about the overall settings for data extraction controlling the other tasks in the classifier, VCAP-II, analyzer, and rewriter.

The following table lists the registers associated with general data extraction.

Table 23 • **General Data Extraction Registers**

Register	Description	Replication
SYS::PORT_MODE.L3_PARSE_CFG	Enables the use of Layer 3 and 4 protocol information for classification and frame processing.	Per port
SYS::VLAN_ETYPE_CFG	Ethernet Type for S-tags in addition to default value 0x88A8.	None
ANA:PORT.VLAN_CFG.VLAN_INNER_TAG_ENA	Enables using inner VLAN tag for basic classification if available in incoming frame.	Per port

Table 23 • **General Data Extraction Registers *(continued)***

Register	Description	Replication
ANA:PORT:S1_VLAN_INNER_TAG_ENA	Enables using inner VLAN tag for IS1 key generation if available in incoming frame.	Per port per IS1 lookup

In the device, it is programmable which VLAN tags are recognized. The use of Layer-3 and Layer-4 information for classification and forwarding can also be controlled.

The device recognizes three different VLAN tags:

- Customer tags (C-TAGs), which use TPID 0x8100.
- Service tags (S-TAGs), which use TPID 0x88A8 (IEEE 802.1ad).
- Service tags (S-TAGs), which use a custom TPID programmed in SYS::VLAN_ETYPE_CFG.

The device can parse and use information from up to two VLAN tags of any of the kinds described above.

By default, the outer VLAN tag is extracted and used for both the basic classification and the VCAP IS1 key generation. However, for both the basic classification and the VCAP IS1, there is an option to use the inner VLAN tag instead for frames with at least two VLAN tags. For basic classification, this is controlled in VLAN_CFG.VLAN_INNER_TAG_ENA and affects both QoS, DP, and VLAN classification as well as the frame acceptance filter. For IS1, this is controlled per lookup in S1_VLAN_INNER_TAG_ENA.

Various device blocks use Layer-3 and Layer-4 information for classification and forwarding. Layer-3 and Layer-4 information can be extracted from a frame with up to two VLAN tags. Frames with more than two VLAN tags are considered non-IP frames.

The actual use of Layer-3 and Layer-4 information for classification, forwarding, and rewriting is enabled in SYS::PORT_MODE.L3_PARSE_CFG. The following blocks are affected by this functionality:

- Basic classification: QoS, DP, and DSCP classification, link aggregation code generation, CPU forwarding
- VCAP-II: TCAM keys (IS1, IS2) using Layer 3 and Layer4 information
- Analyzer: Flooding and forwarding of IP multicast frames
- Rewriter: Rewriting of IP information

4.6.2 Frame Acceptance Filtering

The following table lists the registers associated with frame acceptance filtering.

Table 24 • **Frame Acceptance Filtering Registers**

Register	Description	Replication
PORT::PORT_MISC	Configures forwarding of special frames	Per port
ANA:PORT:DROP_CFG	Configures discarding of illegal frame types	Per port

Based on the configurations in the DROP_CFG and PORT_MISC registers, the classifier instructs the queue system to drop or forward certain frames types, such as:

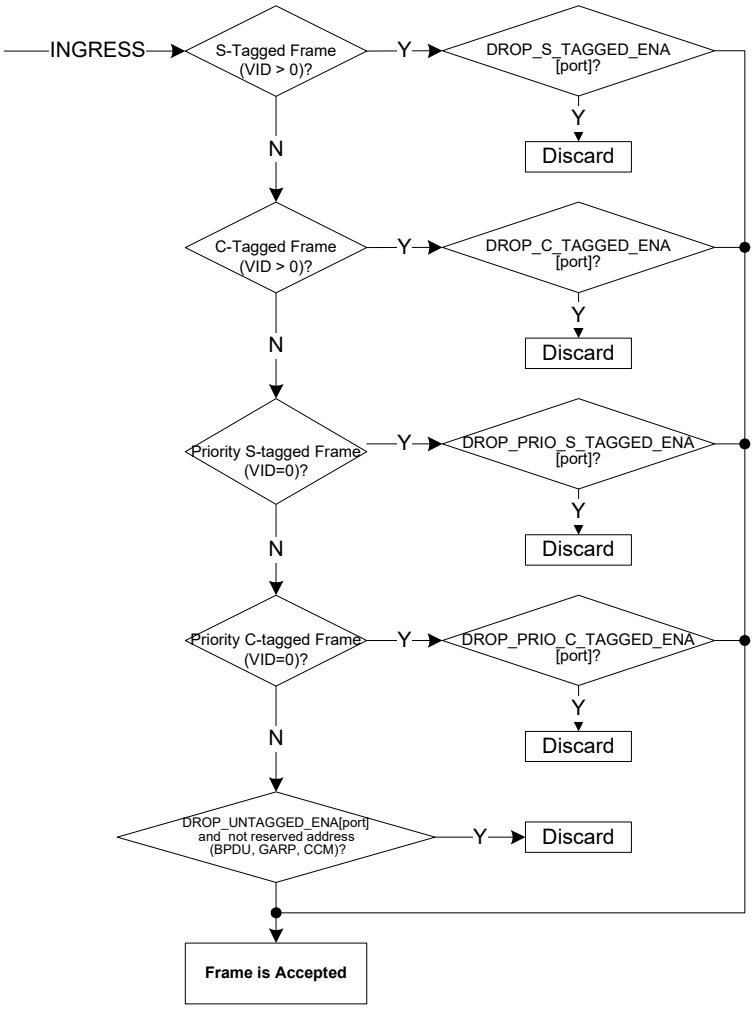
- Frames with a multicast source MAC address
- Frames with a null source or null destination MAC address (address = 0x000000000000)
- Frames with errors signaled by the MAC (for example, an FCS error)
- MAC control frames
- Pause frames after flow control processing in the MAC.
- Untagged frames (excluding frames with reserved destination MAC addresses from the BPDU, GARP, and Link trace/CCM address ranges).
- Priority S-tagged frames
- Priority C-tagged frames
- VLAN S-tagged frames
- VLAN C-tagged frames

By default, MAC control frames, pause frames, and frames with errors are dropped by the classifier.

The VLAN acceptance filter decides whether a frame's VLAN tagging is allowed on the port. By default, the outer VLAN tag is used as input to the filter, however, there is an option to use the inner VLAN tag instead for double tagged frames (VLAN_CFG.VLAN_INNER_TAG_ENA).

The following illustration shows the flowchart for the VLAN acceptance filter.

Figure 16 • **VLAN Acceptance Filter**



If the frame is accepted by the VLAN acceptance filter, it can still be discarded in other places of the switch, such as:

- Policers, due to traffic exceeding a peak information rate.
- IS2 Security TCAM, due to permit/deny rules.
- Analyzer, due to forwarding decisions such as VLAN ingress filtering.
- Queue system, due to lack of resources, frame aging, or excessive collisions.

4.6.3 QoS, DP, and DSCP Classification

This section provides information about the functions in the QoS, DP, and DSCP classification. The three tasks are described one, because the tasks have a significant amount of functionality in common.

The following table lists the registers associated with QoS, DP, and DSCP classification.

Table 25 • **QoS, DP, and DSCP Classification Registers**

Register	Description	Replication
ANA.PORT.QOS_CFG	Configuration of the overall classification flow for QoS, DP, and DSCP.	Per port
ANA:PORT:QOS_PCP_DEI_MAP_CFG	Mapping from (DEI, PCP) to (DP, QoS).	Per port per DEI per PCP
ANA::DSCP_CFG	DSCP configuration per DSCP value.	Per DSCP
ANA::DSCP_REWR_CFG	DSCP rewrite values per DP level and QoS class.	Per DP and per QoS

The basic classification provides the user with control of the QoS, DP, and DSCP classification algorithm. The result of the basic classification are the following frame properties, which follow the frame through the switch:

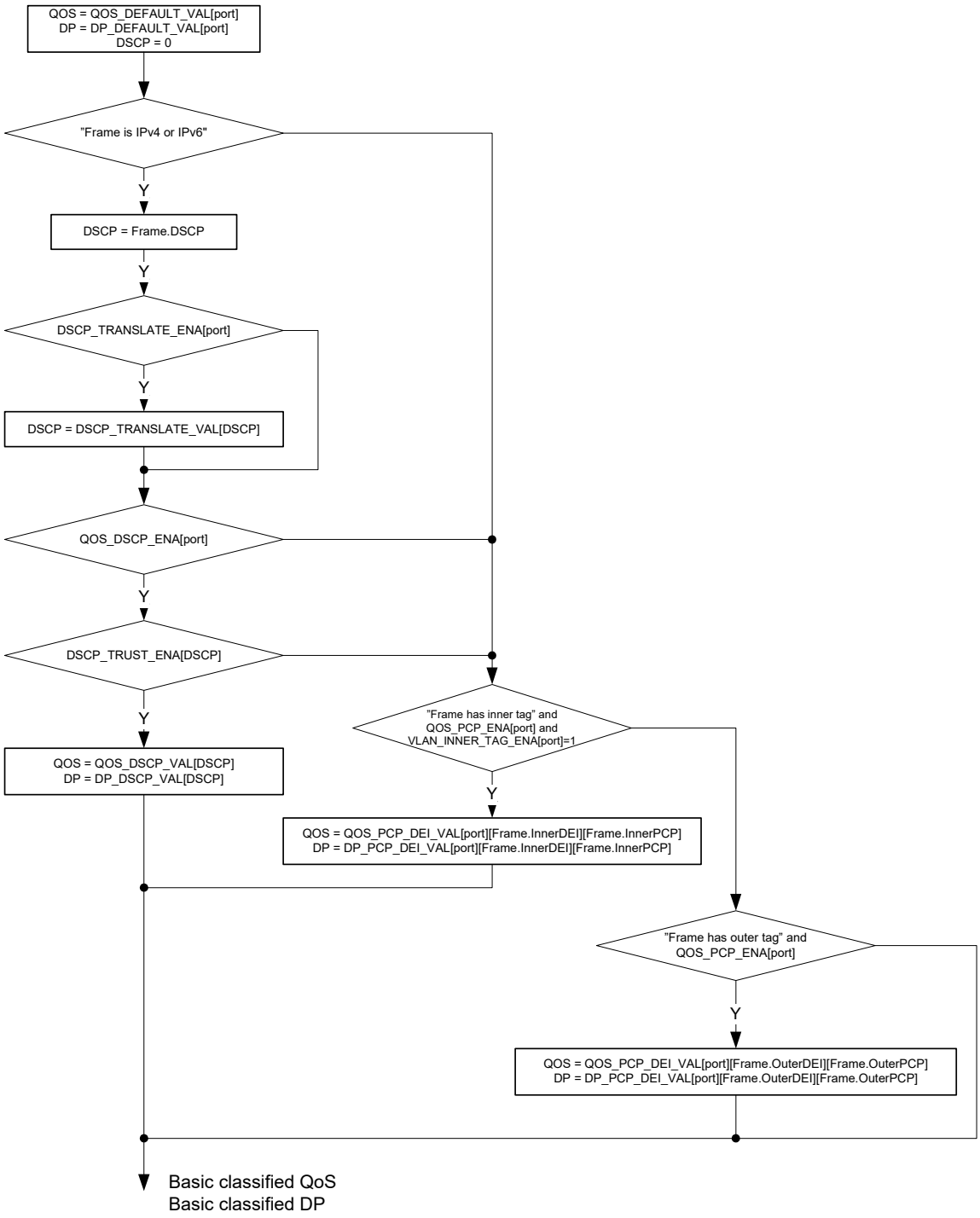
- The frame's QoS class. This class is encoded in a 3-bit field, where 7 is the highest priority QoS class and 0 is the lowest priority QoS class. The QoS class is used by the queue system when enqueuing frames and when evaluating resource consumptions, for policing, statistics, and rewriter actions.
- The frame's DP level. This level is encoded in a 1-bit field, where frames with DP = 1 have the highest probability of being dropped and frames with DP = 0 have the lowest probability. The DP level is used by the MEF compliant policers for measuring committed and peak information rates, for restricting memory consumptions in the queue system, for collecting statistics, and for rewriting priority information in the rewriter. The DP level is incremented by the policers if a frame is exceeding a programmed committed information rate.
- The frame's DSCP. This value is encoded in a 6-bit fields. The DSCP value is forwarded with the frame to the rewriter where it is translated and rewritten into the frame. The DSCP value is only applicable to IPv4 and IPv6 frames.

The classifier looks for the following fields in the incoming frame to determine the QoS, DP, and DSCP classification:

- Port default QoS class and DP level. The default DSCP value is the frame's DSCP value. For non-IP frames, the DSCP is 0 and it not used elsewhere in the switch.
- Priority Code Point (PCP) when the frame is VLAN tagged or priority tagged. There is an option to use the inner tag for double tagged frames (VLAN_CFG.VLAN_INNER_TAG_ENA). Both S-tagged and C-tagged frames are considered.
- Drop Eligible Indicator (DEI) when the frame is VLAN tagged or priority tagged. There is an option to use the inner tag for double tagged frames (VLAN_CFG.VLAN_INNER_TAG_ENA). Both S-tagged and C-tagged frames are considered.
- DSCP (all 6 bits, both for IPv4 and IPv6 packets). The classifier can look for the DSCP value behind up to two VLAN tags.

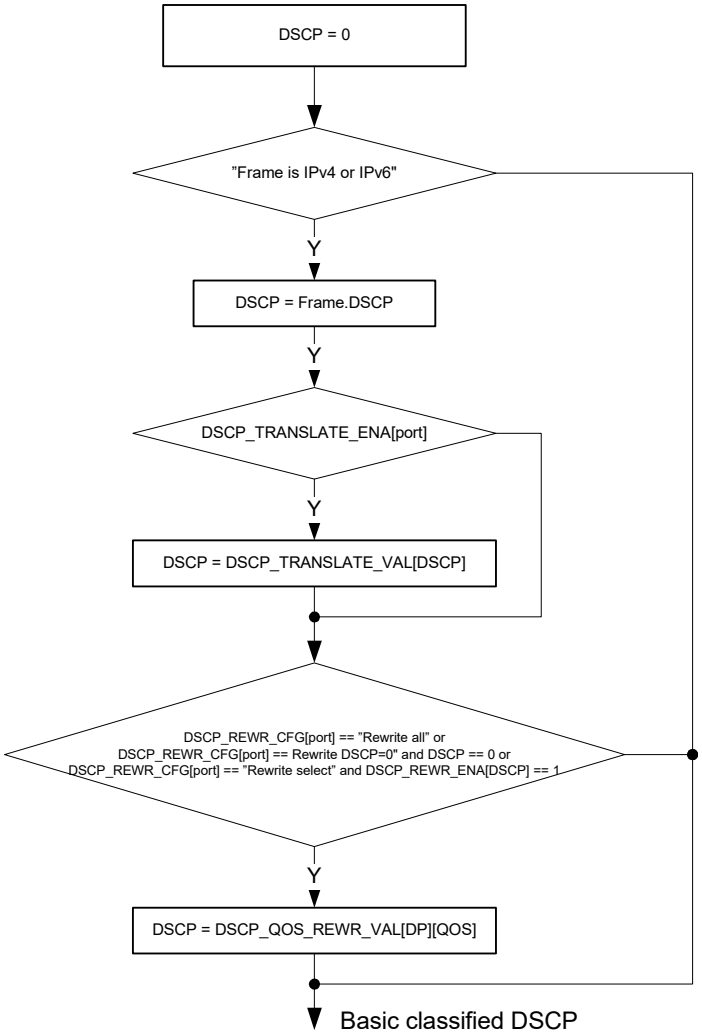
The following illustration shows the flow chart of basic QoS and DP classification.

Figure 17 • **QoS and DP Basic Classification Flow Chart**



The following illustration shows the flow chart for basic DSCP classification.

Figure 18 • **Basic DSCP Classification Flow Chart**



The translation part of the DSCP classification is common for both QoS, DP and DSCP classification.

The basic classified QoS, DP, and DSCP can be overwritten by more intelligent decisions made in the VCAP IS1.

4.6.4 VLAN Classification

The following table lists the registers associated with VLAN classification.

Table 26 • **VLAN Configuration Registers**

Register	Description	Replication
ANA:PORT:VLAN_CFG	Configures the port's processing of VLAN information in VLAN-tagged and priority-tagged frames. Configures the port-based VLAN.	Per port

The VLAN classification determines a tag header for all frames. The tag header includes the following information:

- Priority Code Point (PCP)
- Drop Eligible Indicator (DEI)
- VLAN Identifier (VID)
- Tag Protocol Identifier (TPID) type (TAG_TYPE). This field informs whether tag used for classification was a C-tag or an S-tag.

The tag header determined by the classifier is carried with the frame through the switch and is used in various places such as the analyzer for forwarding and the rewriter for egress tagging operations.

The device recognizes three kinds of tags based on the TPID, which is the EtherType in front of the tag:

- Customer tags (C-TAGs), which use TPID 0x8100.
- Service tags (S-TAGs), which use TPID 0x88A8 (IEEE 802.1ad).
- Service tags (S-TAGs), which use a custom TPID programmed in SYS::VLAN_ETYPE_CFG.

For customer tags and service tags, both VLAN tags (tags with nonzero VID) and priority tags (tags with VID = 0) are processed.

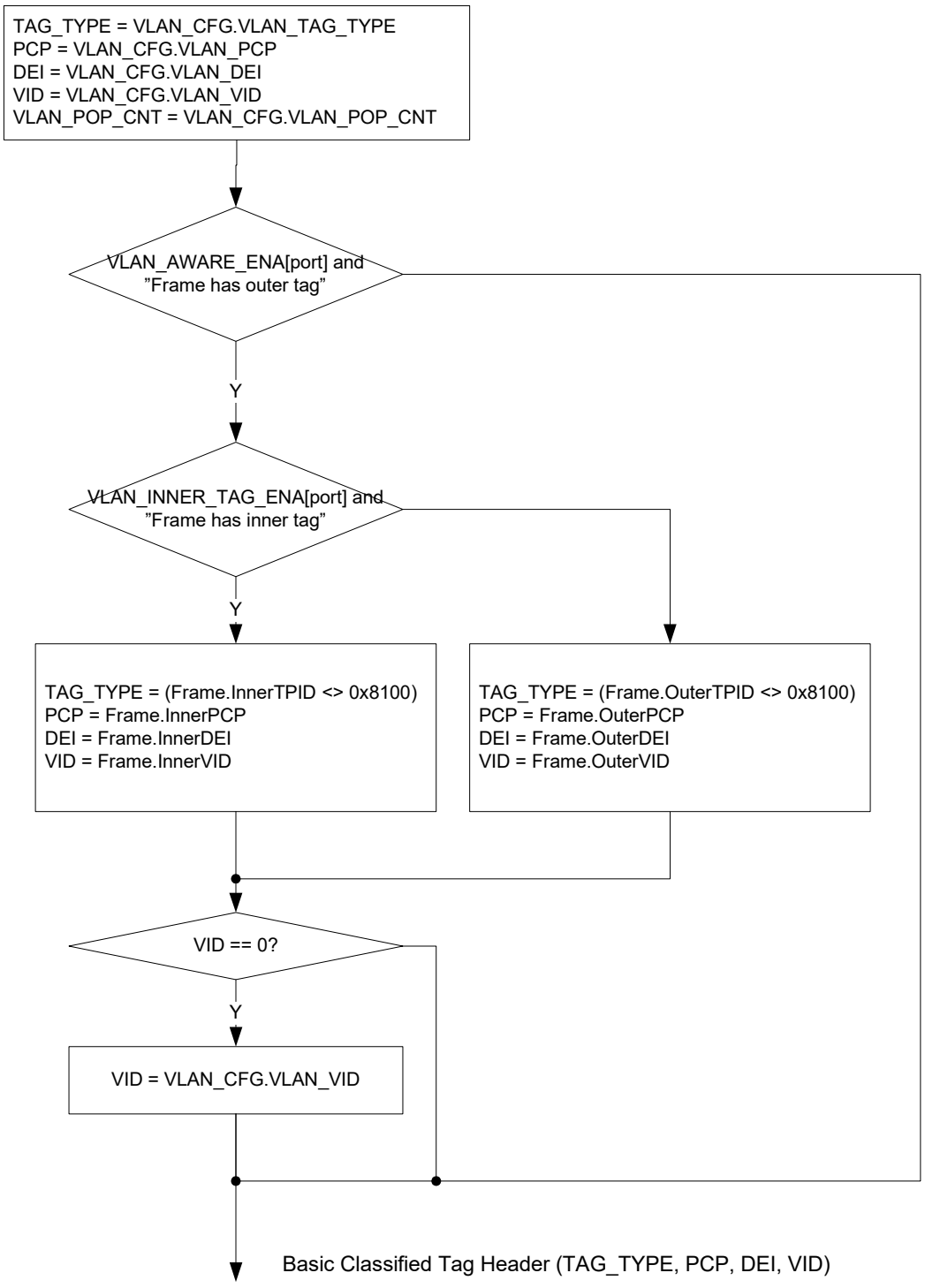
The tag header is either retrieved from a tag in the incoming frame or from a default port-based tag header. The port-based tag header is configured in ANA:PORT:VLAN_CFG.

For double tagged frames, there is an option to use the inner tag instead of the outer tag (VLAN_CFG.VLAN_INNNER_TAG_ENA).

In addition to the tag header, the ingress port decides the number of VLAN tags to pop at egress (VLAN_POP_CNT). If the configured number of tags to pop is greater than the actual number of tags in the frame, the number is reduced to the number of actual tags in the frame.

The following illustration shows the flow chart for basic VLAN classification.

Figure 19 • **Basic VLAN Classification Flow Chart**



The basic classified tag header can be overwritten by more intelligent decisions made in the VCAP IS1.

4.6.5 Link Aggregation Code Generation

This section provides information about the functions in link aggregation code generation.

The following table lists the registers associated with aggregation code generation.

Table 27 • **Aggregation Code Generation Registers**

Register	Description	Replication
ANA::AGGR_CFG	Configures use of Layer-2 through Layer-4 flow information for link aggregation code generation.	Common

The classifier generates a link aggregation code, which is used in the analyzer when selecting to which port in a link aggregation group a frame is forwarded.

The following contributions to the link aggregation code is configured in the AGGR_CFG register:

- Destination MAC address—use the lower 12 bits of the DMAC.
- Source MAC address—use the lower 12 bits of the SMAC.
- IPv6 flow label—use the 20 bits of the flow label.
- IPv4 source and destination IP addresses—use the lower 8 bits of the SIP and DIP.
- TCP/UDP source and destination port for IPv4 and IPv6 frames—use the lower 8 bits of the SPORT and DPORT.
- Random aggregation code—use a pseudo-random number instead of the frame information.

Each of the enabled contributions are XOR'ed together, yielding a 4-bit aggregation code ranging from 0 to 15. For more information about how the aggregation code is used, see Link Aggregation, page 216.

4.6.6 CPU Forwarding Determination

The following table lists the registers associated with CPU forwarding.

Table 28 • **CPU Forwarding Determination**

Register	Description	Replication
CPU_FWD_CFG	Enables CPU forwarding for various frame types	Per port
CPU_FWD_BPDU_CFG	Enables CPU forwarding per BPDU address	Per port
CPU_FWD_GARP_CFG	Enables CPU forwarding per GARP address	Per port
CPU_FWD_CCM_CFG	Enables CPU forwarding per CCM/Link trace address	Per port
CPUQ_CFG	CPU extraction queues for various frame types	None
CPUQ_8021_CFG	CPU extraction queues for BPDU, GARP, and CCM addresses.	None

The classifier has support for determining whether certain frames must be forwarded to the CPU extraction queues. Other parts of the device can also determine CPU forwarding, for example, the analyzer, based on MAC table entries or the VCAP IS2. All events leading to CPU forwarding are OR'ed together, and the final CPU extraction queue mask, which is available to the user, contains the sum of all events leading to CPU extraction. For more information, see CPU Extraction Header Insertion, page 118.

Upon CPU forwarding by the classifier, the frame type determines whether the frame is redirected or copied to the CPU. Any frame type or event causing a redirection to the CPU cause all front ports to be removed from the forwarding decision - only the CPU receives the frame. When copying a frame to the CPU, the normal forwarding of the frame is unaffected.

The following table lists the frame types, with respect to CPU forwarding, that are recognized by the classifier.

Table 29 • **Frame Type Definitions for CPU Forwarding**

Frame	Condition	Copy/Redirect
BPDU frames. Reserved Addresses (IEEE 802.1D 7.12.6)	DMAC = 0x0180C2000000 to 0x0180C20000F (BPDUs and various Slow protocols supporting spanning tree, link aggregation, port authentication)	Redirect
Reserved ALLBRIDGE address	DMAC = 0x0180C2000010	Redirect
GARP Application Addresses (IEEE 802.1D 12.5)	DMAC = 0x0180C2000020 to 0x0180C200002F	Redirect
CCM/Link Trace Addresses (IEEE P802.1ag)	DMAC = 0x0180C2000030 to 0x0180C200003F	Redirect
IGMP	DMAC = 0x01005E000000 to 0x01005E7FFFFF EtherType = IPv4 IP Protocol = IGMP	Redirect
MLD	DMAC = 0x333300000000 to 0x3333FFFFFFFF EtherType = IPv6 IPv6 Next Header = 0 Hop-by-hop options header with the first option being a Router Alert option with the MLD message (Option Type = 5, Opt Data Len = 2, Option Data = 0).	Redirect
IPv4 Multicast Ctrl	DMAC = 0x01005E000000 to 0x01005E7FFFFF EtherType = IPv4 IP protocol is not IGMP IPv4 DIP inside 224.0.0.x	Copy
Source port	All frames received on enabled ingress port	Copy
All other frames		

4.7 VCAP-II

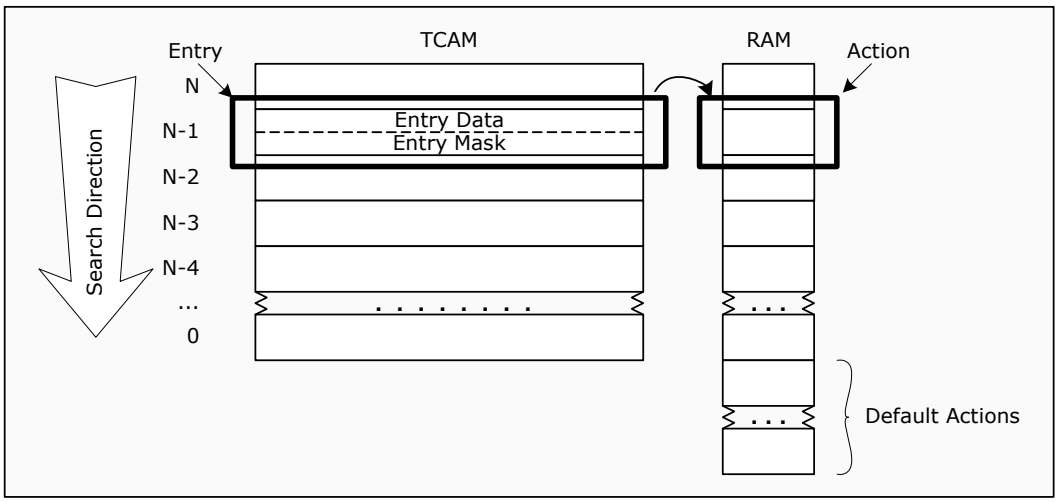
The VCAP-II is a second generation content-aware packet processor for wire-speed packet inspection for rich implementation of, for example, advanced VLAN and QoS classifications and manipulations, IP source guarding, and security features for wireline and wireless applications.

The following describes the three VCAPs implemented in the device: IS1, IS2, and ES0. IS1 and IS2 are ingress VCAPs working on the incoming frames while ES0 is an egress VCAP working on all outgoing frames.

When a VCAP is enabled, each frame is examined to determine the frame type (for example IPv4 TCP frame) so that the frame information is extracted according to the frame type. Together with port-specific configuration and classification results from the basic classification, the extracted frame information makes up an entry key, which is passed to a TCAM and matched against entries in the TCAM.

An entry in the TCAM consists of a pattern and a mask, where the mask allows pattern-matching with the use of “don’t cares”. The first matching entry is then used to select an action. The following illustration provides a functional overview of a general TCAM.

Figure 20 • **VCAP Functional Overview**



Each frame results in five ingress VCAP lookups and one egress lookup per destination port. The lookups use different keys and the results determine the frame's ingress classification, security handling, and egress VLAN manipulation. The five ingress lookups and the associated VCAPs are:

1. Advanced ingress classification, first lookup
   VCAP: IS1
   Key: IS1
   Entry: IS1 Control Entry
2. Advanced ingress classification, second lookup
   VCAP: IS1
   Key: IS1
   Entry: IS1 Control Entry
3. IP source guarding check
   VCAP: IS1
   Key: SMAC_SIP4 (IPv4 frames) or SMAC_SIP6 (IPv6 frames)
   Entry: SMAC_SIP4 Control Entry or SMAC_SIP6 Control Entry
4. Security enforcement, first lookup
   VCAP: IS2
   Key: MAC_ETYPE, MAC_LLC, MAC_SNAP, ARP, IP4_OTHER, IP4_TCP_UDP, or IP6_STD, depending on frame type
   Entry: Access Control Entry
5. Security enforcement, second lookup
   VCAP: IS2
   Key: MAC_ETYPE, MAC_LLC, MAC_SNAP, ARP, IP4_OTHER, IP4_TCP_UDP, or IP6_STD, depending on frame type
   Entry: Access Control Entry

The egress lookup per destination port and associated VCAP is:

1. Egress tagging and frame manipulations
   VCAP: ES0
   Key: ES0
   Entry: Egress Control Entry

The IP source guarding check is only carried out for IP frames.

CPU injected frames are subject to all the above VCAP lookups in IS1 and IS2, and the ES0 lookup is not performed.

Each frame is classified to one of six overall VCAP frame types. The frame type determines the information to extract from the frame and also which VCAP entries to match against. The following table lists which frame types are used and which VCAP entries the frame types are matched against in IS1 and

IS2. Note that a lookup in ES0 is independent of the frame type and all frames match against all entries in the TCAM.

Table 30 • **VCAP Frame Types**

Frame Type	Condition	IS1 Entries	IS2 Entries
IPv6 Frame	The Type/Len field is equal to 0x86DD. The IP version is 6. Special IPv6 frames: •IPv6 TCP frame: Next header is TCP (0x6) •IPv6 UDP frame: Next header is UDP (0x11) •IPv6 Other frame: Next header is neither TCP nor UDP	Frame type flags: ETYPE_LEN = 1 IP_SNAP = 1 IP4 = 0 TCP_UDP TCP	IP6_STD
IPv4 Frame	The Type/Len field is equal to 0x800. The IP version is 4. Special IPv4 frames: •IPv4 TCP frame: IP protocol is TCP (0x6) •IPv4 UDP frame: IP protocol is UDP (0x11) •IPv4 Other frame: IP protocol is neither TCP nor UDP	Frame type flags: ETYPE_LEN = 1 IP_SNAP = 1 IP4 = 1 TCP_UDP TCP	IP4_TCP_UDP IP4_OTHER
(R)ARP Frame	The Type/Len field is equal to 0x0806 (ARP) or 0x8035 (RARP).	Frame type flags: ETYPE_LEN = 1 IP_SNAP = 0	ARP
SNAP Frame	The Type/Len field is less than 0x600. The Destination Service Access Point field, DSAP is equal to 0xAA. The Source Service Access Point field, SSAP is equal to 0xAA. The Control field is equal to 0x3.	Frame type flags: ETYPE_LEN = 0 IP_SNAP = 1	MAC_SNAP
LLC Frame	The Type/Len field is less than 0x600 The LLC header does not indicate a SNAP frame.	Frame type flags: ETYPE_LEN = 0 IP_SNAP = 0	MAC_LLC
ETYPE Frame	The Type/Len field is greater than or equal to 0x600. The Type field does not indicate any of the previously mentioned frame types, that is, ARP, RARP, IPv4, or IPv6.	Frame type flags: ETYPE_LEN = 1 IP_SNAP = 0	MAC_ETYPE

In addition, Precision Time Protocol (PTP) frames are handled specifically by IS2. The following encapsulations of PTP frames are supported:

- PTP over Ethernet:
  ETYPE frame with Type/Len = 0x88F7.
  Matched against MAC_ETYPE entries.
- PTP over UDP over IPv4:
  IPv4 UDP frame with UDP destination port numbers 319 or 320.
  Matched against IP4_TCP_UDP entries.
- PTP over UDP over IPv6
  IPv6 UDP frame with UDP destination port numbers 319 or 320.
  Matched against IP6_STD entries or IP4_TCP_UDP when IP6_STD entries are disabled. For more information, see Port Configuration, page 60.

For PTP over Ethernet, the following PTP fields are always extracted:

- TransportSpecific (byte 0)
- MessageType (byte 0)
- VersionPTP (byte 1)

In addition, bytes 2-7 following the EtherType can be extracted when source MAC address overloading is used. For more information, see Port Configuration, page 60.

Note Byte 0 is the byte immediately following the EtherType, then byte 1, byte 2, and so on.

For PTP over UDP, the following PTP fields are always extracted:

- messageType (byte 0)
- domainNumber (byte 4)
- flagField: flags 1, 2, and 7 (byte 6)

In addition, the bytes 0, 1, 4, and 6 following the UDP header can be extracted when source IP address overloading is used.

Note Byte 0 is the byte immediately following the EtherType, then byte 1, byte 2, and so on.

4.7.1 Port Configuration

This section provides information about special port configurations that control the key generation for the VCAPs.

The following table lists the registers associated with port configuration for VCAP.

Table 31 • **Port Module Configuration of VCAP**

Register	Description	Replication
ANA:PORT:VCAP_CFG	Configuration of the key generation for the VCAPs	Per port
REW:PORT:PORT_CFG	Enables VCAP ES0	Per port

Each port module affects the key generation for VCAPs IS1 and IS2 through the VCAP_CFG registers, and the rewriter affects VCAP ES0 through the REW:PORT:PORT_CFG.ES0_ENA register.

4.7.1.1 VCAP IS1 Port Configuration

The following port configurations are available for IS1:

- Enable lookups in IS1 (VCAP_CFG.S1_ENA). If disabled, frames received by the port module are not matched against rules in VCAP IS1.
- Use destination information rather than source information (VCAP_CFG.S1_DMAC_DIP_ENA). By default, the two advanced classification lookups in IS1 use the source MAC address and source IP address from the incoming frame when generating the key. Through S1_DMAC_DIP_ENA, the corresponding destination information, destination MAC address, and destination IP address can be used instead. This can be controlled per lookup so that, for example, the first lookup applies source information, and the second applies destination information.
- Use inner VLAN tag rather than outer VLAN tag (VCAP_CFG.S1_VLAN_INNER_TAG_ENA). By default, the two advanced classification lookups in IS1 use the outer VLAN tag from the incoming frame when generating the key. Through S1_VLAN_INNER_TAG_ENA, the inner tag for double tagged frames can be used. This can be controlled per lookup so that, for example, the first lookup applies the outer tag, and the second lookup applies the inner tag. For single tagged frames, the outer VLAN tag is always used.

4.7.1.2 VCAP IS2 Port Configuration

The following port configurations are available for IS2:

- Enable lookups in IS2 (VCAP_CFG.S2_ENA). If disabled, frames received by the port module are not matched against rules in VCAP IS2.
- Default PAG value (VCAP_CFG.PAG_VAL). This PAG value is the initial value. Actions out of IS1 can change the PAG value before it is used in the key for IS2.
- Source IP address overloading (VCAP_CFG.S2_UDP_PAYLOAD_ENA). If enabled, UDP payload overwrites the source IP address for IP4_TCP_UDP entry types in IS2. The UDP payload is bytes 0, 1, 4, and 6 following the UDP header. This is controllable per lookup.

- Source MAC address overloading (VCAP_CFG.S2_ETYPE_PAYLOAD_ENA). If enabled, frame payload bytes overwrites the source MAC address for MAC_ETYPE entry types in IS2. The frame payload used is bytes 2 through 7 following the EtherType. This is controllable per lookup.

Each port module can control a hierarchy of which entry types in IS2 to use for different frame types. For instance, it is controllable whether IPv6 frames are matched against IP6_STD entries, IP4_TCPUDP entries, or MAC_ETYPE entries. Note that matching against an entry type also controls how the key is generated.

With reference to the VCAP_CFG register, the following table lists the hierarchy for different frame types.

Table 32 • **Hierarchy of IS2 Entry Types**

Frame Type	Description
IPv6 Frames	Configuration: S2_IP6_STD_DIS and S2_IP6_TCPUDP_OTHER_DIS. If S2_IP6_STD_DIS is cleared, IPv6 frames are matched against IP6_STD entries. If S2_IP6_STD_DIS is set and S2_IP6_TCPUDP_OTHER_DIS is cleared, IPv6 frames are matched against IP4_TCPUDP or IP4_OTHER entries. If both are set, IPv6 frames are matched against MAC_ETYPE entries.
IPv4 TCP and UDP frames	Configuration: S2_IP_TCPUDP_DIS If S2_IP_TCPUDP_DIS is cleared, IPv4 TCP and UDP frames are matched against IP4_TCPUDP entries. If S2_IP_TCPUDP_DIS is set, IPv4 TCP and UDP frames are matched against MAC_ETYPE entries.
IPv4 Other frames (non-TCP and non-UDP)	Configuration: S2_IP_OTHER_DIS If S2_IP_OTHER_DIS is cleared, IPv4 Other frames are matched against IP4_OTHER entries. If S2_IP_OTHER_DIS is set, IPv4 Other frames are matched against MAC_ETYPE entries.
ARP frames	Configuration: S2_ARP_DIS If S2_ARP_DIS is cleared, ARP frames are matched against MAC_ETYPE entries. If S2_ARP_DIS is set, ARP frames are matched against MAC_ETYPE entries.
SNAP frames	Configuration: S2_SNAP_DIS If S2_SNAP_DIS is cleared, SNAP frames are matched against LLC entries. If S2_SNAP_DIS is set, SNAP frames are matched against LCC entries.

4.7.1.3 Port Configuration of VCAP ES0

The rewriter configures VCAP ES0 through REW:PORT:PORT_CFG.ES0_ENA. If ES0 is disabled, frames transmitted on the port are not matched against rules in ES0.

4.7.2 VCAP IS1

This section provides information about the IS1 key, the SMAC_SIP4 key, the SMAC_SIP6 key, and associated actions.

4.7.2.1 IS1 Entry Key Encoding

All frame types are subject to the two IS1 lookups. The same key is used for all frame types, however, within the key there are frame type flags that indicate the originating frame type. In addition, certain key

fields are overloaded with different frame fields depending on the frame type flag settings. The following table lists the IS1 key.

Table 33 • **IS1 Key**

Field name	Bit	Width	Description
Match Information			
IS1_TYPE	0	1	Cleared for IS1 lookups and set for SMAC_SIP6 lookups.
FIRST	1	1	Set for first lookup and cleared for second lookup.
Interface Information			
IGR_PORT_MASK	2	27	Ingress port mask. VCAP generated with one bit set in the mask corresponding to the ingress port.
Tagging Information			
VLAN_TAGGED	29	1	Set if frame has one or more Q-tags. Independent of port VLAN awareness.
VLAN_DBL_TAGGED	30	1	Set if frame has two or more Q-tags. Independent of port VLAN awareness.
TPID	31	1	0: Customer TPID 1: Service TPID (88A8 or programmable) TPID is derived from tag pointed to by VCAP_CFG.S1_VLAN_INNER_TAG_ENA.
VID	32	12	Frame's VID if frame is tagged, otherwise port default. VID is taken from tag pointed to by VCAP_CFG.S1_VLAN_INNER_TAG_ENA.
DEI	44	1	Frame's DEI if frame is tagged, otherwise port default. DEI is taken from tag pointed to by VCAP_CFG.S1_VLAN_INNER_TAG_ENA.
PCP	45	3	Frame's PCP if frame is tagged, otherwise port default. PCP is taken from tag pointed to by VCAP_CFG.S1_VLAN_INNER_TAG_ENA.
Layer-2 Information			
L2_SMAC_HIGH	48	16	Frame's source MAC address, bits 47:32. Use destination MAC address if VCAP_CFG.S1_DMAC_DIP_ENA is set for ingress port.
L2_SMAC_LOW	64	32	Frame's source MAC address, bits 31:0. Use destination MAC address if VCAP_CFG.S1_DMAC_DIP_ENA is set for ingress port.
L2_MC	96	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1)
L2_BC	97	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF)
IP_MC	98	1	Set if frame is IPv4 frame and frame's destination MAC address is an IPv4 multicast address (0x01005E0 /25). Set if frame is IPv6 frame and frame's destination MAC address is an IPv6 multicast address (0x3333 /16).
ETYPE_LEN	99	1	Frame type flag. Set if frame has EtherType >= 0x600 (Frame is type encoded). Otherwise cleared (Frame is length encoded).

Table 33 • **IS1 Key *(continued)***

Field name	Bit	Width	Description
ETYPE	100	16	Overloaded field for different frame types: LLC frame: ETYPE = [DSAP, SSAP] SNAP frame: ETYPE = PID[4:3] IPv4 or IPv6 TCP/UDP frame: ETYPE = DPORT IPv4 or IPv6 Other frame: ETYPE = IP protocol ARP or ETYPE frame: ETYPE = Frame's EtherType.
IP_SNAP	116	1	Frame type flag. Set if frame is IPv4, IPv6, or SNAP frame.
IP4	117	1	Frame type flag. Set if frame is IPv4 frame
Layer-3 Information			
L3_FRAGMENT	118	1	Set if IPv4 frame is fragmented (More Fragments flag = 1 or Fragments Offset > 0). Layer 4 information cannot not be trusted.
L3_OPTIONS	119	1	Set if IPv4 frame contains options (IP len > 5). IP options are not skipped nor parsed. Layer 4 information cannot not be trusted.
L3_DSCP	120	6	Frame's DSCP value. The DSCP value may have been translated during basic classification, see QoS, DP, and DSCP Classification, page 50.
L3_IP4_SIP	126	32	Overloaded fields for different frame types: LLC frame: L3_IP4_SIP = [CTRL, PAYLOAD[0:2]] SNAP frame: L3_IP4_SIP = [PID[2:0], PAYLOAD[0]] IPv4 or IPv6 frame: L3_IP4_SIP = source IP address, bits [31:0] ARP or ETYPE frame: L3_IP4_SIP = PAYLOAD[0:3] For IPv4 or IPv6 frames, use destination IP address if VCAP_CFG.S1_DMAC_DIP_ENA is set for ingress port.
Layer-4 Information			
TCP_UDP	158	1	Frame type flag. Set if frame is IPv4/IPv6 TCP or UDP frame.
TCP	159	1	Frame type flag. Set if frame is IPv4/IPv6 TCP frame.
L4_SPORT	160	16	TCP/UDP frame's source port.
L4_RNG	176	8	Range mask with one bit per range. A bit is set, if the corresponding range is matched. Range types: SPORT, DPORT, SPORT or DPORT, VID, DSCP Input to range checkers: – SPORT/DPORT: From frame – VID: From frame if tagged, otherwise port's VID – DSCP: Translated DSCP from the basic classification. See Range Checkers, page 76.

Fields not applicable to a certain frame type (for example, L3_OPTIONS for an IPv6 frame) must be set to don't care for entries the frame type can match.

If L3_FRAGMENT or L3_OPTIONS are set to 1 or set to don't care, Layer 4 information cannot be trusted and should be set to don't-care for such entries.

4.7.2.2 SMAC_SIP6 Entry Key Encoding

All IPv6 frames are subject to a SMAC_SIP6 lookup. The following table lists the SMAC_SIP6 key.

Table 34 • **SMAC_SIP6 Key**

Field name	Bit	Width	Description
Lookup Information			
IS1_TYPE	0	1	Cleared for IS1 lookups and set for SMAC_SIP6 lookups.
Interface Information			
IGR_PORT	1	5	The port number where the frame was received (0-26).
Layer-2 Information			
L2_SMAC_HIGH	6	16	Frame's source MAC address, bits 47:32.
L2_SMAC_LOW	22	32	Frame's source MAC address, bits 31:0.
Layer-3 Information			
L3_IP6_SIP_3	54	32	Frame's source IPv6 address, bits 127:96.
L3_IP6_SIP_2	86	32	Frame's source IPv6 address, bits 95:64.
L3_IP6_SIP_1	118	32	Frame's source IPv6 address, bits 63:32.
L3_IP6_SIP_0	150	32	Frame's source IPv6 address, bits 31:0.

4.7.2.3 SMAC_SIP4 Entry Key Encoding

All IPv4 frames are subject to a SMAC_SIP4 lookup. The following table lists the SMAC_SIP4 key.

Table 35 • **SMAC_SIP4 Key**

Field name	Bit	Width	Description
Interface Information			
IGR_PORT	0	5	The port number where the frame was received (0-26).
Layer-2 Information			
L2_SMAC_HIGH	5	16	Frame's source MAC address, bits 47:32.
L2_SMAC_LOW	21	32	Frame's source MAC address, bits 31:0.
Layer-3 Information			
L3_IP4_SIP	53	32	Frame's source IPv4 address.

4.7.2.4 IS1, SMAC_SIP4, and SMAC_SIP6 Action Encoding

The VCAP generates an action vector from each of the two IS1 lookups and, for IP frames, from the SMAC_SIP6 or SMAC_SIP4 lookups. The action vectors are combined into one action vector, which is applied to the classification of the frame.

There are no default action vectors for the IS1.

The following table lists the available fields for the IS1 action vector.

Table 36 • **IS1 Action Fields**

Action field	Bit	Width	Description
DSCP_ENA	0	1	If set, use DSCP_VAL as classified DSCP value. Otherwise, DSCP value from basic classification is used.
DSCP_VAL	1	6	See DSCP_ENA.
DP_ENA	7	1	If set, use DP_VAL as classified drop precedence level. Otherwise, drop precedence level from basic classification is used.

Table 36 • **IS1 Action Fields *(continued)***

Action field	Bit	Width	Description
DP_VAL	8	1	See DP_ENA.
QOS_ENA	9	1	If set, use QOS_VAL as classified QoS class. Otherwise, QoS class from basic classification is used.
QOS_VAL	10	3	See QOS_ENA.
PAG_ENA	13	1	If set, use PAG_VAL as policy association group (PAG) input to IS2. Otherwise, PAG from ANA:PORT:VCAP_CFG.PAG_VAL is used.
PAG_VAL	14	8	See PAG_ENA.
VID_REPLACE_ENA	22	1	Controls the classified VID: VID_REPLACE_ENA=0: Add VID_ADD_VAL to classified VID and use result as new classified VID. VID_REPLACE_ENA = 1: Replace classified VID with VID_VAL value and use as new classified VID.
VID_ADD_VAL	23	12	See VID_REPLACE_ENA.
FID_SEL	35	2	Controls the Filter Identifier (FID) used when looking up the MAC table. 0: Disabled: FID = classified VID. 1: Use FID_VAL for SMAC lookup in MAC table. 2: Use FID_VAL for DMAC lookup in MAC table. 3: Use FID_VAL for DMAC and SMAC lookup in MAC table.
FID_VAL	37	12	See FID_SEL.
PCP_DEI_ENA	49	1	If set, use PCP_VAL and DEI_VAL as classified PCP and DEI values. Otherwise, PCP and DEI from basic classification are used.
PCP_VAL	50	3	See PCP_DEI_ENA.
DEI_VAL	53	1	See PCP_DEI_ENA.
VLAN_POP_CNT_ENA	54	1	If set, use VLAN_POP_CNT as the number of VLAN tags to pop from the incoming frame. This number is used by the Rewriter. Otherwise, VLAN_POP_CNT from ANA:PORT:VLAN_CFG.VLAN_POP_CNT is used.
VLAN_POP_CNT	55	2	See VLAN_POP_CNT_ENA.
HOST_MATCH	57	1	Used for IP source guarding. If set, it signals that the host is a valid (for instance a valid combination of source MAC address and source IP address). HOST_MATCH is input to the IS2 key.
HIT_STICKY		1	If set, a frame has matched against the associated entry.

The following table lists the available fields for the SMAC_SIP4 and SMAC_SIP6 actions.

Table 37 • **IS1 SMAC_SIP4 and SMAC_SIP6 Action Fields**

Action field	Bit	Width	Description
HOST_MATCH	0	1	Used for IP source guarding. If set, it signals that the host is a valid (for instance a valid combination of source MAC address and source IP address). HOST_MATCH is input to the IS2 key.
HIT_STICKY		1	If set, a frame has matched against the associated entry.

The two IS1 action vectors are applied in two steps. First, the action vector from the first lookup is applied, then the action vector from the second lookup is applied. This implies that if both the first and the second lookup return an action of DP_ENA = 1, for example, the DP_VAL from the second lookup is used. With respect to VID_REPLACE_ENA and VID_VAL, both first and second lookup can add to the classified VID if both action vectors have VID_REPLACE_ENA cleared and VID_VAL > 0.

The action HOST_MATCH is returned by both action vectors from IS1 and by the SMAC_SIP4 and SMAC_SIP6 action vectors. The resulting HOST_MATCH is the inputs OR'ed together so that a host is valid if at least one action vectors has HOST_MATCH = 1.

4.7.3 VCAP IS2

This section provides information about the IS2 keys and associated actions.

4.7.3.1 IS2 Entry Key Encoding

All frame types are subject to the two IS2 lookups. The frame type determines the key entry type. For more information about VCAP frame types, see Table 30, page 59. The following illustration shows which entry fields are available for each frame type (indicated by the field IS2_TYPE), and the following tables list how the key that is matched against these fields are generated for each of the frame types.

Figure 21 • **IS2 Entry Type Overview**

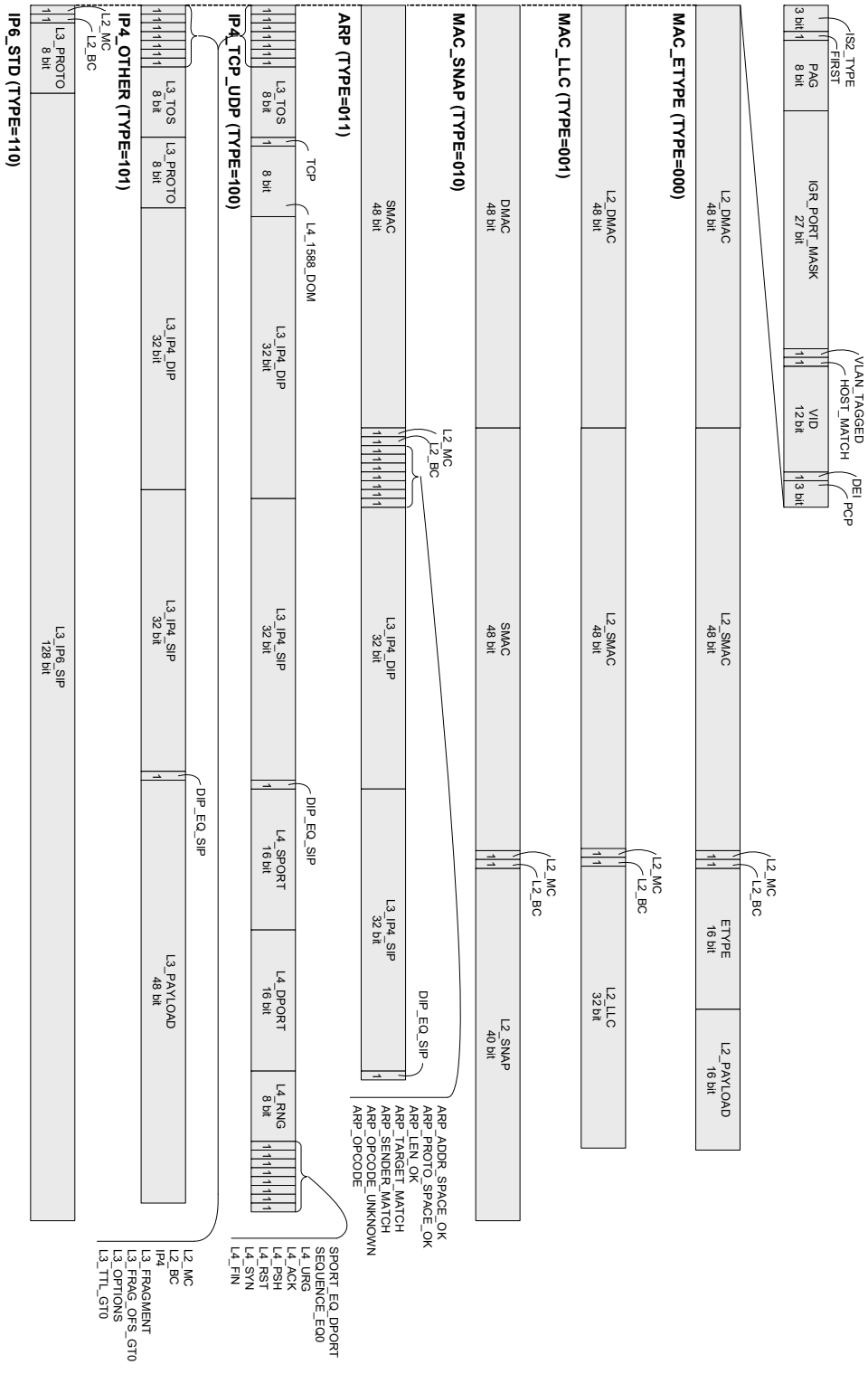


Table 38 • **IS2 Common Key Fields**

Field name	Bit	Width	Description
Lookup Information			
IS2_TYPE	0	3	0: MAC ETYPE entries 1: MAC LLC entries 2: MAC SNAP entries 3: ARP entries 4: IPv4 TCP/UDP entries 5: IPv4 OTHER entries 6: IPv6 STD entries
FIRST	3	1	Set for first lookup and cleared for second lookup.
Interface Information			
PAG	4	8	Policy association group. Action from VCAP IS1.
IGR_PORT_MASK	12	27	Ingress port mask. VCAP generated with one bit set in the mask corresponding to the ingress port.
Tagging and IP Source Guarding Information			
VLAN_TAGGED	39	1	Set if frame has one or more Q-tags. Independent of port VLAN awareness.
HOST_MATCH	40	1	The combined action from the IS1, SMAC_SIP4, and SMAC_SIP6 lookups. Used for IP source guarding.
VID	41	12	Classified VID which is the result of the VLAN classification in basic classification and IS1.
DEI	53	1	Classified DEI which is the final result of the VLAN classification in basic classification and IS1.
PCP	54	3	Classified PCP which is the final result of the VLAN classification in basic classification and IS1.

Table 39 • **IS2 MAC_ETYPE Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_DMAC_HIGH	57	16	Frame's destination MAC address, bits 47:32.
L2_DMAC_LOW	73	32	Frame's destination MAC address, bits 31:0.
L2_SMAC_HIGH	105	16	Frame's source MAC address, bits 47:32. If ANA:PORT:VCAP_CFG.S2_ETYPE_PAYLOAD_ENA[lookup] is enabled, use payload bytes 2-3 after the frame's EtherType instead of SMAC.
L2_SMAC_LOW	121	32	Frame's source MAC address, bits 31:0. If ANA:PORT:VCAP_CFG.S2_ETYPE_PAYLOAD_ENA[lookup] is enabled, use payload bytes 4-7 after the frame's EtherType instead of SMAC.
L2_MC	153	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	154	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
ETYPE	155	16	Frame's EtherType. This is the EtherType after up to two VLAN tags.

Table 39 • **IS2 MAC_ETYPE Key *(continued)***

Field name	Bit	Width	Description
L2_PAYLOAD	171	16	Payload bytes 0-1 after the frame's EtherType.

Table 40 • **IS2 MAC_LLC Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_DMAC_HIGH	57	16	Frame's destination MAC address, bits 47:32.
L2_DMAC_LOW	73	32	Frame's destination MAC address, bits 31:0.
L2_SMAC_HIGH	105	16	Frame's source MAC address, bits 47:32.
L2_SMAC_LOW	121	32	Frame's source MAC address, bits 31:0.
L2_MC	153	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	154	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
L2_LLC	155	32	LLC header and data after up to two VLAN tags and the type/length field.

Table 41 • **IS2 MAC_SNAP Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_DMAC_HIGH	57	16	Frame's destination MAC address, bits 47:32.
L2_DMAC_LOW	73	32	Frame's destination MAC address, bits 31:0.
L2_SMAC_HIGH	105	16	Frame's source MAC address, bits 47:32.
L2_SMAC_LOW	121	32	Frame's source MAC address, bits 31:0.
L2_MC	153	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	154	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
L2_SNAP	155	40	SNAP header after LLC header (AA-AA-03).

Table 42 • **IS2 ARP Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_SMAC_HIGH	57	16	Frame's source MAC address, bits 47:32.
L2_SMAC_LOW	73	32	Frame's source MAC address, bits 31:0.
L2_MC	105	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	106	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
Layer-3 Information			
ARP_ADDR_SPACE_OK	107	1	Set if hardware address is Ethernet.

Table 42 • **IS2 ARP Key *(continued)***

Field name	Bit	Width	Description
ARP_PROTO_SPACE_OK	108	1	Set if protocol address space is IP.
ARP_LEN_OK	109	1	Set if hardware address length = 6 (Ethernet) and IP address length = 4 (IP).
ARP_TARGET_MATCH	110	1	Target hardware address = SMAC (RARP).
ARP_SENDER_MATCH	111	1	Sender hardware address = SMAC (ARP).
ARP_OPCODE_UNKNOWN	112	1	Set if ARP opcode is none of the below are mentioned.
ARP_OPCODE	113	2	0: ARP request 1: ARP reply. 2: RARP request. 3: RARP reply.
L3_IP4_DIP	115	32	Target IPv4 address.
L3_IP4_SIP	147	32	Sender IPv4 address.
DIP_EQ_SIP	179	1	Set if sender IP address is equal to target IP address.

Table 43 • **IS2 IP4_TCP_UDP Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_MC	57	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	58	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
Layer-3 and Layer-4 Information			
IP4	59	1	Set if frame is IPv4 frame. IPv6 frames can also use IP4_TCP_UDP entries when IP6_STD entries are disabled.
L3_FRAGMENT	60	1	Set if IP frame is fragmented (More Fragments flag = 1 or Fragments Offset > 0).
L3_FRAG_OFS_GT0	61	1	Set if IP frame is fragmented and it is not the first fragment (Fragments Offset > 0). Such frames do not carry Layer-4 information all Layer-4 information fields in the key are automatically set to don't-care when generating the key.
L3_OPTIONS	62	1	Set if IP frame contains options (IP len > 5). IP options are not skipped nor parsed which implies that Layer-4 information cannot be used. All Layer-4 information fields in the key are automatically set to don't-care when generating the key.
L3_TTL_GT0	63	1	Set if IP TTL is greater than 0.
L3_TOS	64	8	IP TOS field. The DSCP part is the final result from basic classification and IS1.
TCP	72	1	Set if IP Proto = 6 (TCP).
L4_1588_DOM	73	8	PTP over UDP: domainNumber.
L3_IP4_DIP	81	32	IPv4 frames: Destination IPv4 address. IPv6 frames: Source IPv6 address, bits 63:32.

Table 43 • **IS2 IP4_TCP_UDP Key *(continued)***

Field name	Bit	Width	Description
L3_IP4_SIP	113	32	If UDP frame and VCAP_CFG.S2_UDP_PAYLOAD_ENA[lookup] = 1: Bytes 0, 1, 4, and 6 after the UDP header. Otherwise for IPv4 frames: Source IPv4 address. Otherwise for IPv6 frames: Source IPv6 address, bit 31:0.
DIP_EQ_SIP	145	1	Set if source IP address is equal to destination IP address.
L4_DPORT	146	16	TCP/UDP destination port.
L4_SPORT	162	16	TCP/UDP source port.
L4_RNG	178	8	Range mask with one bit per range. A bit is set, if the corresponding range is matched. Range types: SPORT, DPORT, SPORT or DPORT, VID, DSCP. Input to range checkers: – SPORT, DPORT: From frame – VID, DSCP: Classified result from IS1 See Range Checkers, page 76.
SPORT_EQ_DPORT	186	1	Set if UDP or TCP source port equals UDP or TCP destination port.
SEQUENCE_EQ0	187	1	TCP: Set if TCP sequence number is 0. PTP over UDP: messageType bit 0.
L4_FIN	188	1	TCP: TCP flag FIN. PTP over UDP: messageType bit 1.
L4_SYN	189	1	TCP: TCP flag SYN. PTP over UDP: messageType bit 2.
L4_RST	190	1	TCP: TCP flag RST. PTP over UDP: messageType bit 3.
L4_PSH	191	1	TCP: TCP flag PSH. PTP over UDP: flagField bit 1 (twoStepFlag).
L4_ACK	192	1	TCP: TCP flag ACK. PTP over UDP: flagField bit 2 (unicastFlag).
L4_URG	193	1	TCP: TCP flag URG. PTP over UDP: flagField bit 7 (reserved).

Frames with IP options (L3_OPTIONS set to 1 in key) or fragmented frames, which are not the initial fragment (L3_FRAG_OFS_GT0 set to 1 in key), do not carry Layer-4 information. The Layer-4 fields in the key (L4_SPORT, L4_DPORT, L4_RNG, SPORT_EQ_DPORT, SEQUENCE_EQ0, L4_FIN, L4_SYN, L4_RST, L4_PSH, L4_ACK, and L4_URG) are automatically set to don't care.

Table 44 • **IS2 IP4_OTHER Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_MC	57	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	58	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
Layer-3 Information			

Table 44 • **IS2 IP4_OTHER Key *(continued)***

Field name	Bit	Width	Description
IP4	59	1	Set if frame is IPv4 frame. IPv6 frames can also use IP4_OTHER entries when IP6_STD entries are disabled.
L3_FRAGMENT	60	1	Set if IP frame is fragmented (More Fragments flag = 1 or Fragments Offset > 0)
L3_FRAG_OFS_GT0	61	1	Set if IP frame is fragmented and if it is not the first fragment (Fragments Offset > 0).
L3_OPTIONS	62	1	Set if IPv4 frame contains options (IP len > 5). IP options are not skipped nor parsed, which implies that L3_PAYLOAD contains data from the IP options for IPv4 frames with IP options.
L3_TTL_GT0	63	1	Set if IP TTL is greater than 0.
L3_TOS	64	8	IP TOS field. The DSCP part is the final result from basic classification and IS1.
L3_PROTO	72	8	IPv4: IP protocol. IPv6: next header.
L3_IP4_DIP	80	32	IPv4 frames: Destination IPv4 address. IPv6 frames: Source IPv6 address, bits 63:32.
L3_IP4_SIP	112	32	IPv4 frames: Source IPv4 address. IPv6 frames: Source IPv6 address, bit 31:0.
DIP_EQ_SIP	144	1	Set if source IP address is equal to destination IP address.
L3_PAYLOAD	145	48	Bytes 0-5 after IP header.

Table 45 • **IS2 IP6_STD Key**

Field name	Bit	Width	Description
Layer-2 Information			
L2_MC	57	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).
L2_BC	58	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).
Layer-3 Information			
L3_PROTO	59	8	IPv6 next header.
L3_IP6_SIP_3	67	32	Frame's source IPv6 address, bits 127:96.
L3_IP6_SIP_2	99	32	Frame's source IPv6 address, bits 95:64.
L3_IP6_SIP_1	131	32	Frame's source IPv6 address, bits 63:32.
L3_IP6_SIP_0	163	32	Frame's source IPv6 address, bits 31:0.

4.7.3.2 IS2 Action Encoding

The VCAP generates an action vector from each of the two IS2 lookups for each frame.

The first IS2 lookup returns a default action vector per ingress port when no entries are matched, and the second IS2 lookup returns a common default action vector when no entries are matched. There are no difference between an action vector from a match and a default action vector.

The following table lists the available fields for the action vector.

Table 46 • **IS2 Action Fields**

Action field	Bit	Width	Description
HIT_ME_ONCE	0	1	Setting this bit to 1 causes the first frame that hits this action where the HIT_CNT counter is zero to be copied to the CPU extraction queue specified in CPU_QU_NUM. The HIT_CNT counter is then incremented and any frames that hit this action later are not copied to the CPU. To re-enable the HIT_ME_ONCE functionality, the HIT_CNT counter must be cleared.
CPU_COPY_ENA	1	1	Setting this bit to 1 causes all frames that hit this action to be copied to the CPU extraction queue specified in CPU_QU_NUM.
CPU_QU_NUM	2	3	Determines the CPU extraction queue that is used when a frame is copied to the CPU due to a HIT_ME_ONCE or CPU_COPY_ENA action.
MASK_MODE	5	2	Controls how PORT_MASK is applied. 0: No action from PORT_MASK 1: Permit/deny (PORT_MASK AND'ed with destination set) 2: Policy forwarding (DMAC lookup replaced with PORT_MASK) 3: Redirect (SRC, AGGR, VLAN, DMAC lookup replaced with PORT_MASK). The CPU port is never touched by MASK_MODE.
MIRROR_ENA	7	1	Setting this bit to 1 causes frames to be mirrored to the mirror target port (ANA::MIRRPORPORTS)
LRN_DIS	8	1	Setting this bit to 1 disables learning of frames hitting this action.
POLICE_ENA	9	1	Setting this bit to 1 causes frames that hit this action to be policed by the ACL policer specified in POLICE_IDX. Only applies to the first lookup.
POLICE_IDX	10	8	Selects policer index used when policing frames (POLICE_ENA).
PORT_MASK	18	26	Port mask applied to the forwarding decision based on MASK_MODE.
PTP_ENA	44	2	PTP_ENA[0] (One-step): If set, the correction field in PTP header is updated with the residence time. PTP_ENA[1] (Two-step): If set, the egress timestamp information is enqueued in the timestamp queue.
HIT_CNT		32	A statistics counter that is incremented by one each time the given action is hit.

The two action vectors from the first and second lookups are combined into one action vector, which is applied in the analyzer. For more information, see Forwarding Engine, page 90. The actions are combined as follows:

- HIT_ME_ONCE, CPU_COPY_ENA, CPU_QU_NUM:
  If any of the two action vectors have HIT_ME_ONCE or CPU_COPY_ENA set, CPU_COPY_ENA is forwarded to the analyzer. The settings in the action vector from second lookup takes precedence with respect to the CPU extraction queue number.
- MIRROR_ENA:
  If any of the two action vectors have MIRROR_ENA set, MIRROR_ENA is forwarded to the analyzer.

- LRN_DIS:
  If any of the two action vectors have LRN_DIS set, LRN_DIS is forwarded to the analyzer.
- PTP_ENA:
  The settings in the action vector from the second lookup takes precedence if PTP_ENA[0] or PTP_ENA[1] are set.
- POLICE_ENA, POLICE_IDX:
  Only applies to actions from the first lookup.

The following table lists the combinations for MASK_MODE and PORT_MASK when combining actions from the first and second lookups.

Table 47 • **MASK_MODE and PORT_MASK Combinations**

	Second Lookup			
First Lookup	**No action**	**Permit/deny**	**Policy**	**Redirect**
No action	No action	Permit P(1) = P2(2)	Policy P = P2	Redirect P = P2
Permit/deny	Permit P = P1(3)	Permit P = P1 and P2	Policy P = P1 and P2	Redirect P = P2
Policy	Policy P = P1	Policy P = P1 and P2	Policy P = P1 and P2	Redirect P = P2
Redirect	Redirect P = P1	Redirect P = P1 and P2	Redirect P = P1 and P2	Redirect P = P2

1. P: Resulting PORT_MASK to analyzer.
2. P2: PORT_MASK from second match.
3. P1: PORT_MASK from first match.

Policy forwarding for frames matching an IPv4 and IPv6 multicast entry in the MAC table is not possible. Policy forwarding is handled as a permit/deny action for such frames.

4.7.4 VCAP ES0

This section provides information about the ES0 key and associated actions.

4.7.4.1 ES0 Entry Key Encoding

All frames are subject to one ES0 lookup per destination port, except for frames injected by the CPU port module, which are not matched against ES0 entries. The key in ES0 is independent of frame types. The following table lists the ES0 key.

Table 48 • **ES0 VID Key**

Field name	Bit	Width	Description
Interface Information			
EGR_PORT	0	5	The port number where the frame is transmitted (0-26).
IGR_PORT	5	5	The port number where the frame was received (0-26).
Tagging Information			
VID	10	12	Classified VID that is the result of the VLAN classification in basic classification and IS1.
DEI	22	1	Classified DEI that is the final result of the VLAN classification in basic classification and IS1.
PCP	23	3	Classified PCP that is the final result of the VLAN classification in basic classification and IS1.
Layer-2 Information			
L2_MC	26	1	Set if frame's destination MAC address is a multicast address (bit 40 = 1).

Table 48 • **ES0 VID Key *(continued)***

Field name	Bit	Width	Description
L2_BC	27	1	Set if frame's destination MAC address is the broadcast address (FF-FF-FF-FF-FF-FF).

4.7.4.2 ES0 Action Encoding

The VCAP generates one action vector from the ES0 lookup. The lookup returns a default action vector per egress port when no entries are matched. There are no difference between an action vector from a match and a default action vector.

The following table lists the available action fields for ES0. For more information about how the actions are applied to the VLAN manipulations, see VLAN Editing, page 115.

Table 49 • **ES0 Action Fields**

Action field	Bit	Width	Description
VLD	0	1	Valid bit, set if entry is in use.
TAG_ES0	1	2	Control ES0 tagging. 0: No ES0 tagging. 1: Push ES0 tag only, overrules port settings. 2: Push port tag as outer tag if enabled for port and push ES0 as inner tag. 3: Always push port tag as outer tag and ES0 as inner tag.
TAG_TPID_SEL	3	2	Selects TPID for ES0 tag. 0: 0x8100. 1: 0x88A8. 2: custom PORT_TPID. 3: If IFH.TAG.TAG_TYPE = 0 then 0x8100 else custom. When "No ES0 Tagging" is set for TAG_ES0: 0: Push Port tag if enabled for the egress port. 1: No port tagging. 2-3: Reserved.
TAG_VID_SEL	5	2	Selects VID source for ES0 tag. 0: IFH.TAG.VID + VID_B_VAL. 1: VID_A_VAL. 2: VID_B_VAL. 3: REW:PORT:PORT_VLAN_CFG.PORT_VID.
VID_A_VAL	7	12	See TAG_VID_SEL.
VID_B_VAL	19	12	See TAG_VID_SEL.
QOS_SRC_SEL	31	2	Selects the source for DEI and PCP. 0: Classified PCP and DEI. 1: PCP_VAL and DEI_VAL from ES0. 2: REW:PORT:PORT_VLAN_CFG.PORT_DEI, REW:PORT:PORT_VLAN_CFG.PORT_PCP. 3: DP and QoS mapped to PCP and DEI (per port table).
PCP_VAL	33	3	See QOS_SRC_SEL.
DEI_VAL	36	1	See QOS_SRC_SEL.
HIT_STICKY		1	If set, a frame has matched the associated entry.

4.7.5 Range Checkers

The following table lists the registers associated with configuring range checkers.

Table 50 • **Range Checker Configuration**

Register	Description	Replication
ANA::VCAP_RNG_TYPE_CFG	Configuration of the range checker types	None
ANA::VCAP_RNG_VAL_CFG	Configuration of range start and end points	None

The IS1 entries and the IP4_TCP_UDP entry in IS2 contain eight range checker flags (L4_RNG), which are matched against an 8-bit range key. The range key is generated for each frame based on extracted frame data and the configuration in ANA::VCAP_RNG_TYPE_CFG and ANA::VCAP_RNG_VAL_CFG. Each of the eight range checkers can be configured to one of the following range types:

- TCP/UDP destination port range
  Input to the range is the frame's TCP/UDP destination port number.
- TCP/UDP source port range
  Input to the range is the frame's TCP/UDP source port number.
- TCP/UDP source and destination ports range. Range is matched if either source or destination port is within range.
  Input to the range are the frame's TCP/UDP source and destination port numbers.
- VID range
  IS1: Input to the range is the frame's VID or the port VID if the frame is untagged.
  IS2: Input to the range is the classified VID.
- DSCP range
  IS1: Input to the range is the translated DSCP value from basic classification.
  IS2: Input to the range is the classified DSCP value.

For IS2, the range key is only applicable to TCP/UDP frames. For IS1, the range key is generated for any frame types. Specific range types not applicable to a certain frame type (for example, TCP/UDP port ranges for IPv4 Other frames) must be set to don't care in entries the frame type can match.

Range start points and range end points are configured in ANA::VCAP_RNG_VAL_CFG.

4.7.6 VCAP-II Configuration

This section provides information about how the VCAPs IS1, IS2, and ES0 are configured. The following table lists the registers associated with VCAP configuration.

Table 51 • **VCAP Configuration**

Register	Description	Replication
VCAP_UPDATE_CTRL	General configuration register	None
VCAP_MV_CFG	Move configuration	None
VCAP_ENTRY_DAT	Entry data cache	32
VCAP_MASK_DAT	Entry mask cache	32
VCAP_ACTION_DAT	Action data cache	32
VCAP_CNT_DAT	Counter data cache	32
VCAP_TG_DAT	Type-Group cache	None
VCAP_STICKY	Sticky-bit indications	None

Each VCAP has defined various constants and are accessed using the registers listed in the following table.

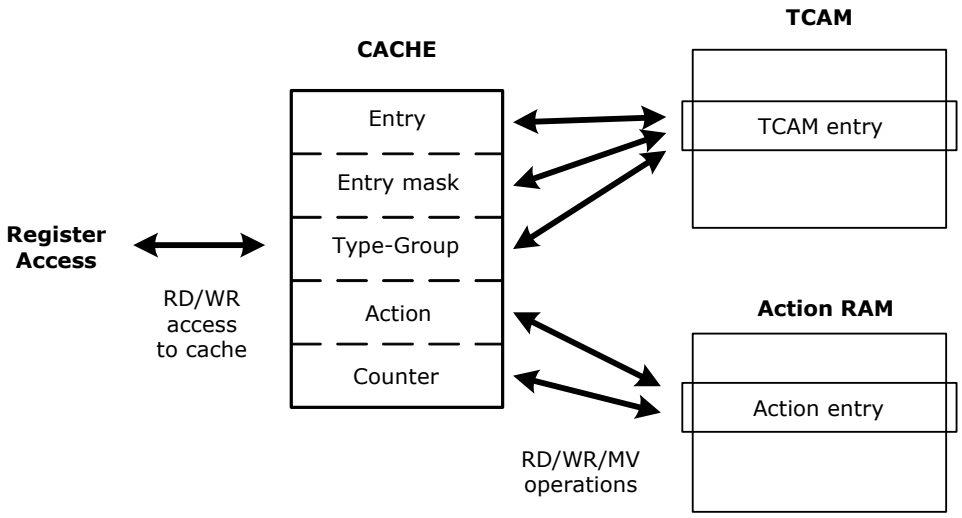
Table 52 • **VCAP Constants**

Register	Description	Replication
ENTRY_WIDTH	Width of entry field	None
ENTRY_CNT	Number of entries	None
ENTRY_SWCNT	Number of subwords	None
ENTRY_TG_WIDTH	Width of type-group field	None
ACTION_DEF_CNT	Number of default actions	None
ACTION_WIDTH	Width of action field	None
CNT_WIDTH	Width of counter field	None

Each VCAP implements its own set of the registers listed in Table 51, page 76 and Table 52, page 77.

Entries in a VCAP are accessed indirectly through an entry and action cache. The cache is accessible using the VCAP configuration registers listed in Table 51, page 76. As shown in the following illustration, an entry in the VCAP consists of a TCAM entry and an associated action and counter entry.

Figure 22 • **VCAP Configuration Overview**



A TCAM entry consists of entry data, entry mask, and a type-group value. The type-group value is used internally to differentiate between VCAP lookups of different subword sizes. Each TCAM entry has an associated action entry. Additionally, the action RAM has an entry for each of the default actions in the VCAP. The entries in the action RAM consists of action data and a counter value.

For a write access, the TCAM and action entry must be written to the cache and then copied from the cache to the TCAM/RAM. For a read access, the TCAM and action entry must first be retrieved from the TCAM/RAM before being read from the cache. When a read or write operation is initiated, it is possible to individually select if the operation should be applied to the TCAM and/or action RAM. When data is moved between the cache and the TCAM/RAM, it is always the entire entry that is moved. For VCAPs with several subwords per entry, this must be taken into account if only a single subword of a TCAM entry should be updated. To modify a single subword, the entire TCAM entry must be read, then the subword must be modified in the cache, and finally the entry must be written back to the TCAM.

The cache can hold only one VCAP entry (TCAM and action entry) at a time. After the TCAM and action entry are written to the cache, the cache must be copied to the TCAM and RAM before new entries can be written to the cache.

The following table lists the different parameters for the three VCAPs available in <CHIPID>. The parameters are needed to format the data to be written to the cache. The parameters can also be read in the registers listed in Table 52, page 77.

Table 53 • **VCAP Parameters**

VCAP	Entry Width	Number of Entries	Action Width	Number of Default Actions	Counter Width	Subwords	Type-Group Width
IS1	188	256	60	0	2 (sticky)	2	2
IS2	196	256	46	28	32	1	1
ES0	29	256	37	26	1 (sticky)	1	1

4.7.6.1 Creating a VCAP Entry in the Cache

Before a VCAP entry can be created in the TCAM and RAM, the entry must be created in the cache. The cache is accessed through these 32-bit registers:

- VCAP_ENTRY_DAT
- VCAP_MASK_DAT
- VCAP_ACTION_DAT
- VCAP_CNT_DAT
- VCAP_TG_DAT

Each of the cache registers are replicated 32 times, however, only the bits used by the VCAP are mapped to physical registers. For example, for VCAP IS1, only the lowest 188 bits of VCAP_ENTRY_DAT and VCAP_MASK_DAT is mapped to physical registers. As mentioned previously, a VCAP entry consists of a TCAM entry and an action entry.

The TCAM entry consists of entry data, mask data, a type value, and a type-group value. The entry data prefixed with the type value is written to VCAP_ENTRY_DATA. The mask data is written to VCAP_MASK_DATA, and the type-group value is written to VCAP_TG_DAT. The type and type-group values are used internally in the VCAP to distinguish between the different entry types. The following table lists the type and type-group value for each of the entry types.

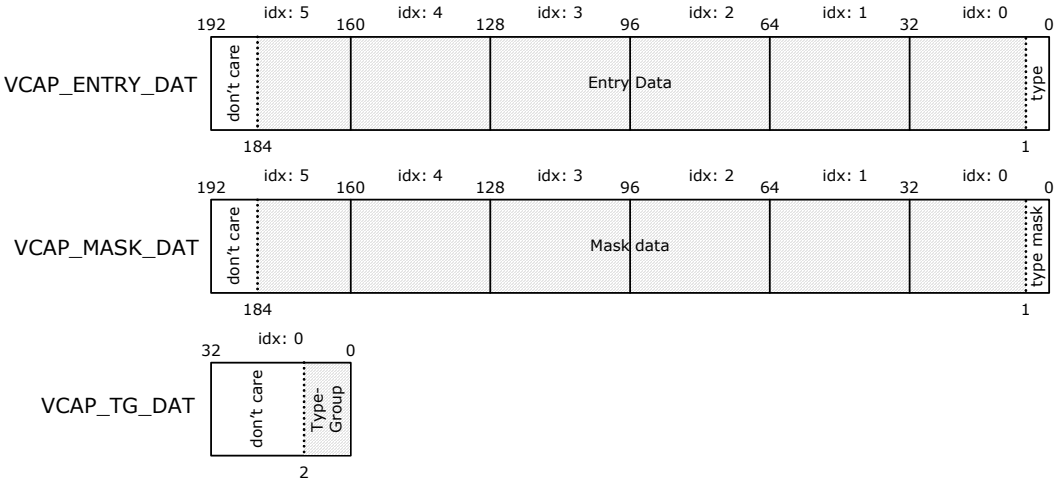
Table 54 • **Entry, Type, and Type-Group Parameters**

VCAP	Entry Type	Entry Width	Subwords	Type Value [width in ()]	Type-Group Value [width in ()]
IS1	IS1	183	1	0 (1)	1 (2)
IS1	SMAC_SIP4	85	2	Not used (0)	2 (2)
IS1	SMAC_SIP6	181	1	1 (1)	1 (2)
IS2	MAC_ETYPE	184	1	0 (3)	1 (1)
IS2	MAC_LCC	184	1	1 (3)	1 (1)
IS2	MAC_SNAP	192	1	2 (3)	1 (1)
IS2	ARP	177	1	3 (3)	1 (1)
IS2	IP4_TCP_UCP	191	1	4 (3)	1 (1)
IS2	IP4_OTHER	190	1	5 (3)	1 (1)
IS2	IP6_STD	192	1	6 (3)	1 (1)
ES0	VID	28	1	Not used (0)	1 (1)

Note that the type value is not used for all entry types. If the type value is not used for an entry type, write the entry data from bit 0 of VCAP_ENTRY_DAT.

As an example of how a TCAM entry is laid out in the cache register, the following illustration shows a TCAM entry of the IS1 entry type for the VCAP IS1.

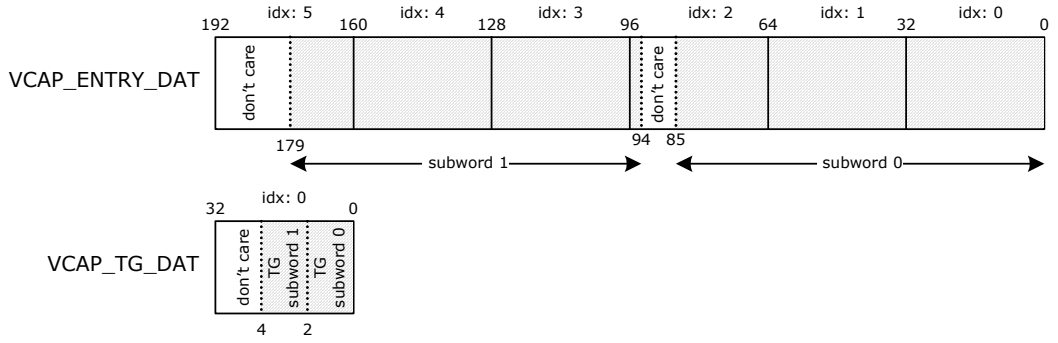
Figure 23 • **Entry Layout In Register Example**



Generally, the type value must never be masked. However, by masking the type bits a lookup in the VCAP is able to match several different entry types. For example, the IS2 entry types MAC_ETYPE and MAC_LLC have the type values 000 and 001, respectively. By masking bit 0, a lookup is able to match both entry types.

The entry type used in the preceding example only has one subword per entry in the TCAM. Creating a TCAM entry with an entry type that has several subwords per TCAM entry is a little more complicated. In the example shown in the following illustration, the SMAC_SIP4 entry type of the VCAP IS1 is used. The SMAC_SIP4 entry type has two subwords per TCAM entry. From Table 54, page 78, it can be seen that the SMAC_SIP4 entry type has a width of 85 bits per subword. A row in the IS1 TCAM is 188 bits wide For more information, see Table 53, page 78). Each subword is assigned to half a TCAM row; that is, subword 0 is assigned to bits 0-93 and subword 1 is assigned to bits 94-187. Because the SMAC_SIP4 entry only is 85 bits wide, there are nine unused bits for each subword, as shown in the following illustration. Note that the SMAC_SIP4 entry type does not use a type field. The layout for VCAP_MASK_DAT is similar to VCAP_ENTRY_DAT. Additionally, a type-group value is associated to each subword and that the type-group values are laid out back-to-back in VCAP_TG_DAT as shown.

Figure 24 • **Entry Layout In Register Using Subwords Example**



To invalidate an entry in the TCAM (so a lookup never matches the entry), set the type-group for the entry to 0. If there are more subwords in the entry, each subword can be individually invalidated by setting its corresponding type-group value to 0.

The action entry is written to VCAP_ACTION_DAT. Similar to an entry data, an action entry also has a prefixed type value. The following table lists the parameters for the different action types available in VCAPs.

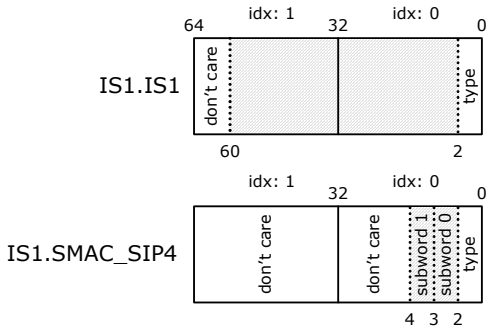
Table 55 • **Action and Type Field Parameters**

VCAP	Action Type	Action Width	Subwords	Type Value [width in ()]
IS1	IS1	58	1	0 (2)
IS1	SMAC_SIP4	1	2	1 (2)
IS1	SMAC_SIP6	1	1	2 (2)
IS2	BASE_TYPE	46	1	Not used (0)
ES0	VID	37	1	Not used (0)

An action that is associated with an entry type with several subwords per entry has an equal number of subwords. For actions with several subwords, the subwords are simply concatenated together.

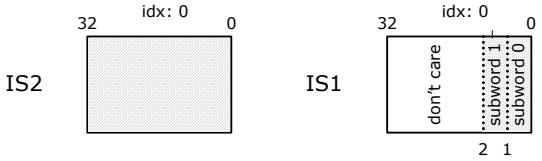
The following illustration shows the action layout in the VCAP_ACTION_DAT register for an IS1 and an SMAC_SIP4 action entry. The IS1 action entry has one subword per row, and the SMAC_SIP4 has two subwords per row.

Figure 25 • **Action Layout in Register Example**



The counter value associated to the action is written to VCAP_CNT_DAT. VCAP_CNT_DAT contains a counter value for each subword in the TCAM entry. For action entries, the counter values for each subword are simply concatenated together. The counter layout for the VCAP_CNT_DAT register the VCAPs IS1 and IS2 is shown in the following illustration. The VCAP IS2 features a 32-bit counter with one subword, and the VCAP IS1 features a 1-bit sticky counter with two subwords.

Figure 26 • **Counter Layout in Register Example**



4.7.6.2 Copying Entries Between the Cache and TCAM/RAM

When an entry and associated action is created in the cache, the data in the cache must be copied to a given address in the TCAM and RAM. This is done using the VCAP_UPDATE_CTRL register using the following procedure:

1. Set VCAP_UPDATE_CTRL.UPDATE_CMD to copy from cache to TCAM/RAM.
2. Set the address for the entry in VCAP_UPDATE_CTRL.UPDATE_ADDR.
3. Set VCAP_UPDATE_CTRL.UPDATE_SHOT to initiate the copy operation. The bit is cleared by hardware when the operation is finished.

Initiating another operation before the UPDATE_SHOT field is cleared is not allowed. The delay between setting the UPDATE_SHOT field and the clearing of that field depends on the type of operation and the traffic load on the VCAP.

By setting the fields UPDATE_ENTRY_DIS, UPDATE_ACTION_DIS, and/or UPDATE_CNT_DIS in the VCAP_UPDATE_CTRL register the writing of the TCAM, action, and/or the counter entry can be disabled.

Copying a VCAP entry from the TCAM/RAM to the cache is done in a similar fashion by setting VCAP_UPDATE_CTRL.UPDATE_CMD to copy from TCAM/RAM to the cache. Note that due to internal mapping of the entry data and mask data, the values that are read back from the TCAM cannot always match with the values that were originally written to the TCAM. The internal mapping that happens is listed in the following table. There are differences, because a masked 1 is read back as a masked 0, which functionally is the same.

Table 56 • **Internal Mapping of Entry and Mask**

Written Entry	Written Mask	Description	Read Entry	Read Mask
0	0	Match-0	0	0
0	1	Match-Any	0	1
1	0	Match-1	1	0
1	1	Match-Any	0	1

If an entry match is not found during a lookup for a given frame, a default action is selected by the VCAP. Default actions and counter values are copied between the cache and the action RAM similar to a regular VCAP entry. The default actions are stored in the RAM right below the last regular action entry; for example, VCAP IS2 has 256 regular entries, so the first default action in VCAP IS2 is stored at address 256, the second at address 257, and so on. For more information about the number of regular VCAP entries in each VCAP, see Table 53, page 78. When a default action is copied from the cache to the RAM, VCAP_UPDATE_CTRL.UPDATE_ENTRY_DIS must be set to disable the update of the TCAM. If updating of the TCAM is not disabled, the operation may overwrite entries in the TCAM.

The cache can be cleared by setting VCAP_UPDATE_CTRL.CLEAR_CACHE. This sets all replications of VCAP_ENTRY_DAT, VCAP_MASK_DAT, VCAP_ACTION_DAT, VCAP_CNT_DAT, and VCAP_TG_DAT to zeros. The CLEAR_CACHE field is automatically cleared by hardware when the cache is cleared.

4.7.7 Advanced VCAP Operations

The VCAP supports a number of advanced operations that allow easy moving and removal of entries and actions during frame traffic.

4.7.7.1 Moving Entries and Actions

A number of entries and actions can be moved up by several positions in the TCAM and RAM, and a single entry and action can be moved down by several positions in the TCAM and RAM. This is done using the VCAP_UPDATE_CTRL and VCAP_MV_CFG registers.

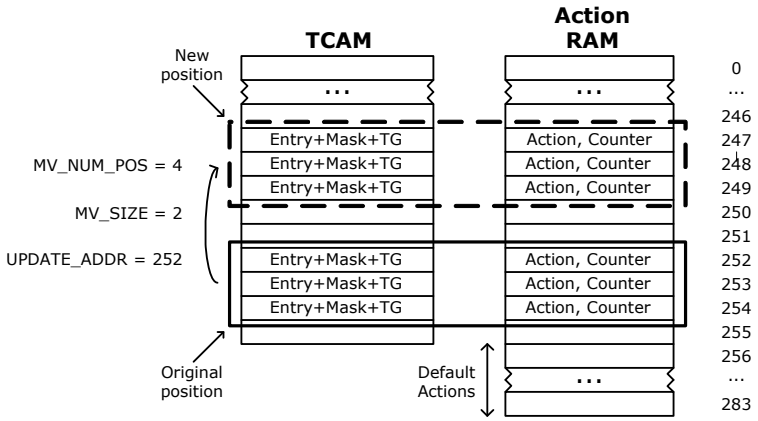
A Move operation is performed by:

- Setting VCAP_UPDATE_CTRL.UPDATE_ADDR equal to the address of the entry with the lowest address, among the entries that must be moved.
- Setting VCAP_MV_CFG.MV_SIZE to the number of entries that must be moved; *n* + 1 entries are moved. Note that a move down operation can only move one entry at a time, which means VCAP_MV_CFG.MV_SIZE must be 0 for move down operations.
- Setting VCAP_MV_CFG.MV_NUM_POS to the number of positions the entries must be moved. The entries are moved *n* positions up or down.
- Setting UPDATE_ENTRY_DIS, UPDATE_ACTION_DIS, and/or UPDATE_CNT_DIS to only move some parts of the VCAP entry.
- Setting VCAP_UPDATE_CTRL.UPDATE_CMD to move up (decreasing addresses) or move down (increasing addresses).
- Initiating the Move operation by setting VCAP_UPDATE_CTRL.VCAP_UPDATE_SHOT.

A new command must not be setup until after the VCAP_UPDATE_CTRL.VCAP_UPDATE_SHOT field has automatically cleared. Also note that the cache is used by the VCAP while a Move operation is being performed. As a result, any value in cache prior to a Move operation is lost, and a write is not permitted to the cache while a Move operation is performed.

The following illustration shows an example of a Move operation.

Figure 27 • **Move Up Operation Example**



A Move operation can be performed hitlessly during frame traffic, that is, all entries and actions are still available during a Move operation, and all hits are counted by the action hit counters. The TCAM entries at the original positions are invalidated after the Move operation is complete.

During heavy frame traffic, it can take some time for a large move operation to complete, because the moving of individual rows are restarted each time a lookup is performed. If it is not important that the hit counters are accurately updated while the move operation is processed, VCAP_UPDATE_CTRL.MV_TRAFFIC_IGN can be set. This prevents the VCAP from restarting moves and consequently, decreases the time it takes for the move operation to complete. It may, however, lead to inaccurate hit counter values. Note that even if MV_TRAFFIC_IGN is set, the VCAP still processes all lookups correctly.

Default actions can also be moved, however, VCAP_UPDATE_CTRL.UPDATE_ENTRY_DIS must be set.

If a row is moved to a negative address (above address 0), the row is effectively deleted. If a block is partly moved above address 0, the block is also only partially deleted. In other words, the rows that are effectively moved to an address below 0 are not deleted. If one or more rows are deleted during a move operation, the sticky bit VCAP_STICKY.VCAP_ROW_DELETED_STICKY is set.

4.7.7.2 Initializing a Block of Entries

A block of entries can be set to the value of the cache in a single operation. For example, it can be used to initialize all TCAM, action, and counter entries to a specific value. The block of entries to initialize can also include the default action and counter entries.

To perform an initialization operation:

- Set VCAP_UPDATE_CTRL.UPDATE_ADDR equal to the address of the entry with the lowest address, among the entries that should be written.
- Set VCAP_MV_CFG.MV_SIZE to the number of entries that must be included in the initialization operation: *n* + 1 entries are included.
- Set UPDATE_ENTRY_DIS, UPDATE_ACTION_DIS, and/or UPDATE_CNT_DIS to select if the TCAM, action RAM, and/or the counter RAM should be excluded from the initialization operation.
- Set VCAP_UPDATE_CTRL.UPDATE_CMD to the initialization operation.
- Start the initialization operation by setting VCAP_UPDATE_CTRL.VCAP_UPDATE_SHOT.

A new command must not be set up until after the VCAP_UPDATE_CTRL.VCAP_UPDATE_SHOT field is automatically cleared neither must the cache be written to before VCAP_UPDATE_SHOT is cleared.

4.8 Analyzer

The analyzer module is responsible for a number of tasks:

- Determining the set of destination ports, also known as the forwarding decision, for frames received by port modules. This includes Layer-2 forwarding, CPU-forwarding, mirroring, and SFlow sampling.
- Keeping track of network stations and their MAC addresses through MAC address learning and aging.
- Holding VLAN membership information (configured by CPU) and applying this to the forwarding decision.
- Assigning PTP identifiers to PTP frames requesting timestamp updating.

The analyzer consists of three main blocks:

- MAC table
- VLAN table
- Forwarding Engine

The MAC and VLAN tables are the main databases used by the forwarding engine. The forwarding engine determines the forwarding decision and initiates learning in the MAC table when appropriate.

The analyzer operates on analyzer requests initiated by the port modules. For each received frame, the port module requests the analyzer to determine the forwarding decision. Initially, the analyzer request is directed to the VCAP-II. The result from the VCAP-II (the IS2 action) is forwarded to the analyzer along with the original analyzer request. For more information about VCAP-II, see VCAP-II, page 57.

The analyzer request contains the following frame information:

- Destination and source MAC addresses.
- Physical port number where the frame was received (referred to as PPORT).
- Logical port number where the frame was received (referred to as LPORT).
  By default, LPORT and PPORT are the same. However, when using link aggregation, multiple physical ports map to the same logical port. The LPORT value for each physical port is configured in ANA:PORT:PORT_CFG.PORTID_VAL in the analyzer.
- Frame properties derived by the classifier and VCAP-II IS1:
  Classified VID
  Link aggregation code
  Basic CPU forwarding
  CPU forwarding for special frame types determined by the classifier

Based on this information, the analyzer determines an analyzer reply, which is returned to the ingress port modules. The analyzer reply contains:

- The forwarding decision (referred to as DEST). This mask contains 27 bits, 1 bit for each front port and the CPU port.
- The final CPU extraction queue mask (referred to as CPUQ). This mask contains 8 bits, 1 bit for each CPU extraction queue.

The terms PPORT, LPORT, DEST and CPUQ, as previously defined, are used throughout the remainder of this section.

4.8.1 MAC Table

This section provides information about the MAC table block in the analyzer. The following table lists the registers associated with MAC table access.

Table 57 • **MAC Table Access**

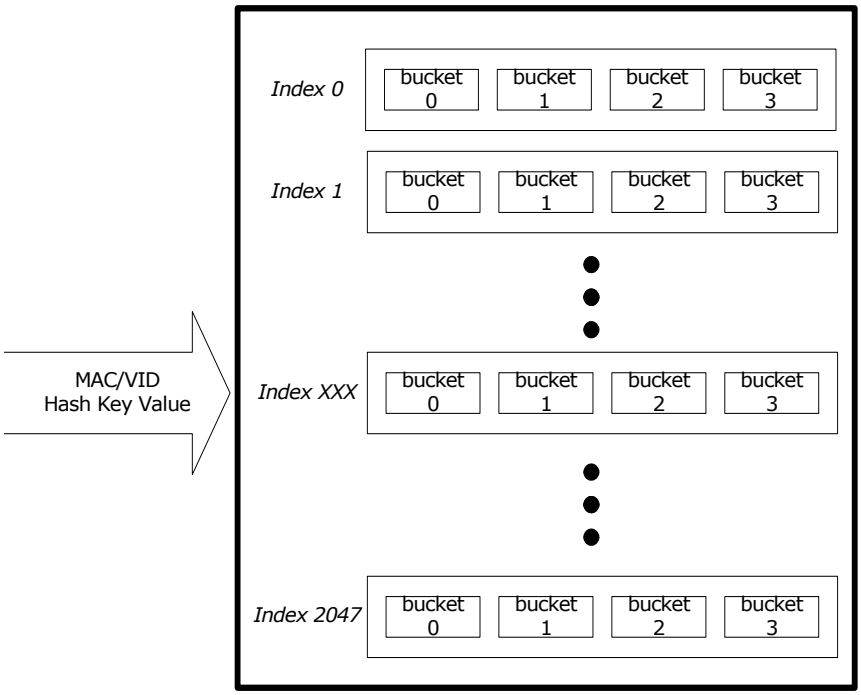
Register	Description	Replication
MACHDATA	MAC address and VID when accessing the MAC table.	None
MACLDATA	MAC address when accessing the MAC table.	None
MACTINDX	Direct address into the MAC table for direct read and write.	None
MACACCESS	Flags and command when accessing the MAC table.	None

Table 57 • **MAC Table Access *(continued)***

Register	Description	Replication
MACTOPTIONS	Flags when accessing the MAC table.	None
AUTOAGE	Age scan period.	None
AGENCTRL	Controls the default values for new entries in MAC table.	None
ENTRYLIM	Controls limits on number of learned entries per port.	Per port
LEARNDISC	Counts the number of MAC table entries not learned due lack of storage in the MAC table.	None

The analyzer contains a MAC table with 8,192 entries containing information about stations learned by the device. The table is organized as a hash table with four buckets and 2,048 rows. Each row is indexed by an 11-bit hash value, which is calculated based on the station's (MAC, VID) pair, as shown in the following illustration.

Figure 28 • **MAC Table Organization**



The following table lists the fields for each entry in the MAC table.

Table 58 • **MAC Table Entry**

Field	Bits	Description
VALID	1	Entry is valid.
MAC	48	The MAC address of the station (primary key).
VID	12	VLAN identifier that the station is learned with (primary key).
DEST_IDX	6	Destination mask index pointing to a destination mask in the destination mask table (PGID entries 0 through 63).
IP6_MASK	3	Partial IPv6 multicast destination port mask. See **IPv6 Multicast Entries,** page 87.

Table 58 • **MAC Table Entry *(continued)***

Field	Bits	Description
ENTRY_TYPE	2	Entry type: 0: Normal entry subject to aging. 1: Normal entry not subject to aging (locked). 2: IPv4 multicast entry not subject to aging. Full port set is encoded in MAC table entry. 3: IPv6 multicast entry not subject to aging. Full port set is encoded in MAC table entry.
AGED_FLAG	1	Entry is aged once by an age scan. See **Age Scan,** page 85.
MAC_CPU_COPY	1	Copy frames from or to this station to the CPU.
SRC_KILL	1	Do not forward frames from this station. **Note** This flag is not used for destination lookups.
IGNORE_VLAN	1	Do not use the VLAN_PORT_MASK from the VLAN table when forwarding frames to this station.

Entries in the MAC table can be added, deleted, or updated in three ways:

- Hardware-based learning of source MAC addresses (that is, inserting new (MAC, VID) pairs in the MAC table).
- Age scans (setting AGED_FLAG and deleting entries.)
- CPU commands (for example, for CPU-based learning.)

4.8.1.1 Hardware-Based Learning

The analyzer adds an entry to the MAC table when learning is enabled, and the MAC table does not contain an entry for a received frame's (SMAC, VID). The new entry is formatted as follows:

- VALID is set
- MAC is set to the frame's SMAC
- VID set to the frame's VID
- ENTRY_TYPE is set to 0 (normal entry subject to aging)
- DEST_IDX is set to the frame's LPORT
- MAC_CPU_COPY is set to AGENCTRL.LEARN_CPU_COPY
- SRC_KILL is set to AGENCTRL.LEARN_SRC_KILL
- IGNORE_VLAN is set to AGENCTRL.LEARN_IGNORE_VLAN
- All other fields are cleared

When a frame is received from a known station, that is, the MAC table already contains an entry for the received frame's (SMAC, VID), the analyzer can update the entry as follows.

For entries of entry type 0 (unlocked entries):

- The AGED_FLAG is cleared. This implies the station is active, avoiding the deletion of the entry due to aging.
- If the existing entry's DEST_IDX differs from the frame's LPORT, then the entry's DEST_IDX is set to the frame's LPORT. This implies the station has moved to a new port.

For entries of entry type 1 (locked entries):

- The AGED_FLAG is cleared. This implies the station is active.

Entries of entry types 2 and 3 are never updated, because their multicast MAC addresses are never used as source MAC addresses.

For more information about learning, see **SMAC Analysis,** page 96.

4.8.1.2 Age Scan

The analyzer scans the MAC table for inactive entries. An age scan is initiated by either a CPU command or automatically performed by the device with a configurable age scan period (AUTOAGE). The age scan checks the flag AGED_FLAG for all entries in the MAC table. If an entry's AGED_FLAG is already set and the entry is of entry type 0, the entry is removed. If the AGED_FLAG is not set, it is set to 1. The flag

is cleared when receiving frames from the station identified by the MAC table entry. For more information, see **Hardware-Based Learning**, page 85.

4.8.1.3 CPU Commands

The following table lists the set of commands that a CPU can use to access the MAC table. The MAC table command is written to MACACCESS.MAC_TABLE_CMD. Some commands require the registers MACLDATA, MACHDATA, and MACTINDX to be preloaded before the command is issued. Some commands return information in MACACCESS, MACLDATA, and MACHDATA.

Table 59 • **MAC Table Commands**

Command	Purpose	Use
LEARN	Insert/learn new entry in MAC table. Position given by (MAC, VID)	Configure MAC and VID of the new entry in MACHDATA and MACLDATA. Configure remaining entry fields in MACACCESS. The location in the MAC table is calculated based on (MAC, VID).
FORGET	Delete/unlearn entry given by (MAC, VID)	Configure MAC and VID in MACHDATA and MACLDATA.
AGE	Start age scan	No preload required. Issue command.
READ	Read entry pointed to by (row, column)	Configure row (0-2047) and column (0-3) of the entry to read in: MACTINDX.INDEX (row) MACTINDX.BUCKET (column) MACACCESS.VALID must be 0. When MAC_TABLE_CMD changes to IDLE, MACHDATA, MACLDATA, and MACACCESS contain the information read.
LOOKUP	Lookup entry pointed to by (MAC, VID)	Configure MAC and VID of station to look up in MACHDATA and MACLDATA. MACACCESS.VALID must be 1. Issue a READ command. When MAC_TABLE_CMD changes to IDLE, success of the lookup is indicated by MACACESS.VALID. If successful, MACACCESS contains the entry information.
WRITE	Write entry, MAC table position given by (row, column)	Configure MAC and VID of the new entry in MACHDATA and MACLDATA. Configure remaining entry fields in MACACCESS. The location in the MAC table is given by row and column in MACTINDX.
INIT	Initialize the table	No preload required. Issue command.
GET_NEXT	Get the smallest entry in the MAC table numerically larger than the specified (MAC, VID). The VID and MAC are evaluated as a 60-bit number with the VID being most significant.	Configure MAC and VID of the starting point for the search in MACHDATA and MACLDATA. When MAC_TABLE_CMD changes to IDLE, success of the search is indicated by MACACESS.VALID. If successful, MACHDATA, MACLDATA, and MACACCESS contain the information read.
IDLE	Indicate that MAC table is ready for new command	

4.8.1.4 Known Multicasts

From a CPU, entries can be added to the MAC table with any content. This makes it possible to add a known multicast address with multiple destination ports:

- Set the MAC and VID in MACHDATA and MACLDATA
- Set MACACCESS.ENTRY_TYPE = 1 because this is not an entry subject to aging.
- Set MACACCESS.AGED_FLAG to 0.
- Set MACACCESS.DEST_IDX to an unused value.
- Set the destination mask in the destination mask table pointed to by DEST_IDX to the desired ports.

Example All frames in VLAN 12 with MAC address 0x010000112233 are to be forwarded to ports 8, 9, and 12.

This is done by inserting the following entry in the MAC table:

VID = 12
MAC = 0x010000112233
ENTRY_TYPE = 1
VALID = 1
AGED_FLAG = 0
DEST_IDX = 40

and configuring the destination mask table:

PGID[40 = 0x1300.

IPv4 and IPv6 multicast entries can be programmed differently without using the destination mask table. This is described in the following subsection.

4.8.1.5 IPv4 Multicast Entries

MAC table entries with the ENTRY_TYPE = 2 settings are interpreted as IPv4 multicast entries.

IPv4 multicasts entries match IPv4 frames, which are classified to the specified VID, and which have DMAC = 0x01005Exxxxxx, where xxxxxx is the lower 24 bits of the MAC address in the entry.

Instead of a lookup in the destination mask table (PGID), the destination set is set to the lower 2 bits of the DEST_IDX value concatenated with the upper 24 bits of the entry MAC address. This is shown in the following table.

Table 60 • **IPv4 Multicast Destination Mask**

Destination Ports	Record Bit Field
Ports 23-0	MAC[47-24]
Ports 25-24	DEST_IDX[1-0]

Example All IPv4 multicast frames in VLAN 12 with MAC 01005E112233 are to be forwarded to ports 8, 9, and 12. This is done by inserting the following entry in the MAC table entry:

VALID = 1
VID = 12
MAC = 0x001300112233
ENTRY_TYPE = 2
DEST_IDX = 0

4.8.1.6 IPv6 Multicast Entries

MAC table entries with the ENTRY_TYPE = 3 settings are interpreted as IPv6 multicast entries:

IPv6 multicasts entries match IPv6 frames, which are classified to the specified VID, and which have DMAC=0x3333xxxxxxxx, where xxxxxxxx is the lower 32 bits of the MAC address in the entry.

Instead of a lookup in the destination mask table (PGID), the destination set is set to AGED_FLAG field concatenated with the IP6_MASK field, the DEST_IDX field and the upper 16 bits the MAC field. This is shown in the following table.

Table 61 • **IPv6 Multicast Destination Mask**

Destination Ports	Record Bit Field
Port 25	AGED_FLAG
Ports 24-22	IP6_MASK
Ports 21-16	DEST_IDX
Ports 15-0	MAC [47-32]

Example All IPv6 multicast frames in VLAN 12 with MAC 333300112233 are to be forwarded to ports 8, 9, and 12.

This is done by inserting the following entry in the MAC table entry:

VID = 12
MAC = 0x130000112233
ENTRY_TYPE = 3
VALID = 1
AGED_FLAG = 0
IP6_MASK = 0
DEST_IDX = 0

4.8.1.7 Port and VLAN Filter

The following table lists the registers associated with the port and VLAN filter.

Table 62 • **VID/Port Filters**

Register	Description	Replication
ANAGEFIL	Port and VLAN filter for limiting the target for aging and search operations on MAC table.	None

The ANAGEFIL register can be used to only hit specific VLANs or ports when doing certain operations. If the filter is enabled, it affects:

- Manual age scan command (MACACCESS.MAC_TABLE_CMD = AGE)
- The LOOKUP and GET_NEXT MAC table commands. For more information, see **CPU Commands**, page 86.

4.8.1.8 Shared VLAN Learning

The following table lists the location of the Filter Identifier (FID) used for shared VLAN learning.

Table 63 • **FID Definition Registers**

Register	Description	Replication
IS1_ACTION.FID_SEL	Specifies the use of IS1_ACTION.FID_VAL for the DMAC lookup, the SMAC lookup, or for both lookups.	Per IS1 entry
IS1_ACTION.FID_VAL	FID value.	Per IS1 entry
AGENCTRL.FID_MASK	Combines multiple VIDs in the MAC table.	None

In the default configuration, the device is set up to do Independent VLAN Learning (IVL), that is, MAC addresses are learned separately on each VLAN. The device also supports Shared VLAN Learning (SVL), where a MAC table entry is shared among a group of VLANs. For shared VLAN learning, a MAC address and a Filter Identifier (FID) define each MAC table entry. A set of VIDs then map to the FID.

The device supports shared VLAN learning in two ways, either through an IS1 action specifying the FID to use or by using the AGENCTRL.FID_MASK,which controls a mapping between FID and VIDs.

The IS1 action FID_SEL selects whether to use the FID_VAL for the DMAC lookup, for the SMAC lookup, or for both lookups. If set for a lookup, the FID_VAL replaces the VID when calculating the hash key into the MAC table, when comparing with the entry's VID, and when learning. If an IS1 action returns a FID_SEL > 0, it overrules the use of the FID_MASK for the specific lookup.

The 12-bit FID_MASK masks out the corresponding bits in the VID. The FID used for learning and lookup is therefore calculated as FID = VID AND (NOT FID_MASK).

All VIDs mapping to the same FID share the same MAC table entries.

If the FID_MASK is cleared, Independent VLAN Learning is used. This is the default.

Example Configure all MAC table entries to be shared among all VLANs.

This is done by setting FID_MASK to 111111111111.

Example Split the MAC table into two separate databases: one for even VIDs and one for odd VIDs.

This is done by setting FID_MASK to 111111111110.

4.8.1.9 Learn Limit

The following table lists the registers associated with controlling the number of MAC table entries per port.

Table 64 • **Learn Limit Definition Registers**

Register	Description	Replication
ENTRYLIM	Configures maximum number of unlocked entries in the MAC table per ingress port.	Per port
PORT_CFG. LIMIT_CPU	If set, learn frames exceeding the limit are copied to the CPU.	Per port
PORT_CFG. LIMIT_DROP	If set, learn frames exceeding the limit are discarded.	Per port
LEARNDISC	The number of MAC table entries that could not be learned due to a lack of storage space.	None

The ENTRYLIM.ENTRYLIM register specifies the maximum number of unlocked entries in the MAC table that a port is allowed to use. Locked and IPMC entries are not taken into account.

After the limit is reached, both auto-learning and CPU-based learning on unlocked entries are denied. A learn frame causing the limit to be exceeded can be copied to the CPU (PORT_CFG.LIMIT_DROP) and the forwarding to other front ports can be denied (PORT_CFG.LIMIT_DROP).

The ENTRYLIM.ENTRYSTAT register holds the current number of entries in the MAC table. MAC table aging and manual removing of entries through the CPU cause the current number to be reduced. If a MAC table entry moves from one port to another port, this is also reduces the current number. If the move causes the new port's limit to be exceeded, the entry is denied and removed from the MAC table.

The LEARNDISC counts all events where a MAC table entry is not created or updated due to a learn limit.

4.8.2 VLAN Table

The following table lists the registers associated with the VLAN Table.

Table 65 • **VLAN Table Access**

Register	Description	Replication
VLANTIDX	VID to access, and VLAN flags.	None

Table 65 • **VLAN Table Access *(continued)***

Register	Description	Replication
VLANACCESS	VLAN port mask for VID and command for access	None

The analyzer has a VLAN table that contains information about the members of each of the 4096 VLANs. The following table lists fields for each entry in the VLAN table.

Table 66 • **Fields in the VLAN Table**

Field	Bits	Description
VLAN_PORT_MASK	26	One bit for each port. Set if port is member of VLAN. The CPU port is always a member of all VLANs.
VLAN_MIRROR	1	Mirror frames received in the VLAN. See **Mirroring,** page 99.
VLAN_SRC_CHK	1	VLAN ingress filtering. If set, frames classified to this VLAN are dropped if PPORT is not member of the VLAN.
VLAN_LEARN_DISABLED	1	Disable learning in the VLAN.
VLAN_PRIV_VLAN	1	Set VLAN to private.

By default, all ports are members of all VLANs. This default can be changed through a CPU command. The following table lists the set of commands that a CPU can issue to access the VLAN table. The VLAN table command is written to VLANACCESS.VLAN_TBL_CMD.

Table 67 • **VLAN Table Commands**

Command	Purpose	Use
INIT	Initialize the table	Issue command. When VLAN_TBL_CMD changes to IDLE, initialization has completed and all ports are member of all VLANs. All flags are cleared.
READ	Read VLAN table entry for specific VID.	Configure the VLAN to read from in VLANTIDX.INDEX. When VLAN_TBL_CMD changes to IDLE, VLANACCESS and VLANTIDX contain the information read.
WRITE	Write VLAN table entry for specific VID.	Configure the VLAN to write to in VLANTIDX.INDEX. Configure the content of the VLAN record in VLANACCESS.VLANACCESS VLANTIDX.VLAN_MIRROR VLANTIDX.VLAN_SRC_CHK VLANTIDX.VLAN_LEARN_DISABLED VLANTIDX.VLAN_PRIV_VLAN
IDLE	Indicate that VLAN table is ready for new command	

4.8.3 Forwarding Engine

The analyzer determines the set of ports to which each frame is forwarded, in several configurable steps. The resulting destination port set can include any number of ports, as well as the CPU port.

The analyzer request from the port modules is passed through all the processing steps of the forwarding engine. As each step is carried out, the destination port set (DEST) and CPU extraction queue mask (CPUQ) are built up.

In addition to the forwarding decision, the analyzer determines which frames are subject to learning (also known as learn frames). Learn frames trigger insertion of a new entry in the MAC table or update of an

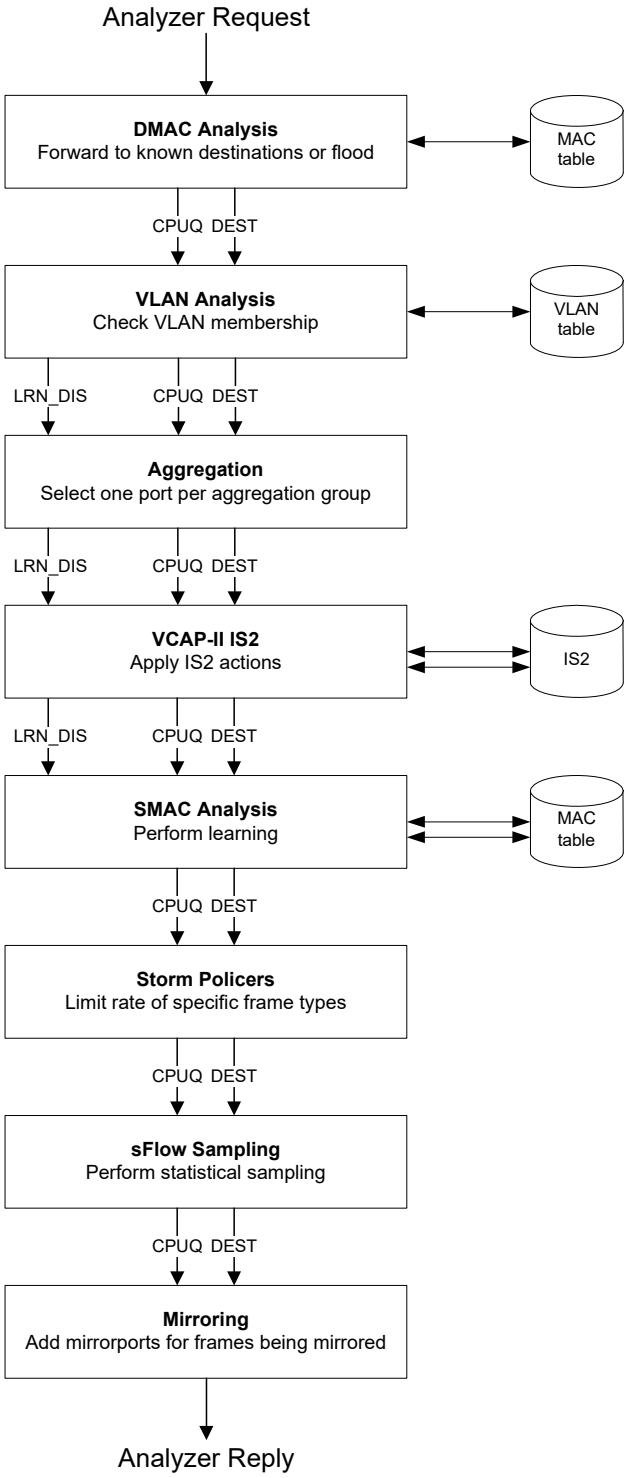
existing entry. Learning is presented as part of the forwarding, because in some cases, learning changes the normal forwarding of a frame, such as secure learning.

During the processing, the analyzer determines a local frame property. The learning-disabled flag, LRN_DIS is used in the SMAC Learning step:

- If the learning-disabled flag is set, learning based on (SMAC, VID) is disabled.
- If the learning-disabled flag is cleared, learning is conducted according to the configuration in the SMAC learning step.

The following illustration shows the configuration steps in the analyzer.

Figure 29 • **Analysis Steps**



4.8.3.1 DMAC Analysis

During the DMAC analysis step, the (DMAC, VID) pair is looked up in the MAC table to get the first input to the calculation of the destination port set. For more information about the MAC table, see MAC Table, page 83.

The following table lists the registers associated with the DMAC analysis step.

Table 68 • **DMAC Analysis Registers**

Register	Description	Replication
FLOODING.FLD_UNICAST	Index into the PGID table used for flooding of unicast frames.	None
FLOODING.FLD_BROADCAST	Index into the PGID table used for flooding of broadcast frames.	None
FLOODING.FLD_MULTICAST	Index into the PGID table used for flooding of multicast frames, not flooded by the IPMC flood masks.	None
FLOODING_IPMC.FLD_MC4_CTRL	Index into the PGID table used for flooding of IPv4 multicast control frames.	None
FLOODING_IPMC.FLD_MC4_DATA	Index into the PGID table used for flooding of IPv4 multicast data frames.	None
FLOODING_IPMC.FLD_MC6_CTRL	Index into the PGID table used for flooding of IPv6 multicast control frames.	None
FLOODING_IPMC.FLD_MC6_DATA	Index into the PGID table used for flooding of IPv6 multicast data frames.	None
PGID[63:0]	Destination and flooding masks table	64
AGENCTRL. IGNORE_DMAC_FLAGS	Controls the use of MAC table flags from (DMAC, VID) entry and flooding flags	None
CPUQ_CFG	Configuration of CPU extraction queues	None

The (DMAC, VID) pair is looked up in the MAC table. If a match is found, the entry is returned and DEST is determined based on the MAC table entry. For more information, see MAC Table, page 83.

If an entry is found in the MAC table entry of ENTRY_TYPE 0 or 1 and the CPU port is set in the PGID pointed to by the MAC table entry, CPU extraction queue PGID.DST_PGID is added to the CPUQ.

If an entry is not found for the (DMAC, VID) in the MAC table, the frame is flooded. The forwarding decision is set to one of the seven flooding masks defined in ANA::FLOODING or ANA::FLOODING_IPMC, based on one of the flood type definitions listed in the following table.

Table 69 • **Forwarding Decisions Based on Flood Type**

Frame Type	Condition
IPv4 multicast data	DMAC = 0x01005E000000 to 0x01005E7FFFFF EtherType = IPv4 IP protocol is not IGMP IPv4 DIP outside 224.0.0.x
IPv6 multicast data	DMAC = 0x333300000000 to 0x3333FFFFFFFF EtherType = IPv6 IPv6 DIP outside 0xFF02::/16
IPv4 multicast control	DMAC = 0x01005E000000 to 0x01005E7FFFFF EtherType = IPv4 IP protocol is not IGMP IPv4 DIP inside 224.0.0.x
IPv6 multicast control	DMAC = 0x333300000000 to 0x3333FFFFFFFF EtherType = IPv6 IPv6 DIP inside 0xFF02::/16

Table 69 • **Forwarding Decisions Based on Flood Type *(continued)***

Frame Type	Condition
Broadcast	DMAC = 0xFFFFFFFFFFFF non-IPv4-multicast-data non-IPv6-multicast-data non-IPv4-multicast-control non-IPv6-multicast-control
Multicast	Bit 40 in DMAC = 1 non-broadcast non-IPv4-multicast-data non-IPv6-multicast-data non-IPv4-multicast-control non-IPv6-multicast-control
Unicast	Bit 40 in DMAC = 0

Additionally, the MAC table flag MAC_CPU_COPY is processed if MAC_CPU_COPY is set, if the CPU port is added to DEST, and if CPUQ_CFG.CPUQ_MAC is added to CPUQ.

The processing of this flag can be disabled through AGENCTRL.IGNORE_DMAC_FLAGS.

Finally, classifier-based CPU-forwarding is processed if:

- The classifier decided to redirect the frame to the CPU, DEST is set to the CPU port only. The corresponding CPU extraction queue is added to CPUQ.
- The classifier decided to copy the frame to the CPU, the CPU port is added to DEST. The corresponding CPU extraction queue is added to CPUQ.

For more information about frame type definitions for CPU forwarding, see Table 29, page 57.

4.8.3.2 VLAN Analysis

During the VLAN analysis step, VLAN configuration is taken into account. As a result, ports can be removed from the forwarding decision. For more information about VLAN configuration, see VLAN Table, page 89.

The following table lists the registers associated with VLAN analysis.

Table 70 • **VLAN Analysis Registers**

Register	Description	Replication
VLANMASK	If PPORT is set in this mask, and PPORT is not member of the VLAN to which the frame is classified, DEST is cleared. This is also called VLAN ingress filtering.	None
PORT_CFG.RECV_ENA	If this bit is cleared for PPORT, forwarding from this port to other front ports is disabled, and DEST is cleared.	Per port
PGID[106:80]	Source port mask. Port mask per port, which specifies allowed destination ports for frames received on PPORT. By default, a port can forward to all other ports except itself.	Per port
ISOLATED_PORTS	Private VLAN mask. Isolated ports are cleared in this mask.	None
COMMUNITY_PORTS	Private VLAN mask. Community ports are cleared in this mask.	None
ADVLEARN.VLAN_CHK	If set and VLAN ingress filtering clears DEST, then SMAC learning is disabled.	None

The frame's VID is used as an address for lookup in the VLAN table and the returned VLAN information is processed as follows:

- All ports that are not members of the VLAN (VLAN_PORT_MASK) are removed from DEST, except if the (DMAC, VID) match in the MAC table has VLAN_IGNORE set, or if there is no match in the MAC table and AGENCTRL.FLOOD_IGNORE_VLAN is set.
- **Note** These two exceptions are skipped if AGENCTRL.IGNORE_DMAC_FLAGS is set.
- If the VLAN_PRIV_VLAN flag in the VLAN table is set, the VLAN is private, and isolated and community ports must be treated differently. An isolated port is identified as an ingress port for which PPORT is cleared in the ISOLATED_PORTS register. An community port is identified as an ingress port for which PPORT is cleared in the COMMUNITY_PORTS register. For frames received on an isolated port, all isolated and community ports are removed from the forwarding decision. For frames received on a community port, all isolated ports are removed from the forwarding decision.
- If VLAN ingress filtering is enabled, it is checked whether PPORT is member of the VLAN (VLAN_PORT_MASK). If this is not the case, DEST is cleared.

  VLAN ingress filtering is enabled per port in the VLANMASK register or per VLAN in the VLAN_SRC_CHK flag in the VLAN table. If either is set, VLAN ingress filtering is performed.

Next, it is checked whether the ingress port is enabled to forward frames to other front ports and the source mask (PGID[80+PPORT]) is processed as follows:

- If PORT_CFG.RECV_ENA for PPORT is 0, DEST is cleared except for the CPU port.
- Any ports, which are cleared in PGID[80+PPORT], are removed from DEST.

Finally, SMAC learning is disabled by setting the LRN_DIS flag when either of the following two conditions is fulfilled as follows:

- VLAN_LEARN_DISABLED is set in the VLAN table for the VLAN.
- A frame is subject to VLAN ingress filtering (frame dropped due to PPORT not being member of VLAN), and ADVLEARN.VLAN_CHK is set.

4.8.3.3 Aggregation

During the aggregation step, link aggregation is handled. The following table lists the registers associated with aggregation.

Table 71 • **Analyzer Aggregation Registers**

Register	Description	Replication
PGID[79:64]	Aggregation mask table.	16

The purpose of the aggregation step is to ensure that when a frame is destined for an aggregation group, it is forwarded to exactly one of the group's member ports.

For non-aggregated ports, there is a one-to-one correspondence between logical port (LPORT) and physical port (PPORT). The aggregation step does not change the forwarding decision.

For aggregated ports, all physical ports in the aggregation group map to the same logical port, and the entry in the destination mask table for the logical port includes all physical ports, which are members of the aggregation group. As a result, all but one member port must be removed from the destination port set.

The lni aggregation code generated in the classifier is used to look up an aggregation mask in the aggregation masks table. Finally, ports that are cleared in the selected aggregation mask are removed from DEST.

For more information about link aggregation, see Link Aggregation, page 216.

4.8.3.4 VCAP-II Action Handling

During the VCAP IS2 action handling step, the VCAP IS2 actions are processed. The following table lists the processing of the VCAP actions. The order of processing is from top to bottom.

Table 72 • **VCAP IS2 Action Processing**

IS2 Action Field	Description
CPU_COPY_ENA CPU_QU_NUM	If CPU_COPY_ENA is set, the CPU port is added to DEST. The CPU_QU_NUM bit is set in CPUQ.
HIT_ME_ONCE CPU_QU_NUM	If HIT_ME_ONCE is set and the HIT_CNT counter is zero, the CPU port is added to DEST. The CPU_QU_NUM bit is set in CPUQ.
LRN_DIS	If set, learning is disabled (LRN_DIS flag is set).
POLICE_ENA POLICE_IDX	If POLICE_ENA is set (only applies to first lookup), the POLICE_IDX instructs which policer to use for this frame. For more information, see Policers, page 101.
MASK_MODE PORT_MASK	The following actions are defined for MASK_MODE. 0: No action. 1: Permit. Ports cleared in PORT_MASK are removed from DEST. 2: Policy. DEST from the DMAC analysis step is replaced with PORT_MASK. The CPU port in DEST is not changed. 3: Redirect - DEST as the outcome of the DMAC, VLAN, and Aggregation analysis steps is replaced with PORT_MASK. The CPU port in DEST is not changed.
MIRROR_ENA	If MIRROR_ENA is set, mirroring is enabled. This is used in the Mirroring step (see **Mirroring**, page 99).
PTP_ENA	The following actions are defined for PTP_ENA. 0: No action. 1: Do one-step PTP update. 2: Do two-step PTP update. 3: Do both one-step and two-step PTP update. See Hardware Timestamping, page 124.

4.8.3.5 SMAC Analysis

During the SMAC analysis step, the MAC table is searched for a match against the (SMAC, VID), and the MAC table is updated due to learning. The learning part is skipped if the LRN_DIS flag was set by any of the previous steps.

The following table lists the registers associated with SMAC learning.

Table 73 • **SMAC Learning Registers**

Register	Description	Replication
PORT_CFG.LEARN_ENA	If set for PPORT, learning is skipped (that is, LEARNAUTO, LEARNCPU, LEARNDROP, LIMIT_CPU, LIMIT_DROP, LOCKED_PORTMOVE_CPU, and LOCKED_PORTMOVE_DROP are ignored).	Per port
PORT_CFG.LEARNAUTO	If set for PPORT, hardware-based learning is performed.	Per port
PORT_CFG.LEARNCPU	If set for PPORT, learn frames are copied to the CPU.	Per port
PORT_CFG.LEARNDROP	If set for PPORT, the CPU drops or forwards learn frames.	Per port

Table 73 • **SMAC Learning Registers *(continued)***

Register	Description	Replication
PORT_CFG.LIMIT_CPU	If set for PPORT, learn frames for which PPORT exceeds the port's limit are copied to the CPU.	Per port
PORT_CFG.LIMIT_DROP	If set for PPORT, learn frames for which PPORT exceeds the port's limit are discarded.	Per port
PORT_CFG. LOCKED_PORTMOVE_CPU	If set for PPORT, frames triggering a port move of a locked entry are copied to the CPU.	Per port
PORT_CFG. LOCKED_PORTMOVE_DROP	If set for PPORT, frames triggering a port move of a locked entry are discarded.	Per port
AGENCTRL.IGNORE_SMAC_ FLAGS	Controls the use of the MAC table flags from (SMAC, VID) entry.	None

Three different type of learn frames are identified:

- **Normal learn frames** Frames for which an entry for the (SMAC, VID) is not found in the MAC table or the (SMAC, VID) entry in the MAC table is unlocked and has a DEST_IDX different from LPORT. In addition, the learn limit for the LPORT must not be exceeded (ENTRYLIM).
- **Learn frames exceeding the learn limit** Same condition as for normal learn frames except that the learn limit for the LPORT is exceeded (ENTRYLIM)
- **Learn frames triggering a port move of a locked MAC table entry** Frames for which the (SMAC, VID) entry in the MAC table is locked and has a DEST_IDX different from LPORT.

For all learn frames, the following must apply before learning related processing is applied:

- Learning is enabled by PORT_CFG.LEARN_ENA.
- The LRN_DIS flag from previous processing steps must be cleared, which implies that:
  – Learning is not disabled due to VLAN ingress filtering
  – Learning is not disabled due to VCAP IS2 action
  – Learning is enabled for the VLAN (VLAN_LEARN_DISABLED is cleared in the VLAN table)

In addition, learning must not be disabled due to the ingress policer having policed the frame. For more information, see Policers, page 101.

If learning is enabled, learn frames are processed according to the setting of the following configuration parameters.

Normal learn frames:

- Automatic learning. If PORT_CFG.LEARNAUTO is set for PPORT, the (SMAC, VID) entry is automatically added to the MAC table
- Drop learn frames. If PORT_CFG.LEARNDROP is set for PPORT, DEST is cleared for learn frames. Therefore, learn frames are not forwarded on any ports. This is used for secure learning, where the CPU must verify a station before forwarding is allowed.
- Copy learn frames to the CPU. If PORT_CFG.LEARNCPU is set for PPORT, the CPU port is added to DEST for learn frames and CPUQ_CFG.CPUQ_LRN is set in CPUQ. This is used for CPU based learning.

Learn frames exceeding the learn limit:

- Drop learn frames. If PORT_CFG.LIMIT_DROP is set for PPORT, DEST is cleared for learn frames. As a result, learn frames are not forwarded on any ports.
- Copy learn frames to the CPU – If PORT_CFG.LIMIT_CPU is set for PPORT, the CPU port is added to DEST and CPUQ_CFG.CPUQ_LRN is set in CPUQ for learn frames.

Learn frames triggering a port move of a locked MAC table entry:

- Drop learn frames. If PORT_CFG.LOCKED_PORTMOVE_DROP is set for PPORT, DEST is cleared for learn frames. Therefore, learn frames are not forwarded on any ports.

- Copy learn frames to the CPU. If PORT_CFG.LOCKED_PORTMOVE_CPU is set for PPORT, the CPU port is added to DEST and CPUQ_CFG.CPUQ_LOCKED_PORTMOVE is added to CPUQ.

Finally, if a match is found in the MAC table for the (SMAC, VID), adjustments can be made to the forwarding decision.

- If the (SMAC, VID) match in the MAC table has SRC_KILL set, DEST is cleared except the CPU port.
- If the (SMAC, VID) match in the MAC table has MAC_CPU_COPY set, the CPU port is added to DEST and CPUQ_CFG.CPUQ_MAC_COPY is added to CPUQ.

The processing of the MAC table flags from the (SMAC, VID) match can be disabled through AGENCTRL.IGNORE_SMAC_FLAGS.

4.8.3.6 Storm Policers

The storm policers are activated during the storm policers step. The following table lists the registers associated with storm policers.

Table 74 • **Storm Policer Registers**

Register	Description	Replication
STORMLIMIT_CFG	Enable policing of various frame types.	4
STORMLIMIT_BURST	Configure maximum allowed rates of the different frame types.	None

The analyzer contains four storm policers that can limit the maximum allowed forwarding frame rate for various frame types. The storm policers are common to all ports and, as a result, measure the sum of traffic forwarded by the switch. A frame can activate several storm policers, and the frame is discarded if any of the activated storm policers exceed a configured rate. The storm policers work independently of other policers in the system (for example, port policers). As a result, frames policed by other policers are still measured by the storm policers.

Each storm policer can be configured to a frame rate ranging from 1 frame per second to 1 million frames per second.

The following table lists the available storm policers.

Table 75 • **Storm Policers**

Storm Policer	Description
Broadcast	Flooded frames with DMAC = 0xFFFFFFFFFFFF.
Multicast	Flooded frames with DMAC bit 40 set, except broadcasts.
Unicast	Flooded frames with DMAC bit 40 cleared.
Learn	Learn frames copied or redirected to the CPU due to learning (LOCKED_PORTMOVE_CPU, LIMIT_CPU, LEARNCPU).

For each of the storm policers, a maximum rate is configured in STORMLIMIT_CFG and STORMLIMIT_BURST:

- STORM_UNIT chooses between a base unit of 1 frame per second or 1 kiloframes per second.
- STORM_RATE sets the rate to 1, 2, 4, 8, …, 1024 times the base unit (STORM_UNIT).
- STORM_BURST configures the maximum number of frames in a burst.
- STORM_MODE specifies how the policer affects the forwarding decision. The options are:
  When policing, clear the CPU port in DEST.
  When policing, clear DEST except for the CPU port.
  When policing, clear DEST

Note that frames where the DMAC lookup returned a PGID with the CPU port set are always forwarded to the CPU even when the frame is policed by the storm policers. For more information, see **DMAC Analysis**, page 92.

4.8.3.7 sFlow Sampling

This process step handles sFlow sampling. The following table lists the registers associated with sFlow sampling.

Table 76 • **sFlow Sampling Registers**

Register	Description	Replication
SFLOW_CFG	Configures sFlow samplers (type and rates).	Per port
CPUQ_CFG.CPUQ_SFLOW	CPU extraction queue for sFLow sampled frames.	None

sFlow is a standard for monitoring high-speed switch networks through statistical sampling of incoming and outgoing frames. Each port in the device can be set up as an sFlow agent monitoring the particular link and generating sFlow data. If a frame is sFlow sampled, it is copied to the sFlow CPU extraction queue (CPUQ_SFLOW).

An sFlow agent is configured through SFLOW_CFG with the following options:

- SF_RATE specifies the probability that the sampler copies a frame to the CPU. Each frame being candidate for the sampler has the same probability of being sampled. The rate is set in steps of 1/4096.
- SF_SAMPLE_RX enables incoming frames on the port as candidates for the sampler.
- SF_SAMPLE_TX enables outgoing frames on the port as candidates for the sampler.

The Rx and Tx can be enabled independently. If both are enabled, all incoming and outgoing traffic on the port is subject to the statistical sampling given by the rate in SF_RATE.

4.8.3.8 Mirroring

This processing step handles mirroring. The following table lists the registers associated with mirroring.

Table 77 • **Mirroring Registers**

Register	Description	Replication
ADVLEARN.LEARN_MIRROR	For learn frames, ports in this mask (mirror ports) are added to DEST.	None
AGENCTRL.MIRROR_CPU	Mirror all frames forwarded to the CPU port module	None
PORT_CFG.SRC_MIRROR_ENA	Mirror all frames received on an ingress port (ingress port mirroring).	Per port
EMIRRORPORTS	Mirror frames that are to be transmitted on any ports set in this mask (egress port mirroring)	None
VLANTIDX.VLAN_MIRROR	Mirror all frames classified to a specific VID.	Per VLAN
IS2_ACTION.MIRROR_ENA	Mirror when an IS2 action is hit.	Per VCAP IS2 entry
MIRRORPORTS	When mirroring a frame, ports in this mask are added to DEST.	None
AGENCTRL.CPU_CPU_KILL_ENA	Clear the CPU port if source port is the CPU port and the CPU port is set in DEST.	None

Frames subject to mirroring are identified based on the following mirror probes:

- Learn mirroring if ADVLEARN.LEARN_MIRROR is set and frame is a learn frame.
- CPU mirroring if AGENCTRL.MIRROR_CPU is set and the CPU port is set in DEST.
- Ingress mirroring if PORT_CFG.SRC_MIRROR_ENA is set.
- Egress mirroring if any port set in EMIRRORPORTS is also set in DEST.
- VLAN mirroring if VLAN_MIRROR set in the VLAN table entry.
- VCAP-II mirroring if an action is hit that requires mirroring.

The following adjustment is made to the forwarding decision for frames subject to mirroring:

- Ports set in MIRRORPORTS are added to DEST.

If the CPU port is set in the MIRRORPORTS, CPU extraction queue CPUQ_CFG.CPUQ_MIRROR is added to the CPUQ.

For learn frames with learning enabled, all ports in ADVLEARN.LEARN_MIRROR are added to DEST. For more information, see **SMAC Analysis**, page 96.

For more information about mirroring, see Mirroring, page 219.

Finally, if AGENCTRL.CPU_CPU_KILL_ENA is set, the CPU port is removed if the ingress port is the CPU port itself. This is similar to source port filtering done for front ports and prevents the CPU from sending frames back to itself.

4.8.4 Analyzer Monitoring

Miscellaneous events in the analyzer can be monitored, which can provide an understanding of the events during the processing steps. The following table lists the registers associated with analyzer monitoring.

Table 78 • **Analyzer Monitoring**

Register	Description	Replication
ANMOVED	ANMOVED[n] is set when a known station has moved to port n.	None
ANEVENTS	Sticky bit register for various events.	None
LEARNDISC	The number of learn events that failed due to a lack of storage space in the MAC table.	None

Port moves, defined as a known station moving to a new port, are registered in the ANMOVED register. A port move occurs when an existing MAC table entry for (MAC, VID) is updated with new port information (DEST_IDX). Such an event is registered in ANMOVED by setting the bit corresponding to the new port.

Continuously occurring port moves may indicate a loop in the network or a faulty link aggregation configuration.

A list of 27 events, such as frame flooding or policer drop, can be monitored in ANEVENTS.

The LEARNDISC counter registers every time an entry in the MAC table cannot be made or if an entry is removed due to lack of storage.

4.9 Policers and Ingress Shapers

Each device has a pool of 256 policers that can be shared between ingress ports, ingress queues, and VCAP IS2 entries. Each ingress port also has an ingress shaper. Both the policers and the shapers can limit the bandwidth of received frames. When configured bandwidth is exceeded, the policers discard frames, while the ingress shaper holds back the traffic in the queue system. Each frame can hit up to three policers and one ingress shaper.

In addition to the policers and ingress shapers described, a number of storm policers and an egress scheduler with per-port and per-egress queue shapers are supported. For more information, see **Storm Policers**, page 98 and Scheduler and Shaper, page 111.

4.9.1 Policers

This section explains the functions of the policers. The following table lists the registers associated with policer control.

Table 79 • **Policer Control Registers**

Register	Description	Replication
ANA:PORT:POL_CFG	Enables use of port and queue policers.	Per port
SYS:POL:POL_PIR_CFG	Configures the policer's peak information rate.	256
SYS:POL:POL_CIR_CFG	Configures the policer's committed information rate	256
SYS:POL:POL_MODE_CFG	Configures the policer's mode of operation.	256
SYS:POL:POL_PIR_STATE	Current state of the peak information rate bucket.	256
SYS:POL:POL_CIR_STATE	Current state of the committed information rate bucket.	256
SYS:PORT:POL_FLOWC	Flow control settings	Per port
SYS::POL_HYST	Hysteresis settings.	None

The pool of policers can be assigned to the following three blocks:

- Ingress ports. Port 'p' use policer 'p'.
- Ingress queues. Ingress queue 'q' on port 'p' use policer 32 + 8x 'p' + 'q'. Each of the eight per-port ingress queues can be assigned to its own policer.
- VCAP IS2. Any remaining policers can be pointed to by IS2_ACTION.POLICE_IDX.

Port and queue policers are enabled through ANA:PORT:POL_CFG.PORT_POL_ENA and ANA:PORT:POL_CFG.QUEUE_POL_ENA. VCAP IS2 policers are enabled by creating IS2 rules with POLICE_ENA and POLICE_IDX actions. IS2 policers actions only apply to the first lookup in IS2.

Each frame can hit a policer from each block; one port policer, one queue policer, and one VCAP IS2 policer. The policers are selected as follows:

- The ingress port where the frame was received points to the port policer.
- The QoS class classified to by the classifier and VCAP IS1 points to the queue policer.
- The POLICE_IDX action from the VCAP IS2 lookup points to the VCAP IS2 policer.

Any frame received by the MAC and forwarded to the classifier is applicable to policing. Frames with errors, pause frames, or MAC control frames are not forwarded by the MAC and, as a result, they are not accounted for in the policers. That is, they are not policed and are not adding to the rate measured by the policers.

In addition, the following special frame types can bypass the policers:

- If ANA:PORT:POL_CFG.POL_CPU_REDIR_8021 is set, frames being redirected to the CPU due to the classifier detecting the frames as being BPDU, ALLBRIDGE, GARP, or CCM/Link trace frames are not policed.
- If ANA:PORT:POL_CFG.POL_CPU_REDIR_IP is set, frames being redirected to the CPU due to the classifier detecting the frames as being IGMP or MLD frames are not policed.

These frames are still considered part of the rates being measured so the frames add to the relevant policer buckets but they are never discarded due to policing.

The order in which the policers are executed is controlled through ANA:PORT:POL_CFG.POL_ORDER. The order can take the following main modes:

- **Serial** The policers are checked one after another. If a policer is closed, the frame is discarded and the subsequent policer buckets are not updated with the frame. The serial order is programmable.
- **Parallel with independent bucket updates** The three policers are working in parallel independently of each other. Each frame is added to a policer bucket if the policer is open, otherwise the frame is discarded. A frame may be added to one policer although another policer is closed.

- **Parallel with dependent bucket updates** The three policers are working in parallel but dependent on each other with respect to bucket updates. A frame is only added to the policer buckets if all three policers are open.

Each of the 256 policers are MEF-compliant dual leaky bucket policers. This implies that each policer supports the following configurations:

- Committed Information Rate (CIR) – Specified in POL_CIR_CFG.CIR_RATE in steps of 100 kbps. Maximum is 3.277 Gbps.
- Committed Burst Size (CBS) – Specified in POL_CIR_CFG.CIR_BURST in steps of 4 kilobytes. Maximum is 252 kilobytes.
- Excess Information Rate (EIR) – Specified in POL_PIR_CFG.PIR_RATE in steps of 100 kbps. Maximum is 3.277 Gbps.
- Excess Burst Size (EBS) – Specified in POL_PIR_CFG.PIR_BURST in steps of 4 kilobytes. Maximum is 252 kilobytes.
- Coupling flag – If POL_MODE_CFG.DLB_COUPLED is set, frames classified as yellow (DP level = 1) are allowed to use of the committed information rate when not fully used by frames classified as green (DP level = 0). If cleared, the rate of frames classified as yellow are bounded by EIR.
- Color mode – Color-blind or color-aware. A policer always obey the frame color assigned by the classifier. To achieve color-blindness, the classifier must be set up to classify all incoming frames to DP level = 0.

Additionally, the following parameters can be configured per policer:

- The leaky bucket calculation can be configured to include or exclude preamble and inter-frame gap through configuration of POL_MODE_CFG.IPG_SIZE.
- Each policer can be configured to measure frame rates instead of bit rates (POL_MODE_CFG.FRM_MODE). The rate unit can be configured to 100 frames per second or 1 frame per second.
- POL_MODE_CFG.OVERSHOOT_ENA controls whether a bucket is allowed to use more than the actual number of tokens in the bucket when accepting a frame (overshooting). If POL_MODE_CFG.OVERSHOOT_ENA is cleared, the number of tokens in the bucket must be larger than the number of tokens required to accept the frame.
- Each policer can operate as a single leaky bucket by disabled POL_MODE_CFG.CIR_ENA. When operating as a single leaky bucket, the POL_PIR_CFG register controls the rate and burst of the policer.

By default, a policer discards frames while the policer is closed. A discarded frame is neither forwarded to any ports (including the CPU) nor is it learned.

However, each port policer has the option to run in flow control where the policer instructs the MAC to issue flow control pause frames instead of discarding frames. This is enabled in SYS:PORT:POL_FLOWC. Common for all port policers, POL_HYST.POL_FC_HYST specifies a hysteresis, which controls when the policer can re-open after having closed.

To improve fairness between small and large frames being policed by the same policer, POL_HYST.POL_DROP_HYST specifies a hysteresis, which controls when the policer can re-open after being closed. By setting it to a value larger than the maximum transmission unit, it guarantees that when the policer opens again, all frames have the same chance of being accepted. This setting only applies to policers working in drop mode.

The current fill level of the dual leaky buckets can be read in POL_PIR_STATE and POL_CIR_STATE. The unit is 0.5 bits.

4.9.2 Ingress Shapers

The following table lists the registers associated with ingress shaper control.

Table 80 • **Ingress Shaper Control Registers**

Register	Description	Replication
SYS:PORT:ISHP_CFG	Configures rate and burst.	Per port

Table 80 • **Ingress Shaper Control Registers *(continued)***

Register	Description	Replication
SYS:PORT:ISHP_MODE_CFG	Configures mode of operation.	Per port
SYS:PORT:ISHP_STATE	Current level of leaky bucket.	Per port

In addition to the policers, each port has an ingress shaper that controls the rate at which ingress ports are allowed to transfer data to egress ports. An ingress shaper does not discard any frames when its rate is exceeded, but simply holds back the frames in the ingress queues until the rate is below the configured value again. To ensure proper operation of the ingress shapers, all frames on all ports must be assigned the same QoS class when the ingress shapers are enabled.

The ingress shaper is enabled in ISHP_CFG.ISHP_ENA. Each of the ingress shapers contains a leaky bucket with the following configurations:

- Maximum transfer rate is specified in ISHP_CFG.ISHP_RATE in steps of 100 kbps. Maximum is 3.277 Gbps.
- Maximum burst size is specified in ISHP_CFG.ISHP_BURST in steps of 4 kilobytes. Maximum is 252 kilobytes.

Additionally, the following parameters can be configured per ingress shaper:

- The leaky bucket calculation can be configured to include or exclude preamble and inter-frame gap through configuration of ISHP_MODE_CFG.ISHP_IPG_SIZE.
- Each ingress shaper can be configured to measure frame rates instead of bit rates (ISHP_MODE_CFG.ISHP_FRM_MODE). The rate unit can be configured to 100 frames per second or 1 frame per second.

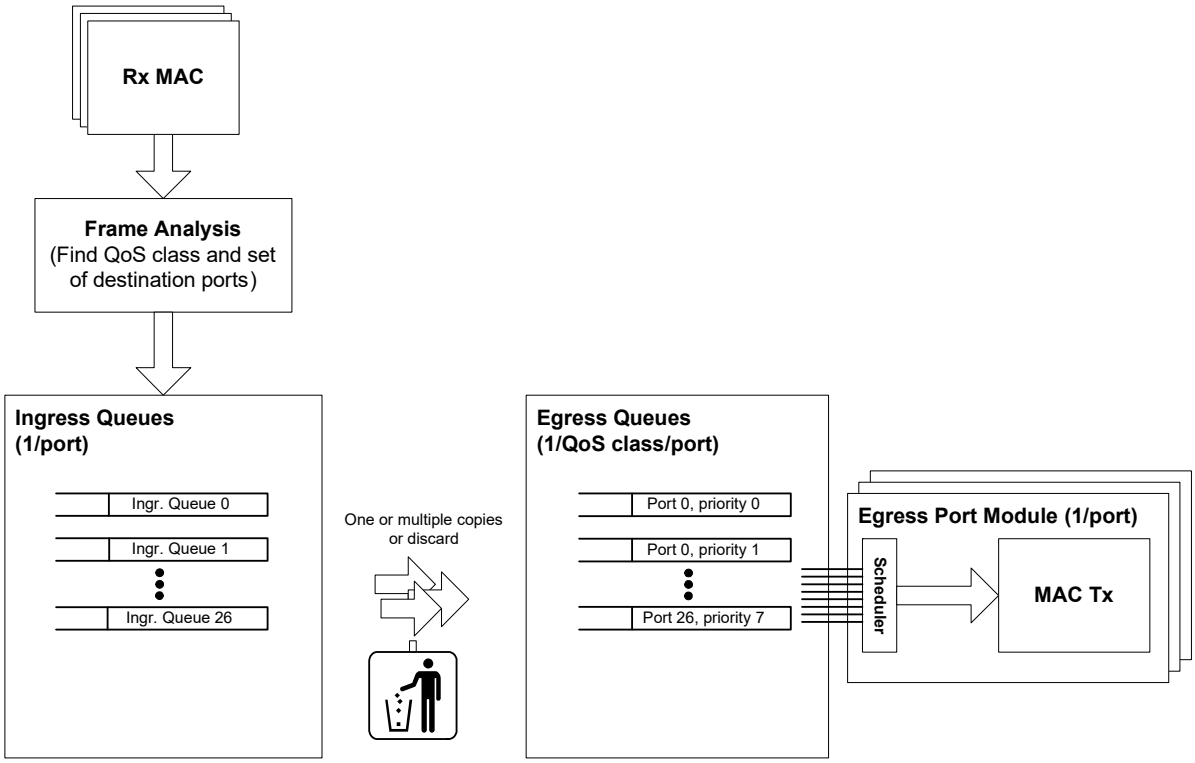
The current fill level of the leaky bucket can be read in ISHP_STATE. The unit is 0.5 bits.

4.10 Shared Queue System

The device includes a shared queue system with one ingress queue and eight egress queues per port. The queue system has 512 kilobytes of buffer.

Frames are stored in the ingress queue after frame analysis. Each egress port module selected by the frame analysis receives a copy of the frame and stores the frame in the appropriate egress queue given by the frame's QoS class. The transfer from ingress to egress is extremely efficient with a transfer time of 8 ns per frame copy (equivalent to a transfer rate of 64 Gbps for 64-byte frames and 1.5 Tbps for 1518-byte frames. Each egress port module has a scheduler, which selects between the egress queues when transmitting frames.

The following illustration shows the shared queue system.



Resource depletion can prevent one or more of the frame copies from the ingress queue to the egress queues. If a frame copy cannot be made due to lack of resources, the ingress port's flow control mode determines the behavior as follows:

- Ingress port is in drop mode: The frame copy is discarded.
- Ingress port is in flow control mode: The frame is held back in the ingress queue and the frame copy is made when the congestion clears.

For more information about special configurations of the shared queue system with respect to flow control, see Ingress Pause Request Generation, page 109.

4.10.1 Buffer Management

A number of watermarks control how much data can be pending in the egress queues before the resources are depleted. There are no watermarks for the ingress queues, except for flow control, because the ingress queues are empty most of the time due to the fast transfer rates from ingress to egress. For more information, see Ingress Pause Request Generation, page 109. When the watermarks are configured properly, congested traffic does not influence the forwarding of non-congested traffic. F

The memory is split into two main areas:

- A reserved memory area. The reserved memory area is subdivided into areas per port per QoS class per direction (ingress/egress).
- A shared memory area, which is shared by all traffic.

For setting up the reserved areas, egress queue watermarks exist per port and per QoS class for both ingress and egress. The following table lists the reservation watermarks.

Table 81 • **Reservation Watermarks**

Register	Description	Replication
BUF_Q_RSRV_E	Configures the reserved amount of egress buffer per egress queue.	Per egress queue

Table 81 • **Reservation Watermarks *(continued)***

Register	Description	Replication
BUF_P_RSRV_E	Configures the reserved amount of egress buffer shared among the eight egress queues.	Per egress port
BUF_Q_RSRV_I	Configures the reserved amount of egress buffer per ingress port per QoS class across all egress ports.	Per ingress port per QoS class
BUF_P_RSRV_I	Configures the reserved amount of egress buffer per ingress port shared among the eight QoS classes.	Per ingress port

All the watermarks, including the ingress watermarks, are compared against the memory consumptions in the egress queues. For example, the ingress watermarks in BUF_Q_RSRV_I compare against the total consumption of frames across all egress queues received on the specific ingress port and classified to the specific QoS class. The ingress watermarks in BUF_P_RSRV_I compare against the total consumption of all frames across all egress queues received on the specific ingress port.

The reserved areas are guaranteed minimum areas. A frame cannot be discarded or held back in the ingress queues if the frame's reserved areas are not yet used.

The shared memory area is the area left when all the reservations are taken out. The shared memory area is shared between all ports, however, it is possible to configure a set of watermarks per QoS class and per drop precedence level (green/yellow) to stop some traffic flows before others. The following table lists the sharing watermarks.

Table 82 • **Sharing Watermarks**

Register	Description	Replication
BUF_PRIO_SHR_E	Configures how much of the shared memory area that egress frames with the given QoS class are allowed to use.	Per QoS class
BUF_COL_SHR_E	Configures how much of the shared memory area that egress frames with the given drop precedence level are allowed to use.	Per drop precedence level
BUF_PRIO_SHR_I	Configures how much of the shared memory area that ingress frames with the given QoS class are allowed to use.	Per QoS class
BUF_COL_SHR_I	Configures how much of the shared memory area that ingress frames with the given drop precedence level are allowed to use.	Per drop precedence level

The sharing watermarks are maximum areas in the shared memory that a given traffic flow can use. They do not guarantee anything.

When a frame is enqueued into the egress queue system, the frame first consumes from the queue's reserved memory area, then from the port's reserved memory area. When all the frame's reserved memory areas are full, it consumes from the shared memory area.

The following provides some simple examples on how to configure the watermarks and how that influences the resource management:

- Setting BUF_Q_RSRV_E(egress port = 17, QoS class = 4) to 2 kilobytes guarantees that traffic destined for port 17 classified to QoS class 4 have room for 2 kilobytes of frame data before frames can get discarded.
- Setting BUF_Q_RSRV_I(ingress port = 17, QoS class = 4) to 2 kilobytes guarantees that traffic received on port 17 classified to QoS class 4 have room for 2 kilobytes of frame data before frames can get discarded.

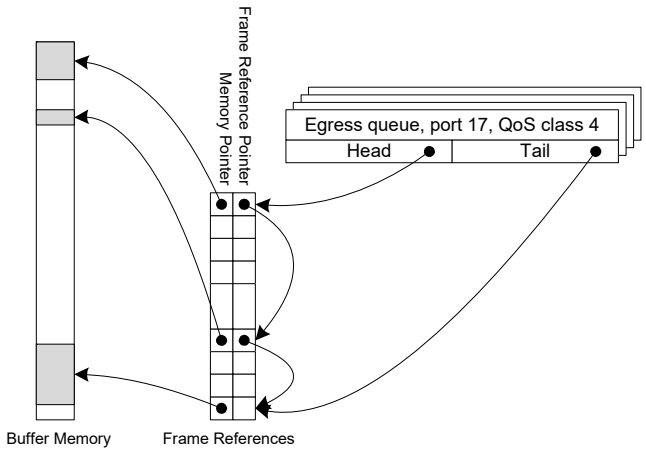
- Setting BUF_P_RSRV_I(ingress port 17) to 10 kilobytes guarantees that traffic received on port 17 have room for 10 kilobytes of data before frames can get discarded.
- The three above reservations reserve in total 14 kilobytes of memory (2 + 2+ 10 kilobytes) for port 17. If the same reservations are made for all ports, there are 512 – 27 × 14 = 134 kilobytes left for sharing. If the sharing watermarks are all set to 134 kilobytes, all traffic groups can consume memory from the shared memory area without restrictions.

  If, instead, setting BUF_PRIO_SHR_E(QoS class = 7) to 100 kilobytes and the other watermarks BUF_PRIO_SHR_E(QoS class = 0:6) to 70 kilobytes guarantees that traffic classified to QoS class 7 has 30 kilobytes extra buffer. The buffer is shared between all ports.

4.10.2 Frame Reference Management

Each frame in an egress queue consumes a frame reference, which is a pointer element that points to the frame's data in the memory and to the pointer element belonging to the next frame in the queue. The following illustrations shows how the frame references are used for creating the queue structure.

Figure 30 • **Frame Reference**



The shared queue system holds a table of 5500 frame references. The consumption of frame references is controlled through a set of watermarks. The set of watermarks is the exact same as for the buffer control. The frame reference watermarks are prefixed REF_. Instead of controlling the amount of consumed memory, they control the number of frame references. Both reservation and sharing watermarks are available. For more information, see Table 81, page 104 and Table 82, page 105.

When a frame is enqueued into the shared queue system, the frame consumes first from the queue's reserved frame reference area, then from the port's reserved frame reference area. When all the frame's reserved frame reference areas are full, it consumes from the shared frame reference area.

4.10.3 Resource Depletion Condition

A frame copy is made from an ingress port to an egress port when both a memory check and a frame reference check succeed. The memory check succeeds when at least one of the following conditions is met:

- Ingress memory is available: BUF_Q_RSRV_I or BUF_P_RSRV_I are not exceeded.
- Egress memory is available: BUF_Q_RSRV_E or BUF_P_RSRV_E are not exceeded.
- Shared memory is available: None of BUF_PRIO_SHR_E, BUF_COL_SHR_E, BUF_PRIO_SHR_I, or BUF_COL_SHR_I are exceeded.

The frame reference check succeeds when at least one of the following conditions is met:

- Ingress frame references are available: REF_Q_RSRV_I or REF_P_RSRV_I are not exceeded.
- Egress frame references are available: REF_Q_RSRV_E or REF_P_RSRV_E are not exceeded.
- Shared frame references are available: None of REF_PRIO_SHR_E, REF_COL_SHR_E, REF_PRIO_SHR_I, or REF_COL_SHR_I are exceeded.

4.10.4 Configuration Example

This section provides an example of how the watermarks can be configured for a QoS-aware switch with no color handling and the effects of the settings.

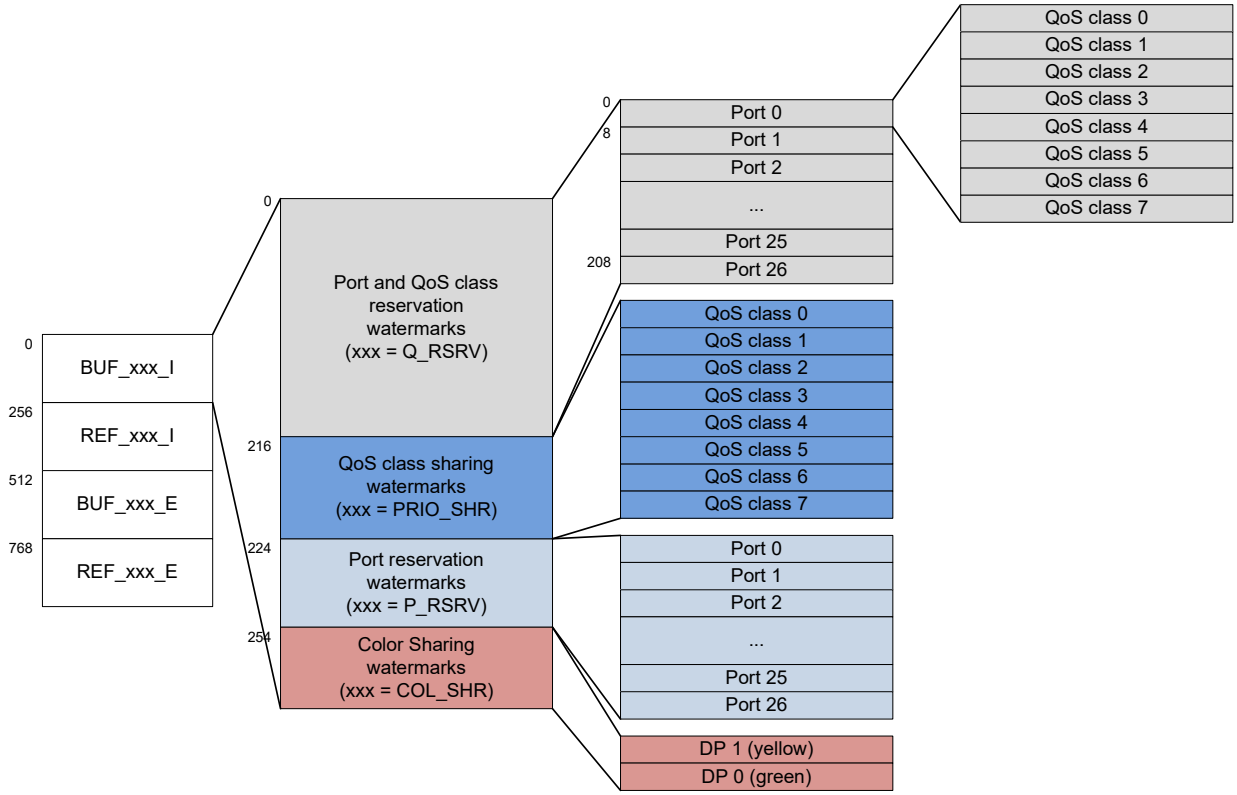
Table 83 • **Watermark Configuration Example**

Watermark	Value	Comment
BUF_Q_RSRV_I	500 bytes	Guarantees that a port is capable of receiving at least one frame in all QoS classes. **Note** It is not necessary to assign a full MTU, because the watermarks are checked before the frame is added to the memory consumption.
BUF_P_RSRV_I	0	No additional guarantees for the ingress port.
BUF_Q_RSRV_E	200 bytes	Guarantees that all QoS classes are capable of sending a non-congested stream of traffic through the switch.
BUF_P_RSRV_E	10 kilobytes	Guarantees that all egress ports have 10 kilobytes of buffer, independently of other traffic in the switch. This is the most demanding reservation in this setup, reserving 270 kilobytes of the total 512 kilobytes.
BUF_COL_SHR_E BUF_COL_SHR_I	Maximum	Effectively disables frame coloring as watermark is never reached.
BUF_PRIO_SHR_E BUF_PRIO_SHR_I	82 kilobytes to 103 kilobytes	The different QoS classes are cut-off with 3 kilobytes distance (82, 85, 88, 91, 94, 97, 100, and 103 kilobytes). This gives frames with higher QoS classes a larger part of the shared buffer area. Effectively, this means that the burst capacity is 92 kilobytes for frames belonging to QoS class 0 and up to 113 kilobytes for frame belonging to QoS class 7.
REF_Q_RSRV_E REF_Q_RSRV_I	4	For both ingress and egress, this guarantees that four frames can be pending from and to each port.
REF_P_RSRV_E REF_P_RSRV_I	20	For both ingress and egress, this guarantees that an extra 20 frames can be pending, shared between all QoS classes within the port.
REF_COL_SHR_E REF_COL_SHR_I	Maximum	Effectively disables frame coloring as watermark is never reached.
REF_PRIO_SHR_E REF_PRIO_SHR_I	2350 - 2700	The different QoS classes are cut-off with a distance of 50 frame references (2350, 2400, 2450, 2500, 2550, 2600, 2650, and 2700). This gives frames with higher QoS classes a larger part of the shared reference area.

4.10.5 Watermark Programming and Consumption Monitoring

The watermarks previously described are all found in the SYS::RES_CFG register. The register is replicated 1024 times. The following illustration the organization.

Figure 31 • **Watermark Layout**



The illustration shows the watermarks available for the BUF_xxx_I group of watermarks. For the other groups of watermarks (BUF_xxx_I, REF_xxx_I, BUF_xxx_E, and REF_xxx_E), the exact same set of watermarks is available.

For monitoring purposes, SYS::RES_STAT provides information about the resource consumption currently in use as well as the maximum consumption for corresponding watermarks. The information is available for each of the watermarks listed, and the layout of the RES_STAT register follows the layout of the watermarks. SYS::MMGT.FREECNT holds the amount of free memory in the shared queue system and SYS::EQ_CTRL.FP_FREE_CNT holds the number of free frame references in the shared queue system.

4.10.6 Advanced Resource Management

A number of additional handles into the resource management system are available for special use of the device. They are described in the following table.

Table 84 • **Resource Management**

Resource Management	Description
Forced drop of egress frames	SYS:PORT:EGR_DROP_FORCE. If an ingress port is in configured in flow control mode, frames received on the port are by default held back if one or more destination ports do not allow more data. However, if forced drop of egress frames is enabled for the egress port, frames are discarded. This could be enabled for the CPU port and for a mirror target port in order not to cause head-of-line blocking of non-congested traffic.

Table 84 • **Resource Management** ***(continued)***

Resource Management	Description
Prevent ingress port from using of the shared resources.	SYS:IGR_NO_SHARING. For frames received on ports set in this mask, the shared watermarks are considered exceeded. This prevents the port from using more resources than allowed by the reservation watermarks.
Prevent egress port from using of the shared resources.	SYS:EGR_NO_SHARING. For frames switched to ports set in this mask the shared watermarks are considered exceeded. This prevents the port from using more resources than allowed by the reservation watermarks.
Preferred sources	SYS::EQ_PREFER_SRC. By default, ingress ports that have frames for transmission of equal QoS class are serviced in round robin. However, ingress ports marked in this mask are preferred over ingress ports not marked.
Truncating	SYS:PORT:EQ_TRUNCATE. Each egress queue can be configured to truncate frames to 92 bytes. Frames shorter than 92 bytes are not changed. This could be the enabled for a specific CPU extraction queue used for learning or a mirror target port where the first segment of the frames is sufficient for further frame processing.
Prevent dequeuing	SYS:PORT:PORT_MODE.DEQUEUE_DIS. Each egress port can disable dequeuing of frames from the egress queues.

4.10.7 Ingress Pause Request Generation

During resource depletion, the shared queue system either discards frames when the ingress port operates in drop mode, or holds back frames when the ingress port operates in flow control mode. The following describes special configuration for the flow control mode.

The shared queue system is enabled for holding back frames during resource depletion in SYS:PORT:PAUSE_CFG.PAUSE_ENA. In addition, this enables the generation of pause requests to the port module based on memory consumptions. The MAC uses the pause request to generate pause frames or create back pressure collisions to halt the link partner. This is done according to the MAC configuration. For more information about MAC configuration, see MAC, page 16.

The shared queue system generates the pause request based on the ingress port's memory consumption and also based on the total memory consumption in the shared queue system. This enables a larger burst capacity for a port operating in flow control while not jeopardizing the non-dropping flow control.

Generating the pause request partially depends on a memory consumption flag, TOT_PAUSE, which is set and cleared under the following conditions:

- The TOT_PAUSE flag is set when the total consumed memory in the shared queue system exceeds the SYS:PORT:PAUSE_TOT_CFG.PAUSE_TOT_START watermark.
- The TOT_PAUSE flag is cleared when the total consumed memory in the shared queue system is below the SYS:PORT:PAUSE_TOT_CFG.PAUSE_TOT_STOP watermark.

The pause request is asserted when both of the following conditions are met:

- The TOT_PAUSE flag is set.
- The ingress port memory consumption exceeds the SYS:PORT:PAUSE_CFG.PAUSE_START watermark.

The pause request is deasserted the following condition is met:

- The ingress port's consumption is below the SYS:PORT:PAUSE_CFG.PAUSE_STOP watermark.

4.10.8 Tail Dropping

The shared queue system implements a tail dropping mechanism where incoming frames are discarded if the port's memory consumption and the total memory consumption exceed certain watermarks. Tail dropping implies that the frame is discarded unconditionally. All ports in the device are subject to tail dropping. It is independent of whether the port is in flow control mode or drop mode.

Tail dropping can be effective under special conditions. For example, tail dropping can prevent an ingress port from consuming all the shared memory when pause frames are lost or the link partner is not responding to pause frames.

The shared queue system initiates tail dropping by discarding the incoming frame if the following two conditions are met at any point while writing the frame data to the memory:

- The ingress port memory consumption exceeds the SYS:PORT:ATOP_CFG.ATOP watermark.
- The total consumed memory in the shared queue system exceeds the SYS:PORT:ATOP_TOT_CFG.ATOP_TOT watermark.

4.10.9 Test Utilities

This section describes some of test utilities that are built into the shared queue system.

Each egress port can enable a frame repeater (SYS::REPEATER), which means that the head-of-line frames in the egress queues are transmitted but not dequeued after transmission. As a result, the scheduler sees the same frames again and again while the repeater function is active.

The SYS:PORT:PORT_MODE.DEQUEUE_DIS disables both transmission and dequeuing from the egress queues when set.

4.10.10 Energy Efficient Ethernet

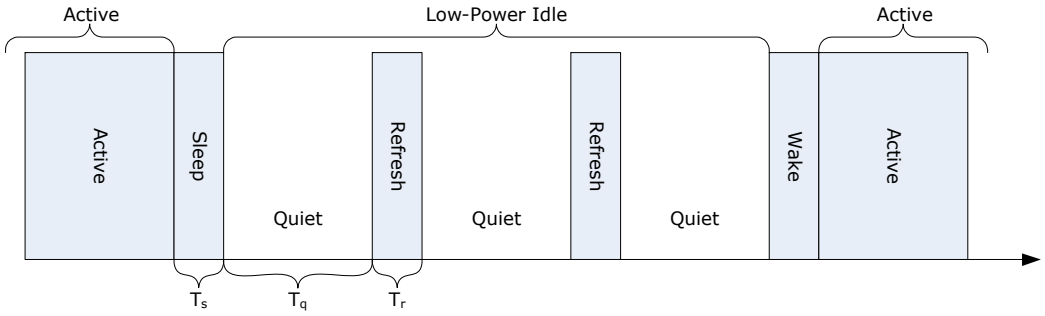
This section provides information about the functions of Energy Efficient Ethernet in the shared queue system. The following tables lists the registers associated with Energy Efficient Ethernet.

Table 85 • **Energy Efficient Ethernet Control Registers**

Register	Description	Replication
SYS:PORT:EEE_CFG	Enabling and configuration of Energy Efficient Ethernet	Per port
SYS:EEE_THRES	Configuration of thresholds (bytes and frames)	None
SYS::SW_STATUS.PORT_LPI	Status bit indicating that egress port is in LPI state	Per port

The shared queue system supports Energy Efficient Ethernet (EEE) as defined by IEEE 802.3az by initiating the Low Power Idle (LPI) mode during periods of low link use. EEE is controlled per port by an egress queue state machine that monitors the queue fillings and ensures correct wake-up and sleep timing. The egress queue state machine is responsible for informing the connected PCS or internal PHY of changes in EEE states (active, sleep, low power idle, and wake up).

Figure 32 • **Low Power Idle Operation**



Energy Efficient Ethernet is enabled per port through SYS:PORT:EEE_CFG.EEE_ENA.

By default, the egress port is transmitting enqueued data. This is the active state. If none of the port's egress queues have enqueued data for the time specified in SYS:PORT:EEE_CFG.EEE_TIMER_HOLDOFF, the egress port instructs the PCS or internal PHY to enter the EEE sleep state.

When data is enqueued in any of the port's egress queues, a timer (SYS:PORT:EEE_CFG.EEE_TIMER_AGE) is started. When one of the following conditions is met, the port enters the wake up state:

- A queue specified as high priority (SYS:PORT:EEE_CFG.EEE_FAST_QUEUES) has any data to transmit.
- The total number of frames in the port's egress queues exceeds SYS::EEE_THRESS.EEE_HIGH_FRAMES.
- The total number of bytes in the port's egress queues exceeds SYS::EEE_THRESS.EEE_HIGH_FRAMES.
- The time specified in SYS:PORT:EEE_CFG.EEE_TIMER_AGE has passed.

PCS and or the internal PHY is instructed to wake up. To ensure that PCS, PHY, and link partner are resynchronized; the egress port holds back transmission of data until the time specified in SYS:PORT:EEE_CFG.EEE_TIMER_WAKEUP has passed. After this time interval, the port resumes transmission of data.

The status bit SYS::SW_STATUS.PORT_LPI is set while the egress port holds back data due to LPI (from the sleep state to the wake up state, both included).

4.11 Scheduler and Shaper

The following table lists the registers associated with the scheduler and egress shaper control.

Table 86 • **Scheduler and Egress Shaper Control Registers**

Register	Description	Replication
SYS::LB_DWRR_FRM_ADJ	Configuration of gap value	Common
SYS::LB_DWRR_CFG	Enabling of gap value adjustment for use in scheduler and shapers	Per port
SYS::SCH_DWRR_CFG	Enabling of DWRR scheduler and configurations of costs	Per port
SYS::SCH_SHAPING_CTRL	Enabling of shaping	Per port
SYS::SCH_LB_CTRL.LB_INIT	Initialization of scheduler and shapers	Common
SYS::LB_THRES	Configuration of shaper threshold	Per shaper
SYS::LB_RATE	Configuration of shaper rate	Per shaper

Each egress port contains a scheduler and a set of egress shapers that control the read out from the egress queuing system to the associated port module.

By default, the scheduler operates in strict priority. The egress queues are searched in the following prioritized order: Queue for QoS class 7 has highest priority followed by 6, 5, 4, 3, 2, 1, and 0.

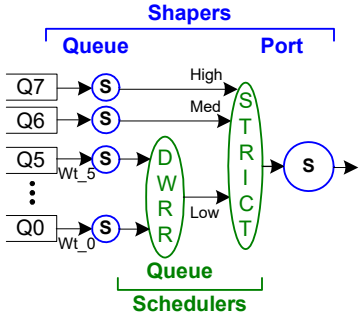
In addition, the scheduler can operate in a mixed mode, where queue 7 and queue 6 are strictly served and queues 5 through 0 operate in a deficit weighted round robin (DWRR) mode. In DWRR mode, QoS class queues 5 through 0 are given a weight and the scheduler selects frames from these queues according to the weights.

Both the egress port and each of the egress queues have an associated leaky-bucket shaper. The egress port shaper is positioned towards the MAC and limits the overall transmission bandwidth on the port. Frames are only scheduled if the port shaper is open. The egress queue shapers control the input to the scheduler for each egress queue. Generally, the scheduler only searches an egress queue if the egress queue's shaper is open.

DWRR is used to guarantee queues a minimum share of the available bandwidth, and shaping is used to configure a maximum rate that cannot be exceeded.

The following illustration shows the egress shapers and scheduler.

Figure 33 • **Egress Scheduler and Shapers**



The overall scheduling algorithm is as follows:

1. If the port shaper is closed, no frames are scheduled. Frames are held back until the port shaper opens.
2. If the port shaper is open, queues with an open queue shaper are candidates for scheduling. Queue 7 has highest priority followed by 6. Queues 5 through 0 may operate in strict mode or in the DWRR mode where each queue is weighted relatively to the other queues. Frames in a queue with a closed queue shaper are held back until the queue shaper opens.
3. If no frames are scheduled during step 2, a second round of scheduling is performed. Queues programmed as work conserving and having a closed queue shaper become candidates for the second round of scheduling.

The following are the configuration options for the shapers and scheduler. Each port is configured independently of other ports. Within a port, the following functionality can be enabled independently:

- DWRR mode (SCH_DWRR_CFG.DWRR_MODE): If set, queues 5 through 0 are scheduled according to the associated weights.
- Port shaping (SCH_SHAPING_CTRL.PORT_SHAPING_ENA): If set, the egress bandwidth is controlled by the port shaper settings.
- Per-queue shaping (SCH_SHAPING_CTRL.PRIO_SHAPING_ENA): If set for a queue, the queue shaper settings control the rate into the scheduler.

4.11.1 Egress Shapers

Each of the egress shapers (port and queues) contains a leaky bucket with the following configurations:

- Maximum rate – Specified in LB_RATE.LB_RATE in steps of 100160 bps. Maximum is 3.282 Gbps.
- Maximum burst size – Specified in LB_THRES.LB_THRES in steps of 4 kilobytes. Maximum is 252 kilobytes.

The frame adjustment value LB_DWRR_FRM_ADJ.FRM_ADJ can be used to program the fixed number of extra bytes to add to each frame transmitted (irrespective of QoS class) in the shaper and DWRR calculations. A value of 20 bytes corresponds to line-rate calculation and accommodates for 12 bytes of inter-frame gap and 8 bytes of preamble. Data-rate based shaping and DWRR calculations are achieved by programming 0 bytes.

Each port can enable the use of the frame adjustment value LB_DWRR_FRM_ADJ.FRM_ADJ through LB_DWRR_CFG.FRM_ADJ_ENA. If enabled on a port, both shapers and scheduler are affected.

By default, while a queue shaper is closed, frames in the queue are not scheduled, even if none of the other queues have frames to transmit. Each queue can enable a work-conserving mode (SCH_SHAPING_CTRL.PRIO_LB_EXS_ENA) in which a second scheduling round is possible. If none of the queues with an open shaper have frames for transmission, work-conserving queues with closed shapers may get a share of the excess bandwidth. The sharing of the excess bandwidth obeys the same configured scheduling rules as for the first round of scheduling.

The queue shapers implement two burst modes. By default, a leaky bucket is continuously assigned new credit according to the configured shaper rate (LB_RATE). This implies that during idle periods, credit is building up, which allows for a burst of data when the queue again has data to transmit. This is not convenient in an Audio/Video Bridging (AVB) environment where this behavior enforces a requirement for larger buffers in end-equipment. To circumvent this, each queue shaper can enable an AVB mode (SCH_SHAPING_CTRLPRIO_LB_AVB_ENA) in which credit is only assigned during periods where the queue shaper has data to transmit and is waiting for another queue to finish a transmission. This AVB mode prevents the accumulation of large amount of credits.

The shapers must be initialized through SCH_LB_CTRL.LB_INIT before use.

4.11.2 Deficit Weighted Round Robin

The DWRR uses a cost-based algorithm compared to a weight-based algorithm. A high cost implies a small share of the bandwidth. When the DWRR is enabled, each of queues 5 through 0 are programmed with a cost (SCH_DWRR_CFG.COST_CFG). A cost is a number between 1 and 32.

The programmable DWRR costs determine the behavior of the DWRR algorithm. The costs result in weights for each queue. The weights are relative to one another, and the resulting share of the egress bandwidth for a particular QoS class is equal to the queue's weight divided by the sum of all the queues' weights.

Costs are easily converted to weights and vice versa given the following two algorithms:

Weights to Costs Given a desired set of weights (W0, W1, W2, W3, W4, W5), the costs can be calculated using the following algorithm:

1. Set the cost of the queue with the smallest weight (Wsmallest) to cost 32.
2. For any other queue Qn with weight Wn, set the corresponding cost Cn to:
   Cn = 32 × Wsmallest/Wn

Costs to Weights Given a set of costs for all queues (C0, C1, C2, C3, C4, C5), the resulting weights can be calculated using the following algorithm:

1. Set the weight of the queue with the highest cost (Chighest) to 1.
2. For any other queue Qn with cost Cn, set the corresponding weight Wn to Wn = Chighest/Cn

Cost and Weight Conversion Examples

The following bandwidth distribution must be implemented:

- Queue 0: 5% (W0 = 5)
- Queue 1: 10% (W1 = 10)

- Queue 2: 15% (W2 = 15)
- Queue 3: 20% (W3 = 20)
- Queue 4: 20% (W4 = 20)
- Queue 5: 30% (W5 = 30)

Given the algorithm to get from weights to costs, the following costs are calculated:

- C0 = 32 (Smallest weight)
- C1 = 32*5/10 = 16
- C2 = 32*5/15 = 10.67 (rounded up to 11)
- C3 = 32*5/20 = 8
- C4 = 32*5/20 = 8
- C5 = 32*5/30 = 5.33 (rounded down to 5)

Due to the rounding off, these costs result in the following bandwidth distribution, which is slightly off compared to the desired distribution:

- Queue 0: 4.92%
- Queue 1: 9.85%
- Queue 2: 14.32%
- Queue 3: 19.70%
- Queue 4: 19.70%
- Queue 5: 31.51%

4.11.3 Shaping and DWRR Scheduling Examples

This section provides examples and additional information about the use of the egress shapers and scheduler.

Mixing DWRR and Shaping Example

- Port is shaped down to 500 Mbps.
- Queues 7 and 6 are strict while queue 5 through 0 are weighted.
- Queue 7 is shaped to 100 Mbps.
- Queue 6 is shaped to 50 Mbps.
- The following traffic distribution is desired for queue 5 through 0:
  Q0: 5%, Q1: 10%, Q2: 15%, Q3: 20%, Q4: 20%, Q5: 30%
- Each queue receives 125 Mbps of incoming traffic.

The following table lists the DWRR configuration and the resulting egress bandwidth for the various queues.

Table 87 • **Example of Mixing DWRR and Shaping**

Queue	Distribution of Weighted Traffic	Configuration Costs/Weights (C*n*/W*n*)	Result: Egress Bandwidth
Q0	5%	32/1	1/(1+2+2.9+4+4+6.4) × (500 – Mbps – 150 Mbps) = 17.2 Mbps
Q1	10%	16/2	2/(1+2+2.9+4+4+6.4) × (500 – Mbps – 150 Mbps) = 34.5 Mbps
Q2	15%	11/2.9	2.9/(1+2+2.9+4+4+6.4) × (500 – Mbps – 50 Mbps) = 50.1 Mbps
Q3	20%	8/4	4/(1+2+2.9+4+4+6.4) × (500 – Mbps – 150 Mbps) = 68.9 Mbps
Q4	20%	8/4	4/(1+2+2.9+4+4+6.4) × (500 – Mbps – 150 Mbps) = 68.9 Mbps
Q5	30%	5/6.4	6.4/(1+2+2.9+4+4+6.4) × (500 – Mbps – 150 Mbps) = 110.3 Mbps
Q6			50 = Mbps
Q7			100 = Mbps
Sum:	100%		**500** = **Mbps**

Strict and Work-Conserving Shaping Example

- Port is shaped down to 500 Mbps.
- All queues are strict.

- All queues are shaped to 50 Mbps.
- Queues 6 and 7 are work-conserving (allowed to use excess bandwidth).
- All queues receive 125 Mbps of traffic each.

The following table lists the resulting egress bandwidth for the various queues.

Table 88 • **Example of Strict and Work-Conserving Shaping**

Queue	Result: Egress Bandwidth
Q0	50 Mbps
Q1	50 Mbps
Q2	50 Mbps
Q3	50 Mbps
Q4	50 Mbps
Q5	50 Mbps
Q6	75 Mbps (Gets the last 25 Mbps of the 100 Mbps in excess not used by queue 7)
Q7	125 Mbps (Gets 75 Mbps of the 100 Mbps in excess limited only by the received rate)
Sum:	**500 Mbps**

4.12 Rewriter

The switch core includes a rewriter common for all ports that determines how the egress frame is edited before transmitted. The rewriter performs the following editing:

- VLAN editing; tagging of frames and remapping of PCP and DEI.
- DSCP remarking; rewriting the DSCP value in IPv4 and IPv6 frames based on classified DSCP value.
- FCS updating.
- Precision Time Protocol timestamp updating.
- CPU extraction header insertion.

Each port module including the CPU port module has its own set of configuration in the rewriter. Each frame is handled by the rewriter one time per destination port.

4.12.1 VLAN Editing

The following table lists the registers associated with VLAN editing.

Table 89 • **VLAN Editing Registers**

Register	Description	Replication
PORT_VLAN_CFG	Port VLAN for egress port. Used for untagged set.	Per port
TAG_CFG	Tagging rules for port tag	Per port
PORT_CFG.ESO_ENA	Enable lookups in ES0.	Per port
PCP_DEI_QOS_MAP_CFG	Mapping table. Maps DP level and QoS class to new PCP and DEI values.	Per port per QoS per DP

The rewriter initially pops the number of VLAN tags specified by the VLAN_POP_CNT parameter received with the frame from the classifier or VCAP IS1. Up to two VLAN tags can be popped. The rewriter itself does not influence the number of VLAN tags being popped.

For more information about each frame and destination port VCAP ES0 that is looked up using the ES0 key, see VCAP ES0, page 74. The action from an ES0 hit is used in the following to determine the frame's VLAN editing.

After popping the VLAN tags, the rewriter decides whether to push zero, one, or two new VLAN tags to the outgoing frame according to the port's tagging configuration in register TAG_CFG and the action from a potential VCAP ES0 hit. When adding two tags, the outer tag is based on configuration in TAG_CFG while the inner tag is based on the ES0 action. When adding zero or one tag, it can either be based on TAG_CFG or ES0. Tags based on TAG_CFG settings are referred to as port tags while tags based on ES0 actions are referred to as ES0 tags.

The following table lists the possible tagging combinations:

Table 90 • **Tagging Combinations**

ES0_ACTION	TAG_CFG.TAG_CFG	Tagging action
No ES0 hit	0	No tagging.
No ES0 hit	1	Tag all frames according to the port's tagging configuration. Do not tag if VID=0 or VID=PORT_VLAN.PORT_VID.
No ES0 hit	2	Tag all frames according to the port's tagging configuration. Do not tag if VID=0.
No ES0 hit	3	Tag all frames according to the port's tagging configuration.
TAG_ES0=0 and TAG_TPID_SEL=0	0	No tagging.
TAG_ES0=0 and TAG_TPID_SEL=0	1	Tag all frames according to the port's tagging configuration. Do not tag if VID=0 or VID=PORT_VLAN.PORT_VID.
TAG_ES0=0 and TAG_TPID_SEL=0	2	Tag all frames according to the port's tagging configuration. Do not tag if VID=0.
TAG_ES0=0 and TAG_TPID_SEL=0	3	Tag all frames with port tag.
TAG_ES0=0 and TAG_TPID_SEL=1	Don't care	No tagging. Overrules port settings.
TAG_ES0=1	Don't care	Tag with ES0 tag only. Do not tag according to the port's tagging configuration.
TAG_ES0=2	0	Tag with ES0 tag only.
TAG_ES0=2	1	Tag with ES0 tag as inner tag and tag according to the port's tagging configuration as outer tag. Do not push port tag if VID=0 or VID=PORT_VLAN.PORT_VID.
TAG_ES0=2	2	Tag with ES0 tag as inner tag and tag according to the port's tagging configuration as outer tag. Do not push port tag if VID=0.
TAG_ES0=2	3	Tag with ES0 tag as inner tag and tag according to the port's tagging configuration as outer tag.
TAG_ES0=3	Don't care	Tag with ES0 tag as inner tag and according to the port's tagging configuration as outer tag overruling tagging rule on port.

When adding a VLAN tag, the contents of the tag header, including the TPID, is highly programmable. The starting point is the classified tag header coming from the analyzer containing a PCP, DEI, VID and tag type.

For each of the fields in the resulting tag, it is programmable how the value is determined. For the port tag, the following options are available:

Port tag: PCP and DEI

- Use the classified values.
- For frames generating an ES0 hit, use ES0_ACTION.PCP and ES0_ACTION.DEI; otherwise use classified values.
- Use the egress port's port VLAN (PORT_VLAN.PORT_PCP, PORT_VLAN.PORT_DEI).
- Map the DP level and QoS class to a new set of PCP and DEI using the per-port table PCP_DEI_QOS_MAP_CFG.
- Set the DEI to the DP level, independently of the preceding PCP and DEI configurations.

Port Tag: VID

- Use the classified VID.
- For frames generating an ES0 hit, use ES0_ACTION.VID_A_VAL; otherwise use classified VID.

Port Tag: TPID

- Use Ethernet type 0x8100 (C-tag)
- Use Ethernet type 0x88A8 (S-tag)
- Use custom Ethernet type programmed in PORT_VLAN.PORT_TPID.
- Use custom Ethernet type programmed in PORT_VLAN.PORT_TPID unless the incoming tag was a C-tag.

Similar options for the ES0 tag are available:

ES0 tag: PCP and DEI

- Use the classified values.
- Use ES0_action.PCP and ES0_ACTION.DEI
- Use the egress port's port VLAN (PORT_VLAN.PORT_PCP, PORT_VLAN.PORT_DEI).
- Map the DP level and QoS class to a new set of PCP and DEI using the per-port table PCP_DEI_QOS_MAP_CFG.

ES0 tag: VID

- Use the classified VID incremented with ES0_ACTION.VID_B_VAL.
- Use ES0_ACTION.VID_A_VAL.
- Use ES0_ACTION.VID_B_VAL.
- Use egress port's port VLAN (PORT_VLAN.PORT_VID).

ES0 tag: TPID

- Use Ethernet type 0x8100 (C-tag)
- Use Ethernet type 0x88A8 (S-tag)
- Use custom Ethernet type programmed in PORT_VLAN.PORT_TPID.
- Use custom Ethernet type programmed in PORT_VLAN.PORT_TPID unless the incoming tag was a C-tag.

4.12.2 DSCP Remarking

The following table lists the registers associated with DSCP remarking.

Table 91 • **DSCP Remarking Registers**

Register	Description	Replication
DSCP_CFG	Selects how the DSCP remarking is done	Per port
DSCP_REMAP_CFG	Mapping table from DSCP to DSCP for DP level = 0.	None
DSCP_REMAP_DP1_CFG	Mapping table from DSCP to DSCP for DP level = 1.	None

The rewriter can remark the DSCP value in IPv4 and IPv6 frames, that is, write a new DSCP value to the DSCP field in the frame.

If a port is enabled for DSCP remarking (DSCP_CFG.DSCP_REWR_CFG), the new DSCP value is derived by using the classified DSCP value from the analyzer (the basic classification or the VCAP IS1) in the ingress port. This DSCP value can be mapped before replacing the existing value in the frame. The following options are available:

- No DSCP remarking - Leave the DSCP value in the frame untouched.

- Update the DSCP value in the frame with the value received from the analyzer
- Update the DSCP value in the frame with the value received from the analyzer remapped through DSCP_REMAP_CFG. This is done independently of the value of the drop precedence level.
- Update the DSCP value in the frame with the value received from the analyzer remapped through DSCP_REMAP_CFG or DSCP_REMAP_DP1_CFG dependent on the drop precedence level. This enables one mapping for green frames and another for yellow frames so that the resulting DSCP value can reflect the color of the frame.

Additionally, the IP checksum is updated for IPv4 frames. Note that the IPv6 header does not contain a checksum. As a result, checksum updating does not apply for IPv6 frames.

DSCP remarking is not possible for frames where PTP timestamps are also generated and is automatically disabled.

4.12.3 FCS Updating

The following table lists the registers associated with FCS updating.

Table 92 • **FCS Updating Registers**

Register	Description	Replication
PORT_CFG.FCS_UPDATE_NONCPU_CFG	FCS update configuration for non-CPU injected frames.	Per port
PORT_CFG.FCS_UPDATE_CPU_ENA	FCS update configuration for CPU injected frames.	Per port

The rewriter updates a frame's FCS when required or instructed to do so. Different handling is available for frames injected by the CPU and for all other frames.

For non-CPU injected frames, the following update options are available:

- Never update the FCS.
- Conditional update - Update the FCS if the frame was modified due to PTP timestamping, VLAN tagging or DSCP remarking.
- Always update the FCS.

Additionally, the rewriter can update the FCS for all frames injected from the CPU through the CPU injection queues in the CPU port module:

- Never update the FCS.
- Always update the FCS.

4.12.4 CPU Extraction Header Insertion

The following table lists the registers associated with CPU extraction header insertion.

Table 93 • **CPU Extraction Header Insertion Registers**

Register	Description	Replication
PORT_CFG.IFH_INSERT_ENA	Enables insertion of the CPU extraction header.	Per port
PORT_CFG.IFH_INSERT_MODE	Configures the position of the CPU extraction header.	Per port

Any port in the switch core can request the rewriter to insert a CPU extraction header in the frame before transmission. For more information about the contents of the CPU extraction header, see CPU Extraction and Injection, page 234.

The CPU extraction header can be placed before the DMAC or right after the SMAC. When inserting the header, the frame is extended with eight bytes. Note that the FCS is only updated when the header is inserted after the SMAC.

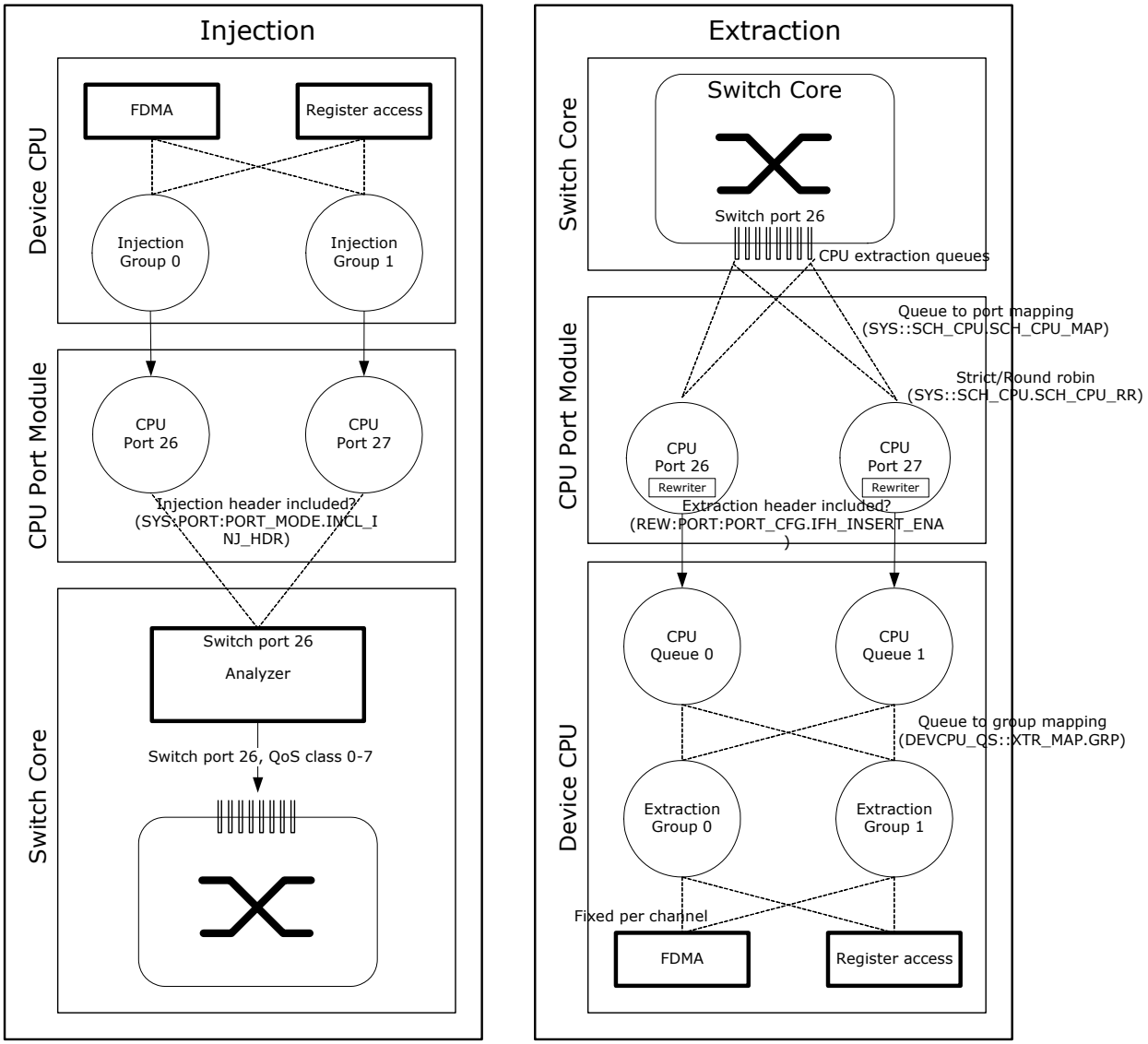
The insertion of the CPU extraction header is the last editing in the rewriter. This implies that any VLAN tags in the frame will appear after the extraction header.

4.13 CPU Port Module

The CPU port module connects the switch core to the CPU system so that frames can be injected from or extracted to the CPU. It is also possible to use a regular front port as a CPU port. This is known as a Network Processor Interface (NPI).

The following illustration shows how the switch core interfaces to the CPU system through the CPU port module for injection and extraction of frames.

Figure 34 • **CPU Injection And Extraction**



4.13.1 Frame Extraction

The following table lists the registers associated with frame extraction.

Table 94 • **Frame Extraction Registers**

Register	Description	Replication
SYS::SCH_CPU.SCH_CPU_MAP	Configuration of mapping of extraction queues to CPU ports	Per CPU port (ports 26 and 27)
SYS::SCH_CPU.SCH_CPU_RR	Configuration of CPU scheduler	Per CPU port (ports 26 and 27)
REW:PORT:PORT_CFG.IFG_INSERT_ENA	Enables insertion of extraction header	Per CPU port (port 26 and 27)

In the switch core, extracted frames are forwarded to one of the eight CPU extraction queues. Each of these queues is mapped to one of two CPU ports (port 26 and port 27) through SYS::SCH_CPU.SCH_CPU_MAP. For each CPU port, there is a scheduler working either in strict mode or round robin, which selects between the CPU extraction queues mapped to the same CPU port (SYS::SCH_CPU.SCH_CPU_RR). In strict mode, higher queue numbers are preferred over smaller queue numbers. In round robin, all queue are serviced one after another.

The two CPU ports contain the same rewriter as regular front ports. The rewriter modifies the frames before sending them to the CPU. In particular, the rewriter inserts an extraction header (REW::PORT:PORT_CFG.IFH_INSERT_ENA), which contains relevant side band information about the frame such as the frame's classification result (VLAN tag information, DSCP, QoS class) and the reason for sending the frame to the CPU. For more information about the rewriter, see Rewriter, page 115.

The device CPU contains the functionality for reading out the frames. This can be done through the frame DMA or regular register access.

The following table lists the contents of the CPU extraction header.

Table 95 • **CPU Extraction Header**

Field	Bit	Width	Description
SIGNATURE	56	8	Must be 0xFF.
SRC_PORT	51	5	The port number where the frame was received (0-26).
DSCP	45	6	The frame's classified DSCP value. If the frame is hardware timestamped (frame has hit a rule in IS2 with PTP_ENA), the DSCP field contains the timestamp identifier provided by the analyzer, see **Two-Step Timestamping,** page 129.
ACL_IDX	37	8	If ACL_HIT is set, this value is the entry number of the rule hit in IS2. If both IS2 lookups hit a rule which copy the frame to the CPU, the second lookup's entry number is used.
SFLOW_ID	32	5	sFlow sampling ID. 0-26: Frame was SFlow sampled by a Tx sampler on port given by SFLOW_ID. 27: Frame was SFlow sampled by an RX sampler on port given by SRC_PORT. 28-30: Reserved. 31: Frame was not SFlow sampled.
ACL_HIT	31	1	Set if frame has hit a rule in IS2, which copies the frame to the CPU (IS2 actions CPU_COPY_ENA or HIT_ME_ONCE). ACL_IDX contains the IS2 entry number.
DP	30	1	The frame's drop precedence (DP) level after policing.

Table 95 • **CPU Extraction Header *(continued)***

Field	Bit	Width	Description
LRN_FLAGS	28	2	The source MAC address learning action triggered by the frame. 0: No learning. 1: Learning of a new entry. 2: Updating of an already learned unlocked entry. 3: Updating of an already learned locked entry.
CPU_QUEUE	20	8	CPU extraction queue mask (one bit per CPU extraction queue). Each bit set implies the frame was subjected to CPU forwarding to the specific queue.
QOS_CLASS	17	3	The frame's classified QoS class.
TAG_TYPE	16	1	The tag information's associated Tag Protocol Identifier (TPID). The definitions are: 0: C-tag: EtherType = 0x8100. 1: S-tag: EtherType = 0x88A8 or custom value.
PCP	13	3	The frame's classified PCP.
DEI	12	1	The frame's classified DEI.
VID	0	12	The frame's classified VID.

4.13.2 Frame Injection

The following table lists the registers associated with frame injection.

Table 96 • **Frame Injection Registers**

Register	Description	Replication
SYS:PORT:PORT_MODE.INCL_INJ_HDR	Enable parsing of injection header	Per CPU port (ports 26 and 27)
SYS:PORT:EQ_PREFER_SRC	Enable preferred arbitration of the CPU port (port 26) over front ports	CPU port (port 26 only)

The CPU injects frames through the two CPU injection groups independent of each other. The injection groups connect to the two CPU ports (port 26 and port 27) in the CPU port module. In CPU port module, each of the two CPU ports have dedicated access to the switch core. Inside the switch core, all CPU injected frames are seen as coming from CPU port (port 26). This implies that both CPU injection groups consume memory resources from the shared queue system for port 26 and that analyzer configuration for port 26 are applied to all frames.

In the switch core, the CPU port can be preferred over other ingress ports when transferring frames to egress queues by enabling precedence of the CPU port (SYS::EQ_PREFER_SRC).

The first eight bytes of a frame written to a CPU injection group is an injection header containing relevant side band information about how the frame must be processed by the switch core. The CPU ports must be enabled to expect the CPU injection header (SYS:PORT:INCL_INJ_HDR).

On a per-frame basis, the CPU controls whether frames injected through the CPU port module are processed by the analyzer. If the frame is processed by the analyzer, it is sent through the processing steps to calculate the destination ports for the frame. If analyzer processing is not selected, the CPU can specify the destination port set and related information to fully control the forwarding of the frame. For more information about the analyzer's processing steps, see Forwarding Engine, page 90.

The contents of the CPU injection header is listed in the following table.

Table 97 • **CPU Injection Header**

Field	Bit	Width	Description
BYPASS	63	1	When this bit is set, the analyzer processing is skipped for this frame. The destination set is specified in DEST and CPU_QUEUE. Forwarding uses the QOS_CLASS, and the rewriter uses the tag information (POP_CNT, TAG_TYPE, PCP, DEI, VID) for rewriting actions. When this bit is cleared, the analyzer determines the destination set, QoS class, and VLAN classification for the frame through normal frame processing including lookups in the MAC table and VLAN table.
PTP	61	2	The frame's Precision Time Protocol action. The definitions are: 0: No PTP action. 1: One-step; update the residence time in the PTP protocol. 2: Two-step; register the residence time in the PTP timestamp queue using the PTP_ID as identifier. 3: Both one-step and two-step. Used when BYPASS = 1.
PTP_ID	59	2	The PTP identifier used for two-step PTP actions. The CPU can only use from IDs 0 through 3. Used when BYPASS = 1.
DEST	32	27	This is the destination set for the frame. DEST[26] is the CPU. Used when BYPASS = 1.
RESERVED	30	2	Unused.
POP_CNT	28	2	Number of VLAN tags that must be popped in the rewriter before adding new tags. Used when BYPASS = 1. 0: No tags must be popped. 1: One tag must be popped. 2: Two tags must be popped. 3: Disable rewriting of VLAN tags and DSCP value. The FCS is still updated.
CPU_QUEUE	20	8	CPU extraction queue mask (one bit per CPU extraction queue). Each bit set implies the frame must be forwarded by the CPU to the specific queue. Used when BYPASS = 1 and DEST[26] = 1.
QOS_CLASS	17	3	The frame's classified QoS class. Used when BYPASS = 1.
TAG_TYPE	16	1	The tag information's associated Tag Protocol Identifier (TPID). Used when BYPASS = 1. 0: C-tag: EtherType = 0x8100. 1: S-tag: EtherType = 0x88A8 or custom value.
PCP	13	3	The frame's classified PCP. Used when BYPASS = 1.
DEI	12	1	The frame's classified DEI. Used when BYPASS = 1.
VID	0	12	The frame's classified VID. Used when BYPASS = 1.

4.13.3 Network Processor Interface (NPI)

The following table lists the registers associated with the network processor interface.

Table 98 • **Network Processor Interface Registers**

Register	Description	Replication
SYS::EXT_CPU_CFG	Configuration of the NPI port number and configuration of which CPU extraction queues are redirected to the NPI.	None
REW:PORT:PORT_CFG.IFG_INSERT_ENA	Enables insertion of extraction header.	Per port
SYS:PORT:PORT_MODE.INCL_INJ_HDR	Configuration of NPI ingress mode.	Per port

Any front port can be configured as a network processor interface through which frames can be injected from and extracted to an external CPU. Only one port can be an NPI at the same time. SYS::EXT_CPU_CFG.EXT_CPU_PORT holds the port number of the NPI.

A dual CPU system is possible where both the internal and the external CPU are active at the same time. Through SYS::EXT_CPU_CFG.EXT_CPUQ_MSK, it is configurable to which of the eight CPU extraction queues are directed to the internal CPU and which are directed to external CPU. A frame can be extracted to both the internal CPU and the external CPU if the frame is extracted for multiple reasons.

A frames being extracted to the external CPU can have the CPU extraction header inserted in front of the frame (REW:PORT:PORT_CFG.IFG_INSERT_ENA), and a frame being injected to the switch core can have the CPU injection header inserted in front of the frame (SYS:PORT:PORT_MODE.INCL_INJ_HDR).

Through the BYPASS field in the CPU injection header, the external CPU can control forwarding of injected frames by either letting the frame analyze and forward accordingly or directly specifying the destination set

4.14 Layer-1 Timing

The following table lists the registers associated with Layer-1 timing.

Table 99 • **Layer-1 Timing Configuration Registers**

Register	Description	Replication
HSIO::SYNC_ETH_CFG	Configuration of recovered clock output pins	None
HSIO::SERDES1G_COMMON_CFG	Recovered clock selection	Per SERDES1G port
HSIO::SERDES6G_COMMON_CFG	Recovered clock selection	Per SERDES6G port

Two timing sources can be derived from the incoming data stream, on any combination of two ports. This is controlled by registers SERDES1G_COMMON_CFG.RECO_SEL_A, SERDES1G_COMMON_CFG.RECO_SEL_B, SERDES6G_COMMON_CFG.RECO_SEL_A, and SERDES6G_COMMON_CFG.RECO_SEL_B. These timing sources are provided to external timing circuitry on output pins RCVRD_CLK[1:0] for redundant timing implementations as configured by HSIO::SYNC_ETH_CFG. If timing is compromised on either of the two sources, the appropriate clock output can be squelched to assist with fast timing switchover in the clock synchronization circuitry. Squelching on a SERDES 1G port is controlled by SERDES1G_COMMON_CFG.SE_AUTO_SQUELCH_A_ENA and SERDES1G_COMMON_CFG.SE_AUTO_SQUELCH_B_ENA. Similar registers exists for SERDES6G ports.

The clock frequency provided on the reference clock outputs can be divided down through registers HSIO::SYNC_ETH_CFG.SEL_RECO_CLK_A and HSIO::SYNC_ETH_CFG.SEL_RECO_CLK_B.

The following table lists supported output clock frequencies.

Table 100 • **Recovered Clock Output Frequencies**

Sourcing Macro/Data Rate	Recovered Clock Output Frequency
SERDES1G port Data rates: 10/100/1000 Mbps	125 MHz, 31.25 MHz, or 25 MHz
SERDES6G port Data rates: 10/100/1000/2500 Mbps	125 MHz, 31.25 MHz, or 25 MHz

With this functionality Synchronous Ethernet as defined by ITU-T G.8261 can be supported. For more information, see Synchronous Ethernet Operation, page 253.

4.15 Hardware Timestamping

Hardware timestamping provides nanosecond-accurate frame arrival and departure time stamps, which are used to obtain high precision timing synchronization and timing distribution, as well as significantly better accuracy in performance monitoring measurements than what is obtained from pure software implementations.

For more information about hardware timestamping as part of an IEEE 1588-2008 implementation, see IEEE 1588 Operation, page 254.

All frames are Rx timestamped on arrival with a 32-bit timestamp value using a hardware timer (timestamper) implemented in the Media Access Control (MAC) block. The Rx timestamper provides high timestamp accuracy relative to actual arrival time of the first byte of the frame from the PHY device. Within the VCAP IS2, it is decided if the frame and associated Rx timestamp must be redirected or copied to CPU for processing. The frame is forwarded as normal otherwise.

The VCAP IS2 also decides if a Tx timestamp must be triggered for a frame. Given the Rx and Tx timestamps, the frame's residence time inside the switch is calculated. The residence time can be stored in a timestamp queue for the CPU to access (two-step timestamping) or the residence time can be used to update the residence time field inside Precision Time Protocol frames (one-step timestamping).

The Tx timestamper is located at the transmit side of the MAC block as close to the PHY device as possible and provides high accuracy of timestamp relative to when the first byte of the frame is actually transmitted to the PHY.

The device also implements a time of day counter with nanosecond accuracy. The time of day counter is derived from a one-second timer. The one-second timer generates a pulse per second and is either is derived from an adjusted system clock or from external timing equipment.

4.15.1 Timestamp Classification

Frames requiring Rx or Tx timestamping are identified by VCAP IS2. The IS2 action that triggers timestamping is PTP_ENA, where PTP_ENA[0] enables one-step timestamping, and PTP_ENA[1] enables two-step timestamping.

IS2 can be configured to identify the following frame formats from IEEE 1588-2008:

- Transport of PTP over User Datagram Protocol over Internet Protocol Version 4
- Transport of PTP over User Datagram Protocol over Internet Protocol Version 6
- Transport of PTP over IEEE 802.3/Ethernet

Hardware timestamping can also be used as part of performance monitoring such as those functions defined by standard ITU-T Y.1731. Two examples are delay measurements and delay variation measurements. The frame formats defined by this standard are supported.

For more information about the frame encapsulations and PTP protocol fields supported by the Carrier Ethernet devices, see VCAP IS2, page 66.

4.15.2 One-Second Timer

The one-second timer generates one synchronization pulse per second, which is used for the time of day counter. The one-second timer and the time of day counter are located in the CPU System block.

The one-second timer can provide a synchronization pulse output or a reference clock output derived from the one-second synchronization pulse. The one-second timer synchronization pulse can also be controlled from an external pin.

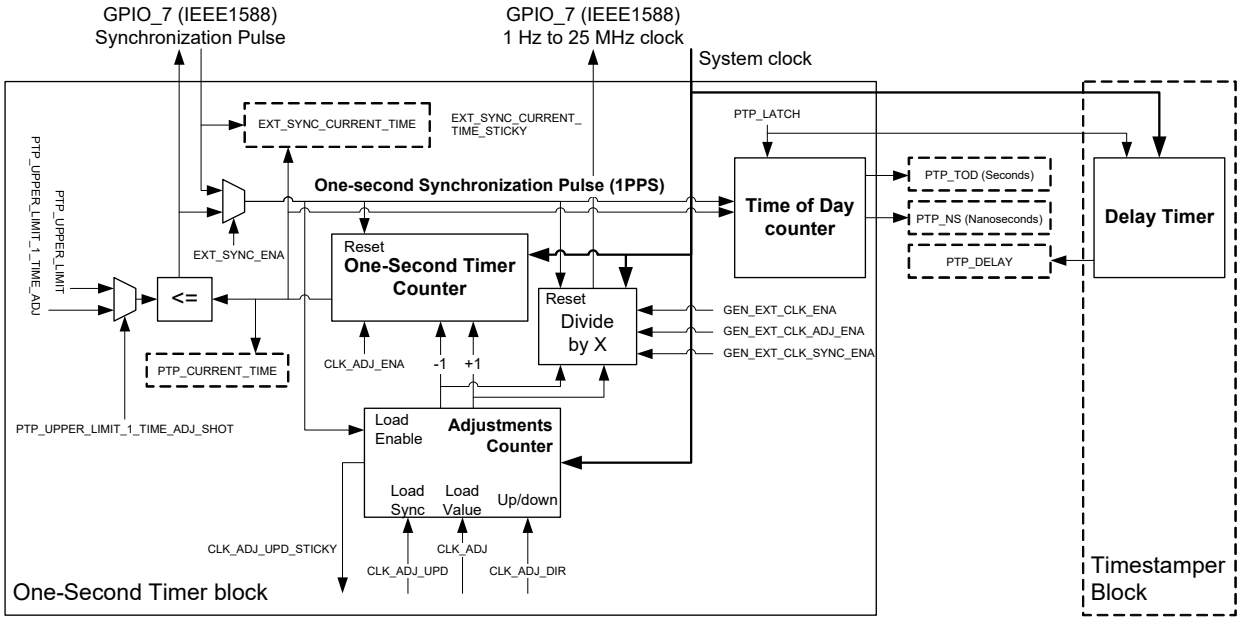
The registers listed in the following table control and monitor the one-second timer.

Table 101 • **One-Second Timer Registers**

Target:Register_group:Register.field	Description	Replication
DEVCPU_GCB::PTP_MISC_CFG	GPIO configuration of hardware timer.	1
DEVCPU_GCB::PTP_UPPER_LIMIT_CFG	One-second counter configuration.	1
DEVCPU_GCB::PTP_UPPER_LIMIT_1_TIME_ADJ_CFG	One-second counter configuration.	1
DEVCPU_GCB::GEN_EXT_CLK_HIGH_PERIOD_CFG	External clock output configuration.	1
DEVCPU_GCB::GEN_EXT_CLK_LOW_PERIOD_CFG	External clock output configuration.	1
DEVCPU_GCB::GEN_EXT_CLK_CFG	External clock output configuration.	1
DEVCPU_GCB::CLK_ADJ_CFG	One-second counter adjustment configuration.	1
DEVCPU_GCB::PTP_SYNC_INTR_ENA_CFG	Interrupts control.	1
DEVCPU_GCB::PTP_CURRENT_TIME_STAT	One-second counter statistics. Current count value.	1
DEVCPU_GCB::EXT_SYNC_CURRENT_TIME_STAT	One-second counter statistics. One-second counter value at the last external synchronization pulse input.	1
DEVCPU_GCB::PTP_EVT_STAT	One-second timer event statistics.	1

The one-second timer block diagram is shown in the following illustration.

Figure 35 • **One-Second Timer Block Diagram**



DEVCPU_GCB::PTP_MISC_CFG.PTP_ENA enables the one-second timer and must be set for one-second timer synchronization pulse generation.

By default, the one-second timer synchronization pulse is generated internally and with a frequency of one pulse per second (1 PPS) derived from the system clock. Other one-second timer synchronization pulse frequencies are obtained using register DEVCPU_GCB::PTP_UPPER_LIMIT_CFG. Every time a one-second timer synchronization pulse is generated, a sticky bit is set (DEVCPU_GCB::PTP_EVT_STAT.SYNC_STAT) and an interrupt is generated if DEVCPU_GCB::PTP_SYNC_INTR_ENA_CFG.SYNC_STAT_ENA is enabled.

4.15.2.1 One-Second Timer Counter Adjustments

If a one time correction to the one-second timer synchronization pulse is required, the correction time value must be written into register DEVCPU_GCB::PTP_UPPER_LIMIT_1_TIME_ADJ_CFG.PTP_UPPER_LIMIT_1_TIME_ADJ and one shot is enabled in register DEVCPU_GCB::PTP_UPPER_LIMIT_1_TIME_ADJ_CFG.PTP_UPPER_LIMIT_1_TIME_ADJ_SHOT.

The one-second timer can also be controlled by issuing counter corrections to the one-second timer counter. One-second timer counter corrections are enabled in register DEVCPU_GCB::CLK_ADJ_CFG.CLK_ADJ_ENA.

Corrections to the one-second timer counter is controlled by the adjustments counter. The adjustments counter issues ±1 corrections to the one-second timer counter. The time period between one-second timer corrections is determined by the load value of the adjustments counter. Time periods between corrections ranges from nanoseconds to one second.

The adjustments counter operates as follows:

- When the counter value of the adjustments counter equals the load value (DEVCPU_GCB::CLK_ADJ_CFG.CLK_ADJ), a one tick correction is generated.
- Up or down corrections are determined by DEVCPU_GCB::CLK_ADJ_CFG.CLK_ADJ_DIR.
- The DEVCPU_GCB::CLK_ADJ_CFG.CLK_ADJ_UPD register controls whether a load value change takes immediate effect or whether it is synchronized to the next one-second timer synchronization pulse.
- When the load value change occurs, a sticky bit is set (DEVCPU_GCB::PTP_EVT_STAT.CLK_ADJ_UPD_STICKY). This sticky does not gate future updates to the load value and is informative only. The adjustment counter is reset by loading all zeros.

4.15.2.2 External Synchronization Pulse Input

A synchronization pulse can be provided as an input to the device. This is controlled through register DEVCPU_GCB::PTP_MISC_CFG. When this input is used to control the one-second timer synchronization pulse, the register DEVCPU_GCB::PTP_MISC_CFG.EXT_SYNC_ENA must be set. Also, if set the one-second timer counter is reset by the external synchronization pulse.

Every time an external synchronization pulse arrives, the one-second timer counter value is captured in register DEVCPU_GCB::EXT_SYNC_CURRENT_TIME_STAT and DEVCPU_GCB::PTP_EVT_STAT.EXT_SYNC_CURRENT_TIME_STICKY is set. If DEVCPU_GCB::PTP_SYNC_INTR_ENA_CFG.EXT_SYNC_CURRENT_TIME_ENA is set, an interrupt is generated when an external synchronization pulse is received.

Because EXT_SYNC_CURRENT_TIME_STAT is updated, even when EXT_SYNC_ENA is cleared, a software function can be implemented that monitors the difference between internally controlled one-second clock and an external timing reference. That is, differences in counter values provided in register EXT_SYNC_CURRENT_TIME_STAT is an indication of the frequency difference between the one-second clock frequency and the clock frequency of the external synchronization pulse input.

4.15.2.3 One-Second Timer Synchronization Pulse Output

The one-second timer synchronization pulse can be provided as an output to the device. This is controlled through register DEVCPU_GCB::PTP_MISC_CFG. The output pulse goes active one system clock cycle (4 ns) after the internal one-second timer rolls over.

4.15.2.4 Divide by X External Clock

A “divide by *X*” version of the one-second timer frequency can be provided as an output to the device. External clock frequencies up to 25 MHz are supported. The default clock frequency is 10 kHz.

The frequency and duty cycle of the external clock is controlled by registers DEVCPU_GCB::GEN_EXT_CLK_HIGH_PERIOD_CFG and DEVCPU_GCB::GEN_EXT_CLK_LOW_PERIOD_CFG. The “divide by *X*” counter implements a high period and a low period of the external clock, based on these register values. The clock period of the external clock is calculated as:
(GEN_EXT_CLK_HIGH_PERIOD_CFG+GEN_EXT_CLK_LOW_PERIOD_CFG) × 4 ns

The duty cycle of the external clock is only 50%/50% if GEN_EXT_CLK_HIGH_PERIOD_CFG and GEN_EXT_CLK_LOW_PERIOD_CFG are configured to the same value.

Register DEVCPU_GCB::GEN_EXT_CLK_CFG.GEN_EXT_CLK_SYNC_ENA controls if the “divide by *X*” counter controlling the external clock is synchronized to the one-second timer synchronization pulse.

Register DEVCPU_GCB::GEN_EXT_CLK_CFG.GEN_EXT_CLK_ADJ_ENA controls whether the “divide by *X*” counter controlling the external clock is corrected by counter adjustments made to the one-second timer counter. If this register is enabled, the two counters are locked to each other. If this register is disabled, the counter is free-running of the system clock.

Divide by *X* counter adjustments show up directly on the external clock (unfiltered).

4.15.3 Delay Timer

This section explains the functions of the hardware timestamping module. The following table lists the registers associated with the delay timer.

Table 102 • **Hardware Timestamping Registers**

Register	Description	Replication
SYS:PORT:PTP_CFG	Enabling of Tx handling. Rx and Tx timestamp adjustments.	Per port
SYS:PORT:PTP_DELAY	Timestamp value in timestamp queue.	Per port
SYS:PORT:PTP_NXT	Advancing the timestamp queue.	Per port
SYS:PORT:PTP_STATUS	Timestamp queue status and entry data.	Per port

Table 102 • **Hardware Timestamping Registers *(continued)***

Register	Description	Replication
ANA::PTP_ID_HIGH	Release of timestamp identifiers, values 32 through 63.	None
ANA::PTP_ID_LOW	Release of timestamp identifiers, values 0 through 31.	None

Each port module contains a hardware timestamping module that measures arrival and departure times based on a free-running delay timer. The delay timer is derived from the system clock and is independent of the one-second timer. The two timing domains can be correlated using the time of day latching. For more information, see Time of Day Counter, page 129.

4.15.3.1 Rx and Tx Timestamps

When the MAC block determines that a new frame has arrived, the Rx timestamper generates a timestamp, which follows the frame all the way to the Tx side. At the Tx side, the Tx timestamper generates a timestamp only if the frame has matched a VCAP IS2 entry with a PTP_ENA action set.

The arrival and departure times can be shifted in time so that the timestamps match the exact arrival and departure times of the first byte in the frame (SYS:PORT:PTP_CFG.IO_RX_DELAY, SYS:PORT:PTP_CFG.IO_TX_DELAY). Rx and Tx can be adjusted individually. The resulting arrival and departure times are given as:

- Arrival time — Sampling of delay timer minus SYS:PORT:PTP_CFG.IO_RX_DELAY
- Departure time — Sampling of delay timer plus SYS:PORT:PTP_CFG.IO_TX_DELAY

When Tx timestamping is performed, the frame's residence time is calculated as departure time minus arrival time. The residence time can be handled in two different ways based on the action received from the IS2.

Note In 10 Mbps mode, the ingress and egress latencies are larger than can be captured by the IO_RX_DELAY and IO_TX_DELAY registers. To maintain a high timestamp precision, it is not recommended to use 10 Mbps links.

4.15.3.2 One-Step Timestamping

If the IS2_ACTION.PTP_ENA[0] action is set, one-step timestamping is performed. This only applies to the following frame formats:.

- IEEE1588 PTP frames over UDP over IPv4 with zero, one, or two VLAN tags.
- IEEE1588 PTP frames over UDP over IPv6 with zero, one, or two VLAN tags.
  Note The IEEE1588-2008 standard supports the addition of data after the normal PTP payload in form of TLV extensions (Type-Length-Value). The standard recommends that TLVs are not added to PTP event frames (the frames that require timestamping), but does not mandate this. VSC7428-12 does not support TLVs located in PTP event frames sent over IPv6/UDP. If it cannot be guaranteed that PTP event frames are transmitted without any TLVs, configure the VSC7428-12 device to drop any PTP/IPv6/UDP event frames containing TLVs.
- IEEE1588 PTP frames over IEEE 802.3/Ethernet with zero, one, or two VLAN tags.

The number of VLAN tags here is defined as the number of VLAN tags after the rewriter has completed the VLAN editing of the frame in terms of popping and pushing VLAN tags.

When performing one-step timestamping, the residence time is added to the frame's PTP correction field by:

1. Reading the correction field in the received PTP header
2. Adding the frame's residence time
3. Writing the result back into the frame's correction field.

When changing the correction field in IEEE1588 PTP frames over UDP, the UDP checksum is simultaneously cleared (set to zero). This is the case for both IPv4 and IPv6 frames.

One-step timestamping can be disabled per egress port using SYS:PORT:PTP_CFG.PTP_1STEP_DIS. This setting overrules the IS2 action.

4.15.3.3 Two-Step Timestamping

Two-step timestamping is performed if the IS2_ACTION.PTP_ENA[1] action is set. This action applies to any frame, because the frame itself is not modified. The residence time is stored in a timestamp FIFO queue, which the CPU can access (SYS:PORT:PTP_STATUS). The timestamp is common for all egress ports and can contain up to 128 timestamps. Each entry in the timestamp queue contains the following fields:

- SYS:PORT:PTP_STATUS.PTP_MESS_VLD: A 1-bit valid bit meaning the entry is ready for reading.
- SYS:PORT:PTP_STATUS.PTP_MESS_ID: A 6-bit timestamp identifier. A unique timestamp identifier is assigned to each frame for which one or more Tx timestamps are generated. The timestamp identifier is also available in the CPU extraction header for frames extracted to the CPU. The timestamp identifier overloads the DSCP value in the CPU extraction header. For more information about the CPU extraction header, see Table 95, page 120. By providing the timestamp identifier in both the timestamp queue and in the extracted frames, the CPU can correlate which timestamps belong to which frames. Note that timestamp identifier value 63 implies that no free identifier could be assigned to the frame. The timestamp entry can therefore not be trusted.
- SYS:PORT:PTP_STATUS.PTP_MESS_TXPORT: The port number where the frame is transmitted. When transmitting a frame on multiple ports, there are generated multiple entries in the timestamp queue. Each entry uses the same timestamp identifier but with different Tx port numbers.
- SYS:PORT:PTP_DELAY: The frame's residence time when the Tx port is a front port or the frame's arrival time when the Tx port is the CPU port.

The timestamp queue is a simple FIFO that can be read by the CPU. The timestamp queue provides the following handles for reading:

- Overflow of the queue is signaled through SYS:PORT:PTP_STATUS.PTP_OVFL. Overflow implies that one or more timestamps could not be enqueued due to all 128 entries being in use. Timestamp not enqueued are lost.
- The head-of-line entry is read through SYS:PORT:PTP_STATUS and SYS:PORT:PTP_DELAY.
- Writing to the one-shot register SYS:PORT_PTP_NXT removes the current head-of-line entry and advances the pointer to the next entry in the timestamp queue.

When two-step Tx timestamping is performed for a frame destined for the CPU extraction queues, the frame's arrival timestamp is enqueued in the timestamp queue instead of the frame's residence time. This enables the CPU to acknowledge the arrival time of the frame and simultaneously sample the delay timer when the frame is extracted from the CPU extraction queues to calculate the exact residence time from the frame enters the switch to the CPU receives the frame.

The timestamp identifiers can take values between 0 to 63. Value 63 implies that all values 0-62 are in use. Values 0 – 3 are pre-assigned to the CPU to be used for injection of frames. The remaining values are assigned by the analyzer to frames requesting timestamping through the VCAP IS2 action. The assigned values must be released again by the CPU by writing to the corresponding bit in ANA::PTP_ID_HIGH (values 32 through 63) or ANA::PTP_ID_LOW (values 0 through 31). The CPU releases a timestamp identifier when it has read the anticipated timestamp entries from the timestamp queue. Note that multicasted frames generate a timestamp entry per egress port using the same timestamp identifier. Each of these entries must be read before the timestamp identifier is released.

Two-step timestamping can be disabled per egress port using SYS:PORT:PTP_CFG.PTP_2STEP_DIS. This setting overrules the IS2 action.

4.15.3.4 DSCP Remarking

If a frame is being timestamped, DSCP remarking is automatically disabled for the frame.

4.15.4 Time of Day Counter

The time of day counter holds a 32 bits seconds counter and a 28 bits nanoseconds counter. The nanoseconds counter is derived from the one-second timer counter, and the seconds counter increments based on the one-second synchronization pulse.

The registers listed in the following table are used for controlling and monitoring the time of day counter.

Table 103 • **Time of Day Counter Registers**

Target:Register_group:Register.field	Description	Replication
SYS::PTP_TOD_SECS	Latched value of time of day counter (seconds)	None
SYS::PTP_TOD_NANOSECS	Latched value of time of day counter (nanoseconds)	None
SYS::PTP_DELAY	Latched value of delay timer	None
SYS::PTP_TIMER_CTRL	Control of latching	None

The time of day counter is enabled through SYS::PTP_TIMER_CTRL.PTP_TIMER_ENA. The 32-bit seconds counter can be reset (SYS::PTP_TIMER_CTRL.PTP_TOD_RST), and the 28-bit nanoseconds counter directly follows the one-second timer counter.

The time of day counter and the delay timer used in the port modules for timestamping can be latched at the same time so that the timestamps in frames can be correlated to day using the one-shot SYS::PTP_TIMER_CTRL.PTP_LATCH. The results of the latching are stored in the following registers and contain counter values from the same point in time:

- Delay timer: SYS::PTP_DELAY
- Time of day counter (seconds): SYS::PTP_TOD_SECS
- Time of day counter (nanoseconds): SYS::PTP_TOD_NANOSECS

4.16 Clocking and Reset

The following table lists the registers associated with clocking and reset.

Table 104 • **Clocking and Reset Registers**

Target:Register_group:Register.field	Description	Replication
HSIO::PLL5G_CFG0	LCPLL configuration	None
HSIO::PLL5G_STATUS0	LCPLL status	None
DEVCPU_GCB:: SOFT_CHIP_RST	Reset of the internal copper PHYs or the entire device	None
DEVCPU_GCB::SOFT_DEVCPU_RST	Reset of the extraction and injection modules	None
CFG::RESET	CPU reset configuration	None

The LCPLL provides the clocks used by the SerDes, the central part of the switch core, and the VCore-III CPU system.

The reference clock for the LCPLL (REFCLK_P and REFCLK_N pins) is either differential or single-ended. The frequency can be 25 MHz, 125 MHz, or 156.25 MHz, or 250 MHz. For more information about the reference clock frequency selections, see the Pins by Function section for the appropriate device.

For more information about reference clock options, see Reference Clock, page 682.

A global software reset is performed with DEVCPU_GCB::SOFT_CHIP_RST.

For more information about the configuration of the CPU frequency and software reset options when using the V-Core-III, see Clocking and Reset, page 133.

For more information about the clock and reset configuration for the Ethernet interfaces in the port modules, see MAC, page 16, SERDES1G, page 23, and SERDES6G, page 27. The MAC clock domains are not included in the global reset.

5 VCore-III System and CPU Interface

This section provides information about the functional aspects of blocks and the interfaces related to the VCore-III on-chip microprocessor system.

The VSC7428-12 device contains a powerful VCore-III CPU system that is based on an embedded MIPS24KEc-compatible microprocessor and a high bandwidth DMA engine. The VCore-III system can control the devices independently or it can support an external CPU, relieving the external CPU of the otherwise time-consuming tasks of transferring frames, maintaining the switch core, and handling networking protocols.

When the VCore-III CPU is enabled, it either boots up independently from Flash or a code-image can be manually loaded and started from an external CPU.

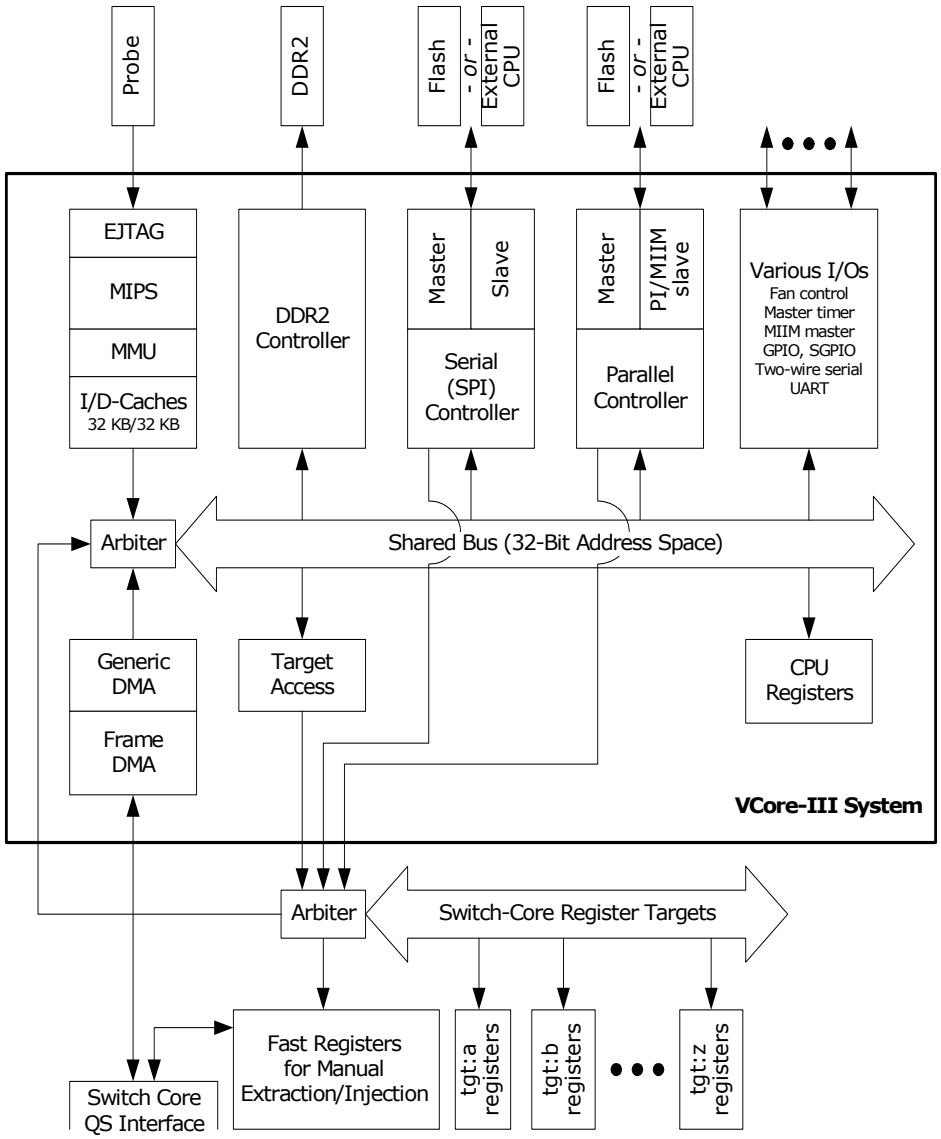
An external CPU can be connected to the VSC7428-12 device through the serial interface (SI), parallel interface (PI), or dedicated MIIM slave interface. When the VCore-III CPU is enabled and boots up from Flash, the SI is reserved as boot interface and cannot be used by an external CPU.

The VCore-III CPU and the external CPUs can access internal chip registers for configuration, monitoring, and collecting statistics.

The VCore-III system includes a number of functional blocks and registers that are tightly coupled to the VCore-III CPU. The external CPU can access these blocks and register through an indirect addressing scheme. The registers are available when the VCore-III CPU is enabled or disabled.

The following illustration shows how the serial, parallel, and MIIM controllers operate in either master or slave mode. When the VCore-III CPU is enabled, it forces the boot interface to master mode. An interface in slave mode allows an external CPU access to register targets inside the device.

Figure 36 • **VCore-III System Block Diagram**



5.1 VCore-III Configurations

The following table summarizes possible VCore-III configurations.

Table 105 • **VCore-III Configurations**

Level of Strapping Pins			
VCore_CFG[2]	**VCore_CFG[1]**	**VCore_CFG[0]**	**Behavior**
Endian mode	0	0	MIPS is enabled and boots up from SI.
Endian mode	0	1	Automatic boot is disabled by forcing the MIPS into reset. SI slave mode is enabled. The MIPS can be manually started from the DDR.

Table 105 • **VCore-III Configurations *(continued)***

Level of Strapping Pins			
VCore_CFG[2]	**VCore_CFG[1]**	**VCore_CFG[0]**	**Behavior**
Endian mode	1	0	Automatic boot is disabled by forcing the MIPS into reset. PI and SI slave modes are enabled. The MIPS can be manually started from the DDR or Flash on the SI interface.
Endian mode	1	1	Automatic boot is disabled by forcing the MIPS into reset. MIIM and SI slave modes are enabled. The MIPS can be manually started from the DDR or Flash on the SI interface.

The VCORE_CFG pins control the behavior of the VCore-III system. The VCore-III CPU operates either in little endian or big endian mode. To enable big endian mode, tie the VCORE_CFG[2] configuration input high. In big endian mode, register access must be byte-swapped when reading and writing. For more information, see the API documentation on www.vitesse.com.

The EJTAG interface of the VCore-III CPU and the Boundary Scan JTAG controller are both multiplexed onto the JTAG interface of the device. When the VCore_ICE_nEn pin is low, the MIPS's EJTAG controller is selected. When the VCore_ICE_nEn pin is high, the Boundary Scan JTAG controller is selected.

5.2 Clocking and Reset

The following table lists the registers associated with clocking and reset.

Table 106 • **Clocking and Reset Configuration Registers**

Register	Description
PLL5G_CFG0	Configures VCore-III CPU frequency
RESET	VCore-III reset configuration and release of specific blocks from reset
SOFT_CHIP_RST	Resets configuration
WDT	Watchdog timer configuration and status

The frequency of the VCore-III CPU is controlled by PLL5G_CFG0.CPU_CLK_DIV. The VCore-III system operates at the same frequency as the VCore-III CPU. The frequency can be changed on-the-fly while the VCore-III CPU is running. When using devices that require a constant clock frequency during normal operation (for example, UART), it is recommended that software configure the clock frequency once during boot up.

The frequency of the VCore-III CPU must not exceed the speed of the available DDR2 SDRAMs. The DDR frequency is locked to half the VCore-III CPU frequency. For example, if DDR400 is used (with a maximum clock of 200 MHz), the maximum VCore-III CPU frequency, when equipped with DDR400 SDRAM, is 312.5 MHz.

The VCore-III CPU (including the VCore-III system) can be soft-reset by setting RESET.CORE_RST_FORCE. By default, this resets both the VCore-III CPU and the VCore-III system. The VCore-III system can be excluded from a soft reset by setting RESET.CORE_RST_CPU_ONLY;soft-reset using CORE_RST_FORCE only then resets the VCore-III CPU. The Frame DMA must be disabled prior to a soft reset of the VCore-III system. When CORE_RST_CPU_ONLY is set, the Frame DMA and memory system are unaffected by a soft reset and continue to operate throughout soft reset of the VCore-III CPU.

The VSC7428-12 device can be soft-reset by using SOFT_CHIP_RST.SOFT_CHIP_RST, which by default, resets the entire device. The VCore-III system and CPU can be protected from a chip-level soft reset by configuring RESET.CORE_RST_PROTECT. In this case, a chip-level soft reset is applied to all

other blocks except the VCore-III system and CPU. When protecting the VCore-III system and CPU from a soft reset, the Frame DMA must be disabled prior to a chip-level soft reset.

The GPIO alternate modes are reset to the default values when performing chip-level soft reset. This must be taken into account when the VCore-III system is protected from chip-level soft reset (by means of RESET.CORE_RST_PROTECT).

When automatic booting of the VCore-III CPU is disabled using the VCORE_CFG pins, the VCore-III CPU can be manually released through RESET.CPU_RELEASE.

5.2.1 Watchdog Timer

The VCore-III system has a built-in watchdog timer (WDT) with a time-out cycle of two seconds. The watchdog timer is enabled, disabled, or reset through the WDT register. The watchdog timer is disabled by default.

After the watchdog timer is enabled, it must be regularly reset by software. Otherwise, it times out and causes a VCore-III soft reset equivalent to setting RESET.CORE_RST_FORCE. Improper use of the WDT.WDT_LOCK causes an immediate timeout-reset as if the watchdog timer had run out. The WDT.WDT_STATUS field shows if the last VCore-III CPU reset was caused by WDT timeout (or improper locking sequence). The WDT.WDT_STATUS field is updated only during VCore-III CPU reset.

To enable or to reset the watchdog timer, write the locking sequence, as described in WDT.WDT_LOCK, at the same time as setting the WDT.WDT_ENABLE field.

Because watchdog timeout is equivalent to setting RESET.CORE_RST_FORCE, the RESET.CORE_RST_CPU_ONLY field also applies to watchdog initiated soft reset.

5.3 Shared Bus

The following table lists the registers associated with the shared bus.

Table 107 • **Shared Bus Configuration Registers**

Register	Description
GENERAL_CTRL	Memory map and interface ownership configuration
PL1, PL2, PL3	Master priorities
WT_EN	Weighted token scheme enable
WT_tcl	Weighted token refresh period
WT_CL1, WT_CL2, WT_CL3	Token weights for masters

The shared bus is a 32-bit address and 32-bit data bus with dedicated master and slave interfaces that interconnect all blocks in the VCore-III system. The VCore-III CPU, Frame DMA, and external CPU are masters on the shared bus and only they can start access on the bus.

The shared bus uses byte addresses, and transfers of 8, 16, or 32 bits can be made. For 16-bit and 32-bit access, the addresses must be aligned to 16-bit and 32-bit addresses, respectively. To increase performance, bursting of multiple 32-bit words on the shared bus can be performed.

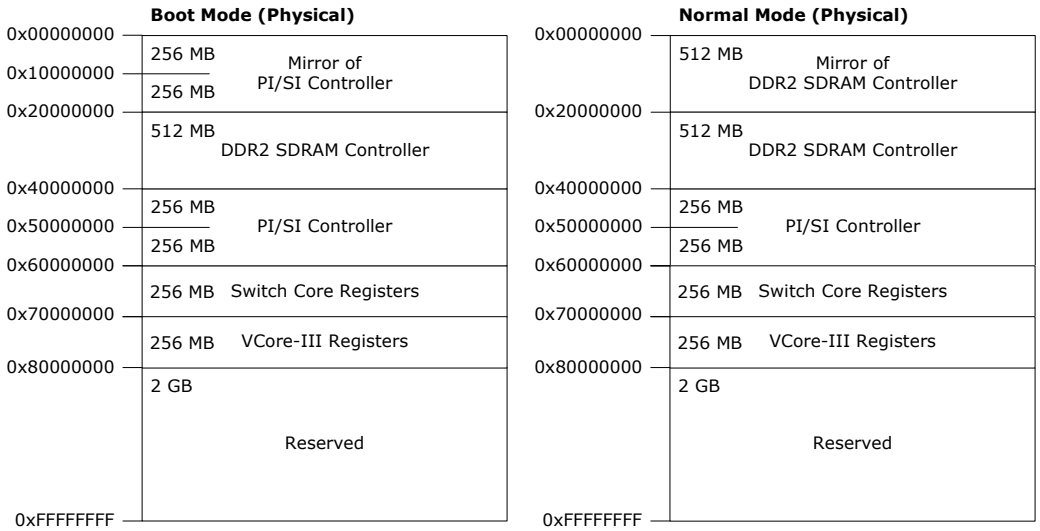
All slaves are mapped into the VCore-III systems 32-bit address space and can be accessed directly by masters on the shared bus. There are two possible mappings of VCore-III shared bus slaves:

- Boot mode. Boot mode is active after power-up and reset of the VCore-III system. In this mode, the PI and SI controller is mirrored into the lowest address region.
- Normal mode. In normal mode, the DDR2 SDRAM controller is mirrored into the lowest address region.

Changing from boot mode to normal mode (GENERAL_CTRL.BOOT_MODE_ENA) interchanges PI/SI for DDR2 SDRAM memory space.

The following illustration shows the mapping of the shared bus memory.

Figure 37 • **Shared Bus Memory Map**



Note: When the VCore-III system is protected from a soft reset using RESET.CORE_RST_CPU_ONLY, a soft reset or a watchdog timeout does not change shared bus memory mapping. For more information about protecting the VCore-III system when using a soft reset, see Clocking and Reset, page 133.

The SI interface is accessible through the lower 256 megabytes of the PI/SI controller's memory region. The upper 256 megabytes are reserved for the PI. The PI is mapped as overlaid functions on the GPIO interface. It is possible for the VCore-III CPU to take ownership of the PI interface by setting GENERAL_CTRL.IF_MASTER_PI_ENA, this automatically enables the parallel interface mode for the appropriate GPIO pins. For more information about the overlaid functions for the PI, see **GPIO Overlaid Functions**, page 176.

Note: GENERAL_CTRL.IF_MASTER_PI_ENA must not be set when an external CPU is using the PI in slave mode for accessing the device.

In boot mode, the PI/SI controller's memory is mirrored into the lowest region of the memory map. In normal mode, the DDR2 SDRAM controller's memory is mirrored to the lowest region of the memory map. If the contents of the PI or SI memory and the DDR2 SDRAM memory are the same, software can execute from the mirrored region when swapping from boot mode to normal mode. Otherwise, software executes from the fixed PI/SI controller's memory when changing from boot mode to normal mode.

5.3.1 Shared Bus Arbitration

The VCore-III shared bus arbitrates between masters that want to access the bus; the default is to use a strict prioritized arbitration scheme where the VCore-III CPU has highest priority. Priorities can be changed using registers PL1 though PL3.

It is possible to enable weighted token arbitration scheme (WT_EN). When using this scheme, specific masters can be guaranteed a certain amount of bandwidth on the shared bus. Guaranteed bandwidth that is not used is given to other masters requesting the shared bus.

When weighted token arbitration is enabled, the masters on the shared bus are grated a configurable number of tokens (WT_CL1, WT_CL2, WT_CL3) at the start of each refresh period. The length of each refresh period is configurable (WT_TCL). For each clock-cycle that the master uses the shared bus, the token counter for that master is decremented. When all tokens are spent, the master is forced to a low priority. Masters with tokens always take priority over masters with no tokens. The strict prioritized scheme is used to arbitrate between masters with tokens and between masters without tokens.

Example: Guarantee That The Frame DMA Can Get 25% Bandwidth. Configure WT_TCL to a refresh period of 2048 clock cycles; the optimal length of the refresh period depends on the scenario, experiment to find the right setting. Guarantee Frame DMA access in 25% of the refresh period by setting WT_CL2 to 512 (2048 x 25%). Set WT_CL1 and WT_CL3 to 0. This gives the VCore-III CPU and External CPU unlimited tokens. Configure the Frame DMA to highest priority by setting PL2 to 15. Finally, enable the

weighted token scheme by setting WT_EN to 1. For each refresh period of 2048 clock cycles, the Frame DMA is guaranteed access to the shared bus for 512 clock cycles, because it is the highest priority master. When all the tokens are spend, it is put into the low-priority category. Until the start of the next refresh period, the VCore-III CPU and the External CPU has priority when accessing the shared bus.

5.3.2 SI Memory Region

This section provides information about the functional aspects of the serial interface (SI) in master mode. For information about using an external CPU to access register targets using the serial interface, see Serial Interface in Slave Mode, page 159.

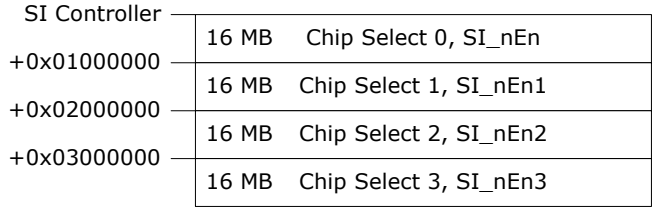
The following table lists the registers associated with the SI controller.

Table 108 • **SI Controller Configuration Registers**

Register	Description
SPI_MST_CFG	Serial interface speed
SW_MODE	Manual control of the serial interface pins

When the VCore-III system controls the SI, there are four programmable chip selects. Through individually mapped memory regions, each chip select can address up to 16 megabytes of memory. Reading from the memory region for a specific SI chip select generates SI read on that chip select. It is possible for the VCore-III CPU to execute code directly from Flash by executing from the SI Controller's memory region.

Figure 38 • **SI Controller Memory Map**



The SI controller accepts 8-bit, 16-bit, and 32-bit read-access with or without bursting. Writing to the SI requires manual control of the SI-pins using software. Setting SW_MODE.SW_PIN_CTRL_MODE places all SI pins under software control. Output enable and the value of SI_Clk, SI_DO, SI_nEn[3:0] are controlled through the SW_MODE register. The value of the SI_DI pin is available in SW_MODE.SW_SPI_SDI.

Note: The VCore-III CPU cannot execute code directly from the SI controller's memory region at the same time as manually writing to the serial interface.

The following table lists the serial interface pins.

Table 109 • **Serial Interface Pins**

Pin Name	I/O	Description
SI_nEn SI_nEn1, GPIO SI_nEn2, GPIO SI_nEn3, GPIO	O	Active low chip selects. Only one chip select can be active at any time. Chip selects 1 through 3 are overlaid functions on the GPIOs. See **GPIO Overlaid Functions**, page 176.
SI_Clk	O	Clock output.
SI_DO	O	Data output (MOSI).
SI_DI	I	Data input (MISO).

The SI controller does speculative perfecting of data. After reading address *n*, the SI controller automatically continues reading address *n* + 1, so that the next value is ready if or when requested by

the VCore-III CPU. This greatly optimizes reading from sequential addresses in the Flash, such as when copying data from Flash into program memory.

Figure 39 • **SI Read Timing in Normal Mode**

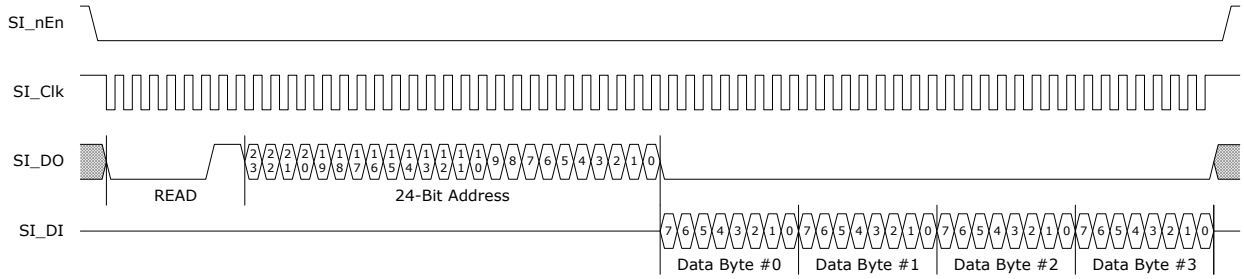
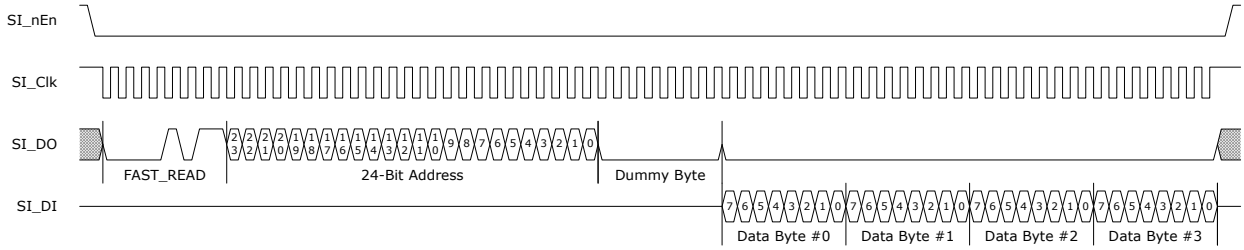


Figure 40 • **SI Read Timing in Fast Mode**



The default timing of the SI controller operates with most serial interface Flash devices. Use the following process to calculate the optimized SI parameters for a specific SI device:

1. Calculate an appropriate frequency divider value as described in SPI_MST_CFG.CLK_DIV. The SI operates at no more than 25 MHz, and the maximum frequency of the SPI device must not be exceeded. For information about the VCore-III system frequency, see Clocking and Reset, page 133.
2. The SPI device may require a FAST_READ command rather than normal READ when the SI frequency is increased. Setting SPI_MST_CFG.FAST_READ_ENA makes the SI controller use FAST_READ commands.
3. Calculate SPI_MST_CFG.CS_DESELECT_TIME so that it matches how long the SPI device requires chip-select to be deasserted between accesses. This value depends on the SI clock period that results from the SPI_MST_CFG.CLK_DIV setting.

These parameters must be written to SPI_MST_CFG. The CLK_DIV field must either be written last or at the same time as the other parameters. The SPI_MST_CFG register can be configured while also booting up from the SI.

When the VCore CPU boots from the SI interface, the default values of the SPI_MST_CFG register are used until the SI_MST_CFG is reconfigured with optimized parameters. This implies that SI_Clk is operating at approximately 4 MHz, with normal read instructions, and maximum gap between chip select operations to the Flash.

5.3.3 PI Memory Region

This section provides information about the functions of the parallel interface (PI) in master mode. For information about how an external CPU can access register targets using the PI, see Parallel Interface in Slave Mode, page 161.

The following table lists the PI controller registers.

Table 110 • **PI Controller Configuration Registers**

Pin Name	Description
PI_MSI_CFG	Parallel interface speed
PI_MST_CTRL	Configuration of interface width, transfer type, and timing

Table 110 • **PI Controller Configuration Registers *(continued)***

Pin Name	Description
PI_MST_STATUS	Timeout indication
GENERAL_CTRL	Enables the PI master

The parallel interface on the device is optimized for NAND Flash access and for connection to external programmable logic. There are four address pins available. The PI chip select is mapped to the low part of the PI controller memory region. There are no limitations on the type of access that can be done within this region; 8-bit, 16-bit, and 32-bit access with or without bursting are all translated to an appropriate number of accesses on the parallel interface.

The parallel interface pins on the device are all overlaid functions on the GPIO interface. Before accessing the parallel interface, the VCore-III system must take ownership of the PI using GENERAL_CTRL.IF_MASTER_PI_ENA. which automatically overtakes the appropriate GPIO pins. For more information, see **GPIO Overlaid Functions**, page 176.

The following table lists the parallel interface pins.

Table 111 • **Parallel Interface Pins**

Pin Name	I/O	Description
PI_nCS, GPIO	O	Active low chip selects. Only one chip select can be active at any time.
PI_Addr[3:0], GPIO	O	These are the address lines. The least significant bit is 0, and the most significant bit is 25.
PI_nWR, GPIO	O	Active low write enable. This is asserted throughout write access on the PI.
PI_nOE, GPIO	O	Active low output enable. This is asserted during read access on the parallel interface.
PI_Data[7:0], GPIO	I/O	These are the data lines.
PI_nDone, GPIO	I	An external device can use this input to indicate when a transfer is done. This input is only used when a chip select is configured to use device-paced mode. See **Device-Paced Mode**, page 139.

The timing of the parallel interface is described in clock cycles. This refers to PI_Clk, which is a clock derived from the VCore-III system clock (PI_MST_CFG.CLK_DIV). In the PI controller, all signals are set or sampled on the rising edge of PI_Clk.

Successive accesses on PI are always spaced with at least one PI_Clk cycle. However, when an access to the PI controller is wider than the interface (for example, 32-bit access to an 8-bit interface), the access is split into multiple back-to-back access.

For read and write access, there are three functional timing parameters that can be adjusted.

- CSCC: The delay from setting PI_Addr, Pi_nWR, PI_nOE, and PI_nBE until PI_nCS is asserted.
- WAITCC+1: The delay from starting an access to PI_nCS is deasserted.
- HLDCC: The delay from deasserting PI_nCS until control signals are changed.

For read access, one additional parameter applies:

- OECC: The delay from PI_nCS is asserted to PI_nOE is asserted.

For read access, data is sampled at the same time as PI_nCS is deasserted.

The following illustrations show the PI write and read timing. The internal PI_Clk signal is included to illustrate the functional PI timing.

Figure 41 • **PI Write Timing**

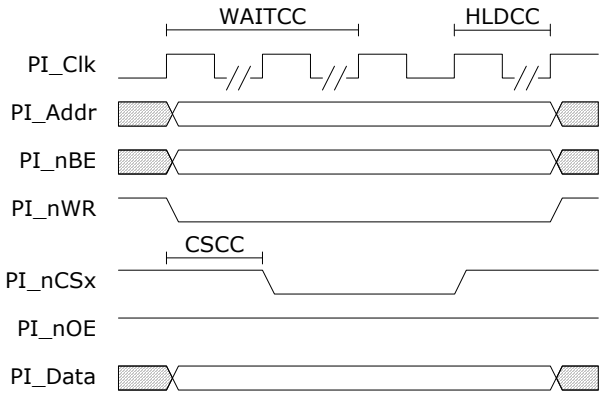
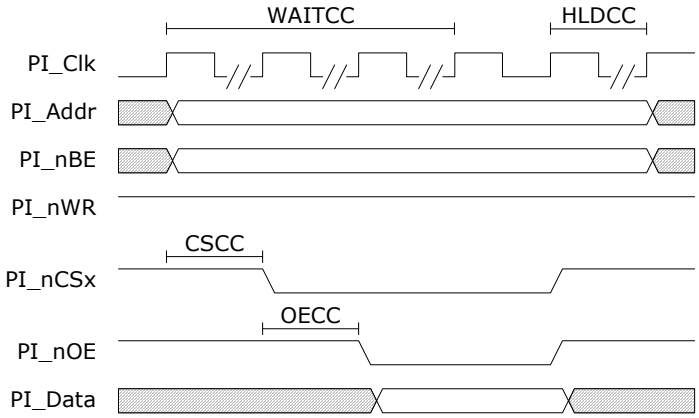


Figure 42 • **PI Read Timing**



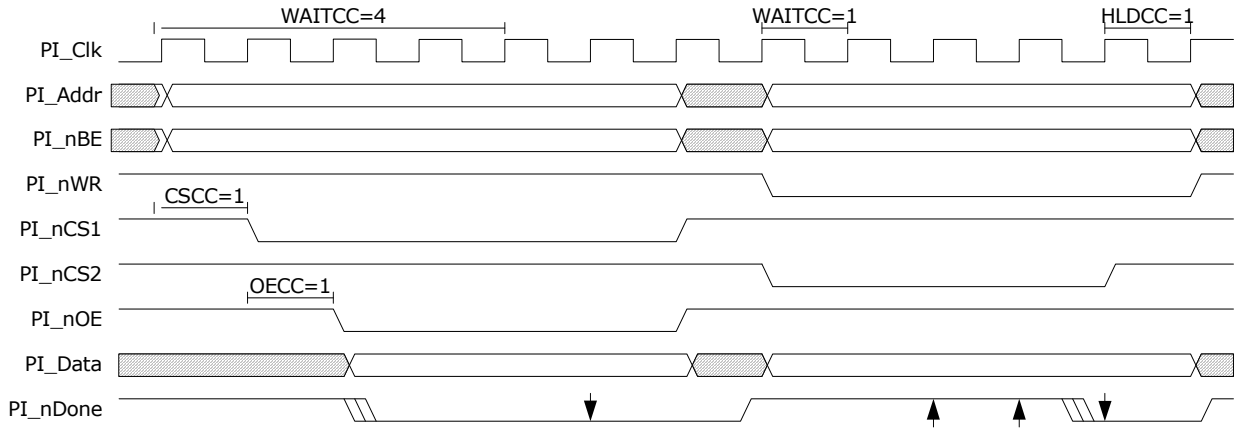
For both read and write access, WAITCC must be greater than or equal to CSCC + OECC. The WAITCC, CSCC, and OECC parameters can be zero, as well as HLDCC. If all parameters are zero, access is done in a single PI clock cycle.

5.3.4 Device-Paced Mode

Device-paced mode can be enabled using PI_MST_CTRL.DEVICE_PACED_XFER_ENA. When device-paced mode is enabled, the cycle in-between WAITCC and HLDCC is stretched until an external device allows the access to be completed by signaling on the PI_nDone pin. The default polarity of this signal is active low, but it can be changed (PI_MST_CTRL.DONE_POL). The PI controller starts to sample the PI_nDone pin after the WAITCC part is over. After the PI_nDone signal is asserted, the PI controller waits one additional cycle. It then proceeds with the transfer (and sample data when reading) by going into the hold-period, or terminates the transfer if HLDCC is zero. The one cycle delay after detecting an asserted PI_nDone signal can be removed, allowing the PI controller to read data and proceed in the same cycle as PI_nDone is detected (PI_MST_CTRL.SAMPLE_ON_DONE).

Example: Use of Device-Paced Mode This example shows two different configurations of chip selects; called PI_nCS1 and PI_nCS2, the example shows a read using PI_nCS1 and a write using PI_nCS2. PI_nCS1 is configured with CSCC = 1, OECC = 1, WAITCC = 4, and HLDCC = 0. PI_nCS2 is configured with CSCC = 0, WAITCC = 1, and HLDCC = 1. Both configurations have device-paced mode enabled, and PI_nCS2 is configured with SAMPLE_ON_DONE.

Figure 43 • **Device-Paced PI Example**



The arrows show where the PI controller samples PI_nDone. Note how PI_MST_CTRL.SAMPLE_ON_DONE causes the access on PI_nCS2 to proceed in the same cycle as PI_nDone is asserted, as opposed to PI_nCS1.

PI_nDone is an asynchronous signal. It takes a maximum of two VCore-III system clock cycles for the PI controller to detect an asserted PI_nDone signal.

In device-paced mode, a timeout can be enabled using PI_MST_CTRL.DEVICE_PACED_TIMEOUT_ENA. The timeout period counts from the start of the access and is configured in the range of 16 through 2048 cycles (PI_MST_CTRL.DEVICE_PACED_TIMEOUT). If a timeout occurs, a transfer is immediately terminated; reads return invalid data. The sticky register bit PI_MST_STATUS.TIMEOUT_ERR_STICKY is set when a transfer has timed out.

5.3.5 DDR2 Memory Region

This section provides information about how to configure the DDR2 memory controller and interface.

The following table lists the registers associated with the DDR2 controller.

Table 112 • **DDR2 Controller Registers**

Register	Description
MEMCTRL_CTRL	Start of initialization
MEMCTRL_CFG	Configuration
MEMCTRL_STAT	Status for initialization
MEMCTRL_REF_PERIOD	Refresh period
MEMCTRL_TIMING0	Timing configuration
MEMCTRL_TIMING1	Timing configuration
MEMCTRL_TIMING2	Timing configuration
MEMCTRL_TIMING3	Timing configuration
MEMCTRL_MR0_VAL	Mode register 0 value
MEMCTRL_MR1_VAL	Mode register 1 value
MEMCTRL_MR2_VAL	Mode register 2 value
MEMCTRL_MR3_VAL	Mode register 3 value
MEMCTRL_DQS_DLY	DQS window configuration
MEMPHY_CFG	Interface configuration

Table 112 • **DDR2 Controller Registers *(continued)***

Register	Description
MEMPHY_ZCAL	Interface calibration

The memory controller is designed to work with JEDEC-compliant DDR2 memory modules. The controller supports up to 14 addresses, 4 or 8 bank, and single row configurations (fixed CS). The memory controller has a single byte lane supporting one 8-bit DDR2 module.

Note: The memory controller supports single row systems, which means there is no DDR_nCS output; the nCS input on the DDR2 module must be tied to 0.

The following steps are required to bring up the memory controller:

1. Configure timing and mode parameters. Configuration depends on the DDR2 modules selected for the product. For more information, see **Configuration of Timing and Mode Parameters**, page 141.
2. Enable and calibrate the SSTL I/Os. For more information, see **Enabling and Calibrating the SSTL I/Os**, page 143.
3. Initialize the memory controller and modules. For more information, see **Memory Controller and Module Initialization**, page 144.
4. Calibrate the DQS read window. For more information, **DQS Read Window Calibration**, page 144.

Note: For selected DDR2 modules, the bring-up of the memory controller is already implemented as part of the Board Support Package (BSP). Please see the BSP for example implementation of the bring-up procedure.

5.3.5.1 Configuration of Timing and Mode Parameters

This section lists each of the parameters that must be configured prior to initialization of the memory controller. The register list contains a more comprehensive explanation of each field; this section provides a quick overview of fields that must be configured and the recommended values.

All divisions in this section are performed as floating point division and then rounded up to nearest integer, unless otherwise is explicitly mentioned for that division.

The following table defines the variables that must be extracted from the datasheet of the DDR2 module (referred to as “module”) that have selected for use with the device. Note that some of the variables listed in the table depend on the frequency at which the module is run. It is assumed that a target frequency was determined. For more information, see Clocking and Reset, page 133.

Table 113 • **Selected Memory Module Variables**

Variable	Description
clk_ns	The clock period in nanoseconds at which the module runs.
CL	The CAS latency of the module in clock cycles.
t_{REFI_ns}	The t_{REFI} parameter for the module in nanoseconds.
t_{WR_ns}	The t_{WR} parameter for the module in nanoseconds.
$t_{RAS_min_ns}$	The $t_{RAS(MIN)}$ parameter for the module in nanoseconds.
t_{WTR_ns}	The t_{WTR} parameter for the module in nanoseconds.
t_{RCD_ns}	The t_{RCD} parameter for the module in nanoseconds.
t_{RRD_ns}	The t_{RRD} parameter for the module in nanoseconds.
t_{RP_ns}	The t_{RP} parameter for the module in nanoseconds.
t_{FAW_ns}	The t_{FAW} parameter for the module in nanoseconds. Required for 8-bank modules.
t_{RC_ns}	The t_{RC} parameter for the module in nanoseconds.
t_{RFC_ns}	The t_{RFC} parameter for the module in nanoseconds.
t_{MRD}	The t_{MRD} parameter for the module in clock cycles.

Table 113 • **Selected Memory Module Variables *(continued)***

Variable	Description
t_{RPA_ns}	The t_{RPA} parameter in nanoseconds. Required for 8-bank modules.

The timing parameters listed in the following table must be configured. For more information about each register field, see the detailed register on each field. Where multiple configurations are possible, the most optimal solution is selected.

Table 114 • **Memory Controller Timing Parameters**

Timing Parameter	Description
MEMCTRL_CFG.MSB_COL_ADDR	Set to one less than the number of column address bits for the DDR2 module.
MEMCTRL_CFG.MSB_ROW_ADDR	Set to one less than the number of row address bits for the DDR2 module.
MEMCTRL_CFG.BANK_CNT	Set to 0 when using a 4-bank DDR2 module. Set to 1 when using an 8-bank DDR2 module.
MEMCTRL_CFG.BURST_LEN	Set to 1, BURST8 mode.
MEMCTRL_CFG.BURST_SIZE	Set to 0.
MEMCTRL_REF_PERIOD.REF_PERIOD	Set to (tREFI_ns/clk_ns). Round down the result to the nearest integer.
MEMCTRL_REF_PERIOD.MAX_PEND_REF	Set to 1.
MEMCTRL_TIMING0.RD_DATA_XFR_DLY	Set to (CL – 3).
MEMCTRL_TIMING0.WR_DATA_XFR_DLY	Set to (CL – 3).
MEMCTRL_TIMING0.RD_TO_PRECH_DLY	Set to 3.
MEMCTRL_TIMING0.WR_TO_PRECH_DLY	Set to (CL + 2 + (tWR_ns/clk_ns)).
MEMCTRL_TIMING0.RAS_TO_PRECH_DLY	Set to ((tRAS_min_ns/clk_ns) – 1).
MEMCTRL_TIMING0.RD_TO_WR_DLY	Set to 4.
MEMCTRL_TIMING1.WR_TO_RD_DLY	Set to the highest value of either (CL + 4) or (CL + 2 + (tWTR_ns/clk_ns)).
MEMCTRL_TIMING1.RAS_TO_CAS_DLY	Set to ((tRCD_ns/clk_ns) – 1).
MEMCTRL_TIMING1.RAS_TO_RAS_DLY	Set to ((tRRD_ns/clk_ns) – 1).
MEMCTRL_TIMING1.PRECH_TO_RAS_DLY	Set to ((tRP_ns/clk_ns) – 1).
MEMCTRL_TIMING1.BANK8_FAW_DLY	Set to 0 for a 4-bank module. Set to ((tFAW_ns/clk_ns) – 1) for an 8-bank module.
MEMCTRL_TIMING1.RAS_TO_RAS_SAME_BANK_DLY	Set to ((tRC_ns/clk_ns) – 1).
MEMCTRL_TIMING2.FOUR_HUNDRED_NS_DLY	Set to (400 /clk_ns).
MEMCTRL_TIMING2.REF_DLY	Set to ((tRFC_ns/clk_ns) – 1).
MEMCTRL_TIMING2.MDSET_DLY	Set to (tMRD – 1).
MEMCTRL_TIMING2.PRECH_ALL_DLY	Set to ((tRP_ns/clk_ns) – 1) for a 4-bank module. Set to ((tRPA_ns/clk_ns) – 1) for an 8-bank module.

Table 114 • **Memory Controller Timing Parameters *(continued)***

Timing Parameter	Description
MEMCTRL_TIMING3.WR_TO_RD_CS_CHANGE_DLY	Set to the highest value of either 3 or (CL – 1).
MEMCTRL_TIMING3.LOCAL_ODT_RD_DLY	Set to (CL – 1).
MEMCTRL_TIMING3.ODT_WR_DLY	Set to (CL – 1).

The memory controller supports single-row systems, which implies that the data connections between the memory controller and the DDR2 modules are point-to-point connections. As a result, on-die-termination is not required.

The following table lists the mode parameters that need to be configured. The suggestions in the table are inline with the timing parameters that are listed in the previous table. Where multiple configurations are possible, the most optimal solution is selected.

Table 115 • **Memory Controller Mode Parameters**

Mode Parameter	Description
MEMCTRL_MR0_VAL.MR0_VAL	This value is written to the Mode register in the DDR2 module during initialization. Set to (3|(CL<<4)|(((tWR_ns/clk_ns) – 1)<<9))
MEMCTRL_MR1_VAL.MR1_VAL	This value is written to the Extended Mode register in the DDR2 module during initialization. Set to 0x0382.
MEMCTRL_MR2_VAL.MR2_VAL	This value is written to the Extended Mode Register 2 in the DDR2 module during initialization. Set to 0x0000.
MEMCTRL_MR3_VAL.MR3_VAL	This value is written to the Extended Mode Register 3 in the DDR2 module during initialization. Set to 0x0000.

The mode registers are specified by the JEDEC standards, and bit positions in the mode registers across different DDR2 vendors remain fixed.

5.3.5.2 Enabling and Calibrating the SSTL I/Os

The memory controller is designed to operate with point-to-point PCB traces on the timing critical control and data connections to and from the DDR2 modules.

Prior to controller initialization, the device's SSTL I/O drivers must be enabled and calibrated to correct drive strength and termination resistor values. For single row systems with short point-to-point connections, it is recommended that the device's I/O drive strength be 60 Ω/60 Ω. Using these values ensures proper low power and low noise communication.

Complete the following tasks to enable and calibrate the SSTL I/Os:

1. Release the I/Os and related logic from reset.
2. Enable the SSTL mode by clearing MEMPHY_CFG.PHY_RST and setting MEMPHY_CFG.PHY_SSTL_ENA.
3. Perform calibration with the previously mentioned strength and termination values by writing 0xEH to MEMPHY_ZCAL.
4. Ensure that software waits until MEMPHY_ZCAL.ZCAL_ENA is cleared (indicates calibration is done) before continuing.
5. Enable drive of the SSTL I/Os by setting MEMPHY_CFG.PHY_CK_OE, MEMPHY_CFG.PHY_CL_OE, and MEMPHY_CFG.PHY_ODT_OE.

The SSTL interface is now enabled and calibrated, and the initialization of the memory controller can commence.

5.3.5.3 Memory Controller and Module Initialization

After all timing parameters and mode registers are configured, and after the SSTL I/Os are enabled and calibrated, the memory controller (and DDR2 modules) can be initialized by setting MEMCTRL_CTRL.INITIALIZE. For more information about configuring timing and mode parameters, see **Configuration of Timing and Mode Parameters**, page 141. For more information about the DDR2 SSTL I/Os, see **Enabling and Calibrating the SSTL I/Os**, page 143.

During initialization, the memory controller automatically follows the proper JEDEC defined procedure for initialization and writing of mode registers to the DDR2 memory modules.

The memory controller sets the MEMCTRL_STAT.INIT_DONE field after the controller and the DDR2 memory are operational. Software must wait for the INIT_DONE indication before continuing to calibrate the read window.

5.3.5.4 DQS Read Window Calibration

After initialization of the memory controller, writes to the memory are guaranteed to be successful. Reading is not yet possible, however, because the round trip delay between controller and DDR2 modules is not calibrated.

Calibration of the read window includes writing a known value to the start of the DDR memory and then continually reading this value while adjusting the DQS window until the correct value is read from the memory.

Complete the following steps before starting the calibration routine:

- Write 0x000000FF to SBA address 0x20000000
- Set the MEMCTRL_DQS_DLY.DQS_DLY field to 0.

Perform the following steps to calibrate the read window. Do not increment the DQS_DLY field beyond its maximum value. If the DQS_DLY maximum value is exceeded, it is an indication something is incorrect, and the DDR2 memory will not be functional.

1. Read byte address 0 from the DDR2 memory. If the content of byte address 0 is different from 0xFF, increment MEMCTRL_DQS_DLY.DQS_DLY by one, and repeat step 1, else continue to step 2.
2. Read byte address 0 from the DDR2 memory. If the content of byte address 0 is different from 0x00, increment MEMCTRL_DQS_DLY.DQS_DLY by one, and repeat step 2, else continue to step 3.
3. Decrement MEMCTRL_DQS_DLY.DQS_DLY by three.

The last step configures the appropriate DSQ read window. The DDR memory is operational after this step and can be used for random access.

5.3.6 Switch Core Registers Memory Region

Register targets in the Switch Core are memory-mapped into the Switch Core registers region of the shared bus memory map. All registers are 32-bit wide and must only be accessed using 32-bit reads and writes. Bursts are supported.

Writes to this region are buffered (there is a one-word write buffer). Multiple back-to-back write access pauses the shared bus until the write buffer is freed up (until the previous writes are done). Reads from this region pause the shared bus until read data is available.

Registers in the 0x60000000 though 0x6FFFFFFF region in the 0x6 targets are physically located in other areas of the device rather than the VCore-III system; reading from these targets may take up to 1.1 µs in a single master system. For more information, see Register Access and Multimaster Systems, page 159.

5.3.7 VCore-III Registers Memory Region

Registers inside the VCore-III domain are memory mapped into the VCore-III registers region of the shared bus memory map. All registers are 32-bit wide and must only be accessed using 32-bit reads and writes, bursts are supported.

The registers in the 0x70000000 though 0x7FFFFFFF region are all placed inside the VCore-III, read and write access to these registers is fast (done in a few clock cycles).

5.4 VCore-III CPU

The VCore-III CPU system is based on a powerful MIPS24KEc-compatible microprocessor with 16-entry MMU, 32 kilobyte instruction, and 32 kilobyte data caches.

This section describes how the VCore-III CPU is integrated into the VCore-III system. For more information about internal VCore-III functions, for example, bringing up caches, MMU, and so on.

When automatic boot is enabled using the VCORE_CFG strapping pins, the VCore-III CPU automatically starts to execute code in the Flash at byte-address 0.

A typical automatic boot sequence is as follows:

1. Configure appropriate VCore-III CPU frequency. For more information, see Clocking and Reset, page 133.
2. Speed up the boot interface. For more information, see Shared Bus, page 134.
3. Initialize the DDR2 controller and memory. For more information, see DDR2 Memory Region, page 140.
4. Copy code-image from Flash to DDR2 memory.
5. Change memory map from boot mode to normal mode For more information, see Shared Bus, page 134.

When automatic boot is disabled, an external CPU can start the VCore-III CPU through registers.

A typical manual boot sequence is:

1. Configure appropriate VCore-III CPU frequency. For more information, see Clocking and Reset, page 133.
2. Initialize the DDR2 controller and memory. For more information, see DDR2 Memory Region, page 140.
3. Copy code-image to DDR2 memory.
4. Change memory map from boot mode to normal mode. For more information, see Shared Bus, page 134.
5. Release reset to the VCore-III CPU. For more information, see Clocking and Reset, page 133.

The boot vector of the VCore-III CPU is mapped to the start of the KESEG1, which translates to physical address 0x00000000 on the VCore-III shared bus.

The VCore-III interrupts are mapped to interrupt inputs 0 and 1, respectively.

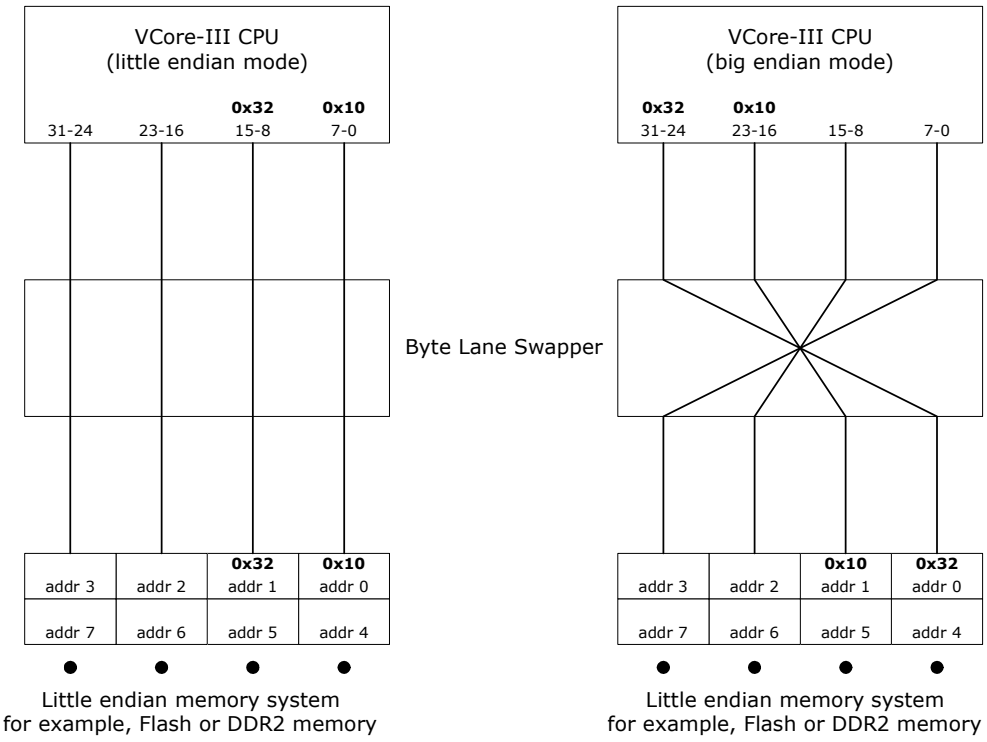
5.4.1 Big Endian Support

The endianess of the VCore-III CPU is controlled through strapping pins. For more information about how to select endian modes, see VCore-III System and CPU Interface, page 131.

The VCore-III system is constructed as a little endian system, and registers descriptions reflect little endian encoding. When big endian mode is enabled, instructions and data are byte-lane swapped just before they enter and when they leave the VCore-III CPU. This is the standard way of translating between a CPU in big endian mode and a little endian system.

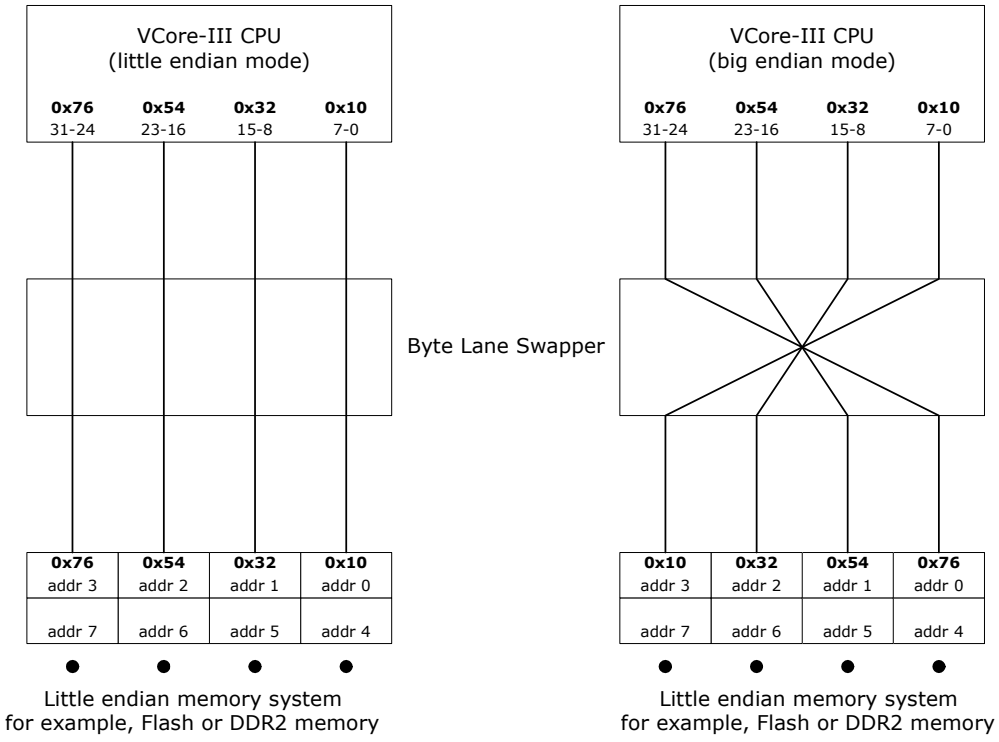
The following illustration shows how the 16-bit value 0x3210 is transferred between the VCore-III CPU and the VCore-III shared bus in little endian and big endian modes.

Figure 44 • **16-Bit Access in Little Endian and Big Endian Modes**



For 32-bit access, the difference is less obvious. The following illustration shows how the value 0x76543210 is transferred between the VCore-III CPU and the VCore-III shared bus in little endian and big endian modes.

Figure 45 • **32-Bit Access in Little Endian and Big Endian Mode**



Note: The swapping of byte lanes ensures that no matter the endian mode, the VCore-III CPU is always accessing the appropriate part of the little endian memory system.

In big-endian mode, care must be taken when accessing parts of the memory system which is also used by other users than the VCore-III CPU. For example, device registers are written and read by the VCore-III CPU, but they are also used by the device (which sees them in little endian mode). The VCore-III BSP contains examples of code that correctly handles register access for big endian mode.

5.4.2 Software Debug and Development

The VCore-III CPU has a standard MIPS EJTAG debug interface that can be used for breakpoints, loading of code, and examining memory. When the VCore_ICE_nEn strapping pin is pulled low, the device's JTAG interface is attached to the VCore-III EJTAG controller.

5.5 Manual Frame Injection and Extraction

This section provides information about the manual frame injection and extraction to and from the CPU system. There are two injection groups and two extraction groups available.

5.5.1 Manual Frame Extraction

This section provides information about manual frame extraction.

The following table lists the registers associated with manual frame extraction.

Table 116 • **Manual Frame Extraction Registers**

Register	Description	Replication
XTR_FRM_PRUNING	Frame pruning	Per xtr queue
XTR_GRP_CFG	Extraction group configuration	Per xtr group
XTR_MAP	Map extraction queue to group	Per xtr queue
XTR_RD	Extraction read data	Per xtr group
XTR_QU_SEL	Software controlled queue selection	Per xtr group
XTR_QU_FLUSH	Extraction queue flush	None
XTR_DATA_PRESENT	Extraction status	None

The device has two extraction queues to which data can be redirected. Before data can be extracted each extraction queue must be enabled and mapped to an extraction group. There are two extraction groups available, and the mapping between queues and groups can be set arbitrary. A queue is enabled by setting the corresponding XTR_MAP.MAP_ENA field and the mapping to an extraction group is set in XTR_MAP.GRP.

The XTR_DATA_PRESENT register shows if data is present in the extraction queues. It has two fields:

- XTR_DATA_PRESENT.DATA_PRESENT shows the data present status per extraction queue
- XTR_DATA_PRESENT.DATA_PRESENT_GRP shows the data present status per extraction group.

When frame data is available in an extraction group, it can be read from the associated XTR_RD register, which is replicated per extraction group. The XTR_RD register returns the next 4 bytes of the frame data. When the read operation is completed, the register is automatically updated with the next 4 bytes of the frame data. End-of-frame (EOF) and other status indications are indicated by special data words in the data stream (when reading XTR_RD). The following table lists the possible special data words.

Table 117 • **Extraction Data Special Values**

Data Value	Description
0x80000000-0x80000003	EOF. The two LSBs indicate the number of unused bytes.
0x80000004	EOF. Frame was pruned.

Table 117 • **Extraction Data Special Values *(continued)***

Data Value	Description
0x80000005	EOF. The frame was aborted and is invalid.
0x80000006	Escape. Next data is frame data and not a status word.
0x80000007	Data not ready.

Each read operation on the XTR_RD register must check for the special values listed above and act accordingly. The escape data word (0x80000006) is inserted into the data stream when the frame data matches one of the special data words. When the escape data word is read it means that the next data word to be read is actual frame data and not a status word.

The position of the EOF data word in the data stream can be configured in XTR_GRP_CFG.STATUS_WORD_POS. The possibilities are to have the EOF status word after the last frame data word or to have EOF status word just before the last frame data word. The default is to have the EOF status word after the last frame data word.

The byte order of the XTR_RD register can be configured in XTR_GRP_CFG.BYTE_SWAP. The default is to have the byte order in little-endian. By clearing XTR_GRP_CFG.BYTE_SWAP, the byte order is changed to big-endian (network order). The byte order of the status words listed in Table 117, page 147 is not affected by the value of XTR_GRP_CFG.BYTE_SWAP.

It is possible to configure a prune size for all extracted frames from an extraction queue using XTR_FRM_PRUNING. When pruning is enabled, all frames that are larger than the specified prune size is pruned to the prune size. When a frame is pruned, the EOF status word is set to 0x80000004. The maximum prune size is 1024 bytes, and the prune size is defined in whole 32-bit words only.

Frames in individual extraction queues can be flushed by setting the corresponding bit in XTR_QU_FLUSH.FLUSH. Flushing is disabled by clearing XTR_QU_FLUSH.FLUSH.

Note: Flushing does not affect the queues in the OQS so it may be needed to make the OQS stop sending data to the CPU extraction queues before flushing.

When a frame is extracted, it can be prefixed with an 8-byte CPU extraction header (EH). The option to prefix an EH to the frame data is set in the rewriter. For more information about the extraction header format, see CPU Extraction Header Insertion, page 118.

The extraction queue from which the frame originates is available through the CPU_QUEUE field in the CPU extraction header.

The following table shows an example of reading a 65-byte frame, followed by a 64-byte frame. In the example, it is assumed that each frame is prefixed with an EH. Data is read big endian, and the EOF status word is configured to come just before the last frame data word. Undefined bytes cannot be assumed to be zero.

Table 118 • **Frame Extraction Example**

Read Number	INJ_WR Bits 31:24	INJ_WR Bits 23:16	INJ_WR Bits 15:8	INJ_WR Bits 7:0
1	EH bit 63:56	EH bit 55:48	EH bit 47:40	EH bit 39:32
2	EH bit 31:24	EH bit 23:16	EH bit 15:8	EH bit 7:0
3	Frame byte 1 (DMAC)	Frame byte 2 (DMAC)	Frame byte 3 (DMAC)	Frame byte 4 (DMAC)
4	Frame byte 5 (DMAC)	Frame byte 6 (DMAC)	Frame byte 7 (SMAC)	Frame byte 8 (SMAC)
…				
19	0x80 (EOF)	0x00 (EOF)	0x00 (EOF)	0x03 (EOF)

Table 118 • **Frame Extraction Example *(continued)***

Read Number	INJ_WR Bits 31:24	INJ_WR Bits 23:16	INJ_WR Bits 15:8	INJ_WR Bits 7:0
20	Frame byte 65 (FCS)	Undefined	Undefined	Undefined
21	EH bit 63:56	EH bit 55:48	EH bit 47:40	EH bit 39:32
…				
38	0x80 (EOF)	0x00 (EOF)	0x00 (EOF)	0x00 (EOF)
39	Frame byte 61	Frame byte 62	Frame byte 63	Frame byte 64

5.5.2 Manual Frame Injection

This section provides information about manual frame injection on the device.

The following table lists the register associated with manual frame injection.

Table 119 • **Manual Frame Injection Registers**

Register	Description	Replication
INJ_GRP_CFG	Injection group configuration	Per injection group
INJ_WR	Injection write data	Per injection group
INJ_CTRL	Injection control	Per injection group
INJ_STATUS	Injection status	None
INJ_ERR	Injection errors	Per injection group

There are two injection groups available. Frames can be injected from the CPU injection groups using register writes. There are two ways of injecting frames:

- Directly forwarding to a specific port, bypassing the analyzer.
- Normal forwarding of a frame through the analyzer.

To control the injection mode, an 8-byte injection header (IH) must be prefixed to the frame data. For more information about the injection modes and the injection header, see Frame Injection, page 121.

Frame data is injected by doing consecutive writes of 4 bytes to the INJ_WR register, which is replicated per injection group. Endianess of the INJ_WR register is configured in INJ_GRP_CFG.BYTE_SWAP. Start-of-frame (SOF) and end-of-frame (EOF) indications are set in INJ_CTRL. INJ_CTRL must be written prior to INJ_WR. SOF and EOF is indicated in INJ_CTRL.SOF and INJ_CTRL.EOF respectively. In INJ_CTRL.VLD_BYTES the number of valid bytes of the last write to INJ_WR is indicated and VLD_BYTES must be set together with the EOF indication. The frame data must include the 4-byte FCS, but it does not have to be correct, because it is recalculated by the egress port module. While a frame is being injected it can be aborted by setting INJ_CTRL.ABORT. The SOF, EOF, and ABORT fields of INJ_CTRL are automatically cleared by hardware.

Dummy bytes can be injected in front of a frame before the actual frame data (including injection header). The dummy bytes are discarded before the frame data is transmitted by the CPU system. The number of bytes to discard from the frame data is set in INJ_CTRL.GAP_SIZE. The GAP_SIZE field must be set together with SOF.

Before each write to INJ_WR, the status fields INJ_STATUS.WMARK_REACHED and INJ_STATUS.FIFO_RDY must be checked to ensure successful injection. The INJ_ERR register shows if an error occurred during frame injection.

The following table shows an example of injecting a 65-byte frame followed by a 64-byte frame. Both frames are prefixed by a CPU injection header and big-endian mode is used for the INJ_WR register. The “don’t care” bytes can be any value.

Table 120 • **Frame Injection Example**

Register Access	INJ_WR Bits 31:24	INJ_WR Bits 23:16	INJ_WR Bits 15:8	INJ_WR Bits 7:0
INJ_CTRL #1	GAP_SIZE = 0, ABORT = 0, EOF = 0, SOF = 1, VLD_BYTES = 0			
INJ_WR #1	IH bit 63:56	IH bit 55:48	IH bit 47:40	IH bit 39:32
INJ_WR #2	IH bit 31:24	IH bit 23:16	IH bit 15:8	IH bit 7:0
INJ_WR #3	Frame byte 1 (DMAC)	Frame byte 2 (DMAC)	Frame byte 3 (DMAC)	Frame byte 4 (DMAC)
INJ_WR #4	Frame byte 5 (DMAC)	Frame byte 6 (DMAC)	Frame byte 7 (SMAC)	Frame byte 8 (SMAC)
…				
INJ_CTRL #2	GAP_SIZE = 0, ABORT = 0, EOF = 1, SOF = 0, VLD_BYTES = 1			
INJ_WR #19	Frame byte 65 (FCS)	Don’t care	Don’t care	Don’t care
INJ_CTRL #3	GAP_SIZE = 0, ABORT = 0, EOF = 0, SOF = 1, VLD_BYTES = 0			
INJ_WR #20	IH bit 63:56	IH bit 55:48	IH bit 47:40	IH bit 39:32
…				
INJ_CTRL #4	GAP_SIZE = 0, ABORT = 0, EOF = 1, SOF = 0, VLD_BYTES = 0			
INJ_WR #37	Frame byte 61	Frame byte 62	Frame byte 63	Frame byte 64

5.5.3 Frame Interrupts

Software can be interrupted when frame data is available for extraction or when there is room for frames to be injected.

The value of DEVCPU_QS::XTR_DATA_PRESENT.DATA_PRESENT_GRP is provided directly as interrupt inputs to the VCore-III system’s interrupt controller (the XTR_RDY interrupts), so that software can be interrupted when frame data is available for extraction. Using the interrupt controller, these interrupts can be mapped independently to either the VCore-III CPU or external interrupt outputs.

The negated value of DEVCPU_QS::INJ_STATUS.WMARK_REACHED is provided as interrupt inputs to the VCore-III system’s interrupt controller (the INJ_RDY interrupts), so that software can be interrupted when there is room in the IQS. Using the interrupt controller, these can be mapped independently to either the VCore-III CPU or external interrupt outputs.

5.6 Frame DMA

The Frame DMA (FDMA) engine is a modified general-purpose DMA engine that extracts and injects frames directly from or to the queue system.

The FDMA has access to the entire VCore-III shared bus. Although DDR2 memory is the most obvious working area for FDMA, transfers can be made across the parallel interface or even the serial interface.

The FDMA engine features eight individual channels that can be configured for either frame injection or frame extraction. A single channel can operate in only one of these modes.

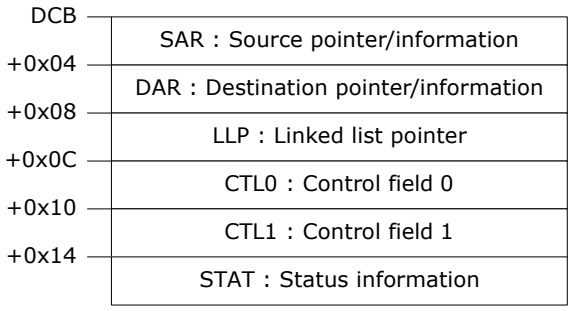
5.6.1 DMA Control Block Structures

It is possible to manually instruct the FDMA engine to move arbitrary memory around though register configurations. But most of the time it is desirable to configure transfers though control structures in memory holding information about length, offsets, destinations, pointer to data area, and so forth. The

FDMA engine supports this through the use of DMA Control Block structures (DCB). DCBs are structures that can be linked together to form lists of sequential transfers to be executed by the FDMA.

The following illustration shows the general layout of a DCB.

Figure 46 • **General DCB Layout**



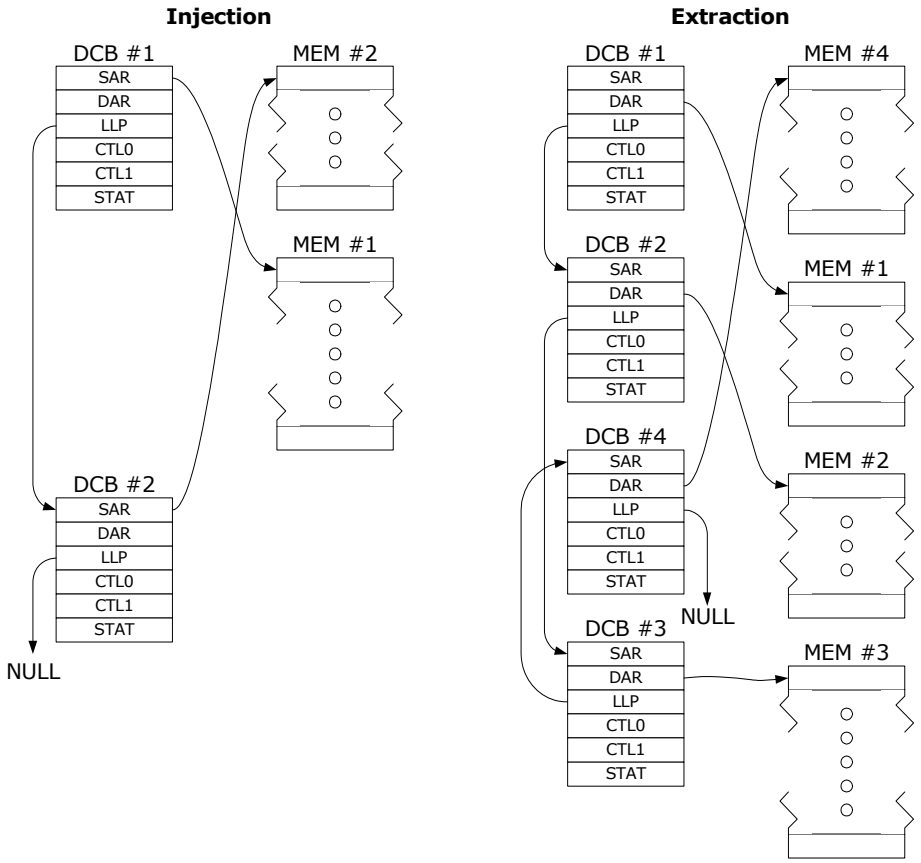
During injection and extraction, one Ethernet frame can be contained within the data area of a single DCB or it can be split across multiple data areas of consecutive DCBs. The data area of one DCB can never contain more than one Ethernet frame.

DCBs and the corresponding data area must be aligned to 32-bit addresses. The encoding of SAR, DAR, CTL0, CTL1, and STAT DCB-fields differs when used for general-purpose data transfers, injection, or extraction. The sections dealing with each transfer type also explain how to configure the DCB fields.

The LLP field in the DCB is always used for linking DCBs into chains. The FDMA engine interprets the LLP field as a 32-bit pointer, when linking DCBs together the LLP of one DCB must point to the SAR field of the next DCB. The last DCB in a chain must always have the LLP field set to NULL (0x00000000).

The following illustration shows two examples of DCB chains with corresponding data areas. It shows how chains of DCBs and corresponding data areas can be placed in any order inside the memory and how the data areas can be of different sizes. For injection, the SAR points to a memory area. For extraction, the DAR points to a memory area.

Figure 47 • **DCB Chain Examples**



The FDMA engine autonomously processes chains of DCBs, so adding DCBs to an active chain requires care. Chains of new DCBs must be constructed separately from the active chain. Channels must be configured for injection or extraction before adding chains of DCBs. For more information about adding lists of DCBs to the FDMA channels or initializing the FDMA engine, see Injection, page 155 and Extraction, page 152.

The switch stores local information about each frame in an internal frame header. When extracting a frame from the queue system, the Extraction Header (EH) is prepended to the frame data (it is located before the actual Ethernet frame). When injecting a frame into the queue system or to an Ethernet port using super priority injection, a suitable Injection Header (IH) must be generated and prepended to the frame data (before the actual Ethernet frame). For information about interpreting and generating the headers for extraction and injection, see CPU Port Module, page 119.

The FDMA engine always interprets frame data in network order (big endian format). This means that no matter which endianess it uses, the CPU must access extracted frame data in network order by doing byte accesses on incrementing byte addresses. The first byte received by the switch is put on the lowest address, and subsequent bytes are put on incrementing byte addresses.

When constructing frames for transmission, the CPU must put frame data on incrementing byte addresses. The first byte that the switch transmits is put on the lowest byte address, and subsequent bytes are put on incrementing byte addresses.

Generally, when the CPU is in big endian mode, it can access fields directly in the frames that are wider than 1 byte. When the CPU is in little endian mode, software must swap bytes when accessing fields wider than 1 byte.

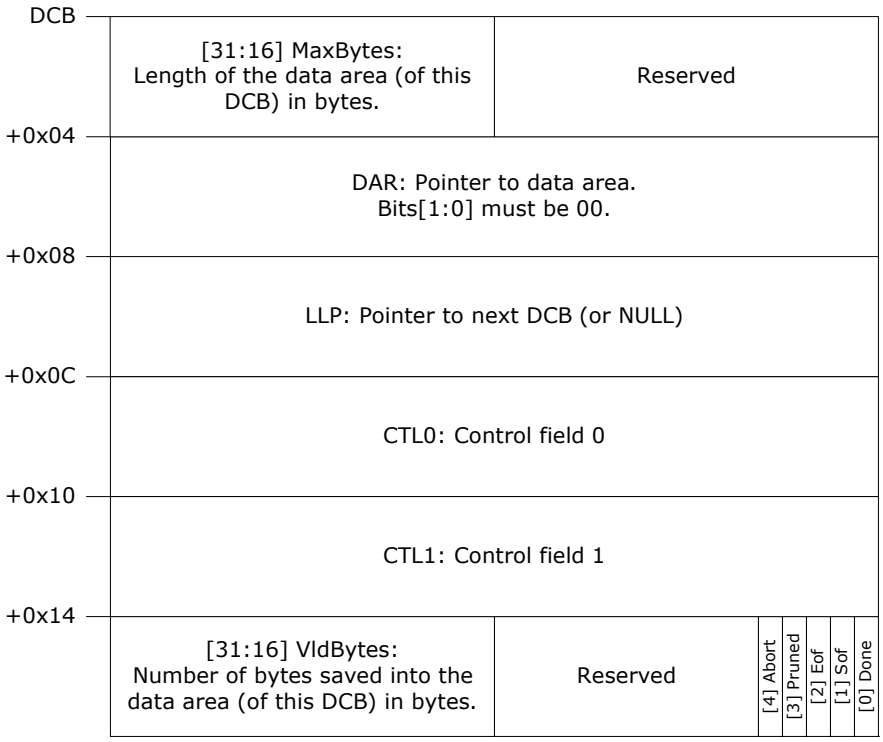
5.6.2 Extraction

Frames can be extracted from the queue system. The queue system has eight queues available for extraction. When extracting through the FDMA, the same queues, groups, extraction header, and

mapping apply as when manually extracting through registers. For more information about queues, groups, and frame header information, see Manual Frame Extraction, page 147.

Note: The “data special values” that are used during manual extraction do not apply when using the FDMA. The FDMA extracts frame data and automatically updates special indications, which are then stored in the DCBs.

Figure 48 • **Extraction DCB Layout**



For extraction, the DAR field holds the pointer to the first 32-bit word in the data area. For more information about LLP, see DMA Control Block Structures, page 150.

The FDMA channels are optimized for bursting data into the working memory. As a result, the minimum data area size for extraction DCBs is 68 bytes (17 32-bit words).

5.6.2.1 SAR Field Encoding for Extraction

SAR holds source information and configurations related to extraction of frames. Reserved fields must be set to zero.

The SAR.MaxBytes must be set to the total number of bytes available in the data area of that particular DCB. The value of this field must be divisible by four, that is, bits [1:0] of the field must be 00.

5.6.2.2 CTL0 and CTL1 Field Encoding for Extraction

The CTL0 and CTL1 fields are loaded into the corresponding FDMA registers when processing extraction DCBs. Reserved fields must be set to 0.

The least significant bit of CTL0 is a block-interrupt enable field. To achieve optimal performance, use the following values for extraction:

- CTL0: 0x1A40DC24 + (block-interrupt ? 1 : 0)
- CTL1: 0x00000000

When block interrupt is enabled, the FDMA can assert interrupt after a DCB is processed. The interrupt does not stop the FDMA; it can be used by software for detecting arrival of new frames.

5.6.2.3 STAT Field Encoding for Extraction

After a DCB is processed by the FDMA, the STAT field is updated with information about extraction status. When preparing a DCB for extraction, the entire STAT field must be set to 0.

The STAT.Done field is set to 1 after the DCB is processed (this is an indication that the STAT field is valid). STAT.Sof is set if the current DCB contains start-of-frame (when it contains the first byte of the frame header). STAT.Eof is set when the current DCB contains end-of-frame (when it contains the last byte of the frame).

STAT.Pruned is set if the frame was pruned. STAT.Abort is set if the frame was aborted. Frames may be aborted if they are longer than the programmed MTU. For more information about pruning frames, see Manual Frame Extraction, page 147.

The STAT.VldBytes indicates the number of bytes that was saved to the data area of the current DCB.

Note: When frames are spread across multiple DCBs, the STAT.VldBytes of all the DCBs must be accumulated to get the total frame length.

5.6.2.4 Initialization of FDMA Extraction Channels

There is a one-to-one mapping from extraction groups to FDMA channels (that is, extraction group zero can only be serviced by FDMA channel 0).

Using the extraction queue to group mapping, one FDMA channel can extract from multiple extraction queues. One FDMA channel can handle all extraction queues. For increased performance, use different FDMA channels to separate high-priority and low-priority extraction queues.

Decide on a mapping of extraction queues to FDMA channels. Perform the following steps to enable each FDMA channel (ch) for extraction:

1. Allow QS to control extraction by configuring FDMA:CH[ch]:CFG1.SRC_PER and FDMA:CH[ch]:CFG1.DST_PER to ch. Clear FDMA:CH[ch]:CFG0.HS_SEL_SRC, and set FDMA:CH[ch]:CFG0.HS_SEL_DST.
2. Configure priority through FDMA:CH[ch]:CFG0.CH_PRIOR. The priority controls access to the VCore-III shared bus (the working memory). The FDMA selects between channels with the same priority by using round robin.
3. Configure locking of frame interface by setting FDMA:CH[ch]:CFG0.LOCK_CH and FDMA:CH[ch]:CFG0.LOCK_CH_L to 1.
4. Specify to the frame interface which burst size the FDMA is using by setting ICPU_CFG::FDMA_XTR_CFG[ch].XTR_BURST_SIZE to 2.
5. Allow the FDMA to update the DCBs STAT field by setting FDMA:CH[ch]:CFG1.DS_UPD_EN and FDMA:CH[ch]:DSTATAR to the VCore-III shared bus address of the ICPU_CFG::FDMA_XTR_STAT_LAST_DCB[ch] register.
6. Extraction queues (eq) must be mapped to extraction groups (same as ch). For each extraction queue, configure DEVCPU_QS::XTR_MAP[eq].GRP to ch and set DEVCPU_QS::XTR_MAP[eq].CH_ENA.
7. Enable linked list DCB operation by setting FDMA:CH[ch]:CTL0.LLP_SRC_EN and FDMA_CH[ch]:CTL0.LLP_DST_EN.
8. Configure the FDMA channel for extraction by clearing ICPU_CFG::FDMA_CH_CFG[ch.].USAGE and then setting ICPU_CFG::FDMA_CH_CFG[ch].CH_ENA to enable it.

This procedure assumes that all registers related to the FDMA channel are at their default values before starting configuration. If an extraction channel needs to be reconfigured, reverse all of the above registers to their default values before attempting a new configuration.

5.6.2.5 Extraction of Frames

After initializing an FDMA channel for extraction, frames can be extracted by providing the FDMA with a chain of extraction DCBs. For more information about initializing FDMA channels, see **Initialization of FDMA Injection Channels**, page 157.

When enabled, the FDMA writes DCBs autonomously, which complicates adding additional DCBs to an enabled FDMA channel (ch). Use the following procedure when adding additional a (null terminated) list of DCBs:

1. Overwrite tail's LLP field (of existing DCB list) with pointer to the head of the new DCB list. Skip this step if there is no existing DCB list for this FDMA channel.
2. Check the state of the FDMA channel. If FDMA::CH_EN_REG.CH_EN[ch]==1, the adding was successful. Do not continue this procedure.
3. If the channel is not enabled, check the STAT field of the head of the new DCB list. If STAT.Done==1, the adding was successful. Do not continue this procedure.
4. If the channel is not enabled and the new DCB list is not used, overwrite FDMA:CH[ch]:LLP with the pointer to the head of the new DCB list. Re-enable the FDMA channel by setting FDMA::CH_EN_REG.CH_EN[ch] and FDMA::CH_EN_REG.CH_EN_WE[ch] at the same time.

Note: This procedure requires that software keep track of the current DCB list for each FDMA channel. This is part of any software implementation that needs to look at extraction DCBs after they have filled with frame data.

5.6.3 Injection

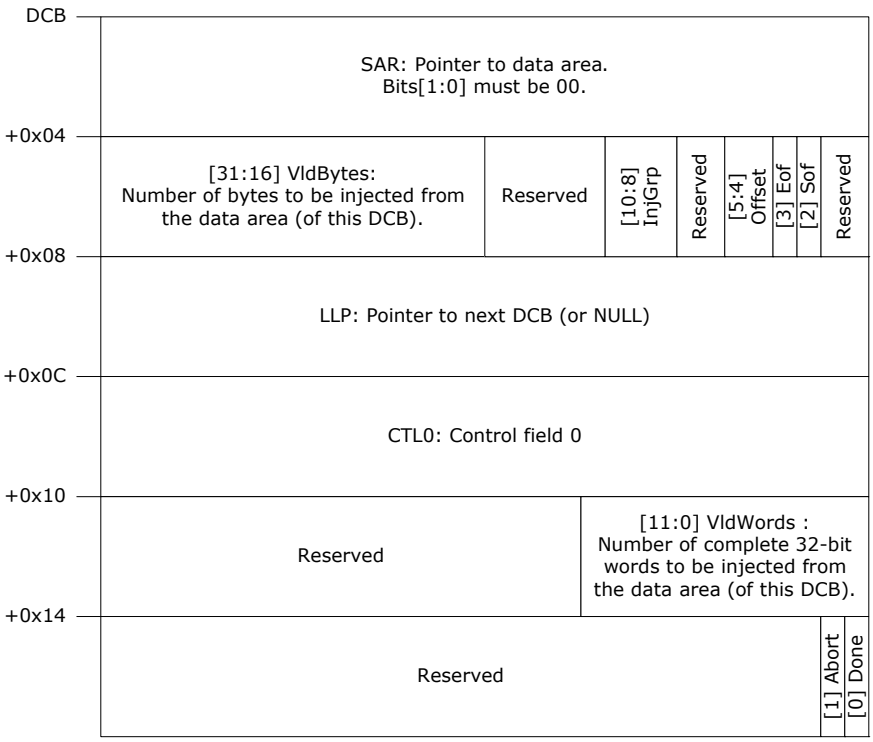
Frames can be injected to the queue system or directly to specific ports. The queue system has two queues (with priorities) available for injection. The same groups and frame header applies when injecting through the FDMA as when manually injecting through registers. For more information about available groups and frame header information, see Manual Frame Injection, page 149.

Each frame has one (and only one) injection group destination encoded directly into the DAR field of the DCB. When a frame is split across multiple DCBs, all the DCBs (for that frame) must be configured with the same destination injection group.

One channel in the FDMA can inject to more than one injection group, however, each injection group must only receive frames from one FDMA channel.

The following illustration shows the detailed layout of an injection DCB. For injection the SAR field holds pointer to the first 32-bit word in the data area. The DAR, CTL0, CTL1, and STAT fields are described in the following sections. For more information about LLP fields, see DMA Control Block Structures, page 150.

Figure 49 • **Injection DCB Layout**



5.6.3.1 DAR Field Encoding for Injection

DAR holds destination information and configurations related to injection of frames. Reserved fields must be set to zero.

The DAR.Sof (start-of-frame) field must be set in each DCB containing the first byte of the frame header. That is; for each frame to be injected, the first DCB for that frame must have DAR.Sof set. The DAR.Eof (end-of-frame) field must be set in each DCB containing the last byte of the frame. That is; for each frame to be injected, the last DCB for that frame must have DAR.Eof set.

Note: When a frame and its header are contained entirely within a single DCB, that DCB must have both DAR.Sof and DAR.Eof set.

The DAR.Offset field specifies the first valid byte address in the 32-bit word that SAR points to. The following table describes the encoding of the DAR.Offset field.

Table 121 • **DAR.Offset Field Encoding**

DAR.Offset	Description
0	Byte address 0 contains the first valid byte.
1	Byte address 1 contains the first valid byte.
2	Byte address 2 contains the first valid byte.
3	Byte address 3 contains the first valid byte.

The destination group field (DAR.InjGrp) must be set for every DCB.

The DAR.VldBytes field reflects the number of valid bytes in the data area of the DCB. The smallest allowed value is 1, and the largest allowed value is the maximum allowed frame size (that is, MTU) plus the length of the frame header. This means that it is possible to store anything from 1 byte to a complete frame in the data area of one DCB.

DAR.VldBytes does not have to be a multiple of four; the FDMA engine takes care of appropriate buffering and realignment of frame data.

Important The DAR.VldBytes field only reflects the number of valid bytes in the data area of the specific DCB. That is, when an Ethernet frame and an internal frame header are contained in multiple DCBs, the DAR.VldBytes field in each individual DCB only indicates the number of valid bytes in the data area of that particular DCB.

5.6.3.2 CTL0 and CTL1 Field Encoding for Injection

The CTL0 and CTL1 fields are loaded into the corresponding FDMA registers when processing injection DCBs. Reserved fields must be set to zero.

The least significant bit of CTL0 is a block-interrupt enable field. CTL1 is set to a ceiling-divide-by-four of VldBytes + Offset. The following values will achieve optimal performance for injection.

- CTL0: 0x1890D924 + (block-interrupt ? 1 : 0)
- CTL1: ((DAR:VldBytes + DAR:Offset + 3) >> 2) & 0x00000FFF

Note: For injection, block-interrupt is typically enabled for DCBs that contain end-of-frame (where DAR.Eof is set).

5.6.3.3 STAT Field Encoding for Injection

When a DCB is processed by the FDMA, the STAT field is updated with information about injection status. When preparing a DCB for injection, the entire STAT field must be set to 0.

The STAT.Done field is set to 1 when the DCB is processed, which indicates that the STAT field is valid. STAT.Abort is set when injection of the current DCB (or any previous DCBs belonging to the current frame) are aborted by the user (through the ICPU_CFG::FDMA_CFG register).

5.6.3.4 Initialization of FDMA Injection Channels

Any FDMA channel can be configured for frame injection. When an FDMA channel is configured for injection, it can only be used for that purpose. That is, it can no longer be used for extraction or general-purpose transfers.

One FDMA channel can inject to multiple injection groups, however, one injection group must only receive frames from more than one FDMA channel. One FDMA channel can handle all injection groups; however backpressure on any injection group will cause backpressure on the corresponding FDMA channel. For increased performance, separate high-priority and low-priority injection groups by using different FDMA channels.

Decide on a mapping of FDMA channels and injection groups. Perform the following steps to enable each FDMA channel (ch) for injection:

1. Allow QS to control injection by setting FDMA:CH[ch]:CFG1.SRC_PER and FDMA:CH[ch]:CFG1.DST_PER to ch. And setting FDMA:CH[ch]:CFG0.HS_SEL_SRC and FDMA:CH[ch]:CFG0.HS_SEL_DST to zero.
2. Configure priority through FDMA:CH[ch]:CFG0.CH_PRIOR, the priority controls access to the VCore-III shared bus (the working memory). The FDMA selects between channels with the same priority by using round robin.
3. Allow the FDMA to update the DCBs STAT field by setting FDMA:CH[ch]:CFG1.DS_UPD_ENA.
4. Injection groups (ig) which receive frames from the FDMA channel ch must send backpressure to this channel. For each injection group: configure ICPU_CFG::FDMA_INJ_CFG[ig].INJ_GRP_BP_MAP to ch and set ICPU_CFG::FDMA_INJ_CFG[ig].INJ_GRP_BP_ENA.
5. Enable linked list DCB operation by setting FDMA:CH[ch]:CTL0.LLP_SRC_EN and FDMA_CH[ch]:CTL0.LLP_DST_EN.
6. Configure the FDMA channel for injection and then enable it by setting ICPU_CFG::FDMA_CH_CFG[ch].USAGE and ICPU_CFG::FDMA_CH_CFG[ch].CH_ENA.

This procedure assumes that all registers related to the FDMA channel are at their default values before starting configuration. If an injection channel needs reconfiguration, reverse all of the above registers to their default values before attempting a new configuration.

5.6.3.5 Injection of Frames

After initializing an FDMA channel for injection, frames can be injected by providing the FDMA with a chain of injection DCBs. The destination injection group must be specified in the DCB's DAR field. For more information, see **Initialization of FDMA Injection Channels**, page 157 and **DAR Field Encoding for Injection**, page 156.

Software must ensure that the FDMA channel only injects to groups that have already been associated with the channel (done during initialization of FDMA injection channels).

When enabled, the FDMA reads DCBs autonomously, which complicates adding additional DCBs to an enabled FDMA channel (ch). Use the following procedure when adding a (null terminated) list DCBs for injection.

1. Overwrite tail's LLP field (of existing DCB list) with pointer to the head of the new DCB list. Skip this step if there is no existing DCB list for this FDMA channel.
2. Check the state of the FDMA channel. If FDMA::CH_EN_REG.CH_EN[ch]==1, the adding was successful. Do not continue this procedure.
3. If channel is not enabled, check the STAT field of the head of the new DCB list. If STAT.Done==1, the adding was successful. Do not continue this procedure.
4. If the channel is not enabled and the new DCB list is not injected, overwrite FDMA:CH[ch]:LLP with the pointer to the head of the new DCB list. Re-enable the FDMA channel by setting FDMA::CH_EN_REG.CH_EN[ch] and FDMA::CH_EN_REG.CH_EN_WE[ch] at the same time.

This procedure requires that software keep track of the current DCB list for each FDMA channel. This should be part of any software implementation that wants to reclaim injection DCBs after they have been injected.

5.6.3.6 Continuous Injection of Frames

The FDMA can be configured for continual injection of frames by linking the tail to the head of a DCB list. This will cause a continuous transmission of all the DCBs in the list. This feature is useful when specific frames are needed for monitoring links between switches in the network, for example, continual transmission of CCM frames.

The following table lists the registers associated with injection frame spacing.

Table 122 • **Injection Frame Spacing Registers**

Register	Description	Replication
INJ_FRM_SPC_TMR	Injection frame spacing timer	Per DMA channel
INJ_FRM_SPC_TMR_CFG	Reload value for the injection frame spacing timer	Per DMA channel
INJ_FRM_SPC_LACK_CNTR	Lack counter	Per DMA channel
INJ_FRM_SPC_CFG	Injection frame spacing configuration register	Per DMA channel

A delay can be inserted between each DCB so that frames are spaced evenly when injected. The delay between the transmissions of DCBs in the list is configured in INJ_FRM_SPC_TMR.TMR. The resulting delay depends on the VCore-III system frequency. The frame space timer is down-counting and the current value of the timer can be read in INJ_FRM_SPC_TMR.TMR.

To enable the frame spacing feature, the INJ_FRM_SPC_CFG.FRM_SPC_ENA must be set. The frame spacing timer can be enabled/disabled using INJ_FRM_SPC_CFG.TMR_ENA.

If the switch queue systems fill-level causes the FDMA transfers to stop for an extended period of time or if the MIPS or DDR controller occupies the AHB bus, the requested frame spacing may not be met. When it is possible to start the transmission again the frames that have been postponed are transmitted without a delay is inserted between them. The number of frames to transmit “unspaced” is counted by the lack counter. The lack counter is incremented every time the frame space timer ticks while frames cannot be transmitted. The lack counter saturates at 511 and cannot go negative, thus up to 511 outstanding frames are supported. The current value of the lack counter can be read in INJ_FRM_SPC_LACK_CNTR.LACK_CNTR.

There should be a one-to-one correspondence between frames and DCBs when configuring the DCB ring. If the frame to be injected spans several DCBs, it will take a frame space timer-tick per DCB to inject the frame.

The frame space timer is 32 bits wide, allowing transmission rates down to 17.1 seconds with a VCore-III system frequency of 250 MHz. If longer transmission rates are required, dummy frames must be inserted in the DCB ring.

5.6.4 Frame DMA Interrupt

The Frame DMA generates an interrupt if any of the following events occur:

- When the FDMA tries to access an illegal memory region (this does not occur unless the FDMA was misconfigured). This is an ERR-event.
- When a DCB, with LLP field set to NULL, is processed. This is a TFR-event.
- When a DCB is processed. This is a BLOCK-event.

Note: Software is most likely interested in getting interrupts when the FDMA finishes processing DCBs. Getting BLOCK events requires enabling of BLOCK interrupt for the (active) extraction channels. The BLOCK-event is useful for reclaiming used injection DCBs or detecting when new frames are extracted from the QS. When interrupt is received, the status of the interrupting channels can be read from FDMA::STATUS_BLOCK. When interrupt has been handled, the event can be cleared by writing to FDMA::CLEAR_BLOCK.

The behavior of BLOCK-events described previously applies directly to ERR and TFR events. Just replace the *_BLOCK registers with _ERR and _TFR, respectively.

5.7 External CPU Support

This section describes the handles of the device, which is dedicated to supporting external CPU systems. In addition to the dedicated logic, an external CPU can interact with most of the VCore-III system.

An external CPU attaches to the device through the SI, PI, or MIIM and has access to register targets in the switch core domain. Through these register targets, indirect access into the VCore-III system on the VCore-III SBA is possible. For more information, Access to the VCore-III Shared Bus, page 167. The external CPU can coexist with the internal VCore-III CPU and hardware-semaphores and interrupts are implemented for inter-CPU communication. For more information, see Mailbox and Semaphores, page 168.

5.7.1 Register Access and Multimaster Systems

The access time is the time it takes for a CPU interface to read or write a register inside a register target. The access time depends on the target and the number of CPU interfaces that are attempting to access the target. There are two types of targets:

- Fast Register Targets have dedicated logic for each CPU interface, and the interfaces have guaranteed access to the fast targets; the access time is no more than 35 ns.
- Normal Register Targets are accessible by all CPU interfaces. When different interfaces access the same target, each interface competes for access. When a target is accessed by only one CPU interface, the maximum access time is 1.1 µs. When a target is accessed by more than one CPU interface, the access time is increased to no more than 2.2 µs.

Fast Targets are DEVCPU_QS, DEVCPU_ORG, DEVCPU_PI (only accessible through the parallel interface), and the VCore-III registers (ICPU_CFG, UART, and so on). All other register targets in the device are considered Normal Targets.

The VCore-III registers are placed on the VCore-III shared bus and are indirectly accessible to an external CPU through the DEVCPU_GCB register target.

5.7.2 Serial Interface in Slave Mode

This section provides information about the function of the serial interface (SI) in slave mode.

The following table lists the registers associated with SI slave mode.

Table 123 • **SI Slave Mode Register**

Register	Description
SI	Configuration of endianess, bit order, and padding

The serial interface implements a SPI-compatible protocol that allows an external CPU to perform read and write accesses to register targets inside the device. Endianess and bit order is configurable, and several options for high frequencies are supported.

The serial interface is available to an external CPU when the VCore-III CPU does not own the SI. For more information, VCore-III System and CPU Interface, page 131.

The following table lists the pins of the SI interface.

Table 124 • **SI Slave Mode Pins**

Pin Name	Direction	Description
SI_nEn	I	Active low chip select
SI_Clk	I	Clock input
SI_DI	I	Data input (MOSI)
SI_DO	O	Data output (MISO)

SI_DI is sampled on rising edge of SI_Clk. SI_DO is changed on falling edge of SI_Clk. There are no requirements on the logical values of the SI_Clk and SI_DI inputs when SI_nEn is asserted or deasserted, they can be either 0 or 1. SI_DO is only driven during reading when read-data is shifted out of the device.

The external CPU initiates access by asserting chip select and then transmitting one bit read/write indication, one don't care bit, and 22 address bits. For write access, an additional 32 data bits are transmitted. For read access, the external CPU continues to clock the interface while reading out the result.

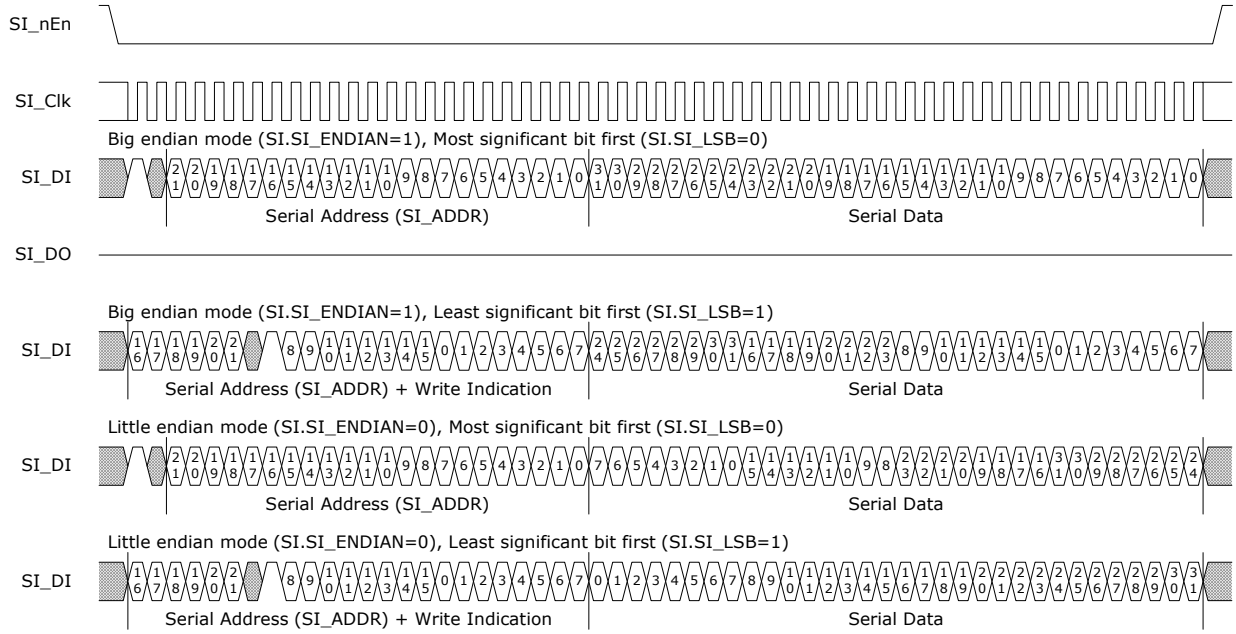
With the register address of a specific register (REG_ADDR), the SI address (SI_ADDR) is calculated:

```
SI_ADDR = (REG_ADDR) - 0x60000000)>>2
```

Data word endianess is configured through SI.SI_ENDIAN. The order of the data bits is configured using SI.SI_LSB. Setting SI.SI_LSB affects both the first 24 bits of the SI command and the 32 bits of data.

The following illustration shows various configurations for write access. The data format during writing, as depicted, is also used when the device is transmitting data during read operations.

Figure 50 • **Write Sequence for SI**



When reading registers using the SI interface, the device needs to prepare read data after receiving the last address bit. The access time of the register that is read must be satisfied before shifting out the first bit of read data. For information about access time, see Register Access and Multimaster Systems, page 159. The external CPU must apply one of the following solutions to satisfy access time:

- Use SI_Clk with a period that is a minimum of twice the access time for the register target. For example, for Normal Targets (single master): 1/(2 × 1.1 µs) = 450 kHz.
- Pause the SI_Clk between shifting of serial address bit 0 and the first data bit with enough time to satisfy the access time for the register target.
- Configure the device to send out enough padding (dummy) bytes before transmitting the read data to satisfy the access time for the register target.

Inserting padding (dummy) bytes is configured in SI.SI_WAIT_STATES. The required number of padding bytes depends on the SI frequency. The SI_DO output is not driven while shifting though padding bytes.

Note: When using padding bytes, it is usually cumbersome to change the padding configuration on the fly. Then it makes sense to use enough padding to support the worst case access time.

Example: The required number of padding bytes for 20 MHz SI. The clock period at 20 MHz is 50 ns; it will take 50 ns × 8 = 400 ns to shift through one padding byte. For a single master system, the worst-

case access time to any register target is 1.1 µs. To satisfy this delay, SI.SI_WAIT_STATES must be configured to at least three. This means that the external CPU must shift a total of 56 bits when reading from the device (the last 32 bits are the read data).

The following illustrations show the options for serial read access. The illustrations show only one mapping of read data, little endian with most significant bit first. Any of the mappings can be configured and apply to read data in the same way as for write data.

Figure 51 • **Read Sequence for SI_Clk Slow**

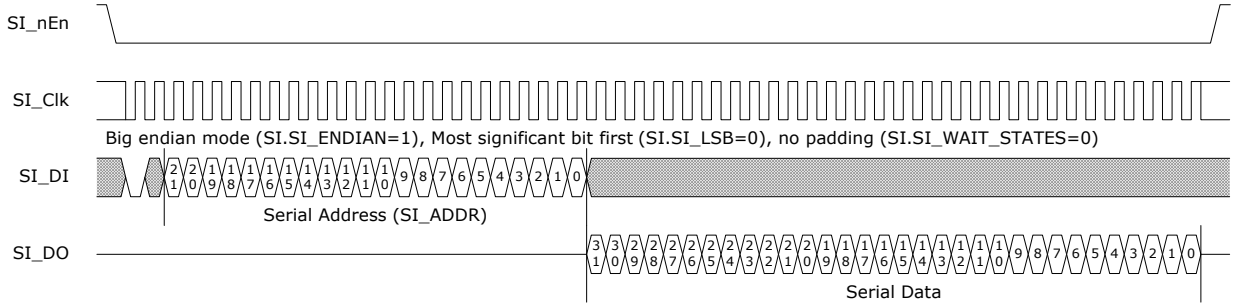


Figure 52 • **Read Sequence for SI_Clk Pause**

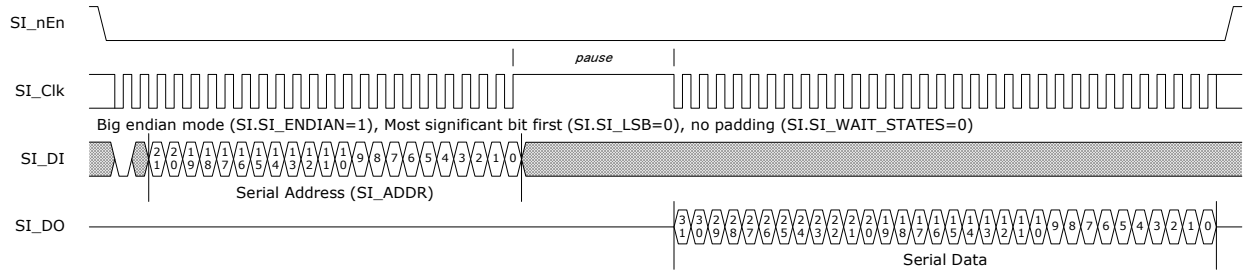
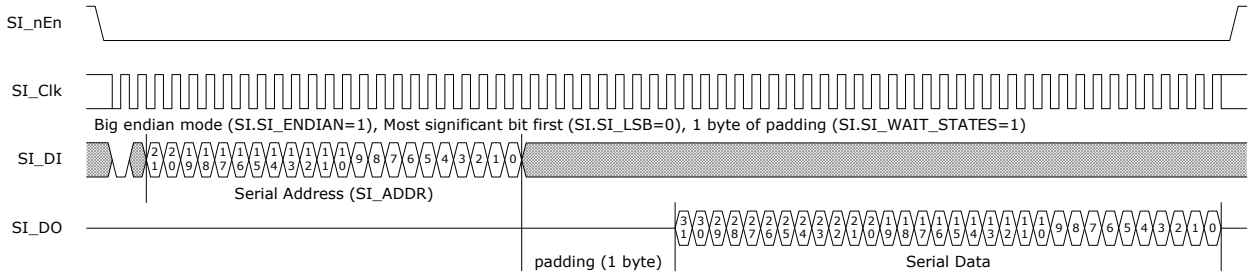


Figure 53 • **Read Sequence for One-Byte Padding**



When using SI, the external CPU must first configure the SI register after power-up, reset, or chip-level soft reset. To configure the device into a known state

1. Write 0 to the SI register.
2. Write the desired configuration using data formatted as little endian with most significant bit first.

5.7.3 Parallel Interface in Slave Mode

This section provides information about the functions of the parallel interface (PI) when working in slave mode.

The following table lists the registers associated with PI slave mode.

Table 125 • **PI Slave Mode Registers**

Register	Description
PI_MODE	Controls endianess and done pin polarity

Table 125 • **PI Slave Mode Registers *(continued)***

Register	Description
PI_CTRL	Configuration of slow access methods
PI_CFG	Configuration of PI accesses
PI_STAT	Status for PI accesses
PI_SLOW_DATA	Slow access registers (two replications)

The parallel interface allows an external CPU to do read and write access to 32-bit register targets inside the device. Endianess is configurable. Several different access methods are also supported.

All parallel interface pins on the device are overlaid functions on the GPIO interface. PI slave mode is enabled by appropriate configuration of the VCORE_CFG strapping pins. When PI slave mode is enabled, the appropriate GPIO pins are automatically overtaken. For more information, see **GPIO Overlaid Functions**, page 176. For more information about configuring the VCORE_CFG strapping pins, see VCore-III System and CPU Interface, page 131.

The following table lists the pins of the parallel interface.

Table 126 • **PI Slave Mode Pins**

Pin Name	I/O	Description
PI_nCS, GPIO	I	Active low chip select.
PI_Addr[3:0], GPIO	I	These are the address lines, PI_Addr[1:0] can be left unconnected unless auto (sub-word) addressing is disabled.
PI_nWR, GPIO	I	Active low write enable.
PI_nOE, GPIO	I	Active low output enable.
PI_Data[7:0], GPIO	I/O	These are the data lines.
PI_nDone, GPIO	OZ	An external device can use this output to detect when transfers are done, and thereby optimize the speed of transfers.

PI_Data is driven by the device when PI_nCS and PI_nOE are both asserted. PI_nDone is driven when PI_nCS is asserted. The drive of PI_nDone is extended a short period after PI_nCS is deasserted, which gives the device time to “park” the PI_nDone signal as inactive before it is released.

The external CPU initiates access by asserting chip select and then driving the appropriate control signals. The timing of the parallel interface is asynchronous; it takes the device from 5 ns to 15 ns to detect an asserted chip select. After detecting chip select, the device waits a configurable amount of time (PI_CFG.PI_WAIT) and then sample PI_Addr, PI_nWR, and PI_Data (PI_Data is only sampled when writing to the device).

To access registers in the device, 32-bit reads and writes must be performed. Because the PI width is 8 bits, four sequential PI accesses are needed for each register access. By default, the parallel interface automatically keeps track of outstanding accesses and aligns current PI_Data appropriately. This feature is called auto (subword) addressing, which is when active PI_Addr[1:0] pins are don’t care and can be left unconnected. Automatic (sub-word) addresses can be disabled by setting PI_MODE.ADDR_AUTO_DIS. When disabled, the external CPU must drive PI_Addr[1:0].

With the register address of a specific register (REG_ADDR), the PI address (PI_ADDR) is calculated as:

```
PI_ADDR = REG_ADDR - 0x60000000
```

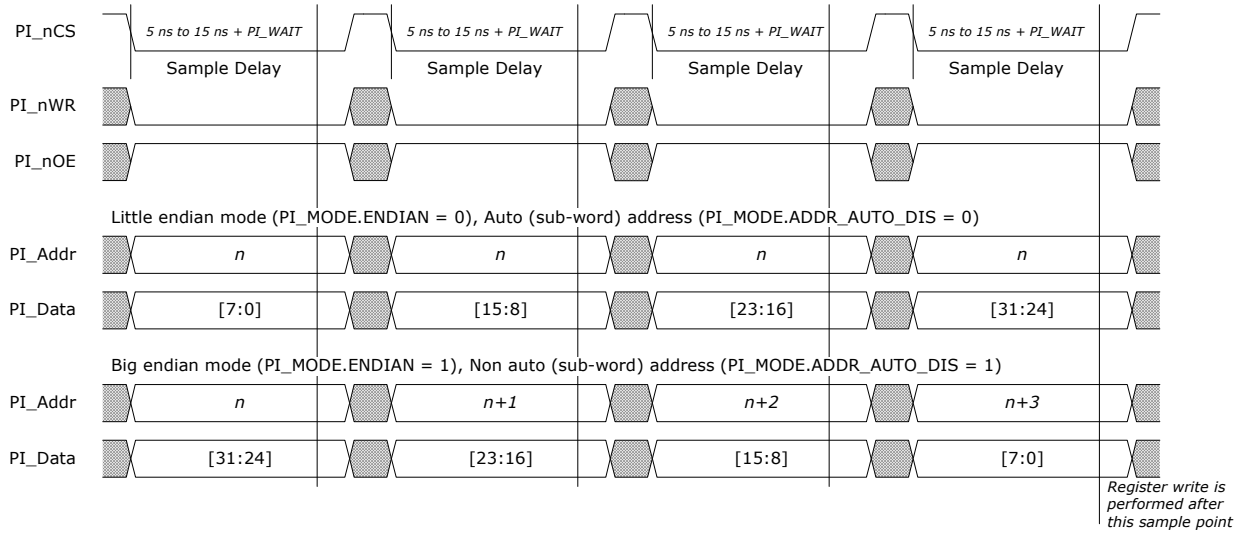
Note: The parallel interface is byte addressable, because 8-bit mode is supported. However, by default, PI_Addr[1:0] is not used due to the auto (subword) address feature.

The device only has the lower four address bits mapped to GPIO pins. A windowed mode is used for accessing the full range of parallel addresses (PI_ADDR). For more information, see **Windowed Addressing Mode**, page 165.

The endianess of the parallel interface is configured through PI_MODE.ENDIAN. The following two illustrations show two configurations of the parallel interface, and how, when auto (subword) addressing is enabled, PI_Addr[1:0] is a don't care and to be left unconnected (this is why the first configuration uses the same address for all accesses). For second configuration the external CPU drives PI_Addr[1:0] (and increments these for each 8-bit write access).

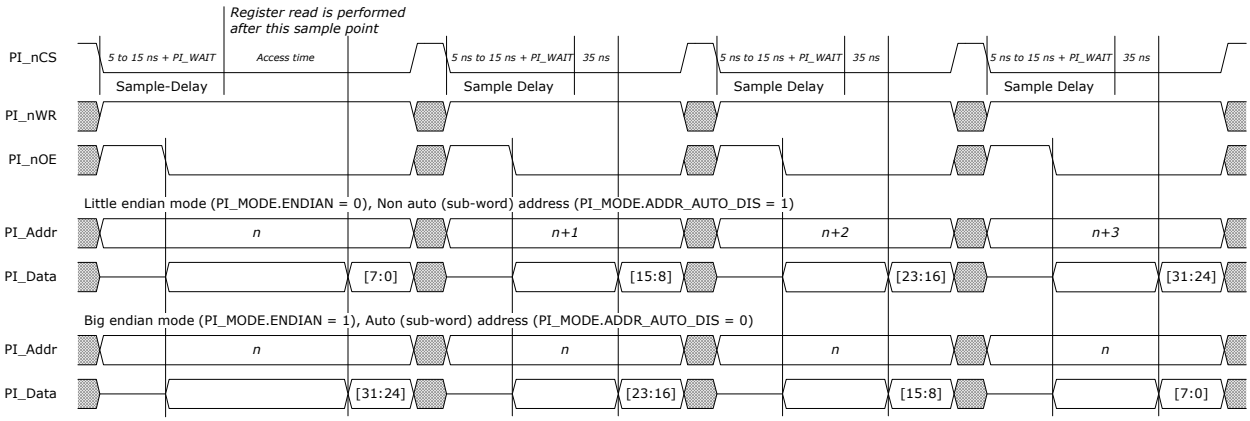
The following illustration shows the write sequence for the parallel interface. This example depicts that the actual register write is performed after the last sample point, which means that a subsequent access on the parallel interface must not be performed until the access is done. For more information about access time for different register targets, see Register Access and Multimaster Systems, page 159.

Figure 54 • **Write Sequence for PI**



When reading registers using the parallel interface, the first access on the parallel interface is subjected to fetching of register data. The access time of the register, which is read, must be satisfied before the external CPU can sample the read-data. The remaining accesses (reading the rest of the 32-bit register data) have an access time equal to reading from the DEVCPU_PI target. For more information about access time see Register Access and Multimaster Systems, page 159.

Figure 55 • **Read Sequence for PI**



When using PI, the first thing the external CPU must do after power-up, reset, or chip-level soft reset is to configure the PI_MODE register. Perform two writes to PI_MODE register with the desired configuration

mirrored throughout the entire 32-bit data word. For more information, see the PI_MODE register. information.

5.7.3.1 Using PI_nDone to Speed Up Register Access

The parallel interface provides the PI_nDone signal, which is driven during all accesses on the parallel interface.

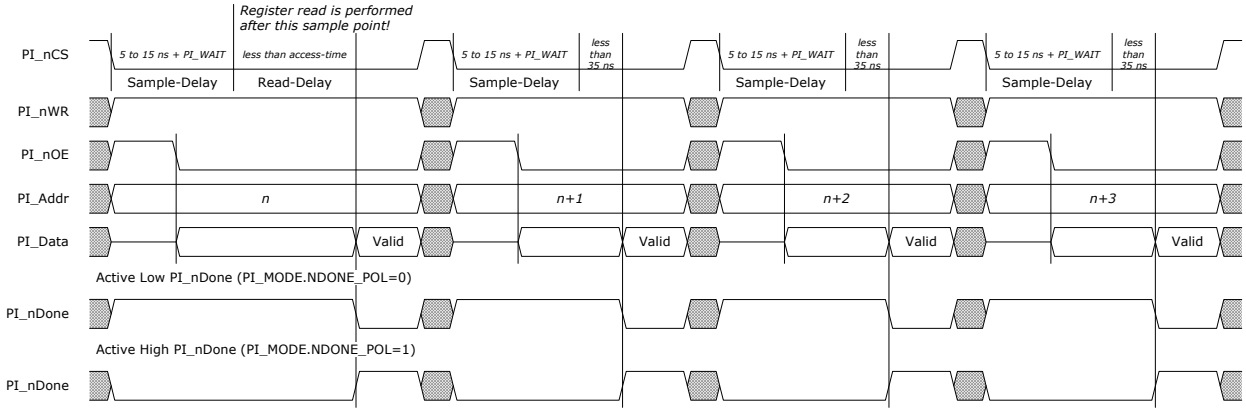
The PI_nDone signal shows when the parallel interface is done with a given access. By monitoring the PI_nDone signal, and terminating accesses when the PI_nDone signal is asserted, an external CPU uses exactly the amount of time that each access requires. The polarity of the PI_nDone is configurable through PI_MODE.NDONE_POL.

When using PI_nDone, an external CPU does not have to take any precautions with regards to the access time parameter. For more information, see Register Access and Multimaster Systems, page 159.

Note The access time is a worst-case parameter. Access to Normal Targets when using PI_nDone is typically done after 0.5 µs. Using PI_nDone significantly speeds up access to the parallel interface.

The following illustration shows an example of reading with the PI_nDone signal.

Figure 56 • **PI Read Sequence Using PI_nDone**



Writing is similar, however, because the parallel interface cache writes, the actual register write occurs after the last write access to a given register. When using PI_nDone timing, the subsequent access after writing to the device can be performed immediately. The PI_nDone signaling takes in account additional delay required for finishing the (previous) write access.

5.7.3.2 Using Paged Access to Get Fixed PI Timing

By enabling paged access, all parallel access to the device has timing as if it was directly accessing the DEVCPU_PI target (Fast Target). This means that an external CPU does not have to change I/O timing, depending on the register target that is accessed.

Paging is enabled using PI_CTRL.SLOW_ENA. Access to any register target other than DEVCPU_PI is paged. Paging works by storing read and write values internally inside the parallel interface, write values are cached, and read values, when ready, are available in the PI_SLOW_DATA registers. Which of the PI_SLOW_DATA registers to use for a specific paged access is configured in PI_CTRL.SLOW_IDX.

The external CPU can see when accesses are done by polling PI_STAT.SLOW_BUSY field corresponding to the PI_CTRL.SLOW_IDX is used. The PI_STAT.SLOW_DONE field shows when read data is available in the corresponding PI_SLOW_DATA register. The PI_STAT.SLOW_DONE indications are also available to the VCore-III interrupt controller through the PI_SD0 and PI_SD1 interrupts. By means of the interrupt controller, done-indications can be mapped to external interrupt outputs so that an external CPU can use these when waiting for paged reads to complete.

Note: The PI_SLOW_DATA, PI_STAT.SLOW_BUSY, and PI_STAT.SLOW_DONE are replicated two times, which allows two different threads on an external CPU to use their own dedicated paging logic. This is useful when, for example, an interrupt thread needs access to the device in parallel with normal device

access. The interrupt routine must configure PI_CTRL.SLOW_IDX at the start of the interrupt-routine and reset it before returning.

Paged accesses are cached and handled internally inside the parallel interface. Use the following sequence to perform a paged read of the DEVCPU_GCB::GENERAL_PURPOSE register:

1. Perform a register read from DEVCPU_GCB::GENERAL_PURPOSE, ignore the read-data.
2. Wait until the read access is done. Either poll PI_STAT.SLOW_DONE or examine external interrupt output.
3. Read the result of the read from the PI_SLOW_DATA register corresponding to the PI_CTRL.SLOW_IDX that was set when the register read was performed.

Writing is similar to reading; again the same register is used as an example:

1. Perform register write to DEVCPU_GCB::GENERAL_PURPOSE.
2. Do not start a new access until the write access is done, poll PI_STAT.SLOW_BUSY until done.

When mapping done indications using the VCore-III interrupt controller, it is recommended that you disable interrupt stickiness so that reading the PI_SLOW_DATA registers also clears the external interrupt indication. For more information, see Interrupt Controller, page 183.

5.7.3.3 Windowed Addressing Mode

The parallel interface allows configuration of address offset through an address window. The address window is accessed by writing to or reading from the highest register address (highest possible 32-bit word address). When windowed addressing is used; the address window must be configured prior to accessing a device register. The address window is not changed by hardware; subsequent accesses to the same register do not require re-configuration of the address window.

Note: The internal register address is 22 bits wide (excluding the byte addresses). Only the lowest four parallel address pins are provided on the GPIO interface. All other addresses are tied high internally in the parallel interface. When an external CPU drives both PI_Addr[3:2] pins high, it is accessing the address window register.

The address window register is physically a part of the parallel interface and is not listed in the register list.

An external CPU that cannot or does not want to drive all PI_Addr wires can use widowed mode to access the device. Unused PI_Addr connections must be left floating or tied high.

By using both the auto (sub word) addressing feature and address window mode; an external CPU can connect to as few as one address pin (PI_Addr[2]) and still control the device.

The address window register is all-ones per default. If bits [23:3] in the address window register are set to 0, then the corresponding parallel address [23:3] are also forced to 0. If bit [2] in the address window register set to 0, then parallel address [2] is forced to 1. Bits [31:26] and [1:0] are not implemented and read as zeros; bits [25:24] must always be written to 11.

Example: Read from to DEVCPU_ORG::ERR_CNTS using PI_Addr[3:2]. All other PI_Addr pins have been left floating and auto (sub word) addressing has not been disabled. DEVCPU_ORG has id 0 and ERR_CNTS has register address 3. After programming address window to 0x03000008 (by writing to PI_Addr[3:2] = 11),ERR_CNTS is accessible on PI_Addr[3:2] = 01.

5.7.4 MIIM Interface in Slave Mode

This section provides the functional aspects of the MIIM slave interface.

Note: The MIIM slave I/F, due to its low bandwidth, is not aimed at supporting or recommended for managed switch applications.

The MIIM slave interface allows an external CPU to perform read and write access to the register targets inside the device. Register access is done indirectly, because the address and data fields of the MIIM protocol is less than those used by the register targets. Transfers on the MIIM interface are using the Management Frame Format protocol specified in IEEE 802.3, Clause 22.

The MIIM slave pins on the device are overlaid functions on the GPIO interface. MIIM slave mode is enabled by configuring the appropriate VCORE_CFG strapping pins. For more information, see VCore-III

System and CPU Interface, page 131. When MIIM slave mode is enabled, the appropriate GPIO pins are automatically overtaken. For more information, see **GPIO Overlaid Functions**, page 176.

The following table lists the pins of the MIIM slave interface.

Table 127 • **MIIM Slave Pins**

Pin Name	I/O	Description
MDC_SLV, GPIO	I	MIIM slave clock input
MDIO_SLV, GPIO	I/O	MIIM slave data input/output
MIIM_SLV_ADDR, GPIO	I	MIIM slave address select

MDIO_SLV is sampled or changed on the rising edge of MDC_SLV by the MIIM slave interface.

The MIIM slave can be configured to answer on two different PHY addresses using the MIIM_SLV_ADDR pin. Setting the MIIM_SLV_ADDR pin to 0 configures the MIIM slave to use PHY address 0, and setting it to 1 configures the MIIM slave to use PHY address 31.

The MIIM slave has seven 16-bit MIIM registers defined as listed in the following table.

Table 128 • **MIIM Registers**

Register Address	Register Name	Description
0	ADDR_REG0	Bit 15:0 of the address to read or write. The address field must be formatted as a word address.
1	ADDR_REG1	Bit 31:16 of the address to read or write.
2	DATA_REG0	Bit 15:0 of the data to read or write. Returns 0x0000 if a register read error occurred.
3	DATA_REG1	Bit 31:16 of the data to read or write. The read or write operation is initiated after this register is read or written. Returns 0x8000 if read while busy or a register read error occurred.
4	DATA_REG1_INCR	Bit 31:16 of data to read or write. The read or write operation is initiated after this register is read or written. When the operation is complete, the address register is incremented by one. Returns 0x8000 if read while busy or if a register read error occurred.
5	DATA_REG1_INERT	Bit 31:16 of data to read or write. Reading or writing to this register will not cause a register access to be initiated. Returns 0x8000 if a register read error occurred.
6	STAT_REG	The status register gives the status of any ongoing operations. Bit 0: Busy - Is set while a register read/write operation is in progress. Bit 1: Busy_rd - the busy status during the last read or write operation. Bit 2: Err - Is set if a register access error occurred. Others: Reserved.

A 32-bit register read or write transaction over the MIIM interface is done indirectly due to the limited data width of the MIIM frame. First, the address of the register inside the device must be set in the two 16-bit address registers of the MIIM slave using two MIIM write transactions. Afterwards the two 16-bit data registers can be read/written to access the data value of the register inside the device. Thus, it requires up to four MIIM transactions to perform a single read or write operation on a register target.

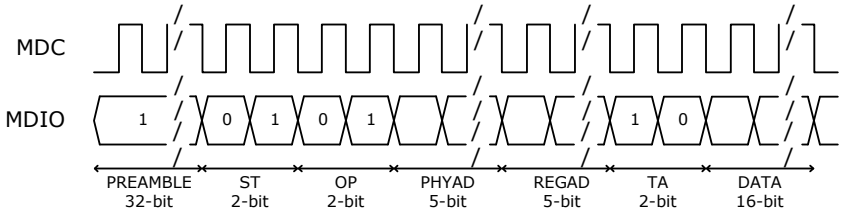
The address of the register to read/write is set in registers ADDR_REG0 and ADDR_REG1. The data to write to the register pointed to by the address in ADDR_REG0 and addr_reg1 is first written to DATA_REG0 and then to DATA_REG1. When the write transaction to DATA_REG1 is completed, the MIIM slave initiates the register transaction.

With the register address of a specific register (REG_ADDR), the MIIM address (MIIM_ADDR) is calculated as:

```
MIIM_ADDR = (REG_ADDR - 0x60000000)>>2
```

The following illustration shows a single MIIM write transaction on the MIIM interface.

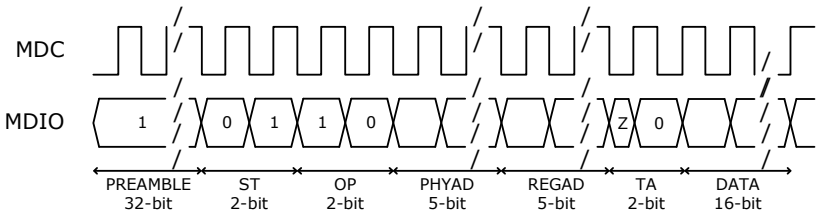
Figure 57 • **MIIM Slave Write Sequence**



A reading transaction is done in a similar way. First, read the DATA_REG0 and then read the DATA_REG1. As with a write operation. The register transaction is not initiated before the DATA_REG1 register is read. In other words, the returned read value is from the previous read transaction.

The following illustration shows a single MIIM read transaction on the MIIM interface.

Figure 58 • **MIIM Slave Read Sequence**



5.7.5 Access to the VCore-III Shared Bus

This section provides information about how to access the VCore-III shared bus (SBA) from an external CPU. The following table lists the registers associated with the VCore-III shared bus access.

Table 129 • VCore-III **Shared Bus Access Registers**

Register	Description
VA_CTRL	Status for ongoing accesses
VA_ADDR	Configuration of shared bus address
VA_DATA	Data register
VA_DATA_INCR	Data register, access increments VA_ADDR
VA_DATA_INERT	Data register, access does not start new accesses

An external CPU perform 32-bit reads and writes to the SBA through the VCore Access (VA) registers. In the VCore-III system, there is a dedicated master on the shared bus that handles VA accesses. For information about arbitration between masters on the shared bus, see Shared Bus Arbitration, page 135.

The SBA address is configured in VA_ADDR. Accessing the VA_DATA register starts an SBA access. Writing to VA_DATA starts a write with the 32-bit value that was written to VA_DATA. Reading from VA_DATA returns the current value of the register and starts a read access, when the read-access completes the result will automatically be stored in the VA_DATA register.

The VA_DATA_INCR register behaves like VA_DATA, except that after starting an access the VA_ADDR register is incremented by 4 (so that it points to the next word address in the SBA domain). Reading from the VA_DATA_INCR register returns the value of VA_DATA, writing to VA_DATA_INCR overwrites the value of VA_DATA.

Note By using VA_DATA_INCR, sequential addresses can be accessed without having to manually increment the VA_ADDR register between each access.

The VA_DATA_INERT register provides direct access to the VA_DATA value without starting accesses on the SBA. Reading from the VA_DATA_INERT register returns the value of VA_DATA, writing to VA_DATA_INERT overwrites the value of VA_DATA.

The VCore-III shared bus is capable of returning error-indication when illegal register regions are accessed. If a VA access result in an error-indication from the SBA, the VA_CTRL.VA_ERR field is set, and the VA_DATA is set to 0x80000000.

Note: SBA error indications only occur when non-existing memory regions or illegal registers are accessed. It does not occur during normal operation, so the VA_CTRL.VA_ERR indication is useful during debugging only.

Example: Reading from ICPU_CFG::GRP[1] through the VA registers. The ICPU_GPR register is the second register in the SBA VCore-III Registers region. Set VA_ADDR to 0x70000004, read once from VA_DATA (and discard the read-value). Wait until VA_CTRL.VA_BUSY is cleared, then VA_DATA contains the value of the ICPU_CFG::GRP[1] register. Using VA_DATA_INERT (instead of VA_DATA) to read the data is appropriate because this does not start a new SBA access.

5.7.5.1 Optimized Reading

SBA access is typically much faster than the CPU interface, which is used to access the VA registers. The VA_DATA register (VA_DATA_INCR and VA_DATA_INERT) return 0x80000000 while VA_CTRL.VA_BUSY is set. This means that it is possible to skip checking for busy between read access to SBA.

For example, after initiating a read access from SBA, software can proceed directly to reading from VA_DATA, VA_DATA_INCR, or VA_DATA_INERT.

- If the second read is different from 0x80000000; then the second read returned valid read data (the SBA access was done before the second read was performed).
- If the second read is equal to 0x80000000; VA_CTRL must be read.

  If VA_CTRL.VA_BUSY_RD is cleared (and VA_CTRL.VA_ERR_RD is also cleared), then 0x80000000 is the actual read data

  If VA_CTRL.VA_BUSY_RD is set, the SBA access was not yet done at the time of the second read. Start over again by repeating the read from VA_DATA.

Optimized reading can be used for single-read access (reading VA_DATA and then VA_DATA_INERT). For sequential reads (reading VA_DATA_INCR several times), the VA_ADDR is only incremented on successful (non-busy) reads.

5.7.6 Mailbox and Semaphores

This section provides information about the semaphores and mailbox features for CPU to CPU communication. The following table lists the registers associated with mailbox and semaphore.

Table 130 • **Mailbox and Semaphore Registers**

Register	Description
SEMA	Taking of semaphores, replicated per semaphore.
SEMA_FREE	Current status for all semaphores.
SEMA_INTR_ENA	Enable software interrupt on free semaphores.

Table 130 • **Mailbox and Semaphore Registers *(continued)***

Register	Description
SEMA_INTR_ENA_CLR	Atomic clear of the SEMA_INTR_ENA register.
SEMA_INTR_ENA_SET	Atomic set of the SEMA_INTR_ENA register.
SW_INTR	Asserting of software interrupts.
MAILBOX	Mailbox.
MAILBOX_CLR	Atomic clear of bits in the mailbox register.
MAILBOX_SET	Atomic set of bits in the mailbox register.

The device implements eight independent semaphores. The semaphores are controlled through the SEMA register. The SEMA register is replicated once per semaphore; SEMA[0] corresponds to the first semaphore, SEMA[1] the second semaphore, and so on.

Any CPU can attempt to take a semaphore n by reading SEMA[n].SEMA. If the result is 1, the semaphore was successfully taken and is now owned by the CPU. If the result is 0, the semaphore was not free. After a CPU successfully takes a semaphore, all additional reads from the corresponding SEMA register will return 0. To release semaphore *n*, a CPU must write 1 to SEMA[n].SEMA.

Note: Any CPU can release semaphores; it does not have to the one that has taken the semaphore, this allows implementation of handshaking protocols.

The current status for all semaphores is available in SEMA_FREE.SEMA_FREE.

A software interrupt can be generated when one or more semaphores are free. Interrupt is enabled in SEMA_INTR_ENA.SEMA_INTR_ENA, atomic set and clear are possible through SEMA_INTR_ENA_CLR and SEMA_INTR_ENA_SET. Semaphores [3:0] can trigger SW0 interrupt when enabled and semaphores [7:4] can trigger SW1 interrupt.

The currently interrupting semaphores are available through SEMA_INTR_ENA.SEMA_INTR_IDENT; this field is the result of a logical AND between SEMA_INTR_ENA.SEMA_INTR_ENA and SEMA_FREE.SEMA_FREE.

In addition to interrupting on free semaphores, a software interrupt can be manually set by writing to SW_INTR.SW0_INTR or SW_INTR.SW1_INTR, these fields are self-clearing.

Note: Software interrupts (SW0 and SW1) can be mapped independently by means of the VCore-III interrupt controller to either VCore-III CPU or external interrupt outputs.

The mailbox is a 32-bit register that can be set and cleared atomically using any CPU interface (including the VCore-III CPU). The MAILBOX register allows reading (and writing) of the current mailbox value. Atomic clear of specific bits in the mailbox register is done by writing a mask to MAILBOX_CLR. Atomic setting of specific bits in the mailbox register is done by writing a mask to MAILBOX_SET.

5.8 VCore-III System Peripherals

This section describes the subblocks of the VCore-III system. They are primarily intended to be used by the VCore-III CPU. However, an external CPU can access and control these through the shared bus.

5.8.1 Timers

This section provides information about the timers. The following table lists the registers associated with timers.

Table 131 • **Timer Registers**

Register	Description	Replication
TIMER_CTRL	Enable/disable timer	Per timer
TIMER_VALUE	Current timer value	Per timer

Table 131 • **Timer Registers *(continued)***

Register	Description	Replication
TIMER_RELOAD_VALUE	Value to load when wrapping	Per timer
TIMER_TICK_DIV	Common timer-tick divider	None

There are three decrementing 32-bit timers in the VCore-III system that run from a common divider. The common divider is driven by a fixed 250 MHz clock and can generate timer ticks in the range of 0.1 µs (10 MHz) to 1 ms (1 kHz), configurable through TIMER_TICK_DIV. The default timer tick is 100 µs (10 kHz).

Note: The timers are independent of the VCore-III CPU frequency, because the common divider uses a fixed clock.

Software can access each timer value through the TIMER_VALUE registers. These can be read or written at any time, even when the timers are active.

When a timer is enabled through TIMER_CTRL.TIMER_ENA, it decrements from the current value until it reaches zero. An attempt to decrement a TIMER_VALUE of zero generates interrupt and assigns TIMER_VALUE to the contents of TIMER_RELOAD_VALUE. Interrupts generated by the timers are send to the VCore-III interrupt controller. From here, interrupts can be forwarded to the VCore-III CPU or to an external CPU. For more information, see Interrupt Controller, page 183.

By setting TIMER_CTRL.ONE_SHOT_ENA the timer disables itself after generating one interrupt. When this field is cleared, timers will decrement, interrupt, and reload indefinitely (or until disabled by software, that is, by clearing of TIMER_CTRL.TIMER_ENA).

A timer can be reloaded from TIMER_RELOAD_VALUE at the same time as it is enabled by setting both TIMER_CTRL.FORCE_RELOAD and TIMER_CTRL.TIMER_ENA.

Example: Configure Timer0 So That It Interrupts Every 1 ms. With the default timer tick of 100 µs ten timer ticks are needed for a timer that wraps every 1 ms. Configure TIMER_RELOAD_VALUE[0] to 0x9. Then enable the timer and force a reload by setting TIMER_CTRL[0].TIMER_ENA and TIMER_CTRL[0].FORCE_RELOAD at the same time.

5.8.2 UART

This section provides information about the UART (Universal Asynchronous Receiver/Transmitter) controller.

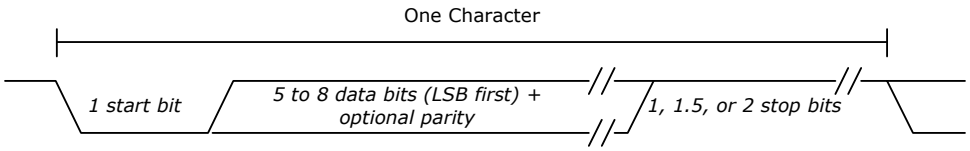
The following table lists the registers associated with the UART.

Table 132 • **UART Registers**

Register	Description
RBR_THR	Receive buffer/transmit buffer/Divisor (low)
IER	Interrupt enable/Divisor (high)
IIR_FCR	Interrupt identification/FIFO control
LCR	Line control
MCR	Modem control
LSR	Line status
MSR	Modem status
SCR	Scratchpad
USR	UART status

The VCore-III system UART is functionally based on the industry-standard 16550 UART (RS232 protocol). This implementation features a 16-byte receive and a 16-byte transmit FIFO.

Figure 59 • **UART Timing**



The number of data-bits, parity, parity-polarity, and stop-bit length are all programmable using LCR.

The UART pins on the device are overlaid functions on the GPIO interface. Before enabling the UART, the VCore-III CPU must enable overlaid modes for the appropriate GPIO pins. For more information, see For more information about enabling the overlaid functionality of the GPIOs, see **GPIO Overlaid Functions**, page 176.

The following table lists the pins of the UART interface.

Table 133 • **UART Interface Pins**

Pin Name	I/O	Description
UART_RX/ GPIO_31	I	UART receive data
UART_TX/GPIO_30	O	UART transmit data

The baud rate of the UART is derived from the VCore-III system frequency. The divider value is indirectly set through the RBR_THR and IER registers. The baud rate is equal to the VCore-III system clock frequency divided by sixteen multiplied by the value of the baud rate divisor. A divider of zero disables the baud rate generator and no serial communications occur. The default value for the divisor register is zero.

Example: Configure a baud rate of 9600 in a 125 MHz system. To generate a baud rate of 9600, the divisor register must be set to 0x32E (125 MHz/(16 × 9600 Hz)). Set LCR.DLAB and write 0x2E to RBR_THR and 0x03 to IER (this assumes that the UART is not in use). Finally, clear LCR.DLAB to change the RBR_THR and IER registers back to the normal mode.

By default, the FIFO mode of the UART is disabled. Enabling the 16-byte receive and 16-byte transmit FIFOs (through IIR_FCR) is recommended.

Note: Although the UART itself supports RTS and CTS, these signals are not available on the pins of the device.

5.8.2.1 UART Interrupt

The UART can generate interrupt whenever any of the following prioritized events are enabled (through IER):

- Receiver error
- Receiver data available
- Character timeout (in FIFO mode only)
- Transmit FIFO empty or at or below threshold (in programmable THRE interrupt mode)

When an interrupt occurs, the IIR_FCR register can be accessed to determine the source of the interrupt. Note that the IIR_FCR register has different purposes when reading or writing. When reading, the interrupt status is available in bits 0 through 3. For more information about interrupts and how to handle them, see the IIR_FCR register description.

Example: Enable Interrupt When Transmit FIFO is Below One-Quarter Full. To get this type of interrupt, the THRE interrupt must be used. First, configure TX FIFO interrupt level to one-quarter full by setting IIR_FCR.TET to 10; at the same time, ensure that the IIR_FCR.FIFOE field is also set. Set IER.PTIME to enable the THRE interrupt in the UART. In addition, the VCore-III interrupt controller must be configured for the CPU to be interrupted. For more information, see Interrupt Controller, page 183.

5.8.3 Two-Wire Serial Interface

This section provides information about the functions of the two-wire serial interface controller.

The following table lists the registers associated with the two-wire serial interface.

Table 134 • **Two-Wire Serial Interface Registers**

Register	Description
CFG	General configuration
TAR	Target address
SAR	Slave address
DATA_CMD	Receive/transmit buffer and command
SS_SCL_HCNT	Standard speed high time clock divider
SS_SCL_LCNT	Standard speed low time clock divider
FS_SCL_HCNT	Fast speed high time clock divider
FS_SCL_LCNT	Fast speed low time clock divider
INTR_STAT	Masked interrupt status
INTR_MASK	Interrupt mask register
RAW_INTR_STAT	Unmasked interrupt status
RX_TL	Receive FIFO threshold for RX_FULL interrupt
TX_TL	Transmit FIFO threshold for TX_EMPTY interrupt
CLR_*	Individual CLR_* registers are used for clearing specific interrupts. See register descriptions for corresponding interrupt.
CTRL	Control register
STAT	Status register
TXFLR	Current transmit FIFO level
RXFLR	Current receive FIFO level
TX_ABRT_SOURCE	Arbitration sources
SDA_SETUP	Data delay clock divider
ACK_GEN_CALL	Acknowledge of general call
ENABLE_STATUS	General two-wire serial controller status
TWI_CONFIG	Configuration of SDA hold-delay

The two-wire serial interface controller is compatible with the industry standard two-wire serial interface protocol. The controller supports standard speed up to 100 kbps and fast speed up to 400 kbps. Multiple bus masters, as well as both 7-bit and 10-bit addressing are also supported.

By default, the two-wire serial interface controller operates as master only (CFG.MASTER_ENA), however, slave mode can be enabled (CFG.SLAVE_DIS). In slave mode, the controller generates an interrupt when addressed by an external master. For read requests, the controller then halts the two-wire serial bus until the VCore-III CPU has processed the request and provided a response (reply-data) to the controller. The slave addresses (SAR) of the two-wire serial interface controller must be unique on the two-wire serial interface bus. This must be configured before enabling slave mode. For information about addresses that have a special meaning on the bus, see **Two-Wire Serial Interface Addressing**, page 173.

The two-wire serial interface pins on the device are overlaid functions on the GPIO interface. Before enabling the two-wire serial interface, the VCore-III CPU must enable overlaid functions for the appropriate GPIO pins. For more information, see **GPIO Overlaid Functions**, page 176.

The following table lists the pins of the two-wire serial interface.

Table 135 • **Two-Wire Serial Interface Pins**

Pin Name	I/O	Description
TWI_SCL, GPIO	O	Two-wire serial interface clock, open-collector output.
TWI_SDA, GPIO	I/O	Two-wire serial interface data, open-collector output.

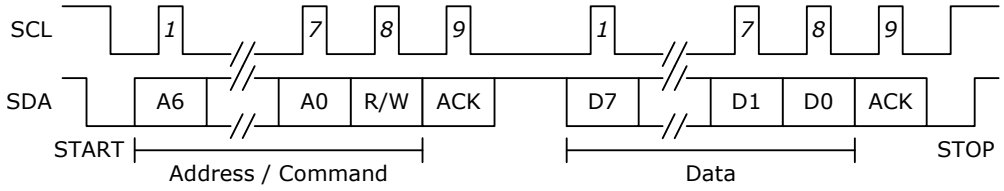
Setting CTRL.ENABLE enables the controller. The controller can be disabled by clearing the CTRL.ENABLE field, there is a chance that disabling is not allowed (at the time when it is attempted); the ENABLE_STATUS register shows if the controller was successful disabled.

Before enabling the controller, the user must decide on either standard or fast mode (CFG.SPEED) and configure clock dividers for generating the correct timing (SS_SCL_HCNT, SS_SCL_LCNT, FS_SCL_HCNT, FS_SCL_LCNT, and SDA_SETUP). The configuration of the divider registers depends on the VCore-III system clock frequency. The register descriptions explain how to calculate the required values.

Some two-wire serial devices requires a hold time on SDA after SCK when transmitting from the two-wire serial interface controller. The device supports a configurable hold delay through the TWI_CONFIG register.

The two-wire serial interface controller has an 8-byte combined receive and transmit FIFO.

Figure 60 • **Two-Wire Serial Interface Timing for 7-bit Address Access**



During normal operation of the two-wire serial interface controller, the STATUS register shows the activity and FIFO states.

5.8.3.1 Two-Wire Serial Interface Addressing

Use CFG.MASTER_10BITADDR and CFG.SLAVE_10BITADDR to configure either 7 or 10 bit addressing for master and slave modes respectively.

There are a number of reserved two-wire serial interface addresses. The two-wire serial interface controller does not restrict the use of these. However, if they are used out of context, there may be compatibility issues with other two-wire serial devices. The following table lists the two-wire serial interface reserved addresses.

Table 136 • **Reserved Two-Wire Serial Interface Addresses**

Register Address	Description
0000 000	General Call address/START Byte If the slave is enabled the two-wire serial interface controller places the data in the receive buffer and issues a general call interrupt. The acknowledge response is configurable (through ACK_GEN_CALL).
0000 001	CBUS address. The two-wire serial interface controller ignores this address.
0000 01X	Reserved, do not use.
0000 1XX	Reserved, do not use.
1111 1XX	Reserved, do not use.
1111 0XX	10-bit addressing indication, 7-bit address devices must not use this.

The two-wire serial interface controller can general both General Call and START Byte. Initiate this through TAR.GC_OR_START_ENA or TAR.GC_OR_START. When operating as master, the target/slave address is configured using the TAR register.

5.8.3.2 Two-Wire Serial Interface Interrupt

The two-wire serial interface controller can generate a multitude of interrupts. All of these are described in the RAW_INTR_STAT register. The RAW_INTR_STAT register contains interrupt fields that are always set when their “trigger” conditions occur. The INTR_MASK register is used for masking interrupts and allowing interrupts to propagate to the INTR_STAT register. When set in the INTR_STAT register, the two-wire serial interface controller asserts interrupt toward the VCore-III interrupt controller.

The RAW_INTR_STAT register also specifies what is required to clear the specific interrupts. When the source of the interrupt is removed, reading the appropriate CLR_* register (for example, CLR_RX_OVER) clears the interrupt.

5.8.4 MII Management Controller

This section provides information about the MII Management controllers. The following table lists the registers associated with the MII Management controllers.

Table 137 • **MIIM Registers**

Register	Description
MII_STATUS	General configuration
MII_CMD	Target address
MII_DATA	Slave address
MII_CFG	Receive/transmit buffer and command
MII_SCAN_0	Standard speed high time clock divider
MII_SCAN_1	Standard speed low time clock divider
MII_SCAN_LAST_RSLTS	Fast speed high time clock divider
MII_SCAN_LAST_RSLTS_VLD	Fast speed low time clock divider

The device contains two MIIM controllers with equal functionality. Controller 0 is connected to the internal PHY, and controller 1 is used to manage external PHYs. Only the interface of controller 1 is available as pins on the device. Data is transferred on the MIIM interface using the Management Frame Format protocol specified in IEEE 802.3, Clause 22 or the MDIO Manageable Device protocol defined in IEEE 802.3, Clause 45. The clause 45 protocol differs from the clause 22 protocol by using indirect register accesses to increase the address range. The controller supports both Clause 22 and 45.

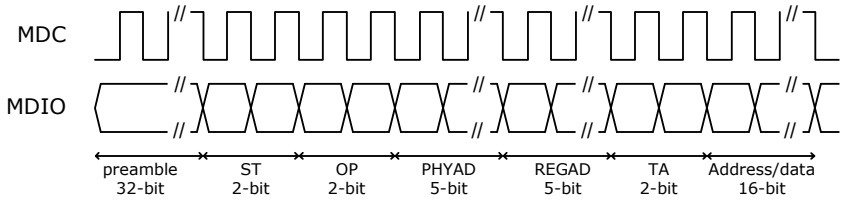
The following table lists the pins of the MIIM interface for controller 1.

Table 138 • **MIIM Management Controller Pins**

Pin Name	I/O	Description
MDC	O	MIIM clock
MDIO	I/O	MIIM data input/output

The MDIO signal is changed or sampled on the falling edge of the MDC clock by the controller. When the controller does not drive the MDIO pin, it is tri-stated.

Figure 61 • **MII Management Timing**



5.8.4.1 Clock Configuration

The frequency of the management interface clock generated by the MIIM controller is derived from the VCore-III system frequency. The MIIM clock frequency is configurable and is selected with MII_CFG.MIIM_CFG_PRESCALE. The calculation of the resulting frequency is explained in the register description for MII_CFG.MIIM_CFG_PRESCALE. The maximum frequency of the MIIM clock is 25 MHz.

5.8.4.2 MII Management PHY Access

Reads and writes across the MII management interface are performed through the MII_CMD register. Details of the operation, such as the PHY address, the register address of the PHY to be accessed, the operation to perform on the register (for example, read or write), and write data (for write operations) are set in the MII_CMD register. When the appropriate fields of MII_CMD are set, the operation is initiated by writing 0x1 to MII_CMD.MIIM_CMD_VLD. The register is automatically cleared when the MIIM command is initiated. When initiating single MIIM commands, MII_CMD.MIIM_CMD_SCAN must be set to 0x0.

When an operation is initiated, the current status of the operation can be read in MII_STATUS. The fields MII_STATUS.MIIM_STAT_PENDING_RD and MII_STATUS.MIIM_STAT_PENDING_WR can be used to poll for completion of the operation. For a read operation, the read data is available in MII_DATA.MIIM_DATA_RDDATA after completion of the operation. The value of MII_DATA.MIIM_DATA_RDDATA is only valid if MII_DATA.MIIM_DATA_SUCCESS indicates no read errors.

The MIIM controller contains a small command FIFO. Additional MIIM commands can be queued as long as MII_STATUS.MIIM_STAT_OPR_PEND is cleared. Care must be taken with read operations, because multiple queued read operations will overwrite MII_DATA.MIIM_DATA_RDDATA.

Note: A typical software implementation will never queue read operations, because the software needs read data before progressing the state of the software. In this case MIIM_STATUS.MIIM_STAT_OPR_PEND is checked before issuing MIIM read or write commands, for read-operations MII_STATUS.MIIM_STAT_BUSY is checked before returning read result.

By default, the MIIM controller operates in clause 22 mode. To access clause 45 compatible PHYs, MII_CFG.MIIM_ST_CFG_FIELD and MII_CMD.MIIM_CMD_OPR_FIELD must be set according to clause 45 mode of operation.

5.8.4.3 PHY Scanning

The MIIM controller can be configured to continuously read certain PHY registers and detect if the read value is different from an expected value. If a difference is detected, a special sticky bit register is set or a CPU interrupt is generated, or both. For example, the controller can be programmed to read the status registers of one or more PHYs and detect whether the Link Status changed since the sticky register was last read.

The reading of the PHYs is performed sequentially with the low and high PHY numbers specified in MII_SCAN_0 as range bounds. The accessed address within each of the PHYs is specified in MII_CMD.MIIM_CMD_REGAD. The scanning begins when a 0x1 is written to MII_CMD.MIIM_CMD_SCAN and a read operation is specified in MII_CMD.MIIM_CMD_OPR_FIELD. Setting MII_CMD.MIIM_CMD_SINGLE_SCAN stops the scanning after all PHYs have been scanned one time. The remaining fields of MII_CMD register is not used when scanning is enabled.

In MII_SCAN_1.MIIM_SCAN_EXPECT the expected value for the PHY register is set. The expected value is compared to the read value after applying the mask set in MII_SCAN_1.MIIM_SCAN_MASK. To “don’t care” a bit-position, write a 0 to the mask. If the expected value for a bit position differs from the

read value during scanning, and the mask register has a 1 for the corresponding bit, a mismatch for the PHY is registered.

The scan results from the most recent scan can be read in MII_SCAN_LAST_RSLTS. The register contains one bit for each of the possible 32 PHYs. A mismatch during scanning is indicated by a 0. MII_SCAN_LAST_RSLTS_VLD will indicate for each PHY if the read operation performed during the scan was successful. The sticky-bit register MII_SCAN_RSLTS_STICKY has the mismatch bit set for all PHYs that had a mismatch during scanning since the last read of the sticky-bit register. When the register is read, its value is reset to all-ones (no mismatches).

5.8.4.4 MII Management Interrupt

The MII management controllers can generate interrupts during PHY scanning. Each MII management controller has a separate interrupt signal to the interrupt controller. Interrupt is asserted when one or more PHYs have a mismatch during scan. The interrupt is cleared by reading the MII_SCAN_RSLTS_STICKY register, which resets all MII_SCAN_RSLTS_STICKY indications.

5.8.5 GPIO Controller

This section provides information about the use of GPIO pins.

The following table lists the registers associated with GPIO.

Table 139 • **GPIO Registers**

Register	Description
GPIO_OUT	Value to drive on GPIO outputs
GPIO_OUT_SET	Atomic set of bits in GPIO_OUT
GPIO_OUT_CLR	Atomic clear of bits in GPIO_OUT
GPIO_IN	Current value on the GPIO pins
GPIO_OE	Enable of GPIO output mode (drive GPIOs)
GPIO_ALT	Enables overlaid GPIO functions
GPIO_INTR	Interrupt on changed GPIO value
GPIO_INTR_ENA	Enables interrupt on changed GPIO value
GPIO_INTR_IDENT	Currently interrupting sources

The GPIO pins are individually programmable. By default, GPIOs are inputs, however, they can be individually changed to outputs through GPIO_OE. For GPIOs that are in input mode, the value of the GPIO pin is reflected in the GPIO_IN register. GPIOs that are in output mode are driven to the value specified in GPIO_OUT.

In a system where multiple different CPU threads (or different CPUs) may work on the GPIOs at the same time, the GPIO_OUT_SET and GPIO_OUT_CLR registers provide a way for each thread to safely control the output value of GPIOs that are under their control, without having to implement locked regions and semaphores.

5.8.5.1 GPIO Overlaid Functions

Most of the GPIO pins have alternate functions that can be enabled through the replicated GPIO_ALT register. The overlaid functions are selected by software on a pin-by-pin basis. For a particular GPIO *n*: Enable overlaid mode 1 by setting GPIO_ALT[0][n] and clearing GPIO_ALT[1][n]. Overlaid mode 2 is enabled by clearing GPIO_ALT[0][n] and setting GPIO_ALT[1][n]. For normal GPIO mode, clear both GPIO_ALT[0][n] and GPIO_ALT[1][n].

For example, to enable the UART_RX and UART_TX overlaid functions, set bits 30 (enable UART_TX) and 31 (enable UART_RX) in the GPIO_ALT[0] register. The UART now has control of the GPIO pins.

When the parallel interface is enabled (either master or slave mode), specific GPIO pins are overtaken and used for the parallel interface. This happens automatically when PI slave mode is enabled through

the VCORE_CFG strapping pins or when the VCore-III CPU enables PI master mode through ICPU_CFG::GENERAL_CTRL.IF_MASTER_PI_ENA.

When the MIIM slave mode is enabled through the VCORE_CFG strapping pins, specific GPIO pins are overtaken and used for the MIIM slave interface. The parallel interface master mode must not be enabled when MIIM slave mode is active.

The following table shows the GPIO pins and their available overlaid functions.

Table 140 • **GPIO Pin Mapping**

Name	Overlaid Function 1	Overlaid Function 2	Parallel Interface	MIIM Slave Interface
GPIO_0	SIO_CLK			
GPIO_1	SIO_LD			
GPIO_2	SIO_DO			
GPIO_3	SIO_DI			
GPIO_4	TACHO			
GPIO_5	TWI_SCL	PHY0_LED1		
GPIO_6	TWI_SDA	PHY1_LED1		
GPIO_7	IEEE1588	PHY2_LED1		
GPIO_8	EXT_IRQ0	PHY3_LED1		
GPIO_9	EXT_IRQ1	PHY4_LED1		
GPIO_10		PHY5_LED1		
GPIO_11		PHY6_LED1		
GPIO_12		PHY7_LED1		
GPIO_13			PI_nCS	
GPIO_14	SI_nEn1		PI_nWR	SLV_ADDR
GPIO_15	SI_nEn2		PI_nOE	SLV_MDC
GPIO_16	SI_nEn3		PI_nDone	SLV_MDIO
GPIO_17		PHY0_LED0	PI_Addr0	
GPIO_18		PHY2_LED0	PI_Addr1	
GPIO_19		PHY2_LED0	PI_Addr2	
GPIO_20		PHY3_LED0	PI_Addr3	
GPIO_21		PHY4_LED0	PI_Data0	
GPIO_22		PHY5_LED0	PI_Data1	
GPIO_23	SFP24_SD	PHY6_LED0	PI_Data2	
GPIO_24	SFP25_SD	PHY7_LED0	PI_Data3	
GPIO_25			PI_Data4	
GPIO_26			PI_Data5	
GPIO_27			PI_Data6	
GPIO_28	SFP23_SD		PI_Data7	
GPIO_29	PWM			
GPIO_30	UART_TX			
GPIO_31	UART_RX			

5.8.5.2 GPIO Interrupt

The GPIO controller continually monitors all inputs and set bits in the GPIO_INTR register whenever a GPIO changes its input value. By enabling specific GPIO pins in the GPIO_INTR_ENA register, a change indication from GPIO_INTR is allowed to propagate (as GPIO interrupt) from the GPIO controller to the VCore-III Interrupt Controller.

The currently interrupting sources can be read from GPIO_INTR_IDENT, this register is the result of a binary AND between the GPIO_INTR and GPIO_INTR_ENA registers.

Note: When the GPIO_INTR_IDENT register is different from zero, the GPIO controller is indicating an interrupt.

5.8.6 Serial GPIO Controller

The VSC7428-12 device features a serial GPIO controller (SIO). By using a serial interface, the SIO controller significantly extends the number of available GPIOs with a minimum number of additional pins on the device. The main purpose of the SIO controller is to connect control signals from SFP modules; however, it can also act as an LED controller.

The SIO controller supports up to 128 serial GPIOs (SGPIOs) organized into 32 ports, with four SGPIOs per port. The following table lists the registers associated with the serial GPIO.

Table 141 • **SIO Registers**

Register	Description	Replication
SIO_INPUT_DATA	Input data	SGPIOs per port (4)
SIO_INT_POL	Interrupt polarity	SGPIOs per port (4)
SIO_PORT_INT_ENA	Interrupt enable	None
SIO_PORT_CONFIG	Output port configuration	Per port (32)
SIO_PORT_ENABLE	Port enable	None
SIO_CONFIG	General configuration	None
SIO_CLOCK	Clock configuration	None
SIO_INT_REG	Interrupt register	SGPIOs per port (4)

The following table lists the pins of the SIO controller. The pins of the SIO controller are overlaid on GPIOs. For more information about enabling the overlaid functionality of the GPIOs, see **GPIO Overlaid Functions**, page 176.

Table 142 • **SIO Controller Pins**

Pin Name	I/O	Description
SIO_CLK/GPIO_0	O	SIO clock output, frequency is configurable using SIO_CLOCK.SIO_CLK_FREQ.
SIO_LD/GPIO_1	O	SIO load data, polarity is configurable using SIO_CONFIG.SIO_LD_POLARITY.
SIO_DO/GPIO_2	O	SIO data output.
SIO_DI/GPIO_3	I	SIO data input.

The SIO controller works by shifting SGPIO values out on SIO_DO though a chain of shift registers on the PCB. After shifting a configurable number of SGPIO bits, the SIO controller asserts SIO_LD, which causes the shift registers to apply the values of the shifted bits to outputs. The SIO controller is also capable of reading inputs, at the same time as shifting out SGPIO values on SIO_DO, it also samples the SIO_DI input. The values sampled on SIO_DI are made available to software.

If the SIO controller is only used for outputs, the use of the load signal is optional. If the load signal is omitted, simpler shift registers (without load) can be used, however, the outputs of these registers will toggle during shifting.

When driving LED outputs, it is acceptable that the outputs will toggle when SGPIO values are updated (shifted through the chain). When the shift frequency is fast, the human eye is not able to see the shifting though the LEDs.

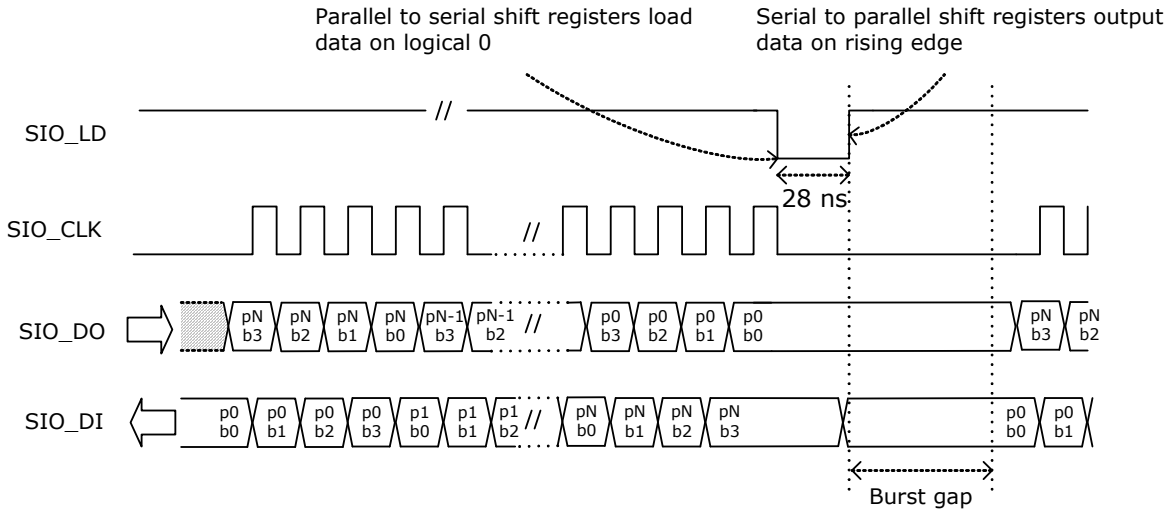
The number of shift registers in the chain is configurable. The SIO controller allows enabling of individual ports through SIO_PORT_ENABLE; only enabled ports are shifted out on SI_DO. Ports that are not enabled are skipped during shifting of GPIO values.

Note: SIO_PORT_ENABLE allows skipping of ports in the SGPIO output stream that are not in use. The number of GPIOs per (enabled) port is configurable as well, through SIO_CONFIG.SIO_PORT_WIDTH this can be set to 1,2,3, or 4 bits. The number of bits per port is common for all enabled ports, so the number of shift registers on the PCB must be equal to the number of enabled ports times the number of SGPIOs per port.

Enabling of ports and configuration of SGPIOs per port applies to both output mode and input mode. Unlike a regular GPIO port, a single SGPIO position can be used both as output and input. That is, software can control the output of the shift register AND read the input value at the same time. Using SGPIOs as inputs requires load-capable shift registers.

Regular shift registers and load-capable shift-registers can be mixed, which is useful when driving LED indications for integrated PHYs at the same time as supporting reading of link status from SFP modules, for example.

Figure 62 • **SIO Timing**



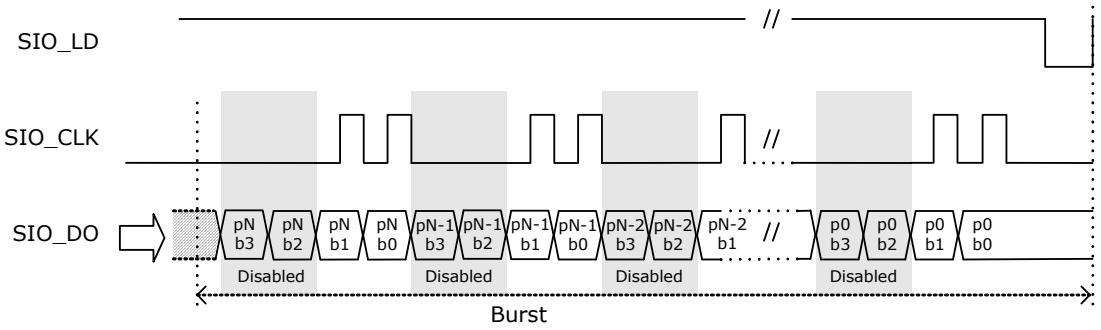
The SGPIO values are output in bursts followed by assertion of the SIO_LD signal. Values can be output as a single burst, or as continuous bursts separated by a configurable burst gap. The maximum length of a burst is 32 × 4 data cycles. The burst gap is configurable in steps of approximately 1 ms between 0 ms and 33 ms through SIO_CONFIG.SIO_BURST_GAP_DIS and SIO_CONFIG.SIO_BURST_GAP.

A single burst is issued by setting SIO_CONFIG.SIO_SINGLE_SHOT. The field is automatically cleared by hardware when the burst is finished. To issue continuous bursts, set SIO_CONFIG.SIO_AUTO_REPEAT. The SIO controller continues to issue bursts until SIO_CONFIG.SIO_AUTO_REPEAT is cleared.

SGPIO output values are configured in SIO_PORT_CONFIG.BIT_SOURCE. The input value is available in SIO_INPUT_DATA.S_IN.

The following illustration shows what happens when the number of SGPIOs per port is configured to 2 (through SIO_CONFIG.SIO_PORT_WIDTH). Disabling of ports (through SIO_PORT_ENABLE) is handled in the same way as disabling the SGPIO ports.

Figure 63 • **SIO Timing with SGPIOs Disabled**



The frequency of the SIO_CLK clock output is configured through SIO_CLOCK.SIO_CLK_FREQ. The SIO_LD output is asserted after each burst, this output is asserted for 28 ns. The polarity of SIO_LD is configurable through SIO_CONFIG.SIO_LD_POLARITY.

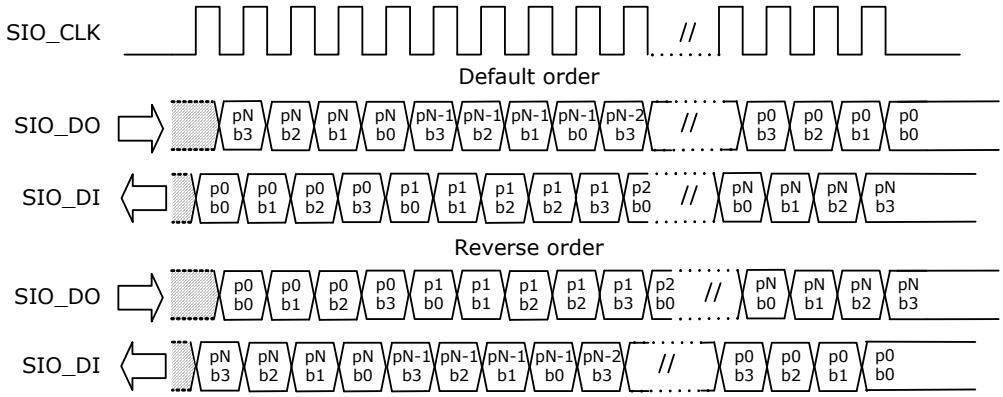
The SIO_LD output can be used to ensure that outputs are stable when serial data is being shifted through the registers. This can be done by using the SIO_LD output to shift the output values into serial-to-parallel registers after the burst is completed. If serial-to-parallel registers are not used, the outputs will toggle while the burst is being shifted through the chain of shift registers. A universal serial-to-parallel shift register outputs the data on a positive-edge load signal, and a universal parallel-to-serial shift register shifts data when the load pin is high, so one common load signal can be used for both input and output serial <-> parallel conversion.

The assertion of SIO_LD happens after the burst to ensure that after power up, the single burst will result in well-defined output registers. Consequently, to sample input values one time, two consecutive bursts must be issued. The first burst results in the input values being sampled by the serial-to-parallel registers, and the second burst shifts the input values into the SIO controller.

The required port order in the serial bitstream depends on the physical layout of the shift register chain. Often the input and output port orders must be opposite in the serial streams. The port order of the input and output bitstream is independently configurable in SIO_CONFIG.SIO_REVERSE_INPUT and SIO_CONFIG.SIO_REVERSE_OUTPUT.

The following illustration shows the port order.

Figure 64 • **SIO Output Order**



5.8.6.1 Output Modes

The output mode of each SGPIO can be individually configured in SIO_PORT_CONFIG.BIT_SOURCE. The SIO controller features three output modes:

- Static
- Blink
- Link activity

Static Mode The static mode is used to assign a fixed value to the SGPIO, for example, fixed 0 or fixed 1.

Blink Mode The blink mode makes the SGPIO blink at a fixed rate. The SIO controller features two blink modes that can be set independently. A SGPIO can then be configured to use either blink mode 0 or blink mode 1. The blink outputs are configured in SIO_CONFIG.SIO_BMODE_0 and SIO_CONFIG.SIO_BMODE_1. To synchronize the blink modes between different devices, reset the blink counter using SIO_CONFIG.SIO_BLINK_RESET. The “burst toggle” mode of blink mode 1 toggles the output with every burst.

Table 143 • **Blink Modes**

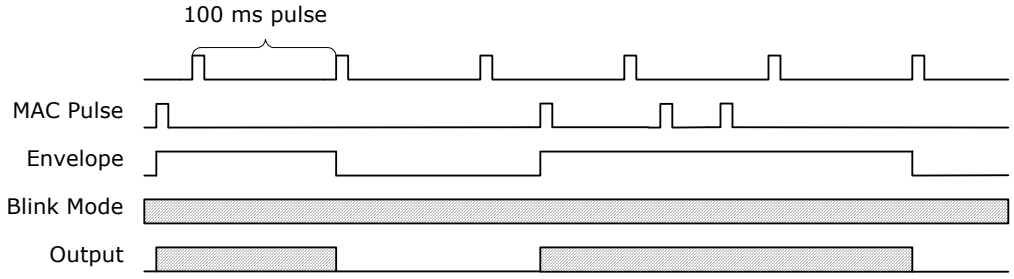
Mode	Description
Blink mode 0	0: 20 Hz blink frequency 1: 10 Hz blink frequency 2: 5 Hz blink frequency 3: 2.5 Hz blink frequency
Blink mode 1	0: 20 Hz blink frequency 1: 10 Hz blink frequency 2: 5 Hz blink frequency 3: Burst toggle

Link Activity Mode The link activity mode makes the output blink when there is activity on the port module (Rx or Tx). The mapping between SIO port number port module number is 1:1, For example, port 0 is connected to port module 0, port 1 is connected to port module 1, and so on.

The link activity mode uses an envelope signal to gate the selected blinking pattern (blink mode 0 or blink mode 1). When the envelope signal is asserted, the output blinks, and when the envelope pattern is de-asserted, the output is turned off. To ensure that even a single packet makes a visual blink, an activity pulse from the port module is extended to minimum 100 ms. If another packet is sent while the envelope signal is asserted, the activity pulse is extended by another 100 ms. The polarity of the link activity modes can be set in SIO_PORT_CONFIG.BIT_SOURCE.

The following illustration shows the link activity timing.

Figure 65 • **Link Activity Timing**



5.8.6.2 SIO Interrupt

The SIO controller can generate interrupts based on the value of the input value of the SGPIOs. All interrupts are level sensitive.

Interrupts are enabled using the two registers. Interrupts can be individually enabled for each port in SIO_PORT_INT_ENA.INT_ENA (32 bits) and in SIO_CONFIG.SIO_INT_ENA (4 bits) interrupts are enabled for the four inputs per port. In other words, SIO_CONFIG.SIO_INT_ENA is common for all 32 ports. The polarity of interrupts is configured for each SGPIO in SIO_INT_POL.

The SIO controller has one interrupt output connected to the main interrupt controller, which is asserted when one or more interrupts are active. To determine which SGPIO is causing the interrupt, the CPU must read the sticky bit interrupt register SIO_INT_REG. The register has one bit per SGPIO and can

only be cleared by software. A bit is cleared by writing a 1 to the bit position. The interrupt output remains high until all interrupts in SIO_INT_REG are cleared.

5.8.6.3 Loss of Signal Detection

The SIO controller can propagate loss of signal detection inputs directly to the signal detection input of the port modules. This is useful when, for example, SFP modules are connected to the device. The mapping between SIO ports and port modules is the same as for the link activity inputs; port 0 is connected to port module 0, port1 is connected to port module 1, and so on.

The value of SGPIO bit 0 of each SIO port is forwarded directly to the loss of signal input on the corresponding device. The device must enable the loss of signal input locally in the device.

Loss of signal can also be taken directly from overlaid functions on the regular GPIOs. When that is the case the input from the SIO controller is ignored. For more information, see **GPIO Overlaid Functions**, page 176.

The polarity of the loss of signal input is configured using SIO_INT_POL, meaning the same polarity must be used for loss of signal detect and interrupt.

5.8.7 FAN Controller

A fan controller that can be used to control and monitor a system fan is included. The fan speed is regulated using a pulse-width-modulation (PWM) output. The fan speed is monitored using a TACHO input. This is especially powerful when combined with the internal temperature sensor (in the PHY).

The following table lists the registers associated with the fan controller.

Table 144 • **Fan Controller Registers**

Register	Description
FAN_CFG	General configuration
FAN_CNT	Fan revolutions counter

The following table lists the pins of the fan controller. The pins of the fan controller are overlaid on GPIOs. For more information about enabling the overlaid functionality of GPIOs, see **GPIO Overlaid Functions**, page 176.

Table 145 • **Fan Controller Pins**

Pin Name	I/O	Description
TACHO/GPIO_4	I	TACHO input for counting revolutions.
PWM/GPIO_29	O	PWM fan output.

The PWM output can be configured to any of the following frequencies in FAN_CFG.PWM_FREQ:

- 10 Hz
- 20 Hz
- 40 Hz
- 60 Hz
- 80 Hz
- 100 Hz
- 120 Hz
- 25 kHz

The low frequencies can be used for driving three-wire fans using a FET/transistor. The 25 kHz frequency can be used for four-wire fans that use the PWM input internally to control the fan. The duty cycle of the PWM output is programmable from 0% to 100%, with 8-bit accuracy. The polarity of the output can be controlled by FAN_CFG.INV_POL, so a duty-cycle of 100%, for example, can be either always low or always high.

The PWM output pin can be configured to act as a normal output or as an open-collector output, where the output value of the pin is kept low, but the output enable is toggled. The open-collector output mode is enabled by setting FAN_CFG.PWM_OPEN_COL_ENA.

Note: By using open-collector mode, it is possible to do external pull-up to higher voltage than the maximum GPIO I/O supply. The GPIOs are 5V-tolerable.

The speed of the fan can be measured using a 16-bit wrapping counter that counts the rising edges on the TACHO-input. A fan usually gives 1-4 pulses per revolution depending on the fan type. Optionally, the TACHO-input can be gated by the polarity-corrected PWM output by setting FAN_CFG.GATE_ENA, so that only TACHO pulses received while the polarity corrected PWM output is high are counted. Glitches on the TACHO-input can occur right after the PWM output goes high, therefore the gate signal is delayed by 10 µs when PWM goes high. There is no delay when PWM goes low, and the length of the delay is not configurable. Software reads the counter value in FAN_CNT and calculates the RPM of the fan.

The following is an example of how to calculate the RPM of the fan: If the fan controller is configured to 100 Hz and a 20% duty cycle, each PWM pulse is high in 2 ms and low in 8 ms. If gating is enabled the gating of the TACHO-input is “open” in 1.99 ms and “closed” in 8.01 ms. If the fan is turning with 100 RPM and gives two TACHO pulses per revolution, it will ideally give 200 pulses per minute. TACHO pulses are only counted in 19.99% of the time, so it will give 200× 0.1999 = 39.98 pulses per minute. If the additional 10 µs gating time is ignored, the counter value is multiplied by 5/2 to get the RPM value, because there is a 20% duty cycle with two TACHO pulses per revolution. By multiplying with 5/2, the RPM value is calculated to 99.95, which is 0.05% off the correct value (due to the 10 µs gating time).

5.8.8 Interrupt Controller

This section provides information about the VCore-III interrupt controller.

The following table lists the registers associated with the interrupt controller.

Table 146 • **Interrupt Controller Registers**

Register	Description
Configuration and status for interrupts	
ICPU_IRQ0_ENA	Global enable of ICPU_IRQ0 interrupt
ICPU_IRQ0_IDENT	Currently interrupting ICPU_IRQ0 sources
ICPU_IRQ1_ENA	Global enable of ICPU_IRQ1 interrupt
ICPU_IRQ1_IDENT	Currently interrupting ICPU_IRQ1 sources
EXT_IRQ0_ENA	Global enable of EXT_IRQ0 interrupt
EXT_IRQ0_IDENT	Currently interrupting EXT_IRQ0 sources
EXT_IRQ1_ENA	Global enable of EXT_IRQ1 interrupt
EXT_IRQ1_IDENT	Currently interrupting EXT_IRQ1 sources
Configuration of individual interrupt sources	
EXT_IRQ0_INTR_CFG	EXT_IRQ0 source configuration
EXT_IRQ1_INTR_CFG	EXT_IRQ1 source configuration
SW0_INTR_CFG	SW0 source configuration
SW1_INTR_CFG	SW1 source configuration
PI_SD0_INTR_CFG	PI_SD0 source configuration
PI_SD1_INTR_CFG	PI_SD1 source configuration
UART_INTR_CFG	UART source configuration
TIMER0_INTR_CFG	TIMER0 source configuration
TIMER1_INTR_CFG	TIMER1 source configuration

Table 146 • **Interrupt Controller Registers *(continued)***

Register	Description
TIMER2_INTR_CFG	TIMER2 source configuration
FDMA_INTR_CFG	FDMA source configuration
TWI_INTR_CFG	TWI source configuration
GPIO_INTR_CFG	GPIO source configuration
SGPIO_INTR_CFG	SGPIO source configuration
DEV_ALL_INTR_CFG	DEV_ALL source configuration
XTR_RDY0_INTR_CFG	XTR_RDY0 source configuration
XTR_RDY1_INTR_CFG	XTR_RDY1 source configuration
INJ_RDY0_INTR_CFG	INJ_RDY0 source configuration
INJ_RDY1_INTR_CFG	INJ_RDY1 source configuration
PTP_SYNC_INTR_CFG	PTP_SYNC source configuration
MIIM0_INTR_CFG	MIIM0 source configuration
MIIM1_INTR_CFG	MIIM1 source configuration
General enable/disable and status for all interrupt sources	
INTR	Interrupt sticky bits
INTR_ENA	Interrupt enable
INTR_ENA_SET	Atomic set of bits in INTR_ENA
INTR_ENA_CLR	Atomic clear of bits in INTR_ENA
INTR_RAW	Raw value of interrupt from sources
DEV_IDENT	Currently interrupting DEV_ALL sources

Possible sources of the DEV_ALL interrupt are:

- Fast link status from the PHYs for port 0 through 7 (DEV_IDENT[7:0])
- PCS link status from the PCS for port 23 through 25 (DEV_IDENT[25:23])
- Global PHY interrupt (DEV_IDENT[28])

Each of the interrupt sources in the VCore-III system can be individually assigned to one of four possible interrupt outputs: Two ICPU_IRQ interrupt outputs go directly to the VCore-III CPU, and two EXT_IRQ interrupt allow interrupting external devices.

Each interrupt output has a global enable register, ICPU_IRQ0_ENA, ICPU_IRQ1_ENA, EXT_IRQ0_ENA, and EXT_IRQ1_ENA. This register must be set in order for the interrupt outputs to propagate interrupts. When there is an active interrupt on any interrupt output, the ICPU_IRQ0_IDENT, ICPU_IRQ1_IDENT, EXT_IRQ0_IDENT, and EXT_IRQ1_IDENT registers show the active interrupt sources for each individual interrupt.

The two EXT_IRQ0 pins are special, because they are overlaid functions on the GPIO interface. The active level of the EXT_IRQ pins is configured individually through the INTR_POL field of EXT_IRQ0_INTR_CFG and EXT_IRQ1_INTR_CFG. Additionally, the EXT_IRQ pins operate as either interrupt outputs or as interrupt sources. This is individually configured through the INTR_DIR field of EXT_IRQ0_INTR_CFG and EXT_IRQ1_INTR_CFG. When operating as outputs, the EXT_IRQ pins can be tri-stated when there is no interrupt. This is configured through the field INTR_DRV in EXT_IRQ0_INTR_CFG and EXT_IRQ1_INTR_CFG.

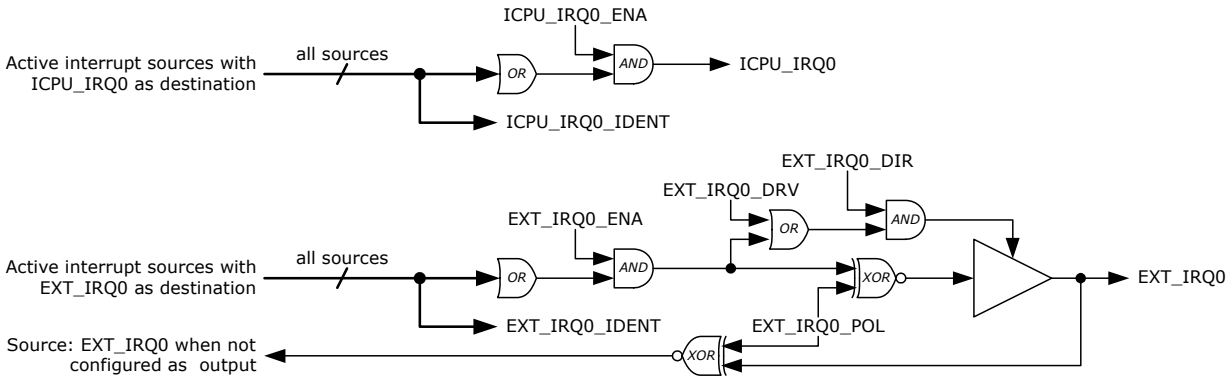
For more information about the location on the GPIOs and how to enable the overlaid function, see GPIO Controller, page 176.

When an interrupt output is configured to drive only during interrupt, interrupt outputs from multiple devices can be connected in parallel with a pull-resistor to make wired-or/and interrupts.

EXT_IRQ0_INTR_CFG and EXT_IRQ1_INTR_CFG (or both) must be configured before enabling the overlaid GPIO functions.

The following illustration depicts only ICPU_IRQ0 and EXT_IRQ0. ICPU_IRQ1 and EXT_IRQ1 is similar, except zeros replace the ones.

Figure 66 • **Logical Equivalent for Interrupt Outputs**



Note Internally in the device, all interrupt sources are active high.

Each interrupt source has its own configuration register (*_INTR_CFG). The sticky functionality can be bypassed by means of the INTR_BYPASS field. For software development, an interrupt event can be emulated by setting the one-shot INTR_FORCE field. The destination interrupt output is configured through the INTR_SEL field. Interrupt outputs can have many sources, but each source can only have one destination.

The bypass feature can be useful when only a single, or just a few, interrupt source is enabled for a specific interrupt output. When stickiness in the interrupt controller is bypassed, clearing the interrupt indication at its source also clears the associated interrupt.

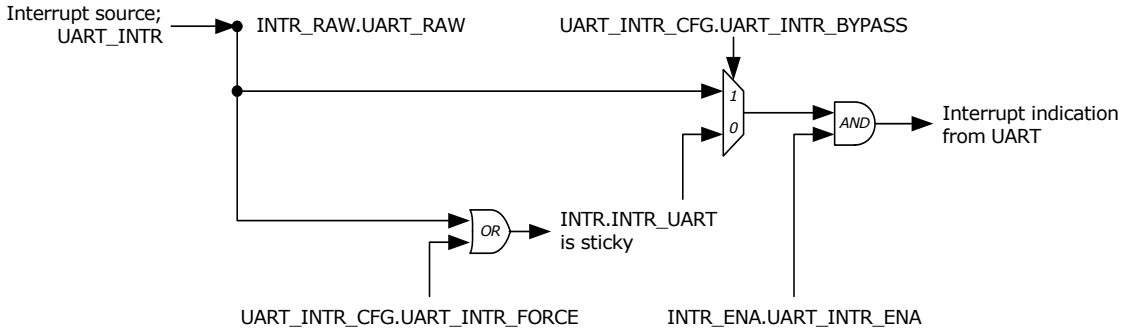
If an interrupt source indicates an interrupt, the associated field in the INTR register is set, this is a sticky indication. The current interrupt inputs from the sources are available through INTR_RAW.

For an interrupt to propagate to its destination, it must be enabled by setting the associated INTR_ENA field. In a system where multiple different CPU threads (or different CPUs) may work on the interrupts at the same time, the INTR_ENA_SET and INTR_ENA_CLR registers provide a method for each thread to safely control enabling and disabling of the interrupts that are under their control, without having to implement locked regions and semaphores.

The following illustration shows an example of the UART interrupt; however, it is representative to any other interrupt by substituting UART for the interrupt name.

The timer interrupt sources are only asserted for a single clock cycle (when the timer wraps). As a result, the trigger and bypass functions (as depicted) are not needed (nor implemented) for the timer interrupt sources.

Figure 67 • **Logical Equivalent for Interrupt Sources**



6 Features

This section provides information about specific features supported by individual blocks in the VSC7428-12 device and describes how these features are administrated by configurations across the entire device. Examples of various standard features are described such as the support for different spanning tree versions and VLAN operations, and more advanced features, such as QoS and VCAP.

6.1 Port Mapping

This section provides information about the mapping from switch core port modules to SerDes type to physical interface pins on the VSC7428-12 device.

When accessing port module registers (PORT::), port masks in the analyzer, or in general, whenever a switch core register refers to a port, the internal switch port module number must be used.

6.1.1 Port Mapping

The switch core port modules map to external pins on the VSC7428-12 device as shown in the following table. There are 11 fixed ports (not including the CPU).

Table 147 • **Mapping from Port Modules to Physical Interface Pins**

Switch Port Module	Interface Type	SerDes Type	Interface Pins
0 – 7	Internal PHY		P*x*_D[3:0]N, P*x*_D[3:0]P, where *x* is 0 through 7
8 – 22	Not used	Not used	Reserved
23	1G SGMII	SERDES1G	SerDes0_TxP, SerDes0_TxN, SerDes0_RxP, SerDes0_RxN
24	2.5G SGMII	SERDES6G	SerDes_E1_TxP, SerDes_E1_TxN, SerDes_E1_RxP, SerDes_E1_RxN
25	2.5G SGMII	SERDES6G	SerDes_E0_TxP, SerDes_E0_TxN, SerDes_E0_RxP, SerDes_E0_RxN
26	CPU port		

6.2 Switch Control

This section provides information about the minimum requirements for switch operation.

6.2.1 Switch Initialization

The following initialization sequence is required to ensure proper operation of the switch:

1. Configure the desired switch mode in DEVCPU_GCB::MISC_CFG.SW_MODE.
2. Initialize memories:
   SYS.RESET_CFG.MEM_ENA = 1.
   SYS.RESET_CFG.MEM_INIT = 1.
3. Wait 100 µs for memories to initialize (SYS.RESET_CFG.MEM_INIT cleared).
4. Enable the switch core:
   SYS.RESET_CFG.CORE_ENA = 1.
5. Release reset of the internal PHYs:
   DEVCPU_GCB.SOFT_CHIP_RST.SOFT_PHY_RST = 0.
6. Enable each port module through SYS.PORT.SWITCH_PORT_MODE.PORT_ENA = 1.

6.3 Port Module Control

This section provides information about the features and configurations for port control, port reset procedures, and port counters.

6.3.1 MAC Configuration Port Mode Control

All port modules can be configured independently to the speed and duplex modes listed in the following tables.

Table 148 • **MAC Configuration of Port Modes for Ports with Internal PHYs**

Configuration	10 Mbps, Half Duplex	10 Mbps, Full Duplex	100 Mbps, Half Duplex	100 Mbps, Full Duplex	1 Gbps, Full Duplex
PORT::CLOCK_CFG.LINK_SPEED					
PORT::MAC_MODE_CFG.FDX_ENA	0	1	0	1	1
PORT::MAC_MODE_CFG.GIGA_MODE_ENA	0	0	0	0	1
SYS:PORT:FRONT_PORT_MODE.HDX_MODE	1	0	1	0	0
PORT::MAC_IFG_CFG.TX_IFG	17	17	17	17	5
PORT::MAC_IFG_CFG.RX_IFG1	11		11		
PORT::MAC_IFG_CFG.RX_IFG2	9		9		
PORT::MAC_HDX_CFG.LATE_COL_POS	64		64		
SYS:PORT:FRONT_PORT_MODE.HDX_MODE	1	0	1	0	0

Table 149 • **MAC Configuration of Port Modes for Ports with SerDes**

Configuration	10 Mbps, Half Duplex	10 Mbps, Full Duplex	100 Mbps, Half Duplex	100 Mbps, Full Duplex	1 Gbps, Full Duplex	2.5 Gbps, Full Duplex
PORT::CLOCK_CFG.LINK_SPEED	3	3	2	2	1	1
PORT::MAC_MODE_CFG.FDX_ENA	0	1	0	1	1	1
PORT::MAC_MODE_CFG.GIGA_MODE_ENA	0	0	0	0	1	1
SYS:FRONT_PORT_MODE.HDX_MODE	1	0	1	0	0	0
PORT::MAC_IFG_CFG.TX_IFG	15	15	15	15	5	5
PORT::MAC_IFG_CFG.RX_IFG1	11		7			
PORT::MAC_IFG_CFG.RX_IFG2	9		9			
PORT::MAC_HDX_CFG.LATE_COL_POS	67		67			
SYS::FRONT_PORT_MODE.HDX_MODE	1	0	1	0	0	0

6.3.2 SerDes Configuration Port Mode Control

Each SerDes port can connect to one of two types of SerDes macros. Ports connecting to SERDES6G must be configured according to the following table.

Table 150 • **SERDES6G Configuration**

Configuration	SGMII Mode	2.5G Mode
hsio::serdes6g_pll_cfg.pll_rot_frq	0	1
hsio::serdes6g_pll_cfg.pll_rot_dir	1	0
hsio::serdes6g_pll_cfg.pll_ena_rot	0	1
hsio::serdes6g_common_cfg.ena_lane	1	1
hsio::serdes6g_common_cfg.if_mode	1	1
hsio::serdes6g_common_cfg.qrate	1	0
hsio::serdes6g_common_cfg.hrate	0	1
hsio::serdes6g_common_cfg.hrate	0	1
hsio::serdes6g_ib_cfg1.ib_reserved	1	1

Ports connecting to a SERDES1G must be configured according to the following table.

Table 151 • **SERDES1G Configuration**

Configuration	SGMII mode
hsio::serdes1g_common_cfg.ena_lane	1

6.3.3 Port Reset Procedure

When changing a switch port's mode of operation or restarting a switch port, the following port reset procedure must be followed:

1. Disable the MAC frame reception in the switch port:
   PORT::MAC_ENA_CFG.RX_ENA = 0.
2. Disable traffic being sent to or from the switch port:
   SYS:PORT:SWITCH_PORT_MODE_ENA = 0
   SYS:PORT:FRONT_PORT_MODE_HDX_MODE = 0.
3. Disable shaping to speed up flushing of frames
   SYS:SCH_SHAPING_CTRL.PORT_SHAPING_ENA = 0,
   SYS:SCH_SHAPING_CTRL.PRIO_SHAPING_ENA = 0.
4. Flush the queues associated with the port:
   REW:PORT:PORT_CFG.FLUSH_ENA = 1.
5. Wait at least the time it takes to receive a frame of maximum length on the port Worst-case delays for 10 kilobyte jumbo frames are:
   8 ms on a 10M port
   800 µs on a 100M port
   80 µs on a 1G port, 32 µs on a 2.5G port.
6. Reset the switch port by setting the following reset bits in CLOCK_CFG:
   PORT::CLOCK_CFG.MAC_TX_RST = 1,
   PORT::CLOCK_CFG.MAC_RX_RST = 1,
   PORT::CLOCK_CFG.PORT_RST = 1,
   PORT::CLOCK_CFG.PHY_RST = 1 (if port is connected to an internal PHY).
7. Wait until flushing is complete:
   SYS:PORT:SW_STATUS.EQ_AVAIL must return 0.
8. Clear flushing again:
   REW:PORT:PORT_CFG.FLUSH_ENA = 0.

9. Re-enable traffic being sent to or from the switch port: SYS:PORT:SWITCH_PORT_MODE.PORT_ENA = 1.
10. Set up the switch port to the new mode of operation. Keep the reset bits in CLOCK_CFG set. For more information about port mode configurations, see Table 148, page 188 or Table 149, page 188.
11. Release the switch port from reset by clearing the reset bits in CLOCK_CFG.

It is not necessary to reset the SerDes macros.

6.3.4 Port Counters

The statistics collected in each port module provide monitoring of various events. This section describes how industry-standard Management Information Bases (MIBs) can be implemented using the counter set in this device. The following MIBs are considered:

- RMON statistics group (RFC 2819)
- IEEE 802.3-2005 Annex 30A counters
- SNMP interfaces group (RFC 2863)
- SNMP Ethernet-like group (RFC 3536)

6.3.4.1 RMON Statistics Group (RFC 2819)

The following table provides the mapping of RMON counters to port counters.

Table 152 • **Mapping of RMON Counters to Port Counters**

RMON Counter	Rx/Tx	Switch Core Implementation
EtherStatsDropEvents	Rx	C_RX_CAT_DROP + C_DR_TAIL + sum of C_DR_YELLOW_PRIO_x + sum of C_DR_GREEN_PRIO_x, where x is 0 through 7.
EtherStatsOctets	Rx	C_RX_OCT
EtherStatsPkts	Rx	C_RX_SHORT + C_RX_FRAG + C_RX_JABBER + C_RX_LONG + C_RX_SZ_64 + C_RX_SZ_65_127 + C_RX_SZ_128_255 + C_RX_SZ_256_511 + C_RX_SZ_512_1023 + C_RX_SZ_1024_1526 + C_RX_SZ_JUMBO
EtherStatsBroadcastPkts	Rx	C_RX_BC
EtherStatsMulticastPkts	Rx	C_RX_MC
EtherStatsCRCAlignErrors	Rx	C_RX_CRC
EtherStatsUndersizePkts	Rx	C_RX_SHORT
EtherStatsOversizePkts	Rx	C_RX_LONG
EtherStatsFragments	Rx	C_RX_FRAG
EtherStatsJabbers	Rx	C_RX_JABBER
EtherStatsPkts64Octets	Rx	C_RX_SZ_64
EtherStatsPkts65to127Octets	Rx	C_RX_SZ_65_127
EtherStatsPkts128to255Octets	Rx	C_RX_SZ_128_255
EtherStatsPkts256to511Octets	Rx	C_RX_SZ_256_511
EtherStatsPkts512to1023Octets	Rx	C_RX_SZ_512_1023
EtherStatsPkts1024to1518Octets	Rx	C_RX_SZ_1024_1526
EtherStatsDropEvents	Tx	C_TX_DROP + C_TX_AGE
EtherStatsOctets	Tx	C_TX_OCT

Table 152 • **Mapping of RMON Counters to Port Counters *(continued)***

RMON Counter	Rx/Tx	Switch Core Implementation
EtherStatsPkts	Tx	C_TX_SZ_64 + C_TX_SZ_65_127 + C_TX_SZ_128_255 + C_TX_SZ_256_511 + C_TX_SZ_512_1023 + C_TX_SZ_1024_1526 + C_TX_SZ_JUMBO
EtherStatsBroadcastPkts	Tx	C_TX_BC
EtherStatsMulticastPkts	Tx	C_TX_MC
EtherStatsCollisions	Tx	C_TX_COL
EtherStatsPkts64Octets	Tx	C_TX_SZ_64
EtherStatsPkts65to127Octets	Tx	C_TX_SZ_65_127
EtherStatsPkts128to255Octets	Tx	C_TX_SZ_128_255
EtherStatsPkts256to511Octets	Tx	C_TX_SZ_256_511
EtherStatsPkts512to1023Octets	Tx	C_TX_SZ_512_1023
EtherStatsPkts1024to1518Octets	Tx	C_TX_SZ_1024_1526

6.3.4.2 IEEE 802.3-2005 Annex 30A Counters

This section provides the mapping of IEEE 802.3-2005 Annex 30A counters to port counters. Only counter groups with supported counters are listed.

Table 153 • **Mandatory Counters**

Counter	Rx/Tx	Switch Core Implementation
aFramesTransmittedOK	Tx	C_TX_SZ_64 + C_TX_SZ_65_127 + C_TX_SZ_128_255 + C_TX_SZ_256_511 + C_TX_SZ_512_1023 + C_TX_SZ_1024_1526 + C_TX_SZ_JUMBO
aSingleCollisionFrames	Tx	Does not apply
aMultipleCollisionFrames	Tx	Does not apply
aFramesReceivedOK	Rx	Sum of C_RX_GREEN_PRIO_x + C_RX_YELLOW_PRIO_x, where x is 0 through 7.
aFrameCheckSequenceErrors	Rx	Not available. C_RX_CRC is the sum of FCS and alignment errors.
aAlignmentErrors	Rx	Not available. C_RX_CRC is the sum of FCS and alignment errors.

Table 154 • **Optional Counters**

Counter	Rx/Tx	Switch Core Implementation
aMulticastFramesXmittedOK	Tx	C_TX_MC
aBroadcastFramesXmittedOK	Tx	C_TX_BC
aMulticastFramesReceivedOK	Rx	C_RX_MC
aBroadcastFramesReceivedOK	Rx	C_RX_BC
aInRangeLengthErrors	Rx	Not available
aOutOfRangeLengthField	Rx	Not available

Table 154 • **Optional Counters *(continued)***

Counter	Rx/Tx	Switch Core Implementation
aFrameTooLongErrors	Rx	C_RX_LONG

Table 155 • **Recommended MAC Control Counters**

Counter	Rx/Tx	Switch Core Implementation
aMACControlFramesTransmitted	Tx	Not available
aMACControlFramesReceived	Rx	C_RX_CONTROL
aUnsupportedOpcodesReceived	Rx	Not available

Table 156 • **Pause MAC Control Recommended Counters**

Counter	Rx/Tx	Switch Core Implementation
aPauseMACControlFramesTransmitted	Tx	C_TX_PAUSE. Transmitted pause frames in 10/100 Mbps full-duplex are not counted.
aPauseMACControlFramesReceived	Rx	C_RX_PAUSE

6.3.4.3 SNMP Interfaces Group (RFC 2863)

The following table provides the mapping of SNMP interfaces group counters to port counters.

Table 157 • **Mapping of SNMP Interfaces Group Counters to Port Counters**

Counter	Rx/Tx	Switch Core Implementation
IfInOctets	Rx	C_RX_OCT
IfInUcastPkts	Rx	C_RX_UC
IfInNUcastPkts	Rx	C_RX_BC + C_RX_MC
IfInBroadcast (RFC 1573)	Rx	C_RX_BC
IfInMulticast (RFC 1573)	Rx	C_RX_MC
IfInDiscards	Rx	C_DR_TAIL + C_RX_CAT_DROP
IfInErrors	Rx	C_RX_CRC + C_RX_SHORT + C_RX_FRAG + C_RX_JABBER + C_RX_LONG
IfInUnknownProtos	Rx	Always zero.
IfOutOctets	Tx	C_TX_OCT
IfOutUcastPkts	Tx	C_TX_UC
IfOutNUcastPkts	Tx	C_TX_BC + C_TX_MC
ifOutMulticast (RFC 1573)	Tx	C_TX_MC
ifOutBroadcast (RFC 1573)	Tx	C_TX_BC
IfOutDiscards	Tx	Always zero.
IfOutErrors	Tx	C_TX_DROP + C_TX_AGE

6.3.4.4 SNMP Ethernet-Like Group (RFC 3536)

The following table provides the mapping of SNMP Ethernet-like group counters to port counters.

Table 158 • **Mapping of SNMP Ethernet-Like Group Counters to Port Counters**

Counter	Rx/Tx	Switch Core Implementation
dot3StatsAlignmentErrors	Rx	Not available. C_RX_CRC is the sum of FCS and alignment errors.
dot3StatsFCSErrors	Rx	Not available. C_RX_CRC is the sum of FCS and alignment errors.
dot3StatsSingleCollisionFrames	Tx	Not available.
dot3StatsMultipleCollisionFrames	Tx	Not available.
dot3StatsSQETestErrors	Rx	Not applicable.
dot3StatsDeferredTransmissions	Tx	Not available.
dot3StatsLateCollisions	Tx	Not available. C_TX_DROP is the sum of Late collisions and Excessive collisions.
dot3StatsExcessiveCollisions	Tx	Not available. C_TX_DROP is the sum of Late collisions and Excessive collisions.
dot3StatsInternalMacTransmitErrors	Tx	Not applicable. Always 0.
dot3StatsCarrierSenseErrors	Tx	Not available.
dot3StatsFrameTooLongs	Rx	C_RX_LONG.
dot3StatsInternalMacReceiveErrors	Rx	Not applicable. Always 0.
dot3InPauseFrames	Rx	C_RX_PAUSE.
dot3OutPauseFrames	Tx	C_TX_PAUSE. Transmitted pause frames in 10/100 Mbps full-duplex are not counted.

6.4 Layer-2 Switch

This section describes the Layer-2 switch features:

- Switching
- VLAN and GVRP
- Rapid and Multiple Spanning Tree
- Link aggregation
- Port-based access control
- Mirroring
- SNMP support

6.4.1 Basic Switching

Basic switching covers forwarding, address learning, and address aging.

6.4.1.1 Forwarding

The device contains a Layer-2 switch, and frames are forwarded using Layer-2 information only. Exceptions to this are possible using VCAP capabilities. For example, to provide source-specific IP multicast forwarding.

The switch is designed to comply with the IEEE Bridging standard in IEEE 802.1D and the IEEE VLAN standard in IEEE 802.1Q:

- Unicast frames are forwarded to a single destination port that corresponds to the DMAC.
- Multicast frames are forwarded to multiple ports determined by the DMAC multicast group. The CPU configures multicast groups in the MAC table and the port group identifier (PGID) table. A multicast group can span across any set of ports.

- Broadcast frames (DMAC = FF-FF-FF-FF-FF-FF) are, by default, flooded to all ports except the ingress port. Also, in compliance with the standard, a unicast or multicast frame with unknown DMAC is flooded to all ports except the ingress port. It is possible to configure flood masks to restrict the flooding of frames. There are separate flood masks for the following frame types:

  Unicast (ANA::FLOODING.FLD_UNICAST)
  Layer 2 multicast (ANA::FLOODING.FLD_MULTICAST)
  Layer 2 broadcast (ANA::FLOODING.FLD_BROADCAST)
  IPv4 multicast data (ANA::FLOODING_IPMC.FLD_MC4_DATA)
  IPv4 multicast control (ANA::FLOODING_IPMC.FLD_MC4_CTRL)
  IPv6 multicast data (ANA::FLOODING_IPMC.FLD_MC6_DATA)
  IPv6 multicast control (ANA::FLOODING_IPMC.FLD_MC6_CTRL)

For frames with a known destination MAC address, the destination mask comes from an entry in the port group identifier table (ANA::PGID). The PGID table contains 107 entries (entry 0 through 106), where entry 0 through 63 are used for destination masks. The remaining PGID entries are used for other parts of the forwarding and are described below.

The following table shows the PGID table organization.

Table 159 • **Port Group Identifier Table Organization**

Entry Type	Number
Unicast entries	0 – 26 (including CPU)
Multicast entries	27 – 63
Aggregation Masks	64 – 79
Source Masks	80 – 106

The unicast entries contains only the port number corresponding to the entry number.

Destination masks for multicast groups must be manually entered through the CPU into the destination masks table. IPv4 and IPv6 multicast entries can also be entered using direct encoding in the MAC table, where the destination masks table is not used. For information about forwarding and configuring destination masks, see MAC Table, page 83.

The aggregation masks ensures that a frame is forwarded to exactly one member of an aggregation group.

For all forwarding decisions, a source mask prevents frames from being sent back to the ingress port. The source mask removes the ingress port from the destination mask.

All ports are enabled for receiving frames by default. This can be disabled by clearing ANA:PORT:PORT_CFG.RECV_ENA.

6.4.1.2 Address Learning

The learning process minimizes the flooding of frames. A frame's source MAC address is learned together with its VID. Each entry in the MAC table is uniquely identified by a (MAC,VID) pair. In the forwarding process, a frame's (DMAC,VID) pair is used as the key for the MAC table lookup.

The learning of unknown SMAC addresses can be either hardware-based or CPU-based. The following list shows the available learn schemes, which can be configured per port:

- **Hardware-based learning** autonomously adds entries to the MAC table without interaction from the CPU. Use the following configuration:
  ANA:PORT:PORT_CFG.LEARN_ENA = 1
  ANA:PORT:PORT_CFG.LEARNCPU = 0
  ANA:PORT:PORT_CFG.LEARNDROP = 0
  ANA:PORT:PORT_CFG.LEARNAUTO = 1
- **CPU-based learning** copies frames with unknown SMACs, or when the SMAC appears on a different port, to the CPU. These frames are forwarded as usual. Use the following configuration.
  ANA:PORT:PORT_CFG.LEARN_ENA = 1

ANA:PORT:PORT_CFG.LEARNCPU = 1
ANA:PORT:PORT_CFG.LEARNDROP = 0
ANA:PORT:PORT_CFG.LEARNAUTO = 0

- **Secure CPU-based learning** is similar to CPU-based learning, except that it allows the CPU to verify the SMAC addresses before both learning and forwarding. Secure CPU-based learning redirects frames with unknown SMACs, or when the SMAC appears on a different port, to the CPU. These frames are not forwarded by hardware. Use the following configuration.
  ANA::PORT_CFG.LEARN_ENA = 1
  ANA::PORT_CFG.LEARNCPU = 1
  ANA::PORT_CFG.LEARNDROP = 1
  ANA::PORT_CFG.LEARNAUTO = 0
- **No learning** where all learn frames are discarded. Frames with known SMAC in the MAC table are forwarded by hardware. Use the following configuration.
  ANA:PORT:PORT_CFG.LEARN_ENA = 1
  ANA:PORT:PORT_CFG.LEARNCPU = 0
  ANA:PORT:PORT_CFG.LEARNDROP = 1
  ANA:PORT:PORT_CFG.LEARNAUTO = 0

Frames forwarded to the CPU for learning can be extracted from the CPU extraction queue configured in ANA:PORT:CPUQ_CFG.CPUQ_LRN.

During CPU-based learning, the rate of frames subject to learning being copied or redirected to the CPU can be controlled with the learn storm policer (ANA::STORMLIMIT_CFG[3]). This policer puts a limit on the number of frames per second that are subject to learning being copied or redirected to the CPU. The learn frames storm policer can help prevent a CPU from being overloaded when performing CPU based learning.

6.4.1.3 MAC Table Address Aging

To keep the MAC table updated, an aging scan is conducted to remove entries that were not recently accessed. This ensures that stations that have moved to a new location are not permanently prevented from receiving frames in their new location. It also frees up MAC table entries occupied by obsolete stations to give room for new stations.

In IEEE 802.1D, the recommended period for aging-out entries in the MAC address table is 300 seconds per entry. The device aging implementation checks for the aging-out of all the entries in the table. The first age scan sets the age bit for every entry in the table. The second age scan removes entries where the age bit has not been cleared since the first age scan. An entry's age bit is cleared when a received frame's (SMAC, VID) matches an entry's (MAC, VID); that is, the station is active and transmits frames. To ensure that 300 seconds is the longest an entry can reside not accessed (and unchanged) in the table, the maximum time between age scans is 150 seconds.

The device can conduct age scans in two ways:

- Automatic age scans
- CPU initiated age scans

When using automatic aging, the time between age scans is set in the ANA::AUTOAGE register in steps of 1 second, in the range from 1 second to 12 days.

When using CPU-initiated aging, the CPU implements the timing between age scans. A scan is initiated by sending an aging command to the MAC address table (ANA::MACACCESS. MAC_TABLE_CMD).

The CPU-controlled age scan process can conveniently be used to flush the entire MAC table by conducting two age scans, one immediately after the other.

Flushing selective MAC table entries is also possible. Incidents that require MAC table flushing are:

- Reconfiguration of Spanning Tree protocol port states, which may cause station moves to occur.
- If there is a link failure notification (identified by a PHY layer device), flush the MAC table on the specific port where the link failed.

To deal with these incidents, the age scan process is configurable to run only for entries learned on a specified port or for a specified VLAN (ANA:: ANAGEFIL.VID_VAL). The filters can also be combined to do aging on entries that match both the specific port and the specific VLAN.

Single entries can be flushed from the MAC table by sending the FORGET command to the MAC address table.

6.4.2 Standard VLAN Operation

This section provides information about configuring and operating the VSC7428-12 device as a standard VLAN-aware switch. For more information about using the switch as a Q-in-Q enabled provider bridge, see Provider Bridges and Q-in-Q Operation, page 199. For information about the use of private VLANs and asymmetric VLANs, see Private VLANs, page 203 and Asymmetric VLANs, page 207.

The following table lists the port module registers for standard VLAN operation.

Table 160 • **Port Module Registers for Standard VLAN Operation**

Register/Register Field	Description	Replication
MAC_TAGS_CFG	Allows tagged frames to be 4 bytes longer than the length configured in MAC_MAXLEN_CFG.	Per port

The following table lists the analyzer configurations and status bits for standard VLAN operation.

Table 161 • **Analyzer Registers for Standard VLAN Operation**

Register/Register Field	Description	Replication
DROP_CFG.DROP_UNTAGGED_ENA	Discard untagged frames.	Per port
DROP_CFG.DROP_C_TAGGED_ENA	Discard VLAN tagged frames.	Per port
DROP_CFG.DROP_PRIO_C_TAGGED_ENA	Discard priority tagged frames.	Per port
VLAN_CFG.VLAN_AWARE_ENA	Use incoming VLAN tags in VLAN classification.	Per port
VLAN_CFG.VLAN_POP_CNT	Remove VLAN tags from frames in the rewriter.	Per port
VLAN_CFG.VLAN_DEI VLAN_CFG.VLAN_PCP VLAN_CFG.VLAN_VID	Ingress port VLAN configuration.	Per port
VLANMASK	Per-port VLAN ingress filtering enable.	None
ANEVENTS.VLAN_DISCARD	A sticky bit indicating that a frame was dropped due to lack of VLAN membership of source port.	None
ADVLEARN.VLAN_CHK	Disable learning for frames discarded due to source port VLAN membership check.	None
VLANACCESS	VLAN table command. For indirect access to configuration of the 4096 VLANs.	None
VLANTIDX	VLAN table index. For indirect access to configuration of the 4096 VLANs.	None
AGENCTRL.FID_MASK	Enable shared VLAN learning.	None
CPU_FWD_GARP_CFG	Enable capture of frames with reserved GARP DMAC addresses, including GVRP for VLAN registration. Per-address configuration.	Per port
CPUQ_8021_CFG.CPUQ_GARP_VAL	CPU queue for captured GARP frames.	Per GARP address

The following table lists the rewriter registers for standard VLAN operation.

Table 162 • **Rewriter Registers for Standard VLAN Operation**

Register/Register Field	Description	Replication
TAG_CFG	Egress VLAN tagging configuration	Per port
PORT_VLAN_CFG	Egress port VLAN configuration	Per port

In a VLAN-aware switch, each port is a member of one or more virtual LANs. Each incoming frame must be assigned a VLAN membership and forwarded according to the assigned VID. The following information draws on the definitions and principles of operations in IEEE 802.1Q. Note that the switch supports more features than mentioned in the following section, which only describes the basic requirements for a VLAN aware switch.

Standard VLAN operation is configured individually per switch port using the following configuration:

- MAC_TAGS_CFG.VLAN_AWR_ENA = 1
  MAC_TAGS_CFG.VLAN_LEN_AWR_ENA = 1
- VLAN_CFG.VLAN_AWARE_ENA = 1,
  VLAN_CFG.VLAN_POP_CNT = 1.

Each switch port has an Acceptable Frame Type parameter, which is set to Admit Only VLAN tagged frames or Admit All Frames:

- Admit Only VLAN-tagged frames:
  DROP_CFG.DROP_UNTAGGED_ENA = 1,
  DROP_CFG.DROP_PRIO_C_TAGGED_ENA = 1,
  DROP_CFG.DROP_C_TAGGED = 0.
- Admit All Frames:
  DROP_CFG.DROP_UNTAGGED_ENA = 0,
  DROP_CFG.DROP_PRIO_C_TAGGED_ENA = 0,
  DROP_CFG.DROP_C_TAGGED = 0.

Frames that are not discarded are subject to the VLAN classification. Untagged and priority-tagged frames are classified to a Port VLAN Identifier (PVID). The PVID is configured per port in VLAN_CFG.VLAN_VID. Tagged frames are classified to the VID given in the frame's tag. For more information about VLAN classification, see VLAN Classification, page 54.

6.4.2.1 Forwarding

Forwarding is always based on the combination of the classified VID and the destination MAC address. By default, all switch ports are members of all VLANs. This can be changed in VLANACCESS and VLANTIDX where port masks per VLAN are set up.

6.4.2.2 Ingress Filtering

VLAN ingress filtering can be enabled per switch port with the register VLANMASK and per router port with MACx_CFG.INGRESS_CHK.

The filter checks for all incoming frames to determine if the ingress port is a member of the VLAN to which the frame is classified. If the port is not a member, the frame is discarded. Whenever a frame is discarded due to lack of VLAN membership, the ANEVENTS.VLAN_DISCARD sticky bit is set. To ensure that VLAN ingress filtered frames are not learned, ADVLEARN.VLAN_CHK must be set.

6.4.2.3 GARP VLAN Registration Protocol (GVRP)

GARP VLAN Registration Protocol (GVRP) is used to propagate VLAN configurations between bridges. On a GVRP-enabled switch, all GVRP frames must be redirected to the CPU for further processing. The GVRP frames use a reserved GARP MAC address (01-80-C2-00-00-21) and can be redirected to the CPU by setting bit 1 in the analyzer register CPU_FWD_GARP_CFG.

6.4.2.4 Shared VLAN Learning

The device can be configured for either Independent VLAN learning or Shared VLAN learning. Independent VLAN learning is the default.

Shared VLAN learning, where multiple VLANs map to the same filtering database, is enabled through Filter Identifiers (FIDs). Basically, this means that learning is unique for a (MAC, FID) set and that a learned MAC address is learned for all VIDs that map to the FID. Shared VLAN learning is enabled in AGENCTRL.FID_MASK.

The 12-bit FID mask sets which bits in the VID are indifferent to the learning. For example, if the least significant two bits are set in the FID mask, the following VID sets are sharing learning, where X and Y are any hexadecimal digits:

- VID set 1: 0xXY0, 0xXY1, 0xXY2, 0xXY3
- VID set 2: 0xXY4, 0xXY5, 0xXY6, 0xXY7
- VID set 3: 0xXY8, 0xXY9, 0xXYA, 0xXYB
- VID set 4: 0xXYC, 0xXYD, 0xXYE, 0xXYF

6.4.2.5 Untagging

An untagged set can be configured for each egress port, which defines the VIDs for which frames are transmitted untagged. The untagged set can consist of zero, one, or all VIDs. For all VIDs not in the untagged set, frames are transmitted tagged. The available configurations are:

- The untagged set is empty:
  TAG_CFG.TAG_CFG = 3.
- The untagged set consists of all VIDs:
  TAG_CFG.TAG_CFG = 0.
- The untagged set consists of one VID <VID>:
  TAG_CFG.TAG_CFG = 1.
  PORT_VLAN_CFG.PORT_VID = <VID>.

Optionally, frames received as priority-tagged frames (VID = 0) can also be transmitted as untagged (TAG_CFG.TAG_CFG=2).

Port-Based VLAN Example

Situation:

Ports 0 and 1 are isolated from ports 2 and 3 using port-based VLANs. Ports 0 and 1 are assigned port VID 1 and ports 2 and 3 port VID 2. All frames in the network are untagged.

Resolution:

```
# Port module configuration of ports 0 - 1.
# Configure the ports to always use the port VID.
VLAN_CFG.VLAN_AWARE_ENA = 0
# Allow only untagged frames.
DROP_CFG.DROP_UNTAGGED_ENA = 0
DROP_CFG.DROP_PRIO_C_TAGGED = 1
DROP_CFG.DROP_C_TAGGED = 1
# Configure the port VID to 1.
VLAN_CFG.VLAN_VID = 1

# Port module configuration of ports 2 - 3.
# Same as for ports 0-1, except that the port VID is set to 2.
VLAN_CFG.VLAN_VID = 2
# Analyzer configuration.
# Configure VLAN 1 to contain ports 0-1.
VLANTIDX.INDEX = 1
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don't care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 1
VLANACCESS.VLAN_PORT_MASK = 0x03
VLANACCESS.VLAN_TBL_CMD = 2
# Configure VLAN 2 to contain ports 2-3.
VLANTIDX.INDEX = 2
```

```
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don't care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 1
VLANACCESS.VLAN_PORT_MASK = 0x0C
VLANACCESS.VLAN_TBL_CMD = 2
```

6.4.3 Provider Bridges and Q-in-Q Operation

The following table lists the port module configurations for provider bridge VLAN operation.

Table 163 • **Port Module Configurations for Provider Bridge VLAN Operation**

Register/Register Field	Description	Replication
MAC_TAGS_CFG	Allow single tagged frames to be 4 bytes longer and double-tagged frames to be 8 bytes longer than the length configured in MAC_MAXLEN_CFG.	Per port

The following table lists the port module configurations for provider bridge VLAN operation.

Table 164 • **System Configurations for Provider Bridge VLAN Operation**

Register/Register Field	Description	Replication
VLAN_ETYPE_CFG.VLAN_S_TAG_ETYPE_VAL	TPID for S-tagged frames. EtherType 0x88A8 and the configurable value VLAN_ETYPE_CFG.VLAN_S_TAG_ETYPE_VAL are identified as the S-tag identifier.	Per port

The following table lists the analyzer configurations for provider bridge VLAN operation.

Table 165 • **Analyzer Configurations for Provider Bridge VLAN Operation**

Register/Register Field	Description	Replication
DROP_CFG.DROP_UNTAGGED_ENA	Discard untagged frames.	Per port
DROP_CFG.DROP_S_TAGGED_ENA	Discard VLAN S-tagged frames.	Per port
DROP_CFG.DROP_PRIO_S_TAGGED_ENA	Discard priority S-tagged frames.	Per port
VLAN_CFG.VLAN_AWARE_ENA	Use incoming VLAN tags in VLAN classification.	Per port
VLAN_CFG.VLAN_POP_CNT	Remove VLAN tags from frames in the rewriter.	Per port
VLAN_CFG.VLAN_TAG_TYPE	Tag type for untagged frames (Customer tag or service tag).	Per port
VLAN_CFG.VLAN_INNER_TAG_ENA	Use inner tag for VLAN classification instead of outer tag.	Per port
VLAN_CFG.VLAN_DEI VLAN_CFG.VLAN_PCP VLAN_CFG.VLAN_VID	Ingress port VLAN configuration.	Per port
VLANACCESS	VLAN table command. For indirect access to configuration of the 4096 VLANs.	None

Table 165 • **Analyzer Configurations for Provider Bridge VLAN Operation** ***(continued)***

Register/Register Field	Description	Replication
VLANTIDX	VLAN table index. For indirect access to configuration of the 4096 VLANs.	None

The device supports the standard provider bridge features in IEEE 802.1ad (Provider Bridges). The features related to provider bridges are:

- Support for multiple tag headers (EtherTypes 0x8100, 0x88A8, and a programmable value are recognized as tag header EtherTypes)
- Pushing and popping of up to two VLAN tags
- Selective VLAN classification using either inner or outer VLAN tag
- Translating VLAN tag headers at ingress and/or at egress (using the IS1 and ES0 TCAMs)
- Enabling or disabling learning per VLAN

The following section discusses briefly how to configure these different features in the switch.

Multiple VLAN tags are supported. They can be used in MAN applications as a provider bridge, aggregating traffic from numerous independent customer LANs into the MAN space. One of the purposes of the provider bridge is to recognize and use VLAN tags so that the VLANs in the MAN space can be used independent of the customers' VLANs. This is accomplished by adding a VLAN tag with a MAN-related VID for frames entering the MAN. When leaving the MAN, the tag is stripped, and the original VLAN tag with the customer-related VID is again available. This provides a tunneling mechanism to connect remote customer VLANs through a common MAN space without interfering with the VLAN tags. All tags use EtherType 0x8100 for customer tags and EtherType 0x88A8, or a programmable value, for service provider tags.

If a given service VLAN only has two member ports on the switch, the learning can be disabled for the particular VLAN (VLANTIDX.VLAN_LEARN_DISABLE) and can rely on flooding as the forwarding mechanism between the two ports. This way, the MAC table requirements are reduced.

MAN Access Switch Example

Situation:

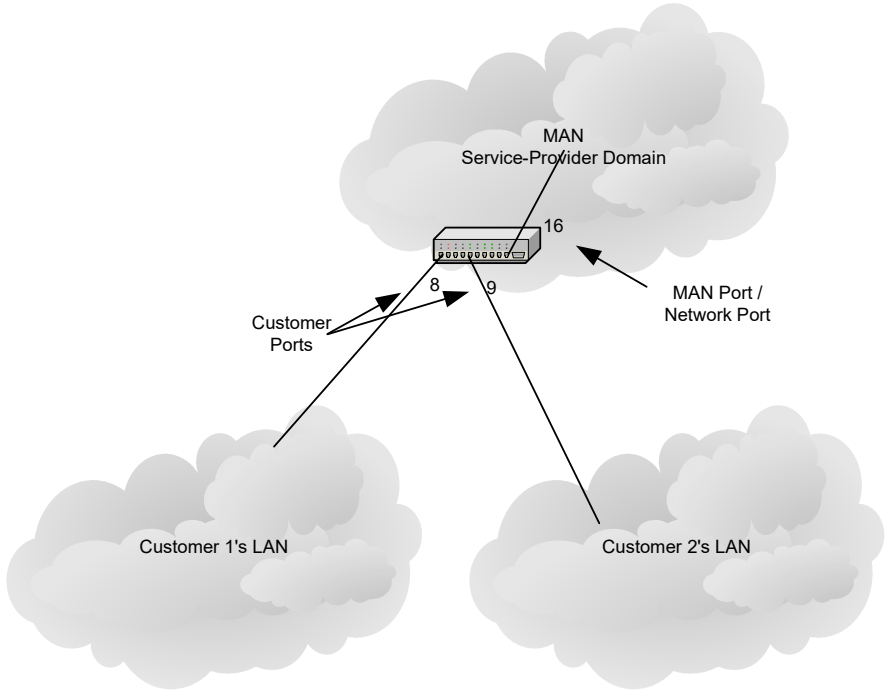
The following is an example of setting up the device as a MAN access switch with these requirements:

- Customer ports are aggregated into a network port for tunneling through the MAN to access remote VLANs.
- Local switching between ports of the different customers must be eliminated.
- Frames must be label-switched from network port to correct customer port without need for MAC address learning.

Figure 68 • **MAN Access Switch Setup**

Frames in This Segment

Service Provider Tag (Outer Tag)		Customer Tag (Inner Tag)		
EtherType	VID	EtherType	VID	Description
0x88A8	1	0x8100	1	Frames to/from customer 1's VLAN 1
0x88A8	1	0x8100	118	Frames to/from customer 1's VLAN 118
0x88A8	1	0x8100	0	Priority-tagged frames to/from customer 1
0x88A8	2	0x8100	1	Frames to/from customer 2's VLAN 1
0x88A8	2	0x8100	4	Frames to/from customer 2's VLAN 4
0x88A8	2	N/A	N/A	Untagged frames to/from customer 2



Frames in This Segment

Customer Tag		
EtherType	VID	Description
0x8100	1	Frames in Customer 1's VLAN 1
0x8100	118	Frames in Customer 1's VLAN 118
0x8100	0	Customer 1's Priority-Tagged Frames

Frames in This Segment

Customer Tag		
EtherType	VID	Description
0x8100	1	Frames in Customer 2's VLAN 1
0x8100	4	Frames in Customer 2's VLAN 4
N/A	N/A	Customer 2's Untagged Frames

This example is typically accomplished by letting each customer port have a unique port VID (PVID), which is used in the outer VLAN tag (the service provider tag). In the MAN, the VID directly indicates the customer port from which the frame is received or the customer port to which the frame is going.

A customer port is VLAN-unaware and classifies to a port-based VLAN. In the egress direction of the customer port, frames are transmitted untagged, which facilitates the stripping of the outer tag. That is, the provider tag is stripped, but the customer tag is kept. The port must allow frames with a maximum size of 1522 bytes.

Resolution:

```
# Configuration of customer 1’s port (port 8).
# Allow for a single VLAN tag in the length check and set the maximum length
without VLAN
# tag to 1518 bytes.
MAC_TAGS_CFG.VLAN_LEN_AWR_ENA = 1
MAC_TAGS_CFG.VLAN_AWAR_ENA = 1
MAC_MAXLEN_CFG.MAX_LEN = 1518
# Configure the port to leave any incoming tags in the frame and to ignore any
# incoming VLAN tags in the VLAN classification. The port VID is always used
in the
# VLAN classification.
VLAN_CFG.VLAN_POP_CNT = 0
VLAN_CFG.VLAN_AWARE_ENA = 0
# Allow both C-tagged and untagged frames coming in to the device to also
support customer traffic not using VLANs to be carried across the MAN.
DROP_CFG.DROP_UNTAGGED_ENA = 0
DROP_CFG.DROP_C_TAGGED = 0
DROP_CFG.DROP_PRIO_C_TAGGED = 0
DROP_CFG.DROP_S_TAGGED = 1
DROP_CFG.DROP_PRIO_S_TAGGED = 1
# Use service provider tagging when frames from this port exit the switch.
# (EtherType 0x88A8).
VLAN_CFG.VLANTAG_TYPE = 1
# Configure the port VID to 1.
VLAN_CFG.VLAN_VID = 1
# Configure the egress side of the port to not insert tags.
# (The service provider tags are stripped in the ingress side of the MAN port).
TAG_CFG.TAG_CFG = 0
# Configuration of customer 2's port (port 9).
# Same as for customer 1’s port (port 8), except that the port VID is set to 2.
VLAN_CFG.VLAN_VID = 2
# Configuration of the network port (port 16).
# MAN traffic in transit between network ports is supported by configuring all
network
# ports as follows:
# Allow for two VLAN tags in the length check and set the max length without
# VLAN tags to 1518 bytes.
MAC_TAGS_CFG.VLAN_LEN_AWR_ENA = 1
MAC_TAGS_CFG.VLAN_AWAR_ENA = 1
MAC_TAGS_CFG.PB_ENA =1
MAC_MAXLEN_CFG.MAX_LEN = 1518
# Configure the port to use incoming VLAN tags in the VLAN classification,
# and to remove the first (outer) VLAN tag (the service tag) from incoming
frames.
VLAN_CFG.VLAN_POP_CNT = 1
VLAN_CFG.VLAN_AWARE_ENA = 1
# Allow only S-tagged frames.
DROP_CFG.DROP_UNTAGGED_ENA = 1
DROP_CFG.DROP_C_TAGGED = 1
DROP_CFG.DROP_PRIO_C_TAGGED = 1
DROP_CFG.DROP_S_TAGGED = 0
DROP_CFG.DROP_PRIO_S_TAGGED = 0
# The tag type is unused on the network port
VLAN_CFG.VLANTAG_TYPE = 0
# Configure the egress side of the port to insert tags.
TAG_CFG.TAG_CFG = 1
# Common configuration in the analyzer.
```

```
# Configure VLAN 1 to contain customer 1’s port (port 8) and the network port
# (port 16). Disable learning in VLAN 1. Ingress filtering is don’t care for
port
# based VLANs.
VLANTIDX.INDEX = 1
VLANTIDX.VLAN_PRIV_VLAN = 0 (don’t care, for this example)
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 1
VLANTIDX.VLAN_SRC_CHK = 0 (don’t care, for this example)
VLANACCESS.VLAN_PORT_MASK = 0x00010100
VLANACCESS.VLAN_TBL_CMD = 2
# Configure VLAN 2 to contain customer 2's port (port 9) and the network port
# (port 16). Disable learning in VLAN 2. Ingress filtering is don’t-care for
port
# based VLANs.
VLANTIDX.INDEX = 2
VLANTIDX.VLAN_PRIV_VLAN = 0 (don’t care, for this example)
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 1
VLANTIDX.VLAN_SRC_CHK = 0 (don’t care, for this example)
VLANACCESS.VLAN_PORT_MASK = 0x00010200
VLANACCESS.VLAN_TBL_CMD = 2
```

6.4.4 Private VLANs

The following table lists the analyzer configuration registers for private VLAN support.

Table 166 • **Private VLAN Configuration Registers**

Register	Description	Replication
VLANACCESS	VLAN table command. For indirect access to configuration of the 4096 VLANs.	None
VLANTIDX	VLAN table index. For indirect access to configuration of the 4096 VLANs.	None
ISOLATED_PORTS	VLAN port mask indicating isolated ports in private VLANs.	None
COMMUNITY_PORTS	VLAN port mask indicating community ports in private VLANs.	None

When a VLAN is configured to be a private VLAN, communication between ports within that VLAN can be prevented. Two application examples are:

- Customers connected to an ISP can be members of the same VLAN, but they are not allowed to communicate with each other within that VLAN.
- Servers in a farm of web servers in a Demilitarized Zone (DMZ) are allowed to communicate with the outside world and with database servers on the inside segment, but are not allowed to communicate with each other

For private VLANs to be applied, the switch must first be configured for standard VLAN operation. For more information, see Standard VLAN Operation, page 196. When this is in place, one or more of the configured VLANs can be configured as private VLANs. Ports in a private VLAN fall into one of three groups:

- Promiscuous ports
  Ports from which traffic can be forwarded to all ports in the private VLAN

  Ports that can receive traffic from all ports in the private VLAN
- Community Ports
  Ports from which traffic can only be forwarded to community and promiscuous ports in the private

VLAN

Ports that can receive traffic from only community and promiscuous ports in the private VLAN

- Isolated ports
  Ports from which traffic can only be forwarded to promiscuous ports in the private VLAN

  Ports that can receive traffic from only promiscuous ports in the private VLAN

The configuration of promiscuous, community, and isolated ports applies to all private VLANs.

The forwarding of frames classified to a private VLAN happens:

- When traffic comes in on a promiscuous port in a private VLAN, the VLAN mask from the VLAN table is applied.
- When traffic comes in on a community port, the ISOLATED_PORT mask is applied in addition to the VLAN mask from the VLAN table.
- When traffic comes in on an isolated port, the ISOLATED_PORT mask and the COMMUNITY_PORT mask are applied in addition to the VLAN mask from the VLAN table.

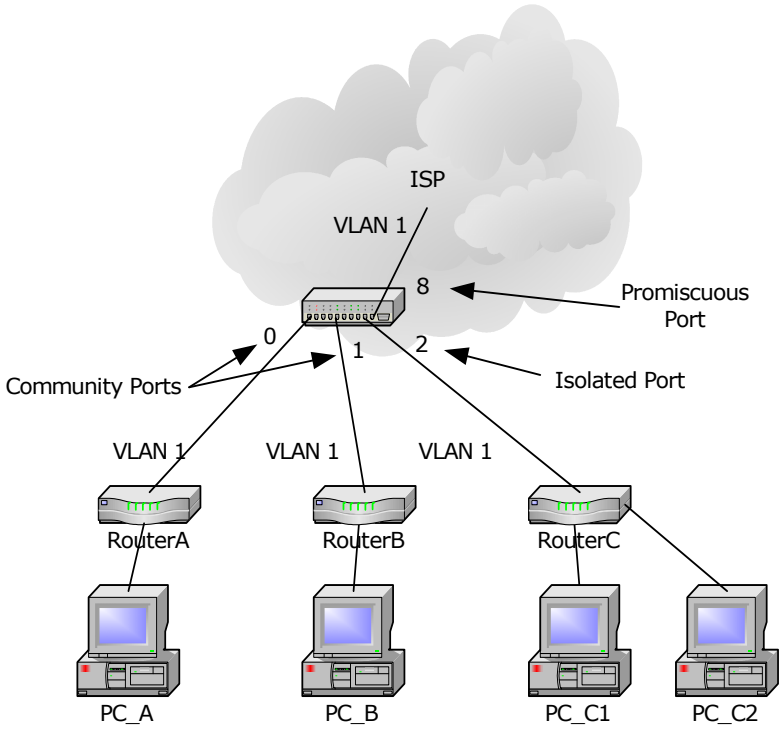
ISP Example

Situation:

Customers A, B, and C are connected to the same switch at the ISP. Customers A and B are allowed to communicate with each other, as well as the ISP. Customer C can only communicate with the ISP. VLAN 1 is the private VLAN that isolates Customers A, B from C. Traffic on VLAN 1 coming in from the ISP (port 8) uses the VLAN mask in the VLAN table. Traffic on VLAN 1 from customer A or B has the ISOLATED_PORTS mask applied in addition to the mask from the VLAN table, with the result that traffic from customer A and B is not forwarded to customers C. Traffic on VLAN 1 from customer C has the ISOLATED_PORTS mask and the COMMUNITY_PORTS mask applied in addition to the mask from the VLAN table, with the result that traffic from customer C is not forwarded to customers A and B.

The following illustration shows the desired setup.

Figure 69 • **ISP Example for Private VLAN**



VLAN Table

VID	Ports in Mask	Private
⋮	⋮	⋮
1	0, 1, 2, 8	1
⋮	⋮	⋮

ISOLATED_PORTS
(Isolated ports set to 0)

Bit	Value
0	1
1	1
2	0
⋮	⋮
8	1
⋮	⋮

COMMUNITY_PORTS
(Community ports set to 0)

Bit	Value
0	0
1	0
2	1
⋮	⋮
8	1
⋮	⋮

Resolution:

```
# It is assumed that Port VID and tag handling for VLAN 1 is already
# configured according to the description in Standard VLAN Operation.
# Configure VLAN 1 as a private VLAN in the VLAN table by performing these
steps:
# - Point to VLAN 1.
# - Set it as private.
# - Disable mirroring of the VLAN (not important for the example).
# - Enable learning within the VLAN (not important for the example).
# - Disable source check within the VLAN (not important for the example).
# - Include ports 0, 1, 2, and 8 in the VLAN mask.
# Insert the entry into the VLAN table.
VLANTIDX.INDEX = 1
VLANTIDX.VLAN_PRIV_VLAN = 1
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0 (don’t care, for this example)
VLANTIDX.VLAN_SRC_CHK = 0 (don't care, for this example)
VLANACCESS.VLAN_PORT_MASK = 0x00000107
VLANACCESS.VLAN_TBL_CMD = 2
# Configure the private VLAN mask so that port 8 is a promiscuous
# port, ports 0 and 1 are community ports, and port 2 is an isolated port.
ISOLATED_PORTS.ISOL_PORTS = 0x00000103
COMMUNITY_PORTS.COMM_PORTS = 0x00000104
```

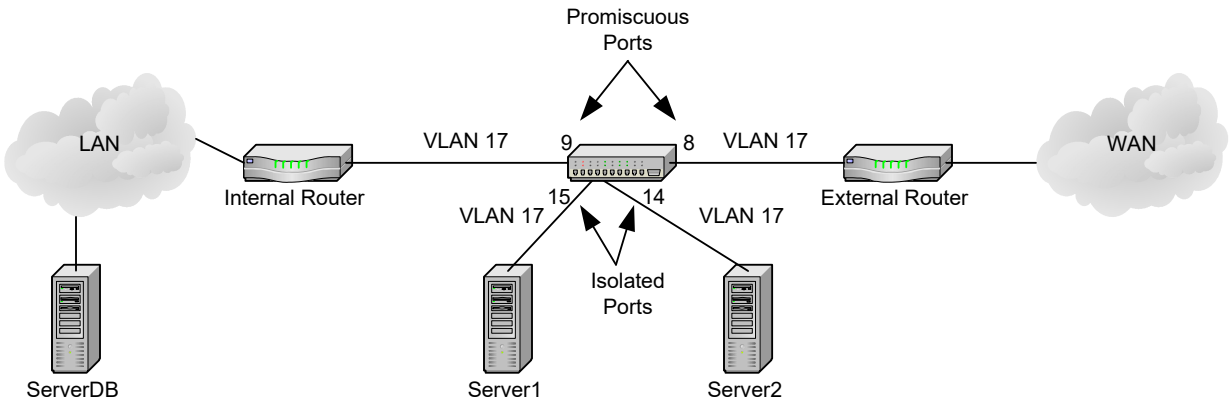
DMZ Example

Situation:

VLAN 17 is a private VLAN that isolates Server1 and Server2. Traffic on VLAN 17 coming from the internal or the external router (ports 8 and 9) uses the VLAN mask in the VLAN table. Traffic on VLAN 17 from Server1 and Server2 (ports 14 and 15) has the ISOLATED_PORTS applied in addition to the mask from the VLAN table, with the result that traffic from Server1 is not forwarded to Server2 and visa versa.

The following illustration shows the desired setup.

Figure 70 • **DMZ Example for Private VLAN**



VLAN Table

VID	Ports in Mask	Private
⋮	⋮	⋮
17	8, 9, 14, 15	1
⋮	⋮	⋮

ISOLATED_PORTS
(Promiscuous Ports Set to 1)

Bit	Value
⋮	⋮
8	1
9	1
⋮	⋮
14	0
15	0
⋮	⋮

Resolution:

```
# It is assumed that Port VID and tag handling for VLAN 17 is already
# configured according to the description in Standard VLAN Operation.
# Configure VLAN 17 as a private VLAN in the VLAN table by performing these
steps:
# - Point to VLAN 17.
# - Set it as private.
# - Disable mirroring of the VLAN (not important for the example).
# - Enable learning within the VLAN (not important for the example).
# - Disable source check within the VLAN (not important for the example).
# - Include ports 8, 9, 14, and 15 in the VLAN mask.
# - Insert the entry into the VLAN table.
VLANTIDX.INDEX = 17
VLANTIDX.VLAN_PRIV_VLAN = 1
VLANTIDX.VLAN_MIRROR = 0 (don't care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0 (don't care, for this example)
VLANTIDX.VLAN_SRC_CHK = 0 (don't care, for this example)
VLANACCESS.VLAN_PORT_MASK = 0x0000C300
VLANACCESS.VLAN_TBL_CMD = 2
# Configure the private VLAN mask so that ports 8 and 9 are promiscuous
# ports.
ISOLATED_PORTS.ISOL_PORTS = 0x00000300
```

6.4.5 Asymmetric VLANs

Asymmetric VLANs use the same configuration registers as for standard VLAN operation. For more information about standard VLAN operation, see Standard VLAN Operation, page 196.

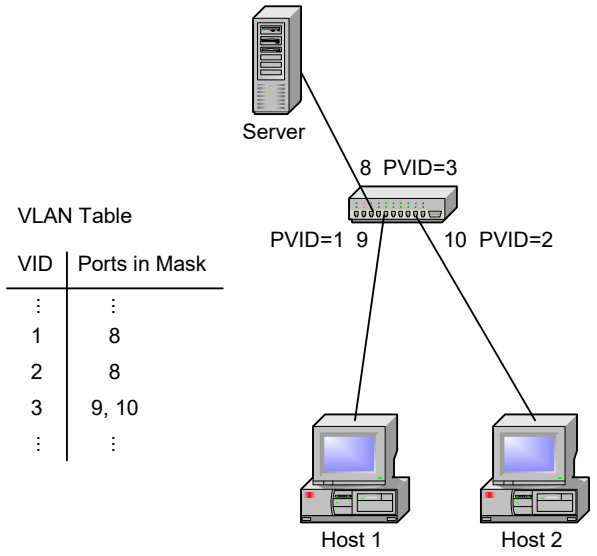
Asymmetric VLANs can be used to prevent communication between hosts in a network. This behavior is similar to what can be obtained by using private VLANs. For more information, seePrivate VLANs, page 203.

Situation:

A server and two hosts are connected to a switch. Communication between the hosts and the server should be allowed, but the hosts are not allowed to communicate directly. All traffic between the server and the hosts is untagged. Host 1 is connected to port 9, host 2 to port 10, and the server to port 8.

The host-1 port gets port VID 1 and the host-2 port gets port VID 2. The server port is a member of both VLANs 1 and 2. The server port gets port VID 3, and the two host ports are members of VLAN 3, as shown in the following illustration.

Figure 71 • **Asymmetric VLANs**



Resolution:

```
# Analyzer configurations common for ports 8, 9, and 10.
# Allow only untagged frames.
DROP_CFG.DROP_UNTAGGED_ENA = 0
DROP_CFG.DROP_C_TAGGED_ENA = 1
DROP_CFG.DROP_PRIO_C_TAGGED_ENA = 1
# As tagged frames are dropped all frames are classified to the port VID.
VLAN_CFG.VLAN_AWARE_ENA = 0 (don’t care, for this example)
# Configure the egress side of the port to not insert tags.
TAG_CFG.TAG_CFG = 0
# Analyzer configuration specific for port 8. Set the port VID to 3.
VLAN_CFG.VLAN_VID = 3
VLAN_CFG.VLAN_DEI = 0 (don’t care, for this example)
# Analyzer configuration specific for port 9. Set the port VID to 1.
VLAN_CFG.VLAN_VID = 1
VLAN_CFG.VLAN_DEI = 0 (don’t care, for this example)


# Analyzer configuration specific for port 10. Set the port VID to 2.
VLAN_CFG.VLAN_VID = 2
VLAN_CFG.VLAN_DEI = 0 (don’t care, for this example)
# Analyzer configuration common to all ports.
# Configure VLAN 1 to contain port 8.
VLANTIDX.INDEX = 1
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 0
```

```
VLANACCESS.VLAN_PORT_MASK = 0x00000100
VLANACCESS.VLAN_TBL_CMD = 2
# Configure VLAN 2 to contain port 8.
VLANTIDX.INDEX = 2
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don't care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 0
VLANACCESS.VLAN_PORT_MASK = 0x00000100
VLANACCESS.VLAN_TBL_CMD = 2
# Configure VLAN 3 to contain ports 9 and 10.
VLANTIDX.INDEX = 3
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don't care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 0
VLANACCESS.VLAN_PORT_MASK = 0x00000600
VLANACCESS.VLAN_TBL_CMD = 2
```

6.4.6 Spanning Tree Protocols

This section provides information about Rapid Spanning Tree Protocol (RSTP) support and Multiple Spanning Tree Protocol (MSTP) support. The device also supports legacy Spanning Tree Protocol (STP). STP was obsoleted by RSTP in IEEE 802.1D and is not described in this document.

It is assumed that only LAN ports connected to the switch core participate in the spanning tree protocol. This implies that BPDUs are terminated by the switch core.

6.4.6.1 Rapid Spanning Tree Protocol

The following table lists the analyzer configuration registers for Rapid Spanning Tree Protocol (RSTP) operation.

Table 167 • **Analyzer Configurations for RSTP Support**

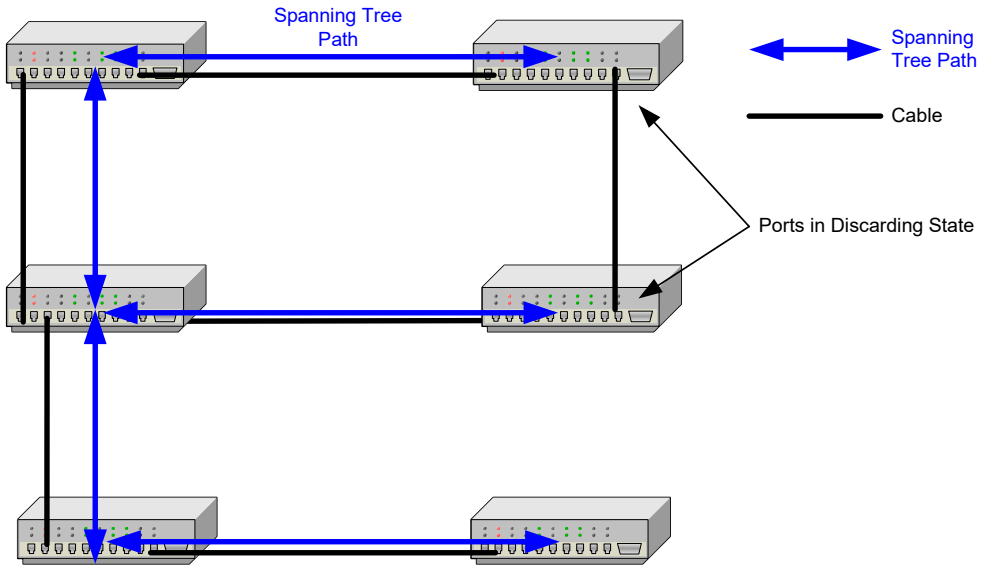
Register/Register Field	Description	Replication
PGID[80-106]	Source masks used for ingress filtering	Per port
PGID[64-79]	Aggregation masks that can be used for egress filtering for RSTP	16
PORT_CFG.LEARN_ENA	Enable learning per port	Per port
CPU_FWD_BPDU_CFG	Enable redirection of frames with reserved BPDU DMAC addresses	Per port per address
CPUQ_8021_CFG.CPUQ_BPDU_VAL	CPU extraction queue for redirected BPDU frames	Per address

To eliminate potential loops in a network, the Rapid Spanning Tree Protocol in IEEE 802.1D creates a single path between any two bridges in a network, adding stability and predictability to the network. The protocol is implemented by assigning states to all ports. Each state controls a port's functionality, limiting its ability to receive and transmit frames and learn addresses.

Establishing a spanning tree is done through the exchange of BPDUs between bridge entities. BPDUs are frequently exchanged between neighboring bridges. These frames are identified by the Bridge protocol address range (DMAC = 01-80-C2-00-00-0x).

When there is a change in the network topology, the protocol reconfigures the port states.

Figure 72 • **Spanning Tree Example**



The following table lists the Rapid Spanning Tree port state properties.

Table 168 • **RSTP Port State Properties**

State	BPDU Reception	BPDU Generation	Frame Forwarding	SMAC Learning
Discarding	Yes	Yes	No	No
Learning	Yes	Yes	No	Yes
Forwarding	Yes	Yes	Yes	Yes

The legacy STP states disabled, blocking, and listening correspond to the discarding state of RSTP.

All frames with a Bridge protocol address must be redirected to the CPU. This is configured in CPU_FWD_BPDU_CFG. BPDUs are forwarded to the CPU irrespective of the port's RSTP state. CPUQ_8021_CFG.CPUQ_BPDU_VAL can be used to configure in which CPU extraction queue the BPDUs are placed. BPDU generation is done through frame injection from the CPU.

Frame forwarding is controlled through ingress filtering and egress filtering. Ingress filtering can be done by using the source masks (PGID[80-106]), and egress filtering can be done by using the aggregation masks (PGID[64-79]). Forwarding can be disabled for ports not in the Forwarding state by clearing their source masks and excluding them from all aggregation masks. The use of the aggregation masks for egress filtering does not preclude the combination of link aggregation and RSTP support. All ports in a link aggregation group that are not in the Forwarding state must be disabled in all aggregation masks. For link aggregated ports in the Forwarding state, the aggregation masks must be configured for link aggregation (such as when RSTP is not supported.)

Learning can be enabled per port with the PORT_CFG.LEARN_ENA.

The following table provides an overview of the port state configurations for port p.

Table 169 • **RSTP Port State Configuration for Port p**

State	CPU_FWD_BPDU_CFG[p].BPDU_REDIR_ENA[0]	PGID[80+p]	PGID[64-79], All 16 Masks, Bit p	PORT_CFG[p].LEARN_ENA
Discarding	1	0	0	0
Learning	1	0	0	1

Table 169 • **RSTP Port State Configuration for Port p *(continued)***

State	CPU_FWD_BPDU_CFG[p].BPDU_REDIR_ENA[0]	PGID[80+p]	PGID[64-79], All 16 Masks, Bit p	PORT_CFG[p].LEARN_ENA
Forwarding	1	1 except for bit p	1	1

RSTP Example

Situation:

Port 0 is in the RSTP Discarding state. Port 2 is in the RSTP Learning state. Port 3 is in the RSTP Forwarding state. All other ports on the switch are unused.

Resolution:

```
# Get Spanning Tree Protocol BDPUs to CPU extraction queue 0 for port 0, 2,
and 3.
CPU_FWD_BPDU_CFG[0].BPDU_REDIR_ENA[0] = 1
CPU_FWD_BPDU_CFG[2].BPDU_REDIR_ENA[0] = 1
CPU_FWD_BPDU_CFG[3].BPDU_REDIR_ENA[0] = 1
CPUQ_8021_CFG.CPUQ_BPDU_VAL[0] = 0
# Configure the source mask for port 0 (Discarding state).
PGID[80] = 0x00
# Configure the source mask for port 2 (Learning state).
PGID[82] = 0x00
# Configure the source mask for port 3 (Forwarding state).
PGID[83] = 0x77
# Configure the aggregation masks to only allow forwarding to port 3
# (Forwarding state).
PGID[64-79] = 0x08
# Configure the learn mask to only allow learning on ports
# 2 (Learning state) and 3 (Forwarding state).
PORT_CFG[0].LEARN_ENA = 0
PORT_CFG[2].LEARN_ENA = 1
PORT_CFG[3].LEARN_ENA = 1
```

6.4.6.2 Multiple Spanning Tree Protocol

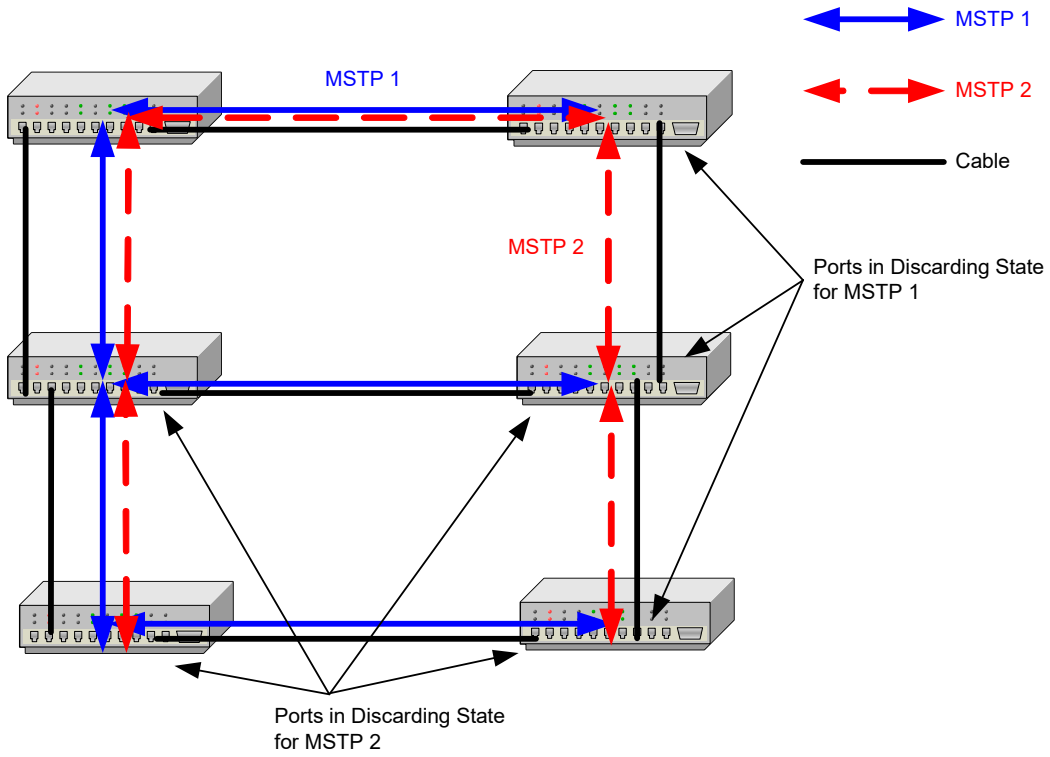
The following table lists the analyzer configuration registers for Multiple Spanning Tree Protocol (MSTP) operation.

Table 170 • **Analyzer Configurations for MSTP Support**

Register/Register Field	Description	Replication
VLANACCESS.VLAN_SRC_CHK	Per-VLAN ingress filtering enable. Part of VLAN table command for indirect access to configuration of the 4095 VLANs	None
VLANMASK	Per-port VLAN ingress filtering enable	None
ADVLEARN.VLAN_CHK	Disable learning for frames discarded due to VLAN membership source port filtering	None
PORT_CFG.LEARN_ENA	Enable learning per port	Per port
CPU_FWD_BPDU_CFG	Enable redirection of frames with reserved BPDU DMAC addresses	Per port per address
CPUQ_8021_CFG.CPUQ_BPDU_VAL	CPU extraction queue for redirected BPDU frames	Per address

The Multiple Spanning Tree Protocol (MSTP) in IEEE 802.1Q increases network use, relative to RSTP, by creating multiple spanning trees that VLANs can map to independently, rather than having only one path between bridges common for all VLANs. The multiple spanning trees are created by assigning different bridge identifiers for each spanning tree. Mapping the VLANs to spanning trees is done arbitrarily.

Figure 73 • **Multiple Spanning Tree Example**



The Learning state is not supported for MSTP. However, this has limited impact, because when the port is taken to the Forwarding state, learning is done at wire-speed, and, as a result, the SMAC learn delay is less important. MSTP is supported for all VLANs.

The following table lists the multiple spanning tree port state properties.

Table 171 • **MSTP Port State Properties**

State per VLAN	BPDU Reception	BPDU Generation	Frame Forwarding	SMAC Learning
Discarding	Yes	Yes	No	No
Learning (not supported)	Yes	Yes	No	Yes
Forwarding	Yes	Yes	Yes	Yes

To enable the MSTP port states:

- Ensure that the switch is VLAN-aware. For more information, see Standard VLAN Operation, page 196.
- Set the ADVLEARN.VLAN_CHK bit to prevent learning of frames discarded due to VLAN ingress filtering.
- Configure all ports as defined for the forwarding state of the RSTP port. For more information, see Table 169, page 210.

Port states per VLAN are hereafter solely configured through the VLAN masks as listed in the following table for port p and VLAN v.

Table 172 • **MSTP Port State Configuration for Port p and VLAN v**

State	VLAN_ACCESS. VLAN_SRC_CHKVLAN v	VLAN_ACCESS. VLAN_PORT_MASK Bit p, VLAN v
Discarding	1	0
Learning	Not supported	Not supported
Forwarding	1	1

As an alternative to setting the VLANACCESS.VLAN_SRC_CHK bit in all VLAN entries in the VLAN table, VLAN ingress filtering can be enabled globally for all VLANs on a per port basis through VLANMASK.

For all multiple spanning tree instances, BPDUs are forwarded to the CPU irrespective of the port states.

MSTP Example

Situation:

Ports 10 and 11 are both members of VLANs 20 and 21. Two spanning trees are used:

- Spanning tree for VLAN 20, where both ports 10 and 11 are in the Forwarding state
- Spanning tree for VLAN 21, where port 10 is in the Discarding state and port 11 is in the Forwarding state

All other ports on the switch are unused.

Resolution:

```
# Get all BDPUs to CPU queue 0.
CPU_FWD_BPDU_CFG[*].BPDU_REDIR_ENA[0] = 1
CPUQ_8021_CFG.CPUQ_BPDU_VAL[0] = 0
# Enable learning on all ports. The VLAN table controls forwarding and
learning.
PORT::PORT_CFG.LEARN_ENA = 1
# Disable learning of VLAN membership source port filtered frames.
ADVLEARN.VLAN_CHK = 1
# Configure VLAN 20 for ports 10 and 11 in Forwarding state.
VLANTIDX.INDEX = 20
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 1
VLANACCESS.VLAN_PORT_MASK = 0x00000C00
VLANACCESS.VLAN_TBL_CMD = 2
```

```
# Configure VLAN 21 for port 10 in Discarding state and port 11 in Forwarding
state.
VLANTIDX.INDEX = 21
VLANTIDX.VLAN_PRIV_VLAN = 0
VLANTIDX.VLAN_MIRROR = 0 (don’t care, for this example)
VLANTIDX.VLAN_LEARN_DISABLE = 0
VLANTIDX.VLAN_SRC_CHK = 1
VLANACCESS.VLAN_PORT_MASK = 0x00000800
VLANACCESS.VLAN_TBL_CMD = 2
```

6.4.7 IEEE 802.1X: Network Access Control

IEEE 802.1X Port-Based Network Access Control provides a standard for authenticating and authorizing devices attached to a LAN port.

Generally, IEEE 802.1X is port-based; however, the device also supports MAC-based network access control.

This section provides information about the configuration settings for port-based and MAC-based network access control.

Port-Based Network Access Control

The following table lists the configuration settings that are required for port-based network access control.

Table 173 • **Configurations for Port-Based Network Access Control**

Register/Register Field	Description/Value	Replication
ANA::CPU_FWD_BPDU_CFG.BPDU_REDIR_ENA[3]	Must be set to 1 to redirect frames with destination MAC addresses 01-80-C2-00-00-03 to the CPU Port Module. IEEE 802.1X uses MAC address 01-80-C2-00-00-03.	Per port
ANA::CPUQ_8021_CFG.CPUQ_BPDU_VAL[3]	Queue to which authentication BPDUs are redirected.	None
ANA::PGID[64-79]	When a port is not yet authenticated, any forwarding of frames to the port can be disabled by clearing the port’s bit in all 16 aggregation masks. After authenticated, these bits must be set.	16
ANA::PGID[80-106]	Source masks. When a port is not yet authenticated, any forwarding of frames received on the port must be disabled. This can be done by setting the ANA::PGID[80+port] to all-zeros. After authenticated, the port’s source mask must be set back to its normal value.	Per port

The configuration settings required for port-based network access control enable the following functionality:

- Redirects frames with DMAC 01-80-C2-00-00-03 to CPU, even if the port is not yet authenticated.
- Stops forwarding of frames to ports that are not yet authenticated. This is configured in ANA::PGID[64-79].
- Stops forwarding of frames received on ports that are not yet authenticated. This is configured in ANA::PGID[80-106].

6.4.7.1 MAC-Based Authentication with Secure CPU-Based Learning

The following table lists the configuration settings required for MAC-based network access control with secure CPU-based learning.

Table 174 • **Configurations for MAC-Based Network Access Control with Secure CPU-Based Learning**

Register/Register Field	Description/Value	Replication
ANA:PORT:CPU_FWD_BPDU_CFG.BPDU_REDIR_ENA[3]	Must be set to 1 to redirect frames with destination MAC addresses 01-80-C2-00-00-03 to the CPU Port Module. IEEE 802.1X uses MAC address 01-80-C2-00-00-03.	Per port
ANA::CPUQ_8021_CFG.CPUQ_BPDU_VAL[3]	Queue to which authentication BPDUs are redirected.	None
ANA:PORT:PORT_CFG.LEARN_ENA ANA:PORT:PORT_CFG.LEARNCPU ANA:PORT:PORT_CFG.LEARNDROP ANA:PORT:PORT_CFG.LEARNAUTO	Must be set to support secure CPU-based learning. See Address Learning, page 194. PORT_CFG.LEARN_ENA = 1 PORT_CFG.LEARNCPU = 1 PORT_CFG.LEARNDROP = 1 PORT_CFG.LEARNAUTO = 0	Per port

The MAC-based network access control with secure CPU-based learning enables the following functionality:

- Redirects frames with DMAC 01-80-C2-00-00-03 to CPU.
- Only frames from known, authenticated MAC addresses are forwarded to other ports.
- Frames from unknown MAC addresses are redirected to CPU for authentication. After the address is authenticated, the CPU must insert an entry in the MAC table. The authentication process may be initiated from the CPU when receiving learn frames.

6.4.7.2 MAC-Based Authentication with No Learning

The following table lists the configuration settings required for MAC-based network access control with no learning.

Table 175 • **Configurations for MAC-Based Network Access Control with No Learning**

Register/Register Field	Description/Value	Replication
ANA:PORT:CPU_FWD_BPDU_CFG.BPDU_REDIR_ENA[3]	Must be set to 1 to redirect frames with destination MAC addresses 01-80-C2-00-00-03 to the CPU Port Module. IEEE 802.1X uses MAC address 01-80-C2-00-00-03.	Per port
ANA::CPUQ_8021_CFG.CPUQ_BPDU_VAL[3]	Queue to which authentication BPDUs are redirected.	None
ANA:PORT:PORT_CFG.LEARN_ENA ANA:PORT:PORT_CFG.LEARNCPU ANA:PORT:PORT_CFG.LEARNDROP ANA:PORT:PORT_CFG.LEARNAUTO	Must be set to support no learning. See Address Learning, page 194. PORT_CFG.LEARN_ENA = 1 PORT_CFG.LEARNCPU = 1 PORT_CFG.LEARNDROP = 1 PORT_CFG.LEARNAUTO = 0	None

The MAC-based network access control with no learning enables the following functionality:

- Frames with DMAC 01-80-C2-00-00-03 are redirected to CPU. Unauthenticated and unauthorized devices must initiate an 802.1X session by sending 802.1X BPDUs (MAC address: 01-80-C2-00-00-03). After the address is authenticated, the CPU must insert an entry in the MAC table.
- Only frames from known, authenticated MAC addresses are forwarded to other ports.
- Frames from unknown MAC addresses are discarded and the CPU can therefore not initiate the authentication process.

6.4.8 Link Aggregation

Link aggregation bundles multiple ports (member ports) together into a single logical link. It is primarily used to increase available bandwidth without introducing loops in the network and to improve resilience against faults. A link aggregation group (LAG) can be established with individual links being dynamically added or removed. This enables bandwidth to be incrementally scaled based on changing requirements. A link aggregation group can be quickly reconfigured if faults are identified.

Frames destined for a LAG are sent on only one of the LAG's member ports. The member port on which a frame is forwarded is determined by a 4-bit aggregation code (AC) that is calculated for the frame.

The aggregation code ensures that frames belonging to the same frame flow (for example, a TCP connection) are always forwarded on the same LAG member port. For that reason, reordering of frames within a flow is not possible. The aggregation code is based on the following information:

- SMAC
- DMAC
- Source and destination IPv4 address.
- Source and destination TCP/UDP ports for IPv4 packets
- Source and destination TCP/UDP ports for IPv6 packets
- IPv6 Flow Label

For best traffic distribution among the LAG member ports, enable all six contributions to the aggregation code.

Each LAG can consist of up to 16 member ports. Any quantity of LAGs may be configured for the device (only limited by the quantity of ports on the device.) To configure a proper traffic distribution, the ports within a LAG must use the same link speed.

A port cannot be a member of multiple LAGs.

6.4.8.1 Link Aggregation Configuration

The following table lists the registers associated with link aggregation groups.

Table 176 • **Link Aggregation Group Configuration Registers**

Register/Register Field	Description/Value	Replication
ANA::PGID[0 – 63]	Destination mask	64
ANA::PGID[80 – 106]	Source mask.	Per port
ANA::PGID[64 – 79]	Aggregation mask.	16
ANA::PORT_CFG.PORTID_VAL	Logical port number. Must be set to the same value for all ports that are part of a given LAG; for example, the lowest port number that is a member of the LAG.	Per port
ANA::AGGR_CFG. AC_IP6_FLOW_LBL_ENA	Use IPv6 flow label when calculating AC. Configure identically for all ports. Recommended value is 1.	None

Table 176 • **Link Aggregation Group Configuration Registers** ***(continued)***

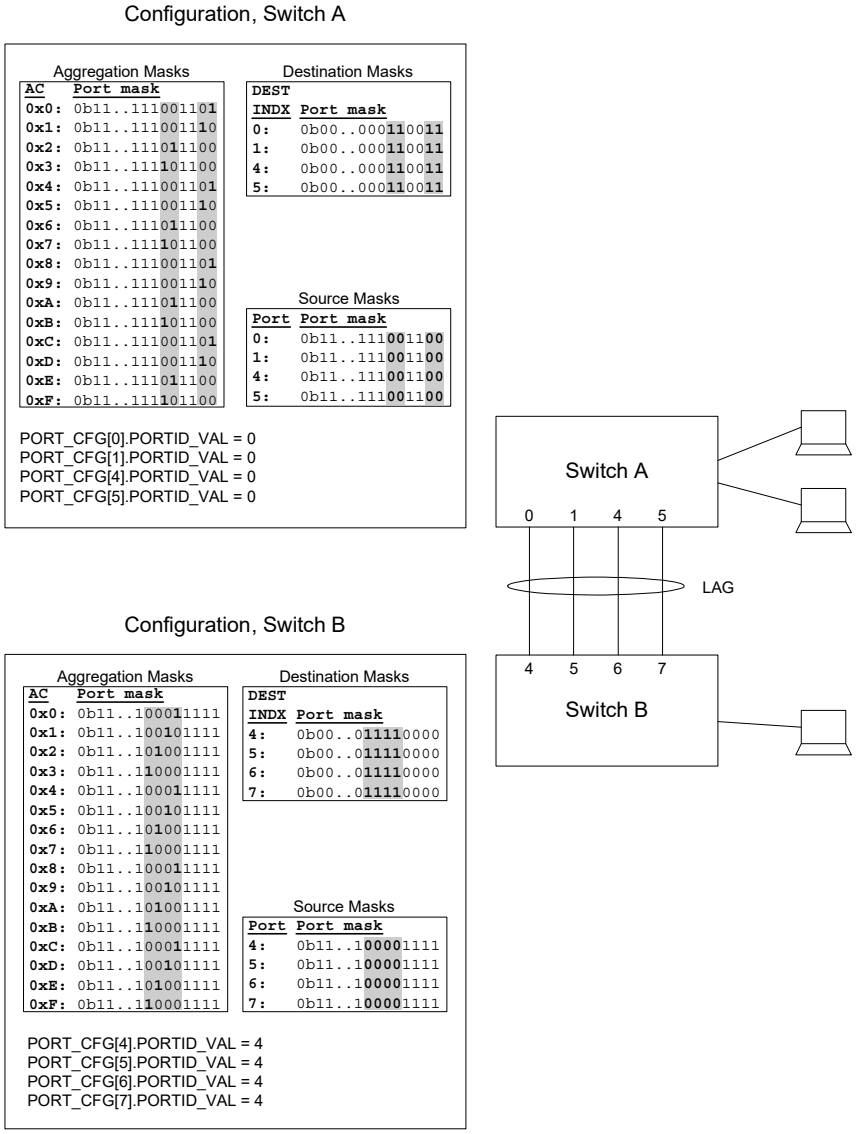
Register/Register Field	Description/Value	Replication
ANA::AGGR_CFG. AC_SIPDIP_ENA	Use IPv4 source and destination IP address when calculating aggregation code. Configure identically for all ports. Recommended value is 1.	None
ANA::AGGR_CFG. AC_TCPUDP_PORT_ENA	Use IPv4 TCP/UDP port when calculating aggregation code. Configure identically for all ports. Recommended value is 1.	None
ANA:: AGGR_CFG. AC_DMAC_ENA	Use destination MAC address when calculating aggregation code. Configure identically for all ports. Recommended value is 1.	None
ANA:: AGGR_CFG. AC_SMAC_ENA	Use source MAC address when calculating aggregation code. Configure identically for all ports. Recommended value is 1.	None
ANA:: AGGR_CFG. AC_RND_ENA	Use random aggregation code. Recommended value is 0.	None

To set up a link aggregation group, the following destination masks, source masks, and aggregation masks must be configured:

- **Destination Masks: ANA::PGID[0-63]** — For each of the member ports, the corresponding destination mask must be configured to include all member ports of the LAG.
- **Source Masks: ANA::PGID[80-106]** — The source masks must be configured to avoid flooding frames that are received at one member port back to another member port of the LAG. As a result, the source masks for each of the member ports must be configured to exclude all of the LAG's member ports.
- **Aggregation Masks: ANA::PGID[64-79]** — The aggregation masks must be configured to ensure that when a frame is destined for the LAG, it gets forwarded to exactly one of the LAG's member ports. Also, the distribution of traffic between member ports is determined by this configuration.

The following illustration shows an example of a LAG configuration.

Figure 74 • **Link Aggregation Example**



In this example, ports 0, 1, 4, and 5 of switch A are configured as a LAG. These ports are connected to 4 ports (4, 5, 6, 7) of switch B, providing an aggregated bandwidth of 4 Gbps between the two switches.

The aggregation masks for switch A are configured such that frames (destined for the LAG) are distributed on the member ports as follows:

- Port 0 if frame's aggregation code (AC) is 0x0, 0x4, 0x8, 0xC
- Port 1 if frame's aggregation code (AC) is 0x1, 0x5, 0x9, 0xD
- Port 4 if frame's aggregation code (AC) is 0x2, 0x6, 0xA, 0xE
- Port 5 if frame's aggregation code (AC) is 0x3, 0x7, 0xB, 0xF

6.4.8.2 Link Aggregation Control Protocol (LACP)

LACP allows switches connected to each other to automatically discover if any ports are member of the same LAG.

To implement LACP, any LACP frames must be redirected to the CPU. Such frames are identified by the DMAC being equal to 01-80-C2-00-00-02 (Slow Protocols Multicast address).

The following table lists the registers associated with configuring the redirection of LACP frames to the CPU.

Table 177 • **Configuration Registers for LACP Frame Redirection to the CPU**

Register/Register Field	Description/Value	Replication
ANA::CPU_FWD_BPDU_CFG.BPDU_REDIR_ENA[2]	Must be set to 1.	Per port

6.4.9 Simple Network Management Protocol (SNMP)

This section provides information about the port module registers and the analyzer registers for SNMP operation.

The following table lists the system registers for SNMP operation.

Table 178 • **System Registers for SNMP Support**

Register	Description	Replication
CNT	The value of the counter. For more information about how to read counters, see Statistics, page 43.	None

The following table lists the analyzer registers for SNMP support.

Table 179 • **Analyzer Registers for SNMP Support**

Register	Description	Replication
MACACCESS	Command register for indirect MAC table access. Supports GET_NEXT command	None
MACHDATA	High part of data word when accessing MAC table.	None
MACLDATA	Low part of data word when accessing MAC table.	None
MACTINDX	Index for direct-mode access to MAC table.	None

For SNMP support according to IETF RFC 1157, use the following features:

- RMON counters
- MAC table GET_NEXT function

For more information about the supported RMON counters, see Port Counters, page 190.

For more information about the MAC table GET_NEXT function, see Table 59, page 86.

6.4.10 Mirroring

To debug network problems, selected traffic can be copied, or mirrored, to a mirror port where a frame analyzer can be attached to analyze the frame flow.

The traffic to be copied to the mirror port can be selected as follows:

- All frames received on a given port (also known as ingress mirroring)
- All frames transmitted on a given port (also known as egress mirroring
- Frames selected through configured VCAP entries
- All frames classified to specific VIDs
- All frames sent to the CPU (may be useful for software debugging)
- Frames where the source MAC address is to be learned (also known as learn frame), which may be useful for software debugging

The mirror port may be any port on the device, including the CPU.

Mirroring Configuration

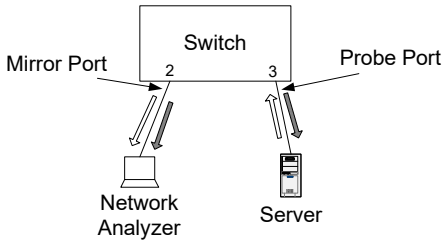
The following table lists configuration registers associated with mirroring.

Table 180 • **Configuration Registers for Mirroring**

Register/Register Field	Description/Value	Replication
ANA::PORT_CFG.SRC_MIRROR_ENA	If set, all frames received on this port are mirrored to the port set configured in MIRRORPORTS, that is, ingress mirroring.	Per port
ANA:: EMIRRORPORTS	Frames forwarded to ports in this mask are mirrored to the port set configured in MIRRORPORTS, that is, egress mirroring.	Per port
ANA::VLANTIDX.VLAN_MIRROR	If set, all frames classified to this VLAN are mirrored to the port set configured in MIRRORPORTS.	One per VID
ANA::AGENCTRL.MIRROR_CPU	Frames destined for the CPU extraction queues are also forwarded to the port set configured in MIRRORPORTS.	None
ANA::MIRRORPORTS	The mirror ports. Usually only one mirror port is configured, that is, only one bit is set in this mask.	None
ANA::CPUQ_CFG.CPUQ_MIRROR	CPU extraction queue used, if CPU is included in MIRRORPORTS.	None
ANA::ADVLEARN.LEARN_MIRROR	Learn frames are also forwarded to ports marked in MIRRORPORTS.	None
VCAP Registers	Configuration of VCAP entries, for example, to trigger copy to mirror port. For more information, see VCAP IS2, page 66.	Per VCAP entry

The following illustration shows a port mirroring example.

Figure 75 • **Port Mirroring Example**



All traffic to and from the server on port 3 (the probe port) is mirrored to port 2 (the mirror port). Note that the mirror port may become congested, because both the Rx frames and Tx frames on the probe port become Tx frames on the mirror port. The following mirror configuration is required:

ANA::PORT_CFG[3].SRC_MIRROR_ENA = 1
ANA::EMIRRORPORTS[3] = 1
ANA::MIRRORPORTS = 0x0000004

In addition to the mirror configuration settings, the egress configuration of the mirror port (port 2) must be configured identically to the egress configuration of the probe port (port 3). This is to ensure that VLAN tagging and DSCP remarking at the mirror port is performed consistently with that of the probe port, such that the frame copies at the mirror port are identical to the original frames on the probe port.

Multiple mirror conditions, such as mirror multiple probe ports, VLANs, and so on, can be enabled concurrently to the same mirror port. However, in such configurations, it may not be possible to configure the egress part of the mirror port to perform tagging and DSCP remarking consistent with that of the original frame.

6.5 IGMP and MLD Snooping

This section provides information about the features and configurations related to Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) snooping.

By default, Layer-3 multicast data traffic is flooded in a Layer-2 network in the broadcast domain spanned by the VLAN. This causes unnecessary traffic in the network and extra processing of unsolicited frames in hosts not listening to the multicast traffic. IGMP and MLD snooping enables a Layer-2 switch to listen to IGMP and MLD conversations between host and routers. The switch can then prune multicast traffic from ports that do not have a multicast listener, and as a result, do not need a copy of the multicast frame. This is done by managing the multicast group addresses and the associated port masks.

IGMP is used to manage IPv4 multicast memberships, and MLD is used to manage IPv6 multicast memberships.

The device supports IGMPv2/v3 and MLDv1/v2. IGPMv2 and MLDv1 use any-source multicasting (ASM), where the multicast listener joins a group and can receive the multicast traffic from any source. IGMPv3 and MLDv2 introduce source-specific multicasting (SSM), where both source and group are specified by the multicast listener when joining a group.

The support in the device is two-fold:

- Control plane: IGMP and MLD frames are redirected to the CPU. This enables the CPU to listen to the queries and reports.
- Data plane: By monitoring the multicast group registrations and de-registrations signaled through the IGMP and MLD frames, the CPU can setup multicast group addresses and associated ports.

6.5.1 IGMP and MLD Snooping Configuration

To implement IGMP and MLD snooping, any IGMP or MLD frames must be redirected to the CPU. For information about by the conditions by which such frames are identified, see CPU Forwarding Determination, page 56. IGMP and MLD frames can be independently snooped and assigned individual CPU extraction queues.

The following table lists the registers associated with configuring the redirection of IGMP and MLD frames to the CPU.

Table 181 • **Configuration Registers for IGMP and MLD Frame Redirection to CPU**

Register/Register Field	Description/Value	Replication
ANA::CPU_FWD_CFG.IGMP_REDIR_ENA	Must be set to 1 to redirect IGMP frames to the CPU	Per port
ANA::CPU_FWD_CFG.MLD_REDIR_ENA	Must be set to 1 to redirect MLD frames to the CPU	Per port
ANA::CPUQ_CFG.CPUQ_IGMP	CPU extraction queue for IGMP frames	None
ANA::CPUQ_CFG.CPUQ_MLD	CPU extraction queue for MLD frames	None

6.5.2 IP Multicast Forwarding Configuration

The following table lists the registers associated with configuring the multicast group addresses and the associated ports.

Table 182 • **IP Multicast Configuration Registers**

Register/Register Field	Description/Value	Replication
MACHDATA	MAC address and VID when accessing the MAC table.	None

Table 182 • **IP Multicast Configuration Registers** ***(continued)***

Register/Register Field	Description/Value	Replication
MACLDATA	MAC address when accessing the MAC table.	None
MACTINDX	Direct address into the MAC table for direct read and write.	None
MACACCESS	Flags and command when accessing the MAC table.	None
MACTOPTIONS	Flags when accessing the MAC table	None
FLOODING_IPMC	Index into the PGID table used for flooding of IPv4/6 multicast control and data frames.	None
PGID[63:0]	Destination and flooding masks table	64
IS1_ACTION.FID_SEL	Specifies the use of IS1_ACTION.FID_VAL for the DMAC lookup, the SMAC lookup, or for both lookups.	Per IS1 entry
IS1_ACTION.FID_VAL	FID value.	Per IS1 entry

IPv4 and IPv6 multicast group addresses are programmed in the MAC table as IPv4 and IPv6 multicast entries. For more information, see MAC Table, page 83. The entry in the MAC table also holds the set of egress ports associated with the group address.

By default, programming an IPv4 or IPv6 multicast entry in the MAC table makes it an any-source multicast, because the actual source IP address is insignificant with respect to forwarding.

To create source-specific IPv4 or IPv6 multicast entries, the Filter Identifier (FID) action in VCAP IS1 can be used, which enables creation of specific FIDs per source IP address. Multiple MAC table entries holding the same IPv4 or IPv6 multicast group address but different FIDs can then be created. This effectively enables source-specific multicasting.

The switch provides full control of flooding of unknown IP multicast frames. For more information, see Table 69, page 93. Generally, an IGMP and MLD snooping switch disables flooding of unknown multicast frames, except to ports connecting to multicast routers. Note that unknown IPv4 multicast control frames should be flooded to all ports, because IPv4 is not as strict as IPv6 in terms of registration for IP multicast groups.

6.6 Quality of Service (QoS)

This section discusses features and configurations related to QoS.

The device includes a number of features related to providing low-latency guaranteed services to critical network traffic such as voice and video in contrast to best-effort traffic such as web traffic and file transfers.

All incoming frames are classified to a QoS class, which is used in the queue system when assigning resources, in the arbitration from ingress to egress queues and in the egress scheduler when selecting the next frame for transmission. The device provides two methods for classifying to a QoS class and for remarking priority information in the frame: Basic and Advanced classification.

Basic QoS classification enables predefined schemes for handling Priority Code Points (PCP), Drop Eligible Indicator (DEI), and Differentiated Service Code Points (DSCP):

- QoS classification based on PCP and DEI for tagged frames. The mapping table from PCP and DEI to QoS class is programmable per port.
- QoS classification based on DSCP values. Can optionally use only trusted DSCP values. The mapping table from DSCP value to QoS class is common between all ports.

- The device can optionally work as a DS boundary node connecting two DS domains together by translating incoming/outgoing DSCP values for selected ports.
- The DSCP values can optionally be remarked based on the frame's classified QoS class.
- For untagged or non-IP frames, a default per-port QoS class is programmable.

Advanced QoS classification uses the VCAP IS1, which provides a flexible classification:

- A large range of higher layer protocol fields (Layer 2 through Layer 4) are available for rule matching.
- The IS1 action vector returns a QoS class, and translations of PCP, DEI, and DSCP values are also possible.
- Through programming of entries in IS1, QoS rules can be made as specific as needed.For example; per source MAC address, per TCP/UDP destination port number, or combination of both.

For more information about advanced QoS classification using the VCAP IS1, see Ingress Control Lists, page 228.

6.6.1 Basic QoS Configuration

The following table lists the registers associated with configuring basic QoS.

Table 183 • **Basic QoS Configuration Registers**

Register	Description	Replication
ANA:PORT:QOS_CFG	QoS and DSCP configuration	Per port
ANA:PORT:QOS_PCP_DEI_MAP_CFG:	Mapping of DEI and PCP to QoS class and drop precedence level	Per port
ANA::DSCP_CFG	DSCP configuration	Per DSCP

Situation:

Assume a configuration with the following requirements:

- All frames with DSCP=7 must get QoS class 7.
- All frames with DSCP=8 must get QoS class 5.
- DSCP=9 is untrusted and all frames with DSCP=9 should be treated as a non-IP frame.
- VLAN-tagged frames with PCP=7 must get QoS class 7
- All other IP frames must get QoS class 1.
- All other non-IP frames must get QoS class 0.

Solution:

```
# Program overall QoS configuration
QOS_CFG.QOS_DSCP_ENA = 1
QOS_CFG.QOS_PCP_ENA = 1


# Program DSCP trust configuration ("*" = 0 through 63)
DSCP_CFG[*].DSCP_TRUST_ENA = 1
DSCP_CFG[9].DSCP_TRUST_ENA = 0

# Program DSCP QoS configuration ("*" = 0 through 63)
DSCP_CFG[*].QOS_DSCP_VAL = 1
DSCP_CFG[7].QOS_DSCP_VAL = 7
DSCP_CFG[8].QOS_DSCP_VAL = 5

# Program PCP QoS configuration ("*" = 0 through 15)
# Note: both 7 and 15 are programmed in order to don't care DEI
QOS_PCP_DEI_MAP_CFG[*] = 0
QOS_PCP_DEI_MAP_CFG[7] = 7
QOS_PCP_DEI_MAP_CFG[15] = 7
```

```
# Program default QoS class for non-IP, non-tagged frames.
QOS_CFG.QOS_DEFAULT_VAL = 0
```

6.6.2 IPv4 and IPv6 DSCP Remarking

IPv4 and IPv6 packets include a 6-bit Differentiated Services Code Point (DSCP), which switches and routers can use to determine the QoS class of a frame. With a proper value in the DSCP field, packets can be prioritized consistently throughout the network. Compared to QoS classification based on user priority, classification based on DSCP provides two main advantages

- DSCP field is already present in all packets (assuming all traffic is IPv4/IPv6).
- DSCP value is preserved during routing and is therefore better suited for end-to-end QoS signaling.

Some hosts may be able to send packets with an appropriate value in the DSCP field, whereas other hosts may not provide an appropriate value in the DSCP field.

For packets without an appropriate value in the DSCP field, the device can be configured to write a new DSCP value into the frame, based on the QoS class of the frame. For example, the device may have determined the QoS class based on the VLAN tag priority information (PCP and DEI). After the packet is transmitted by the egress port, the DSCP field can be rewritten with a value based on the QoS class of the frame. Any subsequent routers or switches can then be easily prioritize the frame, based on the rewritten DSCP value.

The DSCP rewriting functionality available in the device provides flexible, per-ingress port and per-DSCP-value configuration of whether frames should be subject to DSCP rewrite. If it is determined at the ingress port that the DSCP value should be rewritten and to which value, this is then signaled to the egress ports, where the actual change of the DSCP field is done.

Additionally, the IS1 can be programmed to return a DSCP value as part of the action vector. This value overrules the potential DSCP value coming out of the DSCP rewrite functionality described previously. A DSCP value from either the basic classification or the advanced IS1 classification obey the same egress rules for the actual DSCP remarking.

6.6.2.1 DSCP Remarking Configuration

The following table lists the configuration registers associated with DSCP remarking.

Table 184 • **Configuration Registers for DSCP Remarking**

Register/Register Field	Description/Value	Replication
ANA:PORT:DSCP_REWR_CFG	Two-bit DSCP rewrite mode per ingress port: 0x0: No DSCP rewrite. 0x1: Rewrite only if the frame's current DSCP value is zero. 0x2: Rewrite only if the frame's current DSCP value is enabled for remarking in ANA::DSCP_CFG.DSCP_REWR_ENA. 0x3: Rewrite DSCP of all frames, regardless of current DSCP value.	Per ingress port
ANA::DSCP_CFG.DSCP_REWR_ENA	Enables specific DSCP values for rewrite for ports with DSCP rewrite mode set to 0x2.	Per DSCP
ANA::DSCP_REWR_CFG.DSCP_QOS_REWR_VAL	Maps the frame's DP level and QoS class to a DSCP value.	Per DP level and per QoS class
REW::DSCP_CFG.DSCP_REWR_CFG	Enables DSCP rewrite for egress port.	Per egress port
REW::DSCP_REMAP_CFG	Remap table of DSCP values.	None

The configuration related to the ingress port controls whether a frame is to be remarked. For each ingress port, a DSCP rewrite mode is configured in ANA:PORT:DSCP_REWR_CFG. This register defines the four different modes as follows:

- 0x0: No DSCP rewrite, that is, never change the received DSCP value.
- 0x1: Rewrite if DSCP is zero. This may be useful if a DSCP value of zero indicates that the host has not written any value to the DSCP field.
- 0x2: Rewrite selected DSCP values. In ANA::DSCP_CFG.DSCP_REWR_ENA specific DSCP values can be selected for rewrite, for example, if only certain DSCP values are allowed in the network.
- 0x3: Rewrite all DSCP values.

After a frame is selected for DSCP rewrite, based on the configuration for the ingress port, the new DSCP value is determined by mapping the QoS class and DP level to a new DSCP value (ANA::DSCP_REWR_CFG.DSCP_QOS_REWR_VAL).

This DSCP value is overruled by IS1 if a hit in IS1 returns an action vector with DSCP_ENA set.

The resulting DSCP value is forwarded to the Rewriter at the egress port, which determines whether to actually write the new DSCP value into the frame (REW::DSCP_CFG.DSCP_REWR_CFG). Optionally, the DSCP value may be translated before written into the frame (REW::DSCP_REMAP_CFG) for applications where the switch acts as an DS boundary node.

When an IPv4 DSCP is rewritten, the IP header checksum is updated accordingly.

6.6.3 Voice over IP (VoIP)

This section provides information about QoS in applications with Voice over IP (VoIP).

In a typical workgroup switch application with VoIP phones, both workstations and VoIP phones are connected to the switch. A workstation can be connected through a VoIP phone. Traffic from the workstation is usually untagged, whereas traffic from the VoIP phone may or may not be tagged. The QoS classification mechanism applied on the access port depends on the capabilities of the VoIP phone; these capabilities vary from phone to phone. With different VoIP phone models in the network, different access ports require different QoS classification mechanisms. The access switch can perform QoS classification, depending on the VoIP phone model, to achieve consistent VoIP QoS across the network.

Voice traffic can be identified in different ways:

- **Source MAC address (OUI)**: Most vendors use a dedicated OUI for VoIP phones.
- **EtherType**: Legacy phones may use a special EtherType for VoIP.
- **VID**: A special VID used for voice traffic.
- **UDP Port Range**: Voice traffic often uses a well-known port range for the Real-time Transport Protocol (RTP).
- **DSCP or ToS Precedence**: Many phones can set the DSCP value or the ToS precedence bits.
- **Priority Code Point**: Many phones send VLAN tagged frames and can set the priority code point.

All of these identification methods are supported by QoS classification through IS1. They can be used to determine the VoIP traffic's QoS class when entering the switch. For more information about the IS1, see VCAP IS1, page 61.

To ensure consistent QoS across the network, frames can be remarked on the uplink port. Priority Code Points and DSCP values can be remarked based on the QoS class determined by the QCLs. For more information about Priority Code Point and DSCP remarking, see VLAN Editing, page 115, and IPv4 and IPv6 DSCP Remarking, page 224.

Traffic received on the uplink port can usually rely on simple DSCP or PCP QoS classification.

6.7 VCAP Applications

This section provides information about Vitesse Content Aware Processor (VCAP) applications for QoS classification, source IP guarding, and access control.

The following table shows the different control lists that the VCAP can be used to build.

Table 185 • **Control Lists and Application**

Control List	Description
Ingress control lists (ICLs)	QoS classification VLAN classification and translation policy association group classification
IPv4 source guarding control lists (S4CLs)	IPv4 source guarding
IPv6 source guarding control lists (S6CLs)	IPv6 source guarding
Access control lists (ACLs)	Access control
Egress control lists (ECLs)	Tagging and egress translations

6.7.1 Notation for Control Lists Entries

Setting up a control list typically requires a large amount of register configurations. To maintain the overview of the VCAP functionality, the following control list notations are used. The register configurations are not listed. For more information about the VCAP configurations, see VCAP-II Configuration, page 76.

The notation used is:

```
entry_number vcap entry_type {entry_field=value}
→ {action_field=value}
```

Each control entry in the notation consists of:

- The entry number specifying the TCAM address for the specific TCAM
- The VCAP used (IS1, IS2, ES0)
- The entry type (for instance IS1 or MAC_ETYPE).
- Zero, one, or more entry fields with specified values. If no value is supplied, it is assumed that the value is 1.
- The action (indicated with →)
- Zero, one, or more action fields with specified values. If no value is supplied, it is assumed that the value is 1.

All entry fields not listed in the entry part of the control entry are set to don't care.

All action fields not listed in the action part of the control entry are set to zero.

Default actions are special, because they do not have an entry type and a pattern to match:

```
default vcap (first|second) port=value
→ {action_field=value}
```

The notation is illustrated by the following examples.

Example 1:

An example of an ACL entry:

```
255 is2 ipv4_other first igr_port_mask=(1<<11) sip=10.10.12.134
→
```

This ACL entry is located in entry number 255. It is matched for the first lookup, and it is part of the port ACL for port 11. The type is ipv4_other, and the action is not to change the normal flow for frames with SIP = 10.10.12.134.

Example 2:

Policy ACL A can include a monitoring rule that disables forwarding and learning of all incoming IPv4 traffic, but redirects a copy to CPU extraction queue number 3 using the hit-me-once filter. The hit-me-once filter enables the CPU to control when it ready to accept a new frame. The rule would look like this:

```
254 is2 ipv4_other first pag=A
```

```
→ hit_me_once cpu_qu_num = 3
```

Example 3:

This example shows an ACE that allows forwarding and learning of ARP requests from port 11, if the source IP address is 10.10.12.134. The ACL entry also performs ARP sanity checks that frames must pass to match. The checks include checking that it is a Layer-2 broadcast, that the hardware address space is Ethernet, that the protocol address space is IP, that the MAC address and IP address lengths are correct, and that the sender hardware address (SMAC) matches the SMAC of the frame.

```
253 is2 arp first igr_port_mask=(1<<11) l2_bc opcode=arp_request
sip=10.10.12.134
arp_addr_space_ok arp_proto_space_ok arp_len_ok
arp_sender_match
→
```

Example 4:

If the default action from first lookup for port 11 is to discard all traffic, the following notation is used:

```
default is2 first port=11
→ mask_mode=1 port_mask=0x0
```

6.7.2 Ingress Control Lists

The following table lists the registers associated with advanced QoS configuration through Ingress Control Lists.

Table 186 • **Advanced QoS Configuration Register Overview**

Register	Description	Replication
ANA:PORT:QOS_CFG	QoS configuration	Per port

Situation:

Assume a configuration with the following requirements:

- All frames with DSCP = 7 must get QoS class 2.
- All frames with TCP/UDP port numbers in the range 0 – 1023 must get QoS class 3, except frames with TCP/UDP port 25, which must get QoS class 1.
- All other frames must get QoS class 0.

Solution:

The resulting QoS Control List looks like this:

```
255 is1 is1 first etype_len ip_snap dscp = 7
→ qos_ena=1, qos_val = 2
254 is1 is1 first etype_len ip_snap l4_sport = 25
→ qos_ena=1, qos_val = 1
253 is1 is1 first etype_len ip_snap etype = 25
→ qos_ena=1, qos_val = 1
252 is1 is1 first etype_len ip_snap l4_sport = (key: 0, mask: 0x3FF)
→ qos_ena=1, qos_val = 3
251 is1 is1 first etype_len ip_snap etype = (key: 0, mask: 0x3FF)
→ qos_ena=1, qos_val = 3
```

ANA:PORT:QOS_CFG.QOS_DEFAULT_VAL = 0.

6.7.3 Access Control Lists

The examples operate with three levels of ACLs:

- Port ACLs
- Policy ACLs
- Switch ACLs

The port ACLs are specific to a single port or a group of ports that form a link aggregation group. For example, a port ACL can be used for source IP filtering, locking a specific source IP address to a port. For more information about this example, see **Restrictive SIP Filter Using IS2,** page 230.

The policy ACLs are shared for a group of ports that must have the same policy applied. For example, there could be one policy for ports through which workstations access the network and another policy for ports to which servers are connected.

The switch ACLs apply to all ports of the switch. They specify some general rules that apply to all traffic passing through the switch. The rules can still be rather specific, for example, covering a specific VLAN or a specific IP address.

In the examples, the resulting ACL can include one port ACL, one policy ACL, and the switch ACL. This is determined by the way the ingress port mask (IGR_PORT_MASK) and the policy association group (PAG) are used. For information about IGR_PORT_MASK and PAG, see VCAP IS2, page 66. There are

several ways to use the 8-bit PAG, but in this section, all eight bits are used to point out a policy ACL. The IGR_PORT_MASK points out the port ACL. This permits one port ACL per port and a total of 256 policy ACLs. Note that ports may share the same port ACL and a port by don't caring bits in the port ACL's IGR_PORT_MASK.

Each port has a default PAG assigned to it. The IS1 VCAP can be used to change the value of the PAG based on specific protocol fields matched in the IS1 lookup. The resulting PAG is used in the IS2 VCAP lookup and is matched against the PAG field of the ACL entries.

For an ACL entry in the IS2 VCAP, the PAG and IGR_PORT_MASK use this notation:

PAG = PolicyACL_ID
IGR_PORT_MASK = 1<<PortACL_ID

Notes The "<<" operator is the bitwise left shift operator. It shifts the left operand bit-wise to the left the number of positions specified by the right operand.

The IGR_PORT_MASK is a mask so the port number is left-shifted to create the mask.

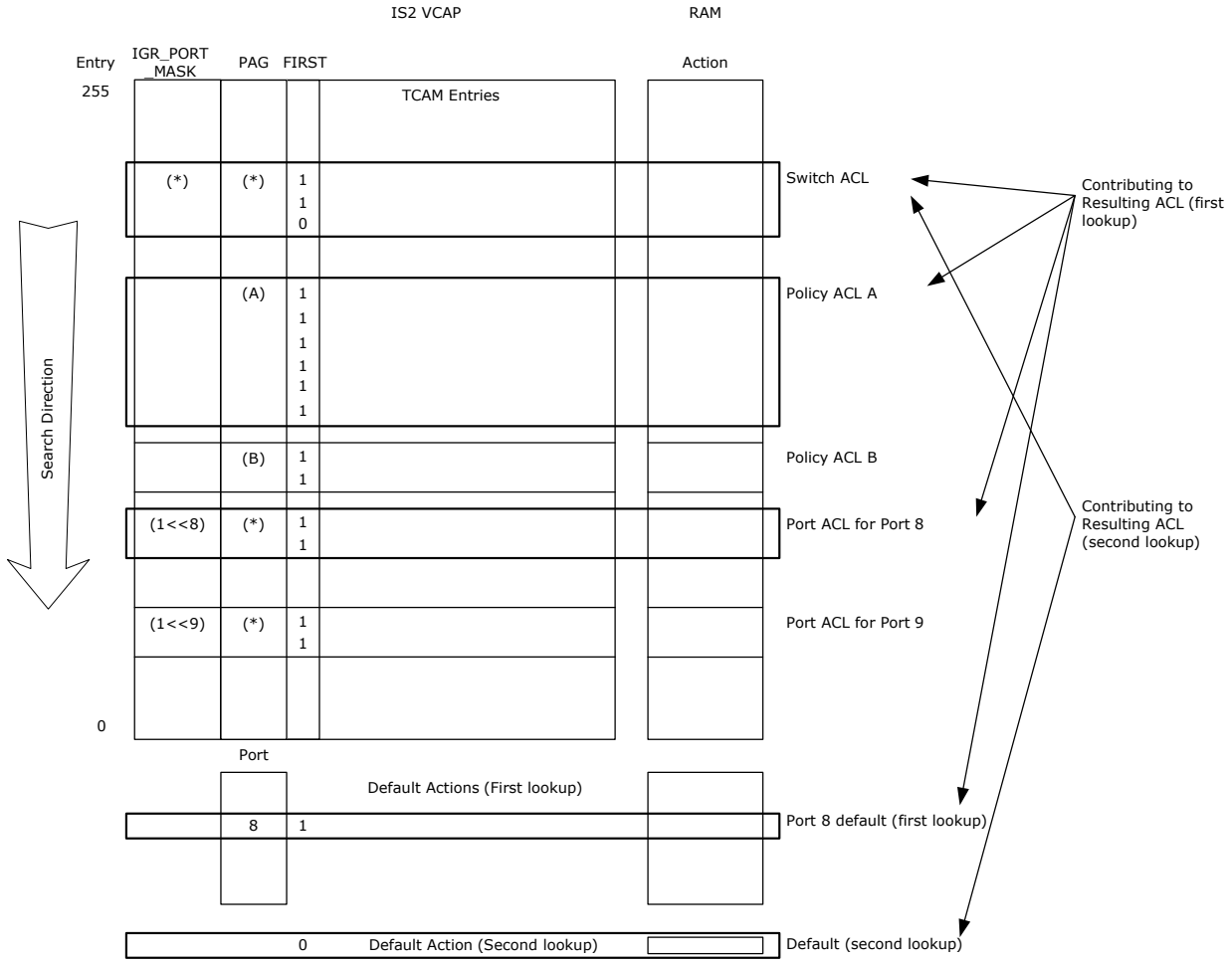
For an ACL entry that is part of a port ACL for port 8, the PAG would be (*) and IGR_PORT_MASK would be (1<<8) = 0x100. The asterisk is a wildcard, which means that the PolicyACL_ID is a don't-care. For an ACL entry that is part of policy ACL A, the PAG would be (A) and the IGR_PORT_MASK would be (*). In this case, the PortACL_ID is a don't-care.

If, for example, port 8 must have policy A applied, the PAG assigned to port 8 is (A). Using this PAG value, the following ACLs match the lookup:

1. The port ACL for port 8 with PAG = (*) and IGR_PORT_MASK = (1<<8)
2. The policy ACL A with PAG = (A) and IGR_PORT_MA
3. SK = (*)
4. The switch ACL with PAG = (*) and IGR_PORT_MASK = (*)
5. The ordering of the port ACL, the policy ACL, and switch ACL in the resulting ACL follows the ordering in the TCAM. In the following illustration, the switch ACL has the highest priority, followed by the policy ACL A, and finally, the port ACL for port 8.

The resulting ingress ACL in the example is made up of the ingress ACL entries in the switch ACL, the policy ACL A, the port ACL for port 8, and the default action for port 8. The VCAP also does a second lookup, for which the resulting ACL has a common default action as the last rule.

Figure 76 • **Resulting ACL for Lookup with PAG = (A) and IGR_PORT_MASK = (1<<8)**



6.7.4 Source IP Filter (SIP Filter)

The VCAP enables filtering of source IP (SIP) addresses on a port also known as source IP guarding. This can be used to only allow IP traffic from a specific SIP to enter the switch on a given port. Doing this can prevent the following denial of service (DoS) attacks: LAND attack, SMURF attack, SYN flood attack, Martian attack, and Ping attack.

Restrictive SIP Filter Using IS2

A restrictive SIP filter can be applied per port in networks where only IP traffic is allowed. The filter locks a specific SIP to the port and only permits ARP frames and IPv4 frames with the specified SIP to enter the switch on the given port.

For monitoring purposes, it is possible to permit IPv4 frames with other SIPs than the SIP locked to the port. The action is to redirect to the CPU, and the amount of traffic can be reduced by using the hit-me-once feature. The ACL entry for this can be part of a policy ACL for all ports on which the SIP filter is applied.

The port ACL has the following options:

- Permit IPv4 with trusted SIP
- Permit ARP with trusted SIP passing ARP sanity checks
- Permit all IPv4 — CPU redirect with hit-me-once filter (for monitoring)
- Default port action — discard all traffic

Situation:

Apply the restrictive SIP filter on port 11 with SIP 10.10.12.134.

Resolution:

The resulting ACL for port 11 looks like this:

```
255 is2 ipv4_tcp_udp first igr_port_mask=(1<<11) sip=10.10.12.134
→
254 is2 ipv4_other first igr_port_mask=(1<<11) sip=10.10.12.134
→
253 is2 arp first igr_port_mask=(1<<11) l2_bc opcode=arp_request
sip=10.10.12.134
arp_addr_space_ok arp_proto_space_ok arp_len_ok
arp_sender_match
→
252 is2 ipv4_tcp_upd first pag=A
→ hit_me_once cpu_queue=3
251 is2 ipv4_other first pag=A
→ hit_me_once cpu_queue=3
default is2 first port=11
→ mask_mode=1 port_mask=0x0
```

Applying this SIP filter requires to two entries per port plus three common entries.

Restrictive SIP Filter Using IS1 and IS2

The same filter as listed above can be achieved using the host_match actions from IS1.

Situation:

Apply the restrictive SIP filter on port 11 with SIP 10.10.12.134.

Resolution:

The resulting ACL for port 11 looks like this:

IS1:

```
255 is1 smac_sip4 igr_port=11 sip=10.10.12.134
→ host_match
```

IS2:

```
255 is2 ip4_tcp_upd first host_match=1
→
254 is2 ip4_other first host_match=1
→
253 is2 arp first igr_port_mask=(1<<11) l2_bc opcode=arp_request
sip=10.10.12.134
arp_addr_space_ok arp_proto_space_ok arp_len_ok
arp_sender_match
→
252 is2 ipv4_tcp_udp first pag=A
→ hit_me_once cpu_queue=3
251 is2 ipv4_other first pag=A
→ hit_me_once cpu_queue=3
default is2 first port=11
→ mask_mode=1 port_mask=0x0
```

Applying this SIP filter requires one entry in IS1 per port and five common entries in IS2. This filter can be extended to create a restrictive MAC/IP-binding filter by including the source MAC address in the key in the IS1 smac_sip4 rule.

Less Restrictive SIP Filter Using IS2

For networks in which non-IP protocols are allowed, for example IPX and ARP, a less restrictive SIP filter can be applied with the following port ACL:

- Permit IPv4 with trusted SIP
- Discard all IPv4
- Default port action; Permit all traffic (non-IPv4, because all IPv4 traffic is covered by the ACL entries from other two items)

For monitoring purposes, the “Discard all IPv4” ACL can be changed to perform CPU redirect. This allows the CPU to monitor all incoming IPv4 frames with source IP addresses different from the trusted SIP, but without allowing these frames to be forwarded to other ports.

Situation:

Apply the less restrictive SIP filter on port 10 with source IP address 10.10.12.134, and monitor any IPv4 traffic with unauthorized source IP addresses with hit-me-once filtering to CPU extraction queue number 2. The monitoring rule is part of policy ACL A that is applied to all user ports.

Resolution:

The resulting ingress ACL for port 10 looks like this:

```
255 is2 ipv4_tcp_udp first igr_port_mask=(1<<10) sip=10.10.12.134
→
254 is2 ipv4_other first igr_port_mask=(1<<10) sip=10.10.12.134
→
63 is2 ipv4_tcp_udp first pag=A
→ hit_me_once cpu_queue=2
62 is2 ipv4_other first pag=A
→ hit_me_once cpu_queue=2
default is2 first port=10
→
```

Applying this SIP filter requires two entries per port plus two common entries.

6.7.5 DHCP Application

A DHCP application can be supported using one policy ACL for the user ports and another policy ACL for the DHCP server ports.

On the user ports, the DHCP requests must be snooped to be able to automatically reset the SIP filters that are applied per port. DHCP replies should be prevented from being forwarded from user ports. For monitoring purposes, such illegal replies are redirected to the CPU.

On the DHCP server ports, DHCP replies are snooped to be able to automatically update the SIP filter for the user port where the reply goes.

In addition, an egress rule is needed to prevent forwarding of all DHCP requests to user ports.

Situation:

Policy ACL A is used for the user port DHCP policy, and policy ACL B is used for the DHCP server policy. The server ports are ports 8 and 9.

Snoop DHCP requests from user ports in CPU extraction queue 1, using policer 0 to protect the CPU. DHCP replies from the servers are snooped in queue 2, and are also subject to policing with policer 0. The illegal DHCP replies from user ports are redirected to queue 3 using the hit-me-once filter.

Resolution:

The PAG assigned to the user ports is (A). The PAG assigned to the DHCP server ports (8 and 9) is (B).

The following shows the ACL entries for the DHCP application:

```
255 is2 ipv4_tcp_udp protocol=udp
sport=bootp_client dport=bootp_server
→ mask_mode=1 port_mask=0x0000300
63 is2 ipv4_tcp_udp first pag=A protocol=udp
sport=bootp_client dport=bootp_server
→ cpu_copy_ena cpu_queue=1 police_ena police_idx=0
62 is2 ipv4_tcp_udp first pag=A protocol=udp
```

```
sport=bootp_server dport=bootp_client
→ hit_me_once cpu_queue=3
31 is2 ipv4_tcp_udp first pag=B protocol=udp
sport=bootp_server dport=bootp_client
→ cpu_copy_ena cpu_queue=2 police_ena police_idx=0
default is2 first
→ mask_mode=1 port_mask=0x0
default is2 second
→
```

Regardless of the number of ports covered, four ACL entries are used: one in the switch ACL, two in policy ACL A, and one in policy ACL B.

6.7.6 ARP Filtering

The VCAP support two useful ARP filters:

- Policing ARP requests to the switch's IP address to mitigate DoS attacks by ARP flooding
- Performing general ARP sanity checks

Because these are general rules, it is sensible to make them part of the switch ACL.

Situation:

Discard all ARP frames that do not pass the ARP sanity checks. Police ARP requests to the switch's IP address 10.10.12.1 using ACL policer 2. ACL policer 2 is configured to allow 16 frames per second, and the frames are copied to CPU extraction queue 0.

RARP is not allowed in the network.

Resolution:

To do ARP filtering in the switch ACL, perform the filtering for the switch's IP address first, then allow all ARP frames passing the sanity checks, and finally, discard all remaining ARP frames. This is illustrated by the following:

```
255 is2 arp first l2_bc opcode=arp_request
dip=10.10.12.1
arp_addr_space_ok arp_proto_space_ok arp_len_ok
arp_sender_match
→ cpu_copy_ena cpu_queue=0 police_ena police_idx=255
254 is2 arp first l2_bc opcode=(arp_request or arp_reply)
arp_addr_space_ok arp_proto_space_ok arp_len_ok
arp_sender_match
→
253 is2 arp
→mask_mode=1 port_mask=0x0
```

The ACL policer configuration for policer 255 is done as follows:

```
# Set the base unit to 1 frame per second, enable the policer, and set the rate
to 16 frames per second and a burst of 1 frame:
SYS:POL[255]:POL_MODE_CFG.FRM_MODE = 1
SYS:POL[255]:POL_PIR_CFG.PIR_RATE = 16
SYS:POL[255]:POL_PIR_CFG.PIR_BURST = 3
```

Three ACL entries are used, irrespective of the number of ports covered.

6.7.7 Ping Policing

The network can easily be protected against ping attacks using a switch ACL rule that applies an ACL policer to all ping packets.

Situation:

Allow no more than 128 ping packets per second to be forwarded through the switch by means of ACL policer 15. Ping packets in excess of 128 frames per second are discarded.

Resolution:

Ping packets are ICMP frames with ICMP Type = Echo Request. Echo Request is specified by the first byte of the ICMP frame being 0x08. The rest of the ICMP frame is don't-care. ICMP frames are carried in IPv4 frames with the protocol value 0x01.

The resulting switch ACL entry is as follows:

```
127 is2 ipv4_other first protocol=icmp ip4_payload_high=0x8*
→ police_ena police_idx=15
```

ACL policer 15 in the policer pool is configured to 128 frames per second like this:

SYS:POL[15]:POL_MODE_CFG.FRM_MODE = 1
SYS:POL[15]:POL_PIR_CFG.PIR_RATE = 128
SYS:POL[15]:POL_PIR_CFG.PIR_BURST = 1

One ACE is used, regardless of the number of ports covered.

6.7.8 TCP SYN Policing

A server in the network can be protected against TCP SYN DoS attacks by policing TCP connection requests to the server's IP address.

Situation:

Allow no more than 128 new TCP connections per second to the server with IP address 10.10.12.99. Use ACL policer 5.

Resolution:

TCP connection requests are TCP frames with the SYN flag set. The resulting switch ACL entry is as follows:

```
127 is2 ipv4_tcp_udp first protocol=tcp
dip=10.10.12.99
syn
→ police_ena police_idx=5
```

ACL policer 5 in the policer pool is configured to 128 frames per second by the following:

SYS:POL[5]:POL_MODE_CFG.FRM_MODE = 1
SYS:POL[5]:POL_PIR_CFG.PIR_RATE = 128
SYS:POL[5]:POL_PIR_CFG.PIR_BURST = 1

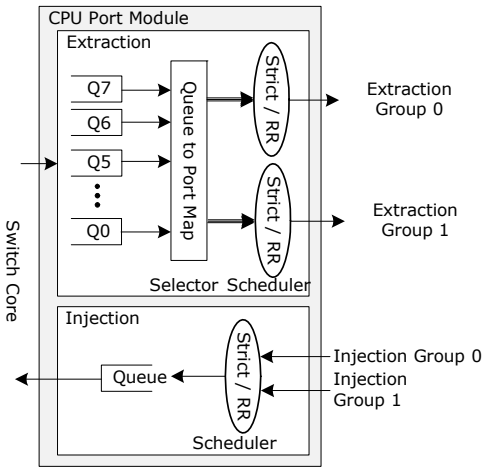
One ACE is used, regardless of the number of ports covered.

6.8 CPU Extraction and Injection

This section provides information about how the CPU extracts and injects frames to and from the switch core.

The following illustration shows the CPU Port Module used for injection and extraction.

Figure 77 • **CPU Extraction and Injection**



The switch core forwards CPU extracted frames to eight CPU extraction queues. Each of these queue is then mapped to one of two CPU Extraction Groups. For each extraction group there is a scheduler (strict or round robin) which selects between the CPU extraction queues mapped to the same group.

When injecting frames, there are two CPU Injection Groups available where for instance one can be used for the Frame DMA and one can be used for manually injected frames. A scheduler (Strict or round robin) selects between the two injection groups meaning the switch core only sees one stream of frames being injected.

6.8.1 Forwarding to CPU

Several mechanisms can be used to trigger redirection or copying of frames to the CPU. They are listed in the following table.

Table 187 • **Configurations for Redirecting or Copying Frames to the CPU**

Frame Type	Configuration (Including Selection of Extraction Queue)	Redirect or Copy
IEEE 802.1D Reserved Range DMAC = 01-80-C2-00-00-0x	ANA:PORT:CPU_FWD_BPDU_CFG ANA::CPUQ_8021_CFG.CPUQ_BPDU_VAL	Redirect
IEEE 802.1D Allbridge DMAC = 01-80-C2-00-00-10	ANA:PORT: CPU_FWD_CFG.CPU_ALLBRIDGE_REDIR_ENA ANA::CPUQ_CFG.CPUQ_ALLBRIDGE	Redirect
IEEE 802.1D GARP Range DMAC = 01-80-C2-00-00-2x	ANA:PORT:CPU_FWD_GARP_CFG ANA::CPUQ_8021_CFG.CPUQ_GARP_VAL	Redirect
IEEE 802.1D CCM/Link Trace Range DMAC = 01-80-C2-00-00-3x	ANA:PORT:CPU_FWD_CCM_CFG ANA::CPUQ_8021_CFG.CPUQ_CCM_VAL	Redirect
IGMP (IPv4)	ANA:PORT:CPU_IGMP_REDIR_ENA ANA::CPUQ_CFG.CPUQ_IGMP	Redirect
IP Multicast Control (IPv4)	ANA:PORT:CPU_IPMC_CTRL_COPY_ENA ANA::CPUQ_CFG.CPUQ_IPMC_CTRL	Copy
MLD (IPv6)	ANA:PORT:CPU_MLD_REDIR_ENA ANA::CPUQ_CFG.CPUQ_MLD	Redirect
CPU-based learning	ANA:PORT:PORT_CFG.LEARNCPU ANA::CPUQ_CFG.CPUQ_LRN	Copy

Table 187 • **Configurations for Redirecting or Copying Frames to the CPU *(continued)***

Frame Type	Configuration (Including Selection of Extraction Queue)	Redirect or Copy
CPU-based learning of locked MAC table entries seen on a new port	ANA:PORT: PORT_CFG.LOCKED_PORTMOVE_CPU ANA::CPUQ_CFG.CPUQ_LOCKED_PORTMOVE	
CPU-based learning of frames exceeding learn limit in MAC table	ANA:PORT:PORT_CFG.LIMIT_CPU ANA::CPUQ_CFG.CPUQ_LRN	
MAC table match using MAC table	ANA::MACACCESS.MAC_CPU_COPY ANA::CPUQ_CFG.CPUQ_MAC_COPY	Copy
MAC table match using PGID table	ANA::MACACCESS.DEST_IDX ANA::PGID.PGID (bit 26) ANA::PGID.CPUQ_DST_PGID	Redirect or copy
Flooded frames	ANA::MACACCESS.DEST_IDX ANA::PGID CPU Extraction Header Insertion, page 118.PGID (bit 26) ANA::PGID.CPUQ_DST_PGID	Redirect or copy
Any frame received on selected ports	ANA:PORT:CPU_SRC_COPY_ENA ANA:CPUQ_CFG.CPUQ_SRC_COPY	Copy
Mirroring	ANA::MIRRORPORTS (bit 26) ANA::CPUQ_CFG:CPUQ_MIRROR For more information about mirroring, see Mirroring, page 219.	Copy
VCAP IS2 rules	For more information about IS2, see VCAP IS2, page 66.	Redirect or copy
SFlow	ANA::CPUQ_CFG.CPUQ_SFLOW For more information about SFlow, see **sFlow Sampling,** page 99.	Copy

6.8.2 Frame Extraction

The CPU receives frames through the eight CPU extraction queues in the CPU port module. The eight queues are using resources (memory and frame descriptor pointers) from the shared queue system and are subject to the thresholds and congestion rules programmed for the CPU port (port 26) and the shared queue system in general.

The CPU can read frames from the CPU extraction queues in two ways:

- Reading registers in the CPU port module. For more information, see Frame Extraction, page 120.
- FDMA from CPU port module to RAM. For more information, see Frame DMA, page 150.

The switch core may place the eight-byte long CPU extraction header before the DMAC or after the SMAC (REW::PORT_CFG.IFH_INSERT_MODE). The CPU extraction header contains relevant side band information about the frame such as the frame's classification result (VLAN tag information, DSCP, or QoS class) and the reason for sending the frame to the CPU. For more information about the contents of the CPU extraction header, see CPU Extraction Header Insertion, page 118.

6.8.3 Frame Injection

The CPU can inject frames through the two CPU injection groups. The two groups merge into one injection queue through the injection scheduler (DEVCPU_QS::INJ_GRP_CFG). The injection queue uses resources (memory and frame descriptor pointers) from the shared queue system and is subject to the thresholds and congestion rules programmed for the CPU port (port 26) and the shared queue system in general.

The CPU can write frames to the CPU injection groups in two ways:

- Registers access to the CPU port module. For more information, see CPU Extraction and Injection, page 234.
- FDMA to CPU port module. For more information, see Frame DMA, page 150.

The first eight bytes of a frame written into a CPU group is an injection header containing relevant side band information about how the frame must be processed by the switch core. For more information, see Table 97, page 122.

6.8.4 Frame Extraction and Injection Using An External CPU

The following table lists the configuration registers associated with using an external CPU.

Table 188 • **Configuration Registers When Using An External CPU**

Register/Register Field	Description/Value	Replication
SYS::EXT_CPU_CFG.EXT_CPU_PORT	Port number where external CPU is connected.	None
SYS::EXT_CPU_CFG.EXT_CPUQ_MSK	Configures which CPU Extraction Queues are sent to the external CPU.	None
REW::PORT_CFG.IFH_INSERT_ENA	Enables the insertion of the CPU extraction header in egress frames.	Per port
REW::PORT_CFG.IFH_INSERT_MODE	Controls the position of the CPU extraction header.	Per port
SYS::PORT_MODE.INCL_INJ_HDR	Enables ingress port to look for CPU injection header in incoming frames.	Per port

An external CPU can connect up to any front port module and use the Ethernet interface for extracting and injecting frames into the switch core.

Note: If an external CPU is connected by means of the serial interface or parallel interface, the frame extraction and injection is performed. For more information, see Frame Extraction, page 236 and Frame Injection, page 236.

When extracting frames, the CPU extraction header can be placed before the DMAC (in the preamble) or after the SMAC (REW::PORT_CFG.IFH_INSERT_MODE). For more information about the contents of the eight-byte long extraction header, see Frame Extraction, page 236.

When injecting frames, the CPU injection header controls whether a frame is processed by the analyzer or forwarded directly to the destination set specified in the injection header. The injection header must be placed before destination MAC address in the frame. For more information about the contents of the eight-byte long injection header, see Frame Injection, page 236.

An internal and external CPU may coexist in a dual CPU system where the two CPUs handles different run-time protocols. When extracting CPU frames, it is selectable which CPU extraction queues are connected to the external CPU and which remain connected to the internal CPU (SYS::EXT_CPU_CFG.EXT_CPUQ_MSK). If a frame is forwarded to the CPU for more than one reason (for example, a BPDU which is also a learn frame), the frame can be forwarded to both the internal CPU extraction queues and to the external CPU.

6.9 Audio Video Bridging

Audio Video Bridging (AVB) defined by the IEEE 802.1 Audio/Video Bridging Task Group enables the delivery of time-synchronized, low-latency audio and video streaming services through Ethernet networks.

In an audio/video network it must be possible to synchronize multiple streams in time so that playback is rendered correctly. For example, keeping audio and video of a movie synchronized or keeping audio for multiple speakers in phase.

To guarantee consistent delivery of the streaming services, it must be possible to reserve network resources while the application needs it. For the switching equipment in the network, this means

allocating enough bandwidth to support the streaming and to configure QoS handling so that latency is within the boundaries specified by the application.

Additionally, the worst-case delay through the network must be low and preferably deterministic so that an AVB system appears responsive to user interaction. A delay also has significant impact on the buffering requirement in the source and destination equipment.

The device supports all aspects of AVB, such as:

- Precise time synchronization defined by IEEE 802.1AS. This is a standard for synchronizing time in all participating nodes. The standard specifies the use of IEEE 1588 in the context of a VLAN-aware LAN switch. For more information about time synchronization, see Hardware Timestamping, page 124.
- Traffic shaping and scheduling of streaming services defined by IEEE 802.1Qav. Traffic shaping reduces bursting of data, and scheduling ensures that allocated bandwidth requirements are met. The device implements eight queues per egress port, with shaping per queue and per port. The scheduler allows queues 6 and 7 to be strict while queues 0 through 5 are weighted. This ensures that time-sensitive data enqueued in queue 6 or 7 can be served before best-effort traffic enqueued in queue 5 or less. The shaper implements a non-bursty transmission mode so that the transmission times for AVB frames are evenly spread out. This reduces the effect of AVB frames being bunched together while reducing buffer requirements in destination equipment. For more information about the shaper and scheduler implementation, see Scheduler and Shaper, page 111.
- Admission control and resource allocation defined by IEEE 802.1Qav. The Stream Reservation Protocol (SRP) relies on the MMRP and MSRP. signaling protocols SRP frames can be redirected to the CPU using the GARP MAC address filter in the switch core.

6.10 Energy Efficient Ethernet

Defined by IEEE 802.3az, Energy Efficient Ethernet (EEE) provides a mechanism for reducing the energy consumption on Ethernet links during times of low utilization. Basically, when the transmission queues on a link are empty, the connecting macros and PHYs can be put into a sleep mode using Low-Power Idles (LPI), where the energy consumption is reduced by turning off unused circuits. When data is ready again for transmission, the macros and PHYs are waked up and data can flow again. The reaction time for bringing the link alive again is in the range of microseconds, so no data is lost due to low-power idles, however, data will experience increased latency.

Both internal PHYs and internal SerDes macros support EEE in both the Rx and Tx direction.

The following table lists configuration registers related to using Energy Efficient Ethernet.

Table 189 • **Configuration Registers When Using Energy Efficient Ethernet**

Register/Register Field	Description/Value	Replication
SYS:PORT:EEE_CFG	Queue system configuration of EEE.	Per port
SYS::EEE_THRESH	EEE thresholds used by queue system.	None
PORT::PCS1G_LPI_CFG	Low power idle configuration for the PCS.	Per SerDes port
PORT::PCS1G_LPI_WAKE_ERROR_CNT	Wake error counter.	Per SerDes port
PORT::PCS1G_LPI_STATUS	Low power idle status.	Per SerDes port
HSIO::SERDES1G_MISC_CFG	Enable LPI in 1G SerDes.	Per SerDes port
HSIO::SERDES6G_MISC_CFG	Enable LPI in 6G SerDes.	Per SerDes port

Table 189 • **Configuration Registers When Using Energy Efficient Ethernet *(continued)***

Register/Register Field	Description/Value	Replication
IEEE Clause 45 PHY registers	EEE configuration for the internal PHYs.	Per Copper PHY port

Ports with internal copper PHYs support LPI for 100BASE-TX and can also reduce the transmit signal amplitude in a 10BASE-Te mode.

For ports with SerDes, the PCS supports LPI for all modes. When the PCS is in LPI, the connecting SerDes macro is also in LPI.

To enable Energy Efficient Ethernet, configure the following functions:

- Enable the ports for EEE and configure the timers and thresholds in the queue system to determine when the system will attempt to enter the LPI state and how fast it can wake up again.
- Enable LPI for the relevant ports in PCS, SerDes macros, and internal PHYs. For more information, see PCS, page 19, SERDES1G, page 23, SERDES6G, page 27, and Cat5 Twisted Pair Media Interface, page 34.

6.11 Carrier Ethernet Overview

This section provides information about the various Carrier Ethernet features and how they can be applied to Caracal. IEEE 802.1 and Metro Ethernet Forum standards are used as a reference for the terminology and modeling used. However, full compliance with precise definitions by these standards is not guaranteed within this overview. For more information about the standards for which the Carrier Ethernet devices are compliant, see Standard References, page 1.

6.11.1 Customer Bridge and Provider Bridge

This section provides information about the interface types supported and introduces fundamental forwarding capabilities of the Carrier Ethernet Switch device.

Metro Ethernet Forum's Services and the service concept functions supported by the Carrier Ethernet device are described in later subsections and can be seen as capabilities layered on top of the basic Layer 2 functionality discussed in this section. That is, the fundamental switch functionality presented here is a prerequisite for what is presented in later sections.

6.11.1.1 VLAN Unaware Bridge

VLAN-unaware Customer Bridge, as defined in IEEE 802.1Q (Virtual Bridged Local Area Networks), is the Carrier Ethernet devices' most fundamental mode of operation. All traffic on arrival, whether VLAN-tagged, priority-tagged, or untagged, is treated as untagged within the device. All frames on arrival are classified to a port-based C-VLAN on which they are forwarded. By default, all ports are members of all VLANs, so a port specific port-based C-VLAN can be configured for all ports without losing connectivity across the bridge. Tag manipulation is not performed on any frame in this mode.

6.11.1.2 VLAN Aware Bridge

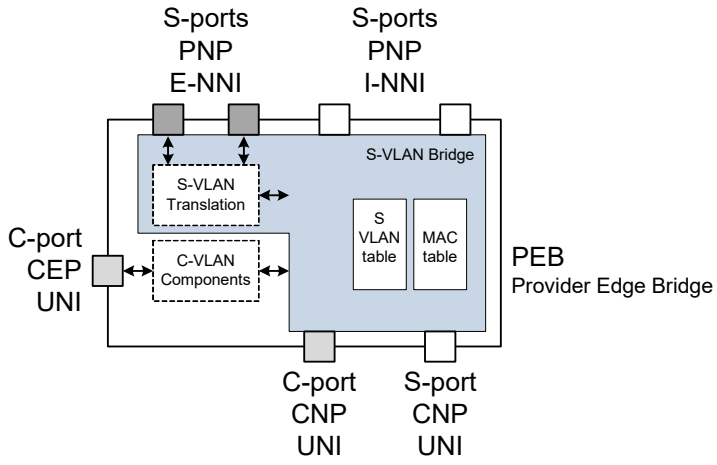
A VLAN-aware Customer Bridge is supported as defined in IEEE 802.1ad (Provider Bridges). Frames are bridged within a single customer network using C-VLANs for traffic separation. In this mode, VLAN unaware equipment attached to the bridge is assigned a port-based C-VLAN on which the traffic is forwarded. Priority-tagged frames are also assigned the port-based C-VLAN. For VLAN aware ports on the bridge, the C-VLAN of arrival frames is used directly for forwarding. C-VLAN tags can be pushed and popped in this mode controlled on a per-port basis.

6.11.1.3 Provider Edge Bridge

Two types of provider bridges are defined in IEEE 802.1ad (Provider Bridges): S-VLAN Bridge/Provider Bridge (PB) and Provider Edge Bridge (PEB). Both the Provider Bridge and the Provider Edge Bridge are supported by the Carrier Ethernet device. The functionality of the Provider Edge Bridge is a superset of the S-VLAN bridge, because it supports customer-edge port interfaces.

The following illustration depicts a model of the five interface types supported by a Provider Edge Bridge implemented using the Carrier Ethernet device.

Figure 78 • **Simple Model of Provider Edge Bridge**



- S-port I-NNI Provider Network Port (PNP) Interface. Ports configured as S-port I-NNI PNPs carry S-VLAN tagged traffic and are directly connected to the S-VLAN.

  Bridge inside the Provider Edge Bridge. These ports connect directly to other equipment within the Service Provider's own network. The two outer most VLAN tags can be used in VLAN classification.
- S-port E-NNI Provider Network Port (PNP) Interface. Ports configured as S-port E-NNI PNPs carry S-VLAN tagged traffic and connect to the S-VLAN Bridge through a S-VLAN translation table. These ports interface equipment from another service provider. In the following illustration, Provider A is peering with Provider C and S-VLAN translation may be required. Also, on another port, Provider A is a customer of Provider B where S-VLAN translation is normally not required. In both cases, the ports on PEB 1 are PNPs as they interface to another provider's network. The two outer most VLAN tags can be used in VLAN classification. The S-VLAN translation table performs 1:1 S-VLAN translations between VLAN spaces of the two providers.

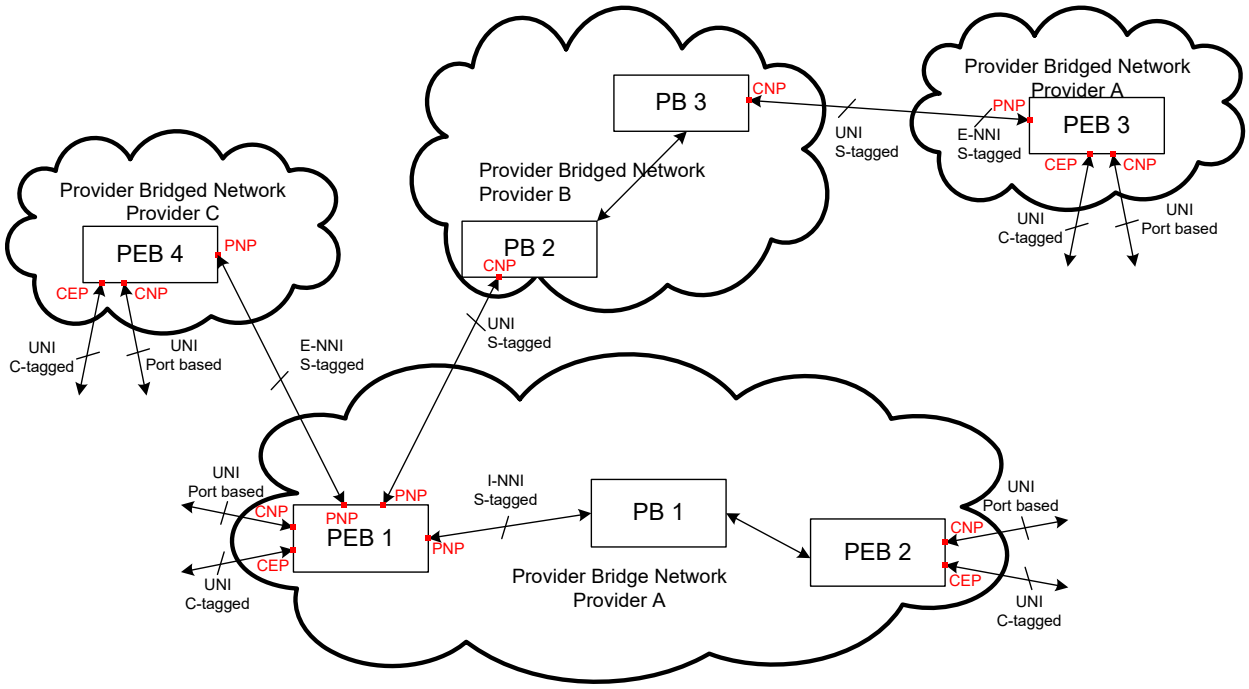
  VSC7428-12 supports up to 256 S-VLAN to S-VLAN translations.
- S-port UNI Customer Network Port (CNP) Interface. Ports configured as S-port UNI CNPs carry S-VLAN tagged traffic. These ports interface to equipment from another service provider's network. In the following illustration, provider A is a customer of Network Provider B, so Provider B's port facing Provider A is a UNI. Incoming frames are classified to Provider B's own VLAN space, and a corresponding S-VLAN tag is pushed and used for forwarding within Provider B's network. The two outer most VLAN tags can be used in VLAN classification. In most instances, the S-VLAN tags of Provider A's network is carried as an inner tag through the provider network. Optionally, Provider A's tags can be removed while carried through Provider B's network. On egress, Provider B's own S-VLAN tag is removed again.

  VSC7428-12 supports up to 256 S-VLAN classifications.
- C-port UNI Customer Network Port (CNP) Interface. A port-based service is provided to ports configured as UNI CNPs, and all customer traffic is classified to a port-based S-VLAN on which the traffic is forwarded within the S-VLAN bridge.
- C-port UNI Customer Edge Port (CEP) Interface. Ports configured as customer edge ports carry C-VLAN tagged, priority tagged, or untagged traffic and are connected to a C-VLAN component. The C-VLAN component classifies incoming traffic to an S-VLAN on which the traffic is forwarded within the S-VLAN bridge. The S-VLAN classification within the C-VLAN component can use the C-VID (if available) as part of S-VID selection. Within this S-VLAN classification, it is also decided if the C-VLAN is kept or removed from the frame before transmission through the provider bridge network. Each customer edge port is attached to its own C-VLAN component, providing independent S-VLAN classification. That is, two C-ports each receiving C-VLAN = 1 tagged frames may be classified to different S-VLANs for transmission through the provider network.

VSC7428-12 supports up to 256 S-VLAN classifications.

The following illustration demonstrates where each of these interfaces is located in a Provider Bridge Network. In this depiction, the connection between PEB 1 and PB 2 is a client-server relationship, where one carrier (Provider A) tunnels through another carrier (Provider B). At the UNI S-port on PB 2's CNP, a specific S-Tag for transmission through Provider B's network is pushed or popped on top of Provider A S-Tags. The connection between PEB 1 and PB 1 is a peering relationship where both ends of the connection (I-NNI S-port PNPs) use the same S-VLAN IDs for all VLANs (no S-Tag translation). The connection between PEB 1 and PEB 4 is a peering relationship where the E-NNI S-port PNPs translate S-Tags.

Figure 79 • **Provider Bridge Network**



The S-VLAN Bridge inside the Provider Edge Bridge includes a S-VLAN table and a MAC address table. The MAC address table contains Customer MAC addresses, as well as Provider Network MAC addresses. All frames are forwarded within the Provider Edge Bridge based on classified S-VLAN. No traffic within a Provider Edge Bridge is forwarded based on C-VLAN tags. Even in the case where two ports of a Provider Edge bridge are connected to equipment from the same customer, the traffic between the two customer sites are forwarded within the Provider Edge Bridge using a S-VLAN of the provider network.

VSC7428-12 supports 4K S-VLANs.

It is possible to push or pop, or both push and pop, any combination of up to two outermost C-VLAN tags or S-VLAN tags per frame within the Provider Edge Bridge. That is, the number of VLANs popped is an arrival port decision, whereas the number of VLANs pushed is decided independently for each departure port of the frame. Note that supporting all three interface types on the same Carrier Ethernet device and being able to multicast or flood between them requires per egress port VLAN manipulation capabilities. Up to 256 specific ingress VLAN and arrival port pop actions and 256 specific egress VLAN and departure port push actions are supported.

Note: The VLAN classification and the VLAN push/pop functionality of the Carrier Ethernet device operates on the two outermost VLAN tags only. Frames with more than two VLAN tags are also supported, however, the third VLAN tag and below are not processed by the VSC7428-12 device.

In summary, the following interfaces are supported by a Provider Edge Bridge using the VSC7428-12:

- Port-based service
- C-Tagged service
- S-Tagged service

6.11.2 MEF Services

The Metro Ethernet Forum (MEF) specifies the following Ethernet Virtual Connection (EVC) types, which can be implemented using the service concept. For more information, see Service Concept, page 244.

- E-LINE EVC: Point-point service. Ethernet Private Line (EPL) allows only one EVC per UNI port, and Ethernet Virtual Private Line (EVPL) allows multiple EVCs per UNI port.
- E-LAN EVC: Multipoint service. Ethernet Private LAN (EP-LAN) allows only one EVC per UNI port, and Ethernet Virtual Private LAN (EVP-LAN) allows multiple EVCs per UNI port. This is a bridged service.
- E-TREE EVC: Rooted Multipoint service. Ethernet Private Tree (EP-TREE) allows only one EVC per UNI port, and Ethernet Virtual Private Tree (EVP-TREE) allows multiple EVCs per UNI port. This is a bridged service where the allowed connectivity can be configured per ASP.

6.11.3 MEF Bandwidth Profiles

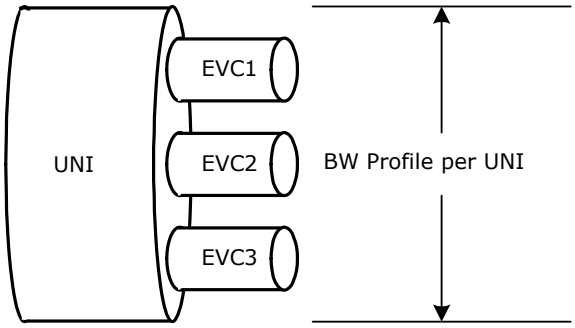
The MEF standards specify a dual-bucket policing scheme to regulate the amount of data arriving at each UNI port. For VSC7428-12, bandwidth profiling (BWP) can be applied in any of the following ways:

6.11.3.1 Bandwidth Profile per Port

The following example shows that three EVCs share one BWP for the port. The bandwidth profile is controlled by configuration of a dual leaky bucket (DLB) policer for the entire port (UNI). Each EVC requires its own ASP to keep statistics EVC specific.

Each EVC can have multiple Classes of Service; however, these are metered and counted separately per CoS.

Figure 80 • **Bandwidth Profile per Port**

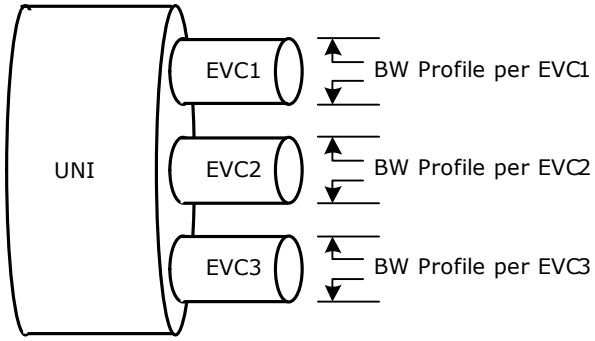


6.11.3.2 Bandwidth Profile Per EVC

The following illustration shows three EVCs, each having its own BWP. Each EVC requires its own ASP, and each ASP maps to its own Service Policer. Statistics are kept separately for each EVC. Each EVC can have multiple Classes of Service; however, these are metered and counted separately. EVCs that share one or more Classes of Service are metered and counted at the CoS level and not per EVC.

A port-level (UNI) DLB policer can be configured to control the bandwidth profile of the entire UNI on top of per EVC DLB policing (not shown). Bandwidth profiling at both EVC level and UNI level is enhanced as compared to the MEF standards.

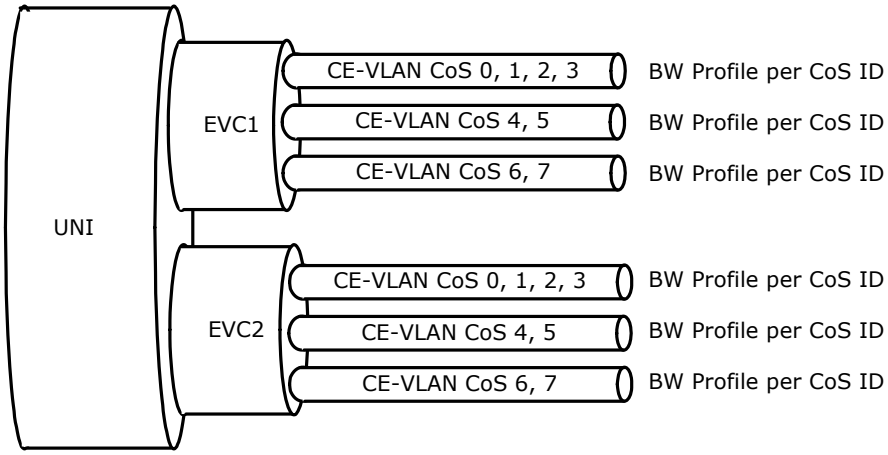
Figure 81 • **Bandwidth Profile Per EVC**



6.11.3.3 Bandwidth Profile per COS Indicator per EVC

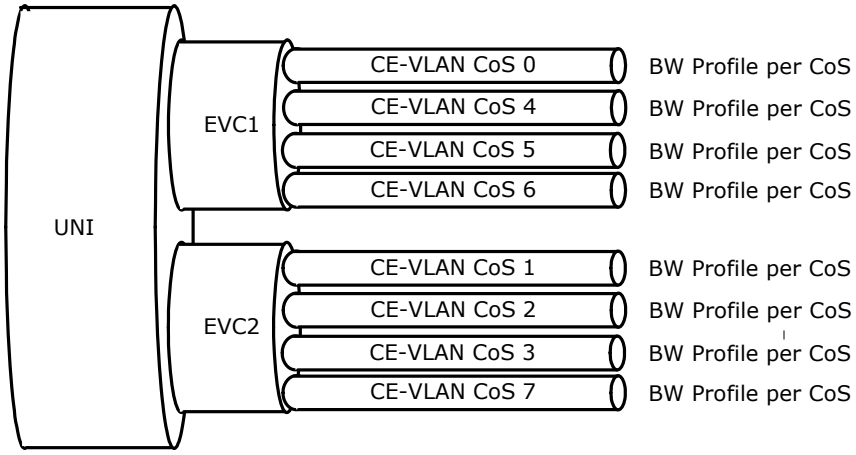
The following illustration shows bandwidth profile per CoS and EVC as defined by MEF. For information about the VSC7428-12 devices' service concept counterpart, see Figure 83, page 243.

Figure 82 • **MEF defined Bandwidth Profile Per COS and EVC**



The following illustration shows two EVCs, each having multiple Classes of Service. Each COS has its own ASP, and each ASP maps to its own Service Policer. Statistics are kept separately for each COS.

Figure 83 • **Caracal Bandwidth Profile Per COS and EVC**



6.11.4 MEF Service Attributes

The MEF standards specify a set of service attributes for each UNI and for each EVC per UNI. Work is in-progress within MEF to also specify per E-NNI service attributes. The following table summarizes the service attributes and associated granularity supported by the VSC7428-12 device.

Supported service attributes are independent of the port type (C-port, S-Port, or B-port).

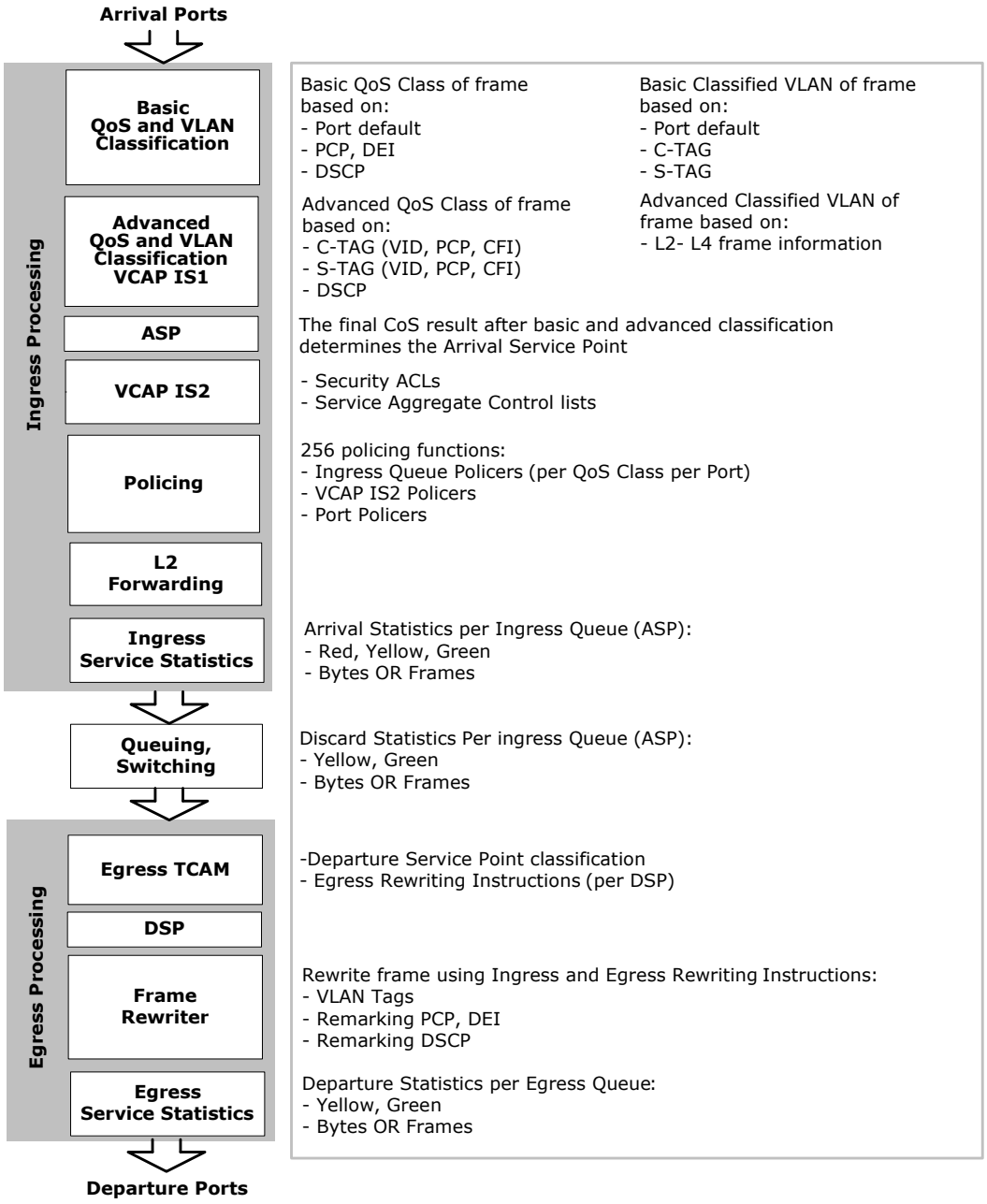
Table 190 • **Supported Service Attributes**

Service Attribute	Granularity
CE-VLAN ID/EVC MAP untag/prio tag	Per UNI
CE-VLAN ID/EVC MAP	Per EVC and UNI Up to 256 CE-VLAN IDs per UNI can be individually mapped to an EVC.
CE-VLAN ID Preservation	Per EVC Configurable per EVC whether CE-VLAN IDs are preserved, removed, or translated
CE-VLAN CoS Preservation	Per EVC Configurable per EVC whether CE-VLAN CoS are preserved or translated
Service multiplex	Per UNI
Bundling	Per UNI
All-to-one bundling	Per UNI
Ingress BW profile	Per UNI Per (EVC, UNI) Per (CoS, EVC, UNI) Per EVC across all UNIs - Proprietary Per (CoS, EVC) across all UNIs - Proprietary
Unicast Service Frame Delivery	Per UNI Per EVC
Multicast Service Frame Delivery	Per UNI Per EVC
Broadcast Service Frame Delivery	Per UNI Per EVC
MTU Size	Per UNI
L2 Control Protocol Processing	Per UNI

6.11.5 Service Concept

This section provides information about how services are delivered by the VSC7428-12. This information only includes the service layer.

Figure 84 • **Carrier Ethernet Service Concept**



The service layer defines the treatment that each service frame receives with the VSC7428-12 device. At ingress, each service frame is mapped to an Arrival Service Point (ASP), and at egress, each service frame is mapped to one Departure Service Point (DSP) per destination port.

6.11.5.1 Service Definitions

A “service” consists of at least one ASP and one DSP.

A service can be unidirectional or bidirectional. It may be point-point, point-multipoint, multipoint-point, or multipoint-multipoint.

An arrival or departure “service point” is a well-defined reference point within the device where a service policy is applied. Service points are always unidirectional. The VSC7428-12 device supports 256 ASPs and 256 DSPs.

ASP Service Parameters Each ASP provides the following parameters:

- Ingress port
- Ingress Class of Service
- Arrival statistics
- Policy association group (PAG): Each service is associated with a policy that can be used as part of efficient and advanced filtering with respect to QoS, profiling, and security.
- Arrival tagging/encapsulation instructions: frame format is independent for each ASP of a service. This also dictates the encapsulation of the service if going out on a network facing port.

Optional ASP Service parameters are:

- C-TAG VLAN ID
- S-TAG VLAN ID

For more advanced ASP selections, the advanced Classification TCAM – Ingress Stage 1 (IS1) can be used.

DSP Service Parameters Each DSP provides:

- Departure tagging/encapsulation instructions: frame format is independent for each DSP of a service.
- QoS markings: QoS markings are independent for each DSP of a service. Frames can also be remarked based on the results of policing.
- Per-DSP departure statistics

The DSP is identified through the Egress Service Encapsulation and Tagging TCAM (Egress Stage 0) using the following fields:

- Departure port
- Ingress port
- Classified VLAN

6.11.5.2 EVCs and Caracal Service Concept

The service concept for the device is QoS oriented, and as such, not Ethernet Virtual Connection aware. It is possible, however, to obtain EVC supporting service structures through appropriate internal classifications.

As explained previously, the Caracal devices' ASPs and DSPs are defined by the Class of Service queue, to which a frame is classified, for the arrival and departure port of the frame. As a result, if EVC specific bandwidth profiling and statistics is required, the characteristics of that EVC (arrival port, C-TAG on a UNI, for example) must be used to derive Class of Service Classification so that all traffic within the EVC is mapped to the same Ingress Queue and thereby the same ASP.

6.11.5.3 Statistics

This section provides information about using Caracal's service concept to obtain per EVC bandwidth profiling and statistics.

Two sets of statistics are supported per ASP:

- Arrival Statistics. All frames coming in on a port, and are mapped to an ASP, are accounted for at that ASP. If one or more DLB policer functions are associated with the ASP, the statistics are maintained per color as classified by the total result of all those DLB policers. Up to three DLB policers can be put in series, and any given frame is policed by all of them. These policers are: arrival port policer, class of service policer, and VCAP policer.
- Discard Statistics. Service Frames that have been measured as in Profile and have passed through all the DLB policers as Green or Yellow may still be dropped due to congestion. As a result, dedicated discard statistics are maintained per ASP.

With these two sets of ASP statistics, the following sets of information are available:

- All traffic arrived at the port (the sum of Green, Yellow and Red traffic measured by the arrival statistics).
- All traffic measured as in profile (the sum of Green and Yellow traffic measured by the arrival statistics).

- All traffic measured as out of profile (RED traffic measured by the arrival statistics).
- All profile traffic dropped internally (the sum of Green and Yellow traffic measured by the discard statistics).
- All profile traffic that is also forwarded out the departure port (subtract the internally dropped traffic from in profile traffic).

One set of statistics is supported per DSP:

- Departure statistics. All frames that are forwarded to a specific class of service queue on a departure port are accounted for at that DSP. Green and Yellow traffic is counted individually per DSP.

6.11.6 Service Examples

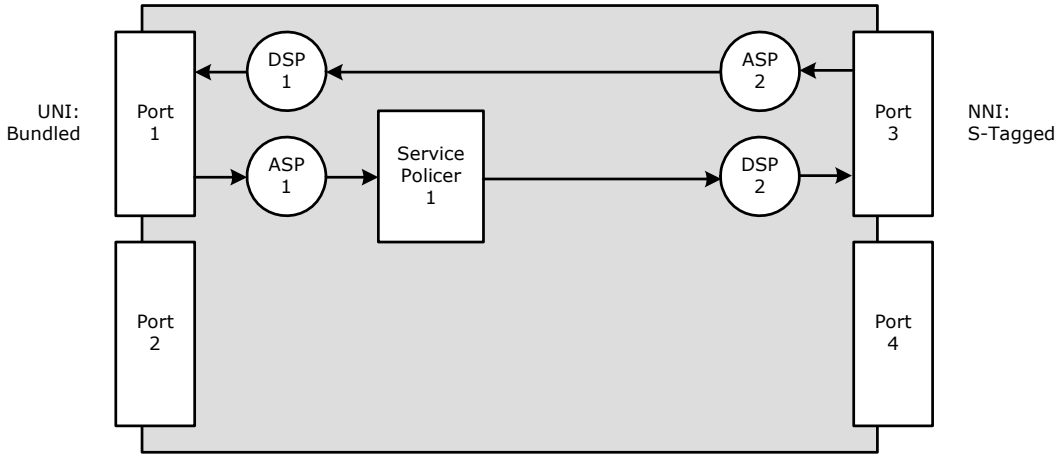
This section provides information about the Provider Bridge services.

6.11.6.1 Provider Bridge E-LINE Service Example

The following illustration shows a bidirectional Provider Bridge E-LINE service.

- Port 1 is a bundled UNI. All frames on this port are mapped to this E-LINE service, tagged or untagged. Any customer tag is preserved.
- Port 3 is an NNI port, connecting into a provider network. This port may have many services mapped to it, each distinguished by a different S-tag.
- Frames belonging to this E-LINE are always classified to an S-tag. Frames are forwarded on the classified S-tag.
  The S-Tag is pushed before departure on NNI port and popped on arrival from the NNI port.
  Frames belonging to this E-LINE may have a C-tag.

Figure 85 • **Provider Bridge E-LINE**



The following services are supported:

- Port 1 ingress:
  Bandwidth profiling (service policer) is implemented at the UNI.
  Statistics are maintained individually for each of the eight Class of Service queues. These ingress statistics for the UNI are service-specific.
  S-Tag is determined by port default configuration.
- Forwarding:
  Forwarding is based on DMAC, classified S-Tag.
  If for any reason a service frame is dropped as part of forwarding, it is accounted for by the discard statistics counters associated with the ASP to which the frame belonged.
- Port 3 egress:
  Classified S-Tag is pushed.
  Departure statistics is maintained individually for each of the Class of Service queues. These statistics are not service-specific, because other traffic mapped to same queues are also included in statistics.
- Port 3 ingress:
  Service is determined by classified VLAN (S-Tag).

Statistics is maintained individually for each of the Class of Service queues. These statistics are not service-specific, because other traffic mapped to same queues are also included in statistics.

- Forwarding:
  Forwarding is based on DMAC, classified S-Tag.
- Port 1 egress:
  S-Tag is popped.
  Statistics are maintained individually for each of the eight Class of Service Queues. These egress statistics for the UNI are service-specific.

This service consumes the following resources:

- One port-level DLB policer for bandwidth profiling at the UNI.
- All eight ASPs at the UNI.
- All eight DSPs at the UNI.
- One of the 4K provider VLANs (S-TAGs). All E-LINEs may share one VLAN.

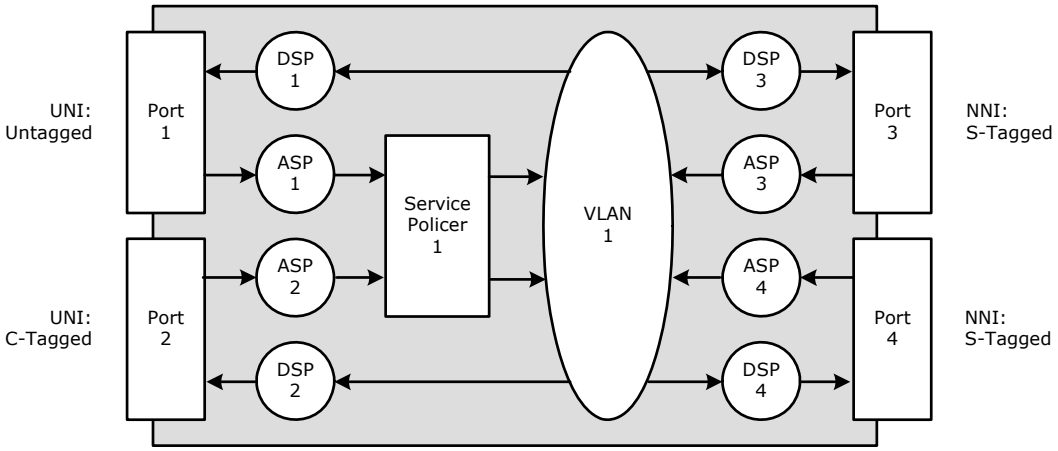
6.11.6.2 Provider Bridge Hierarchical Service Policing Example

The following illustration shows a Provider Bridged service including four ports.

- Port 1 and 2 are VLAN unaware UNIs. All frames on these port (untagged or tagged) are classified to provider VLAN 1. (Alternatively, tagged frames can also be discarded.)
- Ports 3 and 4 are NNI ports, connecting into a provider network. These ports likely have many services mapped to them, each distinguished by a different S-tag. RSTP or MSTP can be used for port protection.

  The S-Tag is pushed before departure and popped on arrival.

Figure 86 • **Hierarchical Service Policing**



Connectivity is determined by the port mask for VLAN 1 and the MAC destination address of the frame.

As depicted, each customer port has a dedicated service policer. Although not shown in this example, it is also possible to assign a service policer to NNI ports.

The VCAP policer A is a service aggregate policer for the sum of traffic arriving on ASP 1 and ASP 2, which is classified to VLAN 1. Note that VCAP Policer A as shown does not police all traffic within VLAN 1, but only what arrives at UNIs (upstream direction). Alternatively, VCAP policer A can be configured to police all traffic within VLAN 1 (independent of direction) or only traffic from ASP 3 and ASP 4 (downstream direction). Multiple VCAP policers can also be configured per VLAN by specific VCAP S2 rules for different groups of ASPs.

Service aggregate level policing enables efficient bandwidth utilization for upstream traffic but with oversubscription protection. Best network utilization is obtained by configuring VCAP Policer A as color-aware with coupling enabled. As an example, the Committed Information Rate (CIR), Committed Burst Size (CBS), Excess Information Rate (EIR), and Excess Burst Size (EBS) of the dual leaky bucket VCAP policer A can be configured as follows:

- CIR equals the sum of CIR from Service Policer 1 and 2

- CBS equals the sum of CBS from Service Policer 1 and 2
- EIR are larger than or equal to zero but less than the sum of EIR from Service Policer 1 and 2
- EBS are larger than or equal to zero but less than the sum of EBS from Service Policer 1 and 2

With this configuration, only yellow traffic is policed by VCAP Policer A and only if the total amount of yellow + green traffic towards the network exceeds the level determined by the CIR + EIR configuration of VCAP Policer A. By enabling coupling on VCAP Policer A yellow traffic is allowed to utilize unused green policer bandwidth without penalizing later arriving green traffic's burst capacity (CBS).

If EIR = 0 and EBS = 0 for VCAP Policer A, the resulting bandwidth towards the network becomes constant bit rate and equal to CIR, but allowing yellow traffic to fill up the "pipe" during times with unused green bandwidth.

As also shown in the illustration, all coloring (and drop) statistics from both the service policers and VCAP Policer A is accounted for per Arrival Service Point. For example, if Service Policer 1 classifies a certain frame as yellow but VCAP Policer A classifies the frame as RED, the frame is counted only as RED (dropped) by ASP 1 statistics.

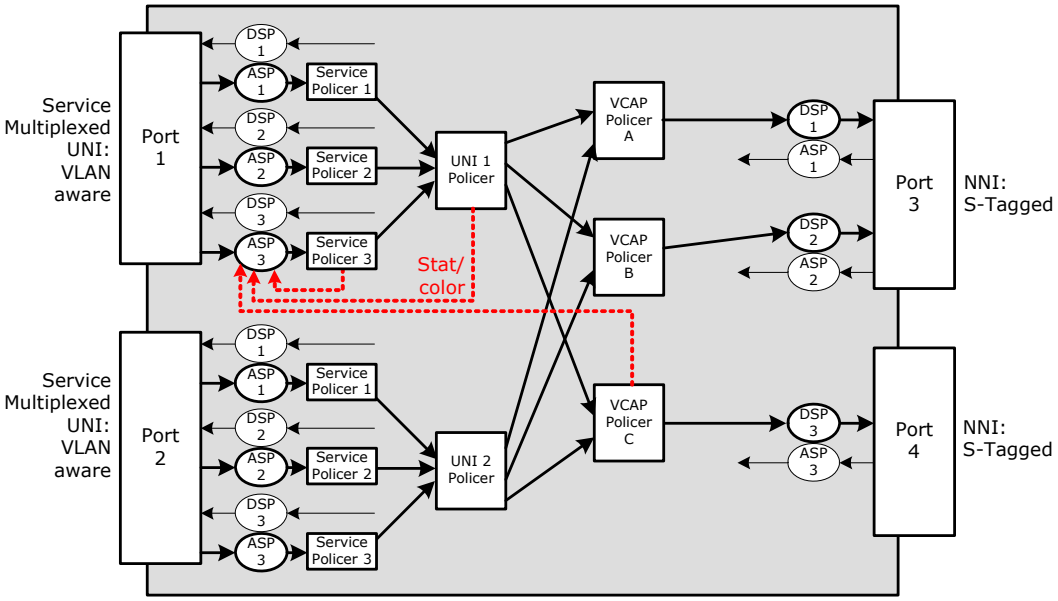
This aggregated service example consumes the following resources:

- Four ASPs and four DSPs
- Two service policers out of the shared pool of 256
- One VCAP policer out of the shared pool of 256
- One of the 4K provider VLANs

6.11.6.3 Access Network Triple-Play Services Example

The following illustration shows a triple-play example. Only the upstream direction is detailed.

Figure 87 • **Triple Play Service Example**



Customer ports 1 and 2 have three services each. These services are identified by their C-Tag value. Within Caracal these C-Tag values are used to determine a Class of Service so that a specific ASP is assigned to each of the three services within the port. Also shown is a port-level policer for the entire UNI. Each of the services are classified to a specific VLAN, which then can be policed again as an aggregate service level as in the previous example. That is, VCAP policer C polices the aggregated amount of traffic within service 3 from both UNIs.

The dotted lines in the illustration indicate that all statistics associated with policing are maintained at the ASP level. That is:

- Port 1 Service Policer 3 statistics are maintained within Port 1 ASP 3.

- Port 1 UNI 1 Policer statistics impacts Port 1 ASP 1,2, or 3 depending on to which ASP the policed frame belongs.
- VCAP Policer C statistics impacts Port 1 ASP 3 or Port 2 ASP 3 depending on to which arrival port the policed frame belongs.

This triple-play service example consumes the following resources:

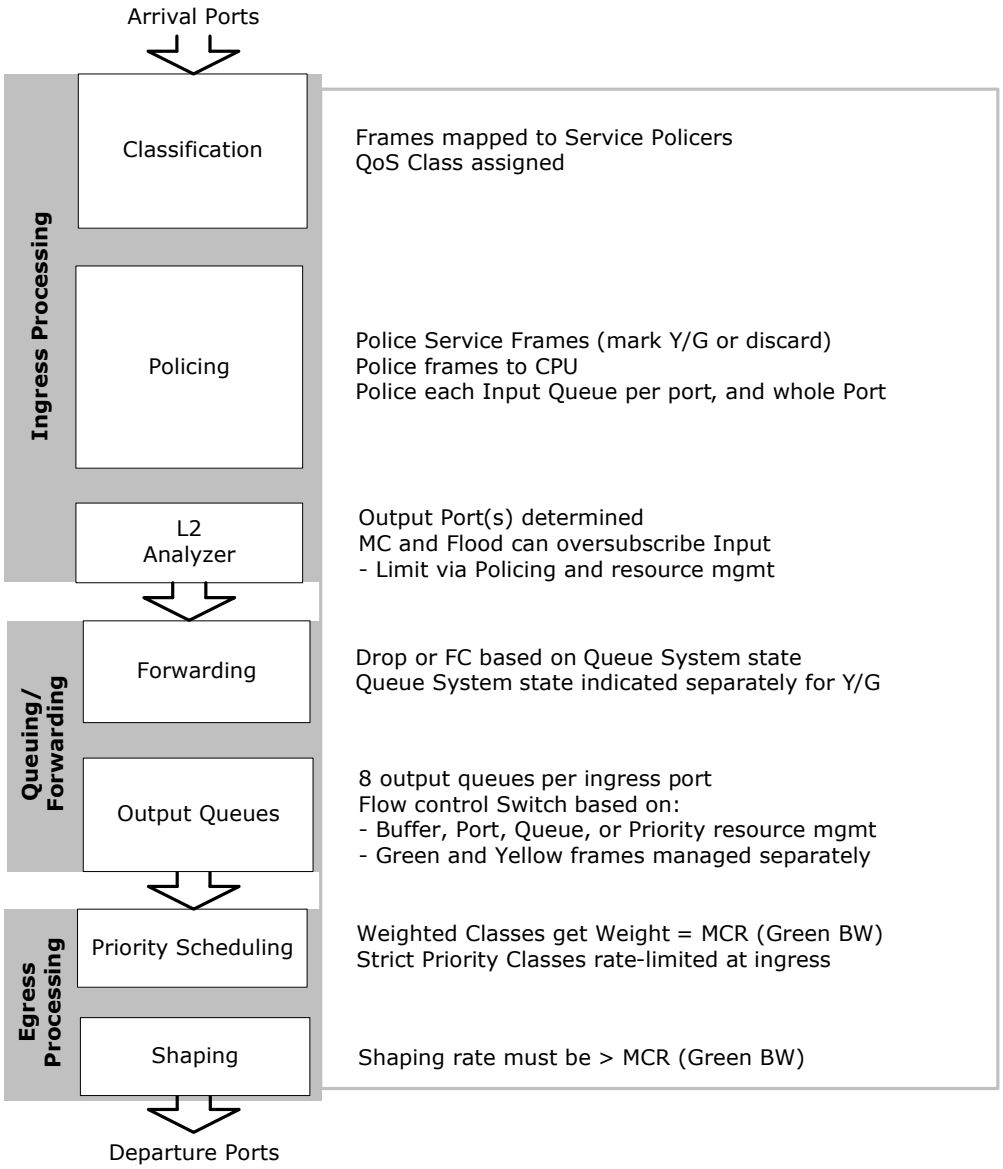
- Three ASPs and three DSPs per UNI. A total of 8 ASPs and DSPs are available per UNI.
- Three service policers per UNI out of the shared pool of 256.
- One UNI policer out of the shared pool of 256.
- One VCAP policer per service out of the shared pool of 256.
- One VLAN per service of the 4K provider VLANs.

6.11.7 Quality of Service Delivery

The device has a powerful set of QoS features to guarantee SLA delivery for each service.

The following illustration shows the approach.

Figure 88 • **Carrier Ethernet Switch QoS Service Concept**



In this approach, all frames are mapped to a Class of Service, and all frames are marked whether they are Committed (Green) or Discard Eligible (Yellow). Frames may be metered (policed) in the Caracal device, or they may have been metered in other locations of the network and must be correctly interpreted by the Caracal device.

Delivery of Green frames is guaranteed by controlling the amount of Green data admitted into the switch, allocating sufficient buffers for Green data, and scheduling enough bandwidth from each port to deliver all Green data. These mechanisms help manage other frames not to impact delivery of Green frames:

- Policing at queue, port, and global levels.
- Protecting the integrity of control and management planes by policing OAM and other control/management protocols through VCAP-II.
- Rate-limiting classes, which are given strict priority.
- Discarding Yellow frames if there are insufficient Yellow buffers in the queue system
- Limiting buffer use at the Queue, Port, and Buffer levels within the pool of shared buffers.
- Scheduling output queues in a bandwidth-aware manner, with the ability to deliver excess bandwidth as available.

Performance properties (bandwidth, delay, delay variation) of each service class can be established due to the class-based queuing, scheduling, and buffer management.

6.11.8 OAM and Protection Switching

The device provides the following hardware mechanisms to support OAM:

- Extraction of specified OAM to internal or external CPU
- Insertion of OAM from internal or external CPU
- CCM generation using hardware Frame DMA engine and MIPS24K CPU

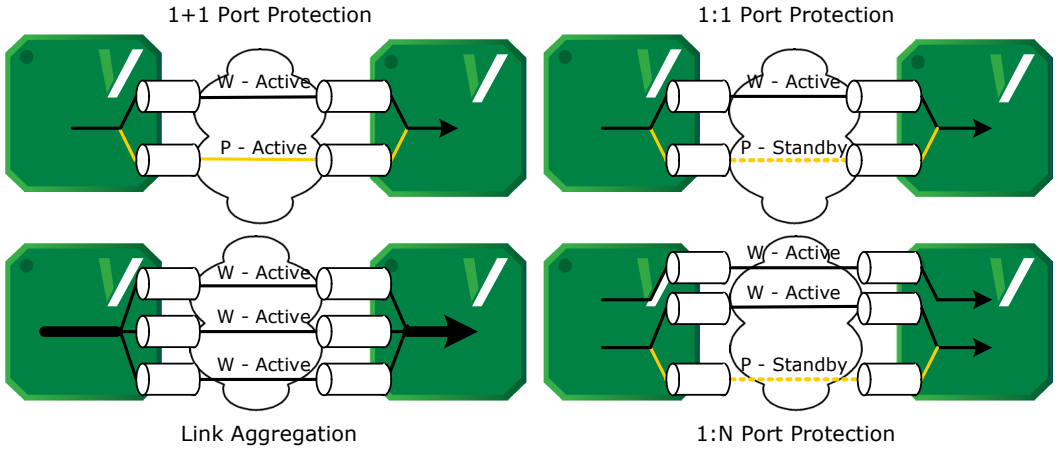
The following hardware mechanisms support protection switching. All switchovers are activated by updating a small number of table entries or register bits per direction:

- Link Aggregation: Update Rx and Tx portmasks
- Port Protection: Update Rx and Tx Port Protect Group table entry
- E-LINE Service Protection: Update Arrival and Departure Service Point entry
- Rapid Spanning Tree Protocol: Update RSTP port states and portmasks
- Multiple Spanning Tree Protocol: Update MSTP port/VLAN states and portmasks

6.11.8.1 Port Protection

The following illustration shows the port protection schemes supported by VSC7428-12. Unique copies of OAM and control plane frames can be sent and received over each port independently. The CCM features can be used in the selection of the active port and failover process.

Figure 89 • **Port Protection**



1+1 Port Protection Identical service frames are sent over both ports by the transmitter. The receiver selects which port to use for service frames. Both ports are pre-provisioned, enabling a fast failover by the receiver.

1:N and 1:1 Port Protection One port protects N active ports, and one copy of each frame is sent by the transmitter. Both ends must select the active port, but all ports are pre-provisioned, enabling a fast failover.

Note that 1:1 protection is a subset of 1:N protection, where N = 1.

Frame formats (VLAN tags) can be independent on working and protect ports, however, this consumes two Service Points. If identical frame formats are used on working and protect ports, only a single Service Point is consumed.

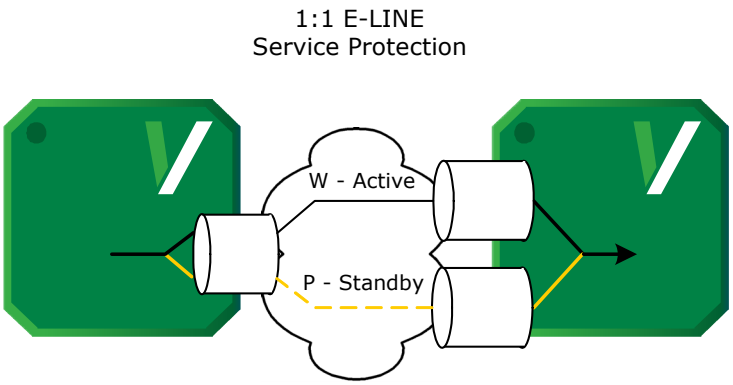
Link Aggregation Up to eight ports are active simultaneously in one Link Aggregation Group (LAG). The transmitter identifies flows and distributes the flows among the ports. Failover consists of redistributing all flows over the remaining active ports. One copy of each service frame is sent by the transmitter.

Link Aggregation Control Protocol (LACP) is used to determine the working ports within each LAG. Because the LAG is treated as a single logical interface, service frame format does not vary based on the physical port used to transmit the frame.

6.11.8.2 E-LINE Service Protection

The following illustration shows the E-LINE service protection scheme supported by the device. Unique copies of OAM frames can be sent and received over each service independently. The CCM features can be used in the selection of the active service and failover process.

Figure 90 • **E-LINE Service Protection**



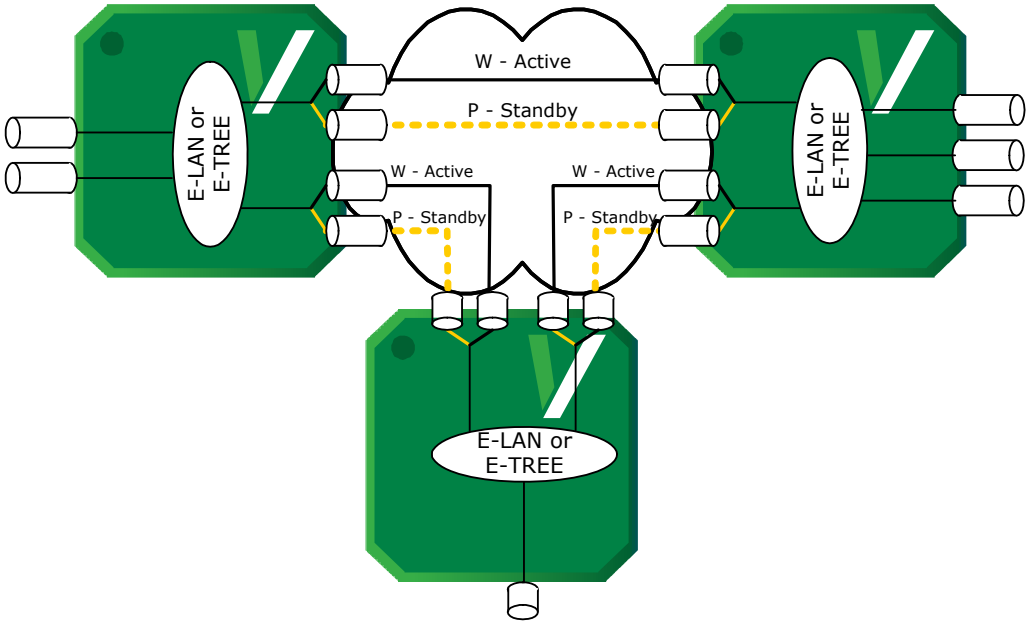
1:1 E-LINE Service Protection Two E-LINE EVCs are provisioned in protect group pairs, with one working and the other protect. One copy of each frame is sent by the transmitter. Both ends must select the active EVC, but all EVCs are pre-provisioned, enabling a fast failover. The EVCs may span different ports or paths, and multiple layers of protection can apply.

Frame formats (C-VIDs, S-VIDs) can be programmed completely independently on the working and protect EVCs.

6.11.8.3 E-LAN and E-TREE Service Protection

The following illustration shows the E-LAN and E-TREE protection schemes supported by the VSC7428-12 device. Unique copies of OAM frames can be sent and received over each port independently.

Figure 91 • **E-LAN and E-TREE Service Protection**



6.11.8.4 Spanning Tree E-LAN and E-TREE Protection

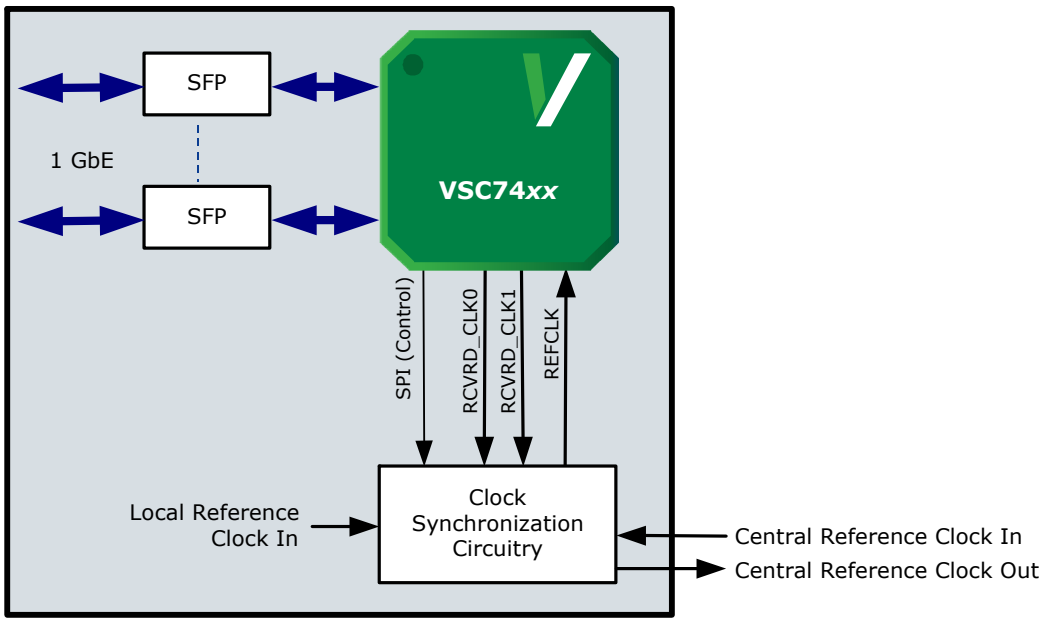
Spanning Tree protection works in partially or fully meshed topologies, with RSTP or MSTP selecting the best port for forwarding and eliminating looping. While the service itself is unaware of the protection applied, it has one Service Point configured for each attached port. Frame formats (C-VIDs, S-VIDs) may be programmed independently on each port.

6.11.9 Synchronous Ethernet Operation

As defined by ITU-T G.8261, Synchronous Ethernet allows for the transfer of quality network timing from a traceable reference to all network elements. Because this is a physical layer process, the timing quality does not vary with the network load.

The following illustration shows how Vitesse Carrier Ethernet switch, MAC, and PHY devices can be used to implement Synchronous Ethernet.

Figure 92 • **Synchronous Ethernet Application**



The device recovers the network timing from each Line Port and outputs the port recovered timing. It provides two clock outputs for redundancy, and allows each output to select recovered timing from all possible Line Ports. If timing is compromised, the appropriate clock output can be squelched to assist with fast timing switchover in the clock synchronization circuitry.

Transmit timing is derived from the REFCLK, which is also used to clock the core logic. This is not an issue, because this clock is always available and is tightly controlled by the clock synchronization circuitry during a timing failover.

The external clock synchronization circuitry is available from multiple third parties. This circuitry receives clocks from many possible sources and generates a set of stable output reference clocks to be used for transmit timing.

The following table shows the supported clock frequencies.

Table 191 • **Synchronous Ethernet Clock Frequencies**

Reference Clock I/O	Frequency (MHz)
Reference clock input	25, 125, 156.25, or 250
Recovered clock output (10/100/1000M port)	125, 31.25, or 25
Recovered clock output (2500M port)	125, 31.25, or 25

6.11.10 IEEE 1588 Operation

The Precision Time Protocol (PTP) is defined by IEEE 1588-2008. The use of PTP allows for the network-wide synchronization of precise time of day. It is also possible to derive network timing. Because this is a packet-based, Layer 2 process, the timing quality varies with the network topology and load.

PTP works by sending Sync messages from one or more 1588 masters, through a number of network elements which may or may not be 1588-aware, to 1588 slaves. The Sync message contains a timestamp with the time of day. PTP can operate with a one-step clock or a two-step clock:

- One-step clock: the Sync timestamp is accurate.
- Two-step clock: the Sync timestamp is approximate. The master accurately records when the Sync message departs, and issues a Follow-up message with a correction time. The combination of Sync+Follow-up timestamps is accurate.

To measure the propagation delay between network elements, 1588 slaves and 1588-aware network elements also implement a delay request-response handshake. This protocol also can operate as a one-step or two-step clock.

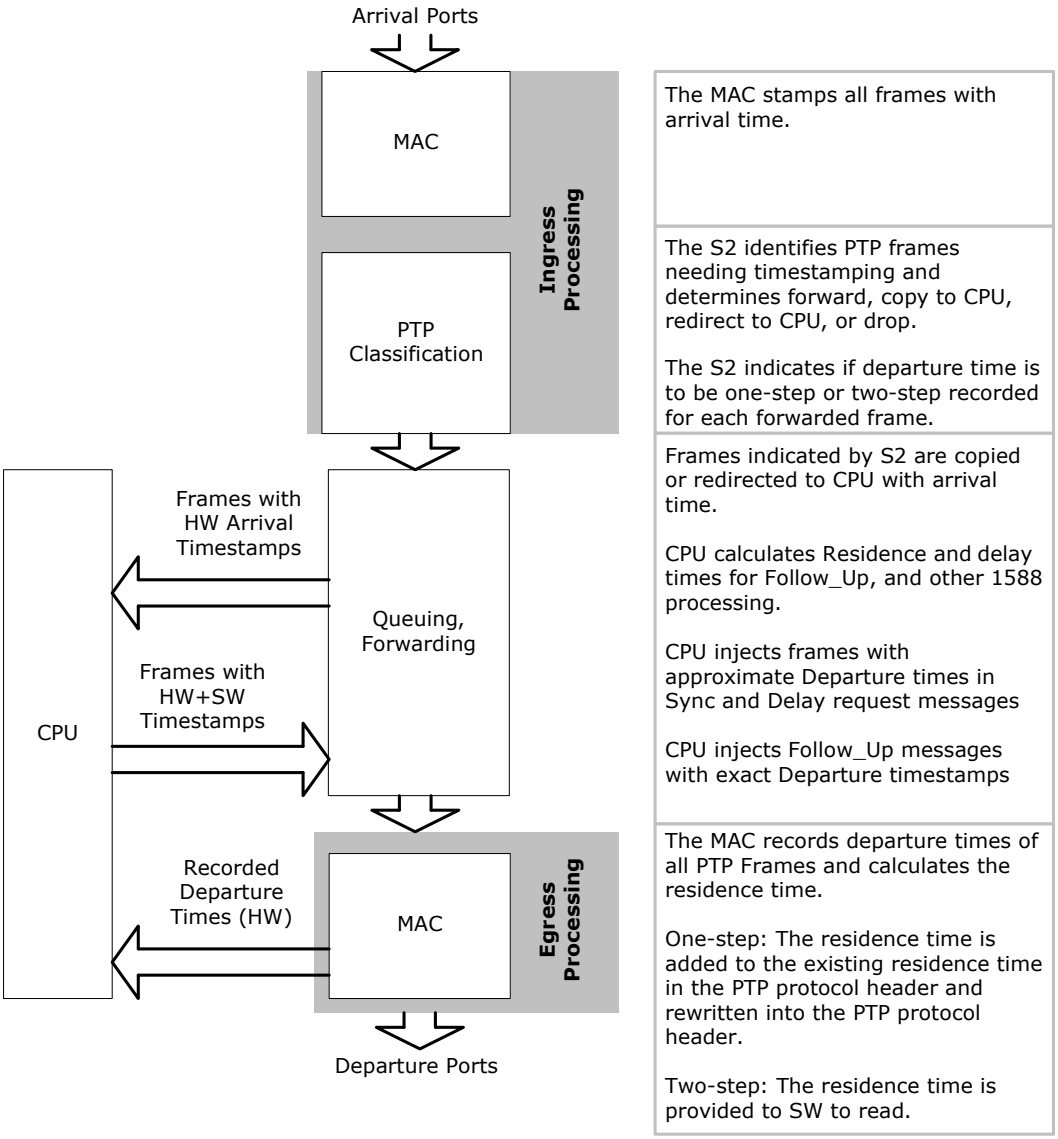
1588-aware network elements can forward certain PTP messages in specific directions; for example, from masters toward slaves. 1588-aware network elements can also accurately measure their Residence Time, which is the delay a specific PTP message exhibited passing through that network element.

Having 1588-aware network elements is especially important in the event of a network failure and topology change. In this case, it is possible to pre-compute the effect of the topology change and instantly correct for it. This also scales better, as it reduces the volume of protocol exchanges with the master clock.

Network time accuracy improves with fewer hops from master to slave, and by having 1588-aware network elements. Synchronous Ethernet may also contribute to network time accuracy due to the quality of the local clocks used throughout the network.

Caracal-1 can accurately implement both one-step and two-step clocks as 1588-aware network elements (peer-to-peer transparent clock) in various switches and routers, and can also be used to implement cost-effective IEEE 1588 master and slave devices (Ordinary Clock). The following illustration shows the approach.

Figure 93 • **IEEE 1588 Processing Concept**



All frames are timestamped upon arrival using a hardware timer in the MAC, providing 20 ns accuracy and 4 ns resolution. PTP frames of interest may be forwarded as normal, forwarded as normal plus copied to the CPU, or redirected only to the CPU.

The time of departure for PTP frames of interest is recorded by the MAC with 20 ns accuracy and 4 ns resolution. A separate departure time is maintained for each port for hardware-forwarded and software-forwarded PTP frames of interest.

For one-step clocks, the residence time in the PTP protocol header is incremented with the calculated residence time for the particular frame passing through Caracal-1. The new total residence time is rewritten into the PTP protocol header upon departure.

For two-step clocks, the CPU is provided information about the residence time for PTP frames along with an accurate timestamp when they were received in the VSC7428-12 device.

To implement two-step clocks, the CPU sends the Sync message with a timestamp based on the internal timer and an estimated insertion delay, monitors the departure time, and then sends a Follow-up message with a completely accurate timestamp.

7 Registers

This section provides information about the programming interface, register maps, register descriptions, and register tables of the VSC7428-12 device.

In writing to registers with reserved bits, use a read-modify-write technique, where the entire register is read, but only the user bits to be changed are modified. Do not change the values of registers and bits marked as reserved. Their read state should not be considered static or unchanging. Unspecified registers and bits must be written to 0 and can be ignored when read.

7.1 Targets and Base Addresses

The following table lists all register targets and associated base addresses for the VSC7428-12 device. The next level lists registers groups and offsets within targets, and the deepest level lists registers within the register groups.

Both register groups and registers may be replicated (repeated) a number of times. The repeat-count and the distance between two repetitions is listed in the “Instances and Address Spacing” column of the tables. If there is only one instance, the spacing is omitted. The “Offset within Target”/”Offset within Register Group” columns hold the offset of the first instance of the register group/register.

To calculate the absolute address of a given register, multiply the register group’s replication number by the register group's address spacing and add it to the register group’s offset within the target. Then multiply the register’s replication number with the register’s address spacing and add it to the register’s offset within the register group. Finally, add these two numbers to the absolute address of the target in question.

Table 192 • **List of Targets and Base Addresses**

Target Name	Base Address	Description	Details
DEVCPU_ORG	0x60000000	CPU Device Origin	Page 258
SYS	0x60010000	Switching Engine Configuration	Page 261
ANA	0x60020000	Analyzer Configuration	Page 288
REW	0x60030000	Rewriter Configuration	Page 321
ES0	0x60040000	VCAP ES0 Configuration	Page 325
IS1	0x60050000	VCAP IS1 Configuration	Page 325
IS2	0x60060000	VCAP IS2 Configuration	Page 325
DEVCPU_GCB	0x60070000	CPU Device General Configuration	Page 355
DEVCPU_QS	0x60080000	CPU Device Queue System	Page 398
DEVCPU_PI	0x60090000	CPU Device Parallel Interface	Page 405
HSIO	0x600A0000	High Speed I/O SerDes Configuration	Page 409
DEV[0]	0x601E0000	Port Configuration (GMII)	Page 430
DEV[1]	0x601F0000	Port Configuration (GMII)	Page 430
DEV[2]	0x60200000	Port Configuration (GMII)	Page 430
DEV[3]	0x60210000	Port Configuration (GMII)	Page 430
DEV[4]	0x60220000	Port Configuration (GMII)	Page 430
DEV[5]	0x60230000	Port Configuration (GMII)	Page 430
DEV[6]	0x60240000	Port Configuration (GMII)	Page 430
DEV[7]	0x60250000	Port Configuration (GMII)	Page 430

Table 192 • **List of Targets and Base Addresses *(continued)***

Target Name	Base Address	Description	Details
DEV[23]	0x60350000	Port Configuration (SERDES)	Page 440
DEV[24]	0x60360000	Port Configuration (SERDES)	Page 440
DEV[25]	0x60370000	Port Configuration (SERDES)	Page 440
ICPU_CFG	0x70000000	VCore Configuration	Page 462
UART	0x70100000	VCore UART Configuration	Page 525
TWI	0x70100400	VCore Two-Wire Interface Configuration	Page 537
SBA	0x70110000	VCore Shared Bus Arbiter Configuration	Page 560
GPDMA	0x70110800	VCore GPDMA Configuration	Page 563
PHY	MIIM	PHY Configuration	Page 584

7.2 DEVCPU_ORG

Table 193 • **Register Groups in DEVCPU_ORG**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
ORG	0x00000000	1	Origin registers	Page 258

7.2.1 DEVCPU_ORG:ORG

Parent: DEVCPU_ORG

Instances: 1

Table 194 • **Registers in ORG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ERR_ACCESS_DROP	0x00000000	1	Target Module ID is Unknown	Page 258
ERR_TGT	0x00000008	1	Target Module is Busy	Page 259
ERR_CNTS	0x0000000C	1	Error Counters	Page 260
CFG_STATUS	0x0000001C	1	Configuration and Status Register	Page 260

7.2.1.1 DEVCPU_ORG:ORG:ERR_ACCESS_DROP

Parent: DEVCPU_ORG:ORG

Instances: 1

Table 195 • **Fields in ERR_ACCESS_DROP**

Field Name	Bit	Access	Description	Default
NO_ACTION_STICKY	24	Sticky	Sticky bit that - when set - indicates that at least one request was received by a target, but the target did not do anything with it (Eg. access to a non existing register) '0': No errors occurred. '1': At least one request was received with no action.	0x0
TGT_MODULE_NO_ACTION_STICKY	23:16	R/O	Target Module ID. When the sticky_no_action bit is set, this field holds the ID of the last target that received a request that didn't resolve in an action. 0x01 : Module id 1 0xFF : module id 255	0x00
UTM_STICKY	8	Sticky	Sticky bit that - when set - indicates that at least one request for an unknown target module has been done. '0': No errors occurred. '1': At least one request to an unknown target has been done.	0x0
TGT_MODULE_UTM_STICKY	7:0	R/O	Target Module ID. When the sticky_utm bit is set, this field holds the ID of the last target that was unknown. 0x01 : Module id 1 0xFF : module id 255	0x00

7.2.1.2 DEVCPU_ORG:ORG:ERR_TGT

Parent: DEVCPU_ORG:ORG

Instances: 1

Write all ones to this register to clear it.

Table 196 • **Fields in ERR_TGT**

Field Name	Bit	Access	Description	Default
BSY_STICKY	8	Sticky	Sticky bit that - when set - indicates that at least one request was not processed because the target was busy. '0': No error has occurred '1': A least one request was dropped due to that the target was busy.	0x0

Table 196 • **Fields in ERR_TGT *(continued)***

Field Name	Bit	Access	Description	Default
TGT_MODULE_BSY	7:0	R/O	Target Module ID. When the sticky_bsy bit is set, this field holds the ID of the last target that was unable to process a request. 0x01 : Module id 1 0xFF : Module id 255	0x00

7.2.1.3 DEVCPU_ORG:ORG:ERR_CNTS

Parent: DEVCPU_ORG:ORG

Instances: 1

Table 197 • **Fields in ERR_CNTS**

Field Name	Bit	Access	Description	Default
NO_ACTION_CNT	31:24	R/W	No action Counter. Counts the number of requests that were not processed by the Target Module, because the target did not know what to do (e.g. access to a non-existing register). This counter saturates at max.	0x00
UTM_CNT	23:16	R/W	Unknown Target Counter. Counts the number of requests that were not processed by the Target Module, because the target was no found. This counter saturates at max.	0x00
BUSY_CNT	15:8	R/W	Busy Counter. Counts the number of requests that were not processed by the Target Module, because it was busy. This may be because the Target Module was waiting for access to/from its host. This counter saturates at max.	0x00

7.2.1.4 DEVCPU_ORG:ORG:CFG_STATUS

Parent: DEVCPU_ORG:ORG

Instances: 1

Table 198 • **Fields in CFG_STATUS**

Field Name	Bit	Access	Description	Default
RD_ERR_STICKY	1	Sticky	If a new read access is initialized before the previous read access has completed this sticky bit is set. Both the 1st and 2nd read access will be handled, but the 2nd access will overwrite data from the 1st access. '0': A read access that has been initialized before the previous read access had completed has never occurred. '1': At least one time a read access has been initialized before the previous read access had completed.	0x0
ACCESS_IN_PROGRESS	0	R/O	When set a access is in progress. '0': No access is in progress. '1': A access is in progress.	0x0

7.3 SYS

Table 199 • **Register Groups in SYS**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
SYSTEM	0x000081B0	1	Switch Configuration	Page 262
SCH	0x0000845C	1	Scheduler registers	Page 269
SCH_LB	0x00003800	1	Scheduler leaky bucket registers	Page 273
RES_CTRL	0x00004000	1024 0x00000008	Watermarks and status for egress queue system	Page 275
PAUSE_CFG	0x000085A4	1	Watermarks for egress queue system	Page 277
MMGT	0x000037A0	1	Memory manager status	Page 279
MISC	0x000037AC	1	Miscellaneous	Page 280
STAT	0x00000000	3558 0x00000004	Frame statistics	Page 280
PTP	0x00008688	1	Precision time protocol	Page 281
POL	0x00006000	256 0x00000020	General policer configuration	Page 283
POL_MISC	0x00008704	1	Flow control configuration	Page 286
ISHP	0x00008000	27 0x00000010	Ingress shaper configuration	Page 287

7.3.1 SYS:SYSTEM

Parent: SYS

Instances: 1

Table 200 • **Registers in SYSTEM**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RESET_CFG	0x00000000	1	Core reset control	Page 262
VLAN_ETYPE_CFG	0x00000008	1	S-tag Ethernet Type	Page 263
PORT_MODE	0x0000000C	28 0x00000004	Per device port configuration	Page 263
FRONT_PORT_MODE	0x0000007C	26 0x00000004	Various Ethernet port configurations	Page 264
SWITCH_PORT_MODE	0x000000E4	27 0x00000004	Various switch port mode settings	Page 264
FRM_AGING	0x00000150	1	Configure Frame Aging	Page 264
STAT_CFG	0x00000154	1	Statistics configuration	Page 265
EEE_CFG	0x00000158	26 0x00000004	Control Energy Efficient Ethernet operation per front port.	Page 266
EEE_THRES	0x000001C0	1	Thresholds for delayed EEE queues	Page 267
IGR_NO_SHARING	0x000001C4	1	Control shared memory users	Page 267
EGR_NO_SHARING	0x000001C8	1	Control shared memory users	Page 268
SW_STATUS	0x000001CC	27 0x00000004	Various status info per switch port	Page 268
EQ_TRUNCATE	0x00000238	27 0x00000004	Truncate frames in queue	Page 268
EQ_PREFER_SRC	0x000002A4	1	Precedence for source ports	Page 268
EXT_CPU_CFG	0x000002A8	1	External CPU port configuration	Page 269

7.3.1.1 SYS:SYSTEM:RESET_CFG

Parent: SYS:SYSTEM

Instances: 1

Controls reset and initialization of the switching core. Proper startup sequence is:

- Enable memories

- Initialize memories

- Enable core

Table 201 • **Fields in RESET_CFG**

Field Name	Bit	Access	Description	Default
CORE_ENA	2	R/W	Switch core is enabled when this field is set.	0x0
MEM_ENA	1	R/W	Core memory controllers are enabled when this field is set.	0x0
MEM_INIT	0	One-shot	Initialize core memories. Field is automatically cleared when operation is complete (approx. 40 us).	0x0

7.3.1.2 SYS:SYSTEM:VLAN_ETYPE_CFG

Parent: SYS:SYSTEM

Instances: 1

Table 202 • **Fields in VLAN_ETYPE_CFG**

Field Name	Bit	Access	Description	Default
VLAN_S_TAG_ETYPE_VAL	15:0	R/W	Custom Ethernet Type for S-tags. Tags with TPID = 0x88A8 are always recognized as S-tags.	0x88A8

7.3.1.3 SYS:SYSTEM:PORT_MODE

Parent: SYS:SYSTEM

Instances: 28

These configurations exists per frontport and for each of the two CPU ports (26+27).

Table 203 • **Fields in PORT_MODE**

Field Name	Bit	Access	Description	Default
RESERVED	4:3	R/W	Must be set to its default.	0x2
L3_PARSE_CFG	2	R/W	Enable frame analysis on Layer-3 and Layer-4 protocol information. If cleared, all frames are seen as non-IP and are handled accordingly. This affects all blocks using IP information such as classification, TCAM lookups, IP flooding and forwarding, and DSCP rewriting.	0x1
DEQUEUE_DIS	1	R/W	Disable dequeuing from the egress queues. Frames are not discarded, but may become aged when dequeuing is re-enabled.	0x0

Table 203 • **Fields in PORT_MODE *(continued)***

Field Name	Bit	Access	Description	Default
INCL_INJ_HDR	0	R/W	Enable parsing of 64-bit injection header, which must be prepended all frames received on this port.	0x0

7.3.1.4 SYS:SYSTEM:FRONT_PORT_MODE

Parent: SYS:SYSTEM

Instances: 26

Table 204 • **Fields in FRONT_PORT_MODE**

Field Name	Bit	Access	Description	Default
HDX_MODE	0	R/W	Enables the queue system to support the half duplex mode. Must be set for a port when enabled for half-duplex mode (MAC_MODE_ENA.FDX_ENA cleared).	0x0

7.3.1.5 SYS:SYSTEM:SWITCH_PORT_MODE

Parent: SYS:SYSTEM

Instances: 27

Table 205 • **Fields in SWITCH_PORT_MODE**

Field Name	Bit	Access	Description	Default
PORT_ENA	3	R/W	Enable port for any frame transfer. Frames to or from a port with PORT_ENA cleared are discarded.	0x0
RESERVED	2	R/W	Must be set to its default.	0x1
RESERVED	1	R/W	Must be set to its default.	0x1

7.3.1.6 SYS:SYSTEM:FRM_AGING

Parent: SYS:SYSTEM

Instances: 1

Table 206 • **Fields in FRM_AGING**

Field Name	Bit	Access	Description	Default
MAX_AGE	31:0	R/W	Frames are aged and removed from the queue system when the frame's age timer becomes two. The frame age timer is increased for all frames whenever the configured time, MAX_AGE, has passed. The unit is 4 ns. Effectively, this means that a frame is aged when the frame has waited in the queue system between one or two times the period specified by MAX_AGE. A value of zero disables the aging. A value less than 6000 (24 us) is illegal.	0x00000000

7.3.1.7 SYS:SYSTEM:STAT_CFG

Parent: SYS:SYSTEM

Instances: 1

Table 207 • **Fields in STAT_CFG**

Field Name	Bit	Access	Description	Default
TX_GREEN_CNT_MODE	10	R/W	Counter mode for the Tx priority counters for green frames (CNT_TX_GREEN_PRIO_x) 0: Count octets 1: Count frames	0x1
TX_YELLOW_CNT_MODE	9	R/W	Counter mode for the Tx priority counters for green frames (CNT_TX_YELLOW_PRIO_x) 0: Count octets 1: Count frames	0x1
DROP_GREEN_CNT_MODE	8	R/W	Counter mode for the drop counters for green frames (CNT_DR_GREEN_PRIO_x) 0: Count octets 1: Count frames	0x1
DROP_YELLOW_CNT_MODE	7	R/W	Counter mode for the drop counters for green frames (CNT_DR_YELLOW_PRIO_x) 0: Count octets 1: Count frames	0x1
STAT_CLEAR_PORT	5:1	R/W	Select which port to clear counters for.	0x00

Table 207 • **Fields in STAT_CFG *(continued)***

Field Name	Bit	Access	Description	Default
STAT_CLEAR_SHOT	0	One-shot	Set STAT_CLEAR_SHOT to clear all counters for the port selected by STAT_CLEAR_PORT port. Auto-cleared when complete (1us).	0x0

7.3.1.8 SYS:SYSTEM:EEE_CFG

Parent: SYS:SYSTEM

Instances: 26

Table 208 • **Fields in EEE_CFG**

Field Name	Bit	Access	Description	Default
EEE_ENA	29	R/W	Enable EEE operation on the port. A port enters the low power mode when no egress queues have data ready. The port is activated when one of the following conditions is true: - A queue has been non-empty for EEE_TIMER_AGE. - A queue has more than EEE_HIGH_FRAMES frames pending. - A queue has more than EEE_HIGH_BYTES bytes pending. - A queue is marked as a fast queue, and has data pending.	0x0
EEE_FAST_QUEUES	28:21	R/W	Queues set in this mask activate the egress port immediately when any of the queues have data available.	0x00
EEE_TIMER_AGE	20:14	R/W	Maximum time frames in any queue must wait before the port is activated. The default value corresponds to 48 us. Time = 4**(EEE_TIMER_AGE/16) * (EEE_TIMER_AGE mod 16) microseconds	0x23

Table 208 • **Fields in EEE_CFG *(continued)***

Field Name	Bit	Access	Description	Default
EEE_TIMER_WAKEUP	13:7	R/W	Time from the egress port is activated until frame transmission is restarted. Default value corresponds to 16 us. Time = 4**(EEE_TIMER_WAKEUP/16) * (EEE_TIMER_WAKEUP mod 16) microseconds	0x14
EEE_TIMER_HOLDOFF	6:0	R/W	When all queues are empty, the port is kept active until this time has passed. Default value corresponds to 5 us. Time = 4**(EEE_TIMER_HOLDOFF/16) * (EEE_TIMER_HOLDOFF mod 16) microseconds	0x05

7.3.1.9 SYS:SYSTEM:EEE_THRES

Parent: SYS:SYSTEM

Instances: 1

Table 209 • **Fields in EEE_THRES**

Field Name	Bit	Access	Description	Default
EEE_HIGH_BYTES	15:8	R/W	Maximum number of bytes in a queue before egress port is activated. Unit is 48 bytes.	0x00
EEE_HIGH_FRAMES	7:0	R/W	Maximum number of frames in a queue before the egress port is activated. Unit is 1 frame.	0x00

7.3.1.10 SYS:SYSTEM:IGR_NO_SHARING

Parent: SYS:SYSTEM

Instances: 1

Table 210 • **Fields in IGR_NO_SHARING**

Field Name	Bit	Access	Description	Default
IGR_NO_SHARING	26:0	R/W	Control whether frames received on the port may use shared resources. If ingress port or queue has reserved memory left to use, frame enqueuing is always allowed. 0: Use shared memory as well 1: Do not use shared memory	0x0000000

7.3.1.11 SYS:SYSTEM:EGR_NO_SHARING

Parent: SYS:SYSTEM

Instances: 1

Table 211 • **Fields in EGR_NO_SHARING**

Field Name	Bit	Access	Description	Default
EGR_NO_SHARING	26:0	R/W	Control whether frames forwarded to the port may use shared resources. If egress port or queue has reserved memory left to use, frame enqueuing is always allowed. 0: Use shared memory as well 1: Do not use shared memory	0x0000000

7.3.1.12 SYS:SYSTEM:SW_STATUS

Parent: SYS:SYSTEM

Instances: 27

Table 212 • **Fields in SW_STATUS**

Field Name	Bit	Access	Description	Default
EQ_AVAIL	9:2	R/O	Status bit per egress queue indicating whether data is ready for transmission.	0x00
PORT_LPI	1	R/O	Status bit indicating whether port is in low-power-idle due to the LPI algorithm (EEE_CFG). If set, transmissions are held back.	0x0
PORT_RX_PAUSED	0	R/O	Status bit indicating whether the switch core is instructing the MAC to pause the ingress port.	0x0

7.3.1.13 SYS:SYSTEM:EQ_TRUNCATE

Parent: SYS:SYSTEM

Instances: 27

Table 213 • **Fields in EQ_TRUNCATE**

Field Name	Bit	Access	Description	Default
EQ_TRUNCATE	7:0	R/W	If a bit is set, frames transmitted from corresponding egress queue are truncated to 92 bytes.	0x00

7.3.1.14 SYS:SYSTEM:EQ_PREFER_SRC

Parent: SYS:SYSTEM

Instances: 1

Table 214 • **Fields in EQ_PREFER_SRC**

Field Name	Bit	Access	Description	Default
EQ_PREFER_SRC	26:0	R/W	When multiple sources have data in the same priority, ingress ports set in this mask are preferred over ingress ports not set when arbitrating frames from ingress to egress. When multiple ports are set, the arbitration between these ports are round-robin.	0x4000000

7.3.1.15 SYS:SYSTEM:EXT_CPU_CFG

Parent: SYS:SYSTEM

Instances: 1

Table 215 • **Fields in EXT_CPU_CFG**

Field Name	Bit	Access	Description	Default
EXT_CPU_PORT	12:8	R/W	Select the port to use as the external CPU port.	0x1B
EXT_CPUQ_MSK	7:0	R/W	Frames destined for a CPU extraction queue set in this mask are sent to the external CPU defined by EXT_CPU_PORT instead of the internal CPU.	0x00

7.3.2 SYS:SCH

Parent: SYS

Instances: 1

Table 216 • **Registers in SCH**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
LB_DWRR_FRM_ADJ	0x00000000	1	Leaky bucket frame adjustment	Page 270
LB_DWRR_CFG	0x00000004	26 0x00000004	Leaky bucked frame adjustment	Page 270
SCH_DWRR_CFG	0x0000006C	26 0x00000004	Deficit weighted round robin control register	Page 270
SCH_SHAPING_CTRL	0x000000D8	26 0x00000004	Scheduler shaping control register	Page 271
SCH_LB_CTRL	0x00000140	1	Leaky bucket control	Page 272

Table 216 • **Registers in SCH *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SCH_CPU	0x00000144	1	Map CPU queues to CPU ports	Page 273

7.3.2.1 SYS:SCH:LB_DWRR_FRM_ADJ

Parent: SYS:SCH

Instances: 1

Table 217 • **Fields in LB_DWRR_FRM_ADJ**

Field Name	Bit	Access	Description	Default
FRM_ADJ	4:0	R/W	Value added to leaky buckets and DWRR each time a frame is scheduled. If set to 20, this corresponds to inclusion of minimum Ethernet IFG and preamble. 0-31: Number of bytes added at start of frame	0x00

7.3.2.2 SYS:SCH:LB_DWRR_CFG

Parent: SYS:SCH

Instances: 26

Table 218 • **Fields in LB_DWRR_CFG**

Field Name	Bit	Access	Description	Default
FRM_ADJ_ENA	0	R/W	If enabled, the value configured in SCH_LB_DWRR_FRM_ADJ.FRM_ADJ is added to the frame length for each frame. The modified frame length is used by both the leaky bucket and DWRR algorithm. 0:Disable frame length adjustment. 1:Enable frame length adjustment.	0x0

7.3.2.3 SYS:SCH:SCH_DWRR_CFG

Parent: SYS:SCH

Instances: 26

Table 219 • **Fields in SCH_DWRR_CFG**

Field Name	Bit	Access	Description	Default
DWRR_MODE	30	R/W	Configure DWRR scheduling for port. Weighted- and strict prioritization can be configured. 0: All priorities are scheduled strict 1: The two highest priorities (6, 7) are strict. The rest is DWRR	0x0
COST_CFG	29:0	R/W	Queue cost configuration. Bit vector used to configure the cost of each priority. Bits 4:0: Cost for queue 0. Bits 9:5: Cost for queue 1. Bits 14:10: Cost for queue 2. Bits 19:15: Cost for queue 3. Bits 24:20: Cost for queue 4. Bits 29:25: Cost for queue 5. Within each cost field, the following encoding is used: 0: Cost 1 1: Cost 2 ... 31: Cost 32	0x00000000

7.3.2.4 SYS:SCH:SCH_SHAPING_CTRL

Parent: SYS:SCH

Instances: 26

Table 220 • **Fields in SCH_SHAPING_CTRL**

Field Name	Bit	Access	Description	Default
PRIO_SHAPING_ENA	7:0	R/W	Enable priority shaping. If enabled the BW of a priority is limited to SCH_LB::LB_RATE. xxxxxxx1: Enable shaping for Prio 0 xxxxxx1x: Enable shaping for Prio 1 ... 1xxxxxxx: Enable shaping for Prio N	0x00
PORT_SHAPING_ENA	8	R/W	Enable port shaping. If enabled the total BW of a port is limited to SCH_LB::LB_RATE. 0: Disable port shaping 1: Enable port shaping	0x0

Table 220 • **Fields in SCH_SHAPING_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
PRIO_LB_EXS_ENA	23:16	R/W	Allow this queue to use excess bandwidth. If none of the priorities are allowed (by their priority LB) to transmit. The resulting BW of a queue is a function of the port- and queue LBs, the DWRR and the excess enable bit: 1) Port LB closed. Hold back frames. 2) Port LB open -> Use strict- or DWRR scheduling to distribute traffic between open Queue LBs 3) All Queue LBs closed -> Hold back frames except for Queues which have PRIO_LB_EXS_ENA set. The excess BW is distributed using strict- or DWRR scheduling. xxxxxxx1: Enable excess BW for Prio 0 xxxxxx1x: Enable excess BW for Prio 1 ... 1xxxxxxx: Enable excess BW for Prio N	0x00
PRIO_LB_AVB_ENA	31:24	R/W	Enable AV Bridging (AVB) shaping mode for queues. In AVB mode the burst capacity of a queue is limited. An AVB queue can only build up burst capacity when it has traffic to send. xxxxxxx1: Enable AVB mode for Prio 0 xxxxxx1x: Enable AVB mode for Prio 1 ... 1xxxxxxx: Enable AVB mode for Prio N	0x00

7.3.2.5 SYS:SCH:SCH_LB_CTRL

Parent: SYS:SCH

Instances: 1

Table 221 • **Fields in SCH_LB_CTRL**

Field Name	Bit	Access	Description	Default
LB_INIT	0	One-shot	Set to 1 to force a complete initialization of state and configuration of leaky buckets. Must be done before the scheduler is used. Field is automatically cleared whether initialization is complete. 0: No Action 1: Force initialization.	0x0

7.3.2.6 SYS:SCH:SCH_CPU

Parent: SYS:SCH

Instances: 1

Table 222 • **Fields in SCH_CPU**

Field Name	Bit	Access	Description	Default
SCH_CPU_MAP	9:2	R/W	Maps the 8 CPU queues to CPU port 26 or 27. Bit <n> set directs CPU queue <n> to CPU port 26/27.	0x00
SCH_CPU_RR	1:0	R/W	Set the scheduler for CPU port <n> to run round robin between queues instead of strict.	0x0

7.3.3 SYS:SCH_LB

Parent: SYS

Instances: 1

Ethernet leaky bucket configuration per port and per priority.

The address of the configuration is based on the following layout: (Assume the priority count is 8)

0: Leaky bucket for priority 0 of port 0

1: Leaky bucket for priority 1 of port 0

2: Leaky bucket for priority 2 of port 0

3: Leaky bucket for priority 3 of port 0

4: Leaky bucket for priority 4 of port 0

5: Leaky bucket for priority 5 of port 0

6: Leaky bucket for priority 6 of port 0

7: Leaky bucket for priority 7 of port 0

8: Leaky bucket port 0

9: Leaky bucket for priority 0 of port 1

10: Leaky bucket for priority 1 of port 1

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The configuration for each leaky bucket includes rate and threshold configuration.

Table 223 • **Registers in SCH_LB**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
LB_THRES	0x00000000	234 0x00000004	Leaky bucket threshold	Page 274
LB_RATE	0x00000400	234 0x00000004	Leaky bucket rate	Page 274

7.3.3.1 SYS:SCH_LB:LB_THRES

Parent: SYS:SCH_LB

Instances: 234

Table 224 • **Fields in LB_THRES**

Field Name	Bit	Access	Description	Default
LB_THRES	5:0	R/W	Burst capacity of leaky buckets The unit is 4KB (1KB = 1024Bytes). The largest supported threshold is 252KB when the register value is set to all "1"s. Queue shaper Q on port P uses shaper 9*P+Q. Port shaper on port P uses shaper 9*P+8. 0: Always closed 1: Burst capacity = 4096 bytes ... n: Burst capacity = n x 4096 bytes	0x00

7.3.3.2 SYS:SCH_LB:LB_RATE

Parent: SYS:SCH_LB

Instances: 234

Table 225 • **Fields in LB_RATE**

Field Name	Bit	Access	Description	Default
LB_RATE	14:0	R/W	Leaky bucket rate in unit of 100160 bps. Queue shaper Q on port P uses shaper 9*P+Q. Port shaper on port P uses shaper 9*P+8. 0: Open until burst capacity is used, then closed. 1: Rate = 100160 bps n: Rate = n x 100160 bps	0x0000

7.3.4 SYS:RES_CTRL

Parent: SYS

Instances: 1024

Table 226 • **Registers in RES_CTRL**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RES_CFG	0x00000000	1	Watermark configuration	Page 275
RES_STAT	0x00000004	1	Resource status	Page 276

7.3.4.1 SYS:RES_CTRL:RES_CFG

Parent: SYS:RES_CTRL

Instances: 1

The queue system tracks four resource consumptions:

Resource 0: Memory tracked per source

Resource 1: Frame references tracked per source

Resource 2: Memory tracked per destination

Resource 3: Frame references tracked per destination

Before a frame is added to the queue system, some conditions must be met:

- Reserved memory for the specific (SRC, PRIO) or for the specific SRC is available

OR

- Reserved memory for the specific (DST,PRIO) or for the specific DST is available

OR

- Shared memory is available

The frame reference resources are checked for availability like the memory resources. Enqueuing of a frame is allowed if both the memory resource check and the frame reference resource check succeed.

The extra resources consumed when enqueuing a frame are first taken from the reserved (SRC,PRIO), next from the reserved SRC, and last from the shared memory area. The same is done for DST. Both memory consumptions and frame reference consumptions are updated.

The register is layed out the following way:

Index 0-215: Reserved amount for (x,PRIO) at index 8*x+PRIO, x=SRC or DST

Index 224-250: Reserved amount for (x)

Resource 0 is accessed at index 0-255, 1 at index 256-511 etc.

The amount of shared memory is located at index 255. An extra watermark at 254 is used for limiting amount of shared memory used before yellow traffic is discarded.

The amount of shared references is located at index 511. An extra watermark at 510 is used for limiting amount of shared references for yellow traffic.

At index 216-223 there is a watermarks per priority used for limiting how much of the shared buffer must be used per priority.

Likewise at offset 472 there are priority watermarks for references.

The allocation size for memory tracking is 48 bytes, and all frames is added a 4 byte header internally.

Table 227 • **Fields in RES_CFG**

Field Name	Bit	Access	Description	Default
WM_HIGH	10:0	R/W	Watermark for resource. Note, the default value depends on the index. Refer to the congestion scheme documentation for details. Bit 10: Unit; 0:1, 1:16 Bits 9-0: Value to be multiplied with unit	0x000

7.3.4.2 SYS:RES_CTRL:RES_STAT

Parent: SYS:RES_CTRL

Instances: 1

Table 228 • **Fields in RES_STAT**

Field Name	Bit	Access	Description	Default
INUSE	27:14	R/W	Current consumption for corresponding watermark in RES_CFG.	0x0000

Table 228 • **Fields in RES_STAT *(continued)***

Field Name	Bit	Access	Description	Default
MAXUSE	13:0	R/W	Maximum consumption for corresponding watermark in RES_CFG.	0x0000

7.3.5 SYS:PAUSE_CFG

Parent: SYS

Instances: 1

Table 229 • **Registers in PAUSE_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PAUSE_CFG	0x00000000	27 0x00000004	Watermarks for flow control condition per switch port.	Page 277
PAUSE_TOT_CFG	0x0000006C	1	Configure total memory pause condition	Page 278
ATOP	0x00000070	27 0x00000004	Tail dropping level	Page 278
ATOP_TOT_CFG	0x000000DC	1	Total raw memory use before tail dropping is activated	Page 278
EGR_DROP_FORCE	0x000000E0	1	Configures egress ports for flowcontrol	Page 279

7.3.5.1 SYS:PAUSE_CFG:PAUSE_CFG

Parent: SYS:PAUSE_CFG

Instances: 27

Table 230 • **Fields in PAUSE_CFG**

Field Name	Bit	Access	Description	Default
PAUSE_START	22:12	R/W	Start pausing ingress stream when the amount of memory consumed by the port exceeds this watermark. The TOTPAUSE condition must also be met. See RES_CFG	0x7FF
PAUSE_STOP	11:1	R/W	Stop pausing ingress stream when the amount of memory consumed by the port is below this watermark. See RES_CFG.	0x7FF

Table 230 • **Fields in PAUSE_CFG *(continued)***

Field Name	Bit	Access	Description	Default
PAUSE_ENA	0	R/W	Enable pause feedback to the MAC, allowing transmission of pause frames or HDX collisions to limit ingress data rate.	0x0

7.3.5.2 SYS:PAUSE_CFG:PAUSE_TOT_CFG

Parent: SYS:PAUSE_CFG

Instances: 1

Table 231 • **Fields in PAUSE_TOT_CFG**

Field Name	Bit	Access	Description	Default
PAUSE_TOT_START	21:11	R/W	Assert TOTPAUSE condition when total memory allocation is above this watermark. See RES_CFG	0x000
PAUSE_TOT_STOP	10:0	R/W	Deassert TOTPAUSE condition when total memory allocation is below this watermark. See RES_CFG	0x000

7.3.5.3 SYS:PAUSE_CFG:ATOP

Parent: SYS:PAUSE_CFG

Instances: 27

Table 232 • **Fields in ATOP**

Field Name	Bit	Access	Description	Default
ATOP	10:0	R/W	When a source port consumes more than this level in the packet memory, frames are tail dropped, unconditionally of destination. See RES_CFG	0x7FF

7.3.5.4 SYS:PAUSE_CFG:ATOP_TOT_CFG

Parent: SYS:PAUSE_CFG

Instances: 1

Table 233 • **Fields in ATOP_TOT_CFG**

Field Name	Bit	Access	Description	Default
ATOP_TOT	10:0	R/W	Tail dropping is activate on a port when the port use has exceeded the ATOP watermark for the port, and the total memory use has exceeded this watermark. See RES_CFG	0x7FF

7.3.5.5 SYS:PAUSE_CFG:EGR_DROP_FORCE

Parent: SYS:PAUSE_CFG

Instances: 1

Table 234 • **Fields in EGR_DROP_FORCE**

Field Name	Bit	Access	Description	Default
EGRESS_DROP_FORCE	26:0	R/W	When enabled for a port, frames to the port are discarded, even when the ingress port is enabled for flow control. Applicable to egress ports that should not create head-of-line blocking in ingress ports operating in flow control mode. An example is the CPU port.	0x0000000

7.3.6 SYS:MMGT

Parent: SYS

Instances: 1

Table 235 • **Registers in MMGT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MMGT	0x00000000	1	Packet Memory Status	Page 279
EQ_CTRL	0x00000008	1	Egress queue status	Page 280

7.3.6.1 SYS:MMGT:MMGT

Parent: SYS:MMGT

Instances: 1

Table 236 • **Fields in MMGT**

Field Name	Bit	Access	Description	Default
FREECNT	19:8	R/O	Number of 192-byte free memory words.	0x000

7.3.6.2 SYS:MMGT:EQ_CTRL

Parent: SYS:MMGT

Instances: 1

Table 237 • **Fields in EQ_CTRL**

Field Name	Bit	Access	Description	Default
FP_FREE_CNT	12:0	R/O	Number of free frame references.	0x0000

7.3.7 SYS:MISC

Parent: SYS

Instances: 1

Table 238 • **Registers in MISC**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
REPEATER	0x00000018	1	Frame repeating setup	Page 280

7.3.7.1 SYS:MISC:REPEATER

Parent: SYS:MISC

Instances: 1

Table 239 • **Fields in REPEATER**

Field Name	Bit	Access	Description	Default
REPEATER	26:0	R/W	A bit set in this mask makes the corresponding port skip dequeing from the queue selected by the scheduler. This can be used for simple frame generation and scheduler experiments.	0x0000000

7.3.8 SYS:STAT

Parent: SYS

Instances: 3558

These registers are used for accessing all frame statistics.

Table 240 • **Registers in STAT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
CNT	0x00000000	1	Counter values	Page 281

7.3.8.1 SYS:STAT:CNT

Parent: SYS:STAT

Instances: 1

Table 241 • **Fields in CNT**

Field Name	Bit	Access	Description	Default
CNT	31:0	R/W	Counter values. The counters are layed in three main blocks where each port has a share within the block: Rx counters: 0x000 - 0x488 - port0: 0x000 - 0x02A - port1: 0x02B - 0x055 ... - port26 (CPU): 0x45E - 0x488 Tx counters: 0x800 - 0xB44 - port0: 0x800 - 0x81E - port1: 0x81F - 0x83D ... - port26 (CPU): 0xB26 - 0xB44 Drop counters: 0xC00 - 0xDE5 - port0: 0xC00 - 0xC11 - port1: 0xC12 - 0xC23 ... - port26 (CPU): 0xDD4 - 0xDE5 SYS::STAT_CFG and ANA::AGENCTRL control whether bytes or frames are counted for specific counters. Counters are cleared through SYS::STAT_CFG.	0x00000000

7.3.9 SYS:PTP

Parent: SYS

Instances: 1

Table 242 • **Registers in PTP**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PTP_STATUS	0x00000000	1	Stored timestamp and timestamp queue status	Page 282
PTP_DELAY	0x00000004	1	Timestamp value	Page 282
PTP_CFG	0x00000008	28 0x00000004	Configuration of Rx and Tx hardware timestamping	Page 283
PTP_NXT	0x00000078	1	Advancing the timestamp queue	Page 283

7.3.9.1 SYS:PTP:PTP_STATUS

Parent: SYS:PTP

Instances: 1

Table 243 • **Fields in PTP_STATUS**

Field Name	Bit	Access	Description	Default
PTP_OVFL	12	R/O	If set, the timestamp queue has overflown implying a timestamp entry could not enqueued. The PTP_OVFL bit is not cleared until the timestamp queue is completely empty.	0x0
PTP_MESS_VLD	11	R/O	A timestamp entry is ready for reading. PTP_MESS_ID, PTP_MESS_TXPORT, and PTP_DELAY contain the data of the timestamp entry.	0x0
PTP_MESS_ID	10:5	R/O	Timestamp identifier for head-of-line timestamp entry.	0x00
PTP_MESS_TXPORT	4:0	R/O	The transmit port for the head-of-line timestamp entry.	0x00

7.3.9.2 SYS:PTP:PTP_DELAY

Parent: SYS:PTP

Instances: 1

Table 244 • **Fields in PTP_DELAY**

Field Name	Bit	Access	Description	Default
PTP_DELAY	31:0	R/O	The timestamp value for the head-of-line timestamp entry. The timestamp value is the frame's arrival time if the transmit port is the CPU port. Otherwise the timestamp value is the frame's residence time. Unit is 4 ns.	0x00000000

7.3.9.3 SYS:PTP:PTP_CFG

Parent: SYS:PTP

Instances: 28

Table 245 • **Fields in PTP_CFG**

Field Name	Bit	Access	Description	Default
PTP_1STEP_DIS	17	R/W	Disable updating of the correction field in PTP frames. This overrules the IS2 PTP_ENA[0] action.	0x0
PTP_2STEP_DIS	16	R/W	Disable adding the entries to the timestamp queue. This overrules the IS2 PTP_ENA[1] action.	0x0
IO_TX_DELAY	15:8	R/W	Delay added to the sampled departure time. Unit is 4 ns.	0x00
IO_RX_DELAY	7:0	R/W	Delay subtracted from the sampled arrival time. Unit is 4 ns.	0x00

7.3.9.4 SYS:PTP:PTP_NXT

Parent: SYS:PTP

Instances: 1

Table 246 • **Fields in PTP_NXT**

Field Name	Bit	Access	Description	Default
PTP_NXT	0	One-shot	Advance to the next timestamp entry. Registers PTP_STATUS and PTP_DELAY points to the next entry.	0x0

7.3.10 SYS:POL

Parent: SYS

Instances: 256

General purpose policers selected by port configuration and ACL actions

Table 247 • **Registers in POL**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
POL_PIR_CFG	0x00000000	1	Peak Information Rate configuration for this policer	Page 284
POL_CIR_CFG	0x00000004	1	Committed Information Rate configuration for this policer	Page 284
POL_MODE_CFG	0x00000008	1	Common configuration for this policer	Page 284
POL_PIR_STATE	0x0000000C	1	State of this policer	Page 285
POL_CIR_STATE	0x00000010	1	State of this policer	Page 285

7.3.10.1 SYS:POL:POL_PIR_CFG

Parent: SYS:POL

Instances: 1

Table 248 • **Fields in POL_PIR_CFG**

Field Name	Bit	Access	Description	Default
PIR_RATE	20:6	R/W	Accepted rate for this policer. Unit is 100 kbps.	0x0000
PIR_BURST	5:0	R/W	Burst capacity of this policer. Unit is 4 kilobytes.	0x00

7.3.10.2 SYS:POL:POL_CIR_CFG

Parent: SYS:POL

Instances: 1

Table 249 • **Fields in POL_CIR_CFG**

Field Name	Bit	Access	Description	Default
CIR_RATE	20:6	R/W	Accepted rate for this policer. Unit is 100 kbps.	0x0000
CIR_BURST	5:0	R/W	Burst capacity of this policer. Unit is 4 kilobytes.	0x00

7.3.10.3 SYS:POL:POL_MODE_CFG

Parent: SYS:POL

Instances: 1

Table 250 • **Fields in POL_MODE_CFG**

Field Name	Bit	Access	Description	Default
IPG_SIZE	9:5	R/W	Size of IPG to add to each frame if line rate policing is chosen in FRM_MODE.	0x14
FRM_MODE	4:3	R/W	Accounting mode of this policer. 0: Line rate. Police bytes including IPG_SIZE. 1: Data rate. Police bytes excluding IPG. 2. Frame rate. Police frames with rate unit = 100 fps and burst unit = 32.8 frames. 3: Frame rate. Police frame with rate unit = 1 fps and burst unit = 0.3 frames.	0x0
DLB_COUPLED	2	R/W	Dual Leaky Bucket function of this policer. 0. Do CIR/PIR policing w/o coupling 1: Do CIR/PIR policing w coupling	0x0
CIR_ENA	1	R/W	Enable yellow marking when commited rate is reached.	0x0
OVERSHOOT_ENA	0	R/W	If set, overshoot is allowed. This implies that a frame of any length is accepted if the policer is open even if the frame causes the bucket to use more than the remaining capacity. If cleared, overshoot is not allowed. This implies that it is checked that the frame will not use more than the remaining capacity in the bucket before accepting the frame.	0x1

7.3.10.4 SYS:POL:POL_PIR_STATE

Parent: SYS:POL

Instances: 1

Table 251 • **Fields in POL_PIR_STATE**

Field Name	Bit	Access	Description	Default
PIR_LVL	21:0	R/W	Current fill level of this policer. Unit is 0.5 bits.	0x000000

7.3.10.5 SYS:POL:POL_CIR_STATE

Parent: SYS:POL

Instances: 1

Table 252 • **Fields in POL_CIR_STATE**

Field Name	Bit	Access	Description	Default
CIR_LVL	21:0	R/W	Current fill level of this policer. Unit is 0.5 bits.	0x000000

7.3.11 SYS:POL_MISC

Parent: SYS

Instances: 1

Table 253 • **Registers in POL_MISC**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
POL_FLOWC	0x00000000	27 0x00000004	Flow control configuration per policer	Page 286
POL_HYST	0x0000006C	1	Set delay between flow control clearings	Page 286

7.3.11.1 SYS:POL_MISC:POL_FLOWC

Parent: SYS:POL_MISC

Instances: 27

Table 254 • **Fields in POL_FLOWC**

Field Name	Bit	Access	Description	Default
POL_FLOWC	0	R/W	Use MAC flow control for lowering ingress rate 0: Standard policing. Frames are discarded when the rate is exceeded. 1: Flow control policing. Policer instructs the MAC to issue pause frames when the rate is exceeded.	0x0

7.3.11.2 SYS:POL_MISC:POL_HYST

Parent: SYS:POL_MISC

Instances: 1

Table 255 • **Fields in POL_HYST**

Field Name	Bit	Access	Description	Default
POL_FC_HYST	9:4	R/W	Set hysteresis for when to re-open a bucket after the burst capacity has been used. Unit is 1 kilobytes. This applies to policer in flow control mode (POL_FLOWC=1).	0x02
POL_DROP_HYST	3:0	R/W	Set hysteresis for when to re-open a bucket after the burst capacity has been used. Unit is 2 kilobytes. This applies to policer in drop mode (POL_FLOWC=0).	0x0

7.3.12 SYS:ISHP

Parent: SYS

Instances: 27

Table 256 • **Registers in ISHP**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ISHP_CFG	0x00000000	1	Rate and burst configuration	Page 287
ISHP_MODE_CFG	0x00000004	1	Mode of operation	Page 287
ISHP_STATE	0x00000008	1	State of this shaper	Page 288

7.3.12.1 SYS:ISHP:ISHP_CFG

Parent: SYS:ISHP

Instances: 1

Table 257 • **Fields in ISHP_CFG**

Field Name	Bit	Access	Description	Default
ISHP_RATE	21:7	R/W	Accepted rate for this shaper. Unit is 100 kbps.	0x0000
ISHP_BURST	6:1	R/W	Burst capacity of this shaper. Unit is 4kB	0x00
ISHP_ENA	0	R/W	Enable ingress shaping for this port.	0x0

7.3.12.2 SYS:ISHP:ISHP_MODE_CFG

Parent: SYS:ISHP

Instances: 1

Table 258 • **Fields in ISHP_MODE_CFG**

Field Name	Bit	Access	Description	Default
ISHP_IPG_SIZE	6:2	R/W	Size of IPG to add each frame if line rate shaping is chosen in ISHP_MODE.	0x14
ISHP_MODE	1:0	R/W	Accounting mode of this shaper. 0: Line rate. Shape bytes including IPG_size 1: Data rate. Shape bytes excluding IPG 2. Frame rate. Shape frames with rate unit = 100 fps and burst unit = 32.8 frames. 3: Frame rate. Shape frame with rate unit = 1 fps and burst unit = 0.3 frames.	0x0

7.3.12.3 SYS:ISHP:ISHP_STATE

Parent: SYS:ISHP

Instances: 1

Table 259 • **Fields in ISHP_STATE**

Field Name	Bit	Access	Description	Default
ISHP_LVL	21:0	R/W	Current fill level of this shaper. Unit is 0.5 bits.	0x000000

7.4 ANA

Table 260 • **Register Groups in ANA**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
ANA	0x00000D80	1	General analyzer configuration	Page 288
ANA_TABLES	0x00001000	1	MAC, VLAN, and PGID table configuration	Page 299
PORT	0x00000000	27 0x00000080	Per port configurations for Classifier	Page 306
COMMON	0x00000E38	1	Common configurations for Classifier	Page 316

7.4.1 ANA:ANA

Parent: ANA

Instances: 1

Table 261 • **Registers in ANA**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ADVLEARN	0x00000000	1	Advanced Learning Setup	Page 289
VLANMASK	0x00000004	1	VLAN Source Port Mask	Page 290
ANAGEFIL	0x00000008	1	Aging Filter	Page 290
ANEVENTS	0x0000000C	1	Event Sticky Bits	Page 291
STORMLIMIT_BURST	0x00000010	1	Storm policer burst	Page 292
STORMLIMIT_CFG	0x00000014	4 0x00000004	Storm Policer configuration	Page 292
ISOLATED_PORTS	0x00000024	1	Private VLAN Mask for isolated ports	Page 293
COMMUNITY_PORTS	0x00000028	1	Private VLAN Mask for community ports	Page 294
AUTOAGE	0x0000002C	1	Auto Age Timer	Page 294
MACTOPTIONS	0x00000030	1	MAC Table Options	Page 295
LEARNDISC	0x00000034	1	Learn Discard Counter	Page 295
AGENCTRL	0x00000038	1	Analyzer Configuration	Page 296
MIRRORPORTS	0x0000003C	1	Mirror Target Ports	Page 297
EMIRRORPORTS	0x00000040	1	Egress Mirror Mask	Page 297
FLOODING	0x00000044	1	Standard flooding configuration	Page 298
FLOODING_IPMC	0x00000048	1	Flooding configuration for IP multicasts	Page 298
SFLOW_CFG	0x0000004C	27 0x00000004	SFlow sampling configuration per port	Page 298

7.4.1.1 ANA:ANA:ADVLEARN

Parent: ANA:ANA

Instances: 1

Table 262 • **Fields in ADVLEARN**

Field Name	Bit	Access	Description	Default
VLAN_CHK	26	R/W	If this bit is set, a frame discarded because of VLAN ingress filtering is not subject to learning. VLAN ingress filtering is controlled by the VLAN_SRC_CHK flag in the VLAN table (see VLANACCESS register) or the VLANMASK register.	0x0

Table 262 • **Fields in ADVLEARN *(continued)***

Field Name	Bit	Access	Description	Default
LEARN_MIRROR	25:0	R/W	Learn frames are also forwarded to ports marked in this mask.	0x0000000

7.4.1.2 ANA:ANA:VLANMASK

Parent: ANA:ANA

Instances: 1

Table 263 • **Fields in VLANMASK**

Field Name	Bit	Access	Description	Default
VLANMASK	26:0	R/W	Mask for requiring VLAN ingress filtering. If the bit for the frame's physical ingress port is set in this mask, then the port must be member of ingress frame's VLAN (VLANACCESS.VLAN_PORT_MASK), otherwise the frame is discarded.	0x0000000

7.4.1.3 ANA:ANA:ANAGEFIL

Parent: ANA:ANA

Instances: 1

This register sets up which entries are touched by an aging operation (manual as well as automatic aging).

In this way, it is possible to have different aging periods in each VLAN and to have quick removal of entries on specific ports.

The register also affects the GET_NEXT MAC table command. When using the register to control the behavior of GET_NEXT, it is recommended to disable automatic aging while executing the GET_NEXT command.

Table 264 • **Fields in ANAGEFIL**

Field Name	Bit	Access	Description	Default
AGE_LOCKED	19	R/W	Select entries to age. If cleared, unlocked entries will be aged and potentially removed. If set, locked entries will be aged but not removed.	0x0
PID_EN	18	R/W	If set, only MAC table entries with a destination index matching PID_VAL are aged.	0x0
PID_VAL	17:13	R/W	Destination index used in selective aging.	0x00

Table 264 • **Fields in ANAGEFIL *(continued)***

Field Name	Bit	Access	Description	Default
VID_EN	12	R/W	If set, only MAC table entries with a VID matching VID_VAL are aged.	0x0
VID_VAL	11:0	R/W	VID used in selective aging.	0x000

7.4.1.4 ANA:ANA:ANEVENTS

Parent: ANA:ANA

Instances: 1

Table 265 • **Fields in ANEVENTS**

Field Name	Bit	Access	Description	Default
AUTOAGE	24	Sticky	An AUTOAGE run was performed.	0x0
STORM_DROP	22	Sticky	A frame was discarded, because it exceeded the flooding storm limitations configured in STORMLIMIT.	0x0
LEARN_DROP	21	Sticky	A frame was discarded, because it was subject to learning, and the DropMode flag was set in ADVLEARN.	0x0
AGED_ENTRY	20	Sticky	An entry was removed at CPU Learn, or CPU requested an aging process.	0x0
CPU_LEARN_FAILED	19	Sticky	A learn operation failed due to hash table depletion. CPU-based learning only.	0x0
AUTO_LEARN_FAILED	18	Sticky	A learn operation of incoming source MAC address failed due to hash table depletion. Hardware-based learning only.	0x0
LEARN_REMOVE	17	Sticky	An entry was removed when learning a new source MAC address.	0x0
AUTO_LEARNED	16	Sticky	An entry was learned from an incoming frame. Hardware-based learning only.	0x0
AUTO_MOVED	15	Sticky	A station was moved to another port.	0x0
CLASSIFIED_DROP	13	Sticky	A frame was not forwarded due to classification (such as BPDUs).	0x0
CLASSIFIED_COPY	12	Sticky	A frame was copied to the CPU due to classification.	0x0
VLAN_DISCARD	11	Sticky	A frame was discarded due to lack of VLAN membership on source port.	0x0

Table 265 • **Fields in ANEVENTS *(continued)***

Field Name	Bit	Access	Description	Default
FWD_DISCARD	10	Sticky	A frame was discarded due to missing forwarding state on source port.	0x0
MULTICAST_FLOOD	9	Sticky	A frame was flooded with multicast flooding mask.	0x0
UNICAST_FLOOD	8	Sticky	A frame was flooded with unicast flooding mask.	0x0
DEST_KNOWN	7	Sticky	A frame was forwarded with known destination MAC address.	0x0
BUCKET3_MATCH	6	Sticky	A destination was found in hash table bucket 3.	0x0
BUCKET2_MATCH	5	Sticky	A destination was found in hash table bucket 2.	0x0
BUCKET1_MATCH	4	Sticky	A destination was found in hash table bucket 1.	0x0
BUCKET0_MATCH	3	Sticky	A destination was found in hash table bucket 0.	0x0
CPU_OPERATION	2	Sticky	A CPU-initiated operation on the MAC or VLAN table was processed. Default is 1 due to auto-initialization of the MAC and VLAN table.	0x1
DMAC_LOOKUP	1	Sticky	A destination address was looked up in the MAC table.	0x0
SMAC_LOOKUP	0	Sticky	A source address was looked up in the MAC table.	0x0

7.4.1.5 ANA:ANA:STORMLIMIT_BURST

Parent: ANA:ANA

Instances: 1

Table 266 • **Fields in STORMLIMIT_BURST**

Field Name	Bit	Access	Description	Default
STORM_BURST	3:0	R/W	Allowed number of frames in a burst is 2**STORM_BURST. The maximum allowed burst is 4096 frames, which corresponds to STORM_BURST = 12. The STORM_BURST is common for all storm policers.	0x0

7.4.1.6 ANA:ANA:STORMLIMIT_CFG

Parent: ANA:ANA

Instances: 4

0: UC storm policer

1: BC storm policer

2: MC policer

3: Learn policer

Table 267 • **Fields in STORMLIMIT_CFG**

Field Name	Bit	Access	Description	Default
STORM_RATE	6:3	R/W	Allowed rate of storm policer is 2**STORM_UNIT frames per second or kiloframes per second. See STORM_UNIT. The maximum allowed rate is 1024 kiloframes per second, which corresponds to STORM_RATE = 10 with STORM_UNIT set to 0.	0x0
STORM_UNIT	2	R/W	If set, the base unit for the storm policer is one frame per second. If cleared, the base unit is one kiloframe per second.	0x0
STORM_MODE	1:0	R/W	Mode of operation for storm policer. 0: Disabled. 1: Police CPU destination only. 2: Police front port destinations only. 3: Police both CPU and front port destinations.	0x0

7.4.1.7 ANA:ANA:ISOLATED_PORTS

Parent: ANA:ANA

Instances: 1

Table 268 • **Fields in ISOLATED_PORTS**

Field Name	Bit	Access	Description	Default
ISOL_PORTS	26:0	R/W	This mask is used in private VLANs applications. Promiscuous and community ports must be set and isolated ports must be cleared. For frames classified to a private VLAN (see the VLAN_PRIV_VLAN field in VLAN table), the resulting VLAN mask is calculated as follows: - Frames received on a promiscuous port use the VLAN mask directly. - Frames received on a community port use the VLAN mask AND'ed with the ISOL_PORTS. - Frames received on a isolated port use the VLAN mask AND'ed with the COMM_PORTS AND'ed with the ISOL_PORTS. For frames classified to a non-private VLAN, this mask is not used.	0x7FFFFFF

7.4.1.8 ANA:ANA:COMMUNITY_PORTS

Parent: ANA:ANA

Instances: 1

Table 269 • **Fields in COMMUNITY_PORTS**

Field Name	Bit	Access	Description	Default
COMM_PORTS	26:0	R/W	This mask is used in private VLANs applications. Promiscuous and isolated ports must be set and community ports must be cleared. See ISOLATED_PORTS.ISOL_PORTS for details.	0x7FFFFFF

7.4.1.9 ANA:ANA:AUTOAGE

Parent: ANA:ANA

Instances: 1

Table 270 • **Fields in AUTOAGE**

Field Name	Bit	Access	Description	Default
AGE_FAST	21	R/W	Sets the unit of PERIOD to 8.2 us. PERIOD must be a minimum of 3 when using the FAST option.	0x0
AGE_PERIOD	20:1	R/W	Time in seconds between automatic aging of a MAC table entry. Setting AGE_PERIOD to zero effectively disables automatic aging. An inactive unlocked MAC table entry is aged after 2*AGE_PERIOD.	0x00000
AUTOAGE_LOCKED	0	R/W	Also set the AGED_FLAG bit on locked entries. They will not be removed.	0x0

7.4.1.10 ANA:ANA:MACTOPTIONS

Parent: ANA:ANA

Instances: 1

Table 271 • **Fields in MACTOPTIONS**

Field Name	Bit	Access	Description	Default
REDUCED_TABLE	1	R/W	When set, the MAC table will be reduced 256 entries (64 hash-chains of 4)	0x0
SHADOW	0	R/W	Enable MAC table shadow registers. The SHADOW bit affects the behavior of the READ command in MACACCESS.MAC_TABLE_CMD: With the shadow bit set, reading bucket 0 causes the remaining 3 buckets in the row to be stored in "shadow registers". Following read accesses to bucket 1-3 return the content of the shadow registers. This is useful when reading a MAC table, which can change while being read.	0x0

7.4.1.11 ANA:ANA:LEARNDISC

Parent: ANA:ANA

Instances: 1

The total number of MAC table entries that have been or would have been learned, but have been discarded due to a lack of storage space.

Table 272 • **Fields in LEARNDISC**

Field Name	Bit	Access	Description	Default
LEARNDISC	31:0	R/W	Number of discarded learn requests due to MAC table overflow (collisions or MAC table entry limits).	0x00000000

7.4.1.12 ANA:ANA:AGENCTRL

Parent: ANA:ANA

Instances: 1

Table 273 • **Fields in AGENCTRL**

Field Name	Bit	Access	Description	Default
FID_MASK	23:12	R/W	Mask used to enable shared learning among multiple VLANs. The FID value used in learning and MAC table lookup is calculated as: FID = VID and (not FID_MASK) By default, FID_MASK is set to all-zeros, corresponding to independent VLAN learning. In this case FID becomes identical to VID.	0x000
IGNORE_DMAC_FLAGS	11	R/W	Do not react to flags found in the DMAC entry or the corresponding flags for flooded frames (FLOOD_IGNORE_VLAN).	0x0
IGNORE_SMAC_FLAGS	10	R/W	Do not react to flags found in the SMAC entry. Note, the IGNORE_VLAN flag is not checked for SMAC entries.	0x0
FLOOD_SPECIAL	9	R/W	Flood frames using the lowest 27 bits of DMAC as destination port mask. This is only added for testing purposes.	0x0
FLOOD_IGNORE_VLAN	8	R/W	VLAN mask is not applied to flooded frames.	0x0
MIRROR_CPU	7	R/W	Frames destined for the CPU extraction queues are also forwarded to the port set configured in MIRRORPORTS.	0x0
LEARN_CPU_COPY	6	R/W	If set, auto-learned stations get the CPU_COPY flag set in the MAC table entry.	0x0
LEARN_SRC_KILL	5	R/W	If set, auto-learned stations get the SRC_KILL flag set in the MAC table entry.	0x0

Table 273 • **Fields in AGENCTRL *(continued)***

Field Name	Bit	Access	Description	Default
LEARN_IGNORE_VLAN	4	R/W	If set, auto-learned stations get the IGNORE_VLAN flag set in the MAC table entry.	0x0
CPU_CPU_KILL_ENA	3	R/W	If set, CPU injected frames are never sent back to the CPU.	0x1
GREEN_COUNT_MODE	2	R/W	Counter mode for the Rx priority counters for green frames (CNT_RX_GREEN_PRIO_x) 0: Count octets 1: Count frames	0x1
YELLOW_COUNT_MODE	1	R/W	Counter mode for the Rx priority counters for yellow frames (CNT_RX_YELLOW_PRIO_x) 0: Count octets 1: Count frames	0x1
RED_COUNT_MODE	0	R/W	Counter mode for the Rx priority counters for red frames (CNT_RX_RED_PRIO_x) 0: Count octets 1: Count frames	0x1

7.4.1.13 ANA:ANA:MIRRORPORTS

Parent: ANA:ANA

Instances: 1

Table 274 • **Fields in MIRRORPORTS**

Field Name	Bit	Access	Description	Default
MIRRORPORTS	26:0	R/W	Ports set in this mask receive a mirror copy. If CPU is included in mask (bit 26 set), then the frame is copied to CPU extraction queue CPUQ_CFG.CPUQ_MIRROR.	0x0000000

7.4.1.14 ANA:ANA:EMIRRORPORTS

Parent: ANA:ANA

Instances: 1

Table 275 • **Fields in EMIRRORPORTS**

Field Name	Bit	Access	Description	Default
EMIRRORPORTS	26:0	R/W	Frames forwarded to ports in this mask are mirrored to the port set configured in MIRRORPORTS (i.e. egress port mirroring).	0x0000000

7.4.1.15 ANA:ANA:FLOODING

Parent: ANA:ANA

Instances: 1

Table 276 • **Fields in FLOODING**

Field Name	Bit	Access	Description	Default
FLD_UNICAST	17:12	R/W	Set the PGID mask to use when flooding unknown unicast frames.	0x3F
FLD_BROADCAST	11:6	R/W	Set the PGID mask to use when flooding unknown broadcast frames.	0x3F
FLD_MULTICAST	5:0	R/W	Set the PGID mask to use when flooding unknown multicast frames (except IP multicasts).	0x3F

7.4.1.16 ANA:ANA:FLOODING_IPMC

Parent: ANA:ANA

Instances: 1

Table 277 • **Fields in FLOODING_IPMC**

Field Name	Bit	Access	Description	Default
FLD_MC4_CTRL	23:18	R/W	Set the PGID mask to use when flooding unknown IPv4 Multicast Control frames.	0x3F
FLD_MC4_DATA	17:12	R/W	Set the PGID mask to use when flooding unknown IPv4 Multicast Data frames.	0x3F
FLD_MC6_CTRL	11:6	R/W	Set the PGID mask to use when flooding unknown IPv6 Multicast Control frames.	0x3F
FLD_MC6_DATA	5:0	R/W	Set the PGID mask to use when flooding unknown IPv6 Multicast Data frames.	0x3F

7.4.1.17 ANA:ANA:SFLOW_CFG

Parent: ANA:ANA

Instances: 27

Table 278 • **Fields in SFLOW_CFG**

Field Name	Bit	Access	Description	Default
SF_RATE	13:2	R/W	Probability of a frame being SFLOW sampled. Unit is 1/4096. A value of 0 makes 1/4096 of the candidates being forwarded to the SFLOW CPU extraction queue. A values of 4095 makes all candidates being forwarded.	0x000
SF_SAMPLE_RX	1	R/W	Enable SFLOW sampling of frames received on this port.	0x0
SF_SAMPLE_TX	0	R/W	Enable SFLOW sampling of frames transmitted on this port.	0x0

7.4.2 ANA:ANA_TABLES

Parent: ANA

Instances: 1

Table 279 • **Registers in ANA_TABLES**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ANMOVED	0x000001AC	1	Station Move Logger	Page 299
MACHDATA	0x000001B0	1	MAC Address High	Page 300
MACLDATA	0x000001B4	1	MAC Address Low	Page 300
MACACCESS	0x000001B8	1	MAC Table Command	Page 300
MACTINDX	0x000001BC	1	MAC Table Index	Page 302
VLANACCESS	0x000001C0	1	VLAN Table Command	Page 303
VLANTIDX	0x000001C4	1	VLAN Table Index	Page 304
PGID	0x00000000	107 0x00000004	Port Group Identifiers	Page 304
ENTRYLIM	0x00000200	27 0x00000004	MAC Table Entry Limits	Page 305
PTP_ID_HIGH	0x000001C8	1	PTP Identifiers 63-32	Page 306
PTP_ID_LOW	0x000001CC	1	PTP Identifiers 31-0	Page 306

7.4.2.1 ANA:ANA_TABLES:ANMOVED

Parent: ANA:ANA_TABLES

Instances: 1

Table 280 • **Fields in ANMOVED**

Field Name	Bit	Access	Description	Default
ANMOVED	26:0	R/W	Sticky bit set when a station has been learned on a port while already learned on another port (i.e. port move). The register is cleared by writing 1 to the bits to be cleared. This mask can be used to detect topology problems in the network, where stations are learned on multiple ports repeatedly. If some bits in this register get asserted repeatedly, the ports can be shut down, or management warnings can be issued.	0x0000000

7.4.2.2 ANA:ANA_TABLES:MACHDATA

Parent: ANA:ANA_TABLES

Instances: 1

Table 281 • **Fields in MACHDATA**

Field Name	Bit	Access	Description	Default
VID	27:16	R/W	VID used in MAC table operations through MACACCESS. For read operations, the VID value is returned in this field.	0x000
MACHDATA	15:0	R/W	Most significant 16 MAC address bits used in MAC table operations through MACACCESS.	0x0000

7.4.2.3 ANA:ANA_TABLES:MACLDATA

Parent: ANA:ANA_TABLES

Instances: 1

Table 282 • **Fields in MACLDATA**

Field Name	Bit	Access	Description	Default
MACLDATA	31:0	R/W	Lower 32 MAC address bits used in MAC table operations through MACACCESS.	0x00000000

7.4.2.4 ANA:ANA_TABLES:MACACCESS

Parent: ANA:ANA_TABLES

Instances: 1

This register is used for updating or reading the MAC table from the CPU.

The command (MAC_TABLE_CMD) selects between different operations and uses the following encoding:

000 - IDLE:

The previous operation has completed.

001 - LEARN:

Insert/learn new entry in MAC table. Position given by (MAC, VID) in MACHDATA and MACLDATA.

010 - FORGET:

Delete/unlearn entry given by (MAC, VID) in MACHDATA and MACLDATA.

Both locked and unlocked entries are deleted.

011 - AGE:

Start an age scan on the MAC table.

100 - GET_NEXT:

Get the smallest entry in the MAC table numerically larger than the (MAC, VID) specified in MACHDATA and MACLDATA. The VID and MAC are evaluated as a 60-bit number with the VID being most significant.

101 - INIT:

Table is initialized (completely cleared).

110 - READ:

The READ command is divided into two modes: Direct mode and indirect mode.

Direct mode (read):

With MACACCESS.VALID cleared, the entry pointed to by MACTINDX.INDEX (row) and MACTINDX.BUCKET (column) is read.

Indirect mode (lookup):

With MACACCESS.VALID set, the entry pointed to by (MAC, VID) in the MACHDATA and MACLDATA is read.

111 - WRITE

Write entry. Address of the entry is specified in MACTINDX.INDEX (row) and MACTINDX.BUCKET (column).

An existing entry (locked or unlocked) is overwritten.

The MAC_TABLE_CMD must be IDLE before a new command can be issued.

The AGE and CLEAR commands run for approximately 50 us. The other commands execute immediately.

The flags IGNORE_VLAN and MAC_CPU_COPY are ignored for DMAC lookup if AGENCTRL.IGNORE_DMAC_FLAGS is set.

The flags SRC_KILL and MAC_CPU_COPY are ignored for SMAC lookup if AGENCTRL.IGNORE_SMAC_FLAGS is set.

Table 283 • **Fields in MACACCESS**

Field Name	Bit	Access	Description	Default
IP6_MASK	18:16	R/W	Bits 24:22 in the destination port mask for IPv6 entries.	0x0
MAC_CPU_COPY	15	R/W	Frames matching this entry are copied to the CPU extraction queue CPUQ_CFG.CPUQ_MAC. Applies to both SMAC and DMAC lookup.	0x0
SRC_KILL	14	R/W	Frames matching this entry are discarded. Applies only to the SMAC lookup. For discarding frames based on the DMAC lookup a NULL PGID mask can be used.	0x0
IGNORE_VLAN	13	R/W	The VLAN mask is ignored for this destination. Applies only to DMAC lookup.	0x0
AGED_FLAG	12	R/W	This flag is set on every aging run. Entry is removed if flag is already set. The flag is cleared when the entry is target for a SMAC lookup. Locked entries will not be removed. Bit is for IPv6 Multicast used for port 25.	0x0
VALID	11	R/W	Entry is valid.	0x0
ENTRY_TYPE	10:9	R/W	Type of entry: 0: Normal entry eligible for aging 1: Locked entry. Entry will not be removed by aging 2: IPv4 Multicast entry. Full portset in mac record 3: IPv6 Multicast entry. Full portset in mac record	0x0
DEST_IDX	8:3	R/W	Index for the destination masks table (PGID). For unicasts, this is a number from 0-EXB_PORT_CNT_MINUS_ONE.	0x00
MAC_TABLE_CMD	2:0	R/W	MAC Table Command. See below.	0x0

7.4.2.5 ANA:ANA_TABLES:MACTINDX

Parent: ANA:ANA_TABLES

Instances: 1

Table 284 • **Fields in MACTINDX**

Field Name	Bit	Access	Description	Default
BUCKET	12:11	R/W	Selects one of the four MAC table entries in a row. The row is addressed with the INDEX field.	0x0
M_INDEX	10:0	R/W	The index selects one of the 2048 MAC table rows. Within a row the entry is addressed by the BUCKET field	0x000

7.4.2.6 ANA:ANA_TABLES:VLANACCESS

Parent: ANA:ANA_TABLES

Instances: 1

The VLAN_TBL_CMD field of this register is used for updating and reading the VLAN table. The command (VLAN_TBL_CMD) selects between different operations and uses the following encoding:

00 - IDLE:

The previous operation has completed.

01 - READ:

The VLAN table entry set in VLANTIDX.INDEX is returned in VLANACCESS.VLAN_PORT_MASK and the VLAN flags in VLANTIDX.

10 - WRITE:

The VLAN table entry pointed to by VLANTIDX.INDEX is updated with VLANACCESS.VLAN_PORT_MASK and the VLAN flags in VLANTIDX.

11 - INIT:

The VLAN table is initialized to default values (all ports are members of all VLANs).

The VLAN_TBL_CMD must be IDLE before a new command can be issued. The INIT command run for approximately 50 us whereas the other commands execute immediately. When an operation has completed, VLAN_TBL_CMD changes to IDLE.

Table 285 • **Fields in VLANACCESS**

Field Name	Bit	Access	Description	Default
VLAN_PORT_MASK	28:2	R/W	Frames classified to this VLAN can only be sent to ports in this mask. Note that the CPU port module is always member of all VLANs and its VLAN membership can therefore not be configured through this mask.	0x3FFFFFF

Table 285 • **Fields in VLANACCESS *(continued)***

Field Name	Bit	Access	Description	Default
VLAN_TBL_CMD	1:0	R/W	VLAN Table Command.	0x0

7.4.2.7 ANA:ANA_TABLES:VLANTIDX

Parent: ANA:ANA_TABLES

Instances: 1

Table 286 • **Fields in VLANTIDX**

Field Name	Bit	Access	Description	Default
VLAN_PRIV_VLAN	15	R/W	If set, a VLAN is a private VLAN. See PRIV_VLAN_MASK for details.	0x0
VLAN_LEARN_DISABLED	14	R/W	Disable learning for this VLAN.	0x0
VLAN_MIRROR	13	R/W	If set, all frames classified to this VLAN are mirrored to the port set configured in MIRRORPORTS.	0x0
VLAN_SRC_CHK	12	R/W	If set, VLAN ingress filtering is enabled for this VLAN. If set, a frame's ingress port must be member of the frame's VLAN, otherwise the frame is discarded.	0x0
V_INDEX	11:0	R/W	Index used to select VLAN table entry for read/write operations (see VLANACCESS). This value equals the VID.	0x000

7.4.2.8 ANA:ANA_TABLES:PGID

Parent: ANA:ANA_TABLES

Instances: 107

Three port masks are applied to all frames, allowing transmission to a port if the corresponding bit is set in all masks.

0-63: A mask is applied based on destination analysis

64-79: A mask is applied based on aggregation analysis

80-106: A mask is applied based on source port analysis

Destination analysis:

There are 64 destination masks in total. By default, the first 26 port masks only have the bit corresponding to their port number set. These masks should not be changed, except for aggregation.

The remaining destination masks are set to 0 by default and are available for use for Layer-2 multicasts and flooding (See FLOODING and FLOODING_IPMC).

Aggregation analysis:

The aggregation port masks are used to select only one port within each aggregation group. These 16 masks must be setup to select only one port in each aggregated port group.

For ports, which are not part of any aggregation group, the corresponding bits in all 16 masks must be set.

I.e. if no aggregation is configured, all masks must be set to all-ones.

The aggregation mask used for the forwarding of a given frame is selected by the frame's aggregation code (see AGGRCTRL).

Source port analysis:

The source port masks are used to prevent frames from being looped back to the ports on which they were received, and must be updated according to the

aggregation configuration. A frame that is received on port n, uses mask 80+n as a mask to filter out destination ports to avoid loopback, or to facilitate port grouping (port-based VLANs). The default values are that all bits are set except for the index number.

Table 287 • **Fields in PGID**

Field Name	Bit	Access	Description	Default
PGID	26:0	R/W	When a mask is chosen, bit N must be set for the frame to be transmitted on port N.	0x7FFFFFF
CPUQ_DST_PGID	29:27	R/W	CPU extraction queue used when CPU port is enabled in PGID. Only applicable for the destination analysis.	0x0

7.4.2.9 ANA:ANA_TABLES:ENTRYLIM

Parent: ANA:ANA_TABLES

Instances: 27

Table 288 • **Fields in ENTRYLIM**

Field Name	Bit	Access	Description	Default
ENTRYLIM	17:14	R/W	Maximum number of unlocked entries in the MAC table learned on this port. Locked entries and IPMC entries do not obey this limit. Both auto-learned and unlocked CPU-learned entries obey this limit. 0: 1 entry 1: 2 entries n: 2**n entries >12: 8192 entries	0xD
ENTRYSTAT	13:0	R/W	Current number of unlocked MAC table entries learned on this port.	0x0000

7.4.2.10 ANA:ANA_TABLES:PTP_ID_HIGH

Parent: ANA:ANA_TABLES

Instances: 1

Table 289 • **Fields in PTP_ID_HIGH**

Field Name	Bit	Access	Description	Default
PTP_ID_HIGH	31:0	R/W	Bit vector with current use of PTP timestamp identifiers 32 through 63. Timestamp identifier is 63 is reserved for signaling that no identifiers are available. A timestamp identifier is released by setting the corresponding bit. Bit 0: Timestamp identifier 32 ... Bit 31: Timestamp identifier 63.	0x00000000

7.4.2.11 ANA:ANA_TABLES:PTP_ID_LOW

Parent: ANA:ANA_TABLES

Instances: 1

Table 290 • **Fields in PTP_ID_LOW**

Field Name	Bit	Access	Description	Default
PTP_ID_LOW	31:0	R/W	Bit vector with current use of PTP timestamp identifiers 0 through 31. A timestamp identifier is released by setting the corresponding bit. Bit 0: Timestamp identifier 0 ... Bit 31: Timestamp identifier 31.	0x00000000

7.4.3 ANA:PORT

Parent: ANA

Instances: 27

Table 291 • **Registers in PORT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VLAN_CFG	0x00000000	1	Port VLAN configuration	Page 307
DROP_CFG	0x00000004	1	VLAN acceptance filtering	Page 308
QOS_CFG	0x00000008	1	QoS and DSCP configuration	Page 308
VCAP_CFG	0x0000000C	1	VCAP configuration	Page 309

Table 291 • **Registers in PORT *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
QOS_PCP_DEI_MAP_CFG	0x00000010	16 0x00000004	Mapping of DEI and PCP to QoS class and drop precedence level	Page 311
CPU_FWD_CFG	0x00000050	1	CPU forwarding of special protocols	Page 312
CPU_FWD_BPDU_CFG	0x00000054	1	CPU forwarding of BPDU frames	Page 313
CPU_FWD_GARP_CFG	0x00000058	1	CPU forwarding of GARP frames	Page 313
CPU_FWD_CCM_CFG	0x0000005C	1	CPU forwarding of CCM/Link trace frames	Page 313
PORT_CFG	0x00000060	1	Special port configuration	Page 313
POL_CFG	0x00000064	1	Policer selection	Page 315

7.4.3.1 ANA:PORT:VLAN_CFG

Parent: ANA:PORT

Instances: 1

Table 292 • **Fields in VLAN_CFG**

Field Name	Bit	Access	Description	Default
VLAN_AWARE_ENA	20	R/W	Enable VLAN awareness. If set, Q-tag headers are processed during the basic VLAN classification. If cleared, Q-tag headers are ignored during the basic VLAN classification.	0x0
VLAN_POP_CNT	19:18	R/W	Number of tag headers to remove from ingress frame. 0: Keep all tags. 1: Pop up to 1 tag (outer tag if available). 2: Pop up to 2 tags (outer and inner tag if available). 3: Reserved.	0x0
VLAN_INNER_TAG_ENA	17	R/W	Set if the inner Q-tag must be used instead of the outer Q-tag. If the received frame is single tagged, the outer tag is used. This bit influences the VLAN acceptance filter (DROP_CFG), the basic VLAN classification (VLAN_CFG), and the basic QoS classification (QOS_CFG).	0x0

Table 292 • **Fields in VLAN_CFG *(continued)***

Field Name	Bit	Access	Description	Default
VLAN_TAG_TYPE	16	R/W	Tag Protocol Identifier type for port-based VLAN. 0: C-tag (EtherType = 0x8100) 1: S-tag (EtherType = 0x88A8 or configurable value (VLAN_ETYPE_CFG))	0x0
VLAN_DEI	15	R/W	DEI value for port-based VLAN.	0x0
VLAN_PCP	14:12	R/W	PCP value for port-based VLAN.	0x0
VLAN_VID	11:0	R/W	VID value for port-based VLAN.	0x000

7.4.3.2 ANA:PORT:DROP_CFG

Parent: ANA:PORT

Instances: 1

Table 293 • **Fields in DROP_CFG**

Field Name	Bit	Access	Description	Default
DROP_UNTAGGED_ENA	6	R/W	Drop untagged frames.	0x0
DROP_S_TAGGED_ENA	5	R/W	Drop S-tagged frames (VID different from 0 and EtherType = 0x88A8 or configurable value (VLAN_ETYPE_CFG)).	0x0
DROP_C_TAGGED_ENA	4	R/W	Drop C-tagged frames (VID different from 0 and EtherType = 0x8100).	0x0
DROP_PRIO_S_TAGGED_ENA	3	R/W	Drop S-tagged frames (VID=0 and EtherType = 0x88A8 or configurable value (VLAN_ETYPE_CFG)).	0x0
DROP_PRIO_C_TAGGED_ENA	2	R/W	Drop priority C-tagged frames (VID=0 and EtherType = 0x8100).	0x0
DROP_NULL_MAC_ENA	1	R/W	Drop frames with source or destination MAC address equal to 0x000000000000.	0x0
DROP_MC_SMAC_ENA	0	R/W	Drop frames with multicast source MAC address.	0x0

7.4.3.3 ANA:PORT:QOS_CFG

Parent: ANA:PORT

Instances: 1

Table 294 • **Fields in QOS_CFG**

Field Name	Bit	Access	Description	Default
DP_DEFAULT_VAL	8	R/W	Default drop precedence level.	0x0

Table 294 • **Fields in QOS_CFG *(continued)***

Field Name	Bit	Access	Description	Default
QOS_DEFAULT_VAL	7:5	R/W	Default QoS class.	0x0
QOS_DSCP_ENA	4	R/W	If set, the DP level and QoS class can be based on DSCP values.	0x0
QOS_PCP_ENA	3	R/W	If set, DP level and QoS class can be based on the PCP and DEI bits for tagged frames.	0x0
DSCP_TRANSLATE_ENA	2	R/W	Set if the DSCP value must be translated before using the DSCP value. If set, the translated DSCP value is given from DSCP_CFG[DSCP].DSCP_TRANSLATE_VAL.	0x0
DSCP_REWR_CFG	1:0	R/W	Configure which DSCP values to rewrite based on DP level and QoS class. If the DSCP value is to be rewritten, then the new DSCP = DSCP_REWR_CFG[8*DP level + QoS class].DSCP_QOS_REWR_VAL. 0: Rewrite none. 1: Rewrite if DSCP=0 2: Rewrite for selected values configured in DSCP_CFG[DSCP].DSCP_REWR_ENA. 3: Rewrite all.	0x0

7.4.3.4 ANA:PORT:VCAP_CFG

Parent: ANA:PORT

Instances: 1

Table 295 • **Fields in VCAP_CFG**

Field Name	Bit	Access	Description	Default
S1_ENA	29	R/W	If S1 is enabled, each frame received on this port is processed and matched against the entries in the S1 TCAM. Each frame results in three lookups (two lookups to determine classification actions such as VLAN and QoS class, and one lookup to check host identity).	0x0

Table 295 • **Fields in VCAP_CFG** ***(continued)***

Field Name	Bit	Access	Description	Default
S1_DMAC_DIP_ENA	28:27	R/W	Set if the destination MAC address and the destination IP address must be passed on to the S1 TCAM instead of the source MAC address and the source IP address. Bit 0 controls destination address information for first lookup in S1. Bit 1 controls destination address information for second lookup in S1. Note that the host identity lookup in S1 always uses source information.	0x0
S1_VLAN_INNER_TAG_ENA	26:25	R/W	Set if the inner Q-tag must be passed on to the S1 TCAM instead of the outer Q-tag. For single tagged frames, the outer tag is used. For untagged frames, the port VLAN is used. This bit influences the TPID, VID, PCP, and DEI input to the S1 key generation.	0x0
S2_UDP_PAYLOAD_ENA	24:23	R/W	If set, payload bytes 0, 1, 4, and 6 following the UDP header replaces the source IP address in the S2 IP4_TCP_UDP key for UDP frames. Bit 0 controls first lookup in S2 and bit 1 controls second lookup in S2.	0x0
S2_ETYPE_PAYLOAD_ENA	22:21	R/W	If set, payload bytes 2-7 following the EtherType replaces the source MAC address in the S2 MAC ETYPE key. Payload bytes 0-1 immediately after the EtherType are already available in the key. Bit 0 controls first lookup in S2 and bit 1 controls second lookup in S2.	0x0
S2_ENA	20	R/W	If S2 is enabled, each frame received on this port is processed and matched against the entries in the S2 TCAM. Each frame results in two lookups to determine both an ingress and an egress action.	0x0
S2_SNAP_DIS	19:18	R/W	If set, MAC_SNAP frames received on this port are treated as MAC_LLC frames when matching in S2. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0

Table 295 • **Fields in VCAP_CFG** ***(continued)***

Field Name	Bit	Access	Description	Default
S2_ARP_DIS	17:16	R/W	If set, MAC_ARP frames received on this port are treated as MAC_ETYPE frames when matching in S2. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0
S2_IP_TCPUDP_DIS	15:14	R/W	If set, IP_TCPUDP frames received on this port are treated as MAC_ETYPE frames when matching in S2. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0
S2_IP_OTHER_DIS	13:12	R/W	If set, IP_OTHER frames received on this port are treated as MAC_ETYPE frames when matching in S2. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0
S2_IP6_STD_DIS	11:10	R/W	If set, IP6_STD frames received on this port are not matched against IP6_STD entries. If S2_IP6_TCPUDP_OTHER_DIS is set, IP6_STD frames are matched against MAC_ETYPE entries. If S2_IP6_TCPUDP_OTHER_DIS is cleared, TCP/UDP IP6_STD frames are matched against IP4_TCPUDP entries, otherwise against IP4_OTHER entries. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0
S2_IP6_TCPUDP_OTHER_DIS	9:8	R/W	See S2_IP6_STD_DIS for details. Bit 0 controls the ingress lookup and bit 1 controls the egress lookup.	0x0
PAG_VAL	7:0	R/W	Default PAG value used as input to S2. The PAG value can be changed by S1 actions.	0x00

7.4.3.5 ANA:PORT:QOS_PCP_DEI_MAP_CFG

Parent: ANA:PORT

Instances: 16

Table 296 • **Fields in QOS_PCP_DEI_MAP_CFG**

Field Name	Bit	Access	Description	Default
DP_PCP_DEI_VAL	3	R/W	Map the frame's PCP and DEI values to a drop precedence level. DP level = QOS_PCP_DEI_MAP_CFG[index].DP_PCP_DEI_VAL, where index = 8*DEI + PCP. Only applicable to tagged frames. The use of Inner or outer tag can be selected using VLAN_CFG.VLAN_INNER_TAG_ENA.	0x0
QOS_PCP_DEI_VAL	2:0	R/W	Map the frame's PCP and DEI values to a QoS class. QoS class = QOS_PCP_DEI_MAP_CFG[index].QOS_PCP_DEI_VAL, where index = 8*DEI + PCP. Only applicable to tagged frames. The use of Inner or outer tag can be selected using VLAN_CFG.VLAN_INNER_TAG_ENA.	0x0

7.4.3.6 ANA:PORT:CPU_FWD_CFG

Parent: ANA:PORT

Instances: 1

Table 297 • **Fields in CPU_FWD_CFG**

Field Name	Bit	Access	Description	Default
CPU_MLD_REDIR_ENA	4	R/W	If set, MLD frames are redirected to the CPU.	0x0
CPU_IGMP_REDIR_ENA	3	R/W	If set, IGMP frames are redirected to the CPU.	0x0
CPU_IPMC_CTRL_COPY_ENA	2	R/W	If set, IPv4 multicast control frames (destination IP address in the range 224.0.0.x) are copied to the CPU.	0x0
CPU_SRC_COPY_ENA	1	R/W	If set, all frames received on this port are copied to the CPU extraction queue given by CPUQ_CFG.CPUQ_SRC_COPY.	0x0
CPU_ALLBRIDGE_REDIR_ENA	0	R/W	If set, All LANs bridge management group frames (DMAC = 01-80-C2-00-00-10) are redirected to the CPU.	0x0

7.4.3.7 ANA:PORT:CPU_FWD_BPDU_CFG

Parent: ANA:PORT

Instances: 1

Table 298 • **Fields in CPU_FWD_BPDU_CFG**

Field Name	Bit	Access	Description	Default
BPDU_REDIR_ENA	15:0	R/W	If bit x is set, BPDU frame (DMAC = 01-80-C2-00-00-0x) is redirected to the CPU.	0x0000

7.4.3.8 ANA:PORT:CPU_FWD_GARP_CFG

Parent: ANA:PORT

Instances: 1

Table 299 • **Fields in CPU_FWD_GARP_CFG**

Field Name	Bit	Access	Description	Default
GARP_REDIR_ENA	15:0	R/W	If bit x is set, GARP frame (DMAC = 01-80-C2-00-00-2x) is redirected to the CPU.	0x0000

7.4.3.9 ANA:PORT:CPU_FWD_CCM_CFG

Parent: ANA:PORT

Instances: 1

Table 300 • **Fields in CPU_FWD_CCM_CFG**

Field Name	Bit	Access	Description	Default
CCM_REDIR_ENA	15:0	R/W	If bit x is set, CCM/Link trace frame (DMAC = 01-80-C2-00-00-3x) is redirected to the CPU.	0x0000

7.4.3.10 ANA:PORT:PORT_CFG

Parent: ANA:PORT

Instances: 1

Table 301 • **Fields in PORT_CFG**

Field Name	Bit	Access	Description	Default
SRC_MIRROR_ENA	14	R/W	If set, all frames received on this port are mirrored to the port set configured in MIRRORPORTS (ie. ingress mirroring). For egress mirroring, see EMIRRORPORTS.	0x0

Table 301 • **Fields in PORT_CFG** ***(continued)***

Field Name	Bit	Access	Description	Default
LIMIT_DROP	13	R/W	If set, learn frames on an ingress port, which has exceeded the maximum number of MAC table entries are discarded. Forwarding to CPU is still allowed. Note that if LEARN_ENA is cleared, then the LIMIT_DROP is ignored.	0x0
LIMIT_CPU	12	R/W	If set, learn frames on an ingress port, which has exceeded the maximum number of MAC table entries are copied to the CPU extraction queue specified in CPUQ_CFG.CPUQ_LRN. Note that if LEARN_ENA is cleared, then the LIMIT_CPU is ignored.	0x0
LOCKED_PORTMOVE_DROP	11	R/W	If set, incoming frames triggering a port move for a locked entry in the MAC table received on this port are discarded. Forwarding to CPU is still allowed. Note that if LEARN_ENA is cleared, then the LOCKED_PORTMOVE_DROP is ignored.	0x0
LOCKED_PORTMOVE_CPU	10	R/W	If set, incoming frames triggering a port move for a locked MAC table entry received on this port are copied to the CPU extraction queue specified in CPUQ_CFG.CPUQ_LOCKED_PORTMOVE. Note that if LEARN_ENA is cleared, then the LOCKED_PORTMOVE_CPU is ignored.	0x0
LEARNDROP	9	R/W	If set, incoming learn frames received on this port are discarded. Forwarding to CPU is still allowed. Note that if LEARN_ENA is cleared, then the LEARNDROP is ignored.	0x0
LEARNCPU	8	R/W	If set, incoming learn frames received on this port are copied to the CPU extraction queue specified in AGENCTRL.CPUQ_LRN. Note that if LEARN_ENA is cleared, then the LEARNCPU is ignored.	0x0
LEARNAUTO	7	R/W	If set, incoming learn frames received on this port are auto learned. Note that if LEARN_ENA is cleared, then the LEARNAUTO is ignored.	0x1

Table 301 • **Fields in PORT_CFG *(continued)***

Field Name	Bit	Access	Description	Default
LEARN_ENA	6	R/W	Enable learning for frames received on this port. If cleared, learning is skipped and any configuration settings in LEARNAUTO, LEARNCPU, LEARNDROP is ignored.	0x1
RECV_ENA	5	R/W	Enable reception of frames. If cleared, all incoming frames on this port are discarded by the analyzer.	0x1
PORTID_VAL	4:0	R/W	Logical port number for front port. If port is not a member of a LLAG, then PORTID must be set to the physical port number. If port is a member of a LLAG, then PORTID must be set to the common PORTID_VAL used for all member ports of the LLAG.	0x00

7.4.3.11 ANA:PORT:POL_CFG

Parent: ANA:PORT

Instances: 1

Table 302 • **Fields in POL_CFG**

Field Name	Bit	Access	Description	Default
POL_CPU_REDIR_8021	19	R/W	If set, frames with a DMAC = IEEE reserved addresses (BPDU, GARP, CCM, ALLBRIGDE), which are redirected to the CPU are not policed by any policers. The frames are still counted in the policer buckets.	0x0
POL_CPU_REDIR_IP	18	R/W	If set, IGMP and MLD frames, which are redirected to the CPU are not policed by any policers. The frames are still counted in the policers buckets.	0x0
PORT_POL_ENA	17	R/W	Enable port policing. Port policing on port P uses policer P.	0x0
QUEUE_POL_ENA	16:9	R/W	Bitmask, where bit<n> enables policing of frames classified to QoS class n on this port. Queue policing of QoS class Q on port P uses policer 32+P*8+Q.	0x00

Table 302 • **Fields in POL_CFG *(continued)***

Field Name	Bit	Access	Description	Default
POL_ORDER	8:0	R/W	Each frame is checked against three policers: PORT(0), QOS/PORT(1) and ACL(2). In this register, a bit set will make updating of a policer be dependant on the result from another. Bit<n+3*m> set means: Policer state <n> is checked before policer <m> is updated. Bit0: Port policer must be open in order to update port policer with frame Bit1: QoS policer must be open in order to update port policer with frame Bit2: ACL policer must be open in order to update port policer with frame Bit3: Port policer must be open in order to update QoS policer with frame Bit4: QoS policer must be open in order to update QoS policer with frame Bit5: ACL policer must be open in order to update QoS policer with frame Bit6: Port policer must be open in order to update ACL policer with frame Bit7: QoS policer must be open in order to update ACL policer with frame Bit8: ACL policer must be open in order to update ACL policer with frame	0x1FF

7.4.4 ANA:COMMON

Parent: ANA

Instances: 1

Table 303 • **Registers in COMMON**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
AGGR_CFG	0x00000000	1	Aggregation code generation	Page 317
CPUQ_CFG	0x00000004	1	CPU extraction queue configuration	Page 318
CPUQ_8021_CFG	0x00000008	16 0x00000004	CPU extraction queue per address of BPDU, GARP, and CCM frames.	Page 318
DSCP_CFG	0x00000048	64 0x00000004	DSCP configuration per DSCP value.	Page 319
DSCP_REWR_CFG	0x00000148	16 0x00000004	DSCP rewrite values per DP level and QoS class	Page 319
VCAP_RNG_TYPE_CFG	0x00000188	8 0x00000004	VCAP range checkers	Page 320
VCAP_RNG_VAL_CFG	0x000001A8	8 0x00000004	Range configuration per range checker	Page 320

7.4.4.1 ANA:COMMON:AGGR_CFG

Parent: ANA:COMMON

Instances: 1

Table 304 • **Fields in AGGR_CFG**

Field Name	Bit	Access	Description	Default
AC_RND_ENA	6	R/W	Use pseudo random number for aggregation code. Overrule other contributions.	0x0
AC_DMAC_ENA	5	R/W	Use the lower 12 bits of the destination MAC address for aggregation code.	0x0
AC_SMAC_ENA	4	R/W	Use the lower 12 bits of the source MAC address for aggregation code.	0x0
AC_IP6_FLOW_LBL_ENA	3	R/W	Use the 20-bit IPv6 flow label for aggregation code.	0x0
AC_IP6_TCPUDP_ENA	2	R/W	Use least significant 8 bits of both source port and destination port of IPv6 frames for aggregation code.	0x0
AC_IP4_SIPDIP_ENA	1	R/W	Use least significant 8 bits of both source IP address and destination IP address of IPv4 frames for aggregation code.	0x0

Table 304 • **Fields in AGGR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
AC_IP4_TCPUDP_ENA	0	R/W	Use least significant 8 bits of both source port and destination port of IPv4 frames for aggregation code.	0x0

7.4.4.2 ANA:COMMON:CPUQ_CFG

Parent: ANA:COMMON

Instances: 1

Table 305 • **Fields in CPUQ_CFG**

Field Name	Bit	Access	Description	Default
CPUQ_MLD	29:27	R/W	CPU extraction queue used for MLD frames.	0x0
CPUQ_IGMP	26:24	R/W	CPU extraction queue used for IGMP frames.	0x0
CPUQ_IPMC_CTRL	23:21	R/W	CPU extraction queue used for IPv4 multicast control frames.	0x0
CPUQ_ALLBRIDGE	20:18	R/W	CPU extraction queue used for allbridge frames (DMAC = 01-80-C2-00-00-10).	0x0
CPUQ_LOCKED_PORTMOVE	17:15	R/W	CPU extraction queue for frames triggering a port move for a locked MAC table entry.	0x0
CPUQ_SRC_COPY	14:12	R/W	CPU extraction queue for frames copied due to CPU_SRC_COPY_ENA	0x0
CPUQ_MAC_COPY	11:9	R/W	CPU extraction queue for frames copied due to CPU_COPY return by MAC table lookup	0x0
CPUQ_LRN	8:6	R/W	CPU extraction queue for frames copied due to learned or moved stations.	0x0
CPUQ_MIRROR	5:3	R/W	CPU extraction queue for frames copied due to mirroring to the CPU.	0x0
CPUQ_SFLOW	2:0	R/W	CPU extraction queue for frames copied due to SFLOW sampling.	0x0

7.4.4.3 ANA:COMMON:CPUQ_8021_CFG

Parent: ANA:COMMON

Instances: 16

Table 306 • **Fields in CPUQ_8021_CFG**

Field Name	Bit	Access	Description	Default
CPUQ_BPDU_VAL	8:6	R/W	CPU extraction queue used for BPDU frames.	0x0
CPUQ_GARP_VAL	5:3	R/W	CPU extraction queue used for GARP frames.	0x0
CPUQ_CCM_VAL	2:0	R/W	CPU extraction queue used for CCM/Link trace frames.	0x0

7.4.4.4 ANA:COMMON:DSCP_CFG

Parent: ANA:COMMON

Instances: 64

Table 307 • **Fields in DSCP_CFG**

Field Name	Bit	Access	Description	Default
DP_DSCP_VAL	11	R/W	Maps the frame's DSCP value to a drop precedence level. This is enabled in QOS_CFG.QOS_DSCP_ENA.	0x0
QOS_DSCP_VAL	10:8	R/W	Maps the frame's DSCP value to a QoS class. This is enabled in QOS_CFG.QOS_DSCP_ENA.	0x0
DSCP_TRANSLATE_VAL	7:2	R/W	Translated DSCP value triggered if DSCP translation is set for port (QOS_CFG[port].DSCP_TRANSLATE_ENA)	0x00
DSCP_TRUST_ENA	1	R/W	Must be set for a DSCP value if the DSCP value is to be used for QoS classification.	0x0
DSCP_REWR_ENA	0	R/W	Set if the DSCP value is selected to be rewritten. This is controlled in QOS_CFG.DSCP_REWR_CFG.	0x0

7.4.4.5 ANA:COMMON:DSCP_REWR_CFG

Parent: ANA:COMMON

Instances: 16

Table 308 • **Fields in DSCP_REWR_CFG**

Field Name	Bit	Access	Description	Default
DSCP_QOS_REWR_VAL	5:0	R/W	Map the frame's DP level and QoS class to a DSCP value. DSCP = DSCP_REWR_CFG[8*DP level + QoS class].DSCP_QOS_REWR_VAL. This is controlled in QOS_CFG.DSCP_REWR_CFG and DSCP_CFG.DSCP_REWR_ENA.	0x00

7.4.4.6 ANA:COMMON:VCAP_RNG_TYPE_CFG

Parent: ANA:COMMON

Instances: 8

Table 309 • **Fields in VCAP_RNG_TYPE_CFG**

Field Name	Bit	Access	Description	Default
VCAP_RNG_CFG	2:0	R/W	0: Idle 1: TCP/UDP destination port is matched against range 2: TCP/UDP source port is matched against range 3: TCP/UDP source and destination ports are matched against range. Match if either source or destination port is within range. 4: VID is matched against range (S1: VID in frame, S2: classified VID) 5: DSCP value is matched against range 6: Reserved 7: Reserved	0x0

7.4.4.7 ANA:COMMON:VCAP_RNG_VAL_CFG

Parent: ANA:COMMON

Instances: 8

Table 310 • **Fields in VCAP_RNG_VAL_CFG**

Field Name	Bit	Access	Description	Default
VCAP_RNG_MIN_VAL	31:16	R/W	Lower value. Value is included in range.	0x0000

Table 310 • **Fields in VCAP_RNG_VAL_CFG *(continued)***

Field Name	Bit	Access	Description	Default
VCAP_RNG_MAX_VAL	15:0	R/W	Upper value. Value is included in range.	0x0000

7.5 REW

Table 311 • **Register Groups in REW**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
PORT	0x00000000	28 0x00000080	Per port configurations for Rewriter	Page 321
COMMON	0x00000E00	1	Common configurations for Rewriter	Page 324

7.5.1 REW:PORT

Parent: REW

Instances: 28

Table 312 • **Registers in PORT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PORT_VLAN_CFG	0x00000000	1	Port VLAN configuration	Page 321
TAG_CFG	0x00000004	1	Tagging configuration	Page 322
PORT_CFG	0x00000008	1	Special port configuration	Page 322
DSCP_CFG	0x0000000C	1	DSCP updates	Page 323
PCP_DEI_QOS_MAP_CFG	0x00000010	16 0x00000004	Mapping of DP level and QoS class to PCP and DEI values.	Page 324

7.5.1.1 REW:PORT:PORT_VLAN_CFG

Parent: REW:PORT

Instances: 1

Table 313 • **Fields in PORT_VLAN_CFG**

Field Name	Bit	Access	Description	Default
PORT_TPID	31:16	R/W	Tag Protocol Identifier for port.	0x0000

Table 313 • **Fields in PORT_VLAN_CFG *(continued)***

Field Name	Bit	Access	Description	Default
PORT_DEI	15	R/W	DEI value for port when TAG_CFG.TAG_QOS_TAG = 2. Otherwise, if PORT_DEI = 1, the DEI value in the port tag is set to the frame's DP level.	0x0
PORT_PCP	14:12	R/W	PCP value for port.	0x0
PORT_VID	11:0	R/W	VID value for port.	0x001

7.5.1.2 REW:PORT:TAG_CFG

Parent: REW:PORT

Instances: 1

Table 314 • **Fields in TAG_CFG**

Field Name	Bit	Access	Description	Default
TAG_CFG	6:5	R/W	Enable VLAN port tagging. 0: Port tagging disabled. 1: Tag all frames, except when VID=PORT_VLAN_CFG.PORT_VID or VID=0. 2: Tag all frames, except when VID=0. 3: Tag all frames.	0x0
TAG_TPID_CFG	4:3	R/W	Select TPID EtherType in port tag. 0: Use 0x8100. 1: Use 0x88A8. 2: Use custom value from PORT_VLAN_CFG.PORT_TPID. 3: Use PORT_VLAN_CFG.PORT_TPID, unless ingress tag was a C-tag (EtherType = 0x8100)	0x0
TAG_VID_CFG	2	R/W	Select VID in port tag. It can be set to either the classified VID or VID_A_VAL from the ES0 service action. 0: Use classified VID. 1: Use VID_A_VAL from ES0 action if hit, otherwise use classified VID.	0x0
TAG_QOS_CFG	1:0	R/W	Select PCP/DEI fields in port tag. 0: Use classified PCP/DEI values. 1: Use PCP/DEI values from ES0 action if hit, otherwise classified values. 2: Use PCP/DEI values from port VLAN tag in PORT_VLAN_CFG. 3: Use DP level and QoS class mapped to PCP/DEI values (PCP_DEI_QOS_MAP_CFG).	0x0

7.5.1.3 REW:PORT:PORT_CFG

Parent: REW:PORT

Instances: 1

Table 315 • **Fields in PORT_CFG**

Field Name	Bit	Access	Description	Default
ES0_ENA	8	R/W	Enable ES0 lookup.	0x0
IFH_INSERT_ENA	7	R/W	Insert IFH into frame (mainly for CPU ports)	0x0
IFH_INSERT_MODE	6	R/W	Select the position of IFH in the generated frames when IFH_INSERT_ENA is set 0: IFH written before DMAC. 1: IFH written after SMAC.	0x0
FCS_UPDATE_NONCPU_CFG	5:4	R/W	FCS update mode for frames not received on the CPU port. 0: Update FCS if frame data has changed 1: Never update FCS 2: Always update FCS	0x0
FCS_UPDATE_CPU_ENA	3	R/W	If set, update FCS for all frames injected by the CPU. If cleared, never update the FCS.	0x1
FLUSH_ENA	2	R/W	If set, all frames destined for the egress port are discarded. **Note** Flushing must be disabled on ports operating in half-duplex mode.	0x0
AGE_DIS	1	R/W	Disable frame ageing for this egress port. **Note** Frame ageing must be disabled on ports operating in half-duplex mode.	0x0

7.5.1.4 REW:PORT:DSCP_CFG

Parent: REW:PORT

Instances: 1

Table 316 • **Fields in DSCP_CFG**

Field Name	Bit	Access	Description	Default
DSCP_REWR_CFG	1:0	R/W	Egress DSCP rewrite. 0: No update of DSCP value in frame. 1: Update with DSCP value from analyzer. 2: Update with DSCP value from analyzer remapped through DSCP_REMAP_CFG. 3. Update with DSCP value from analyzer remapped based on drop precedence level through DSCP_REMAP_CFG or DSCP_REMAP_DP1_CFG.	0x0

7.5.1.5 REW:PORT:PCP_DEI_QOS_MAP_CFG

Parent: REW:PORT

Instances: 16

Table 317 • **Fields in PCP_DEI_QOS_MAP_CFG**

Field Name	Bit	Access	Description	Default
DEI_QOS_VAL	3	R/W	Map the frame's DP level and QoS class to a DEI value. DEI = PCP_DEI_QOS_MAP_CFG[8*DP level + QoS class].DEI_QOS_VAL. This must be enabled in VLAN_CFG.QOS_CFG.	0x0
PCP_QOS_VAL	2:0	R/W	Map the frame's DP level and QoS class to a PCP value. PCP = PCP_DEI_QOS_MAP_CFG[8*DP level + QoS class].PCP_QOS_VAL. This must be enabled in VLAN_CFG.QOS_CFG.	0x0

7.5.2 REW:COMMON

Parent: REW

Instances: 1

Table 318 • **Registers in COMMON**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
DSCP_REMAP_DP1_CFG	0x00000000	64 0x00000004	Remap table of DSCP values for frames with drop precedence set	Page 325
DSCP_REMAP_CFG	0x00000100	64 0x00000004	Remap table of DSCP values.	Page 325

7.5.2.1 REW:COMMON:DSCP_REMAP_DP1_CFG

Parent: REW:COMMON

Instances: 64

Table 319 • **Fields in DSCP_REMAP_DP1_CFG**

Field Name	Bit	Access	Description	Default
DSCP_REMAP_DP1_VAL	5:0	R/W	One to one DSCP remapping table common for all ports. This table is used if DSCP_CFG.DSCP_REWR_ENA =3 and DP=1.	0x00

7.5.2.2 REW:COMMON:DSCP_REMAP_CFG

Parent: REW:COMMON

Instances: 64

Table 320 • **Fields in DSCP_REMAP_CFG**

Field Name	Bit	Access	Description	Default
DSCP_REMAP_VAL	5:0	R/W	One to one DSCP remapping table common for all ports. This table is used if DSCP_CFG.DSCP_REWR_ENA =2 or if DSCP_CFG.DSCP_REWR_ENA =3 and DP=0.	0x00

7.6 VCAP_CORE

Table 321 • **Register Groups in VCAP_CORE**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
VCAP_CORE_CFG	0x00000000	1		Page 326

Table 321 • **Register Groups in VCAP_CORE *(continued)***

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
VCAP_CORE_CACHE	0x00000008	1		Page 329
VCAP_CORE_STICKY	0x0000020C	1		Page 332
VCAP_CONST	0x00000210	1		Page 332
TCAM_BIST	0x0000022C	1	Build in test for TCAM	Page 334

7.6.1 VCAP_CORE:VCAP_CORE_CFG

Parent: VCAP_CORE

Instances: 1

Table 322 • **Registers in VCAP_CORE_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_UPDATE_CTRL	0x00000000	1		Page 326
VCAP_MV_CFG	0x00000004	1		Page 328

7.6.1.1 VCAP_CORE:VCAP_CORE_CFG:VCAP_UPDATE_CTRL

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 323 • **Fields in VCAP_UPDATE_CTRL**

Field Name	Bit	Access	Description	Default
UPDATE_CMD	24:22	R/W	Specifies the operation to be carried out when the vcap_update_shot field is set. The COPY operations will read or write the content of the VCAP_CORE_CACHE to the TCAM/RAMs at the address specified in UPDATE_ADDR. When writing default actions UPDATE_ENTRY_DIS must be set to avoid overwriting entries at the low addresses in the TCAM. The MOVE operations will move one or more rows up or down starting from the address in UPDATE_ADDR. The number of rows to move is specified in VCAP_MV_CFG.MV_NUM_POS. Moving a row up will decrease its address by MV_NUM_POS, moving a row down will increase its address by MV_NUM_POS. The number of rows to include in the move is specified in VCAP_MV_CFG.MV_SIZE. If a row is moved to an destination address that is less than zero, i.e. if UPDATE_ADDR - MV_NUM_POS < 0, the row will be invalidated in the TCAM and the action and counter RAM will be set to zero. The INIT operations will set the range of rows specified by UPDATE_ADDR and VCAP_MV_CFG.MV_SIZE to the value of cache. Note: init starts from the address specified in UPDATE_ADDR. 000: Copy entry and/or action from cache to TCAM/RAM 001: Copy entry and/or action from TCAM/RAM to cache 010: Move entry and/or action up (decreasing addresses) 011: Move entry and/or action down (increasing addresses) 100: Initialize all entries and/or actions with the value in the cache.	0x0

Table 323 • **Fields in VCAP_UPDATE_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
UPDATE_ENTRY_DIS	21	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to entries. 0: Entries are copied/moved/init. 1: Entries are not copied/moved/init.	0x0
UPDATE_ACTION_DIS	20	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to actions. 0: Actions are copied/moved/init. 1: Actions are not copied/moved/init.	0x0
UPDATE_CNT_DIS	19	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to cnts. 0: Counters are copied/moved/init. 1: Counters are not copied/moved/init.	0x0
UPDATE_ADDR	18:3	R/W	The entry/action address (row-wise) used for copy/move operations. When accessing the default actions the offset specified in VCAP_CONST:ENTRY_CNT should be added to the default action addr, i.e. Default action 0: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 0. Default action 1: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 1. Default action n: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + n.	0x0000
UPDATE_SHOT	2	One-shot	Initiate the operation specified in vcap_update_cmd. The bit is cleared by hw when operation has finished.	0x0
CLEAR_CACHE	1	One-shot	Reset all registers in VCAP_CORE_CACHE. The register is cleared by hw when the operation has finished.	0x0
MV_TRAFFIC_IGN	0	R/W	Ignore interrupting traffic during move operation. If a lookup is performed during a move operation the move is finished from where it was interrupted. When this field is set counters are not guaranteed to be up-to-date after the move.	0x0

7.6.1.2 VCAP_CORE:VCAP_CORE_CFG:VCAP_MV_CFG

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 324 • **Fields in VCAP_MV_CFG**

Field Name	Bit	Access	Description	Default
MV_NUM_POS	31:16	R/W	Specifies the number of positions the row must be moved up or down during a move operation. 0x0 The row is moved one position up or down. 0x1: The row is moved two positions up or down. 0xn: The row is moved n+1 positions up or down.	0x0000
MV_SIZE	15:0	R/W	Specifies the number of rows that must be moved up or down during a move operation. This field is also used to define the range that is initialized using the init feature. 0x0: The row at address UPDATE_ADDR is moved up or down. 0x1: The row at address UPDATE_ADDR through UPDATE_ADDR+1 are moved up or down. 0x2: The row at address UPDATE_ADDR through UPDATE_ADDR+2 are moved up or down. 0xn: The row at address UPDATE_ADDR through UPDATE_ADDR+n are moved up or down.	0x0000

7.6.2 VCAP_CORE:VCAP_CORE_CACHE

Parent: VCAP_CORE

Instances: 1

Table 325 • **Registers in VCAP_CORE_CACHE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_ENTRY_DAT	0x00000000	32 0x00000004		Page 330
VCAP_MASK_DAT	0x00000080	32 0x00000004		Page 330
VCAP_ACTION_DAT	0x00000100	32 0x00000004		Page 330

Table 325 • **Registers in VCAP_CORE_CACHE *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_CNT_DAT	0x00000180	32 0x00000004		Page 331
VCAP_TG_DAT	0x00000200	1		Page 331

7.6.2.1 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ENTRY_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 326 • **Fields in VCAP_ENTRY_DAT**

Field Name	Bit	Access	Description	Default
ENTRY_DAT	31:0	R/W	The cache register that holds a single TCAM entry data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.6.2.2 VCAP_CORE:VCAP_CORE_CACHE:VCAP_MASK_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 327 • **Fields in VCAP_MASK_DAT**

Field Name	Bit	Access	Description	Default
MASK_DAT	31:0	R/W	The cache register that holds a single TCAM entry mask row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the mask cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.6.2.3 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ACTION_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 328 • **Fields in VCAP_ACTION_DAT**

Field Name	Bit	Access	Description	Default
ACTION_DAT	31:0	R/W	The cache register that holds a single action ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ACTION_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.6.2.4 VCAP_CORE:VCAP_CORE_CACHE:VCAP_CNT_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 329 • **Fields in VCAP_CNT_DAT**

Field Name	Bit	Access	Description	Default
CNT_DAT	31:0	R/W	The cache register that holds a single counter ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.CNT_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.6.2.5 VCAP_CORE:VCAP_CORE_CACHE:VCAP_TG_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 1

Table 330 • **Fields in VCAP_TG_DAT**

Field Name	Bit	Access	Description	Default
TG_DAT	31:0	R/W	This cache register holds the TypeGroup id for each subword in the TCAM. If the VCAP supports multiple subwords, i.e. VCAP_CONST.ENTRY_SWCNT > 1, the TypeGroup ids are place back to back with subword 0 at the LSBs.	0x00000000

7.6.3 VCAP_CORE:VCAP_CORE_STICKY

Parent: VCAP_CORE

Instances: 1

Table 331 • **Registers in VCAP_CORE_STICKY**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_STICKY	0x00000000	1		Page 332

7.6.3.1 VCAP_CORE:VCAP_CORE_STICKY:VCAP_STICKY

Parent: VCAP_CORE:VCAP_CORE_STICKY

Instances: 1

Table 332 • **Fields in VCAP_STICKY**

Field Name	Bit	Access	Description	Default
VCAP_ROW_DELETED_STICKY	0	Sticky	A move operation has resulted in one or more rows have been deleted.	0x0

7.6.4 VCAP_CORE:VCAP_CONST

Parent: VCAP_CORE

Instances: 1

Table 333 • **Registers in VCAP_CONST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_WIDTH	0x00000000	1		Page 333
ENTRY_CNT	0x00000004	1		Page 333

Table 333 • **Registers in VCAP_CONST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_SWCNT	0x00000008	1		Page 333
ENTRY_TG_WIDTH	0x0000000C	1		Page 333
ACTION_DEF_CNT	0x00000010	1		Page 334
ACTION_WIDTH	0x00000014	1		Page 334
CNT_WIDTH	0x00000018	1		Page 334

7.6.4.1 VCAP_CORE:VCAP_CONST:ENTRY_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 334 • **Fields in ENTRY_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_WIDTH	9:0	R/O	The width of a TCAM entry including TypeGroup ids.	0x000

7.6.4.2 VCAP_CORE:VCAP_CONST:ENTRY_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 335 • **Fields in ENTRY_CNT**

Field Name	Bit	Access	Description	Default
ENTRY_CNT	9:0	R/O	The number of entries in the TCAM.	0x000

7.6.4.3 VCAP_CORE:VCAP_CONST:ENTRY_SWCNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 336 • **Fields in ENTRY_SWCNT**

Field Name	Bit	Access	Description	Default
ENTRY_SWCNT	5:0	R/O	The number of supported subwords in the TCAM.	0x00

7.6.4.4 VCAP_CORE:VCAP_CONST:ENTRY_TG_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 337 • **Fields in ENTRY_TG_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_TG_WIDTH	5:0	R/O	The width of a single TypeGroup id.	0x00

7.6.4.5 VCAP_CORE:VCAP_CONST:ACTION_DEF_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 338 • **Fields in ACTION_DEF_CNT**

Field Name	Bit	Access	Description	Default
ACTION_DEF_CNT	9:0	R/O	The number of default actions.	0x000

7.6.4.6 VCAP_CORE:VCAP_CONST:ACTION_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 339 • **Fields in ACTION_WIDTH**

Field Name	Bit	Access	Description	Default
ACTION_WIDTH	9:0	R/O	The width of the action RAM.	0x000

7.6.4.7 VCAP_CORE:VCAP_CONST:CNT_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 340 • **Fields in CNT_WIDTH**

Field Name	Bit	Access	Description	Default
CNT_WIDTH	9:0	R/O	The width of the counter RAM.	0x000

7.6.5 VCAP_CORE:TCAM_BIST

Parent: VCAP_CORE

Instances: 1

Table 341 • **Registers in TCAM_BIST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_CTRL	0x00000000	1	Control of the TCAM	Page 335

Table 341 • **Registers in TCAM_BIST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_STAT	0x0000000C	1	Status for the TCAM	Page 335

7.6.5.1 VCAP_CORE:TCAM_BIST:TCAM_CTRL

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 342 • **Fields in TCAM_CTRL**

Field Name	Bit	Access	Description	Default
TCAM_INIT	0	One-shot	Set this field to start manual initialization of the TCAM. This field is cleared once initialization is complete. The TCAM has random contents after reset and must be initialized prior to usage.	0x0

7.6.5.2 VCAP_CORE:TCAM_BIST:TCAM_STAT

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 343 • **Fields in TCAM_STAT**

Field Name	Bit	Access	Description	Default
TCAM_RDY	0	R/O	Indicates the current operational state of the TCAM. '0': Busy with initialization. '1': Ready to be used.	0x0

7.7 VCAP_CORE

Table 344 • **Register Groups in VCAP_CORE**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
VCAP_CORE_CFG	0x00000000	1		Page 326
VCAP_CORE_CACHE	0x00000008	1		Page 329
VCAP_CORE_STICKY	0x0000020C	1		Page 332
VCAP_CONST	0x00000210	1		Page 332
TCAM_BIST	0x0000022C	1	Build in test for TCAM	Page 334

7.7.1 VCAP_CORE:VCAP_CORE_CFG

Parent: VCAP_CORE

Instances: 1

Table 345 • **Registers in VCAP_CORE_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_UPDATE_CTRL	0x00000000	1		Page 326
VCAP_MV_CFG	0x00000004	1		Page 328

7.7.1.1 VCAP_CORE:VCAP_CORE_CFG:VCAP_UPDATE_CTRL

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 346 • **Fields in VCAP_UPDATE_CTRL**

Field Name	Bit	Access	Description	Default
UPDATE_CMD	24:22	R/W	Specifies the operation to be carried out when the vcap_update_shot field is set. The COPY operations will read or write the content of the VCAP_CORE_CACHE to the TCAM/RAMs at the address specified in UPDATE_ADDR. When writing default actions UPDATE_ENTRY_DIS must be set to avoid overwriting entries at the low addresses in the TCAM. The MOVE operations will move one or more rows up or down starting from the address in UPDATE_ADDR. The number of rows to move is specified in VCAP_MV_CFG.MV_NUM_POS. Moving a row up will decrease its address by MV_NUM_POS, moving a row down will increase its address by MV_NUM_POS. The number of rows to include in the move is specified in VCAP_MV_CFG.MV_SIZE. If a row is moved to an destination address that is less than zero, i.e. if UPDATE_ADDR - MV_NUM_POS < 0, the row will be invalidated in the TCAM and the action and counter RAM will be set to zero. The INIT operations will set the range of rows specified by UPDATE_ADDR and VCAP_MV_CFG.MV_SIZE to the value of cache. Note: init starts from the address specified in UPDATE_ADDR. 000: Copy entry and/or action from cache to TCAM/RAM 001: Copy entry and/or action from TCAM/RAM to cache 010: Move entry and/or action up (decreasing addresses) 011: Move entry and/or action down (increasing addresses) 100: Initialize all entries and/or actions with the value in the cache.	0x0

Table 346 • **Fields in VCAP_UPDATE_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
UPDATE_ENTRY_DIS	21	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to entries. 0: Entries are copied/moved/init. 1: Entries are not copied/moved/init.	0x0
UPDATE_ACTION_DIS	20	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to actions. 0: Actions are copied/moved/init. 1: Actions are not copied/moved/init.	0x0
UPDATE_CNT_DIS	19	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to cnts. 0: Counters are copied/moved/init. 1: Counters are not copied/moved/init.	0x0
UPDATE_ADDR	18:3	R/W	The entry/action address (row-wise) used for copy/move operations. When accessing the default actions the offset specified in VCAP_CONST:ENTRY_CNT should be added to the default action addr, i.e. Default action 0: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 0. Default action 1: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 1. Default action n: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + n.	0x0000
UPDATE_SHOT	2	One-shot	Initiate the operation specified in vcap_update_cmd. The bit is cleared by hw when operation has finished.	0x0
CLEAR_CACHE	1	One-shot	Reset all registers in VCAP_CORE_CACHE. The register is cleared by hw when the operation has finished.	0x0
MV_TRAFFIC_IGN	0	R/W	Ignore interrupting traffic during move operation. If a lookup is performed during a move operation the move is finished from where it was interrupted. When this field is set counters are not guaranteed to be up-to-date after the move.	0x0

7.7.1.2 VCAP_CORE:VCAP_CORE_CFG:VCAP_MV_CFG

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 347 • **Fields in VCAP_MV_CFG**

Field Name	Bit	Access	Description	Default
MV_NUM_POS	31:16	R/W	Specifies the number of positions the row must be moved up or down during a move operation. 0x0 The row is moved one position up or down. 0x1: The row is moved two positions up or down. 0xn: The row is moved n+1 positions up or down.	0x0000
MV_SIZE	15:0	R/W	Specifies the number of rows that must be moved up or down during a move operation. This field is also used to define the range that is initialized using the init feature. 0x0: The row at address UPDATE_ADDR is moved up or down. 0x1: The row at address UPDATE_ADDR through UPDATE_ADDR+1 are moved up or down. 0x2: The row at address UPDATE_ADDR through UPDATE_ADDR+2 are moved up or down. 0xn: The row at address UPDATE_ADDR through UPDATE_ADDR+n are moved up or down.	0x0000

7.7.2 VCAP_CORE:VCAP_CORE_CACHE

Parent: VCAP_CORE

Instances: 1

Table 348 • **Registers in VCAP_CORE_CACHE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_ENTRY_DAT	0x00000000	32 0x00000004		Page 330
VCAP_MASK_DAT	0x00000080	32 0x00000004		Page 330
VCAP_ACTION_DAT	0x00000100	32 0x00000004		Page 330

Table 348 • **Registers in VCAP_CORE_CACHE *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_CNT_DAT	0x00000180	32 0x00000004		Page 331
VCAP_TG_DAT	0x00000200	1		Page 331

7.7.2.1 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ENTRY_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 349 • **Fields in VCAP_ENTRY_DAT**

Field Name	Bit	Access	Description	Default
ENTRY_DAT	31:0	R/W	The cache register that holds a single TCAM entry data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.7.2.2 VCAP_CORE:VCAP_CORE_CACHE:VCAP_MASK_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 350 • **Fields in VCAP_MASK_DAT**

Field Name	Bit	Access	Description	Default
MASK_DAT	31:0	R/W	The cache register that holds a single TCAM entry mask row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the mask cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.7.2.3 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ACTION_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 351 • **Fields in VCAP_ACTION_DAT**

Field Name	Bit	Access	Description	Default
ACTION_DAT	31:0	R/W	The cache register that holds a single action ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ACTION_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.7.2.4 VCAP_CORE:VCAP_CORE_CACHE:VCAP_CNT_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 352 • **Fields in VCAP_CNT_DAT**

Field Name	Bit	Access	Description	Default
CNT_DAT	31:0	R/W	The cache register that holds a single counter ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.CNT_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.7.2.5 VCAP_CORE:VCAP_CORE_CACHE:VCAP_TG_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 1

Table 353 • **Fields in VCAP_TG_DAT**

Field Name	Bit	Access	Description	Default
TG_DAT	31:0	R/W	This cache register holds the TypeGroup id for each subword in the TCAM. If the VCAP supports multiple subwords, i.e. VCAP_CONST.ENTRY_SWCNT > 1, the TypeGroup ids are place back to back with subword 0 at the LSBs.	0x00000000

7.7.3 VCAP_CORE:VCAP_CORE_STICKY

Parent: VCAP_CORE

Instances: 1

Table 354 • **Registers in VCAP_CORE_STICKY**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_STICKY	0x00000000	1		Page 332

7.7.3.1 VCAP_CORE:VCAP_CORE_STICKY:VCAP_STICKY

Parent: VCAP_CORE:VCAP_CORE_STICKY

Instances: 1

Table 355 • **Fields in VCAP_STICKY**

Field Name	Bit	Access	Description	Default
VCAP_ROW_DELETED_STICKY	0	Sticky	A move operation has resulted in one or more rows have been deleted.	0x0

7.7.4 VCAP_CORE:VCAP_CONST

Parent: VCAP_CORE

Instances: 1

Table 356 • **Registers in VCAP_CONST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_WIDTH	0x00000000	1		Page 333
ENTRY_CNT	0x00000004	1		Page 333

Table 356 • **Registers in VCAP_CONST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_SWCNT	0x00000008	1		Page 333
ENTRY_TG_WIDTH	0x0000000C	1		Page 333
ACTION_DEF_CNT	0x00000010	1		Page 334
ACTION_WIDTH	0x00000014	1		Page 334
CNT_WIDTH	0x00000018	1		Page 334

7.7.4.1 VCAP_CORE:VCAP_CONST:ENTRY_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 357 • **Fields in ENTRY_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_WIDTH	9:0	R/O	The width of a TCAM entry including TypeGroup ids.	0x000

7.7.4.2 VCAP_CORE:VCAP_CONST:ENTRY_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 358 • **Fields in ENTRY_CNT**

Field Name	Bit	Access	Description	Default
ENTRY_CNT	9:0	R/O	The number of entries in the TCAM.	0x000

7.7.4.3 VCAP_CORE:VCAP_CONST:ENTRY_SWCNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 359 • **Fields in ENTRY_SWCNT**

Field Name	Bit	Access	Description	Default
ENTRY_SWCNT	5:0	R/O	The number of supported subwords in the TCAM.	0x00

7.7.4.4 VCAP_CORE:VCAP_CONST:ENTRY_TG_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 360 • **Fields in ENTRY_TG_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_TG_WIDTH	5:0	R/O	The width of a single TypeGroup id.	0x00

7.7.4.5 VCAP_CORE:VCAP_CONST:ACTION_DEF_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 361 • **Fields in ACTION_DEF_CNT**

Field Name	Bit	Access	Description	Default
ACTION_DEF_CNT	9:0	R/O	The number of default actions.	0x000

7.7.4.6 VCAP_CORE:VCAP_CONST:ACTION_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 362 • **Fields in ACTION_WIDTH**

Field Name	Bit	Access	Description	Default
ACTION_WIDTH	9:0	R/O	The width of the action RAM.	0x000

7.7.4.7 VCAP_CORE:VCAP_CONST:CNT_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 363 • **Fields in CNT_WIDTH**

Field Name	Bit	Access	Description	Default
CNT_WIDTH	9:0	R/O	The width of the counter RAM.	0x000

7.7.5 VCAP_CORE:TCAM_BIST

Parent: VCAP_CORE

Instances: 1

Table 364 • **Registers in TCAM_BIST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_CTRL	0x00000000	1	Control of the TCAM	Page 335

Table 364 • **Registers in TCAM_BIST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_STAT	0x0000000C	1	Status for the TCAM	Page 335

7.7.5.1 VCAP_CORE:TCAM_BIST:TCAM_CTRL

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 365 • **Fields in TCAM_CTRL**

Field Name	Bit	Access	Description	Default
TCAM_INIT	0	One-shot	Set this field to start manual initialization of the TCAM. This field is cleared once initialization is complete. The TCAM has random contents after reset and must be initialized prior to usage.	0x0

7.7.5.2 VCAP_CORE:TCAM_BIST:TCAM_STAT

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 366 • **Fields in TCAM_STAT**

Field Name	Bit	Access	Description	Default
TCAM_RDY	0	R/O	Indicates the current operational state of the TCAM. '0': Busy with initialization. '1': Ready to be used.	0x0

7.8 VCAP_CORE

Table 367 • **Register Groups in VCAP_CORE**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
VCAP_CORE_CFG	0x00000000	1		Page 326
VCAP_CORE_CACHE	0x00000008	1		Page 329
VCAP_CORE_STICKY	0x0000020C	1		Page 332
VCAP_CONST	0x00000210	1		Page 332
TCAM_BIST	0x0000022C	1	Build in test for TCAM	Page 334

7.8.1 VCAP_CORE:VCAP_CORE_CFG

Parent: VCAP_CORE

Instances: 1

Table 368 • **Registers in VCAP_CORE_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_UPDATE_CTRL	0x00000000	1		Page 326
VCAP_MV_CFG	0x00000004	1		Page 328

7.8.1.1 VCAP_CORE:VCAP_CORE_CFG:VCAP_UPDATE_CTRL

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 369 • **Fields in VCAP_UPDATE_CTRL**

Field Name	Bit	Access	Description	Default
UPDATE_CMD	24:22	R/W	Specifies the operation to be carried out when the vcap_update_shot field is set. The COPY operations will read or write the content of the VCAP_CORE_CACHE to the TCAM/RAMs at the address specified in UPDATE_ADDR. When writing default actions UPDATE_ENTRY_DIS must be set to avoid overwriting entries at the low addresses in the TCAM. The MOVE operations will move one or more rows up or down starting from the address in UPDATE_ADDR. The number of rows to move is specified in VCAP_MV_CFG.MV_NUM_POS. Moving a row up will decrease its address by MV_NUM_POS, moving a row down will increase its address by MV_NUM_POS. The number of rows to include in the move is specified in VCAP_MV_CFG.MV_SIZE. If a row is moved to an destination address that is less than zero, i.e. if UPDATE_ADDR - MV_NUM_POS < 0, the row will be invalidated in the TCAM and the action and counter RAM will be set to zero. The INIT operations will set the range of rows specified by UPDATE_ADDR and VCAP_MV_CFG.MV_SIZE to the value of cache. Note: init starts from the address specified in UPDATE_ADDR. 000: Copy entry and/or action from cache to TCAM/RAM 001: Copy entry and/or action from TCAM/RAM to cache 010: Move entry and/or action up (decreasing addresses) 011: Move entry and/or action down (increasing addresses) 100: Initialize all entries and/or actions with the value in the cache.	0x0
UPDATE_ENTRY_DIS	21	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to entries. 0: Entries are copied/moved/init. 1: Entries are not copied/moved/init.	0x0

Table 369 • **Fields in VCAP_UPDATE_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
UPDATE_ACTION_DIS	20	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to actions. 0: Actions are copied/moved/init. 1: Actions are not copied/moved/init.	0x0
UPDATE_CNT_DIS	19	R/W	Specifies whether the operation specified in vcap_update_cmd is applied to cnts. 0: Counters are copied/moved/init. 1: Counters are not copied/moved/init.	0x0
UPDATE_ADDR	18:3	R/W	The entry/action address (row-wise) used for copy/move operations. When accessing the default actions the offset specified in VCAP_CONST:ENTRY_CNT should be added to the default action addr, i.e. Default action 0: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 0. Default action 1: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + 1. Default action n: set UPDATE_ADDR to VCAP_CONST:ENTRY_CNT + n.	0x0000
UPDATE_SHOT	2	One-shot	Initiate the operation specified in vcap_update_cmd. The bit is cleared by hw when operation has finished.	0x0
CLEAR_CACHE	1	One-shot	Reset all registers in VCAP_CORE_CACHE. The register is cleared by hw when the operation has finished.	0x0
MV_TRAFFIC_IGN	0	R/W	Ignore interrupting traffic during move operation. If a lookup is performed during a move operation the move is finished from where it was interrupted. When this field is set counters are not guaranteed to be up-to-date after the move.	0x0

7.8.1.2 VCAP_CORE:VCAP_CORE_CFG:VCAP_MV_CFG

Parent: VCAP_CORE:VCAP_CORE_CFG

Instances: 1

Table 370 • **Fields in VCAP_MV_CFG**

Field Name	Bit	Access	Description	Default
MV_NUM_POS	31:16	R/W	Specifies the number of positions the row must be moved up or down during a move operation. 0x0 The row is moved one position up or down. 0x1: The row is moved two positions up or down. 0xn: The row is moved n+1 positions up or down.	0x0000
MV_SIZE	15:0	R/W	Specifies the number of rows that must be moved up or down during a move operation. This field is also used to define the range that is initialized using the init feature. 0x0: The row at address UPDATE_ADDR is moved up or down. 0x1: The row at address UPDATE_ADDR through UPDATE_ADDR+1 are moved up or down. 0x2: The row at address UPDATE_ADDR through UPDATE_ADDR+2 are moved up or down. 0xn: The row at address UPDATE_ADDR through UPDATE_ADDR+n are moved up or down.	0x0000

7.8.2 VCAP_CORE:VCAP_CORE_CACHE

Parent: VCAP_CORE

Instances: 1

Table 371 • **Registers in VCAP_CORE_CACHE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_ENTRY_DAT	0x00000000	32 0x00000004		Page 330
VCAP_MASK_DAT	0x00000080	32 0x00000004		Page 330
VCAP_ACTION_DAT	0x00000100	32 0x00000004		Page 330

Table 371 • **Registers in VCAP_CORE_CACHE *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_CNT_DAT	0x00000180	32 0x00000004		Page 331
VCAP_TG_DAT	0x00000200	1		Page 331

7.8.2.1 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ENTRY_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 372 • **Fields in VCAP_ENTRY_DAT**

Field Name	Bit	Access	Description	Default
ENTRY_DAT	31:0	R/W	The cache register that holds a single TCAM entry data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.8.2.2 VCAP_CORE:VCAP_CORE_CACHE:VCAP_MASK_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 373 • **Fields in VCAP_MASK_DAT**

Field Name	Bit	Access	Description	Default
MASK_DAT	31:0	R/W	The cache register that holds a single TCAM entry mask row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the mask cache is specified in VCAP_CONST.ENTRY_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.8.2.3 VCAP_CORE:VCAP_CORE_CACHE:VCAP_ACTION_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 374 • **Fields in VCAP_ACTION_DAT**

Field Name	Bit	Access	Description	Default
ACTION_DAT	31:0	R/W	The cache register that holds a single action ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.ACTION_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.8.2.4 VCAP_CORE:VCAP_CORE_CACHE:VCAP_CNT_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 32

Table 375 • **Fields in VCAP_CNT_DAT**

Field Name	Bit	Access	Description	Default
CNT_DAT	31:0	R/W	The cache register that holds a single counter ram data row. The register is replicated 32 times where replication index 0 is the 32 LSBs of the cache. Note that the physical width of the entry cache is specified in VCAP_CONST.CNT_WIDTH and that there are only instantiated flops in the CSR target for this width.	0x00000000

7.8.2.5 VCAP_CORE:VCAP_CORE_CACHE:VCAP_TG_DAT

Parent: VCAP_CORE:VCAP_CORE_CACHE

Instances: 1

Table 376 • **Fields in VCAP_TG_DAT**

Field Name	Bit	Access	Description	Default
TG_DAT	31:0	R/W	This cache register holds the TypeGroup id for each subword in the TCAM. If the VCAP supports multiple subwords, i.e. VCAP_CONST.ENTRY_SWCNT > 1, the TypeGroup ids are place back to back with subword 0 at the LSBs.	0x00000000

7.8.3 VCAP_CORE:VCAP_CORE_STICKY

Parent: VCAP_CORE

Instances: 1

Table 377 • **Registers in VCAP_CORE_STICKY**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VCAP_STICKY	0x00000000	1		Page 332

7.8.3.1 VCAP_CORE:VCAP_CORE_STICKY:VCAP_STICKY

Parent: VCAP_CORE:VCAP_CORE_STICKY

Instances: 1

Table 378 • **Fields in VCAP_STICKY**

Field Name	Bit	Access	Description	Default
VCAP_ROW_DELETED_STICKY	0	Sticky	A move operation has resulted in one or more rows have been deleted.	0x0

7.8.4 VCAP_CORE:VCAP_CONST

Parent: VCAP_CORE

Instances: 1

Table 379 • **Registers in VCAP_CONST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_WIDTH	0x00000000	1		Page 333
ENTRY_CNT	0x00000004	1		Page 333

Table 379 • **Registers in VCAP_CONST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
ENTRY_SWCNT	0x00000008	1		Page 333
ENTRY_TG_WIDTH	0x0000000C	1		Page 333
ACTION_DEF_CNT	0x00000010	1		Page 334
ACTION_WIDTH	0x00000014	1		Page 334
CNT_WIDTH	0x00000018	1		Page 334

7.8.4.1 VCAP_CORE:VCAP_CONST:ENTRY_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 380 • **Fields in ENTRY_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_WIDTH	9:0	R/O	The width of a TCAM entry including TypeGroup ids.	0x000

7.8.4.2 VCAP_CORE:VCAP_CONST:ENTRY_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 381 • **Fields in ENTRY_CNT**

Field Name	Bit	Access	Description	Default
ENTRY_CNT	9:0	R/O	The number of entries in the TCAM.	0x000

7.8.4.3 VCAP_CORE:VCAP_CONST:ENTRY_SWCNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 382 • **Fields in ENTRY_SWCNT**

Field Name	Bit	Access	Description	Default
ENTRY_SWCNT	5:0	R/O	The number of supported subwords in the TCAM.	0x00

7.8.4.4 VCAP_CORE:VCAP_CONST:ENTRY_TG_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 383 • **Fields in ENTRY_TG_WIDTH**

Field Name	Bit	Access	Description	Default
ENTRY_TG_WIDTH	5:0	R/O	The width of a single TypeGroup id.	0x00

7.8.4.5 VCAP_CORE:VCAP_CONST:ACTION_DEF_CNT

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 384 • **Fields in ACTION_DEF_CNT**

Field Name	Bit	Access	Description	Default
ACTION_DEF_CNT	9:0	R/O	The number of default actions.	0x000

7.8.4.6 VCAP_CORE:VCAP_CONST:ACTION_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 385 • **Fields in ACTION_WIDTH**

Field Name	Bit	Access	Description	Default
ACTION_WIDTH	9:0	R/O	The width of the action RAM.	0x000

7.8.4.7 VCAP_CORE:VCAP_CONST:CNT_WIDTH

Parent: VCAP_CORE:VCAP_CONST

Instances: 1

Table 386 • **Fields in CNT_WIDTH**

Field Name	Bit	Access	Description	Default
CNT_WIDTH	9:0	R/O	The width of the counter RAM.	0x000

7.8.5 VCAP_CORE:TCAM_BIST

Parent: VCAP_CORE

Instances: 1

Table 387 • **Registers in TCAM_BIST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_CTRL	0x00000000	1	Control of the TCAM	Page 335

Table 387 • **Registers in TCAM_BIST *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TCAM_STAT	0x0000000C	1	Status for the TCAM	Page 335

7.8.5.1 VCAP_CORE:TCAM_BIST:TCAM_CTRL

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 388 • **Fields in TCAM_CTRL**

Field Name	Bit	Access	Description	Default
TCAM_INIT	0	One-shot	Set this field to start manual initialization of the TCAM. This field is cleared once initialization is complete. The TCAM has random contents after reset and must be initialized prior to usage.	0x0

7.8.5.2 VCAP_CORE:TCAM_BIST:TCAM_STAT

Parent: VCAP_CORE:TCAM_BIST

Instances: 1

Table 389 • **Fields in TCAM_STAT**

Field Name	Bit	Access	Description	Default
TCAM_RDY	0	R/O	Indicates the current operational state of the TCAM. '0': Busy with initialization. '1': Ready to be used.	0x0

7.9 DEVCPU_GCB

Table 390 • **Register Groups in DEVCPU_GCB**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
CHIP_REGS	0x00000000	1		Page 356
SW_REGS	0x00000014	1	Registers for software/software interaction	Page 358
VCORE_ACCESS	0x00000054	1		Page 361
GPIO	0x00000068	1		Page 365
DEVCPU_RST_REGS	0x00000090	1		Page 369

Table 390 • **Register Groups in DEVCPU_GCB *(continued)***

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
MIIM	0x000000A0	2 0x00000024		Page 370
MIIM_READ_SCAN	0x000000E8	1		Page 375
RAM_STAT	0x00000114	1		Page 376
MISC	0x00000118	1	Miscellaneous Registers	Page 376
SIO_CTRL	0x00000130	1	Serial IO control configuration	Page 379
FAN_CFG	0x000001F0	1	Configuration register for the fan controller	Page 384
FAN_STAT	0x000001F4	1	Fan controller statistics	Page 385
PTP_CFG	0x000001F8	1	Configuration registers for PTP	Page 385
PTP_STAT	0x00000218	1	Status registers for PTP	Page 390
PTP_TIMERS	0x00000224	1	Latched values of time of day timer for PTP measurements	Page 392
MEMITGR	0x00000234	1	Memory integrity monitor	Page 394

7.9.1 DEVCPU_GCB:CHIP_REGS

Parent: DEVCPU_GCB

Instances: 1

Table 391 • **Registers in CHIP_REGS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
GENERAL_PURPOSE	0x00000000	1	general purpose register	Page 356
SI	0x00000004	1	SI registers	Page 357
CHIP_ID	0x00000008	1	Chip Id	Page 357

7.9.1.1 DEVCPU_GCB:CHIP_REGS:GENERAL_PURPOSE

Parent: DEVCPU_GCB:CHIP_REGS

Instances: 1

Table 392 • **Fields in GENERAL_PURPOSE**

Field Name	Bit	Access	Description	Default
GENERAL_PURPOSE_REG	31:0	R/W	This is a general-purpose register that can be used for testing. The value in this register has no functionality other than general purpose storage.	0x00000000

7.9.1.2 DEVCPU_GCB:CHIP_REGS:SI

Parent: DEVCPU_GCB:CHIP_REGS

Instances: 1

Configuration of serial interface data format. This register modifies how the SI receives and transmits data, when configuring this register first write 0 (to get to a known state), then configure the desired values.

Table 393 • **Fields in SI**

Field Name	Bit	Access	Description	Default
SI_LSB	5	R/W	Setup SI to use MSB or LSB first. See datasheet for more information. 0: SI expect/transmit MSB first 1: SI expect/transmit LSB first	0x0
SI_ENDIAN	4	R/W	Setup SI to use either big or little endian data format. See datasheet for more information. 0: SI uses little endian notation 1: SI uses big endian notation	0x1
SI_WAIT_STATES	3:0	R/W	Configure the number of padding bytes that the SI must insert before transmitting read-data during reading from the device. 0 : don't insert any padding 1 : Insert 1 byte of padding ... 15: Insert 15 bytes of padding	0x0

7.9.1.3 DEVCPU_GCB:CHIP_REGS:CHIP_ID

Parent: DEVCPU_GCB:CHIP_REGS

Instances: 1

Table 394 • **Fields in CHIP_ID**

Field Name	Bit	Access	Description	Default
REV_ID	31:28	R/O	Revision ID.	0x3
PART_ID	27:12	R/O	Part ID. VSC7428-12	0x7428

Table 394 • **Fields in CHIP_ID *(continued)***

Field Name	Bit	Access	Description	Default
MFG_ID	11:1	R/O	Manufacturer's ID.	0x074
ONE	0	R/O	Returns '1'	0x1

7.9.2 DEVCPU_GCB:SW_REGS

Parent: DEVCPU_GCB

Instances: 1

Table 395 • **Registers in SW_REGS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SEMA_INTR_ENA	0x00000000	1	Semaphore SW interrupt enable	Page 358
SEMA_INTR_ENA_CLR	0x00000004	1	Clear of semaphore SW interrupt enables	Page 359
SEMA_INTR_ENA_SET	0x00000008	1	Masking of semaphore	Page 359
SEMA	0x0000000C	8 0x00000004	Semaphore register	Page 359
SEMA_FREE	0x0000002C	1	Semaphore status	Page 360
SW_INTR	0x00000030	1	Manually assert software interrupt	Page 360
MAILBOX	0x00000034	1	Mailbox register	Page 361
MAILBOX_CLR	0x00000038	1	Mailbox register atomic clear	Page 361
MAILBOX_SET	0x0000003C	1	Mailbox register atomic set	Page 361

7.9.2.1 DEVCPU_GCB:SW_REGS:SEMA_INTR_ENA

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 396 • **Fields in SEMA_INTR_ENA**

Field Name	Bit	Access	Description	Default
SEMA_INTR_IDENT	15:8	R/O	This is a bitwise AND of SEMA_FREE and SEMA_INTR_ENA providing an fast access to the cause of an interrupt, given the current mask.	0x00

Table 396 • **Fields in SEMA_INTR_ENA *(continued)***

Field Name	Bit	Access	Description	Default
SEMA_INTR_ENA	7:0	R/W	Set bits in this register to enable interrupt when the corresponding semaphore is free. In a multi-threaded environment, or with more than one active processor the CPU_SEMA_ENA_SET and CPU_SEMA_ENA_CLR registers can be used for atomic modifications of this register. If interrupt is enabled for a particular semaphore, then software interrupt will be asserted for as long as the semaphore is free (and interrupt is enabled for that semaphore). The lower half of the available semaphores are connected to software Interrupt 0 (SW0), the upper half is connected to software interrupt 1 (SW1).	0x00

7.9.2.2 DEVCPU_GCB:SW_REGS:SEMA_INTR_ENA_CLR

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 397 • **Fields in SEMA_INTR_ENA_CLR**

Field Name	Bit	Access	Description	Default
SEMA_INTR_ENA_CLR	7:0	One-shot	Set to clear corresponding interrupt enable in SEMA_INTR_ENA.	0x00

7.9.2.3 DEVCPU_GCB:SW_REGS:SEMA_INTR_ENA_SET

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 398 • **Fields in SEMA_INTR_ENA_SET**

Field Name	Bit	Access	Description	Default
SEMA_INTR_ENA_SET	7:0	One-shot	Set to set corresponding interrupt enable in SEMA_INTR_ENA.	0x00

7.9.2.4 DEVCPU_GCB:SW_REGS:SEMA

Parent: DEVCPU_GCB:SW_REGS

Instances: 8

Table 399 • **Fields in SEMA**

Field Name	Bit	Access	Description	Default
SEMA	0	R/W	General Semaphore.The process to read this field will read a '1' and thus be granted the semaphore. The semaphore is released by the interface by writing a '1' to this field. Read : '0': Semaphore was not granted. '1': Semaphore was granted. Write : '0': No action. '1': Release semaphore.	0x1

7.9.2.5 DEVCPU_GCB:SW_REGS:SEMA_FREE

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 400 • **Fields in SEMA_FREE**

Field Name	Bit	Access	Description	Default
SEMA_FREE	7:0	R/O	Show which semaphores that are currently free. '0' : Corresponding semaphore is taken. '1' : Corresponding semaphore is free.	0xFF

7.9.2.6 DEVCPU_GCB:SW_REGS:SW_INTR

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

This register provides a simple interface for interrupting on either software interrupt 0 or 1, without implementing semaphore support. Note: setting this field causes a short pulse on the corresponding interrupt connection, this kind of interrupt cannot be used in combination with the SW1_INTR_CONFIG.SW1_INTR_BYPASS feature.

Table 401 • **Fields in SW_INTR**

Field Name	Bit	Access	Description	Default
SW1_INTR	1	One-shot	Set this field to inject software interrupt 1. This field is automatically cleared after interrupt has been generated.	0x0

Table 401 • **Fields in SW_INTR *(continued)***

Field Name	Bit	Access	Description	Default
SW0_INTR	0	One-shot	Set this field to assert software interrupt 0. This field is automatically cleared after interrupt has been generated.	0x0

7.9.2.7 DEVCPU_GCB:SW_REGS:MAILBOX

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 402 • **Fields in MAILBOX**

Field Name	Bit	Access	Description	Default
MAILBOX	31:0	R/W	Read/write register. Atomic modifications can be performed by using the MAILBOX_CLR and MAILBOX_SET registers.	0x00000000

7.9.2.8 DEVCPU_GCB:SW_REGS:MAILBOX_CLR

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 403 • **Fields in MAILBOX_CLR**

Field Name	Bit	Access	Description	Default
MAILBOX_CLR	31:0	One-shot	Set bits in this register to atomically clear corresponding bits in the MAILBOX register. This register returns 0 on read.	0x00000000

7.9.2.9 DEVCPU_GCB:SW_REGS:MAILBOX_SET

Parent: DEVCPU_GCB:SW_REGS

Instances: 1

Table 404 • **Fields in MAILBOX_SET**

Field Name	Bit	Access	Description	Default
MAILBOX_SET	31:0	One-shot	Set bits in this register to atomically set corresponding bits in the MAILBOX register. This register returns 0 on read.	0x00000000

7.9.3 DEVCPU_GCB:VCORE_ACCESS

Parent: DEVCPU_GCB

Instances: 1

Table 405 • **Registers in VCORE_ACCESS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
VA_CTRL	0x00000000	1	Control register for VCore accesses	Page 362
VA_ADDR	0x00000004	1	Address register for VCore accesses	Page 363
VA_DATA	0x00000008	1	Data register for VCore accesses	Page 363
VA_DATA_INCR	0x0000000C	1	Data register for VCore accesses (w. auto increment of address)	Page 364
VA_DATA_INERT	0x00000010	1	Data register for VCore accesses (will not initiate access)	Page 365

7.9.3.1 DEVCPU_GCB:VCORE_ACCESS:VA_CTRL

Parent: DEVCPU_GCB:VCORE_ACCESS

Instances: 1

Table 406 • **Fields in VA_CTRL**

Field Name	Bit	Access	Description	Default
VA_ERR_RD	3	R/O	This field is set to the value of VA_CTRL:VA_ERR whenever one of the data registers ACC_DATA, ACC_DATA_INCR, or ACC_DATA_RO is read. By reading this field it is possible to determine if the last read-value from one of these registers was erred.	0x0
VA_ERR	2	R/O	This field is set if the access inside the VCore domain was terminated by an error. This situation can occur when accessing an unmapped part of the VCore memory-map or when accessing a target that reports error (e.g. accessing uninitialized DDR2 memory). If an error occurs during reading, the read-data will be 0x80000000. So as an optimization, software only has to check for error if 0x80000000 is returned (and in that case VA_ERR_RD should be checked). When writing you should always check if successful.	0x0

Table 406 • **Fields in VA_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
VA_BUSY_RD	1	R/O	This field is set to the value of VA_CTRL:VA_BUSY whenever one of the data registers ACC_DATA, ACC_DATA_INCR, or ACC_DATA_RO is read. By reading this field it is possible to determine if the last read-value from one of these registers was valid.	0x0
VA_BUSY	0	R/O	This field is set by hardware when an access into VCore domain is started, and cleared when the access is done.	0x0

7.9.3.2 DEVCPU_GCB:VCORE_ACCESS:VA_ADDR

Parent: DEVCPU_GCB:VCORE_ACCESS

Instances: 1

Table 407 • **Fields in VA_ADDR**

Field Name	Bit	Access	Description	Default
VA_ADDR	31:0	R/W	The address to access in the VCore domain, all addresses must be 32-bit aligned (i.e. the two least significant bit must always be 0). When accesses are initiated using the ACC_DATA_INCR register, then this field is automatically incremented by 4 at the end of the transfer. The memory region of the VCore that maps to switch-core registers may not be accessed by using these registers.	0x00000000

7.9.3.3 DEVCPU_GCB:VCORE_ACCESS:VA_DATA

Parent: DEVCPU_GCB:VCORE_ACCESS

Instances: 1

The VA_DATA, VA_DATA_INCR, and VA_DATA_INERT registers are used for indirect access into the VCore domain. The functionality of the VA_DATA_INCR and VA_DATA_INERT registers are similar to this register - but with minor exceptions. These exceptions are fleshed out in the description of the respective registers.

Table 408 • **Fields in VA_DATA**

Field Name	Bit	Access	Description	Default
VA_DATA	31:0	R/W	Reading or writing from/to this field initiates accesses into the VCore domain. While an access is ongoing (VA_CTRL:VA_BUSY is set) this field may not be written. It is possible to read this field while an access is ongoing, but the data returned will be 0x80000000. When writing to this field; a write into the VCore domain is initiated to the address specified in the VA_ADDR register, with the data that was written to this field. Only 32-bit writes are supported. This field may not be written to until the VA_CTRL:VA_BUSY indicates that no accesses is ongoing. When reading from this field; a read from the VCore domain is initiated from the address specified in the VA_ADDR register. Important: The data that is returned from reading this field (and stating an access) is not the result of the newly initiated read, instead the data from the last access is returned. The result of the newly initiated read access will be ready once the VA_CTRL:VA_BUSY field shows that the access is done. Note: When the result of a read-access is read from this field (the second read), a new access will automatically be initiated. This is desirable when reading a series of addresses from VCore domain. If a new access is not desirable, then the result should be read from the VA_DATA_INERT register instead of this field!	0x00000000

7.9.3.4 DEVCPU_GCB:VCORE_ACCESS:VA_DATA_INCR

Parent: DEVCPU_GCB:VCORE_ACCESS

Instances: 1

Table 409 • **Fields in VA_DATA_INCR**

Field Name	Bit	Access	Description	Default
VA_DATA_INCR	31:0	R/W	This field behaves in the same way as ACC_DATA:ACC_DATA. Except when an access is initiated by using this field (either read or write); the address register (ACC_ADDR) is automatically incremented by 4 at the end of the access, i.e. when VA_CTRL:VA_BUSY is deasserted.	0x00000000

7.9.3.5 DEVCPU_GCB:VCORE_ACCESS:VA_DATA_INERT

Parent: DEVCPU_GCB:VCORE_ACCESS

Instances: 1

Table 410 • **Fields in VA_DATA_INERT**

Field Name	Bit	Access	Description	Default
VA_DATA_INERT	31:0	R/W	This field behaves in the same way as ACC_DATA:ACC_DATA. Except accesses (read or write) does not initiate VCore accesses. Writing to this register just overwrites the value currently held by all of the data registers (ACC_DATA, ACC_DATA_INCR, and ACC_DATA_INERT).	0x00000000

7.9.4 DEVCPU_GCB:GPIO

Parent: DEVCPU_GCB

Instances: 1

General Purpose I/O Control configuration and status registers.

Each register in this group contains one field with one bit per GPIO pin. Bit 0 in each field corresponds to GPIO0, bit 1 to GPIO1, and so on.

Table 411 • **Registers in GPIO**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
GPIO_OUT_SET	0x00000000	1	GPIO output set	Page 366
GPIO_OUT_CLR	0x00000004	1	GPIO output clear	Page 366
GPIO_OUT	0x00000008	1	GPIO output	Page 366
GPIO_IN	0x0000000C	1	GPIO input	Page 367

Table 411 • **Registers in GPIO *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
GPIO_OE	0x00000010	1	GPIO pin direction	Page 367
GPIO_INTR	0x00000014	1	GPIO interrupt	Page 367
GPIO_INTR_ENA	0x00000018	1	GPIO interrupt enable	Page 368
GPIO_INTR_IDENT	0x0000001C	1	GPIO interrupt identity	Page 368
GPIO_ALT	0x00000020	2 0x00000004	GPIO alternate functions	Page 368

7.9.4.1 DEVCPU_GCB:GPIO:GPIO_OUT_SET

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 412 • **Fields in GPIO_OUT_SET**

Field Name	Bit	Access	Description	Default
G_OUT_SET	31:0	One-shot	Setting a bit in this field will immediately set the corresponding bit in GPIO_O::G_OUT. Reading this register always return 0. '0': No change '1': Corresponding bit in GPIO_O::OUT is set.	0x00000000

7.9.4.2 DEVCPU_GCB:GPIO:GPIO_OUT_CLR

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 413 • **Fields in GPIO_OUT_CLR**

Field Name	Bit	Access	Description	Default
G_OUT_CLR	31:0	One-shot	Setting a bit in this field will immediately clear the corresponding bit in GPIO_O::G_OUT. Reading this register always return 0. '0': No change '1': Corresponding bit in GPIO_O::OUT is cleared.	0x00000000

7.9.4.3 DEVCPU_GCB:GPIO:GPIO_OUT

Parent: DEVCPU_GCB:GPIO

Instances: 1

In a multi-threaded software environment using the registers GPIO_OUT_SET and GPIO_OUT_CLR for modifying GPIO values removes the need for software-locked access.

Table 414 • **Fields in GPIO_OUT**

Field Name	Bit	Access	Description	Default
G_OUT	31:0	R/W	Controls the value on the GPIO pins enabled for output (via the GPIO_OE register). This field can be modified directly or by using the GPIO_O_SET and GPIO_O_CLR registers.	0x00000000

7.9.4.4 DEVCPU_GCB:GPIO:GPIO_IN

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 415 • **Fields in GPIO_IN**

Field Name	Bit	Access	Description	Default
G_IN	31:0	R/O	GPIO input register. Reflects the current state of the corresponding GPIO pins.	0x00000000

7.9.4.5 DEVCPU_GCB:GPIO:GPIO_OE

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 416 • **Fields in GPIO_OE**

Field Name	Bit	Access	Description	Default
G_OE	31:0	R/W	Configures the direction of the GPIO pins. '0': Input '1': Output	0x00000000

7.9.4.6 DEVCPU_GCB:GPIO:GPIO_INTR

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 417 • **Fields in GPIO_INTR**

Field Name	Bit	Access	Description	Default
G_INTR	31:0	Sticky	Indicates whether a GPIO input has changed since last clear. '0': No change '1': GPIO has changed	0x00000000

7.9.4.7 DEVCPU_GCB:GPIO:GPIO_INTR_ENA

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 418 • **Fields in GPIO_INTR_ENA**

Field Name	Bit	Access	Description	Default
G_INTR_ENA	31:0	R/W	Enables individual GPIO pins for interrupt.	0x00000000

7.9.4.8 DEVCPU_GCB:GPIO:GPIO_INTR_IDENT

Parent: DEVCPU_GCB:GPIO

Instances: 1

Table 419 • **Fields in GPIO_INTR_IDENT**

Field Name	Bit	Access	Description	Default
G_INTR_IDENT	31:0	R/O	Shows which GPIO sources that are currently interrupting. This field is the result of an AND-operation between the GPIO_INTR and the GPIO_INTR_ENA registers.	0x00000000

7.9.4.9 DEVCPU_GCB:GPIO:GPIO_ALT

Parent: DEVCPU_GCB:GPIO

Instances: 2

Table 420 • **Fields in GPIO_ALT**

Field Name	Bit	Access	Description	Default
G_ALT	31:0	R/W	Configures alternate functions for individual GPIO bits. This field is replicated two times, the functionality of the GPIO is determined by the bit in this field corresponding to the GPIO for BOTH replications. For example, to enable alternate function 1 for GPIO number 3; then bit 3 in G_ALT[0] must be set and bit 3 in G_ALT[1] must be cleared. The encoding describes the result of setting bits in both replications of this field per GPIO. That is, the encoding shows the following concatenation "G_ALT[1] & G_ALT[0]" per GPIO. "00": GPIO mode "01": Alternate mode 1 "10": Alternate mode 2 "11": Reserved	0x00000000

7.9.5 DEVCPU_GCB:DEVCPU_RST_REGS

Parent: DEVCPU_GCB

Instances: 1

Resets the chip

Table 421 • **Registers in DEVCPU_RST_REGS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SOFT_CHIP_RST	0x00000000	1	Reset part or the whole chip	Page 369
SOFT_DEVCPU_RST	0x00000004	1	Soft reset of devcpu.	Page 370

7.9.5.1 DEVCPU_GCB:DEVCPU_RST_REGS:SOFT_CHIP_RST

Parent: DEVCPU_GCB:DEVCPU_RST_REGS

Instances: 1

Table 422 • **Fields in SOFT_CHIP_RST**

Field Name	Bit	Access	Description	Default
SOFT_PHY_RST	1	R/W	Clear this field to release reset in the Cu-PHY. This field is automatically set during hard-reset and soft-reset of the chip. After reset is released the PHY will indicate when it is ready to be accessed via DEVCPU_GCB::MISC_STAT.PHY_READY.	0x1
SOFT_CHIP_RST	0	R/W	Set this field to reset the whole chip. This field is automatically cleared by the reset. Note: It is possible for the VCore to protect itself from soft-reset of the chip, for more info see RESET.CORE_RST_PROTECT inside the VCore register space.	0x0

7.9.5.2 DEVCPU_GCB:DEVCPU_RST_REGS:SOFT_DEVCPU_RST

Parent: DEVCPU_GCB:DEVCPU_RST_REGS

Instances: 1

Table 423 • **Fields in SOFT_DEVCPU_RST**

Field Name	Bit	Access	Description	Default
SOFT_XTR_RST	1	R/W	Set this field to reset the extraction logic. The reset remains asserted until this field is cleared. Note: Extraction logic is also reset while SOFT_CHIP_RST.SOFT_NON_CFG_RST is set.	0x0
SOFT_INJ_RST	0	R/W	Set this field to reset the injection logic. The reset remains asserted until this field is cleared. Note: Injection logic is also reset while SOFT_CHIP_RST.SOFT_NON_CFG_RST is set.	0x0

7.9.6 DEVCPU_GCB:MIIM

Parent: DEVCPU_GCB

Instances: 2

Table 424 • **Registers in MIIM**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MII_STATUS	0x00000000	1	MIIM Status	Page 371
MII_CMD	0x00000008	1	MIIM Command	Page 372
MII_DATA	0x0000000C	1	MIIM Reply Data	Page 373
MII_CFG	0x00000010	1	MIIM Configuration	Page 373
MII_SCAN_0	0x00000014	1	MIIM Scan 0	Page 374
MII_SCAN_1	0x00000018	1	MIIM Scan 1	Page 374
MII_SCAN_LAST_RSLTS	0x0000001C	1	MIIM Results	Page 374
MII_SCAN_LAST_RSLTS_VLD	0x00000020	1	MIIM Results	Page 375

7.9.6.1 DEVCPU_GCB:MIIM:MII_STATUS

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 425 • **Fields in MII_STATUS**

Field Name	Bit	Access	Description	Default
MIIM_STAT_BUSY	3	R/O	Indicates the current state of the MIIM controller. When read operations are done (no longer busy), then read data is available via the DEVCPU_GCB::MII_DATA register. 0: MIIM controller is in idle state 1: MIIM controller is busy performing MIIM cmd (Either read or read cmd).	0x0
MIIM_STAT_OPR_PEND	2	R/O	The MIIM controller has a CMD fifo of depth one. When this field is 0, then it is safe to write another MIIM command to the MIIM controller. 0 : Read or write not pending 1 : Read or write pending.	0x0
MIIM_STAT_PENDING_RD	1	R/O	Indicates whether a read operation via the MIIM interface is in progress or not. 0 : Read not in progress 1 : Read in progress.	0x0

Table 425 • **Fields in MII_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
MIIM_STAT_PENDING_WR	0	R/O	Indicates whether a write operation via the MIIM interface is in progress or not. 0 : Write not in progress 1 : Write in progress.	0x0
MIIM_SCAN_COMPLETE	4	R/O	Signals if all PHYs have been scanned (with auto scan) at least once. 0 : Auto scan has not scanned all PHYs. 1 : Auto scan has scanned all PHY at least once.	0x0

7.9.6.2 DEVCPU_GCB:MIIM:MII_CMD

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 426 • **Fields in MII_CMD**

Field Name	Bit	Access	Description	Default
MIIM_CMD_VLD	31	One-shot	Must be set for starting a new PHY access. This bit is automatically cleared. 0 : Write to this register is ignored. 1 : Write to this register is processed.	0x0
MIIM_CMD_PHYAD	29:25	R/W	Indicates the addressed PHY number.	0x00
MIIM_CMD_REGAD	24:20	R/W	Indicates the addressed of the register within the PHY that shall be accessed.	0x00
MIIM_CMD_WRDATA	19:4	R/W	Data to be written in the PHY register.	0x0000
MIIM_CMD_SINGLE_SCAN	3	R/W	Select if scanning of the PHY shall be done once, or scanning should be done continuously. 0 : Do continuously PHY scanning 1 : Stop once all PHY have been scanned.	0x0

Table 426 • **Fields in MII_CMD *(continued)***

Field Name	Bit	Access	Description	Default
MIIM_CMD_OPR_FIELD	2:1	R/W	Indicates type of operation. Clause 22: 01 : Write 10 : Read Clause 45: 00 : Address 01 : Write 10 : Read inc. 11 : Read.	0x0
MIIM_CMD_SCAN	0	R/W	Indicates whether automatic scanning of PHY registers is enabled. When enabled, the PHY-number for each automatic read is continuously round-robined from PHY_ADDR_LOW through PHY_ADDR_HIGH. This function is started upon a read operation (ACCESS_TYPE). Scan MUST be disabled when doing any configuration of the MIIM controller. 0 : Disabled 1 : Enabled.	0x0

7.9.6.3 DEVCPU_GCB:MIIM:MII_DATA

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 427 • **Fields in MII_DATA**

Field Name	Bit	Access	Description	Default
MIIM_DATA_SUCCESS	17:16	R/O	Indicates whether a read operation failed or succeeded. 00 : OK 11 : Error	0x0
MIIM_DATA_RDDATA	15:0	R/O	Data read from PHY register.	0x0000

7.9.6.4 DEVCPU_GCB:MIIM:MII_CFG

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 428 • **Fields in MII_CFG**

Field Name	Bit	Access	Description	Default
MIIM_CFG_PRESCALE	7:0	R/W	Configures the MIIM clock frequency. This is computed as system_clk/(2*(1+X)), where X is the value written to this register. Note : Setting X to 0 is invalid and will result in the same frequency as setting X to 1.	0x32
MIIM_ST_CFG_FIELD	10:9	R/W	The ST (start-of-frame) field of the MIIM frame format adopts the value of this field. This must be configured for either clause 22 or 45 MIIM operation. "01": Clause 22 "00": Clause 45 Other values are reserved.	0x1

7.9.6.5 DEVCPU_GCB:MIIM:MII_SCAN_0

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 429 • **Fields in MII_SCAN_0**

Field Name	Bit	Access	Description	Default
MIIM_SCAN_PHYADHI	9:5	R/W	Indicates the high PHY number to scan during automatic scanning.	0x00
MIIM_SCAN_PHYADLO	4:0	R/W	Indicates the low PHY number to scan during automatic scanning.	0x00

7.9.6.6 DEVCPU_GCB:MIIM:MII_SCAN_1

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 430 • **Fields in MII_SCAN_1**

Field Name	Bit	Access	Description	Default
MIIM_SCAN_MASK	31:16	R/W	Indicates the mask for comparing the PHY registers during automatic scan.	0x0000
MIIM_SCAN_EXPECT	15:0	R/W	Indicates the expected value for comparing the PHY registers during automatic scan.	0x0000

7.9.6.7 DEVCPU_GCB:MIIM:MII_SCAN_LAST_RSLTS

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 431 • **Fields in MII_SCAN_LAST_RSLTS**

Field Name	Bit	Access	Description	Default
MIIM_LAST_RSLT	31:0	R/O	Indicates for each PHY if a PHY register has matched the expected value (with mask). This register reflects the value of the last reading of the phy register. 0 : Mismatch. 1 : Match.	0x00000000

7.9.6.8 DEVCPU_GCB:MIIM:MII_SCAN_LAST_RSLTS_VLD

Parent: DEVCPU_GCB:MIIM

Instances: 1

Table 432 • **Fields in MII_SCAN_LAST_RSLTS_VLD**

Field Name	Bit	Access	Description	Default
MIIM_LAST_RSLT_VLD	31:0	R/O	Indicates for each PHY if a PHY register matched are valid or not. 0 : Scan result not valid. 1 : Scan result valid.	0x00000000

7.9.7 DEVCPU_GCB:MIIM_READ_SCAN

Parent: DEVCPU_GCB

Instances: 1

Table 433 • **Registers in MIIM_READ_SCAN**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MII_SCAN_RSLTS_STICKY	0x00000000	2 0x00000004	MIIM Results	Page 375

7.9.7.1 DEVCPU_GCB:MIIM_READ_SCAN:MII_SCAN_RSLTS_STICKY

Parent: DEVCPU_GCB:MIIM_READ_SCAN

Instances: 2

Table 434 • **Fields in MII_SCAN_RSLTS_STICKY**

Field Name	Bit	Access	Description	Default
MIIM_SCAN_RSLTS_STICKY	31:0	R/O	Indicates for each PHY if a PHY register has had a mismatch of the expected value (with mask) since last reading of MIIM_SCAN_RSLTS_STICKY. Result is sticky, and result will indicate if there has been a mismatch since the last reading of this register. Upon reading this register, all bits are reset to '1'. 0 : Mismatch 1 : Match.	0x00000000

7.9.8 DEVCPU_GCB:RAM_STAT

Parent: DEVCPU_GCB

Instances: 1

Table 435 • **Registers in RAM_STAT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RAM_INTEGRITY_ERR_STICKY	0x00000000	1	QS RAM status	Page 376

7.9.8.1 DEVCPU_GCB:RAM_STAT:RAM_INTEGRITY_ERR_STICKY

Parent: DEVCPU_GCB:RAM_STAT

Instances: 1

Table 436 • **Fields in RAM_INTEGRITY_ERR_STICKY**

Field Name	Bit	Access	Description	Default
QS_XTR_RAM_INTGR_ERR_STICKY	0	Sticky	Integrity error for QS_XTR RAM '0': No RAM integrity check error occurred '1': A RAM integrity check error occurred Bit is cleared by writing a '1' to this position.	0x0

7.9.9 DEVCPU_GCB:MISC

Parent: DEVCPU_GCB

Instances: 1

Table 437 • **Registers in MISC**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MISC_CFG	0x00000000	1	Miscellaneous Configuration Register	Page 377
MISC_STAT	0x00000004	1		Page 378
PHY_SPEED_1000_STAT	0x00000008	1		Page 378
PHY_SPEED_100_STAT	0x0000000C	1		Page 378
PHY_SPEED_10_STAT	0x00000010	1		Page 378
DUPLEXC_PORT_STAT	0x00000014	1		Page 378

7.9.9.1 DEVCPU_GCB:MISC:MISC_CFG

Parent: DEVCPU_GCB:MISC

Instances: 1

Register to control various muxing in the IO-ring.

Table 438 • **Fields in MISC_CFG**

Field Name	Bit	Access	Description	Default
SYNCE_SRC_CTRL	9:8	R/W	Select if PHY or SwC should control the SyncE pins. 0: SwC owns SyncE pins 1: PHY owns SyncE pins	0x0
SW_MODE	7:6	R/W	Set the SW_mode for HSIO. 0: Reserved. 1: 8x CuPHY + 2x 2.5G SGMII + 1x 1G SGMII. 2: Reserved. 3: Reserved.	0x0
QSGMII_FLIP_LANE1	5	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
QSGMII_FLIP_LANE2	4	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
QSGMII_FLIP_LANE3	3	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
QSGMII_SHYST_DIS	2	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
QSGMII_E_DET_ENA	1	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
QSGMII_USE_I1_ENA	0	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0

7.9.9.2 DEVCPU_GCB:MISC:MISC_STAT

Parent: DEVCPU_GCB:MISC

Instances: 1

Table 439 • **Fields in MISC_STAT**

Field Name	Bit	Access	Description	Default
PHY_READY	3	R/O	This field is set high when the PHY is ready for access after release of PHY reset via DEVCPU_GCB::SOFT_CHIP_RST.SOFT_PHY_RST.	0x0

7.9.9.3 DEVCPU_GCB:MISC:PHY_SPEED_1000_STAT

Parent: DEVCPU_GCB:MISC

Instances: 1

Table 440 • **Fields in PHY_SPEED_1000_STAT**

Field Name	Bit	Access	Description	Default
SPEED_1000	11:0	R/O	p2m_speed1000c status from PHY	0x000

7.9.9.4 DEVCPU_GCB:MISC:PHY_SPEED_100_STAT

Parent: DEVCPU_GCB:MISC

Instances: 1

Table 441 • **Fields in PHY_SPEED_100_STAT**

Field Name	Bit	Access	Description	Default
SPEED_100	11:0	R/O	p2m_speed100 status from PHY	0x000

7.9.9.5 DEVCPU_GCB:MISC:PHY_SPEED_10_STAT

Parent: DEVCPU_GCB:MISC

Instances: 1

Table 442 • **Fields in PHY_SPEED_10_STAT**

Field Name	Bit	Access	Description	Default
SPEED_10	11:0	R/O	p2m_speed10 status from PHY	0x000

7.9.9.6 DEVCPU_GCB:MISC:DUPLEXC_PORT_STAT

Parent: DEVCPU_GCB:MISC

Instances: 1

Table 443 • **Fields in DUPLEXC_PORT_STAT**

Field Name	Bit	Access	Description	Default
DUPLEXC	11:0	R/O	p2m_duplexc_port status from PHY	0x000

7.9.10 DEVCPU_GCB:SIO_CTRL

Parent: DEVCPU_GCB

Instances: 1

Table 444 • **Registers in SIO_CTRL**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SIO_INPUT_DATA	0x00000000	4 0x00000004	Input data registers	Page 379
SIO_INT_POL	0x00000010	4 0x00000004	Interrupt polarity for each GPIO	Page 380
SIO_PORT_INT_ENA	0x00000020	1	Interrupt enable register for each port.	Page 380
SIO_PORT_CONFIG	0x00000024	32 0x00000004	Configuration of output data values	Page 380
SIO_PORT_ENABLE	0x000000A4	1	Port enable register	Page 381
SIO_CONFIG	0x000000A8	1	General configuration register	Page 381
SIO_CLOCK	0x000000AC	1	Configuration of the serial IO clock frequency	Page 383
SIO_INT_REG	0x000000B0	4 0x00000004	Interrupt register	Page 383

7.9.10.1 DEVCPU_GCB:SIO_CTRL:SIO_INPUT_DATA

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 4

Table 445 • **Fields in SIO_INPUT_DATA**

Field Name	Bit	Access	Description	Default
S_IN	31:0	R/O	Serial input data. The first replication holds bit 0 from all ports, the 2nd replication holds bit 1 from all ports, etc. Values of disabled gpios are undefined. bit order: (port-31 bit-n down to port-0 bit-n)	0x00000000

7.9.10.2 DEVCPU_GCB:SIO_CTRL:SIO_INT_POL

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 4

Table 446 • **Fields in SIO_INT_POL**

Field Name	Bit	Access	Description	Default
INT_POL	31:0	R/W	Interrupt polarity. Bit n from all ports. This register defines at which logic value an interrupt is generated. For bit 0, this register is also used to define the polarity of the "loss of signal" output. 0 : interrupt at logic value '1' 1 : interrupt at logic value '0' For "loss of signal": 0 : "loss of signal" is active high 1: "loss of signal" is active low	0x00000000

7.9.10.3 DEVCPU_GCB:SIO_CTRL:SIO_PORT_INT_ENA

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 1

Table 447 • **Fields in SIO_PORT_INT_ENA**

Field Name	Bit	Access	Description	Default
INT_ENA	31:0	R/W	Interrupt enable vector with one enable bit for each port. 0 : Interrupt is disabled for the port. 1 : Interrupt is enabled for the port. port order: (portN down to port0)	0x00000000

7.9.10.4 DEVCPU_GCB:SIO_CTRL:SIO_PORT_CONFIG

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 32

Table 448 • **Fields in SIO_PORT_CONFIG**

Field Name	Bit	Access	Description	Default
BIT_SOURCE	11:0	R/W	Output source select for the four outputs from each port. The source select is encoded using three bits for each output bit. The placement of the source select bits for each output bit in the register: Output bit 0: (2 down to 0) Output bit 1: (5 down to 3) Output bit 2: (8 down to 6) Output bit 3: (11 down to 9) Source select encoding for each output bit: 0 : Forced '0' 1 : Forced '1' 2 : Blink mode 0 3 : Blink mode 1 4 : Link activity blink mode 0 5 : Link activity blink mode 1 6 : Link activity blink mode 0 inversed polarity 7 : Link activity blink mode 1 inversed polarity	0x000

7.9.10.5 DEVCPU_GCB:SIO_CTRL:SIO_PORT_ENABLE

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 1

Table 449 • **Fields in SIO_PORT_ENABLE**

Field Name	Bit	Access	Description	Default
P_ENA	31:0	R/W	Port enable vector with one enable bit for each port. 0 : Port is disabled. 1 : Port is enabled. Port order: (portN down to port0)	0x00000000

7.9.10.6 DEVCPU_GCB:SIO_CTRL:SIO_CONFIG

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 1

Table 450 • **Fields in SIO_CONFIG**

Field Name	Bit	Access	Description	Default
SIO_BMODE_1	21:20	R/W	Configuration for blink mode 1. Supports three different blink modes and a "burst toggle" mode in which blink mode 1 will alternate for each burst. 0 : Blink freq approximately 20Hz 1 : Blink freq approximately 10Hz. 2 : Blink freq approximately 5Hz. 3 : Burst toggle.	0x0
SIO_BMODE_0	19:18	R/W	Configuration of blink mode 0. Supports four different blink modes. 0 : Blink freq approximately 20Hz 1 : Blink freq approximately 10Hz. 2 : Blink freq approximately 5Hz. 3 : Blink freq approximately 2.5Hz.	0x0
SIO_BLINK_RESET	17	R/W	Reset the blink counters. Used to synchronize the blink modes between different chips. 0 : Blink counter is running. 1 : Blink counter is reset until sio_blink_reset is unset again.	0x0
SIO_INT_ENA	16:13	R/W	Bit interrupt enable. Enables interrupts for the four gpios in a port. Is applied to all ports. 0: Interrupt is disabled for bit n for all ports. 1: Interrupt is enabled for bit n for all ports.	0x0
SIO_BURST_GAP_DIS	12	R/W	Set to disable burst gap.	0x0
SIO_BURST_GAP	11:7	R/W	Configures the length of burst gap in steps of approx. 1 ms. Burst gap can be disabled by setting SIO_CONFIG.SIO_BURST_GAP_DIS. 0: 1.05 ms burst gap. 1: 2.10 ms burst gap. 31: 33.55 ms burst gap.	0x00
SIO_SINGLE_SHOT	6	One-shot	Use this to output a single burst. Will be cleared by hardware when the burst has finished.	0x0
SIO_AUTO_REPEAT	5	R/W	Use this to output repeated bursts interleaved with burst gaps. Must be manually reset again to stop output of bursts.	0x0
SIO_LD_POLARITY	4	R/W	Polarity of the "Ld" signal 0: load signal is active low 1: load signal is active high	0x0

Table 450 • **Fields in SIO_CONFIG *(continued)***

Field Name	Bit	Access	Description	Default
SIO_PORT_WIDTH	3:2	R/W	Number of gpios pr. port. 0: 1 gpio pr. port. 1: 2 gpios pr. port. 2: 3 gpios pr. port. 3: 4 gpios pr. port.	0x0
SIO_REVERSE_OUTPUT	1	R/W	Reverse the output bitstream. The default order of the output bit stream is (displayed in transmitted order): (portN bit3, portN bit2, ..., port0 bit1, port0 bit0) The reverse order of the output bit stream is (displayed in transmitted order): (port0 bit0, port0 bit1, ..., portN bit2, portN bit3) 0 : Do not reverse. 1 : Reverse.	0x0
SIO_REVERSE_INPUT	0	R/W	Reverse the input bitstream. The default order of the input bit stream is (displayed in received order): (port0 bit0, port0 bit1, ..., portN bit2, portN bit3) The reverse order of the input bit stream is (displayed in received order): (portN bit3, portN bit2, ..., port0 bit1, port0 bit0) 0: Do not reverse. 1: Reverse.	0x0

7.9.10.7 DEVCPU_GCB:SIO_CTRL:SIO_CLOCK

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 1

Table 451 • **Fields in SIO_CLOCK**

Field Name	Bit	Access	Description	Default
SIO_CLK_FREQ	11:0	R/W	SIO controller clock frequency. Divides the 250MHz system clk with value of this field. E.g. the system clk is 250 MHz and this field is set to 10, the output frequency will be 25 MHz. 0 : Disable clock. 1 : Reserved, do not use. Others : Clock divider value.	0x000

7.9.10.8 DEVCPU_GCB:SIO_CTRL:SIO_INT_REG

Parent: DEVCPU_GCB:SIO_CTRL

Instances: 4

Table 452 • **Fields in SIO_INT_REG**

Field Name	Bit	Access	Description	Default
INT_REG	31:0	Sticky	Interrupt register. Bit n from all ports. Disabled gpios are always '0'. 0: No interrupt for given gpio. 1: Interrupt for given gpio. bit order (portM bit-n down to portM bit-0).	0x00000000

7.9.11 DEVCPU_GCB:FAN_CFG

Parent: DEVCPU_GCB

Instances: 1

Table 453 • **Registers in FAN_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
FAN_CFG	0x00000000	1	Configuration register for the fan controller	Page 384

7.9.11.1 DEVCPU_GCB:FAN_CFG:FAN_CFG

Parent: DEVCPU_GCB:FAN_CFG

Instances: 1

Table 454 • **Fields in FAN_CFG**

Field Name	Bit	Access	Description	Default
PWM_FREQ	5:3	R/W	Set the frequency of the PWM output 0: 25 kHz 1: 120 Hz 2: 100 Hz 3: 80 Hz 4: 60 Hz 5: 40 Hz 6: 20 Hz 7: 10 Hz	0x0
INV_POL	2	R/W	Define the polarity of the PWM output. 0: PWM is logic 1 when "on" 1: PWM is logic 0 when "on"	0x0

Table 454 • **Fields in FAN_CFG *(continued)***

Field Name	Bit	Access	Description	Default
GATE_ENA	1	R/W	Enable gating of the TACH input by the PWM output so that only TACH pulses received when PWM is "on" are counted. 0: Disabled 1: Enabled	0x0
PWM_OPEN_COL_ENA	0	R/W	Configure the PWM output to be open collector	0x0
DUTY_CYCLE	23:16	R/W	Define the duty cycle 0x00: Always "off" 0xFF: Always "on"	0x00

7.9.12 DEVCPU_GCB:FAN_STAT

Parent: DEVCPU_GCB

Instances: 1

Table 455 • **Registers in FAN_STAT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
FAN_CNT	0x00000000	1	TACH counter	Page 385

7.9.12.1 DEVCPU_GCB:FAN_STAT:FAN_CNT

Parent: DEVCPU_GCB:FAN_STAT

Instances: 1

Table 456 • **Fields in FAN_CNT**

Field Name	Bit	Access	Description	Default
FAN_CNT	15:0	R/O	Counts the number of rising edges on the TACH input. The counter is wrapping.	0x0000

7.9.13 DEVCPU_GCB:PTP_CFG

Parent: DEVCPU_GCB

Instances: 1

Configuration registers for PTP

Table 457 • **Registers in PTP_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PTP_MISC_CFG	0x00000000	1	Misc Configuration Register for PTP	Page 386
PTP_UPPER_LIMIT_CFG	0x00000004	1	Configuration register for master counter upper limit	Page 387
PTP_UPPER_LIMIT_1_TIME_ADJ_CFG	0x00000008	1	Configuration register for master counter upper limit one time adjustment	Page 387
PTP_SYNC_INTR_ENA_CFG	0x0000000C	1	Sync Interrupt enable register	Page 388
GEN_EXT_CLK_HIGH_PERIOD_CFG	0x00000010	1	Generated external clock high period configuration register	Page 388
GEN_EXT_CLK_LOW_PERIOD_CFG	0x00000014	1	Generated external clock low period configuration register	Page 389
GEN_EXT_CLK_CFG	0x00000018	1	Configuration register for synchronization of external clock to internal master sync.	Page 389
CLK_ADJ_CFG	0x0000001C	1	Configuration register for generated clock frequency adjustment	Page 390

7.9.13.1 DEVCPU_GCB:PTP_CFG:PTP_MISC_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Misc Configuration Register for PTP

Table 458 • **Fields in PTP_MISC_CFG**

Field Name	Bit	Access	Description	Default
EXT_SYNC_OUTP_SEL	7	R/W	Selection of external sync output. '0': External sync output specified by GEN_EXT_CLK is mapped to GPIO (IEEE 1588) '1': Master Timer Synchronization pulse is mapped to GPIO (IEEE 1588)	0x0
EXT_SYNC_OUTP_INV	6	R/W	Inversion of external sync output. '0': External sync output is not inverted '1': External sync output is inverted	0x0

Table 458 • **Fields in PTP_MISC_CFG *(continued)***

Field Name	Bit	Access	Description	Default
EXT_SYNC_OUTP_ENA	5	R/W	External sync output enable. 0': External sync output is disabled '1': External sync output is enabled	0x0
EXT_SYNC_INP_INV	3	R/W	Inversion of external sync input. '0': External sync input is not inverted '1': External sync input is inverted	0x0
EXT_SYNC_INP_ENA	2	R/W	External sync input enable. '0': External sync input is disabled '1': External sync input is enabled	0x0
EXT_SYNC_ENA	1	R/W	Enable synchronization to external sync. '0': Sync on external signal is disabled '1': Sync on external signal is enabled	0x0
PTP_ENA	0	R/W	Enable master counter. 0: Master counter disabled. 1: Master counter enabled.	0x0

7.9.13.2 DEVCPU_GCB:PTP_CFG:PTP_UPPER_LIMIT_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Configuration register for master counter upper limit

Table 459 • **Fields in PTP_UPPER_LIMIT_CFG**

Field Name	Bit	Access	Description	Default
PTP_UPPER_LIMIT	27:0	R/W	Counter value where the Master counter should be reset Units is time in clock_ticks. 1 clock tick is 4 ns, if system_clk is set to 250MHz.	0xEE6B27F

7.9.13.3 DEVCPU_GCB:PTP_CFG:PTP_UPPER_LIMIT_1_TIME_ADJ_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Configuration register for master counter upper limit one time adjustment

Table 460 • **Fields in PTP_UPPER_LIMIT_1_TIME_ADJ_CFG**

Field Name	Bit	Access	Description	Default
PTP_UPPER_LIMIT_1_TIME_ADJ_SHOT	31	One-shot	One time enable for PTP_UPPER_LIMIT_1_TIME_ADJ 0: Normal operation 1: Timer is adjusted by usage of PTP_UPPER_LIMIT_1_TIME_ADJ Bit is cleared by HW	0x0
PTP_UPPER_LIMIT_1_TIME_ADJ	27:0	R/W	Counter value where the Master counter should be reset Units is time in clock_ticks. 1 clock tick is 4 ns	0xEE6B27F

7.9.13.4 DEVCPU_GCB:PTP_CFG:PTP_SYNC_INTR_ENA_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Sync Interrupt enable register

Table 461 • **Fields in PTP_SYNC_INTR_ENA_CFG**

Field Name	Bit	Access	Description	Default
EXT_SYNC_CURRENT_TIME_ENA	1	R/W	Interrupt mask. Masks interrupt generation when a synchronization pulse is received on external sync input pin. '0': Interrupt is not generated '1': Interrupt is generated	0x0
SYNC_STAT_ENA	0	R/W	Interrupt mask. Masks interrupt generation when Master Timer generates a synchronization pulse. '0': Interrupt is not generated '1': Interrupt is generated	0x0

7.9.13.5 DEVCPU_GCB:PTP_CFG:GEN_EXT_CLK_HIGH_PERIOD_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Generated external clock high period configuration register

Table 462 • **Fields in GEN_EXT_CLK_HIGH_PERIOD_CFG**

Field Name	Bit	Access	Description	Default
GEN_EXT_CLK_HIGH_PERIOD	27:0	R/W	High period for generated external clock in system clock cycles. N: External clock signal is high for (N + 1) * system_clk cycles. E.g. N=999, system clock = 250 MHz which means 4 ns clk period. High Phase is 4 us.	0x00030D4

7.9.13.6 DEVCPU_GCB:PTP_CFG:GEN_EXT_CLK_LOW_PERIOD_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Generated external clock low period configuration register

Table 463 • **Fields in GEN_EXT_CLK_LOW_PERIOD_CFG**

Field Name	Bit	Access	Description	Default
GEN_EXT_CLK_LOW_PERIOD	27:0	R/W	Low period for generated external clock in system clock cycles. N: External clock signal is low for (N + 1) * system_clk cycles. E.g. N=999, system clock = 250 MHz, which means 4 ns clk period. Low Phase is 4 us.	0x00030D4

7.9.13.7 DEVCPU_GCB:PTP_CFG:GEN_EXT_CLK_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Configuration register for synchronization of external clock to internal master sync.

Table 464 • **Fields in GEN_EXT_CLK_CFG**

Field Name	Bit	Access	Description	Default
GEN_EXT_CLK_SYNC_ENA	2	R/W	Enable sync of generated external clock to PTP sync master. 0: Synchronization is disabled 1: Synchronization is enabled	0x0
GEN_EXT_CLK_ADJ_ENA	1	R/W	External clock frequency adjustment enable. 0: Adjustment Disabled 1: Adjustment Enabled	0x0

Table 464 • **Fields in GEN_EXT_CLK_CFG *(continued)***

Field Name	Bit	Access	Description	Default
GEN_EXT_CLK_ENA	0	R/W	Enable generated external clock. 0: Generated external clock disabled. 1: Generated external clock enabled	0x0

7.9.13.8 DEVCPU_GCB:PTP_CFG:CLK_ADJ_CFG

Parent: DEVCPU_GCB:PTP_CFG

Instances: 1

Configuration register for generated clock frequency adjustment

Table 465 • **Fields in CLK_ADJ_CFG**

Field Name	Bit	Access	Description	Default
CLK_ADJ_DIR	31	R/W	Clock frequency adjustment direction. 0: Positive adjustment. Every N cycles a 1 is added to the counter. => clock period is decrease, clock frequency is increased. 1: Negative adjustment. Every N cycles a 1 is subtracted from the counter. => clock period is increase, clock frequency is decreased.	0x0
CLK_ADJ_ENA	30	R/W	Clock frequency adjust enable. 0: Adjustment Disabled 1: Adjustment Enabled	0x0
CLK_ADJ_UPD	29	R/W	Defines when the updated adjustment value and direction takes effect. 0: updated values take immediate effect. 1: updated values take effect after the next sync pulse.	0x0
CLK_ADJ	27:0	R/W	Clock frequency adjust. N: Number of clock cycles after which the counter for the clock must be adjusted.	0x0004E1F

7.9.14 DEVCPU_GCB:PTP_STAT

Parent: DEVCPU_GCB

Instances: 1

Status registers for PTP

Table 466 • **Registers in PTP_STAT**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PTP_CURRENT_TIME_STAT	0x00000000	1	Current PTP master timer value	Page 391
EXT_SYNC_CURRENT_TIME_STAT	0x00000004	1	External sync current time status register	Page 391
PTP_EVT_STAT	0x00000008	1	Stick register for external sync current time status	Page 391

7.9.14.1 DEVCPU_GCB:PTP_STAT:PTP_CURRENT_TIME_STAT

Parent: DEVCPU_GCB:PTP_STAT

Instances: 1

Current PTP master timer value

Table 467 • **Fields in PTP_CURRENT_TIME_STAT**

Field Name	Bit	Access	Description	Default
PTP_CURRENT_TIME	27:0	R/O	Current master counter value. Unit is 4 ns.	0x0000000

7.9.14.2 DEVCPU_GCB:PTP_STAT:EXT_SYNC_CURRENT_TIME_STAT

Parent: DEVCPU_GCB:PTP_STAT

Instances: 1

External sync current time status register

Table 468 • **Fields in EXT_SYNC_CURRENT_TIME_STAT**

Field Name	Bit	Access	Description	Default
EXT_SYNC_CURRENT_TIME	27:0	R/O	Snapshot of current time, when a rising edge was seen in on the external sync input. Note: A new value is only captured when the associated sticky bit is not set. Current time in clock_ticks when the rising edge on the external sync input was seen. Note: This has to be adjusted by 3 clock ticks for synchronizing the signal to core clock.	0x0000000

7.9.14.3 DEVCPU_GCB:PTP_STAT:PTP_EVT_STAT

Parent: DEVCPU_GCB:PTP_STAT

Instances: 1

Stick register for external sync current time status

Table 469 • **Fields in PTP_EVT_STAT**

Field Name	Bit	Access	Description	Default
CLK_ADJ_UPD_STICKY	2	Sticky	Identifies if the adjust value update has already happened in case the adjustment is only allowed to take place at sync. If update is allowed to take place immediately the sticky bit is unused. 0: updated has not yet happened 1: updated has happened Bit is cleared by writing a '1' to this position.	0x0
EXT_SYNC_CURRENT_TIME_STICKY	1	Sticky	Sticky bit that indicates a synchronization pulse has been captured on external sync input pin. '0': No Timestamp has been captured '1': New Timestamp has been captured Bit is cleared by writing a '1' to this position.	0x0
SYNC_STAT	0	Sticky	Master timer has generated a synchronization pulse to the Slave Timers. '0': No master timer wrap happened. '1': Master timer wrap happened. Bit is cleared by writing a '1' to this position.	0x0

7.9.15 DEVCPU_GCB:PTP_TIMERS

Parent: DEVCPU_GCB

Instances: 1

Table 470 • **Registers in PTP_TIMERS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PTP_TOD_SECS	0x00000000	1	Time of day (Seconds)	Page 393
PTP_TOD_NANOSECS	0x00000004	1	Time of day (Nanoseconds)	Page 393
PTP_DELAY	0x00000008	1	Delay timer	Page 393
PTP_TIMER_CTRL	0x0000000C	1	Control register for PTP timers	Page 393

7.9.15.1 DEVCPU_GCB:PTP_TIMERS:PTP_TOD_SECS

Parent: DEVCPU_GCB:PTP_TIMERS

Instances: 1

Time of day (Seconds)

Table 471 • **Fields in PTP_TOD_SECS**

Field Name	Bit	Access	Description	Default
PTP_TOD_SECS	31:0	R/O	Seconds fraction of time of day timer at latch time (PTP_TIMER_CTRL.PTP_LATCH). Unit is seconds.	0x00000000

7.9.15.2 DEVCPU_GCB:PTP_TIMERS:PTP_TOD_NANOSECS

Parent: DEVCPU_GCB:PTP_TIMERS

Instances: 1

Time of day (Nanoseconds)

Table 472 • **Fields in PTP_TOD_NANOSECS**

Field Name	Bit	Access	Description	Default
PTP_TOD_NANOSECS	27:0	R/O	Nanoseconds fraction of time of day timer at latch time (PTP_TIMER_CTRL.PTP_LATCH). Unit is 4 ns.	0x0000000

7.9.15.3 DEVCPU_GCB:PTP_TIMERS:PTP_DELAY

Parent: DEVCPU_GCB:PTP_TIMERS

Instances: 1

Table 473 • **Fields in PTP_DELAY**

Field Name	Bit	Access	Description	Default
PTP_DELAY	31:0	R/O	Delay timer in Rx/Tx timestampers at latch time (PTP_TIMER_CTRL.PTP_LATCH). Unit is 4 ns.	0x00000000

7.9.15.4 DEVCPU_GCB:PTP_TIMERS:PTP_TIMER_CTRL

Parent: DEVCPU_GCB:PTP_TIMERS

Instances: 1

Control register for PTP timers

Table 474 • **Fields in PTP_TIMER_CTRL**

Field Name	Bit	Access	Description	Default
PTP_LATCH	2	One-shot	Latch time of day counter at the same time as the delay timer. 0: No action. 1: The time of day counter and the delay timer are latched at the same time. The results are stored in PTP_TOD_SECS, PTP_TOD_NANOSECS, and PTP_DELAY.	0x0
PTP_TIMER_ENA	1	R/W	Enable delay timer.	0x0
PTP_TOD_RST	0	One-shot	Reset the seconds fraction of the time of day counter.	0x0

7.9.16 DEVCPU_GCB:MEMITGR

Parent: DEVCPU_GCB

Instances: 1

The memory integrity monitor is associated with one or more memories with build-in parity-protection and/or error-correction logic. Through the integrity monitor, address locations of failures and/or corrections can be read out.

There may be more than one integrity controller in the design, also - not all memories has an associated controller.

Table 475 • **Registers in MEMITGR**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MEMITGR_CTRL	0x00000000	1	Monitor control	Page 394
MEMITGR_STAT	0x00000004	1	Monitor status	Page 395
MEMITGR_INFO	0x00000008	1	Memory indication	Page 396
MEMITGR_IDX	0x0000000C	1	Memory index	Page 397

7.9.16.1 DEVCPU_GCB:MEMITGR:MEMITGR_CTRL

Parent: DEVCPU_GCB:MEMITGR

Instances: 1

Table 476 • **Fields in MEMITGR_CTRL**

Field Name	Bit	Access	Description	Default
ACTIVATE	0	One-shot	Setting this field transitions the integrity monitor between operating modes. Transitioning between modes takes time, this field remains set until the new mode is reached. During this time the monitor also reports busy (MEMITGR_MODE.MODE_BUSY is set). From IDLE (MEMITGR_MODE.MODE_IDLE is set) the monitor can transition into either DETECT or LISTEN mode, the DETECT mode is entered if a memory reports an indication - the LISTEN mode is entered if no indications are reported. The first time after reset the monitor will not detect indications, that is; it will transition directly from IDLE to LISTEN mode. From DETECT (MEMITGR_MODE.MODE_DETECT is set) the monitor can transition into either DETECT or LISTEN mode, the DETECT mode is entered if more indications are reported - the LISTEN mode is entered if no more indications are reported. From LISTEN (MEMITGR_MODE.MODE_LISTEN is set) the monitor can transition into IDLE mode.	0x0

7.9.16.2 DEVCPU_GCB:MEMITGR:MEMITGR_STAT

Parent: DEVCPU_GCB:MEMITGR

Instances: 1

Table 477 • **Fields in MEMITGR_STAT**

Field Name	Bit	Access	Description	Default
INDICATION	4	R/O	If this field is set then there is an indication from one of the memories that needs to be analyzed. An indication is either a parity detection or an error correction. This field is only set when the monitor is in LISTEN mode (MEMITGR_MODE.MODE_LISTEN is set), in all other states (including BUSY) this field returns 0.	0x0
MODE_LISTEN	3	R/O	This field is set when the monitor is in LISTEN mode, during listen mode the monitor continually check for parity/correction indications from the memories.	0x0
MODE_DETECT	2	R/O	This field is set when the monitor is in DETECT mode, during detect mode the MEMITGR_INFO register contains valid information about one indication.	0x0
MODE_IDLE	1	R/O	This field is set when the monitor is in IDLE mode.	0x1
MODE_BUSY	0	R/O	The busy signal is a copy of the MEMITGR_CTRL.ACTIVATE field, see description of that field for more information about the different states/modes of the monitor.	0x0

7.9.16.3 DEVCPU_GCB:MEMITGR:MEMITGR_INFO

Parent: DEVCPU_GCB:MEMITGR

Instances: 1

This field is only valid when the monitor is in the DETECT (MEMITGR_MODE.MODE_DETECT is set) mode.

Table 478 • **Fields in MEMITGR_INFO**

Field Name	Bit	Access	Description	Default
MEM_ERR	31	R/O	This field is set if the monitor has detected a parity indication (or an unrecoverable correction).	0x0
MEM_COR	30	R/O	This field is set if the monitor has detected a correction.	0x0

Table 478 • **Fields in MEMITGR_INFO *(continued)***

Field Name	Bit	Access	Description	Default
MEM_ERR_OVF	29	R/O	This field is set if the monitor has detected a parity indication (or an unrecoverable correction) for which the address has not been recorded. If MEMITGR_INFO.MEM_ERR is set then there has been more than one indication, then only the address of the newest indication has been kept. If MEMITGR_INFO.MEM_ERR is cleared then an indication has occurred for which the address could not be stored, this is a very rare situation that can only happen if an indication is detected just as the memory is talking to the monitor.	0x0
MEM_COR_OVF	28	R/O	This field is set if the monitor has correction indication for which the address has not been recorded. If MEMITGR_INFO.MEM_ERR is set then there has also been a parity indication (or an unrecoverable correction) which takes priority over correction indications. If MEMITGR_INFO.MEM_ERR is cleared and MEMITGR_INFO.MEM_COR is set then there has been more than one correction indication, then only the address of the newest correction indication has been kept. If MEMITGR_INFO.MEM_ERR and MEMITGR_INFO.MEM_COR is both cleared then a correction indication has occurred for which the address could not be stored, this is a very rare situation that can only happen if an indication is detected just as the memory is talking to the monitor.	0x0
MEM_ADDR	27:0	R/O	This field is valid only when MEMITGR.MEM_ERR or MEMITGR.MEM_COR is set.	0x0000000

7.9.16.4 DEVCPU_GCB:MEMITGR:MEMITGR_IDX

Parent: DEVCPU_GCB:MEMITGR

Instances: 1

This field is only valid when the monitor is in the DETECT (MEMITGR_MODE.MODE_DETECT is set) mode.

Table 479 • **Fields in MEMITGR_IDX**

Field Name	Bit	Access	Description	Default
MEM_IDX	15:0	R/O	This field contains a unique index for the memory for which info is currently provided in MEMITGR_MEMINFO. Indexes are counted from 1 (not 0).	0x0000

7.10 DEVCPU_QS

Table 480 • **Register Groups in DEVCPU_QS**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
XTR	0x00000000	1	Frame Extraction Related Registers	Page 398
INJ	0x00000034	1	Frame Injection Related Registers	Page 401

7.10.1 DEVCPU_QS:XTR

Parent: DEVCPU_QS

Instances: 1

CPU queue system registers related to frame extraction.

Table 481 • **Registers in XTR**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
XTR_FRM_PRUNING	0x00000000	2 0x00000004	Frame Pruning	Page 398
XTR_GRP_CFG	0x00000008	2 0x00000004	Group Configuration	Page 399
XTR_MAP	0x00000010	2 0x00000004	Map Queue to Group	Page 399
XTR_RD	0x00000018	2 0x00000004	Read from Group FIFO	Page 400
XTR_QU_FLUSH	0x00000028	1	Queue Flush	Page 400
XTR_DATA_PRESENT	0x0000002C	1	Extraction Status	Page 401

7.10.1.1 DEVCPU_QS:XTR:XTR_FRM_PRUNING

Parent: DEVCPU_QS:XTR

Instances: 2

Table 482 • **Fields in XTR_FRM_PRUNING**

Field Name	Bit	Access	Description	Default
PRUNE_SIZE	7:0	R/W	Extracted frames for the corresponding queue are pruned PRUNE_SIZE 32-bit words. Note : PRUNE_SIZE is the frame data size, including the IFH. 0 : No pruning 1: Frames extracted are pruned to 8 bytes. 2: Frames extracted are pruned to 12 bytes. . '0xFF': Frames extracted are pruned to 1024 bytes	0x00

7.10.1.2 DEVCPU_QS:XTR:XTR_GRP_CFG

Parent: DEVCPU_QS:XTR

Instances: 2

Table 483 • **Fields in XTR_GRP_CFG**

Field Name	Bit	Access	Description	Default
BYTE_SWAP	0	R/W	Controls - per extraction group - the byte order of the data word read in XTR_RD. When using little-Endian mode, then the first byte of the destination MAC address is placed at XTR_RD[7:0]. When using network-order, then the first byte of the destination MAC address is placed at XTR_RD[31:25]. 0: Network-order (big-endian). 1: Little-endian.	0x1
STATUS_WORD_POS	1	R/W	Select order of last data and status words. 0: Status just before last data. 1: Status just after last data.	0x1

7.10.1.3 DEVCPU_QS:XTR:XTR_MAP

Parent: DEVCPU_QS:XTR

Instances: 2

Table 484 • **Fields in XTR_MAP**

Field Name	Bit	Access	Description	Default
GRP	4	R/W	Maps a queue to a certain extractor group	0x0
MAP_ENA	0	R/W	Enables extraction of a queue. Disabling of extraction for a queue happens upon next frame boundary. That is, a frame being extracted at the time of queue disabling is not affected. '0' : Queue is not mapped to a queue group (queue is disabled) '1' : Queue is mapped to the queue group defined by XTR::XTR_MAP (queue is enabled)	0x0

7.10.1.4 DEVCPU_QS:XTR:XTR_RD

Parent: DEVCPU_QS:XTR

Instances: 2

Table 485 • **Fields in XTR_RD**

Field Name	Bit	Access	Description	Default
DATA	31:0	R/O	Frame Data. Read from this register to obtain the next 32 bits of the frame data currently stored in the CPU queue system. Each read must check for the special values "0x8000000n", 0<=n<=7, as seen below; Note that when a status word is presented, it can be put just before or just after the last data (XTR_GRP_CFG). n=0-3: EOF. Unused bytes in last is 'n'. n=4 : EOF, but truncated. n=5 : EOF Aborted. Frame invalid. n=6 : Escape. Next read is packet data. n=7 : Data not ready for reading out.	0x00000000

7.10.1.5 DEVCPU_QS:XTR:XTR_QU_FLUSH

Parent: DEVCPU_QS:XTR

Instances: 1

Table 486 • **Fields in XTR_QU_FLUSH**

Field Name	Bit	Access	Description	Default
FLUSH	1:0	R/W	Enable software flushing of a CPU queue. Note that before flushing the a CPU queue it may be necessary to stop the OQS from sending data into the CPU queues. '0': No action '1': Do CPU queue flushing	0x0

7.10.1.6 DEVCPU_QS:XTR:XTR_DATA_PRESENT

Parent: DEVCPU_QS:XTR

Instances: 1

Table 487 • **Fields in XTR_DATA_PRESENT**

Field Name	Bit	Access	Description	Default
DATA_PRESENT	3:2	R/O	When a frame, which should be forwarded to software has been received by the CPU queue system, the corresponding bit is set. When software has extracted all frames from a CPU queue the bit is cleared, i.e. the bit remains set as long as at least one byte of frame data for the corresponding queue is present in the queue system. Note : If a queue isn't map to a group DATA_PRESENT will be '0' '0': No data available for this CPU queue '1': At least one frame is available for this cpu queue	0x0
DATA_PRESENT_GRP	1:0	R/O	When a queue group has a frame present, the bit corresponding to the queue group number gets set. It remains set until all frame data have been extracted. '0': No frames available for this CPU queue group. '1': At least one frame is available for this CPU queue group.	0x0

7.10.2 DEVCPU_QS:INJ

Parent: DEVCPU_QS

Instances: 1

CPU queue system registers related to frame injection.

Table 488 • **Registers in INJ**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
INJ_GRP_CFG	0x00000000	2 0x00000004	Group Configuration	Page 402
INJ_WR	0x00000008	2 0x00000004	Write to Group FIFO	Page 402
INJ_CTRL	0x00000010	2 0x00000004	Injection Control	Page 402
INJ_STATUS	0x00000018	1	Injection Status	Page 403
INJ_ERR	0x0000001C	2 0x00000004	Injection Errors	Page 404

7.10.2.1 DEVCPU_QS:INJ:INJ_GRP_CFG

Parent: DEVCPU_QS:INJ

Instances: 2

Table 489 • **Fields in INJ_GRP_CFG**

Field Name	Bit	Access	Description	Default
BYTE_SWAP	8	R/W	Controls - per injection group - the byte order of the data word in INJ_WR. 0: Network-order (big-endian). 1: Little-endian.	0x1

7.10.2.2 DEVCPU_QS:INJ:INJ_WR

Parent: DEVCPU_QS:INJ

Instances: 2

Table 490 • **Fields in INJ_WR**

Field Name	Bit	Access	Description	Default
DATA	31:0	R/W	Frame Write.Write to this register inject the next 32 bits of the frame data currently injected into the chip.	0x00000000

7.10.2.3 DEVCPU_QS:INJ:INJ_CTRL

Parent: DEVCPU_QS:INJ

Instances: 2

Table 491 • **Fields in INJ_CTRL**

Field Name	Bit	Access	Description	Default
GAP_SIZE	28:21	R/W	It is allowed to inject a number of "dummy" bytes in front of a frame before the actual frame data. The number of bytes that should be discarded is specified with this field.	0x00
ABORT	20	One-shot	Abort frame currently injected. Write: '0': No action '1': Frame currently injected is aborted (Bit is automatically cleared)	0x0
EOF	19	One-shot	EOF must be set before last data of a frame is injected. '0': No action '1': Next word is the last word of the frame injected	0x0
SOF	18	One-shot	SOF must be set before injecting a frame. Write: '0': No action '1': Start of new frame injection Read: '0': First data word has been moved to the IQS. '1': First data word has not been moved to the IQS.	0x0
VLD_BYTES	17:16	R/W	The number of valid bytes in the last word must be set before last data of a frame is injected. 0: Bits 31-0 in the last word are valid. 1: Bits 31-24 in the last word are valid. 2: Bits 31-16 in the last word are valid. 3: Bits 31-7 in the last word are valid. This encoding applies when big-endian is used for INJ_WR.	0x0

7.10.2.4 DEVCPU_QS:INJ:INJ_STATUS

Parent: DEVCPU_QS:INJ

Instances: 1

Table 492 • **Fields in INJ_STATUS**

Field Name	Bit	Access	Description	Default
WMARK_REACHED	5:4	R/O	Before the CPU injects a frame, software may check if the input queue has reached high watermark. If the watermark in the IQS has been reached this bit will be set. '0': Input queue has not reached high watermark '1': Input queue has reached high watermark, and frames injected may be dropped due to buffer overflow.	0x0
FIFO_RDY	3:2	R/O	When '1' the injector group's FIFO is ready for additional data written through the INJ_WR register. '0': The injector group cannot accept additional data. '1': The injector group is able to accept additional data.	0x0
INJ_IN_PROGRESS	1:0	R/O	When '1' the injector group is in the process of receiving a frame, and at least one write to INJ_WR remains before the frame is forwarded to the front ports. When '0' the injector group is waiting for an initiation of a frame injection. '0': A frame injection is not in progress. '1': A frame injection is in progress.	0x0

7.10.2.5 DEVCPU_QS:INJ:INJ_ERR

Parent: DEVCPU_QS:INJ

Instances: 2

The bits in this register are cleared by writing a '1' to the relevant bit-positions.

Table 493 • **Fields in INJ_ERR**

Field Name	Bit	Access	Description	Default
ABORT_ERR_STICKY	1	Sticky	If the CPU aborts an on-going frame injection by a '1' to INJ_CTRL::ABORT, the on-going frame injection is aborted and the injection controller prepares for a new injection. This situation could indicate a software error. '0': No error. '1': Previous frame was aborted with a write to INJ_CTRL::ABORT or due to an internal error.	0x0
WR_ERR_STICKY	0	Sticky	If the CPU writes to INJ_WR without having initiated a frame injection with INJ_CTRL, this sticky bit gets set. '0': No error. '1': Erroneous write to INJ_WR has been made.	0x0

7.11 DEVCPU_PI

Table 494 • **Register Groups in DEVCPU_PI**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
PI	0x00000000	1	Registers for the parallel interface	Page 405

7.11.1 DEVCPU_PI:PI

Parent: DEVCPU_PI

Instances: 1

Registers for the parallel interface. These registers are only reachable via the parallel interface. None of the settings in these register applies to anything else than the parallel interface when it operates in slave mode.

Table 495 • **Registers in PI**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PI_CTRL	0x00000000	1	Control of PI accesses	Page 406
PI_CFG	0x00000004	1	Configuration of PI accesses	Page 407
PI_STAT	0x00000008	1	Status for PI accesses	Page 408

Table 495 • **Registers in PI *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PI_MODE	0x0000000C	1	Mode of the parallel interface	Page 408
PI_SLOW_DATA	0x00000010	2 0x00000004	Slow Data	Page 409

7.11.1.1 DEVCPU_PI:PI:PI_CTRL

Parent: DEVCPU_PI:PI

Instances: 1

Table 496 • **Fields in PI_CTRL**

Field Name	Bit	Access	Description	Default
SLOW_IDX	1	R/W	Use this field to select a destination index register for slow access results. By using different indexes it is possible to have more than one outstanding slow-access at any given time. This may be utilized by interrupt routines, just remember that an interrupt routine should restore this register to its previous value before exiting the routine. Note: If multiple levels of interrupts is required, more than there are slow-access-indexes, then it is possible for the high-priority interrupt routine to use normal-accesses (by disabling slow-access via SLOW_ENA), then the PI will be occupied while reading - but that access will not interfere with any ongoing slow accesses.	0x0

Table 496 • **Fields in PI_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
SLOW_ENA	0	R/W	Set this field to enable slow accesses. For a normal accesses ("slow" is not enabled) the PI access will be stalled until data is ready to be read out of the device. When slow-data is enabled then a read from any register (except these PI registers) will return immediately - the read will then be processed will the external CPU is free to do something else. The field SLOW_IN_PROGRESS indicates when slow accesses are done, once the access has completed the result can be read from the SLOWDATA register at the index corresponding to the SLOW_IDX that was used when the access was initiated. When slow access is enabled, the the data which is returned when the access is started is actually the result from the corresponding SLOWDATA register, this means that it is possible to do "back-to-back" slow accesses, every time a new slow-access is started - the result of the old access is read out.	0x0

7.11.1.2 DEVCPU_PI:PI:PI_CFG

Parent: DEVCPU_PI:PI

Instances: 1

Table 497 • **Fields in PI_CFG**

Field Name	Bit	Access	Description	Default
BUSY_FEEDBACK_ENA	5	R/W	Set this field to enable busy feedback to the physical PI. When set origin-busy causes the physical interface to delay sampling of data (and generating of ndone).	0x1
WR_ACK_ENA	4	R/W	Set this field to hold write accesses until the write-request has reached the target. By default write accesses is completed as soon as the write is detected (by the PI).	0x0

Table 497 • **Fields in PI_CFG *(continued)***

Field Name	Bit	Access	Description	Default
PI_WAIT	3:0	R/W	Configures the delay from detecting asserted PI_nCS until the chip samples the control signals. The delay is configured in steps of 8ns. This field should be lowered to match the performance and interface timing of the external CPU. This field can be set to zero, in that case the control signals will be sampled immediately when asserted PI_nCS is detected.	0xD

7.11.1.3 DEVCPU_PI:PI:PI_STAT

Parent: DEVCPU_PI:PI

Instances: 1

Table 498 • **Fields in PI_STAT**

Field Name	Bit	Access	Description	Default
ORIGIN_ERR_STICKY	6	Sticky	This field is set when accessing an unknown target or an unknown address inside a known target.	0x0
SLOW_BUSY_STICKY	5:4	Sticky	This field is set if a new access has been started on a busy slow index (each bit in this field correspond to a slow index).	0x0
SLOW_BUSY	3:2	R/O	This field indicates if a slow access is in progress. When a bit is set in this field, the corresponding slow access index is currently occupied by an access.	0x0
SLOW_DONE	1:0	R/O	This field indicates if slow-data is pending: When a bit is set in this field, the corresponding slow access index contains unread data. The bits in this field is cleared when the corresponding slow-data index is read.	0x0

7.11.1.4 DEVCPU_PI:PI:PI_MODE

Parent: DEVCPU_PI:PI

Instances: 1

In order for the configuration to work independently of the current transfer mode; The 8 low bits of this register must be mirrored throughout the entire 32-bit dataword when writing. Also the configuration must be written twice, this ensures that an 8-bit interface correctly receives configuration from a 16-bit external CPU.

For example: For default nDone polarity, big-endian mode, auto-address mode, and 16-bit data bus the low 8-bit of this register will be 0x0A. Then the actual 32-bit write value is 0x0A0A0A0A.

Table 499 • **Fields in PI_MODE**

Field Name	Bit	Access	Description	Default
DATA_BUS_WID	3	R/W	This field configures the data-width of the PI interface. Either 8-bit or 16-bit data-bus is supported. By default the width is 8-bit, thus a 16-bit processor has to configure this field to use the entire bus width. 0 : Data bus is 8 bit wide 1 : Data bus is 16 bit wide	0x0
ADDR_AUTO_DIS	2	R/W	Disables automatic tracking of sub-word addresses. By default the low two address bits are not needed, the device keeps track of addresses inside 32-bit words and aligns data accordingly.	0x0
ENDIAN	1	R/W	Configure the byte order mode on the parallel interface. 0 : Little Endian 1 : Big Endian	0x0
NDONE_POL	0	R/W	Configures the nDone pin's active level. 0 : nDone pin is active when low 1 : nDone pin is active when high	0x0

7.11.1.5 DEVCPU_PI:PI:PI_SLOW_DATA

Parent: DEVCPU_PI:PI

Instances: 2

Table 500 • **Fields in PI_SLOW_DATA**

Field Name	Bit	Access	Description	Default
PI_SLOW_DATA	31:0	R/W	When a slow access is done, the result is stored in this register.	0x00000000

7.12 HSIO

Register Collection for Control of Macros (SERDES1G, SERDES6G, LCPLL)

Table 501 • **Register Groups in HSIO**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
PLL5G_CFG	0x00000000	1	PLL5G Configuration Registers	Page 410
PLL5G_STATUS	0x00000018	1	PLL5G Status Registers	Page 411
RCOMP_STATUS	0x00000024	1	RCOMP Status Registers	Page 412
SYNC_ETH_CFG	0x00000028	1	SYNC_ETH Configuration Registers	Page 413
SERDES1G_ANA_CFG	0x0000002C	1	SERDES1G Analog Configuration Registers	Page 413
SERDES1G_DIG_CFG	0x00000048	1	SERDES1G Digital Configuration Register	Page 419
SERDES1G_DIG_STATUS	0x0000005C	1	SERDES1G Digital Status Register	Page 420
MCB_SERDES1G_CFG	0x00000060	1	MCB SERDES1G Configuration Register	Page 421
SERDES6G_ANA_CFG	0x00000064	1	SERDES6G Analog Configuration Registers	Page 422
SERDES6G_DIG_CFG	0x00000088	1	SERDES6G Digital Configuration Registers	Page 428
MCB_SERDES6G_CFG	0x000000AC	1	MCB SERDES6G Configuration Register	Page 429

7.12.1 HSIO:PLL5G_CFG

Parent: HSIO

Instances: 1

Configuration register set for PLL5G.

Table 502 • **Registers in PLL5G_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PLL5G_CFG0	0x00000000	1	PLL5G Configuration 0	Page 410

7.12.1.1 HSIO:PLL5G_CFG:PLL5G_CFG0

Parent: HSIO:PLL5G_CFG

Instances: 1

Configuration register 0 for PLL5G

Table 503 • **Fields in PLL5G_CFG0**

Field Name	Bit	Access	Description	Default
RESERVED	5:0	R/W	Must be set to its default.	0x05
CPU_CLK_DIV	11:6	R/W	Setting for CPU clock divider 5: 250 MHz 6: 416.66 MHz 14: 312.50 MHz Others: Reserved	0x05
RESERVED	12	R/W	Must be set to its default.	0x1
RESERVED	13	R/W	Must be set to its default.	0x1
RESERVED	14	R/W	Must be set to its default.	0x1
RESERVED	15	R/W	Must be set to its default.	0x1
RESERVED	17:16	R/W	Must be set to its default.	0x2
RESERVED	22:18	R/W	Must be set to its default.	0x0D
RESERVED	26:23	R/W	Must be set to its default.	0x7
RESERVED	28	R/W	Must be set to its default.	0x1
RESERVED	29	R/W	Must be set to its default.	0x1
RESERVED	30	R/W	Must be set to its default.	0x1

7.12.2 HSIO:PLL5G_STATUS

Parent: HSIO

Instances: 1

Status register set for PLL5G.

Table 504 • **Registers in PLL5G_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PLL5G_STATUS0	0x00000000	1	PLL5G Status 0	Page 411

7.12.2.1 HSIO:PLL5G_STATUS:PLL5G_STATUS0

Parent: HSIO:PLL5G_STATUS

Instances: 1

Status register 0 for the PLL5G

Table 505 • **Fields in PLL5G_STATUS0**

Field Name	Bit	Access	Description	Default
LOCK_STATUS	0	R/O	PLL lock status 0: not locked, 1: locked	0x0

Table 505 • **Fields in PLL5G_STATUS0 *(continued)***

Field Name	Bit	Access	Description	Default
READBACK_DATA	8:1	R/O	RCPLL Interface to read back internal data of the FSM.	0x00
CALIBRATION_DONE	9	R/O	RCPLL Flag that indicates that the calibration procedure has finished.	0x0
CALIBRATION_ERR	10	R/O	RCPLL Flag that indicates errors that may occur during the calibration procedure.	0x0
OUT_OF_RANGE_ERR	11	R/O	RCPLL Flag that indicates a out of range condition while NOT in calibration mode.	0x0
RANGE_LIM	12	R/O	RCPLL Flag range limiter signaling	0x0

7.12.3 HSIO:RCOMP_STATUS

Parent: HSIO

Instances: 1

Status register set for RCOMP.

Table 506 • **Registers in RCOMP_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RCOMP_STATUS	0x00000000	1	RCOMP Status	Page 412

7.12.3.1 HSIO:RCOMP_STATUS:RCOMP_STATUS

Parent: HSIO:RCOMP_STATUS

Instances: 1

Status register bits for the RCOMP

Table 507 • **Fields in RCOMP_STATUS**

Field Name	Bit	Access	Description	Default
BUSY	12	R/O	Resistor comparison activity 0: resistor measurement finished or inactive 1: resistor measurement in progress	0x0
DELTA_ALERT	7	R/O	Alarm signal if rcomp isn't best choice anymore 0: inactive 1: active	0x0

Table 507 • **Fields in RCOMP_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
RCOMP	3:0	R/O	Measured resistor value 0: maximum resistance value 15: minimum resistance value	0x0

7.12.4 HSIO:SYNC_ETH_CFG

Parent: HSIO

Instances: 1

Configuration register set for SYNC_ETH.

Table 508 • **Registers in SYNC_ETH_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SYNC_ETH_CFG	0x00000000	1	SYNC ETH Configuration 0	Page 413

7.12.4.1 HSIO:SYNC_ETH_CFG:SYNC_ETH_CFG

Parent: HSIO:SYNC_ETH_CFG

Instances: 1

Selection register for SYNC_ETH.

Table 509 • **Fields in SYNC_ETH_CFG**

Field Name	Bit	Access	Description	Default
SEL_RECO_CLK_B	5:4	R/W	Select recovered clock divider B 0: No clock dividing 1: Divide clock by 5 2: Divide clock by 4 3: Reserved	0x0
SEL_RECO_CLK_A	3:2	R/W	Select recovered clock divider A 0: No clock dividing 1: Divide clock by 5 2: Divide clock by 4 3: Reserved	0x0
RECO_CLK_B_ENA	1	R/W	Enable recovered clock B pad 0: Disable (high-impedance) 1: Enable (output recovered clock)	0x0
RECO_CLK_A_ENA	0	R/W	Enable recovered clock A pad 0: Disable (high-impedance) 1: Enable (output recovered clock)	0x0

7.12.5 HSIO:SERDES1G_ANA_CFG

Parent: HSIO

Instances: 1

Configuration register set for SERDES1G (analog parts)

Table 510 • **Registers in SERDES1G_ANA_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SERDES1G_DES_CFG	0x00000000	1	SERDES1G Deserializer Cfg	Page 414
SERDES1G_IB_CFG	0x00000004	1	SERDES1G Input Buffer Cfg	Page 415
SERDES1G_OB_CFG	0x00000008	1	SERDES1G Output Buffer Cfg	Page 416
SERDES1G_SER_CFG	0x0000000C	1	SERDES1G Serializer Cfg	Page 417
SERDES1G_COMMON_CFG	0x00000010	1	SERDES1G Common Cfg	Page 418
SERDES1G_PLL_CFG	0x00000014	1	SERDES1G Pll Cfg	Page 419

7.12.5.1 HSIO:SERDES1G_ANA_CFG:SERDES1G_DES_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for SERDES1G deserializer

Table 511 • **Fields in SERDES1G_DES_CFG**

Field Name	Bit	Access	Description	Default
DES_PHS_CTRL	16:13	R/W	Control of phase regulator logic. Bit 3 must always be set to 0. Optimal settings for bits 2:0 are 4 through 7; recommended setting is 6. 0: Disabled 1: Enabled with 99 ppm limit 2: Enabled with 202 ppm limit 3: Enabled with 485 ppm limit 4: Enabled if corresponding PCS is in sync with 50 ppm limit 5: Enabled if corresponding PCS is in sync with 99 ppm limit 6: Enabled if corresponding PCS is in sync with 202 ppm limit 7: Enabled if corresponding PCS is in sync with 485 ppm limit	0x0
RESERVED	12:11	R/W	Must be set to its default.	0x0

Table 511 • **Fields in SERDES1G_DES_CFG *(continued)***

Field Name	Bit	Access	Description	Default
DES_MBTR_CTRL	10:8	R/W	Des phase control for 180 degrees deadlock block mode of operation 000: Depending on density of input pattern 001: Active until PCS has synchronized 010: Depending on density of input pattern until PCS has synchronized 011: Never 100: Always All other settings are reserved.	0x0
DES_BW_ANA	7:5	R/W	Bandwidth selection for proportional path of CDR loop. 0: Reserved 1: Reserved 2: Reserved 3: Reserved 4: Divide by 16 5: Divide by 32 6: Divide by 64 7: Divide by 128	0x0
RESERVED	4	R/W	Must be set to its default.	0x0
DES_BW_HYST	3:1	R/W	Selection of time constant for integrative path of CDR loop. 0: Reserved 1: Reserved 2: Reserved 3: Divide by 16 4: Divide by 32 5: Divide by 64 6: Divide by 128 7: Divide by 256	0x0
RESERVED	0	R/W	Must be set to its default.	0x0

7.12.5.2 HSIO:SERDES1G_ANA_CFG:SERDES1G_IB_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for SERDES1G input buffer

Table 512 • **Fields in SERDES1G_IB_CFG**

Field Name	Bit	Access	Description	Default
IB_FX100_ENA	27	R/W	Switches signal detect circuit into low frequency mode, must be used in fx100 mode	0x0
IB_DET_LEV	20:19	R/W	Detect thresholds. 00: 159-189mVppd 01: 138-164mVppd 10: 109-124mVppd 11: 74-89mVppd	0x0

Table 512 • **Fields in SERDES1G_IB_CFG *(continued)***

Field Name	Bit	Access	Description	Default
IB_HYST_LEV	14	R/W	Input buffer hysteresis levels. 0: 59-79mV 1: 81-124mV	0x0
IB_ENA_CMV_TERM	13	R/W	Enable common mode voltage termination 0: Low termination (V_{DD_A} × 0.7) 1: High termination (V_{DD_A})	0x0
IB_ENA_DC_COUPLING	12	R/W	Enable dc-coupling of input signal 0: Disable 1: Enable	0x0
IB_ENA_DETLEV	11	R/W	Enable detect level circuit 0: Disable 1: Enable	0x0
IB_ENA_HYST	10	R/W	Enable hysteresis for input signal. Hysteresis can only be enabled if DC offset compensation is disabled. 0: Disable 1: Enable	0x0
IB_ENA_OFFSET_COMP	9	R/W	Enable offset compensation of input stage. This bit must be disabled to enable hysteresis (bit 10). 0: Disable 1: Enable	0x0
IB_EQ_GAIN	8:6	R/W	Selects weighting between AC and DC input path. 0: Reserved 1: Reserved 2: 0dB (recommended value) 3: 1.5dB 4: 3dB 5: 6dB 6: 9dB 7: 12.5dB	0x0
IB_SEL_CORNER_FREQ	5:4	R/W	Corner frequencies of AC path. 0: 1.3GHz 1: 1.5GHz 2: 1.6GHz 3: 1.8GHz	0x0
IB_RESISTOR_CTRL	3:0	R/W	Resistor control. Value must be taken from RCOMP_STATUS.RCOMP.	0x0

7.12.5.3 HSIO:SERDES1G_ANA_CFG:SERDES1G_OB_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for SERDES1G output buffer

Table 513 • **Fields in SERDES1G_OB_CFG**

Field Name	Bit	Access	Description	Default
OB_SLP	18:17	R/W	Slope / slew rate control. 0: 45ps 1: 85ps 2: 105ps 3: 115ps	0x0
OB_AMP_CTRL	16:13	R/W	Amplitude control, in steps of 50mVppd. 0: 0.4Vppd 15: 1.1Vppd	0x0
RESERVED	12:10	R/W	Must be set to its default.	0x2
RESERVED	9:8	R/W	Must be set to its default.	0x0
OB_VCM_CTRL	7:4	R/W	Common mode voltage control. 0: Reserved 1: 440mV 2: 480mV 3: 460mV 4: 530mV 5: 500mV 6: 570mV 7: 550mV	0x4
OB_RESISTOR_CTRL	3:0	R/W	Resistor control. Value must be taken from RCOMP_STATUS.RCOMP.	0x0

7.12.5.4 HSIO:SERDES1G_ANA_CFG:SERDES1G_SER_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for SERDES1G serializer

Table 514 • **Fields in SERDES1G_SER_CFG**

Field Name	Bit	Access	Description	Default
SER_IDLE	9	R/W	Invert output D0b for idle-mode of OB 0: Non-inverting 1. Inverting	0x0
SER_DEEMPH	8	R/W	Invert and delays (one clk cycle) output D1 for de-emphasis of OB 0: Non-inverting and non-delaying 1: Inverting and delaying	0x0
RESERVED	7:4	R/W	Must be set to its default.	0x0
SER_ENHYS	3	R/W	Enable hysteresis for phase alignment 0: Disable hysteresis 1: Enable hysteresis	0x0

Table 514 • **Fields in SERDES1G_SER_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SER_BIG_WIN	2	R/W	Use wider window for phase alignment 0: Use small window for low jitter (100 to 200ps) 1: Use wide window for higher jitter (150 to 300 ps)	0x0
SER_EN_WIN	1	R/W	Enable window for phase alignment 0: Disable window 1: Enable window	0x0
SER_ENALI	0	R/W	Enable phase alignment 0: Disable phase alignment 1: Enable phase alignment	0x0

7.12.5.5 HSIO:SERDES1G_ANA_CFG:SERDES1G_COMMON_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for common SERDES1G functions Note: When enabling the facility loop (ena_floop) also the phase alignment in the serializer has to be enabled and configured adequate.

Table 515 • **Fields in SERDES1G_COMMON_CFG**

Field Name	Bit	Access	Description	Default
SYS_RST	31	R/W	System reset (low active) 0: Apply reset (not self-clearing) 1: Reset released	0x0
SE_AUTO_SQUELCH_B_ENA	22	R/W	Enable auto-squelching for sync. ethernet bus B 0: Disable 1: Enable	0x0
SE_AUTO_SQUELCH_A_ENA	21	R/W	Enable auto-squelching for sync. ethernet bus A 0: Disable 1: Enable	0x0
RECO_SEL_B	20	R/W	Select recovered clock of this lane on sync. ethernet bus B 0: Lane not selected 1: Lane selected	0x0
RECO_SEL_A	19	R/W	Select recovered clock of this lane on sync. ethernet bus A 0: Lane not selected 1: Lane selected	0x0
ENA_LANE	18	R/W	Enable lane 0: Disable lane 1: Enable line	0x0
RESERVED	17:12	R/W	Must be set to its default.	0x00

Table 515 • **Fields in SERDES1G_COMMON_CFG *(continued)***

Field Name	Bit	Access	Description	Default
ENA_ELOOP	11	R/W	Enable equipment loop 0: Disable 1: Enable	0x0
ENA_FLOOP	10	R/W	Enable facility loop 0: Disable 1: Enable	0x0
RESERVED	9:8	R/W	Must be set to its default.	0x0
RESERVED	7	R/W	Must be set to its default.	0x1
RESERVED	0	R/W	Must be set to its default.	0x1

7.12.5.6 HSIO:SERDES1G_ANA_CFG:SERDES1G_PLL_CFG

Parent: HSIO:SERDES1G_ANA_CFG

Instances: 1

Configuration register for SERDES1G RCPLL

Table 516 • **Fields in SERDES1G_PLL_CFG**

Field Name	Bit	Access	Description	Default
RESERVED	22:21	R/W	Must be set to its default.	0x0
PLL_FSM_CTRL_DATA	15:8	R/W	Control data for FSM	0x00
PLL_FSM_ENA	7	R/W	Enable FSM	0x0
RESERVED	6:5	R/W	Must be set to its default.	0x0
RESERVED	3	R/W	Must be set to its default.	0x0

7.12.6 HSIO:SERDES1G_DIG_CFG

Parent: HSIO

Instances: 1

Configuration register set for SERDES1G digital BIST and DFT functions.

Table 517 • **Registers in SERDES1G_DIG_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SERDES1G_MISC_CFG	0x00000010	1	SERDES1G Misc Configuration	Page 419

7.12.6.1 HSIO:SERDES1G_DIG_CFG:SERDES1G_MISC_CFG

Parent: HSIO:SERDES1G_DIG_CFG

Instances: 1

Configuration register for miscellaneous functions

Table 518 • **Fields in SERDES1G_MISC_CFG**

Field Name	Bit	Access	Description	Default
DES_100FX_CPMD_ENA	8	R/W	Enable deserializer cp/md handling for 100fx mode 0: Disable 1: Enable	0x0
RX_LPI_MODE_ENA	5	R/W	Enable RX-Low-Power feature (Power control by LPI-FSM in connected PCS) 0: Disable 1: Enable	0x0
TX_LPI_MODE_ENA	4	R/W	Enable TX-Low-Power feature (Power control by LPI-FSM in connected PCS) 0: Disable 1: Enable	0x0
RX_DATA_INV_ENA	3	R/W	Enable data inversion received from Deserializer 0: Disable 1: Enable	0x0
TX_DATA_INV_ENA	2	R/W	Enable data inversion sent to Serializer 0: Disable 1: Enable	0x0
LANE_RST	0	R/W	Lane Reset 0: No reset 1: Reset (not self-clearing)	0x0

7.12.7 HSIO:SERDES1G_DIG_STATUS

Parent: HSIO

Instances: 1

Status register set for SERDES1G digital BIST and DFT functions.

Table 519 • **Registers in SERDES1G_DIG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SERDES1G_DFT_STATUS	0x00000000	1	SERDES1G DFT Status	Page 420

7.12.7.1 HSIO:SERDES1G_DIG_STATUS:SERDES1G_DFT_STATUS

Parent: HSIO:SERDES1G_DIG_STATUS

Instances: 1

Status register of SERDES1G DFT functions

Table 520 • **Fields in SERDES1G_DFT_STATUS**

Field Name	Bit	Access	Description	Default
BIST_NOSYNC	2	R/O	BIST sync result 0: Synchronization successful 1: Synchronization on BIST data failed	0x0

7.12.8 HSIO:MCB_SERDES1G_CFG

Parent: HSIO

Instances: 1

All SERDES1G macros are accessed via the serial Macro Configuration Bus (MCB). Each macro is configured by one MCB slave. All MCB slaves are connected in a daisy-chain loop.

Table 521 • **Registers in MCB_SERDES1G_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MCB_SERDES1G_ADDR_CFG	0x00000000	1	MCB SERDES1G Address Cfg	Page 421

7.12.8.1 HSIO:MCB_SERDES1G_CFG:MCB_SERDES1G_ADDR_CFG

Parent: HSIO:MCB_SERDES1G_CFG

Instances: 1

Configuration of SERDES1G MCB slaves to be accessed

Table 522 • **Fields in MCB_SERDES1G_ADDR_CFG**

Field Name	Bit	Access	Description	Default
SERDES1G_WR_ONE_SHOT	31	One-shot	Initiate a write access to marked SERDES1G slaves 0: No write operation pending 1: Initiate write to slaves (kept 1 until write operation has finished)	0x0
SERDES1G_RD_ONE_SHOT	30	One-shot	Initiate a read access to marked SERDES1G slaves 0: No read operation pending (read op finished after bit has been set) 1: Initiate a read access (kept 1 until read operation has finished)	0x0

Table 522 • **Fields in MCB_SERDES1G_ADDR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SERDES1G_ADDR	24:0	R/W	Activation vector for SERDES1G-Slaves, one-hot coded, each bit is related to one macro, e.g. bit 0 enables/disables access to macro No. 0 0: Disable macro access via MCB 1: Enable macro access via MCB	0x1FFFFFF

7.12.9 HSIO:SERDES6G_ANA_CFG

Parent: HSIO

Instances: 1

Configuration register set for SERDES6G (analog parts)

Table 523 • **Registers in SERDES6G_ANA_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SERDES6G_DES_CFG	0x00000000	1	SERDES6G Deserializer Cfg	Page 422
SERDES6G_IB_CFG	0x00000004	1	SERDES6G Input Buffer Cfg	Page 424
SERDES6G_IB_CFG1	0x00000008	1	SERDES6G Input Buffer Cfg1	Page 424
SERDES6G_OB_CFG	0x0000000C	1	SERDES6G Output Buffer Cfg	Page 425
SERDES6G_OB_CFG1	0x00000010	1	SERDES6G Output Buffer Cfg1	Page 426
SERDES6G_SER_CFG	0x00000014	1	SERDES6G Serializer Cfg	Page 426
SERDES6G_COMMON_CFG	0x00000018	1	SERDES6G Common Cfg	Page 426
SERDES6G_PLL_CFG	0x0000001C	1	SERDES6G Pll Cfg	Page 427

7.12.9.1 HSIO:SERDES6G_ANA_CFG:SERDES6G_DES_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register for SERDES6G deserializer

Table 524 • **Fields in SERDES6G_DES_CFG**

Field Name	Bit	Access	Description	Default
DES_PHS_CTRL	16:13	R/W	Control of phase regulator logic. Bit 3 must always be set to 0. Optimal settings for bits 2:0 are 4 through 7; recommended setting is 6. 0: Disabled 1: Enabled with 99 ppm limit 2: Enabled with 202 ppm limit 3: Enabled with 485 ppm limit 4: Enabled if corresponding PCS is in sync with 50 ppm limit 5: Enabled if corresponding PCS is in sync with 99 ppm limit 6: Enabled if corresponding PCS is in sync with 202 ppm limit 7: Enabled if corresponding PCS is in sync with 485 ppm limit	0x0
DES_MBTR_CTRL	12:10	R/W	Des phase control for 180 degrees deadlock block mode of operation 000: Depending on density of input pattern 001: Active until PCS has synchronized 010: Depending on density of input pattern until PCS has synchronized 011: Never 100: Always All other settings are reserved.	0x0
RESERVED	9:8	R/W	Must be set to its default.	0x0
DES_BW_HYST	7:5	R/W	Selection of time constant for integrative path of the CDR loop. 0: Reserved 1: Divide by 4 2: Divide by 8 3: Divide by 16 4: Divide by 32 5: Divide by 64 6: Divide by 128 7: Divide by 256 For more information about mode-dependent limitations, see SERDES6G Deserializer Configuration, page 29.	0x0
RESERVED	4	R/W	Must be set to its default.	0x0

Table 524 • **Fields in SERDES6G_DES_CFG *(continued)***

Field Name	Bit	Access	Description	Default
DES_BW_ANA	3:1	R/W	Bandwidth selection for proportional path of the CDR loop. 0: Reserved 1: Reserved 2: Divide by 4 3: Divide by 8 4: Divide by 16 5: Divide by 32 6: Divide by 64 7: Divide by 128 For more information about mode-dependent limitations, see SERDES6G Deserializer Configuration, page 29.	0x0
RESERVED	0	R/W	Must be set to its default.	0x0

7.12.9.2 HSIO:SERDES6G_ANA_CFG:SERDES6G_IB_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register 0 for SERDES6G input buffer

Table 525 • **Fields in SERDES6G_IB_CFG**

Field Name	Bit	Access	Description	Default
RESERVED	27:7	R/W	Must be set to its default.	0x00000
IB_VBCOM	6:4	R/W	Level detection thresholds, in steps of approximately 8mV. 0: 60mV 7: 120mV	0x0
IB_RESISTOR_CTRL	3:0	R/W	Resistor control. Value must be taken from RCOMP_STATUS.RCOMP.	0x0

7.12.9.3 HSIO:SERDES6G_ANA_CFG:SERDES6G_IB_CFG1

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register 1 for SERDES6G input buffer

Table 526 • **Fields in SERDES6G_IB_CFG1**

Field Name	Bit	Access	Description	Default
RESERVED	13:7	R/W	Must be set to its default.	0x00
IB_CTERM_ENA	5	R/W	Common mode termination 0: Disable 1: Enable	0x0
IB_RESERVED	4	R/W	Must be set to 1.	0x0

Table 526 • **Fields in SERDES6G_IB_CFG1 *(continued)***

Field Name	Bit	Access	Description	Default
IB_ENA_OFFSAC	3	R/W	Auto offset compensation for ac path 0: Disable 1: Enable	0x0
IB_ENA_OFFSDC	2	R/W	Auto offset compensation for dc path 0: Disable 1: Enable	0x0
IB_FX100_ENA	1	R/W	Increases timing constant for level detect circuit, must be used in FX100 mode 0: Normal speed 1: Slow speed (oversampling)	0x0
RESERVED	0	R/W	Must be set to its default.	0x0

7.12.9.4 HSIO:SERDES6G_ANA_CFG:SERDES6G_OB_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register 0 for SERDES6G output buffer

Table 527 • **Fields in SERDES6G_OB_CFG**

Field Name	Bit	Access	Description	Default
OB_IDLE	31	R/W	PCIe support 1: idle - force to 0V differential 0: Normal mode	0x0
OB_ENA1V_MODE	30	R/W	Output buffer supply voltage 1: Set to nominal 1V 0: Set to higher voltage	0x0
OB_POL	29	R/W	Polarity of output signal 0: Normal 1: Inverted	0x0
OB_POST0	28:23	R/W	Coefficients for 1st Post Cursor (MSB is sign)	0x00
OB_POST1	22:18	R/W	Coefficients for 2nd Post Cursor (MSB is sign)	0x00
OB_PREC	17:13	R/W	Coefficients for Pre Cursor (MSB is sign)	0x00
RESERVED	12:9	R/W	Must be set to its default.	0x0
OB_SR_H	8	R/W	Half the predriver speed, use for slew rate control 0: Disable - slew rate < 60 ps 1: Enable - slew rate > 60 ps	0x0
OB_RESISTOR_CTRL	7:4	R/W	Resistor control. Value must be taken from RCOMP_STATUS.RCOMP.	0x0

Table 527 • **Fields in SERDES6G_OB_CFG *(continued)***

Field Name	Bit	Access	Description	Default
OB_SR	3:0	R/W	Driver speed, fine adjustment of slew rate 30-60ps (if OB_SR_H = 0), 60-140ps (if OB_SR_H = 1)	0x0

7.12.9.5 HSIO:SERDES6G_ANA_CFG:SERDES6G_OB_CFG1

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register 1 for SERDES6G output buffer

Table 528 • **Fields in SERDES6G_OB_CFG1**

Field Name	Bit	Access	Description	Default
OB_ENA_CAS	8:6	R/W	Output skew, used for skew adjustment in SGMII mode	0x0
OB_LEV	5:0	R/W	Level of output amplitude 0: lowest level 63: highest level	0x00

7.12.9.6 HSIO:SERDES6G_ANA_CFG:SERDES6G_SER_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register for SERDES6G serializer

Table 529 • **Fields in SERDES6G_SER_CFG**

Field Name	Bit	Access	Description	Default
RESERVED	8:4	R/W	Must be set to its default.	0x00
SER_ENHYS	3	R/W	Enable hysteresis for phase alignment 0: Disable hysteresis 1: Enable hysteresis	0x0
RESERVED	2	R/W	Must be set to its default.	0x0
SER_EN_WIN	1	R/W	Enable window for phase alignment 0: Disable window 1: Enable window	0x0
SER_ENALI	0	R/W	Enable phase alignment 0: Disable phase alignment 1: Enable phase alignment	0x0

7.12.9.7 HSIO:SERDES6G_ANA_CFG:SERDES6G_COMMON_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register for common SERDES6G functions Note: When enabling the facility loop (ena_floop) also the phase alignment in the serializer has to be enabled and configured adequate.

Table 530 • **Fields in SERDES6G_COMMON_CFG**

Field Name	Bit	Access	Description	Default
SYS_RST	31	R/W	System reset (low active) 0: Apply reset (not self-clearing) 1: Reset released	0x0
SE_AUTO_SQUELCH_B_ENA	22	R/W	Enable auto-squelching for sync. ethernet bus B 0: Disable 1: Enable	0x0
SE_AUTO_SQUELCH_A_ENA	21	R/W	Enable auto-squelching for sync. ethernet bus A 0: Disable 1: Enable	0x0
RECO_SEL_B	20	R/W	Select recovered clock of this lane on sync. ethernet bus B 0: Lane not selected 1: Lane selected	0x0
RECO_SEL_A	19	R/W	Select recovered clock of this lane on sync. ethernet bus A 0: Lane not selected 1: Lane selected	0x0
ENA_LANE	18	R/W	Enable lane 0: Disable lane 1: Enable line	0x0
RESERVED	17:12	R/W	Must be set to its default.	0x00
RESERVED	9:8	R/W	Must be set to its default.	0x0
ENA_ELOOP	11	R/W	Enable equipment loop 0: Disable 1: Enable	0x0
ENA_FLOOP	10	R/W	Enable facility loop 0: Disable 1: Enable	0x0
HRATE	7	R/W	Enable half rate 0: Disable 1: Enable	0x1
QRATE	6	R/W	Enable quarter rate 0: Disable 1: Enable	0x0
IF_MODE	5:4	R/W	Interface mode 0: Reserved 1: 10-bit mode 2: Reserved 3: 20-bit mode	0x1

7.12.9.8 HSIO:SERDES6G_ANA_CFG:SERDES6G_PLL_CFG

Parent: HSIO:SERDES6G_ANA_CFG

Instances: 1

Configuration register for SERDES6G RCPLL

Table 531 • **Fields in SERDES6G_PLL_CFG**

Field Name	Bit	Access	Description	Default
RESERVED	20	R/W	Must be set to its default.	0x0
PLL_ENA_ROT	18	R/W	Enable rotation	0x1
PLL_FSM_CTRL_DATA	15:8	R/W	Control data for FSM	0x00
PLL_FSM_ENA	7	R/W	Enable FSM	0x0
RESERVED	6:5	R/W	Must be set to its default.	0x0
RESERVED	3	R/W	Must be set to its default.	0x0
PLL_ROT_DIR	2	R/W	Select rotation direction	0x0
PLL_ROT_FRQ	1	R/W	Select rotation frequency	0x1

7.12.10 HSIO:SERDES6G_DIG_CFG

Parent: HSIO

Instances: 1

Configuration register set for SERDES6G digital BIST and DFT functions.

Table 532 • **Registers in SERDES6G_DIG_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SERDES6G_DIG_CFG	0x00000000	1	SERDES6G Digital Configuration register	Page 428
SERDES6G_MISC_CFG	0x00000018	1	SERDES6G Misc Configuration	Page 429

7.12.10.1 HSIO:SERDES6G_DIG_CFG:SERDES6G_DIG_CFG

Parent: HSIO:SERDES6G_DIG_CFG

Instances: 1

Configuration register for SERDES6G digital functions

Table 533 • **Fields in SERDES6G_DIG_CFG**

Field Name	Bit	Access	Description	Default
SIGDET_AST	5:3	R/W	Signal detect assertion time 0: 0 us 1: 35 us 2: 70 us 3: 105 us 4: 140 us 5..7: reserved	0x0

Table 533 • **Fields in SERDES6G_DIG_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SIGDET_DST	2:0	R/W	Signal detect de-assertion time 0: 0 us 1: 250 us 2: 350 us 3: 450 us 4: 550 us 5..7: reserved	0x0

7.12.10.2 HSIO:SERDES6G_DIG_CFG:SERDES6G_MISC_CFG

Parent: HSIO:SERDES6G_DIG_CFG

Instances: 1

Configuration register for miscellaneous functions

Table 534 • **Fields in SERDES6G_MISC_CFG**

Field Name	Bit	Access	Description	Default
DES_100FX_CPMD_ENA	8	R/W	Enable deserializer cp/md handling for 100fx mode 0: Disable 1: Enable	0x0
RX_LPI_MODE_ENA	5	R/W	Enable RX-Low-Power feature (Power control by LPI-FSM in connected PCS) 0: Disable 1: Enable	0x0
TX_LPI_MODE_ENA	4	R/W	Enable TX-Low-Power feature (Power control by LPI-FSM in connected PCS) 0: Disable 1: Enable	0x0
RX_DATA_INV_ENA	3	R/W	Enable data inversion received from Deserializer 0: Disable 1: Enable	0x0
TX_DATA_INV_ENA	2	R/W	Enable data inversion sent to Serializer 0: Disable 1: Enable	0x0
LANE_RST	0	R/W	Lane Reset 0: No reset 1: Reset (not self-clearing)	0x0

7.12.11 HSIO:MCB_SERDES6G_CFG

Parent: HSIO

Instances: 1

All SERDES6G macros are accessed via the serial Macro Configuration Bus (MCB). Each macro is configured by one MCB Slave. All MCB Slaves are connected in a daisy-chain loop.

Table 535 • **Registers in MCB_SERDES6G_CFG**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MCB_SERDES6G_ADDR_CFG	0x00000000	1	MCB SERDES6G Address Cfg	Page 430

7.12.11.1 HSIO:MCB_SERDES6G_CFG:MCB_SERDES6G_ADDR_CFG

Parent: HSIO:MCB_SERDES6G_CFG

Instances: 1

Configuration of SERDES6G MCB Slaves to be accessed

Table 536 • **Fields in MCB_SERDES6G_ADDR_CFG**

Field Name	Bit	Access	Description	Default
SERDES6G_WR_ONE_SHOT	31	One-shot	Initiate a write access to marked SERDES6G Slaves 0: No write operation pending 1: Initiate write to slaves (kept 1 until write operation has finished)	0x0
SERDES6G_RD_ONE_SHOT	30	One-shot	Initiate a read access to marked SERDES6G Slaves 0: No read operation pending (read op finished after bit has been set) 1: Initiate a read access (kept 1 until read operation has finished)	0x0
SERDES6G_ADDR	15:0	R/W	Activation vector for SERDES6G-Slaves, one-hot coded, each bit is related to one macro, e.g. bit 0 enables/disables access to macro No. 0 0: Disable macro access via MCB 1: Enable macro access via MCB	0xFFFF

7.13 DEV_GMII

Table 537 • **Register Groups in DEV_GMII**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
PORT_MODE	0x00000000	1		Page 430
MAC_CFG_STATUS	0x0000000C	1		Page 431

7.13.1 DEV_GMII:PORT_MODE

Parent: DEV_GMII

Instances: 1

Table 538 • **Registers in PORT_MODE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
CLOCK_CFG	0x00000000	1		Page 431
PORT_MISC	0x00000004	1		Page 431

7.13.1.1 DEV_GMII:PORT_MODE:CLOCK_CFG

Parent: DEV_GMII:PORT_MODE

Instances: 1

Table 539 • **Fields in CLOCK_CFG**

Field Name	Bit	Access	Description	Default
MAC_TX_RST	3	R/W		0x1
MAC_RX_RST	2	R/W		0x1
PORT_RST	1	R/W		0x1
PHY_RST	0	R/W		0x1

7.13.1.2 DEV_GMII:PORT_MODE:PORT_MISC

Parent: DEV_GMII:PORT_MODE

Instances: 1

Table 540 • **Fields in PORT_MISC**

Field Name	Bit	Access	Description	Default
FWD_PAUSE_ENA	3	R/W	Forward pause frames (EtherType = 0x8808, opcode = 0x0001). The reaction to incoming pause frames is controlled independently of FWD_PAUSE_ENA.	0x0
FWD_CTRL_ENA	2	R/W	Forward MAC control frames excluding pause frames (EtherType = 0x8808, opcode different from 0x0001).	0x0
GMII_LOOP_ENA	1	R/W	Loop GMII transmit data directly into receive path.	0x0
DEV_LOOP_ENA	0	R/W	Loop the device bus through this port. The MAC is potentially bypassed.	0x0

7.13.2 DEV_GMII:MAC_CFG_STATUS

Parent: DEV_GMII

Instances: 1

The 1G MAC module contains configuration and status registers related to the MAC module of the 1G Device.

Table 541 • **Registers in MAC_CFG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MAC_ENA_CFG	0x00000000	1	Mode Configuration Register	Page 432
MAC_MODE_CFG	0x00000004	1	Mode Configuration Register	Page 432
MAC_MAXLEN_CFG	0x00000008	1	Max Length Configuration Register	Page 433
MAC_TAGS_CFG	0x0000000C	1	VLAN / Service tag configuration register	Page 433
MAC_ADV_CHK_CFG	0x00000010	1	Advanced Check Feature Configuration Register	Page 434
MAC_IFG_CFG	0x00000014	1	Inter Frame Gap Configuration Register	Page 435
MAC_HDX_CFG	0x00000018	1	Half Duplex Configuration Register	Page 435
MAC_FC_CFG	0x00000020	1	MAC Flow Control Configuration Register	Page 437
MAC_FC_MAC_LOW_CFG	0x00000024	1	MAC Flow Control Configuration Register	Page 437
MAC_FC_MAC_HIGH_CFG	0x00000028	1	MAC Flow Control Configuration Register	Page 438
MAC_STICKY	0x0000002C	1	Sticky Bit Register	Page 438

7.13.2.1 DEV_GMII:MAC_CFG_STATUS:MAC_ENA_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 542 • **Fields in MAC_ENA_CFG**

Field Name	Bit	Access	Description	Default
RX_ENA	4	R/W	Receiver Module Enable. '0': Receiver Module Disabled '1': Receiver Module Enabled	0x0
TX_ENA	0	R/W	Transmitter Module Enable. '0': Transmitter Module Disabled '1': Transmitter Module Enabled	0x0

7.13.2.2 DEV_GMII:MAC_CFG_STATUS:MAC_MODE_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 543 • **Fields in MAC_MODE_CFG**

Field Name	Bit	Access	Description	Default
GIGA_MODE_ENA	4	R/W	Enables 1 Gbps mode. '0': 10/100 Mbps mode '1': 1 Gbps mode. Note: FDX_ENA must also be set.	0x1
FDX_ENA	0	R/W	Enables Full Duplex: '0': Half Duplex '1': Full duplex. Note: Full duplex MUST be selected if GIGA_MODE is enabled.	0x1

7.13.2.3 DEV_GMII:MAC_CFG_STATUS:MAC_MAXLEN_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 544 • **Fields in MAC_MAXLEN_CFG**

Field Name	Bit	Access	Description	Default
MAX_LEN	15:0	R/W	When set, single tagged frames are allowed to be 4 bytes longer than the MAC_MAXLEN_CFG configuration and double tagged frames are allowed to be 8 bytes longer. Single tagged frames are adjusted if VLAN_AWR_ENA is also set. Double tagged frames are adjusted if both VLAN_AWR_ENA and VLAN_DBL_AWR_ENA are set.	0x05EE

7.13.2.4 DEV_GMII:MAC_CFG_STATUS:MAC_TAGS_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

The MAC can be configured to accept 0, 1 and 2 tags and the TAG value can be user-defined.

Table 545 • **Fields in MAC_TAGS_CFG**

Field Name	Bit	Access	Description	Default
TAG_ID	31:16	R/W	This field defines which EtherTypes are recognized as a VLAN TPID - besides 0x8100. The value is used for all tag positions. I.e. a double tagged frame can have the following tag values: (TAG1,TAG2): (0x8100, 0x8100) (0x8100, TAG_ID) (TAG_ID, 0x8100) or (TAG_ID, TAG_ID) Single tagged frame can have the following TPID values: 0x8100 or TAG_ID.	0x8100
VLAN_DBL_AWR_ENA	1	R/W	If set, double tagged frames are subject to length adjustments (VLAN_LEN_AWR_ENA). VLAN_AWR_ENA must be set when VLAN_DBL_AWR_ENA is set. '0': The MAC does not look for inner tags. '1': The MAC accepts inner tags with TPID=0x8100 or TAG_ID.	0x0
VLAN_AWR_ENA	0	R/W	If set, single tagged frames are subject to length adjustments (VLAN_LEN_AWR_ENA). '0': The MAC does not look for any tags. '1': The MAC accepts outer tags with TPID=0x8100 or TAG_ID.	0x0
VLAN_LEN_AWR_ENA	2	R/W	When set, single tagged frames are allowed to be 4 bytes longer than the MAC_MAXLEN_CFG configuration and double tagged frames are allowed to be 8 bytes longer. Single tagged frames are adjusted if VLAN_AWR_ENA is also set. Double tagged frames are adjusted if both VLAN_AWR_ENA and VLAN_DBL_AWR_ENA are set.	0x1

7.13.2.5 DEV_GMII:MAC_CFG_STATUS:MAC_ADV_CHK_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 546 • **Fields in MAC_ADV_CHK_CFG**

Field Name	Bit	Access	Description	Default
LEN_DROP_ENA	0	R/W	Length Drop Enable: Configures the Receive Module to drop frames in reference to in-range and out-of-range errors: '0': Length Drop Disabled '1': Length Drop Enabled.	0x0

7.13.2.6 DEV_GMII:MAC_CFG_STATUS:MAC_IFG_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 547 • **Fields in MAC_IFG_CFG**

Field Name	Bit	Access	Description	Default
TX_IFG	12:8	R/W	Used to adjust the duration of the inter-frame gap in the Tx direction and must be set according to the speed and duplex settings. 10/100 Mbps, HDX, FDX 0x19, 0x13 1000 Mbps: 0x07.	0x07
RX_IFG2	7:4	R/W	Used to adjust the duration of the second part of the inter-frame gap in the Rx direction and must be set according to the speed and duplex settings. 10/100 Mbps, HDX, FDX: 0x8, 0xB 1000 Mbps: 0x1.	0x1
RX_IFG1	3:0	R/W	Used to adjust the duration of the first part of the inter-frame gap in the Rx direction and must be set according to the speed settings. 10/100 Mbps: 0x7 1000 Mbps: 0x5.	0x5

7.13.2.7 DEV_GMII:MAC_CFG_STATUS:MAC_HDX_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 548 • **Fields in MAC_HDX_CFG**

Field Name	Bit	Access	Description	Default
WEXC_DIS	24	R/W	Determines whether the MAC backs off after an excessive collision has occurred. If set, back off is disabled after excessive collisions. '0': Back off after excessive collisions '1': Don't back off after excessive collisions	0x0
SEED	23:16	R/W	Seed value loaded into the PRBS of the MAC. Used to prevent excessive collision events.	0x00
SEED_LOAD	12	R/W	Load SEED value into PRNG register. A SEED value is loaded into the PRNG register of the MAC, when SEED_LOAD is asserted. After a load, the SEED_LOAD must be deasserted. '0': Do not load SEED value '1': Load SEED value.	0x0
RETRY_AFTER_EXC_COL_ENA	8	R/W	This bit is used to setup the MAC to retransmit a frame after an early collision even though 16 (or more) early collisions have occurred. This feature violates the IEEE 802.3 standard and should be used only when running in HDX flow control, which is not defined in the IEEE standard. '0': A frame is discarded and counted as an excessive collision if 16 collisions occur for this frame. '1': The MAC retransmits a frame after an early collision, regardless of the number of previous early collisions. The backoff sequence is reset after every 16 collisions.	0x0
LATE_COL_POS	6:0	R/W	Adjustment of early/late collision boundary: This bitgroup is used to adjust the MAC so that a collision on a shared transmission medium before bit 512 is handled as an early collision, whereas a collision after bit 512 is handled as a late collision, i.e. no retransmission is performed.	0x43

7.13.2.8 DEV_GMII:MAC_CFG_STATUS:MAC_FC_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 549 • **Fields in MAC_FC_CFG**

Field Name	Bit	Access	Description	Default
ZERO_PAUSE_ENA	18	R/W	If set, a zero-delay pause frame is transmitted when flow control is deasserted. '0': Don't send zero pause frame. '1': Send zero pause frame.	0x0
TX_FC_ENA	17	R/W	When set the MAC will send pause control frames in the Tx direction. '0': Don't send pause control frames '1': Send pause control frames	0x0
RX_FC_ENA	16	R/W	When set the MAC obeys received pause control frames '0': Don't obey received pause control frames '1': Obey received pause control frames.	0x0
PAUSE_VAL_CFG	15:0	R/W	Pause timer value inserted in generated pause frames. 0: Insert timer value 0 in TX pause frame. ... N: Insert timer value N in TX pause frame.	0x0000
FC_LATENCY_CFG	24:19	R/W	Accepted reaction time for link partner after the port has transmitted a pause frame. Frames starting after this latency are aborted. Unit is 64 byte times. A value of 63 disables the feature. For proper flow control operation, use FC_LATCH_CFG = 7.	0x03

7.13.2.9 DEV_GMII:MAC_CFG_STATUS:MAC_FC_MAC_LOW_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 550 • **Fields in MAC_FC_MAC_LOW_CFG**

Field Name	Bit	Access	Description	Default
MAC_LOW	23:0	R/W	Lower three bytes in the SMAC in generated flow control frames. 0xNNN: Lower three DMAC bytes	0x000000

7.13.2.10 DEV_GMII:MAC_CFG_STATUS:MAC_FC_MAC_HIGH_CFG

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Table 551 • **Fields in MAC_FC_MAC_HIGH_CFG**

Field Name	Bit	Access	Description	Default
MAC_HIGH	23:0	R/W	Higher three bytes in the SMAC in generated flow control frames. 0xNNN: Higher three DMAC bytes	0x000000

7.13.2.11 DEV_GMII:MAC_CFG_STATUS:MAC_STICKY

Parent: DEV_GMII:MAC_CFG_STATUS

Instances: 1

Clear the sticky bits by writing a '0' in the relevant bitgroups (writing a '1' sets the bit)!.

Table 552 • **Fields in MAC_STICKY**

Field Name	Bit	Access	Description	Default
RX_IPG_SHRINK_STICKY	9	Sticky	Sticky bit indicating that an inter packet gap shrink was detected (IPG < 12 bytes).	0x0
RX_PREAM_SHRINK_STICKY	8	Sticky	Sticky bit indicating that a preamble shrink was detected (preamble < 8 bytes). '0': no preamble shrink was detected '1': a preamble shrink was detected one or more times Bit is cleared by writing a '1' to this position.	0x0
RX_CARRIER_EXT_STICKY	7	Sticky	Sticky bit indicating that a carrier extend was detected. '0': no carrier extend was detected '1': one or more carrier extends were detected Bit is cleared by writing a '1' to this position.	0x0

Table 552 • **Fields in MAC_STICKY** *(continued)*

Field Name	Bit	Access	Description	Default
RX_CARRIER_EXT_ERR_STICKY	6	Sticky	Sticky bit indicating that a carrier extend error was detected. '0': no carrier extend error was detected '1': one or more carrier extend errors were detected Bit is cleared by writing a '1' to this position.	0x0
RX_JUNK_STICKY	5	Sticky	Sticky bit indicating that junk was received (bytes not recognized as a frame). '0': no junk was received '1': junk was received one or more times Bit is cleared by writing a '1' to this position.	0x0
TX_RETRANSMIT_STICKY	4	Sticky	Sticky bit indicating that the transmit MAC asked the host for a frame retransmission. '0': no tx retransmission was initiated '1': one or more tx retransmissions were initiated Bit is cleared by writing a '1' to this position.	0x0
TX_JAM_STICKY	3	Sticky	Sticky bit indicating that the transmit host issued a jamming signal. '0': the transmit host issued no jamming signal '1': the transmit host issued one or more jamming signals Bit is cleared by writing a '1' to this position.	0x0
TX_FIFO_OFLW_STICKY	2	Sticky	Sticky bit indicating that the MAC transmit FIFO has overrun.	0x0
TX_FRM_LEN_OVR_STICKY	1	Sticky	Sticky bit indicating that the transmit frame length has overrun. I.e. a frame longer than 64K occurred. '0': no tx frame length error occurred '1': one or more tx frames length errors occurred Bit is cleared by writing a '1' to this position.	0x0
TX_ABORT_STICKY	0	Sticky	Sticky bit indicating that the transmit host initiated abort was executed.	0x0

7.14 DEV

Table 553 • **Register Groups in DEV**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
DEV_CFG_STATUS	0x00000000	1		Page 440
PORT_MODE	0x00000004	1		Page 440
MAC_CFG_STATUS	0x00000010	1		Page 442
PCS1G_CFG_STATUS	0x00000040	1	PCS 1G Configuration Status Registers	Page 449
PCS1G_TSTPAT_CFG_STATUS	0x00000084	1	PCS1G Testpattern Configuration and Status Registers	Page 457
PCS_FX100_CONFIGURATION	0x0000008C	1	PCS FX100 Configuration Registers	Page 459
PCS_FX100_STATUS	0x00000090	1	PCS FX100 Status Registers	Page 460

7.14.1 DEV:DEV_CFG_STATUS

Parent: DEV

Instances: 1

Table 554 • **Registers in DEV_CFG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
DEV_IF_CFG	0x00000000	1	Interface select	Page 440

7.14.1.1 DEV:DEV_CFG_STATUS:DEV_IF_CFG

Parent: DEV:DEV_CFG_STATUS

Instances: 1

GMII interface enable register

Table 555 • **Fields in DEV_IF_CFG**

Field Name	Bit	Access	Description	Default
GMII_DIS	0	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0

7.14.2 DEV:PORT_MODE

Parent: DEV

Instances: 1

Table 556 • **Registers in PORT_MODE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
CLOCK_CFG	0x00000000	1		Page 441
PORT_MISC	0x00000004	1		Page 441

7.14.2.1 DEV:PORT_MODE:CLOCK_CFG

Parent: DEV:PORT_MODE

Instances: 1

Table 557 • **Fields in CLOCK_CFG**

Field Name	Bit	Access	Description	Default
MAC_TX_RST	7	R/W		0x1
MAC_RX_RST	6	R/W		0x1
PCS_TX_RST	5	R/W		0x1
PCS_RX_RST	4	R/W		0x1
PORT_RST	3	R/W		0x1
PHY_RST	2	R/W	Only applicable to ports 10 and 11.	0x1
LINK_SPEED	1:0	R/W	Selects the link speed. 0: No link 1: 1000/2500 Mbps 2: 100 Mbps 3: 10 Mbps	0x0

7.14.2.2 DEV:PORT_MODE:PORT_MISC

Parent: DEV:PORT_MODE

Instances: 1

Table 558 • **Fields in PORT_MISC**

Field Name	Bit	Access	Description	Default
FWD_PAUSE_ENA	2	R/W	Forward pause frames (EtherType = 0x8808, opcode = 0x0001). The reaction to incoming pause frames is controlled independently of FWD_PAUSE_ENA.	0x0
FWD_CTRL_ENA	1	R/W	Forward MAC control frames excluding pause frames (EtherType = 0x8808, opcode different from 0x0001).	0x0
DEV_LOOP_ENA	0	R/W	Loop the device bus through this port. The MAC is potentially bypassed.	0x0

7.14.3 DEV:MAC_CFG_STATUS

Parent: DEV

Instances: 1

The 1G MAC module contains configuration and status registers related to the MAC module of the 1G Device.

Table 559 • **Registers in MAC_CFG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MAC_ENA_CFG	0x00000000	1	Mode Configuration Register	Page 442
MAC_MODE_CFG	0x00000004	1	Mode Configuration Register	Page 443
MAC_MAXLEN_CFG	0x00000008	1	Max Length Configuration Register	Page 443
MAC_TAGS_CFG	0x0000000C	1	VLAN / Service tag configuration register	Page 443
MAC_ADV_CHK_CFG	0x00000010	1	Advanced Check Feature Configuration Register	Page 444
MAC_IFG_CFG	0x00000014	1	Inter Frame Gap Configuration Register	Page 445
MAC_HDX_CFG	0x00000018	1	Half Duplex Configuration Register	Page 445
MAC_FC_CFG	0x00000020	1	MAC Flow Control Configuration Register	Page 446
MAC_FC_MAC_LOW_CFG	0x00000024	1	MAC Flow Control Configuration Register	Page 447
MAC_FC_MAC_HIGH_CFG	0x00000028	1	MAC Flow Control Configuration Register	Page 447
MAC_STICKY	0x0000002C	1	Sticky Bit Register	Page 448

7.14.3.1 DEV:MAC_CFG_STATUS:MAC_ENA_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 560 • **Fields in MAC_ENA_CFG**

Field Name	Bit	Access	Description	Default
RX_ENA	4	R/W	Receiver Module Enable. '0': Receiver Module Disabled '1': Receiver Module Enabled	0x0
TX_ENA	0	R/W	Transmitter Module Enable. '0': Transmitter Module Disabled '1': Transmitter Module Enabled	0x0

7.14.3.2 DEV:MAC_CFG_STATUS:MAC_MODE_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 561 • **Fields in MAC_MODE_CFG**

Field Name	Bit	Access	Description	Default
GIGA_MODE_ENA	4	R/W	Enables 1 Gbps mode. '0': 10/100 Mbps mode '1': 1 Gbps mode. Note: FDX_ENA must also be set.	0x1
FDX_ENA	0	R/W	Enables Full Duplex: '0': Half Duplex '1': Full duplex. Note: Full duplex MUST be selected if GIGA_MODE is enabled.	0x1

7.14.3.3 DEV:MAC_CFG_STATUS:MAC_MAXLEN_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 562 • **Fields in MAC_MAXLEN_CFG**

Field Name	Bit	Access	Description	Default
MAX_LEN	15:0	R/W	When set, single tagged frames are allowed to be 4 bytes longer than the MAC_MAXLEN_CFG configuration and double tagged frames are allowed to be 8 bytes longer. Single tagged frames are adjusted if VLAN_AWR_ENA is also set. Double tagged frames are adjusted if both VLAN_AWR_ENA and VLAN_DBL_AWR_ENA are set.	0x05EE

7.14.3.4 DEV:MAC_CFG_STATUS:MAC_TAGS_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

The MAC can be configured to accept 0, 1 and 2 tags and the TAG value can be user-defined.

Table 563 • **Fields in MAC_TAGS_CFG**

Field Name	Bit	Access	Description	Default
TAG_ID	31:16	R/W	This field defines which EtherTypes are recognized as a VLAN TPID - besides 0x8100. The value is used for all tag positions. I.e. a double tagged frame can have the following tag values: (TAG1,TAG2): (0x8100, 0x8100) (0x8100, TAG_ID) (TAG_ID, 0x8100) or (TAG_ID, TAG_ID) Single tagged frame can have the following TPID values: 0x8100 or TAG_ID.	0x8100
VLAN_DBL_AWR_ENA	1	R/W	If set, double tagged frames are subject to length adjustments (VLAN_LEN_AWR_ENA). VLAN_AWR_ENA must be set when VLAN_DBL_AWR_ENA is set. '0': The MAC does not look for inner tags. '1': The MAC accepts inner tags with TPID=0x8100 or TAG_ID.	0x0
VLAN_AWR_ENA	0	R/W	If set, single tagged frames are subject to length adjustments (VLAN_LEN_AWR_ENA). '0': The MAC does not look for any tags. '1': The MAC accepts outer tags with TPID=0x8100 or TAG_ID.	0x0
VLAN_LEN_AWR_ENA	2	R/W	When set, single tagged frames are allowed to be 4 bytes longer than the MAC_MAXLEN_CFG configuration and double tagged frames are allowed to be 8 bytes longer. Single tagged frames are adjusted if VLAN_AWR_ENA is also set. Double tagged frames are adjusted if both VLAN_AWR_ENA and VLAN_DBL_AWR_ENA are set.	0x1

7.14.3.5 DEV:MAC_CFG_STATUS:MAC_ADV_CHK_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 564 • **Fields in MAC_ADV_CHK_CFG**

Field Name	Bit	Access	Description	Default
LEN_DROP_ENA	0	R/W	Length Drop Enable: Configures the Receive Module to drop frames in reference to in-range and out-of-range errors: '0': Length Drop Disabled '1': Length Drop Enabled.	0x0

7.14.3.6 DEV:MAC_CFG_STATUS:MAC_IFG_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 565 • **Fields in MAC_IFG_CFG**

Field Name	Bit	Access	Description	Default
TX_IFG	12:8	R/W	Used to adjust the duration of the inter-frame gap in the Tx direction and must be set according to the speed and duplex settings. 10/100 Mbps, HDX, FDX 0x19, 0x13 1000 Mbps: 0x07.	0x07
RX_IFG2	7:4	R/W	Used to adjust the duration of the second part of the inter-frame gap in the Rx direction and must be set according to the speed and duplex settings. 10/100 Mbps, HDX, FDX: 0x8, 0xB 1000 Mbps: 0x1.	0x1
RX_IFG1	3:0	R/W	Used to adjust the duration of the first part of the inter-frame gap in the Rx direction and must be set according to the speed settings. 10/100 Mbps: 0x7 1000 Mbps: 0x5.	0x5

7.14.3.7 DEV:MAC_CFG_STATUS:MAC_HDX_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 566 • **Fields in MAC_HDX_CFG**

Field Name	Bit	Access	Description	Default
WEXC_DIS	24	R/W	Determines whether the MAC backs off after an excessive collision has occurred. If set, back off is disabled after excessive collisions. '0': Back off after excessive collisions '1': Don't back off after excessive collisions	0x0
SEED	23:16	R/W	Seed value loaded into the PRBS of the MAC. Used to prevent excessive collision events.	0x00
SEED_LOAD	12	R/W	Load SEED value into PRNG register. A SEED value is loaded into the PRNG register of the MAC, when SEED_LOAD is asserted. After a load, the SEED_LOAD must be deasserted. '0': Do not load SEED value '1': Load SEED value.	0x0
RETRY_AFTER_EXC_COL_ENA	8	R/W	This bit is used to setup the MAC to retransmit a frame after an early collision even though 16 (or more) early collisions have occurred. '1': The MAC retransmits a frame after an early collision, regardless of the number of previous early collisions. The backoff sequence is reset after every 16 collisions.	0x0
LATE_COL_POS	6:0	R/W	Adjustment of early/late collision boundary: This bitgroup is used to adjust the MAC so that a collision on a shared transmission medium before bit 512 is handled as an early collision, whereas a collision after bit 512 is handled as a late collision, i.e. no retransmission is performed.	0x43

7.14.3.8 DEV:MAC_CFG_STATUS:MAC_FC_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 567 • **Fields in MAC_FC_CFG**

Field Name	Bit	Access	Description	Default
ZERO_PAUSE_ENA	18	R/W	If set, a zero-delay pause frame is transmitted when flow control is deasserted. '0': Don't send zero pause frame. '1': Send zero pause frame.	0x0
TX_FC_ENA	17	R/W	When set the MAC will send pause control frames in the Tx direction. '0': Don't send pause control frames '1': Send pause control frames	0x0
RX_FC_ENA	16	R/W	When set the MAC obeys received pause control frames '0': Don't obey received pause control frames '1': Obey received pause control frames.	0x0
PAUSE_VAL_CFG	15:0	R/W	Pause timer value inserted in generated pause frames. 0: Insert timer value 0 in TX pause frame. ... N: Insert timer value N in TX pause frame.	0x0000
FC_LATENCY_CFG	24:19	R/W	Accepted reaction time for link partner after the port has transmitted a pause frame. Frames starting after this latency are aborted. Unit is 64 byte times. A value of 63 disables the feature. For proper flow control operation, use FC_LATENCY_CFG = 7.	0x03

7.14.3.9 DEV:MAC_CFG_STATUS:MAC_FC_MAC_LOW_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 568 • **Fields in MAC_FC_MAC_LOW_CFG**

Field Name	Bit	Access	Description	Default
MAC_LOW	23:0	R/W	Lower three bytes in the SMAC in generated flow control frames. 0xNNN: Lower three DMAC bytes	0x000000

7.14.3.10 DEV:MAC_CFG_STATUS:MAC_FC_MAC_HIGH_CFG

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Table 569 • **Fields in MAC_FC_MAC_HIGH_CFG**

Field Name	Bit	Access	Description	Default
MAC_HIGH	23:0	R/W	Higher three bytes in the SMAC in generated flow control frames. 0xNNN: Higher three DMAC bytes	0x000000

7.14.3.11 DEV:MAC_CFG_STATUS:MAC_STICKY

Parent: DEV:MAC_CFG_STATUS

Instances: 1

Clear the sticky bits by writing a '0' in the relevant bitgroups (writing a '1' sets the bit)!.

Table 570 • **Fields in MAC_STICKY**

Field Name	Bit	Access	Description	Default
RX_IPG_SHRINK_STICKY	9	Sticky	Sticky bit indicating that an inter packet gap shrink was detected (IPG < 12 bytes).	0x0
RX_PREAM_SHRINK_STICKY	8	Sticky	Sticky bit indicating that a preamble shrink was detected (preamble < 8 bytes). '0': no preamble shrink was detected '1': a preamble shrink was detected one or more times Bit is cleared by writing a '1' to this position.	0x0
RX_CARRIER_EXT_STICKY	7	Sticky	Sticky bit indicating that a carrier extend was detected. '0': no carrier extend was detected '1': one or more carrier extends were detected Bit is cleared by writing a '1' to this position.	0x0
RX_CARRIER_EXT_ERR_STICKY	6	Sticky	Sticky bit indicating that a carrier extend error was detected. '0': no carrier extend error was detected '1': one or more carrier extend errors were detected Bit is cleared by writing a '1' to this position.	0x0

Table 570 • **Fields in MAC_STICKY** ***(continued)***

Field Name	Bit	Access	Description	Default
RX_JUNK_STICKY	5	Sticky	Sticky bit indicating that junk was received (bytes not recognized as a frame). '0': no junk was received '1': junk was received one or more times Bit is cleared by writing a '1' to this position.	0x0
TX_RETRANSMIT_STICKY	4	Sticky	Sticky bit indicating that the transmit MAC asked the host for a frame retransmission. '0': no tx retransmission was initiated '1': one or more tx retransmissions were initiated Bit is cleared by writing a '1' to this position.	0x0
TX_JAM_STICKY	3	Sticky	Sticky bit indicating that the transmit host issued a jamming signal. '0': the transmit host issued no jamming signal '1': the transmit host issued one or more jamming signals Bit is cleared by writing a '1' to this position.	0x0
TX_FIFO_OFLW_STICKY	2	Sticky	Sticky bit indicating that the MAC transmit FIFO has overrun.	0x0
TX_FRM_LEN_OVR_STICKY	1	Sticky	Sticky bit indicating that the transmit frame length has overrun. I.e. a frame longer than 64K occurred. '0': no tx frame length error occurred '1': one or more tx frames length errors occurred Bit is cleared by writing a '1' to this position.	0x0
TX_ABORT_STICKY	0	Sticky	Sticky bit indicating that the transmit host initiated abort was executed.	0x0

7.14.4 DEV:PCS1G_CFG_STATUS

Parent: DEV

Instances: 1

Configuration and status register set for PCS1G

Table 571 • **Registers in PCS1G_CFG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PCS1G_CFG	0x00000000	1	PCS1G Configuration	Page 450
PCS1G_MODE_CFG	0x00000004	1	PCS1G Mode Configuration	Page 451
PCS1G_SD_CFG	0x00000008	1	PCS1G Signal Detect Configuration	Page 451
PCS1G_ANEG_CFG	0x0000000C	1	PCS1G Aneg Configuration	Page 452
PCS1G_ANEG_NP_CFG	0x00000010	1	PCS1G Aneg Next Page Configuration	Page 452
PCS1G_LB_CFG	0x00000014	1	PCS1G Loopback Configuration	Page 453
PCS1G_ANEG_STATUS	0x00000020	1	PCS1G ANEG Status Register	Page 453
PCS1G_ANEG_NP_STATUS	0x00000024	1	PCS1G Aneg Next Page Status Register	Page 454
PCS1G_LINK_STATUS	0x00000028	1	PCS1G link status	Page 454
PCS1G_LINK_DOWN_CNT	0x0000002C	1	PCS1G link down counter	Page 455
PCS1G_STICKY	0x00000030	1	PCS1G sticky register	Page 455
PCS1G_LPI_CFG	0x00000038	1	PCS1G Low Power Idle Configuration	Page 456
PCS1G_LPI_WAKE_ERROR_CNT	0x0000003C	1	PCS1G wake error counter	Page 456
PCS1G_LPI_STATUS	0x00000040	1	PCS1G Low Power Idle Status	Page 456

7.14.4.1 DEV:PCS1G_CFG_STATUS:PCS1G_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G main configuration register

Table 572 • **Fields in PCS1G_CFG**

Field Name	Bit	Access	Description	Default
LINK_STATUS_TYPE	4	R/W	Set type of link_status indication at CPU-System 0: Sync_status (from PCS synchronization state machine) 1: Bit 15 of PCS1G_ANEG_STATUS.lp_adv_ability (Link up/down)	0x0

Table 572 • **Fields in PCS1G_CFG *(continued)***

Field Name	Bit	Access	Description	Default
PCS_ENA	0	R/W	PCS enable 0: Disable PCS 1: Enable PCS	0x0

7.14.4.2 DEV:PCS1G_CFG_STATUS:PCS1G_MODE_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G mode configuration

Table 573 • **Fields in PCS1G_MODE_CFG**

Field Name	Bit	Access	Description	Default
UNIDIR_MODE_ENA	4	R/W	Unidirectional mode enable. Implementation of 802.3, Clause 66. When asserted, this enables MAC to transmit data independent of the state of the receive link. 0: Unidirectional mode disabled 1: Unidirectional mode enabled	0x0
SGMII_MODE_ENA	0	R/W	Selection of PCS operation 0: PCS is used in SERDES mode 1: PCS is used in SGMII mode. Configuration bit PCS1G_ANEG_CFG.SW_RESOLVE_ENA must be set additionally	0x1

7.14.4.3 DEV:PCS1G_CFG_STATUS:PCS1G_SD_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G signal_detect configuration

Table 574 • **Fields in PCS1G_SD_CFG**

Field Name	Bit	Access	Description	Default
SD_SEL	8	R/W	Signal detect selection (select input for internal signal_detect line) 0: Select signal_detect line from hardmacro 1: Select external signal_detect line	0x0

Table 574 • **Fields in PCS1G_SD_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SD_POL	4	R/W	Signal detect polarity: The signal level on signal_detect input pin must be equal to SD_POL to indicate signal detection (SD_ENA must be set) 0: Signal Detect input pin must be '0' to indicate a signal detection 1: Signal Detect input pin must be '1' to indicate a signal detection	0x1
SD_ENA	0	R/W	Signal Detect Enable 0: The Signal Detect input pin is ignored. The PCS assumes an active Signal Detect at all times 1: The Signal Detect input pin is used to determine if a signal is detected	0x1

7.14.4.4 DEV:PCS1G_CFG_STATUS:PCS1G_ANEG_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Auto-negotiation configuration register

Table 575 • **Fields in PCS1G_ANEG_CFG**

Field Name	Bit	Access	Description	Default
ADV_ABILITY	31:16	R/W	Advertised Ability Register: Holds the capabilities of the device as described IEEE 802.3, Clause 37. If SGMII mode is selected (PCS1G_MODE_CFG.SGMII_MODE_ENA = 1), SW_RESOLVE_ENA must be set.	0x0000
SW_RESOLVE_ENA	8	R/W	Software Resolve Abilities 0: If Auto Negotiation fails (no matching HD or FD capabilities) the link is disabled 1: The result of an Auto Negotiation is ignored - the link can be setup via software. This bit must be set in SGMII mode.	0x0
ANEG_RESTART_ONE_SHOT	1	One-shot	Auto Negotiation Restart 0: No action 1: Restart Auto Negotiation	0x0
ANEG_ENA	0	R/W	Auto Negotiation Enable 0: Auto Negotiation Disabled 1: Auto Negotiation Enabled	0x0

7.14.4.5 DEV:PCS1G_CFG_STATUS:PCS1G_ANEG_NP_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Auto-negotiation configuration register for next-page function

Table 576 • **Fields in PCS1G_ANEG_NP_CFG**

Field Name	Bit	Access	Description	Default
NP_TX	31:16	R/W	Next page register: Holds the next-page information as described in IEEE 802.3, Clause 37	0x0000
NP_LOADED_ONE_SHOT	0	One-shot	Next page loaded 0: next page is free and can be loaded 1: next page register has been filled (to be set after np_tx has been filled)	0x0

7.14.4.6 DEV:PCS1G_CFG_STATUS:PCS1G_LB_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Loop-Back configuration register

Table 577 • **Fields in PCS1G_LB_CFG**

Field Name	Bit	Access	Description	Default
TBI_HOST_LB_ENA	0	R/W	Loops data in PCS (TBI side) from egress direction to ingress direction. The Rx clock is automatically set equal to the Tx clock 0: TBI Loopback Disabled 1:TBI Loopback Enabled	0x0

7.14.4.7 DEV:PCS1G_CFG_STATUS:PCS1G_ANEG_STATUS

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Auto-negotiation status register

Table 578 • **Fields in PCS1G_ANEG_STATUS**

Field Name	Bit	Access	Description	Default
LP_ADV_ABILITY	31:16	R/O	Advertised abilities from link partner as described in IEEE 802.3, Clause 37	0x0000
PR	4	R/O	Resolve priority 0: ANEG is in progress 1: ANEG nearly finished - priority can be resolved (via software)	0x0

Table 578 • **Fields in PCS1G_ANEG_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
PAGE_RX_STICKY	3	Sticky	Status indicating whether a new page has been received. 0: No new page received 1: New page received Bit is cleared by writing a 1 to this position.	0x0
ANEG_COMPLETE	0	R/O	Auto Negotiation Complete 0: No Auto Negotiation has been completed 1: Indicates that an Auto Negotiation has completed successfully	0x0

7.14.4.8 DEV:PCS1G_CFG_STATUS:PCS1G_ANEG_NP_STATUS

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Auto-negotiation next page status register

Table 579 • **Fields in PCS1G_ANEG_NP_STATUS**

Field Name	Bit	Access	Description	Default
LP_NP_RX	31:16	R/O	Next page ability register from link partner as described in IEEE 802.3, Clause 37	0x0000

7.14.4.9 DEV:PCS1G_CFG_STATUS:PCS1G_LINK_STATUS

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G link status register

Table 580 • **Fields in PCS1G_LINK_STATUS**

Field Name	Bit	Access	Description	Default
SIGNAL_DETECT	8	R/O	Indicates whether or not the selected Signal Detect input line is asserted 0: No signal detected 1: Signal detected	0x0
LINK_STATUS	4	R/O	Indicates whether the link is up or down. A link is up when ANEG state machine is in state LINK_OK or AN_DISABLE_LINK_OK 0: Link down 1: Link up	0x0

Table 580 • **Fields in PCS1G_LINK_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
SYNC_STATUS	0	R/O	Indicates if PCS has successfully synchronized 0: PCS is out of sync 1: PCS has synchronized	0x0

7.14.4.10 DEV:PCS1G_CFG_STATUS:PCS1G_LINK_DOWN_CNT

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G link down counter register

Table 581 • **Fields in PCS1G_LINK_DOWN_CNT**

Field Name	Bit	Access	Description	Default
LINK_DOWN_CNT	7:0	R/W	Link Down Counter. A counter that counts the number of times a link has been down. The counter does not saturate at 255 and is only cleared when writing 0 to the register	0x00

7.14.4.11 DEV:PCS1G_CFG_STATUS:PCS1G_STICKY

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G status register for sticky bits

Table 582 • **Fields in PCS1G_STICKY**

Field Name	Bit	Access	Description	Default
LINK_DOWN_STICKY	4	Sticky	The sticky bit is set when the link has been down - i.e. if the ANEG state machine has not been in the AN_DISABLE_LINK_OK or LINK_OK state for one or more clock cycles. This occurs if e.g. ANEG is restarted or for example if signal-detect or synchronization has been lost for more than 10 ms (1.6 ms in SGMII mode). By setting the UDLT bit, the required down time can be reduced to 9,77 us (1.56 us) 0: Link is up 1: Link has been down Bit is cleared by writing a 1 to this position.	0x0

Table 582 • **Fields in PCS1G_STICKY *(continued)***

Field Name	Bit	Access	Description	Default
OUT_OF_SYNC_STICKY	0	Sticky	Sticky bit indicating if PCS synchronization has been lost 0: Synchronization has not been lost at any time 1: Synchronization has been lost for one or more clock cycles Bit is cleared by writing a 1 to this position.	0x0

7.14.4.12 DEV:PCS1G_CFG_STATUS:PCS1G_LPI_CFG

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

Configuration register for Low Power Idle (Energy Efficient Ethernet)

Table 583 • **Fields in PCS1G_LPI_CFG**

Field Name	Bit	Access	Description	Default
QSGMII_MS_SEL	20	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x1
TX_ASSERT_LPIDLE	0	R/W	Assert Low-Power Idle (LPI) in transmit mode 0: Disable LPI transmission 1: Enable LPI transmission	0x0

7.14.4.13 DEV:PCS1G_CFG_STATUS:PCS1G_LPI_WAKE_ERROR_CNT

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

PCS1G Low Power Idle wake error counter (Energy Efficient Ethernet)

Table 584 • **Fields in PCS1G_LPI_WAKE_ERROR_CNT**

Field Name	Bit	Access	Description	Default
WAKE_ERROR_CNT	15:0	R/W	Wake Error Counter. A counter that is incremented when the link partner does not send wake-up burst in due time. The counter saturates at 65535 and is cleared when writing 0 to the register	0x0000

7.14.4.14 DEV:PCS1G_CFG_STATUS:PCS1G_LPI_STATUS

Parent: DEV:PCS1G_CFG_STATUS

Instances: 1

Status register for Low Power Idle (Energy Efficient Ethernet)

Table 585 • **Fields in PCS1G_LPI_STATUS**

Field Name	Bit	Access	Description	Default
RX_LPI_EVENT_STICKY	12	Sticky	Receiver Low-Power idle occurrence 0: No LPI symbols received 1: Receiver has received LPI symbols Bit is cleared by writing a 1 to this position.	0x0
RX_QUIET	9	R/O	Receiver Low-Power Quiet mode 0: Receiver not in quiet mode 1: Receiver is in quiet mode	0x0
RX_LPI_MODE	8	R/O	Receiver Low-Power Idle mode 0: Receiver not in low power idle mode 1: Receiver is in low power idle mode	0x0
TX_LPI_EVENT_STICKY	4	Sticky	Transmitter Low-Power idle occurrence 0: No LPI symbols transmitted 1: Transmitter has transmitted LPI symbols Bit is cleared by writing a 1 to this position.	0x0
TX_QUIET	1	R/O	Transmitter Low-Power Quiet mode 0: Transmitter not in quiet mode 1: Transmitter is in quiet mode	0x0
TX_LPI_MODE	0	R/O	Transmitter Low-Power Idle mode 0: Transmitter not in low power idle mode 1: Transmitter is in low power idle mode	0x0

7.14.5 DEV:PCS1G_TSTPAT_CFG_STATUS

Parent: DEV

Instances: 1

PCS1G testpattern configuration and status register set

Table 586 • **Registers in PCS1G_TSTPAT_CFG_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PCS1G_TSTPAT_MODE_CFG	0x00000000	1	PCS1G TSTPAT MODE CFG	Page 458
PCS1G_TSTPAT_STATUS	0x00000004	1	PCS1G TSTPAT STATUS	Page 458

7.14.5.1 DEV:PCS1G_TSTPAT_CFG_STATUS:PCS1G_TSTPAT_MODE_CFG

Parent: DEV:PCS1G_TSTPAT_CFG_STATUS

Instances: 1

PCS1G testpattern mode configuration register (Frame based pattern 4 and 5 might be not available depending on chip type)

Table 587 • **Fields in PCS1G_TSTPAT_MODE_CFG**

Field Name	Bit	Access	Description	Default
JTP_SEL	2:0	R/W	Jitter Test Pattern Select: Enables and selects the jitter test pattern to be transmitted. The jitter test patterns are according to the IEEE 802.3, Annex 36A 0: Disable transmission of test patterns 1: High frequency test pattern - repeated transmission of D21.5 code group 2: Low frequency test pattern - repeated transmission of K28.7 code group 3: Mixed frequency test pattern - repeated transmission of K28.5 code group 4: Long continuous random test pattern (packet length is 1524 bytes) 5: Short continuous random test pattern (packet length is 360 bytes)	0x0

7.14.5.2 DEV:PCS1G_TSTPAT_CFG_STATUS:PCS1G_TSTPAT_STATUS

Parent: DEV:PCS1G_TSTPAT_CFG_STATUS

Instances: 1

PCS1G testpattern status register

Table 588 • **Fields in PCS1G_TSTPAT_STATUS**

Field Name	Bit	Access	Description	Default
JTP_ERR_CNT	15:8	R/W	Jitter Test Pattern Error Counter. Due to re-sync measures it might happen that single errors are not counted (applies for 2.5gpbs mode). The counter saturates at 255 and is only cleared when writing 0 to the register	0x00

Table 588 • **Fields in PCS1G_TSTPAT_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
JTP_ERR	4	R/O	Jitter Test Pattern Error 0: Jitter pattern checker has found no error 1: Jitter pattern checker has found an error	0x0
JTP_LOCK	0	R/O	Jitter Test Pattern Lock 0: Jitter pattern checker has not locked 1: Jitter pattern checker has locked	0x0

7.14.6 DEV:PCS_FX100_CONFIGURATION

Parent: DEV

Instances: 1

Configuration register set for PCS 100Base-FX logic

Table 589 • **Registers in PCS_FX100_CONFIGURATION**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PCS_FX100_CFG	0x00000000	1	PCS 100Base FX Configuration	Page 459

7.14.6.1 DEV:PCS_FX100_CONFIGURATION:PCS_FX100_CFG

Parent: DEV:PCS_FX100_CONFIGURATION

Instances: 1

Configuration bit groups for 100Base-FX PCS

Table 590 • **Fields in PCS_FX100_CFG**

Field Name	Bit	Access	Description	Default
SD_SEL	26	R/W	Signal detect selection (select input for internal signal_detect line) 0: Select signal_detect line from hardmacro 1: Select external signal_detect line	0x0
RESERVED	25	R/W	Must be set to its default.	0x1

Table 590 • **Fields in PCS_FX100_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SD_ENA	24	R/W	Signal Detect Enable 0: The Signal Detect input pin is ignored. The PCS assumes an active Signal Detect at all times 1: The Signal Detect input pin is used to determine if a signal is detected	0x1
RESERVED	15:12	R/W	Must be set to its default.	0x4
LINKHYSTTIMER	7:4	R/W	Link hysteresis timer configuration. The hysteresis time lasts [linkhysttimer] * 65536 ns + 2320 ns. If linkhysttime is set to 5, the hysteresis lasts the minimum time of 330 us as specified in IEEE 802.3 - 24.3.3.4.	0x5
UNIDIR_MODE_ENA	3	R/W	Unidirectional mode enable. Implementation 0f 802.3 clause 66. When asserted, this enables MAC to transmit data independent of the state of the receive link. 0: Unidirectional mode disabled 1: Unidirectional mode enabled	0x0
FEFCHK_ENA	2	R/W	Far-End Fault (FEF) detection enable 0: Disable FEF detection 1 Enable FEF detection	0x1
FEFGEN_ENA	1	R/W	Far-End Fault (FEF) generation enable 0: Disable FEF generation 1 Enable FEF generation	0x1
PCS_ENA	0	R/W	PCS enable 0: Disable PCS 1: Enable PCS	0x0

7.14.7 DEV:PCS_FX100_STATUS

Parent: DEV

Instances: 1

Status register set for PCS 100Base-FX logic

Table 591 • **Registers in PCS_FX100_STATUS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PCS_FX100_STATUS	0x00000000	1	PCS 100Base FX Status	Page 460

7.14.7.1 DEV:PCS_FX100_STATUS:PCS_FX100_STATUS

Parent: DEV:PCS_FX100_STATUS

Instances: 1

Status bit groups for 100Base-FX PCS. Note: If sigdet_cfg != "00" is selected status signal "signal_detect" shows the internal signal_detect value is gated with the status of rx toggle-rate control circuitry.

Table 592 • **Fields in PCS_FX100_STATUS**

Field Name	Bit	Access	Description	Default
PCS_ERROR_STICKY	7	Sticky	PCS error has occurred 1: RX_ER was high while RX_DV active 0: No RX_ER indication found while RX_DV active Bit is cleared by writing a 1 to this position.	0x0
FEF_FOUND_STICKY	6	Sticky	Far-end Fault state has occurred 1: A Far-End Fault has been detected 0: No Far-End Fault occurred Bit is cleared by writing a 1 to this position.	0x0
SSD_ERROR_STICKY	5	Sticky	Stream Start Delimiter error occurred 1: A Start-of-Stream Delimiter error has been detected 0: No SSD error occurred Bit is cleared by writing a 1 to this position.	0x0
SYNC_LOST_STICKY	4	Sticky	Synchronization lost 1: Synchronization lost 0: No sync lost occurred Bit is cleared by writing a 1 to this position.	0x0
FEF_STATUS	2	R/O	Current status of Far-end Fault detection state 1: Link currently in fault state 0: Link is in normal state	0x0
SIGNAL_DETECT	1	R/O	Current status of selected signal_detect input line 1: Proper signal detected 0: No proper signal found	0x0
SYNC_STATUS	0	R/O	Status of synchronization 1: Link established 0: No link found	0x0

7.15 ICPU_CFG

Table 593 • **Register Groups in ICPU_CFG**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
CPU_SYSTEM_CTRL	0x00000000	1	Configurations for the CPU system.	Page 462
PI_MST	0x0000002C	1	Parallel Interface Master Configuration	Page 465
SPI_MST	0x00000050	1	SPI Master Configuration	Page 468
INTR	0x00000084	1	Interrupt Registers	Page 470
GPDMA	0x0000013C	1	Frame DMA	Page 504
INJ_FRM_SPC	0x00000188	8 0x00000010	Injection frame spacing	Page 508
TIMERS	0x00000208	1	Timer Registers	Page 510
MEMCTRL	0x00000234	1	DDR2/3 Memory Controller Registers	Page 513
TWI_DELAY	0x000002A4	1	Configuration registers	Page 524

7.15.1 ICPU_CFG:CPU_SYSTEM_CTRL

Parent: ICPU_CFG

Instances: 1

Table 594 • **Registers in CPU_SYSTEM_CTRL**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
GPR	0x00000000	8 0x00000004	General Purpose Register	Page 462
RESET	0x00000020	1	Reset Settings	Page 463
GENERAL_CTRL	0x00000024	1	General control	Page 464
GENERAL_STAT	0x00000028	1	General status	Page 465

7.15.1.1 ICPU_CFG:CPU_SYSTEM_CTRL:GPR

Parent: ICPU_CFG:CPU_SYSTEM_CTRL

Instances: 8

Table 595 • **Fields in GPR**

Field Name	Bit	Access	Description	Default
GPR	31:0	R/W	General purpose 8 times 32-bit registers for software development and debug.	0x00000000

7.15.1.2 ICPU_CFG:CPU_SYSTEM_CTRL:RESET

Parent: ICPU_CFG:CPU_SYSTEM_CTRL

Instances: 1

Table 596 • **Fields in RESET**

Field Name	Bit	Access	Description	Default
CPU_RELEASE	4	R/W	Set this field to enable the VCore CPU. This field is only valid when automatic booting of the VCore CPU has been disabled via VCore_Cfg inputs. This field has no effect when the VCore CPU is configured for automatically boot. Note: By using this field it is possible for an external CPU to manually load a code image to memory, change into normal mode, and then release the VCore CPU after which it will boot from memory rather than FLASH. 0: VCore CPU is forced in reset 1: VCore CPU is allowed to boot	0x0
CORE_RST_CPU_ONLY	3	R/W	Set this field to enable VCore System reset protection. It is possible to protect the VCore System from soft-reset (issued via RESET:CORE_RST_FORCE) and watchdog-timeout. When this field is set the aforementioned resets only reset the VCore CPU, not the VCore System. 0: WDT event reset entire VCore 1: WDT event only reset the VCore CPU	0x0

Table 596 • **Fields in RESET *(continued)***

Field Name	Bit	Access	Description	Default
CORE_RST_PROTECT	2	R/W	Set this field to enable VCore reset protection. It is possible to protect the entire VCore from chip-level soft-reset (issued via DEVCPU_GCB::SOFT_CHIP_RST.SOFT_CHIP_RST). Setting this field does not protect against hard-reset of the chip (by asserting the reset pin). 0: No reset protection 1: VCore is protected from chip-level-soft-reset	0x0
CORE_RST_FORCE	1	One-shot	Set this field to generate a soft reset for the VCore. This field will be cleared when the reset has taken effect. It is possible to protect the VCore system (everything else than the VCore CPU) from reset via RESET.CORE_RST_CPU_ONLY. 0: VCore is not reset 1: Initiate soft reset of the VCore	0x0
MEM_RST_FORCE	0	R/W	While this field is set, the memory controller is held in reset. 0: Memory controller is not reset 1: Memory controller is forced in reset	0x1

7.15.1.3 ICPU_CFG:CPU_SYSTEM_CTRL:GENERAL_CTRL

Parent: ICPU_CFG:CPU_SYSTEM_CTRL

Instances: 1

Table 597 • **Fields in GENERAL_CTRL**

Field Name	Bit	Access	Description	Default
IF_MASTER_PI_ENA	1	R/W	Set this field to force PI interface into master mode. By default only the boot interface of the VCore system is in master mode (controlled by the VCore). This field must be set if the VCore is started manually or requires the non-boot interface for accessing logic outside the chip. Please note, if this field is set, it is no longer possible for an external CPU to access registers in the chip via PI.	0x0

Table 597 • **Fields in GENERAL_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
BOOT_MODE_ENA	0	R/W	Use this field to change from Boot mode to Normal mode. In Boot mode, the reset vector of the VCore CPU maps to CS0 on the parallel interface. When in Normal mode, this address maps instead to the DRAM Controller. The DRAM Controller must be operational before disabling Boot mode. After setting Boot mode, this register must be read back. The change in Boot mode becomes effective during reading. 0: The VCore memory map is in Normal mode. 1: The VCore memory map is in Boot mode.	0x1

7.15.1.4 ICPU_CFG:CPU_SYSTEM_CTRL:GENERAL_STAT

Parent: ICPU_CFG:CPU_SYSTEM_CTRL

Instances: 1

Table 598 • **Fields in GENERAL_STAT**

Field Name	Bit	Access	Description	Default
CPU_SLEEP	3	R/O	This field is set if the VCore CPU has entered sleep mode.	0x0
ENDIAN_MODE	2	R/O	This field shows the endianess that has been configured for the VCore CPU. 0: Little Endian 1: Big Endian	0x0
BOOT_MODE	1	R/O	This field shows which boot strategy that has been configured for the VCore CPU. 0: Automatic booting 1: Manual booting	0x0
BOOT_IF	0	R/O	This field shows which boot interface that has been configured for the VCore CPU. 0: PI 1: SPI	0x0

7.15.2 ICPU_CFG:PI_MST

Parent: ICPU_CFG

Instances: 1

Table 599 • **Registers in PI_MST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PI_MST_CFG	0x00000000	1	PI Master Configuration	Page 466
PI_MST_CTRL	0x00000004	4 0x00000004	PI Master Control Register	Page 466
PI_MST_STATUS	0x00000014	4 0x00000004	PI Master Status Registers	Page 468

7.15.2.1 ICPU_CFG:PI_MST:PI_MST_CFG

Parent: ICPU_CFG:PI_MST

Instances: 1

Table 600 • **Fields in PI_MST_CFG**

Field Name	Bit	Access	Description	Default
RESERVED	5	R/W	Must be set to its default.	0x1
CLK_DIV	4:0	R/W	Controls the clock for the PI Controller. 0: Illegal 1: Illegal 2: Use CPU clock/2 ... 31: Use CPU clock/31	0x1F

7.15.2.2 ICPU_CFG:PI_MST:PI_MST_CTRL

Parent: ICPU_CFG:PI_MST

Instances: 4

This is a replicated register, where each replication holds the configurations for one chip select. Changes to a value in one of the replicated instances apply only to that chip select.

Table 601 • **Fields in PI_MST_CTRL**

Field Name	Bit	Access	Description	Default
DATA_WID	23	R/W	Data width. In 8-bit mode, the unused data-bits contain additional address information. 0: 8 bits 1: 16 bits	0x0
DEVICE_PACED_XFER_ENA	22	R/W	Device-paced transfer enable. When enabled, use PI_nDone to end a transfer. 0: Disabled 1: Enabled	0x0

Table 601 • **Fields in PI_MST_CTRL** ***(continued)***

Field Name	Bit	Access	Description	Default
DEVICE_PACED_TIMEOUT_ENA	21	R/W	Enable timeout on device-paced transfers. If enabled, a device_paced_transfer transfer does not wait indefinitely for assertion of PI_nDone. If a timeout occurs, the TIMEOUT_ERR_STICKY bit is set in the status register and the current transfer is terminated (read-data will be invalid). When enabling device paced timeout ICPU_CFG::PI_MST_CTRL.CSCC field must be set higher than 0 and the timeout defined by ICPU_CFG::PI_MST_CTRL.DEVICE_PACED_TIMEOUT must be higher than ICPU_CFG::PI_MST_CTRL.WAITCC.	0x0
DEVICE_PACED_TIMEOUT	20:18	R/W	Determines the number of PI_Clk cycles from the start of a transfer until a timeout occurs. This field is only valid when timeout for device-paced transfer is enabled. 000: 16 PI_Clk cycles 001: 32 PI_Clk cycles 010: 64 PI_Clk cycles 011: 128 PI_Clk cycles 100: 256 PI_Clk cycles 101: 512 PI_Clk cycles 110: 1024 PI_Clk cycles 111: 2048 PI_Clk cycles	0x0
RESERVED	17	R/W	Must be set to its default.	0x1
DONE_POL	16	R/W	Polarity of PI_nDone for device-paced transfers. 0: PI_nDone is active low 1: PI_nDone is active high	0x0
SMPL_ON_DONE	15	R/W	Controls when data is sampled in relation to assertion of PI_nDone for device-paced reads. 0: Data is sampled one PI_Clk cycle after PI_nDone goes active. 1: Data is sampled on the same PI_Clk cycle where PI_nDone goes active.	0x0
WAITCC	14:7	R/W	Number of wait states measured in PI_Clk cycles on both read and write transfers.	0x01
CSCC	6:5	R/W	Number of PI_Clk cycles from address driven to PI_nCS[x] low.	0x1
OECC	4:3	R/W	Number of PI_Clk cycles from PI_nCS[x] low to PI_nOE low.	0x0

Table 601 • **Fields in PI_MST_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
HLDCC	2:0	R/W	Number of PI_Clk cycles to insert at the end of a transfer.	0x0

7.15.2.3 ICPU_CFG:PI_MST:PI_MST_STATUS

Parent: ICPU_CFG:PI_MST

Instances: 4

This is a replicated register, where each replication holds the status for one chip select.

Table 602 • **Fields in PI_MST_STATUS**

Field Name	Bit	Access	Description	Default
TIMEOUT_ERR_STICKY	0	Sticky	If a timeout is enabled and timeout occurs during a device-paced transfer, this bit is set.	0x0

7.15.3 ICPU_CFG:SPI_MST

Parent: ICPU_CFG

Instances: 1

Table 603 • **Registers in SPI_MST**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SPI_MST_CFG	0x00000000	1	SPI Master Configuration	Page 468
SW_MODE	0x00000014	1	Manual control of the SPI interface	Page 469

7.15.3.1 ICPU_CFG:SPI_MST:SPI_MST_CFG

Parent: ICPU_CFG:SPI_MST

Instances: 1

Table 604 • **Fields in SPI_MST_CFG**

Field Name	Bit	Access	Description	Default
FAST_READ_ENA	10	R/W	The type of read-instruction that the SPI Controller generates for reads. 0: READ (slow read - Instruction code - 0x03) 1: FAST READ (fast read - Instruction code - 0x0B)	0x0

Table 604 • **Fields in SPI_MST_CFG *(continued)***

Field Name	Bit	Access	Description	Default
CS_DESELECT_TIME	9:5	R/W	The minimum number of SPI clock cycles for which the SPI chip select (SI_nEn) must be deasserted in between transfers. Typical value of this is 100 ns. Setting this field to 0 is illegal.	0x1F
CLK_DIV	4:0	R/W	Controls the clock frequency for the SPI interface (SI_Clk). The clock frequency is VCore system clock divided by the value of this field. Setting this field to 0 or 1 value is illegal.	0x1F

7.15.3.2 ICPU_CFG:SPI_MST:SW_MODE

Parent: ICPU_CFG:SPI_MST

Instances: 1

Note: There are 4 chip selects in total, but only chip select 0 is mapped to IO-pin (SI_nEn). The rest of the SPI chip selects are available as alternate functions on GPIOs, these must be enabled in the GPIO controller before they can be controlled via this register.

Table 605 • **Fields in SW_MODE**

Field Name	Bit	Access	Description	Default
SW_PIN_CTRL_MODE	13	R/W	Set to enable software pin control mode (Bit banging), when set software has direct control of the SPI interface. This mode is used for writing into flash.	0x0
SW_SPI_SCK	12	R/W	Value to drive on SI_Clk output. This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set.	0x0
SW_SPI_SCK_OE	11	R/W	Set to enable drive of SI_Clk output. This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set.	0x0
SW_SPI_SDO	10	R/W	Value to drive on SI_DO output. This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set.	0x0
SW_SPI_SDO_OE	9	R/W	Set to enable drive of SI_DO output. This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set.	0x0

Table 605 • **Fields in SW_MODE *(continued)***

Field Name	Bit	Access	Description	Default
SW_SPI_CS	8:5	R/W	Value to drive on SI_nEn outputs, each bit in this field maps to a corresponding chip-select (0 though 3). This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set. Note: Chip selects 1 though 3 are available as alternate GPIO functions.	0x0
SW_SPI_CS_OE	4:1	R/W	Set to enable drive of SI_nEn outputs, each bit in this field maps to a corresponding chip-select (0 though 3). This field is only used if SW_MODE.SW_PIN_CTRL_MODE is set. Note: Chip selects 1 though 3 are available as alternate GPIO functions.	0x0
SW_SPI_SDI	0	R/O	Current value of the SI_DI input.	0x0

7.15.4 ICPU_CFG:INTR

Parent: ICPU_CFG

Instances: 1

Table 606 • **Registers in INTR**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
INTR	0x00000000	1	Interrupt sticky bits	Page 472
INTR_ENA	0x00000004	1	Interrupt enable	Page 475
INTR_ENA_CLR	0x00000008	1	Clear interrupt enable	Page 477
INTR_ENA_SET	0x0000000C	1	Set interrupt enable	Page 478
INTR_RAW	0x00000010	1	Raw of interrupt source	Page 479
ICPU_IRQ0_ENA	0x00000014	1	Enable of ICPU_IRQ0 interrupt	Page 480
ICPU_IRQ0_IDENT	0x00000018	1	Sources of ICPU_IRQ0 interrupt	Page 481
ICPU_IRQ1_ENA	0x0000001C	1	Enable of ICPU_IRQ1 interrupt	Page 482
ICPU_IRQ1_IDENT	0x00000020	1	Sources of ICPU_IRQ1 interrupt	Page 482
EXT_IRQ0_ENA	0x00000024	1	Enable of EXT_IRQ0 interrupt	Page 484
EXT_IRQ0_IDENT	0x00000028	1	Sources of EXT_IRQ0 interrupt	Page 484

Table 606 • **Registers in INTR *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
EXT_IRQ1_ENA	0x0000002C	1	Enable of EXT_IRQ1 interrupt	Page 485
EXT_IRQ1_IDENT	0x00000030	1	Sources of EXT_IRQ1 interrupt	Page 485
DEV_IDENT	0x00000034	1	Device interrupts	Page 487
EXT_IRQ0_INTR_CFG	0x00000038	1	EXT_IRQ0 interrupt configuration	Page 487
EXT_IRQ1_INTR_CFG	0x0000003C	1	EXT_IRQ1 interrupt configuration	Page 488
SW0_INTR_CFG	0x00000040	1	SW0 interrupt configuration	Page 490
SW1_INTR_CFG	0x00000044	1	SW1 interrupt configuration	Page 490
MIIM1_INTR_CFG	0x00000048	1	MIIM1 interrupt configuration	Page 491
MIIM0_INTR_CFG	0x0000004C	1	MIIM0 interrupt configuration	Page 491
PI_SD0_INTR_CFG	0x00000050	1	PI_SD0 interrupt configuration	Page 492
PI_SD1_INTR_CFG	0x00000054	1	PI_SD1 interrupt configuration	Page 493
UART_INTR_CFG	0x00000058	1	UART interrupt configuration	Page 493
TIMER0_INTR_CFG	0x0000005C	1	TIMER0 interrupt configuration	Page 494
TIMER1_INTR_CFG	0x00000060	1	TIMER1 interrupt configuration	Page 494
TIMER2_INTR_CFG	0x00000064	1	TIMER2 interrupt configuration	Page 495
FDMA_INTR_CFG	0x00000068	1	FDMA interrupt configuration	Page 495
TWI_INTR_CFG	0x0000006C	1	TWI interrupt configuration	Page 496
GPIO_INTR_CFG	0x00000070	1	GPIO interrupt configuration	Page 497
SGPIO_INTR_CFG	0x00000074	1	SGPIO interrupt configuration	Page 497
DEV_ALL_INTR_CFG	0x00000078	1	DEV_ALL interrupt configuration	Page 498
BLK_ANA_INTR_CFG	0x0000007C	1	BLK_ANA_ interrupt configuration	Page 498
XTR_RDY0_INTR_CFG	0x00000080	1	XTR_RDY0 interrupt configuration	Page 499

Table 606 • **Registers in INTR *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
XTR_RDY1_INTR_CFG	0x00000084	1	XTR_RDY1 interrupt configuration	Page 500
INJ_RDY0_INTR_CFG	0x00000090	1	INJ_RDY0 interrupt configuration	Page 501
INJ_RDY1_INTR_CFG	0x00000094	1	INJ_RDY1 interrupt configuration	Page 501
INTEGRITY_INTR_CFG	0x000000A4	1	INTEGRITY interrupt configuration	Page 502
PTP_SYNC_INTR_CFG	0x000000A8	1	PTP_SYNC interrupt configuration	Page 503
DEV_ENA	0x000000AC	1	Device Interrupt enable	Page 503

7.15.4.1 ICPU_CFG:INTR:INTR

Parent: ICPU_CFG:INTR

Instances: 1

Asserted for the active interrupt sources.

Table 607 • **Fields in INTR**

Field Name	Bit	Access	Description	Default
MIIM1_INTR	28	Sticky	This field is set when MIIM master1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the MIIM master1 interrupt event is no longer active.	0x0
MIIM0_INTR	27	Sticky	This field is set when MIIM master0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the MIIM master0 interrupt event is no longer active.	0x0
PTP_SYNC_INTR	26	Sticky	This field is set when PTP-Sync interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the PTP-Sync interrupt event is no longer active.	0x0
INTEGRITY_INTR	25	Sticky	This field is set when integrity interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if there are no longer any pending integrity interrupt event.	0x0

Table 607 • **Fields in INTR *(continued)***

Field Name	Bit	Access	Description	Default
INJ_RDY1_INTR	21	Sticky	This field is set when inj-group-1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the inj-group-1 interrupt event is no longer active.	0x0
INJ_RDY0_INTR	20	Sticky	This field is set when inj-group-0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the inj-group-0 interrupt event is no longer active.	0x0
XTR_RDY1_INTR	17	Sticky	This field is set when xtr-group-1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the xtr-group-1 interrupt event is no longer active.	0x0
XTR_RDY0_INTR	16	Sticky	This field is set when xtr-group-0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the xtr-group-0 interrupt event is no longer active.	0x0
BLK_ANA_INTR	15	Sticky	This field is set when analyzer interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the analyzer interrupt event is no longer active.	0x0
DEV_ALL_INTR	14	Sticky	This field is set when interrupt from any device (port) is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if there is still a pending interrupt from any device. This is a cascaded interrupt, read DEV_IDENT to see which device(s) that is/are currently interrupting.	0x0
SGPIO_INTR	13	Sticky	This field is set when Serial-GPIO interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the Serial-GPIO interrupt event is no longer active.	0x0

Table 607 • **Fields in INTR** ***(continued)***

Field Name	Bit	Access	Description	Default
GPIO_INTR	12	Sticky	This field is set when Parallel-GPIO interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the Parallel-GPIO interrupt event is no longer active.	0x0
TWI_INTR	11	Sticky	This field is set when TWI interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the TWI interrupt event is no longer active.	0x0
FDMA_INTR	10	Sticky	This field is set when FDMA interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the FDMA interrupt event is no longer active.	0x0
TIMER2_INTR	9	Sticky	This field is set when Timer-2 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the Timer-2 interrupt event is no longer active.	0x0
TIMER1_INTR	8	Sticky	This field is set when Timer-1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the Timer-1 interrupt event is no longer active.	0x0
TIMER0_INTR	7	Sticky	This field is set when Timer-0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the Timer-0 interrupt event is no longer active.	0x0
UART_INTR	6	Sticky	This field is set when UART interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the UART interrupt event is no longer active.	0x0
PI_SD1_INTR	5	Sticky	This field is set when PI-Slow-Done-1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the PI-Slow-Done-1 interrupt event is no longer active.	0x0

Table 607 • **Fields in INTR *(continued)***

Field Name	Bit	Access	Description	Default
PI_SD0_INTR	4	Sticky	This field is set when PI-Slow-Done-0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the PI-Slow-Done-0 interrupt event is no longer active.	0x0
SW1_INTR	3	Sticky	This field is set when SW1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the SW1 interrupt event is no longer active.	0x0
SW0_INTR	2	Sticky	This field is set when SW0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the SW0 interrupt event is no longer active.	0x0
EXT_IRQ1_INTR	1	Sticky	This field is set when EXT_IRQ1 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the EXT_IRQ1 interrupt event is no longer active.	0x0
EXT_IRQ0_INTR	0	Sticky	This field is set when EXT_IRQ0 interrupt is detected. Clearing of this field is done by writing 1 to this field. This field can only be cleared if the EXT_IRQ0 interrupt event is no longer active.	0x0

7.15.4.2 ICPU_CFG:INTR:INTR_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Controls if active interrupt indications (from INTR) can propagate to their destinations. In a multi-threaded environment, or with more than one active processor the INTR_ENA_SET and INTR_ENA_CLR registers can be used for atomic modifications of this register. Writing 1 to any bit(s) in the INTR_ENA_SET register will set the corresponding bit(s) in this register, Writing 1 to any bit in the INTR_ENA_CLR register will clear the corresponding bit(s) in this register.

Table 608 • **Fields in INTR_ENA**

Field Name	Bit	Access	Description	Default
MIIM1_INTR_ENA	28	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
MIIM0_INTR_ENA	27	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0

Table 608 • **Fields in INTR_ENA** ***(continued)***

Field Name	Bit	Access	Description	Default
PTP_SYNC_INTR_ENA	26	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
INTEGRITY_INTR_ENA	25	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
INJ_RDY1_INTR_ENA	21	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
INJ_RDY0_INTR_ENA	20	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
XTR_RDY1_INTR_ENA	17	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
XTR_RDY0_INTR_ENA	16	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
BLK_ANA_INTR_ENA	15	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
DEV_ALL_INTR_ENA	14	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
SGPIO_INTR_ENA	13	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
GPIO_INTR_ENA	12	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
TWI_INTR_ENA	11	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
FDMA_INTR_ENA	10	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
TIMER2_INTR_ENA	9	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
TIMER1_INTR_ENA	8	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
TIMER0_INTR_ENA	7	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
UART_INTR_ENA	6	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
PI_SD1_INTR_ENA	5	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
PI_SD0_INTR_ENA	4	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
SW1_INTR_ENA	3	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
SW0_INTR_ENA	2	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
EXT_IRQ1_INTR_ENA	1	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0
EXT_IRQ0_INTR_ENA	0	R/W	Set this field to enable the interrupt to propagate to its destination.	0x0

7.15.4.3 ICPU_CFG:INTR:INTR_ENA_CLR

Parent: ICPU_CFG:INTR

Instances: 1

Table 609 • **Fields in INTR_ENA_CLR**

Field Name	Bit	Access	Description	Default
MIIM1_INTR_ENA_CLR	28	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
MIIM0_INTR_ENA_CLR	27	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
PTP_SYNC_INTR_ENA_CLR	26	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
INTEGRITY_INTR_ENA_CLR	25	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
INJ_RDY1_INTR_ENA_CLR	21	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
INJ_RDY0_INTR_ENA_CLR	20	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
XTR_RDY1_INTR_ENA_CLR	17	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
XTR_RDY0_INTR_ENA_CLR	16	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
BLK_ANA_INTR_ENA_CLR	15	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
DEV_ALL_INTR_ENA_CLR	14	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
SGPIO_INTR_ENA_CLR	13	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
GPIO_INTR_ENA_CLR	12	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
TWI_INTR_ENA_CLR	11	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
FDMA_INTR_ENA_CLR	10	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
TIMER2_INTR_ENA_CLR	9	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
TIMER1_INTR_ENA_CLR	8	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
TIMER0_INTR_ENA_CLR	7	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
UART_INTR_ENA_CLR	6	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
PI_SD1_INTR_ENA_CLR	5	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
PI_SD0_INTR_ENA_CLR	4	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0

Table 609 • **Fields in INTR_ENA_CLR *(continued)***

Field Name	Bit	Access	Description	Default
SW1_INTR_ENA_CLR	3	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
SW0_INTR_ENA_CLR	2	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
EXT_IRQ1_INTR_ENA_CLR	1	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0
EXT_IRQ0_INTR_ENA_CLR	0	One-shot	Set to clear corresponding interrupt enable in INTR_ENA.	0x0

7.15.4.4 ICPU_CFG:INTR:INTR_ENA_SET

Parent: ICPU_CFG:INTR

Instances: 1

Table 610 • **Fields in INTR_ENA_SET**

Field Name	Bit	Access	Description	Default
MIIM1_INTR_ENA_SET	28	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
MIIM0_INTR_ENA_SET	27	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
PTP_SYNC_INTR_ENA_SET	26	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
INTEGRITY_INTR_ENA_SET	25	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
INJ_RDY1_INTR_ENA_SET	21	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
INJ_RDY0_INTR_ENA_SET	20	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
XTR_RDY1_INTR_ENA_SET	17	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
XTR_RDY0_INTR_ENA_SET	16	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
BLK_ANA_INTR_ENA_SET	15	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
DEV_ALL_INTR_ENA_SET	14	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
SGPIO_INTR_ENA_SET	13	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
GPIO_INTR_ENA_SET	12	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
TWI_INTR_ENA_SET	11	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
FDMA_INTR_ENA_SET	10	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0

Table 610 • **Fields in INTR_ENA_SET *(continued)***

Field Name	Bit	Access	Description	Default
TIMER2_INTR_ENA_SET	9	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
TIMER1_INTR_ENA_SET	8	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
TIMER0_INTR_ENA_SET	7	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
UART_INTR_ENA_SET	6	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
PI_SD1_INTR_ENA_SET	5	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
PI_SD0_INTR_ENA_SET	4	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
SW1_INTR_ENA_SET	3	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
SW0_INTR_ENA_SET	2	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
EXT_IRQ1_INTR_ENA_SET	1	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0
EXT_IRQ0_INTR_ENA_SET	0	One-shot	Set this field to set corresponding interrupt enable in INTR_ENA.	0x0

7.15.4.5 ICPU_CFG:INTR:INTR_RAW

Parent: ICPU_CFG:INTR

Instances: 1

Shows the current value of the interrupt source to the interrupt controller (interrupts are active high). External interrupt inputs are corrected for polarity before being presented in this register.

Table 611 • **Fields in INTR_RAW**

Field Name	Bit	Access	Description	Default
MIIM1_RAW	28	R/O	Current value of interrupt source input to the interrupt controller.	0x0
MIIM0_RAW	27	R/O	Current value of interrupt source input to the interrupt controller.	0x0
PTP_SYNC_RAW	26	R/O	Current value of interrupt source input to the interrupt controller.	0x0
INTEGRITY_RAW	25	R/O	Current value of interrupt source input to the interrupt controller.	0x0
INJ_RDY1_RAW	21	R/O	Current value of interrupt source input to the interrupt controller.	0x0
INJ_RDY0_RAW	20	R/O	Current value of interrupt source input to the interrupt controller.	0x0
XTR_RDY1_RAW	17	R/O	Current value of interrupt source input to the interrupt controller.	0x0

Table 611 • **Fields in INTR_RAW *(continued)***

Field Name	Bit	Access	Description	Default
XTR_RDY0_RAW	16	R/O	Current value of interrupt source input to the interrupt controller.	0x0
BLK_ANA_RAW	15	R/O	Current value of interrupt source input to the interrupt controller.	0x0
DEV_ALL_RAW	14	R/O	Current value of interrupt source input to the interrupt controller.	0x0
SGPIO_RAW	13	R/O	Current value of interrupt source input to the interrupt controller.	0x0
GPIO_RAW	12	R/O	Current value of interrupt source input to the interrupt controller.	0x0
TWI_RAW	11	R/O	Current value of interrupt source input to the interrupt controller.	0x0
FDMA_RAW	10	R/O	Current value of interrupt source input to the interrupt controller.	0x0
TIMER2_RAW	9	R/O	Current value of interrupt source input to the interrupt controller.	0x0
TIMER1_RAW	8	R/O	Current value of interrupt source input to the interrupt controller.	0x0
TIMER0_RAW	7	R/O	Current value of interrupt source input to the interrupt controller.	0x0
UART_RAW	6	R/O	Current value of interrupt source input to the interrupt controller.	0x0
PI_SD1_RAW	5	R/O	Current value of interrupt source input to the interrupt controller.	0x0
PI_SD0_RAW	4	R/O	Current value of interrupt source input to the interrupt controller.	0x0
SW1_RAW	3	R/O	Current value of interrupt source input to the interrupt controller.	0x0
SW0_RAW	2	R/O	Current value of interrupt source input to the interrupt controller.	0x0
EXT_IRQ1_RAW	1	R/O	Current value of interrupt source input to the interrupt controller, is already corrected for polarity as configured via EXT_IRQ1_INTR_CFG.EXT_IRQ 1_INTR_POL.	0x0
EXT_IRQ0_RAW	0	R/O	Current value of interrupt source input to the interrupt controller, is already corrected for polarity as configured via EXT_IRQ0_INTR_CFG.EXT_IRQ 0_INTR_POL.	0x0

7.15.4.6 ICPU_CFG:INTR:ICPU_IRQ0_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Table 612 • **Fields in ICPU_IRQ0_ENA**

Field Name	Bit	Access	Description	Default
ICPU_IRQ0_ENA	0	R/W	Enables ICPU_IRQ0 interrupt 0: Interrupt is disabled 1: Interrupt is enabled	0x0

7.15.4.7 ICPU_CFG:INTR:ICPU_IRQ0_IDENT

Parent: ICPU_CFG:INTR

Instances: 1

Identifies the source(s) of an active interrupt on output interrupt: ICPU_IRQ0. All asserted interrupts are shown as active high.

Table 613 • **Fields in ICPU_IRQ0_IDENT**

Field Name	Bit	Access	Description	Default
ICPU_IRQ0_MIIM1_IDENT	28	R/O	Set when MIIM1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_MIIM0_IDENT	27	R/O	Set when MIIM0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_PTP_SYNC_IDENT	26	R/O	Set when PTP_SYNC interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_INTEGRITY_IDENT	25	R/O	Set when INTEGRITY interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_INJ_RDY1_IDENT	21	R/O	Set when INJ_RDY1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_INJ_RDY0_IDENT	20	R/O	Set when INJ_RDY0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_XTR_RDY1_IDENT	17	R/O	Set when XTR_RDY1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_XTR_RDY0_IDENT	16	R/O	Set when XTR_RDY0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_BLK_ANA_IDENT	14	R/O	Set when BLK_ANA interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_DEV_ALL_IDENT	14	R/O	Set when DEV_ALL interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_SGPIO_IDENT	13	R/O	Set when SGPIO interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_GPIO_IDENT	12	R/O	Set when GPIO interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_TWI_IDENT	11	R/O	Set when TWI interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_FDMA_IDENT	10	R/O	Set when FDMA interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_TIMER2_IDENT	9	R/O	Set when TIMER2 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0

Table 613 • **Fields in ICPU_IRQ0_IDENT *(continued)***

Field Name	Bit	Access	Description	Default
ICPU_IRQ0_TIMER1_IDENT	8	R/O	Set when TIMER1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_TIMER0_IDENT	7	R/O	Set when TIMER0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_UART_IDENT	6	R/O	Set when UART interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_PI_SD1_IDENT	5	R/O	Set when PI_SD1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_PI_SD0_IDENT	4	R/O	Set when PI_SD0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_SW1_IDENT	3	R/O	Set when SW1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_SW0_IDENT	2	R/O	Set when SW0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_EXT_IRQ1_IDENT	1	R/O	Set when EXT_IRQ1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ0_EXT_IRQ0_IDENT	0	R/O	Set when EXT_IRQ0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0

7.15.4.8 ICPU_CFG:INTR:ICPU_IRQ1_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Table 614 • **Fields in ICPU_IRQ1_ENA**

Field Name	Bit	Access	Description	Default
ICPU_IRQ1_ENA	0	R/W	Enables ICPU_IRQ1 interrupt 0: Interrupt is disabled 1: Interrupt is enabled	0x0

7.15.4.9 ICPU_CFG:INTR:ICPU_IRQ1_IDENT

Parent: ICPU_CFG:INTR

Instances: 1

Identifies the source(s) of an active interrupt on output interrupt: ICPU_IRQ1. All asserted interrupts are shown as active high.

Table 615 • **Fields in ICPU_IRQ1_IDENT**

Field Name	Bit	Access	Description	Default
ICPU_IRQ1_MIIM1_IDENT	28	R/O	Set when MIIM1 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0
ICPU_IRQ1_MIIM0_IDENT	27	R/O	Set when MIIM0 interrupt is a source of the ICPU_IRQ0 interrupt.	0x0

Table 615 • **Fields in ICPU_IRQ1_IDENT *(continued)***

Field Name	Bit	Access	Description	Default
ICPU_IRQ1_PTP_SYNC_IDENT	26	R/O	Set when PTP_SYNC interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_INTEGRITY_IDENT	25	R/O	Set when INTEGRITY interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_INJ_RDY1_IDENT	21	R/O	Set when INJ_RDY1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_INJ_RDY0_IDENT	20	R/O	Set when INJ_RDY0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_XTR_RDY1_IDENT	17	R/O	Set when XTR_RDY1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_XTR_RDY0_IDENT	16	R/O	Set when XTR_RDY0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_BLK_ANA_IDENT	15	R/O	Set when BLK_ANA interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_DEV_ALL_IDENT	14	R/O	Set when DEV_ALL interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_SGPIO_IDENT	13	R/O	Set when SGPIO interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_GPIO_IDENT	12	R/O	Set when GPIO interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_TWI_IDENT	11	R/O	Set when TWI interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_FDMA_IDENT	10	R/O	Set when FDMA interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_TIMER2_IDENT	9	R/O	Set when TIMER2 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_TIMER1_IDENT	8	R/O	Set when TIMER1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_TIMER0_IDENT	7	R/O	Set when TIMER0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_UART_IDENT	6	R/O	Set when UART interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_PI_SD1_IDENT	5	R/O	Set when PI_SD1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_PI_SD0_IDENT	4	R/O	Set when PI_SD0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_SW1_IDENT	3	R/O	Set when SW1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_SW0_IDENT	2	R/O	Set when SW0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_EXT_IRQ1_IDENT	1	R/O	Set when EXT_IRQ1 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0
ICPU_IRQ1_EXT_IRQ0_IDENT	0	R/O	Set when EXT_IRQ0 interrupt is a source of the ICPU_IRQ1 interrupt.	0x0

7.15.4.10 ICPU_CFG:INTR:EXT_IRQ0_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Table 616 • **Fields in EXT_IRQ0_ENA**

Field Name	Bit	Access	Description	Default
EXT_IRQ0_ENA	0	R/W	Enables EXT_IRQ0 interrupt 0: Interrupt is disabled 1: Interrupt is enabled	0x0

7.15.4.11 ICPU_CFG:INTR:EXT_IRQ0_IDENT

Parent: ICPU_CFG:INTR

Instances: 1

Identifies the source(s) of an active interrupt on output interrupt: EXT_IRQ0. All asserted interrupts are shown as active high.

Table 617 • **Fields in EXT_IRQ0_IDENT**

Field Name	Bit	Access	Description	Default
EXT_IRQ0_MIIM1_IDENT	28	R/O	Set when MIIM1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_MIIM0_IDENT	27	R/O	Set when MIIM0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_PTP_SYNC_IDENT	26	R/O	Set when PTP_SYNC interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_INTEGRITY_IDENT	25	R/O	Set when INTEGRITY interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_INJ_RDY1_IDENT	21	R/O	Set when INJ_RDY1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_INJ_RDY0_IDENT	20	R/O	Set when INJ_RDY0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_XTR_RDY1_IDENT	17	R/O	Set when XTR_RDY1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_XTR_RDY0_IDENT	16	R/O	Set when XTR_RDY0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_BLK_ANA_IDENT	15	R/O	Set when BLK_ANA interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_DEV_ALL_IDENT	14	R/O	Set when DEV_ALL interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_SGPIO_IDENT	13	R/O	Set when SGPIO interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_GPIO_IDENT	12	R/O	Set when GPIO interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_TWI_IDENT	11	R/O	Set when TWI interrupt is a source of the EXT_IRQ0 interrupt.	0x0

Table 617 • **Fields in EXT_IRQ0_IDENT *(continued)***

Field Name	Bit	Access	Description	Default
EXT_IRQ0_FDMA_IDENT	10	R/O	Set when FDMA interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_TIMER2_IDENT	9	R/O	Set when TIMER2 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_TIMER1_IDENT	8	R/O	Set when TIMER1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_TIMER0_IDENT	7	R/O	Set when TIMER0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_UART_IDENT	6	R/O	Set when UART interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_PI_SD1_IDENT	5	R/O	Set when PI_SD1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_PI_SD0_IDENT	4	R/O	Set when PI_SD0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_SW1_IDENT	3	R/O	Set when SW1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_SW0_IDENT	2	R/O	Set when SW0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_EXT_IRQ1_IDENT	1	R/O	Set when EXT_IRQ1 interrupt is a source of the EXT_IRQ0 interrupt.	0x0
EXT_IRQ0_EXT_IRQ0_IDENT	0	R/O	Set when EXT_IRQ0 interrupt is a source of the EXT_IRQ0 interrupt.	0x0

7.15.4.12 ICPU_CFG:INTR:EXT_IRQ1_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Table 618 • **Fields in EXT_IRQ1_ENA**

Field Name	Bit	Access	Description	Default
EXT_IRQ1_ENA	0	R/W	Enables EXT_IRQ1 interrupt 0: Interrupt is disabled 1: Interrupt is enabled	0x0

7.15.4.13 ICPU_CFG:INTR:EXT_IRQ1_IDENT

Parent: ICPU_CFG:INTR

Instances: 1

Identifies the source(s) of an active interrupt on output interrupt: EXT_IRQ1. All asserted interrupts are shown as active high.

Table 619 • **Fields in EXT_IRQ1_IDENT**

Field Name	Bit	Access	Description	Default
EXT_IRQ1_MIIM1_IDENT	28	R/O	Set when MIIM1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_MIIM0_IDENT	27	R/O	Set when MIIM0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_PTP_SYNC_IDENT	26	R/O	Set when PTP_SYNC interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_INTEGRITY_IDENT	25	R/O	Set when INTEGRITY interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_INJ_RDY1_IDENT	21	R/O	Set when INJ_RDY1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_INJ_RDY0_IDENT	20	R/O	Set when INJ_RDY0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_XTR_RDY1_IDENT	17	R/O	Set when XTR_RDY1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_XTR_RDY0_IDENT	16	R/O	Set when XTR_RDY0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_BLK_ANA_IDENT	15	R/O	Set when BLK_ANA interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_DEV_ALL_IDENT	14	R/O	Set when DEV_ALL interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_SGPIO_IDENT	13	R/O	Set when SGPIO interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_GPIO_IDENT	12	R/O	Set when GPIO interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_TWI_IDENT	11	R/O	Set when TWI interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_FDMA_IDENT	10	R/O	Set when FDMA interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_TIMER2_IDENT	9	R/O	Set when TIMER2 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_TIMER1_IDENT	8	R/O	Set when TIMER1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_TIMER0_IDENT	7	R/O	Set when TIMER0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_UART_IDENT	6	R/O	Set when UART interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_PI_SD1_IDENT	5	R/O	Set when PI_SD1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_PI_SD0_IDENT	4	R/O	Set when PI_SD0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_SW1_IDENT	3	R/O	Set when SW1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0

Table 619 • **Fields in EXT_IRQ1_IDENT *(continued)***

Field Name	Bit	Access	Description	Default
EXT_IRQ1_SW0_IDENT	2	R/O	Set when SW0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_EXT_IRQ1_IDENT	1	R/O	Set when EXT_IRQ1 interrupt is a source of the EXT_IRQ1 interrupt.	0x0
EXT_IRQ1_EXT_IRQ0_IDENT	0	R/O	Set when EXT_IRQ0 interrupt is a source of the EXT_IRQ1 interrupt.	0x0

7.15.4.14 ICPU_CFG:INTR:DEV_IDENT

Parent: ICPU_CFG:INTR

Instances: 1

Shows the sources of the DEV_ALL interrupt.

Table 620 • **Fields in DEV_IDENT**

Field Name	Bit	Access	Description	Default
DEV_IDENT	31:0	R/O	Bits in this field is set when the corresponding device is interrupting, bit 0 corresponds to device 0, bit 1 to device 1 and so on. When any bit in this field is set the DEV_ALL interrupt is also asserted.	0x00000000

7.15.4.15 ICPU_CFG:INTR:EXT_IRQ0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 621 • **Fields in EXT_IRQ0_INTR_CFG**

Field Name	Bit	Access	Description	Default
EXT_IRQ0_INTR_DRV	6	R/W	Configures when to drive the external interrupt EXT_IRQ0 output, this setting applies only when EXT_IRQ0 is configured for output mode. 0: Only drive when interrupt is active 1: Always driven	0x0

Table 621 • **Fields in EXT_IRQ0_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
EXT_IRQ0_INTR_DIR	5	R/W	Controls the direction of external interrupt: EXT_IRQ0. In input mode the interrupt can used as source in the interrupt controller, in this mode any configurations related to the output mode of the interrupt has no effect. In output mode sources can be assigned to the interrupt, in this mode the EXT_IRQ0 must not be enabled as interrupt source (INTR_ENA.EXT_IRQ0_INTR_ENA must remain 0). 0: Input 1: Output	0x0
EXT_IRQ0_INTR_POL	4	R/W	Controls the interrupt polarity of external interrupt: EXT_IRQ0. This setting is applies to both to input and output mode. The polarity is corrected at the edge of the chip, internally interrupts are always active-high. 0: Active low 1: Active high	0x0
EXT_IRQ0_INTR_FORCE	3	One-shot	Set to force assertion of EXT_IRQ0 interrupt. This field is cleared immediately after generating interrupt.	0x0
EXT_IRQ0_INTR_TRIGGER	2	R/W	Controls whether interrupts from the EXT_IRQ0 interrupt are edge (low-to-high-transition) or level (interrupt while high value is seen) sensitive. 0: LEVEL sensitive 1: EDGE sensitive	0x0
EXT_IRQ0_INTR_SEL	1:0	R/W	Selects the destination of the EXT_IRQ0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.16 ICPU_CFG:INTR:EXT_IRQ1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 622 • **Fields in EXT_IRQ1_INTR_CFG**

Field Name	Bit	Access	Description	Default
EXT_IRQ1_INTR_DRV	6	R/W	Configures when to drive the external interrupt EXT_IRQ1 output, this setting applies only when EXT_IRQ1 is configured for output mode. 0: Only drive when interrupt is active 1: Always driven	0x0
EXT_IRQ1_INTR_DIR	5	R/W	Controls the direction of external interrupt: EXT_IRQ1. In input mode the interrupt can used as source in the interrupt controller, in this mode any configurations related to the output mode of the interrupt has no effect. In output mode sources can be assigned to the interrupt, in this mode the EXT_IRQ1 must not be enabled as interrupt source (INTR_ENA.EXT_IRQ1_INTR_ENA must remain 0). 0: Input 1: Output	0x0
EXT_IRQ1_INTR_POL	4	R/W	Controls the interrupt polarity of external interrupt: EXT_IRQ1. This setting is applies to both to input and output mode. The polarity is corrected at the edge of the chip, internally interrupts are always active-high. 0: Active low 1: Active high	0x0
EXT_IRQ1_INTR_FORCE	3	One-shot	Set to force assertion of EXT_IRQ1 interrupt. This field is cleared immediately after generating interrupt.	0x0
EXT_IRQ1_INTR_TRIGGER	2	R/W	Controls whether interrupts from the EXT_IRQ1 interrupt are edge (low-to-high-transition) or level (interrupt while high value is seen) sensitive. 0: LEVEL sensitive 1: EDGE sensitive	0x0
EXT_IRQ1_INTR_SEL	1:0	R/W	Selects the destination of the EXT_IRQ1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.17 ICPU_CFG:INTR:SW0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 623 • **Fields in SW0_INTR_CFG**

Field Name	Bit	Access	Description	Default
SW0_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
SW0_INTR_FORCE	3	One-shot	Set to force assertion of SW0 interrupt. This field is cleared immediately after generating interrupt.	0x0
SW0_INTR_SEL	1:0	R/W	Selects the destination of the SW0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.18 ICPU_CFG:INTR:SW1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 624 • **Fields in SW1_INTR_CFG**

Field Name	Bit	Access	Description	Default
SW1_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
SW1_INTR_FORCE	3	One-shot	Set to force assertion of SW1 interrupt.	0x0

Table 624 • **Fields in SW1_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
SW1_INTR_SEL	1:0	R/W	Selects the destination of the SW1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.19 ICPU_CFG:INTR:MIIM1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 625 • **Fields in MIIM1_INTR_CFG**

Field Name	Bit	Access	Description	Default
MIIM1_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
MIIM1_INTR_FORCE	3	One-shot	Set to force assertion of MIIM1 interrupt. This field is cleared immediately after generating interrupt.	0x0
MIIM1_INTR_SEL	1:0	R/W	Selects the destination of the MIIM1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.20 ICPU_CFG:INTR:MIIM0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 626 • **Fields in MIIM0_INTR_CFG**

Field Name	Bit	Access	Description	Default
MIIM0_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
MIIM0_INTR_FORCE	3	One-shot	Set to force assertion of MIIM0 interrupt. This field is cleared immediately after generating interrupt.	0x0
MIIM0_INTR_SEL	1:0	R/W	Selects the destination of the MIIM0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.21 ICPU_CFG:INTR:PI_SD0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 627 • **Fields in PI_SD0_INTR_CFG**

Field Name	Bit	Access	Description	Default
PI_SD0_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
PI_SD0_INTR_FORCE	3	One-shot	Set to force assertion of PI_SD0 interrupt. This field is cleared immediately after generating interrupt.	0x0

Table 627 • **Fields in PI_SD0_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
PI_SD0_INTR_SEL	1:0	R/W	Selects the destination of the PI_SD0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.22 ICPU_CFG:INTR:PI_SD1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 628 • **Fields in PI_SD1_INTR_CFG**

Field Name	Bit	Access	Description	Default
PI_SD1_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
PI_SD1_INTR_FORCE	3	One-shot	Set to force assertion of PI_SD1 interrupt. This field is cleared immediately after generating interrupt.	0x0
PI_SD1_INTR_SEL	1:0	R/W	Selects the destination of the PI_SD1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.23 ICPU_CFG:INTR:UART_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 629 • **Fields in UART_INTR_CFG**

Field Name	Bit	Access	Description	Default
UART_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
UART_INTR_FORCE	3	One-shot	Set to force assertion of UART interrupt. This field is cleared immediately after generating interrupt.	0x0
UART_INTR_SEL	1:0	R/W	Selects the destination of the UART interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.24 ICPU_CFG:INTR:TIMER0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 630 • **Fields in TIMER0_INTR_CFG**

Field Name	Bit	Access	Description	Default
TIMER0_INTR_FORCE	3	One-shot	Set to force assertion of TIMER0 interrupt. This field is cleared immediately after generating interrupt.	0x0
TIMER0_INTR_SEL	1:0	R/W	Selects the destination of the TIMER0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.25 ICPU_CFG:INTR:TIMER1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 631 • **Fields in TIMER1_INTR_CFG**

Field Name	Bit	Access	Description	Default
TIMER1_INTR_FORCE	3	One-shot	Set to force assertion of TIMER1 interrupt. This field is cleared immediately after generating interrupt.	0x0
TIMER1_INTR_SEL	1:0	R/W	Selects the destination of the TIMER1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.26 ICPU_CFG:INTR:TIMER2_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 632 • **Fields in TIMER2_INTR_CFG**

Field Name	Bit	Access	Description	Default
TIMER2_INTR_FORCE	3	One-shot	Set to force assertion of TIMER2 interrupt. This field is cleared immediately after generating interrupt.	0x0
TIMER2_INTR_SEL	1:0	R/W	Selects the destination of the TIMER2 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.27 ICPU_CFG:INTR:FDMA_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 633 • **Fields in FDMA_INTR_CFG**

Field Name	Bit	Access	Description	Default
FDMA_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
FDMA_INTR_FORCE	3	One-shot	Set to force assertion of FDMA interrupt. This field is cleared immediately after generating interrupt.	0x0
FDMA_INTR_SEL	1:0	R/W	Selects the destination of the FDMA interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.28 ICPU_CFG:INTR:TWI_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 634 • **Fields in TWI_INTR_CFG**

Field Name	Bit	Access	Description	Default
TWI_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
TWI_INTR_FORCE	3	One-shot	Set to force assertion of TWI interrupt. This field is cleared immediately after generating interrupt.	0x0

Table 634 • **Fields in TWI_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
TWI_INTR_SEL	1:0	R/W	Selects the destination of the TWI interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.29 ICPU_CFG:INTR:GPIO_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 635 • **Fields in GPIO_INTR_CFG**

Field Name	Bit	Access	Description	Default
GPIO_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
GPIO_INTR_FORCE	3	One-shot	Set to force assertion of GPIO interrupt. This field is cleared immediately after generating interrupt.	0x0
GPIO_INTR_SEL	1:0	R/W	Selects the destination of the GPIO interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.30 ICPU_CFG:INTR:SGPIO_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 636 • **Fields in SGPIO_INTR_CFG**

Field Name	Bit	Access	Description	Default
SGPIO_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
SGPIO_INTR_FORCE	3	One-shot	Set to force assertion of SGPIO interrupt. This field is cleared immediately after generating interrupt.	0x0
SGPIO_INTR_SEL	1:0	R/W	Selects the destination of the SGPIO interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.31 ICPU_CFG:INTR:DEV_ALL_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 637 • **Fields in DEV_ALL_INTR_CFG**

Field Name	Bit	Access	Description	Default
DEV_ALL_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
DEV_ALL_INTR_FORCE	3	One-shot	Set to force assertion of DEV_ALL interrupt. This field is cleared immediately after generating interrupt.	0x0

Table 637 • **Fields in DEV_ALL_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
DEV_ALL_INTR_SEL	1:0	R/W	Selects the destination of the DEV_ALL interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.32 ICPU_CFG:INTR:BLK_ANA_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 638 • **Fields in BLK_ANA_INTR_CFG**

Field Name	Bit	Access	Description	Default
BLK_ANA_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
BLK_ANA_INTR_FORCE	3	One-shot	Set to force assertion of DEV_ALL interrupt. This field is cleared immediately after generating interrupt.	0x0
BLK_ANA_INTR_SEL	1:0	R/W	Selects the destination of the BLK_ANA interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.33 ICPU_CFG:INTR:XTR_RDY0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 639 • **Fields in XTR_RDY0_INTR_CFG**

Field Name	Bit	Access	Description	Default
XTR_RDY0_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
XTR_RDY0_INTR_FORCE	3	One-shot	Set to force assertion of XTR_RDY0 interrupt. This field is cleared immediately after generating interrupt.	0x0
XTR_RDY0_INTR_SEL	1:0	R/W	Selects the destination of the XTR_RDY0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.34 ICPU_CFG:INTR:XTR_RDY1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 640 • **Fields in XTR_RDY1_INTR_CFG**

Field Name	Bit	Access	Description	Default
XTR_RDY1_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
XTR_RDY1_INTR_FORCE	3	One-shot	Set to force assertion of XTR_RDY1 interrupt. This field is cleared immediately after generating interrupt.	0x0

Table 640 • **Fields in XTR_RDY1_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
XTR_RDY1_INTR_SEL	1:0	R/W	Selects the destination of the XTR_RDY1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.35 ICPU_CFG:INTR:INJ_RDY0_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 641 • **Fields in INJ_RDY0_INTR_CFG**

Field Name	Bit	Access	Description	Default
INJ_RDY0_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
INJ_RDY0_INTR_FORCE	3	One-shot	Set to force assertion of INJ_RDY0 interrupt. This field is cleared immediately after generating interrupt.	0x0
INJ_RDY0_INTR_SEL	1:0	R/W	Selects the destination of the INJ_RDY0 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.36 ICPU_CFG:INTR:INJ_RDY1_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 642 • **Fields in INJ_RDY1_INTR_CFG**

Field Name	Bit	Access	Description	Default
INJ_RDY1_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
INJ_RDY1_INTR_FORCE	3	One-shot	Set to force assertion of INJ_RDY1 interrupt. This field is cleared immediately after generating interrupt.	0x0
INJ_RDY1_INTR_SEL	1:0	R/W	Selects the destination of the INJ_RDY1 interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.37 ICPU_CFG:INTR:INTEGRITY_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 643 • **Fields in INTEGRITY_INTR_CFG**

Field Name	Bit	Access	Description	Default
INTEGRITY_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
INTEGRITY_INTR_FORCE	3	One-shot	Set to force assertion of INTEGRITY interrupt. This field is cleared immediately after generating interrupt.	0x0

Table 643 • **Fields in INTEGRITY_INTR_CFG *(continued)***

Field Name	Bit	Access	Description	Default
INTEGRITY_INTR_SEL	1:0	R/W	Selects the destination of the INTEGRITY interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.38 ICPU_CFG:INTR:PTP_SYNC_INTR_CFG

Parent: ICPU_CFG:INTR

Instances: 1

Table 644 • **Fields in PTP_SYNC_INTR_CFG**

Field Name	Bit	Access	Description	Default
PTP_SYNC_INTR_BYPASS	4	R/W	Set to bypass sticky interrupt functionality. When set the value from the interrupting source is passed directly to the destination interrupt. This feature can be useful when mapping a small number of interrupts via external interrupt output to an external CPU. When this field is set, the TRIGGER and FORCE fields no longer has any effect.	0x0
PTP_SYNC_INTR_FORCE	3	One-shot	Set to force assertion of PTP_SYNC interrupt. This field is cleared immediately after generating interrupt.	0x0
PTP_SYNC_INTR_SEL	1:0	R/W	Selects the destination of the PTP_SYNC interrupt. 0: ICPU_IRQ0 1: ICPU_IRQ1 2: EXT_IRQ0 3: EXT_IRQ1	0x0

7.15.4.39 ICPU_CFG:INTR:DEV_ENA

Parent: ICPU_CFG:INTR

Instances: 1

Table 645 • **Fields in DEV_ENA**

Field Name	Bit	Access	Description	Default
DEV_ENA	31:0	R/W	Clear individual bits in this register to disable interrupts from specific devices.	0x00000000

7.15.5 ICPU_CFG:GPDMA

Parent: ICPU_CFG

Instances: 1

Table 646 • **Registers in GPDMA**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
FDMA_CFG	0x00000000	1	Common Injection or Extraction Configuration	Page 504
FDMA_CH_CFG	0x00000008	8 0x00000004	FDMA Channel Usage and Flow Control	Page 505
FDMA_INJ_CFG	0x00000028	2 0x00000004	FDMA Injection Parameters	Page 505
FDMA_XTR_CFG	0x00000030	2 0x00000004	FDMA Extraction Parameters	Page 506
FDMA_XTR_STAT_LAST_DCB	0x00000038	2 0x00000004	Extraction Status for FDMA Engine	Page 506
FDMA_FRM_CNT	0x00000040	1	Frame Counter and Flow Control Status	Page 507
FDMA_BP_TO_INT	0x00000044	1	FDMA Backpressure Timeout Interrupt	Page 507
FDMA_BP_TO_DIV	0x00000048	1	FDMA Timeout Divider	Page 508

7.15.5.1 ICPU_CFG:GPDMA:FDMA_CFG

Parent: ICPU_CFG:GPDMA

Instances: 1

Table 647 • **Fields in FDMA_CFG**

Field Name	Bit	Access	Description	Default
INJ_GRP_ABRT_ID	2	R/W	Specifies an injection group ID to abort frames on when setting INJ_GRP_ABRT. This field may only be changed when INJ_GRP_ABRT is cleared.	0x0
INJ_GRP_ABRT	1	One-shot	Set to abort the frame currently being transmitted on the injection group indicated by INJ_GRP_ABRT_ID. This field is cleared once the abort has been accepted. If no frame is currently being transmitted (on the injection group) then no aborting will occur.	0x0

Table 647 • **Fields in FDMA_CFG *(continued)***

Field Name	Bit	Access	Description	Default
FDMA_ENA	0	R/W	Enable FDMA access to the queuing system.When this field is set, manual injection and extraction must not be done through the DEVCPU registers.	0x0

7.15.5.2 ICPU_CFG:GPDMA:FDMA_CH_CFG

Parent: ICPU_CFG:GPDMA

Instances: 8

Configurations for each of the DMA channels.

Table 648 • **Fields in FDMA_CH_CFG**

Field Name	Bit	Access	Description	Default
USAGE	1	R/W	Controls the usage of the channel. The channel can be configured for either frame extraction (XTR) or frame injection (INJ) 0: The channel is an extraction channel (XTR) 1: The channel is an injection channel (INJ)	0x0
CH_ENA	0	R/W	Enable channel for the specified function.	0x0

7.15.5.3 ICPU_CFG:GPDMA:FDMA_INJ_CFG

Parent: ICPU_CFG:GPDMA

Instances: 2

Configurations for each of the injection groups.

Table 649 • **Fields in FDMA_INJ_CFG**

Field Name	Bit	Access	Description	Default
INJ_GRP_BP_TO_INT_ENA	4	R/W	Set this field to enable back pressure timeout interrupt for this injection group, see FDMA_BP_TIMEOUT_INT:INJ_BP_TIMEOUT_INT for more information.	0x0
INJ_GRP_BP_ENA	3	R/W	Enable back pressure from the corresponding injection channel. If an injection channel is used this field (and INJ_GRP_BP_MAP) must be set. 0: Back-pressure is disabled. 1: Back-pressure is enabled.	0x0

Table 649 • **Fields in FDMA_INJ_CFG *(continued)***

Field Name	Bit	Access	Description	Default
INJ_GRP_BP_MAP	2:0	R/W	To correctly generate backpressure to the DMA from individual injection groups, configure the DMA channel ID which may send frames to the corresponding injection group. If the injection group is not used then this field is dont-care. Note that an injection group can only receive frames from a single DMA channel while DMA channels can inject to multiple injection groups. When a DMA channel injects to multiple injection groups, backpressure must be enabled from all of the injection groups.	0x0

7.15.5.4 ICPU_CFG:GPDMA:FDMA_XTR_CFG

Parent: ICPU_CFG:GPDMA

Instances: 2

Configurations for each of the extraction groups.

Table 650 • **Fields in FDMA_XTR_CFG**

Field Name	Bit	Access	Description	Default
XTR_BURST_SIZE	2:0	R/W	Must be configured to the same value as CTL0:SRC_MSIZE for the corresponding DMA channel. 0 : 1 1 : 4 2 : 8 3 : 16 4 : 32 5 : 64 6-7 : reserved, do not use	0x1

7.15.5.5 ICPU_CFG:GPDMA:FDMA_XTR_STAT_LAST_DCB

Parent: ICPU_CFG:GPDMA

Instances: 2

Ths register provides the extraction status to be used by this FDMA engine.

Table 651 • **Fields in FDMA_XTR_STAT_LAST_DCB**

Field Name	Bit	Access	Description	Default
XTR_STAT_FRM_LEN	31:16	R/O	Length of frame (in bytes). If frames are spread across multiple DCBs this field is incremental; it shows the number of bytes written to the current and all previous DCBs, at the last DCB (EOF when is set), then value then represents the total frame-length.	0x0000
XTR_STAT_ABORT	4	R/O	Frame has been aborted, this will happen if frame is longer than maximum allowed size.	0x0
XTR_STAT_PRUNED	3	R/O	Frame has been pruned (see extraction queue registers for more details). 0: Not pruned 1: Pruned	0x0
XTR_STAT_EOF	2	R/O	End of frame 0: Not EOF 1: EOF	0x0
XTR_STAT_SOF	1	R/O	Start of frame 0: Not SOF 1: SOF	0x0
XTR_STAT_VLD	0	R/O	Always reads as '1'.	0x1

7.15.5.6 ICPU_CFG:GPDMA:FDMA_FRM_CNT

Parent: ICPU_CFG:GPDMA

Instances: 1

Table 652 • **Fields in FDMA_FRM_CNT**

Field Name	Bit	Access	Description	Default
FDMA_FRM_CNT	15:0	R/W	This counter is incremented by 1 for every frame that is moved through the FDMA (both XTR or INJ). The counter increments when end-of-frame is processed by the FDMA.	0x0000

7.15.5.7 ICPU_CFG:GPDMA:FDMA_BP_TO_INT

Parent: ICPU_CFG:GPDMA

Instances: 1

As long as a field in this register is set, the FDMA will indicate interrupt towards the interrupt controller.

Table 653 • **Fields in FDMA_BP_TO_INT**

Field Name	Bit	Access	Description	Default
INJ_BP_TO_INT	1:0	Sticky	This is an indication of backpressure timeout interrupt. If a bit in this field is set the corresponding injection group has been in back-pressure for more than the allowed time (as configured in FDMA_BP_TO_DIV:INJ_BP_TO_DIV). Enable backpressure timeout interrupt in FDMA_INJ_CFG:INJ_GRP_BP_TO_INT_ENA.	0x0

7.15.5.8 ICPU_CFG:GPDMA:FDMA_BP_TO_DIV

Parent: ICPU_CFG:GPDMA

Instances: 1

Table 654 • **Fields in FDMA_BP_TO_DIV**

Field Name	Bit	Access	Description	Default
INJ_BP_TO_DIV_RLOAD	16	One-shot	Set this field to force reload of the backpressure timeout divider.	0x0
INJ_BP_TO_DIV	15:0	R/W	Configures the timeout for injection group backpressure interrupt. The timeout is calculated as follows: timeout(s) = <div-value> / (sysfrequency(MHz) * 244) E.g. configuring a timeout value of 1220 in a 200MHz system yields a timeout of 25ms.	0x04C4

7.15.6 ICPU_CFG:INJ_FRM_SPC

Parent: ICPU_CFG

Instances: 8

Table 655 • **Registers in INJ_FRM_SPC**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
INJ_FRM_SPC_TMR	0x00000000	1	Injection frame spacing timer	Page 509
INJ_FRM_SPC_TMR_CFG	0x00000004	1	Reload value for injection frame spacing timer	Page 509

Table 655 • **Registers in INJ_FRM_SPC *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
INJ_FRM_SPC_LACK_CNTR	0x00000008	1	Lack counter	Page 509
INJ_FRM_SPC_CFG	0x0000000C	1	Injection frame spacing configuration register	Page 510

7.15.6.1 ICPU_CFG:INJ_FRM_SPC:INJ_FRM_SPC_TMR

Parent: ICPU_CFG:INJ_FRM_SPC

Instances: 1

Table 656 • **Fields in INJ_FRM_SPC_TMR**

Field Name	Bit	Access	Description	Default
TMR	31:0	R/O	The "frame space" timer, enabled when INJ_FRM_SPC_CONFIG.TMR_ENA is set. When it reaches zero, it provides a tick to INJ_FRM_LACK_CNTR, and reloads the value held in INJ_FRM_SPC_TMR_CFG. The counter is down-counting. The resulting delay between frames is (n+1)*ahb_clk_p where n is the timer reload value and ahb_clk_p is the clock period of the ahb bus.	0x00000000

7.15.6.2 ICPU_CFG:INJ_FRM_SPC:INJ_FRM_SPC_TMR_CFG

Parent: ICPU_CFG:INJ_FRM_SPC

Instances: 1

Table 657 • **Fields in INJ_FRM_SPC_TMR_CFG**

Field Name	Bit	Access	Description	Default
TMR_CFG	31:0	R/W	Reload value for INJ_FRM_SPC_TMR.	0x00000000

7.15.6.3 ICPU_CFG:INJ_FRM_SPC:INJ_FRM_SPC_LACK_CNTR

Parent: ICPU_CFG:INJ_FRM_SPC

Instances: 1

Table 658 • **Fields in INJ_FRM_SPC_LACK_CNTR**

Field Name	Bit	Access	Description	Default
LACK_CNTR	7:0	R/W	When INJ_FRM_SPC_CFG.FRM_SPC_ENA is set, this counter counts the number of ticks provided by the INJ_FRM_SPC_TMR and is decremented by hardware for every transmitted frame. In other words, the value of lack counter value is the number of frames which it is OK to transmit unspaced. Is used in conjunction with the queue-system fill-level to signal to the DMA that it is OK to transmit the next frame.	0x00

7.15.6.4 ICPU_CFG:INJ_FRM_SPC:INJ_FRM_SPC_CFG

Parent: ICPU_CFG:INJ_FRM_SPC

Instances: 1

Table 659 • **Fields in INJ_FRM_SPC_CFG**

Field Name	Bit	Access	Description	Default
FRM_SPC_ENA	0	R/W	This bit is used to generally enable/disable the frame spacing feature.	0x0
TMR_ENA	1	R/W	Controls whether the INJ_FRM_SPC_TMR is counting or not. When this field is 0 the reload value is written to the frame space timer and the timer is not running. When this field is 1 the timer is running and is reloaded when it reaches zero.	0x0

7.15.7 ICPU_CFG:TIMERS

Parent: ICPU_CFG

Instances: 1

Table 660 • **Registers in TIMERS**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
WDT	0x00000000	1	Watchdog Timer	Page 511
TIMER_TICK_DIV	0x00000004	1	Timer Tick Divider	Page 511

Table 660 • **Registers in TIMERS *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TIMER_VALUE	0x00000008	3 0x00000004	Timer value	Page 512
TIMER_RELOAD_VALUE	0x00000014	3 0x00000004	Timer Reload Value	Page 512
TIMER_CTRL	0x00000020	3 0x00000004	Timer Control	Page 513

7.15.7.1 ICPU_CFG:TIMERS:WDT

Parent: ICPU_CFG:TIMERS

Instances: 1

Table 661 • **Fields in WDT**

Field Name	Bit	Access	Description	Default
WDT_STATUS	9	R/O	Shows whether the last reset was caused by a watchdog timer reset. This field is updated during reset, therefore it is always valid. 0: Reset was not caused by WDT 1: Reset was caused by WDT timeout	0x0
WDT_ENABLE	8	R/W	Use this field to enable or disable the watchdog timer. When the WDT is enabled, it causes a reset after 2 seconds if it is not periodically reset. This field is only read by the WDT after a successful lock sequence (WDT_LOCK). 0: WDT is disabled 1: WDT is enabled	0x0
WDT_LOCK	7:0	R/W	Use this field to configure and reset the WDT. When writing 0xBE to this field immediately followed by writing 0xEF, the WDT resets and configurations are read from this register (as set when the 0xEF is written). When the WDT is enabled, writing any value other than 0xBE or 0xEF after 0xBE is written, causes a WDT reset as if the timer had run out.	0x00

7.15.7.2 ICPU_CFG:TIMERS:TIMER_TICK_DIV

Parent: ICPU_CFG:TIMERS

Instances: 1

Table 662 • **Fields in TIMER_TICK_DIV**

Field Name	Bit	Access	Description	Default
TIMER_TICK_DIV	17:0	R/W	The timer tick generator runs from a 250MHz base clock. By default, the divider value generates a timer tick every 100 us (10 KHz). The timer tick is used for all of the timers (except the WDT). This field must not be set to generate a timer tick of less than 0.1 us (higher than 10 MHz). If this field is changed, it may take up to 2 ms before the timers are running stable at the new frequency. The timer tick frequency is: 250MHz/(TIMER_TICK_DIV+1).	0x061A7

7.15.7.3 ICPU_CFG:TIMERS:TIMER_VALUE

Parent: ICPU_CFG:TIMERS

Instances: 3

Table 663 • **Fields in TIMER_VALUE**

Field Name	Bit	Access	Description	Default
TIMER_VAL	31:0	R/W	The current value of the timer. When enabled via TIMER_CTRL.TIMER_ENA the timer decrements at every timer tick (see TIMER_TICK_DIV for more info on timer tick frequency). When the timer has reached 0, and a timer-tick is received, then an interrupt is generated. For example; If a periodic interrupt is needed every 1ms, and the timer tick is generated every 100us then the TIMER_VALUE (and TIMER_RELOAD_VALUE) must be configured to 9. By default the timer will reload from the TIMER_RELOAD_VALUE when interrupt is generated, and then continue decrementing from the reloaded value. It is possible to make the timer stop after generating interrupt by setting TIMER_CTRL.ONE_SHOT.	0x00000000

7.15.7.4 ICPU_CFG:TIMERS:TIMER_RELOAD_VALUE

Parent: ICPU_CFG:TIMERS

Instances: 3

Table 664 • **Fields in TIMER_RELOAD_VALUE**

Field Name	Bit	Access	Description	Default
RELOAD_VAL	31:0	R/W	The contents of this field are loaded into the corresponding timer (TIMER_VALUE) when it wraps (decrements a zero).	0x00000000

7.15.7.5 ICPU_CFG:TIMERS:TIMER_CTRL

Parent: ICPU_CFG:TIMERS

Instances: 3

Table 665 • **Fields in TIMER_CTRL**

Field Name	Bit	Access	Description	Default
ONE_SHOT_ENA	2	R/W	When set the timer will automatically disable itself after it has generated interrupt.	0x0
TIMER_ENA	1	R/W	When enabled, the corresponding timer decrements at each timer-tick. If TIMER_CTRL.ONE_SHOT_ENA is set this field is cleared when the timer reach 0 and interrupt is generated. 0: Timer is disabled 1: Timer is enabled	0x0
FORCE_RELOAD	0	One-shot	Set this field to force the reload of the timer, this will set the TIMER_VALUE to TIMER_RELOAD_VALUE for the corresponding timer. This field can be set at the same time as enabling the counter, in that case the counter will be reloaded and then enabled for counting.	0x0

7.15.8 ICPU_CFG:MEMCTRL

Parent: ICPU_CFG

Instances: 1

Table 666 • **Registers in MEMCTRL**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MEMCTRL_CTRL	0x00000000	1	Control register	Page 514

Table 666 • **Registers in MEMCTRL *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
MEMCTRL_CFG	0x00000004	1	Configuration register	Page 515
MEMCTRL_STAT	0x00000008	1	Status register	Page 516
MEMCTRL_REF_PERIOD	0x0000000C	1	Refresh period configuration	Page 516
MEMCTRL_TIMING0	0x00000014	1	Timing register 0	Page 517
MEMCTRL_TIMING1	0x00000018	1	Timing register 1	Page 517
MEMCTRL_TIMING2	0x0000001C	1	Timing register 2	Page 518
MEMCTRL_TIMING3	0x00000020	1	Timing register 3	Page 519
MEMCTRL_MR0_VAL	0x00000024	1	Mode Register 0 Value	Page 520
MEMCTRL_MR1_VAL	0x00000028	1	Mode Register 1 / Extended Mode Register Value	Page 520
MEMCTRL_MR2_VAL	0x0000002C	1	Mode Register 2 / Extended Mode Register 2 Value	Page 521
MEMCTRL_MR3_VAL	0x00000030	1	Mode Register 3 / Extended Mode Register 3 Value	Page 521
MEMCTRL_TERMRES_CTRL	0x00000034	1	TBA	Page 521
MEMCTRL_DQS_DLY	0x0000003C	1	DQS window configuration	Page 522
MEMCTRL_DQS_AUTO	0x00000040	1	DQS window automatic drift detect/adjust	Page 522
MEMPHY_CFG	0x00000044	1	Control register	Page 523
MEMPHY_ZCAL	0x00000060	1	Impedance calibration	Page 523

7.15.8.1 ICPU_CFG:MEMCTRL:MEMCTRL_CTRL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 667 • **Fields in MEMCTRL_CTRL**

Field Name	Bit	Access	Description	Default
STALL_REF_ENA	1	R/W	Set this field to postpone refresh of the SDRAM for as long as possible. Refresh will not be initiated until the number of pending refreshes reaches MEMCTRL_REF_PERIOD.MAX_PEND_REF. Interrupt routines and other high-priority tasks can set this field to ensure uninterrupted access to the memory.	0x0
INITIALIZE	0	One-shot	Set this field to force the memory controller to initialize the SDRAM. This field is automatically cleared after the initialization sequence is complete. Note: All other memory controller registers must have been configured appropriatly before setting this field.	0x0

7.15.8.2 ICPU_CFG:MEMCTRL:MEMCTRL_CFG

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 668 • **Fields in MEMCTRL_CFG**

Field Name	Bit	Access	Description	Default
BURST_SIZE	10	R/W	The number of data-bytes that is transmitted during one burst (of the defined burst length: BURST_LEN). 0: 8 data-bytes per burst. 1: 16 data-bytes per burst.	0x0
BURST_LEN	9	R/W	The burst size that is used by the SDRAM controller. The SDRAM must be configured with the corresponding burst size (through the MEMCTRL_MDSET_VAL register.) Note: The number of data-bytes that is transmitted during one burst must be encoded in the BURST_SIZE field. 0 : BURST4 1 : BURST8	0x0

Table 668 • **Fields in MEMCTRL_CFG *(continued)***

Field Name	Bit	Access	Description	Default
BANK_CNT	8	R/W	Number of banks in the SDRAM configuration being used. 0 : 4 banks 1 : 8 banks	0x0
MSB_ROW_ADDR	7:4	R/W	This field should be programmed to 1 less than the number of row address bits for the SDRAM configuration in use.	0x0
MSB_COL_ADDR	3:0	R/W	This field should be programmed to 1 less than the number of column address bits for the SDRAM configuration in use.	0x0

7.15.8.3 ICPU_CFG:MEMCTRL:MEMCTRL_STAT

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 669 • **Fields in MEMCTRL_STAT**

Field Name	Bit	Access	Description	Default
INIT_DONE	0	R/O	This field is set after initalization of the SDRAM is done.	0x0

7.15.8.4 ICPU_CFG:MEMCTRL:MEMCTRL_REF_PERIOD

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 670 • **Fields in MEMCTRL_REF_PERIOD**

Field Name	Bit	Access	Description	Default
MAX_PEND_REF	19:16	R/W	Maximum number of refreshes that are allowed to be outstanding at any time. If the number of outstanding refreshes reaches this value, the memory controller will stop the data transfer in progress, issue the required number of refreshes and then continue. This field must not be set to 0 (will disable the controller).	0x1
REF_PERIOD	15:0	R/W	Refresh interval of the SDRAM expressed in terms of number of clock cycles. This value is calculated by dividing the average periodic refresh interval (tREFI) by the clock period.	0x0100

7.15.8.5 ICPU_CFG:MEMCTRL:MEMCTRL_TIMING0

Parent: ICPU_CFG:MEMCTRL

Instances: 1

All asynchronous timing delays should be converted into the equivalent number of core-clocks (round up). Note: The SDRAM datasheet may specify parameters in a number of tCK cycles these are the same as clock cycles.

Table 671 • **Fields in MEMCTRL_TIMING0**

Field Name	Bit	Access	Description	Default
RD_TO_WR_DLY	31:28	R/W	Suggested value is 4. Value of 4 gives 2 cycles turn around time between the last read from the SDRAM and the first write to the SDRAM.	0x4
RESERVED	27:24	R/W	Must be set to its default.	0x3
RESERVED	23:20	R/W	Must be set to its default.	0x2
RAS_TO_PRECH_DLY	19:16	R/W	tRAS - 1 clock. Minimum delay between RAS and precharge commands.	0x0
WR_TO_PRECH_DLY	15:12	R/W	This value depends on the burst length used by the configuration. BURST4: CL + tWR. BURST8: CL + 2 + tWR. Minimum delay between write and precharge commands.	0x0
RD_TO_PRECH_DLY	11:8	R/W	This value depends on the burst length used by the configruation. BURST4: 1. BURST8: 3. Minimum delay between read and precharge commands.	0x0
WR_DATA_XFR_DLY	7:4	R/W	CL - 3. Delay between the issue of a write command and when the data is transmitted. CL must not be less than 3 (this register cannot be configured to less than 0).	0x0
RD_DATA_XFR_DLY	3:0	R/W	This field should be programmed to 1. The receive window is also adjusted by the DQS drift detection logic, which adds an additional delay on top of this value.	0x0

7.15.8.6 ICPU_CFG:MEMCTRL:MEMCTRL_TIMING1

Parent: ICPU_CFG:MEMCTRL

Instances: 1

All asynchronous timing delays should be converted into the equivalent number of core-clocks (round up). Note: The SDRAM datasheet may specify parameters in a number of tCK cycles these are the same as clock cycles.

Table 672 • **Fields in MEMCTRL_TIMING1**

Field Name	Bit	Access	Description	Default
RAS_TO_RAS_SAME_BANK_DLY	31:24	R/W	tRC - 1. Minimum delay between successive open commands to the same bank.	0x00
BANK8_FAW_DLY	23:16	R/W	tFAW - 1 for an 8-bank DDR2 SDRAM. 0 for a 4-bank DDR2 SDRAM. For 8 bank DDR2 SDRAM configurations; this value specifies an additional row opening restriction when a fifth bank is opened consecutively after 4 banks have been opened with minimum tRRD on the same chip select.	0x00
PRECH_TO_RAS_DLY	15:12	R/W	tRP - 1. Minimum delay between issuing a precharge command and a RAS command to the same bank.	0x0
RAS_TO_RAS_DLY	11:8	R/W	tRRD - 1. Minimum delay between two RAS commands issued to the same chip select.	0x0
RAS_TO_CAS_DLY	7:4	R/W	tRCD - AL - 1. Minimum delay between issuing of a RAS command and a CAS command to the same bank.	0x0
WR_TO_RD_DLY	3:0	R/W	BURST4: CL + tWTR, where tWTR converted to clock cycles must be atleast 2. BURST8: CL + 2 + tWTR, where tWTR converted to clock cycles must be atleast 2. Minimum delay from a write to a read command.	0x0

7.15.8.7 ICPU_CFG:MEMCTRL:MEMCTRL_TIMING2

Parent: ICPU_CFG:MEMCTRL

Instances: 1

All asynchronous timing delays should be converted into the equivalent number of core-clocks (round up). Note: The SDRAM datasheet may specify parameters in a number of tCK cycles these are the same as clock cycles.

Table 673 • **Fields in MEMCTRL_TIMING2**

Field Name	Bit	Access	Description	Default
PRECH_ALL_DLY	31:28	R/W	tRP - 1 for 4 bank memory and tRPA - 1 for 8 bank memory. Minimum delay between issuing a precharge all command and a LM/RAS command to any bank.	0x0
MDSET_DLY	27:24	R/W	tMRD - 1. Minimum delay required after a modeset command and before issuing any other command.	0x0
REF_DLY	23:16	R/W	tRFC - 1. Minimum delay between issuing of a refresh command and a RAS command. This value is assumed to be less than 67 clocks.	0x00
FOUR_HUNDRED_NS_DLY	15:0	R/W	Four hundred nanoseconds expressed in clock periods (round up). This is used during the initialization sequence.	0x0000

7.15.8.8 ICPU_CFG:MEMCTRL:MEMCTRL_TIMING3

Parent: ICPU_CFG:MEMCTRL

Instances: 1

All asynchronous timing delays should be converted into the equivalent number of core-clocks (round up). Note: The SDRAM datasheet may specify parameters in a number of tCK cycles these are the same as clock cycles.

Table 674 • **Fields in MEMCTRL_TIMING3**

Field Name	Bit	Access	Description	Default
ODT_WR_DLY	11:8	R/W	Value to be used is AL + CL - 4. Number of clocks after the write command that the ODT signal for the SDRAM should be turned on. This implies that AL + CL should be greater than or equal to 4.	0x0
LOCAL_ODT_RD_DLY	7:4	R/W	Value to be used is MEMCTRL_TIMING0.RD_DATA_XFR_DLY. Number of clocks after the read command to enable of local on-die-termination (ODT). This delay is also adjusted by the DQS drift detection logic, which adds an additional delay on top of this value.	0x0

Table 674 • **Fields in MEMCTRL_TIMING3** ***(continued)***

Field Name	Bit	Access	Description	Default
WR_TO_RD_CS_CHANGE_DLY	3:0	R/W	AL + CL - 1 but no less than 3. Minimum delay between a write command issued to one chip select followed by a read command to the other chip select. This value is less than the MEMCTRL_TIMING1:WR_TO_RD_DLY.	0x0

7.15.8.9 ICPU_CFG:MEMCTRL:MEMCTRL_MR0_VAL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Note: The memory controller will automatically generate the required bank-addresses used for addressing the different mode registers. Do not specify bank-addresses in this register.

Table 675 • **Fields in MEMCTRL_MR0_VAL**

Field Name	Bit	Access	Description	Default
MR0_VAL	15:0	R/W	Value to be programmed into the mode register (0) during SDRAM intialization. Bit 8 (DLL Reset) of this register must be set to 0, the memory controller automatically sets this bit when required during the initialization procedure.	0x0000

7.15.8.10 ICPU_CFG:MEMCTRL:MEMCTRL_MR1_VAL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Note: The memory controller will automatically generate the required bank-addresses used for addressing the different mode registers. Do not specify bank-addresses in this register.

Table 676 • **Fields in MEMCTRL_MR1_VAL**

Field Name	Bit	Access	Description	Default
MR1_VAL	15:0	R/W	Value to be programmed into mode register 1 / extended mode register during SDRAM initialization. Bits 7 thorugh 9 (OCD Calibration Program) of this register must be set to 0x7, the memory controller set this field when required during the initialization procedure.	0x0000

7.15.8.11 ICPU_CFG:MEMCTRL:MEMCTRL_MR2_VAL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Note: The memory controller will automatically generate the required bank-addresses used for addressing the different mode registers. Do not specify bank-addresses in this register.

Table 677 • **Fields in MEMCTRL_MR2_VAL**

Field Name	Bit	Access	Description	Default
MR2_VAL	15:0	R/W	Value to be programmed into mode register 2 / extended mode register 2 during SDRAM initialization.	0x0000

7.15.8.12 ICPU_CFG:MEMCTRL:MEMCTRL_MR3_VAL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Note: The memory controller will automatically generate the required bank-addresses used for addressing the different mode registers. Do not specify bank-addresses in this register.

Table 678 • **Fields in MEMCTRL_MR3_VAL**

Field Name	Bit	Access	Description	Default
MR3_VAL	15:0	R/W	Value to be programmed into mode register 3 / extended mode register 3 during SDRAM initialization.	0x0000

7.15.8.13 ICPU_CFG:MEMCTRL:MEMCTRL_TERMRES_CTRL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 679 • **Fields in MEMCTRL_TERMRES_CTRL**

Field Name	Bit	Access	Description	Default
ODT_WR_EXT	3	R/W	Set this field to extend the ODT termination output by one clock during write operations.	0x0
ODT_WR_ENA	2	R/W	Enables external termination during write operations.	0x0
LOCAL_ODT_RD_EXT	1	R/W	Set this field to extend the local termination by one clock during read operations.	0x0
LOCAL_ODT_RD_ENA	0	R/W	Enables local termination during a read operation.	0x0

7.15.8.14 ICPU_CFG:MEMCTRL:MEMCTRL_DQS_DLY

Parent: ICPU_CFG:MEMCTRL

Instances: 1

This register is replicated two times, once for each Byte Lane (first replication corresponds to Byte Lane 0).

After initialization of the DRAM memory controller the read-data-path must be trained. This is needed so that the controller knows exactly when to sample read-data from the DRAM(s). During training a window of DQS_DLY settings is determined during which correct read-data is returned from the DRAM(s), after finding the window the mid-window-value (round down) is programmed into DQS_DLY and then auto-adjusting is enabled by setting MEMCTRL_DQS_AUTO:DQS_AUTO_ENA. Training is done per Byte-Lane, two DRAM addresses are needed for training (a low and a high address), the actual addresses depends on the number of byte-lanes in the system, and which byte-lane that is trained: In a system with _one_ byte lane (x8), addresses 0x0 and 0xF is used. In a system with _two_ byte lanes (x16), DRAM addresses 0x0 and 0xE is used for training Byte Lane 0, and addresses 0x1 and 0xF is used for training Byte Lane 1.

Training is done for in the following steps:

1) Clear DRAM addresses 0x0 through 0xF by writing 0x00 to each address.

2) Write 0xFF to both the low and the high DRAM address (the actual addresses are defined in the above section) .

3) Find the lower DQS_DLY limit by sweeping through delay settings (DQS_DLY, starting from 0x0) while reading the high DRAM address. Continue sweeping (incrementing DQS_DLY) until 0xFF is returned when reading the high address.

4) Find the upper DQS_DLY limit by continuing the sweep through delay settings (starting at the lower limit determined during step 3) while reading the low DRAM address. Continue sweeping (incrementing DQS_DLY) until reading from the low address no longer returns 0xFF. The upper limit is then the current DQS_DLY - 1.

Table 680 • **Fields in MEMCTRL_DQS_DLY**

Field Name	Bit	Access	Description	Default
RESERVED	10:8	R/W	Must be set to its default.	0x3
RESERVED	7:5	R/W	Must be set to its default.	0x3
DQS_DLY	4:0	R/W	This field configures read-window delay as an offset in 1/4 clock cycles from the fixed read-delay configured in MEMCTRL_TIMING0:RD_DATA_XFR_DLY.	0x00

7.15.8.15 ICPU_CFG:MEMCTRL:MEMCTRL_DQS_AUTO

Parent: ICPU_CFG:MEMCTRL

Instances: 1

This register is subjected to the same replication scheme and encoding as MEMCTRL_DQS_DLY.

Table 681 • **Fields in MEMCTRL_DQS_AUTO**

Field Name	Bit	Access	Description	Default
DQS_AUTO_ENA	0	R/W	Set this field to enable automatic detection of drifting read-data-window. Drifting of the DQS read window occurs as the chip is heating/cooling. When this field is set MEMCTRL_DQS_DLY.DQS_DLY field will automatically be adjusted when a drift is detected by the hardware.	0x0

7.15.8.16 ICPU_CFG:MEMCTRL:MEMPHY_CFG

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 682 • **Fields in MEMPHY_CFG**

Field Name	Bit	Access	Description	Default
PHY_ODT_OE	4	R/W	Set to enable output drive of the ODT output.	0x0
PHY_CK_OE	3	R/W	Set to enable output drive of the CK/nCK and CKE outputs.	0x0
PHY_CL_OE	2	R/W	Set to enable output drive of the Command Lane outputs.	0x0
PHY_SSTL_ENA	1	R/W	Set this field to enable the SSTL drivers/receivers in the memory controllers physical interface.	0x0
PHY_RST	0	R/W	Master reset to the memory controller physical interface. 0: PHY is in working mode. 1: PHY is forced in reset.	0x1

7.15.8.17 ICPU_CFG:MEMCTRL:MEMPHY_ZCAL

Parent: ICPU_CFG:MEMCTRL

Instances: 1

Table 683 • **Fields in MEMPHY_ZCAL**

Field Name	Bit	Access	Description	Default
ZCAL_PROG_ODT	8:5	R/W	Together with the external reference resistor this field configures the SSTL On-Die-Termination (ODT) impedance. This field must be configured prior to, or at the same time as, setting the ZCAL_ENA field. 2: 150ohms 5: 75ohms 8: 50ohms Other values are reserved.	0x3
ZCAL_PROG	4:1	R/W	Together with the external reference resistor this field configures the SSTL output impedance. This field must be configured prior to, or at the same time as, setting the ZCAL_ENA field. 11: 40ohms Other values are reserved.	0xB
ZCAL_ENA	0	One-shot	Set this field to start automatic SSTL output and ODT impedance calibration. This field is cleared when the automatic calibration has completed.	0x0

7.15.9 ICPU_CFG:TWI_DELAY

Parent: ICPU_CFG

Instances: 1

Table 684 • **Registers in TWI_DELAY**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
TWI_CONFIG	0x00000000	1	Configuration registers	Page 524

7.15.9.1 ICPU_CFG:TWI_DELAY:TWI_CONFIG

Parent: ICPU_CFG:TWI_DELAY

Instances: 1

Table 685 • **Fields in TWI_CONFIG**

Field Name	Bit	Access	Description	Default
TWI_CNT_RELOAD	8:1	R/W	Configure the hold time delay to apply to SDA after SCK when transmitting from the device. The delay depends on the VCore system clock period. If for example the VCore system clock is 125MHz then the period is 8ns, in turn the hold time will then be (TWI_CNT_RELOAD+2) * 8ns. Replace the clock period for other VCore system frequencies. The resulting value should be as close to 300ns as possible without going below 300ns.	0x00
TWI_DELAY_ENABLE	0	R/W	Set this field to enable hold time on the TWI SDA output. When enabled the TWI_CONFIG.TWI_CNT_RELOAD field determines the amount of hold time to apply to SDA.	0x0

7.16 UART

Table 686 • **Register Groups in UART**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
UART	0x00000000	1	UART registers	Page 525

7.16.1 UART:UART

Parent: UART

Instances: 1

Table 687 • **Registers in UART**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RBR_THR	0x00000000	1	Receive Buffer / Transmit Holding Register / Divisor (Low)	Page 526
IER	0x00000004	1	Interrupt Enable Register / Divisor (High)	Page 527

Table 687 • **Registers in UART *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
IIR_FCR	0x00000008	1	Interrupt Identification Register / FIFO Control Register	Page 528
LCR	0x0000000C	1	Line Control Register	Page 530
MCR	0x00000010	1	Modem Control Register	Page 531
LSR	0x00000014	1	Line Status Register	Page 532
MSR	0x00000018	1	Modem Status Register	Page 535
SCR	0x0000001C	1	Scratchpad Register	Page 536
USR	0x0000007C	1	UART Status Register	Page 536

7.16.1.1 UART:UART:RBR_THR

Parent: UART:UART

Instances: 1

When the LCR.DLAB is set, this register is the lower 8 bits of the 16-bit Divisor register that contains the baud rate divisor for the UART.

The output baud rate is equal to the VCore system clock frequency divided by sixteen times the value of the baud rate divisor, as follows: baud rate = (VCore clock freq) / (16 * divisor). Note that with the Divisor set to zero, the baud clock is disabled and no serial communications occur. In addition, once this register is set, wait at least 0.1us before transmitting or receiving data.

Table 688 • **Fields in RBR_THR**

Field Name	Bit	Access	Description	Default
RBR_THR	7:0	R/W	Use this register to access the Rx and Tx FIFOs. When reading: The data in this register is valid only if LSR.DR is set. If FIFOs are disabled (IIR_FCR.FIFOE), the data in this register must be read before the next data arrives, otherwise it is overwritten, resulting in an overrun error. When FIFOs are enabled (IIR_FCR.FIFOE), this register accesses the head of the receive FIFO. If the receive FIFO is full and this register is not read before the next data character arrives, then the data already in the FIFO is preserved, but any incoming data is lost and an overrun error occurs. When writing: Data should only be written to this register when the LSR.THRE indicates that there is room in the FIFO. If FIFOs are disabled (IIR_FCR.FIFOE), writes to this register while LSR.THRE is zero, causes the register to be overwritten. When FIFOs are enabled (IIR_FCR.FIFOE) and LSR.THRE is set, 16 characters may be written to this register before the FIFO is full. Any attempt to write data when the FIFO is full results in the write data being lost.	0x00

7.16.1.2 UART:UART:IER

Parent: UART:UART

Instances: 1

When the LCR.DLAB is set, this register is the upper 8 bits of the 16-bit Divisor register that contains the baud rate divisor for the UART. For more information and a description of how to calculate the baud rate, see RBR_THR.

Table 689 • **Fields in IER**

Field Name	Bit	Access	Description	Default
PTIME	7	R/W	Programmable THRE interrupt mode enable. This is used to enable or disable the generation of THRE interrupt. 0: Disabled 1: Enabled	0x0
EDSSI	3	R/W	Enable modem status interrupt. This is used to enable or disable the generation of Modem Status interrupt. This is the fourth highest priority interrupt. 0: Disabled 1: Enabled	0x0
ELSI	2	R/W	Enable receiver line status interrupt. This is used to enable or disable the generation of Receiver Line Status interrupt. This is the highest priority interrupt. 0: Disabled 1: Enabled	0x0
ETBEI	1	R/W	Enable transmit holding register empty interrupt. This is used to enable or disable the generation of Transmitter Holding Register Empty interrupt. This is the third highest priority interrupt. 0: Disabled 1: Enabled	0x0
ERBFI	0	R/W	Enable received data available interrupt. This is used to enable or disable the generation of Received Data Available interrupt and the Character Timeout interrupt (if FIFOs are enabled). These are the second highest priority interrupts. 0: Disabled 1: Enabled	0x0

7.16.1.3 UART:UART:IIR_FCR

Parent: UART:UART

Instances: 1

This register has special meaning when reading, here the lowest 4 bits indicate interrupting sources. The encoding is as follows:

0110; type: Receiver line status, priority: Highest. Overrun/parity/ framing errors or break interrupt. Cleared by reading LSR.

0100; type: Received data available, priority: Second. RCVR FIFO trigger level reached. Cleared when FIFO drops below the trigger level.

1100; type: Character timeout indication, priority: Second. No characters in or out of the RCVR FIFO during the last four character times and there is at least 1 character in it during this time. Cleared by reading the receiver buffer register.

0010; type: Transmit holding register empty, priority: Third. Transmitter holding register empty (Prog. THRE Mode disabled) or XMIT FIFO at or below threshold (Prog. THRE Mode enabled). Cleared by reading the IIR register (if source of interrupt); or, writing into THR (THRE Mode disabled) or XMIT FIFO above threshold (THRE Mode enabled).

0000; type: Modem status, priority: Fourth. Clear to send. Note that if auto flow control mode is enabled, a change in CTS (that is, DCTS set) does not cause an interrupt. Cleared by reading the Modem status register.

0111; type: Busy detect indication, priority: Fifth. Master has tried to write to the Line Control register while the UART is busy (USR[0] is set to one). Cleared by reading the UART status register.

0001: No interrupting sources.

Table 690 • **Fields in IIR_FCR**

Field Name	Bit	Access	Description	Default
FIFOSE_RT	7:6	R/W	When reading this field, the current status of the FIFO is returned; 00 for disabled or 11 for enabled. Writing this field selects the trigger level in the receive FIFO at which the Received Data Available interrupt is generated (see encoding.) In auto flow control mode, it is used to determine when to generate back-pressure using the RTS signal. 00: 1 character in the Rx FIFO 01: Rx FIFO 1/4 full 10: Rx FIFO 1/2 full 11: Rx FIFO 2 less than full	0x1
TET	5:4	R/W	Tx empty trigger. When the THRE mode is enabled (IER.PTIME), this field selects the empty threshold level at which the THRE Interrupts are generated. 00: Tx FIFO empty 01: 2 characters in the Tx FIFO 10: Tx FIFO 1/4 full 11: Tx FIFO 1/2 full	0x0
XFIFOR	2	R/W	This description is valid for writes only. Reading this field has special meaning; for more information, see the general register description. Tx FIFO Reset. This resets the control portion of the transmit FIFO and treats the FIFO as empty. Note that this bit is self-clearing. It is not necessary to clear this bit.	0x0

Table 690 • **Fields in IIR_FCR *(continued)***

Field Name	Bit	Access	Description	Default
RFIFOR	1	R/W	This description is valid for writes only. Reading this field has special meaning; for more information, see the general register description. Rx FIFO Reset. This resets the control portion of the receive FIFO and treats the FIFO as empty. Note that this bit is self-clearing. It is not necessary to clear this bit.	0x0
FIFOE	0	R/W	This description is valid for writes only. Reading this field has special meaning; for more information, see the general register description. FIFO Enable. This enables or disables the transmit (XMIT) and receive (RCVR) FIFOs. Whenever the value of this bit is changed, both the XMIT and RCVR controller portion of FIFOs are reset.	0x0

7.16.1.4 UART:UART:LCR

Parent: UART:UART

Instances: 1

Writes can be made to this register, with the exception of the BC field, only when UART is not busy, that is, when USR.BUSY is zero. This register can always be read.

Table 691 • **Fields in LCR**

Field Name	Bit	Access	Description	Default
DLAB	7	R/W	Divisor latch access bit. This bit is used to enable reading and writing of the Divisor registers (RBR_THR and IER) to set the baud rate of the UART. To access other registers, this bit must be cleared after initial baud rate setup.	0x0
BC	6	R/W	Break control bit.This bit is used to cause a break condition to be transmitted to the receiving device. If set to one, the serial output is forced to the spacing (logic 0) state. When not in Loopback Mode, as determined by MCR[4], the serial output is forced low until the Break bit is cleared.	0x0

Table 691 • **Fields in LCR *(continued)***

Field Name	Bit	Access	Description	Default
EPS	4	R/W	Even parity select. This bit is used to select between even and odd parity, when parity is enabled (PEN set to one). If set to one, an even number of logic 1s is transmitted or checked. If set to zero, an odd number of logic 1s is transmitted or checked.	0x0
PEN	3	R/W	Parity enable. This bit is used to enable or disable parity generation and detection in both transmitted and received serial characters. 0: Parity disabled 1: Parity enabled	0x0
STOP	2	R/W	Number of stop bits. This is used to select the number of stop bits per character that the peripheral transmits and receives. If set to zero, one stop bit is transmitted in the serial data. If set to one and the data bits are set to 5 (LCR.DLS), one and a half stop bits are transmitted. Otherwise, two stop bits are transmitted. Note that regardless of the number of stop bits selected, the receiver checks only the first stop bit. 0: 1 stop bit 1: 1.5 stop bits when LCR.DLS is zero, otherwise, 2 stop bits	0x0
DLS	1:0	R/W	Data length select. This is used to select the number of data bits per character that the peripheral transmits and receives. The following settings specify the number of bits that may be selected. 00: 5 bits 01: 6 bits 10: 7 bits 11: 8 bits	0x0

7.16.1.5 UART:UART:MCR

Parent: UART:UART

Instances: 1

Table 692 • **Fields in MCR**

Field Name	Bit	Access	Description	Default
AFCE	5	R/W	Auto flow control enable. This mode requires that FIFOs are enabled and that MCR.RTS is set. 0: Auto flow control mode disabled 1: Auto flow control mode enabled	0x0
LB	4	R/W	Loopback Bit. This is used to put the UART into a diagnostic mode for test purposes. The transmit line is held high, while serial transmit data is looped back to the receive line internally. In this mode, all the interrupts are fully functional. In addition, in loopback mode, the modem control input CTS is disconnected, and the modem control output RTS is looped back to the input internally.	0x0
RTS	1	R/W	Request to send. This is used to directly control the Request to Send (RTS) output. The RTS output is used to inform the partner that the UART is ready to exchange data. The RTS is still controlled from this field when Auto RTS Flow Control is enabled (MCR.AFCE), but the output can be forced high by the flow control mechanism. If this field is cleared, the UART permanently indicates backpressure to the partner. 0: RTS is set high 1: RTS is set low	0x0

7.16.1.6 UART:UART:LSR

Parent: UART:UART

Instances: 1

Table 693 • **Fields in LSR**

Field Name	Bit	Access	Description	Default
RFE	7	R/W	Receiver FIFO error bit. This bit is only valid when FIFOs are enabled. This is used to indicate whether there is at least one parity error, framing error, or break indication in the FIFO. This bit is cleared when the LSR is read, the character with the error is at the top of the receiver FIFO, and there are no subsequent errors in the FIFO. 0: No error in Rx FIFO 1: Error in Rx FIFO	0x0
TEMT	6	R/W	Transmitter empty bit. If FIFOs are enabled, this bit is set whenever the Transmitter Shift Register and the FIFO are both empty.	0x1
THRE	5	R/W	If FIFO (IIR_FCR.FIFOE) and THRE mode are enabled (IER.PTIME), this bit indicates that the Tx FIFO is full. Otherwise, this bit indicates that the Tx FIFO is empty.	0x1
BI	4	R/W	Break interrupt bit. This is used to indicate the detection of a break sequence on the serial input data. It is set whenever the serial input is held in a logic 0 state for longer than the sum of start time + data bits + parity + stop bits. A break condition on serial input causes one and only one character, consisting of all-zeros, to be received by the UART. In the FIFO mode, the character associated with the break condition is carried through the FIFO and is revealed when the character is at the top of the FIFO. Reading the LSR clears the BI bit. In the non-FIFO mode, the BI indication occurs immediately and persists until the LSR is read.	0x0

Table 693 • **Fields in LSR** ***(continued)***

Field Name	Bit	Access	Description	Default
FE	3	R/W	Framing error bit. This is used to indicate the a framing error in the receiver. A framing error occurs when the receiver does not detect a valid STOP bit in the received data. A framing error is associated with a received character. Therefore, in FIFO mode, an error is revealed when the character with the framing error is at the top of the FIFO. When a framing error occurs, the UART tries to resynchronize. It does this by assuming that the error was due to the start bit of the next character and then continues to receive the other bit, that is, data and/or parity, and then stops. Note that this field is set if a break interrupt has occurred, as indicated by Break Interrupt (LSR.BI). This field is cleared on read. 0: No framing error 1: Framing error	0x0
PE	2	R/W	Parity error bit. This is used to indicate the occurrence of a parity error in the receiver if the Parity Enable bit (LCR.PEN) is set. A parity error is associated with a received character. Therefore, in FIFO mode, an error is revealed when the character with the parity error arrives at the top of the FIFO. Note that this field is set if a break interrupt has occurred, as indicated by Break Interrupt (LSR.BI). This field is cleared on read. 0: No parity error 1: Parity error	0x0

Table 693 • **Fields in LSR *(continued)***

Field Name	Bit	Access	Description	Default
OE	1	R/W	Overrun error bit. This is used to indicate the occurrence of an overrun error. This occurs if a new data character was received before the previous data was read. In non-FIFO mode, the OE bit is set when a new character arrives before the previous character was read. When this happens, the data in the RBR is overwritten. In FIFO mode, an overrun error occurs when the FIFO is full and a new character arrives at the receiver. The data in the FIFO is retained and the data in the receive shift register is lost. This field is cleared on read. 0: No overrun error 1: Overrun error	0x0
DR	0	R/W	Data ready. This is used to indicate that the receiver contains at least one character in the receiver FIFO. This bit is cleared when the RX FIFO is empty. 0: No data ready 1: Data ready	0x0

7.16.1.7 UART:UART:MSR

Parent: UART:UART

Instances: 1

Table 694 • **Fields in MSR**

Field Name	Bit	Access	Description	Default
CTS	4	R/O	Clear to send. This field indicates the current state of the modem control line, CTS. When the Clear to Send input (CTS) is asserted, it is an indication that the partner is ready to exchange data with the UART. 0: CTS input is deasserted (logic 0) 1: CTS input is asserted (logic 1)	0x0

Table 694 • **Fields in MSR *(continued)***

Field Name	Bit	Access	Description	Default
DCTS	0	R/O	Delta clear to send. This is used to indicate that the modem control line, CTS, has changed since the last time the MSR was read. Reading the MSR clears the DCTS bit. Note: If the DCTS bit is not set, the CTS signal is asserted, and a reset occurs (software or otherwise), then the DCTS bit is set when the reset is removed, if the CTS signal remains asserted. A read of the MSR after reset can be performed to prevent unwanted interrupts. 0: No change on CTS since the last read of the MSR 1: Change on CTS since the last read of the MSR	0x0

7.16.1.8 UART:UART:SCR

Parent: UART:UART

Instances: 1

Table 695 • **Fields in SCR**

Field Name	Bit	Access	Description	Default
SCR	7:0	R/W	This register is for programmers to use as a temporary storage space. It has no functional purpose for the UART.	0x00

7.16.1.9 UART:UART:USR

Parent: UART:UART

Instances: 1

Table 696 • **Fields in USR**

Field Name	Bit	Access	Description	Default
BUSY	0	R/O	UART busy. 0: UART is idle or inactive 1: UART is busy (actively transferring data)	0x0

7.17 TWI

Table 697 • **Register Groups in TWI**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
TWI	0x00000000	1	Two-Wire Interface Controller Registers	Page 537

7.17.1 TWI:TWI

Parent: TWI

Instances: 1

Table 698 • **Registers in TWI**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
CFG	0x00000000	1	TWI Configuration	Page 538
TAR	0x00000004	1	Target Address	Page 540
SAR	0x00000008	1	Slave Address	Page 540
DATA_CMD	0x00000010	1	Rx/Tx Data Buffer and Command	Page 541
SS_SCL_HCNT	0x00000014	1	Standard Speed TWI Clock SCL High Count	Page 542
SS_SCL_LCNT	0x00000018	1	Standard Speed TWI Clock SCL Low Count	Page 543
FS_SCL_HCNT	0x0000001C	1	Fast Speed TWI Clock SCL High Count	Page 543
FS_SCL_LCNT	0x00000020	1	Fast Speed TWI Clock SCL Low Count	Page 544
INTR_STAT	0x0000002C	1	Interrupt Status	Page 544
INTR_MASK	0x00000030	1	Interrupt Mask	Page 544
RAW_INTR_STAT	0x00000034	1	Raw Interrupt Status	Page 545
RX_TL	0x00000038	1	Receive FIFO Threshold	Page 549
TX_TL	0x0000003C	1	Transmit FIFO Threshold	Page 550
CLR_INTR	0x00000040	1	Clear Combined and Individual Interrupt	Page 550
CLR_RX_UNDER	0x00000044	1	Clear RX_UNDER Interrupt	Page 550
CLR_RX_OVER	0x00000048	1	Clear RX_OVER Interrupt	Page 551
CLR_TX_OVER	0x0000004C	1	Clear TX_OVER Interrupt	Page 551
CLR_RD_REQ	0x00000050	1	Clear RD_REQ Interrupt	Page 551

Table 698 • **Registers in TWI *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
CLR_TX_ABRT	0x00000054	1	Clear TX_ABRT Interrupt	Page 551
CLR_RX_DONE	0x00000058	1	Clear RX_DONE Interrupt	Page 552
CLR_ACTIVITY	0x0000005C	1	Clear ACTIVITY Interrupt	Page 552
CLR_STOP_DET	0x00000060	1	Clear STOP_DET Interrupt	Page 552
CLR_START_DET	0x00000064	1	Clear START_DET Interrupt	Page 553
CLR_GEN_CALL	0x00000068	1	Clear GEN_CALL Interrupt	Page 553
CTRL	0x0000006C	1	TWI Control	Page 553
STAT	0x00000070	1	TWI Status	Page 554
TXFLR	0x00000074	1	Transmit FIFO Level	Page 555
RXFLR	0x00000078	1	Receive FIFO Level	Page 556
TX_ABRT_SOURCE	0x00000080	1	Transmit Abort Source	Page 556
SDA_SETUP	0x00000094	1	SDA Setup	Page 558
ACK_GEN_CALL	0x00000098	1	ACK General Call	Page 558
ENABLE_STATUS	0x0000009C	1	Enable Status	Page 559

7.17.1.1 TWI:TWI:CFG

Parent: TWI:TWI

Instances: 1

Table 699 • **Fields in CFG**

Field Name	Bit	Access	Description	Default
SLAVE_DIS	6	R/W	This bit controls whether the TWI controller has its slave disabled. If this bit is set (slave is disabled), the controller functions only as a master and does not perform any action that requires a slave. '0': slave is enabled '1': slave is disabled	0x1

Table 699 • **Fields in CFG** ***(continued)***

Field Name	Bit	Access	Description	Default
RESTART_ENA	5	R/W	Determines whether RESTART conditions may be sent when acting as a master. Some older slaves do not support handling RESTART conditions; however, RESTART conditions are used in several operations. When RESTART is disabled, the master is prohibited from performing the following functions: * Change direction within a transfer (split) * Send a START BYTE * Combined format transfers in 7-bit addressing modes * Read operation with a 10-bit address * Send multiple bytes per transfer By replacing RESTART condition followed by a STOP and a subsequent START condition, split operations are broken down into multiple transfers. If the above operations are performed, it will result in setting RAW_INTR_STAT.TX_ABRT. '0': disable '1': enable	0x1
MASTER_10BITADDR	4	R/W	Controls whether transfers starts in 7- or 10-bit addressing mode when acting as a master. '0': 7-bit addressing '1': 10-bit addressing	0x0
SLAVE_10BITADDR	3	R/W	Controls whether the TWI controller responds to 7- or 10-bit addresses in slave mode. In 7-bit mode; transactions that involve 10-bit addressing are ignored and only the lower 7 bits of the SAR register are compared. '0': 7-bit addressing. '1': 10-bit addressing.	0x0
SPEED	2:1	R/W	These bits control at which speed the TWI controller operates; its setting is relevant only in master mode. Hardware protects against illegal values being programmed by software. '1': standard mode (100 kbit/s) '2': fast mode (400 kbit/s)	0x2

Table 699 • **Fields in CFG *(continued)***

Field Name	Bit	Access	Description	Default
MASTER_ENA	0	R/W	This bit controls whether the TWI master is enabled. '0': master disabled '1': master enabled	0x1

7.17.1.2 TWI:TWI:TAR

Parent: TWI:TWI

Instances: 1

Table 700 • **Fields in TAR**

Field Name	Bit	Access	Description	Default
GC_OR_START_ENA	11	R/W	This bit indicates whether software performs a General Call or START BYTE command. '0': ignore bit 10 GC_OR_START and use TAR normally '1': perform special TWI command as specified in GC_OR_START bit	0x0
GC_OR_START	10	R/W	If TAR.SPECIAL is set to 1, then this bit indicates whether a General Call or START byte command is to be performed. '0': General Call Address - after issuing a General Call, only writes may be performed. Attempting to issue a read command results in setting RAW_INTR_STAT.TX_ABRT. The TWI controller remains in General Call mode until the TAR.SPECIAL field is cleared. '1': START BYTE	0x0
TAR	9:0	R/W	This is the target address for any master transaction. When transmitting a General Call, these bits are ignored. To generate a START BYTE, the CPU needs to write only once into these bits. If the TAR and SAR are the same, loopback exists but the FIFOs are shared between master and slave, so full loopback is not feasible. Only one direction loopback mode is supported (simplex), not duplex. A master cannot transmit to itself; it can transmit to only a slave.	0x055

7.17.1.3 TWI:TWI:SAR

Parent: TWI:TWI

Instances: 1

Table 701 • **Fields in SAR**

Field Name	Bit	Access	Description	Default
SAR	9:0	R/W	The SAR holds the slave address when the TWI is operating as a slave. For 7-bit addressing, only SAR[6:0] is used. This register can be written only when the TWI interface is disabled (ENABLE = 0).	0x055

7.17.1.4 TWI:TWI:DATA_CMD

Parent: TWI:TWI

Instances: 1

Table 702 • **Fields in DATA_CMD**

Field Name	Bit	Access	Description	Default
CMD	8	R/W	This bit controls whether a read or a write is performed. This bit does not control the direction when the TWI acts as a slave. It controls only the direction when it acts as a master. When a command is entered in the TX FIFO, this bit distinguishes the write and read commands. In slave-receiver mode, this bit is a "don't care" because writes to this register are not required. In slave-transmitter mode, a "0" indicates that CPU data is to be transmitted and as DATA. When programming this bit, please remember the following: attempting to perform a read operation after a General Call command has been sent results in a TX_ABRT interrupt (RAW_INTR_STAT.R_TX_ABRT), unless TAR.SPECIAL has been cleared. If a "1" is written to this bit after receiving a RD_REQ interrupt, then a TX_ABRT interrupt occurs. NOTE: It is possible that while attempting a master TWI read transfer, a RD_REQ interrupt may have occurred simultaneously due to a remote TWI master addressing this controller. In this type of scenario, the TWI controller ignores the DATA_CMD write, generates a TX_ABRT interrupt, and waits to service the RD_REQ interrupt. '1' = Read '0' = Write	0x0
DATA	7:0	R/W	This register contains the data to be transmitted or received on the TWI bus. If you are writing to this register and want to perform a read, this field is ignored by the controller. However, when you read this register, these bits return the value of data received on the TWI interface.	0x00

7.17.1.5 TWI:TWI:SS_SCL_HCNT

Parent: TWI:TWI

Instances: 1

The clock for the TWI controller is the VCore system clock. This field must be set accordingly to the VCore system frequency; value = (4us / VCore clock period) - 8.

Example: a 178.6MHz clock correspond to a period of 5.6ns, for this frequency this field must not be set lower than (round up): 707 = (4us / 5.6ns) - 8.

Table 703 • **Fields in SS_SCL_HCNT**

Field Name	Bit	Access	Description	Default
SS_SCL_HCNT	15:0	R/W	This register sets the SCL clock divider for the high-period in standard speed. This value must result in a high period of no less than 4us.	0x033A

7.17.1.6 TWI:TWI:SS_SCL_LCNT

Parent: TWI:TWI

Instances: 1

The clock for the TWI controller is the VCore system clock. This field must be set accordingly to the VCore system frequency; value = (4.7us / VCore clock period) - 1.

Example: a 178.6MHz clock correspond to a period of 5.6ns, for this frequency this field must not be set lower than (round up): 839 = (4.7us / 5.6ns) - 1.

Table 704 • **Fields in SS_SCL_LCNT**

Field Name	Bit	Access	Description	Default
SS_SCL_LCNT	15:0	R/W	This register sets the SCL clock divider for the low-period in standard speed. This value must result in a value no less than 4.7us.	0x03D3

7.17.1.7 TWI:TWI:FS_SCL_HCNT

Parent: TWI:TWI

Instances: 1

The clock for the TWI controller is the VCore system clock. This field must be set accordingly to the VCore system frequency; value = (0.6us / VCore clock period) - 8.

Example: a 178.6MHz clock correspond to a period of 5.6ns, for this frequency this field must not be set lower than (round up): 100 = (0.6us / 5.6ns) - 8.

Table 705 • **Fields in FS_SCL_HCNT**

Field Name	Bit	Access	Description	Default
FS_SCL_HCNT	15:0	R/W	This register sets the SCL clock divider for the high-period in fast speed. This value must result in a value no less than 0.6us.	0x0075

7.17.1.8 TWI:TWI:FS_SCL_LCNT

Parent: TWI:TWI

Instances: 1

The clock for the TWI controller is the VCore system clock. This field must be set accordingly to the VCore system frequency; value = (1.3us / VCore clock period) - 1.

Example: a 178.6MHz clock correspond to a period of 5.6ns, for this frequency this field must not be set lower than (round up): 232 = (1.3us / 5.6ns) - 1.

Table 706 • **Fields in FS_SCL_LCNT**

Field Name	Bit	Access	Description	Default
FS_SCL_LCNT	15:0	R/W	This register sets the SCL clock divider for the low-period in fast speed. This value must result in a value no less than 1.3us.	0x010E

7.17.1.9 TWI:TWI:INTR_STAT

Parent: TWI:TWI

Instances: 1

Each field in this register has a corresponding mask field in the INTR_MASK register. These fields are cleared by reading the matching interrupt clear register. The unmasked raw versions of these fields are available in the RAW_INTR_STAT register.

See RAW_INTR_STAT for a description of these fields

Table 707 • **Fields in INTR_STAT**

Field Name	Bit	Access	Description	Default
GEN_CALL	11	R/O		0x0
START_DET	10	R/O		0x0
STOP_DET	9	R/O		0x0
ACTIVITY	8	R/O		0x0
RX_DONE	7	R/O		0x0
TX_ABRT	6	R/O		0x0
RD_REQ	5	R/O		0x0
TX_EMPTY	4	R/O		0x0
TX_OVER	3	R/O		0x0
RX_FULL	2	R/O		0x0
RX_OVER	1	R/O		0x0
RX_UNDER	0	R/O		0x0

7.17.1.10 TWI:TWI:INTR_MASK

Parent: TWI:TWI

Instances: 1

These fields mask the corresponding interrupt status fields (RAW_INTR_STAT). They are active high; a value of 0 prevents the corresponding field in RAW_INTR_STAT from generating an interrupt.

Table 708 • **Fields in INTR_MASK**

Field Name	Bit	Access	Description	Default
M_GEN_CALL	11	R/W		0x1
M_START_DET	10	R/W		0x0
M_STOP_DET	9	R/W		0x0
M_ACTIVITY	8	R/W		0x0
M_RX_DONE	7	R/W		0x1
M_TX_ABRT	6	R/W		0x1
M_RD_REQ	5	R/W		0x1
M_TX_EMPTY	4	R/W		0x1
M_TX_OVER	3	R/W		0x1
M_RX_FULL	2	R/W		0x1
M_RX_OVER	1	R/W		0x1
M_RX_UNDER	0	R/W		0x1

7.17.1.11 TWI:TWI:RAW_INTR_STAT

Parent: TWI:TWI

Instances: 1

Unlike the INTR_STAT register, these fields are not masked so they always show the true status of the TWI controller.

Table 709 • **Fields in RAW_INTR_STAT**

Field Name	Bit	Access	Description	Default
R_GEN_CALL	11	R/O	Set only when a General Call address is received and it is acknowledged. It stays set until it is cleared either by disabling TWI controller or when the CPU reads bit 0 of the CLR_GEN_CALL register. The TWI controller stores the received data in the Rx buffer.	0x0
R_START_DET	10	R/O	Indicates whether a START or RESTART condition has occurred on the TWI regardless of whether the TWI controller is operating in slave or master mode.	0x0
R_STOP_DET	9	R/O	Indicates whether a STOP condition has occurred on the TWI controller regardless of whether the TWI controller is operating in slave or master mode.	0x0

Table 709 • **Fields in RAW_INTR_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
R_ACTIVITY	8	R/O	This bit captures TWI activity and stays set until it is cleared. There are four ways to clear it: * Disabling the TWI controller * Reading the CLR_ACTIVITY register * Reading the CLR_INTR register * VCore system reset Once this bit is set, it stays set unless one of the four methods is used to clear it. Even if the TWI controller module is idle, this bit remains set until cleared, indicating that there was activity on the bus.	0x0
R_RX_DONE	7	R/O	When the TWI controller is acting as a slave-transmitter, this bit is set to 1 if the master does not acknowledge a transmitted byte. This occurs on the last byte of the transmission, indicating that the transmission is done.	0x0

Table 709 • **Fields in RAW_INTR_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
R_TX_ABRT	6	R/O	This bit is set to 1 when the TWI controller is acting as a master is unable to complete a command that the processor has sent. The conditions that set this field are: * No slave acknowledges the address byte. * The addressed slave receiver does not acknowledge a byte of data. * Attempting to send a master command when configured only to be a slave. * When CFG.RESTART_ENA is set to 0 (RESTART condition disabled), and the processor attempts to issue a TWI function that is impossible to perform without using RESTART conditions. * High-speed master code is acknowledged (this controller does not support high-speed). * START BYTE is acknowledged. * General Call address is not acknowledged. * When a read request interrupt occurs and the processor has previously placed data in the Tx buffer that has not been transmitted yet. This data could have been intended to service a multi-byte RD_REQ that ended up having fewer numbers of bytes requested. *The TWI controller loses arbitration of the bus between transfers and is then accessed as a slave-transmitter. * If a read command is issued after a General Call command has been issued. Disabling the TWI reverts it back to normal operation. * If the CPU attempts to issue read command before a RD_REQ is serviced. Anytime this bit is set, the contents of the transmit and receive buffers are flushed.	0x0

Table 709 • **Fields in RAW_INTR_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
R_RD_REQ	5	R/O	This bit is set to 1 when the TWI controller acts as a slave and another TWI master is attempting to read data from this controller. The TWI controller holds the TWI bus in a wait state (SCL=0) until this interrupt is serviced, which means that the slave has been addressed by a remote master that is asking for data to be transferred. The processor must respond to this interrupt and then write the requested data to the DATA_CMD register. This bit is set to 0 just after the required data is written to the DATA_CMD register.	0x0
R_TX_EMPTY	4	R/O	This bit is set to 1 when the transmit buffer is at or below the threshold value set in the TX_TL register. It is automatically cleared by hardware when the buffer level goes above the threshold. When ENABLE is 0, the TX FIFO is flushed and held in reset. There the TX FIFO looks like it has no data within it, so this bit is set to 1, provided there is activity in the master or slave state machines. When there is no longer activity, then with ENABLE_STATUS.BUSY=0, this bit is set to 0.	0x0
R_TX_OVER	3	R/O	Set during transmit if the transmit buffer is filled to TX_BUFFER_DEPTH and the processor attempts to issue another TWI command by writing to the DATA_CMD register. When the module is disabled, this bit keeps its level until the master or slave state machines go into idle, and when ENABLE_STATUS.BUSY goes to 0, this interrupt is cleared.	0x0

Table 709 • **Fields in RAW_INTR_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
R_RX_FULL	2	R/O	Set when the receive buffer reaches or goes above the RX_TL threshold in the RX_TL register. It is automatically cleared by hardware when buffer level goes below the threshold. If the module is disabled (ENABLE=0), the RX FIFO is flushed and held in reset; therefore the RX FIFO is not full. So this bit is cleared once the ENABLE field is programmed with a 0, regardless of the activity that continues.	0x0
R_RX_OVER	1	R/O	Set if the receive buffer is completely filled to RX_BUFFER_DEPTH and an additional byte is received from an external TWI device. The TWI controller acknowledges this, but any data bytes received after the FIFO is full are lost. If the module is disabled (ENABLE=0), this bit keeps its level until the master or slave state machines go into idle, and when ENABLE_STATUS.BUSY goes to 0, this interrupt is cleared.	0x0
R_RX_UNDER	0	R/O	Set if the processor attempts to read the receive buffer when it is empty by reading from the DATA_CMD register. If the module is disabled (ENABLE=0), this bit keeps its level until the master or slave state machines go into idle, and when ENABLE_STATUS.BUSY goes to 0, this interrupt is cleared.	0x0

7.17.1.12 TWI:TWI:RX_TL

Parent: TWI:TWI

Instances: 1

Table 710 • **Fields in RX_TL**

Field Name	Bit	Access	Description	Default
RX_TL	2:0	R/W	Controls the level of entries (or above) that triggers the RX_FULL interrupt (bit 2 in RAW_INTR_STAT register). The valid range is 0-7. A value of 0 sets the threshold for 1 entry, and a value of 7 sets the threshold for 8 entries.	0x0

7.17.1.13 TWI:TWI:TX_TL

Parent: TWI:TWI

Instances: 1

Table 711 • **Fields in TX_TL**

Field Name	Bit	Access	Description	Default
TX_TL	2:0	R/W	Controls the level of entries (or below) that trigger the TX_EMPTY interrupt (bit 4 in RAW_INTR_STAT register). The valid range is 0-7. A value of 0 sets the threshold for 0 entries, and a value of 7 sets the threshold for 7 entries.	0x0

7.17.1.14 TWI:TWI:CLR_INTR

Parent: TWI:TWI

Instances: 1

Table 712 • **Fields in CLR_INTR**

Field Name	Bit	Access	Description	Default
CLR_INTR	0	R/O	Read this register to clear the combined interrupt, all individual interrupts, and the TX_ABRT_SOURCE register. This bit does not clear hardware clearable interrupts but software clearable interrupts. Refer to Bit 9 of the TX_ABRT_SOURCE register for an exception to clearing TX_ABRT_SOURCE.	0x0

7.17.1.15 TWI:TWI:CLR_RX_UNDER

Parent: TWI:TWI

Instances: 1

Table 713 • **Fields in CLR_RX_UNDER**

Field Name	Bit	Access	Description	Default
CLR_RX_UNDER	0	R/O	Read this register to clear the R_RX_UNDER interrupt (bit 0) of the RAW_INTR_STAT register.	0x0

7.17.1.16 TWI:TWI:CLR_RX_OVER

Parent: TWI:TWI

Instances: 1

Table 714 • **Fields in CLR_RX_OVER**

Field Name	Bit	Access	Description	Default
CLR_RX_OVER	0	R/O	Read this register to clear the R_RX_OVER interrupt (bit 1) of the RAW_INTR_STAT register.	0x0

7.17.1.17 TWI:TWI:CLR_TX_OVER

Parent: TWI:TWI

Instances: 1

Table 715 • **Fields in CLR_TX_OVER**

Field Name	Bit	Access	Description	Default
CLR_TX_OVER	0	R/O	Read this register to clear the R_TX_OVER interrupt (bit 3) of the RAW_INTR_STAT register.	0x0

7.17.1.18 TWI:TWI:CLR_RD_REQ

Parent: TWI:TWI

Instances: 1

Table 716 • **Fields in CLR_RD_REQ**

Field Name	Bit	Access	Description	Default
CLR_RD_REQ	0	R/O	Read this register to clear the R_RD_REQ interrupt (bit 5) of the RAW_INTR_STAT register.	0x0

7.17.1.19 TWI:TWI:CLR_TX_ABRT

Parent: TWI:TWI

Instances: 1

Table 717 • **Fields in CLR_TX_ABRT**

Field Name	Bit	Access	Description	Default
CLR_TX_ABRT	0	R/O	Read this register to clear the R_TX_ABRT interrupt (bit 6) of the RAW_INTR_STAT register, and the TX_ABRT_SOURCE register. Refer to Bit 9 of the TX_ABRT_SOURCE register for an exception to clearing TX_ABRT_SOURCE.	0x0

7.17.1.20 TWI:TWI:CLR_RX_DONE

Parent: TWI:TWI

Instances: 1

Table 718 • **Fields in CLR_RX_DONE**

Field Name	Bit	Access	Description	Default
CLR_RX_DONE	0	R/O	Read this register to clear the R_RX_DONE interrupt (bit 7) of the RAW_INTR_STAT register.	0x0

7.17.1.21 TWI:TWI:CLR_ACTIVITY

Parent: TWI:TWI

Instances: 1

Table 719 • **Fields in CLR_ACTIVITY**

Field Name	Bit	Access	Description	Default
CLR_ACTIVITY	0	R/O	Reading this register clears the ACTIVITY interrupt if the TWI controller is not active anymore. If the TWI controller is still active on the bus, the ACTIVITY interrupt bit continues to be set. It is automatically cleared by hardware if the module is disabled and if there is no further activity on the bus. The value read from this register to get status of the R_ACTIVITY interrupt (bit 8) of the RAW_INTR_STAT register.	0x0

7.17.1.22 TWI:TWI:CLR_STOP_DET

Parent: TWI:TWI

Instances: 1

Table 720 • **Fields in CLR_STOP_DET**

Field Name	Bit	Access	Description	Default
CLR_STOP_DET	0	R/O	Read this register to clear the R_STOP_DET interrupt (bit 9) of the RAW_INTR_STAT register.	0x0

7.17.1.23 TWI:TWI:CLR_START_DET

Parent: TWI:TWI

Instances: 1

Table 721 • **Fields in CLR_START_DET**

Field Name	Bit	Access	Description	Default
CLR_START_DET	0	R/O	Read this register to clear the R_START_DET interrupt (bit 10) of the RAW_INTR_STAT register.	0x0

7.17.1.24 TWI:TWI:CLR_GEN_CALL

Parent: TWI:TWI

Instances: 1

Table 722 • **Fields in CLR_GEN_CALL**

Field Name	Bit	Access	Description	Default
CLR_GEN_CALL	0	R/O	Read this register to clear the R_GEN_CALL interrupt (bit 11) of RAW_INTR_STAT register.	0x0

7.17.1.25 TWI:TWI:CTRL

Parent: TWI:TWI

Instances: 1

Table 723 • **Fields in CTRL**

Field Name	Bit	Access	Description	Default
ENABLE	0	R/W	Controls whether the TWI controller is enabled. Software can disable the controller while it is active. However, it is important that care be taken to ensure that the controller is disabled properly. When TWI controller is disabled, the following occurs: * The TX FIFO and RX FIFO get flushed. * The interrupt bits in the RAW_INTR_STAT register are cleared. * Status bits in the INTR_STAT register are still active until the TWI controller goes into IDLE state. If the module is transmitting, it stops as well as deletes the contents of the transmit buffer after the current transfer is complete. If the module is receiving, the controller stops the current transfer at the end of the current byte and does not acknowledge the transfer. '0': Disables TWI controller '1': Enables TWI controller	0x0

7.17.1.26 TWI:TWI:STAT

Parent: TWI:TWI

Instances: 1

Table 724 • **Fields in STAT**

Field Name	Bit	Access	Description	Default
SLV_ACTIVITY	6	R/O	Slave FSM Activity Status. When the Slave Finite State Machine (FSM) is not in the IDLE state, this bit is set. '0': Slave FSM is in IDLE state so the Slave part of the controller is not Active '1': Slave FSM is not in IDLE state so the Slave part of the controller is Active	0x0

Table 724 • **Fields in STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
MST_ACTIVITY	5	R/O	Master FSM Activity Status. When the Master Finite State Machine (FSM) is not in the IDLE state, this bit is set. '0': Master FSM is in IDLE state so the Master part of the controller is not Active '1': Master FSM is not in IDLE state so the Master part of the controller is Active	0x0
RFF	4	R/O	Receive FIFO Completely Full. When the receive FIFO is completely full, this bit is set. When the receive FIFO contains one or more empty location, this bit is cleared. '0': Receive FIFO is not full '1': Receive FIFO is full	0x0
RFNE	3	R/O	Receive FIFO Not Empty. Set when the receive FIFO contains one or more entries and is cleared when the receive FIFO is empty. This bit can be polled by software to completely empty the receive FIFO. '0': Receive FIFO is empty '1': Receive FIFO is not empty	0x0
TFE	2	R/O	Transmit FIFO Completely Empty. When the transmit FIFO is completely empty, this bit is set. When it contains one or more valid entries, this bit is cleared. This bit field does not request an interrupt. '0': Transmit FIFO is not empty '1': Transmit FIFO is empty	0x1
TFNF	1	R/O	Transmit FIFO Not Full. Set when the transmit FIFO contains one or more empty locations, and is cleared when the FIFO is full. '0': Transmit FIFO is full '1': Transmit FIFO is not full	0x1
BUS_ACTIVITY	0	R/O	TWI Activity Status.	0x0

7.17.1.27 TWI:TWI:TXFLR

Parent: TWI:TWI

Instances: 1

Table 725 • **Fields in TXFLR**

Field Name	Bit	Access	Description	Default
TXFLR	2:0	R/O	Transmit FIFO Level. Contains the number of valid data entries in the transmit FIFO.	0x0

7.17.1.28 TWI:TWI:RXFLR

Parent: TWI:TWI

Instances: 1

Table 726 • **Fields in RXFLR**

Field Name	Bit	Access	Description	Default
RXFLR	2:0	R/O	Receive FIFO Level. Contains the number of valid data entries in the receive FIFO.	0x0

7.17.1.29 TWI:TWI:TX_ABRT_SOURCE

Parent: TWI:TWI

Instances: 1

Table 727 • **Fields in TX_ABRT_SOURCE**

Field Name	Bit	Access	Description	Default
ABRT_SLVRD_INTX	15	R/W	When the processor side responds to a slave mode request for data to be transmitted to a remote master and user writes a 1 to DATA_CMD.CMD.	0x0
ABRT_SLV_ARBLOST	14	R/W	Slave lost the bus while transmitting data to a remote master. TX_ABRT_SOURCE[12] is set at the same time. Note: Even though the slave never "owns" the bus, something could go wrong on the bus. This is a fail safe check. For instance, during a data transmission at the low-to-high transition of SCL, if what is on the data bus is not what is supposed to be transmitted, then the TWI controller no longer own the bus.	0x0
ABRT_SLVFLUSH_TXFIFO	13	R/W	Slave has received a read command and some data exists in the TX FIFO so the slave issues a TX_ABRT interrupt to flush old data in TX FIFO.	0x0

Table 727 • **Fields in TX_ABRT_SOURCE** ***(continued)***

Field Name	Bit	Access	Description	Default
ARB_LOST	12	R/W	Master has lost arbitration, or if TX_ABRT_SOURCE[14] is also set, then the slave transmitter has lost arbitration. Note: the TWI controller can be both master and slave at the same time.	0x0
ABRT_MASTER_DIS	11	R/W	User tries to initiate a Master operation with the Master mode disabled.	0x0
ABRT_10B_RD_NORSTRT	10	R/W	The restart is disabled (RESTART_ENA bit (CFG[5]) = 0) and the master sends a read command in 10-bit addressing mode.	0x0
ABRT_SBYTE_NORSTRT	9	R/W	To clear Bit 9, the source of the ABRT_SBYTE_NORSTRT must be fixed first; restart must be enabled (CFG[5]=1), the SPECIAL bit must be cleared (TAR[11]), or the GC_OR_START bit must be cleared (TAR[10]). Once the source of the ABRT_SBYTE_NORSTRT is fixed, then this bit can be cleared in the same manner as other bits in this register. If the source of the ABRT_SBYTE_NORSTRT is not fixed before attempting to clear this bit, bit 9 clears for one cycle and then gets re-asserted. '1': The restart is disabled (RESTART_ENA bit (CFG[5]) = 0) and the user is trying to send a START Byte.	0x0
ABRT_SBYTE_ACKDET	7	R/W	Master has sent a START Byte and the START Byte was acknowledged (wrong behavior).	0x0
ABRT_GCALL_READ	5	R/W	TWI controller in master mode sent a General Call but the user programmed the byte following the General Call to be a read from the bus (DATA_CMD[9] is set to 1).	0x0
ABRT_GCALL_NOACK	4	R/W	TWI controller in master mode sent a General Call and no slave on the bus acknowledged the General Call.	0x0

Table 727 • **Fields in TX_ABRT_SOURCE *(continued)***

Field Name	Bit	Access	Description	Default
ABRT_TXDATA_NOACK	3	R/W	This is a master-mode only bit. Master has received an acknowledgement for the address, but when it sent data byte(s) following the address, it did not receive an acknowledge from the remote slave(s).	0x0
ABRT_10ADDR2_NOACK	2	R/W	Master is in 10-bit address mode and the second address byte of the 10-bit address was not acknowledged by any slave.	0x0
ABRT_10ADDR1_NOACK	1	R/W	Master is in 10-bit address mode and the first 10-bit address byte was not acknowledged by any slave.	0x0
ABRT_7B_ADDR_NOACK	0	R/W	Master is in 7-bit addressing mode and the address sent was not acknowledged by any slave.	0x0

7.17.1.30 TWI:TWI:SDA_SETUP

Parent: TWI:TWI

Instances: 1

This field must be set accordingly to the VCore system frequency; value = 100ns / VCore clock period.

Example: a 178.6MHz clock correspond to a period of 5.6ns, for this frequency and fast TWI speed this field must not be set lower than (round up): 18 = 100ns / 5.6ns. For normal TWI speed this field must not be set lower than (round up): 45 = 250ns / 5.6ns.

Table 728 • **Fields in SDA_SETUP**

Field Name	Bit	Access	Description	Default
SDA_SETUP	7:0	R/W	This register controls the amount of time delay (in terms of number of VCore clock periods) introduced in the rising edge of SCL, relative to SDA changing, when the TWI controller services a read request in a slave-receiver operation. The minimum for fast mode is 100ns, for normal mode the minimum is 250ns.	0x15

7.17.1.31 TWI:TWI:ACK_GEN_CALL

Parent: TWI:TWI

Instances: 1

Table 729 • **Fields in ACK_GEN_CALL**

Field Name	Bit	Access	Description	Default
ACK_GEN_CALL	0	R/W	ACK General Call. When set to 1, the TWI controller responds with a ACK when it receives a General Call. Otherwise, the controller responds with a NACK.	0x1

7.17.1.32 TWI:TWI:ENABLE_STATUS

Parent: TWI:TWI

Instances: 1

Table 730 • **Fields in ENABLE_STATUS**

Field Name	Bit	Access	Description	Default
SLV_FIFO_FILLED_AND_FLUSHED	2	R/O	Slave FIFO Filled and Flushed. This bit indicates if a Slave-Receiver operation has been aborted with at least 1 data byte received from a TWI transfer due to the setting of ENABLE from 1 to 0. When read as 1, the TWI controller is deemed to have been actively engaged in an aborted TWI transfer (with matching address) and the data phase of the TWI transfer has been entered, even though the data byte has been responded with a NACK. When read as 0, the TWI controller is deemed to have been disabled when the TWI bus is idle.	0x0
SLV_RX_ABORTED	1	R/O	Slave-Receiver Operation Aborted. This bit indicates if a Slave-Receiver operation has been aborted due to the setting of the ENABLE register from 1 to 0. When read as 1, the TWI controller is deemed to have forced a NACK during any part of a TWI transfer, irrespective of whether the TWI address matches the slave address set in the TWI controller (SAR register). When read as 0, the TWI controller is deemed to have been disabled when the TWI bus is idle.	0x0

Table 730 • **Fields in ENABLE_STATUS *(continued)***

Field Name	Bit	Access	Description	Default
BUSY	0	R/O	When read as 1, the TWI controller is deemed to be actively involved in an TWI transfer, irrespective of whether being in an address or data phase for all master or slave modes. When read as 0, the TWI controller is deemed completely inactive.	0x0

7.18 SBA

Table 731 • **Register Groups in SBA**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
SBA	0x00000000	1	Shared Bus arbiter registers	Page 560

7.18.1 SBA:SBA

Parent: SBA

Instances: 1

Configurations for the Shared Bus of the CPU system.

Table 732 • **Registers in SBA**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PL1	0x00000000	1	Arbitration Priority CPU	Page 561
PL2	0x00000004	1	Arbitration Priority Frame DMA	Page 561
PL3	0x00000008	1	Arbitration Priority External CPU	Page 561
WT_EN	0x0000004C	1	Weighted-Token Arbitration Scheme Enable	Page 561
WT_TCL	0x00000050	1	Clock Tokens Refresh Period	Page 562
WT_CL1	0x00000054	1	Clock Tokens CPU	Page 562
WT_CL2	0x00000058	1	Clock Tokens Frame DMA	Page 562
WT_CL3	0x0000005C	1	Clock Tokens External CPU	Page 563

7.18.1.1 SBA:SBA:PL1

Parent: SBA:SBA

Instances: 1

Table 733 • **Fields in PL1**

Field Name	Bit	Access	Description	Default
PL1	3:0	R/W	Arbitration priority for CPU. Values 0x1 through 0xF, higher value is prioritized over lower value.	0xE

7.18.1.2 SBA:SBA:PL2

Parent: SBA:SBA

Instances: 1

Table 734 • **Fields in PL2**

Field Name	Bit	Access	Description	Default
PL2	3:0	R/W	Arbitration priority for Frame DMA. Values 0x1 through 0xF, higher value is prioritized over lower value.	0xD

7.18.1.3 SBA:SBA:PL3

Parent: SBA:SBA

Instances: 1

Table 735 • **Fields in PL3**

Field Name	Bit	Access	Description	Default
PL3	3:0	R/W	Arbitration priority for External CPU. Values 0x1 through 0xF, higher value is prioritized over lower value.	0xC

7.18.1.4 SBA:SBA:WT_EN

Parent: SBA:SBA

Instances: 1

When weighted token arbitration is enabled, each master on the shared bus is granted a configurable number of tokens at the start of each refresh period. The length of each refresh period is configurable. In each clock-cycle that a master uses the bus, the token counter for that master decreases. Once all tokens are spent, the master is forced to a low priority. A master with tokens remaining, always takes priority over masters with no tokens remaining.

Table 736 • **Fields in WT_EN**

Field Name	Bit	Access	Description	Default
WT_EN	0	R/W	Set this field to enable weighted-token arbitration scheme.	0x0

7.18.1.5 SBA:SBA:WT_TCL

Parent: SBA:SBA

Instances: 1

Table 737 • **Fields in WT_TCL**

Field Name	Bit	Access	Description	Default
WT_TCL	15:0	R/W	Refresh period length for the weighted-token arbitration scheme.	0xFFFF

7.18.1.6 SBA:SBA:WT_CL1

Parent: SBA:SBA

Instances: 1

Table 738 • **Fields in WT_CL1**

Field Name	Bit	Access	Description	Default
WT_CL1	15:0	R/W	Number of tokens the CPU is granted at the start of each refresh period for weighted-token arbitration scheme. If configured with a value of zero, the master is considered to have infinite tokens.	0x0FFF

7.18.1.7 SBA:SBA:WT_CL2

Parent: SBA:SBA

Instances: 1

Table 739 • **Fields in WT_CL2**

Field Name	Bit	Access	Description	Default
WT_CL2	15:0	R/W	Number of tokens the Frame DMA is granted at the start of each refresh period for weighted-token arbitration scheme. If configured with a value of zero, the master is considered to have infinite tokens.	0x0FFF

7.18.1.8 SBA:SBA:WT_CL3

Parent: SBA:SBA

Instances: 1

Table 740 • **Fields in WT_CL3**

Field Name	Bit	Access	Description	Default
WT_CL3	15:0	R/W	Number of tokens the External CPU is granted at the start of each refresh period for weighted-token arbitration scheme. If configured with a value of zero, the master is considered to have infinite tokens.	0x0FFF

7.19 GPDMA

Table 741 • **Register Groups in GPDMA**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
CH	0x00000000	8 0x00000058	DMA Channel Controller Configuration	Page 563
INTR	0x000002C0	1	DMA Interrupt Configuration	Page 575
MISC	0x00000398	1	Miscellaneous FDMA Registers	Page 582

7.19.1 GPDMA:CH

Parent: GPDMA

Instances: 8

Table 742 • **Registers in CH**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SAR	0x00000000	1	Source Address	Page 564
DAR	0x00000008	1	Destination Address	Page 564
LLP	0x00000010	1	Linked List Pointer	Page 565
CTL0	0x00000018	1	DMA Transfer Control	Page 565
CTL1	0x0000001C	1	DMA Transfer Control	Page 568
SSTAT	0x00000020	1	Source Status	Page 569
DSTAT	0x00000028	1	Destination Status	Page 570

Table 742 • **Registers in CH *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
SSTATAR	0x00000030	1	Source Status Address Location	Page 570
DSTATAR	0x00000038	1	Destination Status Address Location	Page 570
CFG0	0x00000040	1	DMA Transfer Configuration (CFG0)	Page 571
CFG1	0x00000044	1	DMA Transfer Configuration (CFG1)	Page 573

7.19.1.1 GPDMA:CH:SAR

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 743 • **Fields in SAR**

Field Name	Bit	Access	Description	Default
SAR	31:0	R/W	GP (block chaining disabled): Holds the source address aligned to the source transfer width CTL0::SRC_TR_WIDTH of the data to be moved. If the address is not aligned with the source transfer width, H/W auto-aligns. The Current Source Address of DMA transfer is incremented, decremented, or left unchanged on every source transfer throughout the block transfer based on CTL0::SINC.	0x00000000

7.19.1.2 GPDMA:CH:DAR

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 744 • **Fields in DAR**

Field Name	Bit	Access	Description	Default
DAR	31:0	R/W	GP (block chaining disabled): Holds the Destination address aligned to the destination transfer width CTL0::DST_TR_WIDTH of the data to be moved. If the address is not aligned with the destination transfer width, H/W auto-aligns. The Current Destination Address of DMA transfer is incremented, decremented, or left unchanged on every source transfer throughout the block transfer based on CTL0::DINC.	0x00000000

7.19.1.3 GPDMA:CH:LLP

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 745 • **Fields in LLP**

Field Name	Bit	Access	Description	Default
LOC	30:2	R/W	Write the 32-bit aligned address of the first DCB in the chain of DCBs. The DMA channel updates this field as it traverses the list of DCBs. The two least significant bits are zeroed out before being used. 0 : Disable block chaining (initial read of DCB addressed by LLP before a block transfer) >0: Enable block chaining (initial read of DCB addressed by LLP before a block transfer)	0x00000000

7.19.1.4 GPDMA:CH:CTL0

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 746 • **Fields in CTL0**

Field Name	Bit	Access	Description	Default
LLP_SRC_EN	28	R/W	Enable reload of SAR from next DCB in chain. When this field is set and the LLP is non-zero, the SAR will be reloaded from the next DCB upon completion of the current DCB. 0: Disable update 1: Enable	0x0
LLP_DST_EN	27	R/W	Enable reload of DAR from next DCB in chain. When this field is set and the LLP is non-zero, the DAR will be reloaded from the next DCB upon completion of the current DCB. 0: Disable 1: Enable	0x0
SMS	26:25	R/W	Source Master Select. INJ / GP: Must be set to 0 XTR: Must be set to 1 0 = AHB master 1 1 = AHB master 2 Other: reserved	0x0
DMS	24:23	R/W	Destination Master Select. XTR / GP: Must be set to 0 INJ: Must be set to 1 0 = AHB master 1 1 = AHB master 2 Other: Reserved	0x0
TT_FC	22:20	R/W	Transfer Type and Flow Control. GP: Must be set to 0 INJ: Must be set to 0 or 1 XTR: Must be set to 4 0 : Memory to Memory 1 : Memory to Peripheral 4 : Peripheral to Memory Other: Reserved	0x3

Table 746 • **Fields in CTL0** ***(continued)***

Field Name	Bit	Access	Description	Default
SRC_MSIZE	16:14	R/W	Source Burst Transaction Length. INJ / GP: Number of data items, each with a width of CTL.SRC_TR_WIDTH, to be read from the source every time a source burst transaction request is made from either the corresponding hardware or software handshaking interface. XTR : Must be <3 0 : 1 word 1 : 4 words 2 : 8 words 3: 16 words 4: 32 words 5: 64 words 6: 128 words 7: 256 words	0x1
DEST_MSIZE	13:11	R/W	Destination Burst Transaction Length. INJ / GP: Number of data items, each with a width of CTL.DST_TR_WIDTH, to be written to the destination every time a destination burst transaction request is made from either the corresponding hardware or software handshaking interface. XTR : Must be <3 0 : 1 word 1 : 4 words 2 : 8 words 3: 16 words 4: 32 words 5: 64 words 6: 128 words 7: 256 words	0x1
SINC	10:9	R/W	Source Address Increment. INJ / GP: Indicates whether to increment or decrement the source address on every source transfer. If the device is fetching data from a source peripheral FIFO with a fixed address, then set this field to no change. XTR: Must be set to no change. 00 : Increment 01 : Decrement 1x : No change	0x0

Table 746 • **Fields in CTL0** ***(continued)***

Field Name	Bit	Access	Description	Default
DINC	8:7	R/W	Destination Address Increment. XTR / GP: Indicates whether to increment or decrement the destination address on every destination transfer. If your device is writing data to a destination peripheral FIFO with a fixed address, then set this field to no change. INJ: Must be set to no change. 00 : Increment 01 : Decrement 1x : No change	0x0
SRC_TR_WIDTH	6:4	R/W	Source Transfer Width. GP: Specifies source address alignment (for example, 32-bit transfer can only be 32-bit aligned). INJ / XTR: Must be set to 2. 0 : 8-bit 1 : 16-bit 2 : 32-bit Other : Undefined	0x0
DST_TR_WIDTH	3:1	R/W	Destination Transfer Width. GP: Specifies destination address alignment (for example, 32-bit transfer can only be 32-bit aligned). INJ / XTR: Must be set to 2. 0 : 8-bit 1 : 16-bit 2 : 32-bit Other : Undefined	0x0
INT_EN	0	R/W	Interrupt Enable Bit. If set, then all interrupt-generating sources are enabled. 0: Disable 1: Enable	0x1

7.19.1.5 GPDMA:CH:CTL1

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

If status write-back is enabled, the register is used to update the control register location of the DCB in system memory at the end of the block transfer.

Table 747 • **Fields in CTL1**

Field Name	Bit	Access	Description	Default
DONE	12	R/W	Done bit. Software can poll the DCB CTL.DONE bit to see when a block transfer is complete. The DCB CTL.DONE bit should be cleared when the linked lists are set up in memory prior to enabling the channel. 0: Block transfer is not done 0: Block transfer is done	0x0
BLOCK_TS	11:0	R/W	Block Transfer Size. INJ / GP : The number programmed into BLOCK_TS indicates the total number of single transactions to perform for every block transfer. XTR: Updated with the number of 32-bits words returned. Once the transfer starts, the read-back value is the total number of data items already read from the source peripheral.	0x002

7.19.1.6 GPDMA:CH:SSTAT

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 748 • **Fields in SSTAT**

Field Name	Bit	Access	Description	Default
SSTAT	31:0	R/W	GP: After each block transfer completes, the source status information can be retrieved from the address to which the contents of the SSTATAR register point. This retrieval is enabled in CFG0.SS_UPD_EN. Once retrieved, the status information is stored in the SSTAT register and written out to the DCB SSTAT register before the start of the next block. INJ/XTR : Must not be used.	0x00000000

7.19.1.7 GPDMA:CH:DSTAT

Parent: GPDMA:CH

Instances: 1

This register is part of the DCB (and is updated on a DCB-by-DCB basis) when block chaining is enabled.

Table 749 • **Fields in DSTAT**

Field Name	Bit	Access	Description	Default
DSTAT	31:0	R/W	After each block transfer completes, the destination status information can be retrieved from the address to which the contents of the DSTATAR register point. This retrieval is enabled in CFG0.DS_UPD_EN. Once retrieved, the status information is stored in the DSTAT register and written out to the DCB DSTAT register before the start of the next block. INJ : Must not be used.	0x00000000

7.19.1.8 GPDMA:CH:SSTATAR

Parent: GPDMA:CH

Instances: 1

Table 750 • **Fields in SSTATAR**

Field Name	Bit	Access	Description	Default
SSTATAR	31:0	R/W	Specifies the address (if enabled by CFG0.SS_UPD_EN) from where to fetch the source status information, which is registered in the SSTAT register and written out to the DCB SSTAT before the start of the next block.	0x00000000

7.19.1.9 GPDMA:CH:DSTATAR

Parent: GPDMA:CH

Instances: 1

Table 751 • **Fields in DSTATAR**

Field Name	Bit	Access	Description	Default
DSTATAR	31:0	R/W	Specifies the address (if enabled by CFG0.DS_UPD_EN) from where to fetch the destination status information, which is registered in the DSTAT register and written out to the DCB DSTAT before the start of the next block.	0x00000000

7.19.1.10 GPDMA:CH:CFG0

Parent: GPDMA:CH

Instances: 1

This register contains fields that configure the DMA transfer and remains fixed for all blocks of a multi-block transfer.

Table 752 • **Fields in CFG0**

Field Name	Bit	Access	Description	Default
RELOAD_DST	31	R/W	GP: Automatic destination reload. The DAR register can be automatically reloaded from its initial value at the end of every block for multi-block transfers. A new block transfer is then initiated. INJ / XTR : Must be zero. 0 : Disable 1: Enable	0x0
RELOAD_SRC	30	R/W	GP: Automatic source reload. The SAR register can be automatically reloaded from its initial value at the end of every block for multi-block transfers. A new block transfer is then initiated. INJ / XTR : Must be zero.	0x0
LOCK_B	17	R/W	Bus lock bit. When active, the AHB bus master signal block is asserted for the duration specified in CFG.LOCK_B_L.	0x0

Table 752 • **Fields in CFG0** ***(continued)***

Field Name	Bit	Access	Description	Default
LOCK_CH	16	R/W	Channel lock bit. When the channel is granted control of the master bus interface and if the CFG0.LOCK_CH bit is asserted, then no other channels are granted control of the master bus interface for the duration specified in CFG0.LOCK_CH_L. Indicates to the master bus interface arbiter that this channel wants exclusive access to the master bus interface for the duration specified in CFG0.LOCK_CH_L.	0x0
LOCK_B_L	15:14	R/W	Bus lock level. Indicates the duration over which CFG0.LOCK_B bit applies. 0 : Over complete DMA transfer 1 : Over complete DMA block transfer Other: Over complete DMA transaction	0x0
LOCK_CH_L	13:12	R/W	Channel lock level. Indicates the duration over which CFG0.LOCK_CH bit applies. 0 : Over complete DMA transfer 1 : Over complete DMA block transfer Other : Over complete DMA transaction	0x0
HS_SEL_SRC	11	R/W	Source software or hardware handshaking select. INJ / GP : Must be 1 XTR: Must be 0 0 = Hardware handshaking interface. Software-initiated transaction requests are ignored. 1 = Software handshaking interface. Hardware-initiated transaction requests are ignored. If the source peripheral is memory, then this bit is ignored.	0x1

Table 752 • **Fields in CFG0** ***(continued)***

Field Name	Bit	Access	Description	Default
HS_SEL_DST	10	R/W	Destination software or hardware handshaking select. This register selects which of the handshaking interfaces (hardware or software) is active for destination requests on this channel. XTR / GP : Must be 1 0 = Hardware handshaking interface. Software-initiated transaction requests are ignored. 1 = Software handshaking interface. Hardware-initiated transaction requests are ignored. If the destination peripheral is memory, then this bit is ignored.	0x1
FIFO_EMPTY	9	R/O	Indicates if there is data left in the channel FIFO. Can be used in conjunction with CFG0.CH_SUSP to cleanly disable a channel. 1 = Channel FIFO empty 0 = Channel FIFO not empty	0x0
CH_SUSP	8	R/W	Channel suspend. Suspends all DMA data transfers from the source until this bit is cleared. There is no guarantee that the current transaction will complete. Can also be used in conjunction with CFG0.FIFO_EMPTY to cleanly disable a channel without losing any data. 0 = Not suspended 1 = Suspend DMA transfer from the source	0x0
CH_PRIOR	7:5	R/W	Channel priority. 0 : Lowest priority ... 7 : Highest priority	0x0

7.19.1.11 GPDMA:CH:CFG1

Parent: GPDMA:CH

Instances: 1

This register contains fields that configure the DMA transfer and remains fixed for all blocks of a multi-block transfer.

Table 753 • **Fields in CFG1**

Field Name	Bit	Access	Description	Default
DST_PER	14:11	R/W	INJ: Destination peripheral handshaking interface. Valid if CFG0.HS_SEL_DST field is 0. Otherwise, this field is ignored. XTR/GP: Not used Must be mapped according the channel number, that is, channel number 0 must be assigned interface 0, and so on.	0x0
SRC_PER	10:7	R/W	XTR: Source peripheral handshaking interface. Valid if CFG0.HS_SEL_SRC field is 0. Otherwise, this field is ignored. INJ/GP: Not used Must be mapped according the channel number, that is, channel number 0 must be assigned interface 0, and so on.	0x0
SS_UPD_EN	6	R/W	Source status update enable. GP: Source status information is fetched only from the location pointed to by the SSTATAR register, stored in the SSTAT register, and written out to the DCB SSTAT if SS_UPD_EN is high. INJ / XTR : Must be zero 0: Disable 1: Enable	0x0
DS_UPD_EN	5	R/W	Destination status update enable. GP: Destination status information is fetched from the location pointed to by the DSTATAR register, stored in the DSTAT register, and written out to the DCB DSTAT only if DS_UPD_EN is high. INJ : Must be zero XTR : Must be one 0: Disable 1: Enable	0x0
RESERVED	4:2	R/W	Must be set to its default.	0x1

Table 753 • **Fields in CFG1** ***(continued)***

Field Name	Bit	Access	Description	Default
FIFOMODE	1	R/W	FIFO mode select. Determines how much space or data needs to be available in the FIFO before a burst transaction request is serviced. 0 = Space/data available for single AHB transfer of the specified transfer width. 1 = Space/data available is greater than or equal to half the FIFO depth for destination transfers and less than half the FIFO depth for source transfers. The exceptions are at the end of a burst transaction request or at the end of a block transfer.	0x0
FCMODE	0	R/W	Flow control mode. GP : Determines when source transaction requests are serviced when the Destination Peripheral is the flow controller. INJ / XTR : Must be one 0 = Source transaction requests are serviced when they occur. Data pre-fetching is enabled. 1 = Source transaction requests are not serviced until a destination transaction request occurs. In this mode, the amount of data transferred from the source is limited so that it is guaranteed to be transferred to the destination prior to block termination by the destination. Data pre-fetching is disabled.	0x0

7.19.2 GPDMA:INTR

Parent: GPDMA

Instances: 1

Table 754 • **Registers in INTR**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RAW_TFR	0x00000000	1	Raw Status for IntTfr Interrupt	Page 576
RAW_BLOCK	0x00000008	1	Raw Status for IntBlock Interrupt	Page 576

Table 754 • **Registers in INTR *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
RAW_ERR	0x00000020	1	Raw Status for IntErr Interrupt	Page 577
STATUS_TFR	0x00000028	1	Status for IntTfr Interrupt	Page 577
STATUS_BLOCK	0x00000030	1	Status for IntBlock Interrupt	Page 578
STATUS_ERR	0x00000048	1	Status for IntErr Interrupt	Page 578
MASK_TFR	0x00000050	1	Mask for IntTfr Interrupt	Page 578
MASK_BLOCK	0x00000058	1	Mask for IntBlock Interrupt	Page 579
MASK_ERR	0x00000070	1	Mask for IntErr Interrupt	Page 580
CLEAR_TFR	0x00000078	1	Clear for IntTfr Interrupt	Page 580
CLEAR_BLOCK	0x00000080	1	Clear for IntBlock Interrupt	Page 581
CLEAR_ERR	0x00000098	1	Clear for IntErr Interrupt	Page 581
STATUSINT	0x000000A0	1	Status for each interrupt type	Page 582

7.19.2.1 GPDMA:INTR:RAW_TFR

Parent: GPDMA:INTR

Instances: 1

This interrupt is generated when the FDMA reaches the end of a DCB chain (done processing a DCB with LLP field = NULL) or when completing a general purpose operation that does not use DCBs.

Table 755 • **Fields in RAW_TFR**

Field Name	Bit	Access	Description	Default
RAW_TFR	7:0	R/O	Raw interrupt status. Interrupt events are stored in this field before masking. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt condition has occurred.	0x00

7.19.2.2 GPDMA:INTR:RAW_BLOCK

Parent: GPDMA:INTR

Instances: 1

BLOCK: This interrupt is generated when the FDMA has processed one DCB or when completing a general purpose operation that does not use DCBs.

Table 756 • **Fields in RAW_BLOCK**

Field Name	Bit	Access	Description	Default
RAW_BLOCK	7:0	R/O	Raw interrupt status. Interrupt events are stored in this field before masking. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt condition has occurred.	0x00

7.19.2.3 GPDMA:INTR:RAW_ERR

Parent: GPDMA:INTR

Instances: 1

ERR: This interrupt is set if the FDMA receives an error-response on the AHB interface (i.e. accessing un-mapped memory space). This condition will not occur unless the FDMA has been misconfigured.

Table 757 • **Fields in RAW_ERR**

Field Name	Bit	Access	Description	Default
RAW_ERR	7:0	R/O	Raw interrupt status. Interrupt events are stored in this field before masking. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt condition has occurred.	0x00

7.19.2.4 GPDMA:INTR:STATUS_TFR

Parent: GPDMA:INTR

Instances: 1

Table 758 • **Fields in STATUS_TFR**

Field Name	Bit	Access	Description	Default
STATUS_TFR	7:0	R/O	Interrupt status. Interrupt events are stored in this field after masking. If an interrupt is no masked, it will propagate to this field. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt is active.	0x00

7.19.2.5 GPDMA:INTR:STATUS_BLOCK

Parent: GPDMA:INTR

Instances: 1

Table 759 • **Fields in STATUS_BLOCK**

Field Name	Bit	Access	Description	Default
STATUS_BLOCK	7:0	R/O	Interrupt status. Interrupt events are stored in this field after masking. If an interrupt is no masked, it will propagate to this field. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt is active.	0x00

7.19.2.6 GPDMA:INTR:STATUS_ERR

Parent: GPDMA:INTR

Instances: 1

Table 760 • **Fields in STATUS_ERR**

Field Name	Bit	Access	Description	Default
STATUS_ERR	7:0	R/O	Interrupt status. Interrupt events are stored in this field after masking. If an interrupt is no masked, it will propagate to this field. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No interrupt has occurred. 1 : Interrupt is active.	0x00

7.19.2.7 GPDMA:INTR:MASK_TFR

Parent: GPDMA:INTR

Instances: 1

Table 761 • **Fields in MASK_TFR**

Field Name	Bit	Access	Description	Default
INT_MASK_WE_TFR	15:8	One-shot	Interrupt mask write enable. In order to write the INT_MASK_TFR field, the corresponding bit in this field must also be set, i.e. to write bit 3 in INT_MASK_TFR bit 3 in this field must also be set at the same time (during the same register write operation). 0 : Writing is disabled. 1 : Writing is enabled.	0x00
INT_MASK_TFR	7:0	R/W	Interrupt mask. Setting a bit in this field enables the corresponding interrupt to propagate from RAW_TFT to STATUS_TFR and thus activate interrupt. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. In order to write this field the corresponding bit must be set in INT_MASK_WE_TFR. 0 : Interrupt is disabled. 1 : Interrupt is enabled.	0x00

7.19.2.8 GPDMA:INTR:MASK_BLOCK

Parent: GPDMA:INTR

Instances: 1

Table 762 • **Fields in MASK_BLOCK**

Field Name	Bit	Access	Description	Default
INT_MASK_WE_BLOCK	15:8	One-shot	Interrupt mask write enable. In order to write the INT_MASK_BLOCK field, the corresponding bit in this field must also be set, i.e. to write bit 3 in INT_MASK_BLOCK bit 3 in this field must also be set at the same time (during the same register write operation). 0 : Writing is disabled. 1 : Writing is enabled.	0x00

Table 762 • **Fields in MASK_BLOCK *(continued)***

Field Name	Bit	Access	Description	Default
INT_MASK_BLOCK	7:0	R/W	Interrupt mask. Setting a bit in this field enables the corresponding interrupt to propagate from RAW_BLOCK to STATUS_BLOCK and thus activate interrupt. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. In order to write this field the corresponding bit must be set in INT_MASK_WE_BLOCK. 0 : Interrupt is disabled. 1 : Interrupt is enabled.	0x00

7.19.2.9 GPDMA:INTR:MASK_ERR

Parent: GPDMA:INTR

Instances: 1

Table 763 • **Fields in MASK_ERR**

Field Name	Bit	Access	Description	Default
INT_MASK_WE_ERR	15:8	One-shot	Interrupt mask write enable. In order to write the INT_MASK_ERR field, the corresponding bit in this field must also be set, i.e. to write bit 3 in INT_MASK_ERR bit 3 in this field must also be set at the same time (during the same register write operation). 0 : Writing is disabled. 1 : Writing is enabled.	0x00
INT_MASK_ERR	7:0	R/W	Interrupt mask. Setting a bit in this field enables the corresponding interrupt to propagate from RAW_ERR to STATUS_ERR and thus activate interrupt. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. In order to write this field the corresponding bit must be set in INT_MASK_WE_ERR. 0 : Interrupt is disabled. 1 : Interrupt is enabled.	0x00

7.19.2.10 GPDMA:INTR:CLEAR_TFR

Parent: GPDMA:INTR

Instances: 1

Table 764 • **Fields in CLEAR_TFR**

Field Name	Bit	Access	Description	Default
CLEAR_TFR	7:0	One-shot	Interrupt clear. Setting this field clears interrupt indications from the RAW_TFR and STATUS_TFR registers. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No effect. 1 : Clear interrupt indication.	0x00

7.19.2.11 GPDMA:INTR:CLEAR_BLOCK

Parent: GPDMA:INTR

Instances: 1

Table 765 • **Fields in CLEAR_BLOCK**

Field Name	Bit	Access	Description	Default
CLEAR_BLOCK	7:0	One-shot	Interrupt clear. Setting this field clears interrupt indications from the RAW_BLOCK and STATUS_BLOCK registers. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No effect. 1 : Clear interrupt indication.	0x00

7.19.2.12 GPDMA:INTR:CLEAR_ERR

Parent: GPDMA:INTR

Instances: 1

Table 766 • **Fields in CLEAR_ERR**

Field Name	Bit	Access	Description	Default
CLEAR_ERR	7:0	One-shot	Interrupt clear. Setting this field clears interrupt indications from the RAW_ERR and STATUS_ERR registers. Each bit in this field corresponds to a channel in the FDMA, i.e. bit 0 correspond to channel 0, and so on. 0 : No effect. 1 : Clear interrupt indication.	0x00

7.19.2.13 GPDMA:INTR:STATUSINT

Parent: GPDMA:INTR

Instances: 1

Table 767 • **Fields in STATUSINT**

Field Name	Bit	Access	Description	Default
ERR	4	R/O	This field is set if any of the STATUS_ERR.STATUS_ERR interrupts are active. 0 : No ERR interrupts are active. 1 : At least one ERR interrupt is active.	0x0
BLOCK	1	R/O	This field is set if any of the STATUS_BLOCK.STATUS_BLOCK interrupts are active. 0 : No BLOCK interrupts are active. 1 : At least one BLOCK interrupt is active.	0x0
TFR	0	R/O	This field is set if any of the STATUS_TFR.STATUS_TFR interrupts are active. 0 : No TFR interrupts are active. 1 : At least one TFR interrupt is active.	0x0

7.19.3 GPDMA:MISC

Parent: GPDMA

Instances: 1

Table 768 • **Registers in MISC**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
DMA_CFG_REG	0x00000000	1	DMA Enable	Page 582
CH_EN_REG	0x00000008	1	DMA Channel Enable	Page 583
DMA_COMP_VERSION	0x00000064	1	DMA Version	Page 583

7.19.3.1 GPDMA:MISC:DMA_CFG_REG

Parent: GPDMA:MISC

Instances: 1

Table 769 • **Fields in DMA_CFG_REG**

Field Name	Bit	Access	Description	Default
DMA_EN	0	R/W	DMA enable bit 0: Disable 1: Enable	0x0

7.19.3.2 GPDMA:MISC:CH_EN_REG

Parent: GPDMA:MISC

Instances: 1

Table 770 • **Fields in CH_EN_REG**

Field Name	Bit	Access	Description	Default
CH_EN_WE	15:8	One-shot	Channel enable write enable	0x00
CH_EN	7:0	R/W	Enables or disables the channel. Setting this bit enables a channel; clearing this bit disables the channel. The bit is automatically cleared by hardware to disable the channel after the last DMA transfer to the destination has completed. Software can therefore poll this bit to determine when this channel is free for a new DMA transfer. 0: Disable the channel 1: Enable the channel	0x00

7.19.3.3 GPDMA:MISC:DMA_COMP_VERSION

Parent: GPDMA:MISC

Instances: 1

Table 771 • **Fields in DMA_COMP_VERSION**

Field Name	Bit	Access	Description	Default
DMA_COMP_VERSION	31:0	R/O	Version of the component.	0x3231342A

7.20 PHY

Note that the PHYs in the VSC7428-12 device only support 10/100 operation. Support for 1000BASE-T is only for VSC7428-02 and VSC7429-02 devices.

Table 772 • **Register Groups in PHY**

Register Group Name	Offset within Target	Instances and Address Spacing	Description	Details
PHY_STD	0x00000000	1	IEEE Standard and Main Registers	Page 584
PHY_EXT1	0x00000000	1	Extended Page 1 Registers	Page 610
PHY_EXT2	0x00000000	1	Extended Page 2 Registers	Page 616
PHY_GP	0x00000000	1	General Purpose Registers	Page 618
PHY_EEE	0x00000000	1	Clause 45 Registers to Support Energy Efficient	Page 623

7.20.1 PHY:PHY_STD

Parent: PHY

Instances: 1

The following section lists the standard register set for the PHY.

Table 773 • **Registers in PHY_STD**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_CTRL	0x00000000	1	Control (Address 0)	Page 585
PHY_STAT	0x00000001	1	Status (Address 1)	Page 587
PHY_IDF1	0x00000002	1	PHY Identifier Number 1 (Address 2)	Page 587
PHY_IDF2	0x00000003	1	PHY Identifier Number 2 (Address 3)	Page 588
PHY_AUTONEG_ADVERTISMENT	0x00000004	1	Auto-Negotiation Advertisement (Address 4)	Page 588
PHY_AUTONEG_LP_ABILITY	0x00000005	1	Auto-Negotiation Link Partner Base Page Ability (Address 5)	Page 589
PHY_AUTONEG_EXP	0x00000006	1	Auto-Negotiation Expansion (Address 6)	Page 589
PHY_AUTONEG_NEXTPAGE_TX	0x00000007	1	Auto-Negotiation Next-Page Transmit (Address 7)	Page 590
PHY_AUTONEG_LP_NEXTPAGE_RX	0x00000008	1	Auto-Negotiation Next-Page Receive (Address 8)	Page 590

Table 773 • **Registers in PHY_STD *(continued)***

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_CTRL_1000BT	0x00000009	1	1000BASE-T Control (Address 9)	Page 591
PHY_STAT_1000BT	0x0000000A	1	1000BASE-T Status (Address 10)	Page 591
MMD_ACCESS_CFG	0x0000000D	1	MMD Access Control Register (Address 13)	Page 592
MMD_ADDR_DATA	0x0000000E	1	MMD Address or Data Register (Address 14)	Page 593
PHY_STAT_1000BT_EXT1	0x0000000F	1	1000BASE-T Status Extension Number 1 (Address 15)	Page 593
PHY_STAT_100BTX	0x00000010	1	100BASE-TX Status (Address 16)	Page 594
PHY_STAT_1000BT_EXT2	0x00000011	1	1000BASE-T Status Extension Number 2 (Address 17)	Page 594
PHY_BYPASS_CTRL	0x00000012	1	Bypass Control (Address 18)	Page 595
PHY_ERROR_CNT1	0x00000013	1	Error Counter Number 1 (Address 19)	Page 597
PHY_ERROR_CNT2	0x00000014	1	Error Counter Number 2 (Address 20)	Page 597
PHY_ERROR_CNT3	0x00000015	1	Error Counter Number 3 (Address 21)	Page 597
PHY_CTRL_STAT_EXT	0x00000016	1	Extended Control and Status (Address 22)	Page 598
PHY_CTRL_EXT1	0x00000017	1	Extended Control Number 1 (Address 23)	Page 600
PHY_CTRL_EXT2	0x00000018	1	Extended Control Number 2 (Address 24)	Page 600
PHY_INT_MASK	0x00000019	1	Interrupt Mask (Address 25)	Page 602
PHY_INT_STAT	0x0000001A	1	Interrupt Status (Address 26)	Page 603
PHY_AUX_CTRL_STAT	0x0000001C	1	Auxiliary Control and Status (Address 28)	Page 605
PHY_LED_MODE_SEL	0x0000001D	1	LED Mode Select (Address 29)	Page 608
PHY_LED_BEHAVIOR_CTRL	0x0000001E	1	LED Behavior Control (Address 30)	Page 609
PHY_MEMORY_PAGE_ACCESS	0x0000001F	1	Memory Page Access (Address 31)	Page 610

7.20.1.1 PHY:PHY_STD:PHY_CTRL

Parent: PHY:PHY_STD

Instances: 1

Table 774 • **Fields in PHY_CTRL**

Field Name	Bit	Access	Description	Default
SOFTWARE_RESET_ENA	15	R/W	Initiate software reset. This field is cleared as part of this operation. After enabling this field, you must wait at least 4 us before PHY registers can be accessed again.	0x0
LOOPBACK_ENA	14	R/W	Enable loopback mode. The loopback mechanism works at the current speed. If the link is down (see PHY_STAT.LINK_STATUS), SPEED_SEL_LSB_CFG and SPEED_SEL_MSB_CFG determine the operating speed of the loopback.	0x0
SPEED_SEL_LSB_CFG	13	R/W	Least significant bit of the speed selection, along with SPEED_SEL_MSB_CFG, this field determines the speed when auto-negotiation is disabled (See AUTONEG_ENA). 00: 10 Mbps 01: 100 Mbps 10: Reserved 11: Reserved	0x0
AUTONEG_ENA	12	R/W	Enable auto-negotiation. When cleared, the speed and duplex-mode are determined by SPEED_SEL_LSB_CFG, SPEED_SEL_MSB_CFG, and DUPLEX_MODE_CFG.	0x1
POWER_DOWN_ENA	11	R/W	Enable power-down mode. This disables PHY operation until this bit is cleared or the PHY is reset.	0x0
ISOLATE_ENA	10	R/W	Isolate the PHY from the integrated MAC.	0x0
AUTONEG_RESTART_ENA	9	R/W	Restart an auto-negotiation cycle; the PHY clears this field when auto-negotiation is restarted.	0x0
DUPLEX_MODE_CFG	8	R/W	Configure duplex mode when auto-negotiation is disabled (see AUTONEG_ENA). 0: Half-duplex 1: Full-duplex	0x0
COLLISION_TEST_ENA	7	R/W	Enable collision indication test-mode, when enabled the PHY indicate collision when the MAC transmits data to the PHY.	0x0
SPEED_SEL_MSB_CFG	6	R/W	See SPEED_SEL_LSB_CFG.	0x1

7.20.1.2 PHY:PHY_STD:PHY_STAT

Parent: PHY:PHY_STD

Instances: 1

Table 775 • **Fields in PHY_STAT**

Field Name	Bit	Access	Description	Default
MODE_100BT4	15	R/O	The PHY is not 100BASE-T4 capable.	0x0
MODE_100BX_FDX	14	R/O	The PHY is 100BASE-X FDX capable.	0x1
MODE_100BX_HDX	13	R/O	The PHY is 100BASE-X HDX capable.	0x1
MODE_10BT_FDX	12	R/O	The PHY is 10BASE-T FDX capable.	0x1
MODE_10BT_HDX	11	R/O	The PHY is 10BASE-T HDX capable.	0x1
MODE_100BT2_FDX	10	R/O	The PHY is not 100BASE-T2 FDX capable.	0x0
MODE_100BT2_HDX	9	R/O	The PHY is not 100BASE-T2 HDX capable.	0x0
EXT_STATUS	8	R/O	Extended status information are available; see the PHY_STAT_EXT register.	0x1
PREAMBLE_SUPPRESS	6	R/O	The PHY accepts management frames with preamble suppressed.	0x1
AUTONEG_COMPLETE	5	R/O	This field is set when auto-negotiation is completed and cleared during active auto-negotiation cycles.	0x0
REMOTE_FAULT	4	R/O	This field is set when the PHY detects a remote fault condition and cleared on register read.	0x0
AUTONEG_ABILITY	3	R/O	The PHY is capable of auto-negotiation.	0x1
LINK_STAT	2	R/O	This field is cleared when the link is down. It is set when the link is up and a previous link-down indication was read from the register.	0x0
JABBER_DETECT	1	R/O	This field is set when the PHY detects a jabber condition and cleared on register read.	0x0
EXT_CAPABILITY	0	R/O	The PHY provides an extended set of capabilities.	0x1

7.20.1.3 PHY:PHY_STD:PHY_IDF1

Parent: PHY:PHY_STD

Instances: 1

Table 776 • **Fields in PHY_IDF1**

Field Name	Bit	Access	Description	Default
OUI_MS	15:0	R/O	Vitesse's organizationally unique identifier bits 3 through 18.	0x0007

7.20.1.4 PHY:PHY_STD:PHY_IDF2

Parent: PHY:PHY_STD

Instances: 1

Table 777 • **Fields in PHY_IDF2**

Field Name	Bit	Access	Description	Default
OUI_LS	15:10	R/O	Vitesse's organizationally unique identifier bits 19 through 24.	0x01
MODEL_NUMBER	9:4	R/O	The device model number.	0x2D
REVISION_NUMBER	3:0	R/O	The device revision number.	0x0

7.20.1.5 PHY:PHY_STD:PHY_AUTONEG_ADVERTISMENT

Parent: PHY:PHY_STD

Instances: 1

Table 778 • **Fields in PHY_AUTONEG_ADVERTISMENT**

Field Name	Bit	Access	Description	Default
NEXT_PAGE_ENA	15	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
REMOTE_FAULT_CFG	13	R/W	Transmit Remote Fault.	0x0
ASYM_PAUSE_CFG	11	R/W	Advertise asymmetric pause capability.	0x0
SYM_PAUSE_CFG	10	R/W	Advertise symmetric pause capability.	0x0
ADV_100BT4_CFG	9	R/W	Advertise 100BASE-T4 capability.	0x0
ADV_100BX_FDX_CFG	8	R/W	Advertise 100BASE-X FDX capability.	0x1
ADV_100BX_HDX_CFG	7	R/W	Advertise 100BASE-X HDX capability.	0x1
ADV_10BT_FDX_CFG	6	R/W	Advertise 10BASE-T FDX capability.	0x1
ADV_10BT_HDX_CFG	5	R/W	Advertise 10BASE-T HDX capability.	0x1
SELECTOR_FIELD_CFG	4:0	R/W	Select types of message send by auto-negotiation.	0x01

7.20.1.6 PHY:PHY_STD:PHY_AUTONEG_LP_ABILITY

Parent: PHY:PHY_STD

Instances: 1

Table 779 • **Fields in PHY_AUTONEG_LP_ABILITY**

Field Name	Bit	Access	Description	Default
LP_NEXT_PAGE	15	R/O	Link partner advertises desire to engage in next-page exchange.	0x0
LP_ACKNOWLEDGE	14	R/O	Link partner advertises that link code word was successfully received.	0x0
LP_REMOTE_FAULT	13	R/O	Link partner advertises remote fault.	0x0
LP_ASYM_PAUSE	11	R/O	Link partner advertises asymmetric pause capability.	0x0
LP_SYM_PAUSE	10	R/O	Link partner advertises symmetric pause capability.	0x0
LP_100BT4	9	R/O	Link partner advertises 100BASE-T4 capability.	0x0
LP_100BX_FDX	8	R/O	Link partner advertises 100BASE-X FDX capability.	0x0
LP_100BX_HDX	7	R/O	Link partner advertises 100BASE-X HDX capability.	0x0
LP_10BT_FDX	6	R/O	Link partner advertises 10BASE-T FDX capability.	0x0
LP_10BT_HDX	5	R/O	Link partner advertises 10BASE-T HDX capability.	0x0
LP_SELECTOR_FIELD	4:0	R/O	Link partner advertises select type of message send by auto-negotiation.	0x00

7.20.1.7 PHY:PHY_STD:PHY_AUTONEG_EXP

Parent: PHY:PHY_STD

Instances: 1

Table 780 • **Fields in PHY_AUTONEG_EXP**

Field Name	Bit	Access	Description	Default
PARALLEL_DET_FAULT	4	R/O	This field is set when the PHY detects a Receive Link Integrity Test Failure condition and cleared on register read.	0x0
LP_NEXT_PAGE_ABLE	3	R/O	Set if link partner is next-page capable.	0x0
NEXT_PAGE_ABLE	2	R/O	The PHY is next-page capable.	0x1

Table 780 • **Fields in PHY_AUTONEG_EXP *(continued)***

Field Name	Bit	Access	Description	Default
NEXT_PAGE_RECEIVED	1	R/O	This field is set when the PHY receives a valid next-page and cleared on register read.	0x0
LP_AUTONEG_ABLE	0	R/O	Set if link partner is auto-negotiation capable.	0x0

7.20.1.8 PHY:PHY_STD:PHY_AUTONEG_NEXTPAGE_TX

Parent: PHY:PHY_STD

Instances: 1

Table 781 • **Fields in PHY_AUTONEG_NEXTPAGE_TX**

Field Name	Bit	Access	Description	Default
NEXT_PAGE_CFG	15	R/W	Set to indicate that more pages will follow; clear if current page is the last.	0x0
MESSAGE_PAGE_CFG	13	R/W	Set to indicate that this is a message page; clear if the current page consists of unformatted code.	0x1
ACKNOWLEDGE2_CFG	12	R/W	Set to indicate ability to comply with the request of the last received page.	0x0
TOGGLE	11	R/O	Alternates between 0 and 1 for each transmitted page.	0x0
MESSAGE_FIELD_CFG	10:0	R/W	Contains page information - either message or unformatted code. MESSAGE_PAGE_CFG must indicate if this page contains either a message or unformatted code.	0x001

7.20.1.9 PHY:PHY_STD:PHY_AUTONEG_LP_NEXTPAGE_RX

Parent: PHY:PHY_STD

Instances: 1

Table 782 • **Fields in PHY_AUTONEG_LP_NEXTPAGE_RX**

Field Name	Bit	Access	Description	Default
LP_NEXT_PAGE_RX	15	R/O	Set by link partner to indicate that more pages follow. When cleared, this is the last of the next-pages.	0x0
LP_ACKNOWLEDGE_RX	14	R/O	Set by link partner to acknowledge the reception of last message.	0x0

Table 782 • **Fields in PHY_AUTONEG_LP_NEXTPAGE_RX *(continued)***

Field Name	Bit	Access	Description	Default
LP_MESSAGE_PAGE	13	R/O	Set by Link partner if this page contains a message. When cleared this page contains unformatted code.	0x0
LP_ACKNOWLEDGE2	12	R/O	Set by link partner to indicate that it is able to act on transmitted information.	0x0
LP_TOGGLE	11	R/O	Will alternate between 0 and 1 for each received page. Used to check for errors.	0x0
LP_MESSAGE_FIELD	10:0	R/O	Contains page information, MESSAGE_PAGE indicates if this page contains either a message or unformatted code.	0x000

7.20.1.10 PHY:PHY_STD:PHY_CTRL_1000BT

Parent: PHY:PHY_STD

Instances: 1

Table 783 • **Fields in PHY_CTRL_1000BT**

Field Name	Bit	Access	Description	Default
TX_TEST_MODE_CFG	15:13	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
MS_MANUAL_CFG_ENA	12	R/W	Enable manual configuration of master/slave value.	0x0
MS_MANUAL_CFG	11	R/W	Configure if the PHY should configure itself as either master or slave during master/slave negotiations. This field is only valid when MS_MANUAL_CFG_ENA is set. 0: Configure as slave. 1: Configure as master.	0x0
PORT_TYPE_CFG	10	R/W	Set to indicate multi-port device, clear to indicate single-port device.	0x1
ADV_1000BT_FDX_CFG	9	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
ADV_1000BT_HDX_CFG	8	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0

7.20.1.11 PHY:PHY_STD:PHY_STAT_1000BT

Parent: PHY:PHY_STD

Instances: 1

Table 784 • **Fields in PHY_STAT_1000BT**

Field Name	Bit	Access	Description	Default
MS_CFG_FAULT	15	R/O	This field is set when the PHY detects a master/slave configuration fault condition and cleared on register read.	0x0
MS_CFG_RESOLUTION	14	R/O	This field indicates the result of a master/slave Negotiation. 0: Local PHY is resolved to slave. 1: Local PHY is resolved to master.	0x1
LOCAL_RECEIVER_STAT	13	R/O	The status of the local receiver (loc_rcvr_status as defined in IEEE 802.3). 0: Local receiver status is NOT_OK. 1: Local receiver status is OK.	0x0
REMOTE_RECEIVER_STAT	12	R/O	The status of the remote receiver (rem_rcvr_status as defined in IEEE 802.3). 0: Remote receiver status is NOT_OK. 1: Remote receiver status is OK.	0x0
LP_1000BT_FDX	11	R/O	Set if link partner advertises 1000BASE-T FDX capability.	0x0
LP_1000BT_HDX	10	R/O	Set if link partner advertises 1000BASE-T HDX capability.	0x0
IDLE_ERR_CNT	7:0	R/O	Counts each occurrence of rxerror_status = Error (rx_error_status as defined in IEEE 802.3. This field is cleared on read and saturates at all-ones.	0x00

7.20.1.12 PHY:PHY_STD:MMD_ACCESS_CFG

Parent: PHY:PHY_STD

Instances: 1

The bits in this register of the main register space are a window to the EEE registers as defined in IEEE 802.3az Clause 45.

Table 785 • **Fields in MMD_ACCESS_CFG**

Field Name	Bit	Access	Description	Default
MMD_FUNCTION	15:14	R/W	Function. 0: Address 1: Data, no post increment 2: Data, post increment for read and write 3: Data, post increment for write only	0x0
MMD_DVAD	4:0	R/W	Device address as defined in IEEE 802.3az table 45-1.	0x00

7.20.1.13 PHY:PHY_STD:MMD_ADDR_DATA

Parent: PHY:PHY_STD

Instances: 1

The bits in this register of the main register space are a window to the EEE registers as defined in IEEE 802.3az Clause 45.

Table 786 • **Fields in MMD_ADDR_DATA**

Field Name	Bit	Access	Description	Default
MMD_ADDR_DATA	15:0	R/W	If MMD_ACCESS_CFG.MMD_FUNCTION is 0, MMD_ADDR_DATA specifies the address of register of the device that is specified by MMD_ACCESS_CFG.MMD_DVAD. Otherwise, MMD_ADDR_DATA specifies the data to be written to or read from the register.	0x0000

7.20.1.14 PHY:PHY_STD:PHY_STAT_1000BT_EXT1

Parent: PHY:PHY_STD

Instances: 1

Table 787 • **Fields in PHY_STAT_1000BT_EXT1**

Field Name	Bit	Access	Description	Default
MODE_1000BX_FDX	15	R/O	The PHY is not 1000BASE-X FDX capable.	0x0
MODE_1000BX_HDX	14	R/O	The PHY is not 1000BASE-X HDX capable.	0x0
MODE_1000BT_FDX	13	R/O	Reserved. Do not modify this bit. Must be set to its default.	0x1
MODE_1000BT_HDX	12	R/O	Reserved. Do not modify this bit. Must be set to its default.	0x1

7.20.1.15 PHY:PHY_STD:PHY_STAT_100BTX

Parent: PHY:PHY_STD

Instances: 1

These fields are only valid in 100BASE-T mode.

Table 788 • **Fields in PHY_STAT_100BTX**

Field Name	Bit	Access	Description	Default
DESCRAM_LOCKED	15	R/O	This field is set when the 100BASE-TX descrambler is in lock and cleared when it is out of lock.	0x0
DESCRAM_ERR	14	R/O	This field is set when the PHY detects a descrambler error condition and cleared on register read.	0x0
LINK_DISCONNECT	13	R/O	This field is set when the PHY detects a 100BASE-TX link disconnect condition and cleared on register read.	0x0
LINK_STAT_100	12	R/O	This field is set when the 100BASE-TX link status is active and cleared when inactive.	0x0
RECEIVE_ERR	11	R/O	This field is set when the PHY detects a receive error condition and cleared on register read.	0x0
TRANSMIT_ERR	10	R/O	This field is set when the PHY detects a transmit error condition and cleared on register read.	0x0
SSD_ERR	9	R/O	This field is set when the PHY detects a Start-of-Stream Delimiter Error condition and cleared on register read.	0x0
ESD_ERR	8	R/O	This field is set when the PHY detects an End-of-Stream Delimiter Error condition and cleared on register read.	0x0

7.20.1.16 PHY:PHY_STD:PHY_STAT_1000BT_EXT2

Parent: PHY:PHY_STD

Instances: 1

These fields are only valid in 1000BASE-T mode.

Table 789 • **Fields in PHY_STAT_1000BT_EXT2**

Field Name	Bit	Access	Description	Default
DESCRAM_LOCKED_1000	15	R/O	This field is set when the 1000BASE-T descrambler is in lock and cleared when it is out of lock.	0x0
DESCRAM_ERR_1000	14	R/O	This field is set when the PHY detects a Descrambler Error condition and cleared on register read.	0x0
LINK_DISCONNECT_1000	13	R/O	This field is set when the PHY detects a 1000BASE-T link disconnect condition and cleared on register read.	0x0
LINK_STAT_1000	12	R/O	This field is set when the 1000BASE-T link status is active and cleared when inactive.	0x0
RECEIVE_ERR_1000	11	R/O	This field is set when the PHY detects a Receive Error condition and cleared on register read.	0x0
TRANSMIT_ERR_1000	10	R/O	This field is set when the PHY detects a Transmit Error condition and cleared on register read.	0x0
SSD_ERR_1000	9	R/O	This field is set when the PHY detects a Start-of-Stream Delimiter Error condition and cleared on register read.	0x0
ESD_ERR_1000	8	R/O	This field is set when the PHY detects an End-of-Stream Delimiter Error condition and cleared on register read.	0x0
CARRIER_EXT_ERR_1000	7	R/O	This field is set when the PHY detects a 1000BASE-T Carrier Extension Error condition and cleared on register read.	0x0
BCM5400_ERR_1000	6	R/O	This field is set when the PHY detects a non-compliant BCM5400 condition. This field is only valid when the 1000BASE-T descrambler is in locked state (see DESCRAM_LOCKED_1000).	0x0
MDI_CROSSOVER_ERR	5	R/O	This field is set when the PHY detects an MDI crossover error condition.	0x0

7.20.1.17 PHY:PHY_STD:PHY_BYPASS_CTRL

Parent: PHY:PHY_STD

Instances: 1

Table 790 • **Fields in PHY_BYPASS_CTRL**

Field Name	Bit	Access	Description	Default
TX_DIS	15	R/W	Disable the PHY transmitter. When set, the analog blocks are powered down and zeros are send to the DAC.	0x0
ENC_DEC_4B5B	14	R/W	If set, bypass the 4B5B encoder/decoder.	0x0
SCRAMBLER	13	R/W	If set, bypass the scrambler.	0x0
DESCRAMBLER	12	R/W	If set, bypass the descrambler.	0x0
PCS_RX	11	R/W	If set, bypass the PCS receiver.	0x0
PCS_TX	10	R/W	If set, bypass the PCS transmit.	0x0
LFI_TIMER	9	R/W	If set, bypass the link fail inhibit (LFI) timer.	0x0
FORCED_SPEED_AUTO_MDIX_DIS	7	R/W	Bit for disabling HP AutoMDIX in forced 10/100 speeds, even though auto-negotiation is disabled. 0: The HP Auto-MDIX function is enabled. 1: Default value. The HP Auto-MDIX function is disabled. Use the default value when in auto-negotiation mode.	0x1
PAIR_SWAP_DIS	5	R/W	Disable automatic pair swap correction. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
POL_INV_DIS	4	R/W	Disable automatic polarity inversion correction. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
PARALLEL_DET_DIS	3	R/W	When cleared, the PHY ignores its advertised abilities when performing parallel detect. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x1
PULSE_SHAPING_DIS	2	R/W	If set, disable the pulse shaping filter.	0x0

Table 790 • **Fields in PHY_BYPASS_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
AUTO_NP_EXCHANGE_DIS	1	R/W	Disable automatic exchange of 1000BASE-T next pages. If this feature is disabled, you have the responsibility of sending next pages, determining capabilities, and configuration of the PHY after successful exchange of pages. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

7.20.1.18 PHY:PHY_STD:PHY_ERROR_CNT1

Parent: PHY:PHY_STD

Instances: 1

Table 791 • **Fields in PHY_ERROR_CNT1**

Field Name	Bit	Access	Description	Default
RX_ERR_CNT	7:0	R/O	Counter containing the number of packets received with errors for 100/1000BASE-TX. The counter saturates at 255 and it is cleared when read.	0x00

7.20.1.19 PHY:PHY_STD:PHY_ERROR_CNT2

Parent: PHY:PHY_STD

Instances: 1

Table 792 • **Fields in PHY_ERROR_CNT2**

Field Name	Bit	Access	Description	Default
FALSE_CARRIER_CNT	7:0	R/O	Counter containing the number of false carrier incidents for 100/1000BASE-TX. The counter saturates at 255 and it is cleared when read.	0x00

7.20.1.20 PHY:PHY_STD:PHY_ERROR_CNT3

Parent: PHY:PHY_STD

Instances: 1

Table 793 • **Fields in PHY_ERROR_CNT3**

Field Name	Bit	Access	Description	Default
LINK_DIS_CNT	7:0	R/O	Counter containing the number of copper media link disconnects. The counter saturates at 255 and it is cleared when read.	0x00

7.20.1.21 PHY:PHY_STD:PHY_CTRL_STAT_EXT

Parent: PHY:PHY_STD

Instances: 1

Table 794 • **Fields in PHY_CTRL_STAT_EXT**

Field Name	Bit	Access	Description	Default
LINK_10BT_FORCE_ENA	15	R/W	When this field is set, the PHY link integrity state machine is bypassed, and the PHY is forced into link pass status. This is a sticky field; see PHY_CTRL_EXT.STICKY_RESET_ENA.	0x0
JABBER_DETECT_DIS	14	R/W	Disable jabber detect function. When this is disabled, the PHY allows transmission requests to be arbitrarily long without shutting down the transmitter. When cleared, the PHY shuts down the transmitter after the specified time limit specified by IEEE. This is a sticky field; see PHY_CTRL_EXT.STICKY_RESET_ENA.	0x0
ECHO_10BT_DIS	13	R/W	When this field is set, the state of the TX_EN pin does not echo onto the CRS pin, which effectively disables CRS from being asserted in half-duplex operation. When cleared, the TX_EN pin is echoed onto the CRS pin. This applies only in 10BASE-T mode. This is a sticky field; see PHY_CTRL_EXT.STICKY_RESET_ENA.	0x1
SQE_10BT_DIS	12	R/W	Disable SQE (Signal Quality Error) pulses on the MAC interface. This applies only in 10BASE-T mode. This is a sticky field; see PHY_CTRL_EXT.STICKY_RESET_ENA.	0x1

Table 794 • **Fields in PHY_CTRL_STAT_EXT *(continued)***

Field Name	Bit	Access	Description	Default
SQUELCH_10BT_CFG	11:10	R/W	Configure squelch control (this only applies in the 10BASE-T mode). This is a sticky field; see PHY_CTRL_EXT.STICKY_RESET_ENA. 0: The PHY uses the squelch threshold levels prescribed by the IEEE 10BASE-T specification. 1: In this mode, the squelch levels are decreased, which may improve the bit error rate performance on long loops 2: In this mode, the squelch levels are increased, which may improve the bit error rate in high-noise environments 3: Reserved.	0x0
STICKY_RESET_ENA	9	R/W	When set, all fields described as sticky retain their value during software reset. When cleared, all fields marked as sticky are reset to their default values during software reset. This does not affect hardware resets. This is a super-sticky field, which means that it always retain its value during software reset.	0x1
EOF_ERR	8	R/O	When set, this field indicates that a defective EOF (End Of Frame) sequence was received since the last time this field was read. This field is cleared on read.	0x0
LINK_10BT_DISCONNECT	7	R/O	When set, this field indicates that the carrier integrity monitor has broken the 10BASE-T connection since the last read of this bit. This field is cleared on read.	0x0
LINK_10BT_STAT	6	R/O	This field is set when a 10BASE-T link is active. Cleared when inactive.	0x0
BROADCAST_WRITE_ENA	0	R/W	Enable any MII write operation (regardless of destination PHY) to be interpreted as a write to this PHY. This only applies to writes; read-operations are still interpreted with correct address. This is particularly useful when similar settings should be propagated to multiple PHYs. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

7.20.1.22 PHY:PHY_STD:PHY_CTRL_EXT1

Parent: PHY:PHY_STD

Instances: 1

Table 795 • **Fields in PHY_CTRL_EXT1**

Field Name	Bit	Access	Description	Default
RESERVED	15:4	R/W	Must be set to its default.	0x000
FAR_END_LOOPBACK_ENA	3	R/W	Enable far end loopback in this PHY. In this mode all incoming traffic on the media interface is retransmitted back to the link partner. In addition, the incoming data also appears on the internal Rx interface to the MAC. Any data send to the PHY from the internal MAC is ignored when this mode is active.	0x0

7.20.1.23 PHY:PHY_STD:PHY_CTRL_EXT2

Parent: PHY:PHY_STD

Instances: 1

Table 796 • **Fields in PHY_CTRL_EXT2**

Field Name	Bit	Access	Description	Default
EDGE_RATE_CFG	15:13	R/W	Control the transmit DAC slew rate in 100BASE-TX mode only. The difference between each setting is approximately 200ps to 300ps, with the +3 setting resulting in the slowest edge rate, and the -4 setting resulting in the fastest edge rate. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 011: +5 Edge rate (slowest). 010: +4 Edge rate. 001: +3 Edge rate. 000: +2 Edge rate. 111: +1 Edge rate. 110: Nominal edge rate. 101: -1 Edge rate. 100: -2 Edge rate (fastest).	0x1

Table 796 • **Fields in PHY_CTRL_EXT2** ***(continued)***

Field Name	Bit	Access	Description	Default
PICMG_REDUCED_POWER_ENA	12	R/W	Enable PICMC reduce power mode: In this mode, portions of the DSP processor are turned off, which reduces the PHY's operating power. The DSP performance characteristics in this mode are configured to support the channel characteristics specified in the PICMC 2.16 and PICMC 3.0 specifications. The application of this mode is in environments that have a high signal to noise ratio on the media. For example, Ethernet over backplane, or where cable length is short (less than 10m). When this field is cleared, the PHY operates in normal DSP mode. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
RESERVED	8:6	R/W	Must be set to its default.	0x1
JUMBO_PKT_ENA	5:4	R/W	Controls the symbol buffering for the receive synchronization FIFO used in 1000BASE-T mode. Other encodings are reserved and must not be selected. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. Note: When set, the default maximum packet values are based on 100 ppm driven reference clock to the device. Controlling the ppm offset between the MAC and the PHY as specified in the field encoding description results in a higher jumbo packet length. 00: Normal IEEE 1518-byte packet length. 01: 9-kilobyte jumbo packet length (12 kilobytes with 60 ppm or better reference clock). 10: 12-kilobyte jumbo packet length (16 kilobytes with 70 ppm or better reference clock). 11: Reserved.	0x0
RESERVED	3:1	R/W	Must be set to its default.	0x6
CON_LOOPBACK_1000BT_ENA	0	R/W	Set PHY into 1000BASE-T connector loopback mode. When enabled, the PHY only works with a connector loopback.	0x0

7.20.1.24 PHY:PHY_STD:PHY_INT_MASK

Parent: PHY:PHY_STD

Instances: 1

Table 797 • **Fields in PHY_INT_MASK**

Field Name	Bit	Access	Description	Default
PHY_INT_ENA	15	R/W	Enable global PHY interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
SPEED_STATE_CHANGE_INT_ENA	14	R/W	Set to unmask speed change interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
LINK_STATE_CHANGE_INT_ENA	13	R/W	Set to unmask link state/energy detected change interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
FDX_STATE_CHANGE_INT_ENA	12	R/W	Set to unmask FDX change interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
AUTONEG_ERR_INT_ENA	11	R/W	Set to unmask auto-negotiation error interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
AUTONEG_DONE_INT_ENA	10	R/W	Set to unmask auto-negotiation-done/interlock done interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
INLINE_POW_DET_INT_ENA	9	R/W	Set to unmask In-line Powered Device Detected interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
SYMBOL_ERR_INT_ENA	8	R/W	Set to unmask Symbol Error interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
FAST_LINK_FAIL_INT_ENA	7	R/W	Set to unmask fast link failure interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
TX_FIFO_INT_ENA	6	R/W	Set to unmask TX FIFO interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

Table 797 • **Fields in PHY_INT_MASK *(continued)***

Field Name	Bit	Access	Description	Default
RX_FIFO_INT_ENA	5	R/W	Set to unmask RX FIFO interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
FALSE_CARRIER_INT_ENA	3	R/W	Set to unmask False Carrier interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
LINK_SPEED_DOWNSHIFT_INT_ENA	2	R/W	Set to unmask link speed downshift interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
MASTER_SLAVE_INT_ENA	1	R/W	Set to unmask master/slave interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
RX_ER_INT_ENA	0	R/W	Set to unmask RX_ER interrupt. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

7.20.1.25 PHY:PHY_STD:PHY_INT_STAT

Parent: PHY:PHY_STD

Instances: 1

Table 798 • **Fields in PHY_INT_STAT**

Field Name	Bit	Access	Description	Default
PHY_INT_PEND	15	R/O	Set when an unacknowledged 'global' PHY interrupt is pending, the cause of the interrupt can be determined by examining the other fields of this register. This field is set no matter the state of PHY_INT_MASK.PHY_INT_ENA. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
SPEED_STATE_CHANGE_INT_PEND	14	R/O	Set when a speed interrupt is pending, this is activated when the operating speed of the PHY changes (requires that auto-negotiation is enabled; see PHY_CTRL.AUTONEG_ENA). This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0

Table 798 • **Fields in PHY_INT_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
LINK_STATE_CHANGE_INT_PEND	13	R/O	Set when a Link State/Energy Detected interrupt is pending. This interrupt occurs when the link status of the PHY changes, or if ActiPHY mode is enabled and energy is detected on the media (see PHY_AUX_CTRL_STAT.ACTIPHY_ENA). This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
FDX_STATE_CHANGE_INT_PEND	12	R/O	Set when an FDX interrupt is pending. FDX interrupt is caused when the FDX/HDX state of the PHY changes (requires that auto-negotiation is enabled; see PHY_CTRL.AUTONEG_ENA). This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
AUTONEG_ERR_INT_PEND	11	R/O	Set when an auto-negotiation Error interrupt is pending, this is caused when an error is detected by the auto-negotiation state machine. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
AUTONEG_DONE_INT_PEND	10	R/O	Set when an auto-negotiation-Done/Interlock Done interrupt is pending, this is caused when the Auto-negotiation finishes a negotiation process. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
INLINE_POW_DET_INT_PEND	9	R/O	Set when an In-line Powered Device Detected interrupt is pending. This interrupt is caused when a device requiring in-line power is detected (requires that detection is enabled; see PHY_CTRL_EXT4.INLINE_DETECT_ENA). This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
SYMBOL_ERR_INT_PEND	8	R/O	Set when a Symbol Error interrupt is pending, this is caused by detection of a symbol error by the descrambler. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0

Table 798 • **Fields in PHY_INT_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
FAST_LINK_FAIL_INT_PEND	7	R/O	Set when a fast link failure interrupt is pending. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
TX_FIFO_INT_PEND	6	R/O	Set when a TX FIFO interrupt is pending. TX FIFO interrupt is generated by TX FIFO underflow or overflow. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
RX_FIFO_INT_PEND	5	R/O	Set when a RX FIFO interrupt is pending. This interrupt is caused by RX FIFO underflow or overflow. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
FALSE_CARRIER_INT_PEND	3	R/O	Set when a False Carrier interrupt is pending. False Carrier interrupt is generated when the PHY detects a false carrier. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
LINK_SPEED_DOWNSHIFT_INT_PEND	2	R/O	Set when a link speed downshift interrupt is pending. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
MASTER_SLAVE_ERR_INT_PEND	1	R/O	Set when a master/slave interrupt is pending. This interrupt is set when a master/slave resolution error us detected. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0
RX_ER_INT_PEND	0	R/O	Set when a RX_ER interrupt is pending. This interrupt is set when an RX_ER condition occurs. This field is self-clearing; i.e. interrupt is acknowledged on read.	0x0

7.20.1.26 PHY:PHY_STD:PHY_AUX_CTRL_STAT

Parent: PHY:PHY_STD

Instances: 1

Copied fields have the same default values as their source fields.

Table 799 • **Fields in PHY_AUX_CTRL_STAT**

Field Name	Bit	Access	Description	Default
AUTONEG_COMPLETE_AUX	15	R/O	A read-only copy of PHY_STAT.AUTONEG_COMPLETE. Repeated here for convenience. See note for this register.	0x0
AUTONEG_STAT	14	R/O	When set the auto-negotiation function has been disabled (in PHY_CTRL.AUTONEG_ENA.)	0x0
NO_MDI_X_IND	13	R/O	When this field is set, the auto-negotiation state machine has determined that crossover does not exist in the signal path. This field is only valid after 'descrambler lock' has been achieved (see PHY_STAT_1000BT_EXT.DESCRAM_LOCKED) and 'automatic pair swap correction' is enabled (see PHY_BYPASS_CTRL.PAIR_SWAP_DISABLE).	0x0
CD_PAIR_SWAP	12	R/O	When this field is set, the PHY has determined that the subchannel cable pairs C and D were swapped between the far-end transmitter and the receiver. In this case, the PHY corrects this internally. This field is only valid when auto-negotiation is complete (see AUTONEG_COMPLETE).	0x0
A_POL_INVERSION	11	R/O	When set, this field indicates that the polarity of pair A was inverted between the far-end transmitter and the receiver. In this case the PHY corrects this internally. This field is only valid when auto-negotiation is complete (see AUTONEG_COMPLETE). 0: Polarity is swapped on pair A. 1: Polarity is not swapped on pair A.	0x0

Table 799 • **Fields in PHY_AUX_CTRL_STAT** ***(continued)***

Field Name	Bit	Access	Description	Default
B_POL_INVERSION	10	R/O	When set, this field indicates that the polarity of pair B was inverted between the far-end transmitter and the receiver. In this case the PHY corrects this internally. This field is only valid when auto-negotiation is complete (see AUTONEG_COMPLETE). 0: Polarity is swapped on pair B. 1: Polarity is not swapped on pair B.	0x0
C_POL_INVERSION	9	R/O	When set, this field indicates that the polarity of pair C was inverted between the far-end transmitter and the receiver. In this case the PHY corrects this internally. This field is only valid when auto-negotiation is complete (see AUTONEG_COMPLETE) and in 1000BASE-T mode. 0: Polarity is swapped on pair C. 1: Polarity is not swapped on pair C.	0x0
D_POL_INVERSION	8	R/O	When set, this field indicates that the polarity of pair D was inverted between the far-end transmitter and the receiver. In this case the PHY corrects this internally. This field is only valid when auto-negotiation is complete (see AUTONEG_COMPLETE) and in 1000BASE-T mode. 0: Polarity is swapped on pair D. 1: Polarity is not swapped on pair D.	0x0
ACTIPHY_LINK_TIMER_MSB_CFG	7	R/W	Most significant bit of the link status time-out timer. Together with ACTIPHY_LINK_TIMER_LSB_CFG, this field determines the duration from losing the link to the ActiPHY enters low power state. 0: 1 seconds. 1: 2 seconds. 2: 3 seconds. 3: 4 seconds.	0x0
ACTIPHY_ENA	6	R/W	Enable ActiPHY power management mode. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

Table 799 • **Fields in PHY_AUX_CTRL_STAT *(continued)***

Field Name	Bit	Access	Description	Default
FDX_STAT	5	R/O	This field indicates the actual FDX/HDX operating mode of the PHY. 0: Half-duplex. 1: Full-duplex.	0x0
SPEED_STAT	4:3	R/O	This field indicates the actual operating speed of the PHY. 0: Speed is 10BASE-T. 1: Speed is 100BASE-TX. 2: Speed is 1000-BASE-T. 3: Reserved.	0x0
ACTIPHY_LINK_TIMER_LSB_CFG	2	R/W	See ACTIPHY_LINK_TIMER_MSB_CFG.	0x1

7.20.1.27 PHY:PHY_STD:PHY_LED_MODE_SEL

Parent: PHY:PHY_STD

Instances: 1

Table 800 • **Fields in PHY_LED_MODE_SEL**

Field Name	Bit	Access	Description	Default
RESERVED	15:12	R/W	Must be set to its default.	0x8
RESERVED	11:8	R/W	Must be set to its default.	0x0
LED1_MODE_SEL	7:4	R/W	Select from LED modes 0 through 15. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x2
LED0_MODE_SEL	3:0	R/W	Select from LED modes 0 through 15. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 0: Link/Activity 1: Link1000/Activity 2: Link100/Activity 3: Link10/Activity 4: Link100/1000/Activity 5: Link10/1000/Activity 6: Link10/100/Activity 7: Reserved 8: Duplex/Collision 9: Collision 10: Activity 11: Reserved 12: Auto-Negotiation Fault 13: Reserved 14: Force LED Off 15: Force LED On	0x1

7.20.1.28 PHY:PHY_STD:PHY_LED_BEHAVIOR_CTRL

Parent: PHY:PHY_STD

Instances: 1

Table 801 • **Fields in PHY_LED_BEHAVIOR_CTRL**

Field Name	Bit	Access	Description	Default
PULSING_ENA	12	R/W	Enable LED pulsing with programmable duty cycle. The duty cycle is programmed in PHY_GP::PHY_ENHANCED_LED_CTRL.LED_PULSE_DUTY. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 0: Normal operation. 1: LEDs pulse with a 5 kHz, programmable duty cycle when active.	0x0
BLINK_RATE_CFG	11:10	R/W	Configure blink rate of LEDs when applicable. If pulse stretching has been selected rather than blink, this controls the stretch-period rather than frequency. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 00: 2.5 Hz blink rate/400 ms pulse-stretch. 01: 5 Hz blink rate/200 ms pulse-stretch. 10: 10 Hz blink rate/100 ms pulse-stretch. 11: 20 Hz blink rate/50 ms pulse-stretch. The blink rate selection for PHY0 globally sets the rate used for all LED pins on all PHY ports.	0x1
LED1_PULSE_STRETCH_ENA	6	R/W	Enable pulse-stretch behavior instead of blinking for LED1. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
LED0_PULSE_STRETCH_ENA	5	R/W	Enable pulse-stretch behavior instead of blinking for LED0. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0

Table 801 • **Fields in PHY_LED_BEHAVIOR_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
LED1_COMBINE_DIS	1	R/W	Disabling of the LED1 combine feature. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 0: Combine enabled (link/activity, duplex/collision). 1: Disable combination (link only, duplex only).	0x0
LED0_COMBINE_DIS	0	R/W	Disabling of the LED0 combine feature. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 0: Combine enabled (link/activity, duplex/collision). 1: Disable combination (link only, duplex only).	0x0

7.20.1.29 PHY:PHY_STD:PHY_MEMORY_PAGE_ACCESS

Parent: PHY:PHY_STD

Instances: 1

Table 802 • **Fields in PHY_MEMORY_PAGE_ACCESS**

Field Name	Bit	Access	Description	Default
PAGE_ACCESS_CFG	4:0	R/W	This bit controls the mapping of PHY registers 0x10 through 0x1E. When changing pages, all registers in the range 0x10 through 0x1E are replaced - even if the new memory-page does not define all addresses in the range 0x10 through 0x1E. 0: Register Page 0 is mapped (standard set). 1: Register Page 1 is mapped (extended set 1). 2: Register Page 2 is mapped (extended set 2). 16: Register Page 16 is mapped (general purpose).	0x00

7.20.2 PHY:PHY_EXT1

Parent: PHY

Instances: 1

Set register 0x1F to 0x0001 to make the extended set of registers visible in the address range 0x10 through 0x1E. Set register 0x1F to 0x0000 to revert back to the standard register set.

Table 803 • **Registers in PHY_EXT1**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_CRC_GOOD_CNT	0x00000012	1	CRC Good Counter (Address 18E1)	Page 611
PHY_EXT_MODE_CTRL	0x00000013	1	Extended Mode Control (Address 19E1)	Page 611
PHY_CTRL_EXT3	0x00000014	1	Extended Control Number 3 (Address 20E1)	Page 612
PHY_CTRL_EXT4	0x00000017	1	Extended Control Number 4 (Address 23E1)	Page 613
PHY_1000BT_EPG1	0x0000001D	1	1000BASE-T Ethernet Packet Generator Number 1 (Address 29E1)	Page 614
PHY_1000BT_EPG2	0x0000001E	1	1000BASE-T Ethernet Packet Generator Number 2 (Address 30E1)	Page 616

7.20.2.1 PHY:PHY_EXT1:PHY_CRC_GOOD_CNT

Parent: PHY:PHY_EXT1

Instances: 1

Table 804 • **Fields in PHY_CRC_GOOD_CNT**

Field Name	Bit	Access	Description	Default
PACKET_SINCE_LAST_READ	15	R/O	Packet received since last read. This is a self-clearing bit.	0x0
CRC_GOOD_PKT_CNT	13:0	R/O	Counter containing the number of packets with valid CRCs; this counter does not saturate and rolls over. This is a self-clearing field.	0x0000

7.20.2.2 PHY:PHY_EXT1:PHY_EXT_MODE_CTRL

Parent: PHY:PHY_EXT1

Instances: 1

Table 805 • **Fields in PHY_EXT_MODE_CTRL**

Field Name	Bit	Access	Description	Default
LED1_EXT_MODE_ENA	13	R/W	Enable extended LED mode for LED1. For available LED modes, see LED0_EXT_MODE_ENA.	0x0

Table 805 • **Fields in PHY_EXT_MODE_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
LED0_EXT_MODE_ENA	12	R/W	Enable extended LED mode for LED0. If set, the available LED modes selected in PHY_LED_MODE_SEL.LED0_MODE_SEL are: 0-3: Reserved 4: Force LED Off. 5: Force LED On. LED pulsing is disabled in this mode. 6: Fast Link Fail. 7-15: Reserved.	0x0
LED_BLINK_SUPPRESS	11	R/W	Suppress LED blink after reset. 0: Suppress LED blink after COMA_MODE is deasserted. 1: Blink LEDs after COMA_MODE is deasserted.	0x0
FORCE_MDI_CROSSOVER_ENA	3:2	R/W	Force MDI crossover. 00: Normal HP Auto-MDIX operation. 01: Reserved. 10: Copper media forced to MDI. 11: Copper media forced MDI-X.	0x0

7.20.2.3 PHY:PHY_EXT1:PHY_CTRL_EXT3

Parent: PHY:PHY_EXT1

Instances: 1

Table 806 • **Fields in PHY_CTRL_EXT3**

Field Name	Bit	Access	Description	Default
RESERVED	15	R/W	Must be set to its default.	0x1
ACTIPHY_SLEEP_TIMER	14:13	R/W	This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 00: 1 second. 01: 2 seconds. 10: 3 seconds. 11: 4 seconds.	0x1
ACTIPHY_WAKEUP_TIMER	12:11	R/W	This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 00: 160 ms. 01: 400 ms. 10: 800 ms. 11: 2 seconds.	0x0

Table 806 • **Fields in PHY_CTRL_EXT3** ***(continued)***

Field Name	Bit	Access	Description	Default
NO_PREAMBLE_10BT_ENA	5	R/W	If set, 10BASE-T asserts RX_DV indication when data is presented to the receiver even without a preamble preceding it.This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
SPEED_DOWNSHIFT_ENA	4	R/W	Enables automatic downshift the auto-negotiation advertisement to the next lower available speed after the number of failed 1000BASE-T auto-negotiation attempts specified in SPEED_DOWNSHIFT_CFG. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
SPEED_DOWNSHIFT_CFG	3:2	R/W	Configures the number of unsuccessful 1000BASE-T auto-negotiation attempts that are required before the auto-negotiation advertisement is downshifted to the next lower available speed. This field applies only if automatic downshift of speed is enabled (see SPEED_DOWNSHIFT_ENA). This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA. 00: Downshift after 2 failed attempts. 01: Downshift after 3 failed attempts. 10: Downshift after 4 failed attempts. 11: Downshift after 5 failed attempts.	0x1
SPEED_DOWNSHIFT_STAT	1	R/O	This status field indicates that a downshift is required in order for link to be established. If automatic downshifting is enabled (see SPEED_DOWNSHIFT_ENA), the current link speed is a result of a downshift.	0x0

7.20.2.4 PHY:PHY_EXT1:PHY_CTRL_EXT4

Parent: PHY:PHY_EXT1

Instances: 1

The reset value of the address fields (PHY_ADDR) corresponds to the PHY in which it resides.

Table 807 • **Fields in PHY_CTRL_EXT4**

Field Name	Bit	Access	Description	Default
PHY_ADDR	15:11	R/O	This field contains the PHY address of the current PHY port.	0x00
INLINE_POW_DET_ENA	10	R/W	Enables detection of inline powered device as part of the auto-negotiation process. This is a sticky field; see PHY_CTRL_STAT_EXT.STICKY_RESET_ENA.	0x0
INLINE_POW_DET_STAT	9:8	R/O	This field shows the status if a device is connected to the PHY that requires inline power. This field is only valid if inline powered device detection is enabled (see INLINE_POW_DET_ENA). 00: Searching for devices. 01: Device found that requires inline power. 10: Device found that does not require inline power. 11: Reserved.	0x0
CRC_1000BT_CNT	7:0	R/O	This field indicates how many packets are received that contain a CRC error. This field is cleared on read and saturates at all ones.	0x00

7.20.2.5 PHY:PHY_EXT1:PHY_1000BT_EPG1

Parent: PHY:PHY_EXT1

Instances: 1

Table 808 • **Fields in PHY_1000BT_EPG1**

Field Name	Bit	Access	Description	Default
EPG_ENA	15	R/W	Enables the Ethernet packet generator. When this field is set, the EPG is selected as the driving source for the PHY transmit signals, and the MAC transmit pins are disabled.	0x0
EPG_RUN_ENA	14	R/W	Begin transmission of Ethernet packets. Clear to stop the transmission of packets. If a transmission is in progress, the transmission of packets is stopped after the current packet is transmitted. This field is valid only when the EPG is enabled (see EPG_ENA).	0x0

Table 808 • **Fields in PHY_1000BT_EPG1** ***(continued)***

Field Name	Bit	Access	Description	Default
TRANSMIT_DURATION_CFG	13	R/W	Configure the duration of the packet generation. When set, the EPG continuously transmits packets as long as field EPG_RUN_ENA is set. When cleared, the EPG transmits 30,000,000 packets when field EPG_RUN_ENA is set, after which time, field EPG_RUN_ENA is automatically cleared. This field is latched when packet generation begins by setting EPG_RUN_ENA in this register.	0x0
PACKET_LEN_CFG	12:11	R/W	This field selects the length of packets to be generated by the EPG. This field is latched when generation of packets begins by setting EPG_RUN_ENA in this register. 00: 125-byte packets. 01: 64-byte packets. 10: 1518-byte packets. 11: 10,000-byte packets.	0x0
INTER_PACKET_GAB_CFG	10	R/W	This field configures the inter packet gab for packets generated by the EPG. This field is latched when generation of packets begins by setting EPG_RUN_ENA in this register. 0: 96 ns inter-packet gap. 1: 9,192 ns inter-packet gap.	0x0
DEST_ADDR_CFG	9:6	R/W	This field configures the low nibble of the most significant byte of the destination MAC address. The rest of the destination MAC address is all-ones. For example, setting this field to 0x2 results in packets generated with a destination MAC address of 0xF2FFFFFFFFFF. This field is latched when generation of packets begins by setting EPG_RUN_ENA in this register.	0x1

Table 808 • **Fields in PHY_1000BT_EPG1** ***(continued)***

Field Name	Bit	Access	Description	Default
SRC_ADDR_CFG	5:2	R/W	This field configures the low nibble of the most significant byte of the source MAC address. The rest of the source MAC address is all-ones. For example, setting this field to 0xE results in packets generated with a source MAC address of 0xFEFFFFFFFFFF. This field is latched when generation of packets begins by setting EPG_RUN_ENA in this register.	0x0
PAYLOAD_TYPE	1	R/W	Payload type. 0: Fixed based on payload pattern. 1: Randomly generated payload pattern.	0x0
BAD_FCS_ENA	0	R/W	When this field is set, the EPG generates packets containing an invalid Frame Check Sequence (FCS). When cleared, the EPG generates packets with a valid FCS. This field is latched when generation of packets begins by setting EPG_RUN_ENA in this register.	0x0

7.20.2.6 PHY:PHY_EXT1:PHY_1000BT_EPG2

Parent: PHY:PHY_EXT1

Instances: 1

Table 809 • **Fields in PHY_1000BT_EPG2**

Field Name	Bit	Access	Description	Default
PACKET_PAYLOAD_CFG	15:0	R/W	Each packet generated by the EPG contains a repeating sequence of this field as payload. This field is latched when generation of packets begins by setting PHY_1000BT_EPG1.EPG_RUN_ENA.	0x0000

7.20.3 PHY:PHY_EXT2

Parent: PHY

Instances: 1

Set register 0x1F to 0x0002 to make the extended set of registers visible in the address range 0x10 through 0x1E. Set register 0x1F to 0x0000 to revert back to the standard register set.

Table 810 • **Registers in PHY_EXT2**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_PMD_TX_CTRL	0x00000010	1	Cu PMD Transmit Control (Address 16E2)	Page 617
PHY_EEE_CTRL	0x00000011	1	EEE and LED Control (Address 17E2)	Page 617

7.20.3.1 PHY:PHY_EXT2:PHY_PMD_TX_CTRL

Parent: PHY:PHY_EXT2

Instances: 1

This register consists of the bits that provide control over the amplitude settings for the transmit side Cu PMD interface. These bits provide the ability to make small adjustments in the signal amplitude to compensate for minor variations in the magnetic from different vendors. Extreme caution must be exercised when changing these settings from the default values as they have a direct impact on the signal quality. Changing these settings also affects the linearity and harmonic distortion of the transmitted signals. Please contact the Vitesse Applications Support team for further help with changing these values.

Table 811 • **Fields in PHY_PMD_TX_CTRL**

Field Name	Bit	Access	Description	Default
SIG_AMPL_1000BT	15:12	R/W	1000BT signal amplitude trim.	0x2
SIG_AMPL_100BTX	11:8	R/W	100BASE-TX signal amplitude trim.	0x0
SIG_AMPL_10BT	7:4	R/W	10BASE-T signal amplitude trim.	0xF
SIG_AMPL_10BTE	3:0	R/W	10BASE-Te signal amplitude trim.	0x0

7.20.3.2 PHY:PHY_EXT2:PHY_EEE_CTRL

Parent: PHY:PHY_EXT2

Instances: 1

Table 812 • **Fields in PHY_EEE_CTRL**

Field Name	Bit	Access	Description	Default
EEE_10BTE_ENA	15	R/W	Enable energy efficient (IEEE 802.3az) 10BASE-Te operating mode.	0x0
FORCE_1000BT_ENA	5	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x1

Table 812 • **Fields in PHY_EEE_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
FORCE_LPI_TX_ENA	4	R/W	Force transmit LPI. 0: Transmit idles being received from the MAC. 1: Enable the EPG to transmit LPI on the MDI instead of normal idles when receiving normal idles from the MAC.	0x0
EEE_LPI_TX_100BTX_DIS	3	R/W	Disable transmission of EEE LPI on transmit path MDI in 100BASE-TX mode when receiving LPI from MAC.	0x0
EEE_LPI_RX_100BTX_DIS	2	R/W	Disable transmission of EEE LPI on receive path MAC interface in 100BASE-TX mode when receiving LPI from the MDI.	0x0
EEE_LPI_TX_1000BT_DIS	1	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
EEE_LPI_RX_1000BT_DIS	0	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0

7.20.4 PHY:PHY_GP

Parent: PHY

Instances: 1

Set register 0x1F to 0x0010 to access the general purpose registers. This sets all 32 registers to the general purpose register space. Set register 0x1F to 0x0000 to revert back to the standard register set.

Table 813 • **Registers in PHY_GP**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_COMA_MODE_CTRL	0x0000000E	1	Coma Mode Control (Address 14G)	Page 618
PHY_RCVD_CLK0_CTRL	0x00000017	1	Recovered Clock 0 Control (Address 23G)	Page 619
PHY_RCVD_CLK1_CTRL	0x00000018	1	Recovered Clock 1 Control (Address 24G)	Page 620
PHY_ENHANCED_LED_CTRL	0x00000019	1	Enhanced LED Control (Address 25G)	Page 621
PHY_GLOBAL_INT_STAT	0x0000001D	1	Global Interrupt Status (Address 29G)	Page 622

7.20.4.1 PHY:PHY_GP:PHY_COMA_MODE_CTRL

Parent: PHY:PHY_GP

Instances: 1

Table 814 • **Fields in PHY_COMA_MODE_CTRL**

Field Name	Bit	Access	Description	Default
COMA_MODE_OE	13	R/W	COMA_MODE output enable. Active low. 0: COMA_MODE pin is an output. 1: COMA_MODE pin is an input.	0x1
COMA_MODE_OUTPUT	12	R/W	COMA_MODE output data.	0x0
COMA_MODE_INPUT	11	R/O	COMA_MODE input data.	0x0
LED_TRISTATE_ENA	9	R/W	Tri-state enable for LEDs. 0: Drive LED bus output signals to high and low values as appropriate. 1: Tri-state LED output signals instead of driving them high. This allows those signals to be pulled above VDDIO using an external pull-up resistor.	0x0

7.20.4.2 PHY:PHY_GP:PHY_RCVD_CLK0_CTRL

Parent: PHY:PHY_GP

Instances: 1

Table 815 • **Fields in PHY_RCVD_CLK0_CTRL**

Field Name	Bit	Access	Description	Default
RCVD_CLK0_ENA	15	R/W	Enable RCVRD_CLK[0].	0x0
CLK_SRC_SEL0	14:11	R/W	Clock source select. 0000: PHY0 0001: PHY1 0010: PHY2 0011: PHY3 0100: PHY4 0101: PHY5 0110: PHY6 0111: PHY7 1000-1111: Reserved	0x0
CLK_FREQ_SEL0	10:8	R/W	Clock frequency select. 000: 25 MHz output clock 001: 125 MHz output clock 010: 31.25 MHz output clock 011-111: Reserved	0x0

Table 815 • **Fields in PHY_RCVD_CLK0_CTRL *(continued)***

Field Name	Bit	Access	Description	Default
CLK_SQUELCH_LVL0	5:4	R/W	Select clock squelch level. Note that a clock from the Cu PHY will be output on the recovered clock output in this mode when the link is down. 00: Automatically squelch clock to low when the link is not up, is unstable, is up in a mode that does not support the generation of a recovered clock (1000BASE-T master or 10BASE-T), or is up in EEE mode (100BASE-TX or 1000BASE-T slave). 01: Same as 00 except that the clock is also generated in 1000BASE-T master and 10BASE-T link-up modes. This mode also generates a recovered clock output in EEE mode during reception of LP_IDLE. 10: Squelch only when the link is not up. 11: Disable clock squelch.	0x0
CLK_SEL_PHY0	2:0	R/W	Clock selection for specified PHY. 000: Reserved. 001: Copper PHY recovered clock 010: Copper PHY transmitter TCLK 011-111: Reserved.	0x0

7.20.4.3 PHY:PHY_GP:PHY_RCVD_CLK1_CTRL

Parent: PHY:PHY_GP

Instances: 1

Table 816 • **Fields in PHY_RCVD_CLK1_CTRL**

Field Name	Bit	Access	Description	Default
RCVD_CLK1_ENA	15	R/W	Enable RCVRD_CLK[1].	0x0
CLK_SRC_SEL1	14:11	R/W	Clock source select. 0000: PHY0 0001: PHY1 0010: PHY2 0011: PHY3 0100: PHY4 0101: PHY5 0110: PHY6 0111: PHY7 1000-1111: Reserved	0x0

Table 816 • **Fields in PHY_RCVD_CLK1_CTRL** ***(continued)***

Field Name	Bit	Access	Description	Default
CLK_FREQ_SEL1	10:8	R/W	Clock frequency select. 000: 25 MHz output clock 001: 125 MHz output clock 010: 31.25 MHz output clock 011-111: Reserved	0x0
CLK_SQUELCH_LVL1	5:4	R/W	Select clock squelch level. Note that a clock from the Cu PHY will be output on the recovered clock output in this mode when the link is down. 00: Automatically squelch clock to low when the link is not up, is unstable, is up in a mode that does not support the generation of a recovered clock (1000BASE-T master or 10BASE-T), or is up in EEE mode (100BASE-TX or 1000BASE-T slave). 01: Same as 00 except that the clock is also generated in 1000BASE-T master and 10BASE-T link-up modes. This mode also generates a recovered clock output in EEE mode during reception of LP_IDLE. 10: Squelch only when the link is not up. 11: Disable clock squelch.	0x0
CLK_SEL_PHY1	2:0	R/W	Clock selection for specified PHY. 000: Reserved. 001: Copper PHY recovered clock 010: Copper PHY transmitter TCLK 011-111: Reserved.	0x0

7.20.4.4 PHY:PHY_GP:PHY_ENHANCED_LED_CTRL

Parent: PHY:PHY_GP

Instances: 1

Table 817 • **Fields in PHY_ENHANCED_LED_CTRL**

Field Name	Bit	Access	Description	Default
LED_PULSE_DUTY	15:8	R/W	LED pulsing duty cycle control. Programmable control for LED pulsing duty cycle when PHY_STD::PHY_LED_BEHAVIOR_CTRL.PULSING_ENA is set to 1. Valid settings are between 0 and 198. A setting of 0 corresponds to a 0.5% duty cycle and 198 corresponds to a 99.5% duty cycle. Intermediate values change the duty cycle in 0.5% increments.	0x00

7.20.4.5 PHY:PHY_GP:PHY_GLOBAL_INT_STAT

Parent: PHY:PHY_GP

Instances: 1

Table 818 • **Fields in PHY_GLOBAL_INT_STAT**

Field Name	Bit	Access	Description	Default
RESERVED	12:8	R/O	Must be set to its default.	0x1
PHY11_INT_SRC	11	R/O	Must be set to its default.	0x1
PHY10_INT_SRC	10	R/O	Must be set to its default.	0x1
PHY9_INT_SRC	9	R/O	Must be set to its default.	0x1
PHY8_INT_SRC	8	R/O	Must be set to its default.	0x1
PHY7_INT_SRC	7	R/O	Indicates that PHY7 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY7.	0x1
PHY6_INT_SRC	6	R/O	Indicates that PHY6 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY6.	0x1
PHY5_INT_SRC	5	R/O	Indicates that PHY5 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY5.	0x1
PHY4_INT_SRC	4	R/O	Indicates that PHY4 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY4.	0x1

Table 818 • **Fields in PHY_GLOBAL_INT_STAT *(continued)***

Field Name	Bit	Access	Description	Default
PHY3_INT_SRC	3	R/O	Indicates that PHY3 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY3.	0x1
PHY2_INT_SRC	2	R/O	Indicates that PHY2 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY2.	0x1
PHY1_INT_SRC	1	R/O	Indicates that PHY1 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY1.	0x1
PHY0_INT_SRC	0	R/O	Indicates that PHY0 is the source of the interrupt when this bit is cleared. This bit is set high when reading register PHY_INT_STAT in PHY0.	0x1

7.20.5 PHY:PHY_EEE

Parent: PHY

Instances: 1

Access to these registers is through the IEEE standard registers MMD_ACCESS_CFG and MMD_ADDR_DATA.

Table 819 • **Registers in PHY_EEE**

Register Name	Offset within Register Group	Instances and Address Spacing	Description	Details
PHY_PCS_STATUS1	0x00000000	1	PCS Status 1 (Address 3.1)	Page 623
PHY_EEE_CAPABILITIES	0x00000001	1	EEE Capabilities (Address 3.20)	Page 624
PHY_EEE_WAKE_ERR_CNT	0x00000002	1	EEE Wake Error Counter (Address 3.22)	Page 624
PHY_EEE_ADVERTISEMENT	0x00000003	1	EEE Advertisement (Address 7.60)	Page 625
PHY_EEE_LP_ADVERTISEMENT	0x00000004	1	EEE Link Partner Advertisement (Address 7.61)	Page 625

7.20.5.1 PHY:PHY_EEE:PHY_PCS_STATUS1

Parent: PHY:PHY_EEE

Instances: 1

Status of the EEE operation from the PCS for the link that is currently active.

Table 820 • **Fields in PHY_PCS_STATUS1**

Field Name	Bit	Access	Description	Default
TX_LPI_RECV	11	R/O	0: LPI not received 1: Tx PCS has received LPI	0x0
RX_LPI_RECV	10	R/O	1: Rx PCS has received LPI 0: LPI not received	0x0
TX_LPI_INDICATION	9	R/O	1: Tx PCS is currently receiving LPI 0: PCS is not currently receiving LPI	0x0
RX_LPI_INDICATION	8	R/O	1: Rx PCS is currently receiving LPI 0: PCS is not currently receiving LPI	0x0
PCS_RECV_LINK_STAT	2	R/O	1: PCS receive link up 0: PCS receive link down	0x0

7.20.5.2 PHY:PHY_EEE:PHY_EEE_CAPABILITIES

Parent: PHY:PHY_EEE

Instances: 1

Indicate the capability of the PCS to support EEE functions for each PHY type.

Table 821 • **Fields in PHY_EEE_CAPABILITIES**

Field Name	Bit	Access	Description	Default
EEE_1000BT	2	R/O	Reserved. Do not modify this bit. Must be set to its default.	0x0
EEE_100BTX	1	R/O	Set if EEE is supported for 100BASE-TX. 1: EEE is supported for 100BASE-TX 0: EEE is not supported for 100BASE-TX	0x1

7.20.5.3 PHY:PHY_EEE:PHY_EEE_WAKE_ERR_CNT

Parent: PHY:PHY_EEE

Instances: 1

This register is used by PHY types that support EEE to count wake time faults where the PHY fails to complete its normal wake sequence within the time required for the specific PHY type. The definition of the fault event to be counted is defined for each PHY and can occur during a refresh or a wakeup as

defined by the PHY. This 16-bit counter is reset to all zeros when the EEE wake error counter is read or when the PHY undergoes hardware or software reset.

Table 822 • **Fields in PHY_EEE_WAKE_ERR_CNT**

Field Name	Bit	Access	Description	Default
EEE_WAKE_ERR_CNT	15:0	R/O	Count of wake time faults for a PHY.	0x0000

7.20.5.4 PHY:PHY_EEE:PHY_EEE_ADVERTISEMENT

Parent: PHY:PHY_EEE

Instances: 1

Defines the EEE advertisement that is sent in the unformatted next page following a EEE technology message code.

Table 823 • **Fields in PHY_EEE_ADVERTISEMENT**

Field Name	Bit	Access	Description	Default
EEE_1000BT_ADV	2	R/W	Reserved. Do not modify this bit. Must be set to its default.	0x0
EEE_100BTX_ADV	1	R/W	Set if EEE is supported for 100BASE-TX. 1: Advertise that the 100BASE-TX has EEE capability 0: Do not advertise that the 100BASE-TX has EEE capability	0x0

7.20.5.5 PHY:PHY_EEE:PHY_EEE_LP_ADVERTISEMENT

Parent: PHY:PHY_EEE

Instances: 1

All the bits in the EEE LP Advertisement register are read only. A write to the EEE LP advertisement register has no effect. When the AN process has been completed, this register will reflect the contents of the link partner's EEE advertisement register.

Table 824 • **Fields in PHY_EEE_LP_ADVERTISEMENT**

Field Name	Bit	Access	Description	Default
EEE_1000BT_LP_ADV	2	R/O	Set if EEE is supported for 1000BASE-T by link partner. 1: Link partner is advertising EEE capability for 1000BASE-T 0: Link partner is not advertising EEE capability for 1000BASE-T	0x0

Table 824 • **Fields in PHY_EEE_LP_ADVERTISEMENT** ***(continued)***

Field Name	Bit	Access	Description	Default
EEE_100BTX_LP_ADV	1	R/O	Set if EEE is supported for 100BASE-TX by link partner. 1: Link partner is advertising EEE capability for 100BASE-TX 0: Link partner is not advertising EEE capability for 100BASE-TX	0x0

8 Electrical Specifications

This section provides the DC characteristics, AC characteristics, recommended operating conditions, and stress ratings for the VSC7428-12 device.

8.1 DC Characteristics

This section contains the DC specifications for the VSC7428-12 device.

8.1.1 Internal Pull-Up or Pull-Down Resistors

Internal pull-up or pull-down resistors are specified in the following table. For more information about signals with internal pull-up or pull-down resistors, see Pins by Function, page 658.

All internal pull-up resistors are connected to their respective I/O supply.

Table 825 • **Internal Pull-Up or Pull-Down Resistors**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Internal pull-up resistor, GPIO and SI pins	R_{PU}	33	53	90	kΩ
Internal pull-up resistor, all other pins	R_{PD}	96	120	144	kΩ
Internal pull-down resistor	R_{PD}	96	120	144	kΩ

8.1.2 Reference Clock

The following table lists the DC specifications for the differential RefClk signal. Differential and single-ended modes are supported. For more information about single-ended mode operation, see Single-Ended RefClk Input, page 682.

Table 826 • **Reference Clock Input DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit
Input voltage range	V_{IP}, V_{IN}	–25	1260	mV
Input differential voltage, peak-to-peak	$\|V_{ID}\|$	150(1)	1000	mV
Input common-mode voltage	V_{CM}	0	1200(2)	mV

1. To meet jitter specifications, the minimum input differential voltage must be 400 mV. When using a single-ended clock input, the RefClk_P low voltage level must be lower than V_{DD_A} – 200 mV, and the high voltage level must be higher than V_{DD_A} + 200 mV.
2. The maximum common-mode voltage is given without any differential signal, because the input is internally AC-coupled. The common-mode voltage is only limited by the maximum and minimum input voltage range and the input signal's differential amplitude.

8.1.3 DDR2 SDRAM Interface

The DDR2 SDRAM interface supports the requirements of SDRAM devices as described in the JEDEC DDR2 specifications. The SDRAM interface signals are compatible with JESD79-2E (DDR2 SDRAM Specification, April 2008) and the JESD8-15A (Stub Series Terminated Logic for 1.8V (SSTL_18), September 2003). The SSTL I/O buffers have programmable on-die termination (ODT).

The following table lists the DC specifications for SDRAM interface signals.

Table 827 • **DDR2 SDRAM Signal DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Input voltage reference(1)	DDR_V_{REF}	49% V_{DD_IODDR}	51% V_{DD_IODDR}	V	
Input voltage high	$V_{IH(DC)}$	DDR_V_{REF} + 0.125	V_{DD_IODDR} + 0.3	V	
Input voltage low	$V_{IL(DC)}$	–0.3	DDR_V_{REF} – 0.125	V	
Input leakage current	$\|I_L\|$		58	µA	$0V \le V_I \le V_{DD_IODDR}$.
Output source DC current(2)	I_{OH}	–6		mA	External 50 Ω termination to $V_{DD_IODDR}/2$.
Output sink DC current(2)	I_{OL}	6		mA	External 50 Ω termination to $V_{DD_IODDR}/2$.

1. DDR_V_{REF} is expected to track variations in V_{DD_IODDR}. Peak-to-peak AC noise on DDR_V_{REF} must not exceed ±2% of DDR_V_{REF}.
2. With 40 Ω output driver impedance.

8.1.4 SGMII DC Definitions and Test Circuits

This section provides information about the definitions and test circuits that apply to certain parameters for the Enhanced SerDes and SerDes interfaces. The following illustrations show the DC definitions for the SGMII inputs and outputs.

Figure 94 • **SGMII DC Input Definitions**

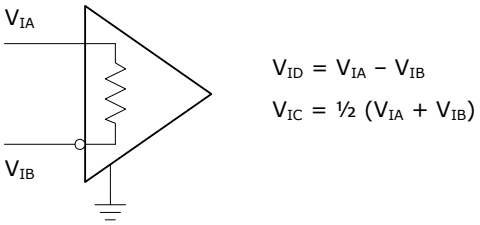


Figure 95 • **SGMII DC Transmit Test Circuit**

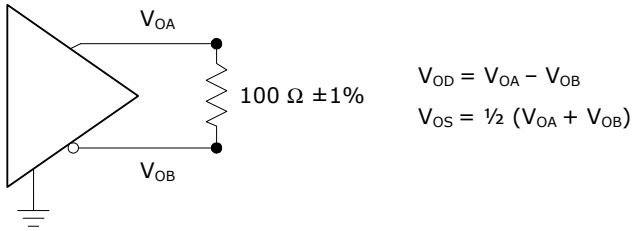
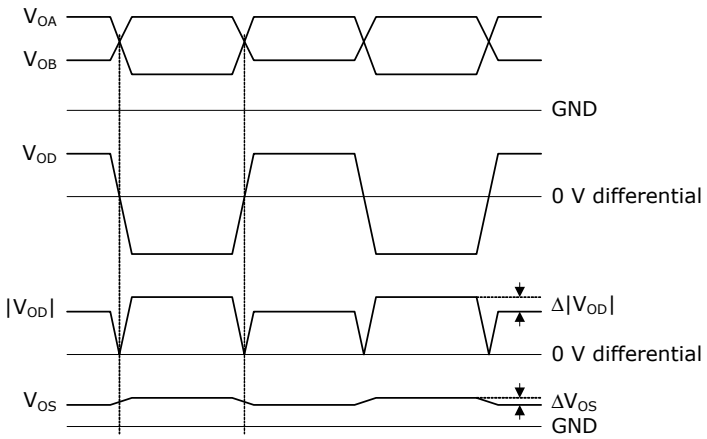


Figure 96 • **SGMII DC Definitions**

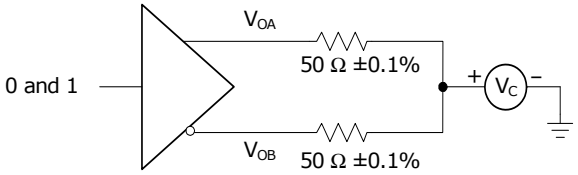


$\Delta|V_{OD}| = | |V_{OAH} - V_{OBL}| - |V_{OBH} - V_{OAL}| |$

$\Delta V_{OS} = | ½(V_{OAH} + V_{OBL}) - ½(V_{OAL} + V_{OBH}) |$

The following illustrations show the SMGII DC driver output impedance test circuit and the DC input definitions.

Figure 97 • **SGMII DC Driver Output Impedance Test Circuit**



8.1.5 Enhanced SerDes Interface

All DC specifications for the Enhanced SerDes interface are compliant with OIF-CEI version 2.0 requirements where applicable.

The Enhanced SerDes interface supports three major modes: SGMII, 2.5G, and SFP. The values in the following table apply to modes specified.

Table 828 • **Enhanced SerDes Driver DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Output differential peak voltage(1), 1.0 V, SFP and 2.5G modes	$\|V_{ODp}\|$	250	400	mV	V_{DD_VS} = 1.0 V. R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.0 V and 1.2 V, SGMII mode	$\|V_{ODp}\|$	150	400	mV	V_{DD_VS} = 1.0 V, V_{DD_VS} = 1.2 V. R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.2 V, SFP mode	$\|V_{ODp}\|$	300	600	mV	V_{DD_VS} = 1.2 V. R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.2 V, 2.5G mode	$\|V_{ODp}\|$	360	600	mV	V_{DD_VS} = 1.2 V. R_L = 100 Ω ±1%, maximum drive

Table 828 • **Enhanced SerDes Driver DC Specifications *(continued)***

Parameter	Symbol	Minimum	Maximum	Unit	Condition
DC output impedance, single-ended, SGMII mode	R_O	40	140	Ω	V_C = 1.0 V and 1.2 V. See Figure 97, page 629.
R_O mismatch between A and B(2), SGMII mode	ΔR_O		10	%	V_C = 1.0 V and 1.2 V. See Figure 97, page 629.
Change in $\|V_{OD}\|$ between 0 and 1, SGMII mode	$\Delta\|V_{OD}\|$		25	mV	R_L = 100 Ω ±1%
Change in V_{OS} between 0 and 1, SGMII mode	ΔV_{OS}		25	mV	R_L = 100 Ω ±1%.
Output current, driver shorted to GND, SGMII mode	$\|I_{OSA}\|$, $\|I_{OSB}\|$		40	mA	
Output current, drivers shorted together, SGMII mode	$\|I_{OSAB}\|$		12	mA	

1. Voltage is adjustable in 64 steps. For more information about setting the adjustable voltages, see the OB_LEV bit in Table 528, page 426. To meet the return loss specification, the maximum swing is 600 mV peak-to-peak for V_{DD_VS} = 1.0 V and 950 mV peak-to-peak for V_{DD_VS} = 1.2 V.
2. Matching of reflection coefficients. For more information about test methods, see IEEE 1596.3-1996.

The following table lists the DC specifications for the Enhanced SerDes receivers. In most applications, AC-coupling is required. For more information, see Enhanced SerDes Interface, page 684.

Table 829 • **Enhanced SerDes Receiver DC Specifications**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Input voltage range, V_{IA} or V_{IB}	V_I	–0.25		1.2	V
Input differential peak voltage(1), SGMII and SFP modes	$\|V_{ID}\|$	50		800	mV
Input differential peak voltage(1), 2.5G mode	$\|V_{ID}\|$	50		800	mV
Receiver differential input impedance	R_I	80	100	120	Ω

1. Ranges specified are for optimal operation.

8.1.6 SerDes (SGMII) Interface

The SerDes output drivers are designed to operate in an SGMII/LVDS mode and in a high-drive/PECL mode (SFP and 1000BASE-KX modes). The SGMII/LVDS mode meets or exceeds the DC requirements of the Serial-GMII Specification version 1.9, unless otherwise noted.

The following table lists the DC specifications for the SGMII driver. The values are valid for all configurations, unless stated otherwise.

Table 830 • **SerDes Driver DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Output high voltage, V_{OA} or V_{OB}	V_{OH}		1250	mV	R_L = 100 Ω ±1%.
Output low voltage, V_{OA} or V_{OB}	V_{OL}	0		mV	R_L = 100 Ω ±1%.

Table 830 • **SerDes Driver DC Specifications *(continued)***

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Output differential peak voltage(1), 1.0 V	$\|V_{OD}\|$	150	400	mV	V_{DD_VS} = 1.0 V, R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.2 V	$\|V_{OD}\|$	150	600	mV	V_{DD_VS} = 1.2 V, R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.0 V and 1.2 V, SGMII mode	$\|V_{OD}\|$	150	400	mV	V_{DD_VS} = 1.0 V, V_{DD_VS} = 1.2 V. R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.2 V, 1000BASE-KX mode	$\|V_{OD}\|$	400	600	mV	V_{DD_VS} = 1.2 V, R_L = 100 Ω ±1%.
Output differential peak voltage(1), 1.2 V, SFP mode	$\|V_{OD}\|$	300	600	mV	V_{DD_VS} = 1.2 V, R_L = 100 Ω ±1%.
Output offset voltage(2), 1.0 V	V_{OS}	420	580	mV	V_{DD_VS} = 1.0 V, R_L = 100 Ω ±1%.
Output offset voltage(2), 1.2 V	V_{OS}	445	605	mV	V_{DD_VS} = 1.2 V, R_L = 100 Ω ±1%.
DC output impedance, single-ended, SMGII mode	R_O	40	140	Ω	V_C = 1.0 V and 1.2 V. See Figure 97, page 629.
R_O mismatch between A and B(3), SMGII mode	ΔR_O		10	%	V_C = 1.0 V and 1.2 V. See Figure 97, page 629.
Change in $\|V_{OD}\|$ between 0 and 1, SGMII mode	$\Delta\|V_{OD}\|$		25	mV	R_L = 100 Ω ±1%.
Change in V_{OS} between 0 and 1, SGMII mode	ΔV_{OS}		25	mV	R_L = 100 Ω ±1%.
Output current, driver shorted to GND, SGMII mode	$\|I_{OSA}\|$, $\|I_{OSB}\|$		40	mA	
Output current, drivers shorted together, SGMII mode	$\|I_{OSAB}\|$		12	mA	

1. Voltage is adjustable in 14 steps. For more information about setting the adjustable voltages, see the OB_AMP_CTRL bit in Table 513, page 417. To meet the return loss specification, the maximum swing is 600 mV peak-to-peak for V_{DD_VS} = 1.0 V and 950 mV peak-to-peak for V_{DD_VS} = 1.2 V.
2. Requires AC-coupling for SGMII compliance.
3. Matching of reflection coefficients. For more information about test methods, see IEEE 1596.3-1996.

The following table lists the DC specifications for the SGMII receivers.

Table 831 • **SerDes Receiver DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Input voltage range, V_{IA} or V_{IB}	V_I	–25	1250	mV	
Input differential peak voltage	$\|V_{ID}\|$	50	1000	mV	

Table 831 • **SerDes Receiver DC Specifications *(continued)***

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Input common-mode voltage(1)	V_{IC}	0	V_{DD_A}(2)	mV	Without any differential signal (internally AC-coupled)
Receiver differential input impedance	R_I	80	120	Ω	
Input differential hysteresis, SGMII mode	V_{HYST}	25		mV	

1. SGMII compliancy requires external AC-coupling. When interfacing with specific Vitesse devices, DC-coupling is possible. For more information, contact your Vitesse representative.
2. The maximum common-mode voltage is given without any differential signal, because the input is internally AC-coupled. The common-mode voltage is only limited by the maximum and minimum input voltage range and the input signal's differential swing.

8.1.7 MIIM, GPIO, SI, JTAG, and Miscellaneous Signals

This section provides the DC specifications for the MII Management (MIIM), GPIO, SI, JTAG, and miscellaneous signals. The following I/O signals comply with the specifications provided in this section.

Table 832 • **I/O Signals**

MDC	JTAG_nTRST	Reserved
MDIO	JTAG_TMS	RefClk_Sel[2:0]
GPIO[31:0]	JTAG_TDO	VCORE_CFG[2:0]
SI_Clk	JTAG_TCK	VCore_ICE_nEn
SI_DI	JTAG_TDI	RCVRD_CLK[1:0]
SI_DO	nReset	
SI_nEn	COMA_MODE	

The outputs and inputs meet or exceed the requirements of the LVTTL and LVCMOS standard, JEDEC JESD8-B (September 1999) standard, unless otherwise stated. The inputs are Schmitt-trigger for noise immunity.

Table 833 • **MIIM, GPIO, SI, JTAG, and Miscellaneous Signals DC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Output high voltage, I_{OH} = –12 mA	V_{OH}	1.7		V	
Output high voltage, I_{OH} = –2 mA	V_{OH}	2.1		V	
Output low voltage, I_{OL} = 12 mA	V_{OL}		0.7	V	
Output low voltage, I_{OL} = 2 mA	V_{OL}		0.4	V	
Input high voltage	V_{IH}	1.85	3.6	V	
Input low voltage	V_{IL}	–0.3	0.8	V	
Input high current(1)	I_{IH}		10	µA	$V_I = V_{DD_IO}$
Input low current(1)	I_{IL}	–10		µA	V_I = 0 V
Input capacitance	C_I		10	pF	

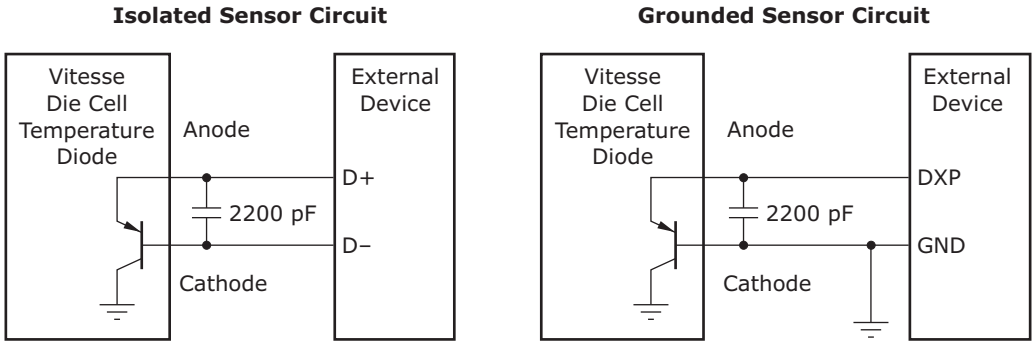
1. Input high current and input low current equals the maximum leakage current, excluding the current in the built-in pull resistors.

8.1.8 Thermal Diode

The device includes an on-die diode and internal circuitry for monitoring die temperature (junction temperature). The operation and accuracy of the diode is not guaranteed and should only be used as a reference.

The on-die thermal diode requires an external thermal sensor, located on the board or in a stand-alone measurement kit. Temperature measurement using a thermal diode is very sensitive to noise. The following illustration shows a generic application design.

Figure 98 • **Thermal Diode**



Note: Vitesse does not support or recommend operation of the thermal diode under reverse bias.

The following table provides the diode parameter and interface specifications with the pins connected internally to VSS in the device.

Table 834 • **Thermal Diode Parameters**

Parameter	Symbol	Typical	Maximum	Unit
Forward bias current	I_{FW}	See note(1)	1	mA
Diode ideality factor	n	1.008		

1. Typical value is device dependent.

The ideality factor, n, represents the deviation from ideal diode behavior as exemplified by the following diode equation:

$$I_{FW} = I_S(e^{(qV_D)/(nkT)} - 1)$$

where, I_S = saturation current, q = electronic charge, V_D = voltage across the diode, k = Boltzmann constant, and T = absolute temperature (Kelvin).

8.2 AC Characteristics

This section provides the AC specifications for the VSC7428-12 device.

8.2.1 Reference Clock

The signal applied to the RefClk differential input must comply with the requirements listed in the following table at the pin of the device.

Table 835 • **Reference Clock AC Specifications**

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Condition
RefClk_Sel = 000	*f*	–100 ppm	125	100 ppm	MHz	
RefClk_Sel = 001	*f*	–100 ppm	156.25	100 ppm	MHz	
RefClk_Sel = 100	*f*	–100 ppm	25	100 ppm	MHz	

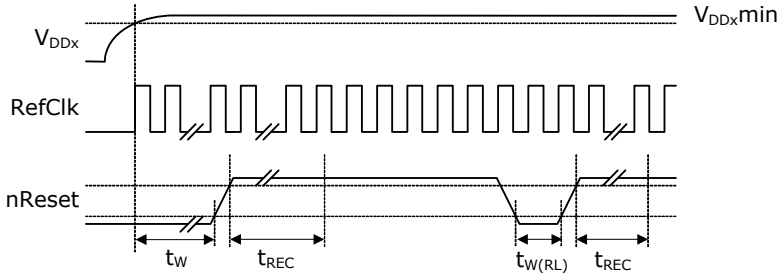
Table 835 • **Reference Clock AC Specifications *(continued)***

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Condition
RefClk_Sel = 010	*f*	–100 ppm	250	100 ppm	MHz	
Clock duty cycle		40		60	%	Measured at 50% threshold.
Rise time and fall time	t_R, t_F			1.5	ns	20% to 80% threshold.
RefClk input RMS jitter, bandwidth between 12 kHz and 500 kHz				20	ps	
RefClk input RMS jitter, bandwidth between 500 kHz and 15 MHz				4	ps	
RefClk input RMS jitter, bandwidth between 15 MHz and 40 MHz				20	ps	
RefClk input RMS jitter, bandwidth between 40 MHz and 80 MHz				100	ps	
Jitter gain from RefClk to SerDes output, bandwidth between 0 MHz and 0.1 MHz				0.3	dB	
Jitter gain from RefClk to SerDes output, bandwidth between 0.1 MHz and 7 MHz				3	dB	
Jitter gain from RefClk to SerDes output, bandwidth above 7 MHz				3 – 20 × log (*f*/7 MHz)	dB	

8.2.2 Reset Timing

The nReset signal waveform and the required measurement points for the timing specification are shown in the following illustration.

Figure 99 • **nReset Signal Timing Specifications**



The signal applied to the nReset input must comply with the specifications listed in the following table at the reset pin of the device.

Table 836 • **nReset Timing Specifications**

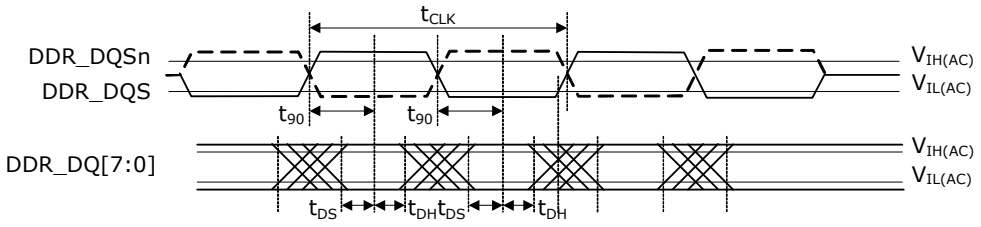
Parameter	Symbol	Minimum	Maximum	Unit
nReset assertion time after power supplies and clock stabilize	t_W	2		ms
Recovery time from reset inactive to device fully active	t_{REC}		50	ms
nReset pulse width	$t_{W(RL)}$	100		ns

8.2.3 DDR2 SDRAM Signal

This section provides the AC characteristics for the DDR2 SDRAM interface.

The following illustration shows the DDR2 SDRAM input timing diagram.

Figure 100 • **DDR2 SDRAM Input Timing Diagram**



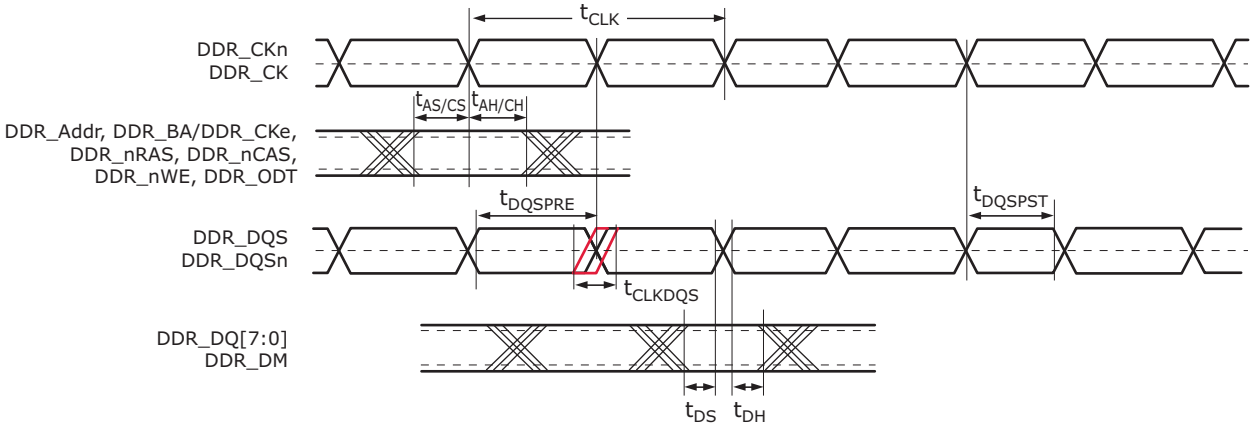
The following table lists the AC specifications for the DDR2 SDRAM input signals.

Table 837 • **DDR2 SDRAM Input Signal AC Characteristics**

Parameter	Symbol	Minimum	Maximum	Unit
Input voltage high	$V_{IH(AC)}$	DDR_V_{REF} + 0.20	V_{DD_IODDR} + 0.3	V
Input voltage low	$V_{IL(AC)}$	–0.3	DDR_V_{REF} – 0.20	V
Differential input voltage	$V_{ID(AC)}$	0.5	V_{DD_IODDR}	V
Differential crosspoint voltage	$V_{IX(AC)}$	0.5 × V_{DD_IODDR} – 0.175	0.5 × V_{DD_IODDR} + 0.175	V
DDR_DQ[7:0] input setup time relative to DDR_DQS/DDR_DQSn	t_{DS}		350	ps
DDR_DQ[7:0] input hold time relative to DDR_DQS/DDR_DQSn	t_{DH}		250	ps

The following illustration shows the timing diagram for the DDR2 SDRAM outputs.

***Figure 101* • DDR2 SDRAM Output Timing Diagram**



The following table lists the AC characteristics for the DDR2 SDRAM output signals.

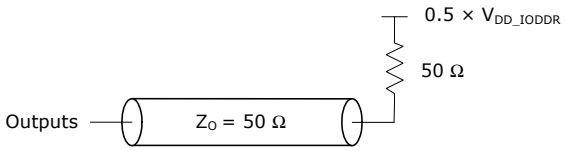
***Table 838* • DDR2 SDRAM Output Signal AC Characteristics**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
DDR_CK cycle time 208 MHz (DDR400)(1)	t_{CLK}		4.80		ns
DDR_CK/CKn duty cycle		48		52	%
DDR_A, DDR_BA, DDR_CKe, DDR_nRAS, DDR_nCAS, DDR_ODT, and DDR_nWE output setup time relative to DDR_CK/CKn	t_{AS}	1000			ps
DDR_A, DDR_BA, DDR_CKe, DDR_nRAS, DDR_nCAS, DDR_ODT, and DDR_nWE output hold time relative to DDR_CK/CKn	t_{AH}	1000			ps
DDR_CK/CKn to DDR_DQS/DDR_DQSn skew	t_{CLKDQS}	–600		600	ps
DDR_DQ[7:0]/DDR_DM output setup time with relative to DDR_DQS/DDR_DQSn	t_{DS}	700			ps
DDR_DQ[7:0]/DDR_DM output hold time relative to DDR_DQS/DDR_DQSn	t_{DH}	700			ps
DDR_DQS/DDR_DQSn preamble start	t_{DQSPRE}	0.4 × t_{CLK}		–0.6 × t_{CLK}	ps
DDR_DQS/DDR_DQSn postamble end	t_{DQSPST}	0.4 × t_{CLK}		–0.6 × t_{CLK}	ps

1. Timing reference is DDR_CK/DDR_CKn crossing ±0.1 V.

The following illustration shows the test load circuit for the DDR2 outputs.

***Figure 102* • Test Load Circuit for DDR2 Outputs**



8.2.4 Enhanced SerDes Interface

All AC specifications are compliant with OIF-CEI version 2.0 requirements where applicable.

The Enhanced SerDes interface supports three major modes: SGMII, 2.5G, and SFP. The values in the tables in the following sections apply to modes listed in the condition column and are based on the test circuit. For more information, see Figure 95, page 628.

8.2.4.1 Enhanced SerDes Outputs

The following table provides the AC specifications for the Enhanced SerDes outputs in SGMII mode.

Table 839 • **Enhanced SerDes Output AC Specifications in SGMII Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Unit interval, 1.25G	UI				800 ps.
V_{OD} ringing compared to V_S	V_{RING}		±10	%	R_L = 100 Ω ±1%.
V_{OD} rise time and fall time	t_R, t_F	100	200	ps	20% to 80% of V_S, R_L = 100 Ω ±1%.
Differential output peak-to-peak voltage	V_{OD}		30	mV	Tx disabled.
Differential output return loss, 1000BASE-KX mode, 50 MHz to 625 MHz	RL_{TX_DIFF}	≥10		dB	R_L = 100 Ω ±1%.
Differential output return loss, 1000BASE-KX mode, 625 MHz to 1250 MHz	RL_{TX_DIFF}	10–10 × log (f/625 MHz)		dB	R_L = 100 Ω ±1%
Common mode return loss, 1000BASE-KX mode	RL_{CM}	6		dB	50 MHz to 625 MHz
Intrapair skew, SGMII mode	t_{SKEW}		20	ps	

The following table provides the AC specifications for the Enhanced SerDes outputs in 2.5G mode.

Table 840 • **Enhanced SerDes Output AC Specifications in 2.5G Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Unit interval, 2.5G	UI				320 ps.
V_{OD} rise time and fall time	t_R, t_F	60	130	ps	20% to 80% of V_S, R_L = 100 Ω ±1%.
Differential output peak-to-peak voltage, SGMII mode	V_{OD}		30	mV	Tx disabled.
Differential output return loss, 100 MHz to 625 MHz	RL_{TX_DIFF}	10		dB	R_L = 100 Ω ±1%.
Differential output return loss, 625 MHz to 3.125 GHz		10–10 × log (*f*/625 MHz)		dB	R_L = 100 Ω ±1%.
Eye mask (T_X1)			0.175	UI	
Eye mask (T_X2)			0.390	UI	
Eye mask (T_Y1)		200		mV	
Eye mask (T_Y2)			400	mV	

8.2.4.2 Enhanced SerDes Driver Jitter Characteristics

The following table lists the jitter characteristics for the Enhanced SerDes driver in SGMII mode.

Table 841 • **Enhanced SerDes Driver Jitter Characteristics in SGMII Mode**

Parameter	Symbol	Maximum	Unit	Condition
Total output jitter	$t_{JIT(O)}$	192	ps	Measured according to IEEE 802.3.38.5.
Deterministic output jitter	$t_{JIT(OD)}$	80	ps	Measured according to IEEE 802.3.38.5.

8.2.4.3 Enhanced SerDes Inputs

The following table lists the AC specifications for the Enhanced SerDes inputs in SGMII mode.

Table 842 • **Enhanced SerDes Input AC Specifications in SGMII Mode**

Parameter	Symbol	Minimum	Unit	Condition
Unit interval, 1.25G	UI		ps	800 ps.
Differential input return loss	RL_{RX_DIFF}	10	dB	50 MHz to 625 MHz, R_L = 100 Ω ±1%.
Common-mode input return loss		6	dB	50 MHz to 625 MHz.

The following table lists the AC specifications for the Enhanced SerDes inputs in 2.5G mode.

Table 843 • **Enhanced SerDes Input AC Specifications in 2.5G Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Unit interval, 2.5G	UI				320 ps.
Differential input return loss	RL_{RX_DIFF}	10		dB	100 MHz to 2.5 GHz, R_L = 100 Ω ±1%.
Common-mode input return loss		6		dB	100 MHz to 2.5 GHz.
Eye mask (R_X1)			0.275	UI	
Eye mask (R_X2)			0.5	UI	
Eye mask (R_Y1)		100		mV	
Eye mask (R_Y2)			800	mV	

8.2.4.4 Enhanced SerDes Receiver Jitter Tolerance

The following table lists jitter tolerances for the Enhanced SerDes receiver in SGMII mode.

Table 844 • **Enhanced SerDes Receiver Jitter Tolerance in SGMII Mode**

Parameter	Symbol	Minimum	Unit	Condition
Total input jitter tolerance, 1000BASE-KX and SFP modes	$t_{JIT(I)}$	600	ps	Above 637 kHz. Measured according to IEEE 802.3 38.6.8.
Deterministic input jitter tolerance, 1000BASE-KX and SFP mode	$t_{JIT(ID)}$	370	ps	Above 637 kHz. Measured according to IEEE 802.3 38.6.8.

Table 844 • **Enhanced SerDes Receiver Jitter Tolerance in SGMII Mode**

Parameter	Symbol	Minimum	Unit	Condition
Cycle distortion input jitter tolerance, 100BASE-FX mode	D_{CD}	1.4	ns	Measured according to ISO/IEC 9314-3:1990. IB_ENA_CMV_TERM = 1 IB_ENA_DC_COUPLING = 1
Data-dependent input jitter tolerance, 100BASE-FX mode	D_{DJ}	2.2	ns	Measured according to ISO/IEC 9314-3:1990. IB_ENA_CMV_TERM = 1 IB_ENA_DC_COUPLING = 1
Random input jitter tolerance, peak-to-peak, 100BASE-FX mode	R_J	2.27	ns	Measured according to. ISO/IEC 9314-3:1990. IB_ENA_CMV_TERM = 1 IB_ENA_DC_COUPLING = 1

8.2.5 SerDes (SGMII) Interface

In SGMII mode, the SGMII interface is compliant with Serial-GMII Specification, version 1.9.

In 1000BASE-KX mode, the SGMII interface is compliant with IEEE 802.3 clause 70.

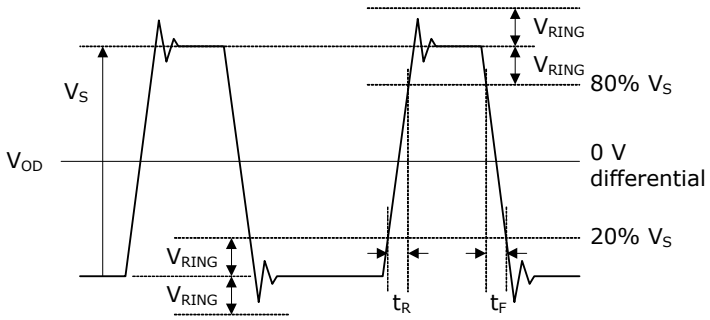
In SFP mode, the SGMII interface is compliant with the SFP MSA standard.

In 100BASE-FX mode, the SGMII interface is compliant with IEEE 802.3 clause 26.

The rise time and fall time parameters and other transient performance specifications are defined in the following illustration. The definition of V_S is the difference between the steady state high and low voltage of the differential signal.

In addition, the signals are monotonic between 20% and 80% of V_S when loaded with 100 Ω ±1%.

Figure 103 • **SGMII Transient Parameters**



All SerDes driver signals comply with the conditions listed in the following table when measured with the test circuit shown in Figure 95, page 628.

8.2.5.1 SerDes Outputs

The values in the following table are valid for all configurations, unless stated in the conditions column.

Table 845 • **SerDes Output AC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
V_{OD} ringing compared to V_S, SGMII mode	V_{RING}		±10	%	R_L = 100 Ω ±1%.
V_{OD} rise time and fall time, SGMII mode	t_R, t_F	100	200	ps	20% to 80% of V_S, R_L = 100 Ω ±1%.

Table 845 • **SerDes Output AC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Differential output peak-to-peak voltage	V_{OD}		30	mV	Tx disabled.
Differential output return loss, 1000BASE-KX mode, 50 MHz to 625 MHz	RL_{TX_DIFF}	≥10		dB	R_L = 100 Ω ±1%.
Differential output return loss, 1000BASE-KX mode, 625 MHz to 1250 MHz	RL_{TX_DIFF}	10–10 × log (*f*/625 MHz)		dB	R_L = 100 Ω ±1%.
Common-mode return loss, 1000BASE-KX mode	RL_{CM}	6		dB	50 MHz to 625 MHz.
Intrapair skew, SGMII mode	t_{SKEW}		20	ps	

8.2.5.2 SerDes Driver Jitter Characteristics

The following table lists the jitter characteristics for the SerDes driver.

Table 846 • **SerDes Driver Jitter Characteristics**

Parameter	Symbol	Maximum	Unit	Condition
Total output jitter	$t_{JIT(O)}$	192	ps	Measured according to IEEE 802.3.38.5.
Deterministic output jitter	$t_{JIT(OD)}$	80	ps	Measured according to IEEE 802.3.38.5.

8.2.5.3 SerDes Inputs

The following table lists the AC specifications for the SerDes inputs.

Table 847 • **SerDes Input AC Specifications**

Parameter	Symbol	Maximum	Unit	Condition
Differential input return loss, 1000BASE-KX mode, 50 MHz to 625 MHz		≥10	dB	R_L = 100 Ω ±1%.
Differential input return loss, 1000BASE-KX mode, 625 MHz to 1250 MHz		10–10 × log (*f*/625 MHz)	dB	R_L = 100 Ω ±1%.

8.2.5.4 SerDes Receiver Jitter Tolerance

The following table lists jitter tolerances for the SerDes receiver.

Table 848 • **SerDes Receiver Jitter Tolerance**

Parameter	Symbol	Minimum	Unit	Condition
Total input jitter tolerance, 1000BASE-KX and SFP modes	$t_{JIT(I)}$	600	ps	Above 637 kHz. Measured according to IEEE 802.3 38.6.8.
Deterministic input jitter tolerance, 1000BASE-KX and SFP modes	$t_{JIT(ID)}$	370	ps	Above 637 kHz. Measured according to IEEE 802.3 38.6.8.

Table 848 • **SerDes Receiver Jitter Tolerance**

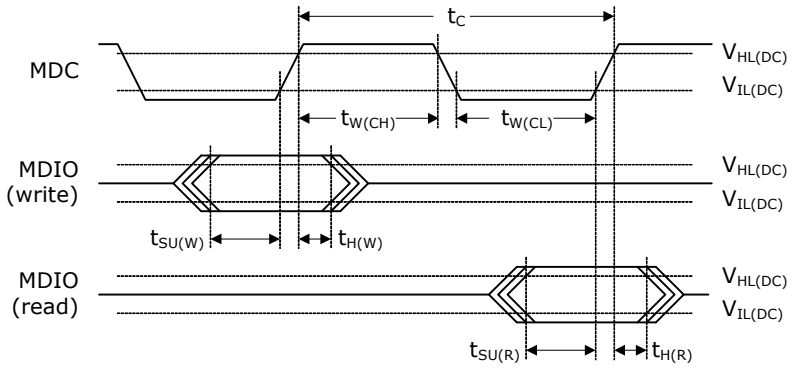
Parameter	Symbol	Minimum	Unit	Condition
Cycle distortion input jitter tolerance, 100BASE-FX mode	D_{CD}	1.4	ns	Measured according to ISO/IEC 9314-3:1990.
Data-dependent input jitter tolerance, 100BASE-FX mode	D_{DJ}	2.2	ns	Measured according to ISO/IEC 9314-3:1990.
Random input jitter tolerance, peak-to-peak, 100BASE-FX mode	R_J	2.27	ns	Measured according to ISO/IEC 9314-3:1990.

8.2.6 MII Management

All AC specifications for the MII Management (MIIM) interface meet or exceed the requirements of IEEE 802.3-2002 (clause 22.2-4).

All MIIM AC timing requirements are specified relative to the input low and input high threshold levels. The following illustration shows the MIIM waveforms and required measurement points for the signals.

Figure 104 • **MIIM Timing Diagram**



The setup time of MDIO relative to the rising edge of MDC is defined as the length of time between when the MDIO exits and remains out of the switching region and when MDC enters the switching region. The hold time of MDIO relative to the rising edge of MDC is defined as the length of time between when MDC exits the switching region and when MDIO enters the switching region.

All MIIM signals comply with the specifications in the following table. The MDIO signal requirements are requested at the pin of the device.

Table 849 • **MIIM Timing Specifications**

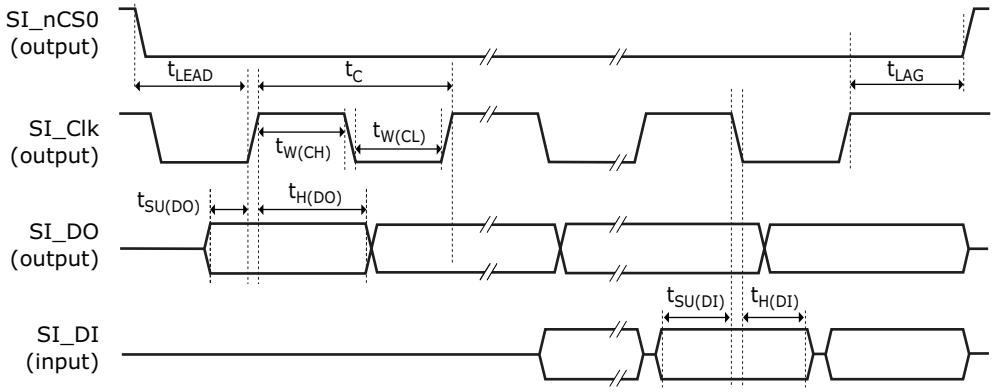
Parameter	Symbol	Minimum	Maximum	Unit	Condition
MDC frequency(1)	f	0.488	20.83	MHz	
MDC cycle time(2)	t_C	48	2048	ns	
MDC time high	$t_{W(CH)}$	20		ns	C_L = 50 pF
MDC time low	$t_{W(CL)}$	20		ns	C_L = 50 pF
MDC input rise and fall time for slave mode	t_R, t_F		10	ns	Between $V_{IL(MAX)}$ and $V_{IH(MIN)}$
MDIO setup time to MDC on write	$t_{SU(W)}$	15		ns	C_L = 50 pF
MDIO hold time from MDC on write	$t_{H(W)}$	15		ns	C_L = 50 pF
MDIO setup time to MDC on read	$t_{SU(R)}$	30		ns	C_L = 50 pF on MDC
MDIO hold time from MDC on read	$t_{H(R)}$	0		ns	C_L = 50 pF

1. For the maximum value, the device supports an MDC clock speed of up to 20 MHz for faster communication with the PHYs. If the standard frequency of 2.5 MHz is used, the MIIM interface is designed to meet or exceed the IEEE 802.3 requirements of the minimum MDC high and low times of 160 ns and an MDC cycle time of minimum 400 ns, which is not possible at faster speeds.
2. Calculated as $t_C = 1/f$.

8.2.7 Serial CPU Interface (SI) Master Mode

All serial CPU interface (SI) timing requirements for master mode are specified relative to the input low and input high threshold levels. The following illustration shows the timing parameters and measurement points.

Figure 105 • **SI Timing Diagram for Master Mode**



All SI signals comply with the specifications shown in the following table. The SI input timing requirements are requested at the pins of the device.

Table 850 • **SI Timing Specifications for Master Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Clock frequency	f		25(1)	MHz	
Clock cycle time	t_C	40		ns	
Clock time high	$t_{W(CH)}$	16		ns	
Clock time low	$t_{W(CL)}$	16		ns	
Clock rise time and fall time	t_R, t_F		10	ns	Between $V_{IL(MAX)}$ and $V_{IH(MIN)}$. C_L = 30 pF.
DO setup time to clock	$t_{SU(DO)}$	10		ns	
DO hold time from clock	$t_{H(DO)}$	10		ns	
Enable active before first clock	t_{LEAD}	10		ns	
Enable inactive after clock	t_{LAG}	5		ns	
DI setup time to clock	$t_{SU(DI)}$	22		ns	
DI hold time from clock	$t_{H(DI)}$	–2		ns	

1. Frequency is programmable. The startup frequency is 4 MHz.

8.2.8 Serial CPU Interface (SI) for Slave Mode

All serial CPU interface (SI) slave mode timing requirements are specified relative to the input low and input high threshold levels. The following illustrations show the timing parameters and measurement points for SI input and output data.

***Figure 106* • SI Input Data Timing Diagram for Slave Mode**

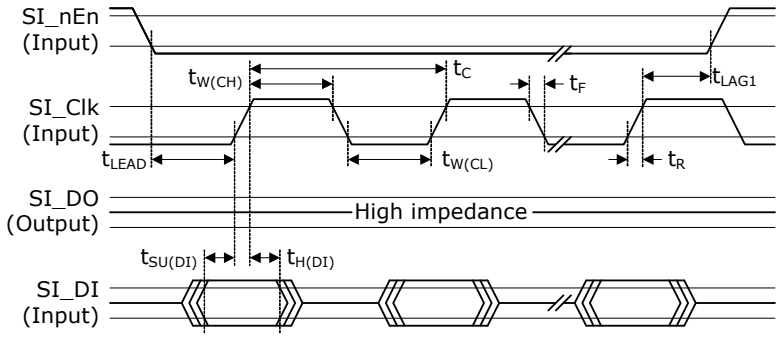
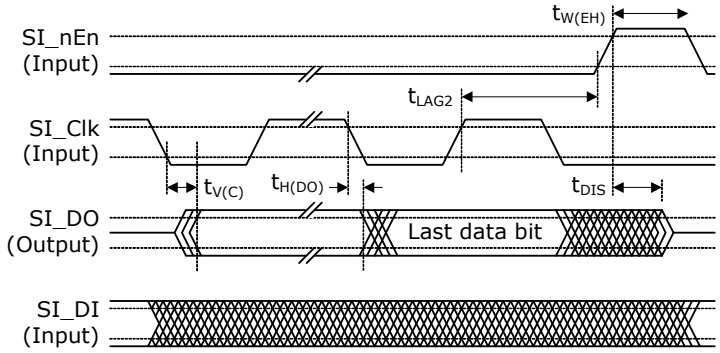


***Figure 107* • SI Output Data Timing Diagram for Slave Mode**



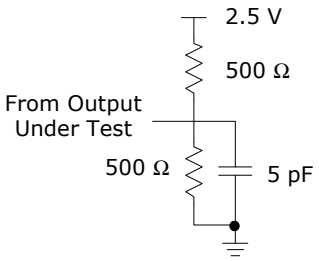
All SI signals comply with the specifications shown in the following table. The SI input timing requirements are requested at the pins of the device.

***Table 851 •* SI Timing Specifications for Slave Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Clock frequency	f		25	MHz	
Clock cycle time	t_C	40		ns	
Clock time high	$t_{W(CH)}$	16		ns	
Clock time low	$t_{W(CL)}$	16		ns	
Clock rise time and fall time	t_R, t_F		10	ns	Between $V_{IL(MAX)}$ and $V_{IH(MIN)}$.
DI setup time to clock	$t_{SU(DI)}$	4		ns	
DI hold time from clock	$t_{H(DI)}$	4		ns	
Enable active before first clock	t_{LEAD}	10		ns	
Enable inactive after clock (input cycle)(1)	t_{LAG1}	25		ns	
Enable inactive after clock (output cycle)	t_{LAG2}	See note(2)		ns	
Enable inactive width	$t_{W(EH)}$	20		ns	
DO valid after clock	$t_{V(C)}$		20	ns	C_L = 30 pF.
DO hold time from clock	$t_{H(DO)}$	0		ns	C_L = 0 pF.
DO disable time(3)	t_{DIS}		15	ns	See Figure 108, page 644.

1. t_{LAG1} is defined only for write operations to the device, not for read operations.
2. The last rising edge on the clock is necessary for the external master to read in the data. The lag time depends on the necessary hold time on the external master data input.
3. Pin begins to float when a 300 mV change from the loaded V_{OH} or V_{OL} level occurs.

Figure 108 **• SI_DO Disable Test Circuit**



8.2.9 Parallel Interface (PI) Master Mode

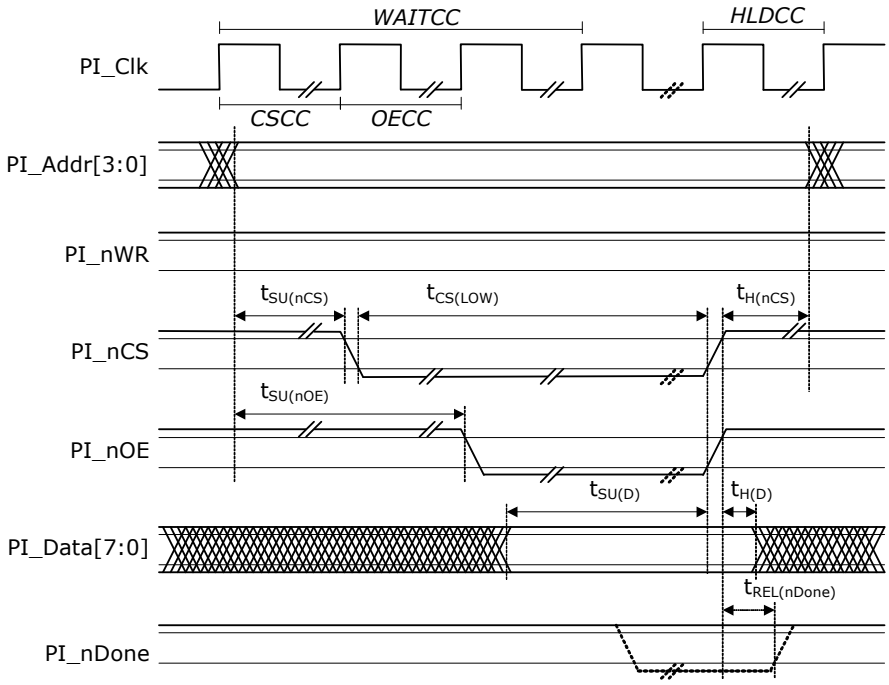
This section provides the AC timing specifications for the PI master mode signals: PI_nCS, PI_nWR, PI_nOE, PI_nDone, PI_Addr[3:0], and PI_Data[7:0]. The PI signals are alternate function signals on GPIO_[13-28] pins. For more information about the GPIO pin mapping, see Table 866, page 659

The timing specifications for parallel interface refer to the VCore-III CPU's external RAM/ROM interface. The timing is programmable and shown as defined by default register values.

8.2.9.1 VCore-III CPU External PI Read Access

The VCore-III CPU timing parameters and required measurement points for external PI read access are defined in the following illustration. All VCore-II CPU signals for external PI read accesses comply with the specifications in the table following the illustration.

Figure 109 **• VCore-III CPU External PI Read Access Timing Diagram**



The timing related to VCore-III external PI access is programmable. The programmable delays adjust timing in steps of the PI_Clk period. The PI_Clk period is determined by the dividers in the HSIO::PLL5G_CFG0 and ICPU_CFG::PI_MST_CFG registers. The default settings correspond to a PI_Clk period of 297.6 ns. The condition used for these specifications corresponds to a PI_Clk period of

22.4 ns. Additionally, the default delay settings are used for WAITCC(1), CSCC(1), OECC(0) and HLDCC(0) as defined by the PI_MST_CTRL registers.

Table 852 • **VCore-III CPU External PI Read Timing Specifications**

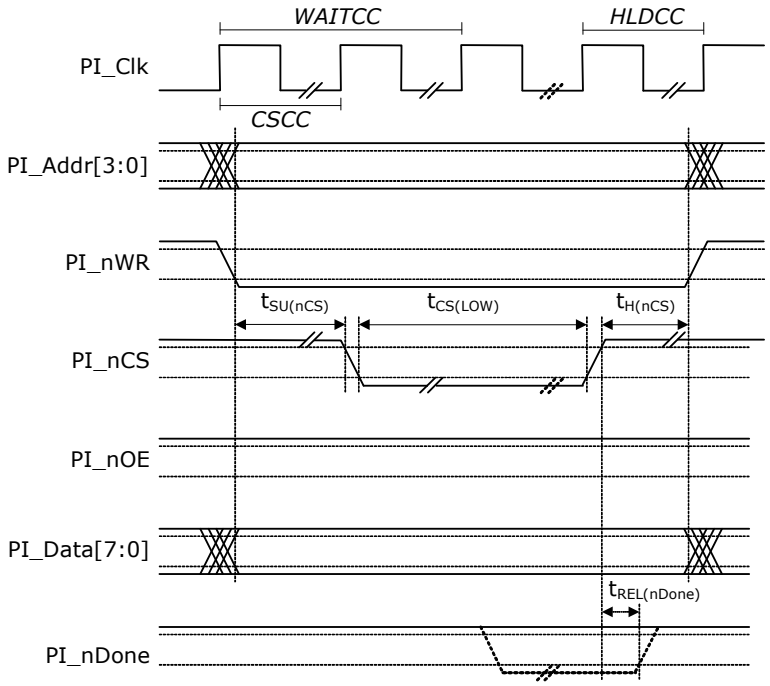
Parameter	Symbol	Minimum	Maximum	Unit	Condition
Address/control setup time to chip select(1)	$t_{SU(nCS)}$	18		ns	C_L = 30 pF
Address/control hold time from chip select(2)	$t_{H(nCS)}$	–4		ns	C_L = 30 pF
Address/control setup time to output enable(3)	$t_{SU(nOE)}$	18		ns	C_L = 30 pF
Address/control hold time from output enable(4)	$t_{H(nOE)}$	–4		ns	C_L = 30 pF
Chip select low(5)	$t_{CS(low)}$	18	23	ns	C_L = 30 pF
Data setup time to chip select high	$t_{SU(D)}$	25		ns	C_L = 30 pF
Data hold time from chip select high	$t_{h(D)}$	0		ns	C_L = 30 pF
PI_nDone release after chip select high(6)	$t_{REL(nDone)}$	0		ns	C_L = 30 pF

1. The minimum setup time of PI_Addr[3:0]/PI_nBE[1:0]/PI_nWR to PI_nCS low may be expressed as WAITCC × 22.4 ns – 4 ns = 18.4 ns.
2. The minimum hold time of PI_Addr[3:0]/PI_nBE[1:0]/PI_nWR from PI_nCS high may be expressed as HLDCC × 22.4 ns – 4 ns = –4 ns.
3. The minimum setup time of PI_Addr[3:0]/PI_nBE[1:0]/PI_nWR to PI_nOE low may be expressed as (WAITCC + OECC) × 22.4 ns – 4 ns = 18.4 ns.
4. The minimum hold time of PI_ADDR[3:0]/PI_nBE[1:0]/PI_nWR from PI_nOE high may be expressed as HLDCC × 22.4 ns – 4 ns = –4 ns.
5. The maximum PI_nCS low time may expressed as (WAITCC + 1 – CSCC) × 22.4 ns = 22.4 ns. The minimum is maximum 4 ns less than the maximum.
6. The interface can operate in a device-paced mode according to the PI_MST_CTRL registers. Device-paced mode allows slow devices to delay the access cycle termination beyond the WAITCC setting. A timeout can be specified in the PI_MST_CTRL registers to terminate access cycles from non-responsive external devices. In device-paced mode, PI_nDone must be released after PI_nCS is observed high and before the next access cycle is started. Slow devices may require HLDCC to be adjusted accordingly.

8.2.9.2 VCore-III CPU External PI Write Access

The VCore-III CPU timing parameters and required measurement points for external PI write access are defined in the following illustration. All VCore-III CPU signals for the external PI write access comply with the specifications in the following table following the illustration.

Figure 110 **• VCore-III CPU ROM/Flash Write Timing Diagram**



The timing related to VCore-III external PI access is programmable. The programmable delays adjust timing in steps of the PI_Clk period. The PI_Clk period is determined by the dividers in the HSIO::PLL5G_CFG0 and ICPU_CFG::PI_MST_CFG registers. The default settings correspond to a PI_Clk period of 297.6 ns. The condition used for these specifications corresponds to a PI_Clk period of 22.4 ns. Additionally, the default delay settings are used for WAITCC(1), CSCC(1), OECC(0) and HLDCC(0) as defined by the PI_MST_CTRL registers.

Table 853 **• VCore-III CPU External PI Write Timing Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Address/control setup time to chip select(1)	$t_{SU(nCS)}$	18		ns	C_L = 30 pF
Address/control hold time from chip select(2)	$t_{H(nCS)}$	–4		ns	C_L = 30 pF
Chip select low(3)	$t_{CS(low)}$	18	23	ns	C_L = 30 pF
Data setup time to chip select high	$t_{SU(D)}$	15		ns	C_L = 30 pF
PI_nDone release after chip select high(4)	$t_{REL(nDone)}$	0		ns	C_L = 30 pF

1. The minimum setup time of PI_ADDR[3:0]/PI_nBE[1:0]/PI_nWR to PI_nCSlow may be expressed as WAITCC × 22.4 ns – 4 ns = 18.4 ns.
2. The minimum hold time of PI_ADDR[3:0]/PI_nBE[1:0]/PI_nWR from PI_nCS high may be expressed as HLDCC × 22.4 ns – 4 ns = –4 ns.
3. The maximum PI_nCS low time may expressed as (WAITCC + 1 – CSCC) × 22.4 ns = 22.4 ns. The minimum is maximum 4 ns less than the maximum.
4. The interface can operate in a device-paced mode according to the PI_MST_CTRL registers. Device-paced mode allows slow devices to delay the access cycle termination beyond the WAITCC setting. A timeout can be specified in the PI_MST_CTRL registers to terminate access cycles from non-responsive external devices.In device-paced mode, PI_nDone must be released after PI_nCS is observed high and before the next access cycle is started. Slow devices may require HLDCC to be adjusted accordingly.

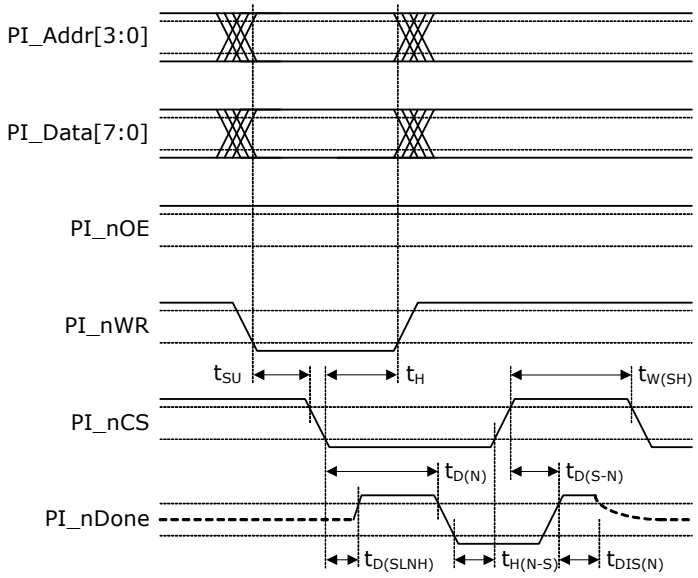
8.2.10 Parallel Interface (PI) Slave Mode

This section provides the AC timing specifications for the PI slave mode signals: PI_nCS, PI_nWR, PI_nOE, PI_nDone, PI_Addr[3:0], and PI_Data[7:0]. The PI signals are alternate function signals on the GPIO_[13:28] pins. For more information about the GPIO pin mapping, see Table 866, page 659.

The AC timing specifications apply when an external CPU accesses the parallel CPU interface (slave mode operation).

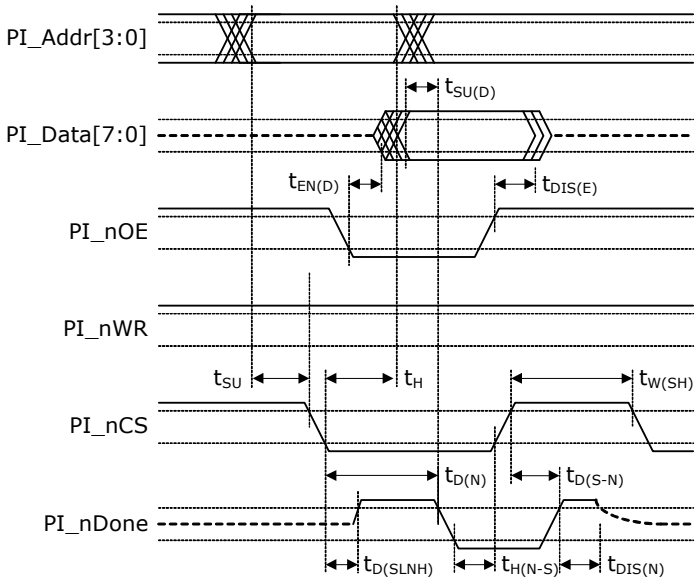
All PI timing specifications are relative to the input low and input high threshold levels. The following two illustrations show the PI timing parameters and the required measurement points.

Figure 111 • **PI Slave Write Cycle Timing Diagram**



PI_nDone's polarity is programmable, shown here as active low.

Figure 112 • **PI Slave Read Cycle Timing Diagram**



PI_nDone's polarity is programmable, shown here as active low.

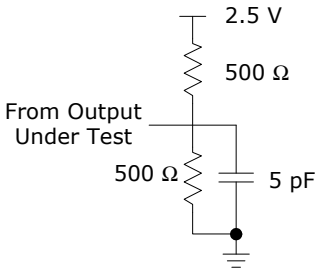
All PI signals comply with the timing parameters specified in the following table. The PI receive signal requirements are requested at the pin of the device.

Table 854 • **PI Slave Mode Timing Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
PI_ADDR, PI_DATA, and PI_nWR setup to PI_nCS falling(1)	t_{SU}	4		ns	Data only on write.
PI_ADDR, PI_DATA, and PI_nWR hold from nCS low(1)	t_{H}	25		ns	Data only on write.
Delay from PI_nCS low to PI_nDone rising(2)	$t_{D(SLNH)}$		25	ns	C_L = 30 pF.
Delay from PI_nCS low to PI_nDone falling(2)	$t_{D(N)}$		55	ns	C_L = 30 pF.
PI_nCS hold from PI_nDone falling(1), (2), (3)	$t_{H(N-S)}$	0		ns	
Delay from PI_nCS high to PI_nDone high(2)	$t_{D(S-N)}$		25	ns	C_L = 30 pF.
PI_nDone disable time from PI_nDone pulled inactive(2), (4)	$t_{DIS(N)}$		12	ns	See Figure 113, page 648.
Width of nCS high	$t_{W(SH)}$	10		ns	
PI_nOE and PI_nCS low to data enabled(1), (5)	$t_{EN(D)}$		20	ns	C_L = 30 pF.
Data setup time to PI_nDone falling on read(2)	$t_{SU(D)}$	0		ns	C_L = 30 pF.
Data disable time from either PI_nCS high or PI_nOE high(5)	$t_{DIS(E)}$		20	ns	See Figure 113, page 648.

1. Before input data or conditions are sampled, an initial delay can be added in steps of 8 ns from 0 ns to 120 ns. The default delay is 104 ns to ensure operation with slow CPUs. Timing values in this table are shown with 0 ns delay.
2. PI_nDone polarity is programmable; it is shown as active low in the timing diagrams.
3. When using extended bus cycles, the response time can be up to 470 ns.
4. Pin begins to float when a 300 mV change from the loaded V_{OH}/V_{OL} level occurs.
5. Internal data output enable requires both nCS and nOE active. A time of 15 ns is valid only if PI_WAIT in the PI_CFG register. If set to a value other than 0×00, the value shown for $t_{EN(D)}$ changes.

Figure 113 • **Signal Disable Test Circuit**

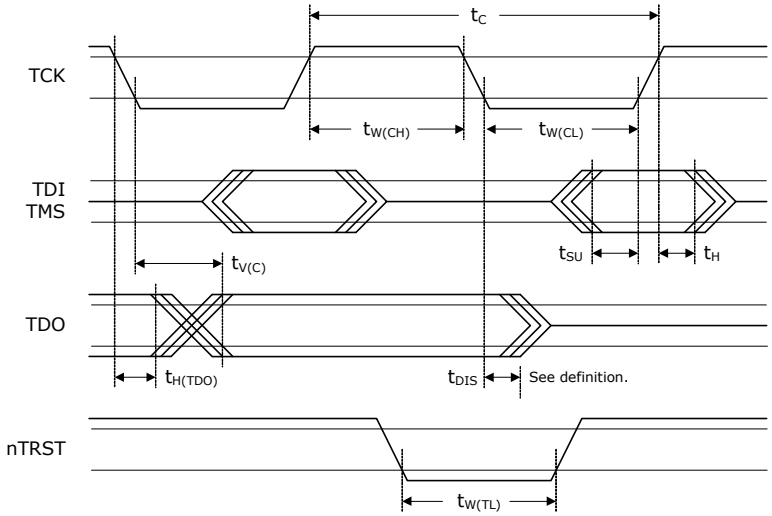


8.2.11 JTAG Interface

All AC specifications for the JTAG interface meet or exceed the requirements of IEEE 1149.1-2001.

The following illustration shows the JTAG transmit and receive waveforms and required measurement points for the different signals.

Figure 114 • **JTAG Interface Timing Diagram**



All JTAG signals comply with the specifications in the following table. The JTAG receive signal requirements are requested at the pin of the device.

The JTAG_nTRST signal is asynchronous to the clock and does not have a setup or hold time requirement.

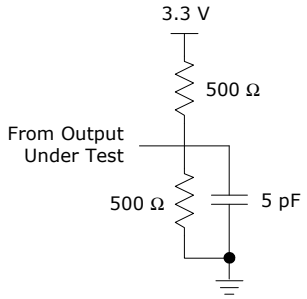
Table 855 • **JTAG Interface AC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
TCK frequency	f		10	MHz	
TCK cycle time	t_C	100		ns	
TCK high time	$t_{W(CH)}$	40		ns	
TCK low time	$t_{W(CL)}$	40		ns	
Setup time to TCK rising	t_{SU}	10		ns	
Hold time from TCK rising	t_H	10		ns	
TDO valid after TCK falling	$t_{V(C)}$		28	ns	C_L = 10 pF
TDO hold time from TCK falling	$t_{H(TDO)}$	0		ns	C_L = 0 pF
TDO disable time(1)	t_{DIS}		30	ns	See Figure 115, page 650.
nTRST time low	$t_{W(TL)}$	30		ns	

1. The pin begins to float when a 300 mV change from the actual V_{OH}/V_{OL} level occurs.

The following illustration shows the test circuit for the TDO disable time.

***Figure 115* • Test Circuit for TDO Disable Time**

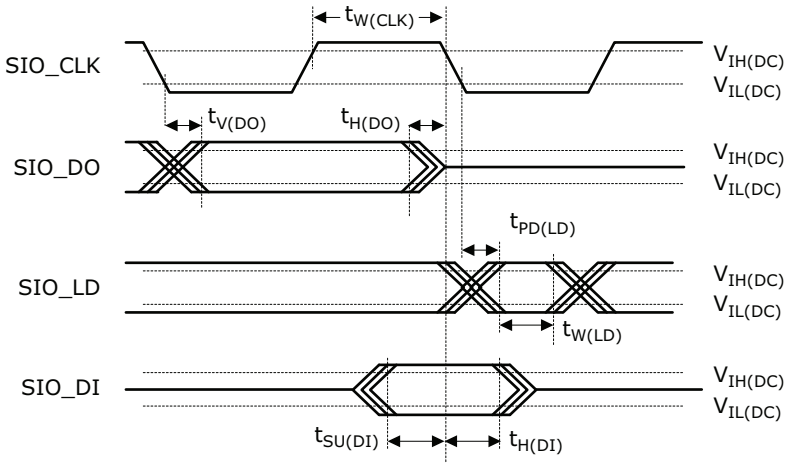


8.2.12 Serial Inputs/Outputs

This section provides the AC characteristics for the serial I/O signals: SIO_CLK, SIO_LD, SIO_DO, and SIO_DI. The SI signals are alternate function signals on the GPIO_[0:3] pins. For more information about the GPIO pin mapping, see Table 866, page 659.

The serial I/O timing diagram is shown in the following illustration.

***Figure 116* • Serial I/O Timing Diagram**



The following table lists the serial I/O timing specifications.

***Table 856 •* Serial I/O Timing Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
Clock frequency(1)	*f*		25	MHz	
SIO_CLK clock pulse width	$t_{W(CLK)}$	16		ns	25 MHz clock
SIO_DO valid after clock falling	$t_{V(DO)}$		6	ns	
SIO_DO hold time from clock falling	$t_{H(DO)}$		6	ns	
SIO_LD propagation delay from clock falling	$t_{PD(LD)}$	40		ns	
SIO_LD width	$t_{W(LD)}$	10		ns	
SIO_DI setup time to clock	$t_{SU(DI)}$	25		ns	
SIO_DI hold time from clock	$t_{H(DI)}$	4		ns	

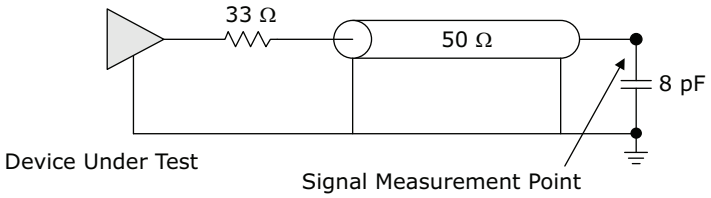
1. The SIO clock frequency is programmable.

8.2.13 Recovered Clock Outputs

This section provides the AC characteristics for the recovered clock output signals: RCVRD_CLK0 and RCVRD_CLK1.

The following illustration shows the test circuit for the recovered clock output signals.

Figure 117 • **Test Circuit for Recovered Clock Output Signals**



The following table lists the AC specifications for the recovered clock outputs.

Table 857 • **Recovered Clock Output AC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
RCVRD_CLK[1:0] clock frequency	*f*		125	MHz	
Clock duty cycle	t_C	40	60	%	Measured at 50% threshold.
RCVRD_CLK[1:0] rise time and fall time	t_R, t_F		1.5	ns	
Squelching delay from SGMII signal to RCVRD_CLK[1:0]			200	ns	Squelch enabled.
Squelching delay from XAUI signal to RCVRD_CLK[1:0]			200	ns	Squelch enabled.
RCVRD_CLK[1:0] peak-to-peak jitter, bandwidth between 12 kHz and 10 MHz.(1)			200	ps	
RCVRD_CLK[1:0] peak-to-peak jitter, bandwidth between 10 MHz and 80 MHz.(1)			200	ps	

1. Maximum jitter on the recovered signal.

8.2.14 Two-Wire Serial Interface

This section provides the AC specifications for the two-wire serial interface signals TWI_SCL and TWI_SDA. The two-wire serial interface signals are alternate function signals on the GPIO_5 and GPIO_6 pins. For more information about the GPIO pin mapping, see Table 866, page 659.

The two-wire serial interface signals are compatible with the Philips I^2C-BUS specifications, except for the minimum rise time and fall time requirements for fast mode.

Figure 118 **• Two-Wire Serial Read Timing Diagram**

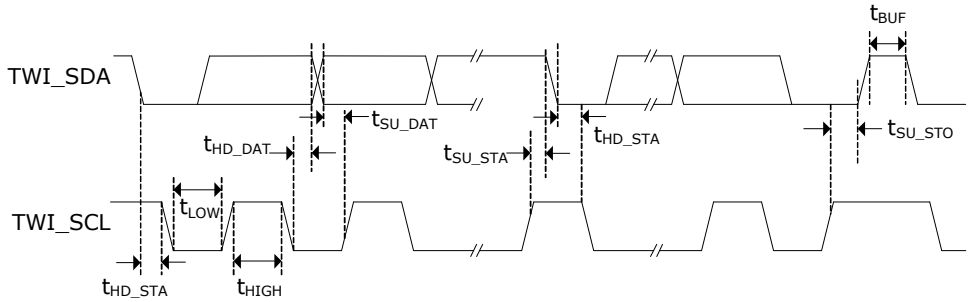
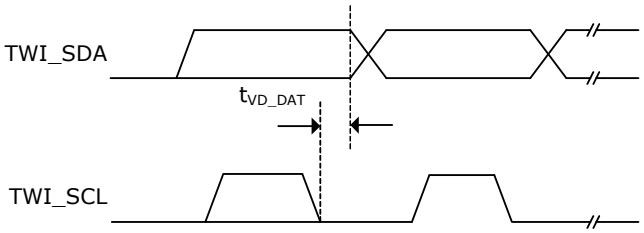


Figure 119 **• Two-Wire Serial Write Timing Diagram**



For the specifications listed in the following table, standard mode is defined as 100 kHz and fast mode is 400 kHz. The data in this table assumes that the software-configurable two-wire interface timing parameters, SS_SCL_HCNT, SS_SCL_LCNT, FS_SCL_HCNT, and FS_SCL_LCNT, are set to valid values for the selected speed. For more information about setting the values for the selected speed, see Table 704, page 543 through Table 706, page 544.

Table 858 • **Two-Wire Serial Interface AC Specifications**

Parameter	Symbol	Minimum	Maximum	Unit	Condition
TWI_SCL clock frequency, standard mode	*f*		100	kHz	
TWI_SCL clock frequency, fast mode	*f*		400	kHz	
TWI_SCL low period, standard mode	t_{LOW}	4.7		µs	
TWI_SCL low period, fast mode	t_{LOW}	1.3		µs	
TWI_SCL high period, standard mode	t_{HIGH}	4.0		µs	
TWI_SCL high period, fast mode	t_{HIGH}	0.6		µs	
TWI_SCL and TWI_SDA rise time, standard mode			1000	ns	
TWI_SCL and TWI_SDA rise time, fast mode			300	ns	
TWI_SCL and TWI_SDA fall time, standard mode			300	ns	
TWI_SDA setup time to TWI_SCL fall, standard mode	t_{SU_DAT}	250		ns	

Table 858 • **Two-Wire Serial Interface AC Specifications *(continued)***

Parameter	Symbol	Minimum	Maximum	Unit	Condition
TWI_SDA setup time to TWI_SCL fall, fast mode	t_{SU_DAT}	100	300	ns	
TWI_SDA hold time to TWI_SCL fall, standard mode(1)	t_{HD_DAT}	300	3450	ns	300 ns delay enabled in ICPU_CFG::TWI_CONFIG register.
TWI_SDA hold time to TWI_SCL fall, fast mode(1)	t_{HD_DAT}	300	900	ns	300 ns delay enabled in ICPU_CFG::TWI_CONFIG register.
Setup time for repeated START condition, standard mode	t_{SU_STA}	4.7		µs	
Setup time for repeated START condition, fast mode	t_{SU_SAT}	0.6		µs	
Hold time after repeated START condition, standard mode	t_{HD_STA}	4.0		µs	
Hold time after repeated START condition, fast mode	t_{HD_STA}	0.6		µs	
Bus free time between STOP and START conditions, standard mode	t_{BUF}	4.7		µs	
Bus free time between STOP and START conditions, fast mode	t_{BUF}	1.3		µs	
Clock to valid data out, standard and fast modes(2)	t_{VD_DAT}	300		ns	
Pulse width of spike suppressed by input filter on TWI_SCL or TWI_SDA		0	5	ns	

1. An external device must provide a hold time of at least 300 ns for the TWI_SDA signal to bridge the undefined region of the falling edge of the TWI_SCL signal.
2. Some external devices may require more data in hold time (target device's t_{HD_DAT}) than what is provided by t_{VD_DAT}, for example, 300 ns to 900 ns. The minimum value of t_{VD_DAT} is adjustable; the typical value given represents the recommended minimum value, which is enabled in CPU_CFG::TWI_CONFIG.

8.2.15 IEEE 1588 Time Tick Output

This section provides the AC specifications for the IEEE_1588 time tick output signal. The IEEE1588 signal is an alternate function signal on the GPIO_7 pin. For more information about the GPIO pin mapping, see **GPIO Overlaid Functions,** page 176.

Table 859 • **IEEE1588 Time Tick Output AC Specifications**

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Condition
IEEE1588 frequency(1)	*f*			25	MHz	
Clock duty cycle		45		55	%	Measured at 50% threshold.
IEEE 1588 rise time and fall time	t_R, t_F	1			ns	20% to 80% threshold.

Table 859 • **IEEE1588 Time Tick Output AC Specifications *(continued)***

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Condition
IEEE 1588 peak-to-peak jitter(2)			100		ps	10 MHz output.

1. Frequency is programmable.
2. Some frequencies may generate an additional 4 ns of jitter, because the frequency is synthesized based on the internal system clock.

8.3 Current and Power Consumption

This section provides the current and power consumption requirements for the VSC7428-12 device.

8.3.1 Current Consumption

This section provides the operating current consumption parameters for the VSC7428-12 device.

Typical current consumption values are over nominal supply settings at 25 °C case temperature, and maximum traffic load. Maximum current consumption values are over worst-case process, temperature, and supply settings, and maximum traffic load.

The following table lists the typical and maximum operating current consumption values for the device.

Table 860 • **Operating Current**

Parameter	Symbol	Typical	Maximum	Unit	Condition
V_{DD} operating current	I_{DD}	1.3	2.1	A	V_{TYP} = 1.0 V
V_{DD_A} operating current	I_{DD_A}	0.16	0.27	A	V_{TYP} = 1.0 V
V_{DD_AL} operating current	I_{DD_AL}	0.16	0.25	A	V_{TYP} = 1.0 V
V_{DD_AH} operating current	I_{DD_AH}	0.9	0.9	A	V_{TYP} = 2.5 V
V_{DD_VS} operating current	I_{DD_VS}	0.13	0.13	A	V_{TYP} = 1.0 V or 1.2 V
V_{DD_IODDR} operating current(1)	I_{DD_IODDR}	0.1	0.1	A	V_{TYP} = 1.8 V
V_{DD_IO} operating current	I_{DD_IO}	0.1	0.1	A	V_{TYP} = 2.5 V

1. DDR2 on-die termination is disabled.

8.3.2 Power Consumption

This section provides the power consumption parameters, based on current consumption and with DDR2 on-die termination disabled.

Typical power consumption values are over nominal supplies and 25 °C case temperature. Maximum power consumption values are over maximum temperature and all supplies at maximum voltages.

The following table lists the typical and maximum power consumption values for the device.

Table 861 • **Power Consumption**

Parameter	Typical	Maximum	Unit
Power consumption, SGMII in LVDS mode V_{DD_VS} = 1.0 V	4.4	5.8	W
Power consumption, SGMII in high-drive mode V_{DD_VS} = 1.2 V	4.5	5.9	W

8.3.3 Power Supply Sequencing

During power on and off, V_{DD_A} and V_{DD_VS} must never be more than 300 mV above V_{DD}.

V_{DD_VS} must be powered, even if the associated interface is not used. These power supplies must not remain at ground or left floating.

A maximum delay of 100 ms from V_{DD_IODDR} to V_{DD} is recommended. There is no requirement from V_{DD} to V_{DD_IODDR}.

There are no sequencing requirements for V_{DD_AL}, V_{DD_AH}, and V_{DD_IO}. These power supplies can remain at ground or left floating if not used.

The nReset and JTAG_nTRST inputs must be held low until all power supply voltages have reached their recommended operating condition values.

8.4 Operating Conditions

The following table lists the recommended operating conditions.

Table 862 • **Recommended Operating Conditions**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Power supply voltage for core supply	V_{DD}	0.95	1.00	1.05	V
Power supply voltage for analog circuits	V_{DD_A}	0.95	1.00	1.05	V
Power supply voltage for analog circuits in twisted pair interface	V_{DD_AL}	0.95	1.00	1.05	V
Power supply voltage for analog driver in twisted pair interface	V_{DD_AH}	2.38	2.50	2.62	V
Power supply voltage for SerDes and Enhanced SerDes interfaces, 1.0 V[(1)]	V_{DD_VS}	0.95	1.00	1.05	V
Power supply voltage for SerDes and Enhanced SerDes interfaces, 1.2 V	V_{DD_VS}	1.14	1.20	1.26	V
Power supply voltage for DDR2 interface	V_{DD_IODDR}	1.70	1.80	1.90	V
Power supply voltage for MIIM, PI, and miscellaneous I/O	V_{DD_IO}	2.38	2.50	2.62	V
Operating temperature[(2)]	T	–40		125	°C

1. The 1.0 V power supply for the enhanced SerDes interface is enabled in HSIO::SERDES6G_OB_CFG.OB_ENA1V_MODE.
2. Minimum specification is ambient temperature, and the maximum is junction temperature.

8.5 Stress Ratings

Warning Stresses listed in the following table may be applied to devices one at a time without causing permanent damage. Functionality at or exceeding the values listed is not implied. Exposure to these values for extended periods may affect device reliability.

Table 863 • **Stress Ratings**

Parameter	Symbol	Minimum	Maximum	Unit
Power supply voltage for core supply	V_{DD}	–0.3	1.10	V
Power supply voltage for analog circuits	V_{DD_A}	–0.3	1.10	V
Power supply voltage for analog circuits in twisted pair interface	V_{DD_AL}	–0.3	1.10	V
Power supply voltage for analog circuits in twisted pair interface	V_{DD_AH}	–0.3	2.75	V

Table 863 • **Stress Ratings** ***(continued)***

Parameter	Symbol	Minimum	Maximum	Unit
Power supply voltage for SerDes and Enhanced SerDes interfaces	V_{DD_VS}	–0.3	1.32	V
Power supply voltage for DDR2 interface	V_{DD_IODDR}	–0.3	1.98	V
Power supply voltage for MIIM, PI, and miscellaneous I/O	V_{DD_IO}	–0.3	2.75	V
Storage temperature	T_S	–55	125	°C
Electrostatic discharge voltage, charged device model	V_{ESD_CDM}	–250	250	V
Electrostatic discharge voltage, human body model	V_{ESD_HBM}	–1750	1750	V

Warning This device can be damaged by electrostatic discharge (ESD) voltage. Vitesse recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures may adversely affect reliability of the device.

9 Pin Descriptions

The VSC7428-12 device has 672 pins, which are described in this section.

The pin information is also provided as an attached Microsoft Excel file, so that you can copy it electronically. In Adobe Reader, double-click the attachment icon.

9.1 Pin Diagram

The following illustration shows the pin diagram. For clarity, the device is shown in two halves, the top left and top right.

Figure 120 **• Pin Diagram, Top Left**

	1	2	3	4	5	6	7	8	9	10	11	12	13
A		Reserved_57	Reserved_55	Reserved_53	Reserved_51	P7_D0P	P7_D1P	Reserved_331	Reserved_329	P6_D0P	P6_D1P	Reserved_327	Reserved_325
B	VSS_1	Reserved_56	Reserved_54	Reserved_52	Reserved_50	P7_D0N	P7_D1N	Reserved_330	Reserved_328	P6_D0N	P6_D1N	Reserved_326	Reserved_324
C	Reserved_59	Reserved_58	COMA_MODE	nRESET	VDD_IO_21	Reserved_1	VCORE_CFG0	VCORE_CFG1	VCORE_CFG2	VCore_ICE_nEn	Reserved_4	RefClk_Sel0	RefClk_Sel1
D	Reserved_61	Reserved_60	Reserved_205	VDD_AH_1	VDD_AH_2	Reserved_206	Reserved_207	Reserved_208	Reserved_209	Reserved_248	VDD_AH_4	Reserved_211	Reserved_13
E	Reserved_63	Reserved_62	Reserved_216	VDD_AH_7	VDD_AH_8	VDD_IO_1	VDD_IO_2	VDD_AH_9	VDD_AL_1	VDD_AL_2	VDD_AH_10	VDD_AH_11	Ref_rext_1
F	Reserved_65	Reserved_64	Reserved_218	VDD_AH_17	VDD_AH_18	VDD_IO_5	VDD_AH_3	VDD_AH_19	VDD_AL_5	VDD_AL_6	VDD_AH_20	VDD_AH_21	Reserved_219
G	Reserved_67	Reserved_66	VSS_3	Reserved_15	VSS_4	VDD_1	VDD_2	VDD_3	VDD_AL_9	VDD_AL_10	VDD_4	VDD_5	Reserved_247
H	Reserved_69	Reserved_68	VSS_7	Reserved_14	VSS_8	VDD_11	VDD_12	VDD_13	VDD_14	VDD_15	VDD_16	VDD_17	Reserved_246
J	Reserved_71	Reserved_70	VDD_AH_27	VDD_AH_28	VDD_AL_13	VDD_AL_14	VDD_AL_15	Reserved_240	Reserved_241	Reserved_242	Reserved_243	Reserved_244	Reserved_245
K	Reserved_73	Reserved_72	VSS_11	Ref_rext_2	VDD_AL_19	VDD_AL_20	VDD_AL_21	VSS_12	VSS_13	VSS_14	VSS_15	VSS_16	VSS_17
L	Reserved_75	Reserved_74	VSS_25	Ref_filt_2	VSS_26	VDD_25	VDD_26	VSS_27	VSS_28	VSS_29	VSS_30	VSS_31	VSS_32
M	Reserved_77	Reserved_76	VDD_AH_31	VDD_AH_32	VDD_AH_33	VDD_29	VDD_30	VSS_41	VSS_42	VSS_43	VSS_44	VSS_45	VSS_46
N	Reserved_79	Reserved_78	VSS_53	VSS_54	VSS_55	VDD_33	VDD_34	VSS_56	VSS_57	VSS_58	VSS_59	VSS_60	VSS_61
P	Reserved_81	Reserved_80	VSS_71	Reserved_24	VDD_IO_7	VDD_37	VDD_38	VSS_72	VSS_73	VSS_74	VSS_75	VSS_76	VSS_77
R	GPIO_31	GPIO_30	GPIO_29	GPIO_28	VDD_IO_8	VDD_41	VDD_42	VSS_86	VSS_87	VSS_88	VSS_89	VSS_90	VSS_91
T	GPIO_27	GPIO_26	GPIO_25	GPIO_24	VDD_IO_9	VDD_45	VDD_46	VSS_98	VSS_99	VSS_100	VSS_101	VSS_102	VSS_103
U	GPIO_23	GPIO_22	GPIO_21	GPIO_20	VDD_IO_10	VSS_110	VSS_111	VSS_112	VSS_113	VSS_114	VSS_115	VSS_116	VSS_117
V	GPIO_19	GPIO_18	GPIO_17	GPIO_16	VDD_IO_11	VDD_49	VDD_50	VDD_51	VDD_52	VDD_53	VDD_54	VDD_55	VDD_56
W	GPIO_15	GPIO_14	GPIO_13	GPIO_12	VDD_IO_12	VDD_65	VDD_66	VDD_67	VDD_68	VDD_69	VDD_70	VDD_71	VDD_72
Y	GPIO_11	GPIO_10	GPIO_9	GPIO_8	VDD_IO_13	Reserved_146	Reserved_141	RefClk_P	Reserved_137	Reserved_134	Reserved_129	VSS_126	Reserved_126
AA	GPIO_7	GPIO_6	GPIO_5	GPIO_4	VDD_IO_14	Reserved_147	Reserved_140	RefClk_N	Reserved_136	Reserved_135	Reserved_128	VSS_145	Reserved_127
AB	GPIO_3	GPIO_2	GPIO_1	GPIO_0	VDD_IO_15	VSS_129	VSS_130	VSS_131	VSS_132	VSS_133	VSS_134	VSS_135	VSS_136
AC	SI_DO	SI_nEn	VSS_148	VDD_IO_16	VDD_IO_17	VDD_A_1	VDD_A_2	VDD_A_3	VDD_A_4	VDD_A_5	VDD_A_6	VDD_A_7	VDD_A_8
AD	SI_Clk	SI_DI	RCVRD_CLK1	VDD_IO_18	VSS_149	VDD_VS_1	VDD_VS_2	VDD_VS_3	VDD_VS_4	VDD_VS_5	VDD_VS_6	VDD_VS_7	VDD_VS_8
AE	VSS_151	RCVRD_CLK0	VDD_IO_19	VSS_163	VSS_152	Reserved_144	Reserved_143	Reserved_22	Reserved_139	Reserved_132	Reserved_131	VSS_153	Reserved_124
AF		VDD_IO_20	MDIO	MDC	VSS_158	Reserved_145	Reserved_142	Reserved_23	Reserved_138	Reserved_133	Reserved_130	VSS_159	Reserved_125

Figure 121 • **Pin Diagram, Top Right**

14	15	16	17	18	19	20	21	22	23	24	25	26	
P5_D0P	P5_D1P	Reserved_323	Reserved_321	P4_D0P	P4_D1P	Reserved_319	Reserved_317	P3_D0P	P3_D1P	Reserved_315	Reserved_313		A
P5_D0N	P5_D1N	Reserved_322	Reserved_320	P4_D0N	P4_D1N	Reserved_318	Reserved_316	P3_D0N	P3_D1N	Reserved_314	Reserved_312	VSS_2	B
RefClk_Sel2	Reserved_8	Reserved_7	Reserved_6	Reserved_5	Reserved_201	Reserved_202	Reserved_203	THERMDC_VSS	THERMDA	Reserved_204	P2_D0N	P2_D0P	C
Reserved_12	Reserved_212	VDD_AH_5	JTAG_CLK	JTAG_DI	JTAG_DO	JTAG_TMS	JTAG_TRST	Reserved_213	Reserved_214	Reserved_215	P2_D1N	P2_D1P	D
Ref_filt_1	VDD_AH_12	VDD_AH_13	VDD_AL_3	VDD_AL_4	VDD_AH_14	VDD_IO_3	VDD_IO_4	VDD_AH_15	VDD_AH_16	Reserved_217	Reserved_310	Reserved_311	E
Reserved_220	VDD_AH_22	VDD_AH_23	VDD_AL_7	VDD_AL_8	VDD_AH_24	VDD_AH_6	VDD_IO_6	VDD_AH_25	VDD_AH_26	Reserved_221	Reserved_308	Reserved_309	F
Reserved_223	VDD_6	VDD_7	VDD_AL_11	VDD_AL_12	VDD_8	VDD_9	VDD_10	VSS_5	Reserved_10	VSS_6	P1_D0N	P1_D0P	G
Reserved_225	VDD_18	VDD_19	VDD_20	VDD_21	VDD_22	VDD_23	VDD_24	VSS_9	Reserved_11	VSS_10	P1_D1N	P1_D1P	H
Reserved_232	Reserved_233	Reserved_234	Reserved_235	Reserved_236	Reserved_237	VDD_AL_16	VDD_AL_17	VDD_AL_18	VDD_AH_29	VDD_AH_30	Reserved_306	Reserved_307	J
VSS_18	VSS_19	VSS_20	VSS_21	VSS_22	VSS_23	VDD_AL_22	VDD_AL_23	VDD_AL_24	Ref_rext_0	VSS_24	Reserved_304	Reserved_305	K
VSS_33	VSS_34	VSS_35	VSS_36	VSS_37	VSS_38	VDD_27	VDD_28	VSS_39	Ref_filt_0	VSS_40	P0_D0N	P0_D0P	L
VSS_47	VSS_48	VSS_49	VSS_50	VSS_51	VSS_52	VDD_31	VDD_32	VDD_AH_34	VDD_AH_35	VDD_AH_36	P0_D1N	P0_D1P	M
VSS_62	VSS_63	VSS_64	VSS_65	VSS_66	VSS_67	VDD_35	VDD_36	VSS_68	VSS_69	VSS_70	Reserved_302	Reserved_303	N
VSS_78	VSS_79	VSS_80	VSS_81	VSS_82	VSS_83	VDD_39	VDD_40	VDD_IODDR_1	VSS_84	VSS_85	Reserved_300	Reserved_301	P
VSS_92	VSS_93	VSS_94	VSS_95	VSS_96	VSS_97	VDD_43	VDD_44	VDD_IODDR_2	Reserved_20	Reserved_19	DDR_Rext	DDR_Vref	R
VSS_104	VSS_105	VSS_106	VSS_107	VSS_108	VSS_109	VDD_47	VDD_48	VDD_IODDR_3	Reserved_21	DDR_A13	DDR_A12	DDR_A11	T
VSS_118	VSS_119	VSS_120	VSS_121	VSS_122	VSS_123	VSS_124	VSS_125	VDD_IODDR_4	DDR_A7	DDR_A9	DDR_A6	DDR_A8	U
VDD_57	VDD_58	VDD_59	VDD_60	VDD_61	VDD_62	VDD_63	VDD_64	VDD_IODDR_5	DDR_A3	DDR_A5	DDR_A2	DDR_A4	V
VDD_73	VDD_74	VDD_75	VDD_76	VDD_77	VDD_78	VDD_79	VDD_80	VDD_IODDR_6	DDR_A10	DDR_A1	DDR_nCAS	DDR_A0	W
Reserved_121	Reserved_118	VSS_127	SerDes_E1_TxP	Reserved_110	SerDes0_TxP	VSS_128	SerDes_E0_TxP	VDD_IODDR_7	DDR_BA0	DDR_BA1	DDR_ODT	DDR_nRAS	Y
Reserved_120	Reserved_119	VSS_146	SerDes_E1_TxN	Reserved_111	SerDes0_TxN	VSS_147	SerDes_E0_TxN	VDD_IODDR_8	DDR_nWE	DDR_BA2	DDR_CK	DDR_CKn	AA
VSS_137	VSS_138	VSS_139	VSS_140	VSS_141	VSS_142	VSS_143	VSS_144	VDD_IODDR_9	DDR_DQ3	DDR_CKE	DDR_DQ2	DDR_DQ5	AB
VDD_A_9	VDD_A_10	VDD_A_11	VDD_A_12	VDD_A_13	VDD_A_14	VDD_A_15	VDD_A_16	VDD_IODDR_10	DDR_DQ1	DDR_DQ4	DDR_DQ7	DDR_DQ0	AC
VDD_VS_9	VDD_VS_10	VDD_VS_11	VDD_VS_12	VDD_VS_13	VDD_VS_14	VDD_VS_15	VDD_VS_16	VSS_150	VDD_IODDR_11	DDR_DQ6	DDR_DQS	DDR_DQSn	AD
Reserved_123	Reserved_116	VSS_154	SerDes_E1_RxP	Reserved_108	SerDes0_RxP	VSS_155	SerDes_E0_RxP	SerDes_Rext_0	VSS_156	VDD_IODDR_12	DDR_DM	VSS_157	AE
Reserved_122	Reserved_117	VSS_160	SerDes_E1_RxN	Reserved_109	SerDes0_RxN	VSS_161	SerDes_E0_RxN	SerDes_Rext_1	VSS_162	VDD_IODDR_14	VDD_IODDR_13		AF

9.2 Pins by Function

This section contains the functional pin descriptions for the VSC7428-12 device. The following table lists the definitions for the pin type symbols.

Table 864 • **Pin Type Symbol Definitions**

Symbol	Pin Type	Description
ABIAS	Analog bias	Analog bias pin.
DIFF	Differential	Differential signal pair.
I	Input	Input signal.
O	Output	Output signal.
I/O	Bidirectional	Bidirectional input or output signal.
A	Analog input	Analog input for sensing variable voltage levels.
PD	Pull-down	On-chip pull-down resistor to VSS.
PU	Pull-up	On-chip pull-up resistor to VDD_IO.
3V		3.3 V-tolerant.
O	Output	Output signal.

Table 864 • **Pin Type Symbol Definitions *(continued)***

Symbol	Pin Type	Description
OZ	3-state output	Output.
ST	Schmitt-trigger	Input has Schmitt-trigger circuitry.
TD	Termination differential	Internal differential termination.

9.2.1 Analog Bias Signals

The following table lists the pins associated with the analog bias signals.

Table 865 • **Analog Bias Pins**

Name	Type	Description
SerDes_Rext_[1:0]	A	Analog bias calibration. Connect an external 626 Ω ±1% resistor between SerDes_Rext_1 and SerDes_Rext_0.
Ref_filt_[2:0]	A	Reference filter. Connect a 1.0 µF external capacitor between each pin and ground.
Ref_rext_[2:0]	A	Reference external resistor. Connect a 2.0 kΩ (1%) resistor between each pin and ground.

9.2.2 DDR2 SDRAM Interface

The following table lists the pins associated with the DDR2 SDRAM interface.

Table 866 • **DDR2 SDRAM Pins**

Name	Type	Description
DDR_CK DDR_CKn	0, Diff	SDRAM differential clock. Differential clock to external SDRAM. DDR_CK is the true part of the differential signal. DDR_nCk is the complement part.
DDR_CKE	O	SDRAM clock enable. 0: Disables clock in external SDRAM. 1: Enables clock in external SDRAM.
DDR_nRAS DDR_nCAS DDR_nWE	O	SDRAM command outputs. DDR_nRAS, DDR_nCAS, and DDR_nWE (along with DDR_ODT) define the command being entered.
DDR_DM	O	SDRAM data mask outputs. DDR_DM and DDR_UDM are mask signals for data written to the SDRAM. DDR_LDM corresponds to data on DDR_DQ[7:0], and DDR_UDM corresponds to data on DDR_DQ[15:8].
DDR_BA[2:0]	O	SDRAM bank address outputs. DDR_BA[2:0] define to which bank an ACTIVE, READ, WRITE, or PRECHARGE command is applied.
DDR_A[13:0]	O	SDRAM address outputs. Provide row and column addresses to the SDRAM.
DDR_DQ[7:0]	I/O	SDRAM data bus.

Table 866 • **DDR2 SDRAM Pins *(continued)***

Name	Type	Description
DDR_DQS DDR_DQSn	I/O, Diff	SDRAM differential data strobes. Bidirectional differential signal that follows data direction. Used by SDRAM to capture data on write operations. Edge-aligned with data from SDRAM during read operations and used by the device to capture data.
DDR_ODT	O	Control signals for the attached DDR2 SDRAM devices on-die termination.
DDR_Rext	ABIAS	External DDR impedance calibration. Connect the pin through an external 240 Ω ±1% resistor to ground.
DDR_Vref	ABIAS	Input reference voltage. Provides the input switching reference voltage to the SSTL DDR signals.

9.2.3 General-Purpose I/O

The following table lists the general-purpose I/O pins. Leave GPIO pins unconnected when not in use.

Many of the GPIO pins serve multiple functions. For more information about these functions and how to configure them, see **GPIO Overlaid Functions,** page 176.

Table 867 • **GPIO Pin Mapping**

Name	Type	Description
GPIO_[31:0]	I/O, PU, ST, 3V	General-purpose inputs and outputs

9.2.4 JTAG Interface

The following table lists the pins associated with the JTAG interface. The JTAG interface can be connected to the boundary scan TAP controller or the internal VCore-III TAP controller for software debug as described under the VCore_ICE_nEn signal.

The JTAG signals are not 5 V tolerant.

Table 868 • **JTAG Interface Pins**

Name	Type	Description
JTAG_nTRST	I, PU, ST, 3V	JTAG test reset, active low. For normal device operation, JTAG_nTRST should be pulled low.
JTAG_TCK	I, PU, ST, 3V	JTAG clock.
JTAG_TDI	I, PU, ST, 3V	JTAG test data in.
JTAG_TDO	OZ, 3V	JTAG test data out.
JTAG_TMS	I, PU, ST, 3V	JTAG test mode select.

9.2.5 MII Management Interface

The following table lists the pins associated with the MII Management interface.

Table 869 • **MII Management Interface Pins**

Name	Type	Description
MDIO	I/O, 3V	Management data input/output. MDIO is a bidirectional signal between a PHY and the device that transfers control and status information. Control information is driven by the device synchronously with respect to MDC and is sampled synchronously by the PHY. Status information is driven by the PHY synchronously with respect to MDC and is sampled synchronously by the device.
MDC	O, 3V	Management data clock. MDC is sourced by the station management entity (the device) to the PHY as the timing reference for transfer of information on the MDIO signal. MDC is an aperiodic signal.

9.2.6 Miscellaneous Signals

The following table lists the pins associated with a particular interface or facility on the device.

Table 870 • **Miscellaneous Pins**

Name	Type	Description
nReset	I, PD, ST, 3V	Global device reset, active low.
COMA_MODE	I/O, PU, ST, 3V	When this pin is asserted high, all PHYs are held in a powered-down state. When this pin is deasserted low, all PHYs are powered up and resume normal operation. Additionally, this signal is used to synchronize the operation of multiple devices on the same printed circuit board to provide visual synchronization for LEDs driven from the separate devices.
VCORE_CFG[2:0]	I, PD, ST, 3V	Configuration signals for controlling the VCore-III CPU functions.
VCore_ICE_nEn	I, PU, 3V	VCore ICE nEn. 0: Enables the VCore-III JTAG debug interface over the JTAG interface pins. 1: Enables normal IO-JTAG over the JTAG interface.
THERMDA	A	Thermal diode anode (p-junction).
THERMDC_VSS	A	Thermal diode cathode (n-junction). Connected on-die to V_{SS}.
EXT_IRQ[1:0](1)	I/O PD, 3V	This pin interrupts inputs or outputs to the internal VCore-III CPU system or to an external processor. Signal polarity is programmable.
Reserved_1 Reserved_5 Reserved_6	I, PD, ST, 3V	Tie to V_{DD_IO}.
Reserved_4 Reserved_[7:8]	I, PD, ST, 3V	Tie to V_{SS}.

Table 870 • **Miscellaneous Pins *(continued)***

Name	Type	Description
Reserved_[10:15] Reserved_[19:24] Reserved_[50:81] Reserved_[108:111] Reserved_[116:147] Reserved_[201:209] Reserved_[211:221] Reserved_[223] Reserved_[225] Reserved_[232:237] Reserved_[240:248] Reserved_[300:331]	I, PD, ST, 3V	Leave floating.

1. Available as an alternate function on the GPIO_8 and GPIO_9 pins.

9.2.7 Parallel Interface

The parallel interface (PI) can operate in a Master mode or a Slave mode according to the VCORE_CFG[1:0] signal settings. In Master mode, the internal VCore-III CPU system controls the PI and can access external peripherals over it. In Slave mode, the PI can be used by an external CPU to access internal device resources.

The PI master and slave mode signals are alternate function signals on GPIO pins. For more information about the GPIO mapping, see **GPIO Overlaid Functions**, page 176.

Table 871 • **Parallel Interface VCore-III Master Mode Pins**

Name	Type	Description
PI_Addr[3:0]	OZ, 3V	External address bus. Used for addressing external memory space. PI_Addr0 is LSB.
PI_Data[7:0]	I/O, 3V	External data bus. PI_Data0 is LSB.
PI_nCS	OZ, 3V	Programmable active low chip selects. PI_nCS is used as default for booting from external memory (typically Flash).
PI_nDone	I, 3V	Acknowledges an operation. Used for external device-paced access operation. Signal polarity is programmable.
PI_nOE	OZ, 3V	Active low signal that signals external device to drive data bus during read access.
PI_nWR	OZ, 3V	Active low signal that signals external access direction. Read (1) or write (0).

The following pins are associated with the parallel CPU interface slave mode.

Table 872 • **Parallel CPU Interface Slave Mode Pins**

Name	Type	Description
PI_Addr[3:0]	I, 3V	Internal device register address bus. Controlled by external CPU. PI_Addr0 is LSB.
PI_Data[7:0]	I/O, 3V	Data bus. PI_Data[0] is LSB.
PI_nCS	I, 3V	Device chip select.

Table 872 • **Parallel CPU Interface Slave Mode Pins *(continued)***

Name	Type	Description
PI_nDone	O, 3V	Acknowledges an operation. Signal polarity is programmable.
PI_nOE	I, 3V	Signals device to drive data bus during read operations.
PI_nWR	I, 3V	Signals access direction. Read (1) or write (0).

9.2.8 Power Supplies and Ground

The following table lists power supply and ground pins.

Table 873 • **Power Supply and Ground Pins**

Name	Type	Description
VDD	Power	1.0 V power supply voltage for core
VDD_A	Power	1.0 V power supply voltage for analog circuits
VDD_AL	Power	1.0 V power supply voltage for analog circuits for twisted pair interface
VDD_AH	Power	2.5 V power supply voltage for analog driver in twisted pair interface
VDD_IO	Power	2.5 V power supply for parallel CPU interface, MII Management interface, and miscellaneous I/Os
VDD_IODDR	Power	1.8 V power supply for DDR interface
VDD_VS	Power	1.0 V or 1.2 V power supply for SerDes and Enhanced SerDes interfaces
VSS	Ground	Ground reference

9.2.9 Serial CPU Interface

The serial CPU interface (SI) can be used as a serial slave, master, or boot interface.

As a slave interface, it allows external CPUs to access internal registers. As a master interface, it allows the device to access external devices using a programmable protocol. The serial CPU interface also allows the internal VCore-III CPU system to boot from an attached serial memory device when the VCORE_CFG signals are set appropriately.

The following table lists the pins associated with the serial CPU interface (SI).

Table 874 • **Serial CPU Interface Pins**

Name	Type	Description
SI_Clk	I/O, 3V	Slave mode: Input receiving serial interface clock from external master. Master mode: Output controlled directly by software through register bit. Boot mode: Output driven with clock to external serial memory device.
SI_DI	I, 3V	Slave mode: Input receiving serial interface data from external master. Master mode: Input directly read by software from register bit. Boot mode: Input boot data from external serial memory device.

Table 874 • **Serial CPU Interface Pins *(continued)***

Name	Type	Description
SI_DO	OZ, 3V	Slave mode: Output transmitting serial interface data to external master. Master mode: Output controlled directly by software through register bit. Boot mode: No function.
SI_nEn SI_nEn[3:1](1)	I/O, 3V	Slave mode: Input used to enable SI slave interface. 0 = Enabled 1 = Disabled Master mode: Output controlled directly by software through register bit. Boot mode: Output driven while booting from EEPROM or serial flash to internal VCore-III CPU system. Released when booting is completed.

1. Available as an alternate function on the GPIO_16, GPIO_15, and GPIO_14 pins. For more information about GPIO pin mapping, see **GPIO Overlaid Functions**, page 176.

9.2.10 SerDes Interface

The following pins are associated with the SerDes (SGMII) interface.

Table 875 • **SerDes Interface Pins**

Name	Type	Description
SerDes0_RxP, N	I, Diff, TD	Differential SerDes data inputs.
SerDes0_TxP, N	O, Diff	Differential SerDes data outputs.

9.2.11 Enhanced SerDes Interface

The following pins are associated with the Enhanced SerDes interface.

Table 876 • **Enhanced SerDes Interface Pins**

Name	Type	Description
SerDes_E[1:0]_RxP, N	I, Diff, TD	Differential Enhanced SerDes data inputs.
SerDes_E[1:0]_TxP, N	O, Diff	Differential Enhanced SerDes data outputs.

9.2.12 System Clock Interface

The following table lists the pins associated with the system clock interface.

Table 877 • **System Clock Interface Pins**

Name	Type	Description
RefClk_Sel[2:0]	I, PD	Reference clock frequency selection. 0: Connect to pull-down or leave floating. 1: Connect to pull-up to V_{DD_IO}. Coding: 000: 125 MHz (default). 001: 156.25 MHz. 010: 250 MHz. 011: Reserved. 100: 25 MHz. 101: Reserved. 110: Reserved. 111: Reserved.
RefClk_P RefClk_N	I, Diff	Reference clock input. The input can be either differential or single-ended. In differential mode, REFCLK_P is the true part of the differential signal, and REFCLK_N is the complement part of the differential signal. In single-ended mode, the REFCLK_N should be pulled to V_{DD_A}. REFCLK_P can be used as single-ended LVTTL or LVCMOS input with appropriate circuitry. For more information, see Single-Ended RefClk Input, page 682. Required applied frequency depends on RefClk_Sel[2:0] input state. See description for RefClk_Sel[2:0] pins.
RCVRD_CLK[1:0]	OZ, 3V	The output clock frequency can be between 25 MHz and 125 MHz, based on the selected active recovered media programmed for this pin and the divider configuration. For more information about supported output clock frequencies, see Table 191, page 254. These pins are not active when nReset is asserted. Clock outputs can be enabled or disabled from registers. When disabled, the pin is held low.
IEEE1588(1)	I/O, 3V	This pin can be programmed independently to either output or input. The pin can be used as either an input pulse for synchronization of the internal 1588 master timer or as programmable divided-frequency outputs from the internal 1588 master timer. The programmable divided frequency is between 25 MHz and 1 pulse per second. The programmed output signals duty cycle depends on the programmed divider factor.

1. Available as an alternate function on the GPIO_7 pin.

9.2.13 Twisted Pair Interface

The following pins are associated with the twisted pair interface. The PHYn_LED[1:0] LED control signals associated with the twisted pair interfaces are alternate functions on the GPIOs. For more information about the GPIO pin mapping, see **GPIO Overlaid Functions**, page 176.

Table 878 • **Twisted Pair Interface Pins**

Name	Type	Description
P0_D0P P1_D0P P2_D0P P3_D0P P4_D0P P5_D0P P6_D0P P7_D0P	A_{DIFF}	Tx/Rx channel A positive signal. Positive differential signal connected to the positive primary side of the transformer. This pin signal forms the positive signal of the A data channel. In all three speeds, these pins generate the secondary side signal, normally connected to RJ-45 pin 1.
P0_D0N P1_D0N P2_D0N P3_D0N P4_D0N P5_D0N P6_D0N P7_D0N	A_{DIFF}	Tx/Rx channel A negative signal. Negative differential signal connected to the negative primary side of the transformer. This pin signal forms the negative signal of the A data channel. In all three speeds, these pins generate the secondary side signal, normally connected to RJ-45 pin 2.
P0_D1P P1_D1P P2_D1P P3_D1P P4_D1P P5_D1P P6_D1P P7_D1P	A_{DIFF}	Tx/Rx channel B positive signal. Positive differential signal connected to the positive primary side of the transformer. This pin signal forms the positive signal of the B data channel. In all three speeds, these pins generate the secondary side signal, normally connected to RJ-45 pin 3.
P0_D1N P1_D1N P2_D1N P3_D1N P4_D1N P5_D1N P6_D1N P7_D1N	A_{DIFF}	Tx/Rx channel B negative signal. Negative differential signal connected to the negative primary side of the transformer. This pin signal forms the negative signal of the B data channel. In all three speeds, these pins generate the secondary side signal, normally connected to RJ-45 pin 6.

9.3 Pins by Number

This section provides a numeric list of the VSC7428-12 pins.

A2	Reserved_57
A3	Reserved_55
A4	Reserved_53
A5	Reserved_51
A6	P7_D0P
A7	P7_D1P
A8	Reserved_331
A9	Reserved_329
A10	P6_D0P
A11	P6_D1P
A12	Reserved_327
A13	Reserved_325
A14	P5_D0P
A15	P5_D1P
A16	Reserved_323
A17	Reserved_321
A18	P4_D0P
A19	P4_D1P
A20	Reserved_319
A21	Reserved_317
A22	P3_D0P
A23	P3_D1P
A24	Reserved_315
A25	Reserved_313
AA1	GPIO_7
AA2	GPIO_6
AA3	GPIO_5
AA4	GPIO_4
AA5	VDD_IO_14
AA6	Reserved_147
AA7	Reserved_140
AA8	RefClk_N
AA9	Reserved_136
AA10	Reserved_135
AA11	Reserved_128
AA12	VSS_145
AA13	Reserved_127
AA14	Reserved_120
AA15	Reserved_119
AA16	VSS_146
AA17	SerDes_E1_TxN
AA18	Reserved_111
AA19	SerDes0_TxN
AA20	VSS_147
AA21	SerDes_E0_TxN
AA22	VDD_IODDR_8
AA23	DDR_nWE
AA24	DDR_BA2
AA25	DDR_CK
AA26	DDR_CKn
AB1	GPIO_3
AB2	GPIO_2
AB3	GPIO_1
AB4	GPIO_0
AB5	VDD_IO_15
AB6	VSS_129
AB7	VSS_130
AB8	VSS_131
AB9	VSS_132
AB10	VSS_133
AB11	VSS_134
AB12	VSS_135
AB13	VSS_136
AB14	VSS_137
AB15	VSS_138
AB16	VSS_139
AB17	VSS_140
AB18	VSS_141
AB19	VSS_142
AB20	VSS_143
AB21	VSS_144
AB22	VDD_IODDR_9
AB23	DDR_DQ3
AB24	DDR_CKE
AB25	DDR_DQ2
AB26	DDR_DQ5
AC1	SI_DO
AC2	SI_nEn
AC3	VSS_148
AC4	VDD_IO_16
AC5	VDD_IO_17
AC6	VDD_A_1
AC7	VDD_A_2
AC8	VDD_A_3
AC9	VDD_A_4
AC10	VDD_A_5
AC11	VDD_A_6
AC12	VDD_A_7
AC13	VDD_A_8
AC14	VDD_A_9
AC15	VDD_A_10
AC16	VDD_A_11
AC17	VDD_A_12
AC18	VDD_A_13
AC19	VDD_A_14
AC20	VDD_A_15
AC21	VDD_A_16
AC22	VDD_IODDR_10
AC23	DDR_DQ1
AC24	DDR_DQ4
AC25	DDR_DQ7
AC26	DDR_DQ0
AD1	SI_Clk
AD2	SI_DI
AD3	RCVRD_CLK1
AD4	VDD_IO_18
AD5	VSS_149
AD6	VDD_VS_1
AD7	VDD_VS_2
AD8	VDD_VS_3
AD9	VDD_VS_4
AD10	VDD_VS_5
AD11	VDD_VS_6
AD12	VDD_VS_7

Pins by number *(continued)*

AD13	VDD_VS_8
AD14	VDD_VS_9
AD15	VDD_VS_10
AD16	VDD_VS_11
AD17	VDD_VS_12
AD18	VDD_VS_13
AD19	VDD_VS_14
AD20	VDD_VS_15
AD21	VDD_VS_16
AD22	VSS_150
AD23	VDD_IODDR_11
AD24	DDR_DQ6
AD25	DDR_DQS
AD26	DDR_DQSn
AE1	VSS_151
AE2	RCVRD_CLK0
AE3	VDD_IO_19
AE4	VSS_163
AE5	VSS_152
AE6	Reserved_144
AE7	Reserved_143
AE8	Reserved_22
AE9	Reserved_139
AE10	Reserved_132
AE11	Reserved_131
AE12	VSS_153
AE13	Reserved_124
AE14	Reserved_123
AE15	Reserved_116
AE16	VSS_154
AE17	SerDes_E1_RxP
AE18	Reserved_108
AE19	SerDes0_RxP
AE20	VSS_155
AE21	SerDes_E0_RxP
AE22	SerDes_Rext_0
AE23	VSS_156
AE24	VDD_IODDR_12
AE25	DDR_DM
AE26	VSS_157
AF2	VDD_IO_20
AF3	MDIO
AF4	MDC
AF5	VSS_158
AF6	Reserved_145
AF7	Reserved_142
AF8	Reserved_23
AF9	Reserved_138
AF10	Reserved_133
AF11	Reserved_130
AF12	VSS_159
AF13	Reserved_125
AF14	Reserved_122
AF15	Reserved_117
AF16	VSS_160
AF17	SerDes_E1_RxN
AF18	Reserved_109
AF19	SerDes0_RxN
AF20	VSS_161
AF21	SerDes_E0_RxN
AF22	SerDes_Rext_1
AF23	VSS_162
AF24	VDD_IODDR_14
AF25	VDD_IODDR_13
B1	VSS_1
B2	Reserved_56
B3	Reserved_54
B4	Reserved_52
B5	Reserved_50
B6	P7_D0N
B7	P7_D1N
B8	Reserved_330
B9	Reserved_328
B10	P6_D0N
B11	P6_D1N
B12	Reserved_326
B13	Reserved_324
B14	P5_D0N
B15	P5_D1N
B16	Reserved_322
B17	Reserved_320
B18	P4_D0N
B19	P4_D1N
B20	Reserved_318
B21	Reserved_316
B22	P3_D0N
B23	P3_D1N
B24	Reserved_314
B25	Reserved_312
B26	VSS_2
C1	Reserved_59
C2	Reserved_58
C3	COMA_MODE
C4	nRESET
C5	VDD_IO_21
C6	Reserved_1
C7	VCORE_CFG0
C8	VCORE_CFG1
C9	VCORE_CFG2
C10	VCore_ICE_nEn
C11	Reserved_4
C12	RefClk_Sel0
C13	RefClk_Sel1
C14	RefClk_Sel2
C15	Reserved_8
C16	Reserved_7
C17	Reserved_6
C18	Reserved_5
C19	Reserved_201
C20	Reserved_202
C21	Reserved_203
C22	THERMDC_VSS
C23	THERMDA
C24	Reserved_204
C25	P2_D0N
C26	P2_D0P
D1	Reserved_61
D2	Reserved_60
D3	Reserved_205
D4	VDD_AH_1
D5	VDD_AH_2
D6	Reserved_206
D7	Reserved_207

Pins by number *(continued)*

D8	Reserved_208
D9	Reserved_209
D10	Reserved_248
D11	VDD_AH_4
D12	Reserved_211
D13	Reserved_13
D14	Reserved_12
D15	Reserved_212
D16	VDD_AH_5
D17	JTAG_CLK
D18	JTAG_DI
D19	JTAG_DO
D20	JTAG_TMS
D21	JTAG_TRST
D22	Reserved_213
D23	Reserved_214
D24	Reserved_215
D25	P2_D1N
D26	P2_D1P
E1	Reserved_63
E2	Reserved_62
E3	Reserved_216
E4	VDD_AH_7
E5	VDD_AH_8
E6	VDD_IO_1
E7	VDD_IO_2
E8	VDD_AH_9
E9	VDD_AL_1
E10	VDD_AL_2
E11	VDD_AH_10
E12	VDD_AH_11
E13	Ref_rext_1
E14	Ref_filt_1
E15	VDD_AH_12
E16	VDD_AH_13
E17	VDD_AL_3
E18	VDD_AL_4
E19	VDD_AH_14
E20	VDD_IO_3
E21	VDD_IO_4
E22	VDD_AH_15
E23	VDD_AH_16
E24	Reserved_217
E25	Reserved_310
E26	Reserved_311
F1	Reserved_65
F2	Reserved_64
F3	Reserved_218
F4	VDD_AH_17
F5	VDD_AH_18
F6	VDD_IO_5
F7	VDD_AH_3
F8	VDD_AH_19
F9	VDD_AL_5
F10	VDD_AL_6
F11	VDD_AH_20
F12	VDD_AH_21
F13	Reserved_219
F14	Reserved_220
F15	VDD_AH_22
F16	VDD_AH_23
F17	VDD_AL_7
F18	VDD_AL_8
F19	VDD_AH_24
F20	VDD_AH_6
F21	VDD_IO_6
F22	VDD_AH_25
F23	VDD_AH_26
F24	Reserved_221
F25	Reserved_308
F26	Reserved_309
G1	Reserved_67
G2	Reserved_66
G3	VSS_3
G4	Reserved_15
G5	VSS_4
G6	VDD_1
G7	VDD_2
G8	VDD_3
G9	VDD_AL_9
G10	VDD_AL_10
G11	VDD_4
G12	VDD_5
G13	Reserved_247
G14	Reserved_223
G15	VDD_6
G16	VDD_7
G17	VDD_AL_11
G18	VDD_AL_12
G19	VDD_8
G20	VDD_9
G21	VDD_10
G22	VSS_5
G23	Reserved_10
G24	VSS_6
G25	P1_D0N
G26	P1_D0P
H1	Reserved_69
H2	Reserved_68
H3	VSS_7
H4	Reserved_14
H5	VSS_8
H6	VDD_11
H7	VDD_12
H8	VDD_13
H9	VDD_14
H10	VDD_15
H11	VDD_16
H12	VDD_17
H13	Reserved_246
H14	Reserved_225
H15	VDD_18
H16	VDD_19
H17	VDD_20
H18	VDD_21
H19	VDD_22
H20	VDD_23
H21	VDD_24
H22	VSS_9
H23	Reserved_11
H24	VSS_10
H25	P1_D1N
H26	P1_D1P

Pins by number *(continued)*

J1	Reserved_71
J2	Reserved_70
J3	VDD_AH_27
J4	VDD_AH_28
J5	VDD_AL_13
J6	VDD_AL_14
J7	VDD_AL_15
J8	Reserved_240
J9	Reserved_241
J10	Reserved_242
J11	Reserved_243
J12	Reserved_244
J13	Reserved_245
J14	Reserved_232
J15	Reserved_233
J16	Reserved_234
J17	Reserved_235
J18	Reserved_236
J19	Reserved_237
J20	VDD_AL_16
J21	VDD_AL_17
J22	VDD_AL_18
J23	VDD_AH_29
J24	VDD_AH_30
J25	Reserved_306
J26	Reserved_307
K1	Reserved_73
K2	Reserved_72
K3	VSS_11
K4	Ref_rext_2
K5	VDD_AL_19
K6	VDD_AL_20
K7	VDD_AL_21
K8	VSS_12
K9	VSS_13
K10	VSS_14
K11	VSS_15
K12	VSS_16
K13	VSS_17
K14	VSS_18
K15	VSS_19
K16	VSS_20
K17	VSS_21
K18	VSS_22
K19	VSS_23
K20	VDD_AL_22
K21	VDD_AL_23
K22	VDD_AL_24
K23	Ref_rext_0
K24	VSS_24
K25	Reserved_304
K26	Reserved_305
L1	Reserved_75
L2	Reserved_74
L3	VSS_25
L4	Ref_filt_2
L5	VSS_26
L6	VDD_25
L7	VDD_26
L8	VSS_27
L9	VSS_28
L10	VSS_29
L11	VSS_30
L12	VSS_31
L13	VSS_32
L14	VSS_33
L15	VSS_34
L16	VSS_35
L17	VSS_36
L18	VSS_37
L19	VSS_38
L20	VDD_27
L21	VDD_28
L22	VSS_39
L23	Ref_filt_0
L24	VSS_40
L25	P0_D0N
L26	P0_D0P
M1	Reserved_77
M2	Reserved_76
M3	VDD_AH_31
M4	VDD_AH_32
M5	VDD_AH_33
M6	VDD_29
M7	VDD_30
M8	VSS_41
M9	VSS_42
M10	VSS_43
M11	VSS_44
M12	VSS_45
M13	VSS_46
M14	VSS_47
M15	VSS_48
M16	VSS_49
M17	VSS_50
M18	VSS_51
M19	VSS_52
M20	VDD_31
M21	VDD_32
M22	VDD_AH_34
M23	VDD_AH_35
M24	VDD_AH_36
M25	P0_D1N
M26	P0_D1P
N1	Reserved_79
N2	Reserved_78
N3	VSS_53
N4	VSS_54
N5	VSS_55
N6	VDD_33
N7	VDD_34
N8	VSS_56
N9	VSS_57
N10	VSS_58
N11	VSS_59
N12	VSS_60
N13	VSS_61
N14	VSS_62
N15	VSS_63
N16	VSS_64
N17	VSS_65
N18	VSS_66
N19	VSS_67

Pins by number *(continued)*

N20	VDD_35
N21	VDD_36
N22	VSS_68
N23	VSS_69
N24	VSS_70
N25	Reserved_302
N26	Reserved_303
P1	Reserved_81
P2	Reserved_80
P3	VSS_71
P4	Reserved_24
P5	VDD_IO_7
P6	VDD_37
P7	VDD_38
P8	VSS_72
P9	VSS_73
P10	VSS_74
P11	VSS_75
P12	VSS_76
P13	VSS_77
P14	VSS_78
P15	VSS_79
P16	VSS_80
P17	VSS_81
P18	VSS_82
P19	VSS_83
P20	VDD_39
P21	VDD_40
P22	VDD_IODDR_1
P23	VSS_84
P24	VSS_85
P25	Reserved_300
P26	Reserved_301
R1	GPIO_31
R2	GPIO_30
R3	GPIO_29
R4	GPIO_28
R5	VDD_IO_8
R6	VDD_41
R7	VDD_42
R8	VSS_86
R9	VSS_87
R10	VSS_88
R11	VSS_89
R12	VSS_90
R13	VSS_91
R14	VSS_92
R15	VSS_93
R16	VSS_94
R17	VSS_95
R18	VSS_96
R19	VSS_97
R20	VDD_43
R21	VDD_44
R22	VDD_IODDR_2
R23	Reserved_20
R24	Reserved_19
R25	DDR_Rext
R26	DDR_Vref
T1	GPIO_27
T2	GPIO_26
T3	GPIO_25
T4	GPIO_24
T5	VDD_IO_9
T6	VDD_45
T7	VDD_46
T8	VSS_98
T9	VSS_99
T10	VSS_100
T11	VSS_101
T12	VSS_102
T13	VSS_103
T14	VSS_104
T15	VSS_105
T16	VSS_106
T17	VSS_107
T18	VSS_108
T19	VSS_109
T20	VDD_47
T21	VDD_48
T22	VDD_IODDR_3
T23	Reserved_21
T24	DDR_A13
T25	DDR_A12
T26	DDR_A11
U1	GPIO_23
U2	GPIO_22
U3	GPIO_21
U4	GPIO_20
U5	VDD_IO_10
U6	VSS_110
U7	VSS_111
U8	VSS_112
U9	VSS_113
U10	VSS_114
U11	VSS_115
U12	VSS_116
U13	VSS_117
U14	VSS_118
U15	VSS_119
U16	VSS_120
U17	VSS_121
U18	VSS_122
U19	VSS_123
U20	VSS_124
U21	VSS_125
U22	VDD_IODDR_4
U23	DDR_A7
U24	DDR_A9
U25	DDR_A6
U26	DDR_A8
V1	GPIO_19
V2	GPIO_18
V3	GPIO_17
V4	GPIO_16
V5	VDD_IO_11
V6	VDD_49
V7	VDD_50
V8	VDD_51
V9	VDD_52
V10	VDD_53
V11	VDD_54
V12	VDD_55

Pins by number *(continued)*

V13	VDD_56
V14	VDD_57
V15	VDD_58
V16	VDD_59
V17	VDD_60
V18	VDD_61
V19	VDD_62
V20	VDD_63
V21	VDD_64
V22	VDD_IODDR_5
V23	DDR_A3
V24	DDR_A5
V25	DDR_A2
V26	DDR_A4
W1	GPIO_15
W2	GPIO_14
W3	GPIO_13
W4	GPIO_12
W5	VDD_IO_12
W6	VDD_65
W7	VDD_66
W8	VDD_67
W9	VDD_68
W10	VDD_69
W11	VDD_70
W12	VDD_71
W13	VDD_72
W14	VDD_73
W15	VDD_74
W16	VDD_75
W17	VDD_76
W18	VDD_77
W19	VDD_78
W20	VDD_79
W21	VDD_80
W22	VDD_IODDR_6
W23	DDR_A10
W24	DDR_A1
W25	DDR_nCAS
W26	DDR_A0
Y1	GPIO_11
Y2	GPIO_10
Y3	GPIO_9
Y4	GPIO_8
Y5	VDD_IO_13
Y6	Reserved_146
Y7	Reserved_141
Y8	RefClk_P
Y9	Reserved_137
Y10	Reserved_134
Y11	Reserved_129
Y12	VSS_126
Y13	Reserved_126
Y14	Reserved_121
Y15	Reserved_118
Y16	VSS_127
Y17	SerDes_E1_TxP
Y18	Reserved_110
Y19	SerDes0_TxP
Y20	VSS_128
Y21	SerDes_E0_TxP
Y22	VDD_IODDR_7
Y23	DDR_BA0
Y24	DDR_BA1
Y25	DDR_ODT
Y26	DDR_nRAS

9.4 Pins by Name

This section provides an alphabetical list of the VSC7428-12 pins.

COMA_MODE	C3
DDR_A0	W26
DDR_A1	W24
DDR_A2	V25
DDR_A3	V23
DDR_A4	V26
DDR_A5	V24
DDR_A6	U25
DDR_A7	U23
DDR_A8	U26
DDR_A9	U24
DDR_A10	W23
DDR_A11	T26
DDR_A12	T25
DDR_A13	T24
DDR_BA0	Y23
DDR_BA1	Y24
DDR_BA2	AA24
DDR_CK	AA25
DDR_CKE	AB24
DDR_CKn	AA26
DDR_DM	AE25
DDR_DQ0	AC26
DDR_DQ1	AC23
DDR_DQ2	AB25
DDR_DQ3	AB23
DDR_DQ4	AC24
DDR_DQ5	AB26
DDR_DQ6	AD24
DDR_DQ7	AC25
DDR_DQS	AD25
DDR_DQSn	AD26
DDR_nCAS	W25
DDR_nRAS	Y26
DDR_nWE	AA23
DDR_ODT	Y25
DDR_Rext	R25
DDR_Vref	R26

GPIO_0	AB4
GPIO_1	AB3
GPIO_2	AB2
GPIO_3	AB1
GPIO_4	AA4
GPIO_5	AA3
GPIO_6	AA2
GPIO_7	AA1
GPIO_8	Y4
GPIO_9	Y3
GPIO_10	Y2
GPIO_11	Y1
GPIO_12	W4
GPIO_13	W3
GPIO_14	W2
GPIO_15	W1
GPIO_16	V4
GPIO_17	V3
GPIO_18	V2
GPIO_19	V1
GPIO_20	U4
GPIO_21	U3
GPIO_22	U2
GPIO_23	U1
GPIO_24	T4
GPIO_25	T3
GPIO_26	T2
GPIO_27	T1
GPIO_28	R4
GPIO_29	R3
GPIO_30	R2
GPIO_31	R1
JTAG_CLK	D17
JTAG_DI	D18
JTAG_DO	D19
JTAG_TMS	D20
JTAG_TRST	D21
MDC	AF4

MDIO	AF3
nRESET	C4
P0_D0N	L25
P0_D0P	L26
P0_D1N	M25
P0_D1P	M26
P1_D0N	G25
P1_D0P	G26
P1_D1N	H25
P1_D1P	H26
P2_D0N	C25
P2_D0P	C26
P2_D1N	D25
P2_D1P	D26
P3_D0N	B22
P3_D0P	A22
P3_D1N	B23
P3_D1P	A23
P4_D0N	B18
P4_D0P	A18
P4_D1N	B19
P4_D1P	A19
P5_D0N	B14
P5_D0P	A14
P5_D1N	B15
P5_D1P	A15
P6_D0N	B10
P6_D0P	A10
P6_D1N	B11
P6_D1P	A11
P7_D0N	B6
P7_D0P	A6
P7_D1N	B7
P7_D1P	A7
RCVRD_CLK0	AE2
RCVRD_CLK1	AD3
Ref_filt_0	L23
Ref_filt_1	E14

Pins by name *(continued)*

Ref_filt_2	L4
Ref_rext_0	K23
Ref_rext_1	E13
Ref_rext_2	K4
RefClk_N	AA8
RefClk_P	Y8
RefClk_Sel0	C12
RefClk_Sel1	C13
RefClk_Sel2	C14
Reserved_1	C6
Reserved_4	C11
Reserved_5	C18
Reserved_6	C17
Reserved_7	C16
Reserved_8	C15
Reserved_10	G23
Reserved_11	H23
Reserved_12	D14
Reserved_13	D13
Reserved_14	H4
Reserved_15	G4
Reserved_19	R24
Reserved_20	R23
Reserved_21	T23
Reserved_22	AE8
Reserved_23	AF8
Reserved_24	P4
Reserved_50	B5
Reserved_51	A5
Reserved_52	B4
Reserved_53	A4
Reserved_54	B3
Reserved_55	A3
Reserved_56	B2
Reserved_57	A2
Reserved_58	C2
Reserved_59	C1
Reserved_60	D2
Reserved_61	D1
Reserved_62	E2
Reserved_63	E1
Reserved_64	F2
Reserved_65	F1
Reserved_66	G2
Reserved_67	G1
Reserved_68	H2
Reserved_69	H1
Reserved_70	J2
Reserved_71	J1
Reserved_72	K2
Reserved_73	K1
Reserved_74	L2
Reserved_75	L1
Reserved_76	M2
Reserved_77	M1
Reserved_78	N2
Reserved_79	N1
Reserved_80	P2
Reserved_81	P1
Reserved_110	Y18
Reserved_111	AA18
Reserved_116	AE15
Reserved_117	AF15
Reserved_118	Y15
Reserved_119	AA15
Reserved_120	AA14
Reserved_121	Y14
Reserved_122	AF14
Reserved_123	AE14
Reserved_124	AE13
Reserved_125	AF13
Reserved_126	Y13
Reserved_127	AA13
Reserved_128	AA11
Reserved_129	Y11
Reserved_130	AF11
Reserved_131	AE11
Reserved_132	AE10
Reserved_133	AF10
Reserved_134	Y10
Reserved_135	AA10
Reserved_136	AA9
Reserved_137	Y9
Reserved_138	AF9
Reserved_139	AE9
Reserved_140	AA7
Reserved_141	Y7
Reserved_142	AF7
Reserved_143	AE7
Reserved_144	AE6
Reserved_145	AF6
Reserved_146	Y6
Reserved_147	AA6
Reserved_108	AE18
Reserved_109	AF18
Reserved_211	D12
Reserved_212	D15
Reserved_213	D22
Reserved_214	D23
Reserved_215	D24
Reserved_216	E3
Reserved_217	E24
Reserved_218	F3
Reserved_219	F13
Reserved_220	F14
Reserved_221	F24
Reserved_223	G14
Reserved_225	H14
Reserved_232	J14
Reserved_233	J15
Reserved_234	J16
Reserved_235	J17
Reserved_236	J18
Reserved_237	J19
Reserved_240	J8
Reserved_241	J9
Reserved_242	J10
Reserved_243	J11
Reserved_244	J12
Reserved_245	J13
Reserved_246	H13
Reserved_247	G13
Reserved_248	D10

Pins by name *(continued)*

Reserved_201	C19
Reserved_202	C20
Reserved_203	C21
Reserved_204	C24
Reserved_205	D3
Reserved_206	D6
Reserved_207	D7
Reserved_208	D8
Reserved_209	D9
Reserved_310	E25
Reserved_311	E26
Reserved_312	B25
Reserved_313	A25
Reserved_314	B24
Reserved_315	A24
Reserved_316	B21
Reserved_317	A21
Reserved_318	B20
Reserved_319	A20
Reserved_320	B17
Reserved_321	A17
Reserved_322	B16
Reserved_323	A16
Reserved_324	B13
Reserved_325	A13
Reserved_326	B12
Reserved_327	A12
Reserved_328	B9
Reserved_329	A9
Reserved_330	B8
Reserved_331	A8
Reserved_300	P25
Reserved_301	P26
Reserved_302	N25
Reserved_303	N26
Reserved_304	K25
Reserved_305	K26
Reserved_306	J25
Reserved_307	J26
Reserved_308	F25
Reserved_309	F26

SerDes_E0_RxN	AF21
SerDes_E0_RxP	AE21
SerDes_E0_TxN	AA21
SerDes_E0_TxP	Y21
SerDes_E1_RxN	AF17
SerDes_E1_RxP	AE17
SerDes_E1_TxN	AA17
SerDes_E1_TxP	Y17
SerDes_Rext_0	AE22
SerDes_Rext_1	AF22
SerDes0_RxN	AF19
SerDes0_RxP	AE19
SerDes0_TxN	AA19
SerDes0_TxP	Y19
SI_Clk	AD1
SI_DI	AD2
SI_DO	AC1
SI_nEn	AC2
THERMDA	C23
THERMDC_VSS	C22
VCORE_CFG0	C7
VCORE_CFG1	C8
VCORE_CFG2	C9
VCore_ICE_nEn	C10
VDD_1	G6
VDD_2	G7
VDD_3	G8
VDD_4	G11
VDD_5	G12
VDD_6	G15
VDD_7	G16
VDD_8	G19
VDD_9	G20
VDD_10	G21
VDD_11	H6
VDD_12	H7
VDD_13	H8
VDD_14	H9
VDD_15	H10
VDD_16	H11
VDD_17	H12

VDD_18	H15
VDD_19	H16
VDD_20	H17
VDD_21	H18
VDD_22	H19
VDD_23	H20
VDD_24	H21
VDD_25	L6
VDD_26	L7
VDD_27	L20
VDD_28	L21
VDD_29	M6
VDD_30	M7
VDD_31	M20
VDD_32	M21
VDD_33	N6
VDD_34	N7
VDD_35	N20
VDD_36	N21
VDD_37	P6
VDD_38	P7
VDD_39	P20
VDD_40	P21
VDD_41	R6
VDD_42	R7
VDD_43	R20
VDD_44	R21
VDD_45	T6
VDD_46	T7
VDD_47	T20
VDD_48	T21
VDD_49	V6
VDD_50	V7
VDD_51	V8
VDD_52	V9
VDD_53	V10
VDD_54	V11
VDD_55	V12
VDD_56	V13
VDD_57	V14
VDD_58	V15

Pins by name *(continued)*

VDD_59	V16
VDD_60	V17
VDD_61	V18
VDD_62	V19
VDD_63	V20
VDD_64	V21
VDD_65	W6
VDD_66	W7
VDD_67	W8
VDD_68	W9
VDD_69	W10
VDD_70	W11
VDD_71	W12
VDD_72	W13
VDD_73	W14
VDD_74	W15
VDD_75	W16
VDD_76	W17
VDD_77	W18
VDD_78	W19
VDD_79	W20
VDD_80	W21
VDD_A_1	AC6
VDD_A_2	AC7
VDD_A_3	AC8
VDD_A_4	AC9
VDD_A_5	AC10
VDD_A_6	AC11
VDD_A_7	AC12
VDD_A_8	AC13
VDD_A_9	AC14
VDD_A_10	AC15
VDD_A_11	AC16
VDD_A_12	AC17
VDD_A_13	AC18
VDD_A_14	AC19
VDD_A_15	AC20
VDD_A_16	AC21
VDD_AH_1	D4
VDD_AH_2	D5
VDD_AH_3	F7
VDD_AH_4	D11
VDD_AH_5	D16
VDD_AH_6	F20
VDD_AH_7	E4
VDD_AH_8	E5
VDD_AH_9	E8
VDD_AH_10	E11
VDD_AH_11	E12
VDD_AH_12	E15
VDD_AH_13	E16
VDD_AH_14	E19
VDD_AH_15	E22
VDD_AH_16	E23
VDD_AH_17	F4
VDD_AH_18	F5
VDD_AH_19	F8
VDD_AH_20	F11
VDD_AH_21	F12
VDD_AH_22	F15
VDD_AH_23	F16
VDD_AH_24	F19
VDD_AH_25	F22
VDD_AH_26	F23
VDD_AH_27	J3
VDD_AH_28	J4
VDD_AH_29	J23
VDD_AH_30	J24
VDD_AH_31	M3
VDD_AH_32	M4
VDD_AH_33	M5
VDD_AH_34	M22
VDD_AH_35	M23
VDD_AH_36	M24
VDD_AL_1	E9
VDD_AL_2	E10
VDD_AL_3	E17
VDD_AL_4	E18
VDD_AL_5	F9
VDD_AL_6	F10
VDD_AL_7	F17
VDD_AL_8	F18
VDD_AL_9	G9
VDD_AL_10	G10
VDD_AL_11	G17
VDD_AL_12	G18
VDD_AL_13	J5
VDD_AL_14	J6
VDD_AL_15	J7
VDD_AL_16	J20
VDD_AL_17	J21
VDD_AL_18	J22
VDD_AL_19	K5
VDD_AL_20	K6
VDD_AL_21	K7
VDD_AL_22	K20
VDD_AL_23	K21
VDD_AL_24	K22
VDD_IO_1	E6
VDD_IO_2	E7
VDD_IO_3	E20
VDD_IO_4	E21
VDD_IO_5	F6
VDD_IO_6	F21
VDD_IO_7	P5
VDD_IO_8	R5
VDD_IO_9	T5
VDD_IO_10	U5
VDD_IO_11	V5
VDD_IO_12	W5
VDD_IO_13	Y5
VDD_IO_14	AA5
VDD_IO_15	AB5
VDD_IO_16	AC4
VDD_IO_17	AC5
VDD_IO_18	AD4
VDD_IO_19	AE3
VDD_IO_20	AF2
VDD_IO_21	C5
VDD_IODDR_1	P22
VDD_IODDR_2	R22
VDD_IODDR_3	T22
VDD_IODDR_4	U22

Pins by name *(continued)*

VDD_IODDR_5	V22
VDD_IODDR_6	W22
VDD_IODDR_7	Y22
VDD_IODDR_8	AA22
VDD_IODDR_9	AB22
VDD_IODDR_10	AC22
VDD_IODDR_11	AD23
VDD_IODDR_12	AE24
VDD_IODDR_13	AF25
VDD_IODDR_14	AF24
VDD_VS_1	AD6
VDD_VS_2	AD7
VDD_VS_3	AD8
VDD_VS_4	AD9
VDD_VS_5	AD10
VDD_VS_6	AD11
VDD_VS_7	AD12
VDD_VS_8	AD13
VDD_VS_9	AD14
VDD_VS_10	AD15
VDD_VS_11	AD16
VDD_VS_12	AD17
VDD_VS_13	AD18
VDD_VS_14	AD19
VDD_VS_15	AD20
VDD_VS_16	AD21
VSS_1	B1
VSS_2	B26
VSS_3	G3
VSS_4	G5
VSS_5	G22
VSS_6	G24
VSS_7	H3
VSS_8	H5
VSS_9	H22
VSS_10	H24
VSS_11	K3
VSS_12	K8
VSS_13	K9
VSS_14	K10
VSS_15	K11
VSS_16	K12
VSS_17	K13
VSS_18	K14
VSS_19	K15
VSS_20	K16
VSS_21	K17
VSS_22	K18
VSS_23	K19
VSS_24	K24
VSS_25	L3
VSS_26	L5
VSS_27	L8
VSS_28	L9
VSS_29	L10
VSS_30	L11
VSS_31	L12
VSS_32	L13
VSS_33	L14
VSS_34	L15
VSS_35	L16
VSS_36	L17
VSS_37	L18
VSS_38	L19
VSS_39	L22
VSS_40	L24
VSS_41	M8
VSS_42	M9
VSS_43	M10
VSS_44	M11
VSS_45	M12
VSS_46	M13
VSS_47	M14
VSS_48	M15
VSS_49	M16
VSS_50	M17
VSS_51	M18
VSS_52	M19
VSS_53	N3
VSS_54	N4
VSS_55	N5
VSS_56	N8
VSS_57	N9
VSS_58	N10
VSS_59	N11
VSS_60	N12
VSS_61	N13
VSS_62	N14
VSS_63	N15
VSS_64	N16
VSS_65	N17
VSS_66	N18
VSS_67	N19
VSS_68	N22
VSS_69	N23
VSS_70	N24
VSS_71	P3
VSS_72	P8
VSS_73	P9
VSS_74	P10
VSS_75	P11
VSS_76	P12
VSS_77	P13
VSS_78	P14
VSS_79	P15
VSS_80	P16
VSS_81	P17
VSS_82	P18
VSS_83	P19
VSS_84	P23
VSS_85	P24
VSS_86	R8
VSS_87	R9
VSS_88	R10
VSS_89	R11
VSS_90	R12
VSS_91	R13
VSS_92	R14
VSS_93	R15
VSS_94	R16
VSS_95	R17
VSS_96	R18
VSS_97	R19

Pins by name *(continued)*

VSS_98	T8
VSS_99	T9
VSS_110	U6
VSS_111	U7
VSS_112	U8
VSS_113	U9
VSS_114	U10
VSS_115	U11
VSS_116	U12
VSS_117	U13
VSS_118	U14
VSS_119	U15
VSS_120	U16
VSS_121	U17
VSS_122	U18
VSS_123	U19
VSS_124	U20
VSS_125	U21
VSS_126	Y12
VSS_127	Y16
VSS_128	Y20
VSS_129	AB6
VSS_130	AB7
VSS_131	AB8
VSS_132	AB9
VSS_133	AB10
VSS_134	AB11
VSS_135	AB12
VSS_136	AB13
VSS_137	AB14
VSS_138	AB15
VSS_139	AB16
VSS_140	AB17
VSS_141	AB18
VSS_142	AB19
VSS_143	AB20
VSS_144	AB21
VSS_145	AA12
VSS_146	AA16
VSS_147	AA20
VSS_148	AC3

VSS_149	AD5
VSS_150	AD22
VSS_151	AE1
VSS_152	AE5
VSS_153	AE12
VSS_154	AE16
VSS_155	AE20
VSS_156	AE23
VSS_157	AE26
VSS_158	AF5
VSS_159	AF12
VSS_160	AF16
VSS_161	AF20
VSS_162	AF23
VSS_163	AE4
VSS_100	T10
VSS_101	T11
VSS_102	T12
VSS_103	T13
VSS_104	T14
VSS_105	T15
VSS_106	T16
VSS_107	T17
VSS_108	T18
VSS_109	T19

10 Package Information

The VSC7428XJG-12 package is a lead-free (Pb-free), 672-pin, thermally enhanced, plastic ball grid array (BGA) with a 27 mm × 27 mm body size, 1 mm pin pitch, and 2.44 mm maximum height.

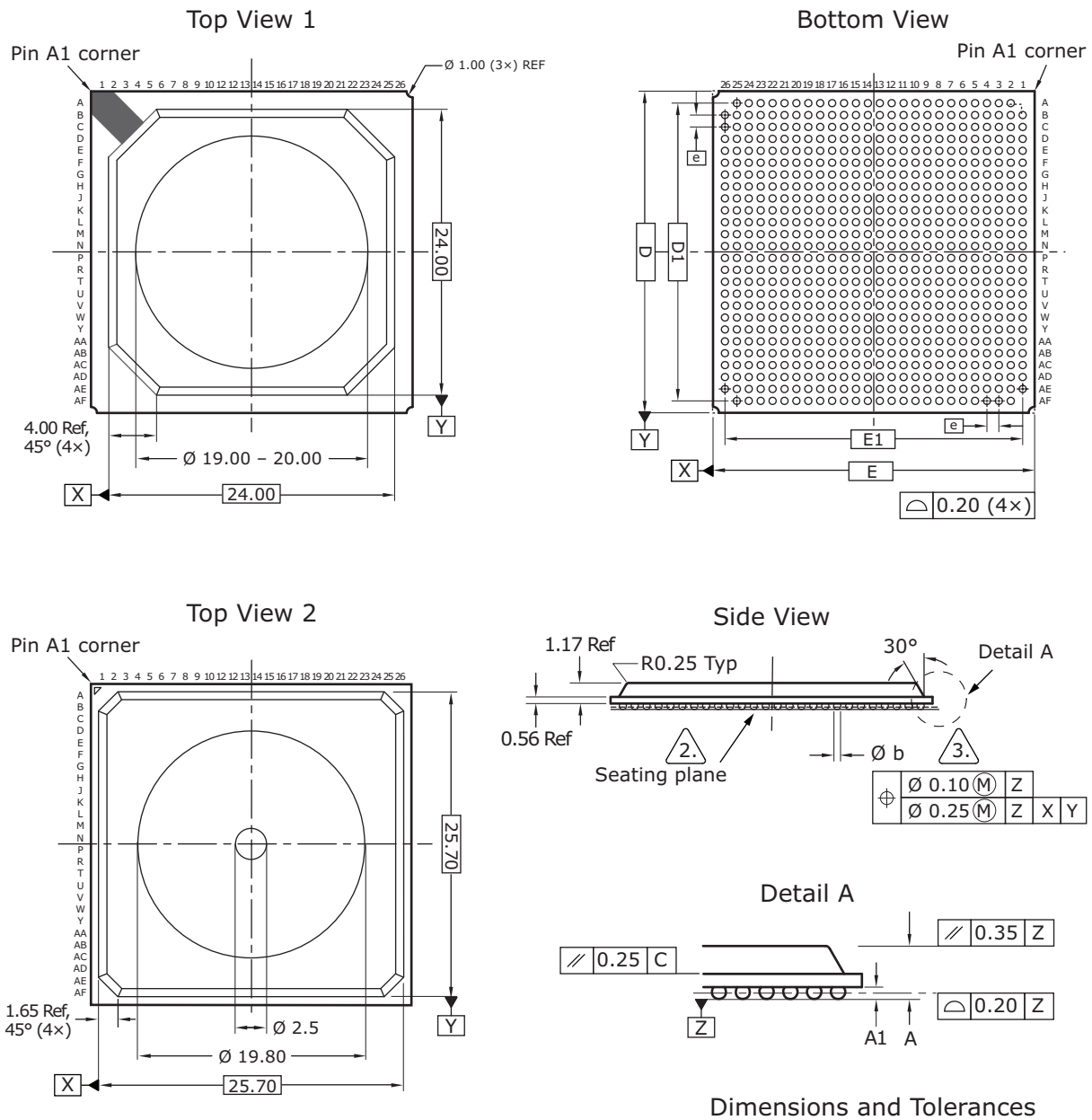
Lead-free products from Vitesse comply with the temperatures and profiles defined in the joint IPC and JEDEC standard IPC/JEDEC J-STD-020. For more information, see the IPC and JEDEC standard.

This section provides the package drawing, thermal specifications, and moisture sensitivity rating for the VSC7428-12 device.

10.1 Package Drawing

The following illustration shows the package drawing for the VSC7428-12 device. The drawing contains two top views, a bottom view, a side view, a detail view, dimensions, tolerances, and notes. The top views reflect one of two packages customers can expect to receive.

Figure 122. Package Drawing



Dimensions and Tolerances

Reference	Minimum	Nominal	Maximum
A	2.10	2.23	2.44
A1	0.40	0.50	0.60
D		27.00	
E		27.00	
D1		25.00	
E1		25.00	
e		1.00	
3. b	0.50	0.60	0.70

Notes

1. All dimensions and tolerances are in millimeters (mm).
2. Primary datum Z and seating plane are defined by the spherical crowns of the solder balls.
3. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.
4. Radial true position is represented by typical values.
5. Top view 1 and top view 2 reflect one of two packages customers can expect to receive.

10.2 Thermal Specifications

Thermal specifications for this device is based on the JEDEC JESD51 family of documents. These documents are available on the JEDEC Web site at www.jedec.org. The thermal specifications are modeled using a four-layer test board with two signal layers, a power plane, and a ground plane (2s2p PCB). For more information about the thermal measurement method used for this device, see the JESD51-1 standard.

Table 879. Thermal Resistances

Symbol	°C/W	Parameter
θ_{JCtop}	3.27	Die junction to package case top
θ_{JB}	6.03	Die junction to printed circuit board
θ_{JA}	12.14	Die junction to ambient
θ_{JMA} at 1 m/s	9.42	Die junction to moving air measured at an air speed of 1 m/s
θ_{JMA} at 2 m/s	8	Die junction to moving air measured at an air speed of 2 m/s

To achieve results similar to the modeled thermal measurements, the guidelines for board design described in the JESD51 family of publications must be applied. For information about applications using BGA packages, see the following:

- JESD51-2A, *Integrated Circuits Thermal Test Method Environmental Conditions, Natural Convection (Still Air)*
- JESD51-6, *Integrated Circuit Thermal Test Method Environmental Conditions, Forced Convection (Moving Air)*
- JESD51-8, *Integrated Circuit Thermal Test Method Environmental Conditions, Junction-to-Board*
- JESD51-9, *Test Boards for Area Array Surface Mount Package Thermal Measurements*

10.3 Moisture Sensitivity

This device is rated moisture sensitivity level 4 as specified in the joint IPC and JEDEC standard IPC/JEDEC J-STD-020. For more information, see the IPC and JEDEC standard.

11 Design Guidelines

This section provides information about design guidelines for the VSC7428-12 device.

11.1 Power Supplies

The following guidelines apply to designing power supplies for use with the VSC7428-12 device.

- Make at least one unbroken ground plane (GND).
- Use the power and ground plane combination as an effective power supply bypass capacitor. The capacitance is proportional to the area of the two planes and inversely proportional to the separation between the planes. Typical values with a 0.25 mm (0.01 inch) separation are 100 pF/in2. This capacitance is more effective than a capacitor of equivalent value, because the planes have no inductance or Equivalent Series Resistance (ESR).
- Do not cut up the power or ground planes in an effort to steer current paths. This usually produces more noise, not less. Furthermore, place vias and clearances in a configuration that maintains the integrity of the plane. Groups of vias spaced close together often overlap clearances. This can form a large slot in the plane. As a result, return currents are forced around the slot, which increases the loop area and EMI emissions. Signals should never be placed on a ground plane, because the resulting slot forces return currents around the slot.
- Vias connecting power planes to the supply and ground balls must be at least 0.25 mm (0.010 inch) in diameter, preferably with no thermal relief and plated closed with copper or solder. Use separate (or even multiple) vias for each supply and ground ball.

11.2 Power Supply Decoupling

Each power supply voltage should have both bulk and high-frequency decoupling capacitors. Recommended capacitors are as follows:

- For bulk decoupling, use 10 µF high capacity and low ESR capacitors or equivalent, distributed across the board.
- For high-frequency decoupling, use 0.1 µF high frequency (for example, X7R) ceramic capacitors placed on the side of the PCB closest to the plane being decoupled, and as close as possible to the power ball. A larger value in the same housing unit produces even better results.
- Use surface-mounted components for lower lead inductance and pad capacitance. Smaller form factor components are best (that is, 0402 is better than 0603).

11.3 Reference Clock

The device reference clock can be a 25 MHz, 125 MHz, 156.25 MHz, or 250 MHz clock signal. It can be either a differential reference clock or a single-ended clock.

11.3.1 Single-Ended RefClk Input

An external resistor network is required to use a single-ended reference clock. The network limits the amplitude and adjusts the center of the swing.

The following illustrations show configurations for a single-ended reference clock.

Figure 123 **• 2.5 V CMOS Single-Ended RefClk Input Resistor Network**

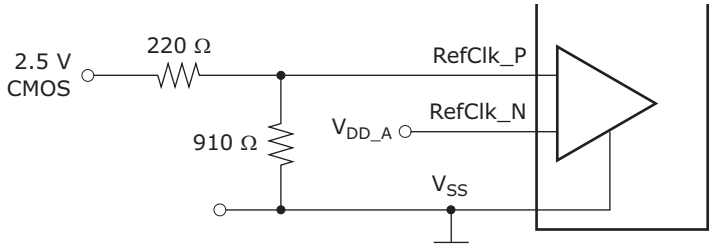
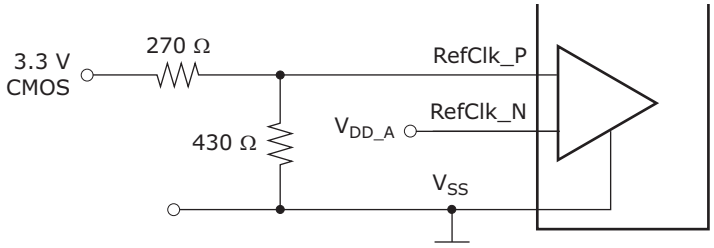


Figure 124 • **3.3 V CMOS Single-Ended RefClk Input Resistor Network**



11.4 Interfaces

This section provides general recommendations for all interfaces and information related to the specific interfaces on the device.

11.4.1 General Recommendations

High-speed signals require excellent frequency and phase response up to the third harmonic. The best design would provide excellent frequency and phase response up to the seventh harmonic. The following recommendations can improve signal quality and minimize transmission distances:

Keep traces as short as possible. Initial component placement should be considered very carefully.

- The impedance of the traces must match the impedance of the termination resistors, connectors, and cable. This reduces reflections due to impedance mismatches.
- Differential impedance must be maintained in a 100 Ω differential application. Routing two 50 Ω traces is not adequate. The two traces must be separated by enough distance to maintain differential impedance. When routing differential pairs, keep the two trace lengths identical. Differences in trace lengths translate directly into signal skew. Note that the differential impedance may be affected when separations occur.
- Keep differential pair traces on the same layer of the PCB to minimize impedance discontinuities.
- Do not group all the passive components together. The pads of the components add capacitance to the traces. At the frequencies encountered, this can result in unwanted reductions in impedance. Use surface-mounted 0603 components to reduce this effect.
- Eliminate or reduce stub lengths.
- Reduce, if not eliminate, vias to minimize impedance discontinuities. Remember that vias and their clearance holes in the power/ground planes can cause impedance discontinuities in nearby signals. Keep vias away from other traces.
- Keep signal traces away from other signals that might capacitively couple noise into the signals. A good rule of thumb is to keep the traces apart by ten times the width of the trace.
- Do not route digital signals from other circuits across the area of the high-speed transmitter and receiver signals.
- Using grounded guard traces is typically not effective for improving signal quality. A ground plane is more effective. However, a common use of guard traces is to route them during the layout, but remove them prior to design completion. This has the benefit of enforcing keep-out areas around sensitive high-speed signals so that vias and other traces are not accidentally placed incorrectly.
- When signals in a differential pair are mismatched, the result is a common-mode current. In a well-designed system, common-mode currents should make up less than one percent of the total differential currents. Mode currents represent a primary source of EMI emissions. To reduce common-mode currents, route differential traces so that their lengths are the same. For example, a 5-mm (0.2-inch) length mismatch between differential signals having the rise and fall times of 200 ps results in the common-mode current being up to 18% of the differential current.

Note: Care must be taken when choosing proper components (such as the termination resistors) in the designing of the layout of a printed circuit board, because of the high application frequency. The use of surface-mount components is highly recommended to minimize parasitic inductance and lead length of the termination resistor.

Matching the impedance of the PCB traces, connectors, and balanced interconnect media is also highly recommended. Impedance variations along the entire interconnect path must be minimized, because they degrade the signal path and may cause reflections of the signal.

11.4.2 SGMII Interface

The SGMII interface consists of a Tx and Rx differential pair operating at 1250 Mbps.

The SGMII signals can be routed on any PCB trace layer with the following constraints:

- The Tx output signals in a pair should have matched electrical lengths.
- The Rx input signals in a pair should have matched electrical lengths.
- SGMII Tx and Rx pairs must be routed as 100 Ω differential traces with ground plane as reference.
- Keep differential pair traces on the same layer of the PCB to minimize impedance discontinuities.
- AC-coupling of Tx and Rx may be needed, depending on the PHY. If AC-coupled, the inputs are self-biased.
- To reduce the crosstalk between pairs or other PCB lines, it is recommended that the spacing on each side of the pair be larger than four times the track width.

11.4.3 Parallel Interface

This section applies when the parallel interface is enabled.

The parallel interface (PI) consists of PI_Addr3:0], PI_Data[7:0], PI_nCS, PI_nDone, PI_nOE, and PI_nWR. Leave these signals floating if the parallel interface is not used.

When using the parallel interface, the timing parameter $t_{D(SLNH)}$ indicates when an issued command is sampled by the VSC7428-12. For more information about the timing parameter, see Table 854, page 648.

To ensure that the PI_nDone signal is driven inactive properly, add a 4.7 kΩ pull-up resistor to this signal, when used.

11.4.4 Serial Interface

If the serial CPU interface is not used, all input signals can be left floating.

The SI bus consists of the SI_Clk clock signal, the SI_DO and SI_DI data signals, and the SI_nCS0 device select signal.

When routing the SI_Clk signal, be sure to create clean edges. If the SI bus is connected to more than one slave device, route it in a daisy-chain configuration with no stubs. Terminate the SI_Clk signal properly to avoid reflections and double clocking.

If it is not possible (or desirable) to route the bus in a daisy-chain configuration, the SI_Clk signal should be buffered and routed in a star topology from the buffers. Each buffered clock should be terminated at its source.

The SI tristates the SI_Clk and SI_DO signals prior to deasserting the SI_nCS0 signal. This makes it possible to implement CPOL/CPHA as 0/0 or 1/1, if the attached SI devices require it, using termination resistors. If the attached devices support both types of CPOL/CPHA, SI_Clk and SI_DO must still have pull resistors to one of the I/O supply rails to prevent spurious clocks being seen when the signals are tristated.

11.4.5 Enhanced SerDes Interface

The Enhanced SerDes interface can be used for fiber connections, backplanes, or direct coupler cable connections, such as the CX4 cable.

The Enhanced SerDes interface can operate in several modes. The physical signal bit rate is between 125 Mbps to 6.25 Mbps.

The inputs are self-biased and have internal AC-coupling. In some modes, the interface requires external AC-coupling, because of the input DC voltage limitation. If external AC-coupling capacitors are required, it is recommended to use small form factor components, such as 0603. The small form factor minimizes impedance mismatch by the AC-coupling capacitors, because the size of the form factor approximately matches the trace width commonly used for these signals.

The Enhanced SerDes interface can be directly connected to either 1 Gbps or 2.5 Gbps SFP modules. For these applications, external AC-coupling capacitors are not required, because the SFP module already includes capacitors.

The following table lists the AC-coupling requirements for common Enhanced SerDes connections.

Table 880 • **Enhanced SerDes Interface Coupling Requirements**

Enhanced SerDes Connection	Mode	External AC-Coupling Requirement
SFP modules	SFP	Not required
SGMII PHY	SGMII	Required(1)
Enhanced SerDes device	Enhanced SerDes	Required

1. AC-coupling is not required with direct connection to the VSC8512 PHY device.

The Enhanced SerDes interface signals must be routed as a differential pair, with a 100 Ω differential characteristic impedance. The differential intrapair skew must be below 5 ps in the PCB trace.

To minimize crosstalk between transmitter and receiver, equal drive strength is recommended in both devices in a link.

To minimize crosstalk between differential pairs, the characteristic differential impedance of the signals must be determined only by the distance to the reference plane and the intra-pair coupling and not the distance to the neighboring traces. To separate the transmitter and receiver signals to minimize crosstalk, it is recommended to route the transmitter and receiver signals on as many different PCB layers as feasible.

11.4.6 Two-Wire Serial Interface

The two-wire serial interface is capable of suppressing small amplitude glitches less than 5 ns in duration, which is less than the 50 ns duration often quoted for similar interfaces. Because the two-wire serial implementation uses Schmitt-triggered inputs, the VSC7428-12 device has a greater tolerance to low amplitude noise. For glitch-free operation, select the proper pull-up resistor value to ensure that the transition time through the input switching region is less than 5 ns given the line's total capacitive load. For capacitive loads up to 40 pF, a pull-up resistor of 510 Ω or less ensures glitch-free operation for noise levels up to 700 mV peak-to-peak.

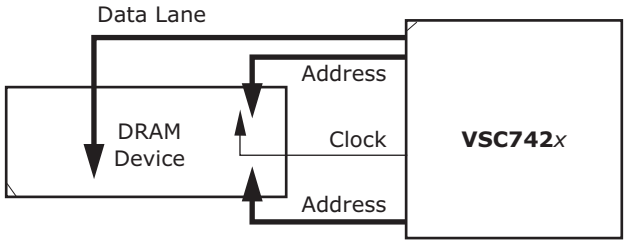
11.4.7 DDR2 SDRAM Interface

The DDR2 SDRAM interface is designed to interface directly with a single 8-bit DDR SDRAM device. The maximum supported density is 128 Mbyte (1 Gbps).

All signals on this interface must be connected one-to-one with the corresponding signals on the DDR SDRAM device. If the memory size of the DDR SDRAM is smaller than maximum, then the upper part of the address and bank address signals can be left unconnected. All eight data bits must be used.

The placement of the VSC7428-12 device interface signals is optimized for point-to-point routing directly to a single DDR SDRAM device.

Figure 125 • **DDR2 SDRAM Point-to-Point Routing**



Because reflections are absorbed by the driver, keep the physical distance of all the SDRAM interface signals below 1 ns to omit any external discrete termination on the address, command, control and clock lines.

When routing the DDR2 interface, attention must be paid to the skew, primary concern is skew within the byte lane between the differential strobe and the single-ended signals. Skew recommendations for the DDR2 interface are listed in the following table.

Table 881 • **Recommended Skew Budget**

Description	Signal	Maximum Skew
Skew within byte lane 0	DDR_DQS/DDR_DQSn	50 ps
Skew within address, command, and control bus	DDR_CK/DDR_CKn DDR_nRAS DDR_CKe DDR_ODT DDR_nCAS DDR_nWE DDR_BA[2:0] DDR_A[13:0]	100 ps
Skew between control bus clock and byte lane clock	DDR_CK/DDR_CKn DDR_DQS/DDR_DQSn	1250 ps
Control bus differential clock intrapair skew	DDR_CK/DDR_CKn	5 ps

- Use a shared voltage reference between the VSC7428-12 device's DDR_Vref supply and the DDR device's reference voltage.
- Generate the DDR_Vref from the V_{DD_IODDR} supply using a resistor divider with value of 1 kΩ and an accuracy of 1% or better.
- Use a decoupling capacitance of at least 0.1 µF on the supply in a manner similar to V_{DD_IODDR} and V_{SS} to ensure tracking of supply variations; however, the time constant of the resistor divider and decoupling capacitance should not exceed the nReset assertion time after power on.

Recommend routing:

- DDR_CK/DDR_CKn must be routed as a differential pair with a 100 Ω differential characteristic impedance.
- DDR_DQS/DDR_DQSn must be routed as a differential pair with a 100 Ω differential characteristic impedance.
- To minimize crosstalk, the characteristic impedance of the single-ended signals should be determined predominantly by the distance to the reference plane and not the distance to the neighboring traces.
- The crosstalk should be below –20 dB.

11.4.8 Thermal Diode External Connection

The internal on-die thermal diode can be used with an external temperature monitor to easily and accurately measure the junction temperature of the VSC7428-12 device.

The on-die thermal diode has internal connected the diode cathode to V_{SS}, the external temperature sensor must support the thermal diode cathode connected to V_{SS}.

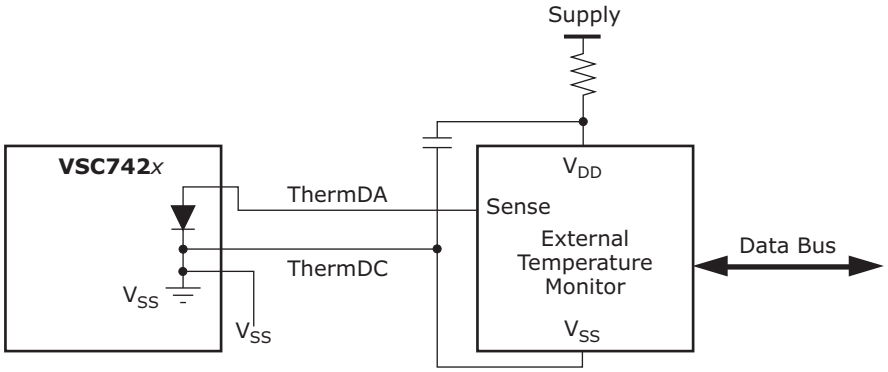
Thermal diode is extremely sensitive to noise. To minimize the temperature measurement errors, follow these guidelines:

- Route the ThermDC and ThermDA signals as a differential pair with a differential impedance less than 100 Ω.
- Place the external temperature monitor as close as is possible to the VSC7428-12 device.
- Add a 47 Ω resistor in series with the external temperature monitor supply to filter noise.

- Place a de-coupling capacitor between the external temperature monitor supply pin and the ThermDC signal. Place the capacitor close to the external temperature sensor, as shown in the following illustration.

Connect the external temperature monitor V_{SS} pin directly to the ThermDC pin, which has the connection to V_{SS}, as shown in the following illustration. Do not connect the external temperature monitor V_{SS} pin to the global V_{SS} plane.

***Figure 126* • External Temperature Monitor Connection**



12 Design Considerations

This section provides information about the design considerations for the VSC7428-12 device.

12.1 10BASE-T Mode Unable to Re-establish Link

10BASE-T mode is unable to re-establish link with the following devices if the link drops while sending data: SparX-III™ and Caracal™ family of switches, VSC8512-02, VSC8522-02, VSC8522-12, VSC8504, VSC8552, VSC8572, and VSC8574. No issue is observed for other link partner devices. The probability of this error occurring is low except in a test environment.

The workaround is to contact Vitesse for the current API software release.

12.2 Software Script for Link Performance

Software script is required for improved link performance. PHY ports may exhibit suboptimal performance. Contact Vitesse for a script to be applied during system initialization.

12.3 10BASE-T Signal Amplitude

10BASE-T signal amplitude can be lower than the minimum specified in IEEE 802.3 paragraph 14.3.1.2.1 (2.2 V) at low supply voltages. This issue is not estimated to present any system level impact. Performance is not impaired with cables up to 130 m with various link partners.

12.4 Clause 45 Register 7.60

Clause 45, register 7.60, bit 10 reads back as a logic 1. This is a reserved bit in the standard and should be ignored by software.

12.5 Clause 45 Register 3.22

Clause 45, register 3.22 is cleared upon read only when extended page access register (register 31) is set to 0. This register cannot be read when page access register is set to a value other than 0.

The workaround is to set the extended page access register to 0 before accessing clause 45, register 3.22.

12.6 Clause 45 Register 3.1

Clause 45, register 3.1, Rx and Tx LPI received bits are cleared upon read only when extended page access register (register 31) is set to 0.

The workaround is to set the extended page access register to 0 before accessing clause 45, register 3.1.

12.7 Clause 45 Register Address Post-Increment

Clause 45 register address post-increment only works when reading registers and only when the extended page access register (register 31) is set to 0. The estimated impact is low, as there are very few Clause 45 registers in a PHY, and they can be addressed individually.

The workaround is to access Clause 45 registers individually.

12.8 IEEE1588 Out of Sync Situation

For CuPHY port 10-11 and all Serdes ports with or without non timestamping PHY: If a short frame of less than approximately 3 bytes is received on a port while the PCS-rx is enabled, the timestamp FIFO erroneously increments. This means that the timestamp of the previous packet is used in any IEEE1588 operation on the given port. The only way to bring the timestamp FIFO in sync is to do a full reset of the switch.

Workaround for CuPHY: Keep the PCS-rx disabled during link state changes to avoid illegal frames getting a timestamp that causes the OOS (out of sync) state.

12.8.1 Copper Port (internal CuPHY 10-11 and External PHYs Without Timestamping)

Initially, before link is up, the switch/port PCS-rx is disabled.

The PHY is configured to advertise all supported speeds (as configured for the port).

On link-up, software reads back the negotiated speed from the PHY and configures the MAC and then enables the PCS-rx.

On link-down, the PCS-rx is disabled.

When the link speed changes to 10M or 100M then the PHY autonegotiation capabilities are removed without restarting autonegotiation.

This is to avoid the PHY changing to a higher speed before the port PCS-rx is disabled.

Next time the link partner restarts autonegotiation the autonegotiation process will end up in not-resolved state with no change to the speed.

The software fix detects link down, disables the PCS-rx, restores the autonegotiation capabilities and restarts autonegotiation. When the new link speed is negotiated the PCS-rx is enabled.

The workaround requires change in the following.

- Port API to support PCS-rx enable/disable/ignore (New: "PCS" field in the vtss_port_conf_t struct).
- PHY API to support removal of autonegotiation capabilities. (New: "no_restart_aneg" member in vtss_phy_aneg_t struct).
- Application (the bulk of the fix).

Pseudo-code for disabling the PCS-rx during link changes:

```
Port polling thread
PHY status = no link;
Disable PCS-rx;
Aneg.cap = user_capabilities;
Aneg restart;
PHY status = link
Design Considerations
VMDS-10393 VSC7424-02, VSC7425-02, VSC7426-02, and VSC7427-02 Datasheet
Revision 4.2 741
If Aneg.speed = 100Mbps or 10Mbps then Aneg.cap = none and Aneg no
restart (see note);
MAC.speed = PHY.speed
Enable PCS-rx;
End port polling thread;
CLI thread (manual configuration)
If Aneg.cap = 100Mbps or 10Mbps then {
Disable PCS-rx;
Aneg restart;}
End CLI thread
```

Note: Disable PCS-rx means setting bit DEV[port#]:PORT_MODE:CLOCK_CFG.PCS_RX_RST. In API, use the new "PCS" field in the vtss_port_conf_set()::vtss_port_conf_t::PCS to control the state of PCS-rx.

Note: Use the new member added to the vtss_phy_conf_set():: vtss_phy_aneg_t::no_restart_aneg.

A software patch for the application and API implementing this PCS-rx disable fix is available. Ensure your 1588-enabled software has this fix implemented. For information regarding official releases, check with your sales representative.

12.8.2 Serdes Port (SFP)

There is no way to prevent a short frame being received on a serdes port. Tests have shown that during disconnection of a fiber while the port is receiving frames at a high speed, many short frames (fragments) are received, and the OOS state is entered on the port.

New designs should use external timestamping PHY on serdes (SFP) ports. The switch port timestamping should not be used.

To avoid the OOS from occurring in existing designs, the port should be set to disabled from the management interface before removing the fiber. As this is not possible in all situations, implement a software work-around to examine the port for OOS state during link down and if OOS is detected, reset the switch with a log message stating OOS state was detected. To detect the OOS state, set the port in loop-back mode, send a PTP frame, and determine if the correct timestamp is used.

13 Ordering Information

The VSC7428XJG-12 package is a lead-free (Pb-free), 672-pin, thermally enhanced, plastic ball grid array (BGA) with a 27 mm × 27 mm body size, 1 mm pin pitch, and 2.44 mm maximum height.

Lead-free products from Vitesse comply with the temperatures and profiles defined in the joint IPC and JEDEC standard IPC/JEDEC J-STD-020. For more information, see the IPC and JEDEC standard.

The following table lists the ordering information.

Table 882 • **Ordering Information**

Part Order Number	Description
VSC7428XJG-12	11-port Carrier Ethernet switch Lead-free, 672-pin, thermally enhanced, plastic BGA with a 27 mm × 27 mm body size, 1 mm pin pitch, and 2.44 mm maximum height