AN-135

802.1Q Tag Based and Port Based VLAN Function and Setting in KSZ8995M/MA

Introduction

This document will discuss IEEE802.1Q tag-based VLAN and port-based VLAN setup for the KSZ8995M/MA devices. The reader should use this design note in conjunction with the datasheet which can be found at: http://www.micrel.com/page.do?page=product-info/fastether_sw_man.jsp.

VLAN Overview

Virtual LANs (VLANs) consist of a logical independent workgroup operating within a physical network. These workgroups behave as independent unique networks. The VLANs are defined by logical boundaries between workgroups.

VLANs can be grouped by applications or functions. For example, the IT manager can define one VLAN for a multimedia application and another for an e-mail application. Alternately, it can have one VLAN for its Engineering Department, another for its Marketing Department, another for its Accounting Department, and so on.

As these examples show, VLANs offers unparalleled flexibility to ensure the best possible performance of the network. The intent of this design note is to serve as a basic guide for using the Micrel KSZ8995M/MA in a VLAN application.

IEEE 802.1Q VLAN

The KSZ8995M/MA supports the IEEE 802.1Q specification for “tagged” frames. The IEEE specification defines a format of the frame in the network environment. An additional 4-octet header (or “tag”) is inserted in a frame after the source MAC address and before the frame type. 12 bits of the tag are used to define the VLAN ID.

When packets pass through the KSZ8995M/MA, the device will look in each of the VLAN, static MAC and dynamic MAC tables for an appropriate forwarding part. If the packet satisfies the necessary condition of the forwarding conditions, then the packet will then be forwarded to the destination port. See the Figure 1 for tagged frame format.

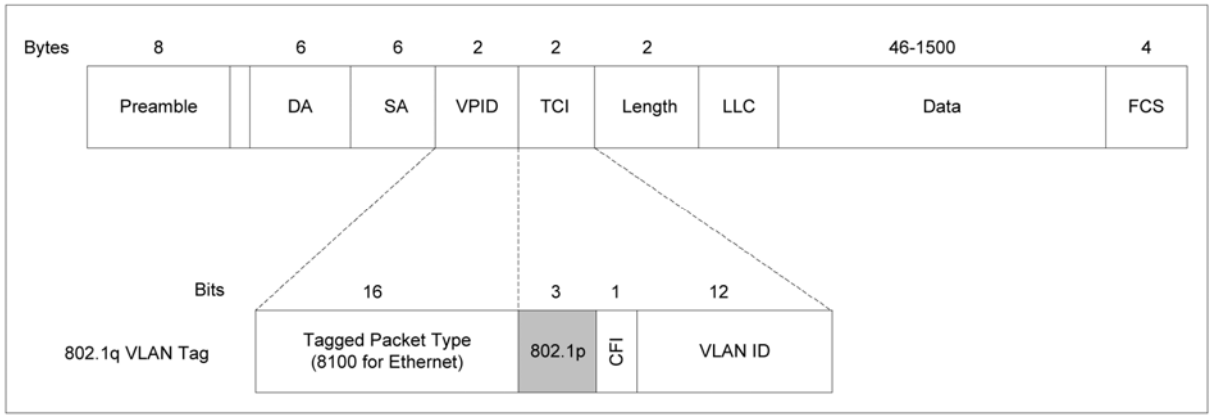

Figure 1. Ethernet Packet with 802.1Q VLAN Tag

Creating VLANs in KSZ8995M/MA

The KSZ8995M/MA supports 16 active VLANs out of a possible 4096 VLANs. The KSZ8995M/MA provides a 16-entry VLAN table. Each entry has a VID (VLAN ID), FID (filter ID), VLAN Membership and Valid fields.

- 12-bit VLAN ID represents 4096 possible VLANs specified in IEEE 802.1Q.
- 4-bit Filter ID is created by the device and it represents the 16 active VLANs supported by the KSZ8995M/MA. The FID is the mapped ID, it maps any one of the 4096 VLANs to one of the 16 active VLANs. By reducing the 12 bits of the VID to only 4 bits of the FID, the look up function is now more efficient. During the lookup and learning of the MAC addresses, the FID+DA and FID+SA combination is used. This look-up mechanism allows identical MAC addresses to be used in different VLAN.
- 5-bit VLAN membership field represents the forwarding ports of the VLAN.
- 1-bit valid field controls the validity of the entry.

The information stored in the VLAN table is compared with the VID embedded in the ingress packet. The VLANs also manage the broadcast domain, and creates a logical partition of the workgroups. When the destination address is unknown or the ingress packet is a broadcast or multicast packet, the chip will only broadcast within the VLAN that the incoming packet belongs to.

Each of the entries in the VLAN table represents a VLAN group. The KSZ8995M/MA supports 16 VLAN groups totally. The membership field of the each of the VLAN entries represents all of the members of this VLAN group. The VLAN table format is shown in Table 1.

Bit	Name	R/W	Description	Default
21	Valid	R/W	=1, the entry is valid =0, entry is invalid	1
20-16	Membership	R/W	Specify which ports are members of the VLAN. If a DA look up fails (no match in both static and dynamic tables), the packet associated with this VLAN will be forwarded to ports specified in this field. E.g. 11001 means port 5, 4, and 1 are in this VLAN.	11111
15-12	FID	R/W	Filter ID. KS8995M/MA supports 16 active VLANs represented by these four bit fields. FID is the mapped ID. If 802.1Q VLAN is enabled, the look up will be based on FID+DA and FID+SA.	0
11-0	VID	R/W	IEEE 802.1Q 12 bit VLAN ID	1

Table 1. Format of the VLAN Table (16 entries)

The 802.1Q Tagged Packet Look-up Process in KSZ8995M/MA

If the 802.1Q VLAN mode is enabled, the KSZ8995M/MA will parse the ingress packets for information needed to identify an egress port. If the ingress is untagged, the chip will then assign a VID to the ingress packet. If the packet is tagged with a null VID, the packet will be assigned the default port VID of the ingress port. If the packet is tagged with non-null VID, the tagged VID will be used. The look up process will start from the VLAN table look up. If the VID is not found, then the packet will be dropped and no address learning will take place. If the VID is found, then the FID will be retrieved and the FID+DA and FID+SA lookups are then performed. The FID+DA look up determines the forwarding ports. If FID+DA lookup fail, the packet will then be broadcast to all of the members (excluding the ingress port) within the VLAN group. FID+SA is used for learning; if FID+SA is unknown, the FID+SA will then be learnt and entered into the lookup table. The look-up procedure is as follows:

- The device begins the look-up phase by referencing the VLAN table based on the VID of the ingress packet. If the VID is not found in the VLAN table, then the packet will be dropped.
- If the VID is found in the VLAN table, then the FID is retrieved. At this point, the packet with FID+DA will go to the static MAC table for look-up.
- If the FID+DA is not found in the static MAC table, then the KSZ8995M/MA will try to look up the FID+DA in the dynamic MAC table.
- If the FID+DA is not found in the dynamic MAC table either, and then the packet will be broadcast to all of the membership ports with the same VLAN ID in the VLAN table.

The following flowchart describes the look-up process as shown in Figure 2 for details.

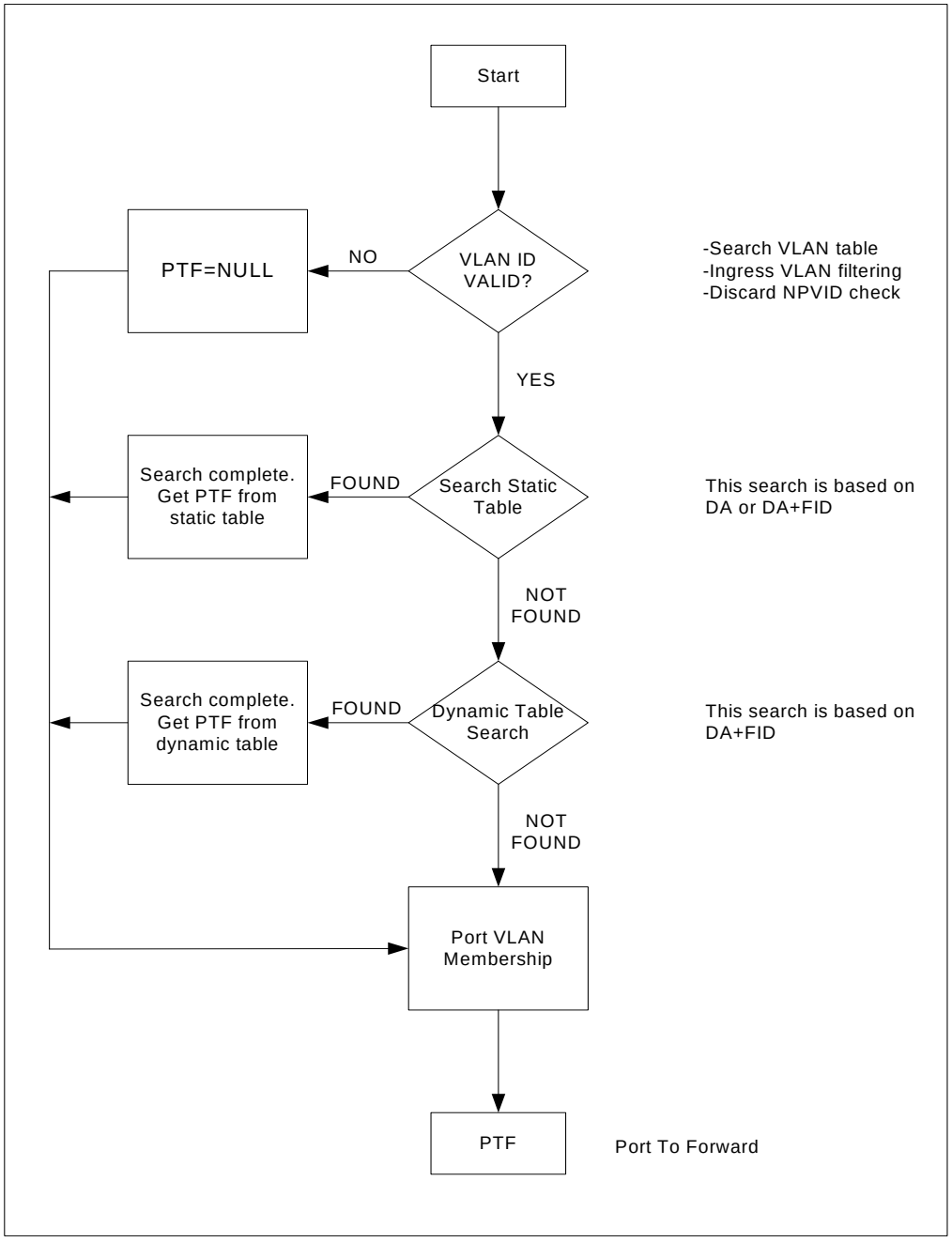

Figure 2. 802.1Q Tagged Packet Look-Up Flowchart

After the FID is derived from the VID, the FID+DA is used to determine the destination ports in the static MAC table and the dynamic MAC table. In 802.1Q VLAN mode, the port-based VLAN membership of the port 1-5 registers should be set to the default value of all '1'. This is because the switch supports both tag-based VLANs and port-based VLANs. The membership within the VLAN is a logical "AND" between the tag-based VLAN membership and the port-based VLAN membership. If the destination port is not part of the port-based membership group, even if the tag is correct the packet will not be forwarded. Because the look-up utilizes both the VID and the DA, it is therefore possible to have identical MAC addresses within different VLAN in the same network.

For details determining forwarding look-up in a variety of cases, please see Table 2.

DA found in Static MAC table	USE FID flag?	FID match?	DA+FID found in dynamic MAC table	Action
No	Don't care	Don't care	No	Broadcast to the membership ports defined in the VLAN table bits [20:16]
No	Don't care	Don't care	Yes	Send to the destination port defined in the dynamic MAC table bits [54:52]
Yes	0	Don't care	Don't care	Send to the destination port(s) defined in the static MAC table bits [52:48]
Yes	1	No	No	Broadcast to the membership ports defined in the VLAN table bits [20:16]
Yes	1	No	Yes	Send to the destination port defined in the dynamic MAC table bits [54:52]
Yes	1	Yes	Don't care	Send to the destination port(s) defined in the static MAC table bits [52:48]

Table 2. FID+DA Look-Up in the VLAN Mode

For details of the learning process, please see Table 3.

SA+FID found in dynamic MAC table	Action
No	The SA+FID will be learned into the dynamic table.
Yes	Time stamp will be updated.

Table 3. FID+SA Look-Up in the VLAN Mode

Note: Refer to datasheet Rev2.4, pages 53 and 56 for Static MAC and Dynamic MAC Tables.

Registers Associated with VLAN Configuration

Additional VLAN configurations support is available in other registers. In addition to the basic VLAN configuration, advanced VLAN features are also supported in the KSZ8995M/MA, e.g. “VLAN ingress filtering” and “discard non-PVID Packets” (PVID= Port default VID) as defined in Port 1-5 Registers Control 2 bit 6 and bit 5. These features can be controlled on a per port basis. Please see Table 4 for related registers.

Register	Bit	Name	Description	Default
Register 5 (0x05): Global Control 3	7	802.1Q VLAN Enable	=1, 802.1Q VLAN mode is turned on. VLAN table needs to set up before the operation. =0, 802.1Q VLAN is disabled	=0
Register 6 (0x06): Global Control 4	3	Null VID Replacement	=1, will replace NULL VID with port VID (12 bits) =0, no replacement for NULL VID	=0
Port Register Control 3 for port 1-5	7-0	Default Tag [15:8]	Port’s default tag, containing 7-5: user priority bits 4: CFI bit 3-0 : VID[11:8]	=0
Port Register Control 4 for port 1-5	7-0	Default Tag [7:0]	Port’s default tag, containing 7-0: VID[7:0]	=0
Port Register Control 2 for port 1-5	6	Ingress VLAN Filtering	=1, the switch will discard packets whose VID port membership in VLAN table bits [20:16] does not include the ingress port. =0, no ingress VLAN filtering	=0
	5	Discard Non-PVID Packets	=1, the switch will discard packets whose VID does not match ingress port default VID. =0, no packets will be discarded	=0
Port Register Control 0 for port 1-5	2	Tag Insertion	=1, when packets are output on the port, the switch will add 802.1Q tags to packets without 802.1Q tags when received. The switch will not add tags to packets already tagged. The tag inserted is the ingress port’s “port VID”. =0, disable tag insertion	=0
	1	Tag Removal	=1, when packets are output on the port, the switch will remove 802.1Q tags from packets with 802.1Q tags when received. The switch will not modify packets received without tags. =0, disable tag removal	=0
Port Register Control 1 for port 1-5	4-0	Port VLAN Membership	Define the port’s “ Port VLAN membership. Bit 4 stands for port 5, bit 3 for port 4… bit 0 for port 1. The Port can only communicate within the membership. A ‘1’ includes a port in the membership, a ‘0’ excludes a port from membership	=0x1F

Table 4. Related Registers with VLAN in the KSZ8995M/MA

Steps for Creating Port-Based VLAN:

1. Set Port 1-5 Registers Control 1, Port VLAN Membership bits [4-0] for port VLAN mask.
2. Confirm Register 5 Global Control 3, bit 7=0 (default) and 802.1Q VLAN is turned off.
3. For example, set up ports 1, 2, 3 and 5 for port-based VLAN 1, and set up ports 4 and 5 for port- based VLAN 2. As VLAN 1 has overlap with VLAN 2 at port 5, the broadcast and multicast packets may cross VLAN boundaries when port 5 is the ingress port. The setting of the membership field on the port 1-5 registers are set as follows:
   - Set port 1, port 2 and port 3 Registers Control 1 bits [4-0] = (1, 0, 1, 1, 1) to the same value.
   - Set Port 4 Register Control 1 bits [4-0] = (1, 1, 0, 0, 0).
   - Set Port 5 Register Control 1 bits [4-0] = (1, 1, 1, 1, 1) for both port based VLAN 1 and VLAN 2. From this setting of port 5, if broadcast and multicast packets come in from port 5, the packets will cross the VLAN boundary to all ports excluding the ingress port 5.

   When using port based VLANs, it is advised not to overlap the ports in the VLANs, as shown in the above example. This will prevent VLAN traffic from crossing boundaries.

Steps for Creating 802.1Q Tag VLAN:

1. Set Register 5 Global Control 3 bit 7 to turn on the 802.1Q VLAN Enable.
2. Set Register 6 Global Control 4 bit 3 for null VID replacement using default VID if the tagged packet is null VID.
3. Set Port 1-5 Register Control 3 and Control 4 for default tag of the ingress port when 802.1Q VLAN is enabled and ingress packet is non-tag or null tag. Then the default tag and its value will be used in VLAN table for look-up.
4. Set Port 1-5 Registers Control 2 bit 6 for ingress VLAN Filtering if it is required.
5. Set Port 1-5 Registers Control 2 bit 5 for Discard Non-PVID packets if it is required.
6. If you want to add the default tag for the ingress packet with non-tag on the egress port, set Port 1-5 Register Control 0 bit 2 for tag insertion at the egress port.
7. When using 802.1Q VLAN mode look-up result, port 1-5 registers control 1 bits [4-0] of the port VLAN membership should be in the default value.
8. Write the VID and FID of the VLAN group into the VLAN table.

   For example:
   - Port 1, 2, 3 and 5 are tag VLAN 1 (Write an entry with VID=1 FID=1 VLAN membership = (1, 0, 1, 1, 1) for port 1, 2, 3, and 5 in the VLAN table).
   - Port 4, 5 are tag VLAN 2 (Write an entry with VID=2 FID=2 VLAN membership= (1, 1, 0, 0, 0) for port 4 and 5 in the VLAN table).
   - Set default tag for VID

     Set Port 1, 2, and 3 Registers Control 4 VID=1

     Set Port 4 Register Control 4 VID=2
   - Set tag insertion for port 5

     Set Port 5 Register Control 0 bit 2=1 for tag insertion on egress port 5.

When packets are passed from ingress port 1, 2, or 3 then the egress port 5 will insert a tag with VID=1. When packets are passed from ingress port 4 then the egress port 5 will insert a tag with VID=2. Usually, port 5 is connected to a microprocessor which will recognize the VID of each packet. When port 5 sends back packets to the ingress ports where the packet originated from, port 5 will segregate the traffic for VLAN 1 and VLAN 2. Since the 8021.Q tag VLAN is based on the VID, and not based on the physical ports, the broadcast and multicast traffic can not pass the VLAN boundaries.

Summary

The KSZ8995M/MA 5-port switch has very flexible VLAN function capabilities. It allows the customer to create a large variety combination of VLAN groups by utilizing both port-based and 802.1Q based VLANs. In addition, the unique lookup algorithm allows identical MAC addresses to coexist within the same network, making the KSZ8995M/MA are very useful in isolating and segregating specific flows within the network.

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