AN3945

Power Over Ethernet Support of MPU32 Applications

Introduction

This application note describes the usage of Microchip Power over Ethernet (PoE) Powered Device (PD) technology to power Microchip Microprocessor or MPU32 products. This document provides specific examples based on existing MPU32 microprocessor and PoE evaluation boards. Further this document briefly describes usage of Microchip MPU32 and PoE Power Source Equipment (PSE) technology to extend the Powered Ethernet loop beyond the 100 m range in the Power Forwarding Application.

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1. MPU32

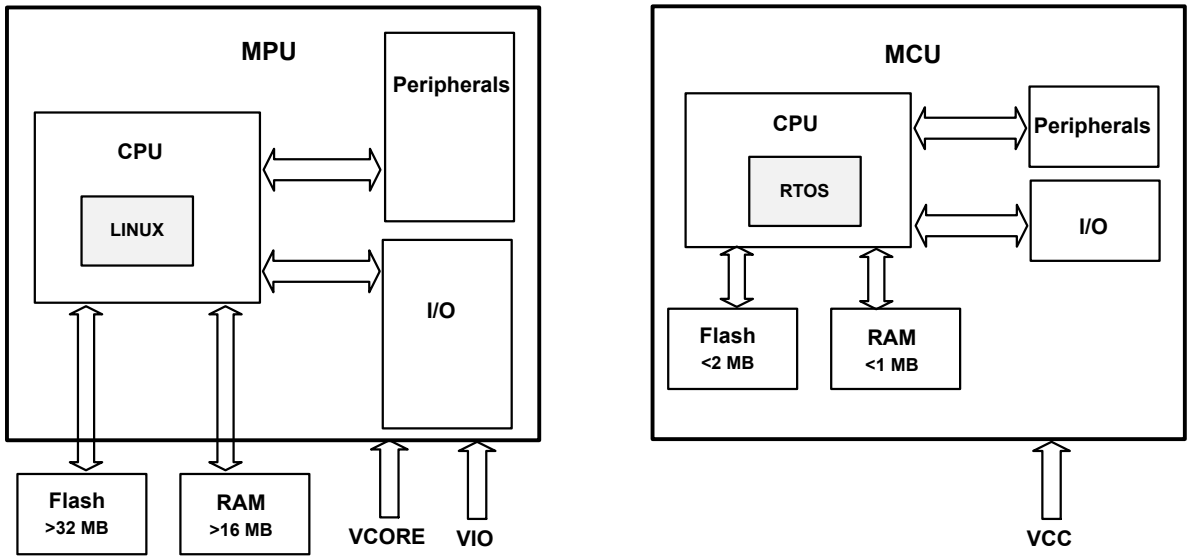
This section describes the MPU32 technology and its products used in the application.

1.1 Microprocessor and Microcontrollers

A Microprocessor (MPU) is a Central Processing Unit (CPU) that utilizes external Flash and DRAM. The benefit of this architecture is that the external memory is used to provide program and data storage, which means the memory connected to the processor is in the range of hundreds of Mbytes and even Gbytes. This allows the MPU to run rich or full operating system such as Linux, which will allow multiple processes to run at the same time via multiple threads. Drivers are required to run peripherals. The tradeoff is slower start up and potentially several different voltage rails for core, memory, and so on. An MPU is different from a Microcontroller (MCU) in that the MCU will integrate the Processor, Flash, and RAM. While the startup time for an MCU is better than MPU, the internal memory is smaller relative to an MPU and can be limiting in the application scope. An MCU requires a single power supply only. However, due to its limited resources, a light-weight RTOS is typically used instead of a rich operating system.

The following figure shows a basic block diagram of an MPU vs MCU.

Figure 1-1. Block Diagram of MPU vs. MCU



1.2 MPU32 Products

Microchip offers the Arm® Cortex®-A5 based SAMA5 family or the ARM9 based SAM9 family of products. Both SAMA5 and SAM9 families feature Ethernet 10/100 MAC interfaces. The SAMA5 series products are high-performance, ultra-low power Cortex-A5 core based MPU devices. They support multiple memories, including DDR3, LPDDR3, and Quad Serial Peripheral Interface (QSPI) flash. A rich set of peripherals, user interfaces, and robust security features simplify the design for control panels/HMI, secure IoT gateways, connectivity, barcode scanners, printers, and POS terminal applications. The low-power features and small packages are ideal for wearables and other battery-operated consumer devices. A wide range of third-party offerings complements Microchip development kits and software support.

SAM9 is based on the Microchip ARM926EJ-S based MPU family. It offers a lower level performance than SAMA5 yet it can run large software applications and provide access to the expansive capabilities of the Linux OS environment. Microchip ARM9 MPUs provide a rich set of peripherals and user interfaces to simplify the design for cost-sensitive consumer, IoT, and industrial applications.

See www.microchip.com/design-centers/32-bit-mpus for details.

2. PoE Technology

This section describes the architecture of PoE, Endspan, Midspan, and PoE PD products.

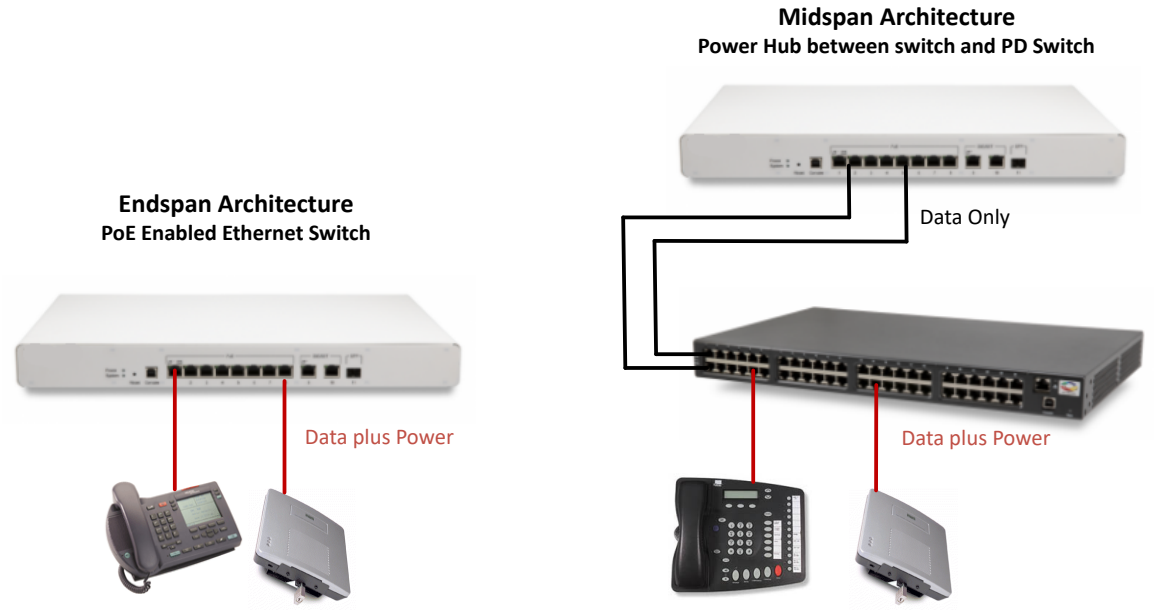
2.1 Architecture

PoE is a standardized technology that enables delivery of power over standard Ethernet cables into IP-based data terminals such as WLAN access points, network cameras, and IP telephones. There are two aspects or applications associated with PoE.

- Powered Device (PD) - A device powered through the Ethernet link.
- Power Sourcing Equipment (PSE) - A device injecting power over the Ethernet link

The PSE can have two architectures: Endspan PSE and Midspan PSE (PoE Injector). In Endspan PSE, the PoE is integrated inside the Ethernet Switch and in the Midspan PSE, or PoE Injector, the PSE unit is placed between a non-PoE Ethernet Switch and the PD. The following figure shows the PoE architecture.

Figure 2-1. PoE Architecture



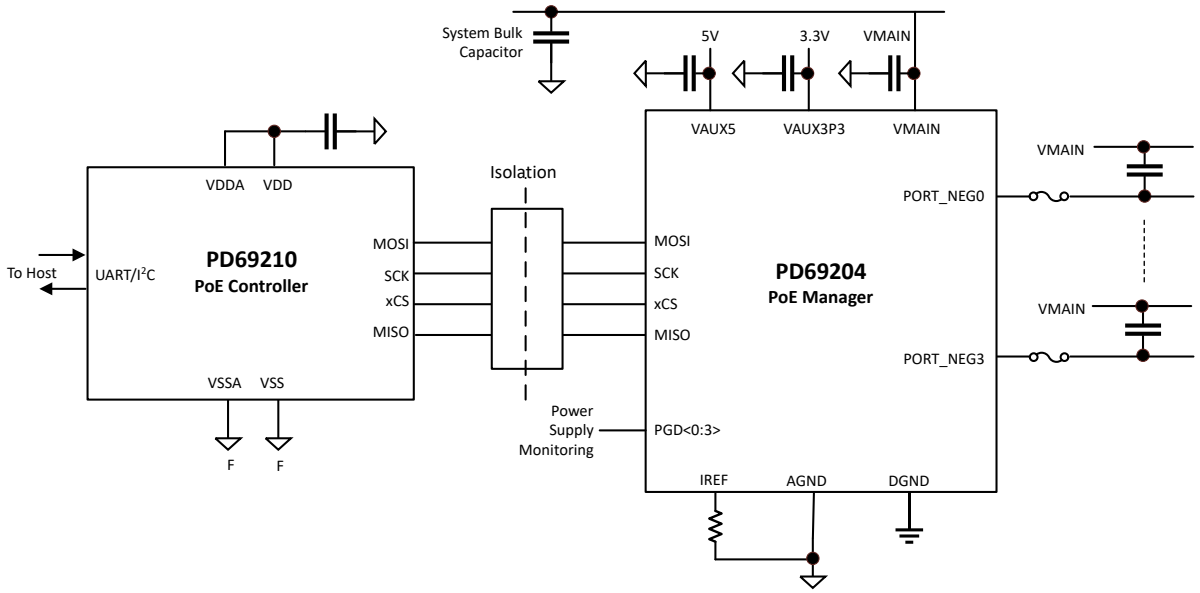
2.2 PoE PSE Products – Endspan Architecture

The PSE detects a valid PD and classifies the power capabilities of the PD. The PSE provides 4 W to 95 W at 44 V to 57 V and applies power in a controlled manner. It also provides fault monitoring and disconnect, undercurrent turn off, overcurrent protection, and isolation from the switch circuitry.

Microchips PSE solution consists of two ICs, the PD69210 Controller and the PD69204 Manager. The PD69210 PoE Controller is based on the Microchip Cortex-M0 Microcontroller. The required firmware comes pre-loaded and this firmware is field upgradable through the I^2C host interface. The PD69204 is a mixed signal and high voltage analog device. The two ICs when paired provide complete PoE PSE functionality.

Microchip offers PSE Integrated Circuit products for the Endspan architecture. Here, the PSE is designed into the Ethernet switch. Microchip offers IEEE® 802.3bt compliant solutions supporting from 4 to 48 2-pair or 4-pair logical ports. Additionally, Microchip offers single and four port solutions for IEEE802.3af/at applications. The following figure shows a block diagram of a 4-pair PSE solution based on the Microchip PD69210 Controller and PD69204T4 Manager.

Figure 2-2. 4-pair PSE Solution based on Microchip PD69210 Controller and PD69204 Manager



2.3 PoE PSE Products – Midspan Architecture

Microchip offers single and multi-port injectors and switches that are IEEE 802.3bt/at/af compliant (up to 90 W). Microchip offers indoor, outdoor, and industrial solutions with AC- and DC-powered options and Multi-Gigabit solutions up to 10 Gbps.

The following figure shows a single port PoE midspan that provides up to 15.4 W of PoE and offers an IEEE 802.3af-compliant solution with data rates of 10/100/1000 Mbps.

Figure 2-3. Single-Port Midspan - PD-3501GC

The following figure shows PD-9624GC, which is a 24-port, 90 W, IEEE 802.3bt-compliant indoor PoE midspan.

Figure 2-4. 24-port PoE Midspan - PD-9624GC

For more information, refer to www.microchip.com/poe.

2.4 PoE PD Products

Microchip offers the PD front-end ICs with and without integrated Pulse-Width Modulation (PWM) controllers. The PD front end provides signatures for detection and correct classification. It also provides controlled power application, power optimization, inrush current protection, and optional bias for DC/DC start up.

The DC/DC uses either an integrated or external PWM controller. The DC/DC also provides optional isolation. The input capacitor provides for legacy detection, EMI, and transient protection. The PD70101 shown in the following figure uses an integrated PWM. The DC/DC converts the high PoE voltage down to regulated supply voltage used by the application. There are two main topologies used in the PoE PD, Flyback, and Forward. A brief comparison is given in the following table.

Parameter	Flyback	Forward
Step Down Voltage	3.3 V - 24 V	3.3 V - 12 V
RBOM Cost[1]	~$1.50	~$2.50
Efficiency	88-91 %	90-93 %
Power Range (V <12 V)	<50 W	>50 W

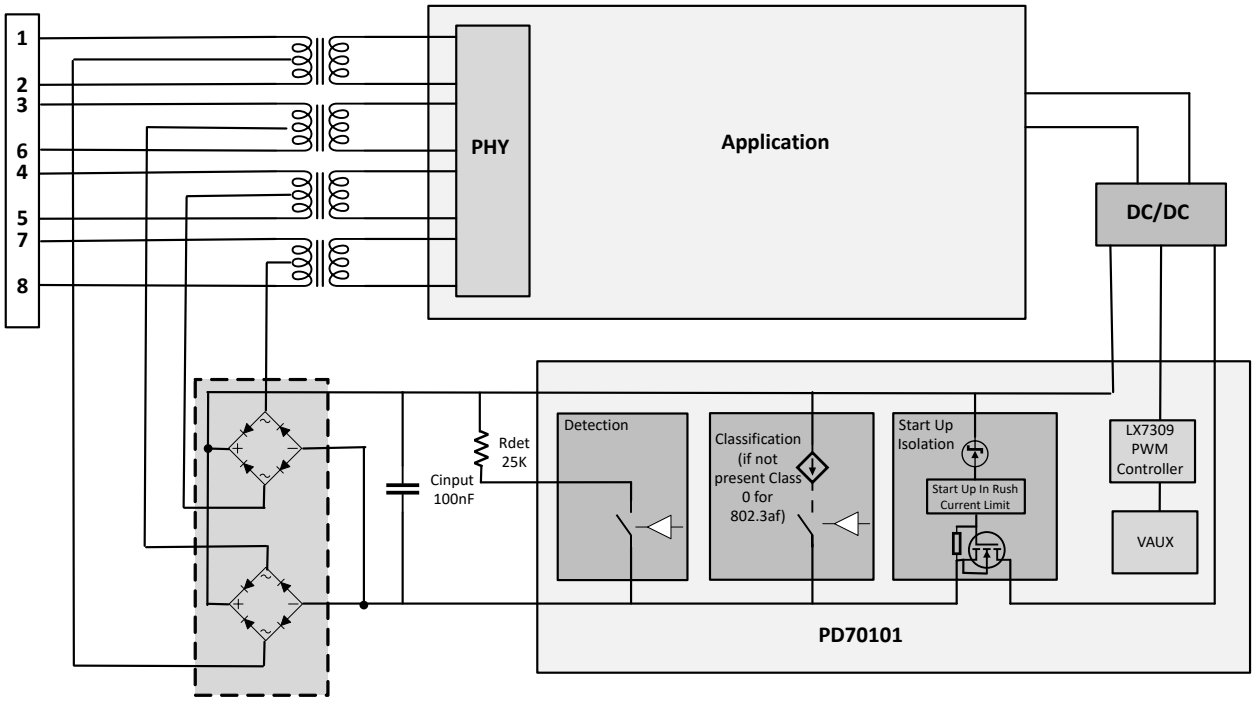
Note: 1. DC/DC only excluding PWM cost.

Microchip PoE offers an automated design tool, MPLAB® Analog Designer or **MAD**. Refer to the tool at www.microchip.com/mad-poe

Mostly, IEEE standards do not guarantee the port polarity, therefore a diode bridge is required at the PD front end. Microchip offers the PD70224 Ideal diode bridge. Alternatively, a standard diode bridge may also be used. The ideal diode bridge is typically used in power sensitive designs that minimizes PCB area. The standard diode bridge is used in more cost sensitive applications.

The following figure shows a block diagram of the PD based on the Microchip PD70101.

Figure 2-5. Block Diagram of a PD using the Microchip PD70101



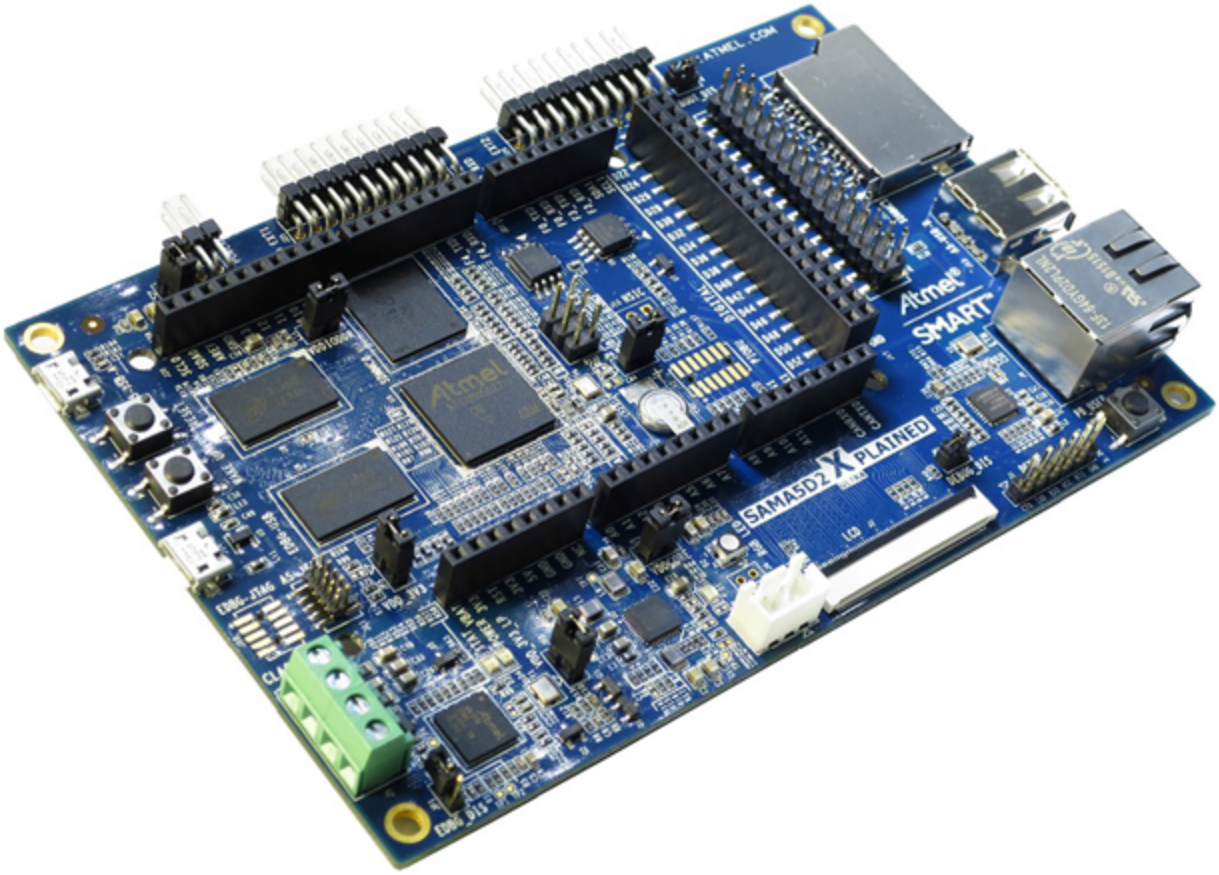
3. Adding PoE Power to MPU32 Applications

This section describes the steps for adding PoE power to MPU32 applications. This section describes how to replace the USB power with PoE power based on the Microchip PD70101 PD.

3.1 Hardware

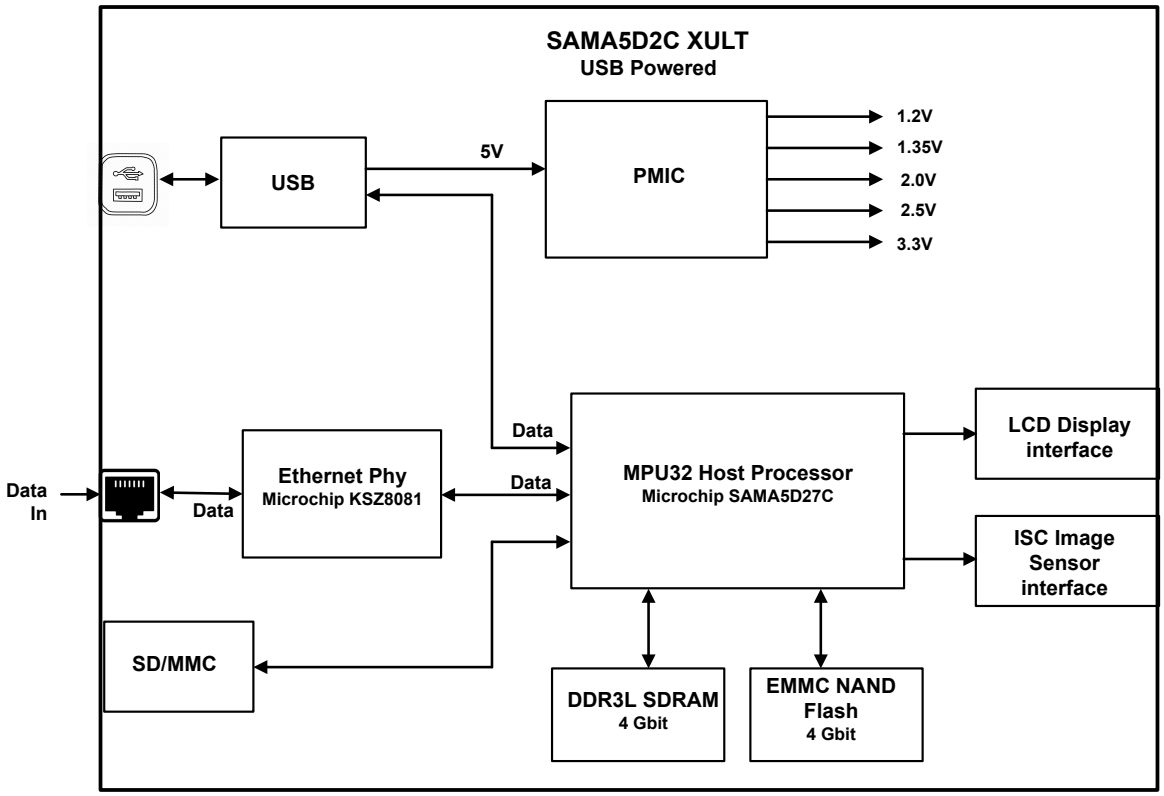
The SAMA5D2C-XULT kit is a full-featured evaluation platform for the SAMA5D2 series ARM-based MPU. The SAMA5D2C-XULT board is based on the integration of an Arm Cortex-A5-based microprocessor with external memory, one Ethernet physical layer transceiver, one SD/MMC interface, one host USB port, one device USB port, and one 24-bit RGB LCD. This board offers several powering options. The default configuration is to provide power through USB. The following image shows the SAMA5D2C-XULT kit.

Figure 3-1. SAMA5D2C-XULT Kit



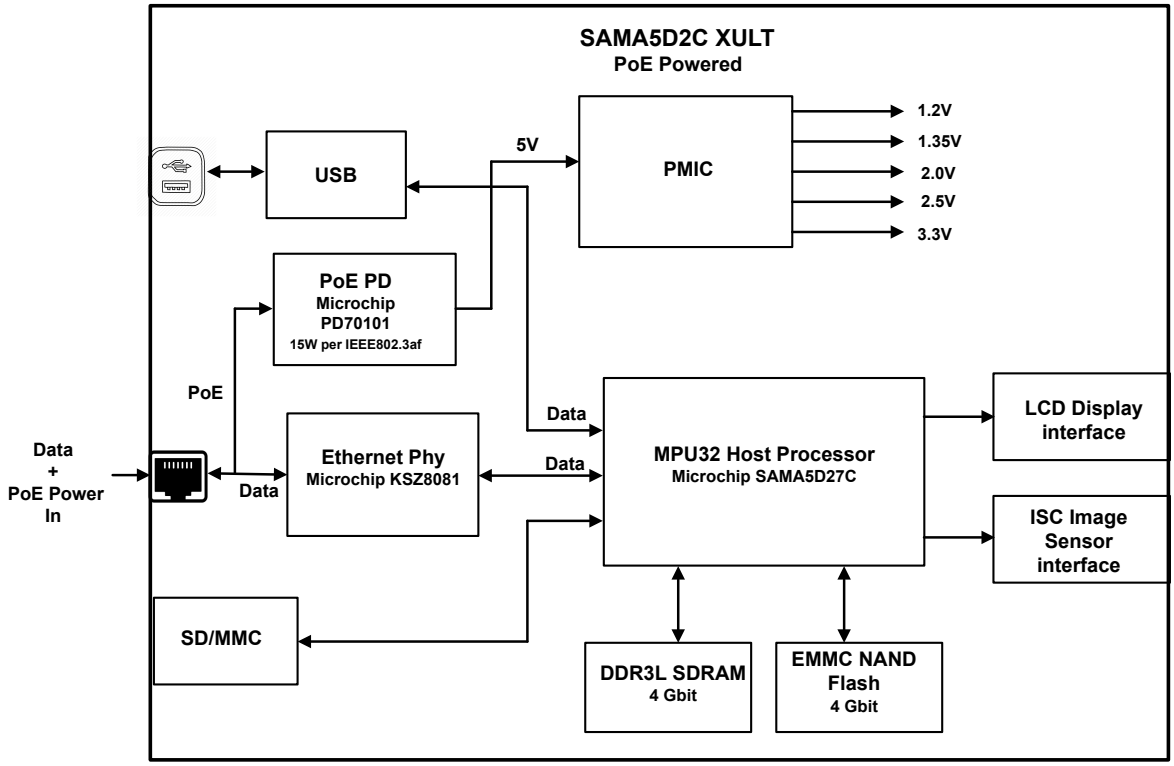
The following figure shows a simplified block diagram of the SAMA5D2C-XULT with the default USB powering.

Figure 3-2. Block Diagram of SAMA5D2C-XULT



A simplified block diagram of the SAMA5D2C-XULT with the default USB powering replaced by PoE power is shown in the following figure.

Figure 3-3. Block Diagram of SAMA5D2C-XULT with PoE Power



The PD70101 is part of the Microchip PD integrated circuits. The PD70101 is designed to meet the IEEE 802.3af standard. This product features both the PD front end and an integrated PWM controller. The following table lists Microchip's complete PD product offerings.

Part	Type	Package	IEEE 802.3af	IEEE 802.3at	HDBase T (PoH)	UPoE
PD70100	Front end	3 mm × 4 mm 12L DFN	x	—	—	—
PD70101	Front end + PWM	5 mm × 5 mm 32L QFN	x	—	—	—
PD70200	Front end	3 mm × 4 mm 12L DFN	x	x	—	—
PD70201	Front end + PWM	5 mm × 5 mm 32L QFN	x	x	—	—
PD70210	Front end	4 mm × 5 mm 16L DFN	x	x	x	x
PD70210A	Front end	4 mm × 5 mm 16L DFN	x	x	x	x
PD70210AL	Front end	5 mm × 7 mm 38L QFN	x	x	x	x
PD70211	Front end + PWM	6 mm × 6 mm 36L QFN	x	x	x	x
PD70224	Ideal Diode Bridge	6 mm x 8 mm 40L QFN	x	x	x	x

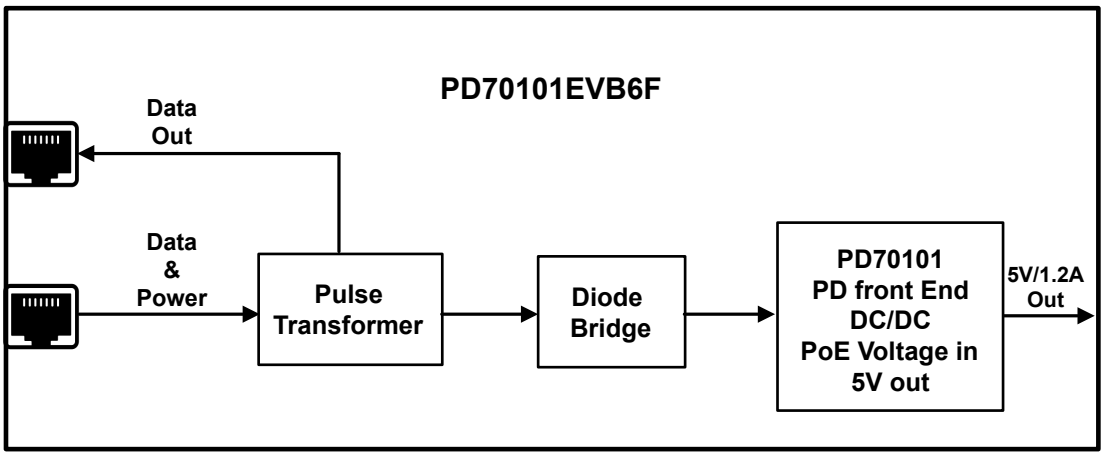
The PD70101EVB6F is an Evaluation Board (EVB) that is IEEE 802.3af/at Type 1 compliant. This EVB is based on the PD70101 with an isolated flyback DC/DC converter designed for a 5 V 1.2A output. For detailed design information on this EVB, refer to: www.microchip.com/DevelopmentTools/ProductDetails/PartNO/PD70101EVB6F

The following image shows the PD70101EVB6F EVB.

Figure 3-4. PD70101EVB6F Evaluation Board

A simplified block diagram of the PD70101EVB6F EVB is shown in the following figure.

Figure 3-5. Block Diagram of the PD70101EVB6F EVB



3.2 Electrical Connections to PoE Power the SAMA5D2

To power the SAMA5D2C-XULT from the PD70101EVB6F, the 5 V output from the PD70101EVB6F is connected to the SAMA5D2C-XULT. Disable the USB power input on the SAMA5D2C-XULT by removing JP8 and connect the green 5 V power output on the PD70101EVB6F to the VDD_5V_IN header on the SAMA5D2C-XULT. These connections are shown in the following figures.

Figure 3-6. PD70101EVB6F Power Output

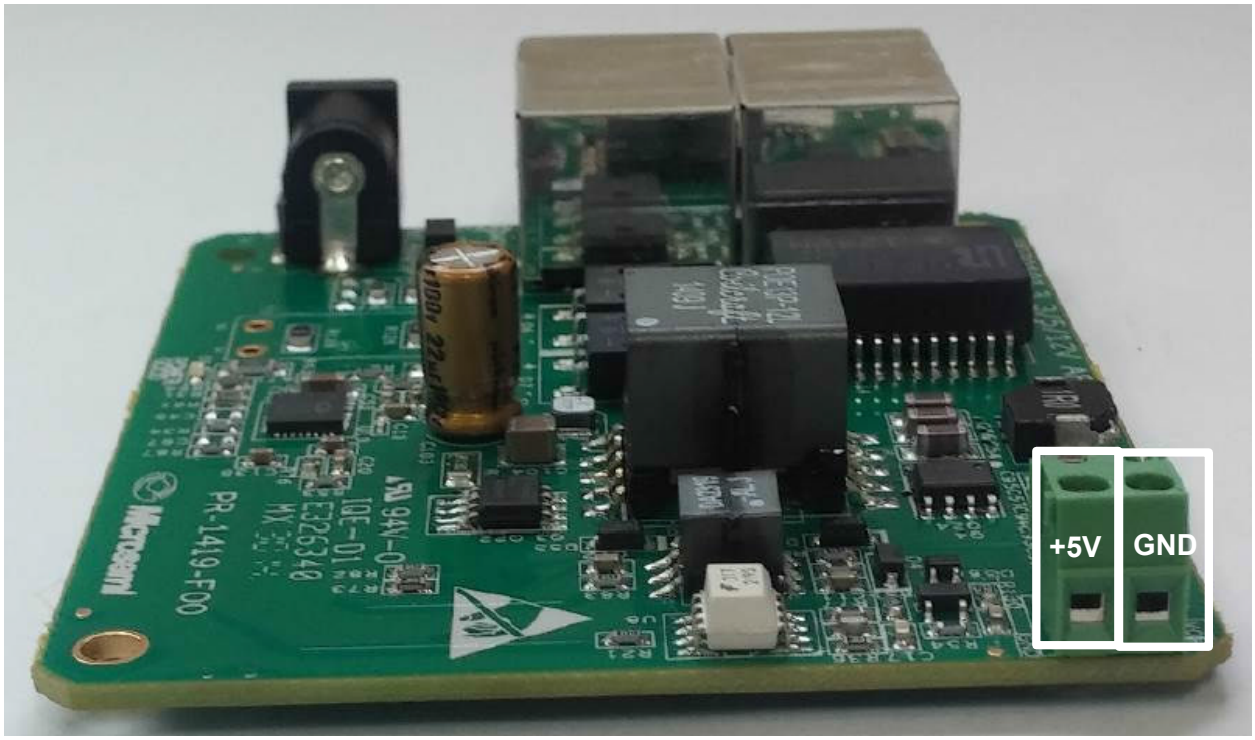
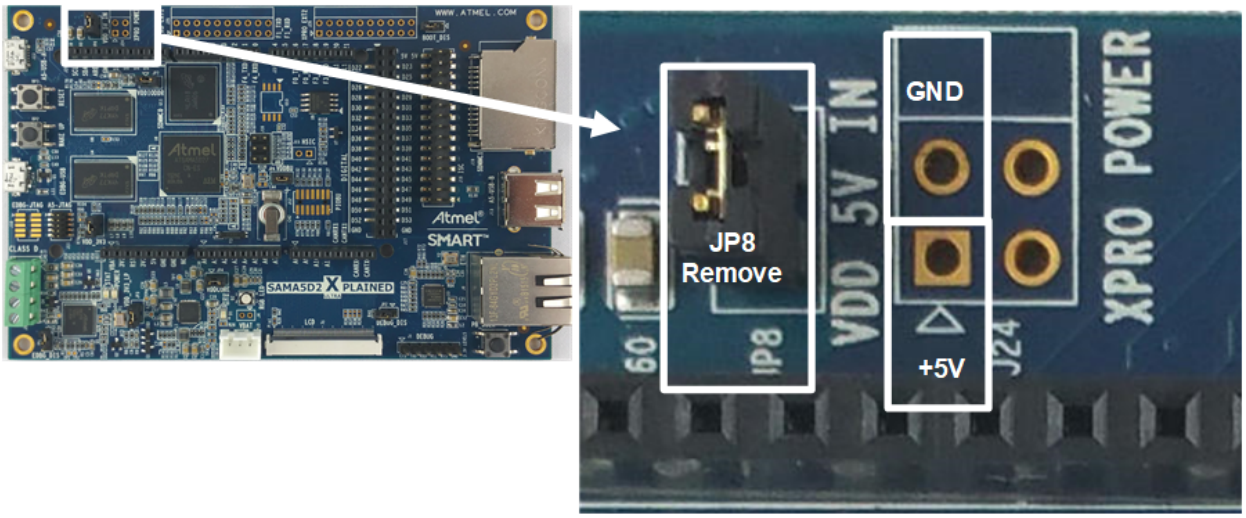


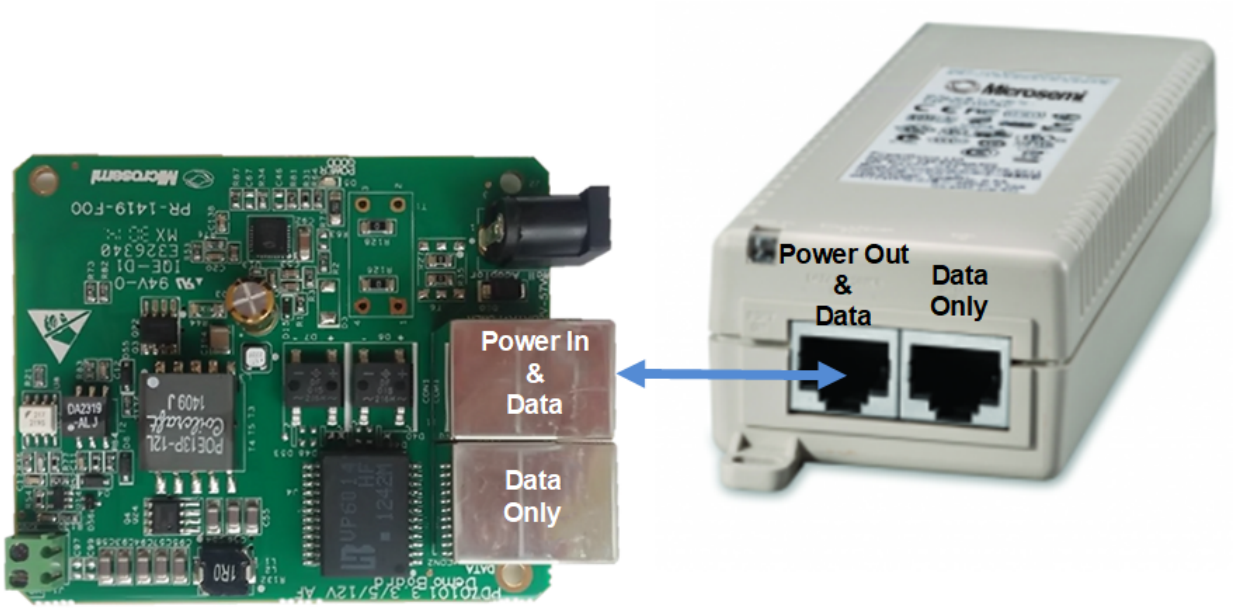
Figure 3-7. SAMA5D2C-XULT JP8 and VDD_5V_IN Connections



3.3 PSE Power to the PD70101EVB6F PD

Input power can be provided to the PD70101EVB6F PD in various methods. The simplest method is to use a Microchip PoE Midspan, such as the PD-3501GC. Using Cat5 or newer cable, connect the Data and Power Out RJ45 of the PD-3501GC to the Data and Power Input RJ45 of the PD70101EVB6F.

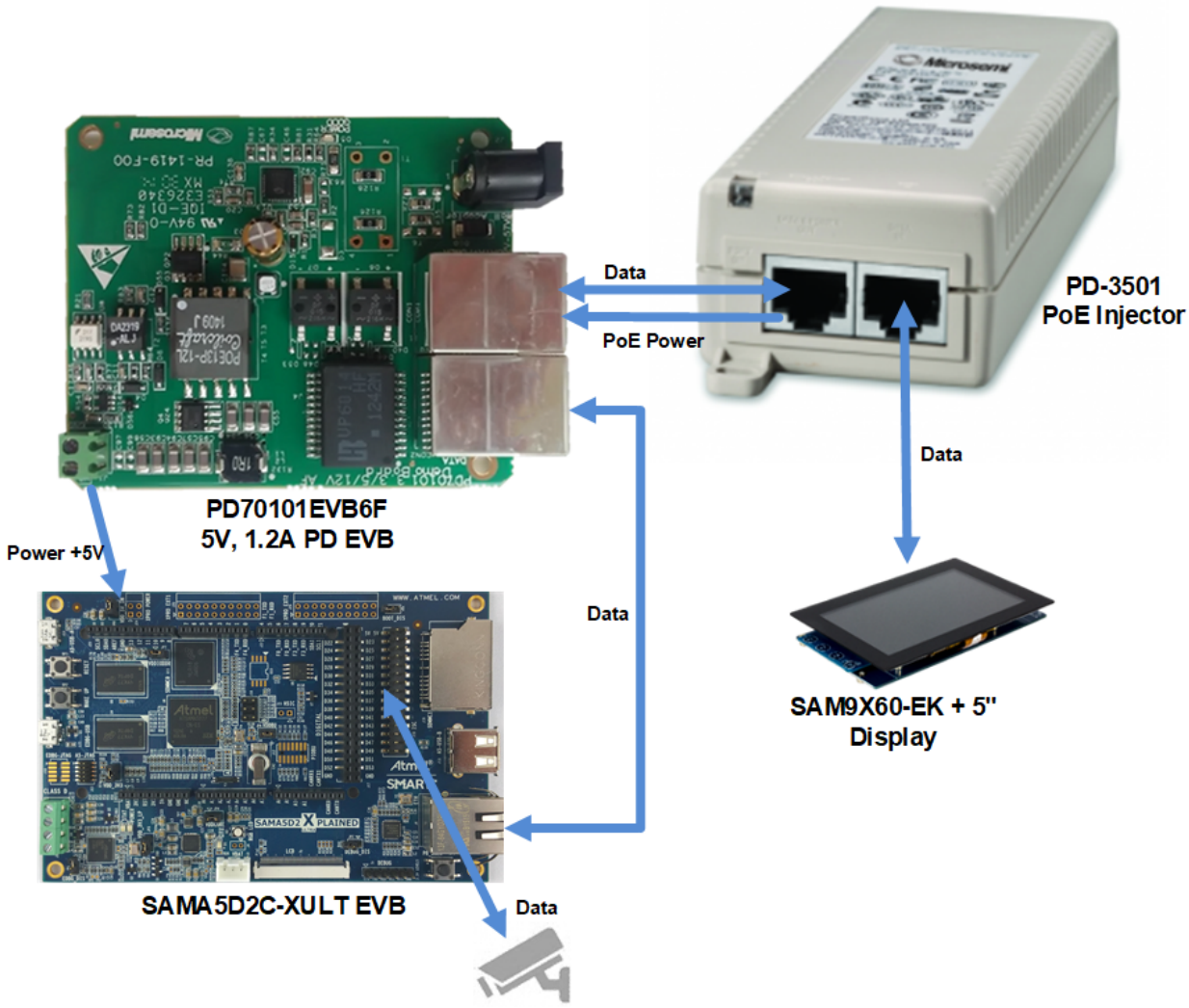
Figure 3-8. PD-3501GC Connected to RJ45



3.4 Complete PD Application using SAMA5D2C-XULT and PD70101EVB6F

The PoE powered SAMA5D2C-XULT can be used for a variety of applications. One such application is an IP Camera and display as shown in the following figure.

Figure 3-9. Complete PD Application using SAMA5D2C-XULT and PD70101EVB6F



All connections are discussed in this document except for the Camera to SAMA52C-XULT. The Camera is connected to the Image Sensor Controller (ISC) on J18. See the SAMA5D2C-XULT User's Guide for additional details.

4. MPU and PoE PSE Applications

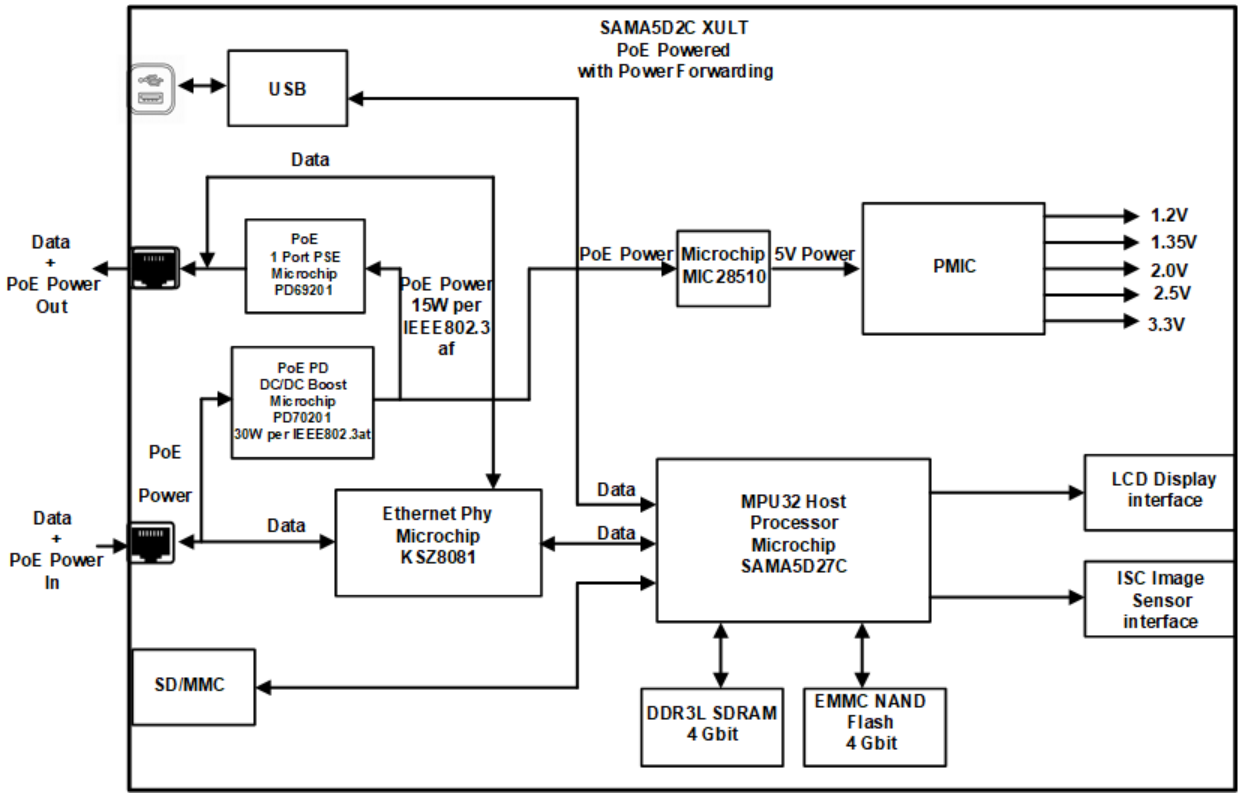
This section describes the power forwarding method.

4.1 Power Forwarding

Power forwarding is an easy method to extend the Ethernet network range beyond 100 m. Power Forwarding acts as a pass through with data repeating capabilities to extend the Ethernet range. Power Forwarding uses both a PD and a PSE PoE IC. The PD receives incoming power and feeds this power to the PSE, which is used to drive the next 100 m of loop, as shown in the following figure.

Note: The PD device is the PD70201, which has IEE 802.3at (30 W) capabilities to accommodate the added power needs of the Power Forwarding. The PSE IC is the Microchip PD69201 single port PSE.

Figure 4-1. Modified SAMA5D2C-XULT Design with PoE Power and Power Forwarding



4.2 Summary

This document describes the use of Microchip PoE PD technology in conjunction with Microchip Microprocessor or MPU32 products. Microchip offers complete reference design packages and Evaluation Boards (EVBs). For access to these design packages, device datasheets, or application notes, consult your local Microchip Client Engagement Manager or visit www.microchip.com. For technical support or questions, consult your local Embedded Solutions Engineers or visit www.microchipsupport.force.com/s/

5. Revision History

Revision	Date	Description
A	05/2021	Initial Revision

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