PD69200

PoE PSE Controller

Introduction

The Microchip family of PSE controllers include the PD69200, PD69210, and PD69220 devices. The PD69200 controller is based on the NXP Kinetis® L family, MKL15Z128VFM4. The PD69210 and PD69220 are based on the Microchip SAM D21 family. The PD69200 and PD69220 are pin compatible with an identical feature set. The PD69200 is available for existing designs. The PD69210 and PS69220 are recommended for all new designs.

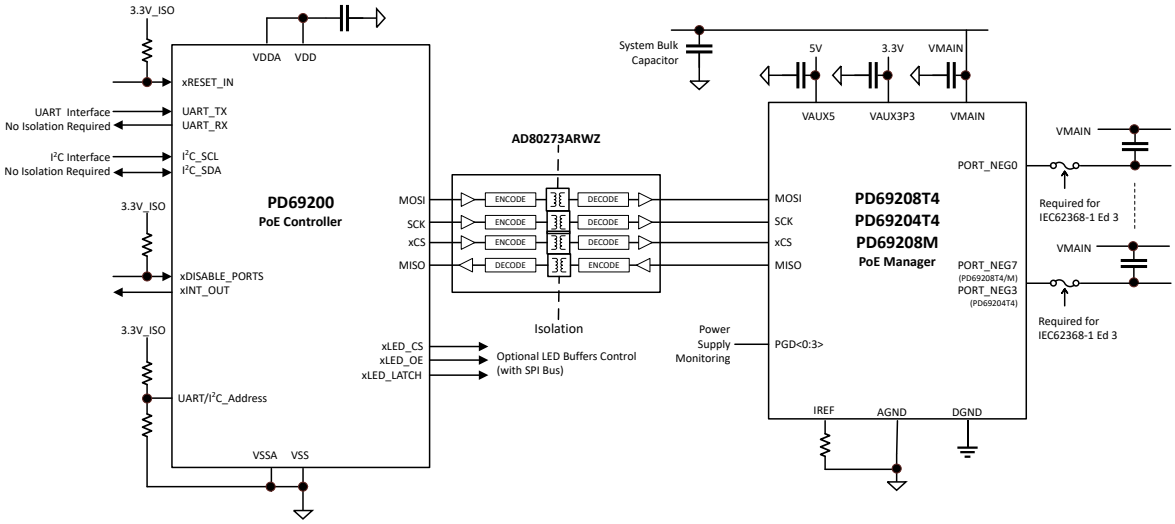
When paired with the Microchip PD69208T4, PD69204T4, or PD69208M Managers, the PD69200 controller is part of a Power over Ethernet Power Source Equipment (PSE) system. This system enables designers to integrate enhanced mode PoE capabilities, as specified in IEEE 802.3af, IEEE 802.3at, IEEE 802.3bt, and PoH standards.

The PD69200 is available in a 32-pin, 5 mm x 5 mm QFN package.

Typical PoE Application

The following figure shows the typical PoE application of PD69208T4 and PD69200 devices.

Figure 1. Typical PoE Application



Consult Microchip AN3361 *Designing an IEEE 802.3af/802.3at/802.3bt-Compliant PD69208 48-Port PoE System* for complete reference design.

Features

The following is the list of feature details of PSE Controller devices.

- Complies with IEEE 802.3 af/at, IEEE 802.3 bt, and HDBaseT (POH) standards
- Port matrix and priority
- Cascade up to 12 PoE devices for 48 logical ports
- 45 W maximum two pair power and capable of 90 W per four pair port (.bt)
- Supports three power management modes: Class (LLDP), Dynamic, and Static
- Supports 16 power banks based on four power supplies
- Port power limit setting
- Interrupt from power supply to PoE drivers
- Interrupt out pin for system and port events
- System OK indication
- Disable ports input pin
- System and port status and port measurements
- Legacy detection support
- LED stream support
- Fast and perpetual PoE support
- Software download through I^2C or UART communication interface
- 32-pin, 5 mm x 5 mm QFN package
- Pin compatible with PD69220
- MSL3 and RoHS compliant

Table of Contents

1. Architecture

The following figures shows the simplified hardware and the firmware architecture of the PoE system based on the PD69200 controller and the PD69208T4, PD69204T4, and PD69208M managers.

Figure 1-1. Simplified Hardware Architecture

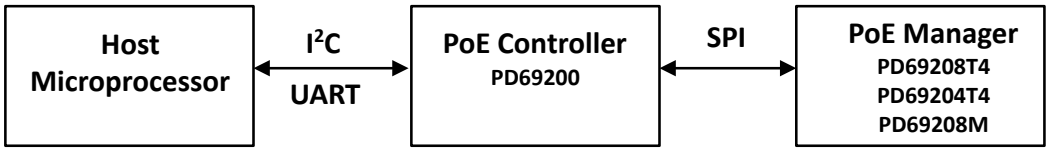
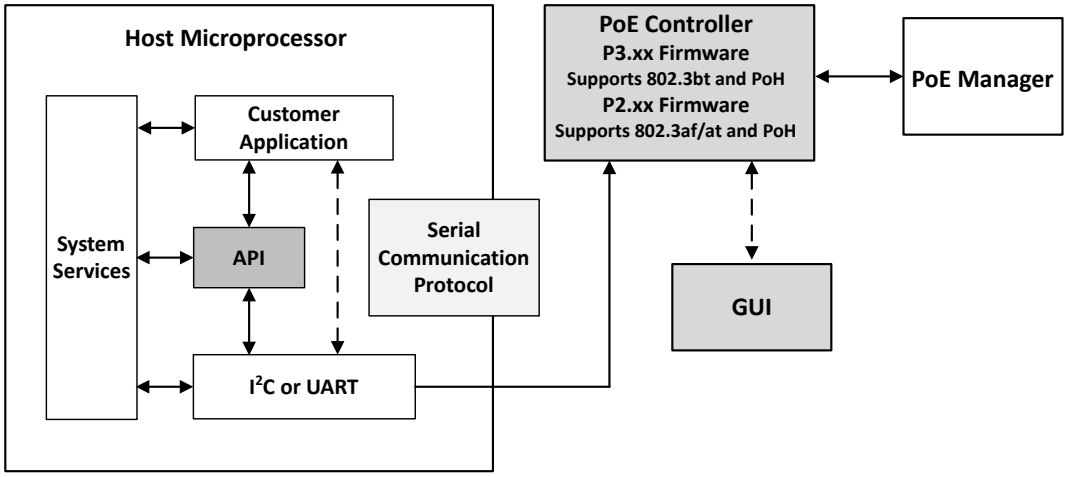


Figure 1-2. Simplified Firmware Architecture



- Dark grey boxes indicate Microchip supplied firmware
- Light grey boxes indicate Microchip provided documentation
- White boxes are user supplied

1.1 Firmware

- Firmware is pre-programmed in PD69200 controller. The firmware version is identifiable via the IC ordering part number.
- Firmware is vendor agnostic with regards to the choice of the host controller.
- May operated “stand alone” or with I^2C or UART communication to host.
- The default profiles are coded into the firmware. Microchip offers a configuration tool for profile modification.
- Firmware is field-upgradeable via the I^2C or UART link.

1.2 Communication

Communication between the host application and the controller’s firmware may be done via a 15 byte protocol. Customers may use a Microchip provided API. Microchip provides a Serial Communication Protocol guide.

1.3 GUI

This is a diagnostic tool to control the Microchip PSE emulating or bypassing the host processor.

1.4 Software Library

The firmware (without the boot section), GUI, and API is available on Microchip's software library https://www.microchip.com/doclisting/SoftwareLib.aspx.

1.5 SPI Communication

The PD69208T4, PD69204T4, and PD69208M managers use SPI communication in SPI slave mode to communicate with the various controllers. Each manager has an address determined by ADDR0-ADDR3 pins. Each controller can support up to 12 ICs at addresses 0–11. The actual frequency between PD69200 and PD6920x ICs is 1 MHz.

The following table lists the SPI communication packet structure.

Table 1-1. SPI Communication – Packet Structure

Control Byte Selects PD69208T4 According to Address	R/W Bit	Internal Register Address	Number of Words (Read Access Only)	Data Written to IC (Write Access Only) Read from IC (Read Access Only)
8 bits	R(0)/W(1)	8 bits	8 bits	16 bits

See the PD69208T4, PD69204T4, and PD69208M Manager datasheet for additional details on the SPI interface.

1.6 UART

A pull-up resistor is required on the UART communication line. For more information, see A*N3361 Designing an IEEE802.3af/at/bt PoE System Based on PD692x0/PD69208*.

Following is the UART communications configuration setting details:

- Bits per second: 19,200 bps
- Data bits: 8
- Parity: None
- Stop bits: 1
- Flow control: None

1.7 I^2C

The PD69200 requires the host to support I^2C clock stretch.

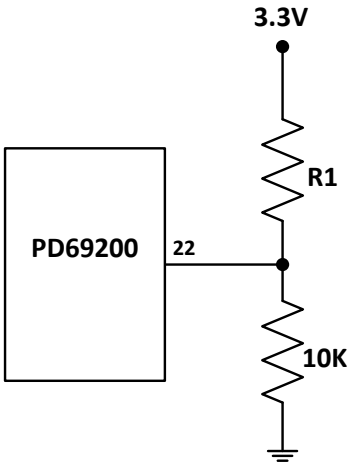
Following is the I^2C communication configuration setting details:

- Address: 7 bits
- Clockstretch: host should support
- Transaction: 15 bytes or 1 byte

1.8 UART - I²C Address Selection

The choice of UART or I²C interface between the host CPU is made by applying a specific voltage level to pin #22 (I2C_ADDR_MEAS) on the PD69200. Additionally, the specific I²C address is also set by this voltage level. The voltage is set via an external resistor as shown in the following figure.

Figure 1-3. I²C Address Selection



The following table shows the specific values of R to choose UART or I²C and to set the address.

Table 1-2. I²C Address Selection for PD69200

I2C_ADDR Voltage Low Level (V)	I2C_ADDR Voltage High Level (V)	I²C Address (Hexadecimal)	R1- KΩ (1%)
0	0.21	UART	N.C.
0.21	0.41	0x4	97.6
0.41	0.62	0x8	53.6
0.62	0.83	0xC	35.7
0.83	1.03	0x10	25.5
1.03	1.24	0x14	19.1
1.24	1.44	0x18	14.7
1.44	1.65	0x1C	11.3
1.65	1.86	0x20	8.87
1.86	2.06	0x24	6.81
2.06	2.27	0x28	5.23
2.27	2.48	0x2C	3.92
2.48	2.68	0x30	2.80
2.68	2.89	0x34	1.87
2.89	3.09	0x38	1.02
3.09	3.30	0x3C	0.324

2. Electrical Specifications

For a complete list of electrical ratings and characteristics, see *NXP KL15P80M48SF0 KL15 Sub-Family Data Sheet*.

2.1 Electrical Characteristics

The following table list typical value conditions of PD69200.

Table 2-1. Typical Value Conditions

Symbol	Parameter	Min Typ	Value	Max	Units
T_A	Ambient temperature	-40	25	85	°C
V_{DD}	3.3 V supply voltage	3.0	3.3	3.63	V

2.2 Immunity

The following table lists the immunity conditions of PD69200.

Table 2-2. PD69200 Immunity

Symbol	Parameter	Conditions	Min	Max	Units
ESD	ESD rating	HBM[1]	-2000	2000	V
	ESD rating	CDM[2]	-500	500	V

Note:

1. Determined according to JEDEC Standard JESD22-A114, *Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)*.
2. Determined according to JEDEC Standard JESD22-C101, *Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components*.

2.3 Absolute Maximum Ratings

Stresses beyond those listed in this section may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect the device reliability.

Table 2-3. Absolute Maximum Ratings

Symbol	Parameter	Minimum	Maximum	Units
V_{DD}	Digital supply voltage	-0.3	3.8	V
V_{DDA}	Analog supply voltage	VDD-0.3	VDD+0.3	V
V_{DIO}	Digital pin input voltage (Except RESET)	-0.3	3.6	V
V_{AIO}	Analog pins[1] and RESET pin input voltage	-0.3	VDD+0.3	V
Lead Soldering Temperature (40 s, reflow)			260	°C
Storage Temperature		-55	150	°C

Note:

1. Analog pins are defined as pins that do not have an associated general purpose I/O port function.

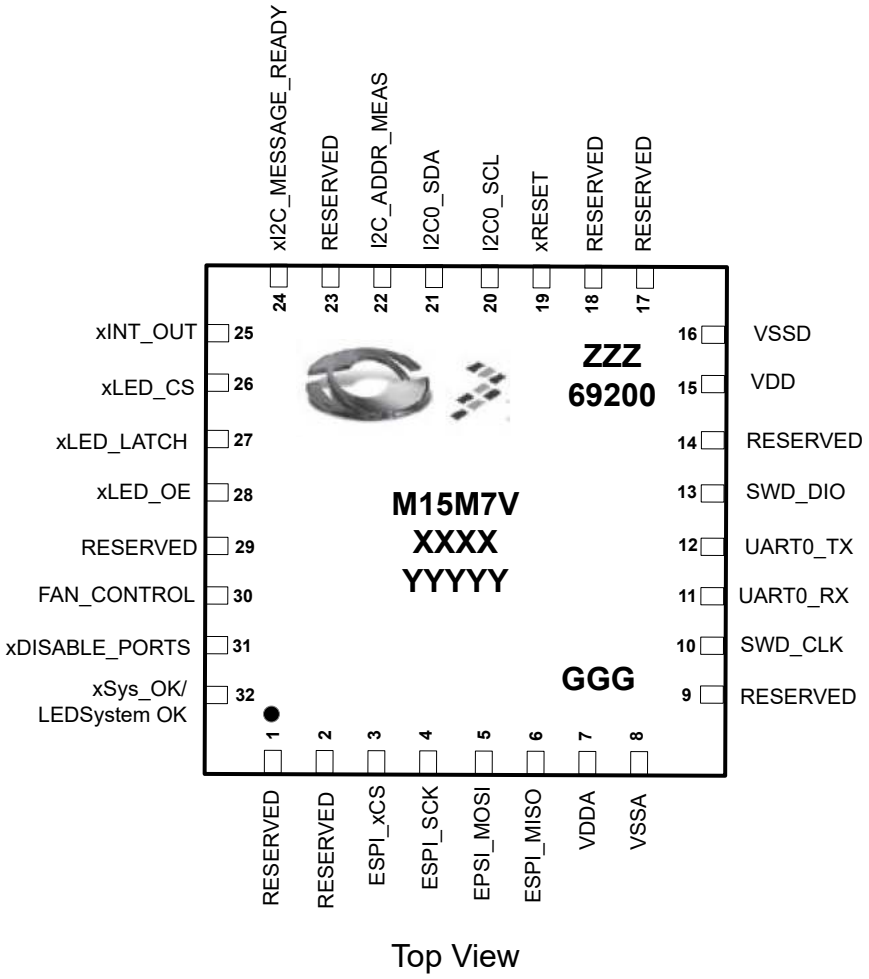
3. Pin Descriptions

The following section describes the 32 pins of PD69200.

3.1 Pin Configuration and Pinout

The following figure shows the top view of PD69200.

Figure 3-1. PD69200 Pin Diagram



Top View

Note: For definitions about markings in the pinout diagram, see Ordering Information.

3.2 Pin Details

The following tables describe the functional pin descriptions of the PD69200 device.

Table 3-1. PD69200 Pin Description

Number	Designation	Type	Description
1	Reserved	OUT	Reserved UART - Leave Open
2	Reserved	IN	Reserved UART - Pull up to 3.3 V via 10K
3	ESPI_xCS	OUT	ESPI Bus to PoE Manager. SPI chip select. Pull-up required. See *AN3361* for pin connection requirements. (Active Low)
4	ESPI_SCK	OUT	ESPI Bus to PoE Manager. SPI clock output to PD6920x, and LED stream clock output, set to 1 MHz.
5	ESPI_MOSI	OUT	ESPI Bus to PoE Manager. SPI Master Out Slave In. SPI packets are transmitted on this line.
6	ESPI_MISO	IN	ESPI Bus to PoE Manager. SPI Master In Slave Out. SPI packets are received on this line.
7	VDDA	Supply	Main Supply 3.3 V
8	VSSA	GND	Ground
9	Reserved	Analog_IN	Reserved Analog_IN. Connect to 3.3 V.
10	SWD_CLK		Leave Open
11	UART0_RXx	IN	UART receive from host. 15-byte protocol commands are received on this line. The baud rate is set to 19,200 bps. A pull up is required. See *AN3361* for details.
12	UART0_TX	OUT	UART transmit to host. 15-byte protocol reply/ telemetry is transmitted on this line. The baud rate is set to 19,200 bps.
13	SWD_DIO		Leave Open
14	Reserved	Analog_IN	Reserved Analog_IN. Connect to 3.3 V or GND through 10 kΩ.
15	VDD	Supply	Main Supply 3.3 V
16	VSSD	GND	Ground
17	Reserved	Oscillator	Reserved – Oscillator input – Leave open
18	Reserved	Oscillator	Reserved – Oscillator output – Leave open
19	xRESET	IN/OUT	Host Reset input. This pin is active low. The controller can generate self-reset. In this case, the xRESET pin is driven low by the controller for about 100 µs. See *AN3361* for pin connection requirements.

.....continued

Number	Designation	Type	Description
20	I2C0_SCL	IN/OUT	I^2C clock from the host master. Speed is limited to 400 KHz. Clock stretch required. Pull-up required, see *AN3361* for details.
21	I2C0_SDA	IN/OUT	I^2C bidirectional data. 15-byte protocol messages are transmitted on this line. A pull up is required. See *AN3361* for more details.
22	I2C_ADDR_MEAS	Analog_IN	Analog input to determine I^2C address or UART operation.
23	Reserved		Connect to GND
24	xI2C_MESSAGE_READY	OUT	I^2C message ready for reading by the host. The controller asserts this line low when it has an answer to the host. Therefore, the host can poll this line and initiate an I^2C read cycle only when the message is ready. This pin is active low. After the host reads the data from the controller, this pin is asserted to high.
25	xINT_OUT	OUT	Interrupt output indication. This line is asserted low when a pre-configured event is in progress. This pin is active low.
26	xLED_CS	OUT	Chip select signal for LED stream. This pin is active low.
27	xLED_LATCH	OUT	Latch signal for LED stream. This pin is active low.
28	xLED_OE	OUT	Output enable signal for LED stream. This pin is active low.
29	Reserved	Analog_IN	Reserved Analog_IN. Connect to 3.3 V.
30	FAN_CONTROL	OUT	Logic out that may be used to control a fan driver. This pin is active high.
31	xDISABLE_PORTS	IN	Disable all PoE ports. When this input is asserted low, the controller shuts down all of the PoE ports in the system. See *AN3361* for pin connection requirements. (Active Low)
32	xSys_OK/LED System OK	OUT	System validity indication. The behavior of this output is controlled by individual software mask. (Active Low)
ePAD	ePAD		Connect to VSSA. Sufficient copper mass is needed to ensure adequate thermal performance.

3.3 Recommended PCB Layouts

3.3.1 Recommended PCB Layout for 32-Pin QFN 5 mm x 5 mm

The following figures show the PCB layout pattern for PD69200. The units are in mm.

Figure 3-2. Top Layer Copper PCB Layout

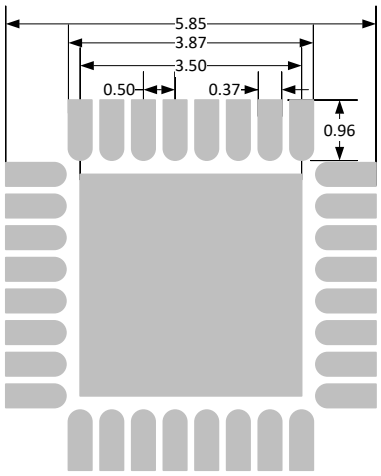
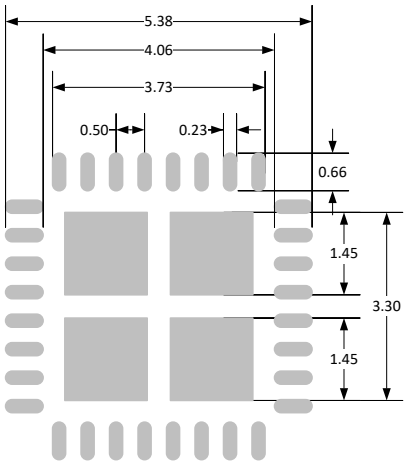


Figure 3-3. PD69200 Top-Layer Solder Paste and Vias PCB Layout for Thermal Pad Array



The contract manufacturer has latitude to modify the solder paste stencil for manufacturability reasons. The solder paste stencil covers 65% to 80% of the thermal pad and must not allow solder to be applied to the thermal vias under the QFN package using any method they deem appropriate. Any design should be subject to system validation and qualification prior to commitment to mass production of field deployment. Use a 5 mil stencil.

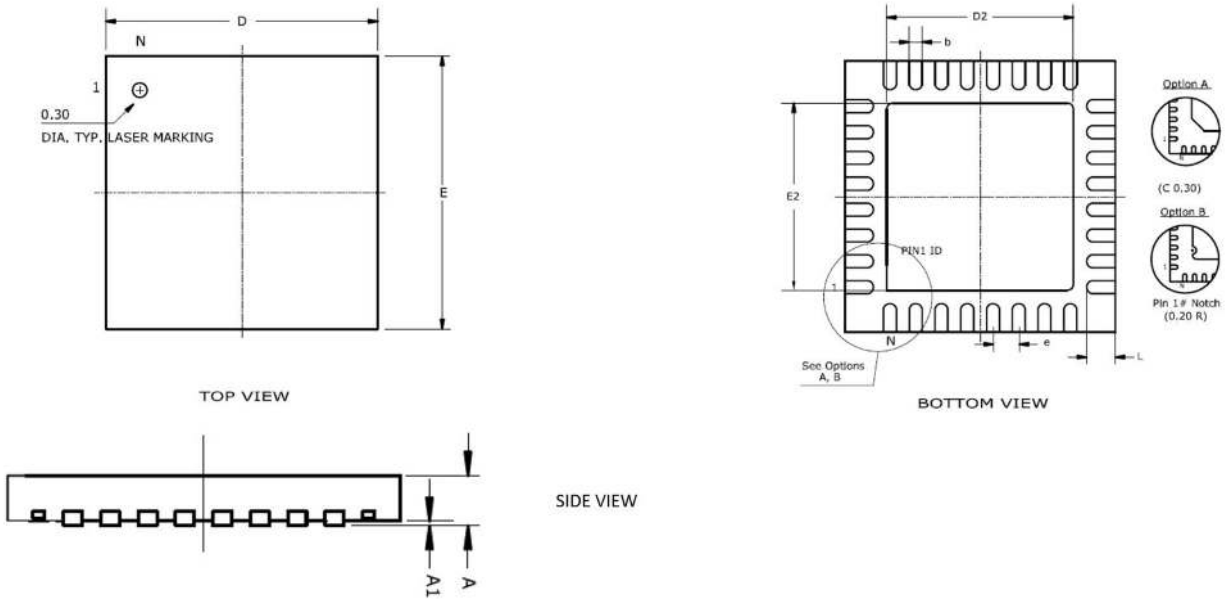
4. Package Information

This section describes the package drawings of PD69200 device.

4.1 PD69200 Package Outline Drawing

The following figure shows the package drawing (32 Pin QFN 5 mm x 5 mm) of the PD69200 device.

Figure 4-1. PD69200 Package Outline Drawing



The following table lists the dimensions and measurements of the PD69200 package.

Table 4-1. PD69200 Package Outline Dimensions and Measurements

Dimension	Millimeters		Inches	
	Min	Max	Min	Max
A	0.80	1.00	0.031	0.039
A1	0.00	0.05	0	0.002
e	0.50 BSC		0.02 BSC	
L	0.30	0.50	0.012	0.02
b	0.18	0.30	0.007	0.012
D2	3.50	3.70	0.138	0.147
E2	3.50	3.70	0.138	0.147
D	5.00 BSC		0.197 BSC	
E	5.00 BSC		0.197 BSC	

Note: Dimensions do not include protrusions. They should not exceed 0.155 mm (.006 in) on any side. Lead dimension should not include solder coverage. The dimensions are in millimeters and inches for reference.

4.2 Thermal Specifications

The following table list the thermal specifications of the PD69200.

Table 4-2. Thermal Specifications

Thermal Resistance	Typ	Units	Notes
θ_{JA}	33	°C/W	Junction-to-ambient thermal resistance
θ_{JC}	1.8	°C/W	Junction-to-case thermal resistance

4.3 Recommended Solder Reflow Information

Following list shows the recommended solder reflow information details.

- RoHS 6/6
- Pb-free 100%
- Matte Tin Finish
- Package Peak Temperature for Solder Reflow (40 s maximum exposure)—260 °C (0 °C, –5 °C)

Table 4-3. Classification Reflow Profiles

Profile Feature	Sn-PbEutectic Assembly	Pb-Free Assembly
Average Ramp-up Rate (TS_{max} to Tp)	3 °C/second max	3 °C/second max
Preheat		
Temperature Min (TS_{min})	100 °C	150 °C
Temperature Max (TS_{max})	150 °C	200 °C
Time (ts_{min} to ts_{max})	60 s to 120 s	60 s to 180 s
Time Maintained		
Time Maintained Temperature (T_L)	183 °C	217 °C
Time (t_L)	60 s to 150 s	60 s to 150 s
Peak Classification Temperature (TP)	210 °C to 235 °C	240 °C to 255 °C
Time within 5 °C of Actual Peak Temperature (tp)	10 s to 30 s	20 s to 40 s
Ramp-down Rate	6 °C/second max	6 °C/second max
Time 25 °C to Peak Temperature	6 minutes max	8 minutes max

Figure 4-2. Classification Reflow Profiles

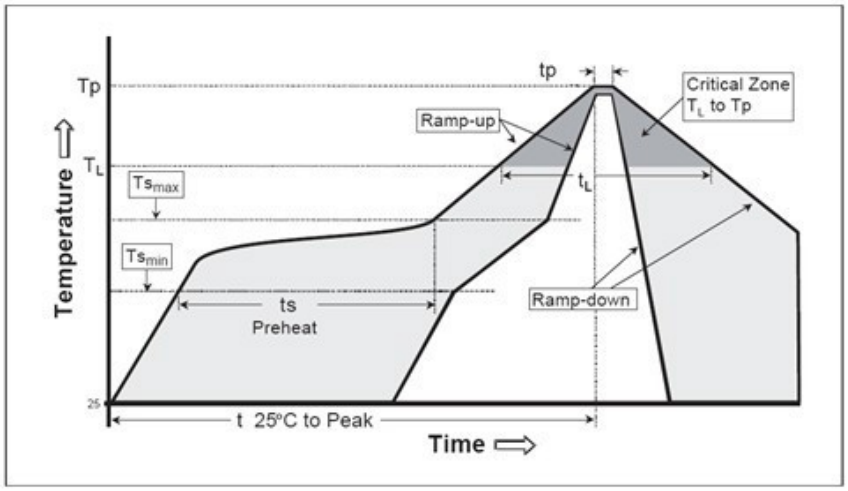


Table 4-4. Pb-Free Process—Package Classification Reflow Temperatures

Package Thickness	Volume mm^3 < 350	Volume mm^3 350– 2000	Volume mm^3 > 2000
Less than 1.6 mm[1]	260 + 0 °C	260 + 0 °C	260 + 0 °C
1.6 mm to 2.5 mm[1]	260 + 0 °C	250 + 0 °C	245 + 0 °C
Greater than or equal to 2.5 mm[1]	250 + 0 °C	245 + 0 °C	245 + 0 °C

Note:

1. Tolerance: The device manufacturer or supplier should assure process compatibility up to and including the stated classification temperature, meaning that the peak reflow temperature is 0 °C. For example, 260 °C to 0 °C, at the rated MSL value.

Note: Exceeding the ratings that are mentioned in the preceding table might cause damage to the device.

4.4 Reference Documents

- IEEE Std 802.3-2018 Clause 33 Power over Ethernet over 2-Pair and Clause 145 Power over Ethernet
- PD692x0 Communication Protocol User Guide
- AN3361 Designing an IEEE802.3af/at/bt PoE System Based on PD692x0/PD69208
- PD69208T4, PD69204T4, and PD69208M PoE PSE Manager Data Sheet
- PD69210 and PD69220 PoE PSE Controller Data Sheet

5. Ordering Information

The following table lists the part ordering information for PD69200 devices.

Table 5-1. Ordering Information

Part Number	Package	Packaging Type	Temperature	Part Marking	Tray Marking
PD69200D[1]-VVVV[2]SS[3]	Plastic QFN 5 mm × 5 mm (32 lead)	Tray	–40 °C to 85 °C	Microsemi Logo NXP Logo 69200 M15M7V[4] XXXX[5] YYYY[6]	PD69200-VVVVSS PD-OOOOGabb[7] YYWW
PD69200D[1]-VVVV[2]SS[3]-TR	Plastic QFN 5 mm × 5 mm (32 lead)	Tape and Reel	–40 °C to 85 °C	Microsemi Logo NXP Logo 69200 M15M7V[4] XXXX[5] YYYY[6]	

Note:

1. D stands for the detection method set as:
   - C = IEEE802.3 and pre-standard
   - R = IEEE802.3 only
2. VVVV is firmware revision.
3. SS stands for firmware parameters options.
4. Short part number
5. Mask set
6. Date code
7. Operational part number

The firmware release note has all required information about how to specify the choice of VVVV and SS. Find the Firmware Release Notes in the Microchip Software Libraries, and register to My Microchip account to access the release notes.

Note: The package meets RoHS, Pb-free of the European Council to minimize the environmental impact of electrical equipment.

Note: Initial burning of controller's firmware is performed in the factory. Firmware upgrades can be performed by users using the communication interface. For more information, see TN-140 (Catalog Number: 06-0024-081).

6. 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.

6.1 Revision 1.0

The PD69200 PoE PSE Controller was previously described in the following documents:

- PD69208T4 and PD69200 Datasheet - Revision 6, September 2019, Document Number PD-000303603
- PD69204T4 and PD69200 Datasheet - Revision 6, September 2019, Document Number PD-000303601
- PD69208M and PD69200 Datasheet - Revision 6, September 2019, Document Number PD-000303451

Table 6-1. PD69200 Revision History

Doc Rev.	Date	Comments
A	March 2020	This is the initial issue of this document.

The Microchip Website

Microchip provides online support via our website at http://www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to http://www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: http://www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with

your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TempTrackr, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

ISBN: 978-1-5224-5921-7

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit http://www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: http://www.microchip.com/support Web Address: http://www.microchip.com **Atlanta** Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455 **Austin, TX** Tel: 512-257-3370 **Boston** Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088 **Chicago** Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075 **Dallas** Addison, TX Tel: 972-818-7423 Fax: 972-818-2924 **Detroit** Novi, MI Tel: 248-848-4000 **Houston, TX** Tel: 281-894-5983 **Indianapolis** Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380 **Los Angeles** Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800 **Raleigh, NC** Tel: 919-844-7510 **New York, NY** Tel: 631-435-6000 **San Jose, CA** Tel: 408-735-9110 Tel: 408-436-4270 **Canada - Toronto** Tel: 905-695-1980 Fax: 905-695-2078	**Australia - Sydney** Tel: 61-2-9868-6733 **China - Beijing** Tel: 86-10-8569-7000 **China - Chengdu** Tel: 86-28-8665-5511 **China - Chongqing** Tel: 86-23-8980-9588 **China - Dongguan** Tel: 86-769-8702-9880 **China - Guangzhou** Tel: 86-20-8755-8029 **China - Hangzhou** Tel: 86-571-8792-8115 **China - Hong Kong SAR** Tel: 852-2943-5100 **China - Nanjing** Tel: 86-25-8473-2460 **China - Qingdao** Tel: 86-532-8502-7355 **China - Shanghai** Tel: 86-21-3326-8000 **China - Shenyang** Tel: 86-24-2334-2829 **China - Shenzhen** Tel: 86-755-8864-2200 **China - Suzhou** Tel: 86-186-6233-1526 **China - Wuhan** Tel: 86-27-5980-5300 **China - Xian** Tel: 86-29-8833-7252 **China - Xiamen** Tel: 86-592-2388138 **China - Zhuhai** Tel: 86-756-3210040	**India - Bangalore** Tel: 91-80-3090-4444 **India - New Delhi** Tel: 91-11-4160-8631 **India - Pune** Tel: 91-20-4121-0141 **Japan - Osaka** Tel: 81-6-6152-7160 **Japan - Tokyo** Tel: 81-3-6880- 3770 **Korea - Daegu** Tel: 82-53-744-4301 **Korea - Seoul** Tel: 82-2-554-7200 **Malaysia - Kuala Lumpur** Tel: 60-3-7651-7906 **Malaysia - Penang** Tel: 60-4-227-8870 **Philippines - Manila** Tel: 63-2-634-9065 **Singapore** Tel: 65-6334-8870 **Taiwan - Hsin Chu** Tel: 886-3-577-8366 **Taiwan - Kaohsiung** Tel: 886-7-213-7830 **Taiwan - Taipei** Tel: 886-2-2508-8600 **Thailand - Bangkok** Tel: 66-2-694-1351 **Vietnam - Ho Chi Minh** Tel: 84-28-5448-2100	**Austria - Wels** Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 **Denmark - Copenhagen** Tel: 45-4450-2828 Fax: 45-4485-2829 **Finland - Espoo** Tel: 358-9-4520-820 **France - Paris** Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 **Germany - Garching** Tel: 49-8931-9700 **Germany - Haan** Tel: 49-2129-3766400 **Germany - Heilbronn** Tel: 49-7131-72400 **Germany - Karlsruhe** Tel: 49-721-625370 **Germany - Munich** Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 **Germany - Rosenheim** Tel: 49-8031-354-560 **Israel - Ra'anana** Tel: 972-9-744-7705 **Italy - Milan** Tel: 39-0331-742611 Fax: 39-0331-466781 **Italy - Padova** Tel: 39-049-7625286 **Netherlands - Drunen** Tel: 31-416-690399 Fax: 31-416-690340 **Norway - Trondheim** Tel: 47-72884388 **Poland - Warsaw** Tel: 48-22-3325737 **Romania - Bucharest** Tel: 40-21-407-87-50 **Spain - Madrid** Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 **Sweden - Gothenberg** Tel: 46-31-704-60-40 **Sweden - Stockholm** Tel: 46-8-5090-4654 **UK - Wokingham** Tel: 44-118-921-5800 Fax: 44-118-921-5820