



## PRODUCT FEATURES

- Low-Cost IEEE 802.3af PD Module
- High Efficiency
- Low EMI
- IEEE 802.3af (13W), POE PD Modules
- On board PI filter for output ripple control
- Overload and short circuit protection<sup>1</sup>
- Highly efficient 1500V isolated DC-DC converter
- Adjustable output voltage
- RoHS compliant
- World's smallest full power 802.3af (POE) solution
- Ultra Compact Size (35mm x 14mm)
- 3.3V, 5V, 12V DC output voltage models
- IEEE 802.3af, Type 1 802.3at and 802.3bt
- Wide input voltage (36V to 57V DC)
- Full Power start up even from 36V input
- Minimal external components required
- Low output ripple and noise

## PRODUCT OVERVIEW

The PEM1400 is the world's smallest full power IEEE802.3af compliant Power Over Ethernet (PoE)Powered Device (PD) module delivering up to 12.95W of power across all its voltage variants, 3.3V(PEM1403), 5V (PEM1405), and 12V (PEM1412). Its low-cost design requires just input diodes and an output capacitor to rapidly enable a POE solution.

The ultra-compact size of 35mm x 14mm (1.38in x 0.55in) occupies just 390 mm<sup>2</sup> (0.605 sq. inches) of footprint on the customer's board making ideal for compact new generation devices like IOT, IP phones, IP cameras, security and access control devices, sensors, routers, and network access points. The PEM1400 has an isolated high efficiency DC-DC converter with in-built frequency dithering to reduce EMI and noise

With on board PI filter, the output ripple is controlled within IEEE specifications.

## APPLICATION AREAS

- Security and alarm systems
- Voice over IP phones
- Access control systems
- IP Cameras
- Displays, Net Monitors
- Public address systems
- Wireless access points
- Environmental control
- Telemetry
- Remote environmental monitoring

<sup>1</sup> If maximum power is exceeded, the PEM1400 will operate in over current mode and will auto recover when the over load condition is removed.

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## PRODUCT SELECTOR

Part Number	Marking	Nominal Input Voltage ( $V_{IN}$ )	Output Voltage <sup>2</sup>	Efficiency <sup>3</sup>	Power (Maximum) <sup>7,10</sup>
		(Volts DC)	(Volts DC)	(%)	(Watts)
PEM1403	03	48	3.3	80	12.95
PEM1405	05	48	5	85	12.95
PEM1412	12	48	12	87	12.95

## INPUT CHARACTERISTICS

Parameter	Symbol	Min.	Typ <sup>4</sup> .	Max.	Units
Input Voltage <sup>4</sup>	$V_{IN}$	36	48	57	Volts
Under Voltage Lockout	$V_{UVLO}$	30		36	Volts
Input Current <sup>5</sup>	$I_{IN}$		350	400	mA
Operating Temperature <sup>6</sup>	$T_{OP}$	-20	25	70	°C
IEEE 802.3af Power Classification <sup>7</sup>	Class 0				

## DC OUTPUT CHARACTERISTICS

Parameter	Symbol	Min.	Typ <sup>4</sup> .	Max.	Units
Line Regulation <sup>8</sup>	$V_{LNRG}$		0.2%		
Load Regulation <sup>8</sup>	PEM1405 and PEM1412		0.5%		
	PEM1403		0.8%		
Output Ripple and Noise <sup>8</sup>	$V_{RIP}$		80		mV p-p
Isolation Voltage	$V_{ISOL}$			1500	V DC
Temperature Coefficient (Slope)	TC		100	300	ppm/°C

## ABSOLUTE MAXIMUM RATINGS<sup>8,9</sup>

Supply Voltage ( $V_{CC}$ )	0V – 57V DC
Storage Temperature ( $T_S$ )	-25°C – 100°C
Output Voltage ( $V_{OUT}$ )	0V to controlled output voltage (operating or non-operating)

<sup>2</sup> Output voltage typical  $\pm 3\%$  at  $T_A$  of 25°C with a nominal input voltage, rated output current and typical connections.

<sup>3</sup> At nominal  $V_{IN}$  at full load.

<sup>4</sup> With minimum load 1Watt or 100mA, whichever is higher.

<sup>5</sup> Please refer to IEEE802.3af standards document.

<sup>6</sup> Please see Thermal Management Section.

<sup>7</sup> Please see Powered Device Signature Section.

<sup>8</sup> All specifications typical are at  $T_A$  of 25°C with a nominal input voltage and rated output current unless otherwise noted. These are meant as a design aid only and are indicative, and not guaranteed.

<sup>9</sup> Exceeding the absolute maximum ratings may cause permanent damage to the product. We do not imply functional operation under these conditions. These ratings assume free air flow.

TYPICAL INPUT CONNECTIONS

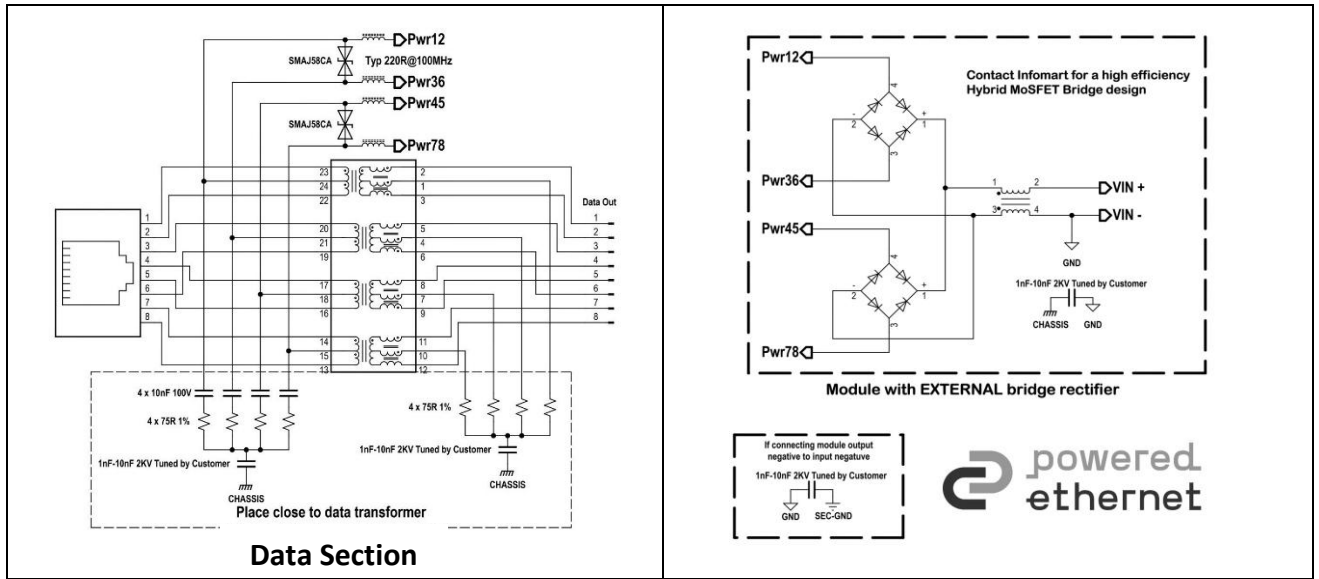


Figure 1- Typical Input Connections

OUTPUT CONNECTION

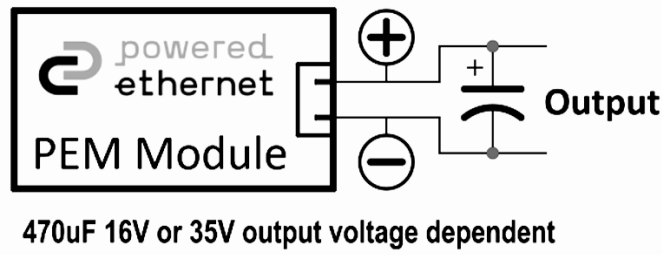


Figure 2- Output Connection

BLOCK DIAGRAM

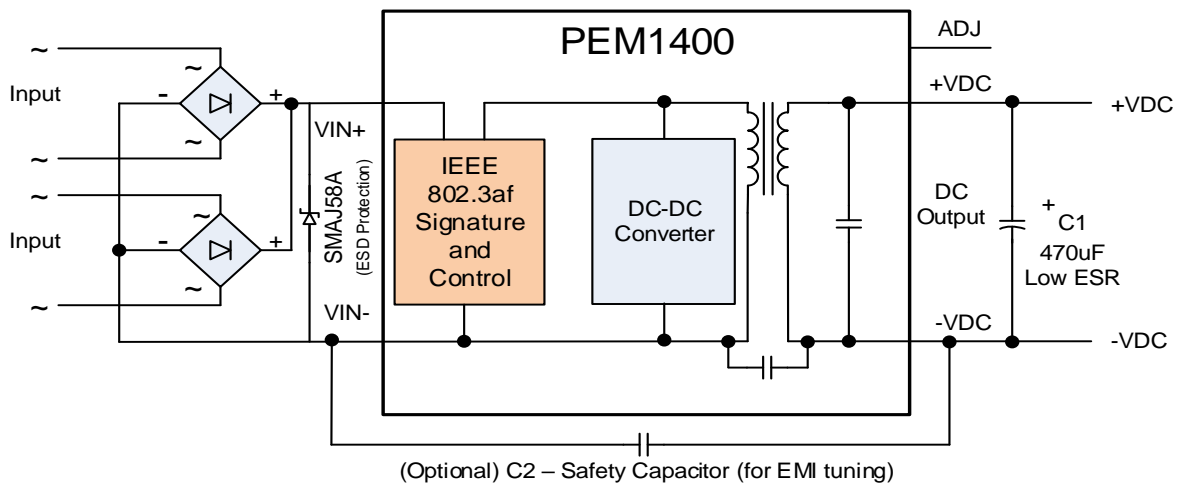


Figure 3- Block Diagram

**PIN CONNECTIONS**

INPUT PINS	
1	<b>VIN+</b> . This pin connects to the positive (+) output of the input bridge rectifiers.
2	<b>VIN-</b> . This pin connects to the negative (-) output of the input bridge rectifiers.
OUTPUT PINS	
3	<b>+VDC</b> . This pin provides the regulated output from the DC/DC converter. Max. Current 3A per pin <sup>10</sup> .
4	<b>OADJ</b> . The output voltage can be adjusted from its nominal value, by connecting an external resistor from this pin to either +VDC pin or -VDC pin. For more details, see <i>OUTPUT VOLTAGE ADJUSTMENT</i> Section.
5	<b>-VDC</b> . The ground return for +VDC output. Max. Current 3A per pin <sup>10</sup> .
<b>To maintain isolation integrity, always connect respective input and output poles only via X or Y safety capacitor. Maintain isolation barrier on motherboard PCB as per physical package.</b>	

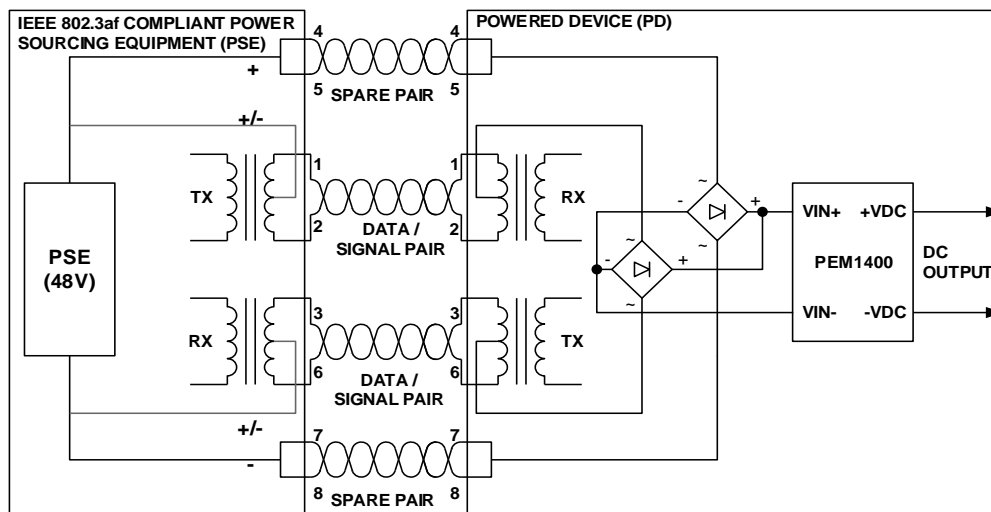
**INPUTS**

The PEM1400 is compatible with all IEEE 802.3af compliant Power Sourcing Equipment (PSE) and supports the different power injection options of Data/Signal pair (Mode A) or Spare Pair (Mode B). See *Figure 4*. As per IEEE 802.3af, it is specified that the PSE does not apply power to the both outputs at the same time i.e. 4 pair injection. (Refer to IEEE802.3af standards for more information).

The PEM1400 provides for external input bridge rectifiers for improved system design flexibility, and distribution of heat generation. As an example, a system designer wanting to provide two RJ45 inputs, both of which are PoE enabled, but use only one PEM1400 module to save costs. Another advantage is that this allows the system designer to control the type and costs of the input rectification diodes.

**TYPICAL SYSTEM CONFIGURATION**

In Mode A – Signal Pair injection, the signal lines carry both data and power. In Mode B – Spare Pair injection, the Signal pair carries only data, and the spare pair carries power.



**Figure 4- Typical System configuration**

<sup>10</sup> Max. Current 4A per pin for PEM1403

**POWERED DEVICE (PD) SIGNATURE**

When the PEM1400 is connected to a Cat 5e or greater Ethernet cable from an IEEE 802.3af compliant Power Sourcing Equipment (PSE), Endspan or Midspan, it will automatically present a Powered Device (PD) signature to the PSE, as and when requested. The PSE will then recognise that a PD is connected to that line and supply power.

The PEM1400 presents class 0 detection to the PSE.

**ISOLATION**

IEEE802.3af section 33.4.1 calls for a Powered Device (PD) to meet safety isolation requirement by meeting the electrical strength test of IEC 60950 sub clause 6.2. Infomart's® PoweredEthernet™ PEM1400 modules meet or exceed 1500V impulse test. This is also referred to as 'Hi Pot Test', 'Flash Tested', 'Withstand Voltage', 'Proof Voltage', 'Dielectric Withstand Voltage' & 'Isolation Test Voltage'.

**FREQUENCY DITHERING**

The PEM1400 series is built with Frequency Dithering to help better controlling of EMI (electromagnetic-interference) emissions. The nominal switching frequency of PEM1400 series is 300KHz, with a dithering range of +/- 10%.

**OUTPUT VOLTAGE ADJUSTMENT**

The PEM1400 series has an OADJ pin, which allows the output voltage to be increased or decreased from its nominal value using a 1/16W power rating or greater and 1% tolerance resistor connected between the OADJ pin and either the +VDC or -VDC pin as per Shown below. Only one connection i.e. between OADJ and +VDC **or** between OADJ and -VDC is permitted at a time. A change of more than ± 10% from nominal is not permitted. Please [contact Infomart technical support](#) for more details or specific resistor values.

An estimate of resistance value for voltage adjustment is provided below. The most appropriate resistance value to be tuned by customers.

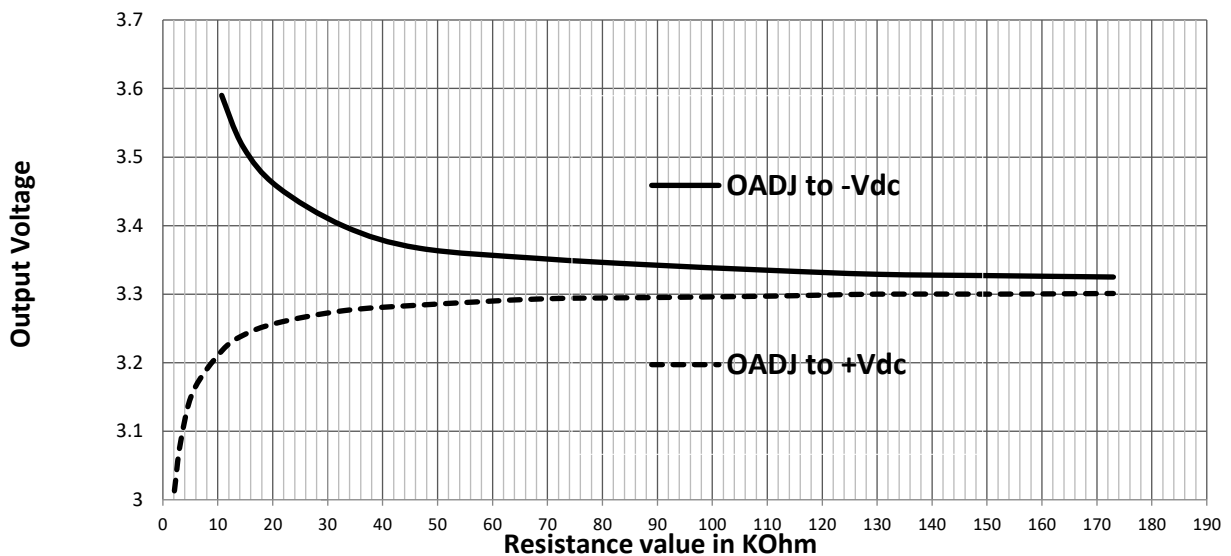


Figure 5- PEM1400 Output Voltage Adjustment

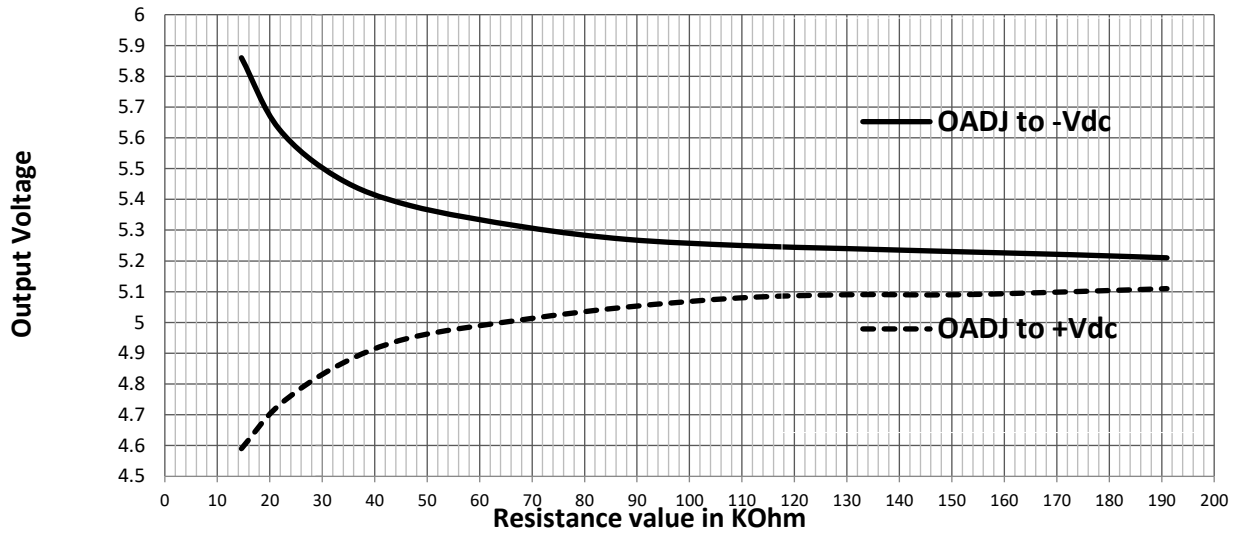


Figure 6- PEM1405 Output Voltage Adjustment

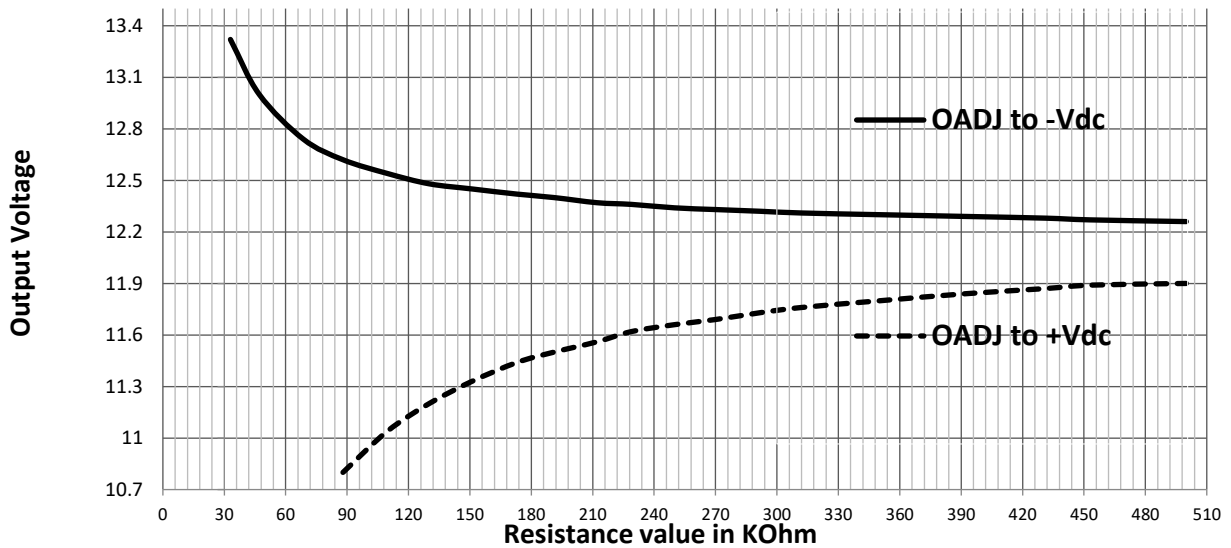


Figure 7- PEM1412 Output Voltage Adjustment

**THERMAL MANAGEMENT**

As with any power component, the PEM1400 modules generate heat. It is important that adequate ventilation and airflow be taken into consideration at the design stage. The quantum of heat generated by the PEM1400 will depend on the output load it is required to drive. The maximum ambient operating temperature is 70°C. Figure below shows the thermal performance of the PEM1400 with a nominal 48VDC input. The PEM1400 thermal performance can be improved by forced airflow cooling over the module and by using a heat sink (a) glued on to the output diodes using a thermal glue, or (b) by a power plane heat sink as described below. The two methods can be combined.

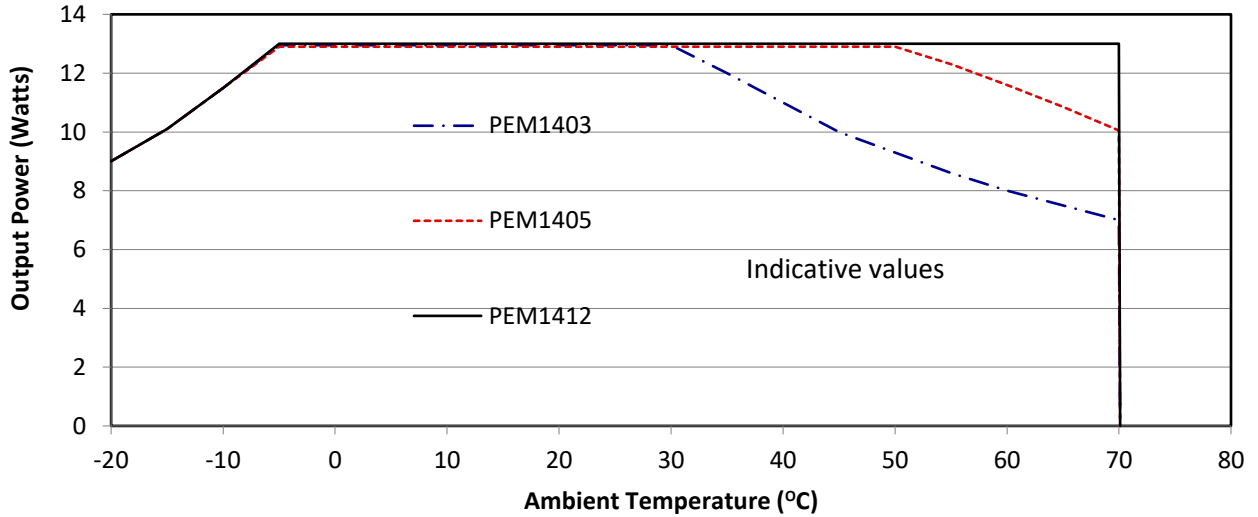


Figure 8- Thermal Performance profile at nominal  $V_{in}$

### POWER PLANE HEAT SINK

A power plane heat sink on the motherboard is a relatively simple method to draw some heat away from the PEM1400 using the output pins (+VDC and -VDC) which are connected to a PCB heat sink on the motherboard. **It is important to maintain electrical isolation between OADJ pin and the +VDC and -VDC pins to ensure proper output voltages.**

These power plane heat sinks must be on the outer layers of the PCB and the PEM1400 must not be fitted into a socket. This method can be combined with forced airflow cooling, and with a heat sink glued on to the two output diodes using a thermal glue.

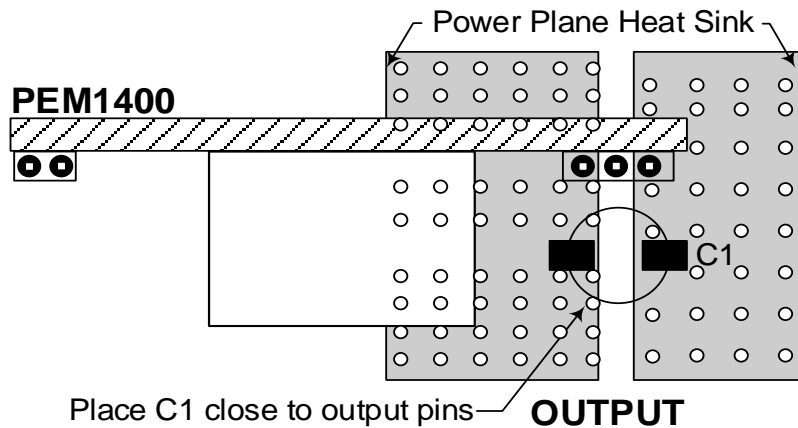


Figure 9- Power Plane Heat Sink



**EFFICIENCY v/s OUTPUT LOAD**

(indicative values from one of our data)

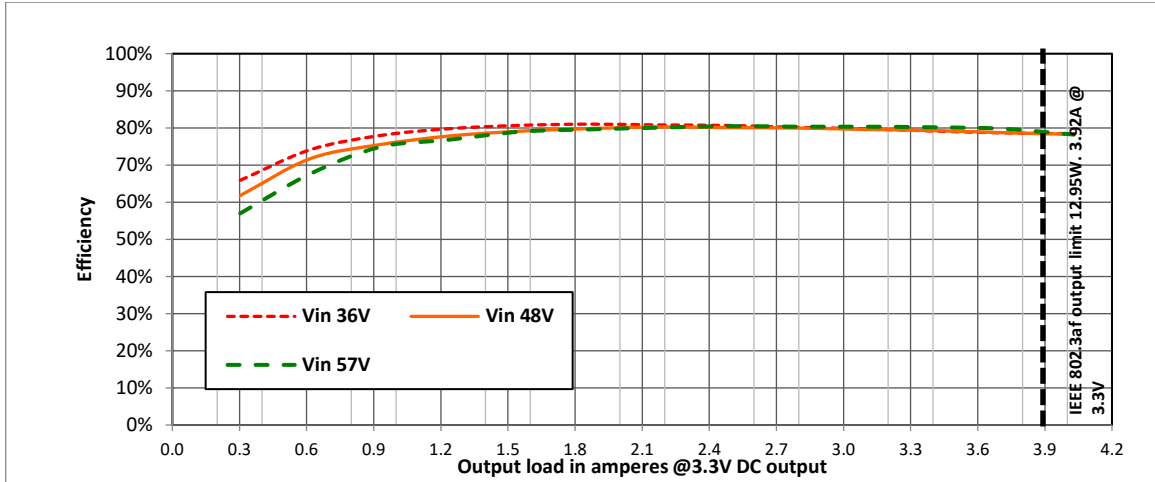


Figure 10- PEM1403 Efficiency vs. Output Load end to end

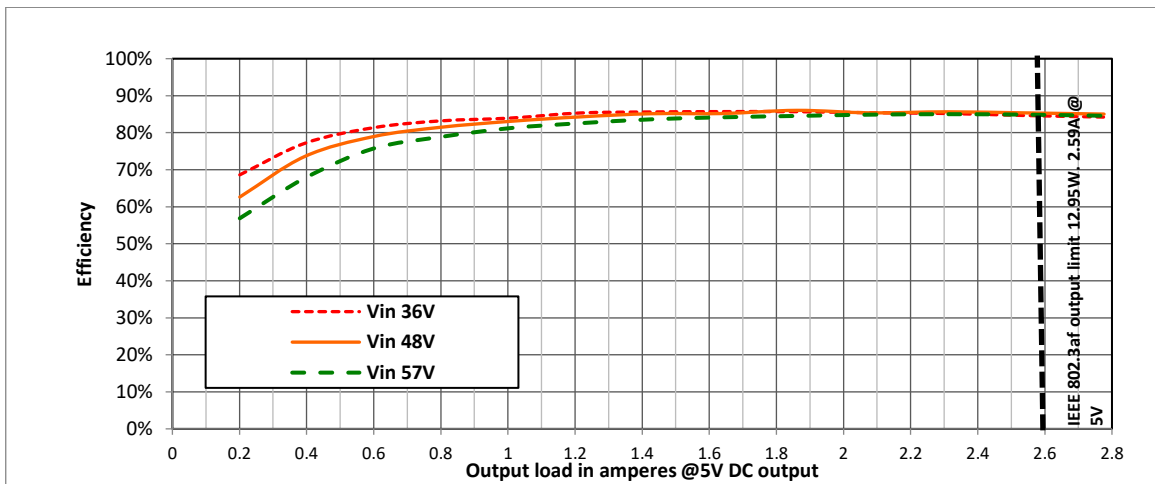


Figure 11- PEM1405 Efficiency vs. Output Load end to end

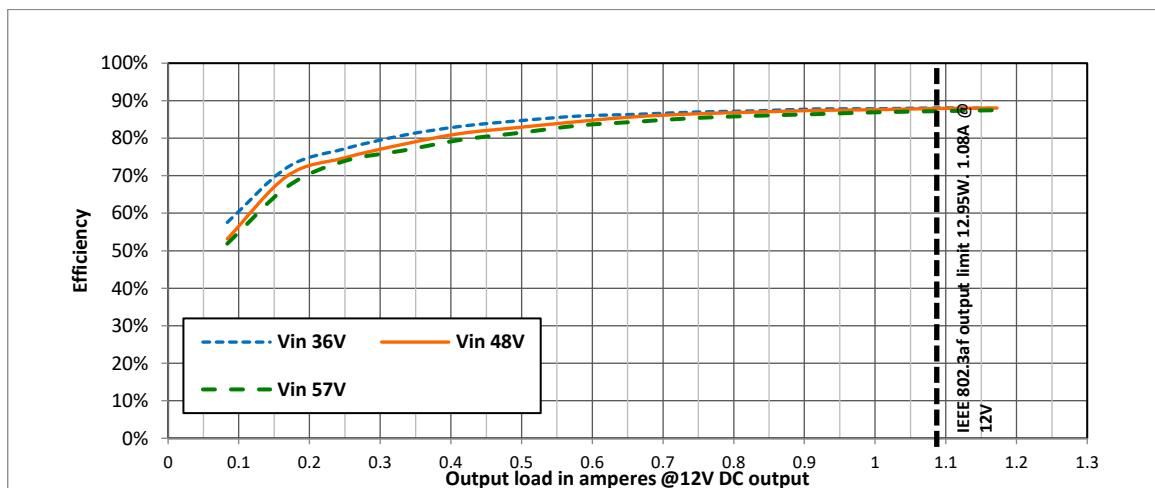
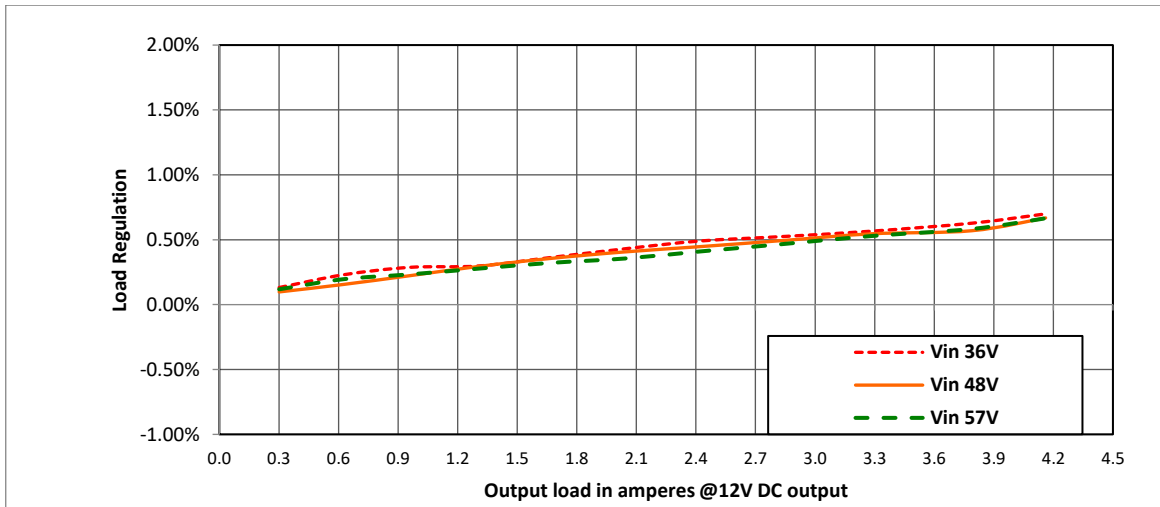


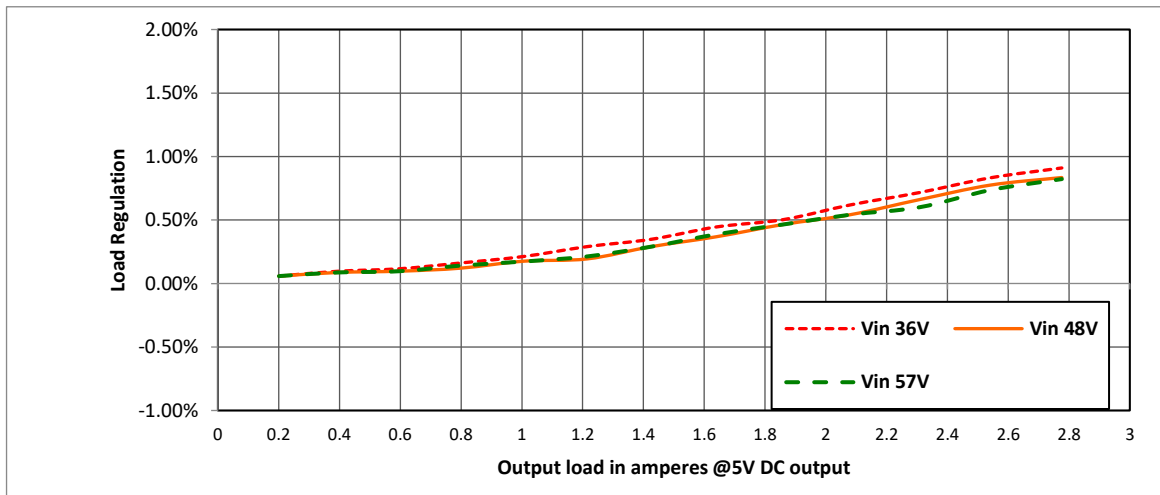
Figure 12- PEM1412 Efficiency vs. Output Load end to end

**LOAD REGULATION v/s OUTPUT LOAD**

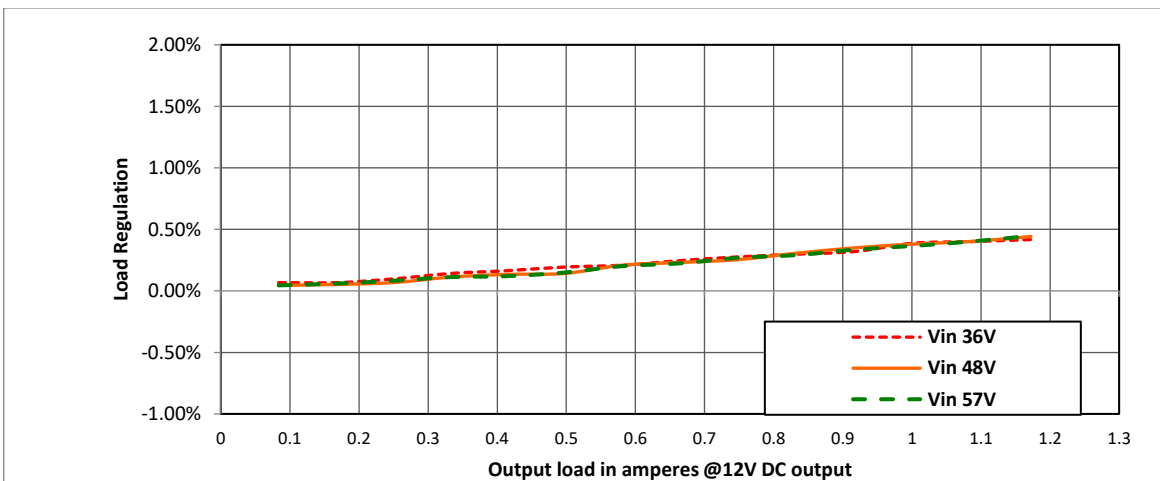
(indicative values from one of our data)



**Figure 13- PEM1403 Load Regulation vs. Output Load end to end**



**Figure14- PEM1405 Load Regulation vs. Output Load end to end**



**Figure 15- PEM1412 Load Regulation vs. Output Load end to end**

**LINE REGULATION**

(indicative values from one of our data)

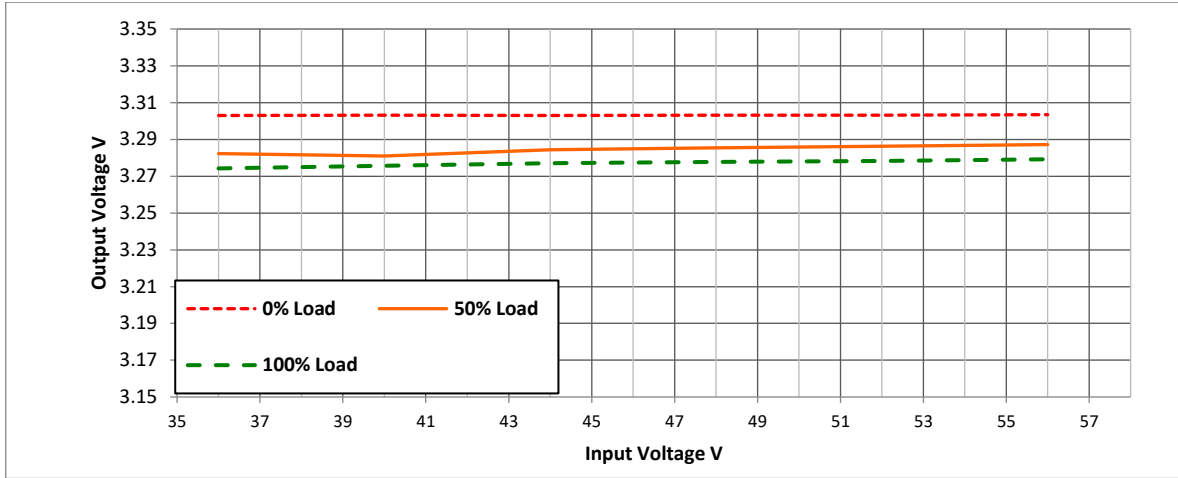


Figure 16- PEM1403 Line Regulation end to end

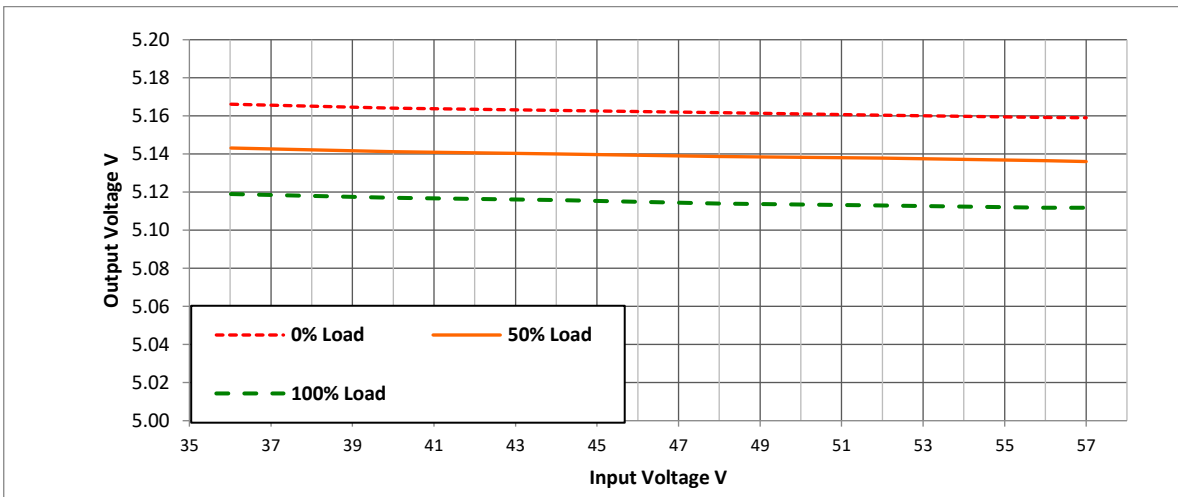


Figure 17- PEM1405 Line Regulation end to end

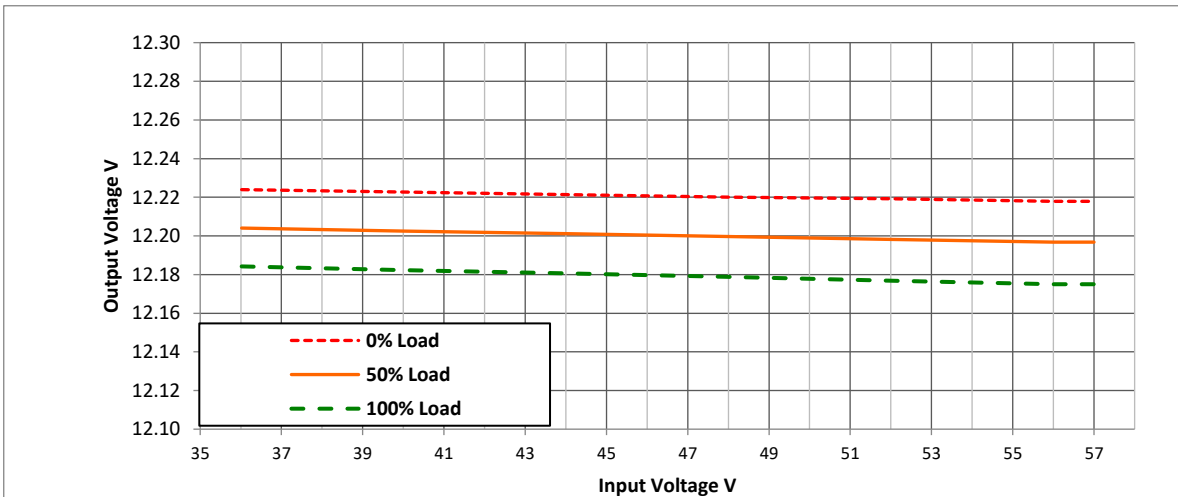
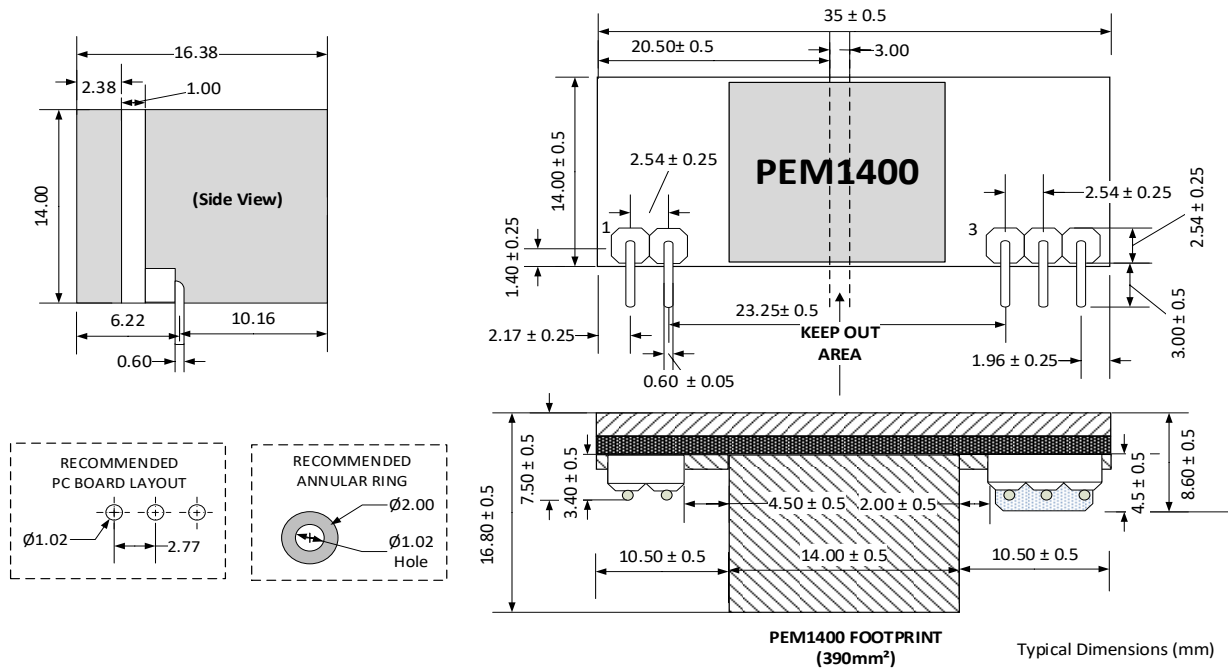


Figure 18- PEM1412 Line Regulation end to end

**PHYSICAL PACKAGE**



**Figure 19- Mechanical Dimensions**

**APPLICATION NOTES**

Power Over Ethernet (PoE) is a technology for wired Ethernet, the most widely installed local area network technology in use today. PoE allows the electrical power necessary for the operation of each end-device to be carried by data cables along with the data, rather than by separate power cords. Thus, it minimizes the number of wires used to install the network, resulting in lower cost, less downtime, easier maintenance and greater installation flexibility.

The IEEE standard governing PoE is IEEE802.3af. Compliance with this standard ensures inter-operability between devices.

The PEM1400 series modules offering a modular solution, incorporating full IEEE802.3af compatibility signature to the PSE and isolated on-board DC/DC converter. The PEM1400 series are ideal modular system blocks allowing manufacturers of Ethernet equipment to “PoE enable” their equipment with minimal effort and cost. The PEM1400 modules series offer simple and quicker product development, maximising return on investment.

PEM1400 can be powered using a user designed power supply which has adequate thermal and over-current protection. It is strongly recommended that only IEEE802.3af compliant power supply equipment be used to prevent damage to the module, which lacks output stage thermal protection.

**ESD AND SURGE PROTECTION**

It is required that the system designer must provide ESD and surge protection such as a TVS diode, like SMAJ58A (Uni-Directional) or SMAJ58CA (bi-directional), at the PEM1400 input to prevent damage from over-voltage surges and for system EMC / ESD compliance.

**ROHS, REACH and CONFLICT MINERALS COMPLIANCE**

ROHS, REACH, and Conflict Minerals compliance details are available on our website.

## REVISION HISTORY

REVISION NUMBER	DESCRIPTION
21GR1-1	<ul style="list-style-type: none"> <li>▪ Image of the Product changed</li> <li>▪ PRODUCT OVERVIEW and PRODUCT FEATURES updated</li> <li>▪ Clerical and aesthetic changes</li> <li>▪ Mechanical dimensions updated</li> <li>▪ Revision History added to Data sheet template</li> </ul>
24JR1	<ul style="list-style-type: none"> <li>▪ Updated OUTPUT CONNECTION diagram</li> </ul>
24LR1	<ul style="list-style-type: none"> <li>▪ Updated IEEE802.3 POWER LEVELS AND CLASSES</li> </ul>
25AR4	<ul style="list-style-type: none"> <li>▪ Updated Dimension of keep out area</li> </ul>
25CR5	<ul style="list-style-type: none"> <li>▪ Update in PHYSICAL PACKAGE</li> </ul>
25DR6	<ul style="list-style-type: none"> <li>▪ Update in TYPICAL INPUT CONNECTIONS</li> </ul>

## IEEE802.3 POWER LEVELS AND CLASSES

### IEEE 802.3 Power levels and Classifications for POE Powered Devices

IEEE Standard	Common Name	PD Class	PD / PSE Type	Max num. of events	PD Power <sup>1</sup>	PSE Power <sup>2</sup>	Wire pairs energised	AUC <sup>3</sup>
802.3af	POE	0	1	-	12.95W	15.4W	2	No Support
802.3af	POE	1	1	1	3.84W	4W	2	No Support
802.3af	POE	2	1	1	6.49W	7W	2	No Support
802.3af	POE	3	1	1	12.95W	15.4W	2	No Support
802.3at	POE+	4	2	2	25.5W	30W	2	No Support
802.3bt	POE++	5	3	4	38.25W	45W	4	Optional
802.3bt	POE++	6	3	4	51W	60W	4	Optional
802.3bt	POE+++	7	4	5	62W	75W	4	Optional
802.3bt	POE+++	8	4	5	71.3W	90W	4	Optional

<sup>1</sup> Min. power delivered to PD / Module input. Max. PD / module output depends on operating conditions

<sup>2</sup> Power delivered from the Power Sourcing Equipment (PSE) (switch or injector) at its output port

<sup>3</sup> Auto Class is supported. It is optional to enable or not.

[www.poweredethernet.com](http://www.poweredethernet.com). E.&O.E.

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