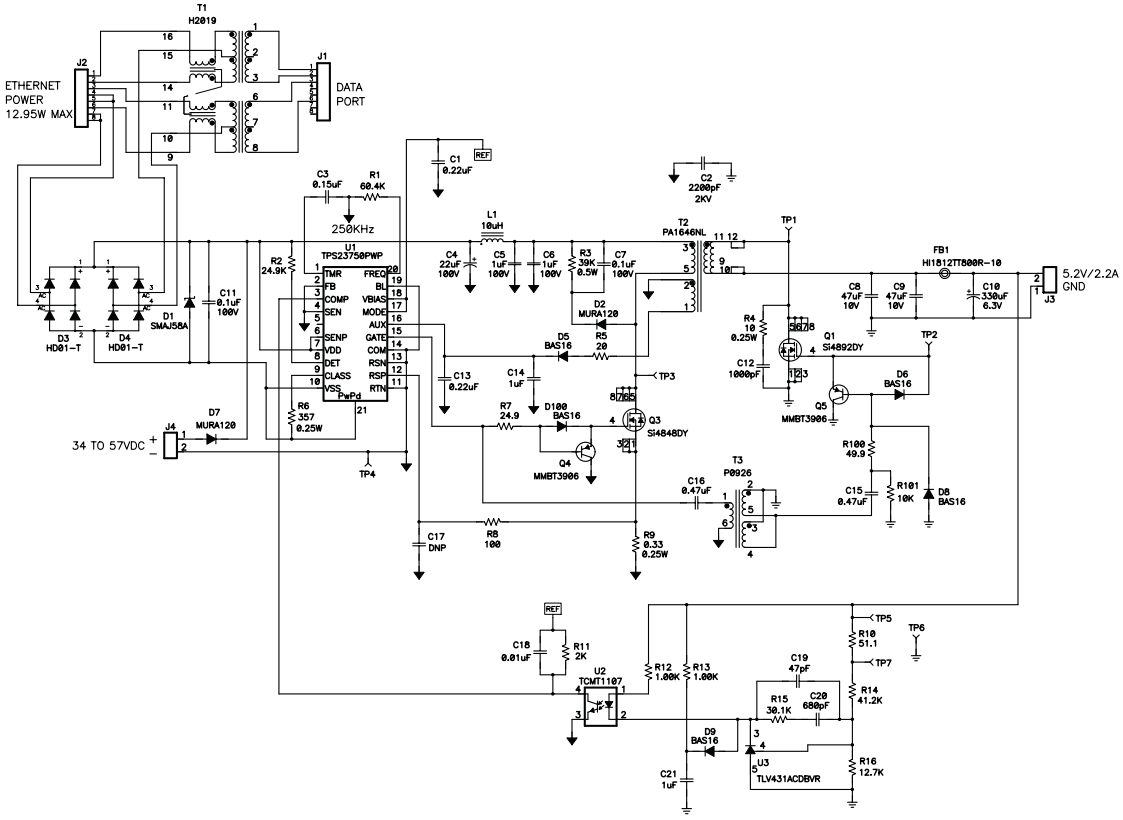
TPS23750 High Efficiency 5V at 2.2A PoE PD

PMP1564 is a high-efficiency, isolated, synchronous flyback Power-over-Ethernet PD power-supply reference design that eases implementation of PoE in devices such as IP phones, WLAN APs and security cameras. The reference design uses a TPS23750 PoE Powered Device Controller with integrated current-mode DC/DC controller. The TPS23750 implements all necessary detection, classification, inrush-current limiting and UVLO functions necessary to comply with the IEEE802.3af Power-over-Ethernet standard. The 48-V PoE input is converted to 5 V at 2.2 A. The design is optimized for 90% efficiency in the smallest board area possible.



1 Efficiency

The efficiency with a 48-V input is given below for the flyback converter (V_{IN} measured on cathode of D7 and for the total system power (J2). V_{OUT} is measured at TP5/TP6.

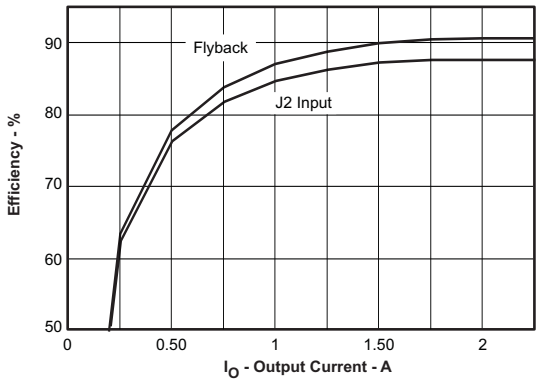


Figure 1.

2 Output Ripple and Noise

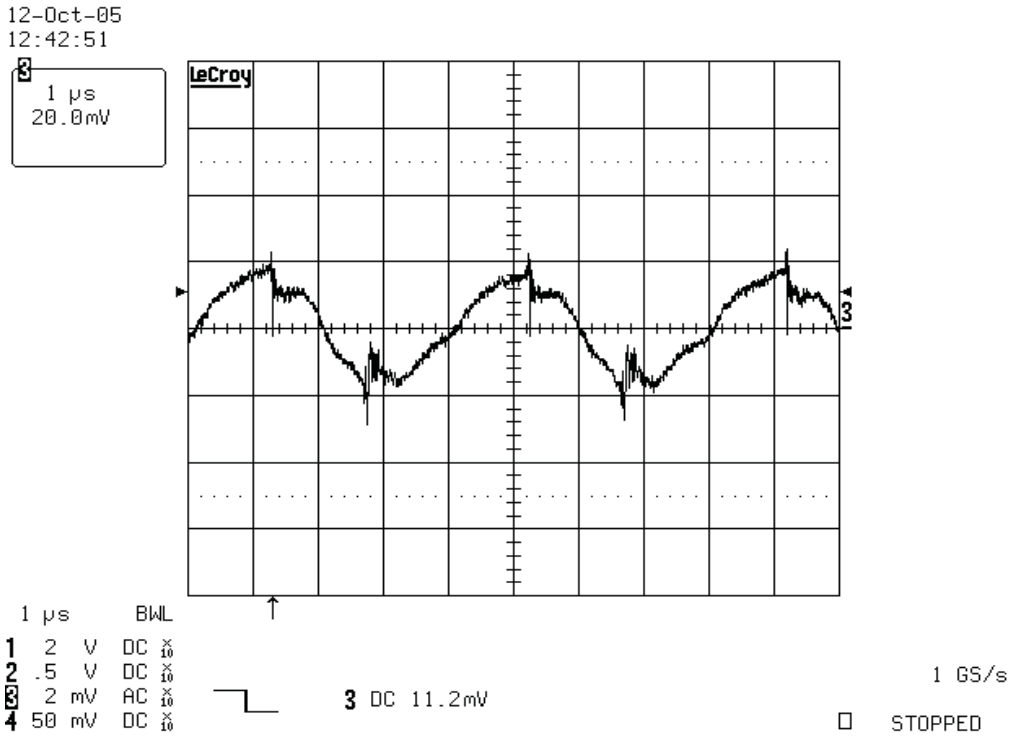


Figure 2. Output Voltage Ripple With 48V Input and 5.2V/2A Load

3 Input Ripple and Noise

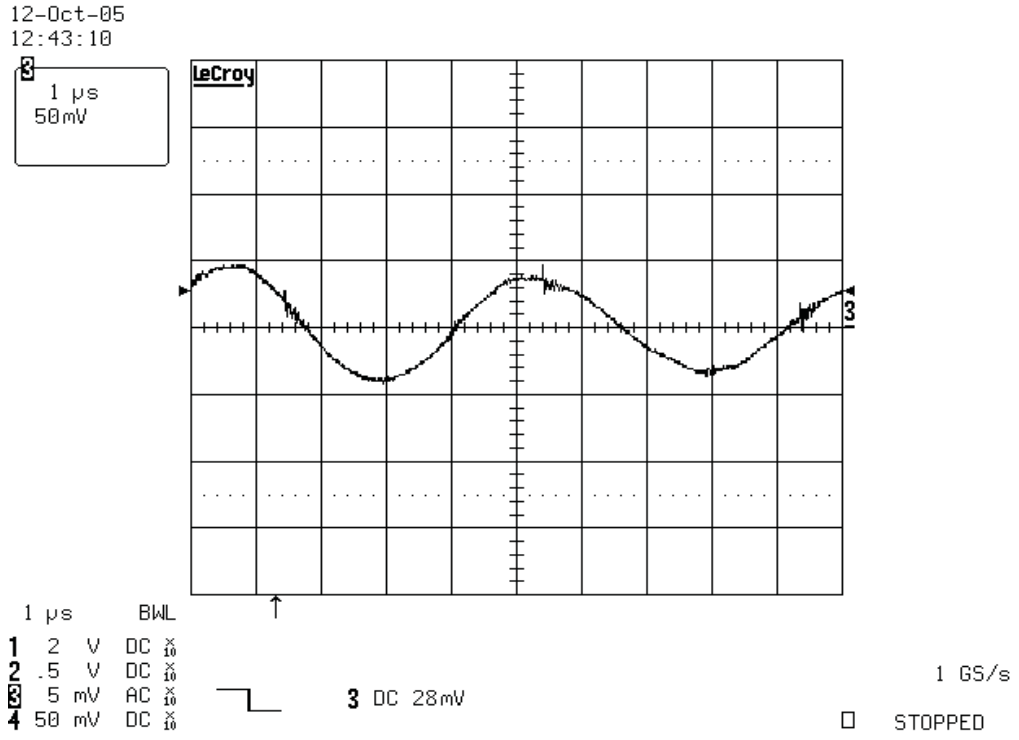


Figure 3. Input Voltage Ripple and Noise Measured at J4 With 48V Input and Max Load on Output

4 Dynamic Loading

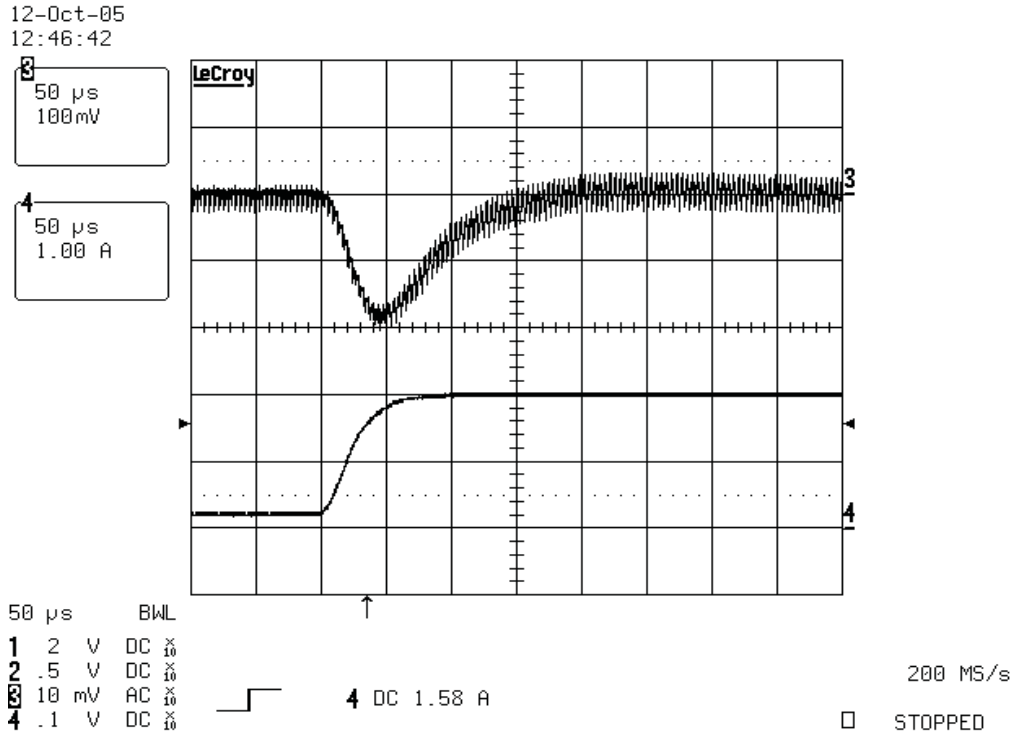


Figure 4. The Output Voltage Transient Response With a Load Step From 10% to 90%

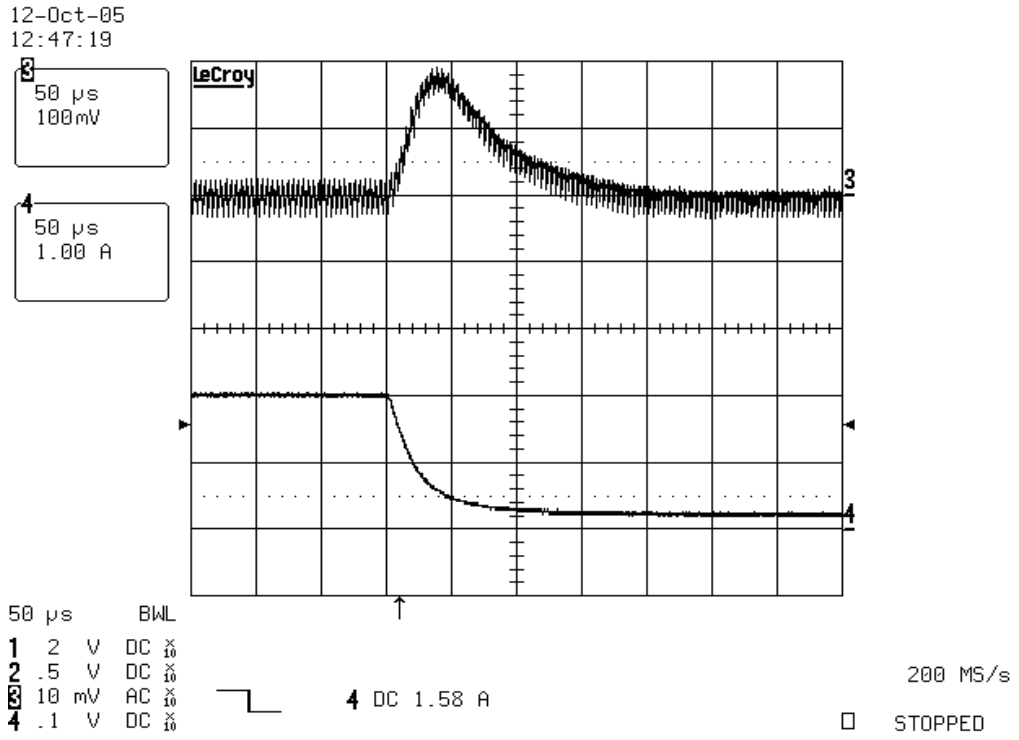


Figure 5. The Output Voltage Transient Response With a Load Step From 90% to 10%

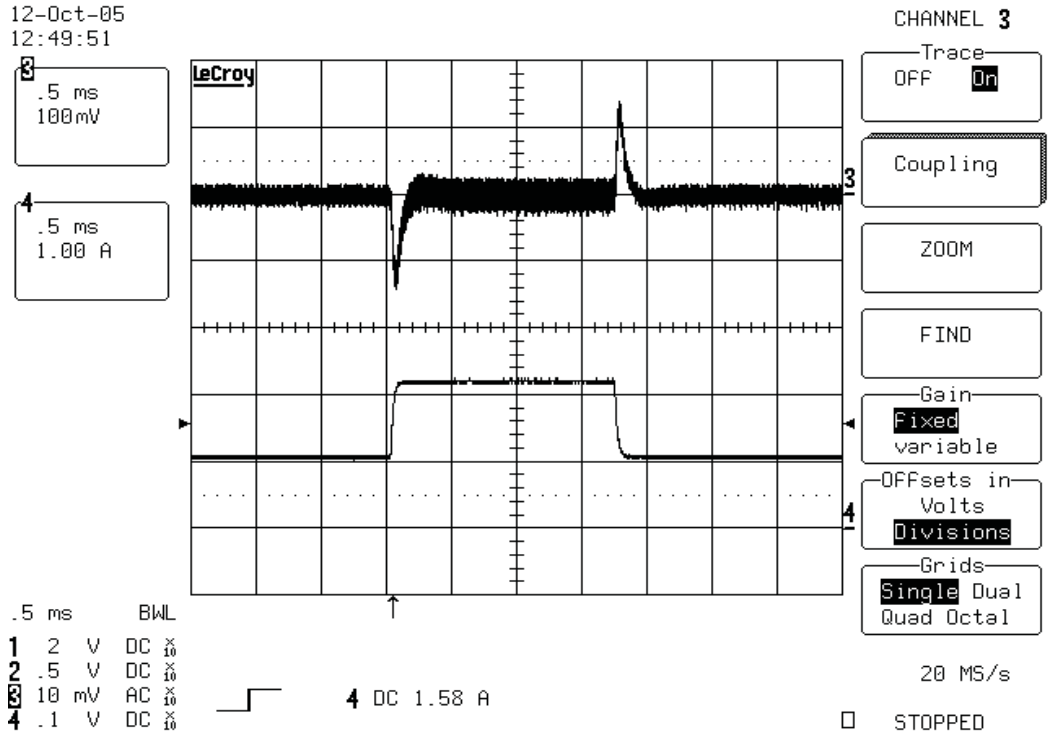


Figure 6. The Output Voltage Transient Response With a Load Step From 50% to 100%

5 Turn On Response

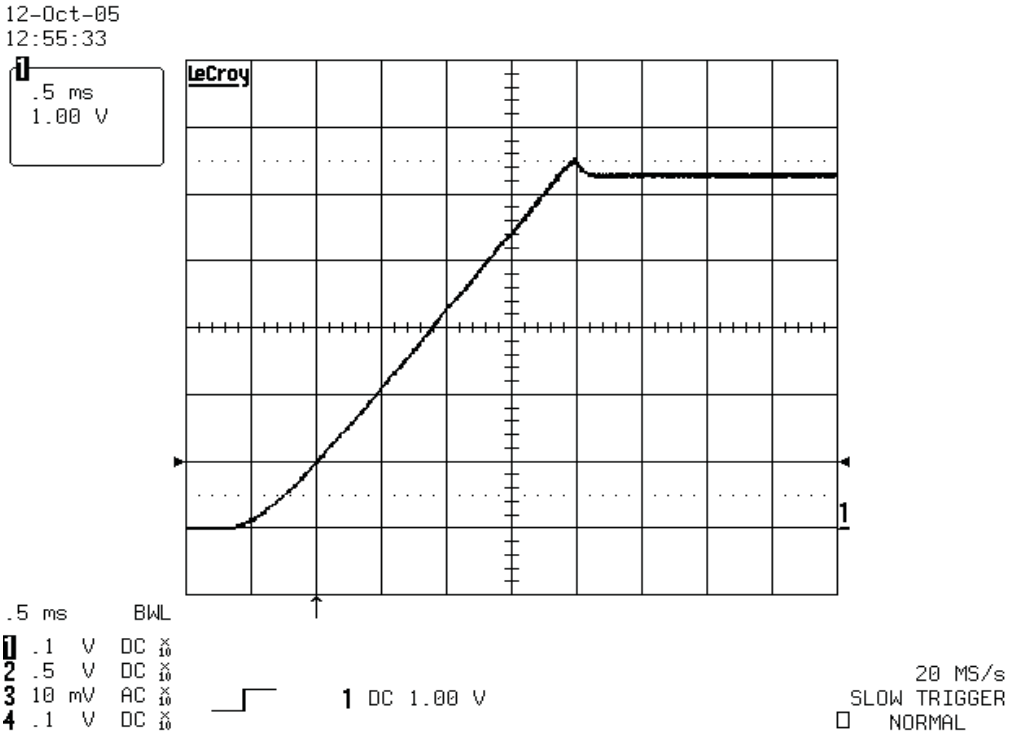


Figure 7. The Output Voltage Turn-On Response With a 48V Input and a 2A Load

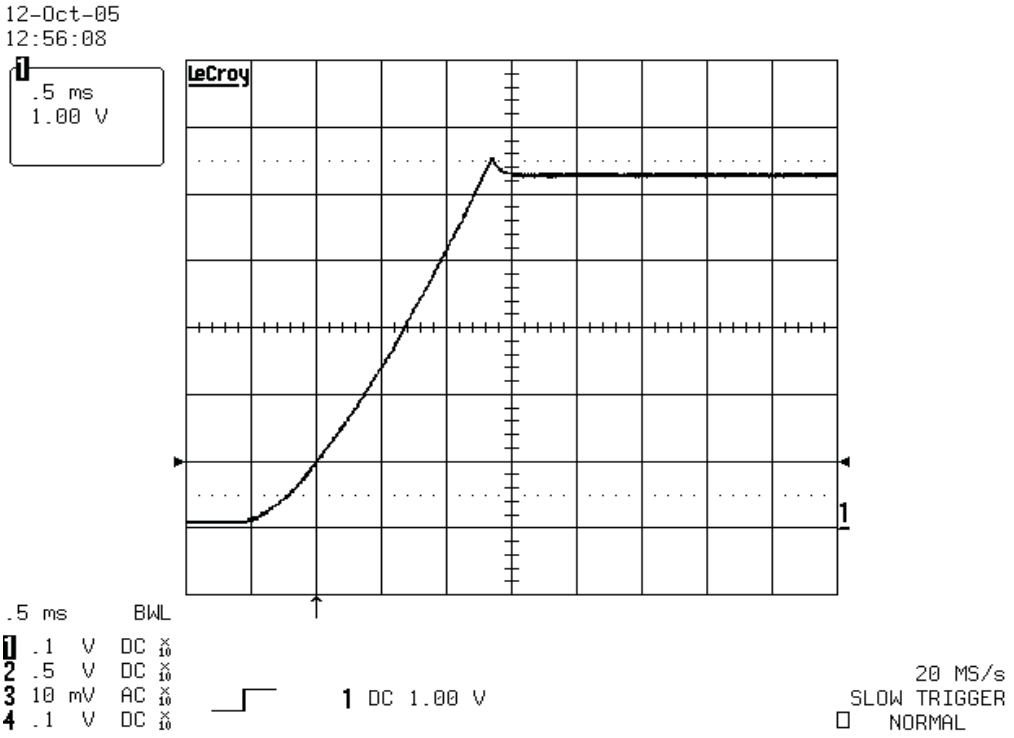


Figure 8. The Output Voltage Turn-On Response With a 48V Input and a 0A Load

6 Stability Analysis (Loop Gain)

The figure below is the flyback-converter loop gain with a 48-V input and a 2-A load. The bandwidth is 3 kHz, the phase margin is 65°, and the gain margin is 18dB.

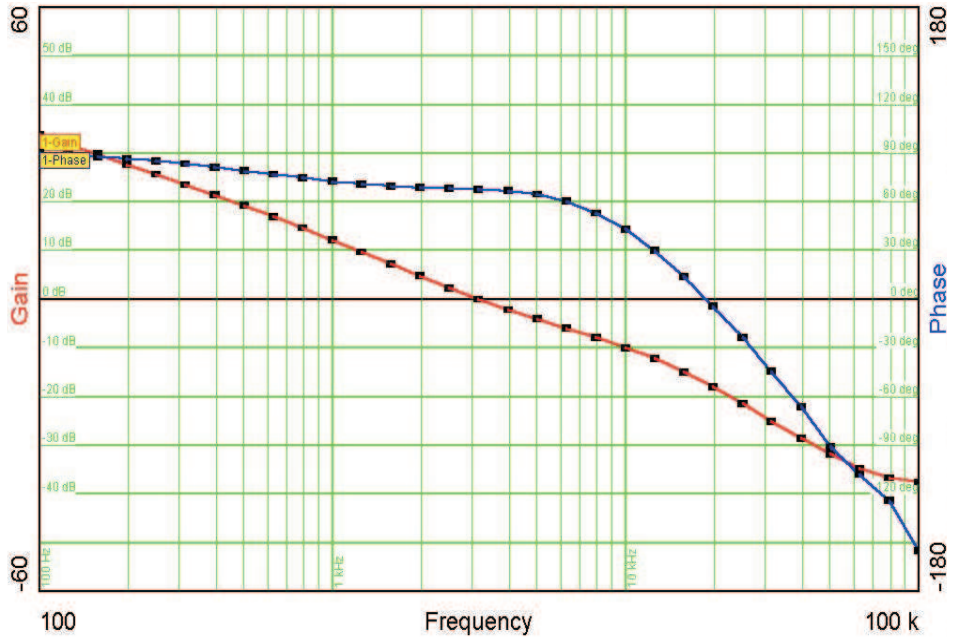


Figure 9. Loop Gain of the Flyback Converter With 48-V Input and 2-A Load

The TPS23750 characteristics makes it an attractive choice for delivering maximum power to the load.

Table 1. TPS23750 Competitive Advantages

Parameter	IEEE 802.3af	TI(1)	Competitor 1(1)	Competitor 2(1)	Units
PSE Outupt Voltage Minimum voltage	44	44	44	44	V
Current Limit min	0.35(2)	0.405	0.325	0.300	A
Available PD Power at input connector	12.9	14.5	12.1	11.4	W
Loss Before PD		14.2	11.9	11.1	W
Minus PD Loss Current (3) Rdson		13.8	11.2	10.5	W
89% Converter Efficiency Power to Load		12.2	10.1	9.4	W

(1) at min current limit and max Rdson
(2) PSE Output Current Maximum current
(3) Adding min current limit + max Rdson + max converter efficiency gives TI and edge over competitiont
See also: Estimating available application power for Power-over-Ethernet applications
http://focus.ti.com/lit/an/slyt085/slyt085.pdf Adding min current limit + max Rdson + max converter efficiency gives TI and edge over competition.

Table 2. PMP1564_Rev A Bill of Materials

Count	RefDes	Value	Description	Size	Part No.	MFR
1	C19	47 pF	Capacitor, Ceramic, 50V, C0G, 5%	603	Std	Std
1	C20	680 pF	Capacitor, Ceramic, 50V, X7R, 10%	603	Std	Std
1	C12	1000 pF	Capacitor, Ceramic, 50V, C0G, 5%	603	Std	Std
1	C18	0.01 µF	Capacitor, Ceramic, 0.01 µF, 50V, X7R, 10%	603	Std	Std
1	C3	0.15 µF	Capacitor, Ceramic, 16V, X7R, 10%	603	Std	Std
2	C1, C13	0.22 µF	Capacitor, Ceramic, 16V, X7R, 10%	603	Std	Std
2	C15, C16	0.47 µF	Capacitor, Ceramic, 16V, X7R, 10%	603	Std	Std
0	C17		DNP	603		
2	C7, C11	0.1 µF	Capacitor, Ceramic, 100V, X7R, 10%	805	C2012X7R2A104K	TDK
2	C14, C21	1 µF	Capacitor, Ceramic, 16V, X7R, 10%	805	Std	Std
2	C5, C6	1 µF	Capacitor, Ceramic, 1 µF, 100V, X7R, 10%	1210	C3225X7R2A105K	TDK
2	C8, C9	47 µF	Capacitor, Ceramic, 10V, X5R, 20%	1210	C3225X5R1A476M	TDK
1	C2	2200 pF	Capacitor, Ceramic, 2KV, X7R, 10%	1812	C4532X7R3D222K	TDK
1	C10	330 µF	Capacitor, Aluminum, 6.3V, 20%	8 × 6,2 mm	EEVFK0J331P	Panasonic
1	C4	22 µF	Capacitor, Aluminum, 100V, 20%	8 × 10,2 mm	EEVFK2A220P	Panasonic
1	D1		Diode, TVS, 58-V, 1W	SMA	SMAJ58A	Diodes Inc.
2	D2, D7		Diode, Rectifier, 1A, 200V	SMA	MURA120	On Semi
2	D3, D4		Bridge Rectifier, 100V, 0.8A	MINI DIP4	HD01-T	Diodes, Inc
5	D5, D6 D8, D9, D100		Diode, Switching, 200mA, 75V, 225 mW	SOT-23	BAS16LT1	On Semi
2	J1, J2		Connector, Jack, Modular, 8 POS	0.705 × 0.820	520252	AMP
2	J3, J4		Terminal Block, 2-pin, 6-A, 3,5 mm	0.27 × 0.25		ED1514
1	L1	10 µH	Inductor, SMT, 1.1A, 130 mΩ	4,45 x 6,6 mm	P0770.103	Pulse
1	FB1		Ferrite Bead, 6A	1812	HI1812T800R	Steward
1	Q1		MOSFET, N-ch, 30V, 12.4A, 12 mΩ	SO8	Si4892DY	Vishay
2	Q2, Q4		Bipolar, PNP, 40V, 200mA, 225 mW	SOT23	MMBT3906LT1	On Semi
1	Q3		MOSFET, N-ch, 150V, 3.7A, 85 mΩ	SO-8	Si4848DY	Vishay
1	R5	20	Resistor, Chip, 1/16W, 5%	603	Std	Std
1	R7	24.9	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R100	49.9	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R10	51.1	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R8	100	Resistor, Chip, 1/16W, 1%	603	Std	Std
2	R12, R13	1.00K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R11	2K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R101	10K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R16	12.7K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R2	24.9K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R15	30.1K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R14	41.2K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R1	60.4K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R9	0.33	Resistor, Chip, 1/4W, 5%	1206	Std	Std
1	R4	10	Resistor, Chip, 1/4W, 5%	1206	Std	Std
1	R6	357	Resistor, Chip, 1/4W, 1%	1206	Std	Std
1	R3	39K	Resistor, Chip, 1/2W, 5%	2010	Std	Std
1	T1		Xfmr, Center-tapped, Voice Over IP	0.500 × 0.370	H2019	Pulse
1	T2		XFMR, Flyback EFD15-SMD	0.875 × 0.675	PA1646NL	Pulse

Table 2. PMP1564_Rev A Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part No.	MFR
1	T3		Transformer, Driver, 330uH, 1500V isolation	0.210 × 0.210	P0926	Pulse
5	TP1–TP3, TP5, TP7		Test Point, Red, Thru Hole Color Keyed	0.100 × 0.100	5000	Keystone
2	TP4, TP6		Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100	5001	Keystone
1	U2		IC, Photocoupler, 3750VRMS, 80-160% CTR	MF4	TCMT1107	Vishay
1	U3		IC, Shunt Regulator, 6V, 10mA, 1%	SOT23-5	TLV431ACDBVR	TI
1	U1		IC, IEEE 802.3af Integrated Primary Side Controller	PWP20	TPS23750PWP	TI

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