TPS23756EVM

This user's guide describes the TPS23756 evaluation module (TPS23756EVM). The TPS23756EVM contains evaluation and reference circuitry for the TPS23756. The TPS23756 integrates a powered-device (PD) controller and power-supply controller targeted at high-power, wide input range, isolated converter topologies. The TPS23756 is compliant with the IEEE 802.3at Power over Ethernet (PoE) standard.

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1 Description

The TPS23756EVM allows reference circuitry evaluation of the TPS23756. It contains input and output power connectors and an array of onboard test points for circuit evaluation.

1.1 Features

- High-power PD and DC-DC converter controllers
  - IEEE 802.3at-compliant PD controller with adapter preference support
  - Converter controller supports high-efficiency, isolated converter topologies
- Wide-input voltage range DC-DC converter
  - Active clamp forward converter design using self-driven synchronous rectifiers
  - End-to-end efficiency at full load: 89% (12 V), 91% (24 V), 88% (48 V), 85% (PoE)
  - Converter efficiency at full load: 91% (12 V), 91% (24 V), 88% (PoE or 48 V)
  - 5-V, 5-A output (25 W) over a 10- to 57-V input voltage range
- Operates from PoE or external adapters
  - Integrated 1000base-T RJ-45 jack including transformer and cable terminations
  - Operates from 12-V, 24-V, and 48-V wall adapters
  - Onboard, “efficient diode” (replaces standard adapter diode) circuit when operating from 12-V adapters
  - Selection of option 1 (PD input using PPD pin) or option 2 (converter input using APD pin) adapter input power using jumpers
  - Selection of PPD1 or PPD2 mode using jumpers
  - Supports option 2 adapter input with either PoE or adapter preference
  - Onboard “smooth handoff” circuit for 48-V adapter using PoE as a hot backup

1.2 Applications

- Voice over Internet Protocol – IP telephones
- Wireless LAN – Wireless Access Points
- Security – Wired IP cameras

2 Electrical Specifications

Table 1. TPS23756EVM Electrical and Performance Specifications

PARAMETER	CONDITION		MIN	TYP	MAX	UNITS
POWER INTERFACE						
Input voltage	Applied to the power pins of connectors J4 or J7		0	–	57	V
Operating voltage	After start-up		30	–	57	V
Input UVLO	Rising input voltage		–	–	36	V
	Falling input voltage		30	–	–	V
Detection voltage	At device terminals		1.6	–	10	V
Classification voltage	At device terminals		100	–	23	V
Classification current	Rclass = 63.4 Ω		38	–	42	mA
Inrush current-limit			100	–	180	mA
Operating current-limit			850	–	1100	mA
DC/DC CONVERTER						
Output voltage	10.5 V ≤ Vin ≤ 57 V, ILOAD ≤ ILOAD (max)	5-V output	4.75	5.00	5.25	V
Output current	10.5 V ≤ Vin ≤ 57 V	5-V output	–	–	5	A
Output ripple voltage, peak-to-peak	Vin = 44 V, ILOAD = 5 A	5-V output	–	50	–	mV
Efficiency, end-to-end	Vin = 44 V, ILOAD = 5 A	5-V output	–	85%	–	
Switching frequency			225	–	275	kHz

3 Schematic

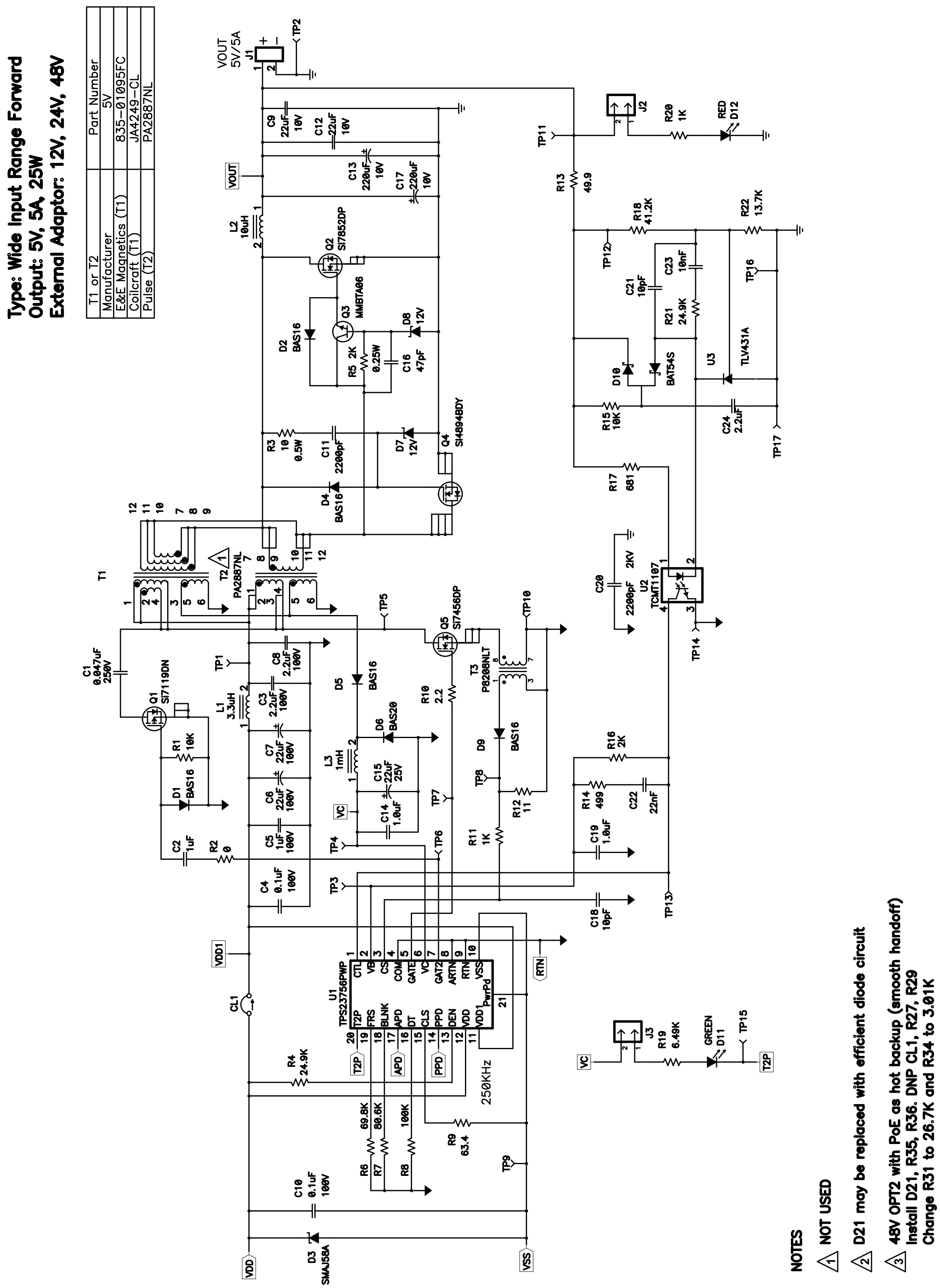

Figure 1. TPS23756EVM Schematic (DC-DC Converter)

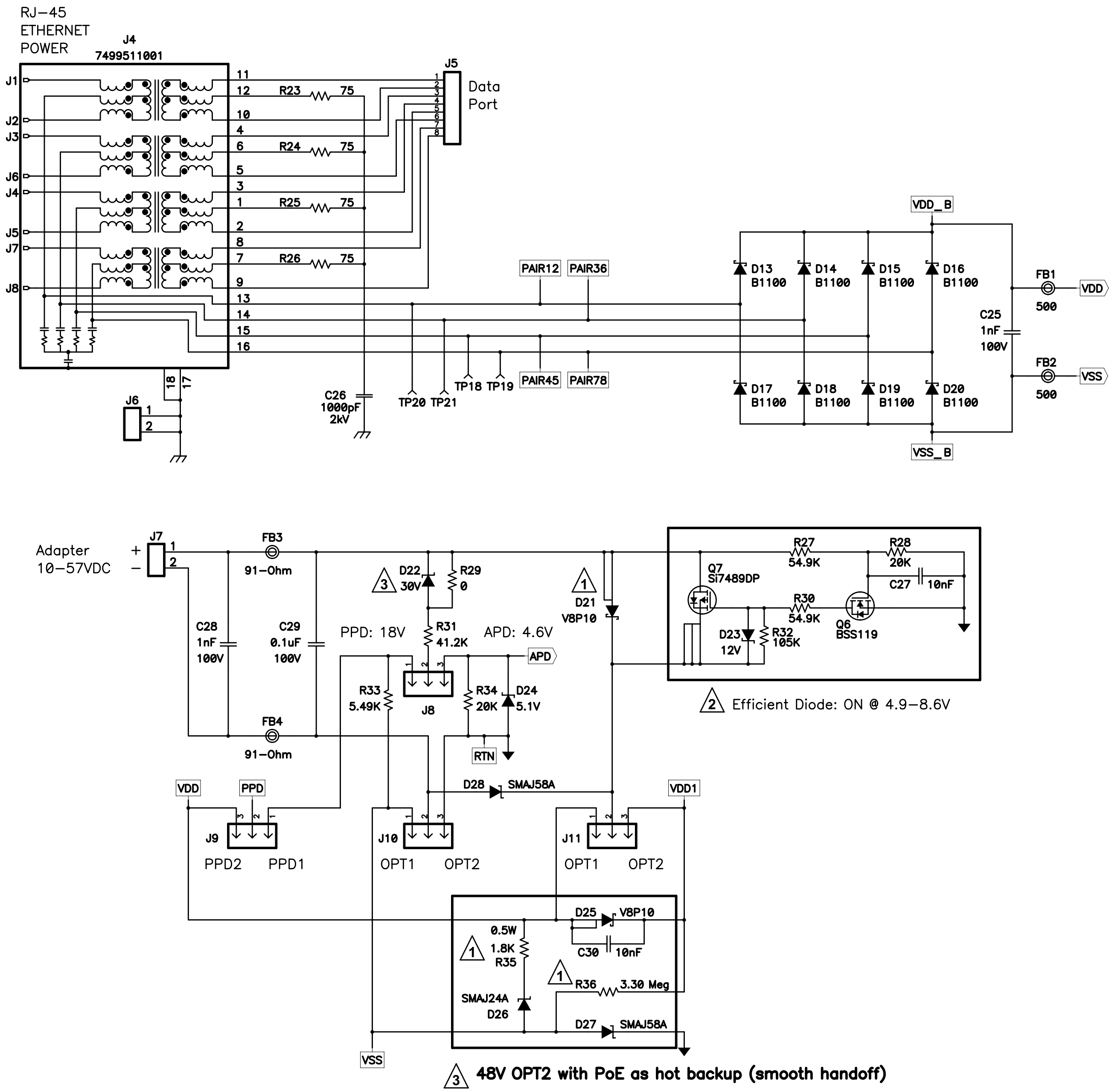

Figure 2. TPS23756EVM Schematic (PoE and Adapter Input Terminals)

4 General Configuration and Description

4.1 Physical Access

Table 2 lists the TPS23756EVM connector functionality and Table 3 describes the test point availability.

Table 2. Connector Functionality

Connector	Label	Description
J7	ADAPTER	External adapter input. J10 (low side) and J11 (high side) can select whether the adapter is at the PD controller input (VDD to VSS) or at the converter input (VDD1 to RTN). J8 is used to select PPD or APD function. J9 along with J8 set to PPD can select the PPD1 or PPD2 function.
J1	VOUT	Output voltage connector.
J4	DATA + PoE POWER	Ethernet power input connector. Contains Ethernet transformer and cable terminations
J5	DATA PORT	Ethernet data port connector
J6	EGND	Earth GND connection

Table 3. Test Points

Test Point	Color	Label	Description
TP2, TP16, TP17	BLK	GND	Secondary-side (output) grounds (GND)
TP4	RED	VC	DC/DC converter bias supply
TP5	ORG	DRAIN	Drain terminal of the primary-side switching MOSFET
TP9	BLK	VSS	POE input, low side
TP10, TP14	BLK	RTN	DC/DC converter return
TP12	ORG	LOOP	Can be used with TP11 for overall feedback loop measurements.
TP11	RED	VOUT	DC/DC converter output voltage.
TP13	WHT	CTL	Control loop input to the pulse width modulator
TP8	WHT	RCS	DC/DC converter primary-side switching MOSFET current sense (before external slope comp resistor).
TP3	RED	VB	Bias voltage regulator
TP7	WHT	GATE	Gate drive for the primary-side switching MOSFET
TP6	WHT	GAT2	Gate drive for the primary-side active clamp MOSFET
TP1	RED	PVDD1	Transformer primary high side.
TP15	WHT	T2P	Type 2 PSE output from TPS23756
TP19	RED	P78	Pair 7, 8
TP20	ORG	P12	Pair 1, 2
TP18	ORG	P45	Pair 4, 5
TP21	RED	P36	Pair 3, 6
D11	GRN	T2P	Type 2 PSE indicator. Remove the shunt on J3 to inhibit the T2P indicator.
D12	RED	POWER ON	Output power indicator. Remove the shunt on J2 to inhibit the output power indicator.
CL1	NA	CL1	CL1 provides a connection between VDD and VDD1, shorting out D25. Removing the short at CL1 allows certain power source priority schemes to be evaluated.

5 Test Setup

Figure 3 shows a typical test setup for TPS23756EVM. Input voltage can be applied as described in Table 2.

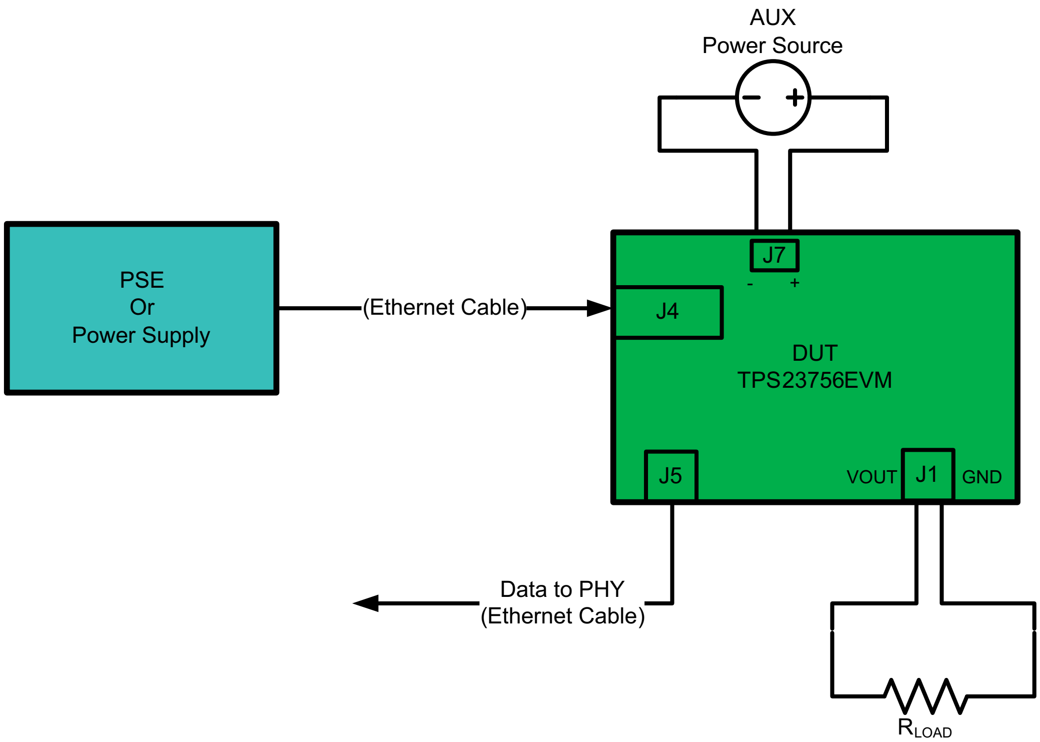

Figure 3. Typical TPS23756EVM Test Setup

6 TPS23756EVM Typical Performance Data

6.1 5-V DC/DC Efficiency

Figure 4, Figure 5, and Figure 6 highlight the TPS23756EVM efficiency over input voltage. Nsupply is measured from TP1/TP10 to J1-1/2; Nadapter is measured from J7-1/2 to J1-1/2; and PoE is measured from J4 input to J1-1/2.

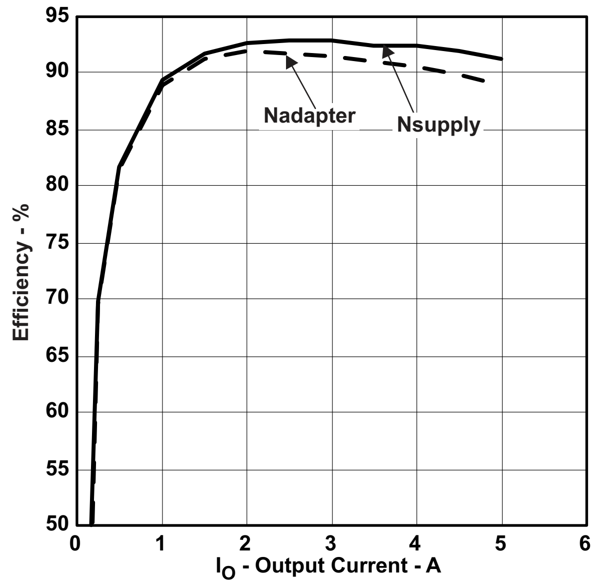

Figure 4. TPS23756EVM Efficiency With 12-V Input

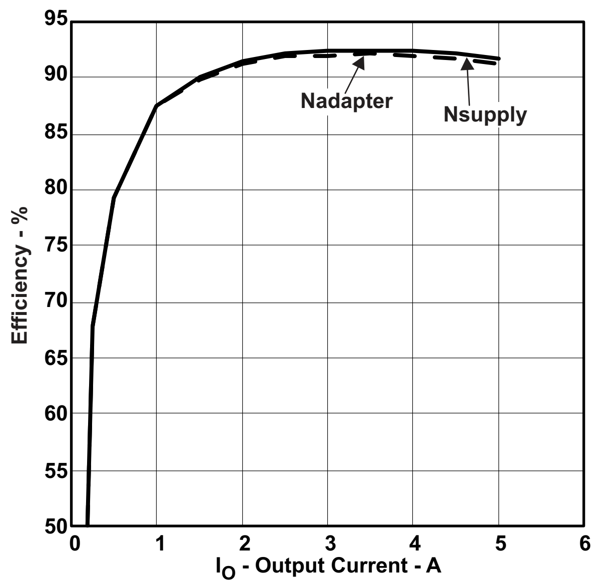

Figure 5. TPS23756EVM Efficiency With 24-V Input

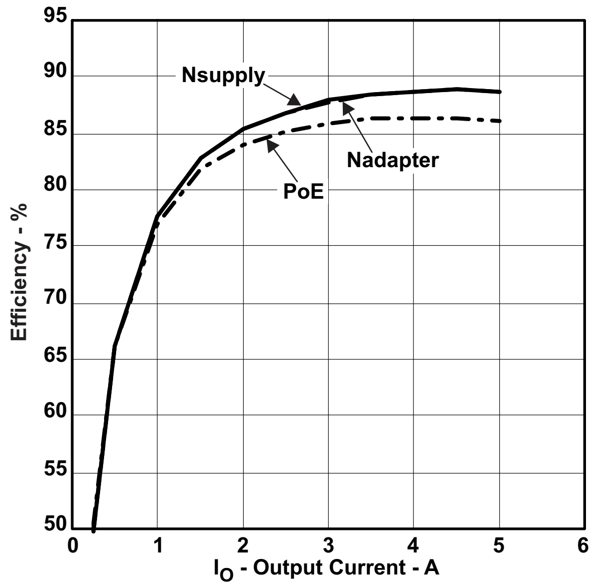

Figure 6. TPS23756EVM Efficiency With 48-V Input

6.2 TPS23756EVM Conducted Emissions

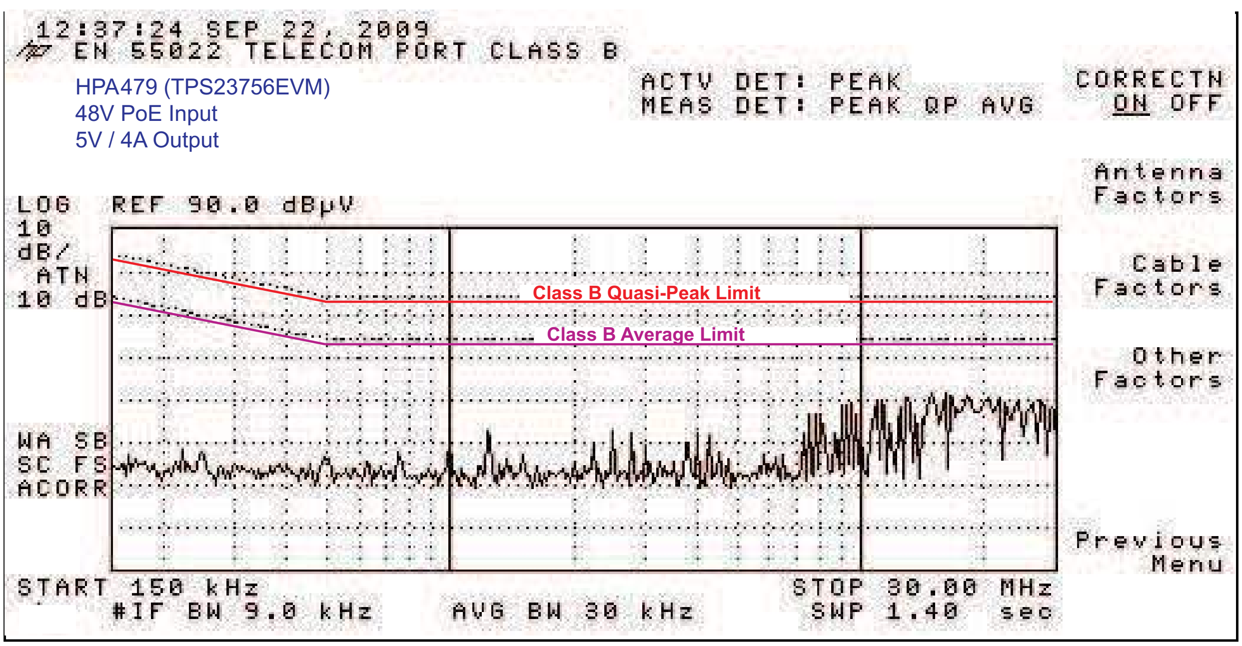

Figure 7. TPS23756EVM Conducted Emissions

7 EVM Assembly Drawings and Layout Guidelines

7.1 PCB Drawings

The following figures shows component placement and layout.

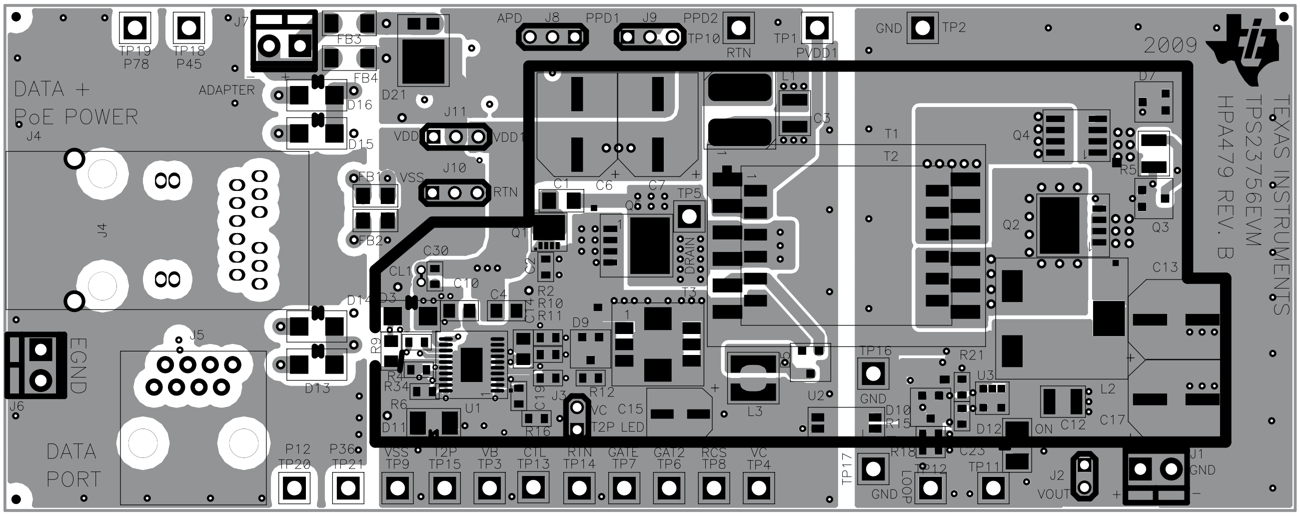

Figure 8. Top-Side Layout/Routing

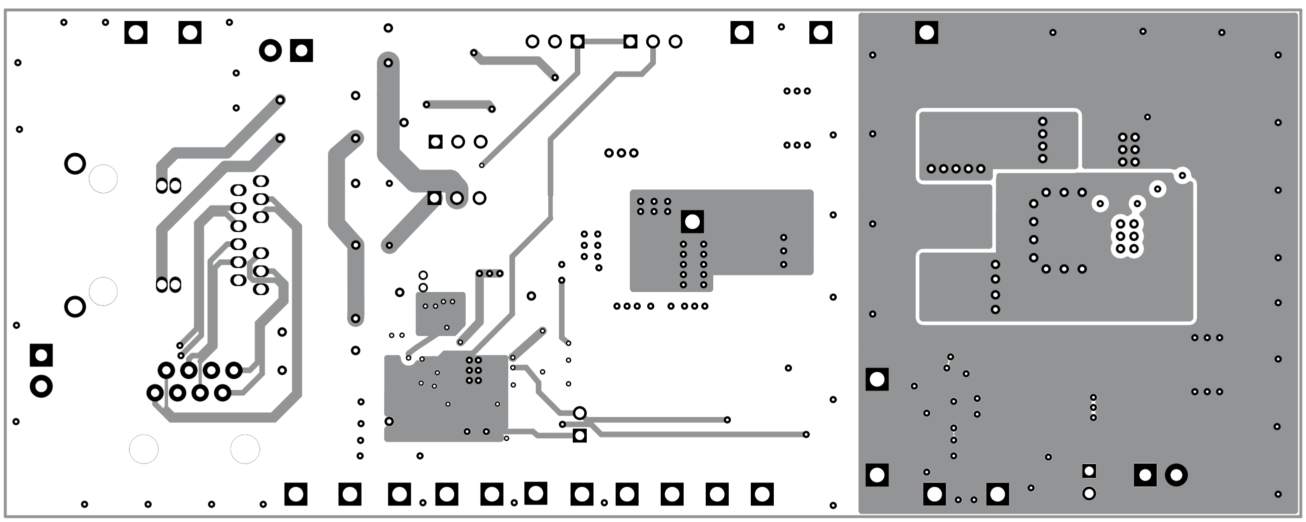

Figure 9. Layer-Two Routing

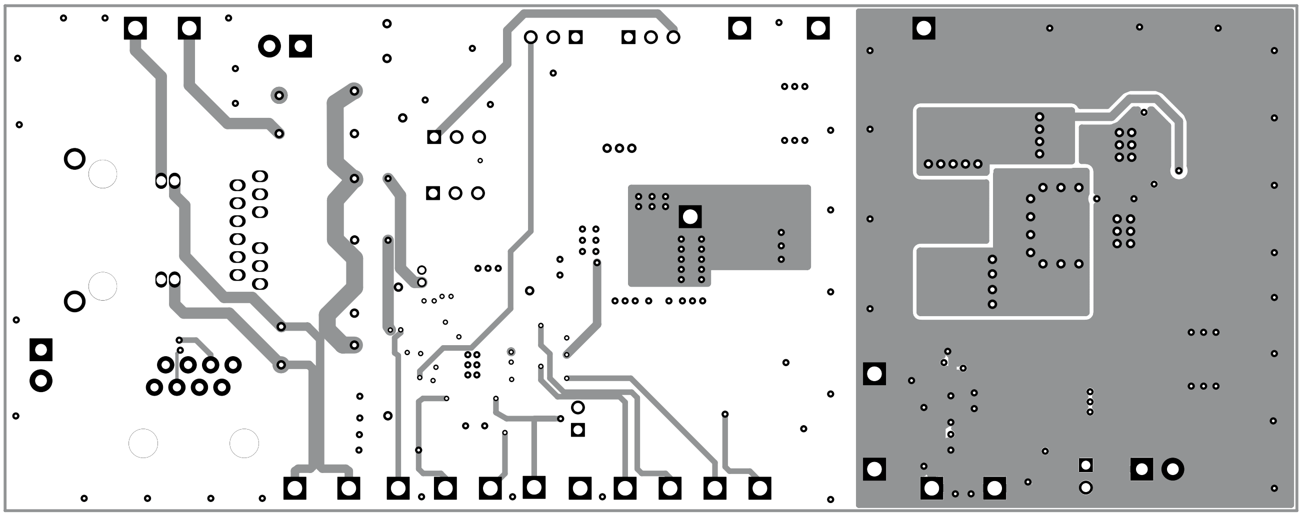

Figure 10. Layer-Three Routing

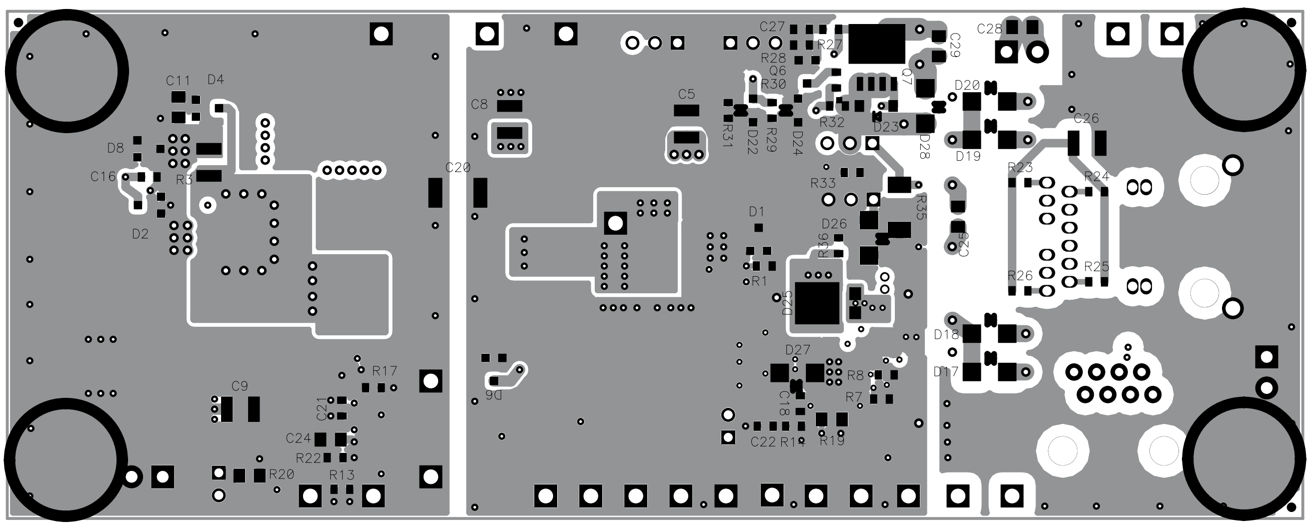

Figure 11. Bottom-Side Placement/Routing

7.2 Layout Guidelines

The layout of the PoE front end must follow power and EMI/ESD best practice guidelines. A basic set of recommendations include:

- Parts placement must be driven by power flow in a point-to-point manner; RJ-45, Ethernet transformer, diode bridges, TVS and 0.1-µF capacitor, and TPS23756 converter input bulk capacitor.
- All leads must be as short as possible with wide power traces and paired signal and return.
- There must not be any crossovers of signals from one part of the flow to another.
- Spacing consistent with safety standards like IEC60950 must be observed between the 48-V input voltage rails and between the input and an isolated converter output.
- The TPS23756 must be located over split, local ground planes referenced to VSS for the PoE input and to RTN for the converter. Whereas the PoE side may operate without a ground plane, the converter side must have one. Logic ground and power layers must not be present under the Ethernet input or the converter primary side.
- Large copper fills and traces must be used on SMT power-dissipating devices, and wide traces or overlay copper fills must be used in the power path.

The DC/DC converter layout can benefit from basic rules such as:

- Pair signals to reduce emissions and noise, especially the paths that carry high-current pulses which include the power semiconductors and magnetics.
- Minimize trace length of high-current, power semiconductors and magnetic components.
- Where possible, use vertical pairing.
- Use the ground plane for the switching currents carefully.
- Keep the high-current and high-voltage switching away from low-level sensing circuits including those outside the power supply.
- Pay special attention to spacing around the high-voltage sections of the converter.

7.3 EMI Containment

- Use compact loops for dv/dt and di/dt circuit paths (power loops and gate drives).
- Use minimal, yet thermally adequate, copper areas for heat sinking of components tied to switching nodes (minimize exposed radiating surface).
- Use copper ground planes (possible stitching) and top layer copper floods (surround circuitry with ground floods).
- Use four-layer PCB if economically feasible (for better grounding).
- Minimize the amount of copper area associated with input traces (to minimize radiated pickup).
- Hide copper associated with switching nodes under shielded magnetics where possible.
- Heat sink the “quiet side” of components instead of the “switching side” where possible (like the output side of inductor).
- Use Bob Smith terminations, Bob Smith EFT capacitor, and Bob Smith plane.
- Use Bob Smith plane as ground shield on input side of PCB (creating a phantom or literal earth ground).
- Use LC filter at DC/DC input.
- Dampen high-frequency ringing on all switching nodes if present (allow for possible snubbers).
- Control rise times with gate drive resistors and possibly snubbers.
- Switching frequency considerations
- Use of EMI bridge capacitor across isolation boundary (isolated topologies)
- Observe the polarity dot on inductors (embed noisy end).
- Use of ferrite beads on input (allow for possible use of beads or 0-Ω resistors)
- Maintain physical separation between input-related circuitry and power circuitry (use ferrite beads as boundary line).
- Balance efficiency vs acceptable noise margin
- Possible use of common-mode inductors
- Possible use of integrated RJ-45 jacks (shielded with internal transformer and Bob Smith terminations)
- End-product enclosure considerations (shielding)

8 Bill of Materials

Table 4. TPS23756EVM Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	0.047uF	Capacitor, Ceramic, 250V, X7R, 10%	1206	Std	Std
1	C11	2200pF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
2	C13, C17	220uF	Capacitor, Aluminum, 10V, 20%	0.328 x 0.354 inch	EEV-FK1A221P	Panasonic
1	C14	1.0uF	Capacitor, Ceramic, 25V, X7R, 10%	0805	Std	Std
1	C15	22uF	Capacitor, Aluminum, 25V, 20%	5x5.8mm	EEVFK1E220R	Panasonic
1	C16	47pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
1	C18	10pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C19	1.0uF	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
1	C2	1uF	Capacitor, Ceramic, 16V, X7R, 20%	0603	C1608X7R1C105M	TDK
1	C20	2200pF	Capacitor, Ceramic, 2KV, X7R, 10%	1812	C4532X7R3D222K	TDK
1	C21	10pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
1	C22	22nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C23	10nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C24	2.2uF	Capacitor, Ceramic, 16V, X7R, 10%	0805	Std	Std
2	C25, C28	1nF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	C26	1000pF	Capacitor, Ceramic, 2kV, X7R, 10%	1210	Std	TDK
2	C27, C30	10nF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
2	C3, C8	2.2uF	Capacitor, Ceramic, 100V, X7R, 10%	1210	Std	Std
3	C4, C10, C29	0.1uF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	C5	1uF	Capacitor, Ceramic, 100V, X7R, 10%	1210	Std	Std
2	C6, C7	22uF	Capacitor, Aluminum, 100V, ±20%	8x10.2mm	EEVFK2A220P	Panasonic
2	C9, C12	22uF	Capacitor, Ceramic, 10-V, X7R, 10%	1210	GRM32ER71A226KE20L	Murata
1	CL1	AWG 24	Wire, 24AWG, Solid, non-insulated, 0.30 inches	0.300 X AWG 24	NA	NA
5	D1, D2, D4, D5, D9	BAS16	Diode, Switching, 75V, 200mA	SOT23	BAS16LT1	Vishay-Liteon
1	D10	BAT54S	Diode, Dual Schottky, 200-mA, 30-V	SOT23	BAT54S	Zetex
1	D11	GREEN	Diode, LED, GRN, 2.0-V, 650-mcd, SM	1210	LTST-C930KGKT	LITE-ON INC
1	D12	RED	Diode, LED, RED, 2.0-V, 850-mcd, SM	1210	LTST-C930KRKT	LITE-ON INC
8	D13, D14, D15, D16, D17, D18, D19, D20	B1100	Diode, Schottky, 1A, 100V	SMA	B1100	Diodes, Inc
0	D21	V8P10	Diode, High Current, Trench MOS Barrier Schottky, 100V, 8A	TO-277A[SMPC]	V8P10	Vishay
1	D25	V8P10	Diode, High Current, Trench MOS Barrier Schottky, 100V, 8A	TO-277A[SMPC]	V8P10	Vishay
1	D22	30V	Diode, Zener, 200mW, 30V	SOD-323	BZT52C30S	Diodes Inc.
1	D23	12V	Diode, Zener, 12V, 5-mA	SOD-123	BZT52C12	Diodes Inc
1	D24	5.1V	Diode, Zener, 200mW, 5.1V	SOD-323	BZT52C5V1S	Diodes Inc.

Table 4. TPS23756EVM Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	D26	SMAJ24A	Diode, TVS, 24-V, 1W	SMA	SMAJ24A	Diodes Inc.
3	D3, D27, D28	SMAJ58A	Diode, TVS, 58-V, 1W	SMA	SMAJ58A	Diodes Inc.
1	D6	BAS20	Diode, Switching, 200-mA, 200-V, 330-mW	SOT23	BAS20	Zetex
2	D7, D8	12V	Diode, Zener, 12-V	SOT23	BZX84C12LT1	ON Semiconductor
2	FB1, FB2	500	Bead, Ferrite, 2000mA, 60 mΩ	1206	MI1206L501R-10	Steward
2	FB3, FB4	91-Ohm	Bead, SMD 3A, Low DC Resistance	1806	EXCML45A910H	Panasonic
3	J1, J6, J7	ED555/2DS	Terminal Block, 2-pin, 6-A, 3,5mm	0.27 x 0.25	ED555/2DS	OST
2	J2, J3	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	J4	7499511001	Connector, RJ45 PoE+Enabled, 1000 Base-T	0.670 x 1.300 inch	7499511001	Wuerth Electronics
1	J5	5556416-1	Connector, Jack Modular, Vertical, Pos.	0.655 x 0.615 inch	5556416-1	AMP
4	J8, J9, J10, J11	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	L1	3.3uH	Inductor, SM Toroid, 3.3A, 20-mΩ	0.287 x 0.287 inch	MSS7341-332	Coilcraft
1	L2	10uH	Inductor, SMT, 7-A, 9-mΩ	0.508 x 0.516 inch	SER1360-103KL	Coilcraft
1	L3	1mH	Inductor, SMT, 100mA, 16.3 Ω	0.169 x 0.169 inch	LPS4414-105MLC	Coilcraft
1	Q1	Si7119DN	MOSFET, Fast Switching, PChan, -200V, 3.8A, 1.05 Ω	PWRPAK 1212	Si7119DN	Vishay
1	Q2	SI7852DP	MOSFET, NChan, 80V, 12A, 16-mΩ	PWRPAK S0-8	SI7852DP	Vishay
1	Q3	MMBTA06	Bipolar, NPN, 80V, 500mA	SOT23	MMBTA06LT1	ON Semiconductor
1	Q4	SI4894BDY	MOSFET, Nch, 30V, 12A, 11mΩ	SO8	SI4894BDY	Vishay
1	Q5	Si7456DP	MOSFET, NChan, 100V, 9.3A, 25-mΩ	PWRPAK S0-8	Si7456DP	Vishay
1	Q6	BSS119	MOSFET, Nch, 100V, 0.17A, 6 Ω	SOT23	BSS119	Infineon
1	Q7	Si7489DP	MOSFET, PChan, -100V, -28A, 41mΩ	PWRPAK S0-8	Si7489DP	Vishay
2	R1, R15	10K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R10	2.2	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	1K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R12	11	Resistor, Chip, 1/10W, 1%	0603	Std	Std
1	R13	49.9	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R14	499	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R16	2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R17	681	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R18, R31	41.2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R19	6.49K	Resistor, Chip, 1/10-W, 1%	0805	Std	Std
2	R2, R29	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R20	1K	Resistor, Chip, 1/10-W, 1%	0805	Std	Std
1	R22	13.7K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R23, R24, R25, R26	75	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R27, R30	54.9K	Resistor, Chip, 1/16W, 1%	0603	Std	Std

Table 4. TPS23756EVM Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
2	R28, R34	20K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	10	Resistor, Chip, 1/2W, 5%	1210	Std	Std
1	R32	105K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R33	5.49K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R35	1.8K	Resistor, Chip, 1/2W, 1%	2010	Std	Std
0	R36	3.30 Meg	Resistor, Chip, 1/10W, 1%	0603	Std	Std
2	R4, R21	24.9K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	2K	Resistor, Chip, 1/4W, 5%	1210	Std	Std
1	R6	69.8K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R7	80.6K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R8	100K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R9	63.4	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	T1 or T2	835-01095FC/JA4249-CL or PA2887NL	Transformer, forward, 5V, 5A, 1.25:1	0.860 × 1.150 inch	835-01095FC/JA4249-CL or PA2887NL	E&E Magnetics/Coilcraft or Pulse
1	T3	P8208NLT	Transformer, 100:1, 10A, 6 mΩ DCR	0.330 × 0.360 inch	P8208NLT	Pulse
6	TP1, TP3, TP4, TP11, TP19, TP21	5010	Test Point, Red, Thru Hole	0.125 × 0.125 inch	5010	Keystone
6	TP2, TP9, TP10, TP14, TP16, TP17	5011	Test Point, Black, Thru Hole	0.125 x 0.125 inch	5011	Keystone
4	TP5, TP12, TP18, TP20	5013	Test Point, Orange, Thru Hole	0.125 × 0.125 inch	5013	Keystone
5	TP6, TP7, TP8, TP13, TP15	5012	Test Point, White, Thru Hole	0.125 × 0.125 inch	5012	Keystone
1	U1	TPS23756PWP	IC, IEEE 802.3at PoE Interface and Isolated Converter Controller	PWP20	TPS23756PWP	TI
1	U2	TCMT1107	IC, Photocoupler, 3750VRMS, 80-160% CTR	MF4	TCMT1107	Vishay
1	U3	TLV431A	IC, Shunt Regulator, 6V, 10mA, 1%	SOT23-5	TLV431ACDBVR	TI
4			Bumpons		2566	SPC
6	—		Shunt, Black	100-mil	929950-00	3M
1	—		PCB, 5.75 In x 2.25 In x 0.062 In		HPA479	Any

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Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

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FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 57 V and the output voltage range of 4 V to 6 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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IMPORTANT NOTICE