TPS23757EVM: Evaluation Module for TPS23757

This user's guide describes the TPS23757 evaluation module (TPS23757EVM). The TPS23757EVM contains evaluation and reference circuitry for the TPS23757. The TPS23757 contains a powered device (PD) and a power supply controller supporting many high-efficiency topologies. The TPS23757EVM supports the IEEE 802.3at standard for a type 1 PD (equivalent to the 13W standard of IEEE 802.3-2008) and contains a power supply controller optimized for high-efficiency converter topologies. The TPS23757EVM is targeted at 11-W, synchronous flyback converter applications.

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1 Description

The TPS23757EVM allows reference circuitry evaluation of the TPS23757. It contains input and output power connectors and an array of onboard test points for circuit evaluation.

1.1 Features

- Efficient, general market design
  - Self-driven, synchronous rectified secondary
  - 11-W output power from power-over-ethernet (POE) or from a 48-V adapter
  - Operates from either POE or external adapters (24 V, 48 V)
  - 5-V (standard) output voltage and 3.3-V (see Table 5) output voltage

    NOTE: Only the 5-V version is orderable. The 5-V version can be converted to the 3.3-V version using Figure 1 and Table 5 as a reference.

1.2 Applications

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

2 Electrical Specifications

Table 1. TPS23757EVM Electrical and Performance Specifications

Parameter	Condition		Min	Typ	Max	Unit
Power Interface						
Input Voltage	Applied to the power pins of connectors J1 or J7		0	–	57	V
Operating Voltage	After start up		30	–	57	
Input UVLO	Rising input voltage		–	–	36	
	Falling input voltage		30	–	-	
Detection voltage	At device terminals		1.6	–	10.0	
Classification voltage	At device terminals		10	–	23.0	
Classification current	Rclass = 90.9 Ω		26	–	30	mA
Inrush current-limit			100	–	180	
Operating current-limit			400	–	525	
DC/DC Converter						
Output Voltage	21.6 V ≤ Vin ≤ 57 V, ILOAD ≤ ILOAD (max)	5-V output	4.75	5.00	5.25	V
		3.3-V output	3.13	3.3	3.47	
Output Current	21.6 V ≤ Vin ≤ 57 V	5-V output	–	–	2.2	A
		3.3-V output	–	–	3.3	
Output ripple voltage, peak-to-peak	Vin = 44 V, ILOAD = 2.2 A	5-V output	–	50	–	mV
	Vin = 44 V, ILOAD = 3.3 A	3.3-V output	–	30	–	
Efficiency, end-to-end	Vin = 44 V, ILOAD = 2.2 A	5-V output	–	87%	–	
	Vin = 44 V, ILOAD = 3.3 A	3.3-V output	–	86%	–	
Switching frequency			180		220	kHz

3 Schematic

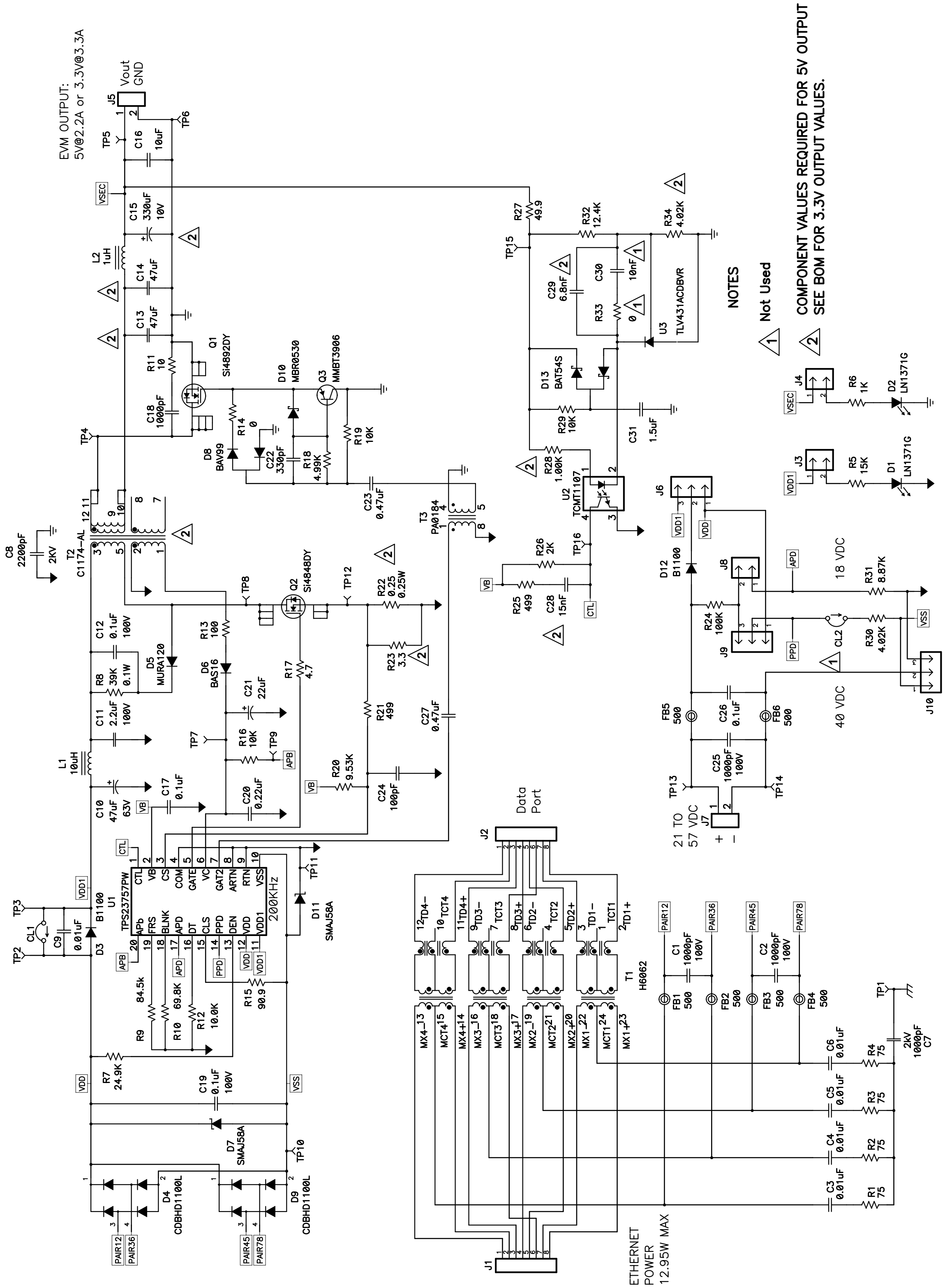

Figure 1. TPS23757EVM Schematic

4 General Configuration and Description

4.1 Physical Access

Table 2 lists the TPS23757EVM 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 J6 (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 installed to select APD function, and J9 is installed to select the PPD function. CL2 along with J9 are installed between pins 2 and 3 to configure PPD1 whereas CL2 is not installed, and J9 is installed between pins 1 and 2 to configure PPD2.
J5	VOUT	Output voltage connector
J1	Ethernet Power	Ethernet power input connector.
J2	Ethernet Data	Ethernet data port connector
TP1	Earth GND	Earth GND connection

Table 3. Test Points and Indicators

Test Point	Color	Label	Description
TP6	BLK	GND	Secondary side (output) grounds (GND)
TP7	RED	VC	DC/DC converter bias supply
TP8	ORG	DRN	Drain terminal of the primary-side switching MOSFET
TP4	ORG	SDRN	Drain terminal of the secondary-side synchronous MOSFET
TP10	BLK	VSS	POE input, low side
TP11	BLK	RTN	DC/DC converter return
TP15	ORG	LOOP	Can be used with TP5 for overall feedback loop measurements.
TP5	RED	VOUT	DC/DC converter output voltage.
TP16	WHT	CTL	Control loop input to the pulse width modulator
TP12	WHT	RCS	DC/DC converter primary-side switching MOSFET current sense
TP2	RED	VDD	PD controller high-side voltage
TP3	ORG	VDD1	DC-DC controller high-side voltage
TP13	RED	ADAPT IN	Adapter input voltage
TP14	BLK	ADAPT RTN	Adapter input voltage return
TP9	WHT	APb	Output from TPS23757 indicating whether a proper source is present at the APD or PPD pin.
TP1	WHT	Earth GND	Earth GND common termination point for chassis terminators
D1	GRN	VDD1-RTN	VDD1-RTN voltage present. Remove the shunt on J3 to inhibit the RTN indicator.
D2	GRN	VOUT-GND	Output power indicator. Remove the shunt on J4 to inhibit the output power indicator.
CL1	NA	CL1	CL1 provides a connection between VDD and VDD1 shorting out D3. Removing the short at CL1 allows certain power source priority schemes to be tested.
CL2	NA	CL2	CL2 is used with J9 to configure PPD1.

5 Test Setup

Figure 2 shows a typical test setup for TPS23757EVM. Input voltage can be applied as described in Table 2.

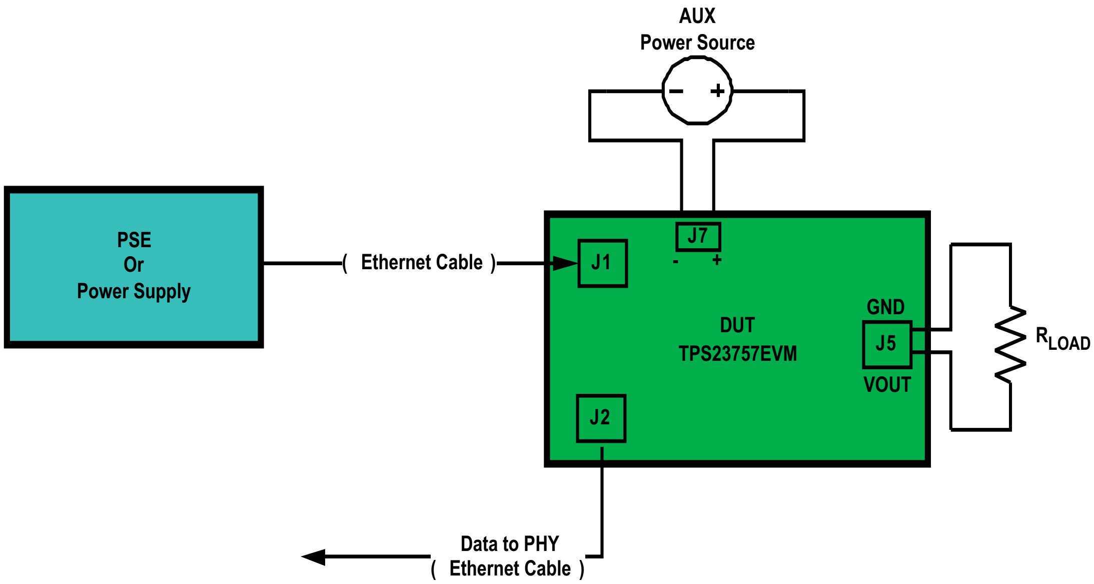

Figure 2. Typical TPS23757EVM Test Setup

6 TPS23757EVM Typical Performance Data

6.1 Efficiency

Figure 3 and Figure 4 highlights the TPS23757EVM efficiency with a 48-V input voltage source. Nsupply is measured from TP3/TP11 to J5-1/2, Nadapter is measured from J7-1/2 to J5-1/2, and PoE is measured from J1 input to J5-1/2.

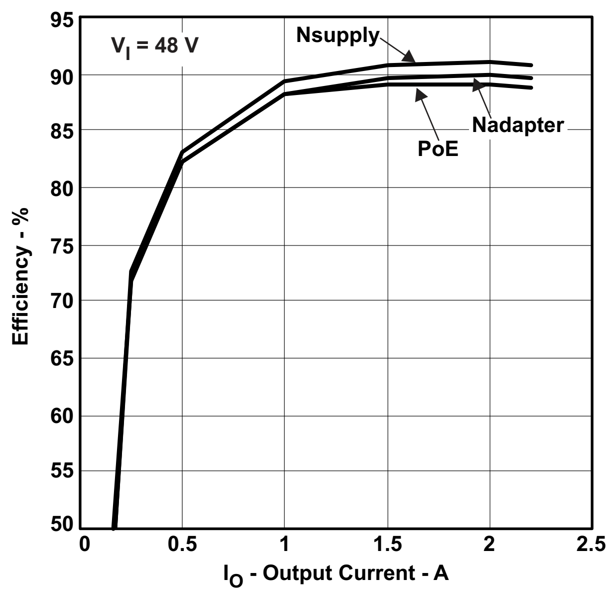

Figure 3. TPS23757EVM Efficiency With 5-V Output

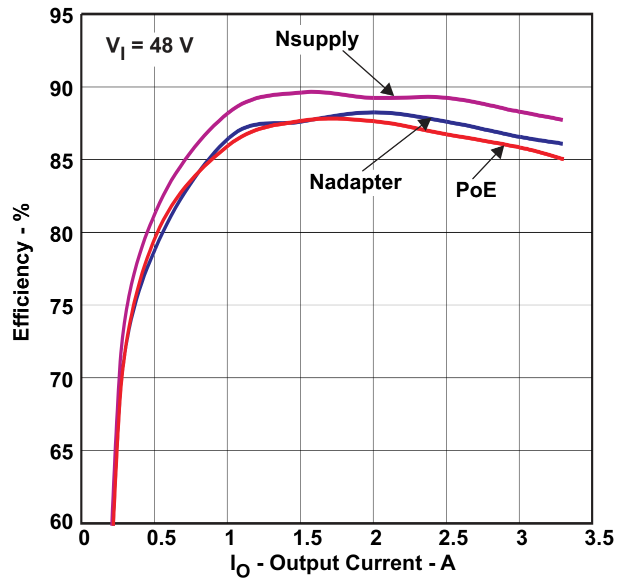

Figure 4. TPS23757EVM Efficiency With 3.3-V Output

7 EVM Assembly Drawings and Layout Guidelines

7.1 PCB Drawings

The following figures shows component placement and layout.

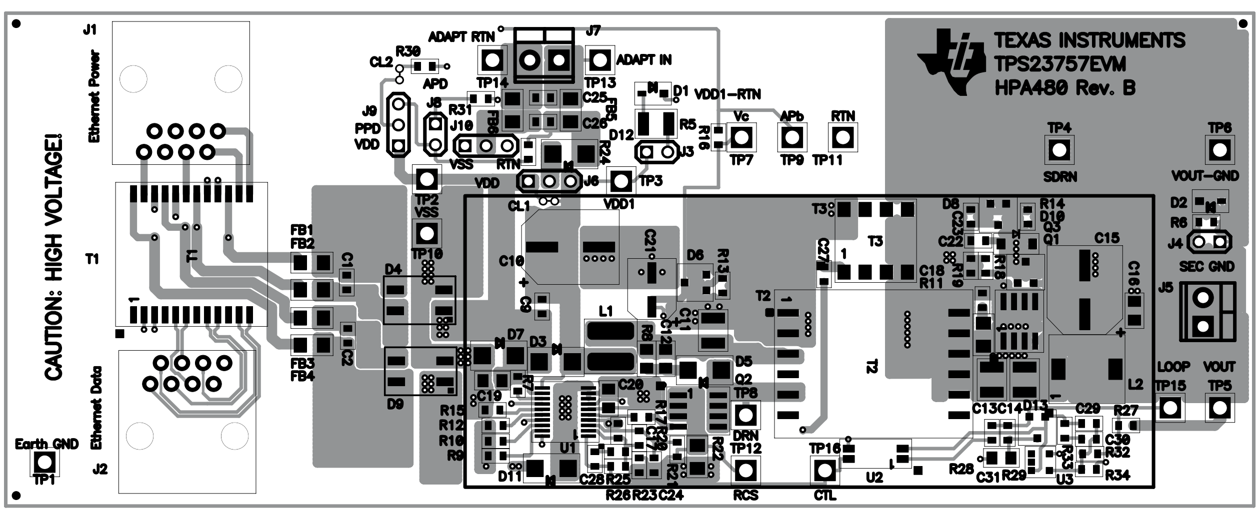

Figure 5. Top Side Layout

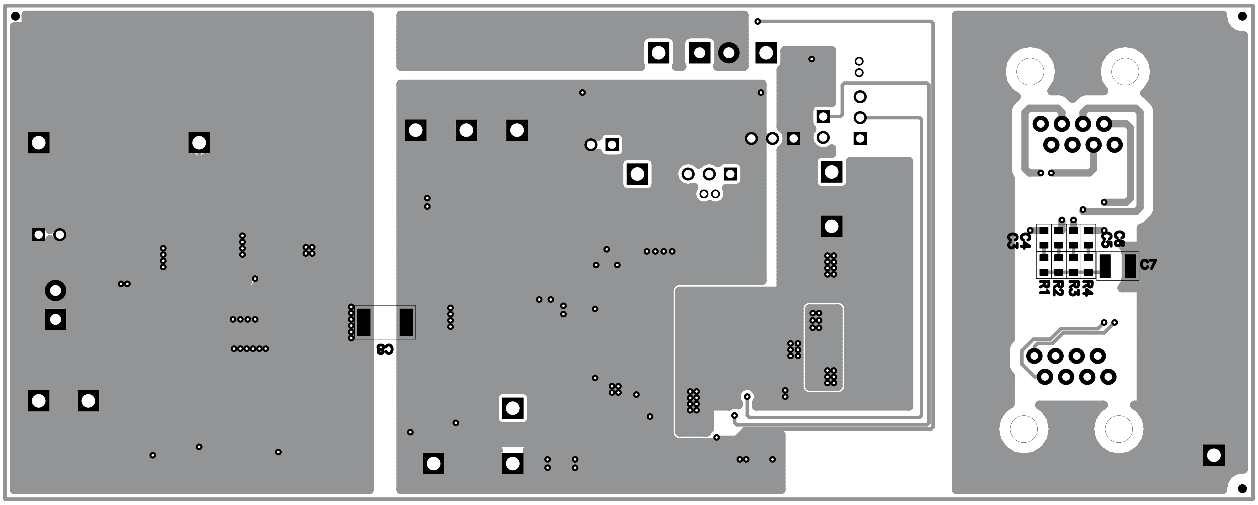

Figure 6. Bottom Side Layout

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 TPS23757 converter input bulk capacitor.
- All leads must be as short as possible with wide power traces and paired signal and return.
- Crossovers of signals from one part of the flow to another is not recommended.
- 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 TPS23757 must be located over split, local ground planes referenced to VSS for the PoE input and to RTN/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 a 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 versus 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. TPS23757EVM Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
3	C1, C2, C25	1000pF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
1	C10	47µF	Capacitor, Aluminum Electrolytic, 63V, ±20%	0.328 x 0.390 inch	EEE-FK1J470P	Panasonic
1	C11	2.µF	Capacitor, Ceramic, 100V, X7R, 10%	1210	Std	Std
2	C12, C19	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	0805	C2012X7R2A104K	TDK
2	C13, C14	47µF	Capacitor, Ceramic, 10V, X5R, 20%	1210	C3225X5R1A476M	TDK
1	C15	330µF	Capacitor, Aluminum, 6.3V, 20%	0.328 x 0.354 inch	EEV-FK0J331P	Panasonic
1	C16	10µF	Capacitor, Ceramic, 10V, X5R, 10%	0805	Std	Std
1	C17	0.1µF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C18	1000pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
1	C20	0.22µF	Capacitor, Ceramic, 16V, X7R, 10%	0805	Std	Std
1	C21	22µF	Capacitor, Aluminum, 25V, ±20%	0.201 x 0.262 inch	EEV-FK1E220R	Panasonic
1	C22	330pF	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
2	C23, C27	0.47µF	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
1	C24	100pF	Capacitor, Ceramic, 0.0µF, 50V, X7R, 10%	0603	Std	Std
1	C26	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	0603	GRM188R72A104KA35D	Murata
1	C28	15nF	Capacitor, Ceramic, 0.01µF, 50V, X7R, 10%	0603	Std	Std
1	C29	6.8nF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
4	C3–C6	0.01µF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
1	C31	1.5µF	Capacitor, Ceramic, 16V, X7R, 10%	0805	Std	Std
1	C7	1000pF	Capacitor, Ceramic, 2kV, X7R, 10%	1210	Std	Std
1	C8	2200pF	Capacitor, Ceramic, 2KV, X7R, 10%	1812	C4532X7R3D222K	TDK
1	C9	0.01µF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
1	CL1	AWG 24	Wire, 24AWG, Solid, non-insulated, 0.30 inches	0.300 x AWG 24	Std	Std
2	D1, D2	LN1371G	Diode, LED, Green, 20-mA, 0.9-mcd	0.114 x 0.049 inch	LN1371G	Panasonic
1	D10	MBR0530	Diode, Schottky, 0.5A, 30V	SOD-123	MBR0530T3	On Semi
1	D13	BAT54S	Diode, Dual Schottky, 200-mA, 30-V	SOT23	BAT54S	Zetex
2	D3, D12	B1100	Diode, Rectifier, 1A, 100V	SMA	B1100	Diodes
2	D4, D9	CDBHD1100L	Bridge Rectifier, 100V, 1A	MINI DIP4	CDBHD1100L	Comchip
1	D5	MURA120	Diode, Rectifier, 1A, 200V	SMA	MURA120	On Semi
1	D6	BAS16	Diode, Switching, 200mA, 75V, 225mW	SOT-23	BAS16LT1	On Semi
2	D7, D11	SMAJ58A	Diode, TVS, 58-V, 1W	SMA	SMAJ58A	Diodes Inc.
1	D8	BAV99	Diode, Dual Ultra Fast, Series, 200-mA, 70-V	SOT23	BAV99	Fairchild
6	FB1–FB6	500	Bead, Ferrite, 2000mA, 60m-ohm	1206	MI1206L501R-10	Steward
2	J1, J2	556416	Connector, Jack, Modular, 8 POS	0.655 x 0.615 inch	556416	AMP
3	J3, J4, J8	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
2	J5, J7	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25	ED555/2DS	OST
3	J6, J9, J10	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	L1	10µH	Inductor, SMT, 1.13A, 83-mΩ	0.200 x 0.200 inch	MSS5131-103ML	Coilcraft
1	L2	1µH	Inductor, TH High Current, High Temp, 5.39A, 9.9mΩ	0.300 sq"	DR74-1R0-R	Coiltronics
1	Q1	Si4892DY	MOSFET, N-ch, 30V, 12.4A, 12mΩ	SO8	Si4892DY	Vishay
1	Q2	Si4848DY	MOSFET, N-ch, 150V, 3.7A, 85mΩ	SO-8	Si4848DY	Vishay
1	Q3	MMBT3906	Bipolar, PNP, 40V, 200mA, 225W	SOT23	MMBT3906LT1	On Semi
4	R1–R4	75	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R10	69.8K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	10	Resistor, Chip, 1/4W, 5%	1206	Std	Std
1	R12	10.0K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	100	Resistor, Chip, 1/16W, 5%	0603	Std	Std

Table 4. TPS23757EVM Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	R14	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R15	90.9	Resistor, Chip, 1/16W,1%	0603	Std	Std
3	R16, R19, R29	10K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R17	4.7	Resistor, Chip, 1/16W, 5%	0603	Std	Std
1	R18	4.99K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R20	9.53K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R21, R25	499	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R22	0.25	Resistor, Chip, 1/4W, 5%	1206	Std	Std
1	R23	3.3	Resistor, Chip, 1/16W, 5%	0603	Std	Std
1	R24	100K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R26	2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R27	49.9	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R28	1.00K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R30, R34	4.02K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R31	8.87K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R32	12.4K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	15K	Resistor, Chip, 1/4W, 1%	1210	Std	Std
1	R6	1K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R7	24.9K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R8	39K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	R9	84.5k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	T1	H6062	XFMR, 1000 Base-T PoE, Ratio 1:1	S024	H6062NL	Pulse
1	T2	C1174-AL	Transformer, 150µH, 48V to 5V, 2A	0.875 x 0.675 inch	C1174-AL	Coilcraft
1	T3	PA0184	XFMR, SMT Gate Drive	0.355 x 0.340 inch	PA0184NLT	Pulse
5	TP1, TP6, TP10, TP11, TP14	5011	Test Point, Black, Thru Hole	0.125 x 0.125 inch	5011	Keystone
4	TP2, TP5, TP7, TP13	5010	Test Point, Red, Thru Hole	0.125 x 0.125 inch	5010	Keystone
4	TP3, TP4, TP8, TP15	5013	Test Point, Orange, Thru Hole	0.125 x 0.125 inch	5013	Keystone
3	TP9, TP12, TP16	5012	Test Point, White, Thru Hole	0.125 x 0.125 inch	5012	Keystone
1	U1	TPS23757PW	IC, C, IEEE 802.3-2005 PoE Interface and Isolated Converter Controller	PW 20	TPS23757PW	TI
1	U2	TCMT1107	IC, Photocoupler, 3750VRMS, 80-160% CTR	MF4	TCMT1107	Vishay
1	U3	TLV431ACDBVR	IC, Shunt Regulator, 6V, 10mA, 1%	SOT23-5	TLV431ACDBVR	TI
4			Bumpons, Dome, 0.44 diameter, 0.20 height, clear	0.44 x 0.20	2566	Voltrex
5	–		Shunt, Black	100-mil	929950-00	3M
1	–		PCB, 5.725 In × 2.36 In x 0.062 In		HPA480	Any

Table 5. Component Changes Required to Convert 5-V to 3.3-V Output

Change RefDes	From: (5-V Output Description)	TO: (3.3-V Output Description)
C13, C14	Capacitor, Ceramic, 47 µF, 10V, X5R, 20%	Capacitor, Ceramic, 100 µF, 10V, X5R, 20%
C15	Capacitor, Aluminum, 330 µF, 10V, 20%	Capacitor, Aluminum, 680 µF, 10V, 20%
C28	Capacitor, Ceramic, 15 nF, 50V, X7R, 10%	Capacitor, Ceramic, 47 nF, 50V, X7R, 10%
C29	Capacitor, Ceramic, 6.8 nF, 50V, X7R, 10%	Capacitor, Ceramic, 0.1 µF, 50V, X7R, 10%
R22	Resistor, Chip, 0.25 Ω, 1/4W, 5%	Resistor, Chip, 0.22 Ω, 1/4W, 5%
R23	Resistor, Chip, 3.3 Ω, 1/16W, 5%	Resistor, Chip, 10 Ω, 1/16W, 5%
R28	Resistor, Chip, 1.00 kΩ, 1/16W, 1%	Resistor, Chip, 402 Ω, 1/16W, 1%
R34	Resistor, Chip, 4.02 kΩ, 1/16W, 1%	Resistor, Chip, 7.5 kΩ, 1/16W, 1%
T2	Transformer, Coilcraft C1174-AL, 150 µH, 48V to 5V, 2A	Transformer, Coilcraft C1173-AL, 166.5 µH, 18V to 72V input, 2A

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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 2 V to 10 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.