

## **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	
<b>Power Interface</b>						
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	$R_{class} = 90.9 \Omega$	26	–	30	mA	
Inrush current-limit		100	–	180		
Operating current-limit		400	–	525		
<b>DC/DC Converter</b>						
Output Voltage	$21.6 \text{ V} \leq V_{in} \leq 57 \text{ V}$ , $I_{LOAD} \leq I_{LOAD}(\text{max})$	5-V output	4.75	5.00	5.25	V
		3.3-V output	3.13	3.3	3.47	
Output Current	$21.6 \text{ V} \leq V_{in} \leq 57 \text{ V}$	5-V output	–	–	2.2	A
		3.3-V output	–	–	3.3	
Output ripple voltage, peak-to-peak	$V_{in} = 44 \text{ V}$ , $I_{LOAD} = 2.2 \text{ A}$	5-V output	–	50	–	mV
	$V_{in} = 44 \text{ V}$ , $I_{LOAD} = 3.3 \text{ A}$	3.3-V output	–	30	–	
Efficiency, end-to-end	$V_{in} = 44 \text{ V}$ , $I_{LOAD} = 2.2 \text{ A}$	5-V output	–	87%	–	
	$V_{in} = 44 \text{ V}$ , $I_{LOAD} = 3.3 \text{ A}$	3.3-V output	–	86%	–	
Switching frequency			180		220	kHz

### 3 Schematic

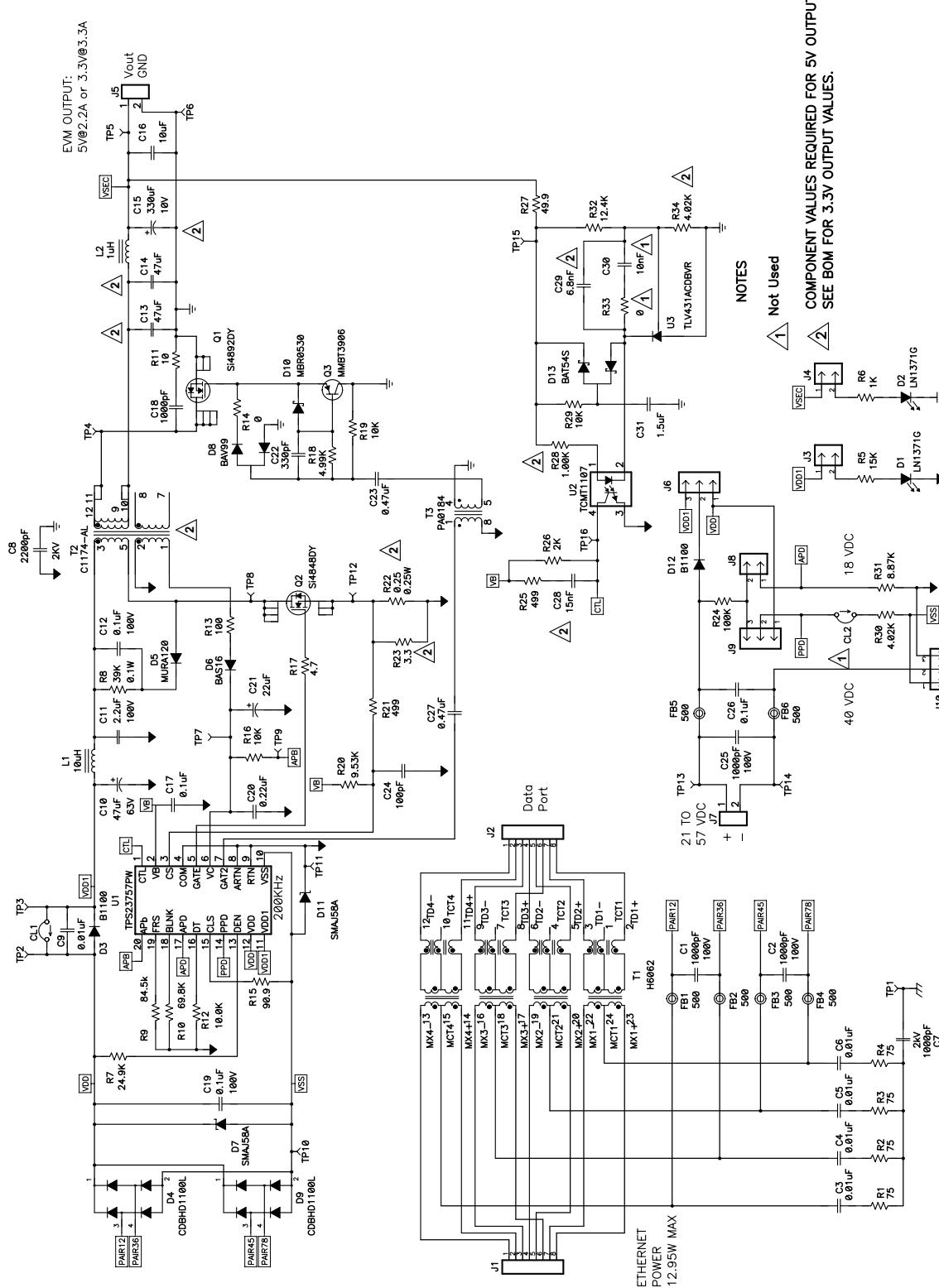


Figure 1. TPS23757EVM Schematic

## 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.

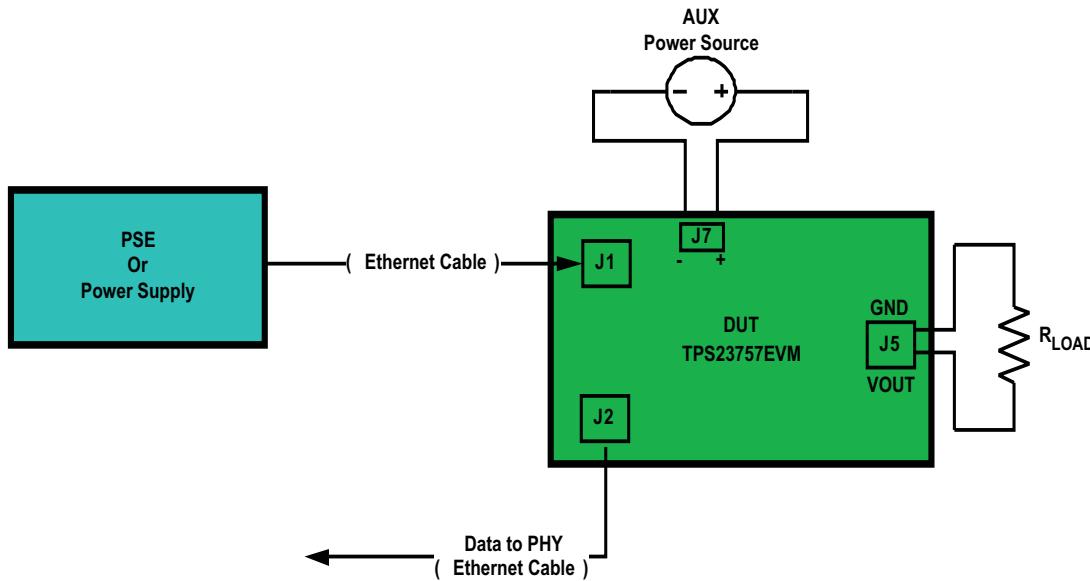


Figure 2. Typical TPS23757EVM Test Setup

## 6 TPS23757EVM Typical Performance Data

### 6.1 Efficiency

Figure 3 and Figure 4 highlights the TPS23757EVM efficiency with a 48-V input voltage source.  $N_{\text{supply}}$  is measured from TP3/TP11 to J5-1/2,  $N_{\text{adapter}}$  is measured from J7-1/2 to J5-1/2, and PoE is measured from J1 input to J5-1/2.

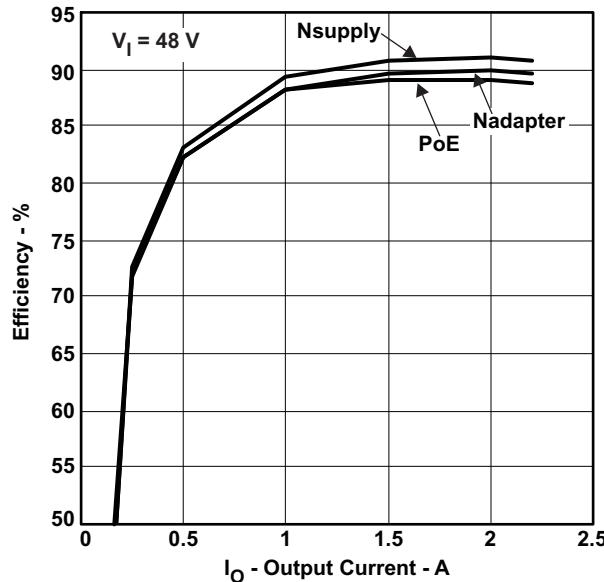
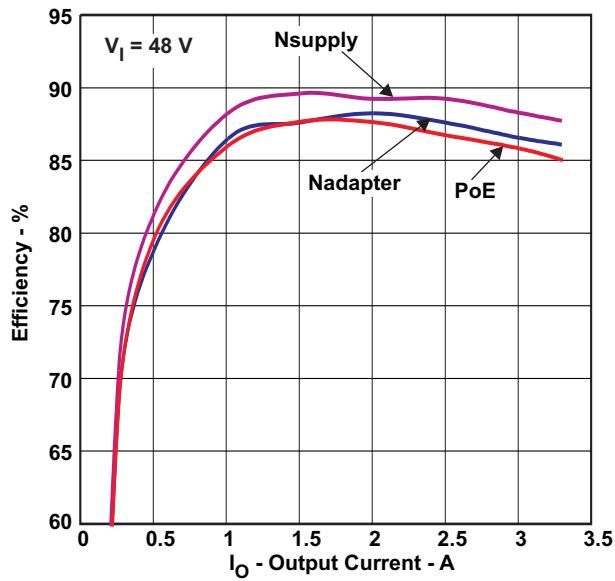


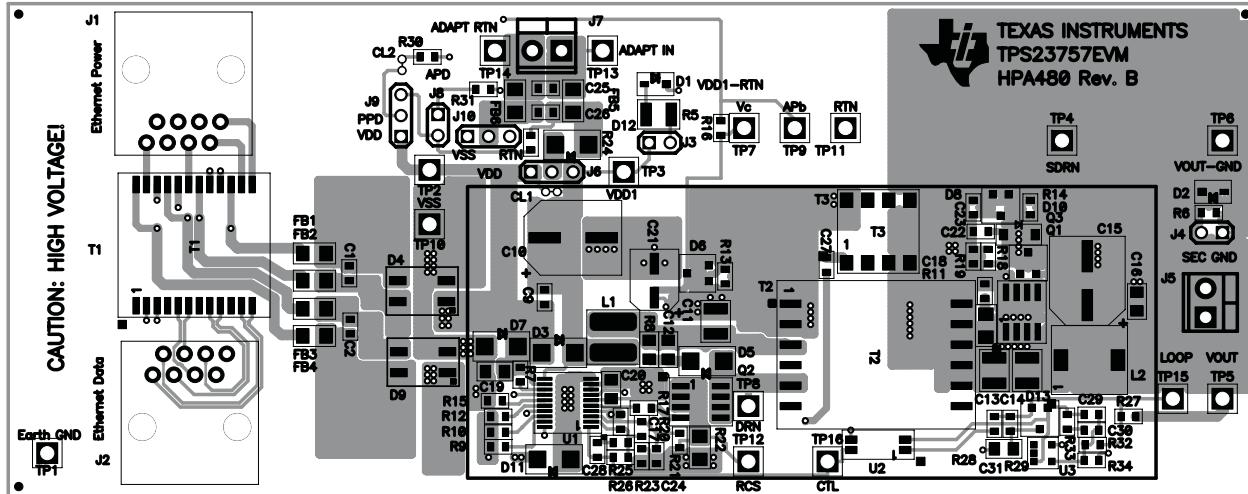
Figure 3. TPS23757EVM Efficiency With 5-V Output

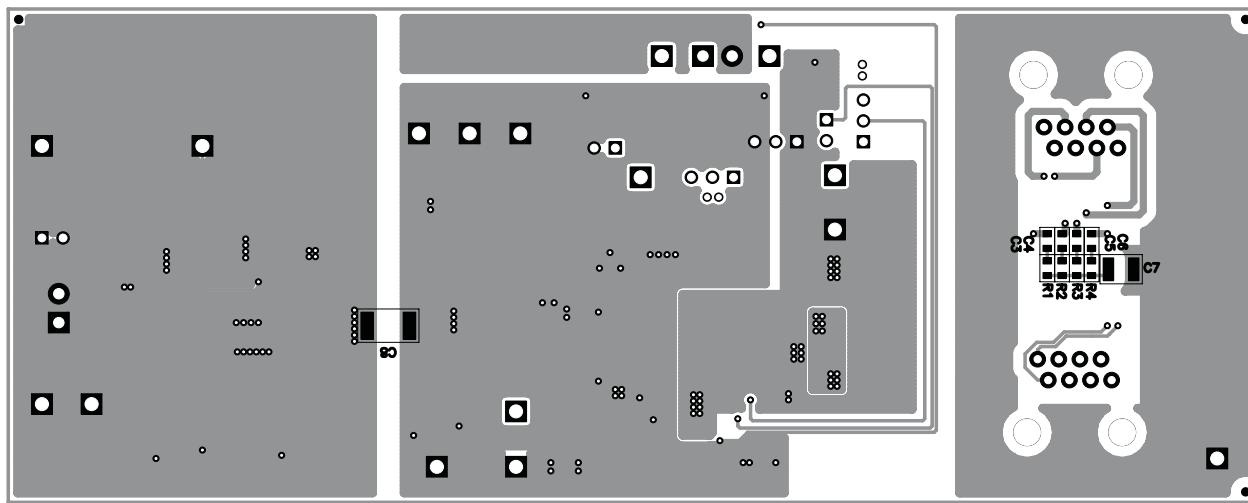

**Figure 4. TPS23757EVM Efficiency With 3.3-V Output**

## 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- $\mu$ F 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  $0\text{-}\Omega$  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 x 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 $\mu$ F, 10V, X5R, 20%	Capacitor, Ceramic, 100 $\mu$ F, 10V, X5R, 20%
C15	Capacitor, Aluminum, 330 $\mu$ F, 10V, 20%	Capacitor, Aluminum, 680 $\mu$ F, 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 $\mu$ F, 50V, X7R, 10%
R22	Resistor, Chip, 0.25 $\Omega$ , 1/4W, 5%	Resistor, Chip, 0.22 $\Omega$ , 1/4W, 5%
R23	Resistor, Chip, 3.3 $\Omega$ , 1/16W, 5%	Resistor, Chip, 10 $\Omega$ , 1/16W, 5%
R28	Resistor, Chip, 1.00 k $\Omega$ , 1/16W, 1%	Resistor, Chip, 402 $\Omega$ , 1/16W, 1%
R34	Resistor, Chip, 4.02 k $\Omega$ , 1/16W, 1%	Resistor, Chip, 7.5 k $\Omega$ , 1/16W, 1%
T2	Transformer, Coilcraft C1174-AL, 150 $\mu$ H, 48V to 5V, 2A	Transformer, Coilcraft C1173-AL, 166.5 $\mu$ H, 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.

## STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
- 2 *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
  - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
  - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

### **WARNING**

**Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.**

**User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.**

**NOTE:**

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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### 3 Regulatory Notices:

#### 3.1 United States

##### 3.1.1 Notice applicable to EVMs not FCC-Approved:

**FCC NOTICE:** This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

##### 3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

#### CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

#### FCC Interference Statement for Class A EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

#### FCC Interference Statement for Class B EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

#### 3.2 Canada

##### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

#### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

#### Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

#### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lsts/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/lsts/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_02.page)  
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#### 3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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8. *Limitations on Damages and Liability:*

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8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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