TPS23750 Flyback-Converter Evaluation Board – HPA108

This user's guide describes the function and operation of the HPA108 evaluation module (EVM). A complete description, schematic, bill of materials, assembly drawing, and printed-circuit board artwork are included.

Contents

List of Figures

List of Tables

1 Introduction

The HPA108 evaluation module implements an IEEE 802.3af-compliant class-3 power interface and a DC/DC switching converter using the Texas Instruments TPS23750 powered device (PD) controller in a typical power-over-Ethernet (PoE) configuration. The DC/DC converter provided on this EVM is a 3.3-V isolated design using a synchronous flyback topology; however, the BOM shows how to build 3.3-V or 5-V isolated and non-isolated variants. In addition, the EVM provides footprints for a simple diode and an associated snubber to implement a nonsynchronous flyback converter. A small prototype area is included on the printed-circuit board. The EVM accepts a TPS23770 in place of the TPS23750 to support a PD with a legacy undervoltage lockout (UVLO) threshold.

The EVM has separate LEDs that show when the DC/DC converter and the PoE interface are active. Test points are provided at all critical nodes. Power to the EVM is provided over the spare or data lines in an Ethernet cable or by an auxiliary source like a wall adapter.

PowerPad is a trademark of Texas Instruments.

2 Specification, Schematic, and Bill of Materials

2.1 Electrical Specification

Table 1 shows the electrical specification over a –40°C to 85°C operating temperature range. Input voltages are measured at the RJ-45 connector unless otherwise noted.

Table 1. HPA108 Electrical Specification

PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
POWER INTERFACE						
Input voltage, V_{IN}	Applied to the power pins of connectors J2 or J4		0	–	57	V
Operating voltage	After startup. Measured at RJ-45 connector J2		36	–	57	V
	Measured at AUX PWR connector J4		36	–	57	
Input UVLO	Rising input voltage		–	–	42	V
	Falling input voltage		30	–	–	
Detection voltage range			2.7	–	10.1	V
Classification voltage range			14.5	–	20.5	V
Classification current			26	–	30	mA
Inrush current limit			100	–	180	mA
Operating current limit			405	–	495	mA
DC/DC CONVERTER						
Output voltage	36 V ≤ V_{IN} ≤ 57 V, I_{LOAD} ≤ I_{LOAD} (max)	3.3-V output	3.13	3.3	3.47	V
		5-V output	4.75	5.0	5.25	
Output current, I_{LOAD}	36 V ≤ V_{IN} ≤ 57 V	3.3-V output	–	–	3	A
		5-V output	–	–	2	
Output ripple voltage, peak-to-peak	V_{IN} = 44 V, I_{LOAD} = 3 A	3.3-V output	–	15	–	mV
	V_{IN} = 44 V, I_{LOAD} = 2 A	5-V output	–	15	–	
Efficiency, end-to-end	V_{IN} = 44 V, I_{LOAD} = 3 A	3.3-V output	–	80%	–	
	V_{IN} = 44 V, I_{LOAD} = 2 A	5-V output	–	82%	–	
Switching frequency			82	–	118	kHz

The end-to-end efficiency curves in Figure 1 and Figure 3 include the losses at the PD switch, bridge diode, and data transformer. The DC/DC converter efficiency curves in Figure 2 and Figure 4 exclude these losses. The curves are plotted for the RJ-45 connector voltages shown.

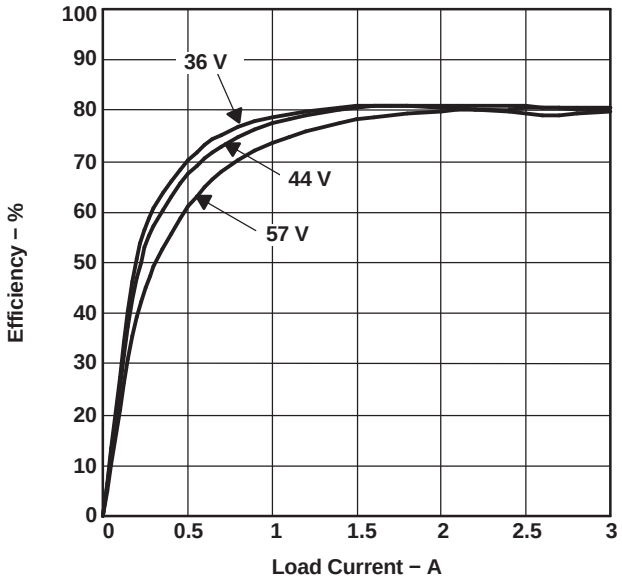


Figure 1. Typical 3.3-V PD End-to-End Efficiency

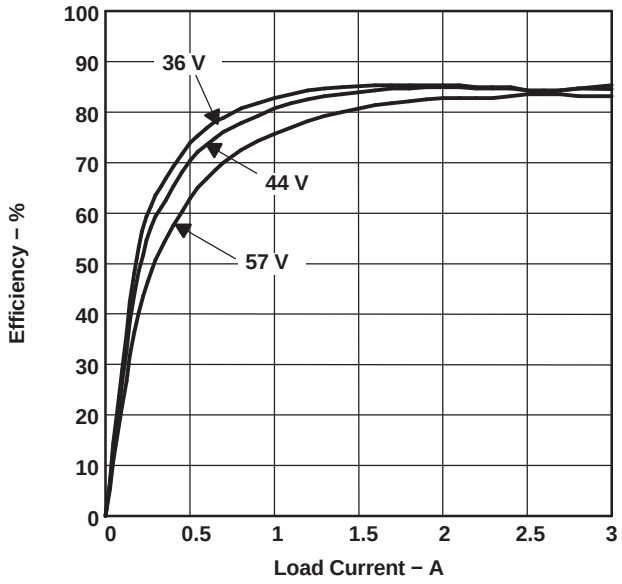


Figure 2. Typical 3.3-V DC/DC Converter Efficiency

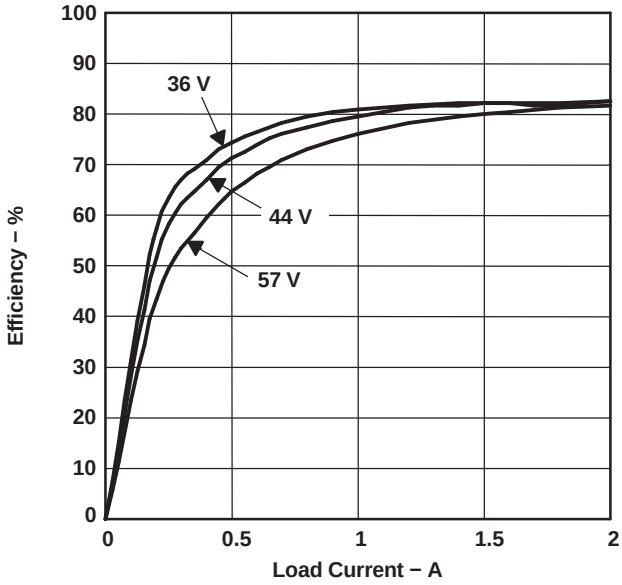


Figure 3. Typical 5-V PD End-to-End Efficiency

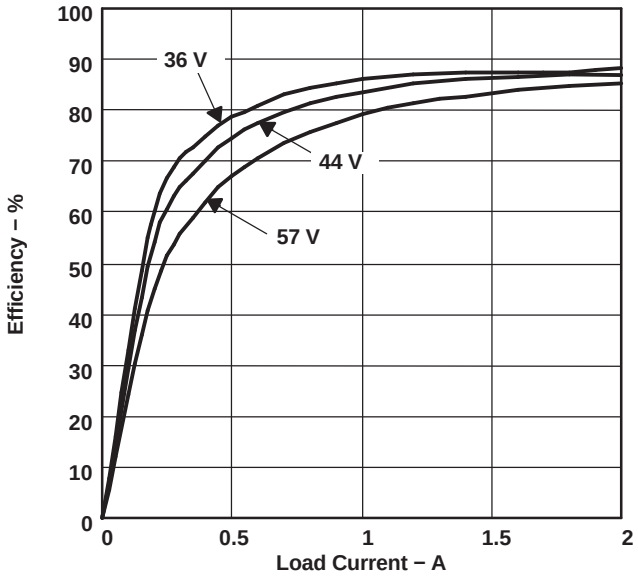
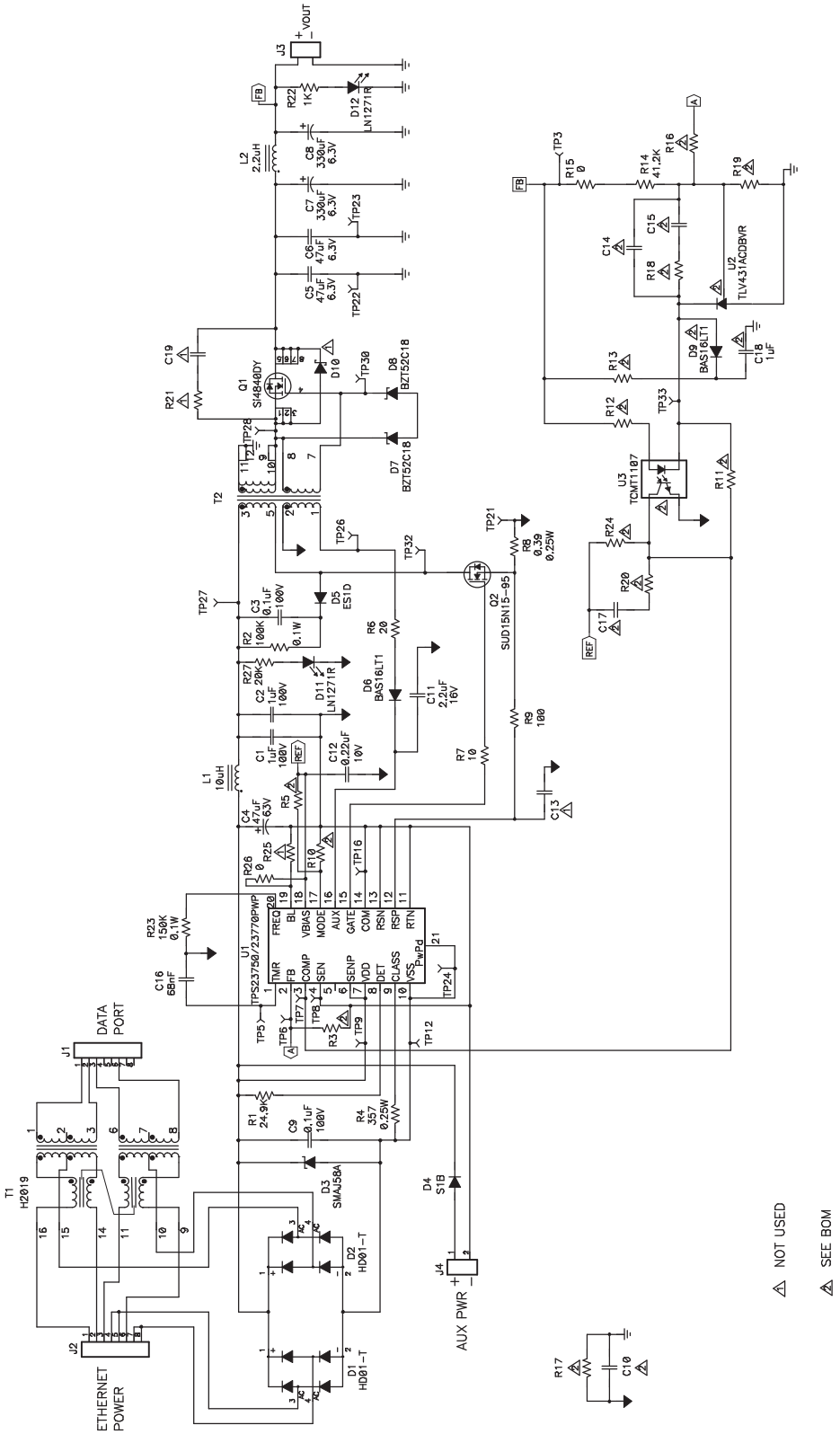


Figure 4. Typical 5-V DC/DC Converter Efficiency

2.2 Schematic



2.3 Bill of Material

Table 2. HPA108 Bill of Material (Rev. A)

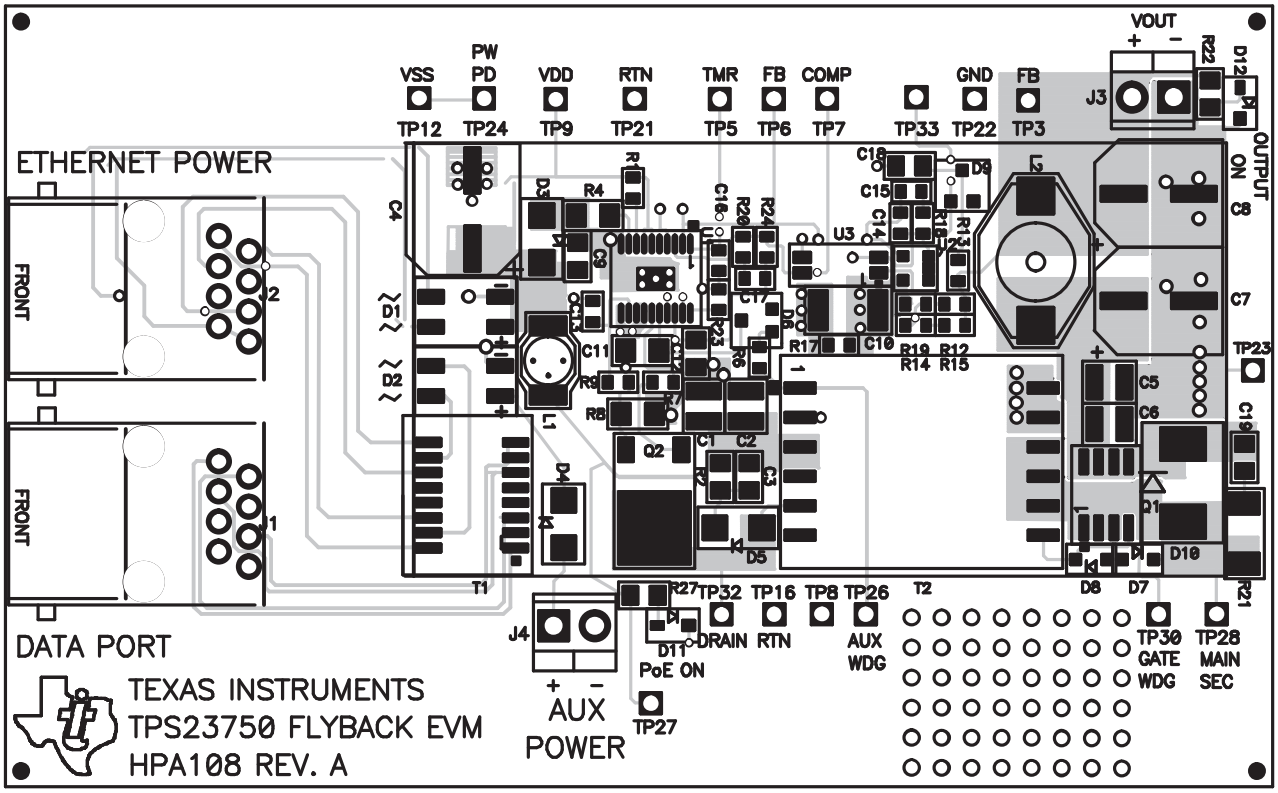
Isolated		Non-Isolated		Ref Des	Description	Size	MFR	Part No.
3.3 V	5 V	3.3 V	5 V					
–001	–002	–003	–004					
Count	Count	Count	Count					
2	2	2	2	C1, C2	Capacitor, ceramic, 1 µF, 100V, X7R, 10%	1210	Murata	GRM32ER72A105KA01L
1	1	0	0	C10	Capacitor, ceramic, 2200 pF, 2KV, X7R, 20%	1812	TDK	C4532X7R3D222KT
1	1	1	1	C11	Capacitor, ceramic, X7R, 2.2 µF, 16-V, 10%	1206	Panasonic	ECJ-3YB1C225K
1	1	1	1	C12	Capacitor, ceramic, 0.22 µF, 10-V, X7R	805	Std	Std
0	0	0	0	C13	Not Used	603		
1	1	0	0	C14	Capacitor, ceramic, 33 pF, 50V, C0G, 5%	603	Std	Std
0	0	1	1	C14	Capacitor, ceramic, 15 pF, 50V, C0G, 5%	603	Std	Std
1	1	0	0	C15	Capacitor, ceramic, 1000 pF, 50V, X7R, 10%	603	Std	Std
0	0	1	1	C15	Capacitor, ceramic, 680 pF, 50V, X7R, 10%	603	Std	Std
1	1	1	1	C16	Capacitor, ceramic, 68 nF, 16-V, X7R, 10%	603	Std	Std
1	1	0	0	C17	Capacitor, ceramic, 0.01 µF, 25V, X7R, 10%	603	Std	Std
1	1	0	0	C18	Capacitor, ceramic, 1 µF, 16V, X7R, 10%	805	Std	Std
0	0	0	0	C19	Not Used	805		
2	2	2	2	C3, C9	Capacitor, ceramic, 0.1 µF, 100V, X7R, 10%	805	TDK	C2012X7R2A104K
1	1	1	1	C4	Capacitor, aluminum, 47 µF, 63V, 20%	8x10mm	Panasonic	EEVFK1J470P
2	2	2	2	C5, C6	Capacitor, ceramic, 47 µF, 6.3V, X5R, 20%	1210	TDK	C3225X5R0J476M
2	2	2	2	C7, C8	Capacitor, aluminum, SM, 330 µF, 6.3V, 20%	8×6,2 mm	Panasonic	EEVFK0J331P
2	2	2	2	D1, D2	Bridge rectifier, 100 V, 0.8A, glass passivated, SMD	MINI DIP4	Diodes, Inc.	HD01-T
0	0	0	0	D10	Diode Schottky, 5-A, 40 V	SMC	On Semi	MBRS540T3
2	2	2	2	D11, D12	Diode, LED, red	0.114 × 0.049	Panasonic	LN1271R
1	1	1	1	D3	Diode, TVS, 58V, 1W	SMA	Diodes Inc., STMicro	SMAJ58A
1	1	1	1	D4	Diode, rectifier, 1A, 100 V	SMA	Diodes, Inc.	S1B
1	1	1	1	D5	Diode, rectifier, 1A, 200 V	SMA	On Semi	ES1D
1	1	1	1	D6	Diode, switching, 200-mA, 75V, 225 mW	SOT-23	On Semi	BAS16LT1
1	1	0	0	D9	Diode, switching, 200-mA, 75 V, 225 mW	SOT-23	On Semi	BAS16LT1
2	2	2	2	D7, D8	Diode, Zener, 200 mW, 18V	SOD-323	General Semiconductor	BZT52C18
2	2	2	2	J1, J2	Connector, Jack, Modular, 8 POS	0.705 x 0.820	AMP	520252
2	2	2	2	J3, J4	Terminal block, 2-pin, 6-A, 3,5 mm	0.27 x 0.25 in	OST	ED1514
1	1	1	1	L1	Inductor, SMT, 10 µH, 1.1A, 160 mΩ	4.45x6.6mm	Coilcraft	DO1608C-103
							Wurth Electronics	7445510
1	1	1	1	L2	Inductor, SMT, 2.2 µH, 6.1A, 15 mΩ	9.4x12.95 mm	Coilcraft	DO3316P-222HCB
1	1	1	1	Q1	MOSFET, N-ch, 40V, 14A, 9 mΩ, T_J = 25°C	SO-8	Vishay	Si4840DY
1	1	1	1	Q2	MOSFET, N-ch, 150V, 15A, 95 mΩ, T_J = 25°C	DPAK	Vishay or International Rectifier	SUD15N15-95 or iRF24N15D or iRF13N15D
1	1	1	1	R1	Resistor, chip, 24.9 kΩ, 1/16W, 1%	603	Std	Std
1	0	0	0	R12	Resistor, chip, 549 Ω, 1/16W, 1%	603	Std	Std
0	1	0	0	R12	Resistor, chip, 1.00 kΩ 1/16W, 1%	603	Std	Std
1	0	0	0	R13	Resistor, chip, 3.01 kΩ, 1/16W, 1%	603	Std	Std
0	1	0	0	R13	Resistor, chip, 1.5 kΩ, 1/16W, 1%	603	Std	Std
1	1	1	1	R14	Resistor, chip, 41.2 kΩ, 1/16W, 1%	603	Std	Std
1	0	0	0	R18	Resistor, chip, 41.2 kΩs, 1/16W, 1%	603	Std	Std
0	1	0	0	R18	Resistor, chip, 86.6K kΩ, 1/16W, 1%	603	Std	Std
0	0	1	1	R18	Resistor, chip, 200 kΩ, 1/16W, 1%	603	Std	Std
1	0	0	0	R19	Resistor, chip, 24.3 kΩ 1/16W, 1%	603	Std	Std
0	0	1	0	R19	Resistor, chip, 34.8 kΩ, 1/16W, 1%	603	Std	Std
0	0	0	1	R19	Resistor, chip, 17.4 kΩ, 1/16W, 1%	603	Std	Std
0	1	0	0	R19	Resistor, chip, 13.3 kΩ, 1/16W, 1%	603	Std	Std
1	1	1	1	R2	Resistor, chip, 100 kΩ, 1/10W, 1%	805	Std	Std
1	0	0	0	R20	Resistor, chip, 249 Ω, 1/16W, 1%	603	Std	Std
0	1	0	0	R20	Resistor, chip, 0 Ω, 1/16W, 1%	603	Std	Std

Table 2. HPA108 Bill of Material (Rev. A) (continued)

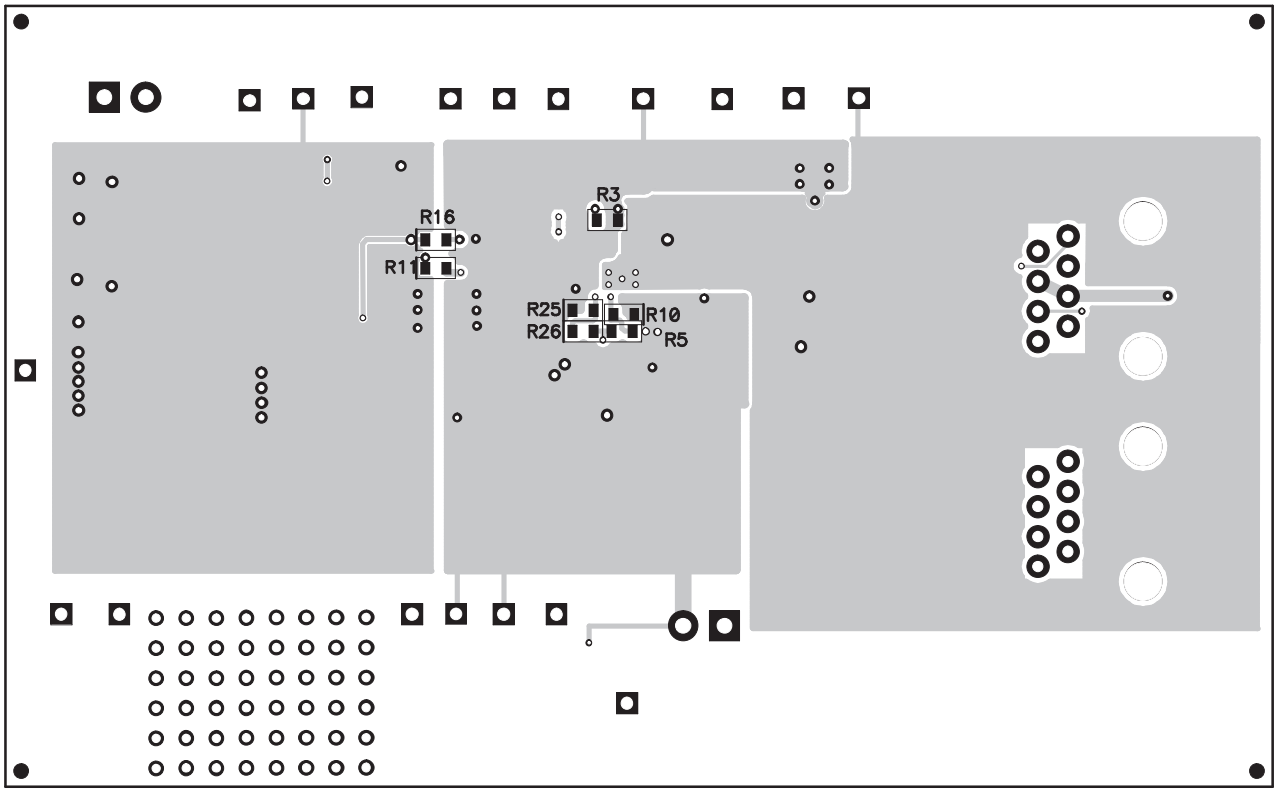
Isolated		Non-Isolated						
3.3 V	5 V	3.3 V	5 V					
–001	–002	–003	–004					
Count	Count	Count	Count	Ref Des	Description	Size	MFR	Part No.
0	0	0	0	R25	Not Used	603		
0	0	0	0	R21	Not Used			
1	1	1	1	R23	Resistor, chip, 150 kΩ, 0.1-W, 1%	603	Std	Std
1	1	0	0	R24	Resistor, chip, 2 kΩ, 1/16W, 1%	603	Std	Std
1	1	1	1	R27	Resistor, chip, 20 kΩ, 1/10-W, 5%	805	Std	Std
1	1	1	1	R22	Resistor, Chip, 1 kΩ,, 1/10-W, 5%	805	Std	Std
1	1	0	0	R3	Resistor, chip, 0 Ω, 1/16W, 1%	603	Std	Std
1	1	1	1	R4	Resistor, chip, 357 Ω, 1/4W, 1%	1206	Std	Std
1	1	0	0	R5	Resistor, chip, 0 Ω, 1/16W, 1%	603	Std	Std
1	1	1	1	R6	Resistor, chip, 20 Ω, 1/16W, 5%	603	Std	Std
1	1	1	1	R7	Resistor, chip, 10 Ω, 1/16W, 5%	603	Std	Std
1	1	1	1	R8	Resistor, Chip, 0.39 Ω, .25W, 1%	1206	Panasonic	ERJ8RQFR39V
1	1	1	1	R9	Resistor, Chip, 100 Ω, 1/16W, 1%	603	Std	Std
2	2	2	2	R15, R26	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
0	0	1	1	R17	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
0	0	1	1	R10	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
0	0	1	1	R11	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
0	0	1	1	R16	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
1	1	1	1	T1	Xfmr, center-tapped, Voice Over IP)	0.500 x 0.370	Pulse	H2019
							Wurth Electronics	749013011
0	1	0	1	T2	XFMR, flyback 2 Pri, 2 Sec, Custom	0.875 x 0.675	Coilcraft	C1174-AL
							Wurth Electronics	750310041
							Pulse (ALT)	PA1039
1	0	1	0	T2	XFMR, flyback 2 Pri, 2 Sec, Custom	0.875 x 0.675	Coilcraft	C1173-AL
							Pulse (ALT)	PA0691
6	6	6	6	TP12,TP16, TP21, TP22, TP23, TP24	Test Point, Black	0.038	Keystone	5001
12	12	12	12	TP3, TP5–TP9, TP26–TP28, TP30, TP32, TP33	Test Point, Red	0.038	Keystone	5000
1	1	1	1	U1	IC, IEEE 802.3af Integrated Primary Side Controller	PWP20	TI	TPS23750PWP
1	1	0	0	U2	IC, Shunt Regulator, 1.24 V Ref, 6V, 10 mA, 1%	SOT23-5	TI	TLV431ACDBVR
1	1	0	0	U3	IC, Photocoupler, 3750VRMS, 80–160% CTR	MF4	Vishay	TCMT1107
4	4	4	4	–	Rubber bumper	–	Spec Tech	2566
1	1	1	1	–	PCB, 0 In x 0 In x 0.062 In	–	Any	HPA108

3 Board Layout

3.1 Top-Side Layout



3.2 Bottom-Side Layout



3.3 Layout Considerations

The layout of the PoE front end must use good practice for power and EMI/ESD. A basic set of recommendations include:

- The parts placement must be driven by the power flow in a point-to-point manner such as RJ-45 → Ethernet transformer → diode bridges → TVS and 0.1-µF capacitor → TPS23750 → bulk capacitor → converter input.
- All leads should be as short as possible with wide power traces and paired signal and return.
- There should 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 TPS23750 should be located over split, local ground planes referenced to V_{SS} for the PoE input and to RTN for the converter operation. Whereas the PoE side may operate without a ground plane, the converter side must have one. The PowerPad™ must be tied to the V_{SS} plane or fill area, especially if power dissipation is a concern. Logic ground and power layers should not be present under the Ethernet input or the converter primary side.
- Large copper fills and *traces* should be used on SMT power-dissipating devices, and wide traces or overlay copper fills should be used in the power path.

Converter layout benefits from basic rules such as:

1. Pair signals to reduce emissions and noise, especially the paths that carry high-current pulses which include the power semiconductors and magnetics.
2. Reduce the length of all the traces in step 1.
3. Where possible, use vertical pairing.
4. Use the *ground plane* for the switching currents carefully.
5. Keep the high-current and high-voltage switching away from low-level sensing circuits including those outside the power supply.
6. The current sensing on RSP/RSN is the most critical, noise-sensitive signal. It must be protected as in

step 5, including exposure to the gate drive sign.

7. Pay special attention to spacing around the high-voltage sections of the converter.

4 Using the EVM

4.1 Setup

Figure 5 shows a typical EVM setup. The user is encouraged to read the TPS23750 data sheet before using the EVM.

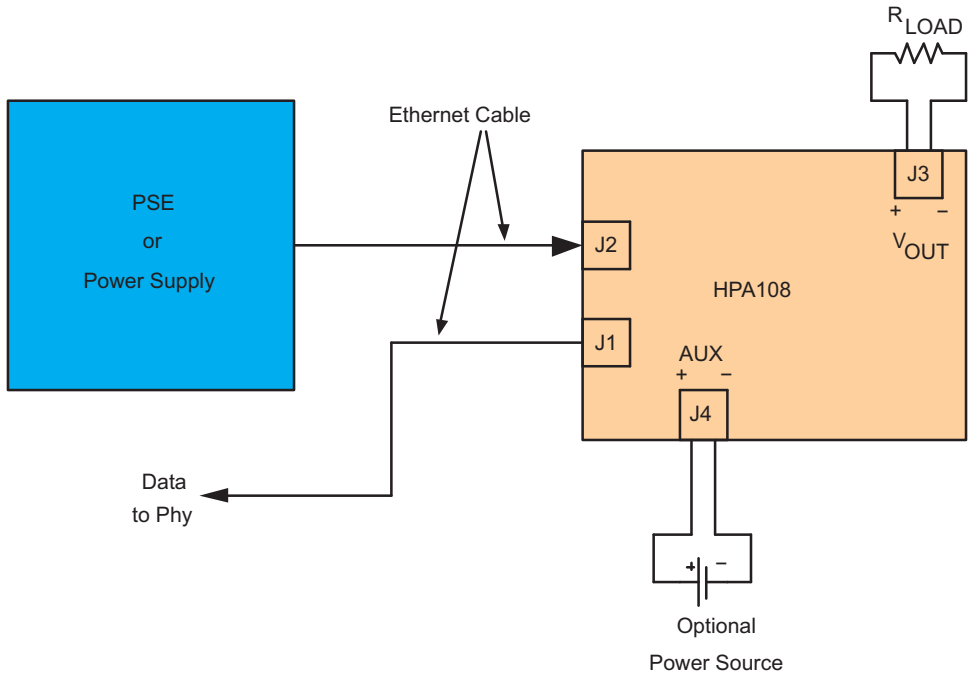


Figure 5. Typical Setup

4.2 Interface

Table 3 describes the EVM interface.

Table 3. EVM I/O Interfaces

Reference Designator	Description
J2	An Ethernet cable connects this port to the power-sourcing equipment (PSE). This port carries both data and power.
J1	This port carries only data. Do not apply power to this port.
J4	This terminal block accepts auxiliary power from a source like a wall adapter.
J3	Output voltage
D12	This LED is lit if the DC/DC converter output is on.
D11	This LED is lit if the PD FET switch is on.

4.3 Making Measurements

Stray magnetic fields from transformer T2 can couple noise into measurements. This noise may be noticeable when measuring a low-level signal like output ripple voltage. Keep the ground lead of the oscilloscope probe short and away from T2 to reduce the amount of noise pick-up.

Ground loops can be created if test equipment is connected to the EVM. Avoid ground loops by floating the test equipment and/or the power supply to the EVM.

4.4 EVM Operation

The TPS23750 data sheet describes the electrical operation and function of the various components in the isolated flyback PD. The circuit provided in the data sheet is similar to the circuit in this EVM.

5 Related Documentation

1. *TPS23750, TPS23770, Integrated 100 V IEEE 802.3af PD and DC/DC Controller* data sheet, SLVS590
2. *IEEE Std 802.3af*

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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 3 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 100°C. The EVM is designed to operate properly with certain components above 100°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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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   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 DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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 isotrope 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/lsds/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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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.

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.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY 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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