TPS23750 Buck-Converter Evaluation Board – HPA107

This user's guide describes the function and operation of the HPA107 evaluation module (EVM). A complete description, schematic, bill of materials, assembly drawing, and printed-circuit board artwork are included.

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1 Introduction

The HPA107 evaluation module implements an IEEE 802.3af-compliant class-3 power interface and a non-isolated 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 is a 5-V output buck converter with a BOM option for 3.3 V. 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. HPA107 Electrical Specification

PARAMETER	CONDITION		MIN	TYP	MAX	UNIT
POWER INTERFACE						
Input voltage, V_{IN}	Applied to the power pins of connectors J1 or J3		0	–	57	V
Operating voltage	After startup		36	–	57	V
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	–	–	2.5	A
		5-V output	–	–	2	
Output ripple voltage, peak-to-peak	V_{IN} = 44 V, I_{LOAD} = 2.5 A	3.3-V output	–	30	–	mV
	V_{IN} = 44 V, I_{LOAD} = 2 A	5-V output	–	32	–	
Efficiency, end-to-end	V_{IN} = 44 V, I_{LOAD} = 2.5 A	3.3-V output	–	75%	–	
	V_{IN} = 44 V, I_{LOAD} = 2 A	5-V output	–	80%	–	
Switching frequency			164	–	236	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.

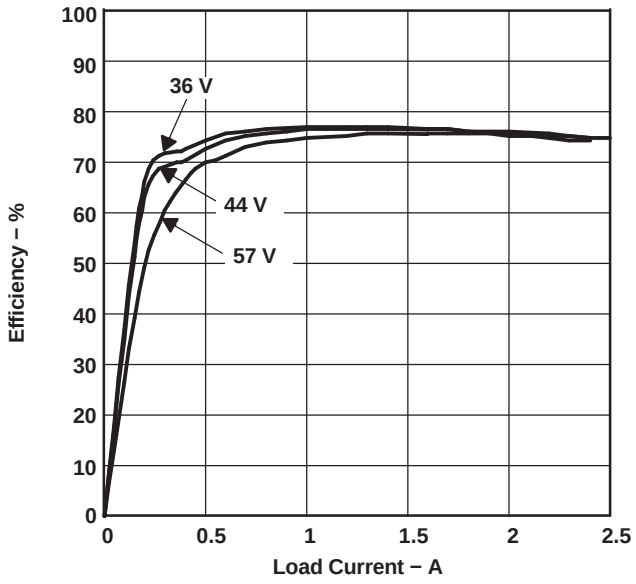


Figure 1. Typical 3.3-V PD End-to-End Efficiency

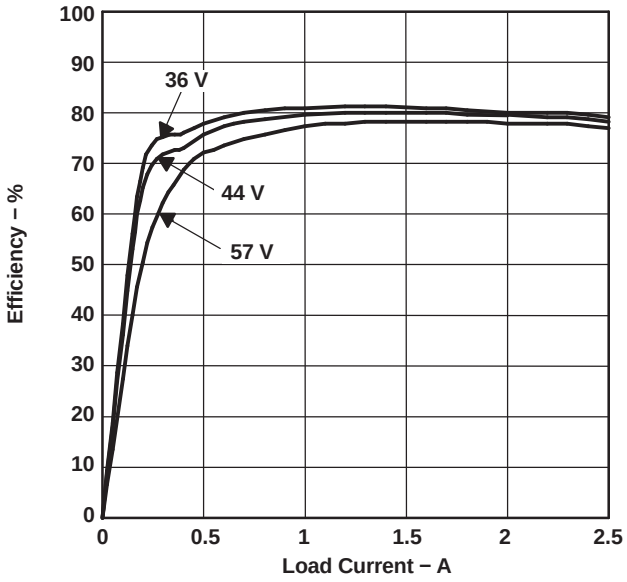


Figure 2. Typical 3.3-V DC/DC Converter Efficiency

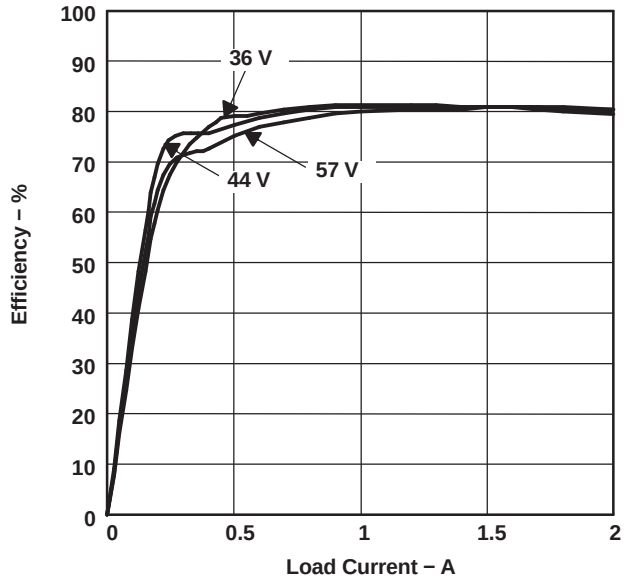


Figure 3. Typical 5-V PD End-to-End Efficiency

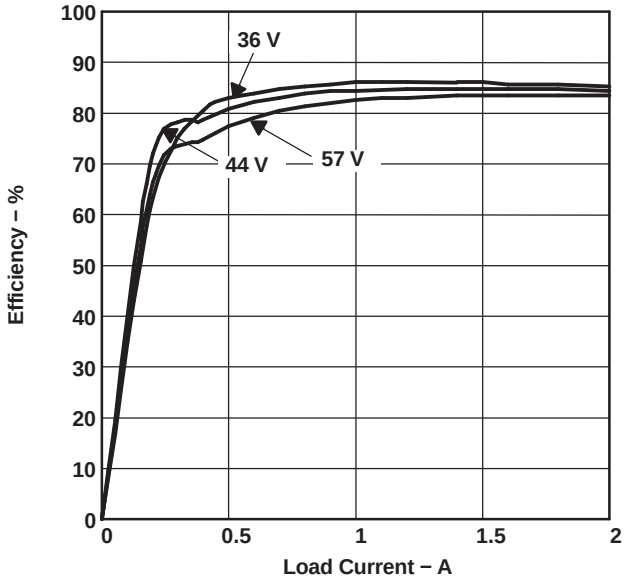
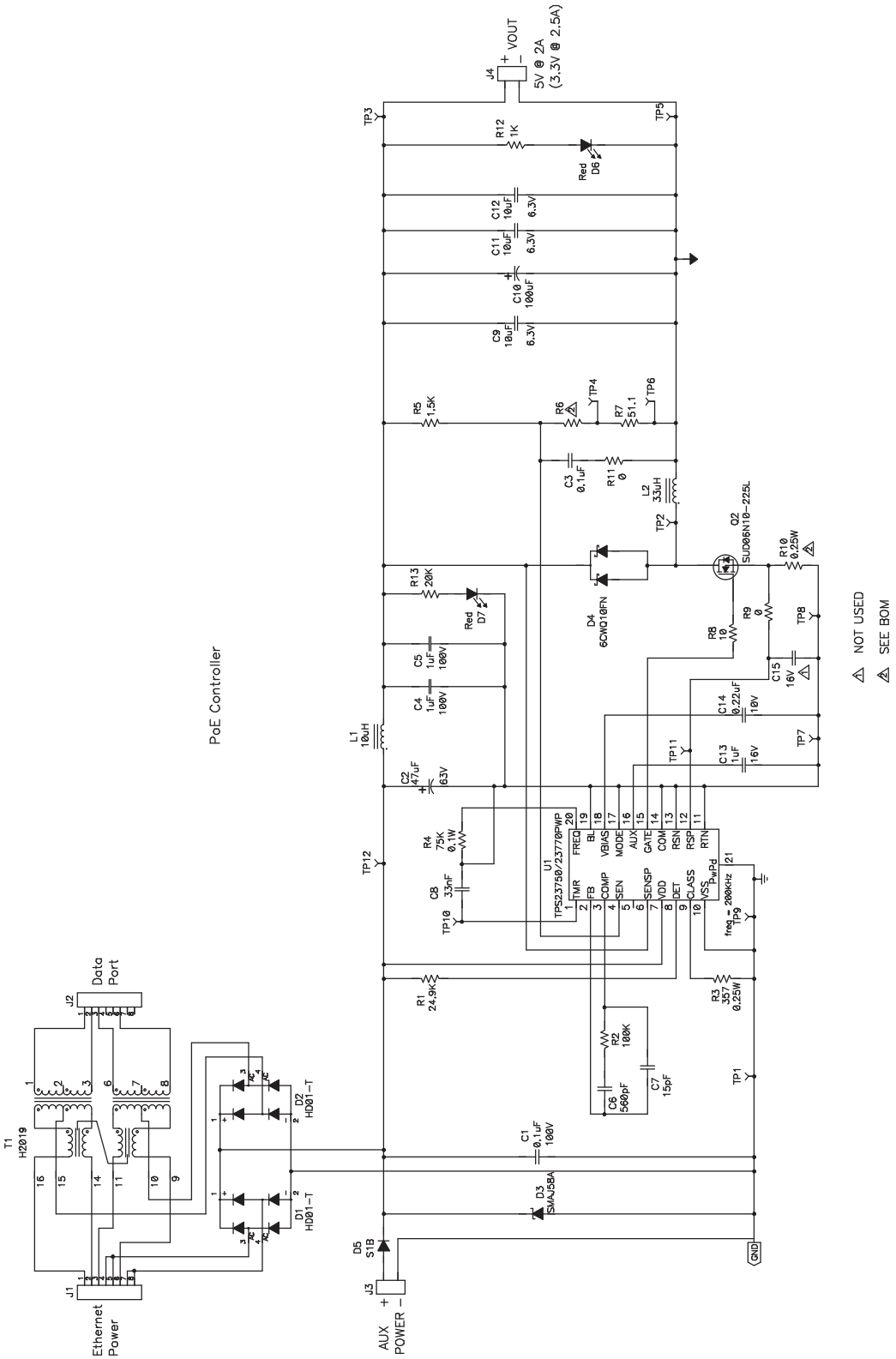


Figure 4. Typical 5-V DC/DC Converter Efficiency

2.2 Schematic



2.3 Bill of Material

Table 2. HPA107 Bill of Materials

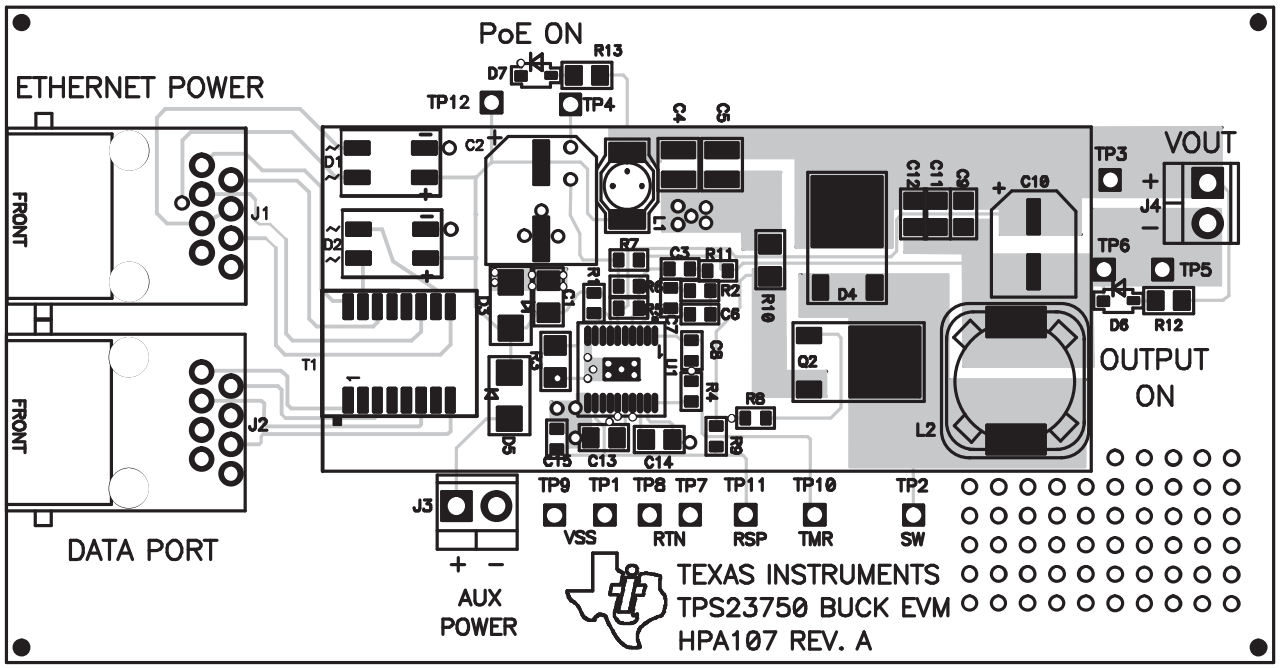
–001	–002	Ref Des	Description	Size	MFR	Part No.
3.3 V Count	5 V Count					
1	1	C1	Capacitor, Ceramic, 0.1 μF, 100 V, X7R, 10%	1206	Vishay	Std
1	1	C10	Capacitor, Aluminum, 100 μF, 6.3-V, 20%	6.3 × 5.8	Panasonic	EEVFK0J101P
1	1	C13	Capacitor, Ceramic, 1 μF, 16-V, X7R, 10%	805	Murata	GRM21BR71C105KA01L
1	1	C14	Capacitor, Ceramic, 0.22 μF, 10V, X7R, 10%	805	Std	Std
1	1	C8	Capacitor, Ceramic, 33 nF, 25V, X7R, 10%	603	Std	Std
1	1	C2	Capacitor, Aluminum, 47 μF, 63V, 20%	8×10 mm	Panasonic	EEVFK1J470P
1	1	C3	Capacitor, Ceramic, X7R, 0.1 μF, 25V, 10%	603	Vishay	Std
0	0	C15	Not used	603		
2	2	C4, C5	Capacitor, Ceramic, 1 μF, 100 V, X7R, 10%	1210	Murata	GRM32ER72A105KA01L
1	1	C6	Capacitor, Ceramic, 560 pF, 50 V, X7R, 10%	603	Std	Std
1	1	C7	Capacitor, Ceramic, 15 pF, 50 V, C0G, 5%	603	Std	Std
3	3	C9, C11, C12	Capacitor, Ceramic, 10 μF, 6.3V, X5R, 10%	805	Murata	GRM21BR60J106KE19L
2	2	D1, D2	Bridge Rectifier, 100V, 0.8A, Glass Passivated, SMD	MINI DIP4	Diodes Inc	HD01-T
2	2	D6, D7	Diode, LED, Red	0.114 × 0.049	Panasonic	LN1271R
1	1	D3	Diode, TVS, 58V, 1W	SMA	Diodes Inc., STMicro	SMAJ58A
1	1	D4	Diode, Dual Schottky, 7-A, 100-V	DPAK	IR	6CWQ10FN
1	1	D5	Diode, Rectifier, 1A, 100V	SMA	Diodes Inc.	S1B
2	2	J1, J2	Connector, Jack, Modular, 8 POS	TH	AMP	520252
2	2	J3, J4	Terminal Block, 2-pin, 6-A, 3,5 mm	TH	OST	ED1514
1	1	L1	Inductor, SMT, 10 μH, 1.1A, 160 mΩ	4.45×6.6 mm	Coilcraft	DO1608C-103
					Wurth Electronics	7445510
1	1	L2	Inductor, SMT, 33 μH, 3.9A, 41 mΩ	0.472 sq	Sumida	CDRH127/LD-330
1	1	Q2	MOSFET, N-ch, 100V, 3.75A, 0.25 Ω	DPAK	Vishay	SUD06N10-225L
1	1	R1	Resistor, Chip, 24.9 kΩ, 1/16W, 1%	603	Std	Std
0	1	R10	Resistor, Chip, 0.18 Ω, 1/4W, 1%	1206	Vishay, Susuma	WSL1206R1800FEA18,
						RL1632R-R180-F
1	0	R10	Resistor, Chip, 0.15 Ω, 1/4W, 1%	1206	Vishay	WSL1206R1500FEA18
1	1	R2	Resistor, Chip, 100 kΩ, 1/16W, 1%	603	Std	Std
1	1	R12	Resistor, Chip, 1 kΩ, 1/10-W, 5%	805	Std	Std
1	1	R13	Resistor, Chip, 20 kΩ, 1/10-W, 5%	805	Std	Std
1	1	R3	Resistor, Chip, 357 Ω, 1/4-W	1206	Std	Std
1	1	R4	Resistor, Chip, 75 kΩ, 1/16-W, 1%	603	Std	Std
1	1	R5	Resistor, Chip, 1.5 kΩ, 1/16W, 1%	603	Std	Std
0	1	R6	Resistor, Chip, 3.48 kΩ, 1/16W, 1%	603	Std	Std
1	0	R6	Resistor, Chip, 1.78 kΩ, 1/16W, 1%	603	Std	Std
1	1	R7	Resistor, Chip, 51.1 Ω, 1/16W, 1%	603	Std	Std
1	1	R8	Resistor, Chip, 10 Ω, 1/16W, 1%	603	Std	Std
2	2	R9, R11	Resistor, Chip, 0 Ω, 1/16W, 1%	603	Std	Std
1	1	T1	Xfmr, Center-tapped, Voice Over IP	0.500 × 0.370	Pulse	H2019
					Wurth Electronics	749013011
5	5	TP1, TP5 TP7–TP9	Test Point, Black	0.038	Keystone	5001
7	7	TP2–TP4, TP6, TP10–TP12	Test Point, Red	0.038	Keystone	5000
1	1	U1	IC, IEEE 802.3af Integrated Primary Side Controller	PWP20	TI	TPS23750PWP
1	1	–	PCB, 2.250 In × 4.350 In × 0.062 In	–	Any	HPA107A

Table 2. HPA107 Bill of Materials (continued)

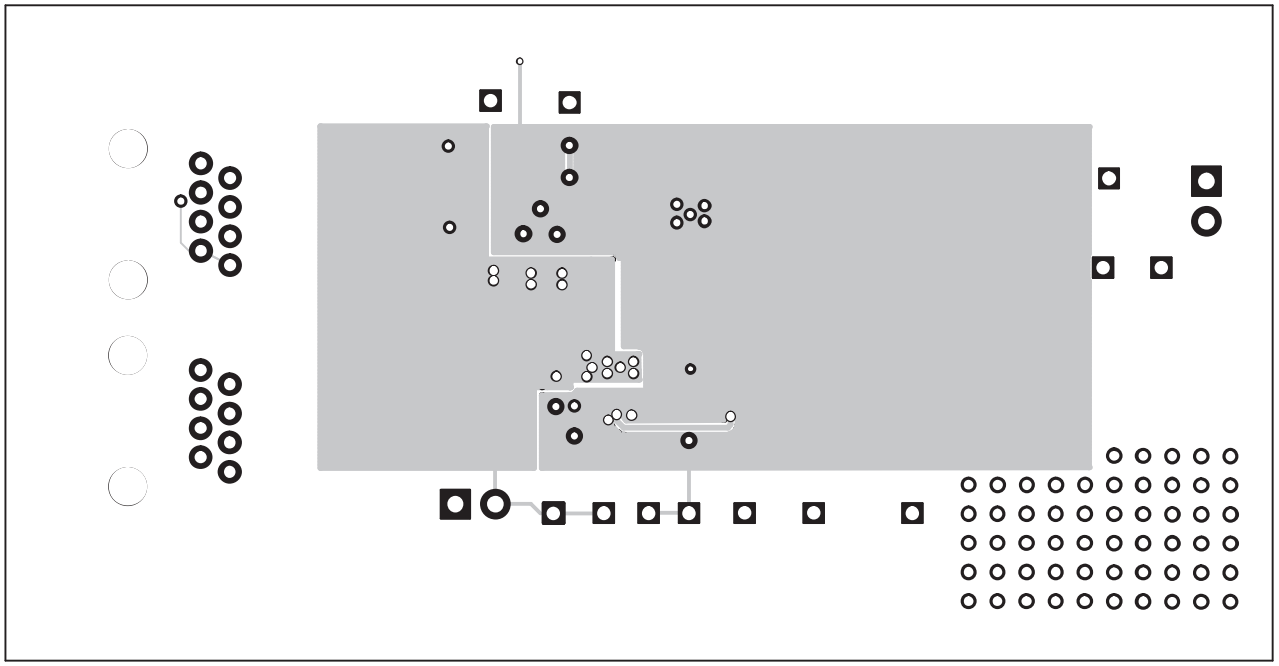
–001 3.3 V Count	–002 5 V Count	Ref Des	Description	Size	MFR	Part No.
4	4	–	Rubber Bumper	–	SPC TECH	2566

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.
- There should not be any crossovers of signals from one part of the flow to another.
- All leads should be as short as possible with wide power traces and paired signal and return.
- 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.

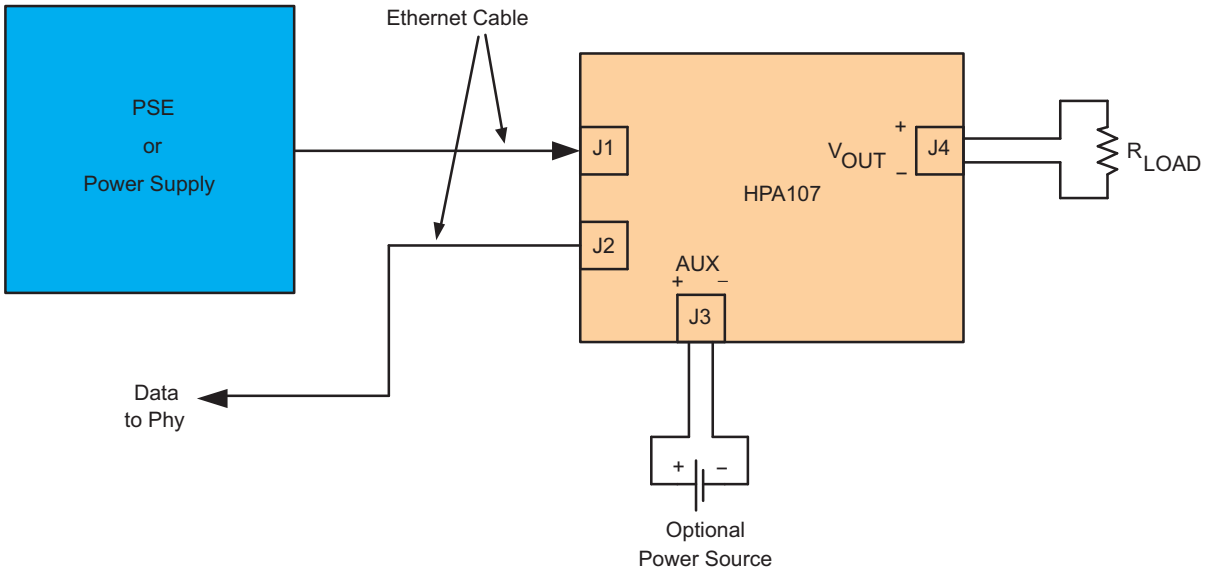


Figure 5. Typical Setup

4.2 Interface

Table 2 describes the EVM interface.

Table 3. EVM I/O Interfaces

Reference Designator	Description
J1	An Ethernet cable connects this port to the power-sourcing equipment (PSE). This port carries both data and power.
J2	This port carries only data. Do not apply power to this port.
J3	This terminal block accepts auxiliary power from a source like a wall adapter.
J4	Output voltage
D6	This LED is lit if the DC/DC converter output is on.
D7	This LED is lit if the PD FET switch is on.

4.3 Making Measurements

Stray magnetic fields from inductor L2 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 L2 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 buck converter powered device. 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*

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 customer 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.

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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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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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.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0 V to 57 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

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 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.

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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。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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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.

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