TPS23754EVM-383 EVM: Evaluation Module for TPS23754

This User's Guide describes the TPS23754 EVM (TPS23754EVM-383). TPS23754EVM-383 contains evaluation and reference circuitry for the TPS23754. The TPS23754 is an IEEE 802.3at compliant powered device (PD) controller and power supply controller optimized for isolated converter topologies. TPS23754EVM-383 is targeted at 25W, active clamp, forward converter applications.

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1 Description

TPS23754EVM-383 will allow reference circuitry evaluation of the TPS23754. It contains input and output power connectors and an array of on board test points for circuit evaluation. A synchronous flyback, 5V, 25W EVM is also available, see SLVU301.

1.1 Features

- Efficient, general market design
  - Self driven, synchronous rectified secondary
  - 25w output power from power over ethernet (POE), 30W output power from a 48V adapter
  - Operates from either POE or external adaptors (48V)
  - 12V output voltage

1.2 Applications

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

2 Electrical Specifications

Table 1. TPS23754EVM-383 Electrical and Performance Specifications

Parameter	Condition		Min	Typ	Max	Units
Power Interface						
Input voltage	Applied to the power pins of connectors J1 or J3		0		57	V
Operating Voltage	After start up		30		57	V
Input UVLO	Rising input voltage				36	V
	Falling input voltage		30			
Detection voltage	At device terminals		1.6		10	V
Classification voltage	At device terminals		10		23	V
Classification current	Rclass = 63.4 Ω		36		44	mA
Inrush current-limit			100		180	mA
Operating current-limit			850		1100	mA
DC/DC Converter						
Output voltage	33 V ≤ Vin ≤ 57 V, I_{LOAD} ≤ I_{LOAD} (max)	12 V output				V
Output current	33 V ≤ Vin ≤ 57 V	12 V output			2.5	Amps
Output ripple voltage, peak-to-peak	Vin = 44 V, I_{LOAD} = 2.5 A	12 V output		100		mV
Efficiency, end-to-end	Vin = 44 V, I_{LOAD} = 2.5 A	12 V output		87%		
Switching frequency			225		275	kHz

3 Schematic

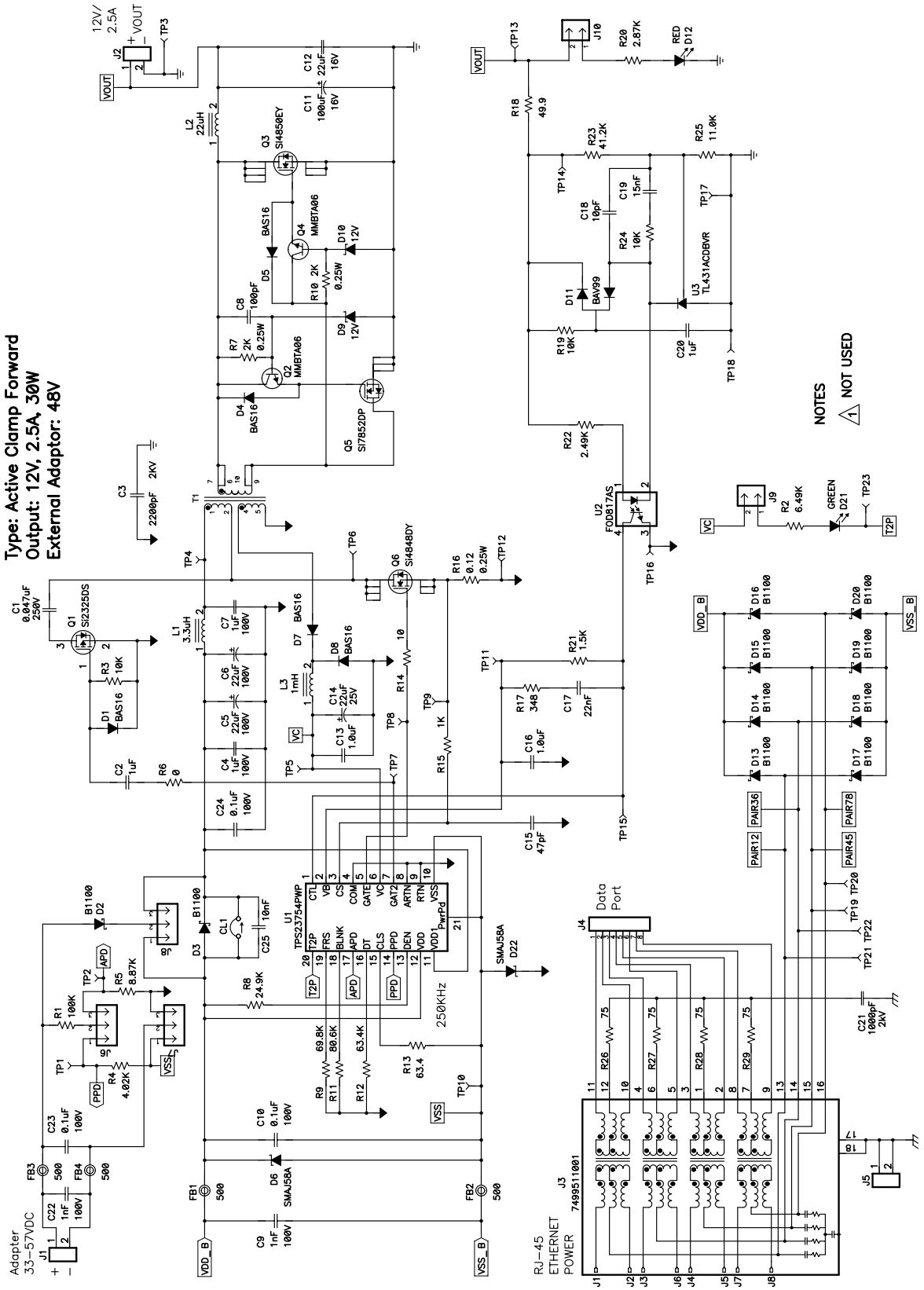

Figure 1. TPS23754EVM-383 Schematic

4 General Configuration and Description

4.1 Physical Access

Table 2 lists the TPS23754EVM-383 connector functionality and Table 3 describes the test point availability.

Table 2. Connector Functionality

Connector	Label	Description
J1	ADAPTER	External adapter input. J7 (low side) and J8 (high side) can select weather the adapter is at the PD controller input (VDD to VSS) or at the converter input (VDD1 to RTN). J6 is used to select PPD or APD function.
J2	VOUT	Output voltage connector
J3	DATA + PoE POWER	Ethernet power input connector. Contains Ethernet transformer and cable terminations
J4	DATA PORT	Ethernet data port connector
J5	EGND	Earth GND connection

Table 3. Test Points

Test Point	Color	Label	Description
TP3, TP17, TP18	BLK	GND	Secondary side (output) grounds (GND)
TP5	RED	VC	DC/DC converter bias supply
TP6	ORG	DRAIN	Drain terminal of the primary side switching MOSFET
TP10	BLK	VSS	POE input, low side
TP12, TP16	BLK	RTN	DC/DC converter return
TP14	ORG	LOOP	Can be used with TP13 for overall feedback loop measurements.
TP13	RED	VOUT	DC/DC converter output voltage.
TP15	WHT	CTL	Control loop input to the pulse width modulator
TP9	WHT	RCS	DC/DC converter primary side switching MOSFET current sense (resistor side).
TP11	RED	VB	Bias voltage regulator
TP8	WHT	GATE	Gate drive for the primary side switching MOSFET
TP7	WHT	GAT2	Gate drive for the primary side active clamp MOSFET
TP4	RED	PVDD1	Transformer primary high side.
TP23	WHT	T2P	Type 2 PSE output from TPS23754
TP1	WHT	PPD	Connected to PPD pin of TPS23754
TP2	WHT	APD	Connected to APD pin of TPS23754
TP20	RED	P78	Pair 7,8
TP21	ORG	P12	Pair 1,2
TP19	ORG	P45	Pair 4,5
TP22	RED	P36	Pair 3,6
D21	GRN	T2P	Type 2 PSE indicator. Remove the shunt on J9 to inhibit the T2P indicator.
D12	RED	POWER ON	Output power indicator. Remove the shunt on J10 to inhibit the output power indicator.
CL1	N/A	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.

5 Test Setup

Figure 2 shows a typical test setup for TPS23754EVM-383. Input voltage can be applied as described in Table 2.

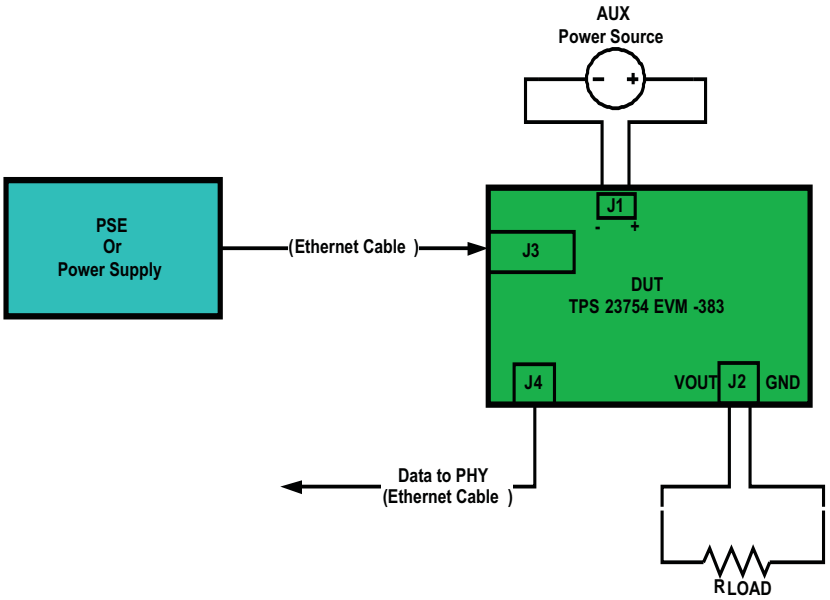

Figure 2. Typical TPS23754EVM-383 Test Setup

6 TPS23754EVM-383 Typical Performance Data

6.1 12V DC/DC Efficiency

Figure 3 illustrates three different 48VDC input efficiency plots:

1. PoE, 48V from J3
2. Converter only 48V
3. Adapter 48V from J1

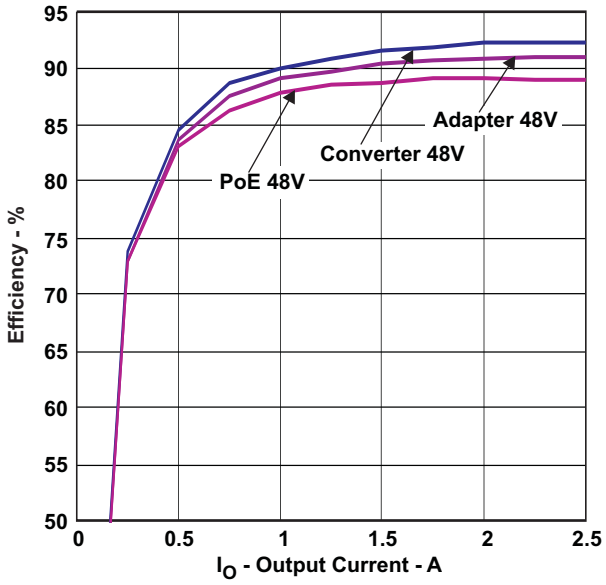

Figure 3. TPS23754EVM-383 Efficiency With 12V Output

6.2 TPS23754EVM-383 Conducted Emissions

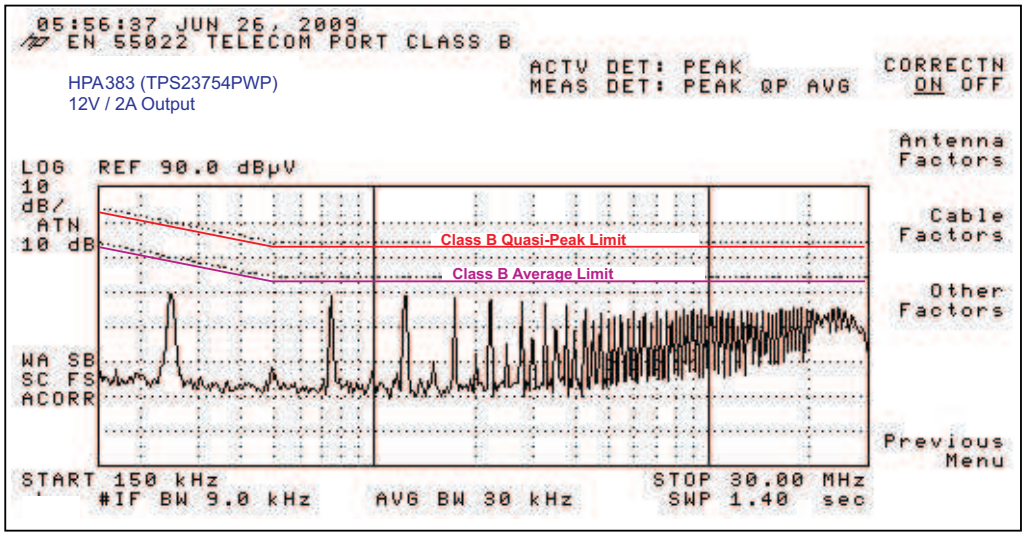

Figure 4. TPS23754EVM-383 Conducted Emissions

7 EVM Assembly Drawings and Layout Guidelines

7.1 PCB Drawings

The following figure shows component placement and layout.

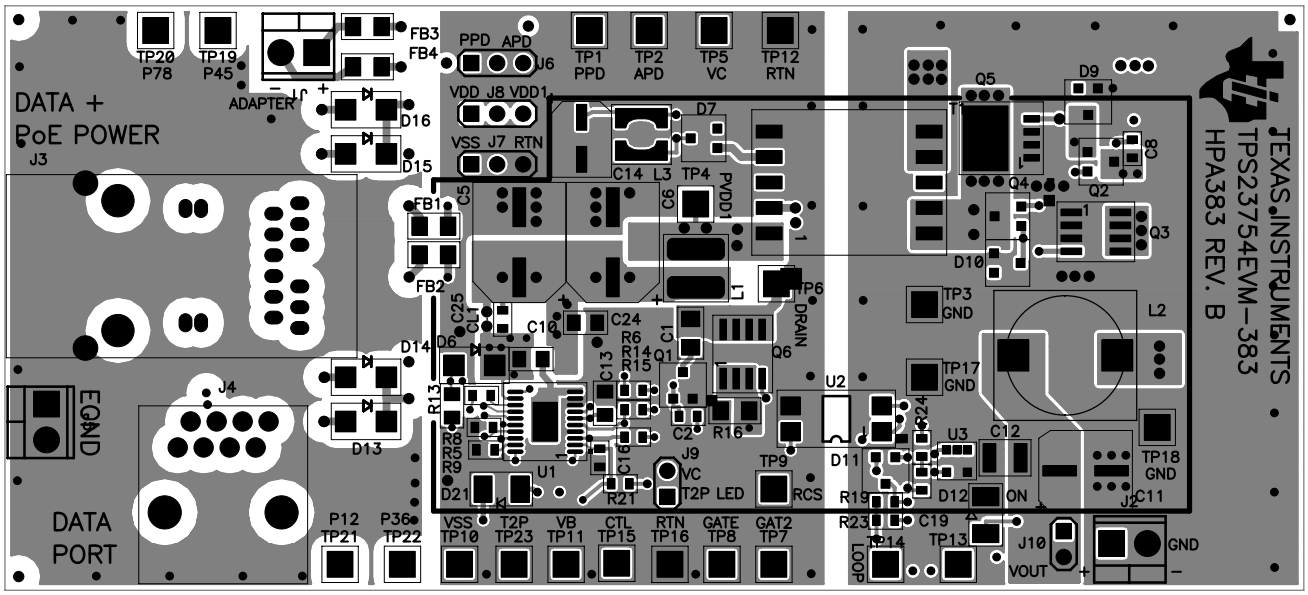

Figure 5. Top Side Layout/Routing

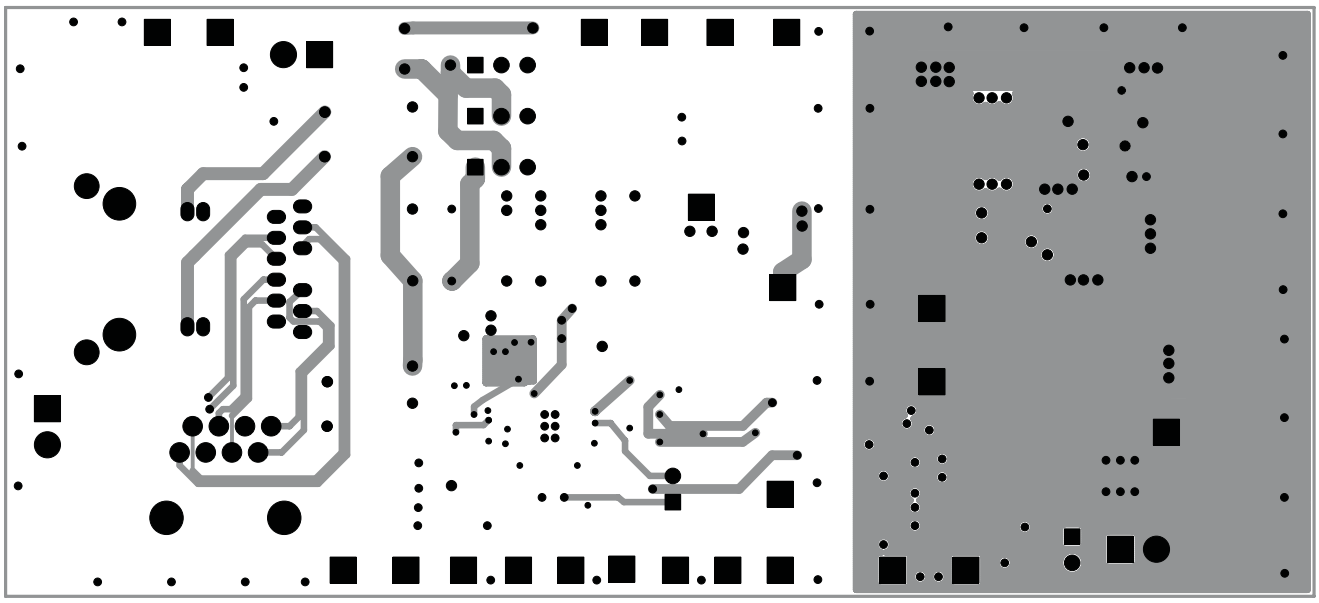

Figure 6. Layer Two Routing

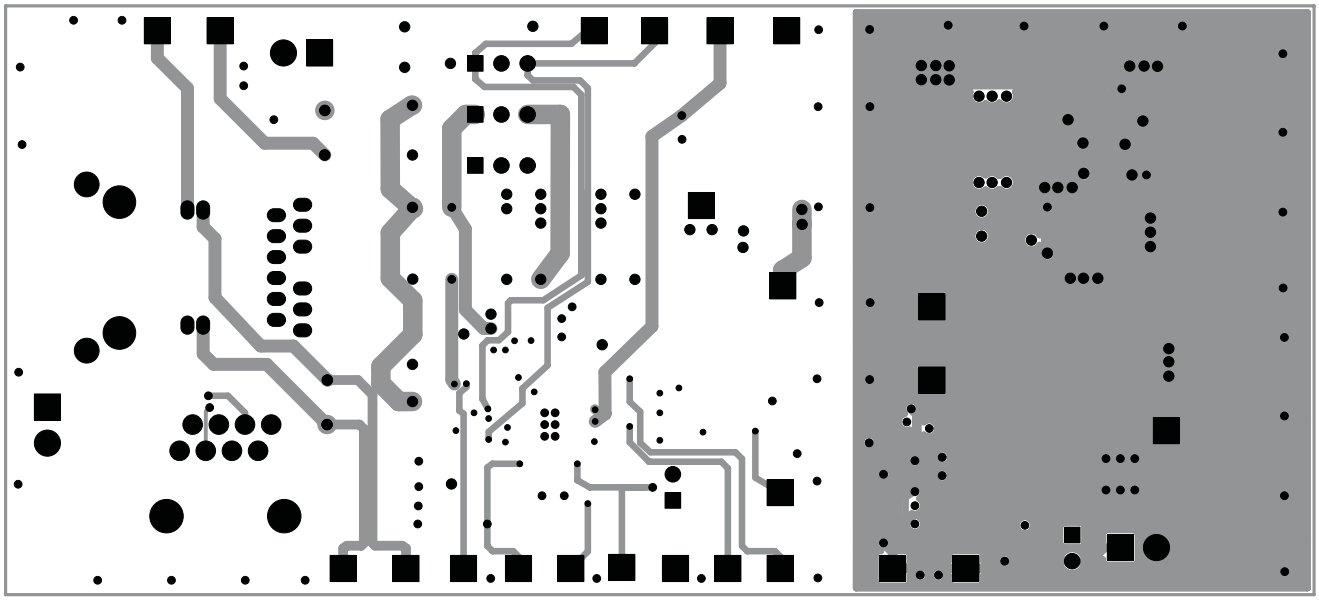

Figure 7. Layer Three Routing

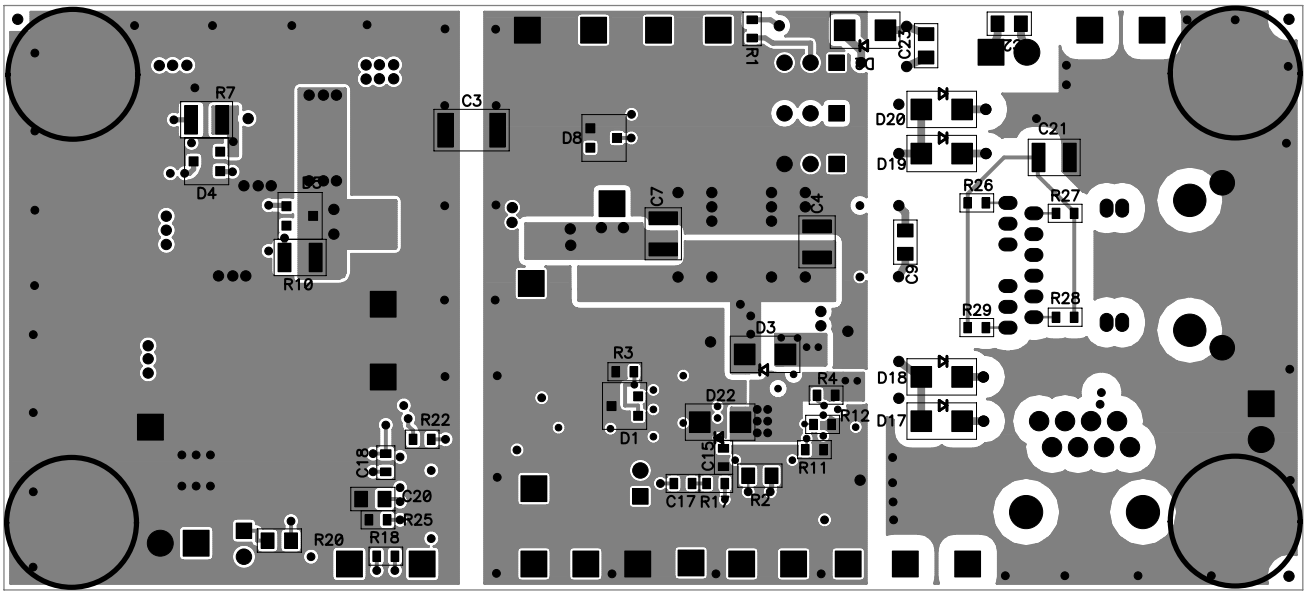

Figure 8. Bottom Side Placement/Routing

7.2 Layout Guidelines

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

- Parts placement must be driven by power flow in a point-to-point manner; RJ-45, Ethernet transformer, diode bridges, TVS and 0.1-µF capacitor, and TPS23754 converter input bulk capacitor.
- 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 TPS23754 should be located over split, local ground planes referenced to VSS for the PoE input and to RTN for the converter. Whereas the PoE side may operate without a ground plane, the converter side must have one. Logic ground and power layers 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.

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 4 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 ohm resistors)
- Maintain physical separation between input-related circuitry and power circuitry (use ferrite beads as boundary line)
- Balance efficiency vs. Acceptable noise margin
- Possible use of common-mode inductors
- Possible use of integrated RJ-45 jacks (shielded with internal transformer and Bob Smith terminations)
- End-product enclosure considerations (shielding)

8 Bill of Materials

Table 4. TPS23754EVM-383 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	0.047 µF	Capacitor, Ceramic, 250V, X7R, 10%	1206	Std	Std
3	C10, C23, C24	0.1 µF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	C11	100 µF	Capacitor, Aluminum, 16V, 20%, FK Series	0.217 × 0.169	EEVFK1C101P	Panasonic
1	C12	22 µF	Capacitor, Ceramic, 16-V, X7R, 20%	1210	C3225X7R1C226MT	TDK
1	C13	1.0 µF	Capacitor, Ceramic, 25V, X7R, 10%	0805	Std	Std
1	C14	22 µF	Capacitor, Aluminum, 25V, 20%	5×5.8mm	EEVFK1E220R	Panasonic
1	C15	47 pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C16	1.0 µF	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
1	C17	22 nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C18	10 pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
1	C19	15 nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C2	1 µF	Capacitor, Ceramic, 16V, X7R, 20%	0603	C1608X7R1C105M	TDK
1	C20	1 µF	Capacitor, Ceramic, 16V, X7R, 10%	0805	Std	Std
1	C21	1000 pF	Capacitor, Ceramic, 2kV, X7R, 10%	1210	Std	TDK
1	C25	10 nF	Capacitor, Ceramic, 100V, X7R, 10%	0603	Std	Std
1	C3	2200 pF	Capacitor, Ceramic, 2KV, X7R, 10%	1812	C4532X7R3D222K	TDK
2	C4, C7	1 µF	Capacitor, Ceramic, 100V, X7R, 10%	1210	Std	Std
2	C5, C6	22 µF	Capacitor, Aluminum, 100V, ±20%	8×10.2mm	EEVFK2A220P	Panasonic
1	C8	100 pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	C1608X7R1H101K	TDK
2	C9, C22	1 nF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
1	CL1	NA	Current Loop, 0.025 holes	0.120 × 0.075 inch	NA	NA
5	D1, D4, D5, D7, D8	BAS16	Diode, Switching, 75V, 200mA	SOT23	BAS16LT1	Vishay-Liteon
1	D11	BAV99	Diode, Dual Ultra Fast, Series, 200-mA, 70-V	SOT23	BAV99	Fairchild
1	D12	RED	Diode, LED, RED, 2.0-V, 850-mcd, SM	1210	LTST-C930KRKT	LITE-ON INC
10	D2, D3, D13–D20	B1100	Diode, Schottky, 1A, 100V	SMA	B1100	Diodes, Inc
1	D21	GREEN	Diode, LED, GRN, 2.0-V, 650-mcd,SM	1210	LTST-C930KGKT	LITE-ON INC
2	D6, D22	SMAJ58A	Diode, TVS, 58-V, 1W	SMA	SMAJ58A	Diodes Inc.
2	D9, D10	12V	Diode, Zener, 12-V	SOT23	BZX84C12LT1	ON Semiconductor
4	FB1–FB4,	500	Bead, Ferrite, 2000mA, 60m-ohm	1206	MI1206L501R-10	Steward
3	J1, J2, J5	ED1514	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 × 0.25	ED1514	OST
1	J3	7499511001	Connector, RJ45, PoE+ Enabled, 1000 Base-T	0.670 x 1.300 inch	7499511001	Wuerth Electronics
1	J4	5556416-1	Connector, Jack Modular, Vertical, Pos.	0.655 × 0.615 inch	5556416-1	AMP

Table 4. TPS23754EVM-383 Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
3	J6–J8	PTC36SAAN	Header, Male 3-pin, 100mil spacing, (36-pin strip)	0.100 inch × 3	PTC36SAAN	Sullins
2	J9, J10	PTC36SAAN	Header, Male 2-pin, 100mil spacing, (36-pin strip)	0.100 inch × 2	PTC36SAAN	Sullins
1	L1	3.3 µH	Inductor, SMT, 2.15A, 35 milliohm or 1.53A, 32 milliohm	5.1×5.1mm	744043003 or MSS5131-332MX	Wurth or Coilcraft
1	L2	22 µH	Inductor, SMT, 4.1A, 43 milliohm or 3.8A, 33 milliohm	0.492 sq"	744770122 or P1173.223T	Wurth or Pulse
1	L3	1 mH	Inductor, SMT, 100mA, 16.3 Ohms	0.169 × 0.169 inch	LPS4414-105MLC	Coilcraft
1	Q1	Si2325DS	MOSFET,P-ch, -150 V, 690-mA, 1.2 Ohms	SOT-23	Si2325DS	Vishay
2	Q2, Q4	MMBTA06	Bipolar, NPN, 80V, 500mA	SOT23	MMBTA06LT1	ON Semiconductor
1	Q3	Si4850EY	MOSFET, Nch, 60V, 8.5A, 22milliohm	SO8	Si4850EY	Vishay
1	Q5	Si7852DP	MOSFET, Nchan, 80V, 12A, 16-milliohm	PWRPAK-S08	Si7852DP	Vishay
1	Q6	Si4848DY	MOSFET, N-ch, 150V, 3.7A, 85 milliohm	SO8	Si4848DY	Vishay
1	R1	100K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	80.6K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R12	63.4K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	63.4	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	R14	10	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R15	1K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R16	0.12	Resistor, Chip, 1/4W, 1%	1206	ERJ-8RQFR12V	Panasonic ECG
1	R17	348	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R18	49.9	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	6.49K	Resistor, Chip, 1/10-W, 1%	0805	Std	Std
1	R20	2.87K	Resistor, Chip, 1/10-W, 1%	0805	Std	Std
1	R21	1.5K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R23	41.2K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R25	11.0K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R26–R29	75	Resistor, Chip, 1/16W, 1%	0603	Std	Std
3	R3, R19, R24	10K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R4	4.02K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R22	2.49K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	8.87K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R7, R10	2K	Resistor, Chip, 1/4W, 5%	1210	Std	Std
1	R8	24.9K	Resistor, Chip, 1/16W, 1%	0603	Std	Std

Table 4. TPS23754EVM-383 Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	R9	69.8K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	T1	750311320 or PA2649NL or 835-01064FC	Transformer, forward, 100 µH, 12V, 2.5A	0.524 × 0.685 inch	750311320 or PA2649NL or 835-01064FC	Wurth or Pulse or E&E Magnetics
7	TP1, TP2, TP7–TP9, TP15, TP23	5012	Test Point, White, Thru Hole	0.125 × 0.125 inch	5012	Keystone
6	TP3, TP10, TP12, TP16–TP18	5011	Test Point, Black, Thru Hole	0.125 × 0.125 inch	5011	Keystone
6	TP4, TP5, TP11, TP13, TP20, TP22	5010	Test Point, Red, Thru Hole	0.125 × 0.125 inch	5010	Keystone
4	TP6, TP14, TP19, TP21	5013	Test Point, Orange, Thru Hole	0.125 × 0.125 inch	5013	Keystone
1	U1	TPS23754PWP	IC, IEEE 802.3at PoE Interface and Isolated Converter Controller	PWP20	TPS23754PWP	TI
1	U2	FOD817AS	IC, Optocoupler, 6-V, 80-160% CTR	SMT-4PDIP	FOD817AS	Fairchild
1	U3	TL431ACDBVR	IC, Shunt Regulator, 2.49-V ref, 36-V, 10-mA, 1%	SOT23-5	TL431ACDBVR	TI
4			Bumpons		2566	SPC
5	—		Shunt, Black	100-mil	929950-00	3M

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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 10 V to 15 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 80°C. The EVM is designed to operate properly with certain components above 80°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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   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.

【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。
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。

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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.

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

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