TPS23785BEVM-522 Evaluation Module

This user's guide describes the TPS23785B evaluation module (TPS23785BEVM-522). TPS23785BEVM-522 contains evaluation and reference circuitry for the TPS23785B. The TPS23785B device is an IEEE 802.3 compliant, powered-device (PD) controller and power supply controller optimized for non-isolated converter topologies. TPS23785BEVM-522 is targeted at a high-efficiency 5.87-W PD solution.

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1 Introduction

The TPS23785BEVM-522 evaluation module (EVM) is a fully assembled and tested circuit for evaluating the TPS23785B high-power, high-efficiency power over Ethernet (PoE) PD and DC-to-DC controller. The TPS23785B is connected to a dual output non-isolated flyback converter capable of outputting 5 V at 580 mA and 3.3 V at 900 mA. The TPS23785B is compliant with the IEEE802.3at PoE standard. The EVM contains header connectors for easy connection to external test and application circuitry.

1.1 Features

- Class 2 PoE applications
- Operates from PoE or auxiliary adapters
- Dual output non-isolated flyback converter (5 V at 580 mA, 3.3 V at 900 mA)

1.2 Applications

- Video and VoIP telephones
- RFID readers
- Security – wired IP cameras
- Wireless access points

2 Electrical Specifications

Table 1. TPS23785BEVM-522 Electrical and Performance Specifications at 25°C

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER INTERFACE					
Input voltage	Applied to the power pins of connector J1	0		57	V
	Applied to the power pins of connector J4	34		57	V
Input UVLO, POE input J1	Rising input voltage			36.1	V
	Falling input voltage	29.14			V
Detection voltage	At device terminals	3		10	V
Classification voltage	At device terminals	13		21	V
Classification current	R_{class} = 137 Ω	17.6		19.4	mA
Inrush current-limit		100		180	mA
Operating current-limit		850		1100	mA
DC/DC CONVERTER					
Output voltage (5 V)	V_{IN} = 48 V, $I_{LOAD} \le I_{LOAD}$ (max)	4.98		4.94	V
Output voltage (3.3 V)	V_{IN} = 48 V, $I_{LOAD} \le I_{LOAD}$ (max)	3.311		3.310	V
Output current (5 V)	34 V ≤ V_{IN} ≤ 57 V			580	mA
Output current (3.3 V)	34 V ≤ V_{IN} ≤ 57 V			900	mA
Switching frequency		250			kHz

3 Description

TPS23785BEVM-522 enables full evaluation of the TPS23785B device. Refer to the schematic in Section 4. Ethernet power is applied from J1 connects to the PoE transformer T1 needed to transfer power/data. Power goes through bridge rectifier; the RC circuits C1, R5, C2, and R6 help balance the Ethernet cable impedance and are critical for ESD and EMI/EMC performance. At the output of the diode bridge is the EMI/EMC filter and transient protection for the TPS23785B.

Input power can also be applied at J4 from a DC source when power at J1 is not present or when the DC-to-DC converter is being evaluated and not the PoE front end.

The TPS23785B (U1) PD and DCDC converter circuitry is shown in Section 4. R33 provides the detection signature and R11 provides the classification (class 2) signature. The switched side of the PD controller is located to the right of U1. The TPS23785B RTN pin provides inrush limited turn on and charge of the bulk capacitor C12.

The DC-to-DC converter is a non-isolated high-efficiency dual-output synchronous flyback converter. The primary (Q3) switching MOSFET is driven from U1 GATE pin and the secondary (Q5 and Q6) switching MOSFET is driven from U1 GATE2 pin.

Output voltage feedback is provided with U2. R20 provides a means for error injection to measure the frequency response of the converter. This feedback circuit drives the U1 CTL pin which provides a voltage proportional to the output load current. As the output load current decreases, the CTL pin voltage decreases.

4 Schematic

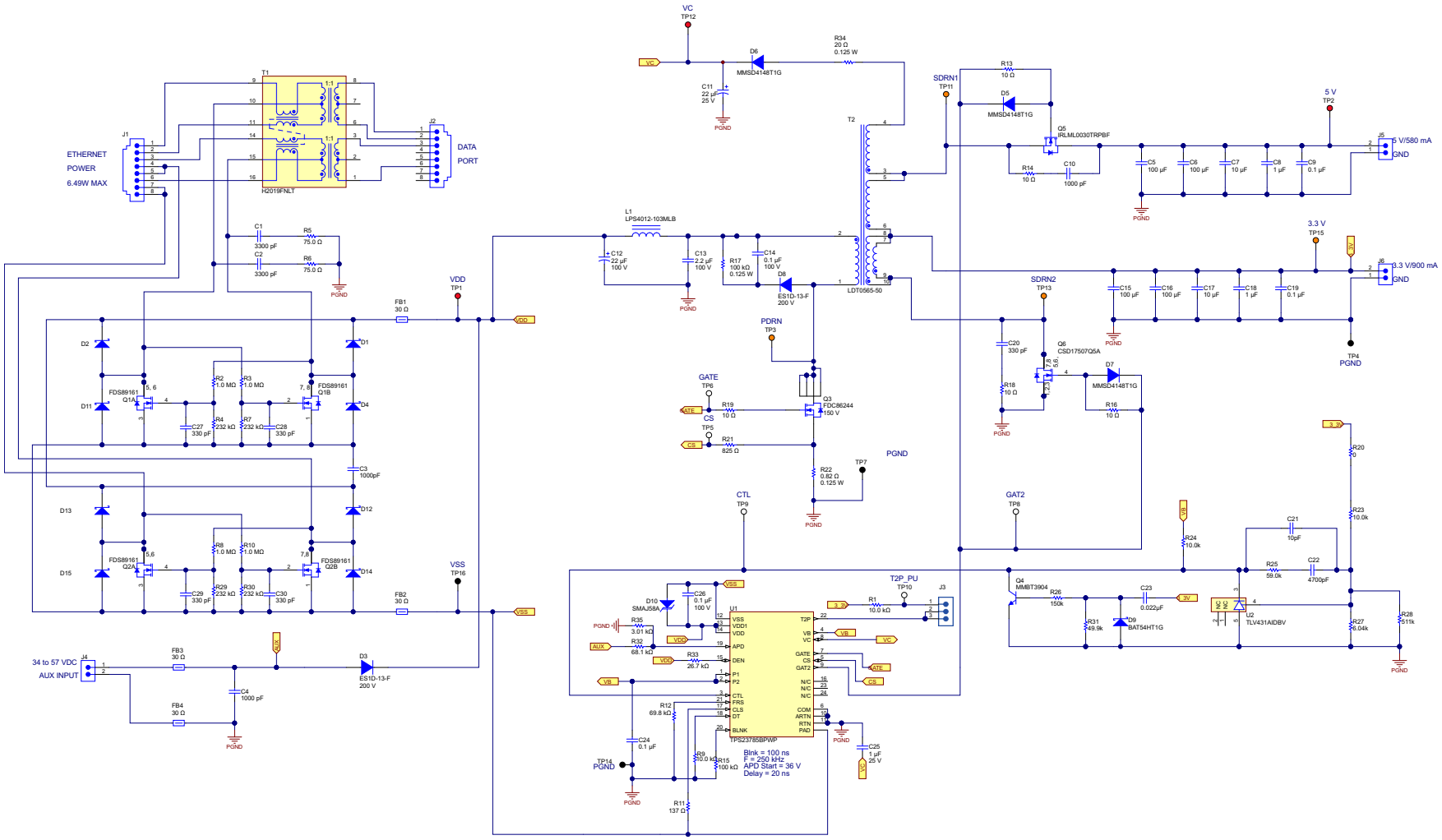

Figure 1. TPS23785BEVM-522 Schematic

5 General Configuration and Description

5.1 Physical Access

Table 2 lists the EVM connector functionality and Table 3 describes the test point availability.

Table 2. Connector Functionality

Connector	Label	Description
J1	PWR+DATA	PoE input. Connect to PSE power and data source.
J2	DATA	Ethernet data passthrough. Connect to downstream Ethernet device.
J3	T2P	Indicated PSE has performed IEEE802.3at type 2 hardware classification.
J4	AUX INPUT	DC-to-DC converter input bypassing the PoE front end. Connect a 34- to 57-V DC power supply if there is no J1 connection to power the converter.
J5	5V VOUT	5-V regulated output
J6	3.3V VOUT	3.3-V regulated output

Table 3. Test Points

Test Point	Color	Label	Description
TP1	RED	VDD	Input voltage
TP2	RED	5V	5-V regulated output
TP3	ORANGE	PDRN	Main FET drain voltage
TP4, TP7, TP14	BLACK	PGND	Converter ground
TP5	WHITE	CS	Current sense voltage
TP6	WHITE	GATE	Main gate voltage
TP8	WHITE	GAT2	Synchronous gate voltage
TP9	WHITE	CTL	Control voltage
TP10	WHITE	T2P_PU	T2P pullup voltage
TP11	ORANGE	SDRN1	5-V synchronous FET source voltage
TP12	RED	VC	Converter bias voltage
TP13	ORANGE	SDRN2	3.3-V synchronous FET drain voltage
TP15	ORANGE	3.3V	3.3-V regulated output
TP16	BLACK	VSS	PoE input return voltage

5.2 Test Setup

Figure 2 shows the typical test setup for the EVM.

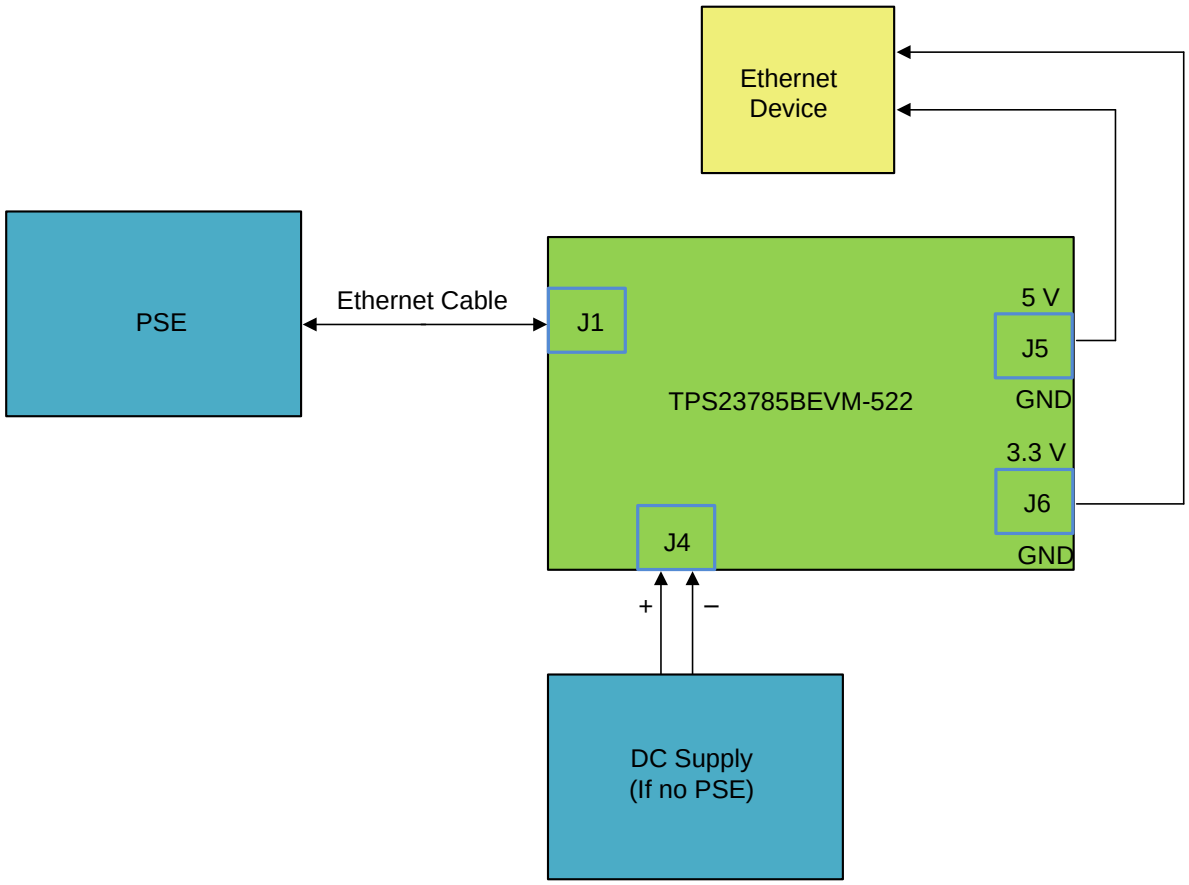

Figure 2. Typical TPS23785BEVM-522 Test Setup

6 TPS23785BEVM-522 Performance Data

6.1 Startup

Figure 3 shows the startup response of the TPS23785BEVM-522.

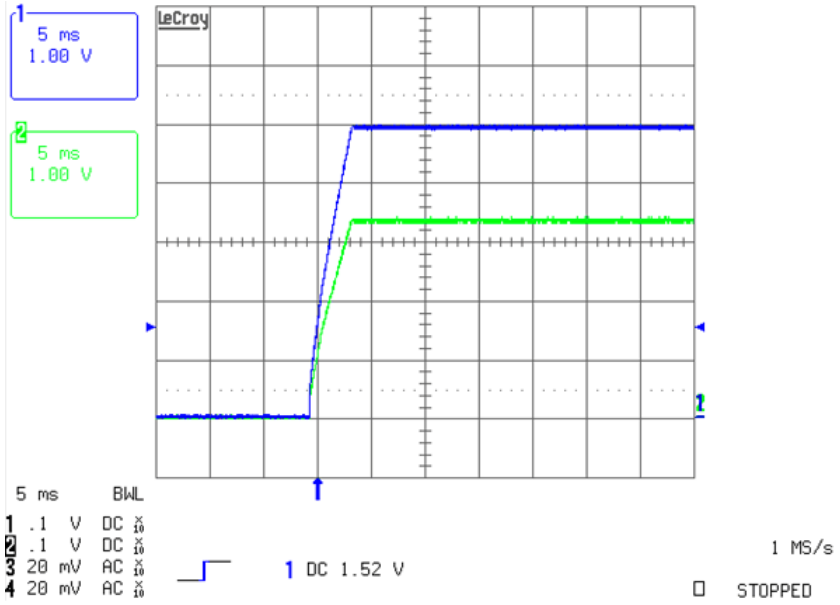

Figure 3. Startup Response to Full Load for a 48-V Input

6.2 Transient Response

Figure 4 and Figure 5 show the transient response of the TPS23785BEVM-522.

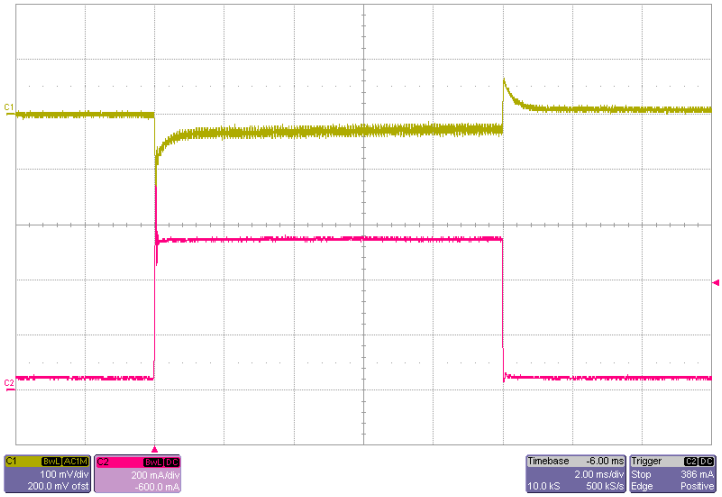

Figure 4. Transient Response of 5-V Output from 58 to 580 mA for a 48-V Input

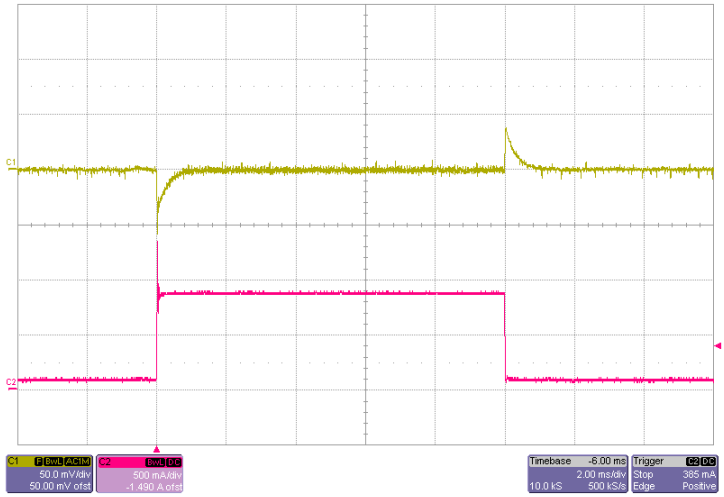

Figure 5. Transient Response of 3.3-V Output from 90 to 900 mA for a 48-V Input

6.3 Efficiency

Table 4 shows the efficiency of the TPS23785BEVM-522

Table 4. Efficiency of the TPS23785BEVM-522

Iout 3.3 V	Iout 5 V	Vout 3.3	Vout 5 V	Pout	Vin (PoE)	Vin (Converter)	Iin	Pin PoE	Pin Converter	Efficiency PoE	Efficiency Converter
1.021	0.601	3.315	4.96	6.365575	48	47.3	0.146	7.008	6.9058	90.8%	92.2%
1.021	0.283	3.315	4.981	4.794238	48	47.4	0.109	5.232	5.1666	91.6%	92.8%
1.02	0	3.315	5.002	3.3813	48	47.4	0.079	3.792	3.7446	89.2%	90.3%
0.465	0.595	3.315	4.949	4.48613	48	47.5	0.103	4.944	4.8925	90.7%	91.7%
0.465	0.281	3.315	4.972	2.938607	48	47.4	0.069	3.312	3.2706	88.7%	89.8%
0.465	0	3.315	4.993	1.541475	48	47.5	0.039	1.872	1.8525	82.3%	83.2%
0	0.592	3.315	4.942	2.925664	48	47.4	0.069	3.312	3.2706	88.3%	89.5%
0	0.281	3.316	4.965	1.395165	48	47.5	0.036	1.728	1.71	80.7%	81.6%
Iout 3.3V	**Iout 5V**	**Vout 3.3**	**Vout 5V**	**Pout**	**Vin (PoE)**	**Vin (Converter)**	**Iin**	**Pin PoE**	**Pin Converter**	**Efficiency PoE**	**Efficiency Converter**
1.026	0.601	3.315	4.953	6.377943	36	35.22	0.199	7.164	7.00878	89.0%	91.0%
1.025	0.287	3.315	4.98	4.827135	36	35.32	0.148	5.328	5.22736	90.6%	92.3%
1.027	0	3.315	5.004	3.404505	36	35.4	0.105	3.78	3.717	90.1%	91.6%
0.466	0.612	3.315	4.941	4.568682	36	35.33	0.141	5.076	4.98153	90.0%	91.7%
0.466	0.286	3.315	4.968	2.965638	36	35.43	0.092	3.312	3.25956	89.5%	91.0%
0.466	0	3.315	4.994	1.54479	36	35.53	0.051	1.836	1.81203	84.1%	85.3%
0	0.616	3.315	4.932	3.038112	36	35.43	0.093	3.348	3.29499	90.7%	92.2%
0	0.281	3.315	4.96	1.39376	36	35.54	0.047	1.692	1.67038	82.4%	83.4%
Iout 3.3V	**Iout 5V**	**Vout 3.3**	**Vout 5V**	**Pout**	**Vin (PoE)**	**Vin (Converter)**	**Iin**	**Pin PoE**	**Pin Converter**	**Efficiency PoE**	**Efficiency Converter**
1.023	0.614	3.315	4.961	6.437299	57	56.4	0.123	7.011	6.9372	91.8%	92.8%
1.024	0.287	3.315	4.982	4.824394	57	56.4	0.093	5.301	5.2452	91.0%	92.0%
1.022	0	3.315	5.002	3.38793	57	56.5	0.067	3.819	3.7855	88.7%	89.5%
0.465	0.63	3.315	4.95	4.659975	57	56.4	0.09	5.13	5.076	90.8%	91.8%
0.466	0.279	3.315	4.974	2.932536	57	56.5	0.058	3.306	3.277	88.7%	89.5%
0.466	0	3.315	4.992	1.54479	57	56.6	0.034	1.938	1.9244	79.7%	80.3%
0	0.635	3.315	4.943	3.138805	57	56.5	0.062	3.534	3.503	88.8%	89.6%
0	0.277	3.315	4.966	1.375582	57	56.6	0.03	1.71	1.698	80.4%	81.0%

7 EVM Assembly Drawing and Layout Guidelines

7.1 PCB Drawings

Figure 6 to Figure 11 show component placement and layout of the TPS23785BEVM-522.

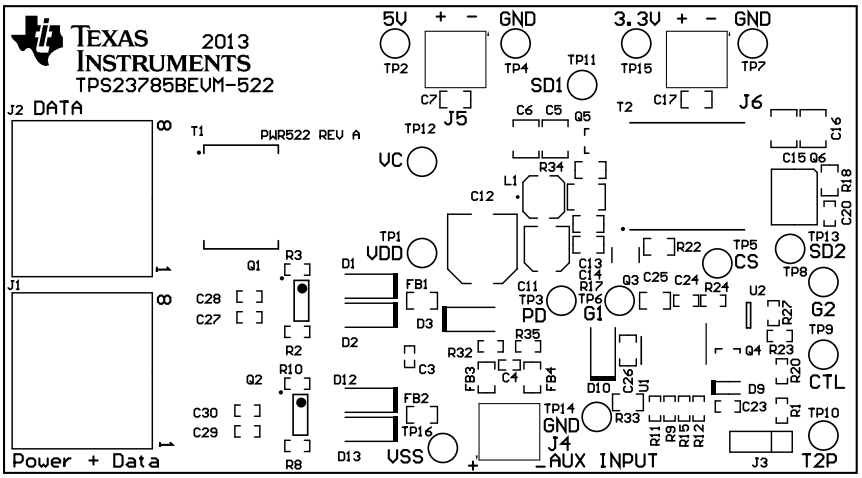

Figure 6. Top Side Component Placement

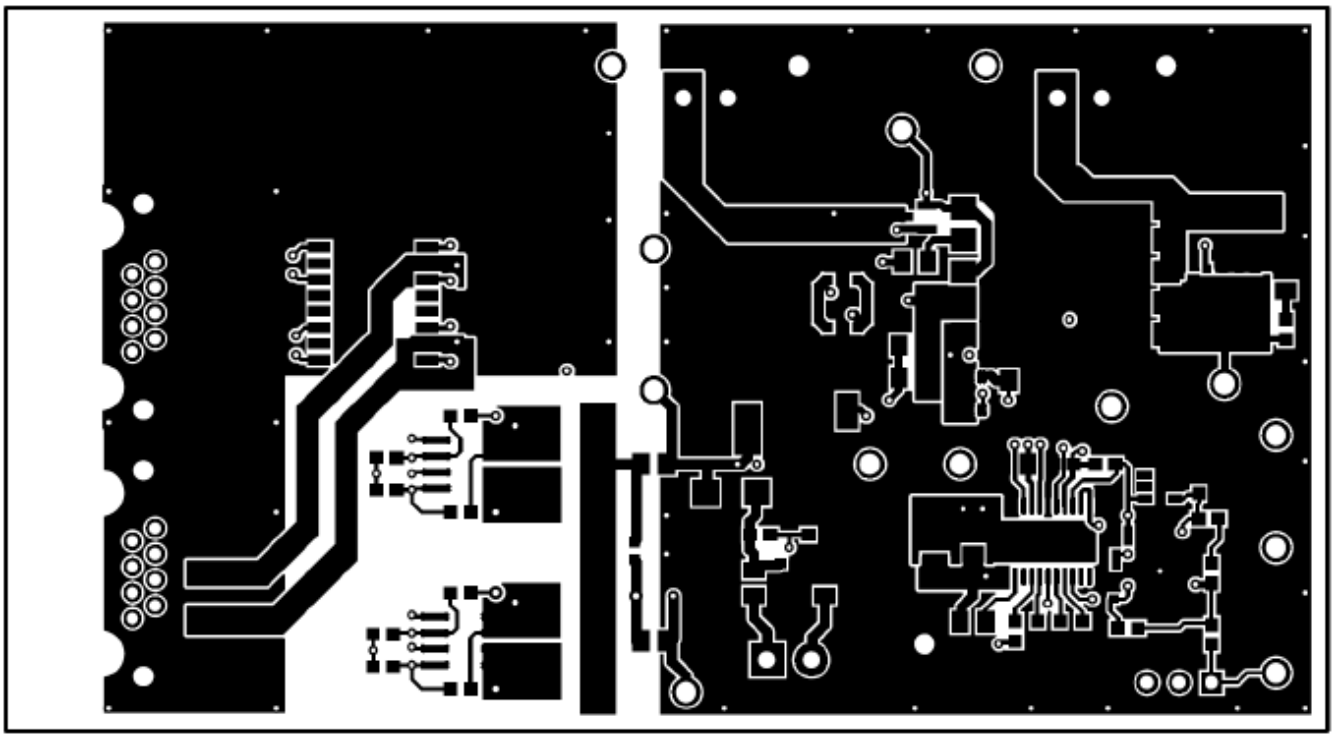

Figure 7. Top Side Routing

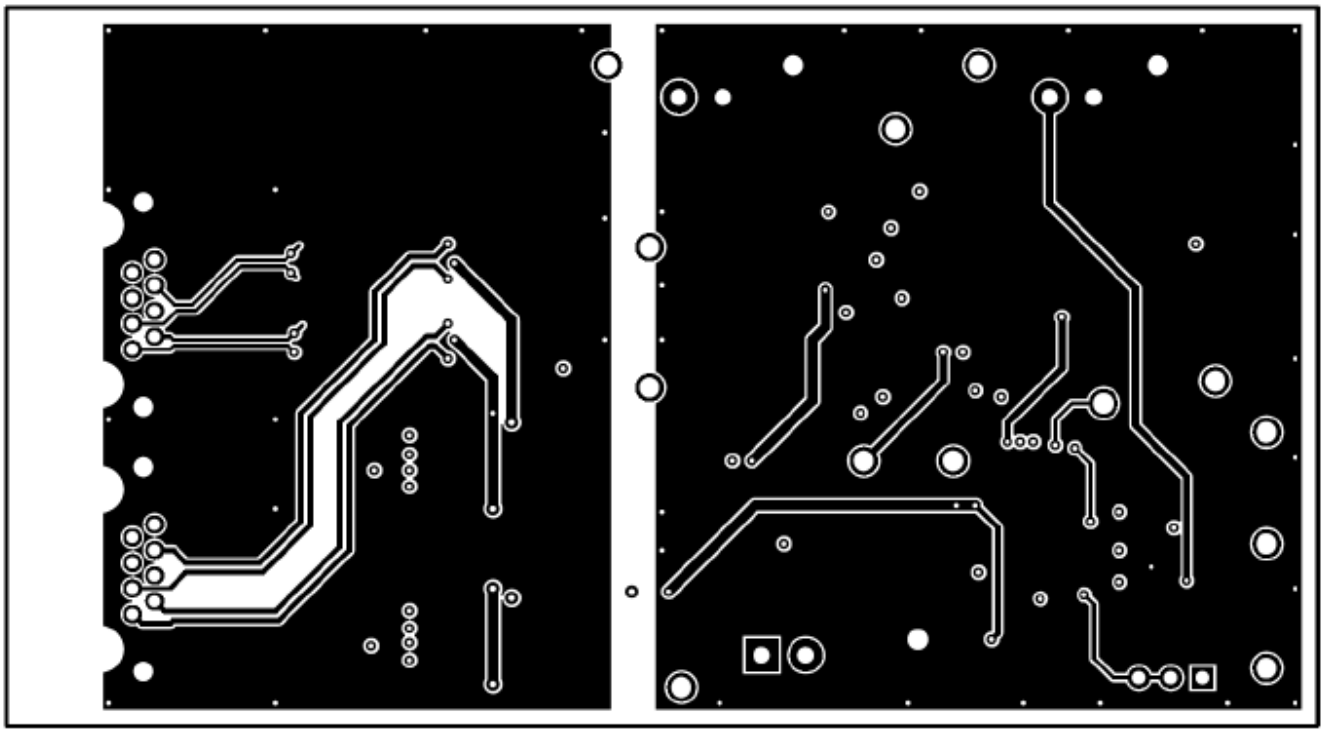

Figure 8. Layer 2 Routing

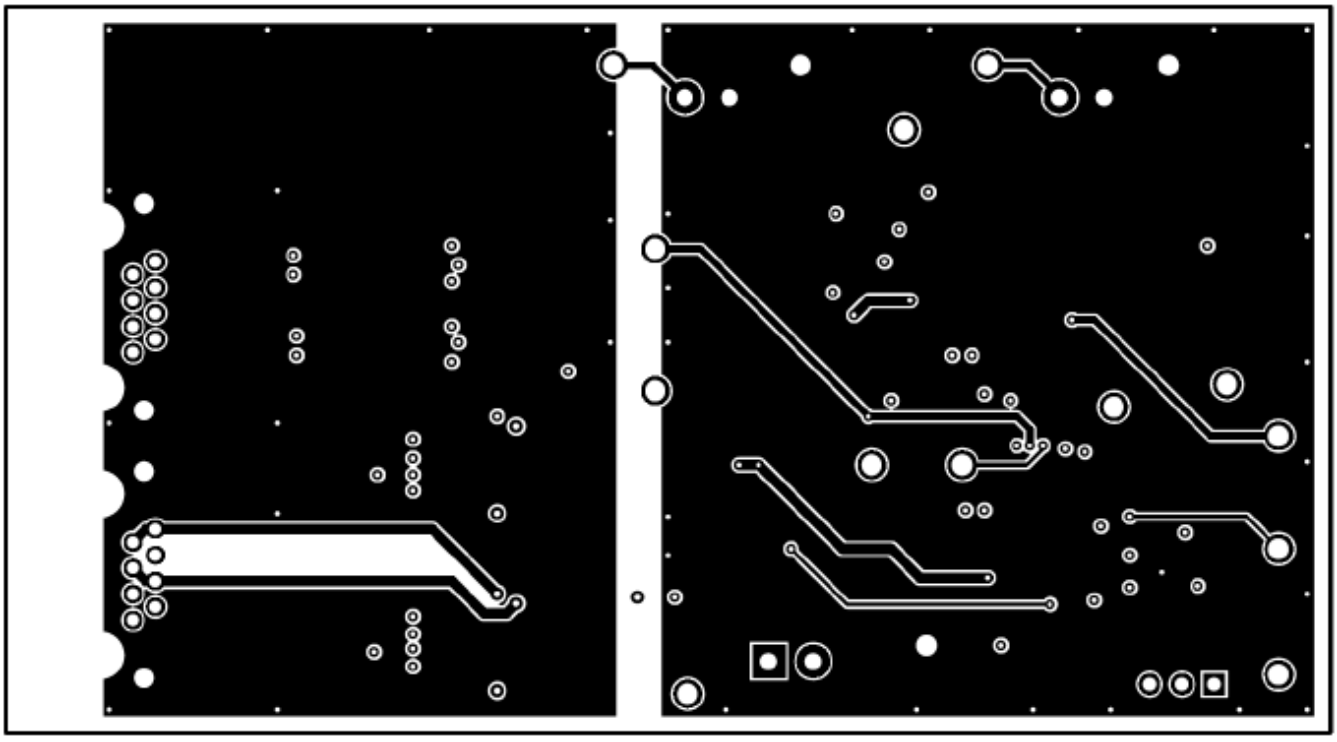

Figure 9. Layer 3 Routing

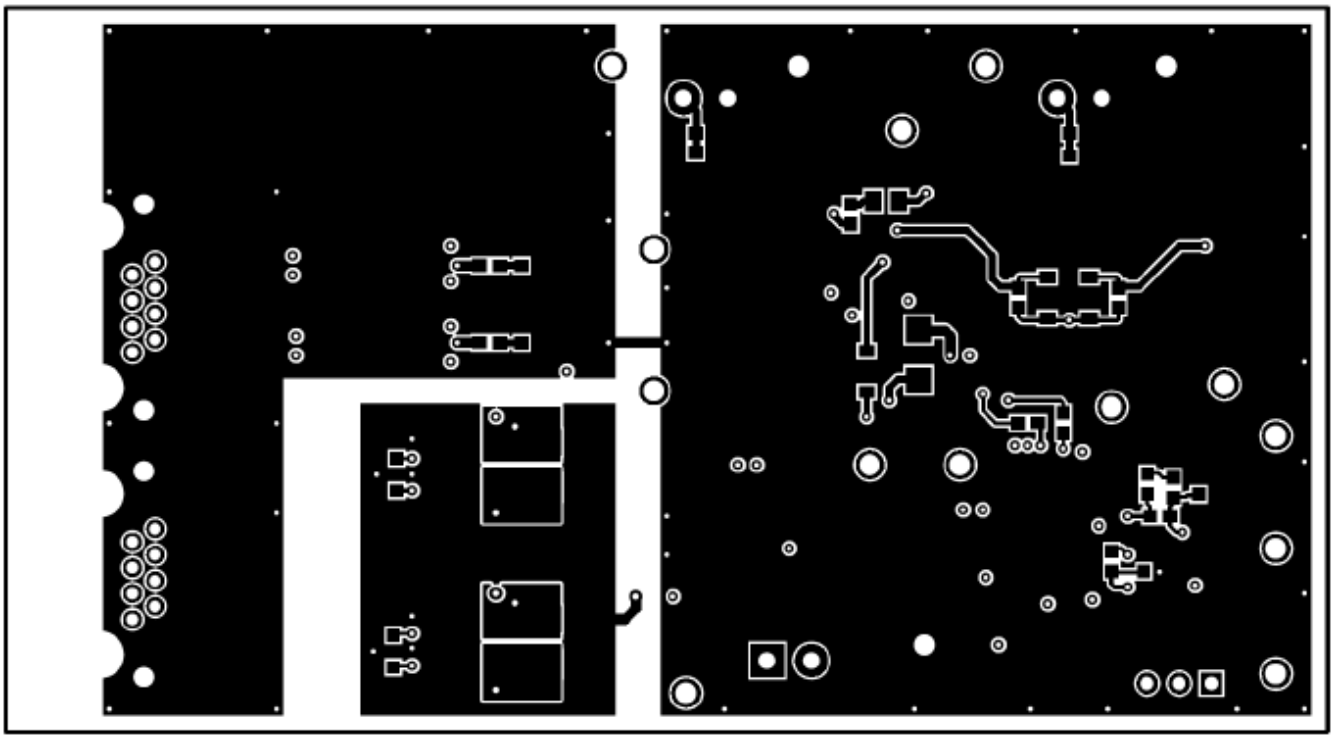

Figure 10. Bottom Side Routing

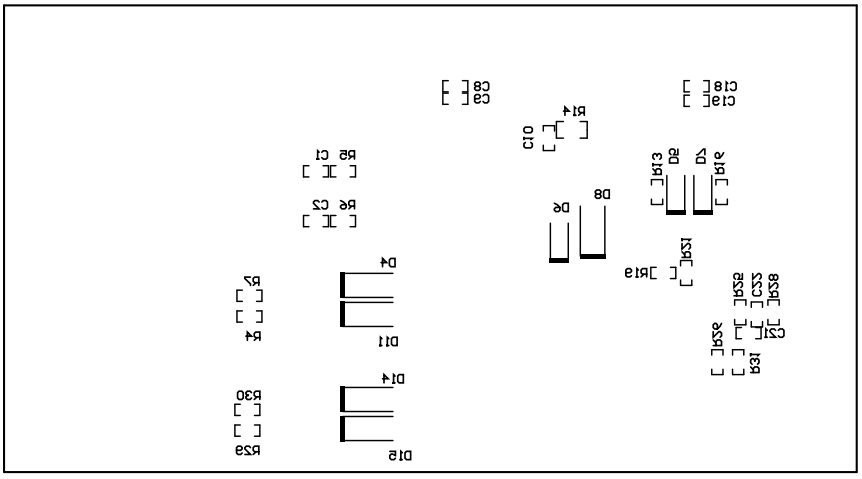

Figure 11. Bottom Component Placement

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 TPS23785B converter input bulk capacitor.
- Make all leads as short as possible with wide power traces and paired signal and return.
- No crossovers of signals from one part of the flow to another are allowed.
- Place the TPS23785B 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. Do not place logic ground and power layers under the Ethernet input.
- Use large copper fills and traces on SMT power-dissipating devices, and use wide traces or overlay copper fills in the power path.

The DC-to-DC converter layout benefits from basic recommendations 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.

7.3 EMI Containment

- Use compact loops for dv/dt and di/dt circuit paths (power loops and gate drives).
- Use minimal, yet thermally adequate, copper areas for heat sinking of components tied to switching nodes (minimize exposed radiating surface).
- Use copper ground planes (possible stitching) and top-layer copper floods (surround circuitry with ground floods).
- Use a 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.
- Use LC filter at DC-to-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
- Observe the polarity dot on inductors (embed noisy end)
- Use of ferrite beads on input (allow for possible use of beads or 0-Ω resistors).
- Maintain physical separation between input-related circuitry and power circuitry (use ferrite beads as boundary line).
- Balance efficiency versus acceptable noise margin.
- Possible use of common-mode inductors
- Possible use of integrated RJ-45 jacks (shielded with internal transformer and Bob Smith terminations)
- End-product enclosure considerations (shielding)

8 Bill of Materials

Table 5. TPS23785BEVM-522 BOM[(1)]

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		PWR522	Any	–	–
C1, C2	2	3300pF	CAP, CERM, 3300pF, 100V, ±5%, X7R, 0603	0603	06031C332JAT2A	AVX		
C3, C4	2	1000pF	CAP, CERM, 1000pF, 100V, ±5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C5, C6, C15, C16	4	100uF	CAP, CERM, 100uF, 6.3V, ±20%, X5R, 1210	1210	C1210C107M9PACTU	Kemet		
C7, C17	2	10uF	CAP, CERM, 10uF, 10V, ±10%, X5R, 0805	0805	C0805C106K8PACTU	Kemet		
C8, C18	2	1uF	CAP, CERM, 1uF, 10V, ±10%, X5R, 0603	0603	C0603C105K8PACTU	Kemet		
C9, C19, C24	3	0.1uF	CAP, CERM, 0.1uF, 50V, ±10%, X7R, 0603	0603	06035C104KAT2A	AVX		
C10	1	1000pF	CAP, CERM, 1000pF, 50V, ±10%, X7R, 0603	0603	C1608X7R1H102K	TDK		
C11	1	22uF	CAP, AL, 22uF, 25V, ±20%, 0.7 ohm, SMD	SMT Radial C	EEE-FK1E220R	Panasonic		
C12	1	22uF	CAP, AL, 22uF, 100V, ±20%, 1.3 ohm, SMD	SMT Radial F	EEE-FK2A220P	Panasonic		
C13	1	2.2uF	CAP, CERM, 2.2uF, 100V, ±10%, X7R, 1210	1210	GRM32ER72A225KA35L	MuRata		
C14, C26	2	0.1uF	CAP, CERM, 0.1uF, 100V, ±10%, X7R, 0805	0805	C2012X7R2A104K	TDK		
C20	1	330pF	CAP, CERM, 330pF, 100V, ±5%, X7R, 0603	0603	06031C331JAT2A	AVX		
C21	1	10pF	CAP, CERM, 10pF, 50V, ±5%, C0G/NP0, 0603	0603	06035A100JAT2A	AVX		
C22	1	4700pF	CAP, CERM, 4700pF, 100V, ±5%, X7R, 0603	0603	06031C472JAT2A	AVX		
C23	1	0.022uF	CAP, CERM, 0.022uF, 25V, ±10%, X7R, 0603	0603	C0603C223K3RACTU	Kemet		
C25	1	1uF	CAP, CERM, 1uF, 25V, ±10%, X5R, 0805	0805	C2012X5R1E105K	TDK		
C27, C28, C29, C30	4	330pF	CAP, CERM, 330pF, 100V, ±10%, X7R, 0603	0603	06031C331KAT2A	AVX	–	–
D1, D2, D4, D11, D12, D13, D14, D15	8	0.79V	Diode, Schottky, 100V, 1A, SMA	SMA	B1100-13-F	Diodes Inc.	Equivalent	Any
D3, D8	2	200V	Diode, Ultrafast, 200V, 1A, SMA	SMA	ES1D-13-F	Diodes Inc.		
D5, D6, D7	3	100V	Diode, Switching, 100V, 0.2A, SOD-123	SOD-123	MMSD4148T1G	ON Semiconductor		
D9	1	30V	Diode, Schottky, 30V, 0.2A, SOD-323	SOD-323	BAT54HT1G	ON Semiconductor		
D10	1	58V	Diode, TVS, Uni, 58V, 400W, SMA	SMA	SMAJ58A	Littelfuse		
FB1, FB2, FB3, FB4	4	30 ohm	1.5A Ferrite Bead, 30 ohm at 100MHz, SMD	0805	MMZ2012R300A	TDK		
J1, J2	2		RJ-45, Right Angle, No LED, tab up	RJ-45 Jack	1-406541-1	AMP		

(1) Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

Table 5. TPS23785BEVM-522 BOM[(1)] (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
J3	1	1x3	Header, TH, 100mil, 1x3, Gold plated, 230 mil above insulator	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions	Equivalent	Any
J4, J5, J6	3		Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology, Inc.		
L1	1	10uH	Inductor, Shielded Drum Core, Ferrite, 10uH, 0.75A, 0.35 ohm, SMD	LPS4012	LPS4012-103MLB	Coilcraft		
Q1, Q2	2		Dual N-Channel MOSFET	SO-8	FDS89161	Fairchild		
Q3	1	150V	MOSFET, N-CH, 150V, 2.3A, SuperSOT-6	SuperSOT-6	FDC86244	Fairchild Semiconductor		None
Q4	1	0.2V	Transistor, NPN, 40V, 0.2A, SOT-23	SOT-23	MMBT3904	Fairchild Semiconductor		
Q5	1	30V	MOSFET, N-CH, 30V, 5.3A, SOT-23	SOT-23	IRLML0030TRPBF	International Rectifier		None
Q6	1	30V	MOSFET, N-CH, 30V, 65A, SON 5x6mm	SON 5x6mm	CSD17507Q5A	Texas Instruments	None	None
R1, R9, R23, R24	4	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R2, R3, R8, R10	4	1.0Meg	RES, 1.0Meg ohm, 5%, 0.1W, 0603	0603	CRCW06031M00JNEA	Vishay-Dale		
R4, R7, R29, R30	4	232k	RES, 232k ohm, 1%, 0.1W, 0603	0603	CRCW0603232KFKEA	Vishay-Dale		
R5, R6	2	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale	Equivalent	Any
R11	1	137	RES, 137 ohm, 1%, 0.1W, 0603	0603	CRCW0603137RFKEA	Vishay-Dale		
R12	1	69.8k	RES, 69.8k ohm, 1%, 0.1W, 0603	0603	CRCW060369K8FKEA	Vishay-Dale		
R13, R16, R19	3	10	RES, 10 ohm, 5%, 0.1W, 0603	0603	CRCW060310R0JNEA	Vishay-Dale		
R14, R18	2	10	RES, 10 ohm, 5%, 0.125W, 0805	0805	CRCW080510R0JNEA	Vishay-Dale		
R15	1	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale	Equivalent	Any
R17	1	100k	RES, 100k ohm, 1%, 0.125W, 0805	0805	CRCW0805100KFKEA	Vishay-Dale		
R20	1	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic		
R21	1	825	RES, 825 ohm, 1%, 0.1W, 0603	0603	CRCW0603825RFKEA	Vishay-Dale		
R22	1	0.82	RES, 0.82 ohm, 1%, 0.125W, 0805	0805	ERJ-6RQFR82V	Panasonic		
R25	1	59.0k	RES, 59.0k ohm, 1%, 0.1W, 0603	0603	CRCW060359K0FKEA	Vishay-Dale		
R26	1	150k	RES, 150k ohm, 1%, 0.1W, 0603	0603	CRCW0603150KFKEA	Vishay-Dale		
R27	1	6.04k	RES, 6.04k ohm, 1%, 0.1W, 0603	0603	CRCW06036K04FKEA	Vishay-Dale		
R28	1	511k	RES, 511k ohm, 1%, 0.1W, 0603	0603	CRCW0603511KFKEA	Vishay-Dale		
R31	1	49.9k	RES, 49.9k ohm, 1%, 0.1W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale		

Table 5. TPS23785BEVM-522 BOM[(1)] (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R32	1	68.1k	RES, 68.1k ohm, 1%, 0.1W, 0603	0603	CRCW060368K1FKEA	Vishay-Dale		
R33	1	26.7k	RES, 26.7k ohm, 1%, 0.125W, 0805	0805	CRCW080526K7FKEA	Vishay-Dale		
R34	1	20	RES, 20 ohm, 5%, 0.125W, 0805	0805	CRCW080520R0JNEA	Vishay-Dale		
R35	1	3.01k	RES, 3.01k ohm, 1%, 0.1W, 0603	0603	CRCW06033K01FKEA	Vishay-Dale		
T1	1	350uH	Transformer, 350uH, SMT	358x236x500mil	H2019FNLT	Pulse Engineering		
T2	1	240uH	Driver Transformer, 240uH, SMT	13.1x13x14mm	LDT0565-50	Linkcom Manufacturing Co.		
TP1, TP2, TP12	3	Red	Test Point, TH, Multipurpose, Red	Keystone5010	5010	Keystone	Equivalent	Any
TP3, TP11, TP13, TP15	4	Orange	Test Point, TH, Multipurpose, Orange	Keystone5013	5013	Keystone	Equivalent	Any
TP4, TP7, TP14, TP16	4	Black	Test Point, TH, Multipurpose, Black	Keystone5011	5011	Keystone	Equivalent	Any
TP5, TP6, TP8, TP9, TP10	5	White	Test Point, TH, Multipurpose, White	Keystone5012	5012	Keystone	Equivalent	Any
U1	1		High-Power, High-Efficiency PoE PD and DC-to-DC Controller, PWP0024B	PWP0024B	TPS23785BPWP	Texas Instruments		None
U2	1		LOW-VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR, DBV0005A	DBV0005A	TLV431AIDBV	Texas Instruments		None
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		

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9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable 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 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using EVMs' schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs 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.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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 its own expense.

FCC Interference Statement for Class B EVM devices

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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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

Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

http://www.tij.co.jp

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