

TPS2372-4EVM-006 Evaluation Module

This user's guide describes the TPS2372-4 evaluation module (TPS2372-4EVM-006). The TPS2372-4EVM-006 contains evaluation and reference circuitry for the TPS2372-4. The TPS2372-4 device is an IEEE 802.3bt compliant, powered-device (PD) controller optimized for high power, power-over-Ethernet (PoE) PD applications such as LED lighting and high-power module applications.

Contents

1	Introduction	2
	1.1 Features	2
	1.2 Applications	2
2	Electrical Specifications	2
3	Description	2
4	Schematic	3
5	General Configuration and Description	5
	5.1 Physical Access	5
6	TPS2372-4EVM-006 Performance Data	6
7	EVM Assembly Drawing and Layout Guidelines	8
	7.1 PCB Drawings	8
	7.2 Layout Guidelines	11
	7.3 EMI Containment	12
8	Bill of Material	13

List of Figures

1	TPS2372-4EVM-006 Front End Interface Schematic	3
2	TPS2372-4EVM-006 PD Controller Schematic	4
3	Startup using .bt PSE and Autoclass Enabled	6
4	PD Startup With Delay	6
5	Current-Limit Protection Performance	6
6	Auto MPS	7
7	Top Side Component Placement	8
8	Top Side Routing	8
9	Layer 2 Routing	9
10	Layer 3 Routing	9
11	Bottom Side Routing	10
12	Bottom Component Placement	10

List of Tables

1	TPS2372-4EVM-006 Electrical and Performance Specifications at 25°C	2
2	Connector Functionality	5
3	Test Points	5
4	TPS2372-4EVM-006 BOM	13

1 Introduction

The TPS2372-4EVM-006 allows reference circuitry evaluation of the TPS2372-4. It contains input and output power connectors and an array of on-board test points for circuit evaluation.

1.1 Features

The TPS2372-4EVM-006 features include:

- High-power PoE
- Selectable classification
- Adjustable auto MPS
- Gigabit Ethernet pass-through interface

1.2 Applications

The TPS2372-4EVM-006 can be used in the following applications:

- Power-over-Ethernet (PoE) lighting
- Internet of Things (IoT)
- PoE modules

2 Electrical Specifications

[Table 1](#) lists the EVM electrical specifications.

Table 1. TPS2372-4EVM-006 Electrical and Performance Specifications at 25°C

Parameter	Test Conditions	Min	Typ	Max	Unit
Power Interface					
Input voltage	Applied to the power pins of connectors J2 or J4	0		57	V
Input UVLO, PoE input J1	Rising input voltage			36	V
	Falling input voltage	30			V
Detection voltage	At device terminals	3		10	V
Classification voltage	At device terminals	10		23	V
Classification current	RclassA = 63.4 Ω	38		42	mA
	RclassB = 90.9 Ω	26.5		29.3	mA
Inrush current-limit		275		395	mA
Operating current-limit		1.9		2.5	A
Adatper voltage		42.5		57	V

3 Description

The TPS2372-4EVM-006 enables full evaluation of the TPS2372-4 device, see the schematic in [Figure 1](#). Ethernet power is applied from J1 and is dropped to the FET bridge rectifier. At the output of the FET bridge is the EMI/EMC filter and transient protection for the TPS2372-4.

Input power can also be applied at J3 from a DC source when power at J1 is not present.

The TPS2372-4 (U1) PD controller is shown in [Figure 1](#). R23 provides the detection signature. To the right of U2 is the switched side of the PD controller. The TPS2372-4 RTN pin provides inrush limited turn on and the charge of the bulk capacitor C11.

4 Schematic

Figure 1 and Figure 2 illustrate the TPS2372-4EVM-006 schematics.

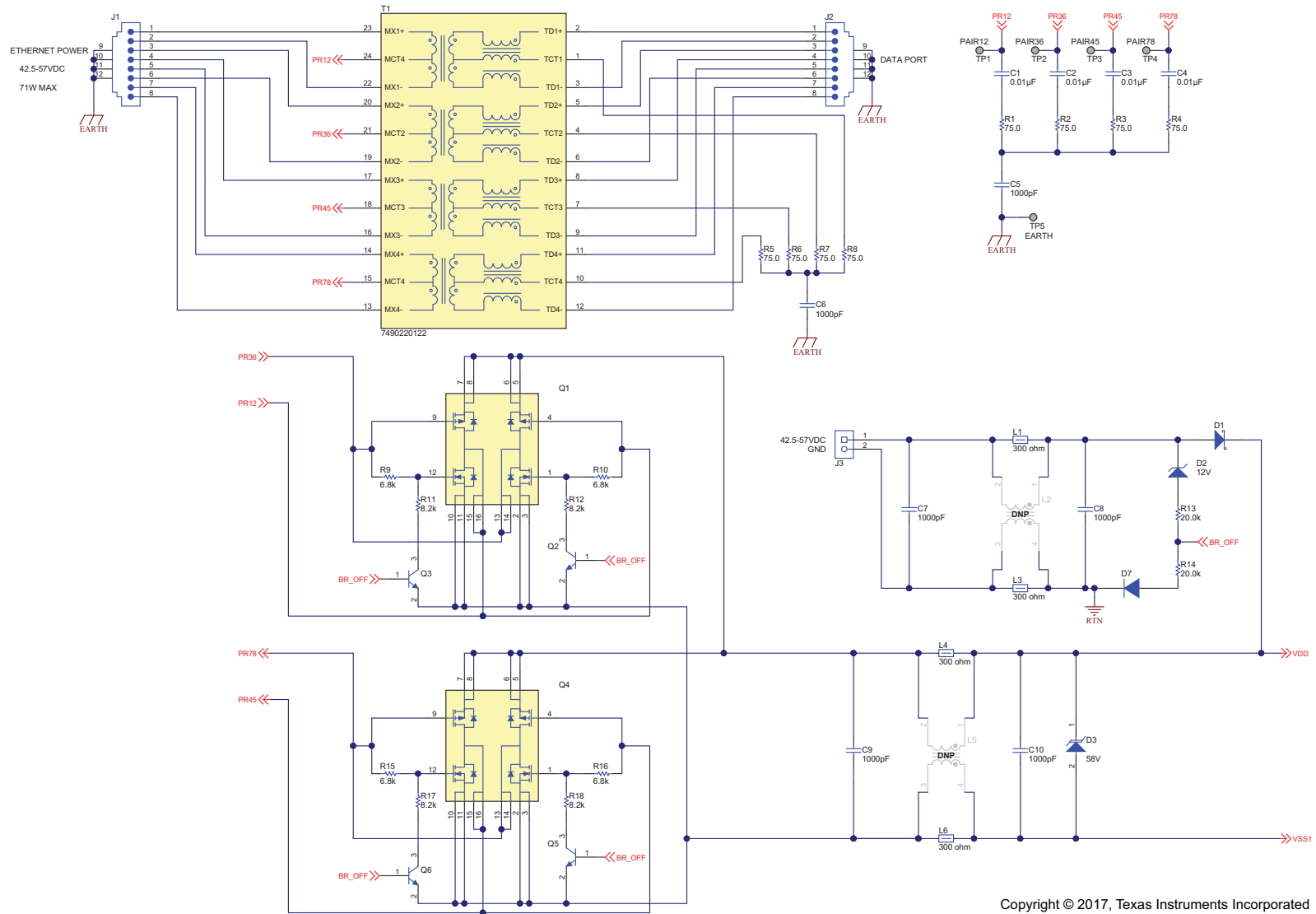
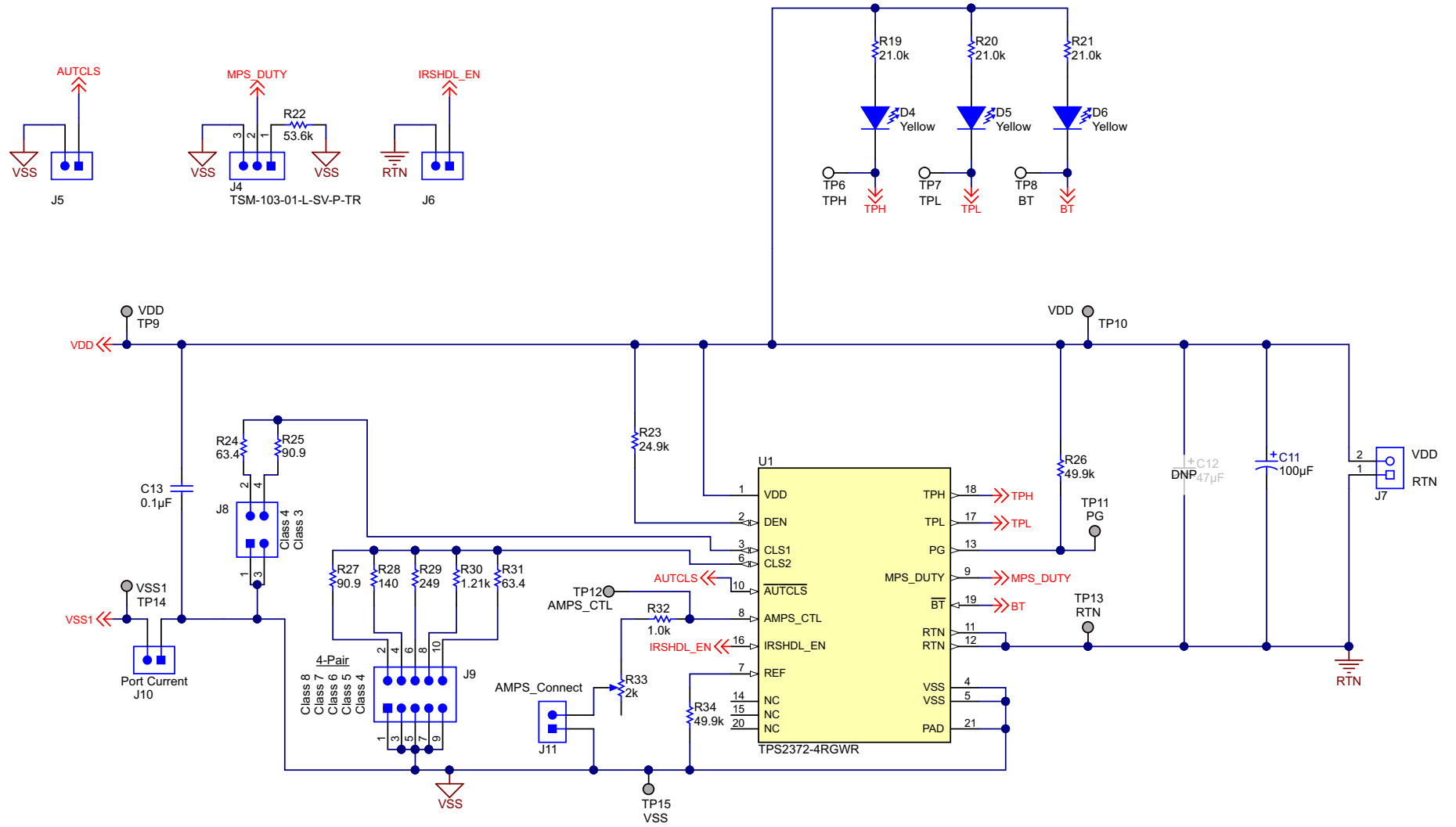


Figure 1. TPS2372-4EVM-006 Front End Interface Schematic



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Figure 2. TPS2372-4EVM-006 PD Controller 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	ETHERNET POWER	PoE input. Connect to PSE power and data source.
J2	DATA	Ethernet data pass-through. Connect to downstream Ethernet device.
J7	Output	Output connector to load
J3	AdapterInput	DC Adapter input. Connect to DC power supply.
J4	MPS_Duty	Automatic MPS duty cycle selection
J5	/AUTCLS	Jump to enable autoclass
J6	IRSHDL_EN	Jump to disable inrush delay
J8	CLSA	Jump to select Class current level
J9	CLSB	Jump to select Class current level
J10	Port Current	Jump connect PD front end and PD controller circuits
J11	AMPS_Connect	Jump to add auto MPS current

Table 3. Test Points

Test Point	Label	Description
TP1	PAIR 12	Data pair from pins 1 and 2 of J1
TP2	PAIR 36	Data pair from pins 3 and 6 of J1
TP3	PAIR 45	Spare pair from pins 4 and 5 of J1
TP4	PAIR 78	Spare pair from pins 7 and 8 of J1
TP5	EARTH	Connect to earth ground, when available
TP6	TPH	TPH output of the TPS2372-4
TP7	TPL	TPL output of the TPS2372-4
TP8	BT	BT output of the TPS2372-4
TP9, TP10	VDD	Input voltage of PD system
TP11	PG	Power Good output fo the TPS2372-4
TP12	AMPS_CTL	AMPS_CTL output voltage
TP13	RTN	Load side return voltage
TP14	VSS1	EMI filter return side voltage
TP15	VSS	PD side return voltage

6 TPS2372-4EVM-006 Performance Data

Figure 3 through Figure 6 illustrate EVM performance waveforms.

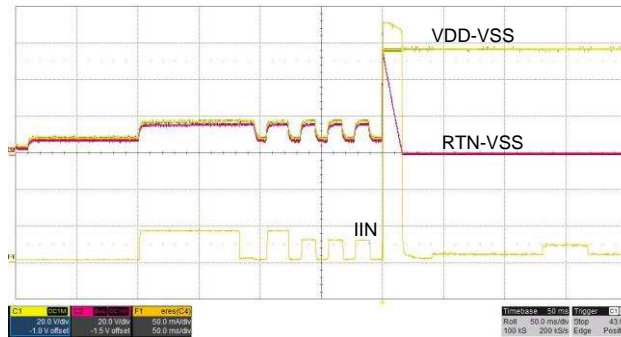


Figure 3. Startup ~using!~With!~.bt PSE!~ and Autoclass Enabled

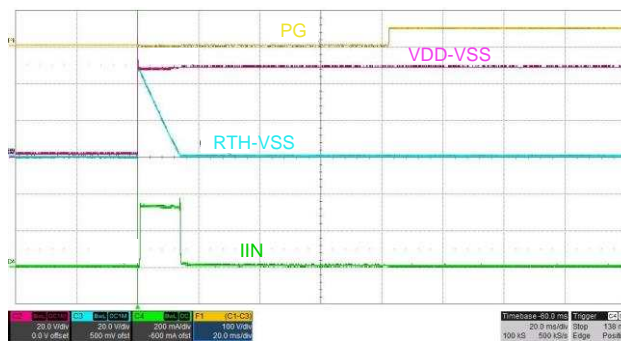


Figure 4. PD Startup With Delay

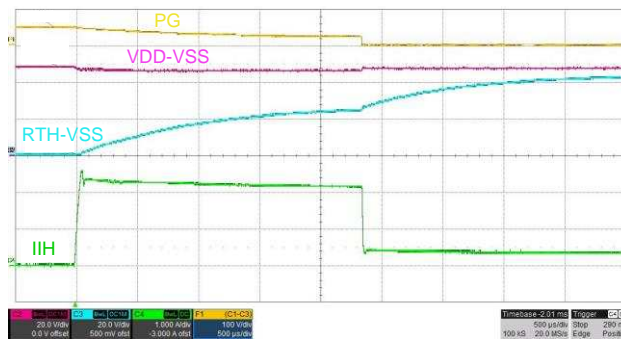


Figure 5. Current-Limit Protection Performance

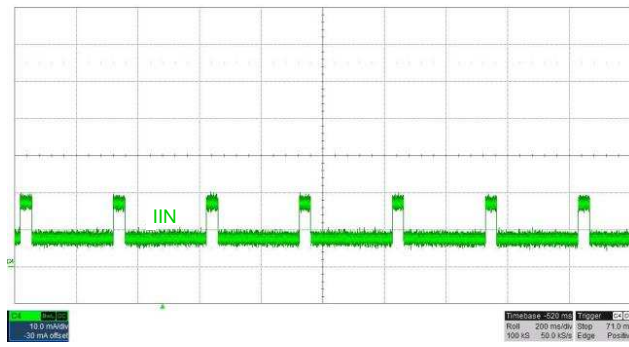


Figure 6. Auto MPS

7 EVM Assembly Drawing and Layout Guidelines

7.1 PCB Drawings

Figure 7 through Figure 12 show component placement and layout of the TPS237xEVM-006.

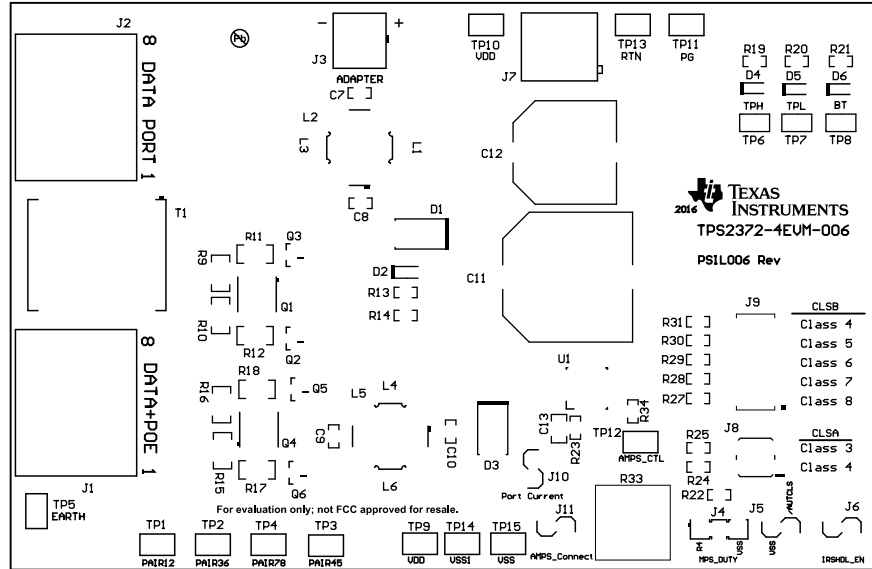


Figure 7. Top Side Component Placement

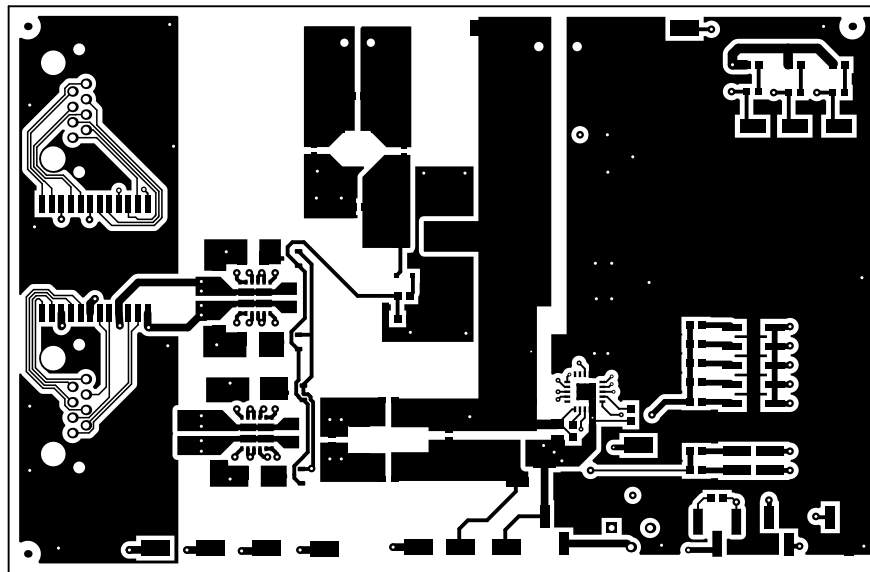


Figure 8. Top Side Routing

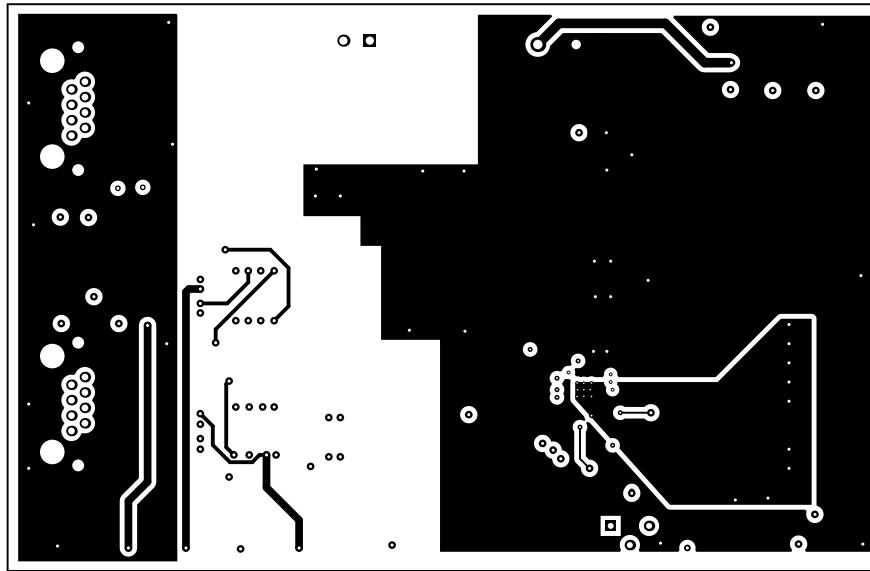


Figure 9. Layer 2 Routing

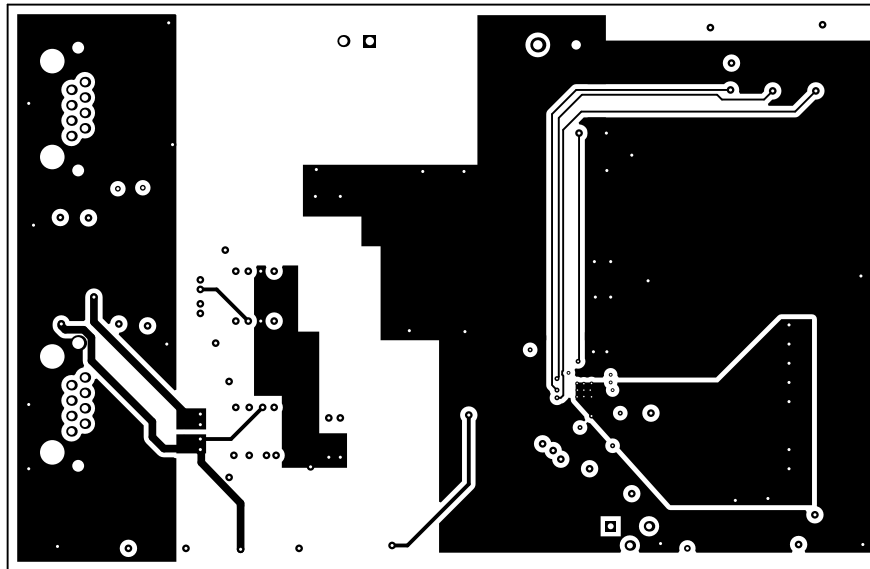


Figure 10. Layer 3 Routing

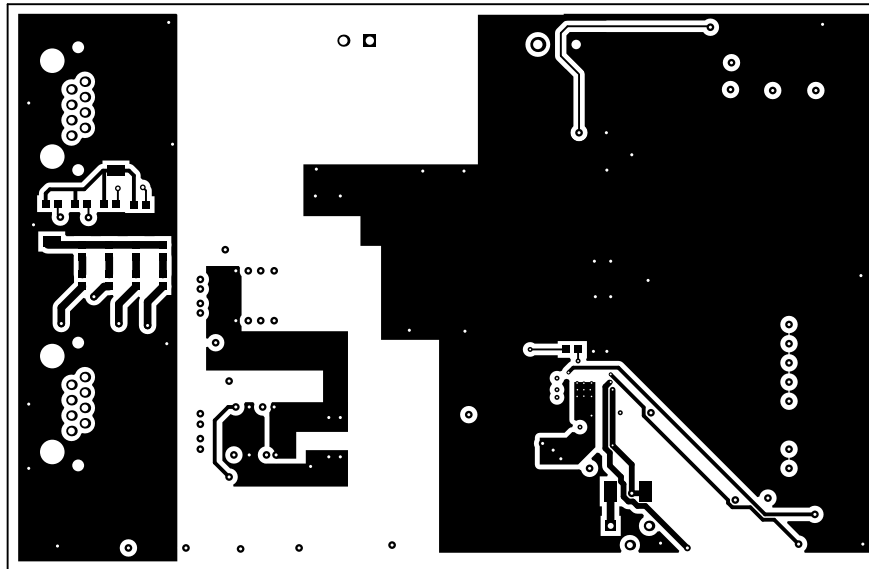


Figure 11. Bottom Side Routing

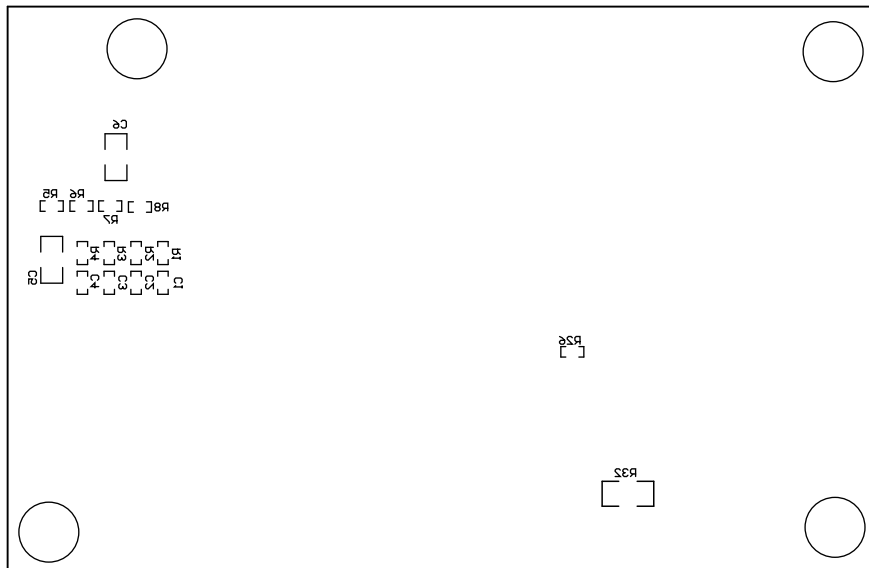


Figure 12. Bottom Component Placement

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- μ F capacitor, and TPS237x 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.
- 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.
- Place the TPS237x over split, local ground planes referenced to VSS for the PoE input and to COM/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 or the converter primary side.
- Use large copper fills and traces on SMT power-dissipating devices, and use wide traces or overlay copper fills in the power path.

7.3 EMI Containment

The following guidelines are provided for 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 the inductor).
- Use Bob Smith terminations, a Bob Smith EFT capacitor, and Bob Smith plane.
- Use a Bob Smith plane as ground shield on input side of PCB (creating a phantom or literal earth ground).
- Use an LC filter at the 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- 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) ~~!-countless~~

8 Bill of Material

Table 4 lists the EVM BOM.

Table 4. TPS2372-4EVM-006 BOM⁽¹⁾

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C1	1	0.01uF	CAP, CERM, 0.01 μF, 100 V, +/- 10%, X7R, 0603	0603	06031C103KAT2A	AVX		
C2	1	0.01uF	CAP, CERM, 0.01 μF, 100 V, +/- 10%, X7R, 0603	0603	06031C103KAT2A	AVX		
C3	1	0.01uF	CAP, CERM, 0.01 μF, 100 V, +/- 10%, X7R, 0603	0603	06031C103KAT2A	AVX		
C4	1	0.01uF	CAP, CERM, 0.01 μF, 100 V, +/- 10%, X7R, 0603	0603	06031C103KAT2A	AVX		
C5	1	1000pF	CAP, CERM, 1000 pF, 2000 V, +/- 10%, X7R, 1808	1808	GR442QR73D102KW01L	Murata		
C6	1	1000pF	CAP, CERM, 1000 pF, 2000 V, +/- 10%, X7R, 1808	1808	GR442QR73D102KW01L	Murata		
C7	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C8	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C9	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C10	1	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
C11	1	100uF	CAP, AL, 100 μF, 100 V, +/- 20%, 0.17 ohm, AEC-Q200 Grade 2, SMD	SMT Radial J16	EEV-FK2A101M	Panasonic		
C12	0	47uF	CAP, AL, 47 μF, 100 V, +/- 20%, 0.42 ohm, AEC-Q200 Grade 1, SMD	12.5x13.5	EEV-TG2A470Q	Panasonic		
C13	1	0.1uF	CAP, CERM, 0.1 μF, 100 V, +/- 10%, X7R, 0805	0805	C0805C104K1RACTU	Kemet		
D1	1	100V	Diode, Schottky, 100 V, 2 A, SMB	SMB	B2100-13-F	Diodes Inc.		
D2	1	12V	Diode, Zener, 12 V, 200 mW, SOD-323	SOD-323	MMSZ5242BS-7-F	Diodes Inc.		
D3	1	58V	Diode, TVS, Uni, 58V, 600W, SMB	SMB	SMBJ58A-13-F	Diodes Inc.		
D4	1	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Würth Elektronik		
D5	1	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Würth Elektronik		
D6	1	Yellow	LED, Yellow, SMD	LED_0603	150060YS75000	Würth Elektronik		
FID1	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
FID2	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
H1	1		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
H2	1		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
H3	1		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
H4	1		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
J1	1		RJ-45, No LED, tab up, R/A, TH	16.26x14.54x15.75	1-406541-1	TE Connectivity		
J2	1		RJ-45, No LED, tab up, R/A, TH	16.26x14.54x15.75	1-406541-1	TE Connectivity		
J3	1		Terminal Block, 3.5 mm, 2x1, Tin, TH	Terminal Block, 3.5 mm, 2x1, TH	39357-0002	Molex		
J4	1		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	TSM-103-01-L-SV-P-TR	Samtec		
J5	1		Header, 2.54 mm, 2x1, Gold, R/A, SMT	Header, 2.54 mm, 2x1, R/A, SMT	87898-0204	Molex		
J6	1		Header, 2.54 mm, 2x1, Gold, R/A, SMT	Header, 2.54 mm, 2x1, R/A, SMT	87898-0204	Molex		
J7	1		Terminal Block, 5.08 mm, 2x1, Brass, TH	2x1 5.08 mm Terminal Block	ED120/2DS	On-Shore Technology		
J8	1		Header, 100mil, 2x2, Tin, SMT	2x2 100mil Tin Header	15-91-2040	Molex		
J9	1		Header, 100mil, 5x2, Tin, SMT	500x180x290mil	TSM-105-01-T-DV-P	Samtec		

⁽¹⁾ Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

Table 4. TPS2372-4EVM-006 BOM⁽¹⁾ (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
J10	1		Header, 2.54 mm, 2x1, Gold, R/A, SMT	Header, 2.54 mm, 2x1, R/A, SMT	87898-0204	Molex		
J11	1		Header, 2.54 mm, 2x1, Gold, R/A, SMT	Header, 2.54 mm, 2x1, R/A, SMT	87898-0204	Molex		
L1	1	300 ohm	Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603	0603	742792641	Würth Elektronik		
L2	0	250uH	Coupled inductor, 250 µH, A, 0.035 ohm, SMD	8.7x10mm	744272251	Würth Elektronik		
L3	1	300 ohm	Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603	0603	742792641	Würth Elektronik		
L4	1	300 ohm	Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603	0603	742792641	Würth Elektronik		
L5	0	250uH	Coupled inductor, 250 µH, A, 0.035 ohm, SMD	8.7x10mm	744272251	Würth Elektronik		
L6	1	300 ohm	Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603	0603	742792641	Würth Elektronik		
PSIL-006	1		Printed Circuit Board		PSIL006	Any	-	-
Q1	1		GreenBridge 2 Series of High-Efficiency Bridge Rectifiers	4.5x5mm	FDMQ8205A	Fairchild Semiconductor		
Q2	1	80 V	Transistor, NPN, 80 V, 0.5 A, SOT-23	SOT-23	MMBTA06-7-F	Diodes Inc.		
Q3	1	80 V	Transistor, NPN, 80 V, 0.5 A, SOT-23	SOT-23	MMBTA06-7-F	Diodes Inc.		
Q4	1		GreenBridge 2 Series of High-Efficiency Bridge Rectifiers	4.5x5mm	FDMQ8205A	Fairchild Semiconductor		
Q5	1	80 V	Transistor, NPN, 80 V, 0.5 A, SOT-23	SOT-23	MMBTA06-7-F	Diodes Inc.		
Q6	1	80 V	Transistor, NPN, 80 V, 0.5 A, SOT-23	SOT-23	MMBTA06-7-F	Diodes Inc.		
R1	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R2	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R3	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R4	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R5	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R6	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R7	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R8	1	75.0	RES, 75.0 ohm, 1%, 0.1W, 0603	0603	CRCW060375R0FKEA	Vishay-Dale		
R9	1	6.8k	RES, 6.8 k, 5%, 0.25 W, 1206	1206	CRCW12066K80JNEA	Vishay-Dale		
R10	1	6.8k	RES, 6.8 k, 5%, 0.25 W, 1206	1206	CRCW12066K80JNEA	Vishay-Dale		
R11	1	8.2k	RES, 8.2 k, 5%, 0.25 W, 1206	1206	CRCW12068K20JNEA	Vishay-Dale		
R12	1	8.2k	RES, 8.2 k, 5%, 0.25 W, 1206	1206	CRCW12068K20JNEA	Vishay-Dale		
R13	1	20.0k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale		
R14	1	20.0k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale		
R15	1	6.8k	RES, 6.8 k, 5%, 0.25 W, 1206	1206	CRCW12066K80JNEA	Vishay-Dale		
R16	1	6.8k	RES, 6.8 k, 5%, 0.25 W, 1206	1206	CRCW12066K80JNEA	Vishay-Dale		
R17	1	8.2k	RES, 8.2 k, 5%, 0.25 W, 1206	1206	CRCW12068K20JNEA	Vishay-Dale		
R18	1	8.2k	RES, 8.2 k, 5%, 0.25 W, 1206	1206	CRCW12068K20JNEA	Vishay-Dale		
R19	1	21.0k	RES, 21.0 k, 1%, 0.1 W, 0603	0603	CRCW060321K0FKEA	Vishay-Dale		
R20	1	21.0k	RES, 21.0 k, 1%, 0.1 W, 0603	0603	CRCW060321K0FKEA	Vishay-Dale		
R21	1	21.0k	RES, 21.0 k, 1%, 0.1 W, 0603	0603	CRCW060321K0FKEA	Vishay-Dale		
R22	1	53.6k	RES, 53.6 k, 1%, 0.1 W, 0603	0603	CRCW060353K6FKEA	Vishay-Dale		
R23	1	24.9k	RES, 24.9 k, 1%, 0.1 W, 0603	0603	CRCW060324K9FKEA	Vishay-Dale		
R24	1	63.4	RES, 63.4 ohm, 1%, 0.1W, 0603	0603	CRCW060363R4FKEA	Vishay-Dale		

Table 4. TPS2372-4EVM-006 BOM⁽¹⁾ (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R25	1	90.9	RES, 90.9, 1%, 0.1 W, 0603	0603	CRCW060390R9FKEA	Vishay-Dale		
R26	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale		
R27	1	90.9	RES, 90.9, 1%, 0.1 W, 0603	0603	CRCW060390R9FKEA	Vishay-Dale		
R28	1	140	RES, 140, 1%, 0.1 W, 0603	0603	CRCW0603140RFKEA	Vishay-Dale		
R29	1	249	RES, 249, 1%, 0.1 W, 0603	0603	CRCW0603249RFKEA	Vishay-Dale		
R30	1	1.21k	RES, 1.21 k, 1%, 0.1 W, 0603	0603	CRCW06031K21FKEA	Vishay-Dale		
R31	1	63.4	RES, 63.4 ohm, 1%, 0.1W, 0603	0603	CRCW060363R4FKEA	Vishay-Dale		
R32	1	1.0k	RES, 1.0 k, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20101K00JNEF	Vishay-Dale		
R33	1	2k	TRIMMER, 2k ohm, 0.5W, TH	375x190x375mil	3386P-1-202LF	Bourns		
R34	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale		
SH-J1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J2	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J3	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J4	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J5	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J6	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
SH-J7	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
T1	1	350 uH	Transformer, 350 uH, SMT	14.7x18.29mm	7490220122	Würth Elektronik		
TP1	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP2	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP3	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP4	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP5	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP6	1	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		
TP7	1	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		
TP8	1	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		
TP9	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP10	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP11	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP12	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP13	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP14	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
TP15	1		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
U1	1		Mid Power "bt" PoE PD Interface with "Automatic" Maintain Power Signature, Advanced Startup and Ultra-Low Standby Power, RGW0020B (VQFN-20)	RGW0020B	TPS2372-4RGWR	Texas Instruments	TPS2372-4RGWT	Texas Instruments

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (August 2017) to A Revision	Page
• Changed TPS2372-4EVM-006 Front End Interface schematic	3

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 semiconductor 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.
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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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

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

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

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3.4 *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.

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

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