User's Guide
SLUUBS6–December 2017

# TPS2373-3EVM-024 Evaluation Module

This user's guide describes the TPS2373-3 evaluation module (TPS2373-3EVM-024). The TPS2373-3EVM-024 contains evaluation and reference circuitry for the TPS2373-3. The TPS2373-3 device is an IEEE 802.3bt-compliant, powered-device (PD) controller optimized for isolated converter topologies. The TPS2373-3EVM-024 is designed for high-efficiency, 51-W, PD solutions.

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## Trademarks

# 1 Introduction

The TPS2373-3EVM-024 allows reference circuitry evaluation of the TPS2373-3. It contains input and output power connectors and an array of onboard test points for circuit evaluation.

## 1.1 Features

The TPS2373-3EVM-024 features include:

- Low-cost flyback converter
- Class 6, 12-V, 4.25-A, 51-W, DC output

## 1.2 Applications

The TPS2373-3EVM-024 can be used in the following applications:

- Voice over internet protocol (VOIP) – IP telephones
- Wireless LAN – wireless access points
- Security – wired IP cameras
- IoT applications

# 2 Electrical Specifications

Table 1 lists the EVM electrical specifications.

**Table 1. TPS2373-3EVM-024 Electrical and Performance Specifications at 25°C**

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **PD Power Interface** | | | | | |
| Input Voltage | Applied to the power pins of connectors J2 or J4 | 0 | | 57 | V |
| Input UVLO, power over Ethernet (PoE) input J2 | 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 = 249 Ω | 9.9 | | 11.2 | mA |
| Inrush Current-Limit | | 165 | | 237 | mA |
| Operating Current-Limit | | 1.55 | | 2.2 | A |
| **DC/DC Converter (UCC2897A)** | | | | | |
| Output Voltage | $V_{IN}$ = 48 V, $I_{LOAD} \le I_{LOAD}$ (max) | 12.064 | | 12.140 | V |
| Output Current | $41.2 \le V_{IN} \le 57$ V | 0.065 | | 4.25 | A |
| Output Ripple Voltage Peak-to-Peak | $V_{IN}$ = 48 V, $I_{LOAD}$ = 4 A | | 76 | | mV |
| Efficiency, end-to-end | $V_{IN}$ = 48 V, $I_{LOAD}$ = 1 A | | 70 | | % |
| | $V_{IN}$ = 48 V, $I_{LOAD}$ = 2 A | | 85 | | % |
| | $V_{IN}$ = 48 V, $I_{LOAD}$ = 4 A | | 86 | | % |
| Switching Frequency | | | 300 | | kHz |
| $t_{DEL}$ | | | 25 | | ns |

# 3 Description

The TPS2373-3EVM-024 enables full evaluation of the TPS2373-3 device. Ethernet power is applied from J1 and is dropped to the half FET-half diode bridge rectifier. At the output of the half FET-half diode bridge is the EMI and EMC filter and transient protection for the TPS2373-3.

Input power can also be applied at J3 from a DC source when power at J1 is not present or when the DC/DC converter is being evaluated and not the PoE front end.

The TPS2373-3 (U1) PD controller is shown in Figure 2. R23 provides the detection signature while J7 and J8 allow user selection of the classification signature and desired power level. To the right of U1 is the switched side of the PD controller. The TPS2373-3 RTN pin provides inrush, current limited turn on, and charge of the bulk capacitor C17.

The DC/DC converter is a high-efficiency, flyback converter. The primary (Q5) switching MOSFET is driven from the U2 OUT pin.

Output voltage feedback is provided with U3 and associated error amplifier (U4) circuitry. R53 provides a means for error injection to measure the frequency response of the converter. This feedback circuit drives the U2 FB pin which provides a voltage proportional to the output load current. As the output load current decreases, the FB pin voltage decreases.

Above the minimum output current of approximately 65 mA, the converter is no longer operating in *Discontinuous Conduction Mode* (DCM) which can cause bursts of current observable from the input. If the load is too small, the DCM bursts will disrupt MPS pulses which may cause the PSE to remove power.

## 4 Schematic

Figure 1, Figure 2, and Figure 3 illustrate the EVM schematics.

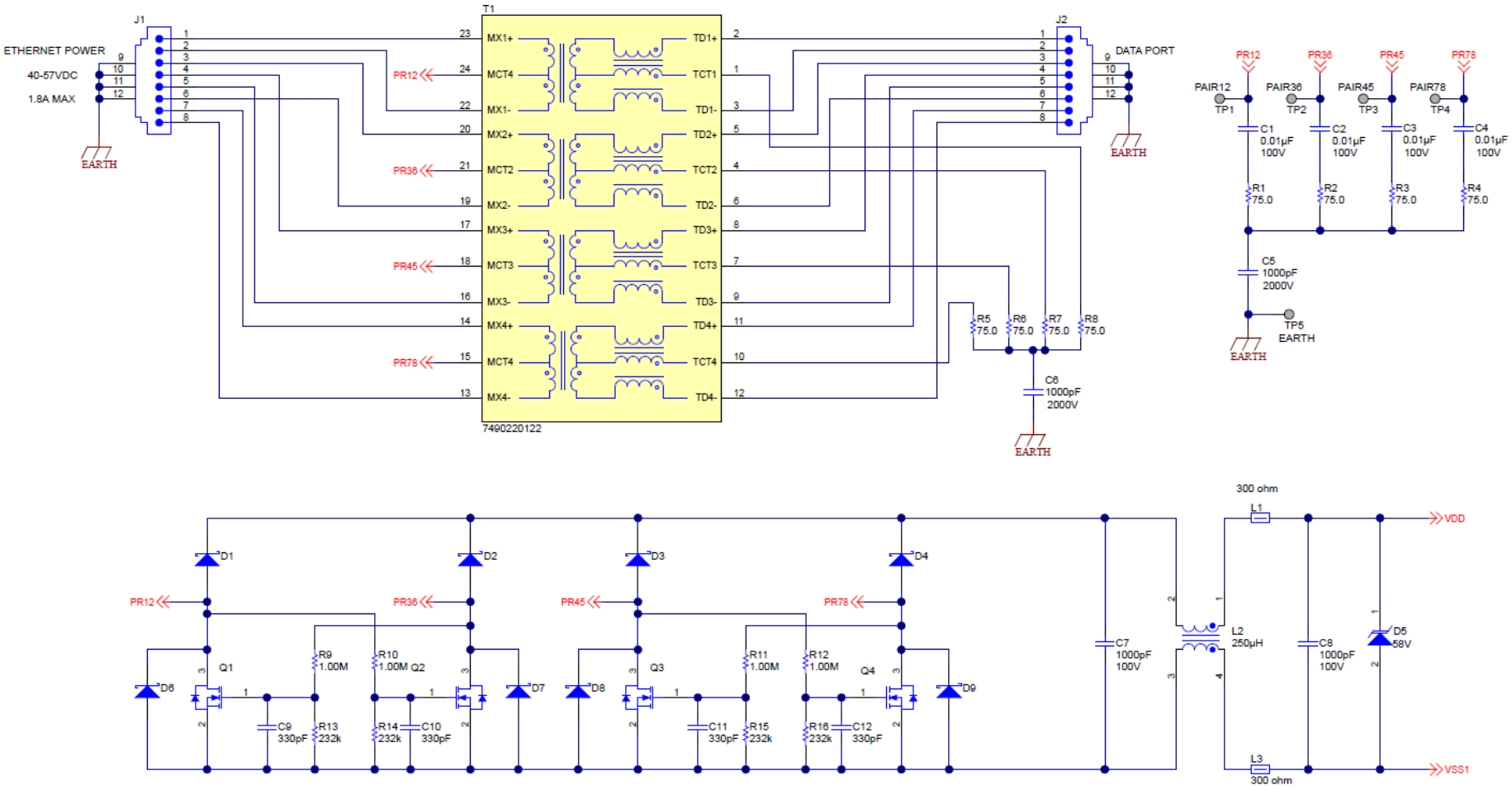


**Figure 1. TPS2373-3EVM-024 Front-End Schematic**

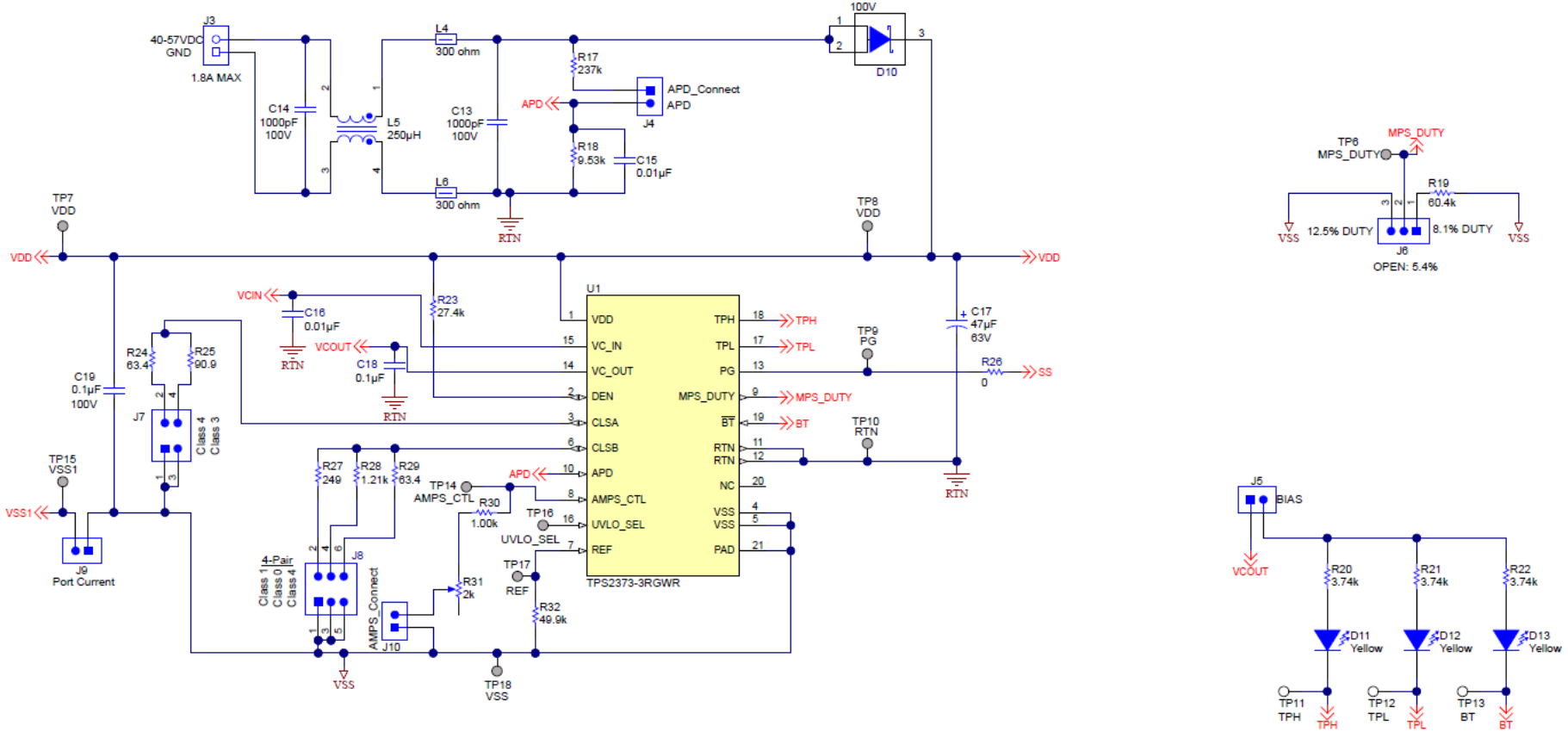


**Figure 2. TPS2373-3EVM-024 PD Schematic**

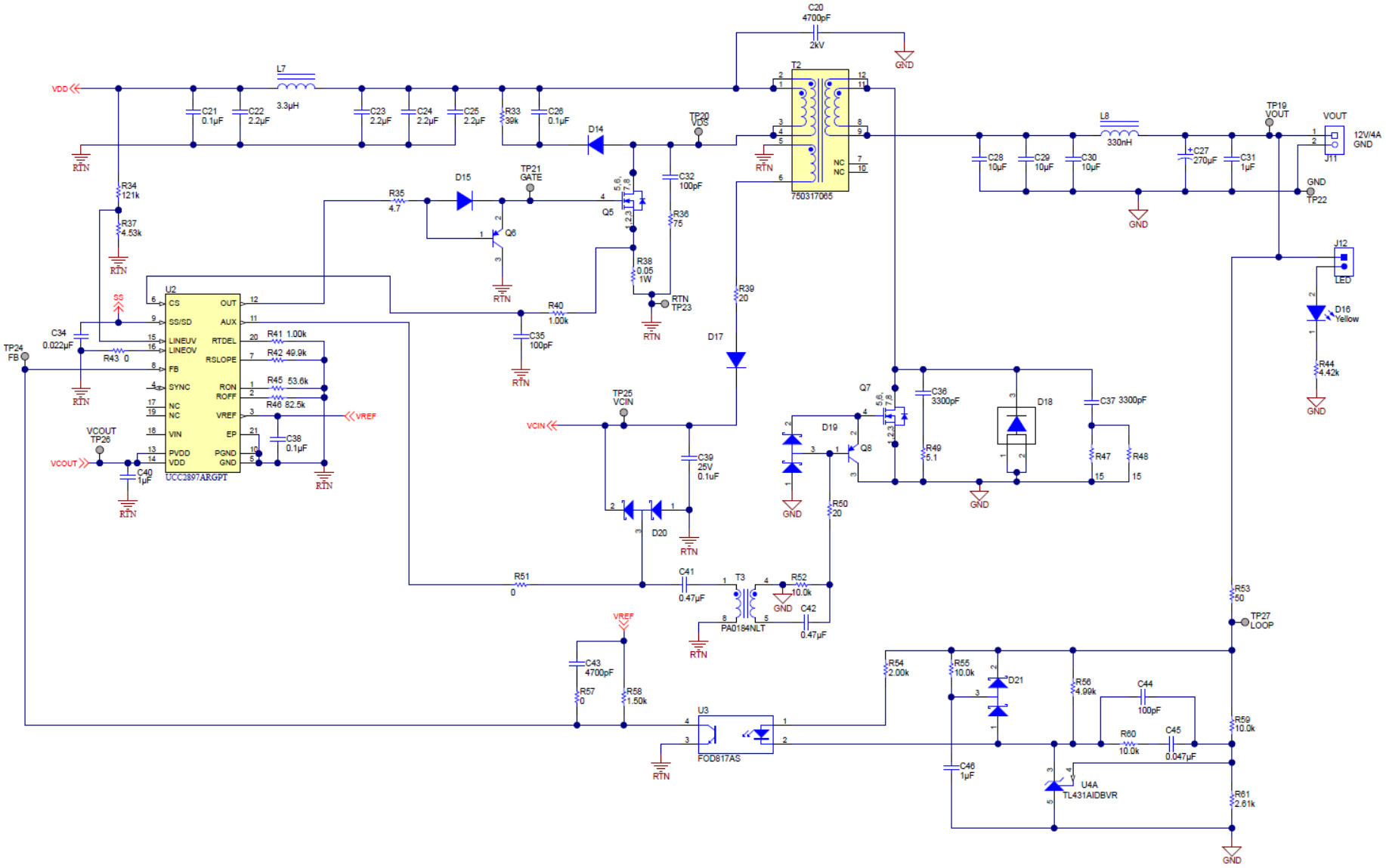


**Figure 3. TPS2373-3EVM-024 DC/DC Converter Schematic**

# 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 4 describes the jumper selections of the EVM.

**Table 2. Connector Functionality**

| Connector | Label | Description |
|---|---|---|
| J1 | ETHERNET POWER | PoE input, connect to PSE power and data source. |
| J2 | DATA | Ethernet data passthrough, connect to downstream Ethernet device. |
| J11 | Output | Output connector to load. |
| J3 | DC/DC Input | DC/DC converter input bypassing the PoE front-end. Connect a DC power supply 40–57. |

**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 | Data pair from pins 4 and 5 of J1. |
| TP4 | PAIR 78 | Data pair from pins 7 and 8 of J1. |
| TP5 | EARTH | Connect to earth ground when available. |
| TP6 | MPS_DUTY | MPS_DUTY pin of the TPS2373-3. |
| TP7, TP8 | VDD | Input voltage of PD system. |
| TP9 | PG | Power Good output of the TPS2373-3. |
| TP10, TP23 | RTN | Load side return voltage. |
| TP11 | TPH | TPH output of the TPS2373-3. |
| TP12 | TPL | TPL output of the TPS2373-3. |
| TP13 | BT | BT output of the TPS2373-3. |
| TP14 | AMPS_CTL | AMPS_CTL output voltage |
| TP15 | VSS1 | EMI filter return side voltage. |
| TP16 | UVLO_SEL | Select UVLO of U1 (open circuited). |
| TP17 | REF | Reference pin output voltage of the TPS2373-3. |
| TP18 | VSS | PD side return voltage. |
| TP19 | VOUT | Converter output voltage. |
| TP20 | VDS | Drain voltage of the primary FET of the converter. |
| TP21 | GATE | Gate voltage of the primary FET of the converter. |
| TP22 | GND | Secondary ground connection. |
| TP24 | FB | Feedback pin voltage of U2 PWM controller. |
| TP25 | VCIN | Bias winding circuit output voltage. |
| TP26 | VCOUT | Output voltage of advanced startup of U1. |
| TP27 | LOOP | Feedback connection for frequency response measurements. |

**Table 4. Jumper Descriptions**

| Jumper | Description |
|---|---|
| J4 | Jump to power TPH, TPL, or BT through the bias winding, or open to power through external circuit. |
| J5 | Automatic MPS duty cycle selection. |
| J6 | Jump for adapter priority. |
| J7 | CLSA selection. |
| J8 | CLSB selection. |
| J9 | Can be used to measure port current; otherwise, J11 should be shorted. |
| J10 | Jump to add auto MPS current. |
| J11 | Jump to power output LED. |

On jumper J10, only the class resistors for class 1, 0, and 4 are selectable. Classes 2 and 3 were removed from CLSB to prevent the class 6 PD from requesting class 7 or 8 power.

# 6 TPS2373-3EVM-024 Performance Data

## 6.1 Startup

Figure 4 illustrates the startup response of the TPS2373-3EVM-024.

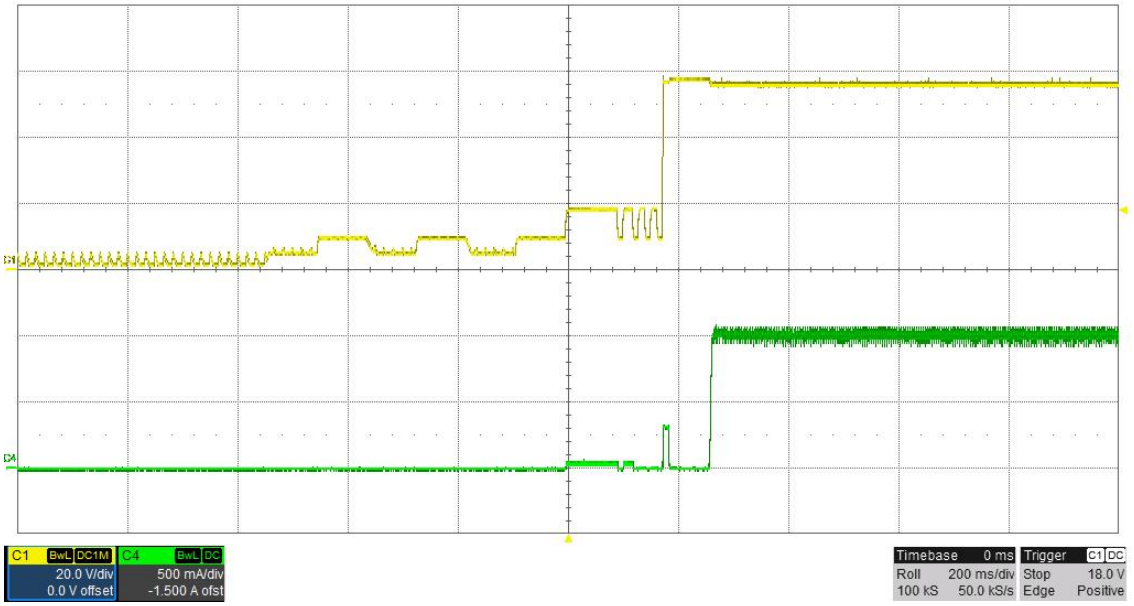


**Figure 4. Startup Response to Full Load (4 A) for a 48-V Input**

## 6.2 Transient Response

Figure 5 illustrates the transient response of the TPS2373-3EVM-024.

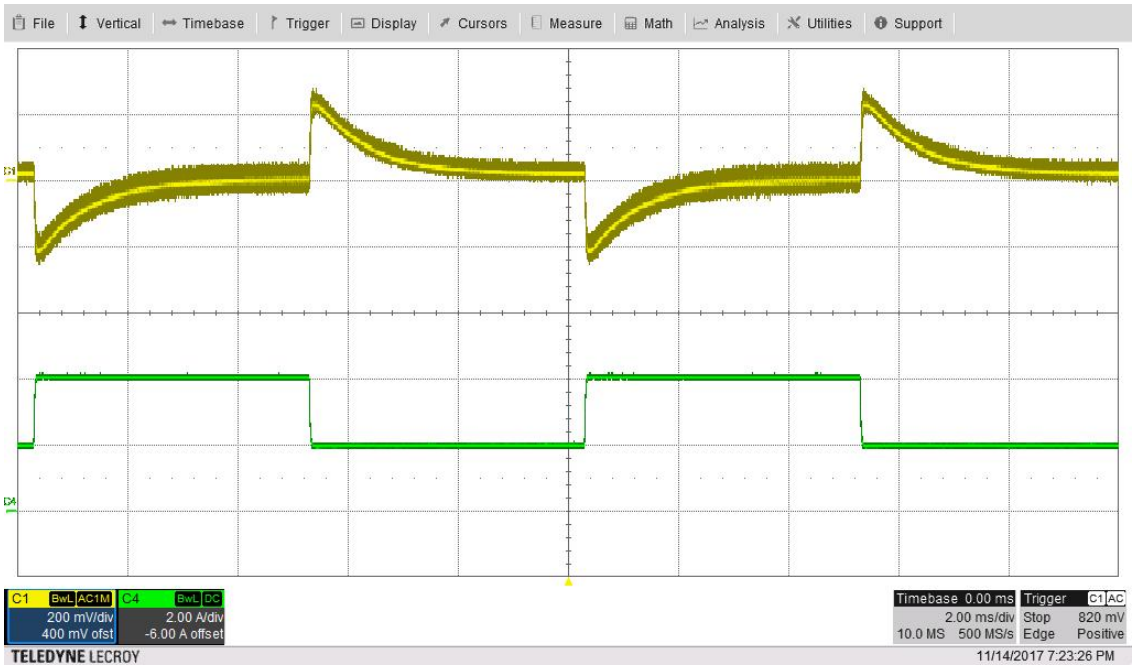


**Figure 5. Transient Response from 2 A to 4 A for a 48-V Input**

## 6.3 Efficiency

Figure 6 illustrates the efficiency of the TPS2373-3EVM-024.

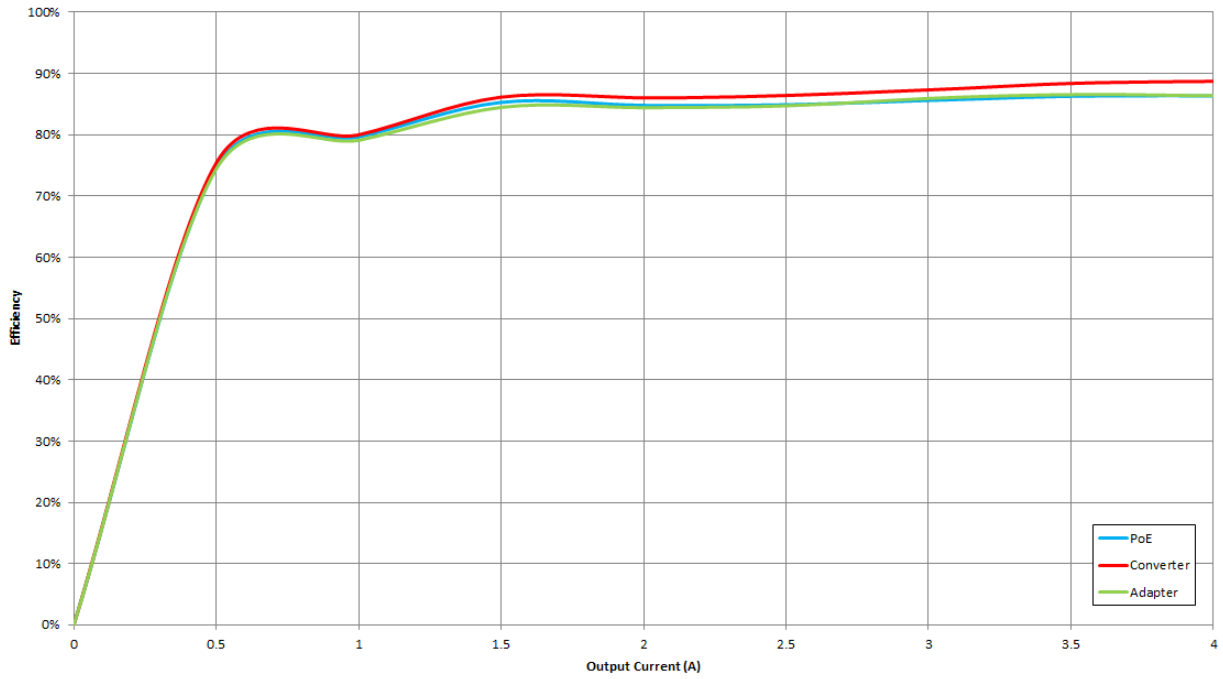


**Figure 6. Efficiency of the TPS2373-3EVM-024, $V_{IN}$ = 48 V**

# 7 EVM Assembly Drawings and Layout Guidelines

This section contains the assembly drawings and layout guidelines.

## 7.1 PCB Drawings

Figure 7 through Figure 12 show component placement and layout of the TPS2373-3EVM-024.

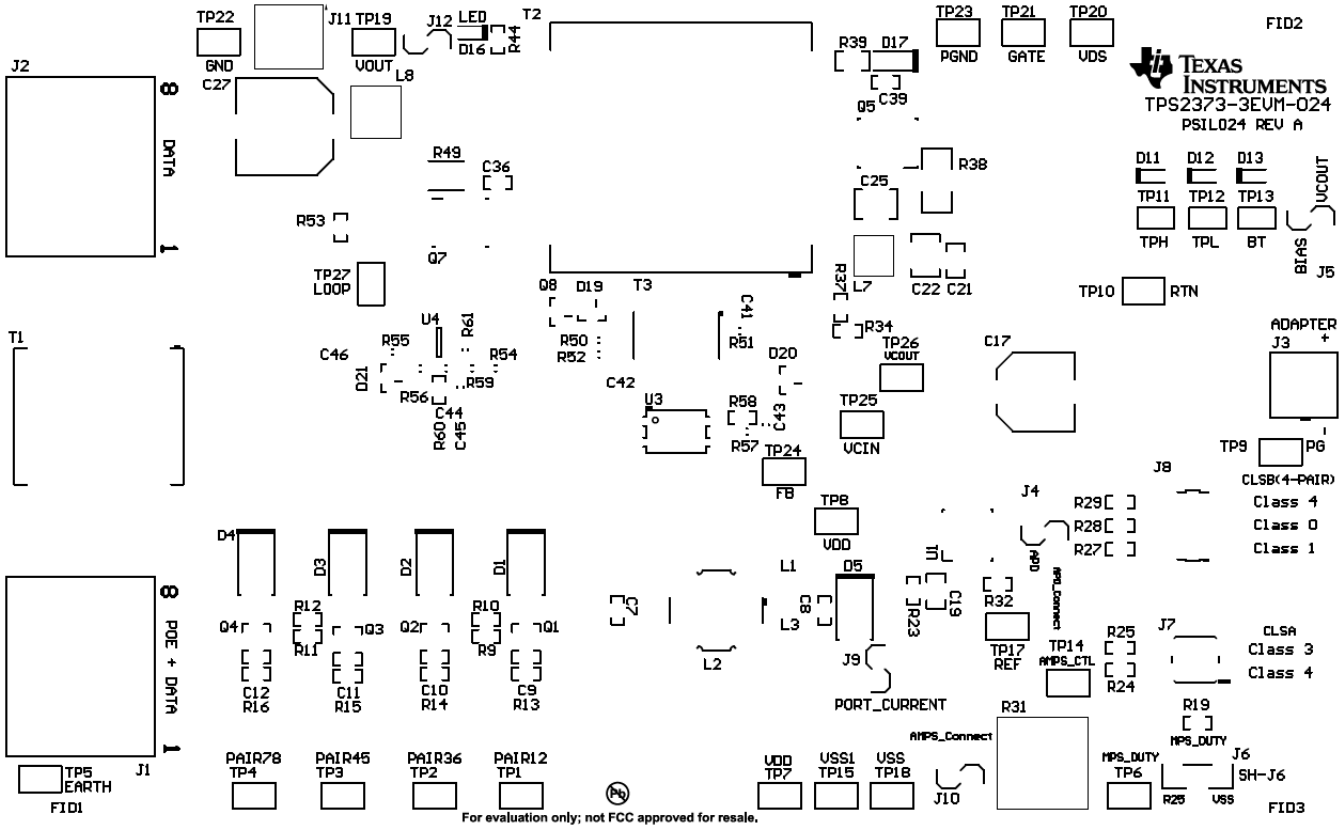


**Figure 7. Top Side Component Placement**

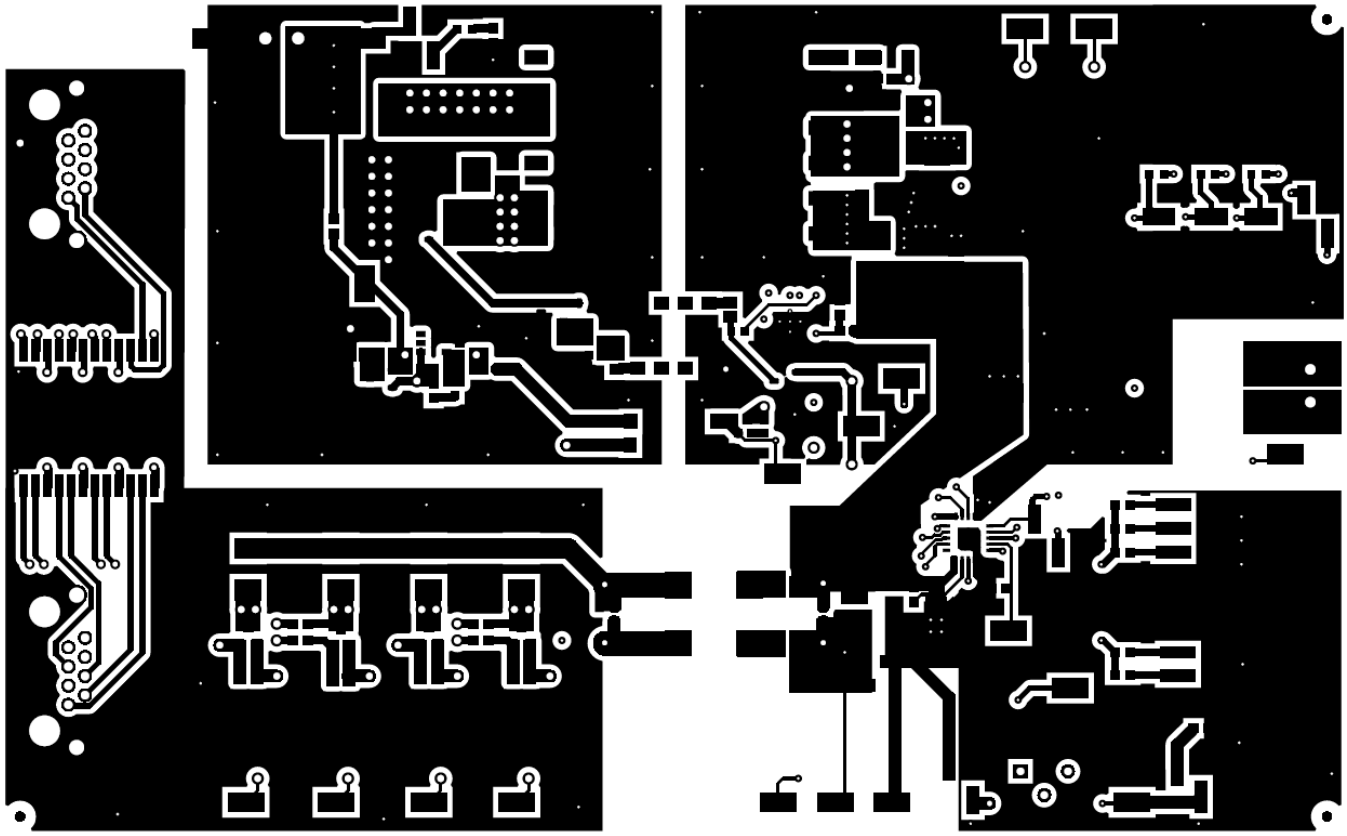

**Figure 8. Top Side Routing**

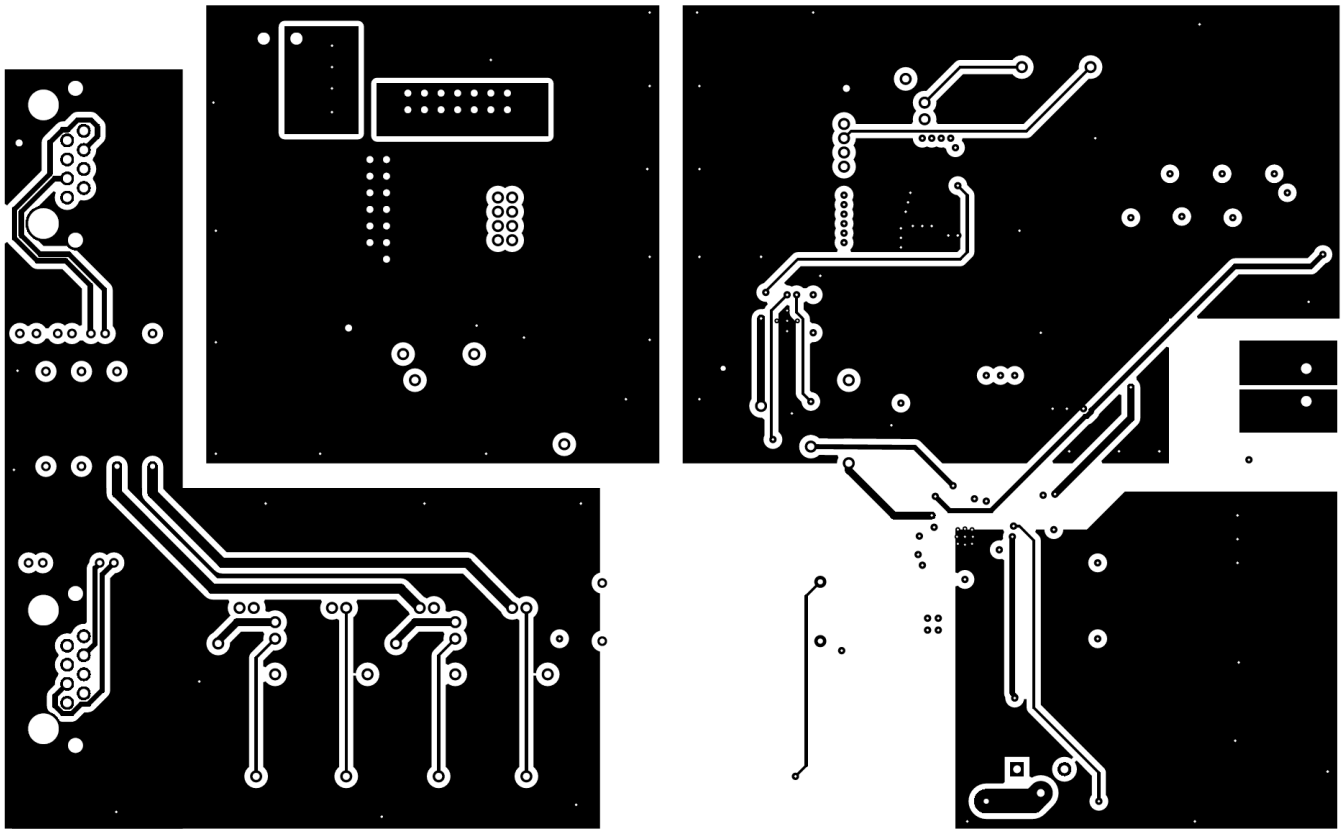

**Figure 9. Layer 2 Routing**

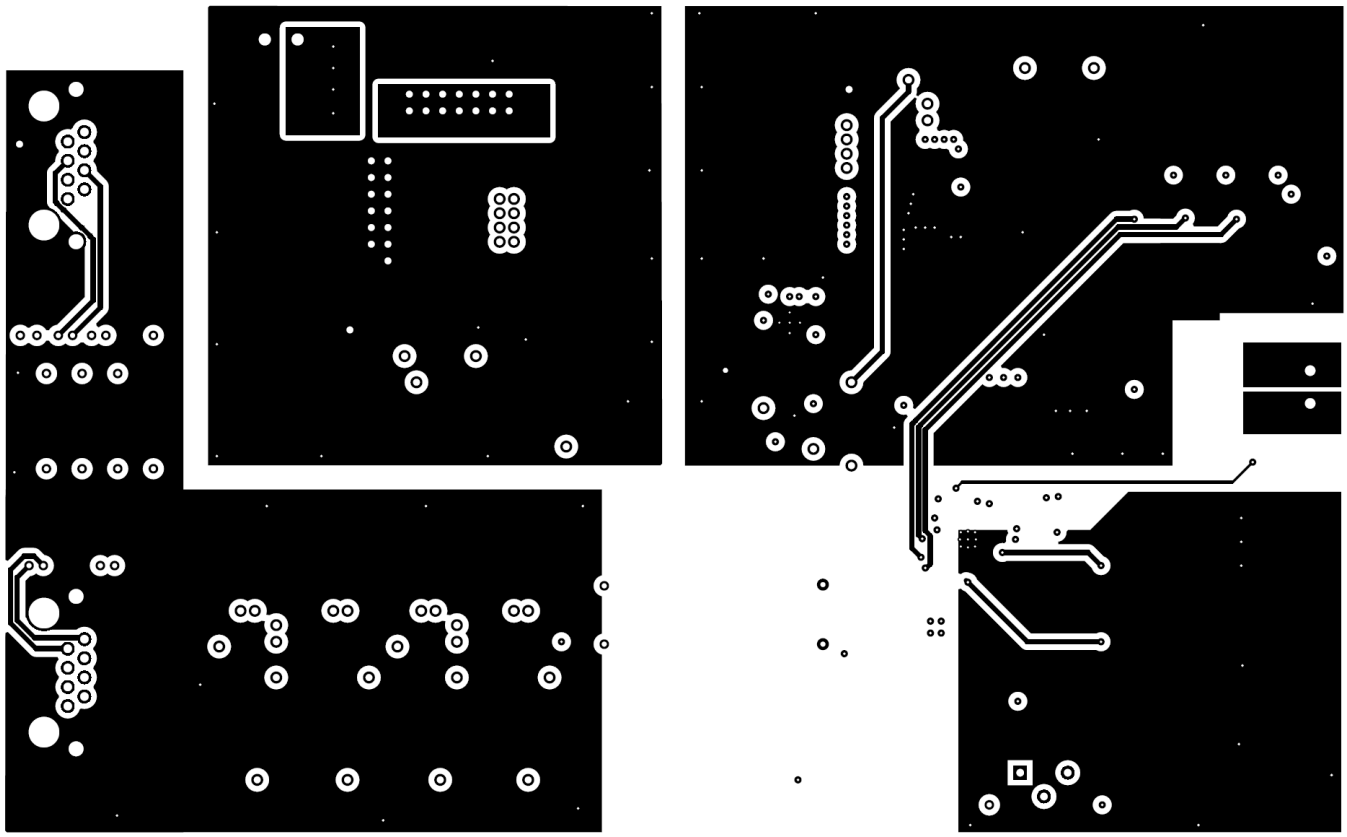

**Figure 10. Layer 3 Routing**

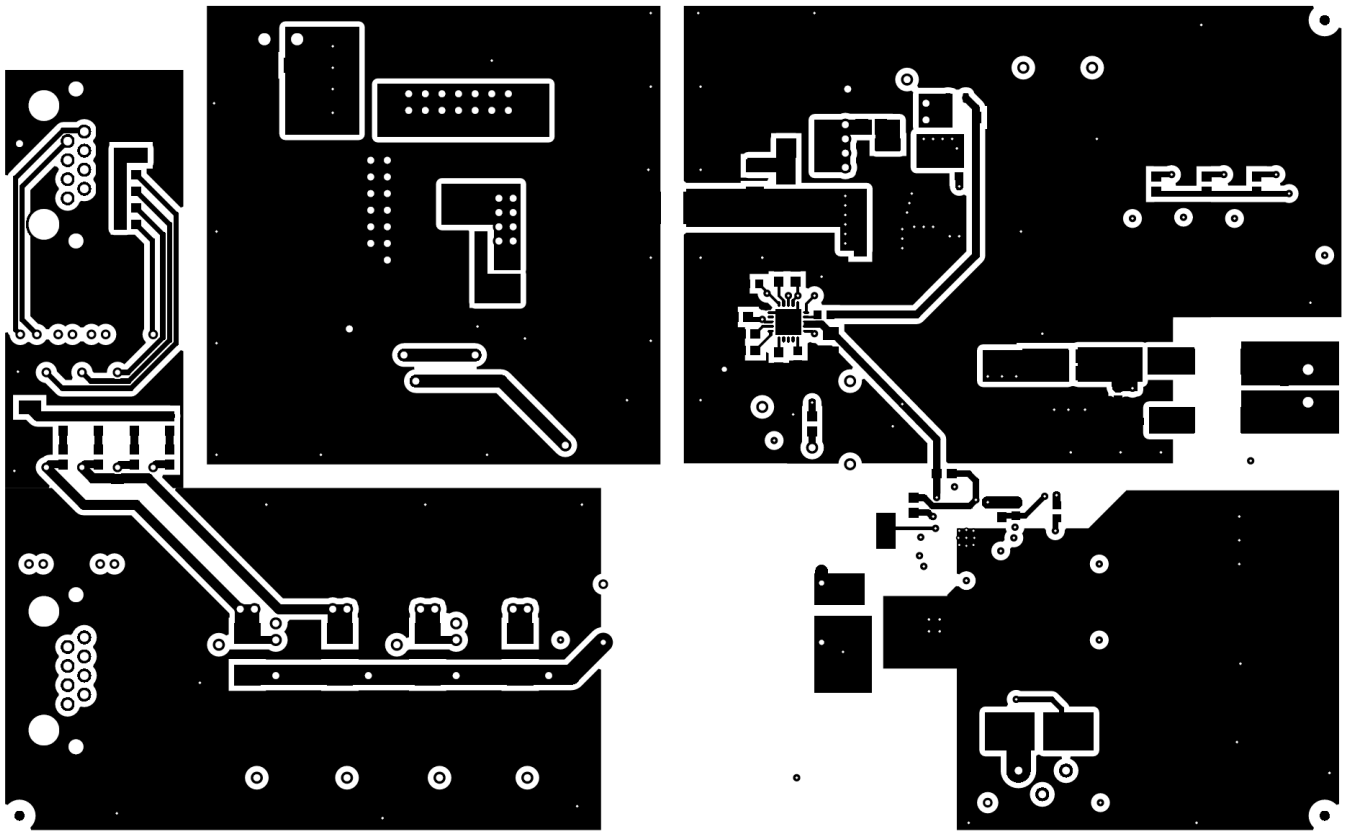

**Figure 11. Bottom Side Routing**

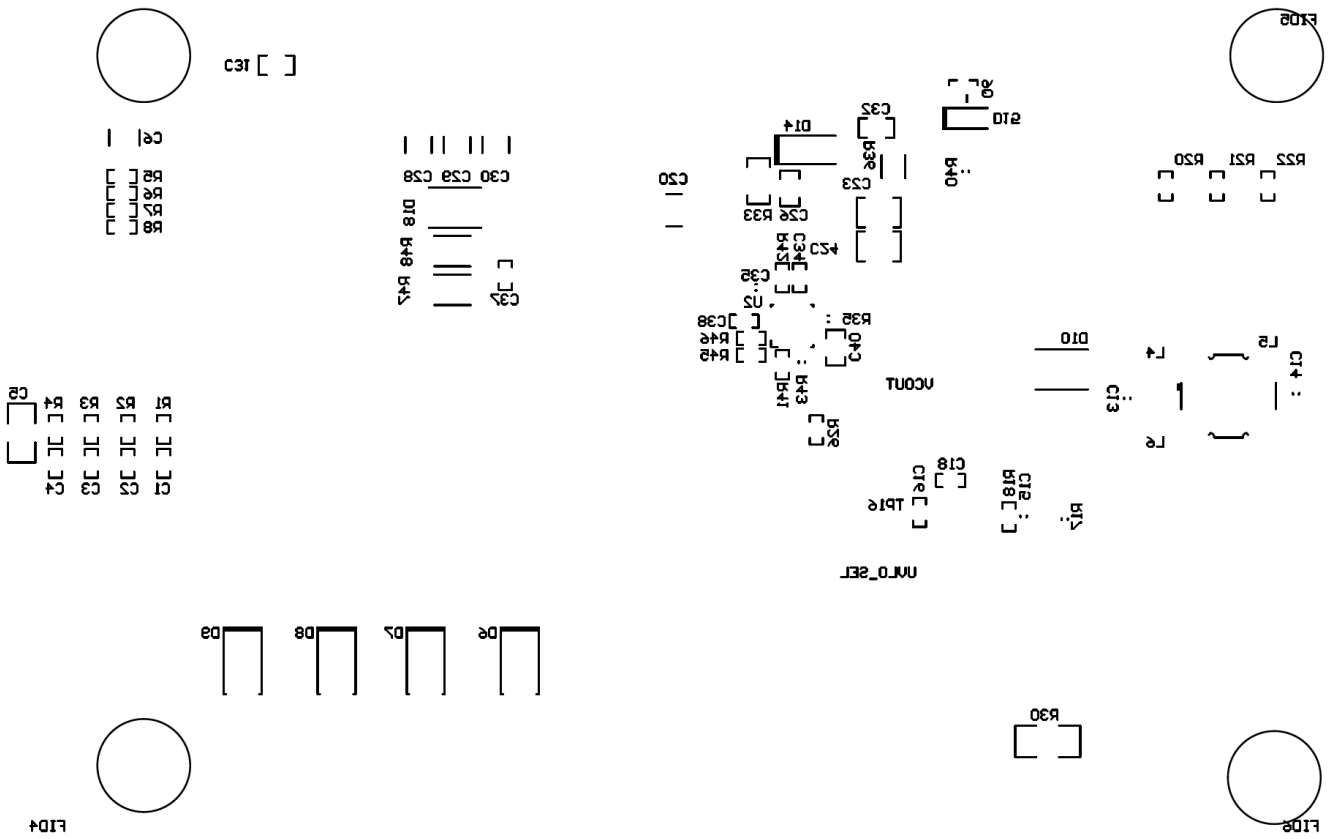

**Figure 12. Bottom Component Placement**

## 7.2 Layout Guidelines

The layout of the PoE front end should follow power and EMI and 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 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 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 primary side of the converter.
- 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/DC converter layout benefits 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.
- Use proper spacing around the high-voltage sections of the converter.

## 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 (as in the output side of inductor).
- Use Bob Smith terminations, Bob Smith EFT capacitor, and Bob Smith plane.
- Use Bob Smith plane as a ground shield on the input side of the 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-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 Material

Table 5 lists the EVM BOM. BOM 001 is the default diode recitifer configuration. BOM 002 is an alternative synchronous FET rectifier configuration.

**Table 5. TPS2373-3EVM-024 BOM(1)**

| Reference Designator | Quantity | | Value | Description | Reference | Part Number | Manufacturer | Alternate Part Number | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|---|
| | 001 | 002 | | | | | | | |
| !PCB1 | 1 | 1 | | Printed Circuit Board | | PSIL024 | Any | - | - |
| C1, C2, C3, C4 | 4 | 4 | 0.01uF | CAP, CERM, 0.01uF, 100V, ±10%, X7R, 0603 | 0603 | C1608X7R2A103K | TDK | | |
| C15 | 1 | 1 | 0.01uF | CAP, CERM, 0.01uF, 50V, ±10%, X7R, 0603 | 0603 | C1608X7R1H103K | TDK | | |
| C16 | 1 | 1 | 0.01uF | CAP, CERM, 0.01 µF, 50 V, ±10%, X5R, 0603 | 0603 | GRM188R61H103KA01D | Murata | | |
| C17 | 1 | 1 | 47uF | CAP, AL, 47 µF, 63 V, ±20%, 0.65 ohm, SMD | SMT Radial F | EEE-FK1J470P | Panasonic | | |
| C18 | 1 | 1 | 0.1uF | CAP, CERM, 0.1 µF, 25 V, ±10%, X5R, 0603 | 0603 | 06033D104KAT2A | AVX | | |
| C19 | 1 | 1 | 0.1uF | CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, 0805 | 0805 | C0805C104K1RACTU | Kemet | | |
| C20 | 1 | 1 | 4700pF | CAP, CERM, 4700 pF, 2000 V, ±10%, X7R, 1812 | 1812 | 1812GC472KAT1A | AVX | | |
| C21, C26 | 2 | 2 | 0.1uF | CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, 0805 | 0805 | C2012X7R2A104K125AA | TDK | | |
| C22, C23, C24, C25 | 4 | 4 | 2.2uF | CAP, CERM, 2.2 µF, 100 V, ±10%, X7R, 1210 | 1210 | GRM32ER72A225KA35L | Murata | | |
| C27 | 1 | 1 | 270uF | CAP, Aluminum Polymer, 270 µF, 25 V,±20%, 0.027 ohm, D10xL12.7mm SMD | D10xL12.7mm | PCV1E271MCL1GS | Nichicon | | |
| C28, C29, C30 | 3 | 3 | 10uF | CAP, CERM, 10 µF, 25 V, ±10%, X7R, 1210 | 1210 | C1210C106K3RACTU | Kemet | | |
| C31, C40, C46 | 3 | 3 | 1uF | CAP, CERM, 1 µF, 25 V, ±10%, X7R, 0805 | 0805 | GRM21BR71E105KA99L | Murata | | |
| C32 | 1 | 1 | 100pF | CAP, CERM, 100 pF, 250 V, ±5%, C0G/NP0, 0805 | 0805 | GRM21A5C2E101JW01D | Murata | | |
| C34 | 1 | 1 | 0.022uF | CAP, CERM, 0.022 µF, 25 V,±10%, X7R, 0603 | 0603 | C0603C223K3RACTU | Kemet | | |
| C35, C44 | 2 | 2 | 100pF | CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603 | 0603 | GRM1885C1H101JA01D | Murata | | |
| C36 | 0 | 1 | 3300pF | CAP, CERM, 3300 pF, 100 V, ±10%, X7R, 0603 | 0603 | GRM188R72A332KA01D | Murata | | |
| C37 | 1 | 0 | 3300pF | CAP, CERM, 3300 pF, 100 V, ±10%, X7R, 0603 | 0603 | GRM188R72A332KA01D | Murata | | |
| C38 | 1 | 1 | 0.1uF | CAP, CERM, 0.1 µF, 25 V,±10%, X7R, 0603 | 0603 | 06033C104KAT2A | AVX | | |
| C39 | 1 | 1 | 0.1uF | CAP, CERM, 0.1 uF, 25 V, ±5%, X7R, 0603 | 0603 | 06033C104JAT2A | AVX | | |
| C41, C42 | 0 | 2 | 0.47uF | CAP, CERM, 0.47 µF, 50 V, ±10%, X7R, 0805 | 0805 | C2012X7R1H474K125AB | TDK | | |
| C43 | 1 | 1 | 4700pF | CAP, CERM, 4700 pF, 50 V, ±10%, X7R, 0603 | 0603 | GRM188R71H472KA01D | Murata | | |
| C45 | 1 | 1 | 0.047uF | CAP, CERM, 0.047 µF, 50 V, ±10%, X7R, 0603 | 0603 | C1608X7R1H473K080AA | TDK | | |
| C5 | 1 | 1 | 1000pF | CAP, CERM, 1000 pF, 2000 V, ±10%, X7R, 1808 | 1808 | GR442QR73D102KW01L | Murata | | |
| C6 | 1 | 1 | 1000pF | CAP, CERM, 1000 pF, 2000 V,±10%, X7R, 1812 | 1812 | 1812GC102KAT1A | AVX | | |
| C7, C8, C13, C14 | 4 | 4 | 1000pF | CAP, CERM, 1000pF, 100V, ±10%, X7R, 0603 | 0603 | C1608X7R2A102K | TDK | | |
| C9, C10, C11, C12 | 4 | 4 | 330pF | CAP, CERM, 330 pF, 50 V, ±5%, C0G/NP0, 0603 | 0603 | 885012006060 | Wurth Elektronik | | |
| D1, D2, D3, D4 | 4 | 4 | 100V | Diode, Schottky, 100 V, 2 A, SMB | SMB | B2100-13-F | Diodes Inc. | | |
| D10 | 1 | 1 | 100V | Diode, Schottky, 100 V, 5 A, PowerDI5 | PowerDI5 | PDS5100-13 | Diodes Inc. | | |
| D11, D12, D13, D16 | 4 | 4 | Yellow | LED, Yellow, SMD | LED_0603 | 150060YS75000 | Wurth Elektronik | | |
| D14 | 1 | 1 | 200V | Diode, Superfast Rectifier, 200 V, 2 A, SMA | SMA | ES2DA-13-F | Diodes Inc. | | |

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

## Table 5. TPS2373-3EVM-024 BOM[(1)] (continued)

| Reference Designator | Quantity | | Value | Description | Reference | Part Number | Manufacturer | Alternate Part Number | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|---|
| | 001 | 002 | | | | | | | |
| D15, D17 | 2 | 2 | 100V | Diode, Switching, 100 V, 0.2 A, SOD-123 | SOD-123 | MMSD4148T1G | ON Semiconductor | | |
| D18 | 1 | 0 | 60V | Diode, Super Barrier Rectifier, 60 V, 20 A, AEC-Q101, PowerDI5 | PowerDI5 | SBRT20U60SP5-7 | Diodes Inc. | | |
| D19, D20 | 0 | 2 | 30V | Diode, Schottky, 30 V, 0.2 A, SOT-23 | SOT-23 | BAT54S-7-F | Diodes Inc. | | |
| D21 | 1 | 1 | 30V | Diode, Schottky, 30 V, 0.2 A, SOT-23 | SOT-23 | BAT54S-7-F | Diodes Inc. | | |
| D5 | 1 | 1 | 58V | Diode, TVS, Uni, 58V, 600W, SMB | SMB | SMBJ58A-13-F | Diodes Inc. | | |
| D6, D7, D8, D9 | 0 | 0 | 100V | Diode, Schottky, 100 V, 2 A, SMB | SMB | B2100-13-F | Diodes Inc. | | |
| H1, H2, H3, H4 | 4 | 4 | | Bumpon, Hemisphere, 0.375 X 0.235, Black | Black Bumpon | SJ61A2 | 3M | | |
| J1, J2 | 2 | 2 | | RJ-45, No LED, tab up, R/A, TH | 16.26x14.54x15.75 | 1-406541-1 | TE Connectivity | | |
| J11 | 1 | 1 | | Terminal Block, 3.5mm Pitch, 2x1, TH | 7.0x8.2x6.5mm | ED555/2DS | On-Shore Technology | | |
| J12 | 1 | 1 | | Header, 2.54 mm, 2x1, Gold, R/A, SMT | Header, 2.54 mm, 2x1, R/A, SMT | 0878980204 | Molex | | |
| J3 | 1 | 1 | | Terminal Block, 3.5 mm, 2x1, Tin, TH | Terminal Block, 3.5 mm, 2x1, TH | 39357-0002 | Molex | | |
| J4, J5, J9, J10 | 4 | 4 | | Header, 2.54 mm, 2x1, Gold, R/A, SMT | Header, 2.54 mm, 2x1, R/A, SMT | 87898-0204 | Molex | | |
| J6 | 1 | 1 | | Header, 100mil, 3x1, Gold, SMT | Samtec_TSM-103-01-X-SV | TSM-103-01-L-SV | Samtec | | |
| J7 | 1 | 1 | | Header, 100mil, 2x2, Tin, SMT | 2x2 100mil Tin Header | 15-91-2040 | Molex | | |
| J8 | 1 | 1 | | Header, 2.54mm, 3x2, Gold, SMT | Header, 2.54mm, 3x2, SMT | TSM-103-01-L-DV | Samtec | | |
| L1, L3, L4, L6 | 4 | 4 | 300 ohm | Ferrite Bead, 300 ohm @ 100 MHz, 2 A, 0603 | 0603 | 742792641 | Wurth Elektronik | | |
| L2, L5 | 2 | 2 | 250uH | Coupled inductor, 250 µH, A, 0.035 ohm, SMD | 8.7x10mm | 744272251 | Wurth Elektronik | | |
| L7 | 1 | 1 | 3.3uH | Inductor, Shielded, Composite, 3.3 µH, 2.9 A, 0.03 ohm, SMD | 4x2x4mm | XFL4020-332MEB | Coilcraft | | |
| L8 | 1 | 1 | 330nH | Inductor, Shielded, Composite, 330 nH, 19.2 A, 0.0032 ohm, SMD | 5.3x31.x5.5mm | XAL5030-331MEB | Coilcraft | | |
| Q1, Q2, Q3, Q4 | 4 | 4 | 100V | MOSFET, N-CH, 100V, 2.7A, SSOT-3 | SSOT-3 | FDN8601 | Fairchild Semiconductor | | |
| Q5 | 1 | 1 | 150V | MOSFET, N-CH, 150 V, 4.6 A, PQFN08A | PQFN08A | FDMS86252 | Fairchild Semiconductor | | |
| Q6 | 1 | 1 | 40 V | Transistor, PNP, 40 V, 0.2 A, SOT-23 | SOT-23 | MMBT3906-7-F | Diodes Inc. | | |
| Q7 | 0 | 1 | 60V | MOSFET, N-CH, 60 V, 50 A, DQJ0008A (VSONP-8) | DQJ0008A | CSD18534Q5A | Texas Instruments | | |
| Q8 | 0 | 1 | 40 V | Transistor, PNP, 40 V, 0.2 A, SOT-23 | SOT-23 | MMBT3906-7-F | Diodes Inc. | | |
| R1, R2, R3, R4, R5, R6, R7, R8 | 8 | 8 | 75.0 | RES, 75.0 ohm, 1%, 0.1W, 0603 | 0603 | CRCW060375R0FKEA | Vishay-Dale | | |
| R13, R14, R15, R16 | 4 | 4 | 232k | RES, 232 k, 1%, 0.1 W, 0603 | 0603 | CRCW0603232KFKEA | Vishay-Dale | | |
| R17 | 1 | 1 | 237k | RES, 237k ohm, 1%, 0.1W, 0603 | 0603 | CRCW0603237KFKEA | Vishay-Dale | | |
| R18 | 1 | 1 | 9.53k | RES, 9.53 k, 1%, 0.1 W, 0603 | 0603 | CRCW06039K53FKEA | Vishay-Dale | | |
| R19 | 1 | 1 | 60.4k | RES, 60.4 k, 1%, 0.1 W, 0603 | 0603 | CRCW060360K4FKEA | Vishay-Dale | | |
| R20, R21, R22 | 3 | 3 | 3.74k | RES, 3.74 k, 1%, 0.1 W, 0603 | 0603 | CRCW06033K74FKEA | Vishay-Dale | | |
| R23 | 1 | 1 | 27.4k | RES, 27.4 k, 1%, 0.1 W, 0603 | 0603 | RC0603FR-0727K4L | Yageo America | | |

**Table 5. TPS2373-3EVM-024 BOM[(1)] (continued)**

| Reference Designator | Quantity | | Value | Description | Reference | Part Number | Manufacturer | Alternate Part Number | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|---|
| | 001 | 002 | | | | | | | |
| R24, R29 | 2 | 2 | 63.4 | RES, 63.4 ohm, 1%, 0.1W, 0603 | 0603 | CRCW060363R4FKEA | Vishay-Dale | | |
| R25 | 1 | 1 | 90.9 | RES, 90.9, 1%, 0.1 W, 0603 | 0603 | CRCW060390R9FKEA | Vishay-Dale | | |
| R26 | 1 | 1 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | CRCW06030000Z0EA | Vishay-Dale | | |
| R27 | 1 | 1 | 249 | RES, 249, 1%, 0.1 W, 0603 | 0603 | CRCW0603249RFKEA | Vishay-Dale | | |
| R28 | 1 | 1 | 1.21k | RES, 1.21 k, 1%, 0.1 W, 0603 | 0603 | CRCW06031K21FKEA | Vishay-Dale | | |
| R30 | 1 | 1 | 1.00k | RES, 1.00 k, 1%, 0.75 W, 2010 | 2010 | CRCW20101K00FKEF | Vishay-Dale | | |
| R31 | 1 | 1 | 2k | TRIMMER, 2k ohm, 0.5W, TH | 375x190x375mil | 3386P-1-202LF | Bourns | | |
| R32 | 1 | 1 | 49.9k | RES, 49.9 k, 1%, 0.1 W, 0603 | 0603 | CRCW060349K9FKEA | Vishay-Dale | | |
| R33 | 1 | 1 | 39k | RES, 39 k, 5%, 0.25 W, 1206 | 1206 | CRCW120639K0JNEA | Vishay-Dale | | |
| R34 | 1 | 1 | 121k | RES, 121 k, 1%, 0.1 W, 0603 | 0603 | CRCW0603121KFKEA | Vishay-Dale | | |
| R35 | 1 | 1 | 4.7 | RES, 4.7, 5%, 0.1 W, 0603 | 0603 | CRCW06034R70JNEA | Vishay-Dale | | |
| R36 | 1 | 1 | 75 | RES, 75, 5%, 0.75 W, AEC-Q200 Grade 0, 2010 | 2010 | CRCW201075R0JNEF | Vishay-Dale | | |
| R37 | 1 | 1 | 4.53k | RES, 4.53 k, 1%, 0.1 W, 0603 | 0603 | CRCW06034K53FKEA | Vishay-Dale | | |
| R38 | 1 | 1 | 0.05 | RES, 0.05, 1%, 1 W, 2010 | 2010 | CRM2010-FZ-R050ELF | Bourns | | |
| R39 | 1 | 1 | 20 | RES, 20, 5%, 0.125 W, 0805 | 0805 | CRCW080520R0JNEA | Vishay-Dale | | |
| R40, R41 | 2 | 2 | 1.00k | RES, 1.00 k, 1%, 0.1 W, 0603 | 0603 | CRCW06031K00FKEA | Vishay-Dale | | |
| R42 | 1 | 1 | 49.9k | RES, 49.9k ohm, 1%, 0.1W, 0603 | 0603 | CRCW060349K9FKEA | Vishay-Dale | | |
| R43, R57 | 2 | 2 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | ERJ-3GEY0R00V | Panasonic | | |
| R44 | 1 | 1 | 4.42k | RES, 4.42 k, 1%, 0.1 W, 0603 | 0603 | CRCW06034K42FKEA | Vishay-Dale | | |
| R45 | 1 | 1 | 53.6k | RES, 53.6 k, 1%, 0.1 W, 0603 | 0603 | CRCW060353K6FKEA | Vishay-Dale | | |
| R46 | 1 | 1 | 82.5k | RES, 82.5k ohm, 1%, 0.1W, 0603 | 0603 | CRCW060382K5FKEA | Vishay-Dale | | |
| R47, R48 | 2 | 0 | 15 | RES, 15, 5%, 1 W, AEC-Q200 Grade 0, 2512 | 2512 | CRCW251215R0JNEG | Vishay-Dale | | |
| R49 | 0 | 1 | 5.1 | RES, 5.1, 5%, 1 W, AEC-Q200 Grade 0, 2512 | 2512 | CRCW25125R10JNEG | Vishay-Dale | | |
| R50 | 0 | 1 | 20 | RES, 20, 5%, 0.1 W, 0603 | 0603 | CRCW060320R0JNEA | Vishay-Dale | | |
| R51 | 0 | 1 | 0 | RES, 0, 5%, 0.1 W, 0603 | 0603 | ERJ-3GEY0R00V | Panasonic | | |
| R52 | 0 | 1 | 10.0k | RES, 10.0 k, 1%, 0.1 W, 0603 | 0603 | CRCW060310K0FKEA | Vishay-Dale | | |
| R53 | 1 | 1 | 50 | RES, 50, 1%, 0.1 W, 0603 | 0603 | CRCW060350R0FKEA | Vishay-Dale | | |
| R54 | 1 | 1 | 2.00k | RES, 2.00 k, 1%, 0.1 W, 0603 | 0603 | CRCW06032K00FKEA | Vishay-Dale | | |
| R55, R59, R60 | 3 | 3 | 10.0k | RES, 10.0 k, 1%, 0.1 W, 0603 | 0603 | CRCW060310K0FKEA | Vishay-Dale | | |
| R56 | 1 | 1 | 4.99k | RES, 4.99 k, 1%, 0.1 W, 0603 | 0603 | CRCW06034K99FKEA | Vishay-Dale | | |
| R58 | 1 | 1 | 1.50k | RES, 1.50 k, 1%, 0.1 W, 0603 | 0603 | CRCW06031K50FKEA | Vishay-Dale | | |
| R61 | 1 | 1 | 2.61k | RES, 2.61 k, 1%, 0.1 W, 0603 | 0603 | CRCW06032K61FKEA | Vishay-Dale | | |
| R9, R10, R11, R12 | 4 | 4 | 1.00Meg | RES, 1.00 M, 1%, 0.1 W, 0603 | 0603 | CRCW06031M00FKEA | Vishay-Dale | | |
| SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8 | 8 | 8 | 1x2 | Shunt, 100mil, Flash Gold, Black | Closed Top 100mil Shunt | SPC02SYAN | Sullins Connector Solutions | | |
| T1 | 1 | 1 | 350 uH | Transformer, 350 uH, SMT | 14.7x18.29mm | 7490220122 | Wurth Elektronik | | |
| T2 | 1 | 1 | 20.5uH | Transformer, 20.5 uH, SMT | 32.45x27.03mm | 750317065 | Wurth Elektronik | | |

**Table 5. TPS2373-3EVM-024 BOM[(1)] (continued)**

| Reference Designator | Quantity | | Value | Description | Reference | Part Number | Manufacturer | Alternate Part Number | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|---|
| | 001 | 002 | | | | | | | |
| T3 | 0 | 1 | 1.2mH | Transformer, Gate Drive, 1.2mH, SMT | 9.02x7.62x8.64mm | PA0184NLT | Pulse Engineering | | |
| TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27 | 24 | 24 | | Test Point, Miniature, SMT | Test Point, Miniature, SMT | 5019 | Keystone | | |
| TP11, TP12, TP13 | 3 | 3 | SMT | Test Point, Miniature, SMT | Testpoint_Keystone_Miniature | 5015 | Keystone | | |
| U1 | 1 | 1 | | High-Power PoE PD Interface with Advanced Startup, RGW0020B (VQFN-20) | RGW0020B | TPS2373-3RGWR | Texas Instruments | TPS2373-3RGWT | Texas Instruments |
| U2 | 1 | 1 | | Advanced Current-Mode Active Clamp PWM Controller with Current Control, -40 to +125 degC, 20-pin QFN (RGP), Green (RoHS & no Sb/Br) | RGP0020D | UCC2897ARGPT | Texas Instruments | | |
| U3 | 1 | 1 | | Optocoupler, 5 kV, 80-160% CTR, SMT | DIP-4L Gullwing | FOD817AS | Fairchild Semiconductor | | |
| U4 | 1 | 1 | | Adjustable Precision Shunt Regulator, 34 ppm / degC, 100 mA, -40 to 85 degC, 5-pin SOT-23 (DBV), Green (RoHS & no Sb/Br) | DBV0005A | TL431AIDBVR | Texas Instruments | | |

# STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

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。
http://www.tij.co.jp/lsds/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.

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.

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8. *Limitations on Damages and Liability:*

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