# TPS23753EVM-004: Evaluation Module for TPS23753

This user's guide describes the TPS23753EVM (TPS23753EVM-004). The TPS23753EVM-004 contains evaluation and reference circuitry for the TPS23753. The TPS23753 is an IEEE 802.3-2005 compliant powered-device controller and power supply controller optimized for isolated converter topologies. The TPS23753EVM-004 is targeted at general, efficient, synchronous rectifier, 10-W flyback converter applications.

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# 1 Description

TPS23753EVM-004 allows users to evaluate the reference circuitry of the TPS23753. It contains input and output power connectors and an array of onboard test points for circuit evaluation. TPS23753EVM-003 (5-V output) and TPS23753EVM-005 (12-V output) can be configured with simple bill of materials (BOM) changes.

## 1.1 Features

- Efficient, general market design
  - Simple gate drive, synchronous rectified secondary
  - 10-W output power from power over Ethernet (PoE), 48-V or 24-V adapter and 6-W output power from a 12-V adapter
  - 5-V or 12-V output voltage with simple BOM changes

## 1.2 Applications

- Voice over Internet protocol – IP telephones
- Wireless LAN – Wireless access points
- Security – Wired IP cameras

## 2 Electrical Specifications

**Table 1. TPS23753EVM-003, -004, and -005 Electrical and Performance Specifications at T = 25°C**

| PARAMETER | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **POWER INTERFACE** | | | | | | |
| Input Voltage | Applied to the power pins of connectors J2, J4, or J6 | | 0 | | 57 | V |
| Operating Voltage | After start up | | 30 | | 57 | V |
| Input UVLO | Rising input voltage | | | | 36 | V |
| | Falling input voltage | | 30 | | | |
| Detection voltage | At device terminals | | 3 | | 10 | mA |
| Classification voltage | At device terminals | | 10 | | 23 | mA |
| Classification current | Rclass = 1270 Ω | | 1.8 | | 2.4 | mA |
| Inrush current-limit | | | 90 | | 190 | mA |
| Operating current-limit | | | 405 | | 495 | mA |
| **DC/DC CONVERTER** | | | | | | |
| Output voltage | 20 V ≤ Vin ≤ 57 V, ILOAD ≤ ILOAD (max)<br>10.8 V ≤ Vin ≤ 13.2 V, ILOAD ≤ ILOAD (max) | 3.3-V output (-004) | 3.13 | 3.3 | 3.47 | V |
| | | 5-V output (-003) | 4.75 | 5.0 | 5.25 | |
| | | 12-V output (-005) | 11.4 | 12.0 | 12.6 | |
| Output current | 20 V ≤ Vin ≤ 57 V | 3.3-V output | | | 3 | A |
| | | 5-V output | | | 2 | |
| | | 12-V output | | | 0.9 | |
| | 10.8 V ≤ Vin ≤ 13.2 V | 3.3-V output | | | 1.8 | A |
| | | 5-V output | | | 1.2 | |
| | | 12-V output | | | 0.5 | |
| Output ripple voltage, peak-to-peak | Vin = 44 V, ILOAD = 3 A | 3.3-V output | | 30 | | mV |
| | Vin = 44 V, ILOAD = 2 A | 5-V output | | 40 | | |
| | Vin = 44 V, ILOAD = 0.9 A | 12-V output | | 100 | | |
| Efficiency, end-to-end | Vin = 44 V, ILOAD = 2 A | 3.3-V output | | 83 | | % |
| | Vin = 44 V, ILOAD = 1.4 A | 5-V output | | 82 | | % |
| | Vin = 44 V, ILOAD = 0.9 A | 12-V output | | 83 | | % |
| Switching frequency | | | 112 | | 138 | kHz |

# 3 Schematic

The TPS23753EVM-004 schematic follows.

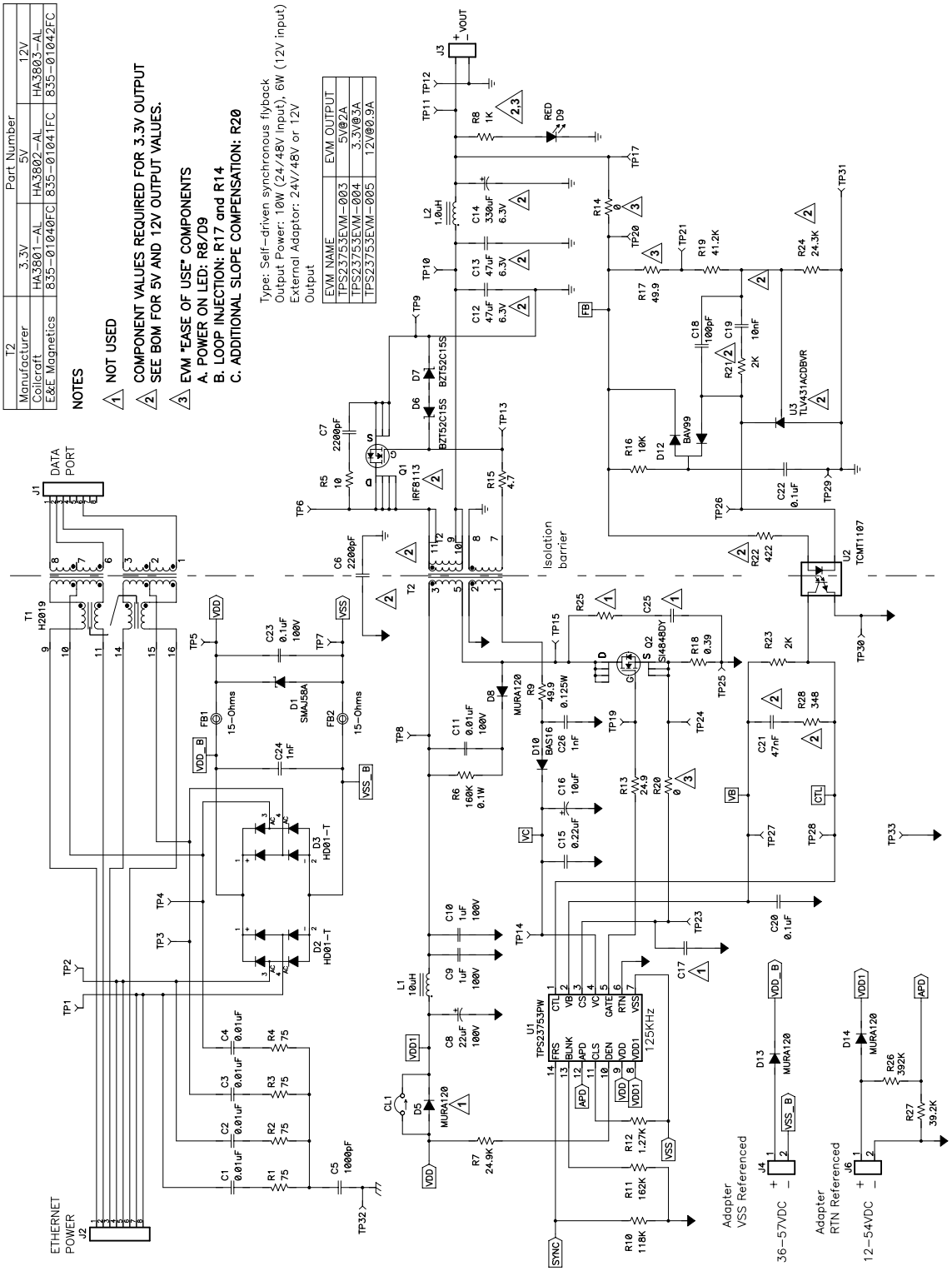


**Figure 1. TPS23753EVM-004 Schematic**

# 4 General Configuration and Description

## 4.1 Physical Access

Table 2 lists the TPS23753EVM-004 connector functionality and Table 3 describes the test point availability.

**Table 2. Connector Functionality**

| Connector | Label | Description |
|---|---|---|
| J1 | DATA PORT | Ethernet data port connector |
| J2 | ETHERNET POWER | Ethernet power input connector. Contains Ethernet transformer and cable terminations |
| J3 | VOUT | Output voltage connector |
| J4 | ADP-VSS | VSS referenced external adapter input connector.<br>J4-1/J4-1 are used with a powered-device adapter input (VSS) |
| J6 | AP-RTN | RTN referenced external adapter input connector.<br>J6-1/J6-2 are used with DC/DC converter adapter input (RTN) and |

**Table 3. Test Points**

| Test Point | Color | Label | Description |
|---|---|---|---|
| TP9, TP12, TP29, TP31 | BLK | GND | Secondary-side (output) grounds (GND) |
| TP14 | RED | VC | DC/DC converter bias supply |
| TP15 | ORG | DR-P | Drain terminal of the primary-side switching MOSFET |
| TP7 | BLK | VSS | POE input, low side |
| TP25, TP30, TP33 | BLK | RTN | DC/DC converter return |
| TP20. | ORG | LOOP | Can be used with TP17 for overall feedback loop measurements. |
| TP21 | WHT | I-LOOP | Can be used with TP17 for outer feedback loop measurements. |
| TP11, TP17 | RED | VOUT | DC/DC converter output voltage. |
| TP10 | RED | VOUT1 | DC/DC converter output voltage (before LC filter). |
| TP13 | WHT | GTS | Gate drive for the secondary-side synchronous rectifier MOSFET |
| TP6 | WHT | DR-S | Drain terminal of the secondary-side synchronous rectifier MOSFET |
| TP28 | WHT | CTL | Control loop input to the pulse width modulator |
| TP24 | WHT | RCS | DC/DC converter primary-side switching MOSFET current sense (resistor side) |
| TP23 | WHT | CS | DC/DC converter primary-side switching MOSFET current sense input (chip side) |
| TP27 | RED | VB | Bias voltage regulator |
| TP19 | WHT | GATE | Gate drive for the primary-side switching MOSFET |
| TP8 | RED | VPRI | Transformer primary high side. |
| TP26 | WHT | VKAT | Error amplifier (secondary-side) output drive for opto-isolator |
| TP1 | RED | PR78 | Pair 7,8 |
| TP4 | RED | PR12 | Pair 1,2 |
| TP2 | ORG | PR45 | Pair 4,5 |
| TP3 | ORG | PR36 | Pair 3,6 |
| D9 | RED | POWER ON | Output power indicator |

# 5 Test Setup

Figure 2 shows a typical test setup for TPS23753EVM-004. Input voltage can be applied as described in Table 2.

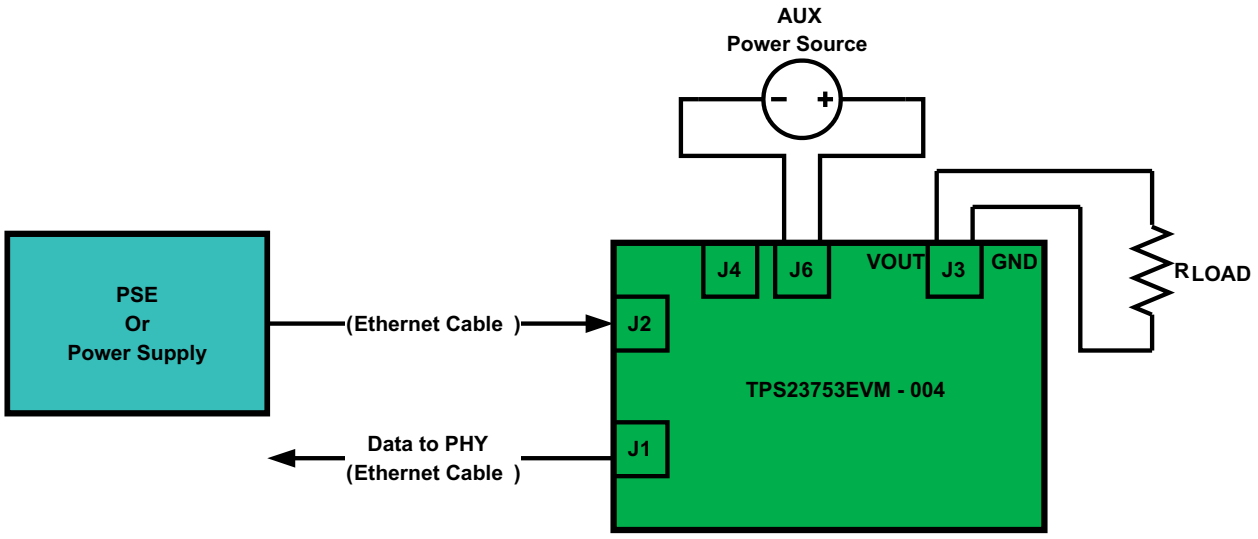


**Figure 2. Typical TPS23753EVM-004 Test Setup**

# 6 TPS23753EVM-004 Typical Performance Data

## 6.1 3.3-V Efficiency

Figure 3 illustrates the efficiency at three different input voltage levels: 1) PoE 48V from J2, 2) 48V RTN-based adapter, and 3) 24V RTN-based adapter.

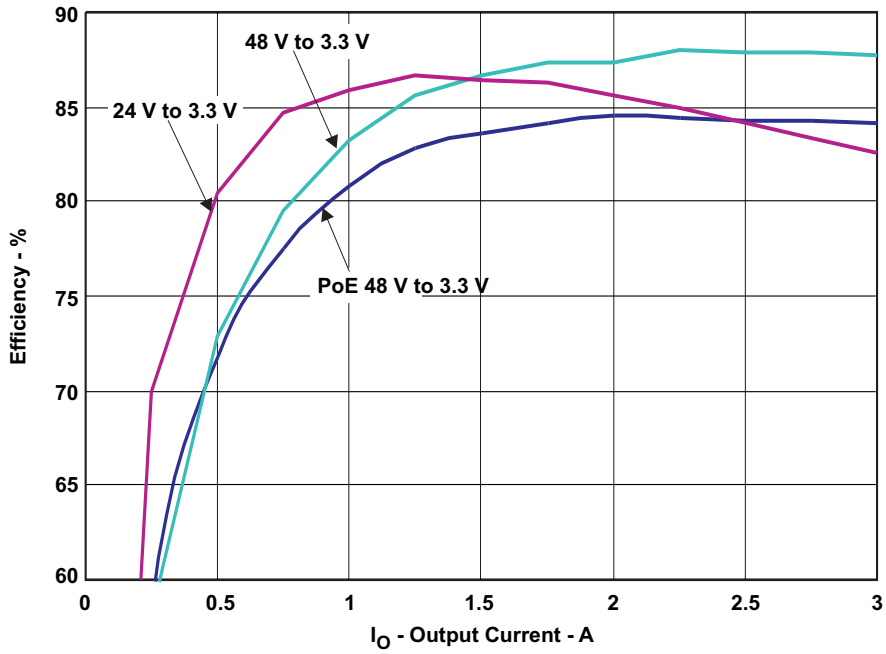


**Figure 3. TPS23753EVM-004 Efficiency With 3.3-V Output**

## 6.2 5-V DC/DC Efficiency

Figure 4 illustrates the efficiency at three different input voltage levels: 1) PoE 48V from J2, 2) 48V RTN-based adapter, and 3) 24V RTN- based adapter.

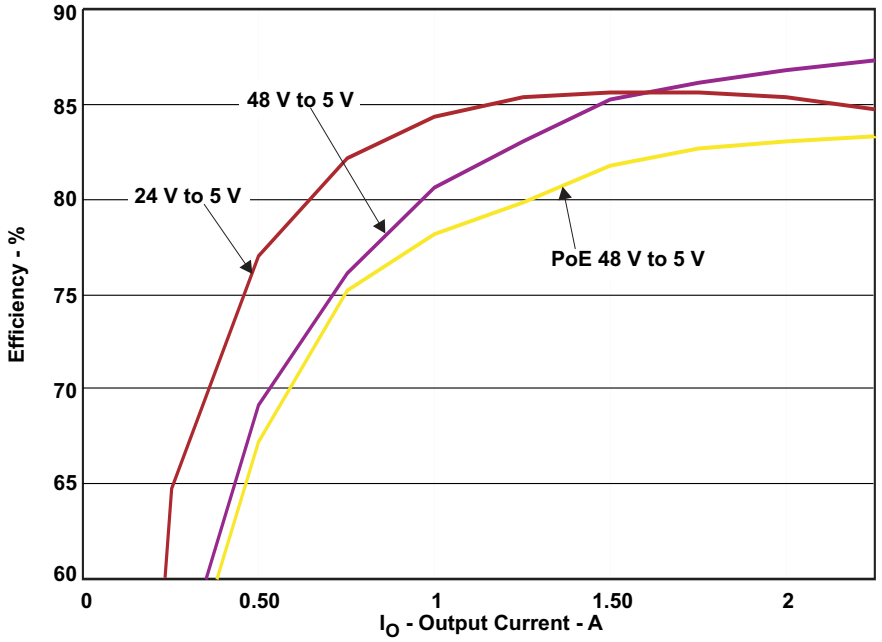


**Figure 4. TPS23753EVM-003 Efficiency With 5-V Output**

## 6.3 12-V DC/DC Efficiency

Figure 5 illustrates the efficiency at three different input voltage levels: 1) PoE 48V from J2, 2) 48V RTN-based adapter, and 3) 24V RTN-based adapter.

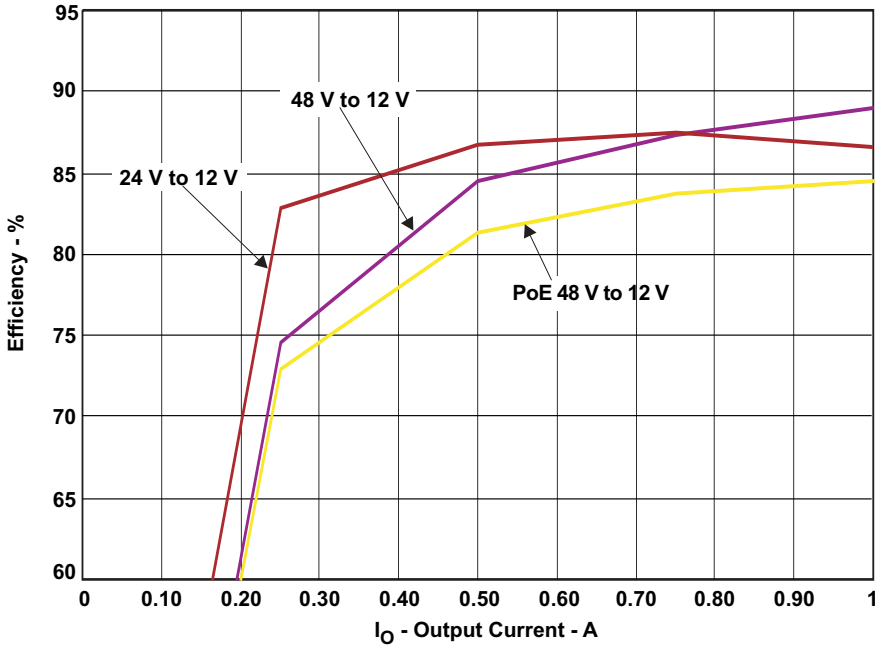


**Figure 5. TPS23753EVM-005 Efficiency With 12-V Output**

# 7 EVM Assembly Drawings and Layout Guidelines

## 7.1 PCB Drawings

Figure 6 shows the component placement and layout.

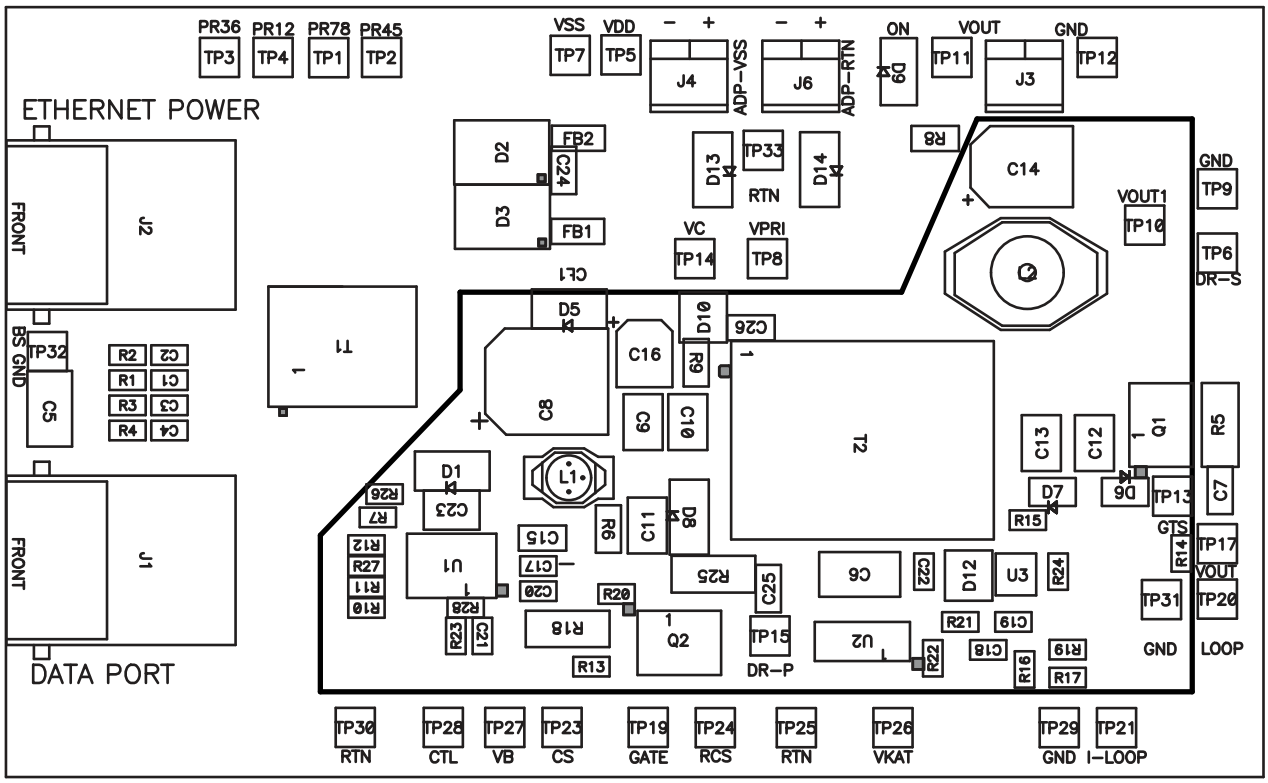


**Figure 6. Top Side Placement**

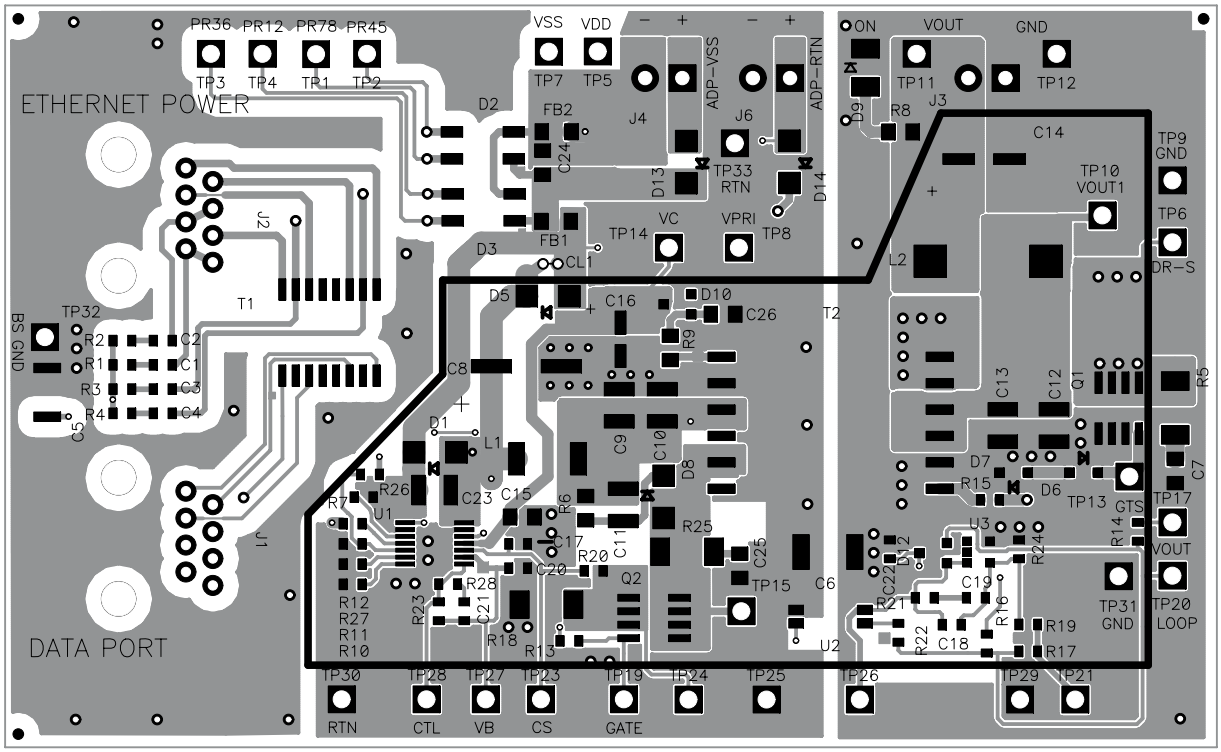


**Figure 7. Top-Side Routing**

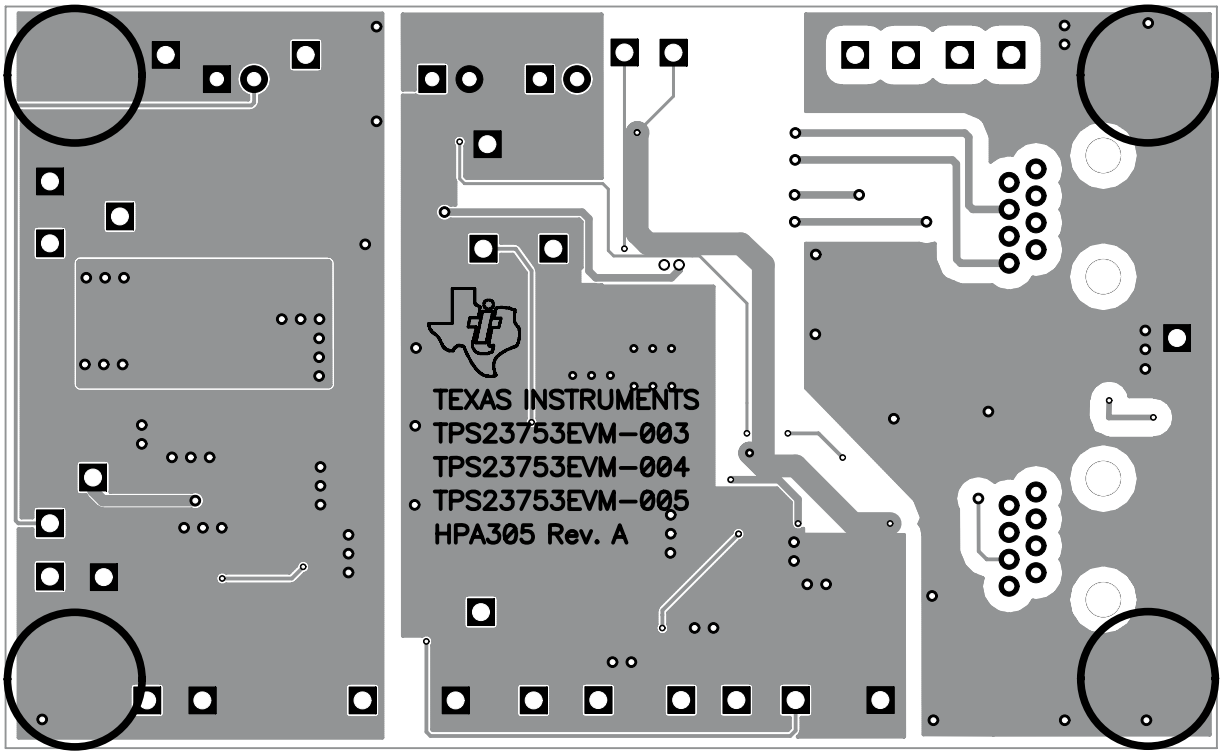


**Figure 8. Bottom-Side Routing**

# 8 Bill of Materials

**Table 4. TPS23753EVM-003, -004, and -005 Bill of Materials**

| TPS23753EVM-X | | | Refdes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|---|---|
| Outputs (V) | | | | | | | | |
| 12 | 3.3 | 5 | | | | | | |
| Count | | | | | | | | |
| X=005 | X=004 | X=003 | | | | | | |
| 4 | 4 | 4 | C1–C4 | 0.01µF | Capacitor, Ceramic, 100V, X7R, 10% | 0603 | Std | Std |
| 1 | 1 | 1 | C11 | 0.01µF | Capacitor, Ceramic, 100V, X7R, 10% | 1210 | Std | Std |
| 0 | 2 | 2 | C12, C13 | 47µF | Capacitor, Ceramic, 6.3-V, X5R, 20% | 1210 | C3225X5R0J476M | TD |
| 2 | 0 | 0 | C12, C13 | 10µF | Capacitor, Ceramic, 16-V, X5R, 20% | 1210 | C3225X5R1C106M | TD |
| 0 | 1 | 1 | C14 | 330µF | Capacitor, Aluminum, 6.3V, 20% | 0.260 × 0.276 in | EEVFK0J331XP | Panasonic |
| 1 | 0 | 0 | C14 | 68µF | Capacitor, Aluminum, 16V, 20% | 0.217 × 0.169 | EEVFK1C680P | Panasonic |
| 1 | 1 | 1 | C15 | 0.22µF | Capacitor, Ceramic, 25V, X7R, 10% | 0805 | Std | Std |
| 1 | 1 | 1 | C16 | 10µF | Capacitor, Aluminum, 25V, = 20% | 0.200 × 0.210 in | EEVFK1E100R | Panasonic |
| 0 | 0 | 0 | C17 | 220pF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 0 | 1 | 1 | C18 | 100pF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | 0 | 0 | C18 | 10pF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 0 | 0 | 1 | C19 | 8.2nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 0 | 1 | 0 | C19 | 10nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | 0 | 0 | C19 | 6.8nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 2 | 2 | 2 | C20, C22 | 0.1µF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 0 | 0 | 1 | C21 | 22nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 0 | 1 | 0 | C21 | 47nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | 0 | 0 | C21 | 10nF | Capacitor, Ceramic, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | 1 | 1 | C23 | 0.1µF | Capacitor, Ceramic, 100V, X7R, 10% | 1210 | Std | Std |
| 2 | 2 | 2 | C24, C26 | 1nF | Capacitor, Ceramic, 100V, X7R, 10% | 0805 | Std | Std |
| 0 | 0 | 0 | C25 | 330pF | Capacitor, Ceramic, 200V, X7R, 10% | 0805 | Std | Std |
| 1 | 1 | 1 | C5 | 1000pF | Capacitor, Ceramic, 2kV, X7R 10% | 1808 | C4520X7R3D102K | TD |
| 1 | 1 | 1 | C6 | 2200pF | Capacitor, Ceramic, 2KV, X7R, 20% | 1812 | C4532X7R3D222K | TD |
| 1 | 1 | 1 | C7 | 2200pF | Capacitor, Ceramic, 100V, X7R, 10% | 0805 | Std | Std |
| 1 | 1 | 1 | C8 | 22µF | Capacitor, Aluminum, 100V, 20% | 8 × 10.2 mm | EEVFK2A220P | Panasonic |
| 2 | 2 | 2 | C9, C10 | 1µF | Capacitor, Ceramic, 100V, X7R, 10% | 1210 | Std | Std |
| 1 | 1 | 1 | CL1 | NA | Current Loop, 0.025 holes | 0.120 × 0.075 in | NA | NA |
| 1 | 1 | 1 | D1 | SMAJ58A | Diode, TVS, 58-V, 1W | SMA | SMAJ58A | Diodes Inc. |
| 1 | 1 | 1 | D10 | BAS16 | Diode, Switching, 200mA, 75V, 225mW | SOT-23 | BAS16LT1 | On Semi |
| 1 | 1 | 1 | D12 | BAV99 | Diode, Dual Ultra Fast, Series, 200-mA, 70-V | SOT23 | BAV99 | Fairchild |
| 2 | 2 | 2 | D2, D3 | HD01-T | Bridge Rectifier, 100V, 0.8A, Glass Passivated, SMD | MINI DIP4 | HD01-T | Diodes, Inc |
| 3 | 3 | 3 | D8, D13, D14 | MURA120 | Diode, Rectifier, 1A, 200V | SMA | MURA120 | On Semi |
| 0 | 0 | 0 | D5 | MURA120 | Diode, Rectifier, 1A, 200V | SMA | MURA120 | On Semi |
| 2 | 2 | 2 | D6, D7 | BZT52C15S | Diode, Zener, 200mW, 15V | SOD-323 | BZT52C15S | Diodes, Inc |
| 2 | 2 | 2 | FB1, FB2 | 15-Ω | Bead, Ferrite, SMT, 15-Ω, 1500mA | 0805 | MMZ2012R150A | TDK |
| 2 | 2 | 2 | J1, J2 | 5520252-4 | Connector, Jack, Modular, 8 POS | 0.705 × 0.820 | 5520252-4 | AMP |
| 3 | 3 | 3 | J3, J4, J6 | ED1514 | Terminal Block, 2-pin, 6-A, 3,5mm | 0.27 × 0.25 | ED1514 | OST |
| 1 | 1 | 1 | L1 | 10uH | Inductor, SMT, 1.1A, 160mΩ | 4.45x6.6mm | DO1608C-103ML_ | Coilcraft |
| 1 | 1 | 1 | L2 | 1.0uH | Inductor, SMT, 1.0-uH, 6.8-A, 9-mΩ | 0.51x0.37 | DO3316P-102HCB | Coilcraft |
| 0 | 1 | 1 | Q1 | IRF8113 | MOSFET, N-ch, 30-V, 17.2-A, 5.6-mΩ | SO8 | IRF8113 | IR |
| 1 | 0 | 0 | Q1 | IRF7855 | MOSFET, N-ch, 60-V, 12-A, 9.4-mΩ | SO8 | IRF7855 | IR |
| 1 | 1 | 1 | Q2 | SI4848DY | MOSFET, N-ch, 150-V, 3.7-A, 85-mΩ | SO8 | SI4848DY | Vishay |
| 4 | 4 | 4 | R1–R4 | 75 | Resistor, Chip, 1/16W, 5% | 0603 | Std | Std |
| 1 | 1 | 1 | R10 | 118K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R11 | 162K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R12 | 1.27K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R13 | 24.9 | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 1 | 1 | 1 | R16 | 10K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |

**Table 4. TPS23753EVM-003, -004, and -005 Bill of Materials (continued)**

| TPS23753EVM-X | | | Refdes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|---|---|
| Outputs (V) | | | | | | | | |
| 12 | 3.3 | 5 | | | | | | |
| Count | | | | | | | | |
| X=005 | X=004 | X=003 | | | | | | |
| 1 | 1 | 1 | R17 | 49.9 | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R18 | 0.39 | Resistor, Chip, 1/2W, 1% | 2010 | Std | Std |
| 1 | 1 | 1 | R19 | 41.2K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 2 | 2 | 2 | R14, R20 | 0 | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 0 | 0 | 1 | R21 | 21K | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 0 | 1 | 0 | R21 | 2K | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 1 | 0 | 0 | R21 | 142K | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 0 | 0 | 1 | R22 | 1K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 0 | 1 | 0 | R22 | 422 | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 0 | 0 | R22 | 4.02K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R23 | 2K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 0 | 0 | 1 | R24 | 13.3K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 0 | 1 | 0 | R24 | 24.3K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 0 | 0 | R24 | 10.7K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R26 | 392K | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 1 | 1 | 1 | R27 | 39.2K | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 0 | 0 | 1 | R28 | 249 | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 0 | 1 | 0 | R28 | 348 | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 1 | 0 | 0 | R28 | 0 | Resistor, Chip, 1/16W, 1% | 0603 | Std | Std |
| 1 | 1 | 1 | R15 | 4.7 | Resistor, Chip, 1/16W, 5% | 0603 | Std | Std |
| 0 | 0 | 0 | R25 | 79 | Resistor, Chip, 1/2W, 5% | 2010 | Std | Std |
| 1 | 1 | 1 | R5 | 10 | Resistor, Chip, 1/2W, 5% | 2010 | Std | Std |
| 1 | 1 | 1 | R6 | 160K | Resistor, Chip, 1/10W, 5% | 0805 | Std | Std |
| 1 | 1 | 1 | R7 | 24.9K | Resistor, Chip, 1/16W,1% | 0603 | Std | Std |
| 1 | 1 | 1 | R9 | 49.9 | Resistor, Chip, 1/8-W, 1% | 0805 | Std | Std |
| 1 | 1 | 1 | T1 | H2019 | XFMR, Center-tapped, Voice Over IP | 0.500 × 0.370 | H2019 | Pulse |
| 0 | 0 | 1 | T2 | HA3802-AL or 835-01041FC | Transformer, PoE 13W, Triple Secondary, 150uH, 5V, 2A | 0.875 × 0.675 | HA3802-AL or 835-01041FC | Coilcraft or E&E Magnetic Products |
| 0 | 1 | 0 | T2 | HA3801-AL or 835-01040FC | Transformer, PoE 13W, Triple Secondary, 165uH, 3.3V, 3A | 0.875 × 0.675 | HA3801-AL or 835-01040FC | Coilcraft or E&E Magnetic Products |
| 1 | 0 | 0 | T2 | HA3803-AL or 835-01042FC | Transformer, PoE 13W, Triple Secondary, 150uH, 12V, 1A | 0.875 × 0.675 | HA3803-AL or 835-01042FC | Coilcraft or E&E Magnetic Products |
| 1 | 1 | 1 | U1 | TPS23753PW | IC, IEEE 802.3-2005 Integrated Primary Side Controller | TSSOP14 | TPS23753PW | TI |
| 1 | 1 | 1 | U2 | TCMT1107 | IC, Photocoupler, 3750VRMS, 80-160% CTR | MF4 | TCMT1107 | Vishay |
| 0 | 1 | 1 | U3 | TLV431ACDBVR | IC, Shunt Regulator, 1.24-V ref, 6-V, 10-mA, 1% | SOT23-5 | TLV431ACDBVR | TI |
| 1 | 0 | 0 | U3 | TL431ACDBVR | IC, Shunt Regulator, 2.49-V ref, 36-V, 10-mA, 1% | SOT23-5 | TL431ACDBVR | TI |
| 1 | 1 | 1 | — | — | PCB, 2.76 In x 4.50 In x 0.062 In | — | HPA305 | Any |

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## EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0 V to 57 V and the output voltage range of 3 V to 15 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

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

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