User's Guide

SLVU174B–August 2006–Revised APRIL 2009

Using the TPS40200

The TPS40200EVM-002 evaluation module (EVM) uses the TPS40200 non-synchronous buck converter to provide a resistor-selected, 3.3-V output that delivers up to 2.5 A from a 24-V input bus. The EVM operates from a single supply and uses a single P-channel power FET and Schottky diode to produce a low-cost buck converter. The part operates at a 200-kHz clock frequency as determined by an external resistor and capacitor.

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1 Description

The TPS40200EVM-002 is designed to operate with an 18 to 36-volt input to produce a regulated 3.3-V output with a load current from 0.125 to 2.5 A. The TPS40200EVM-002 demonstrates the use of the TPS40200 in a typical buck converter application. The board sacrifices some layout density to provide ample test points for device evaluation. This EVM can be modified to support output voltages from 0.7 V to 5 V and above by changing a single feedback resistor. Table 1 gives specific 1% resistor values for some common output voltages.

1.1 Features

- 18-V to 36-V input range
- 3.3-V output, adjustable with single feedback resistor
- 0.125-A to 2.5-A steady-state output current
- 200-kHz switching frequency
- Single P-channel MOSFET and single rectifier
- Two-layer, 1.275-inch × 1.675-inch, surface-mount design with all components on one side
- Convenient test points for probing critical waveforms and noninvasive loop response testing

1.2 Applications

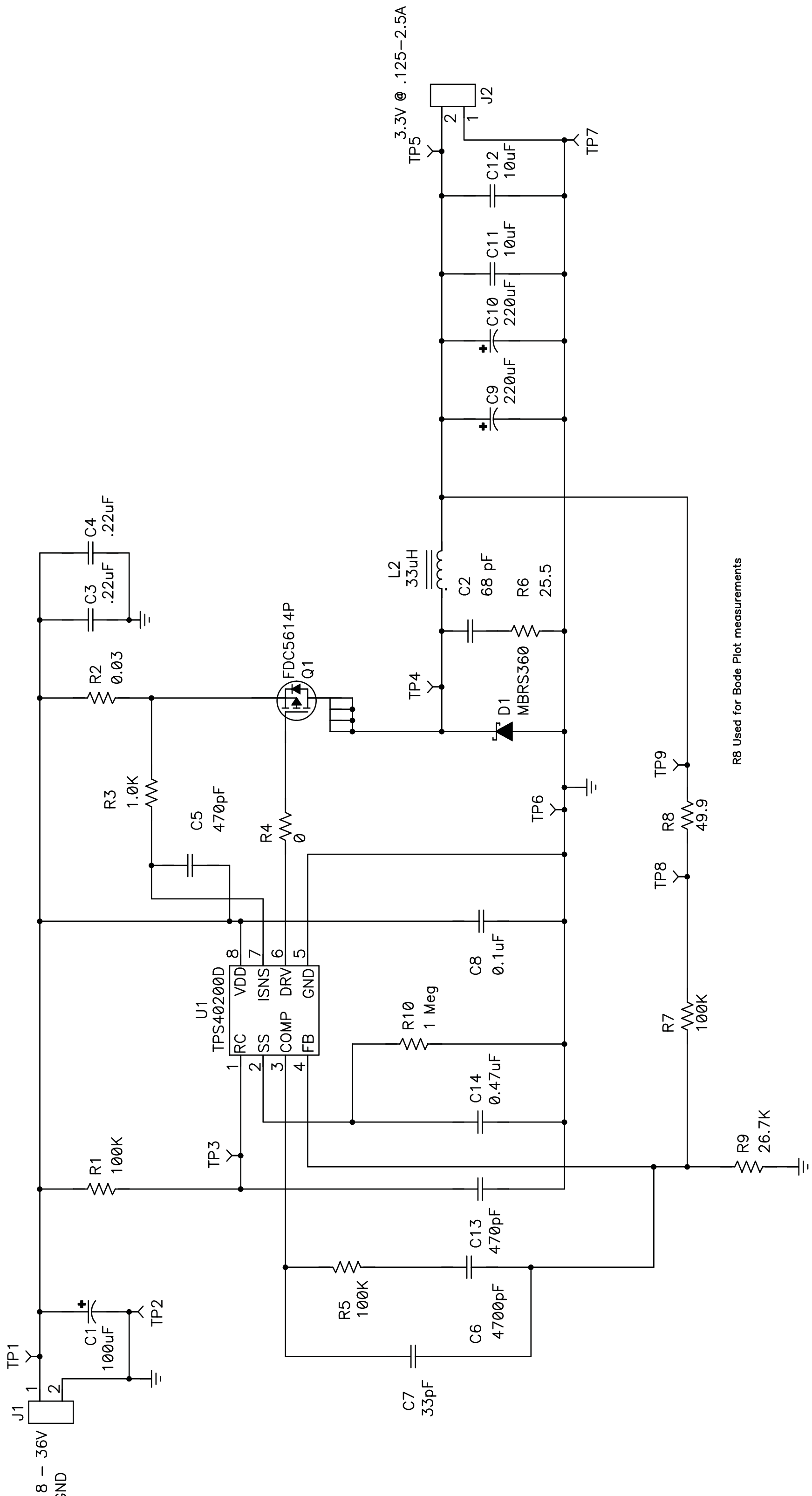
- Non-isolated medium-current, point-of-load and low-voltage bus converters
- Scanners
- Industrial controls
- Distributed power systems
- DSL/cable modems

2 TPS40200EVM-002 Electrical and Performance Specifications

PARAMETER		TEXT CONDITIONS	MIN	NOM	MAX	UNIT
V_{IN}	Input voltage		18	24	36	V
V_{OUT}	Output voltage	V_{IN} = 24 V, I_{OUT} = 2.5 A	3.2	3.3	3.4[(1)]	V
I_{OUT}	Output current		0.125		2.5	A
	Line regulation	V_{IN} = 18-36 V. I_{OUT}= 0.125-2.5 A. Set Point Voltage mV		3	6	mV
	Load regulation	V_{IN} = 18-36 V. I_{OUT}= 0.125-2.5 A. Set Point Voltage mV		3	6	mV
V_{RIPPLE}	Output ripple voltage	V_{IN} = 36 V, I_{OUT} = 2.5 A		60		mV
V_{OVER}	Output overshoot	For 2.5 to 0.125-A load transient		100		mV
V_{UNDER}	Output undershoot	For 0.125 to 2.5-A load transient		100		mV
I_{SCP}	Short-circuit current trip point	I_{MAX} +50% minimum	3.75		5	A
	Efficiency	At nominal input voltage and maximum output current		80		%
F_S	Switching frequency			200		kHz

(1) Set-point accuracy depends on external resistor tolerance. 1% resistors are used in this EVM.

3 Schematic



NOTE: For reference only; see Table 2, Bill of Materials for specific values

Figure 1. TPS40200EVM-002 Schematic

3.1 Adjusting Output Voltage (R7 and R9)

The regulated output voltage can be adjusted within a limited range by changing the ground resistor in the feedback resistor divider (R7 and R9). The value for the feedback resistor (R9) for any output voltage is given by Equation 1

$$R9 = \frac{V_{REF} \bullet R7}{V_{OUT} - V_{REF}} \quad (1)$$

where

- V_{REF} = 0.700 V
- R7 = 100 kΩ

Table 1 contains common values for R9 to generate popular output voltages. TPS40200EVM-002 is stable through this entire range of output voltages. Efficiency rises with output voltage.

Table 1. Adjusting V_{OUT} With R9 Rounded to Standard 1% Resistor Values

OUTPUT VOLTAGE (V)	R9 - FEEDBACK RESISTOR DIVIDER (kΩ)
5	16.2
3.3	26.7
2.5	39
2	53.6
1.8	63.4
1.5	86.6
1.2	140

4 Test Setup

4.1 Equipment

4.1.1 Voltage Source

V_{IN}— The input voltage source (V_{IN}) should be a 0-V to 36-V variable dc source capable of delivering 5 A.

METERS

A1: 0-A to 5-A dc ammeter
V1: V_{IN}, 0-V to 40-V voltmeter
V2: V_{OUT} 0 V to 10-V voltmeter

4.1.2 Loads

LOAD1 — The output load (LOAD1) should be an electronic constant-current-mode load capable of 0-5 A dc at 1.5 V.

4.1.3 Recommended Wire Gauge

V_{IN} to J1 — The connection between the source voltage, V_{IN} and J1 of the HPA154 can carry as much as 3 A dc. The minimum recommended wire size is AWG #16 with the length of wire less than 4 feet (2 feet input, 2 feet return).

J2 to LOAD1 (Power) — The power connection between J3 of the HPA154 and LOAD1 can carry as much as 5 A dc. The minimum recommended wire size is 2x AWG #16, with the length of wire less than 4 feet (2 feet output, 2 feet return).

J2 to LOAD1 (Remote Sense) — If remote sense is used, the remote sense connection between J2 of HPA154 and LOAD1 will carry less than 1 A dc. The minimum recommended wire size is AWG #22, with the length of wire less and 4 feet (2 feet output, 2 feet return).

4.1.4 Oscilloscope

A 60-MHz or faster oscilloscope can be used to measure the ripple voltage on V_{OUT}. The oscilloscope should be set for 1-MΩ impedance, ac coupling, 1-µs/division horizontal resolution, and 20-mV/division vertical resolution for measuring output ripple. TP5 and TP7 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP5 and holding the ground barrel to TP7 as shown in Figure 2. For a hands-free approach, the loop in TP7 can be cut and opened to cradle the probe barrel. Using a leaded ground connection may induce additional noise due to the large ground loop area.

4.2 Equipment Setup

The recommended basic test setup to evaluate the TPS40200EVM-002 is shown in Figure 2. Note that although the return for J1 and J2 are the same, the connections should remain separate as shown in Figure 2.

4.2.1 Procedure

1. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected to earth ground before power is applied to the EVM. Electrostatic smock and safety glasses should also be worn.
2. Prior to connecting the dc-input source, V_{IN}, it is advisable to limit the source current from V_{IN} to a maximum of 5 A. Ensure that V_{IN} is initially set to 0 V and connected as shown in Figure 2.
3. Connect the ammeter A1 (0-A to 5-A range) between V_{IN} and J1 as shown in Figure 2.
4. Connect voltmeter V1 to TP1 and TP2 as shown in Figure 2.
5. Connect LOAD1 to J2 as shown in Figure 1. Set LOAD1 to constant-current mode to sink 0 A dc before V_{IN} is applied.
6. Connect voltmeter, V2 across J2 pin 3 and J2 pin 2 as shown in Figure 2.
7. Connect the oscilloscope probe to TP5 and TP7 as shown in Figure 3.

4.2.2 Diagram

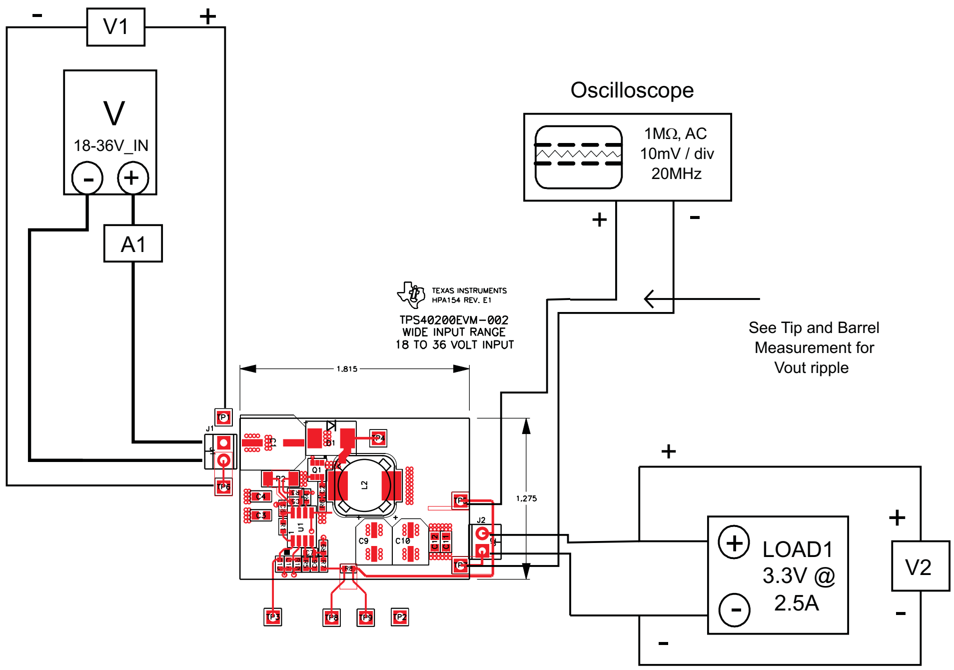


Figure 2. TPS40200EVM-002 Recommended Test Setup

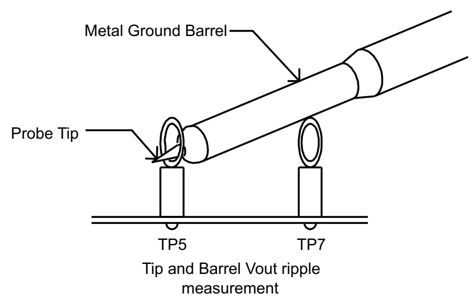


Figure 3. Output Ripple Measurement - Tip and Barrel Using TP14 and TP15

4.3 Startup/Shutdown Procedure

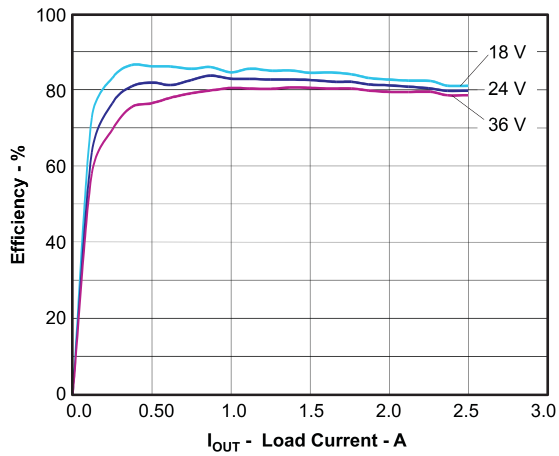
a. Increase V_{IN} (V1) from 0 V to 18 V dc.
b. Vary LOAD1 from 0 A to 2.5 A dc.
c. Vary V_{IN} (V1) from 18 V dc to 36 V dc.
d. Decrease LOAD1 to 0 A.
e. Decrease VIN to 0 V.

4.4 Equipment Shutdown

a. Shut down oscilloscope.
b. Shut down LOAD1.
c. Shut down V_{IN}.

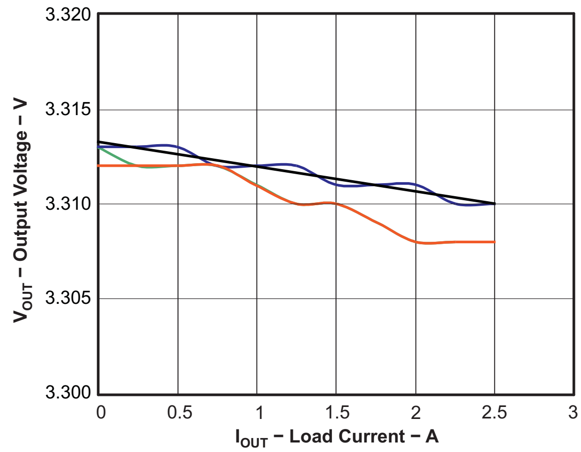
5 TPS40200EVM Typical Performance Data and Characteristic Curves

Figure 4 through Figure 5 present typical performance curves for the TPS40200EVM-002. Because actual performance data can be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.



NOTE: V_{IN} = 18 V, 24 V, and 36 V, V_{OUT} = 3.3 V, I_{OUT} = 0.125 A to 2.5 A

Figure 4. TPS40200EVM-002 Efficiency



NOTE: Data taken at 18 and 36 volts with a straight-line approximation provided.

Figure 5. Typical TPS40200EVM-002 Line and Load Regulation – V_{OUT} = 3.312 V

6 EVM Assembly Drawings and Layout

The following figures (Figure 6 through Figure 9) show the design of the TPS40200EVM-002 printed-circuit board. The EVM has been designed using a 2-layer, 2-oz copper-clad circuit board, 1.275-inch × 1.815-inch in size, with all components on the top side to allow the user to easily view, probe, and evaluate the TPS40200 control IC in a practical application. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space-constrained systems.

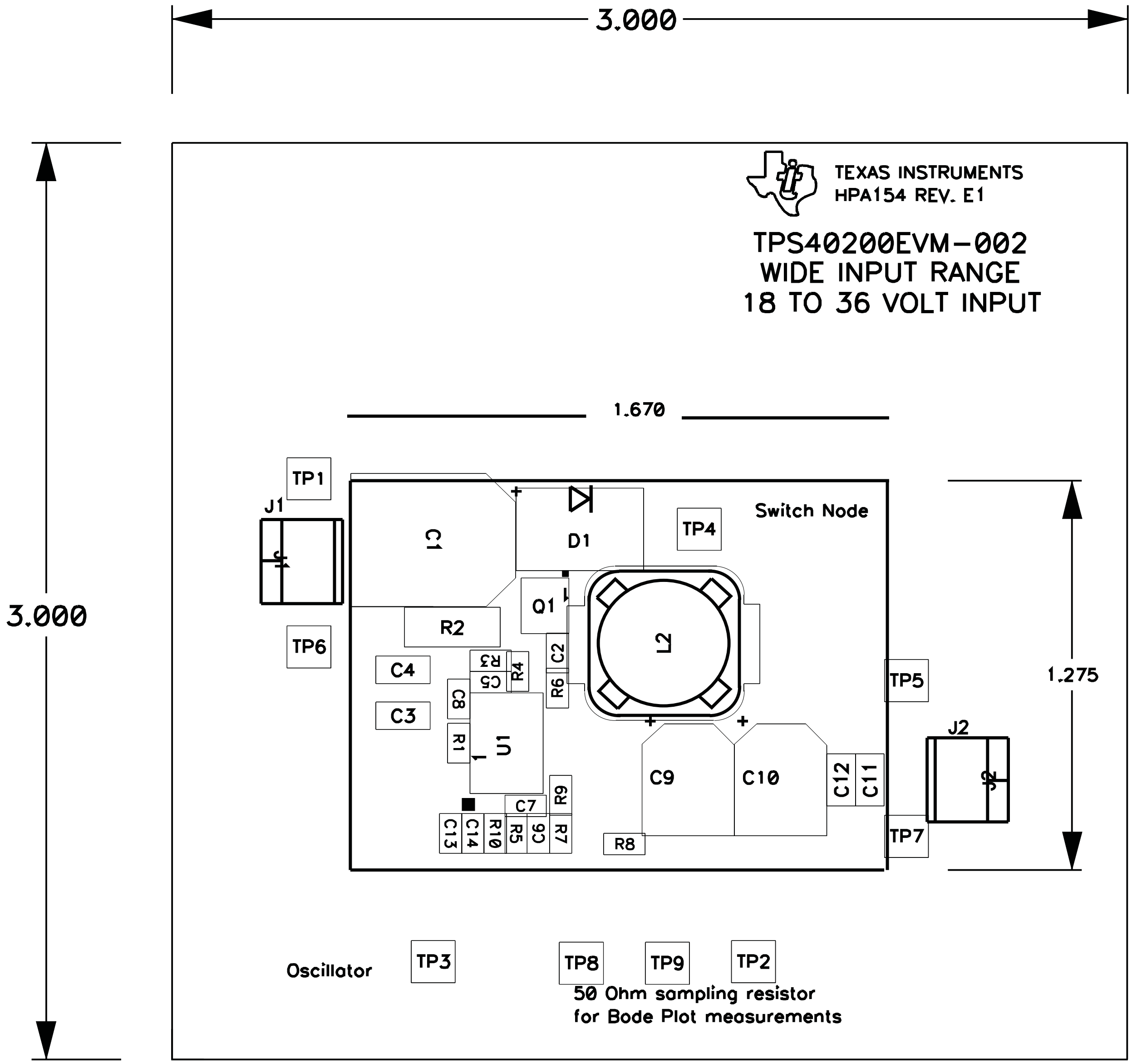


Figure 6. TPS40200EVM-002 Component Placement (Viewed from Top)

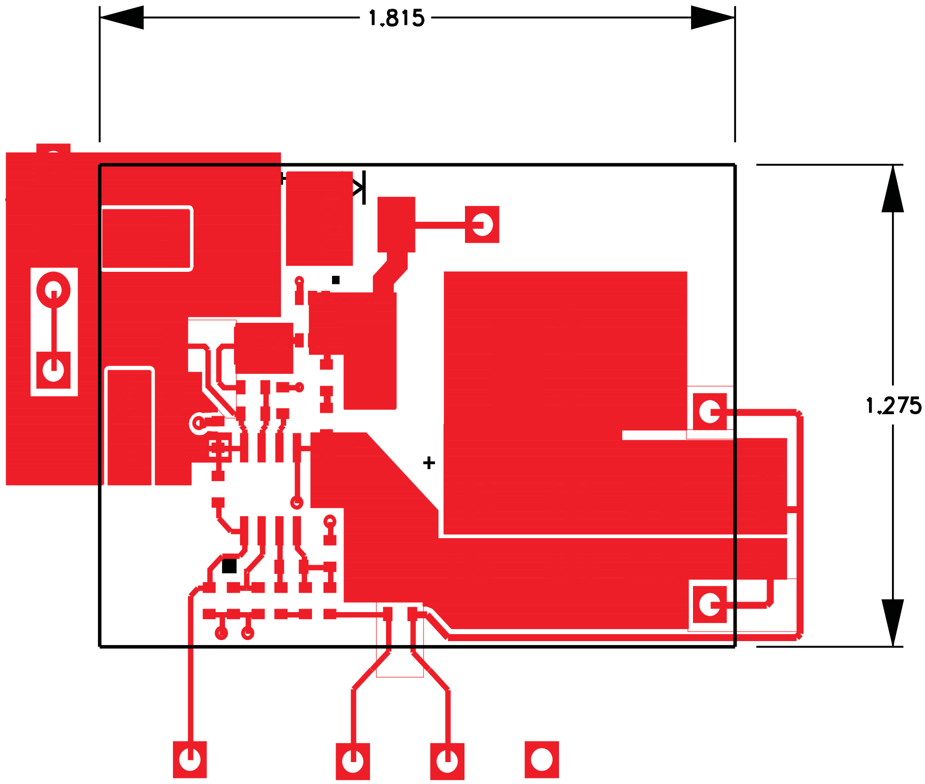


Figure 7. TPS40200EVM-002 Silkscreen (Viewed from Top)

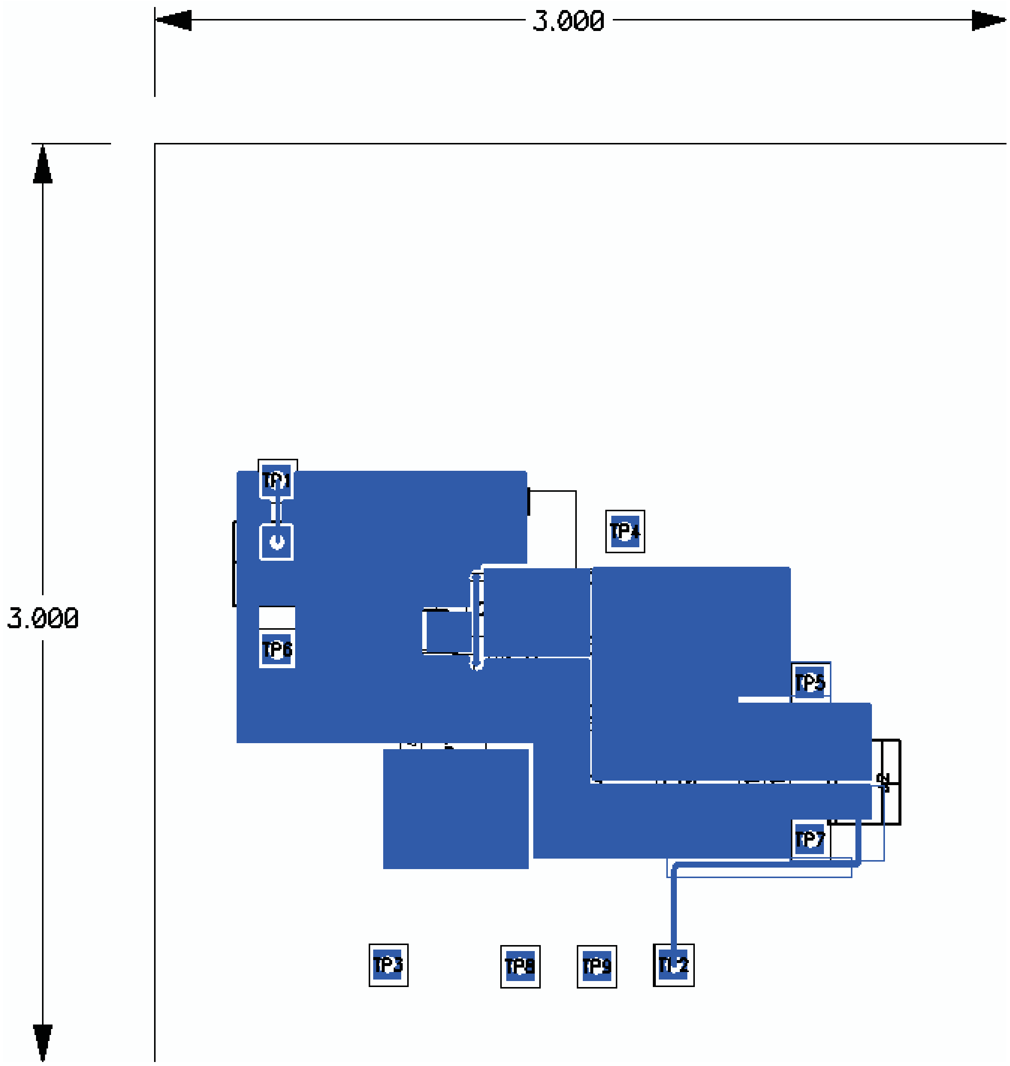


Figure 8. TPS40200EVM-002 Top View

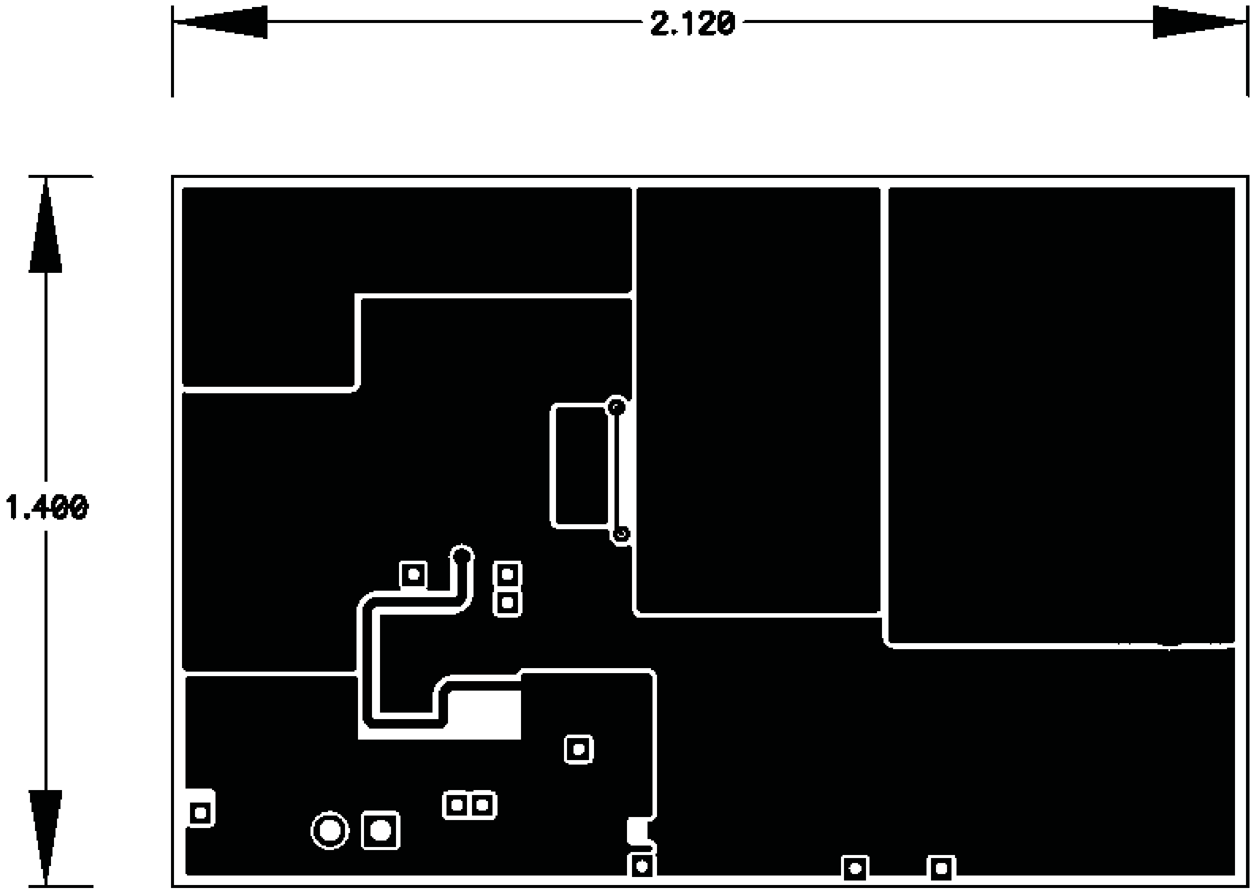


Figure 9. TPS40200EVM-002 Bottom View

7 List of Materials

Table 2 lists the EVM components as configured according to the schematic shown in Figure 1.

Table 2. TPS40200EVM-002 Bill of Materials

Count	Ref Des	Value	Description	Size	Part Number	MFR
1	C1	100 µF	Capacitor, Aluminum, 63 V, 20%	0.457 x 0.406	EEVFK1J101P	Panasonic
2	C11, C12	10 µF	Capacitor, Ceramic, 6.3 V, X5R 20%	0805	Std	Std
1	C14	0.47 µF	Capacitor, Ceramic, 16 V, X5R, 20%	0603	Std	Std
1	C2	68 pF	Capacitor, Ceramic, 50 V, X7R, 20%	0603	Std	Std
2	C3, C4	0.22 µF	Capacitor, Ceramic, 50 V, X7R, 20%	0805	Std	Std
2	C5, C13	470 pF	Capacitor, Ceramic, 50 V, X7R, 20%	0603	Std	Std
1	C6	4700 pF	Capacitor, Ceramic, 50 V, X7R, 20%	0603	Std	Std
1	C7	33 pF	Capacitor, Ceramic, 50 V, X7R, 20%	0603	Std	Std
1	C8	0.1 µF	Capacitor, Ceramic, 50 V, X7R, 20%	0603	Std	Std
2	C9, C10	220 µF	Capacitor, Aluminum, 6.3 V, 20%	0.260 x 0.276 inch	EEVFK0J221P	Panasonic
1	D1	MBRS360	Diode, Schottky, 3 A, 60 V	SMC	MBRS360	On Semi
1	L2	33 µH	Inductor, SMT, 33 µH, 3.23 A, 0.06 Ω	0.492 sq"	DR127-330	Coiltronics
1	Q1	FDC5614P	Transistor, MOSFET, Pch, –3 A, –60 V,	SuperSOT-6	FDC5614P	Fairchild
3	R1, R5, R7	100 kΩ	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R10	1 MΩ	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R2	0.03 Ω	Resistor, Chip, W, 5%	2010	Std	Std
1	R3	1.0 kΩ	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R4	0 Ω	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R6	25.5 Ω	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R8	49.9 Ω	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	R9	26.7 kΩ	Resistor, Chip, 1/16 W, 1%	0603	Std	Std
1	U1	TPS40200D	IC, Low Cost Sync Buck Controller	SO-8	TPS40200D	TI
1	–		PCB, 3 In x 3 In x 0.063 In		HPA154_PCB	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 36 V and the output voltage range of 0 V to 6.3 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 100°C. The EVM is designed to operate properly with certain components above 100°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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