

# ***TPS50601ASPEVM 6-A Regulator Evaluation Module***

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This user's guide contains background information for the TPS50601A-SP as well as support documentation for the TPS50601A-SP evaluation module (TPS50601ASPEVM-S). Also included are the performance specifications, the schematic, and the bill of materials for TPS50601ASPEVM.

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## 1 Introduction

### 1.1 Background

The TPS50601A-SP dc/dc converter is designed to provide up to a 6-A output in single phase operation.

The TPS50601A-SP implements split-input power rails with separate input voltage inputs for the power stage and control circuitry rated for 3 V to 6.3 V. The TPS50601A-SP provides both inputs but is designed and tested using the PVIN connected to VIN. Rated input voltage and output current range for the evaluation module are given in [Table 1](#). This evaluation module is designed to demonstrate features of TPS50601A-SP as well as provide flexibility so input, output capacitors and output inductors as well as other components such as frequency adjust, output voltage and compensations components can be modified to meet their needs when designing with the TPS50601A-SP regulator. The switching frequency is externally set at a nominal 100 kHz. TPS50601A-SP will operate with switching frequency of 100-kHz to 1-MHz range. For the EVM 100 kHz was selected as it would provide higher efficiency. The high-side and low-side MOSFETs are incorporated inside the TPS50601A-SP package along with the gate drive circuitry. The low drain-to-source on-resistance of the MOSFET allows the TPS50601A-SP to achieve high efficiencies and helps keep the junction temperature low at high output currents. The compensation components are external to the integrated circuit (IC), and an external divider allows for an adjustable output voltage. Additionally, the TPS50601A-SP provides adjustable slow start, tracking, and undervoltage lockout inputs.

**Table 1. Input Voltage and Output Current Summary of TPS50601ASPEVM**

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
TPS50601ASPEVM	VIN = 4.45 V to 6.3 V (VIN start voltage = 4.5 V NOM)	0 A to 6 A

### 1.2 Performance Specification Summary

A summary of the TPS50601ASPEVM performance specifications is provided in [Table 2](#). Specifications are given for an input voltage of VIN = 5 V and an output voltage of 2.5 V, unless otherwise specified. The TPS50601ASPEVM is designed and tested for VIN = 4.5 V to 6.3 V with the VIN and PVIN pins connect together with the J1 jumper. The ambient temperature is 25°C for all measurements, unless otherwise noted.

**Table 2. TPS50601ASPEVM Configuration**

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VIN voltage range (PVIN = VIN)		4.5	5	6.3	V
VIN start voltage			4.5		V
VIN stop voltage			4.3		V
Output voltage set point			2.49		V
Output current range	VIN = 4.5 V to 6.3 V	0		6	A

### 1.3 Modifications

These evaluation modules are designed to provide access to the features of the TPS50601A-SP. Some modifications can be made to this module. Layout of EVM is designed to make it easy for customer to modify the configuration to meet their needs and adjust for different input, output capacitors, and output inductors.

#### 1.3.1 Output Voltage Set Point

The output voltage is set by the resistor divider network of R21 and R22. R21 is fixed at 10 kΩ. To change the output voltage of the EVM, it is necessary to change the value of resistor R22. Changing the value of R22 can change the output voltage above 0.804 V. The value of R22 for a specific output voltage can be calculated using [Equation 1](#).

$$R_{22} = \frac{V_{REF} \times R_{21}}{(V_{OUT} - V_{REF})}$$

where

- $V_{REF} = 0.804 \text{ V}$  (1)

Table 3 lists the R22 values for some common output voltages. The values given in Table 3 are standard values, not the exact value calculated using Equation 1.

**Table 3. Output Voltages Available**

Output Voltage (V)	R22 Value (kΩ)
1.2	20
1.8	8.06
2.5	4.7
3.3	3.2

### 1.3.2 Maximum Duty Cycle Limit

The TPS50601A-SP can operate at high duty cycle up to 100%. As we approach 100% duty cycle, via reduction in input voltage, feedback will ensure that high side MOSFET is kept on. This will result in  $V_{out}$  equal to  $V_{in}$  less the circuit drops.

### 1.3.3 Slow-Start Time

The slow-start time can be adjusted by changing the value of C1. Use Equation 2 to calculate the required value of C1 for a desired slow-start time.

$$C_1 (\text{nF}) = \frac{T_{SS} (\text{ms}) \times I_{SS} (\mu\text{A})}{V_{ref} (\text{V})} \quad (2)$$

The EVM is set for a slow-start time of 4 ms using  $C_1 = 0.01 \mu\text{F}$  and  $I_{SS} = 2 \mu\text{A}$ .

### 1.3.4 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted externally using R13 and R15. The EVM is set for a start voltage of 4.6 V and a stop voltage of 4.3 V using  $R_{13} = 10 \text{ k}\Omega$  and  $R_{15} = 3.4 \text{ k}\Omega$  at no load conditions. Use Equation 3 and Equation 4 to calculate required resistor values for different start and stop voltages. When output is loaded, this results in increase in ripple current on PVIN. In order to minimize the effect of Pvin ripple on enable, capacitor C5 = 0.1  $\mu\text{F}$  is installed across R15. Thus R13/C5 behaves as an RC filter.

$$R_6 = \frac{V_{START} \left( \frac{V_{ENFALLING}}{V_{ENRISING}} \right) - V_{STOP}}{I_p \left( 1 - \frac{V_{ENFALLING}}{V_{ENRISING}} \right) + I_h} \quad (3)$$

$$R_7 = \frac{R_1 \times V_{ENFALLING}}{V_{STOP} - V_{ENFALLING} + R_6(I_p + I_h)}$$

where

- $I_h = 3 \mu\text{A}$ ,  $I_p = 6.1 \mu\text{A}$ ,  $V_{ENRISING} = 1.14 \text{ V}$ ,  $V_{ENFALLING} = 1.11 \text{ V}$  (4)

Nominal start voltage is 4.5 V and worse case start voltage is 4.6 V. Nominal stop voltage is 4.3 V and worse case stop voltage 4 V.

## 2 Input Voltage Rails

The EVM is designed to accommodate different input voltage levels for the power stage and control logic. During normal operation, the PVIN and VIN inputs are connected together using a jumper across J1. The single input voltage is supplied at J2 (Pvin+) and J5 (GND). If desired, these input voltage rails may be separated by removing the jumper across J2. Two input voltages must then be provided at both J2 (PVIN), J3 (GND) and J11 (VIN) J15 (GND).

## 3 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS50601A-SP evaluation module. The section also includes test results typical for the evaluation module and covers efficiency, output voltage regulation, load transients, output ripple, input ripple, Loop Characteristics and start-up.

### 3.1 Input/Output Connections

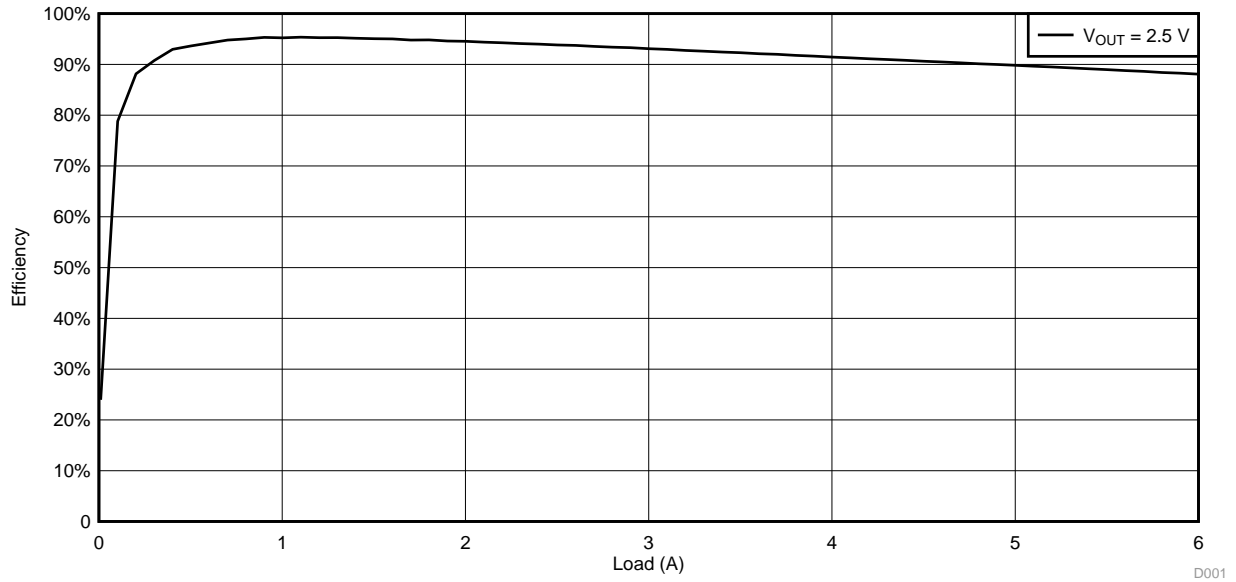
The TPS50601ASPEVM is provided with input/output connectors and test points as shown in [Table 4](#). A power supply capable of supplying 18 A must be connected to J7 through a pair of 16 AWG wires. The jumper across J1 must be in place. See [Section 2](#) for split-input voltage rail operation. The load must be connected to J8/J10 through a pair of 16-AWG wires. The maximum load current capability must be 6 A. Wire lengths must be minimized to reduce losses in the wires. Test-point TP4 provides a place to monitor the  $V_{IN}$  input voltages with TP14 providing a convenient ground reference. TP17 is used to monitor the output voltage with TP24 as the ground reference.

**Table 4. EVM Connectors and Test Points**

Reference Designator	Function
J2	PVIN input voltage banana plug (see <a href="#">Table 2</a> for PVIN range).
J5	PVIN(GND) input voltage banana plug.
J11	VIN input voltage connector. Not normally used.
J1	PVIN to VIN jumper. Normally closed to tie VIN to PVIN for common rail voltage operation.
J3	2-pin header for enable. Connect EN to ground to disable, open to enable.
J6/J7	Connecting phase 1 output to phase 2 output for Dual Operation.
J8	VOUT, 2.5 V at 6 A maximum for Single EVM.
TP6	PVIN test point at PVIN connector.
TP14	GND test point at PVIN connector.
TP4	VIN test point at VIN connector.
J4	Cold note probe to monitor Switch/Phase node.
J9	Cold nose probe to monitor output voltage/ripple.
TP21	Output voltage test point at VOUT connector.
TP24	GND test point at VOUT connector.
TP3	PWRGD test point.

### 3.2 Efficiency

The efficiency of this EVM peaks at a load current of about 1 A and then decreases as the load current increases towards full load. [Figure 1](#) shows the efficiency for the TPS50601ASPEVM at an ambient temperature of 25°C with  $V_{IN} = 5\text{ V}$  and  $V_{OUT} = 2.5\text{ V}$ . Peak efficiency at 1 A is 95%.

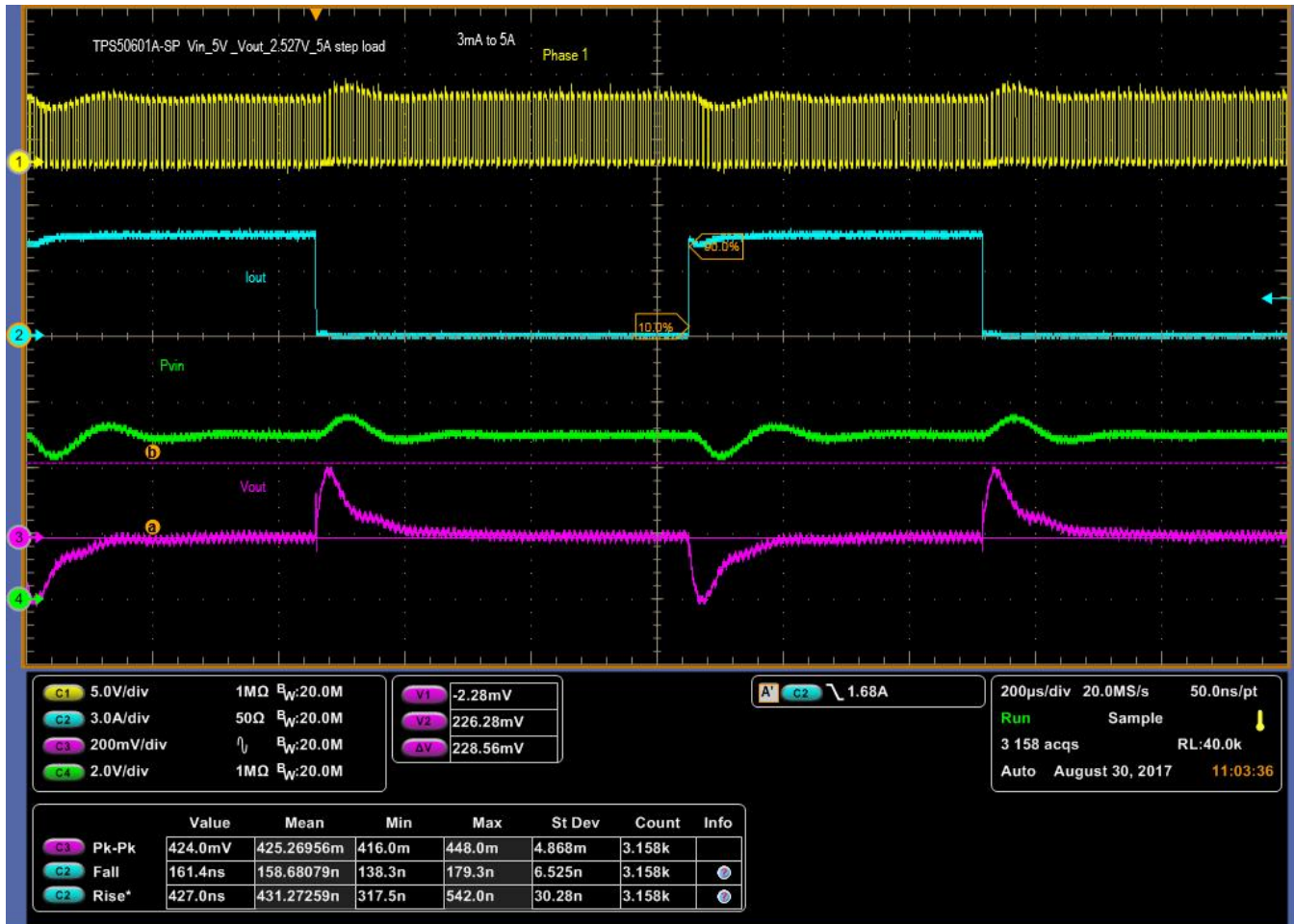


**Figure 1. TPS50601ASPEVM Efficiency**

The efficiency may be lower at higher ambient temperatures, due to temperature variation in the drain-to-source resistance of the internal MOSFET.

### 3.3 Load Transients

Figure 2 shows the TPS50601ASPEVM response to load transients. The current step is from 3 mA to 5 A of maximum rated load at 5-V input. Total peak-to-peak voltage variation is as shown, including ripple and noise on the output.



Ch1 = Phase node

Ch2 = Output load

Ch3 = Vout

Ch 4 = Pvin

Figure 2. TPS50601ASPEVM Transient Response

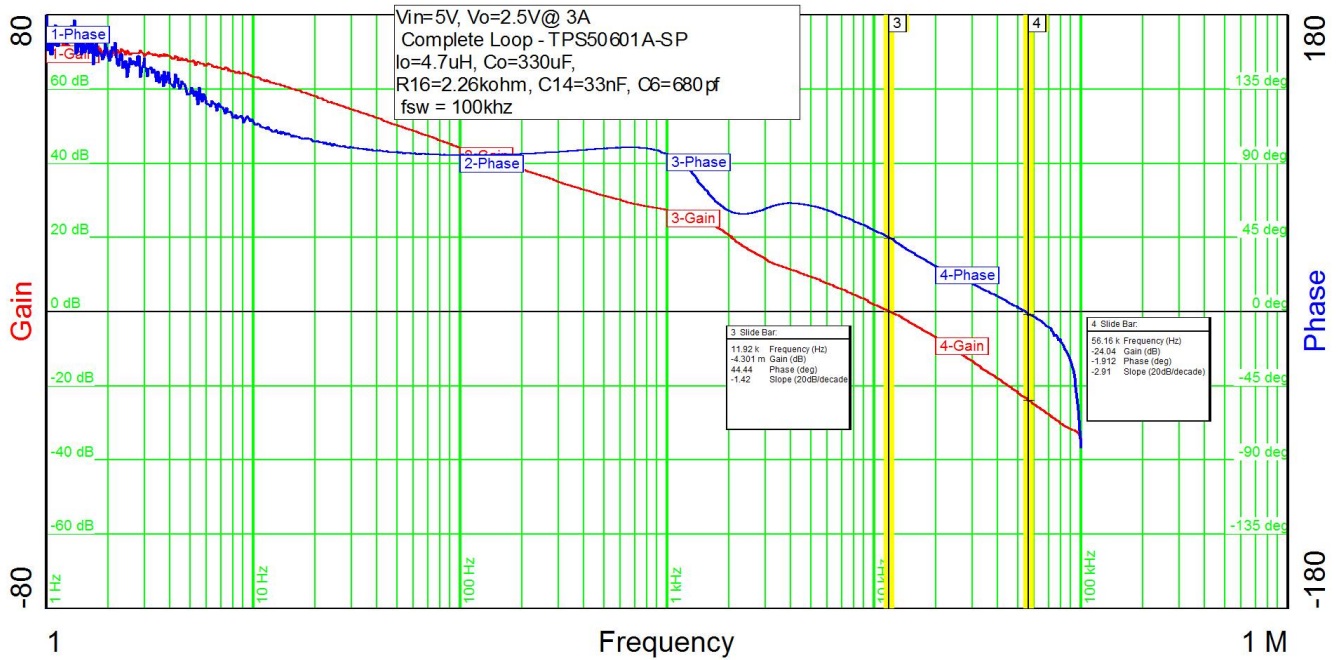
### 3.4 Loop Characteristics

Figure 3 shows the TPS50601ASPEVM loop-response characteristics. Gain and phase plots are shown for VIN voltage of 5 V. Load current for the measurement is 3 A.

Output inductor is selected per Equation 5 where Kind is 0.45 for this application that results in output inductor value of 4.7 μH with pk-pk inductor current of 2.7 A. Output capacitor is 330 μF with 5-mΩ ESR. Compensation components as follows: R16 = 2.26 kΩ, C14 = 33 nF, C8 = 680 pF.

$$L1 = \frac{V_{INMAX} - V_{OUT}}{(I_O - Kind)} \times \frac{V_{OUT}}{V_{INMAX} \times f_{SW}} \tag{5}$$

TPS50601A POL Vin\_5V, Vout = 2.5V



VIN = 5 V

VOUT = 2.5 V @ 3 A

Figure 3. TPS50601ASPEVM Complete Loop Response

Single POL Vin\_5V, Vout = 2.5V

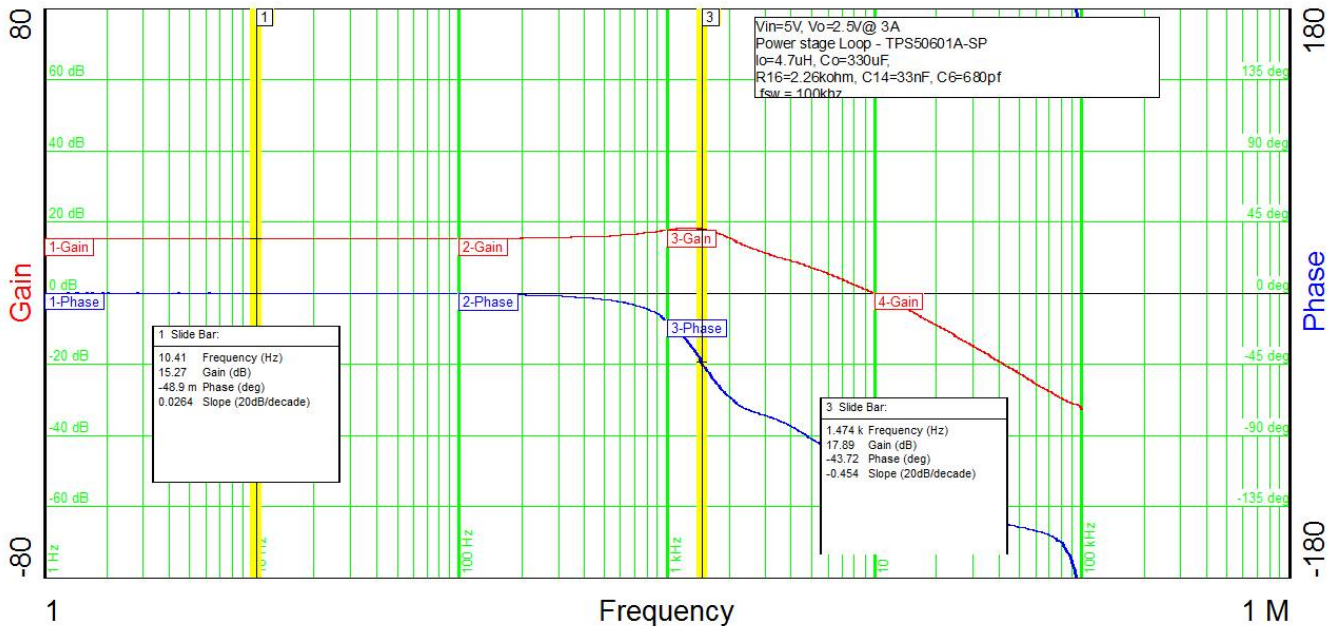


Figure 4. TPS50601ASPEVM Power Stage

### 3.5 Output Voltage Ripple

Figure 5 shows the TPS50601ASPEVM output voltage ripple. The output current is the rated full load of 6 A and  $V_{IN} = 5$  V. The ripple voltage is measured at J9 with oscilloscope bandwidth limited to 20 MHz. Note C20 0.1- $\mu$ F capacitor is installed close to J9 to help suppress high-frequency noise.

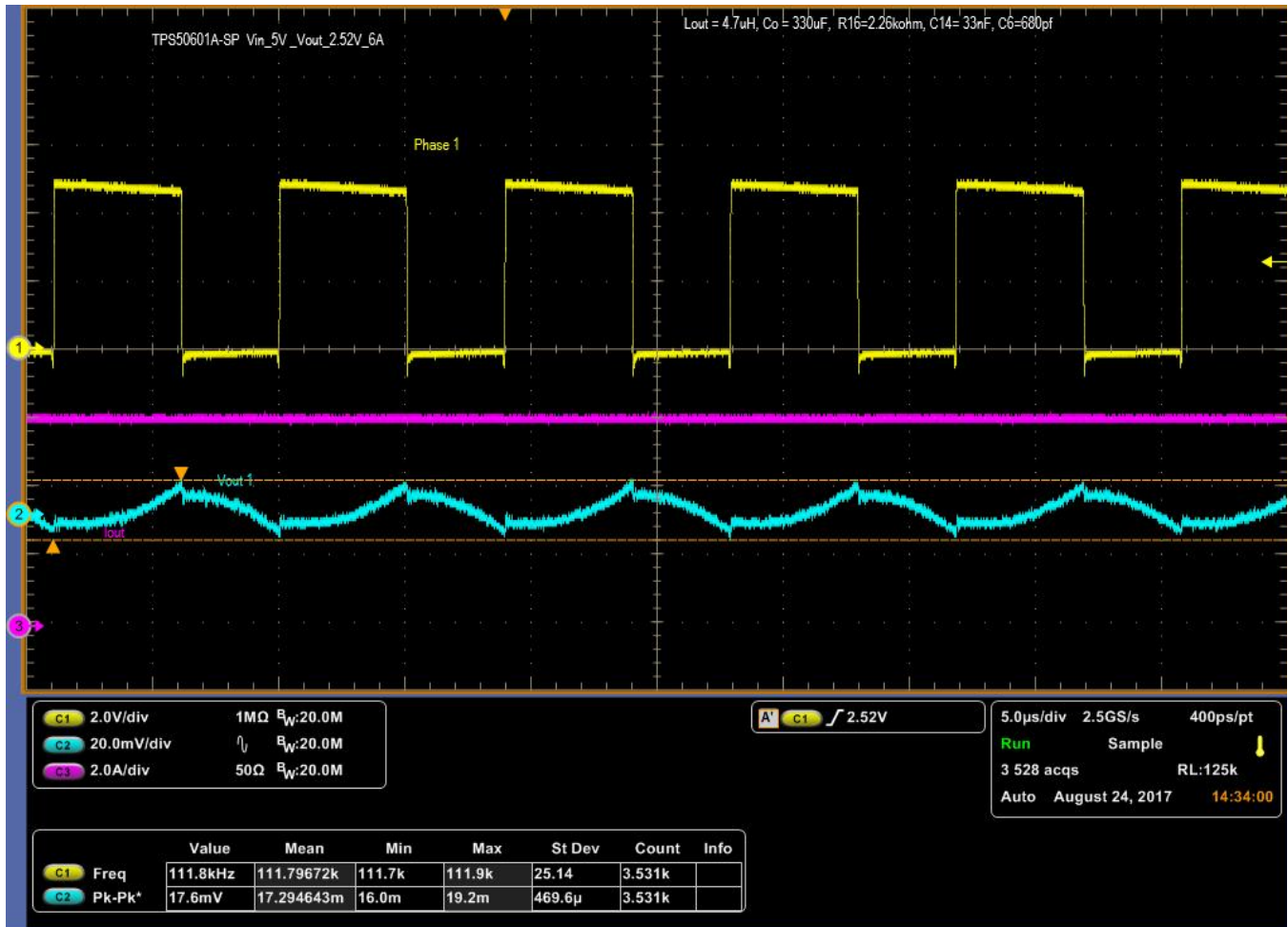


Figure 5. TPS50601ASPEVM Output Ripple



### 3.6 Input Voltage Ripple

Figure 6 shows the TPS50601ASPEVM input voltage. The output current is the rated full load of 6 A and  $V_{IN} = 5\text{ V}$ . The ripple voltage is measured directly across the input capacitors. Ch 3 highlights output ripple, whereas Ch 4 highlights P<sub>vin</sub> ripple.

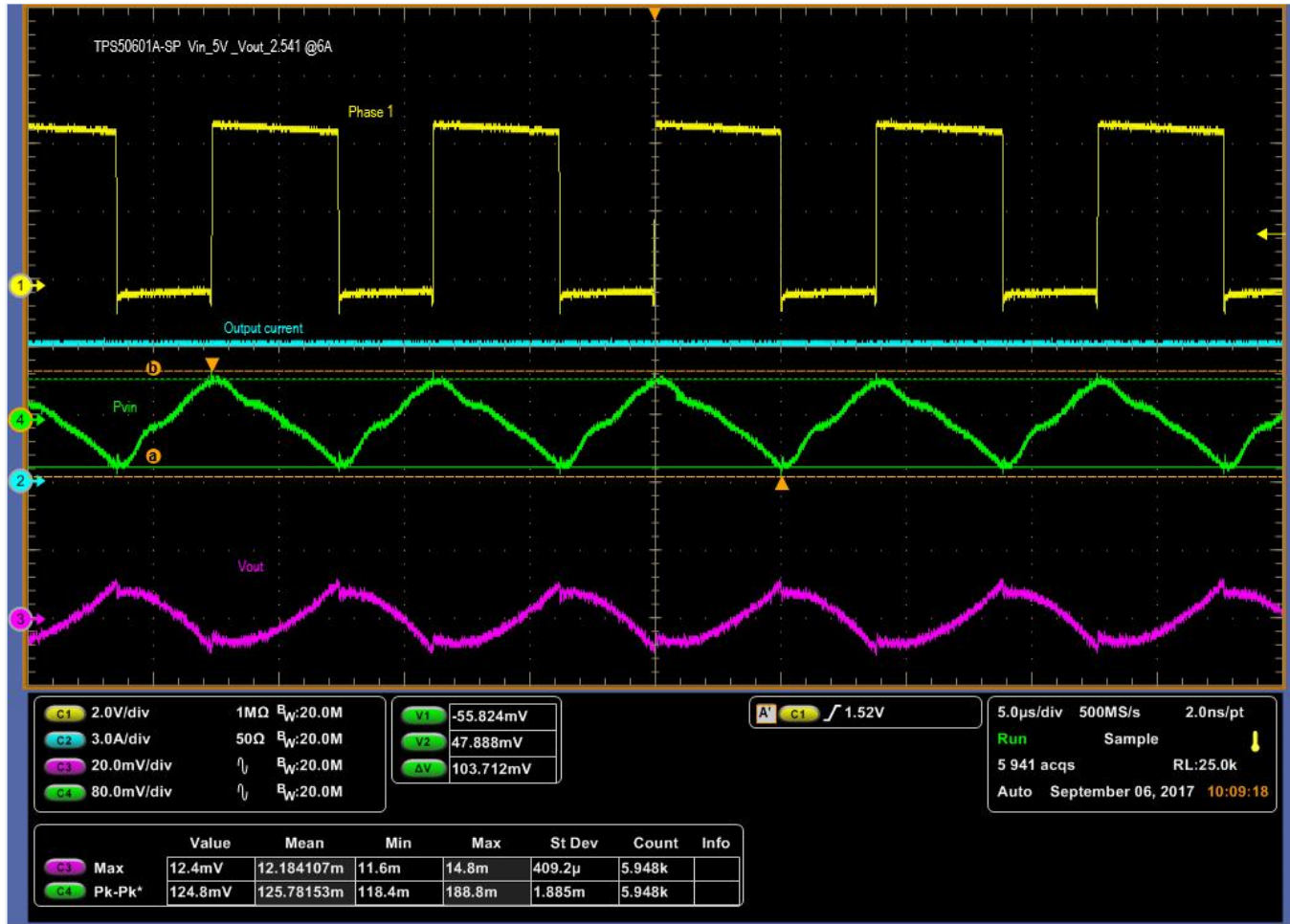


Figure 6. TPS50601ASPEVM Input Ripple

### 3.7 Powering Up

Figure 7 and Figure 8 show the start-up waveforms for the TPS50601ASPEVM. In Figure 7, the output voltage ramps up as soon as the input voltage reaches the UVLO threshold as set by the R13 and R15 resistor divider network. In Figure 8, the input voltage is initially applied and the output is inhibited by using a jumper at J3 to tie EN to GND. When the jumper is removed, EN is released. When the EN voltage reaches the enable-threshold voltage, the start-up sequence begins and the output voltage ramps up to the externally set value of 2.5 V. The input voltage for these plots is 5 V and the load is 6 A.

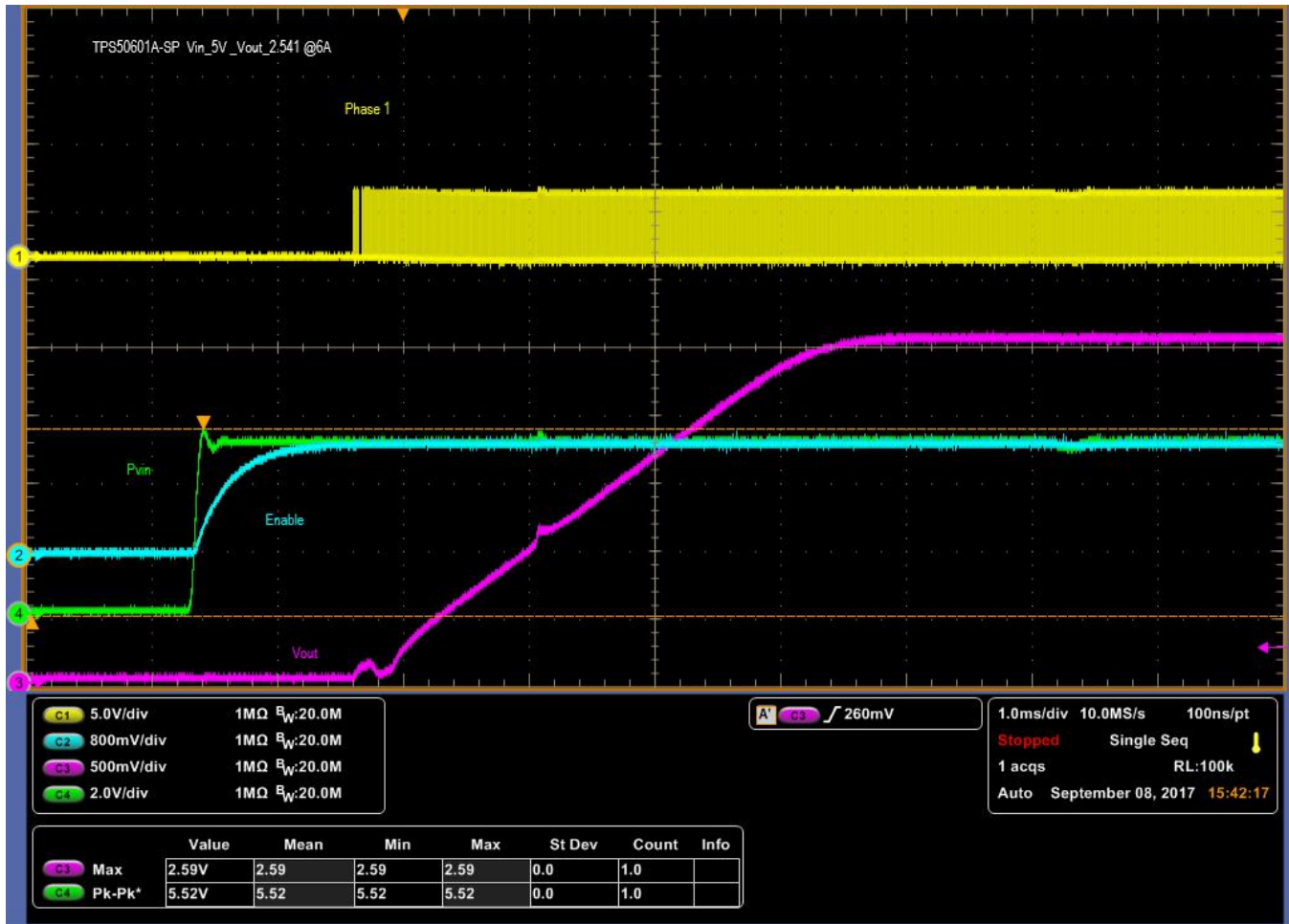


Figure 7. TPS50601ASPEVM Start-Up Relative to  $V_{IN}$

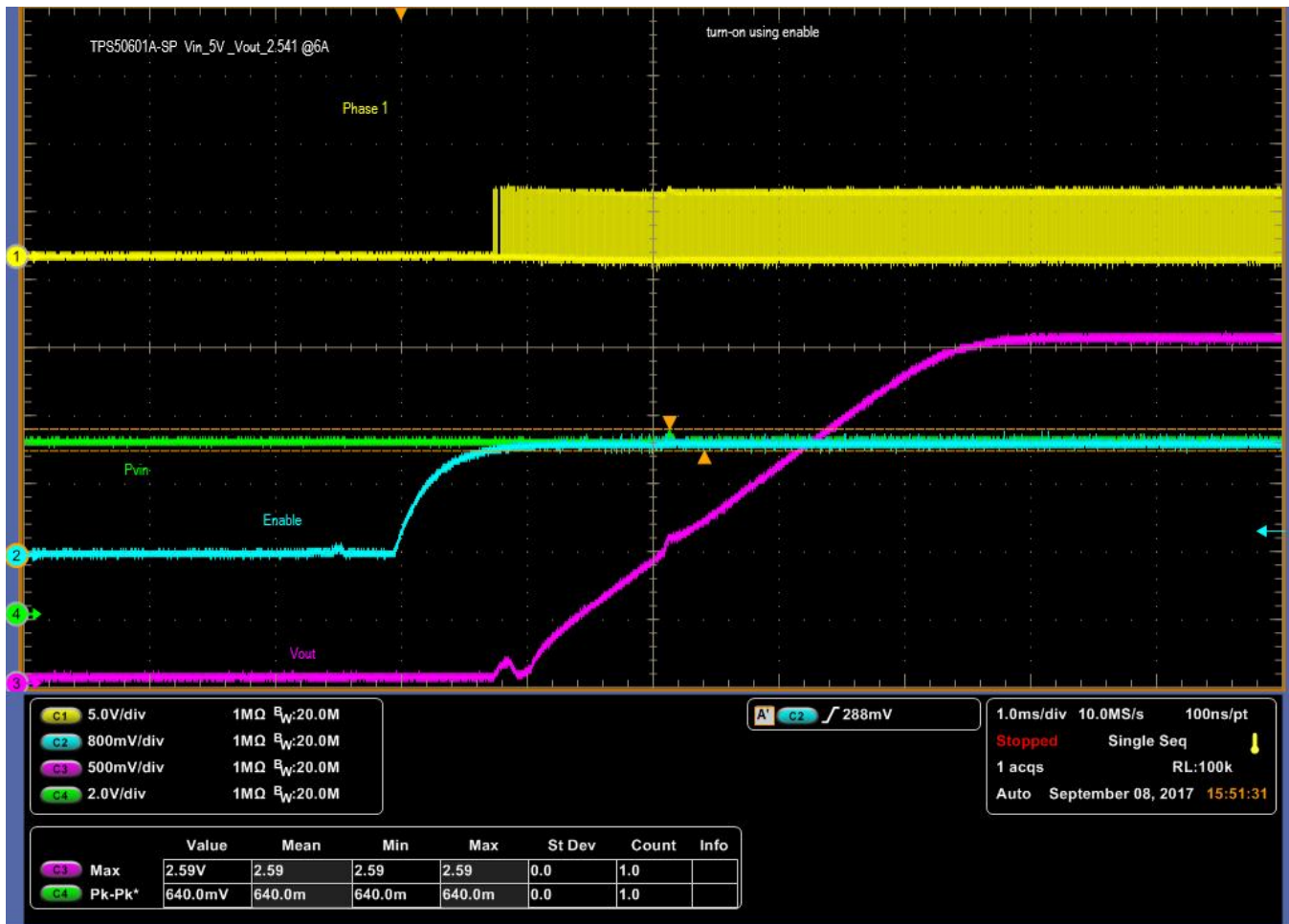


Figure 8. TPS50601ASPEVM Start-up Relative to Enable

## 4 Board Layout

This section provides a description of the TPS50601ASPEVM, board layout, and layer illustrations.

### 4.1 Layout

The board layout for the TPS50601ASPEVM is shown in Figure 9 through Figure 13. The top-side layer of the EVM is laid out in a manner typical of a user application. The top, bottom, and internal layers are 2-oz copper.

The top layer contains the main power traces for PVIN, VIN, VOUT, and VPHASE. On the top layer are power and ground connections of the TPS50601ASPEVM. TPS50601A-SP IC is mounted on the top layer with thermal pad and pin 1 (analog ground) of TPS50601A-SP connected to the second layer, the ground plane. The third layer has signal traces. The top side ground traces are connected to the bottom and internal ground planes with multiple vias placed around the board. Vias directly under the TPS50601A-SP device provide a thermal path from the top-side ground plane to the bottom-side ground plane and connecting to layer 3 (analog ground).

The input decoupling capacitors (C8, C9, C10, C11, C12, C3, C4) are all located as close to the IC as possible. In addition, the voltage set-point resistor divider components are also kept close to the IC. The voltage divider network ties to the output voltage at the point of regulation. Hooks are placed allowing the user to run bode plots on the unit by replacing R19 with a 50- $\Omega$  resistor. For the TPS50601ASPEVM, an additional input bulk capacitor may be required, depending on the EVM connection to the input supply. Critical analog circuits such as the voltage set point divider, frequency set resistor, slow start capacitor and compensation components are terminated to analog ground using a wide ground trace separate from the power ground pour. Analog ground is connected to power ground.

TPS50601ASPEVM PCB is made larger than required to provide flexibility for the customer to add additional capacitors on both input and output as well as replace output inductors to meet their system needs.

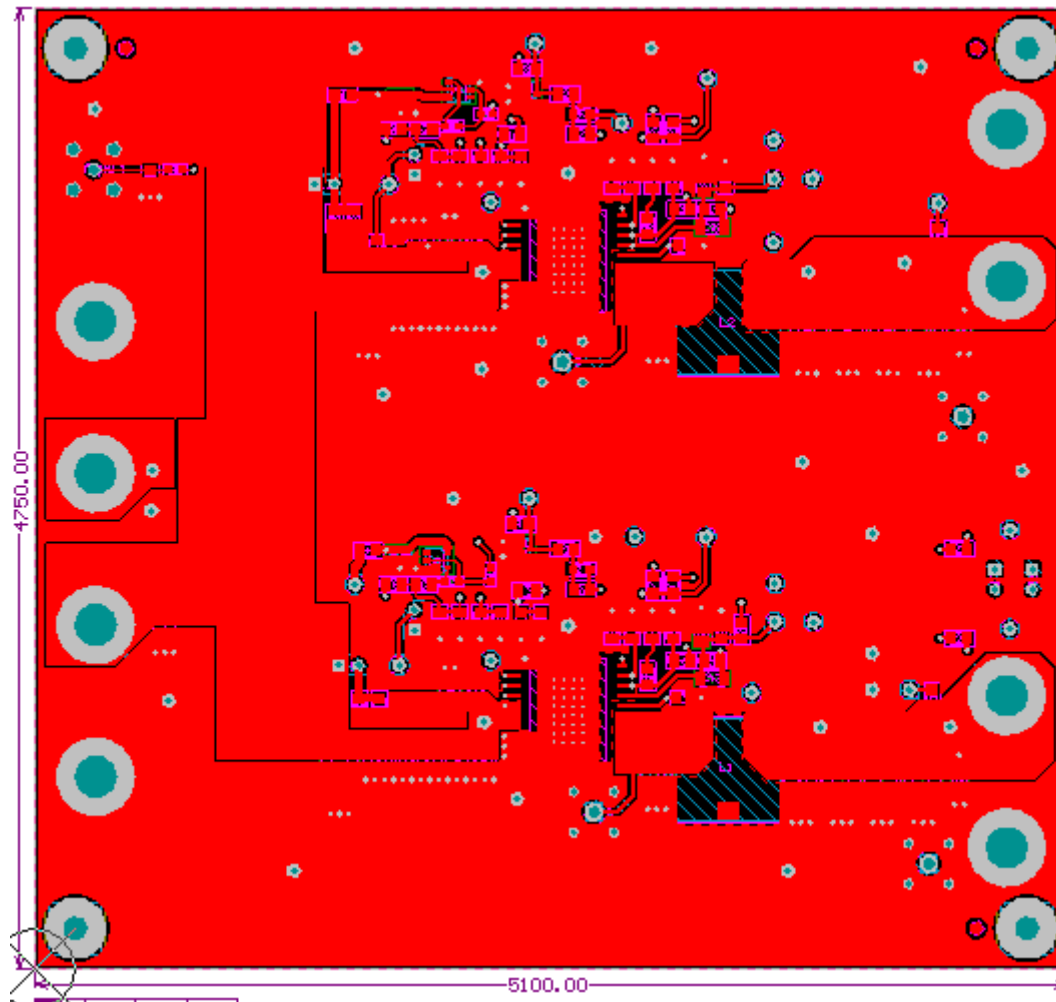


Figure 9. TPS50601ASPEVM Top-Side Layer 1

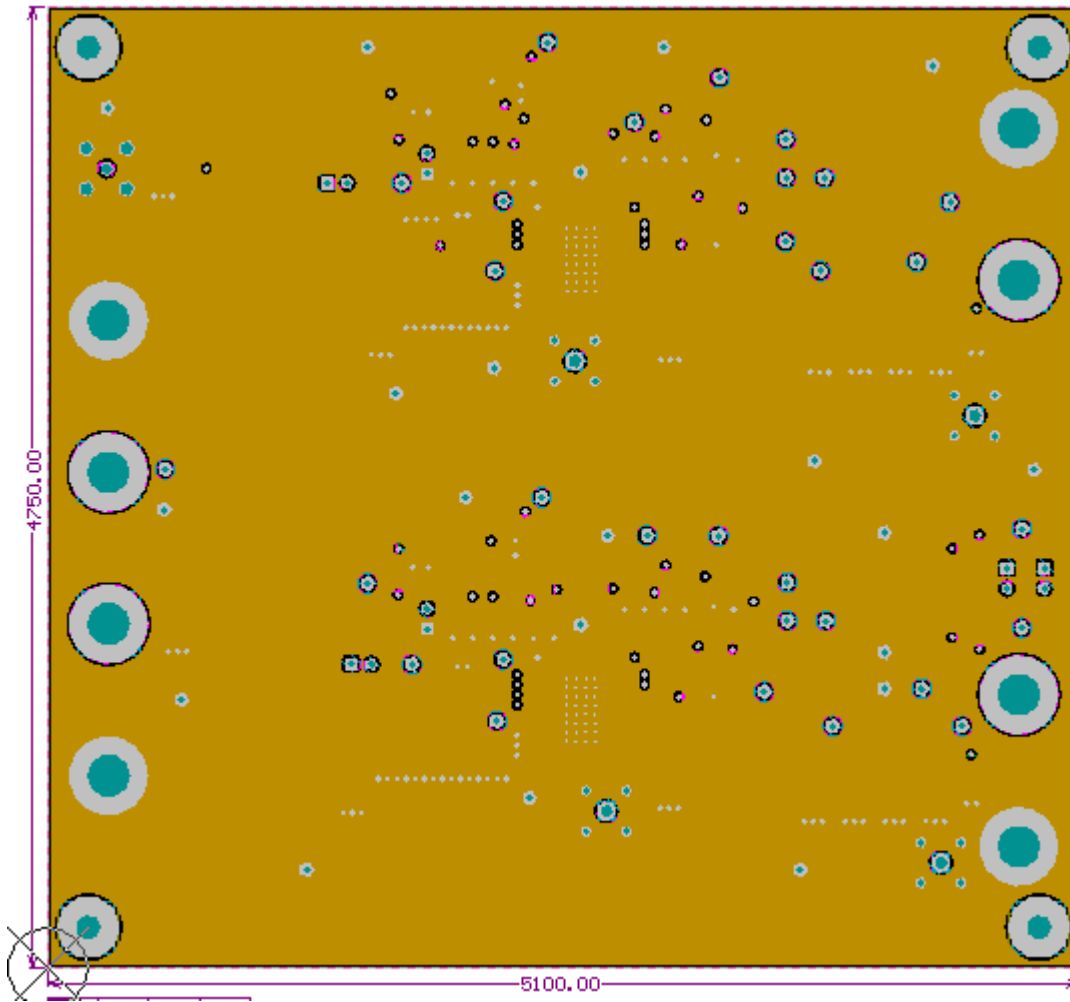


Figure 10. TPS50601ASPEVM Layer 2

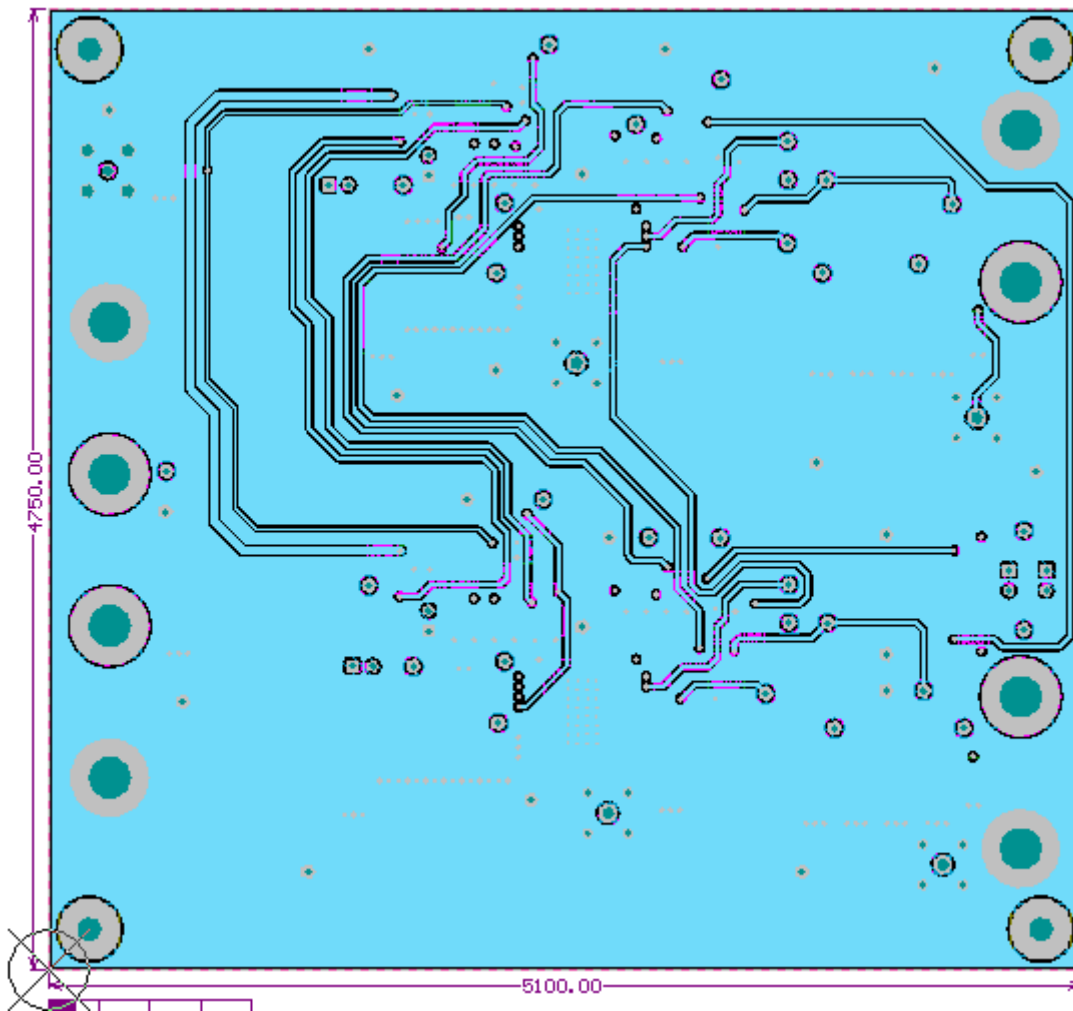


Figure 11. TPS50601ASPEVM Layer 3

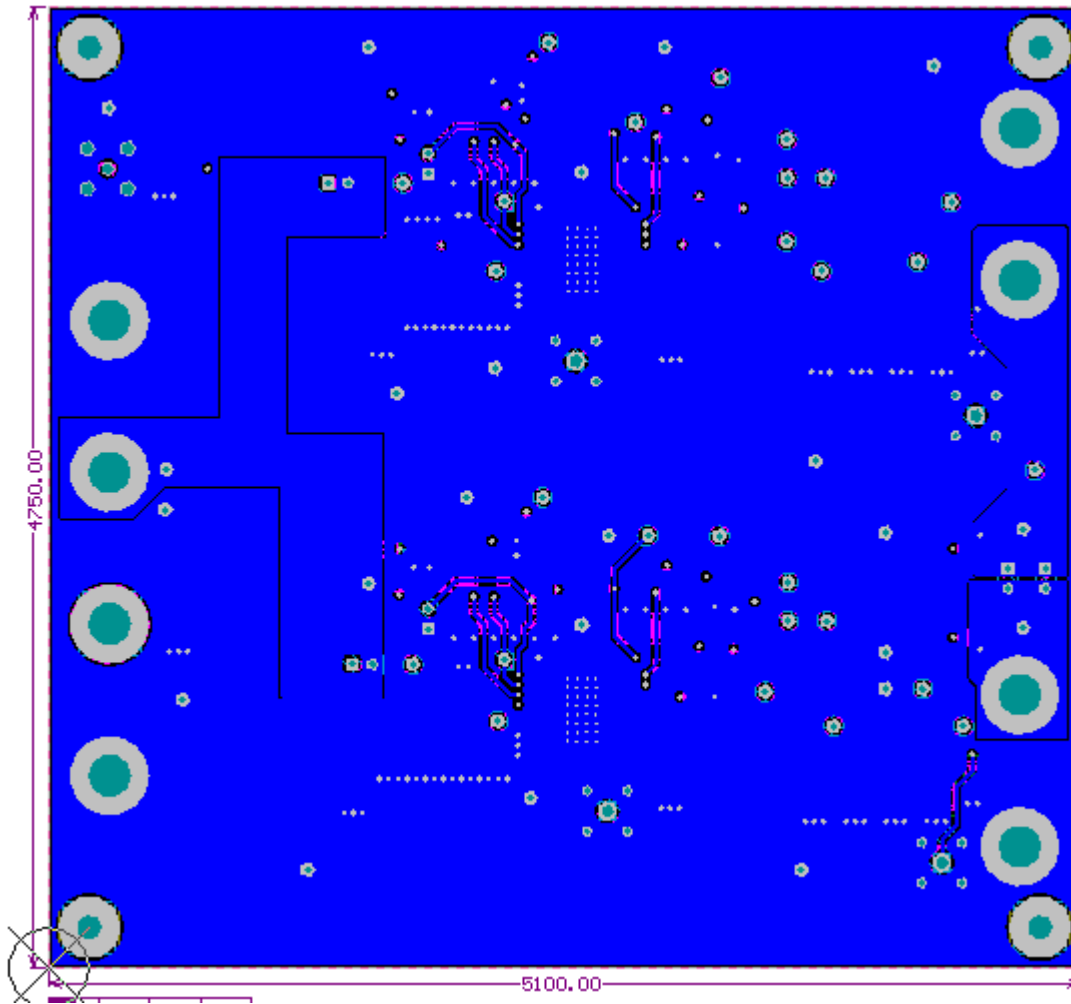


Figure 12. TPS50601ASPEVM Bottom-Side Layer 4

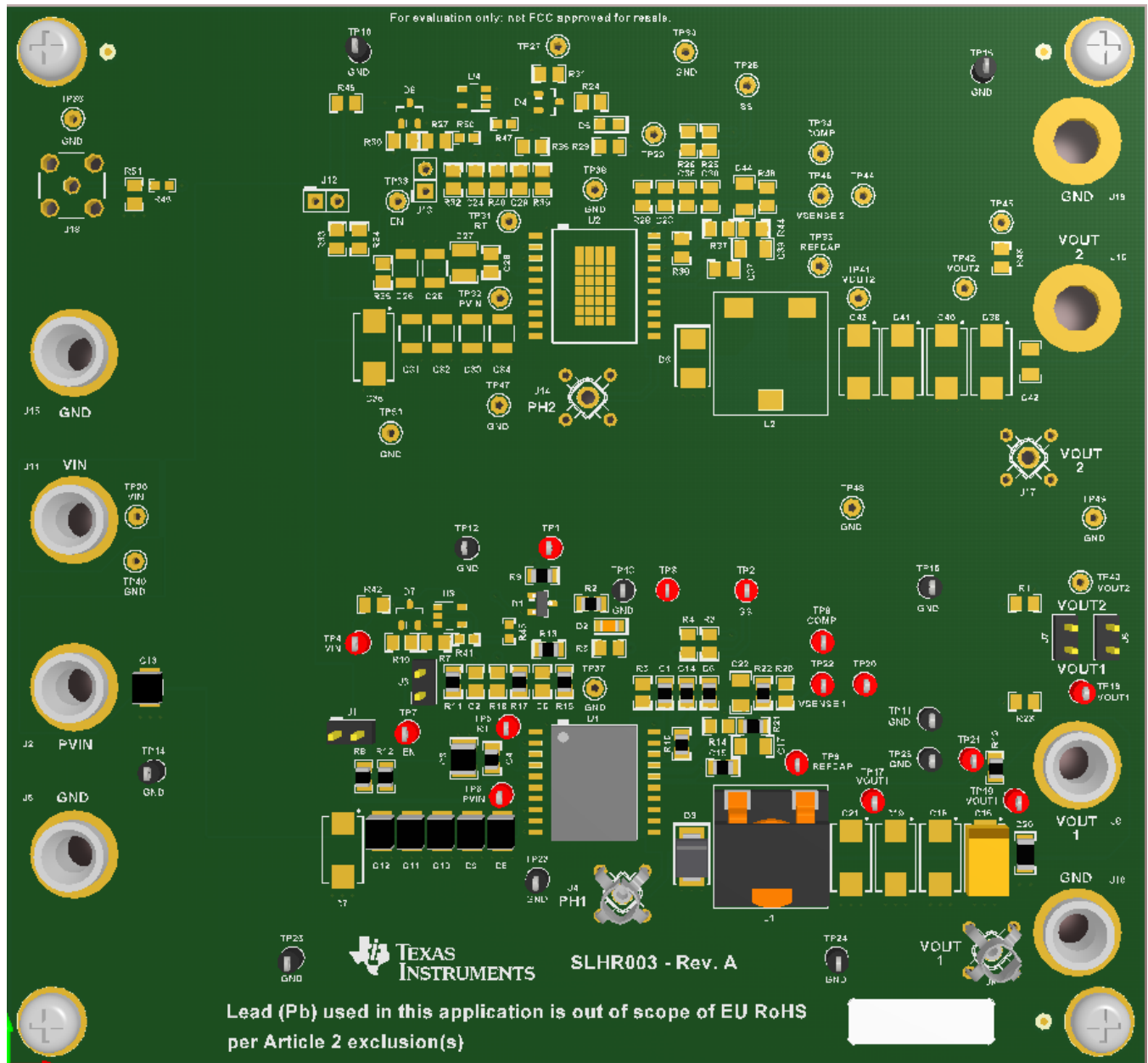


Figure 13. TPS50601ASPEVM Assembly

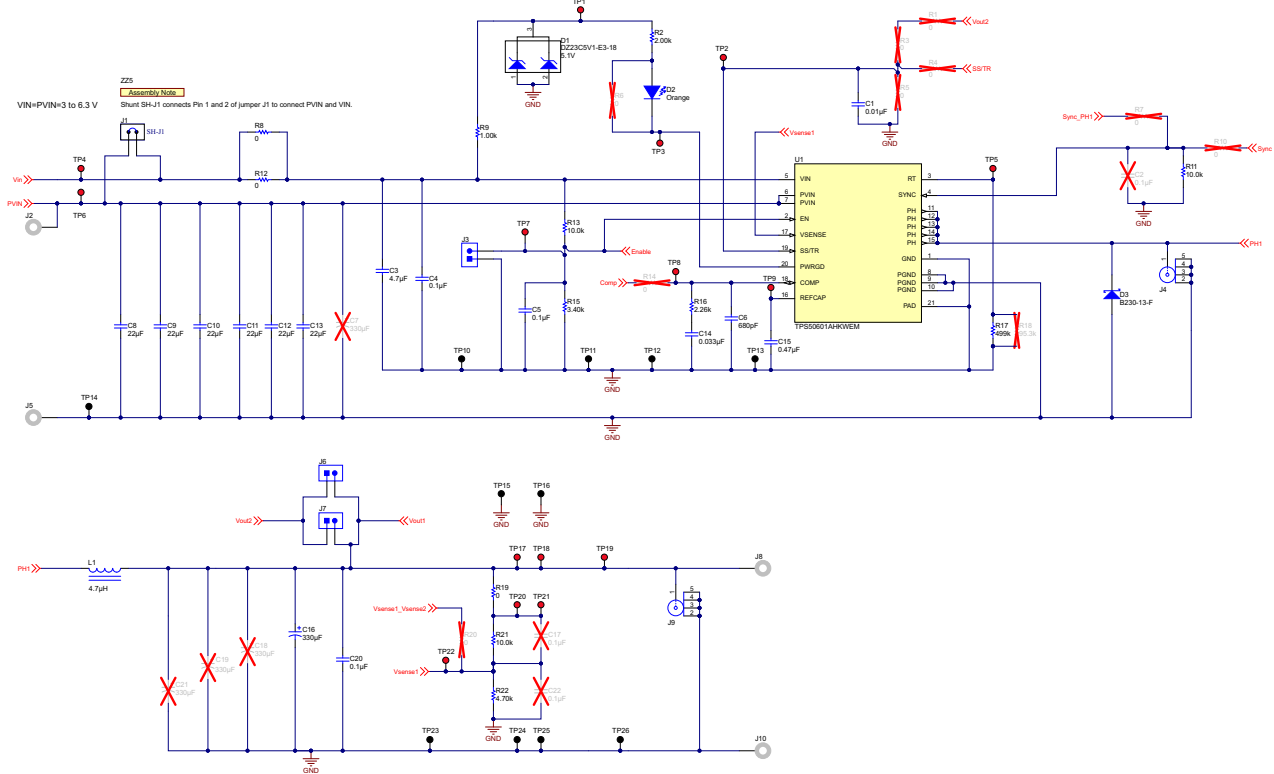


## 5 Schematic and Bill of Materials

This section presents the TPS50601ASPEVM schematics and bill of materials.

### 5.1 Schematic

See the following figure for the TPS50601ASPEVM schematic.



### 5.2 Bill of Materials

Table 5. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		SLHR003	Any
C1	1	0.01µF	CAP, CERM, 0.01 µF, 50 V, +/- 10%, X7R, 0805	0805	GRM216R71H103KA01D	MuRata
C3	1	4.7µF	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X7R, 1210	1210	C1210C475K8RACTU	Kemet
C4, C5	2	0.1µF	CAP, CERM, 0.1 µF, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX
C6	1	680pF	CAP, CERM, 680 pF, 50 V, +/- 5%, COG/NP0, 0805	0805	GRM2165C1H681JA01D	MuRata
C8, C9, C10, C11, C12, C13	6	22µF	CAP, CERM, 22 µF, 16 V, +/- 10%, X7R, 1210	1210	C3225X7R1C226K250AC	TDK
C14	1	0.033µF	CAP, CERM, 0.033 µF, 25 V, +/- 10%, X7R, 0805	0805	GRM216R71E333KA01D	MuRata
C15	1	0.47µF	CAP, CERM, 0.47 µF, 50 V, +/- 10%, X7R, 0805	0805	C2012X7R1H474K125AB	TDK
C16	1	330µF	CAP, Tantalum Polymer, 330 µF, 10 V, +/- 20%, 0.006 ohm, 7343-43 SMD	7343-43	T530X337M010ATE006	Kemet
C20	1	0.1µF	CAP, CERM, 0.1 µF, 50 V, +/- 5%, X7R, 1206	1206	C1206C104J5RACTU	Kemet
D1	1	5.1V	Diode, Zener, 5.1 V, 300 mW, AEC-Q101, SOT-23	SOT-23	DZ23C5V1-E3-18	Vishay-Semiconductor
D2	1	Orange	LED, Orange, SMD	LED_0805	LTST-C170KFKT	Lite-On
D3	1	30V	Diode, Schottky, 30 V, 2 A, SMB	SMB	B230-13-F	Diodes Inc.

**Table 5. Bill of Materials (continued)**

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J3, J6, J7	4		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J2, J5, J8, J10, J11, J15	6		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J4, J9	2		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
L1	1	4.7uH	Inductor, Shielded E Core, Ferrite, 4.7uH, 9.4A, 0.01 ohm, SMD	SER1360	SER1360-472KLB	Coilcraft
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
R2	1	2.00k	RES, 2.00 k, 1%, 0.125 W, 0805	0805	CRCW08052K00FKE A	Vishay-Dale
R8, R12, R19	3	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0E A	Vishay-Dale
R9	1	1.00k	RES, 1.00 k, 1%, 0.125 W, 0805	0805	CRCW08051K00FKE A	Vishay-Dale
R11, R13	2	10.0k	RES, 10.0 k, 1%, 0.125 W, 0805	0805	CRCW080510K0FKE A	Vishay-Dale
R15	1	3.40k	RES, 3.40 k, 1%, 0.125 W, 0805	0805	CRCW08053K40FKE A	Vishay-Dale
R16	1	2.26k	RES, 2.26 k, 1%, 0.125 W, 0805	0805	CRCW08052K26FKE A	Vishay-Dale
R17	1	499k	RES, 499 k, 0.1%, 0.125 W, 0805	0805	RG2012P-4993-B-T5	Susumu Co Ltd
R21	1	10.0k	RES, 10.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-103-B-T5	Susumu Co Ltd
R22	1	4.70k	RES, 4.70 k, 0.1%, 0.125 W, 0805	0805	RG2012P-472-B-T5	Susumu Co Ltd
SH-J1	1	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP17, TP18, TP19, TP20, TP21, TP22	15		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP23, TP24, TP25, TP26	11		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U1	1		Radiation Hardened 3.0- to 6.3-V Input, 6-A Synchronous Buck Converter, HKW0020A (CFP-20)	HKW0020A	TPS50601AHKWEM	Texas Instruments
C2, C24, C28, C29	0	0.1uF	CAP, CERM, 0.1 $\mu$ F, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX
C7, C18, C19, C21, C35, C38, C40, C41, C43	0	330uF	CAP, Tantalum Polymer, 330 $\mu$ F, 10 V, +/- 20%, 0.006 ohm, 7343-43 SMD	7343-43	T530X337M010ATE0 06	Kemet
C17, C22, C39, C42, C44	0	0.1uF	CAP, CERM, 0.1 $\mu$ F, 50 V, +/- 5%, X7R, 1206	1206	C1206C104J5RACTU	Kemet
C23	0	0.01uF	CAP, CERM, 0.01 $\mu$ F, 50 V, +/- 10%, X7R, 0805	0805	GRM216R71H103KA 01D	MuRata
C25, C26	0	10uF	CAP, CERM, 10 $\mu$ F, 25 V, +/- 10%, X7R, 1210	1210	12103C106KAT2A	AVX
C27	0	4.7uF	CAP, CERM, 4.7 $\mu$ F, 10 V, +/- 10%, X7R, 1210	1210	C1210C475K8RACT U	Kemet
C30	0	680pF	CAP, CERM, 680 pF, 50 V, +/- 5%, COG/NP0, 0805	0805	GRM2165C1H681JA0 1D	MuRata
C31, C32, C33, C34	0	22uF	CAP, CERM, 22 $\mu$ F, 16 V, +/- 10%, X7R, 1210	1210	C3225X7R1C226K25 0AC	TDK
C36	0	0.033uF	CAP, CERM, 0.033 $\mu$ F, 25 V, +/- 10%, X7R, 0805	0805	GRM216R71E333KA 01D	MuRata
C37	0	0.47uF	CAP, CERM, 0.47 $\mu$ F, 50 V, +/- 10%, X7R, 0805	0805	C2012X7R1H474K12 5AB	TDK

**Table 5. Bill of Materials (continued)**

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
D4, D7, D8	0	5.1V	Diode, Zener, 5.1 V, 300 mW, AEC-Q101, SOT-23	SOT-23	DZ23C5V1-E3-18	Vishay-Semiconductor
D5	0	Orange	LED, Orange, SMD	LED_0805	LTST-C170KFKT	Lite-On
D6	0	30V	Diode, Schottky, 30 V, 2 A, SMB	SMB	B230-13-F	Diodes Inc.
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
J12, J13	0		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
J14, J17	0		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
J16, J19	0		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J18	0		SMA Straight Jack, Gold, 50 Ohm, TH	SMA Straight Jack, TH	901-144-8RFX	Amphenol RF
L2	0	4.7uH	Inductor, Shielded E Core, Ferrite, 4.7uH, 9.4A, 0.01 ohm, SMD	SER1360	SER1360-472KLB	Coilcraft
R1, R3, R4, R5, R6, R7, R10, R14, R20, R23, R25, R26, R27, R28, R29, R30, R33, R34, R36, R37, R43	0	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0E A	Vishay-Dale
R18, R40	0	95.3k	RES, 95.3 k, 1%, 0.125 W, 0805	0805	CRCW080595K3FKE A	Vishay-Dale
R24	0	2.00k	RES, 2.00 k, 1%, 0.125 W, 0805	0805	CRCW08052K00FKE A	Vishay-Dale
R31	0	1.00k	RES, 1.00 k, 1%, 0.125 W, 0805	0805	CRCW08051K00FKE A	Vishay-Dale
R32, R35	0	10.0k	RES, 10.0 k, 1%, 0.125 W, 0805	0805	CRCW080510K0FKE A	Vishay-Dale
R38	0	2.26k	RES, 2.26 k, 1%, 0.125 W, 0805	0805	CRCW08052K26FKE A	Vishay-Dale
R39	0	3.40k	RES, 3.40 k, 1%, 0.125 W, 0805	0805	CRCW08053K40FKE A	Vishay-Dale
R41, R45, R46, R47, R50	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0E A	Vishay-Dale
R42, R49	0	3.00k	RES, 3.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF3001V	Panasonic
R44	0	10.0k	RES, 10.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-103-B-T5	Susumu Co Ltd
R48	0	4.70k	RES, 4.70 k, 0.1%, 0.125 W, 0805	0805	RG2012P-472-B-T5	Susumu Co Ltd
R51	0	49.9k	RES, 49.9 k, 1%, 0.125 W, 0805	0805	CRCW080549K9FKE A	Vishay-Dale
TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP34, TP35, TP41, TP42, TP43, TP44, TP45, TP46	0		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP36, TP37, TP38, TP39, TP40, TP47, TP48, TP49, TP50	0		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U2	0		Radiation Hardened 3.0- to 6.3-V Input, 6-A Synchronous Buck Converter, HKW0020A (CFP-20)	HKW0020A	TPS50601AHKWEM	Texas Instruments
U3, U4	0		SINGLE SCHMITT-TRIGGER INVERTER GATE, DBV0005A (SOT-5)	DBV0005A	SN74AHC1G04DBVR	Texas Instruments

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