User's Guide

TPS53127 Buck Controller Evaluation Module User's Guide

ABSTRACT

The TPS53127EVM-614 dual-output buck converter evaluation module presents an easy-to-use reference design for a common dual-output power supply using the TPS53127 controller in cost-sensitive applications.

Table of Contents

List of Figures

List of Tables

Trademarks

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1 Introduction

1.1 Description

The TPS53127EVM-614 dual output buck evaluation board provides the user with a convenient way to evaluate the TPS53127 dual D-CAP2™ mode control buck controller in a realistic cost-sensitive application. Providing both a low “core-type” 1.05-V and “I/O type” 1.8-V output at up to 4 A from a loosely regulated 12-V (8 V–22 V) source, the TPS53127EVM-614 includes switches and test points to assist a user in evaluating the performance of the TPS53127 controller in their application.

1.2 Application

- Digital television
- Set-top box
- DSL and cable modems
- Cost-sensitive digital consumer products

1.3 Features

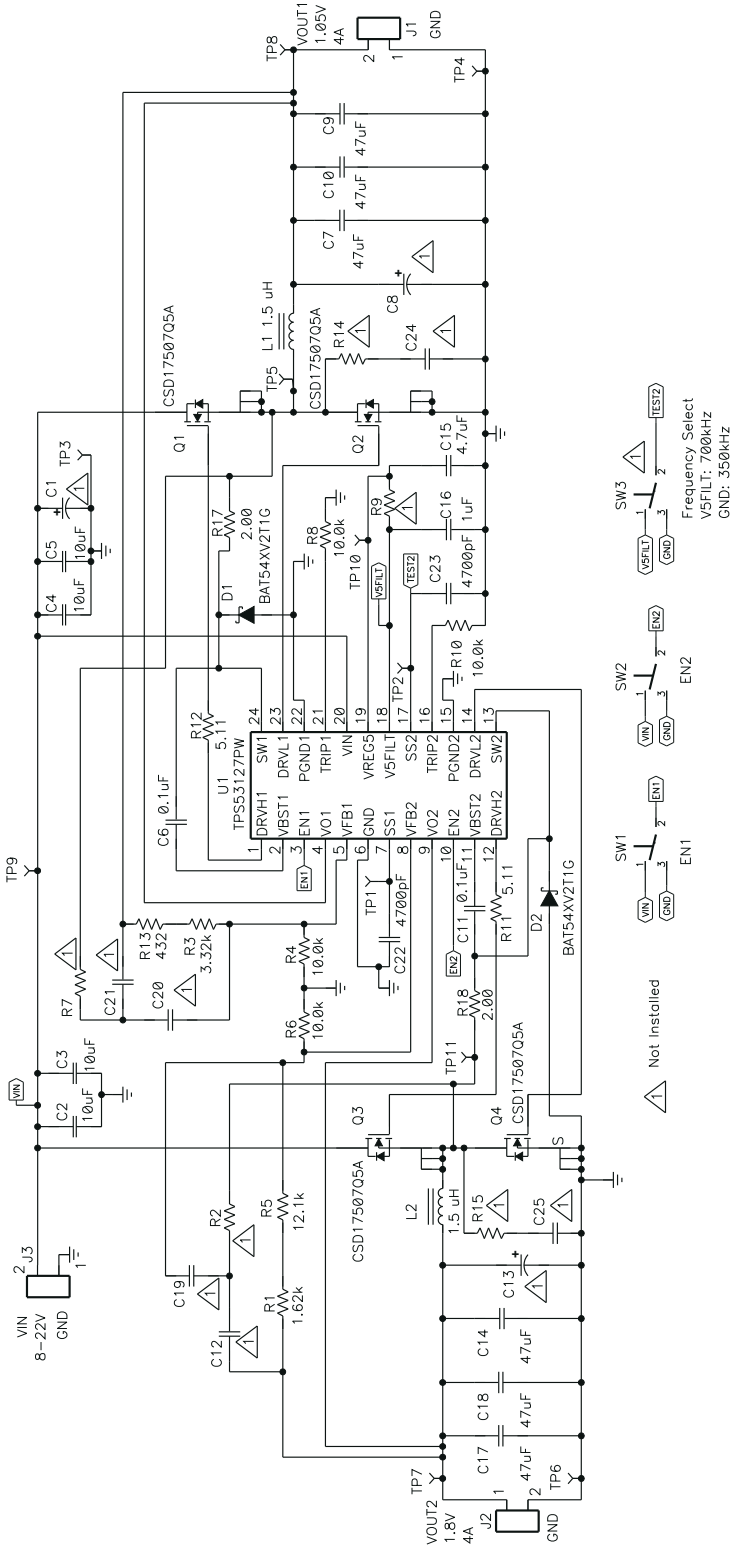
- 8-V to 22-V input
- 1.05-V and 1.8-V output
- Up to 4 A per channel output
- 700-kHz pseudo-fixed frequency D-CAP2 mode control
- Independent enable switches for power-on/power-off testing

2 Electrical Performance Specifications

Table 2-1. TPS53127EVM-614 Electrical and Performance Specifications

Parameter		Notes and Conditions	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS						
V_{IN}	Input voltage		8	12	22	V
I_{IN}	Input current	V_{IN} = 12 V, I_{OUT1} = 4 A, I_{OUT2} = 4 A	—	1.2	1.5	A
	No load input current	V_{IN} = 12 V, I_{OUT} = 0 A	—	20	35	mA
V_{IN_UVLO}	Input UVLO	I_{OUT} = 4 A	4.0	4.2	4.5	V
OUTPUT CHARACTERISTICS						
V_{OUT1}	Output voltage 1	V_{IN} = 12 V, I_{OUT1} = 2 A	1.03	1.05	1.07	V
	Line regulation	V_{IN} = 8 V to 22 V	—	—	1%	
	Load regulation	I_{OUT1} = 0 A to 4 A	—	—	1%	
V_{OUT1_rip}	Output voltage ripple	V_{IN} = 12 V, I_{OUT2} = 4 A	—	-	30	mVpp
I_{OUT1}	Output current 1	V_{IN} = 8 V to 22 V	0		4	A
V_{OUT2}	Output voltage 2	V_{IN} = 12 V, I_{OUT2} = 2 A	1.78	1.80	1.82	V
	Line regulation	V_{IN} = 8 V to 22 V	—	—	1%	
	Load regulation	I_{OUT2} = 0 A to 4 A	—	—	1%	
V_{OUT2_rip}	Output voltage ripple	V_{IN} = 12 V, I_{OUT2} = 4 A	—	—	30	mVpp
I_{OUT2}	Output current 2	V_{IN} = 8 V to 22 V	0		4	A
SYSTEMS CHARACTERISTICS						
F_{SW}	Switching frequency		350	700	800	kHz
ηpk	Peak efficiency	V_{IN} = 12 V	—	85%	—	
η	Full load efficiency	V_{IN} = 12 V, I_{OUT1} = 4 A	—	83%	—	

3 TPS53127EVM-614 Schematic



For reference only. See Table 8-1 for specific values.

Figure 3-1. TPS53127EVM-614 Schematic

4 Connector and Test Point Descriptions

4.1 Enable Switches (SW1 and SW2)

The TPS53127EVM-614 includes independent enable switches for each of the two outputs. When the switch is in the DIS position, the channel is disabled and discharged per the internal discharge characteristics of the TPS53127.

To enable VOUT1, place SW1 in the EN position.

To enable VOUT2, place SW2 in the EN position.

4.2 Switching Frequency Select Switch (SW3)

The TPS53127EVM-614 does not populate SW3. When using the TPS53127EVM-614 to evaluate the TPS53126 controller in the TSSOP package, SW3 can be populated to allow selection of the TPS53126 switching frequency between 350 kHz and 700 kHz.

4.3 Test Point Descriptions

Table 4-1 lists the test points, their labels, uses, and where additional information is located.

Table 4-1. TPS53127EVM-614 Test Points Description

Test Point	Label	Use	Section
TP1	TEST1	Monitor Channel 1 Soft-Start Voltage	Section 4.3.4
TP2	TEST2	Monitor Channel 2 Soft-Start Voltage	Section 4.3.4
TP3	GND	Ground for Input Voltage	Section 4.3.1
TP4	GND	Ground for Channel 1 Output Voltage	Section 4.3.2
TP5	SW1	Monitor Switching Node for Channel 1	Section 4.3.5
TP6	GND	Ground for Channel 2 Output Voltage	Section 4.3.3
TP7	VO2	Monitor Output Voltage for Channel 2	Section 4.3.3
TP8	VO1	Monitor Output Voltage for Channel 1	Section 4.3.2
TP9	VIN	Monitor Input Voltage	Section 4.3.1
TP10	VREG5	Monitor Output of VREG5 Regulator	Section 4.3.6
TP11	SW2	Monitor Switching Node for Channel 2	Section 4.3.5
CN1	VOUT1	Monitor Output Voltage for Channel 1	Section 4.3.2
CN2	VOUT2	Monitor Output Voltage for Channel 2	Section 4.3.3

4.3.1 Input Voltage Monitoring (TP3 and TP9)

The TPS53127EVM-614 provides two test points for measuring the voltage applied to the module. This allows the user to measure the actual module voltage without losses from input cables and connectors. All input voltage measurements should be made between TP9 and TP3. To use TP9 and TP3, connect a voltmeter positive terminal to TP9 and negative terminal to TP3.

4.3.2 Channel 1 Output Voltage Monitoring (TP4 and TP8)

The TPS53127EVM-614 provides two test points for measuring the voltage generated at the VO1 output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. All DC output voltage measurements should be made between TP8 and TP4. To use TP8 and TP4, connect a voltmeter positive terminal to TP8 and negative terminal to TP4.

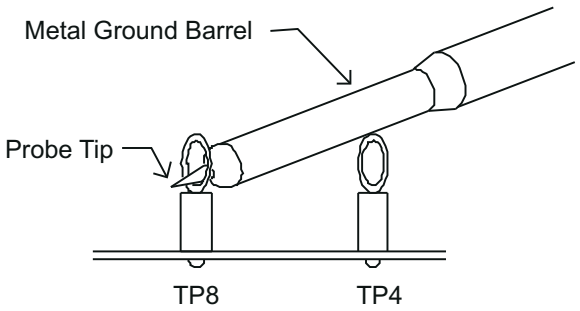


Figure 4-1. Tip and Barrel Measurement for Output Voltage Ripple

4.3.3 Channel 2 Output Voltage Monitoring (TP6 and TP7)

The TPS53127EVM-614 provides two test points for measuring the voltage generated at the VO1 output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. All DC output voltage measurements should be made between TP7 and TP6. To use TP7 and TP6, connect a voltmeter positive terminal to TP7 and negative terminal to TP6.

4.3.4 Soft-Start Voltage Monitoring (TP1, TP2, and TP3)

The TPS53127EVM-614 provides two test points for measuring the soft-start ramp voltages. TP1 monitors the soft-start ramp of Channel 1. TP2 monitors the soft-start ramp of Channel 2. To use TP1 or TP2, connect an oscilloscope probe between TP1 or TP2 and TP3.

4.3.5 Switching Node Monitoring (TP3, TP5, and TP11)

The TPS53127EVM-614 provides two test points for measuring the switching node waveform voltages. TP5 monitors the switching node of Channel 1. TP2 monitors the switching node of Channel 2. To use TP5 or TP11, connect an oscilloscope probe between TP5 or TP11 and TP3.

4.3.6 5-V Regulator Output Monitoring (TP3 and TP10)

The TPS53127EVM-614 provides a test point for measuring the output of the internal 5-V regulator. TP10 monitors the output voltage of the internal 5-V regulator. To use TP10, connect a voltmeter positive terminal to TP10 and negative terminal to TP3.

5 Test Setup

5.1 Equipment

5.1.1 Voltage Source

V_{IN}
The input voltage source (V_{VIN}) is a 0-V to 25-V variable DC source capable of supplying 3.0 A_{DC} minimum.

5.1.2 Meters

A1: 0 A_{DC}–4 A_{DC}, Ammeter

V1: VIN, 0-V to 22-V voltmeter

V2: VOUT1, 0-V to 2-V voltmeter

V3: VOUT2, 0-V to 2-V voltmeter

5.1.3 Loads

LOAD1: The output load is an electronic load set for constant current mode capable of 0 A_{DC} to 4 A_{DC} at 1.05 V_{DC}.

LOAD2: The output load is an electronic load set for constant current mode capable of 0 A_{DC} to 4 A_{DC} at 1.80 V_{DC}.

5.1.4 Oscilloscope

Oscilloscope
The oscilloscope is an analog or digital oscilloscope set for AC-coupled measurement with 20-MHz bandwidth limiting. Use 20-mV/division vertical resolution and 1.0-µs/division horizontal resolution for output ripple voltage test. Set cursors at +20 mV and –20 mV.

Probe
One oscilloscope probe is a Tektronix P6138 or equivalent oscilloscope probe with exposed conductive ground barrels.

5.1.5 Recommended Wire Gauge

V_{IN} to J3
The connection between the source voltage, V_{VIN}, and J1 of the TPS53127EVM-614 can carry as much as 2.0 A_{DC}. The minimum recommended wire size is AWG #16 with the total length of wire less than two feet (1-foot input, 1-foot return).

J1 to LOAD1 and J2 to LOAD2
The connection between J1 and LOAD1 and J2 and LOAD2 of the TPS53127EVM-614 can carry as much as 4 A_{DC} each. The minimum recommended wire size is AWG #14, with the total length of wire less than two feet (1-foot input, 1-foot return).

5.1.6 Other

FAN
The TPS53127EVM-614 evaluation module includes components that can get hot to the touch. Because this EVM is not enclosed to allow probing of circuit nodes, a small fan capable of 200 lfm–400 lfm is required to reduce component temperatures when operating.

5.2 Equipment Setup

Figure 5-1 shows the recommended basic test setup to evaluate the TPS53127EVM-614. Note that although the return for J3 and J1 and JP2 are the same system ground, the connections should remain separate as shown in Figure 5-1.

5.2.1 Procedure

1. Working at an ESD workstation, make sure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM. An 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 3.0 A maximum. Make sure V_{IN} is initially set to 0 V and connected as shown in Figure 5-1.
3. Verify SW1 and SW2 are in the desired position.
4. Place a fan as shown in Figure 5-1. Turn it on, making sure that air is flowing across the EVM.

5.2.2 Diagram

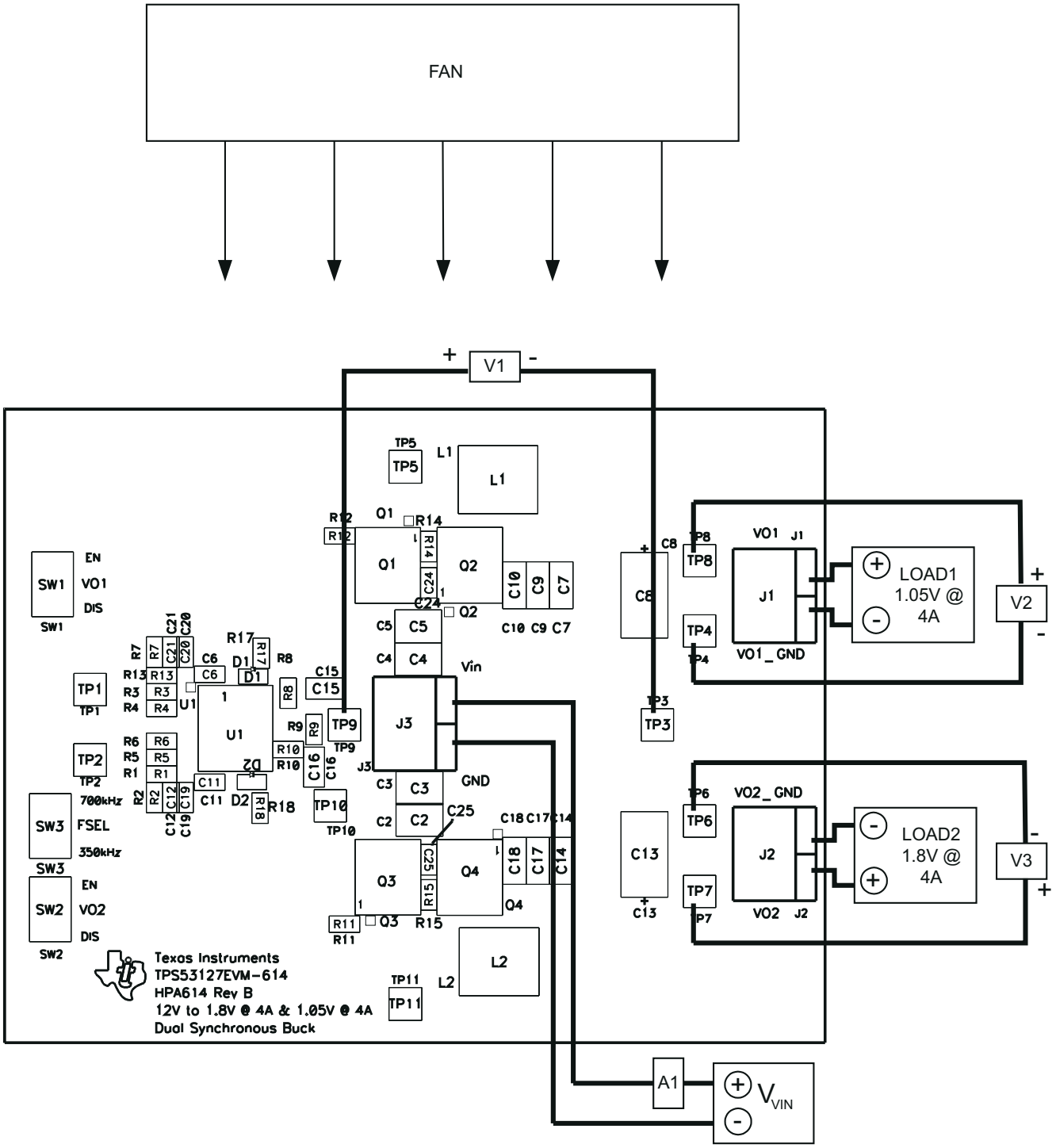


Figure 5-1. TPS53127EVM-614 Recommended Test Setup

5.3 Start-Up/Shutdown Procedure

1. Increase V_{IN} from 0 V to 12 V_{DC}.
2. Vary LOAD1 from 0 A_{DC}–4 A_{DC}.
3. Vary LOAD2 from 0 A_{DC}–4 A_{DC}.
4. Vary V_{IN} from 8 V_{DC} to 22 V_{DC}.
5. Decrease V_{IN} to 0 V_{DC}.
6. Decrease LOAD1 to 0 A.
7. Decrease LOAD2 to 0 A.

5.4 Output Ripple Voltage Measurement Procedure

1. Increase V_{IN} from 0 V to 12 V_{DC}.
2. Adjust LOAD1 to desired load between 0 A_{DC} and 4 A_{DC}.
3. Adjust LOAD2 to desired load between 0 A_{DC} and 4 A_{DC}.
4. Adjust V_{IN} to desired load between 8 V_{DC} and 22 V_{DC}.
5. Connect an oscilloscope probe to CN1 or CN2 shown in Figure 5-1.
6. Measure output ripple.
7. Decrease V_{IN} to 0 V_{DC}.
8. Decrease LOAD1 to 0 A.
9. Decrease LOAD2 to 0 A.

5.5 Equipment Shutdown

1. Shut down the oscilloscope.
2. Shut down V_{IN}.
3. Shut down LOAD1.
4. Shut down LOAD2.
5. Shut down FAN.

6 TPS53127EVM-614 Test Data

Figure 6-1 through Figure 6-8 present typical performance curves for the TPS53127EVM-614. Since 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.

6.1 Efficiency

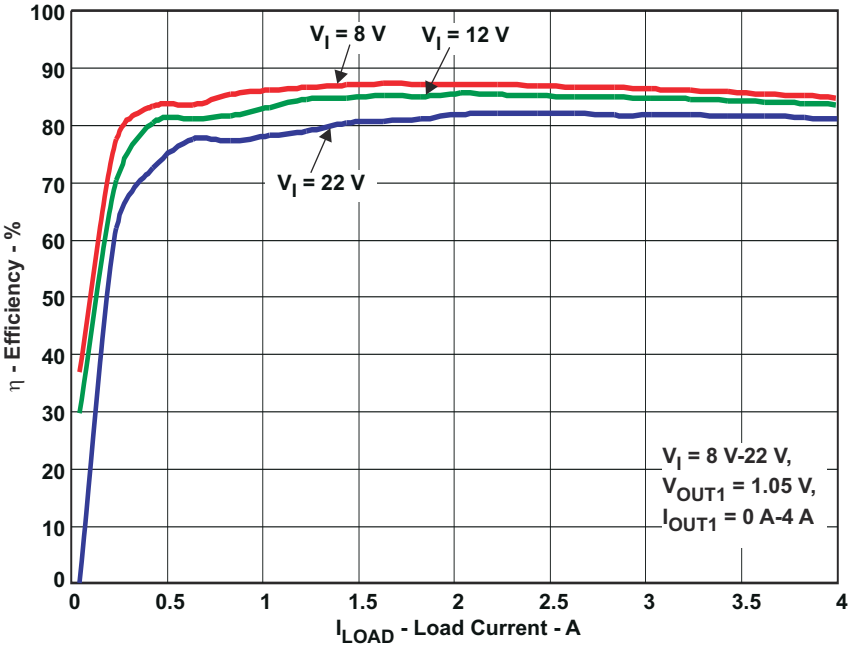


Figure 6-1. Efficiency vs Load (V_{IN} = 8 V–22 V, V_{OUT1} = 1.05 V, I_{OUT1} = 0 A–4 A)

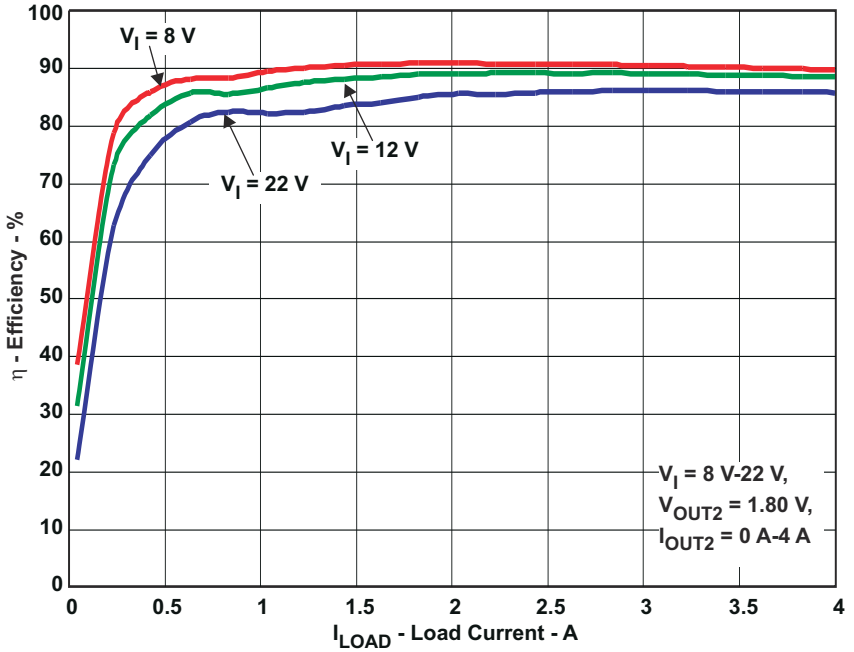


Figure 6-2. Efficiency vs Load (V_{IN} = 8 V–22 V, V_{OUT2} = 1.8 V, I_{OUT2} = 0 A–4 A)

6.2 Line and Load Regulation

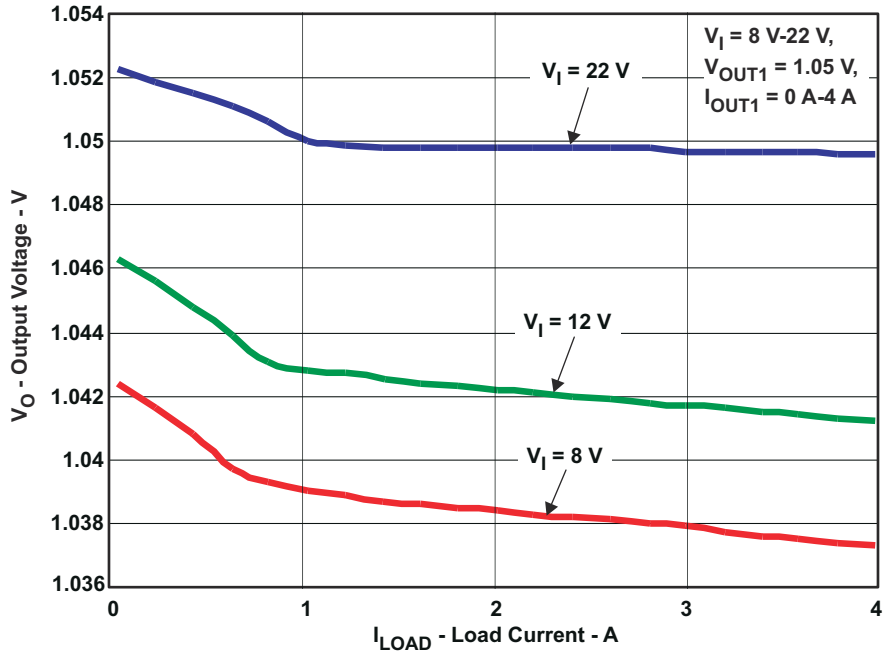


Figure 6-3. Output Voltage vs Load (V_{IN} = 8 V–22 V, V_{OUT1} = 1.05 V, I_{OUT1} = 0 A–4 A)

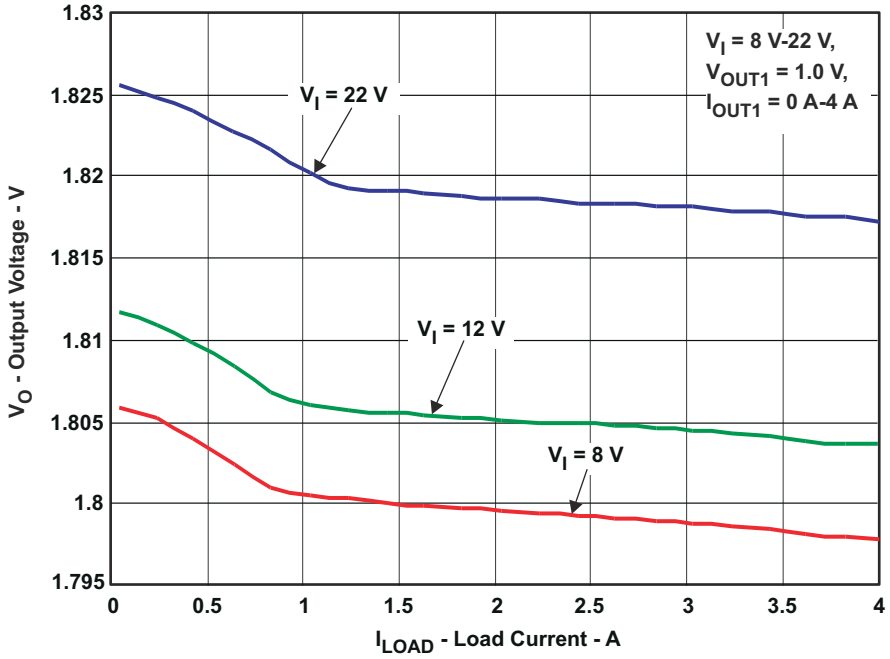


Figure 6-4. Output Voltage vs Load (V_{IN} = 8 V–22 V, V_{OUT2} = 1.05 V, I_{OUT2} = 0 A–4 A)

6.3 Output Voltage Ripple and Switching Node Waveforms

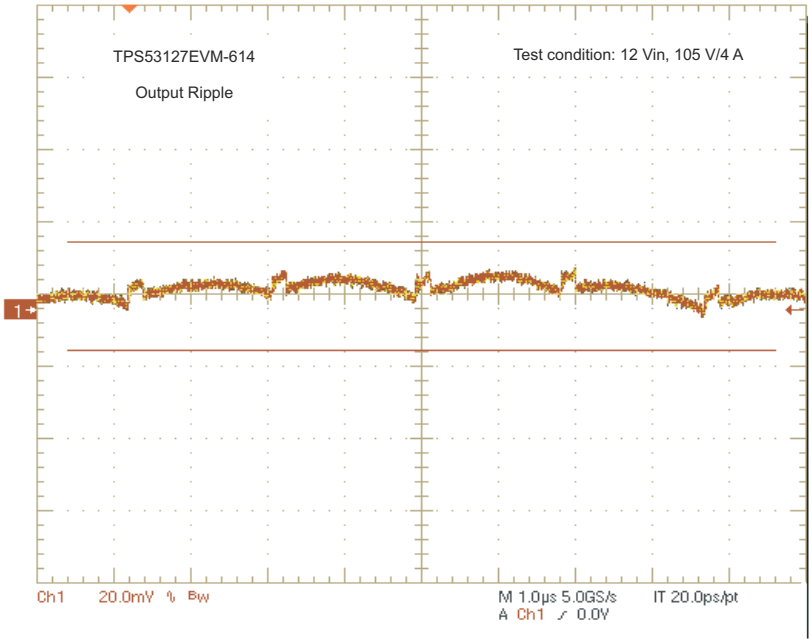


Figure 6-5. Output Voltage Ripple (V_{IN} = 12 V, V_{OUT1} = 1.05 V, I_{OUT1} = 4 A)

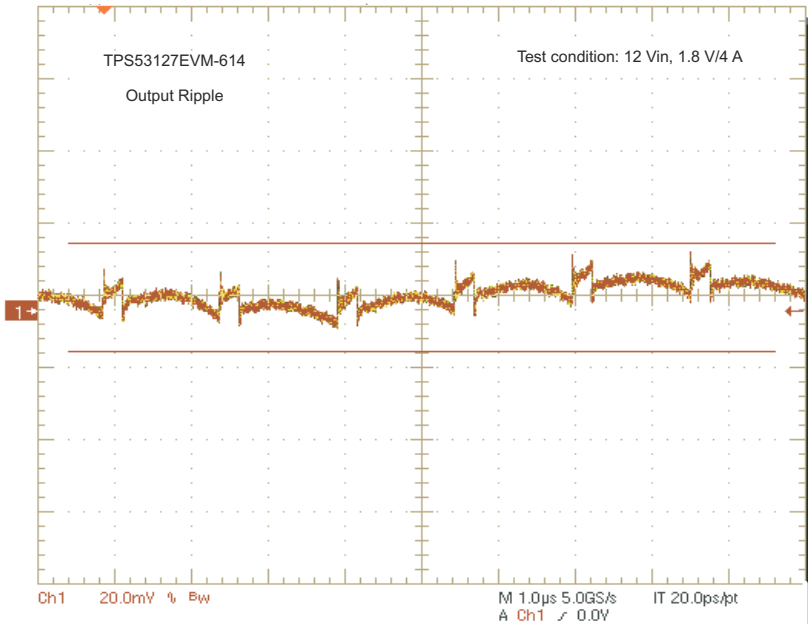


Figure 6-6. Output Voltage Ripple (V_{IN} = 12 V, V_{OUT2} = 1.8 V, I_{OUT2} = 4 A)

6.4 Switch Node

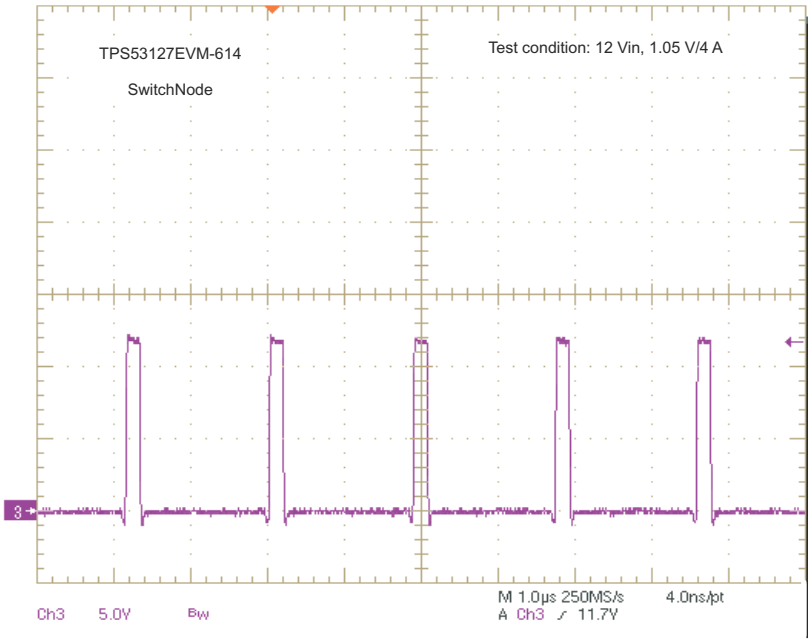


Figure 6-7. Switching Waveform (V_{IN} = 12 V, V_{OUT1} = 1.05 V, I_{OUT1} = 4 A)

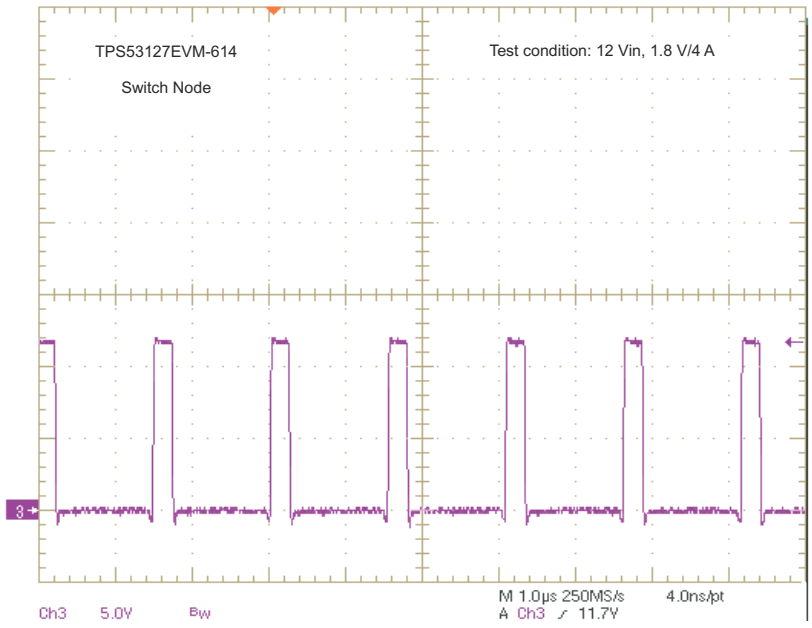


Figure 6-8. Switching Waveform (V_{IN} = 12 V, V_{OUT2} = 1.8 V, I_{OUT2} = 4 A)

7 TPS53127EVM-614 EVM Assembly Drawings and Layout

Figure 7-1 through Figure 7-5 show the design of the TPS53127EVM-614 printed circuit board. The EVM has been designed using a 4-layer, 2-oz copper-clad circuit board 3.5 in 2.7 to allow the user to easily view, probe, and evaluate the TPS53127 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.

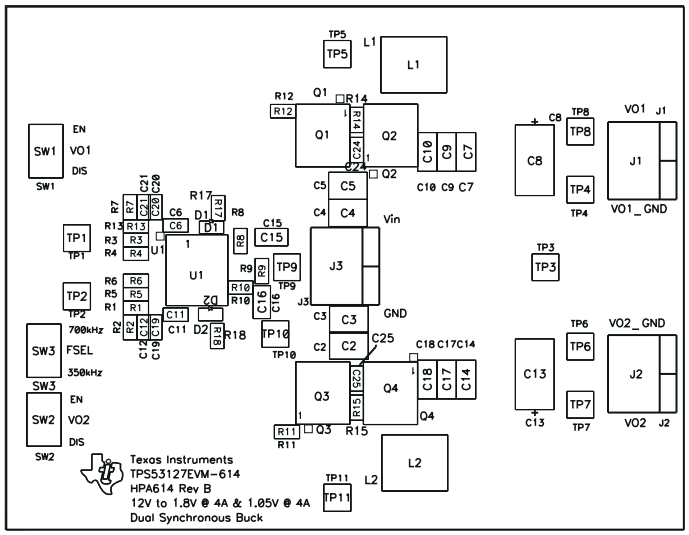


Figure 7-1. Top Assembly

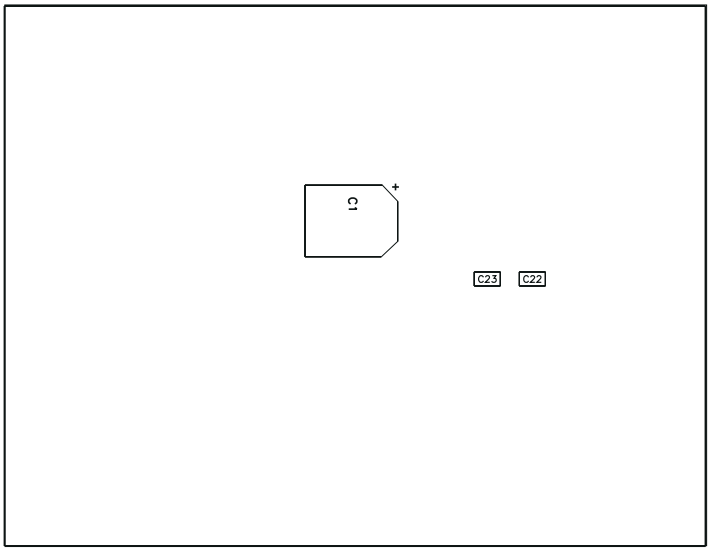


Figure 7-2. Bottom Assembly

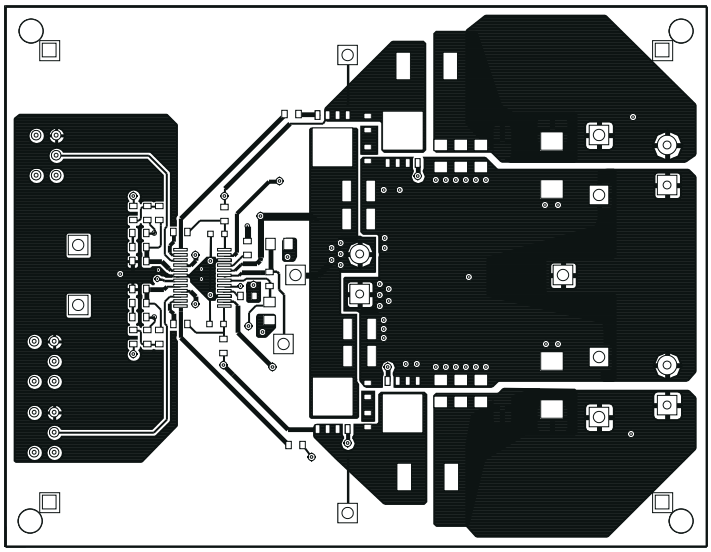


Figure 7-3. Top Layer

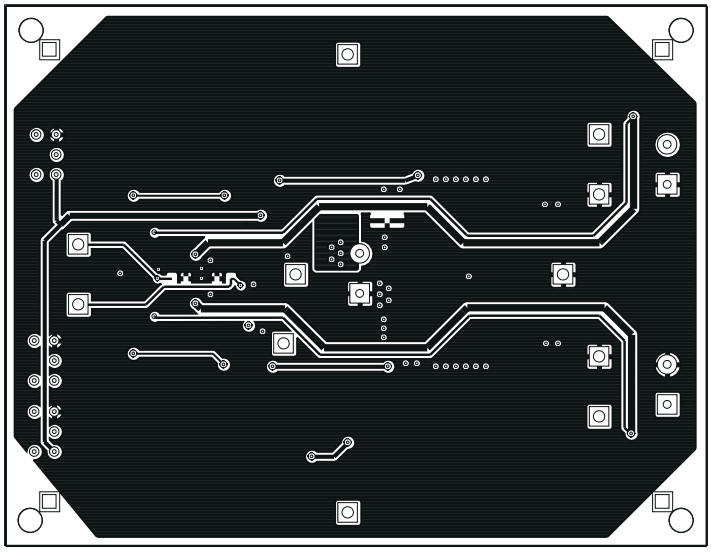


Figure 7-4. Bottom Layer

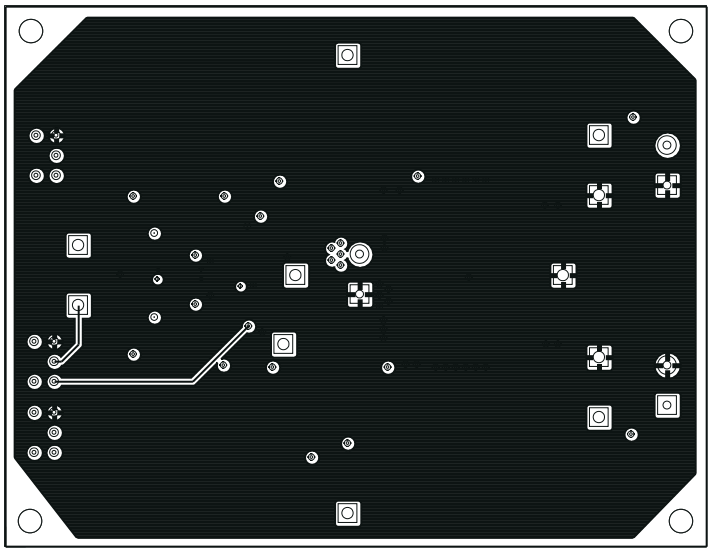


Figure 7-5. Internal Layer 1

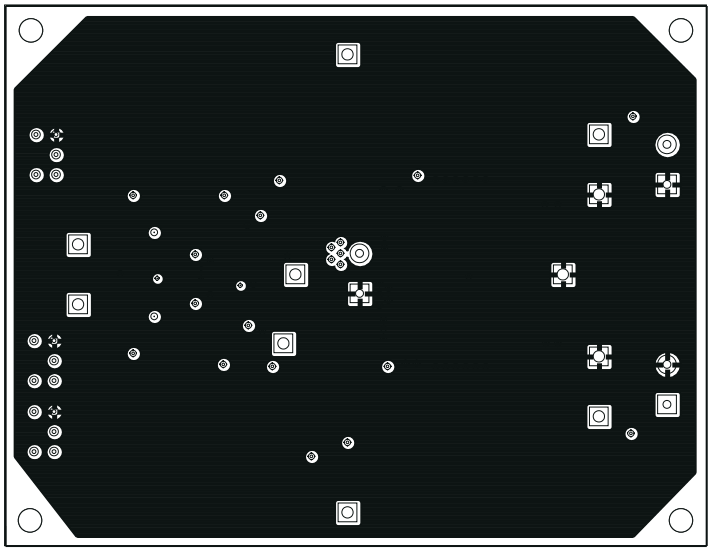


Figure 7-6. Internal Layer 2

8 Bill of Materials

Table 8-1 contains the bill of materials for the TPS53127EVM-614. The reference designators reference the schematic in Figure 3-1 and assembly locations in Figure 7-1. Components with a quantity 0 listed are not populated on the PCB but are provided for reference.

Table 8-1. TPS53127EVM-614 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1		Capacitor, Aluminum, 25 V, 20%	0.328 × 0.390 inch	Std	Std
0	C12, C19, C20, C21		Capacitor, Ceramic	0603	Std	Std
1	C15	4.7 µF	Capacitor, Ceramic, 10 V, X5R, 20%	0805	Std	Std
1	C16	1 µF	Capacitor, Ceramic, 16 V, X5R, 20%	0805	Std	Std
4	C2, C3, C4, C5	10 µF	Capacitor, Ceramic, 25 V, X5R, 20%	1210	Std	Std
2	C22, C23	4700 pF	Capacitor, Ceramic, Low Inductance, 16 V, X7R, 20%	0603	Std	Std
0	C24, C25		Capacitor, Ceramic, 25 V, X7R, 20%	0603	Std	Std
2	C6, C11	0.1 µF	Capacitor, Ceramic, 50 V, X5R, 10%	0603	Std	Std
6	C7, C9, C10, C14, C17, C18	47 µF	Capacitor, Ceramic, 6.3 V, X5R, 20%	1206	Std	Std
0	C8, C13	330 µF	Capacitor, PXE, 4.0 V, 15 mΩ, 20%	7343 (D)	APXE4R0ARA331MF61G	NIPPON CHEMI-CON
2	D1, D2	BAT54XV2T1G	Diode, Schottky, 200 mA, 30 V	SOD523	BAT54XV2T1G	On Semi
3	J1, J2, J3	ED120/2DS	Terminal Block, 2-pin, 15-A, 5.1 mm	0.40 × 0.35 inch	ED120/2DS	OST
2	L1, L2	1.5 µH	Inductor, SMT, 11 A, 9.7 mΩ	0.256 × 0.280 inch	SPM6530T-1R5M100	TDK
4	Q1, Q2, Q3, Q4	CSD17507Q5A	MOSFET, N-Chan, 30 V, 65 A, 11.8 mΩ	QFN-8 POWER	CSD17507Q5A	TI
1	R1	1.62 k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R10, R4, R6, R8	10.0 k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R11, R12	5.11	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	432	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R14, R15		Resistor, Chip, 1/8W, 5%	0603	Std	Std
2	R17, R18	2.00	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R2, R7, R9		Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	3.32 k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	12.1 k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	SW1, SW2	G12AP-RO	Switch, ON-ON Mini Toggle	0.28 × 0.18 inch	G12AP-RO	Nikkai
0	SW3	G12AP-RO	Switch, ON-ON Mini Toggle	0.28 × 0.18 inch	G12AP-RO	Nikkai
4	TP1, TP2, TP5, TP11	5012	Test Point, White, Thru Hole	0.125 × 0.125 inch	5012	Keystone
1	TP10	5013	Test Point, Orange, Thru Hole	0.125 × 0.125 inch	5013	Keystone
3	TP3, TP4, TP6	5011	Test Point, Black, Thru Hole	0.125 × 0.125 inch	5011	Keystone
2	TP7, TP8	5014	Test Point, Yellow, Thru Hole	0.125 × 0.125 inch	5014	Keystone
1	TP9	5010	Test Point, Red, Thru Hole	0.125 × 0.125 inch	5010	Keystone
1	U1	TPS53127PW	IC, Dual Synchronous Step-Down Controller For Low-Voltage Power Rails	TSSOP	TPS53127PW	TI
1	–		PCB, 2.70" × 3.50" × 0.063" FR-4	2.7 × 3.5 inch	HPA614	Any

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

9 Revision History

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

Changes from Revision * (February 2011) to Revision A (January 2022) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document. 3
- Updated the user's guide title..... 3

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