User's Guide

TPS53126 Buck Controller Evaluation Module User's Guide

ABSTRACT

The TPS53126EVM-600 Evaluation Module presents an easy-to-use reference design for a common, dual-output power supply using the TPS53126 controller in cost-sensitive applications.

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Trademarks

D-CAP2™ is a trademark of Texas Instruments.
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1 Introduction

1.1 Description

The TPS53126EVM-600 evaluation board provides the user with a convenient way to evaluate the TPS53126 Dual D-CAP2™ Mode Control Step-Down 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 to 22-V) source, the TPS53126EVM-600 includes switches and test points to assist users in evaluating the performance of the TPS53126 controller in their applications.

1.2 Applications

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

1.3 Features

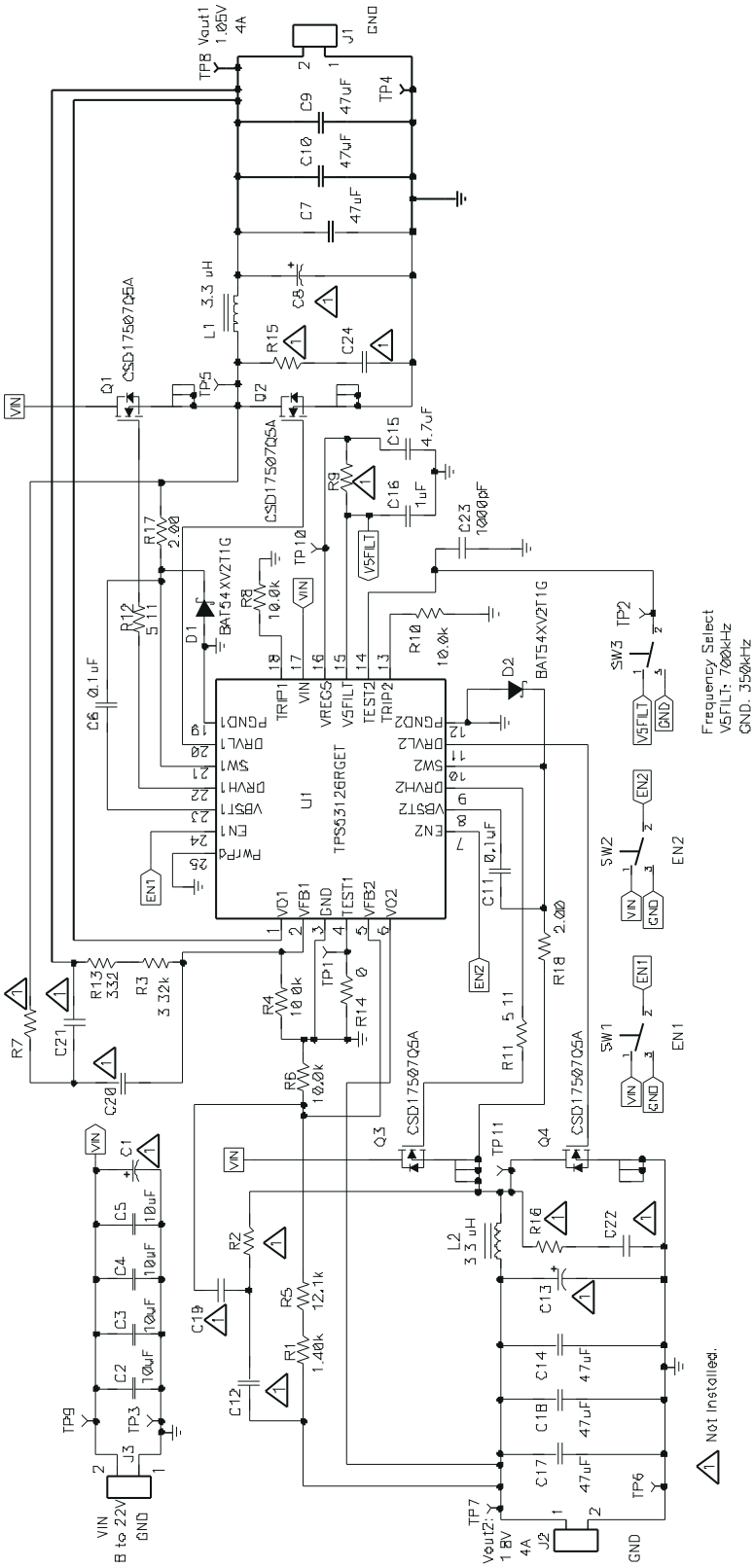
- 8-V to 22-V input
- 1.05-V and 1.8-V output
- Up to 4 A per channel output
- Switch selectable 350-kHz or 700-kHz pseudo-fixed frequency D-CAP2™ mode control
- Independent enable switches for power-on/power-off testing

2 Electrical Performance Specifications

Table 2-1. TPS53126EVM-600 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, SW3 = 350 kHz	–	20	–	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	–	1.05	–	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	–	1.80	–	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	SW3 = 350 kHz	200	350	400	kHz
η_{pk1}	Peak Efficiency of Output 1	V_{IN} = 12 V, SW3 = 350 kHz	–	88%		
η_1	Full Load Efficiency of Output 1	V_{IN} = 12 V, I_{OUT1} = 4 A, SW3 = 350 kHz	–	85%		
η_{pk2}	Peak Efficiency of Output 2	V_{IN} = 12 V, SW3 = 350 kHz	–	9%1		
η_2	Full Load efficiency of Output 2	V_{IN} = 12 V, I_{OUT2} = 4 A, SW3 = 350 kHz	–	91%		

3 Schematic



For Reference Only, See Table 9-1 for Specific Values

Figure 3-1. TPS53126EVM-600 Schematic

4 Connector and Test Point Descriptions

4.1 Enable Switches – SW1 and SW2

TPS53126EVM-600 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 TPS53126's internal discharge characteristics.

To enable V_{OUT1}, place SW1 in the EN position. To enable V_{OUT2}, place SW2 in the EN position.

4.2 Switching Frequency Select Switch – SW3

TPS53126EVM-600 includes a frequency select switch (SW3) to select the frequency programmed by the TEST2 IC pin of the TPS53126. When in the 350-kHz position, the D-CAP2™ mode control selects the Ton for 350-kHz operation. When in the 700-kHz position, the D-CAP2™ mode control selects the Ton for 700-kHz operation. For more details of switching frequency verse V_{IN} and I_{OUT}, see the TPS53126 data sheet .

Do not switch the position of SW3 while the TPS53126EVM-600 module is running. To change frequency selection, disable both Channel 1 and Channel 2 before changing the switching frequency.

4.3 Test Point Descriptions

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

Table 4-1. TPS53126EVM-600 Test Points Description

Test Point	Label	Use	Section
TP1	TEST1	Not Used	
TP2	TEST2	Monitor Frequency Select Voltage (5 V or GND)	
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 4.3.4
TP6	GND	Ground for Channel-2 Output Voltage	Section 4.3.3
TP7	VOUT2	Monitor Output Voltage for Channel 2	Section 4.3.3
TP8	VOUT1	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 4.3.5
TP11	SW2	Monitor Switching Node for Channel 2	Section 4.3.4

4.3.1 Input Voltage Monitoring –TP3 and TP9

TPS53126EVM-600 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. Measure all input voltage 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

TPS53126EVM-600 provides two test points for measuring the voltage generated at the V_{OUT1} output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. Measure all dc output voltage measurements between TP8 and TP4. To use TP8 and TP4, connect a voltmeter positive terminal to TP8 and negative terminal to TP4.

For output ripple measurements, TP8 and TP4 allow a user to limit the ground loop area by using the tip and barrel measurement technique shown in Figure 4-1.

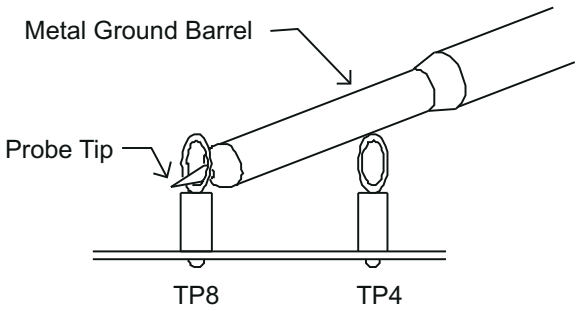


Figure 4-1. Tip and Barrel Measurement for Output Voltage Ripple

4.3.3 Channel-2 Output Voltage Monitoring – TP6 and TP7

TPS53126EVM-600 provides two test points for measuring the voltage generated at the V_{OUT2} output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. Measure all dc output voltage between TP7 and TP6. To use TP7 and TP6, connect a voltmeter positive terminal to TP7 and negative terminal to TP6.

For output ripple measurements, TP7 and TP6 allow a user to limit the ground loop area by using the tip and barrel measurement technique shown in Figure 4-1.

4.3.4 Switching Node Monitoring – TP3, TP5, and TP11

TPS53126EVM-600 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.

4.3.5 5-V Regulator Output Monitoring – TP3 and TP10

TPS53126EVM-600 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

The input voltage source (V_{IN}) shall be a 0-V to 25-V variable dc source capable of supplying 3 Adc minimum.

5.1.2 Meters

A1: 0-Adc to 5-Adc, ammeter

V1: V_{IN}, 0-V to 25-V voltmeter

V2: V_{OUT1}, 0-V to 2-V voltmeter

V3: V_{OUT2}, 0-V to 2-V voltmeter

5.1.3 Loads

LOAD1: One output load is an electronic load set for constant-current mode capable of 0 Adc to 4 Adc at 1.05 Vdc.

LOAD2: The other output load is an electronic load set for constant-current mode capable of 0 Adc to 4 Adc at 1.8 Vdc.

5.1.4 Oscilloscope and Probe

The oscilloscope, analog or digital, must be set for ac-coupled measurement with 20-MHz bandwidth limiting. Use 20-mV/division vertical resolution, 1-µs/division horizontal resolution for output ripple voltage test.

Oscilloscope probes with exposed conductive ground barrels are recommended.

5.1.5 Recommended Wire Gauge

VIN to J3 – The connection between the source voltage V_{IN} and J1 of TPS53126EVM-600 can carry as much as 2 Adc. The minimum recommended wire size is AWG 16 with the total length of wire less than 2 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 TPS53126EVM-600 can carry as much as 4 Adc each. The minimum recommended wire size is AWG 14 with the total length of wire less than 2 feet (1-foot input, 1-foot return).

5.1.6 Other Test Equipment

FAN – The TPS53126EVM-600 evaluation module includes components that can get hot to touch. Because this EVM is not enclosed to allow probing of circuit nodes, a small fan capable of 200-400 lfm is recommended to reduce component temperatures when operating.

5.2 Recommended Setup

Figure 5-1 shows the recommended test setup to evaluate the TPS53126EVM-600. Working at an ESD workstation, ensure 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 also are recommended.

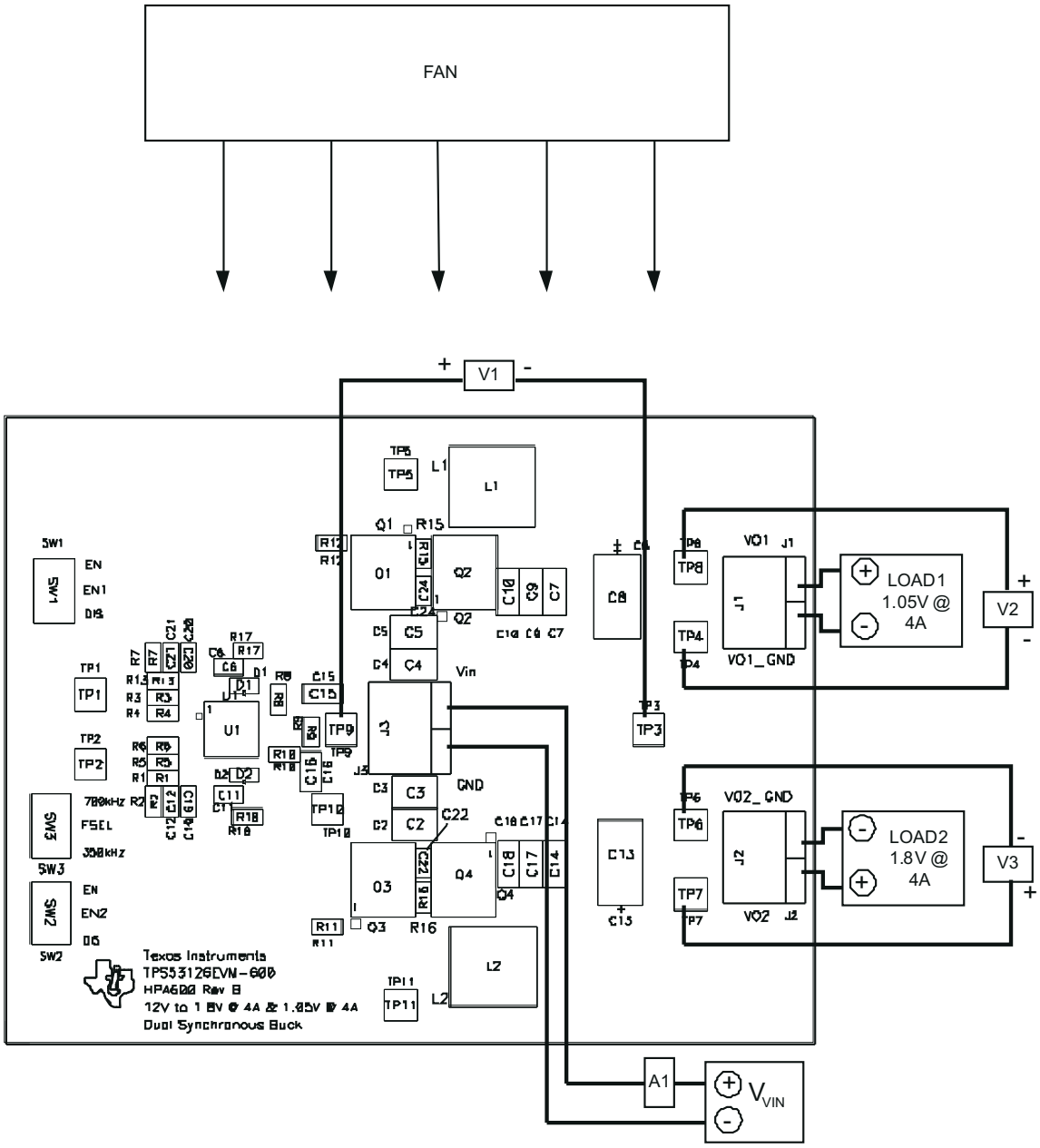


Figure 5-1. TPS53126EVM-600 Recommended Test Setup

6 Test Procedure

6.1 Start-up Procedure

1. Prior to connecting the dc input source V_{IN}, it is advisable to limit the source current from V_{IN} to 2 Adc maximum. Ensure that V_{IN} is initially set to 0 V.
2. Ensure LOAD1 and LOAD2 are set to constant-current mode to sink 0 A before V_{IN} is applied.
3. Verify SW1, SW2, and SW3 are in the desired position.
4. Place a fan as shown in Figure 5-1 and turn on, making sure air is flowing across the EVM.
5. Increase V_{IN} from 0 V to 12 Vdc.

6.2 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up TPS53126EVM-600 per Section 5.2.
2. Start up the TPS53126EVM-600 per Section 6.1.
3. Adjust VIN to desired value between 8 Vdc and 22 Vdc.
4. Adjust LOAD1/LOAD2 to desired load between 0 Adc and 4 Adc.
5. Read input voltage, output voltage, and input current from V1, V2/V3, and A1, respectively.
6. Shut down the TPS53126EVM-600 per Section 6.4.

6.3 Output Ripple Voltage Measurement Procedure

1. Set up the TPS53126EVM-600 per Section 5.2.
2. Start up the TPS53126EVM-600 per Section 6.1.
3. Adjust V_{IN} to desired value between 8 Vdc and 22 Vdc.
4. Adjust LOAD1/LOAD2 to desired load between 0 A and 4 Adc.
5. Connect the oscilloscope probe to TP8 and TP4 for V_{OUT1}, or TP7 and TP6 for V_{OUT2} as shown in Figure 4-1.
6. Measure output ripple.
7. Shut down TPS53126EVM-600 per Section 6.4.

6.4 Shutdown Procedure

1. Set SW1 to DIS.
2. Set SW2 to DIS.
3. Decrease LOAD1 to 0 A, and shut down LOAD1.
4. Decrease LOAD2 to 0 A, and shut down LOAD2.
5. Decrease V_{IN} to 0 V, and shut down V_{IN}.
6. Shut down the fan.

7 Performance Data and Typical Characteristic Curves

Figure 7-1 through Figure 7-8 present typical performance curves for the TPS53126EVM-600. 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.

7.1 Efficiency

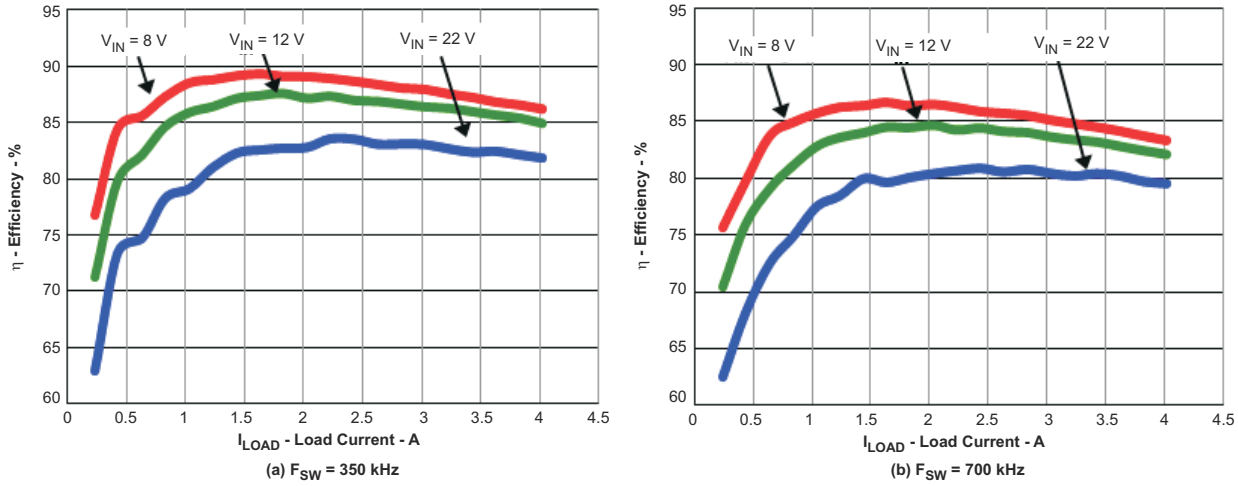


Figure 7-1. Efficiency vs Load (V_{IN} = 8 V–22 V, V_{OUT1} = 1.05 V, I_{OUT1} = 0 A–4 A)

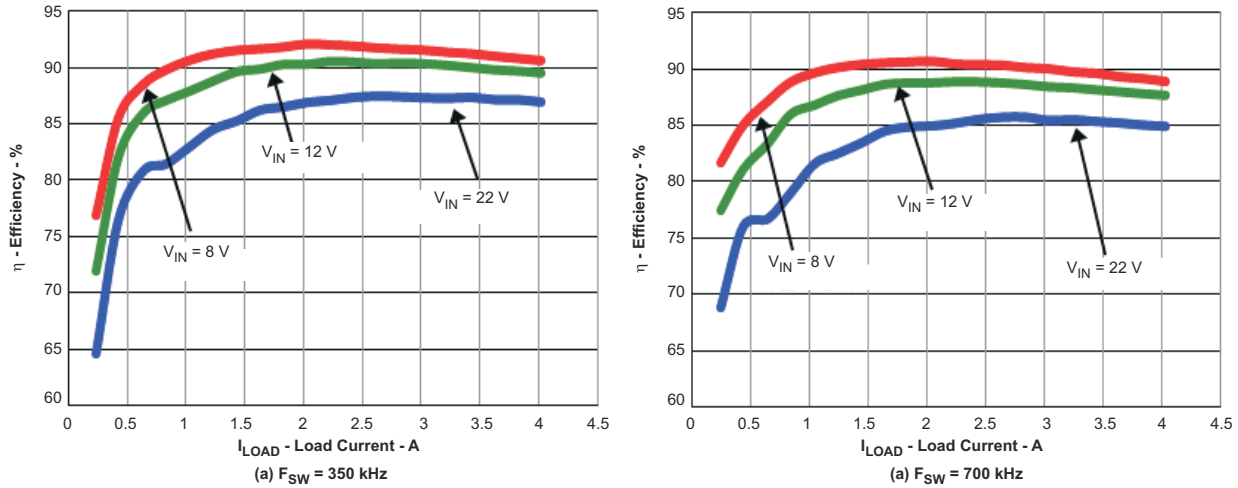


Figure 7-2. Efficiency vs Load (V_{IN} = 8 V–22 V, V_{OUT2} = 1.8 V, I_{OUT2} = 0 A–4 A)

7.2 Line and Load Regulation

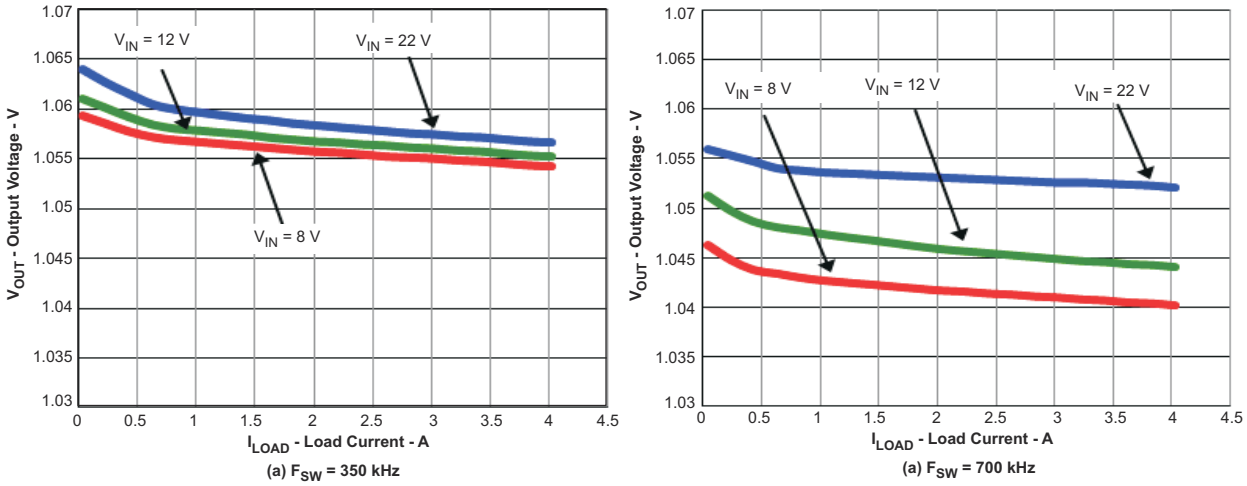


Figure 7-3. Output Voltage vs Load (V_{IN} = 8 V–22 V, V_{OUT1} = 1.05 V, I_{OUT1} = 0 A–4 A)

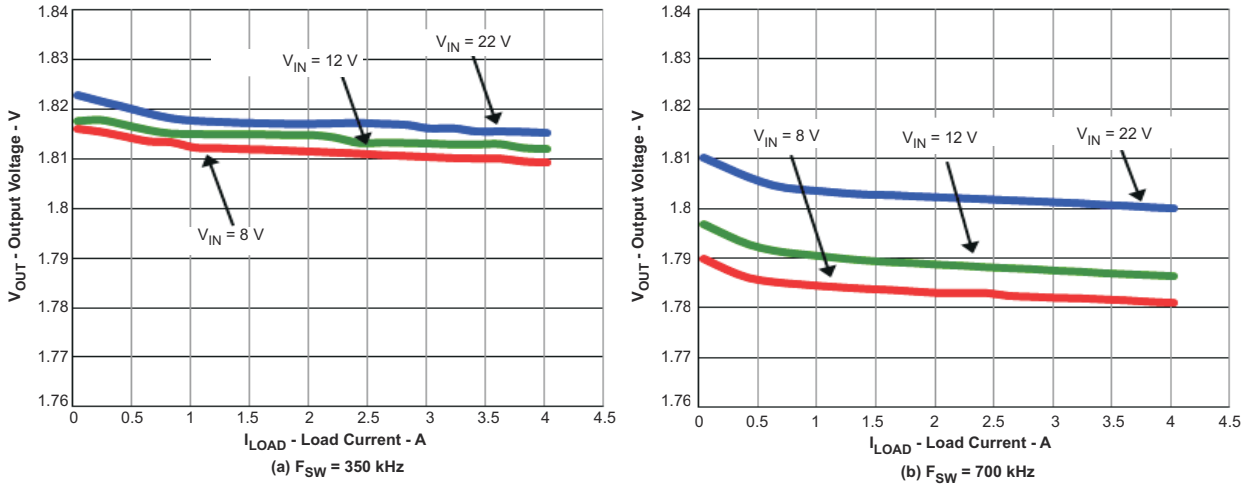


Figure 7-4. Output Voltage vs Load (V_{IN} = 8 V–22 V, V_{OUT2} = 1.8 V, I_{OUT2} = 0 A–4 A)

7.3 Output Voltage Ripple

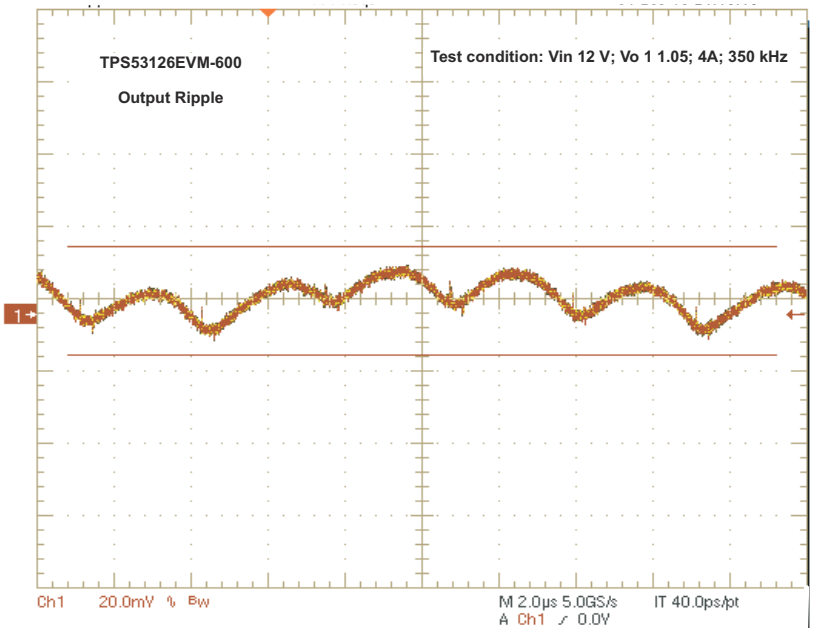


Figure 7-5. Output Voltage Ripple (V_{IN} = 12 V, V_{OUT1} = 1.05 V, I_{OUT1} = 4 A, F_{SW} = 350 kHz)

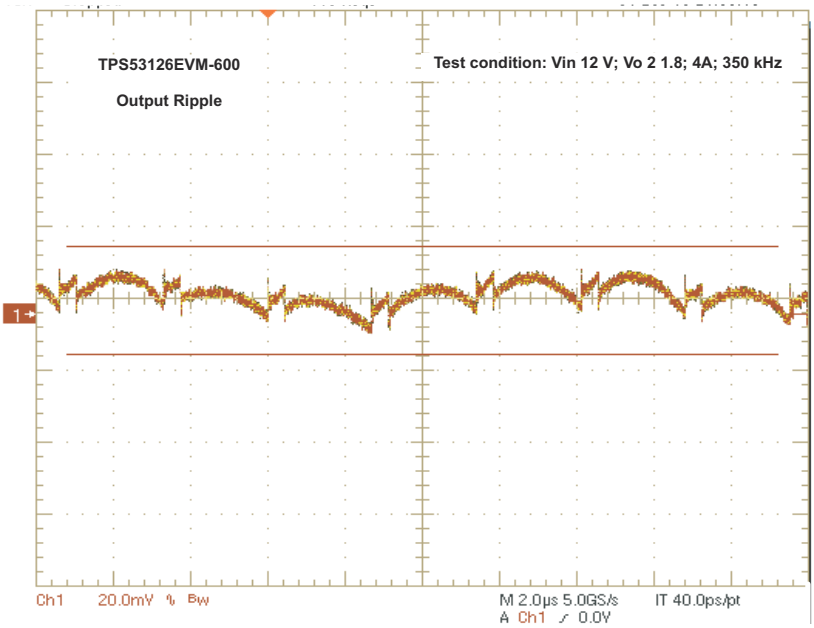


Figure 7-6. Output Voltage Ripple (V_{IN} = 12 V, V_{OUT2} = 1.8 V, I_{OUT2} = 4 A, F_{SW} = 350 kHz)

7.4 Switch Node Waveforms

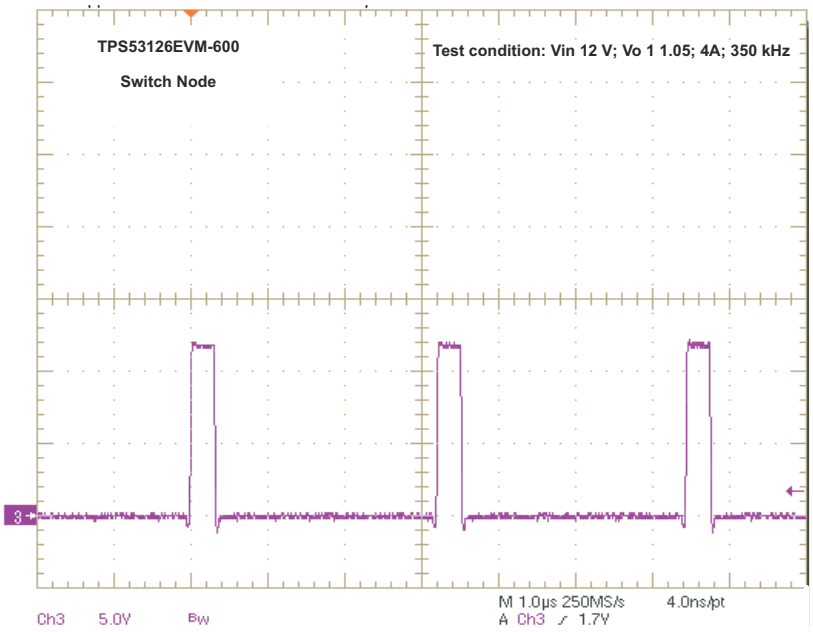


Figure 7-7. Switching Waveform (V_{IN} = 12 V, V_{OUT1} = 1.05 V, I_{OUT1} = 4 A, F_{SW} = 350 kHz)

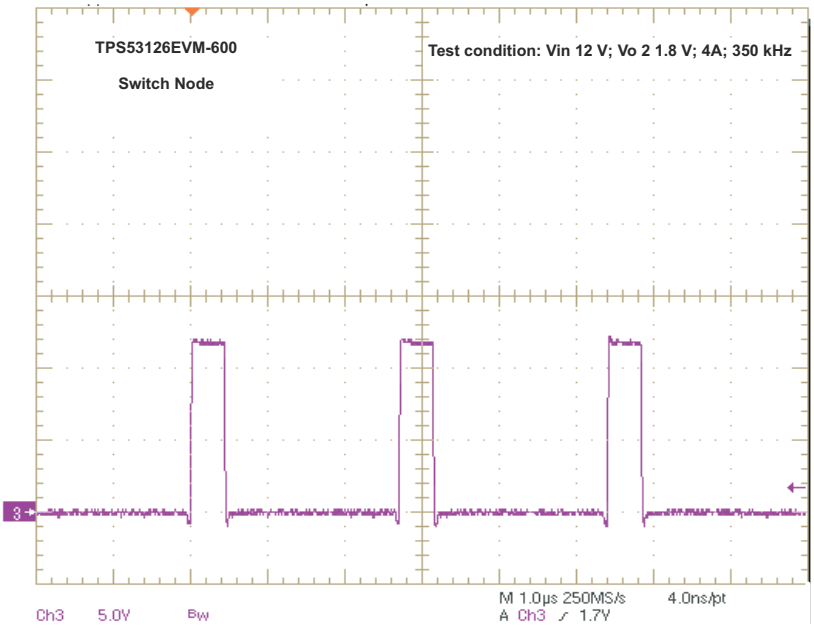


Figure 7-8. Switching Waveform (V_{IN} = 12 V, V_{OUT2} = 1.08 V, I_{OUT2} = 4 A, F_{SW} = 350 kHz)

8 EVM Assembly Drawings and Layout

The following figures (Figure 8-1 through Figure 8-6) show the design of the TPS53126EVM-600 printed-circuit board (PCB). The EVM has been designed using a 4-layer, 2-oz copper-clad circuit board of 3.5 inch by 2.7 inch to allow the user to easily view, probe, and evaluate the TPS53126 control integrated circuit 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.

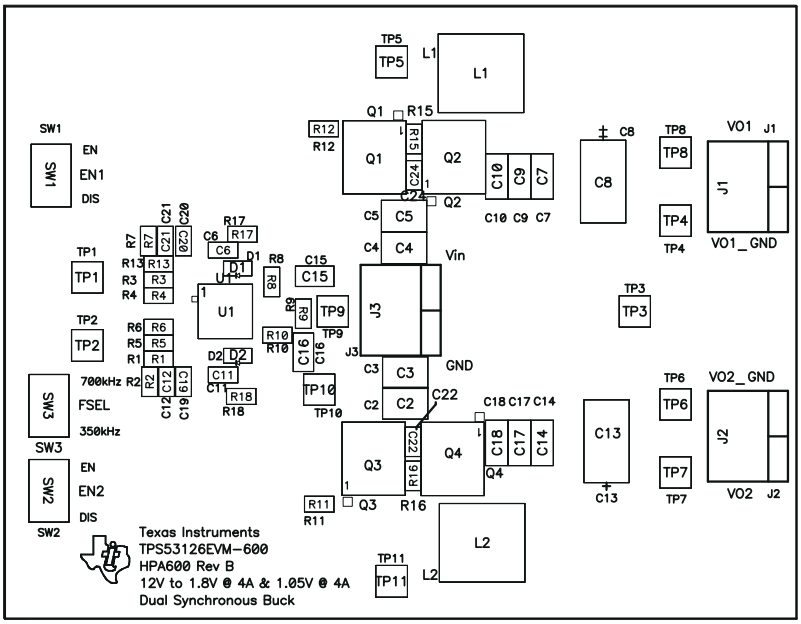


Figure 8-1. Top Assembly

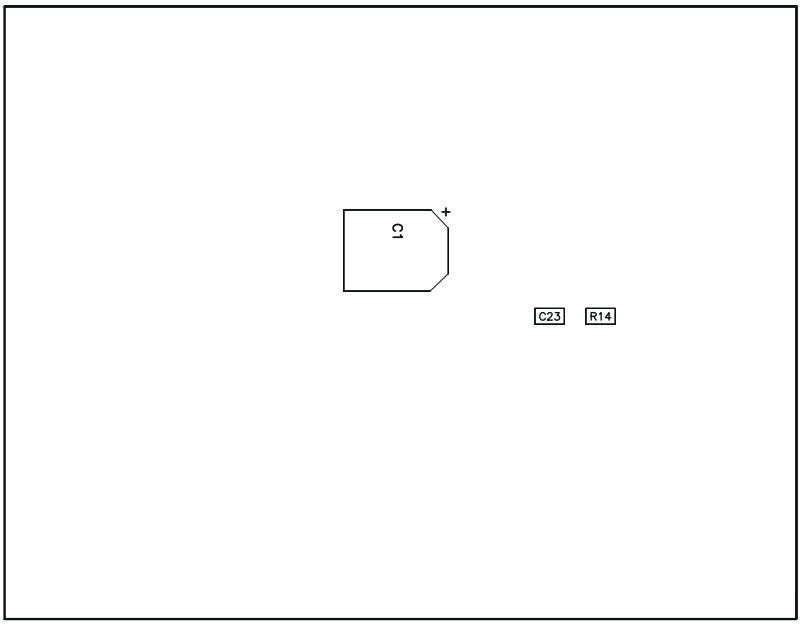


Figure 8-2. Bottom Assembly

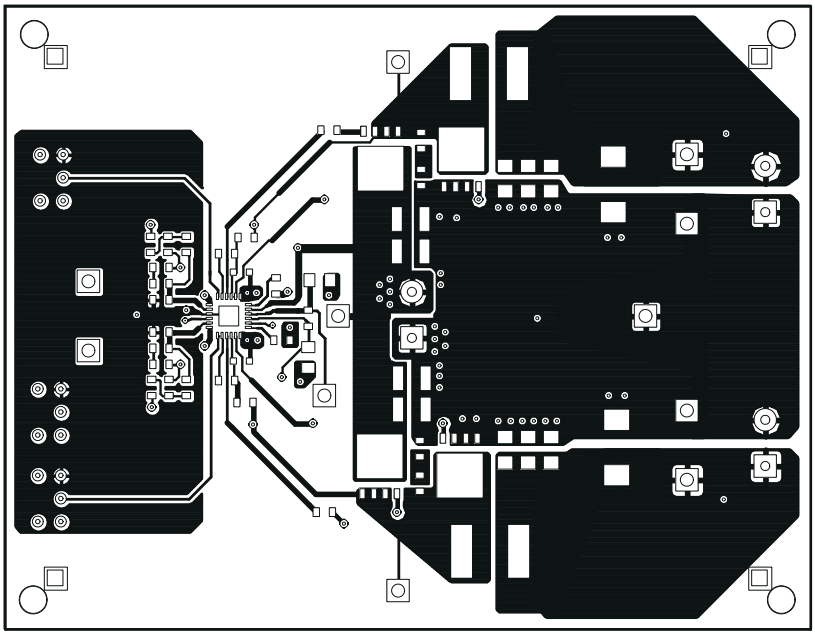


Figure 8-3. Top Layer

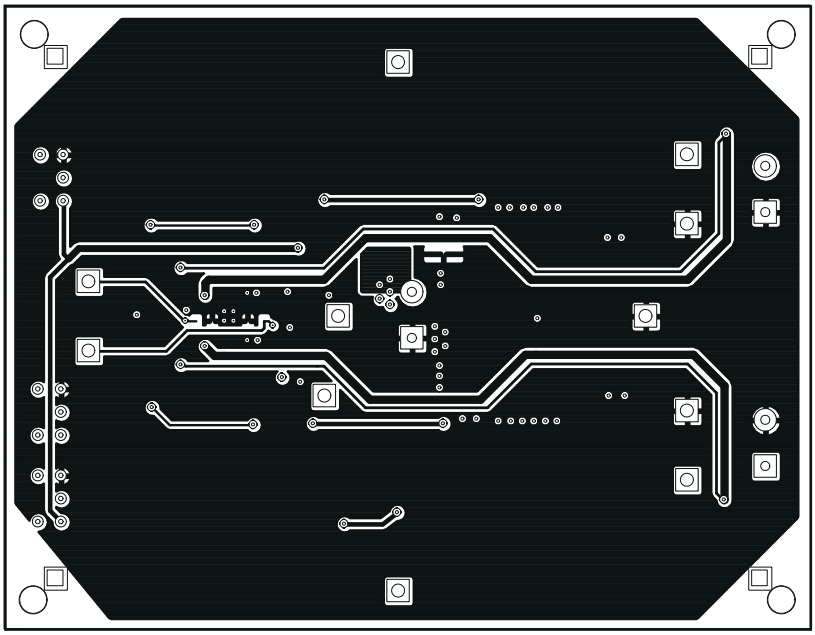


Figure 8-4. Bottom Layer

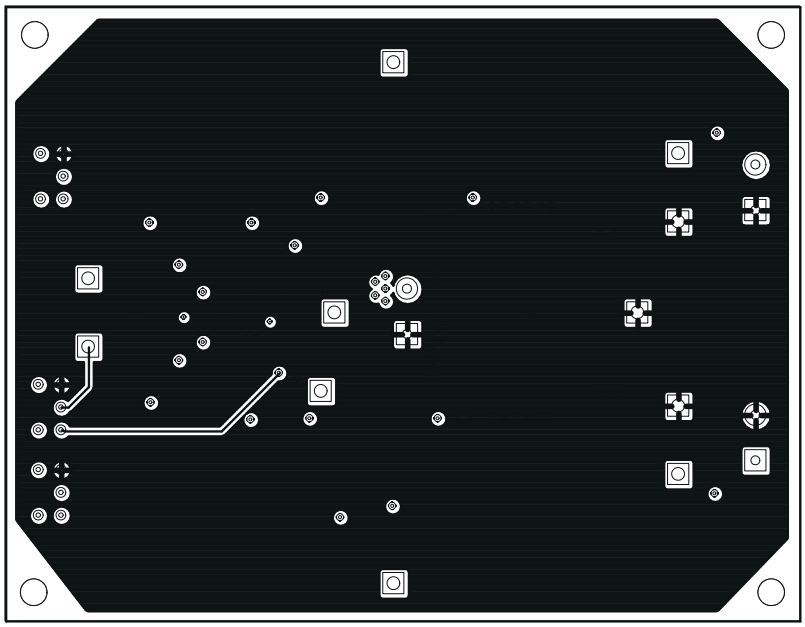


Figure 8-5. Internal Layer 1

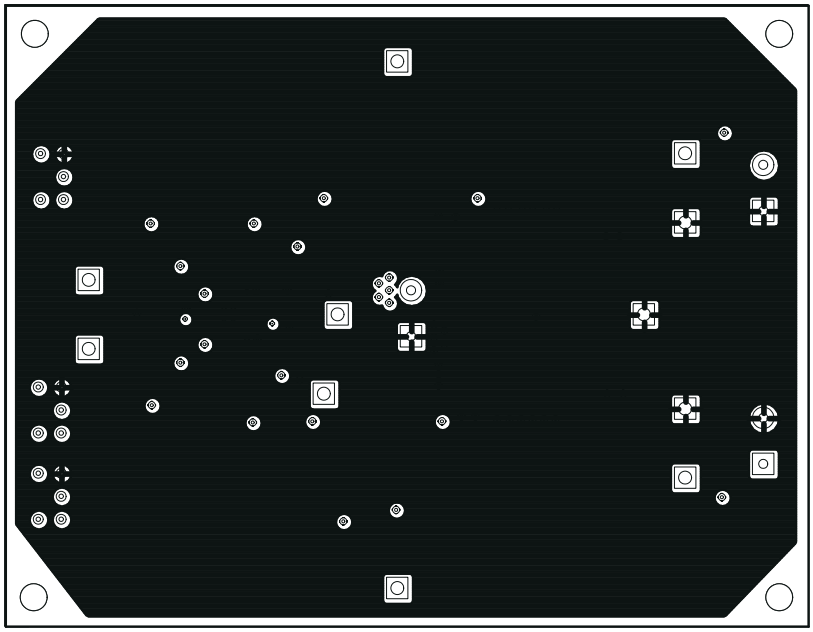


Figure 8-6. Internal Layer 2

9 Bill of Materials

The reference designators refer to the schematic in Figure 3-1 and assembly locations in Figure 8-1 and Figure 8-2. Components with a quantity of 0 listed are not populated on the PCB but are provided for reference.

Table 9-1. TPS53126EVM-600 Bill of Materials

Qty	RefDes	Value	Description	Size	Part Number	MFR
0	C1		Capacitor, Aluminum, 25V, 20%	0.328 x 0.390 inch	Std	Std
0	C12, C19, C20, C21		Capacitor, Ceramic	0603	Std	Std
1	C15	4.7 µF	Capacitor, Ceramic, 10V, X5R, 20%	0805	Std	Std
1	C16	1 µF	Capacitor, Ceramic, 16V, X5R, 20%	0805	Std	Std
4	C2, C3, C4, C5	10 µF	Capacitor, Ceramic, 25V, X5R, 20%	1210	Std	Std
0	C22, C24		Capacitor, Ceramic, 25V, X7R, 20%	0603	Std	Std
1	C23	1000 pF	Capacitor, Ceramic, Low Inductance, 16V, X7R, 20%	0603	Std	Std
2	C6, C11	0.1 µF	Capacitor, Ceramic, 50V, X5R, 10%	0603	Std	Std
6	C7, C9, C10, C14, C17, C18	47 µF	Capacitor, Ceramic, 6.3V, X5R, 20%	1206	Std	Std
0	C8, C13	330 µF	Capacitor, PXE, 4.0V, 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, 5.1mm	0.40 x 0.35 inch	ED120/2DS	OST
2	L1, L2	3.3 µH	Inductor, SMT Chip Coil, ±30%	8 x 8mm	LQH88PN3R3N38	Murata
4	Q1, Q2, Q3, Q4	CSD17507Q5A	MOSFET, N-Chan, 30V, 65A, 11.8mΩ	QFN-8 POWER	CSD17507Q5A	TI
1	R1	1.40k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R11, R12	5.11	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R13	332	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R14	0	Resistor, Chip, 1/16W, 5%	0603	Std	Std
0	R15, R16		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	3.32k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R4, R6, R8, R10	10.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	12.1k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
3	SW1, SW2, SW3	G12AP-RO	Switch, ON-ON Mini Toggle	0.28 x 0.18"	G12AP-RO	Nikkai
4	TP1, TP2, TP5, TP11	5012	Test Point, White, Thru Hole	0.125 x 0.125 inch	5012	Keystone
1	TP10	5013	Test Point, Orange, Thru Hole	0.125 x 0.125 inch	5013	Keystone
3	TP3, TP4, TP6	5011	Test Point, Black, Thru Hole	0.125 x 0.125 inch	5011	Keystone
2	TP7, TP8	5014	Test Point, Yellow, Thru Hole	0.125 x 0.125 inch	5014	Keystone
1	TP9	5010	Test Point, Red, Thru Hole	0.125 x 0.125 inch	5010	Keystone
1	U1	TPS53126RGET	IC, Dual Synchronous Step-Down Controller for Low-Voltage Power Rails	QFN-24	TPS53126RGET	TI
1	–		PCB, 2.70" x 3.50" x 0.063" FR-4	2.7" x 3.5"	HPA600	Any

10 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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