User's Guide

TPS562231 Step-Down Converter Evaluation Module User's Guide

TEXAS INSTRUMENTS

ABSTRACT

This user's guide contains information for the TPS562231 as well as support documentation for the TPS562231EVM evaluation module. Included are the performance specifications, schematic, and the bill of materials of the TPS562231EVM.

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1 Introduction

The TPS562231 is a single, adaptive on-time, D-CAP3™ mode, synchronous buck converter requiring a very low external component count. The proprietary D-CAP3 mode control supports low ESR output capacitors such as specialty polymer capacitors and multi-layer ceramic capacitors without complex external compensation circuits. The fast transient response of D-CAP3 mode control can reduce the output capacitance required to meet a specific level of performance. The switching frequency is internally set at a nominal 850 kHz and enters Advanced Eco-mode in light load conditions. The high-side and low-side switching MOSFETs are incorporated inside the TPS562231 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS562231 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS562231 dc/dc synchronous converter is designed to provide up to a 2-A output from an input voltage source of 4.5 V to 17 V. The output voltage range is from 0.6 V to 7 V. Rated input voltage and output current ranges for the evaluation module are given in Table 1-1.

The TPS562231EVM evaluation module (EVM) is a single, synchronous buck converter providing 3.3 V at 2 A from 4.5-V to 17-V input. This user's guide describes the TPS562231EVM performance.

Table 1-1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
TPS562231EVM	V_{IN} = 4.5 V to 17 V	0 A to 2 A

2 Performance Characteristics Summary

A summary of the TPS562231EVM performance specifications is provided in Table 2-1. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 3.3 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2-1. TPS562231EVM Performance Characteristics Summary

	SPECIFICATIONS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Input voltage range (V_{IN})		4.5	12	17	V
CH1	Output voltage			3.3		V
	Operating frequency	V_{IN} = 12 V, I_O = 2 A		850		kHz
	Output current range		0		2	A
	Over current limit	V_{IN} = 12 V, L_O = 3.3 μH		2.8		A
	Output ripple voltage	V_{IN} = 12 V, I_O = 2 A		15		mV$_{PP}$

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS562231. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, it is necessary to change the value of resistor R5. Changing the value of R5 can change the output voltage above 0.6 V. The value of R5 for a specific output voltage can be calculated using Equation 1.

$$R_5 = \frac{R_6 \times (V_{OUT} - 0.6\,V)}{0.6\,V}$$

(1)

Table 3-1 lists the R5 values for some common output voltages. Note that the values given in Table 3-1 are standard values and not the exact value calculated using Table 3-1.

Table 3-1. Output Voltages

OUTPUT VOLTAGE (V)	R5 (kΩ)	R6 (kΩ)	L1 (µH)			C5 + C6 +C7 (µF)
			Min	**Typ**	**Max**	
1.0	6.65	10.0	1	1.5	4.7	20 - 68
1.05	7.5	10.0	1	1.5	4.7	20 - 68
1.2	10	10.0	1	1.5	4.7	20 - 68
1.5	15	10.0	1.5	2.2	4.7	20 - 68
1.8	20	10.0	1.5	2.2	4.7	20 - 68
2.5	31.6	10.0	2.2	3.3	4.7	20 - 68
3.3	45.3	10.0	2.2	3.3	4.7	20 - 68
5.0	73.2	10.0	3.3	4.7	4.7	20 - 68
6.5	98.3	10.0	3.3	4.7	4.7	20 - 68

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS562231EVM. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start-up, and switching frequency.

4.1 Input/Output Connections

The TPS562231EVM is provided with input/output connectors and test points as shown in Table 4-1. A power supply capable of supplying 2 A must be connected to J1 through a pair of 20-AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 2 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP3 provides a place to monitor the V_{IN} input voltages with TP4 providing a convenient ground reference. TP9 is used to monitor the output voltage with TP5 as the ground reference.

Table 4-1. Connection and Test Points

REFERENCE DESIGNATOR	FUNCTION
J1	V_{IN} (see Table 1-1 for V_{IN} range)
J2	V_{OUT}, 3.3 V at 2-A maximum
JP1	EN control. Shunt EN to GND to disable
TP1	V_{IN} positive power point
TP2,TP11	GND power point
TP3	V_{IN} positive monitor point
TP4,TP5,TP12,TP13	GND monitor test point
TP6	EN test point
TP7	Switch node test point
TP8	Test point for loop response measurements
TP9	V_{OUT} positive monitor point
TP10	V_{OUT} positive power point

4.2 Start-Up Procedure

1. Ensure that the jumper at JP1 (Enable control) pins 1 and 2 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate V_{IN} voltage to VI (J1-2) and GND (J1-1).
3. Move the jumper at JP1 (Enable control) pins 1 and 2 (EN and GND) to enable the output.

4.3 Efficiency

Figure 4-1 shows the efficiency for the TPS562231EVM at an ambient temperature of 25°C.
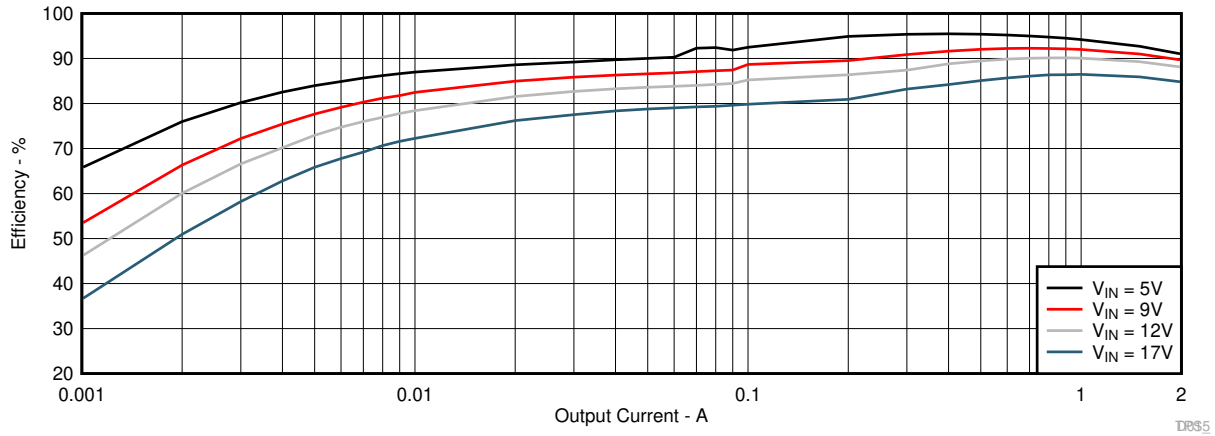

Figure 4-1. TPS562231EVM Efficiency

4.4 Load Transient Response

The TPS562231EVM response to load transient is shown in Figure 4-2. The voltage, current and time scale are indicated in the figures.
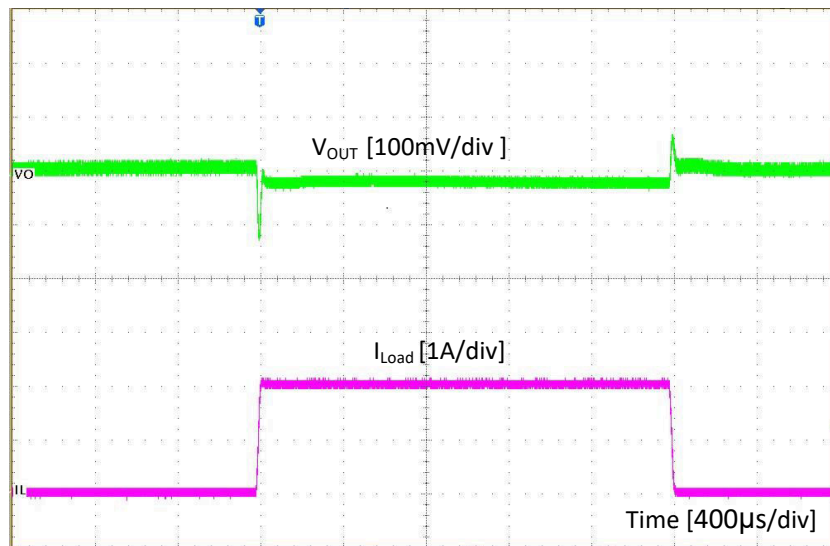

Figure 4-2. TPS562231EVM Load Transient Response

4.5 Output Voltage Ripple

The TPS562231EVM output voltage ripple is shown in Figure 4-3, Figure 4-4, and Figure 4-5. The output currents are as indicated.
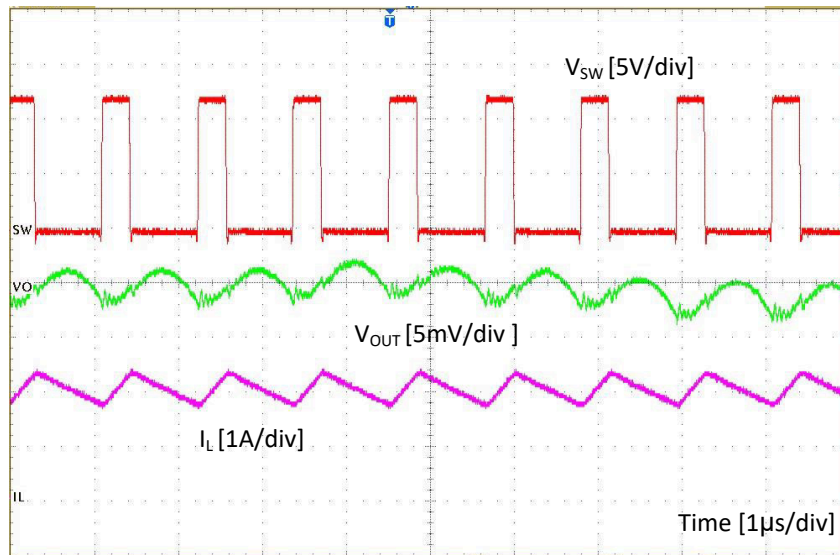

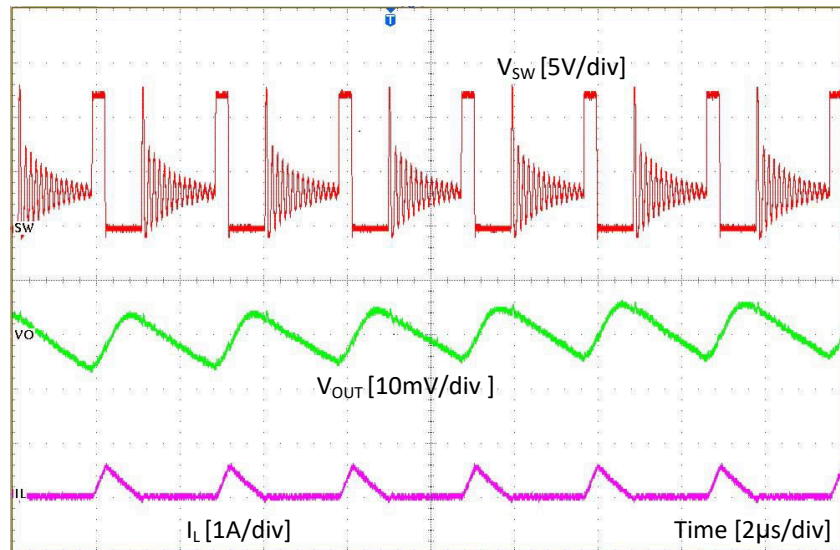**Figure 4-3. TPS562231EVM Output Voltage Ripple in CCM**

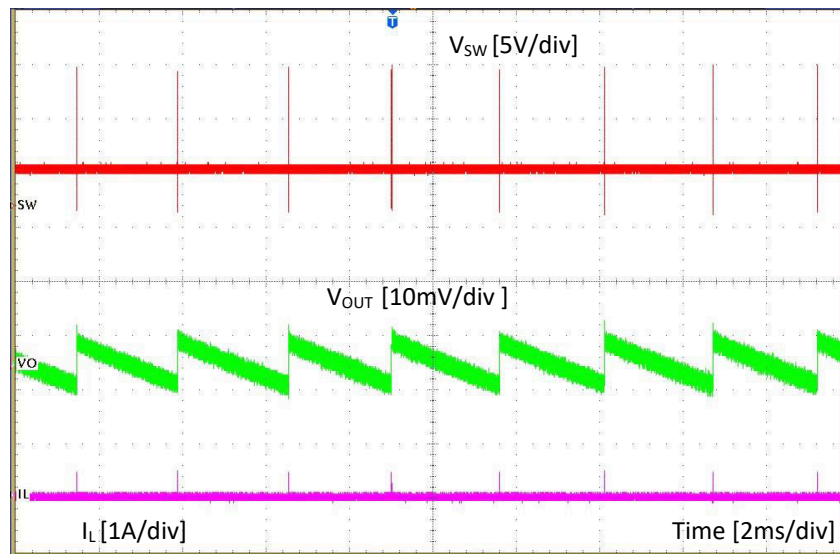**Figure 4-4. TPS562231EVM Output Voltage Ripple in DCM**

Figure 4-5. TPS562231EVM Output Voltage Ripple on No-load

5 Board Layout

This section provides a description of the TPS562231EVM, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS562231EVM is shown in Figure 5-1, Figure 5-2 and Figure 5-3. The top layer contains the main power traces for VIN, VOUT, and ground. Also on the top layer are connections for the pins of the TPS562231 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C1, C2, and C3 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the switching node copper fill, signal ground copper fill and the feed back trace from the point of regulation to the top of the resistor divider network.
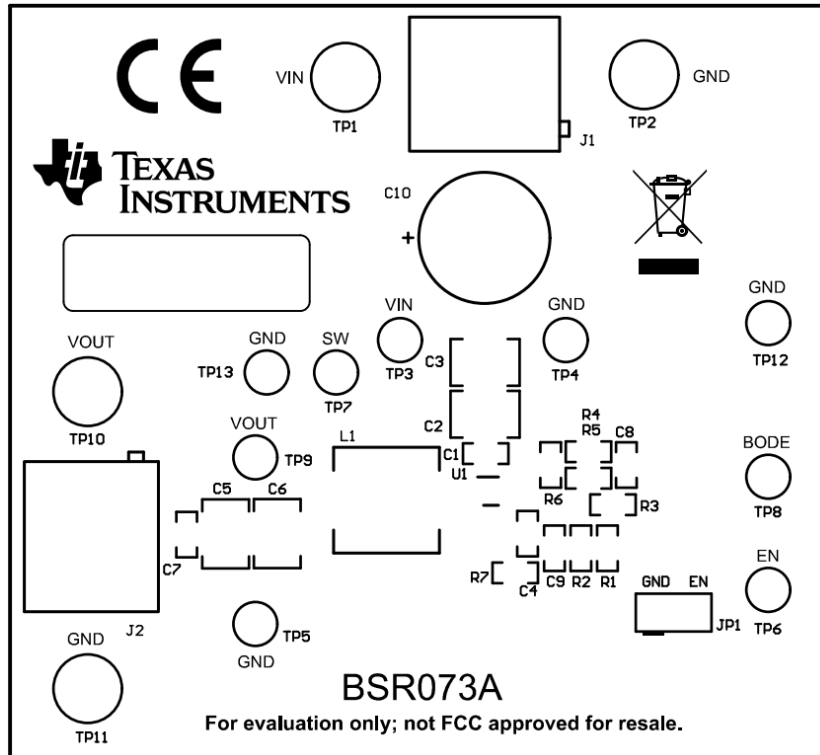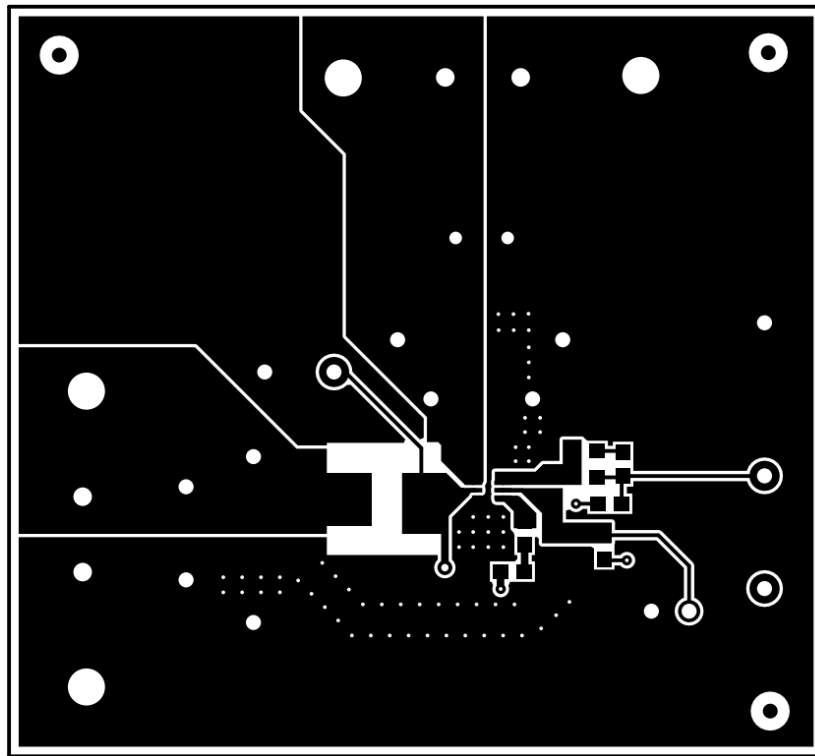

Figure 5-1. Top Assembly

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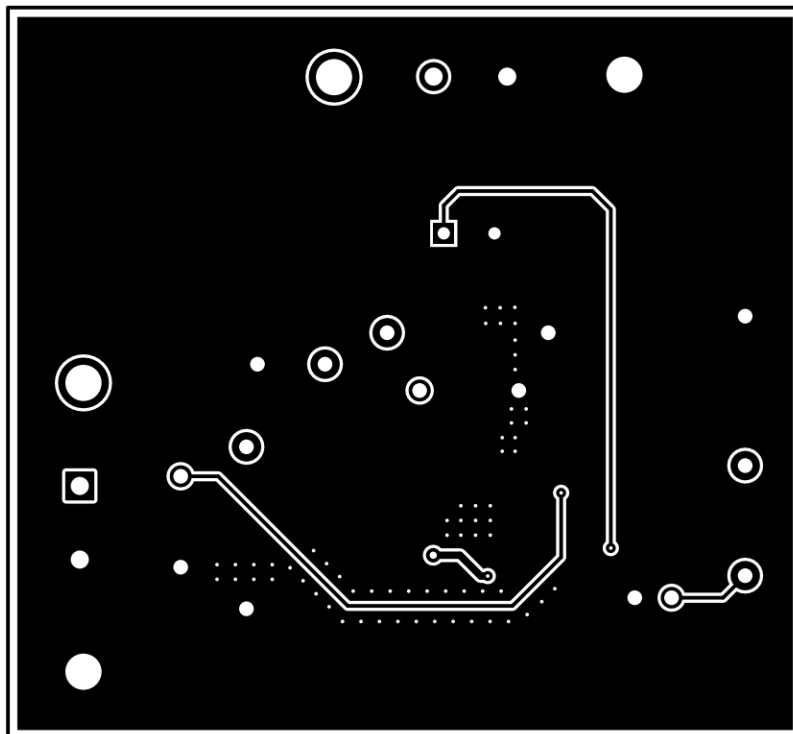
Figure 5-2. Top Layer

Figure 5-3. Bottom Layer

6 Schematic, Bill of Materials, and Reference

6.1 Schematic
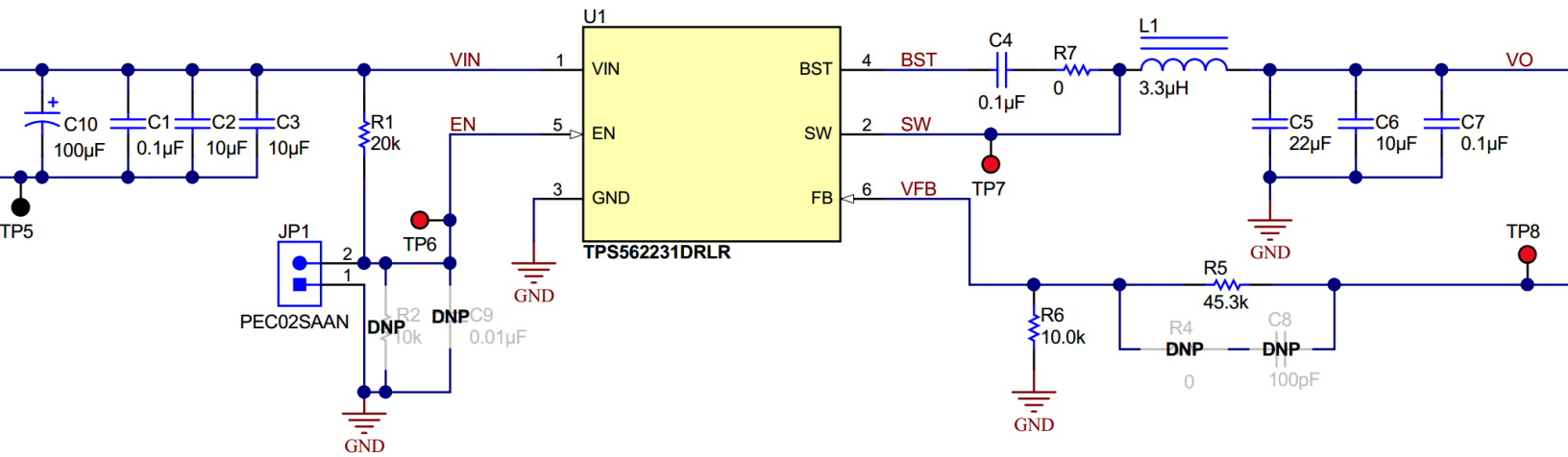
Figure 6-1 is the schematic for the TPS562231EVM.

Figure 6-1. TPS562231EVM Schematic Diagram

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6.2 List of Materials

Table 6-1. List of Materials

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
!PCB	1		Printed Circuit Board		BSR073	Any
C1, C4, C7	3	0.1uF	CAP, CERM, 0.1 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E104KA01D	MuRata
C2, C3	2	10uF	CAP, CERM, 10 µF, 25 V, +/- 10%, X7R, 1210	1210	GRM32DR71E106KA12L	MuRata
C5	1	22uF	CAP, CERM, 22 µF, 10 V, +/- 10%, X7R, 1210	1210	GRM32ER71A226ME20L	MuRata
C6	1	10uF	CAP, CERM, 10 µF, 10 V, +/- 10%, X7R, 1210	1210	GRM32DR71A106KA01L	MuRata
C10	1	100uF	CAP, AL, 100 µF, 25 V, +/- 20%, 0.13 ohm, TH	Cap D8.0x11.5mm	UBT1E101MPD1TD	Nichicon
J1, J2	2		Terminal Block, 5.08 mm, 2x1, Brass, TH	2x1 5.08 mm Terminal Block	ED120/2DS	On-Shore Technology
JP1	1		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
L1	1	3.3uH	Inductor, Shielded Drum Core, Powdered Iron, 3.3 µH, 6 A, 0.019 ohm, SMD	7.30x4.80x6.60mm	74437349033	Wurth Elektronik
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
R1	1	20k	RES, 20 k, 5%, 0.1 W, 0603	0603	CRCW060320K0JNEA	Vishay-Dale
R3	1	51	RES, 51, 5%, 0.1 W, 0603	0603	CRCW060351R0JNEA	Vishay-Dale
R5	1	45.3k	RES, 45.3 k, 1%, 0.1 W, 0603	0603	CRCW060345K3FKEA	Vishay-Dale
R6	1	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R7	1	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
SH-J1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP10, TP11	4		Terminal, Turret, TH, Double	Keystone1502-2	1502-2	Keystone
TP3, TP6, TP7, TP8, TP9	5		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP4, TP5, TP12, TP13	4		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U1	1		4.5V to 17 V Input, 2-A Pulse Skip Mode Synchronous Step-Down Voltage Regulator, DRL0006A (SOT-5X3-6)	DRL0006A	TPS562231DRLR	Texas Instruments
C8	0	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H101JA01D	MuRata
C9	0	0.01uF	CAP, CERM, 0.01 µF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H103KA01D	MuRata
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
R2	0	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	CRCW060310K0JNEA	Vishay-Dale

Table 6-1. List of Materials (continued)

R4	0	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic

6.3 Reference

1. *TPS56223x 4.5 V to 17 V Input, 2-A Synchronous Step-Down Voltage Regulator in SOT563* data sheet (SLUSDA4)

7 Revision History

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

Changes from Revision * (February 2019) to Revision A (July 2021)   **Page**

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