User's Guide

TPS1653EVM: Evaluation Module for TPS16530 eFuse

ABSTRACT

This user's guide describes the evaluation module (EVM) for the Texas instruments TPS16530 eFuse device. The document provides EVM configuration information and test setup details for evaluating TPS16530 eFuse devices with the EVM. The EVM schematic, board layout and bill of materials (BOM) are also included.

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Trademarks

1 Introduction

The TPS1653EVM allows reference circuit evaluation of TI's TPS16530 eFuse device. The TPS16530 is a 4.5-V to 58-V, 0.6-A to 4.5-A industrial eFuse with integrated 31-mΩ FET, programmable undervoltage, overcurrent, inrush current protection, and output current monitoring features.

1.1 REACH Compliance

In compliance with the Article 33 provision of the EU REACH regulation, we are notifying you that this EVM includes a component containing at least one substance of very high concern (SVHC) above 0.1%. These uses from Texas Instruments do not exceed 1 ton per year. Table 1-1 lists the SVHC summary.

Table 1-1. SVHC Summary

Component Manufacturer	Component Type	Component Part Number	SVHC Substance	SVHC CAS (When Available)
Fairchild Semiconductor	Diode	SMCJ54A	Lead	7439-92-1

1.2 EVM Features

The TPS1653EVM features include:

- 4.5-V to 58-V input operating voltage range
- 0.6-A to 4.5-A programmable current limit
- Selectable input UVLO at 4.5 V and 43 V
- Programmable V_{OUT} slew rate control
- Selectable overcurrent fault response (Auto-Retry and Latch)
- Optional on-board transient protection devices, like input TVS and output Schottky diodes
- On-board reset switch, fault, and power good indicators

1.3 Applications

- Power amplifier protection in telecom radios
- Medical equipment
- Fire alarm control panels
- Industrial printers

2 Description

The TPS1653EVM enables full evaluation of the TPS16530 device. This EVM has two independent channels (CH1 and CH2) where two devices can be evaluated together. CH1 accommodates the TPS16530PWPR device while CH2 accommodates the TPS16530RGER device. Input power is applied at T1 (CH1) and T3 (CH2) while T2 (CH1) and T4 (CH2) provide the output connections to the load respectively. Refer to the schematic in Figure 5-1 and EVM test setup in Figure 3-1. S1 and S2 allow U1 and U2 to be reset or disabled and Jumper J4 and J11 allow the current limit setting to be changed.

A fault (FLTb) indicator is provided by D3 and D7 for CH1 and CH2, respectively. Scaled current for each channel can be monitored at TP7 and TP16 with a scaling factor of 0.83 V / A.

Table 2-1. TPS1653EVM Options and Setting

Part Number	EVM Function	V_{IN} Range	UVLO		Current Limit		Versions Available
			CH1	CH2	Minimum Setting	Maximum Setting	
TPS1653EVM	4.5-V to 58-V, 0.6-A to 4.5-A Industrial eFuse	4.5 V to 58 V	4.5 V	4.5 V	0.6 A	4.5 A	Auto retry Latch off Current Limit

3 General Configurations

3.1 Physical Access

Table 3-1 lists the TPS1653EVM input and output connector functionality, Table 3-2 describes the test point availability, and Table 3-3 describes the jumper functionality.

Table 3-1. Input and Output Connector Functionality

Connector		Label	Description
T1	CH1	VIN1(+), GND(–)	CH1 input power supply to the EVM
T2		VOUT1(+), GND(–)	CH1 output from the EVM
T3	CH2	VIN2(+), GND(–)	CH2 input power supply to the EVM
T4		VOUT2(+), GND(–)	CH2 output from the EVM

Table 3-2. Test Points Description

Channel	Test Points	Label	Description
CH1	TP1	VIN1	CH1 system power supply input
	TP2	VOUT1	CH1 output voltage
	TP3	PGOOD1	CH1 output power good
	TP4	FLTb1	CH1 fault indicator
	TP5	ENb1	CH1 Active low enable input control
	TP6	SHDNb1	CH1 shutdown input
	TP7	IMON1	CH1 output current monitor
	TP8, TP9, TP10	GND	GND
CH2	TP11	VIN2	CH2 system power supply input
	TP12	VOUT2	CH2 output voltage
	TP13	PGOOD2	CH2 output power good
	TP14	FLTb2	CH2 fault indicator
	TP15	ENb2	CH2 Active low enable input control
	TP16	IMON2	CH2 output current monitor
	TP17	SHDNb2	CH2 shutdown input
	TP18, TP19, TP20	GND	GND

Table 3-3. Jumper and LED Descriptions

Jumper	Label	Description
J1	J1	CH1 fault LED pulled to VIN1, if installed
J2	J2	CH1 output power good indicator LED pulled to VOUT1, if installed
J3	J3	CH1 UVLO setting: 1-2 position sets 4.5 V as input UVLO and 2-3 position sets 43 V as input UVLO
J4	J4	CH1 current limit setting 1-2 position sets 4.5 A 3-4 position sets 3 A 5-6 position sets 2 A 7-8 position sets 1 A 9-10 position sets 0.6 A
J5	J5	Disables CH1 device if J5 is open and ENb1 is pulled > 1.25 V
J6	J6	CH1 MODE selection Open position sets latch-off mode Closed position sets auto-retry mode
J7	J7	CH2 fault LED pulled to VIN1, if installed
J8	J8	CH2 output power good indicator LED pulled to VOUT1, if installed
J9	J9	CH2 UVLO setting: 1-2 position sets 4.5 V as input UVLO and 2-3 position sets 43 V as input UVLO

Table 3-3. Jumper and LED Descriptions (continued)

Jumper	Label	Description
J10	J10	Disables CH2 device if J10 is open and ENb1 is pulled > 1.25 V
J11	J11	CH2 current limit setting 1-2 position sets 4.5 A 3-4 position sets 3 A 5-6 position sets 2 A 7-8 position sets 1 A 9-10 position sets 0.6 A
J12	J12	CH2 MODE selection Open position sets latch-off mode Closed position sets auto-retry mode
D3, D7 (RED-LED)	Fault LED	CH1, CH2 fault indicators, respectively. LED turns on when the internal MOSFET is disabled due to any fault condition, such as undervoltage, overload, short circuit, and thermal shutdown.
D4, D8 (GREEN-LED)	Output power indicator	CH1, CH2 output power good indicators, respectively. LED turns on whenever the output voltage is close to the VIN.

3.2 Test Equipment

3.2.1 Power Supplies

One adjustable power supply: 0-V to 58-V output and 0-A to 9-A output current limit.

3.2.2 Meters

One DMM minimum needed and may require more if simultaneous measurements are required.

3.2.3 Oscilloscope

A DPO2024, or equivalent. Three 10x voltage probes and one DC current probe.

3.2.4 Loads

One resistive load which can tolerate up to 9-A DC load at 58 V.

Note

A resistive load is recommended for testing. If an electronic load is used, ensure that the output load is set in the Constant Resistance (CR) mode, not in the Constant Current (CC) mode.

3.3 Test Setup

Figure 3-1 shows the typical test setup for the TPS1653EVM. Connect T1/T3 to the power supply and T2/T4 to the load.

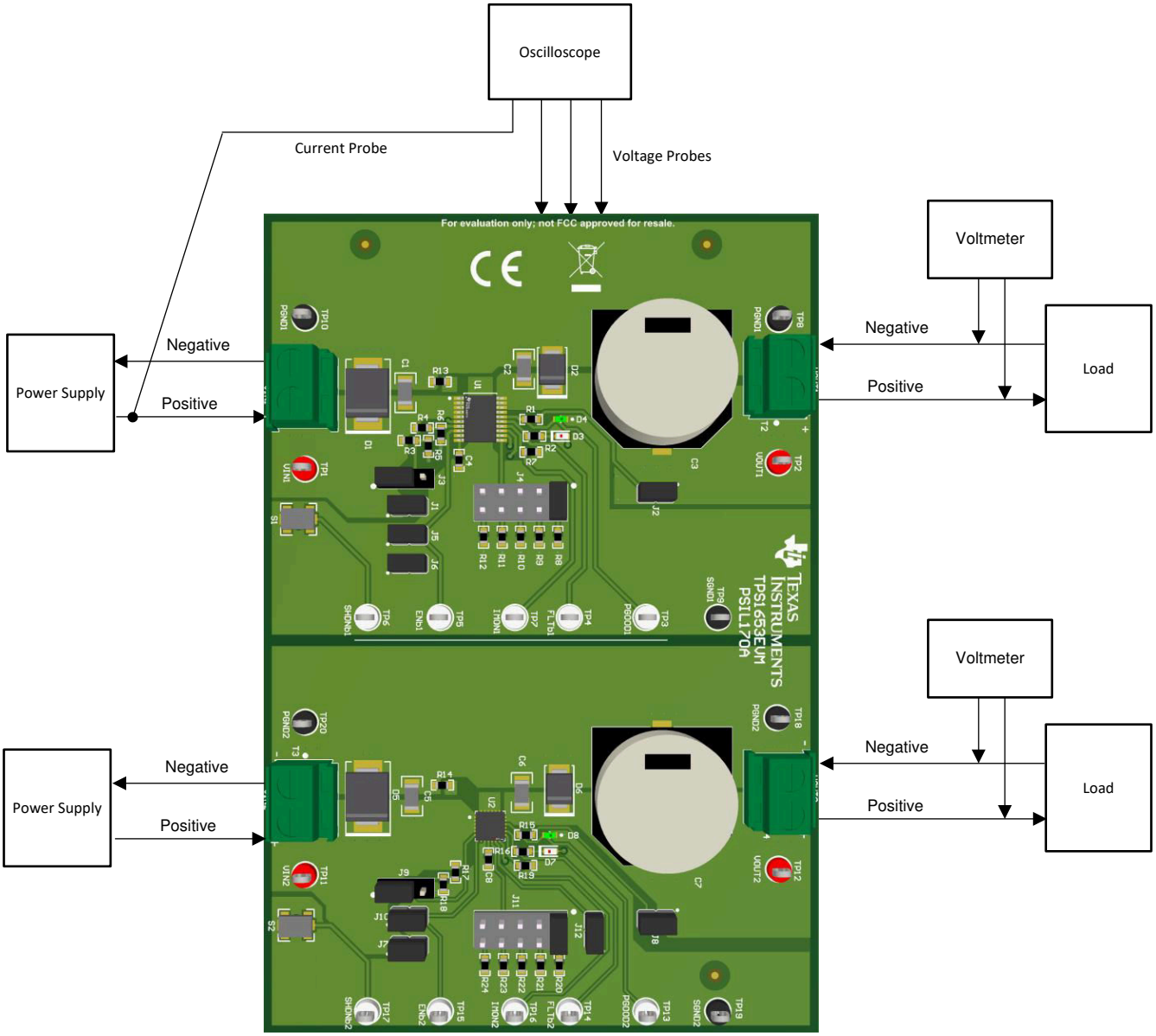

Figure 3-1. EVM Test Setup

3.4 Test Procedure

Note

CH1 and CH2 can be tested one by one with a single power supply and the load.

3.4.1 Preliminary Tests

1. Turn on the power supply and set the output voltage and the current limit according to Table 3-4.

Table 3-4. Power Supply Setting for the TPS1653EVM

EVM	Channel	Voltage Set Point	Power Supply Current Limit
TPS1653EVM	CH1	48 V	9 A
	CH2	48 V	9 A

2. Turn on the load and set the load resistance to 96 Ω ±1 Ω.
3. Disable the power supply and load and hook up the TPS1653EVM assembly as shown in Figure 3-1.
4. Make sure the default evaluation board jumper settings are as shown in Table 3-5.

Table 3-5. Default Jumper Setting for the TPS1653EVM

	J1	J2	J3	J4	J5	J6
CH1	Install	Install	1-2	1-2	Install	Install
	J7	**J8**	**J9**	**J10**	**J11**	**J12**
CH2	Install	Install	1-2	Install	1-2	Install

5. Enable the power supply and the load.
6. Connect the negative probe of the DMM to test point TP8 or TP10, and the positive probe to the respective test points, and verify that the voltages shown in Table 3-6 are obtained.

Table 3-6. TPS1653EVM DMM Readings at Different Test Points

Voltage test on (CH1)	Measured Voltage Reading	Voltage test on (CH2)	Measured Voltage Reading
VIN1 (TP1)	48 V ±1-V DC	VIN2 (TP11)	48 V ±1-V DC
VOUT1 (TP2)	48 V ±1-V DC	VOUT2 (TP12)	48 V ±1-V DC
FLTb1 (TP4)	46.6 V ±0.5-V DC	FLTb2 (TP14)	46.6 V ±0.5-V DC
SHDNb1 (TP6)	2.7 V ±0.5-V DC	SHDNb2 (TP17)	2.7 V ±0.5-V DC

7. Press the CH1/CH2 shutdown switch, S1/S2, and verify the CH1/CH2 output voltage, VOUT1/VOUT2, drops to zero. Release the S1/S2 switch and verify the output voltage resumes to nominal 48 V ±1 V.
8. Disable the power supply and the load.

3.4.2 UVLO Tests

Follow the instructions to verify undervoltage levels of the device:

1. Set jumpers J3 and J9 in 2-3 position to set UVLO level at 43 V.
2. Set the load resistance to 96 Ω ±1 Ω and the power supply voltage to 48 V. Enable the power supply and the load.
3. Reduce the CH1 input voltage and verify that VOUT1 reduces as VN1 reduces and drops to zero when VIN1 falls below 43 V ±1 V (CH1 UVLO limit).
4. Similarly, reduce the CH2 input voltage and verify that VOUT2 reduces as VN2 reduces and drops to zero when VIN2 falls below 43 V ±1 V (CH2 UVLO limit).
5. Verify that CH1 and CH2 FLTb red LEDs (D3/D7) turn on whenever the supply voltage reaches UVLO limits of the respective channels.
6. Disable the power supply and the load.

3.4.3 Current Limit Test with Step Load of 4 A to 7 A

Use the following instructions to perform current limit test:

1. Set the current limit to 4.5 A by installing the J4/J11 jumper in position 1-2.
2. Set the load resistance to 96 Ω ±1 Ω and the power supply voltage to 58 V.
3. Enable the load and the power supply.
4. Decrease the load resistance to set load current of 4 A.
5. Apply overload of 7 A and verify the device current limit behavior.
6. The device allows the pulsed overload current of 7 A for a duration of 25 ms before limiting the current to 4.5 A. In this case, the device turns off the internal FET due to thermal shutdown before the expiry of $t_{CL\_ILIM(dly)}$.
7. Place the jumper J4 and J11 at other settings to test at various other current limits.
8. Disable the power supply and the load.

Figure 3-2 shows current limit behavior for step load of 4 A to 7 A on the TPS1653EVM eFuse Evaluation Board.

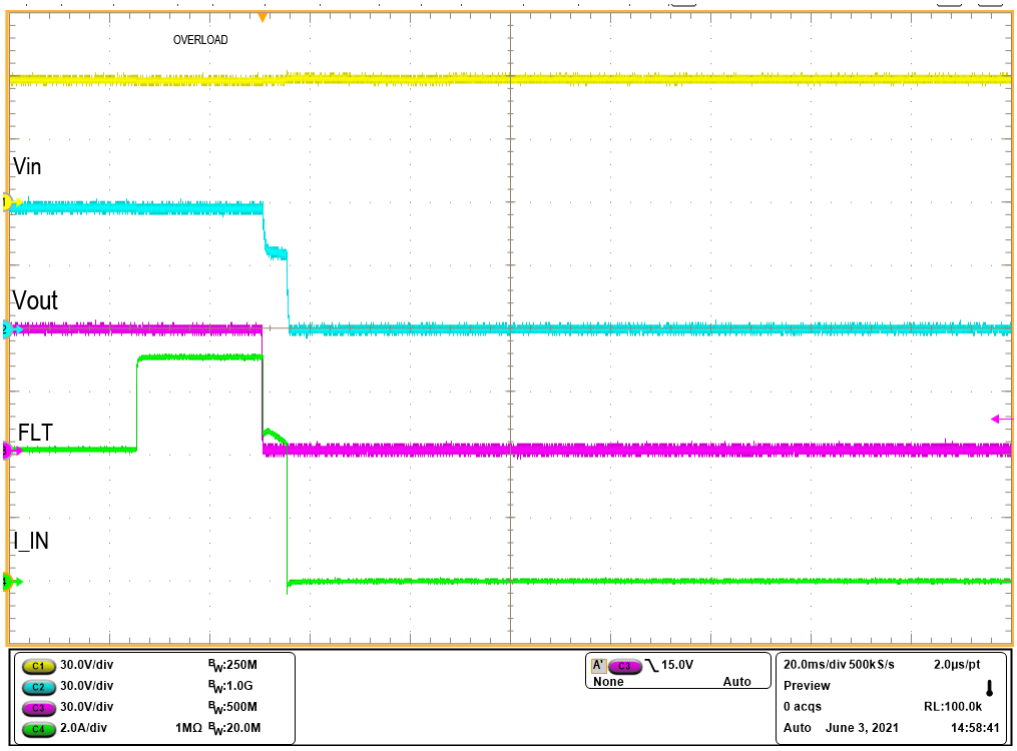

Figure 3-2. Over Current Response of TPS16530 for 4.5-A Current Limit Setting

3.4.4 Output Short-Circuit Protection Test

Follow the instructions to verify the output short-circuit protection feature of the device:

1. Set the current limit to 1 A by installing the J4/J11 jumper in position 7-8.
2. Set the input power supply voltage to 50 V and current limit to 6 A. Turn ON the power supply.
3. Short the output of the device (for example, VOUT to GND with a shorter cable).
4. Verify the output short-circuit response waveform as shown in Figure 3-3.

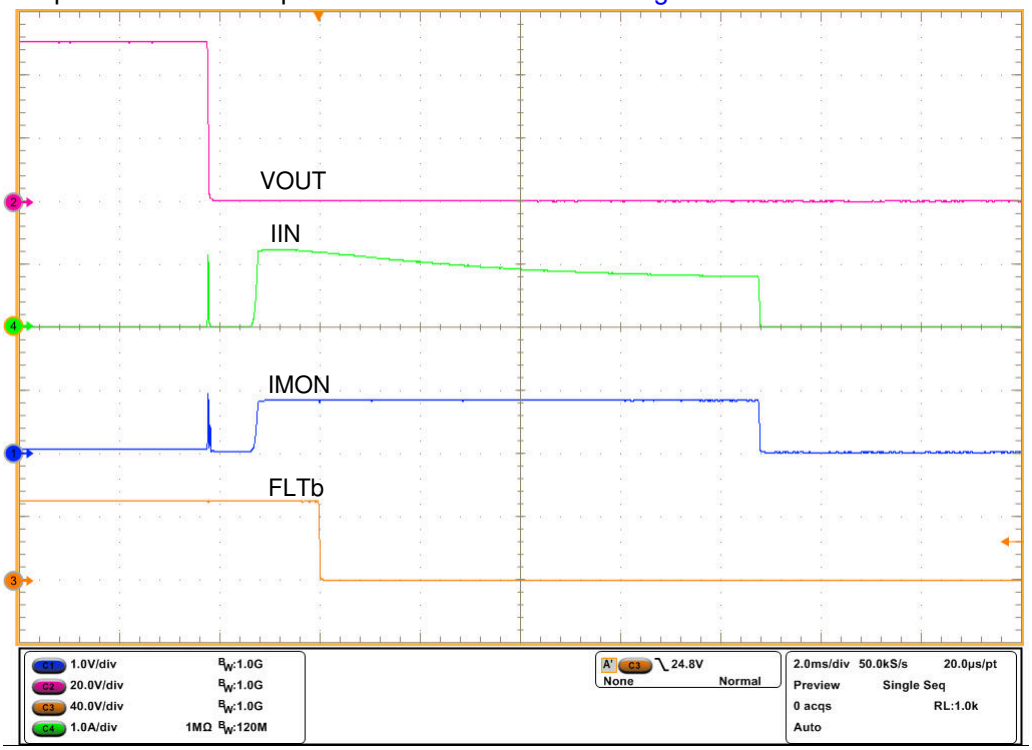

Figure 3-3. Output Short-Circuit Protection

3.4.5 Start-Up With Short-Circuit On Output

Use the following instructions to perform startup into short test.

1. Set the current limit to 4.5 A by installing the J4/J11 jumper in position 1-2.
2. Set the input power supply voltage to 58 V and current limit of 9 A. Turn OFF the power supply.
3. Short the output of the device (for example, VOUT to GND with a shorter cable).
4. Turn ON the power supply.
5. Verify the device behavior for startup into short as shown in Figure 3-4.

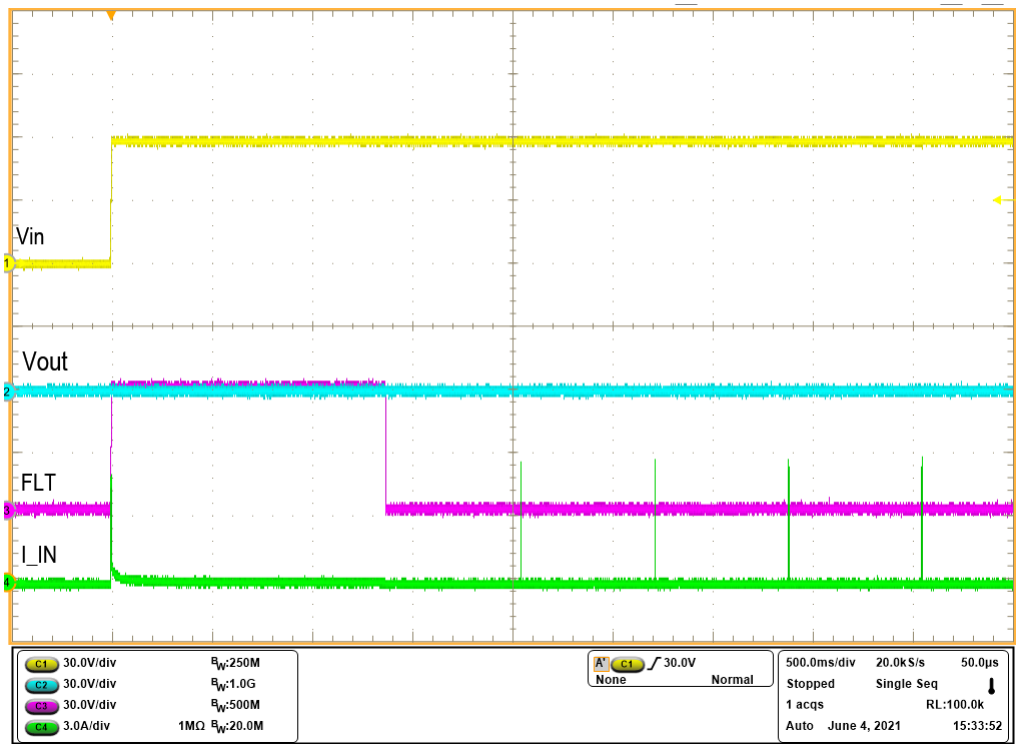

Figure 3-4. Start-Up With Short on Output

4 EVM Board Assembly Drawings and Layout

4.1 PCB Drawings

Figure 4-1 through Figure 4-3 show component placement and layout of the EVM.

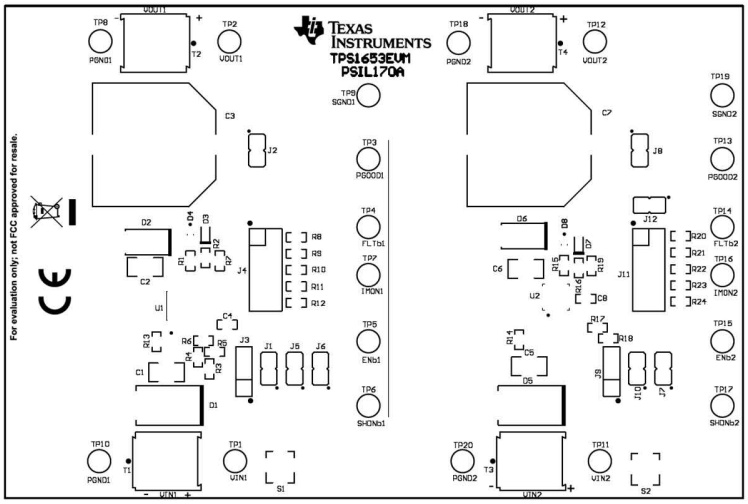

Figure 4-1. Top Side Placement

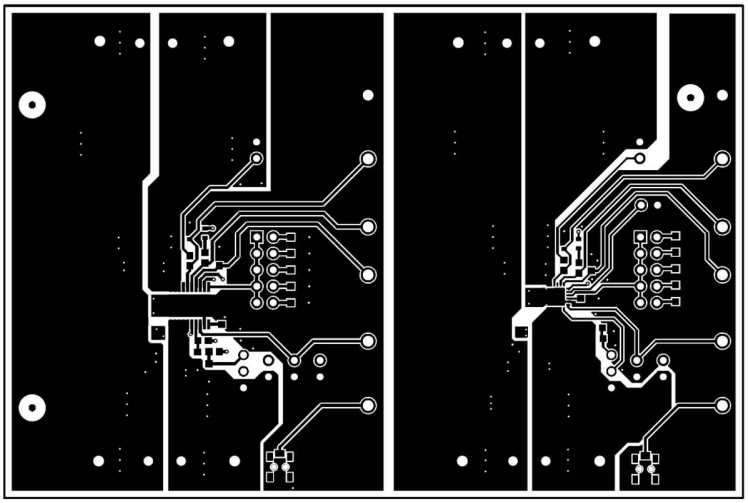

Figure 4-2. Top Layer

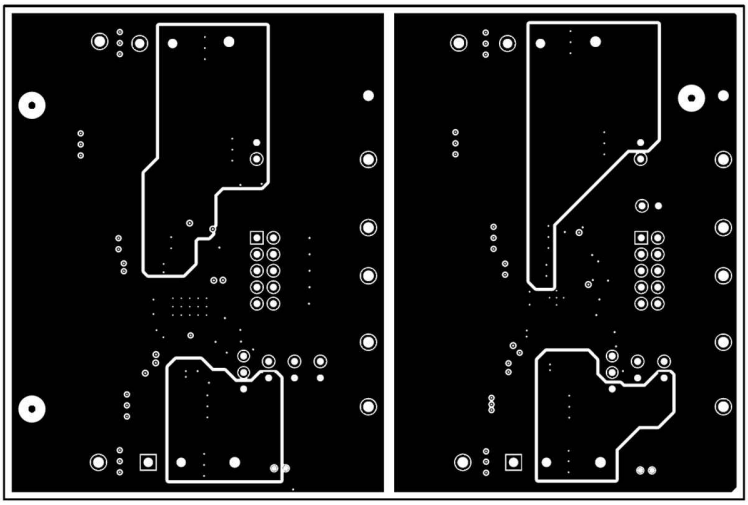

Figure 4-3. Bottom Layer

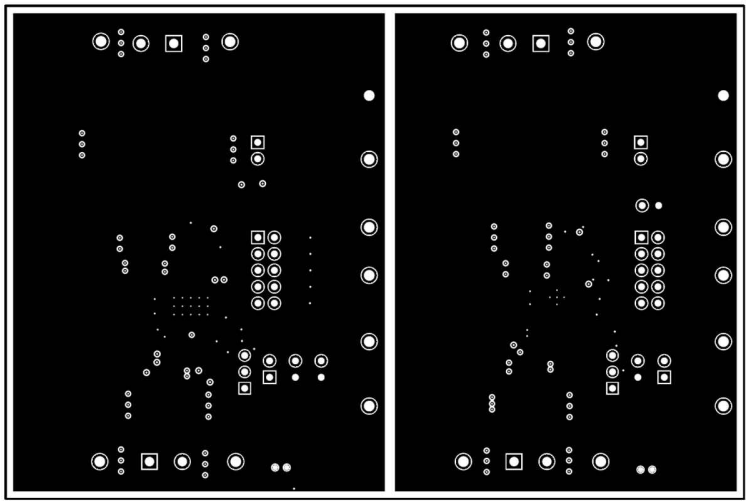

Figure 4-4. Inner Ground Layer

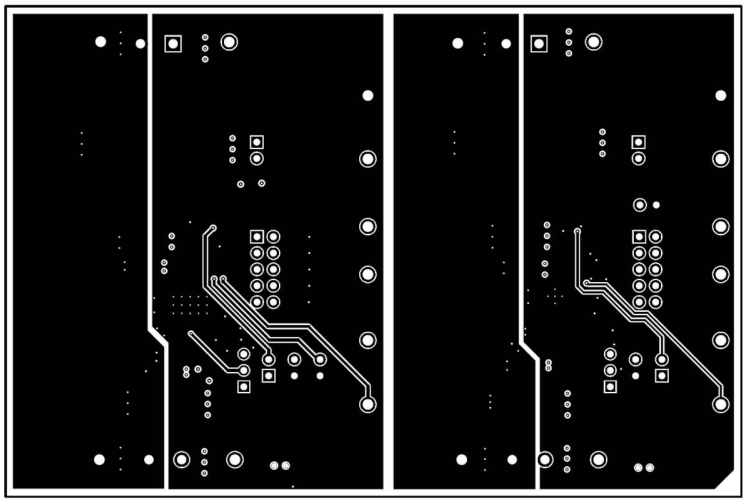

Figure 4-5. Inner Routing Layer

5 Schematics

Figure 5-1 illustrates the TPS1653EVM schematic.

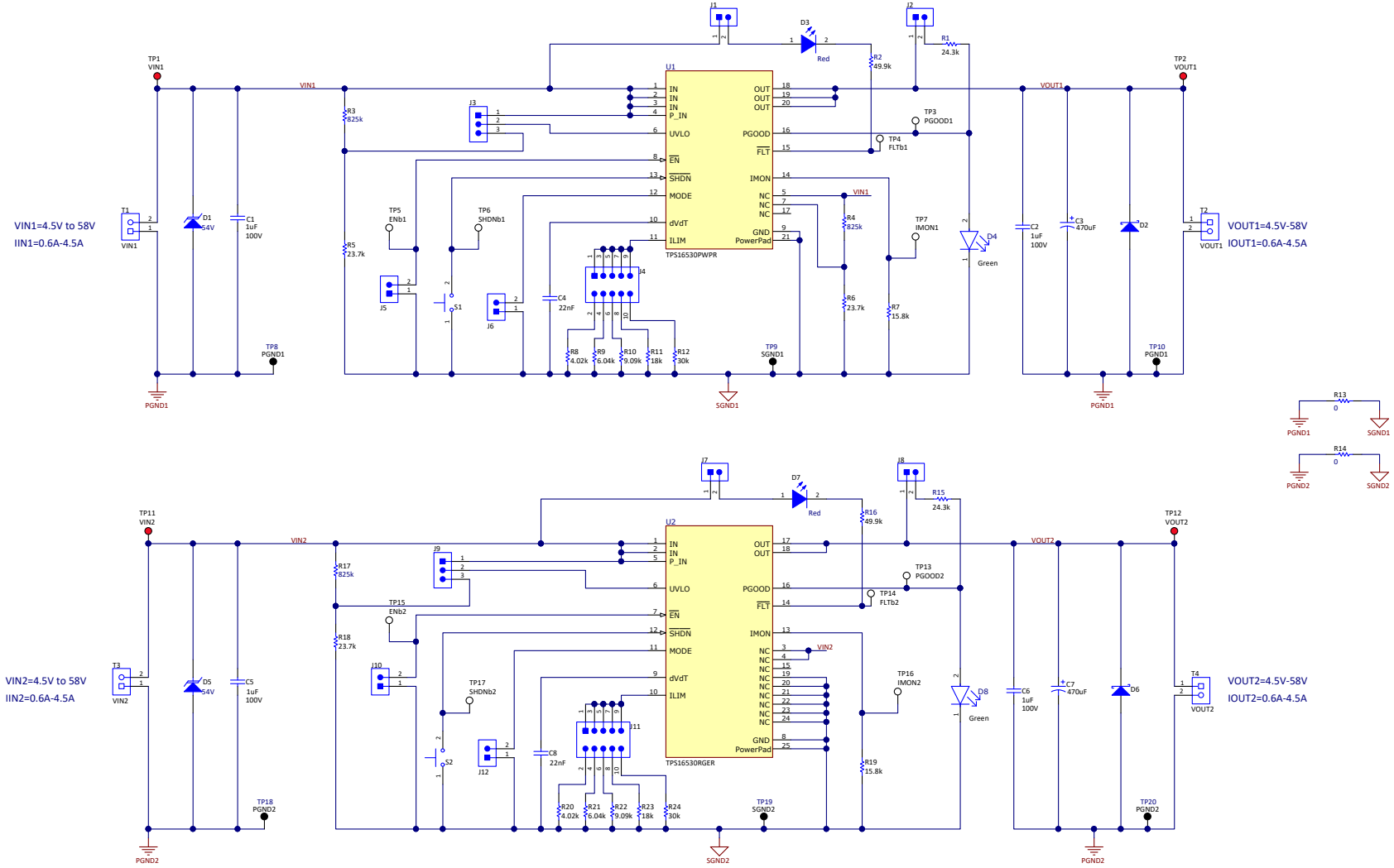

Figure 5-1. TPS1653EVM Schematic

6 Bill of Materials

Table 6-1 lists the TPS1653EVM BOM.

Table 6-1. TPS1653EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PSIL170	Any
C1, C2, C5, C6	4	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
C3, C7	2	470uF	CAP, AL, 470 uF, 80 V, +/- 20%, 0.153 ohm, AEC-Q200 Grade 2, SMD	SMT Radial K16	EEV-FK1K471M	Panasonic
C4, C8	2	0.022uF	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet
D1, D5	2	54V	Diode, TVS, Uni, 54 V, SMC	SMC	SMCJ54A	Fairchild Semiconductor
D2, D6	2	70V	Diode, Schottky, 70 V, 2 A, SMB	SMB	B270-13-F	Diodes Inc.
D3, D7	2	Red	LED, Red, SMD	1.6x0.8mm	TLMS1000-GS08	Vishay-Semiconductor
D4, D8	2		Green 570nm LED Indication - Discrete 2.1V 0603 (1608 Metric)	0603	TLMG1100-GS08	Vishay
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J2, J5, J6, J7, J8, J10, J12	8		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J3, J9	2		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
J4, J11	2		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100mil, Tin	PEC05DAAN	Sullins Connector Solutions
R1, R15	2	24.3k	RES, 24.3 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060324K3FKEA	Vishay-Dale
R2, R16	2	49.9k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
R3, R4, R17	3	825k	RES, 825 k, 1%, 0.1 W, 0603	0603	RC0603FR-07825KL	Yageo

Table 6-1. TPS1653EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R5, R6, R18	3	23.7k	RES, 23.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060323K7FKEA	Vishay-Dale
R7, R19	2	15.8k	RES, 15.8 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060315K8FKEA	Vishay-Dale
R8, R20	2	4.02k	RES, 4.02 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K02FKEA	Vishay-Dale
R9, R21	2	6.04k	RES, 6.04 k, 1%, 0.1 W, 0603	0603	RC0603FR-076K04L	Yageo
R10, R22	2	9.09k	RES, 9.09 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K09FKEA	Vishay-Dale
R11, R23	2	18k	RES, 18 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060318K0JNEA	Vishay-Dale
R12, R24	2	30k	RES, 30 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060330K0JNEA	Vishay-Dale
R13, R14	2	0	RES, 0, 5%, 0.1 W, 0603	0603	ERJ-3GEY0R00V	Panasonic
S1, S2	2		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12	12	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
T1, T2, T3, T4	4		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity
TP1, TP2, TP11, TP12	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3, TP4, TP5, TP6, TP7, TP13, TP14, TP15, TP16, TP17	10		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
TP8, TP9, TP10, TP18, TP19, TP20	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone

Table 6-1. TPS1653EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U1	1		58-V, 4.5-A eFuse with Pulse Current Support for Load Transients, HTSSOP20	TSSOP20	TPS16530PWPR	Texas Instruments
U2	1		58-V, 4.5-A eFuse with Pulse Current Support for Load Transients, VQFN24	VQFN24	TPS16530RGER	Texas Instruments
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A

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