

**ABSTRACT**

This user's guide describes the evaluation module (EVM) for the Texas instruments TPS2640 devices. The document provides configuration information and test setup details for working with the EVM. The EVM schematic, board layout, and bill of materials (BOM) are also included.

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1 Introduction

The TPS2640EVM allows reference circuit evaluation of TI's TPS2640 devices. The TPS2640 are compact 4.2-V to 42-V, 2.23-A industrial eFuses with integrated back-to-back FETs, programmable undervoltage, overvoltage, reverse-polarity, overcurrent, inrush current protection, and output current monitoring features.

1.1 EVM Features

The TPS2640EVM features include:

- 4.2-V to 42-V input operating voltage range
- 0.2-A to 2.23-A jumper-programmable current limit
- Reverse polarity protection up to -42 V
- Programmable input UVLO
- Selectable overload fault response (auto-retry, latch and circuit breaker)
- Programmable input overvoltage protection (OVP) cut off
- Programmable V_{OUT} slew rate control
- Load current monitor output with 1.5 V / A
- Optional onboard transient protection devices like input TVS and output Schottky diodes
- Onboard reset switch and fault indicators

1.2 EVM Applications

- HMI power protection in factory automation
- Fire safety systems
- Electronic thermostats and video doorbells
- Industrial PCs

2 Description

The TPS2640EVM enables full evaluation of the TPS2640 devices. The EVM supports HTSOP and QFN versions of the devices on two channels (CH1 and CH2, respectively). Input power is applied at T1 (CH1) and T3 (CH2) while T2 (CH1) and T4 (CH2) provide an output connection to the load. See the schematic in [Figure 3-1](#) and the test setup in [Figure 4-1](#).

S1 and S2 allow U1 and U2 to RESET. A fault (FLTb) indicator is provided by D1 and D7 for CH1 and CH2, respectively. Scaled current for each channel can be monitored at TP5 and TP14 with a scaling factor of 1.5 V / A.

Table 2-1. TPS2640EVM Options and Setting

Part Number	EVM Function	V _{IN} Range	VIN UVLO	VINOVP	Current Limit		Output Overvoltage	Selectable Fault Response
			CH1 and CH2	CH1 and CH2	Minimum Setting	Maximum Setting		
TPS2640EVM	4.2-V to 42-V, 2.23-A Industrial eFuse	4.2 V–42 V	18.5 V	34.8V	0.2 A ⁽¹⁾	2.23 A	38 V	Auto retry Latch off Circuit Breaker

- (1) Minimum programmable current limit can be changed to 0.1 A by changing the R12 and R24 values to 120 kΩ on CH1 and CH2, respectively.

3 Schematics

Figure 3-1 illustrates the EVM schematic.

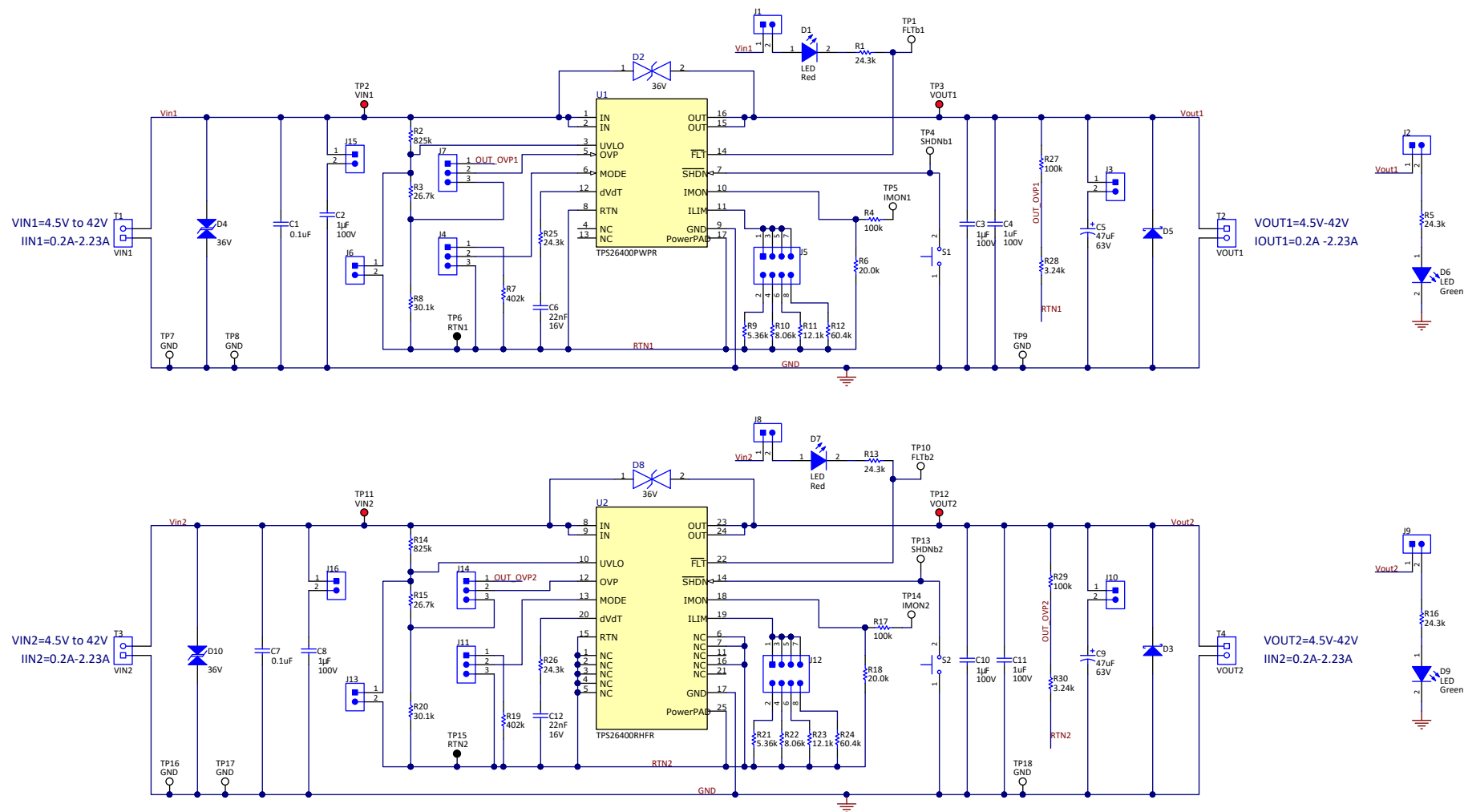


Figure 3-1. TPS2640EVM Schematic

4 General Configurations

4.1 Physical Access

Table 4-1 lists the TPS2640EVM input and output connector functionality, Table 4-2 describes the test point availability, and Table 4-3 describes the jumper functionality.

Table 4-1. 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 4-2. Test Points Description

Channel	Test Points	Label	Description
CH1	TP1	FLTb1	CH1 fault indicator
	TP2	VIN1	CH1 power supply input
	TP3	VOUT1	CH1 output voltage
	TP4	SHDNb1	CH1 shutdown input
	TP5	IMON1	CH1 output current monitor
	TP7, TP8, TP9	GND	GND
CH2	TP10	FLTb2	CH2 fault indicator
	TP11	VIN2	CH2 power supply input
	TP12	VOUT2	CH2 output voltage
	TP13	SHDNb2	CH2 shutdown input
	TP14	IMON2	CH2 output current monitor
	TP16, TP17, TP18	GND	GND

Table 4-3. Jumper and LED Descriptions

Jumper	Label	Description
J1	J1	CH1 fault LED pulled to VIN1, if installed
J2	J2	CH1 output power indicator LED pulled to VOUT1, if installed
J3	J3	CH1 bulk output capacitor connects to VOUT1, if installed
J4	MODE	CH1 MODE selection 1-2 position sets latch-off mode 2-3 position sets auto-retry mode Open position sets circuit breaker with auto-retry mode
J5	ILIM	CH1 current limit setting 1-2 position sets 2.23 A 3-4 position sets 1.5 A 5-6 position sets 1 A 7-8 position sets 0.2 A
J6	UVLO	CH1 UVLO setting Sets internal UVLO (15 V), if installed
J7	OVP	CH1 OVP setting 1-2 position sets Vout OVP (38 V) and 2-3 sets VIN OVP at 34.8 V
J8	J8	CH2 fault LED pulled to VIN2, if installed
J9	J9	CH2 output power indicator LED pulled to VOUT2, if installed
J10	J10	CH2 bulk output capacitor connects to VOUT1, if installed
J11	MODE	CH2 MODE selection 1-2 position sets latch-off mode 2-3 position sets auto-retry mode Open position sets circuit breaker with auto-retry mode

Table 4-3. Jumper and LED Descriptions (continued)

Jumper	Label	Description
J12	ILIM	CH2 current limit setting 1-2 position sets 2.23 A 3-4 position sets 1.5 A 5-6 position sets 1 A 7-8 position sets 0.2 A
J13	UVLO	CH2 UVLO setting Sets internal UVLO (15 V), if installed
J14	OVP	CH2 OVP setting 1-2 position sets Vout OVP (38 V) and 2-3 sets Vin OVP at 34.8 V
J15	J15	CH1 input capacitor connects to VIN1, if installed
J16	J16	CH1 input capacitor connects to VIN2, if installed
D1, 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, overvoltage, overload, short circuit, reverse current, and thermal shutdown.
D6, D9 (GREEN-LED)	Output power indicator	CH1, CH2 output power indicators, respectively. LED turns on whenever the output voltage is available.

4.2 Test Equipment

4.2.1 Power Supplies

One adjustable power supply: 0-V to 42-V output, 0-A to 3-A output current limit.

4.2.2 Meters

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

4.2.3 Oscilloscope

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

4.2.4 Loads

One resistive load which can tolerate up to 3-A DC load at 24 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.

4.3 Test Setup

Figure 4-1 shows the typical test setup for the TPS2640EVM. Connect T1/T3 to the power supply and T2/T4 to the load.

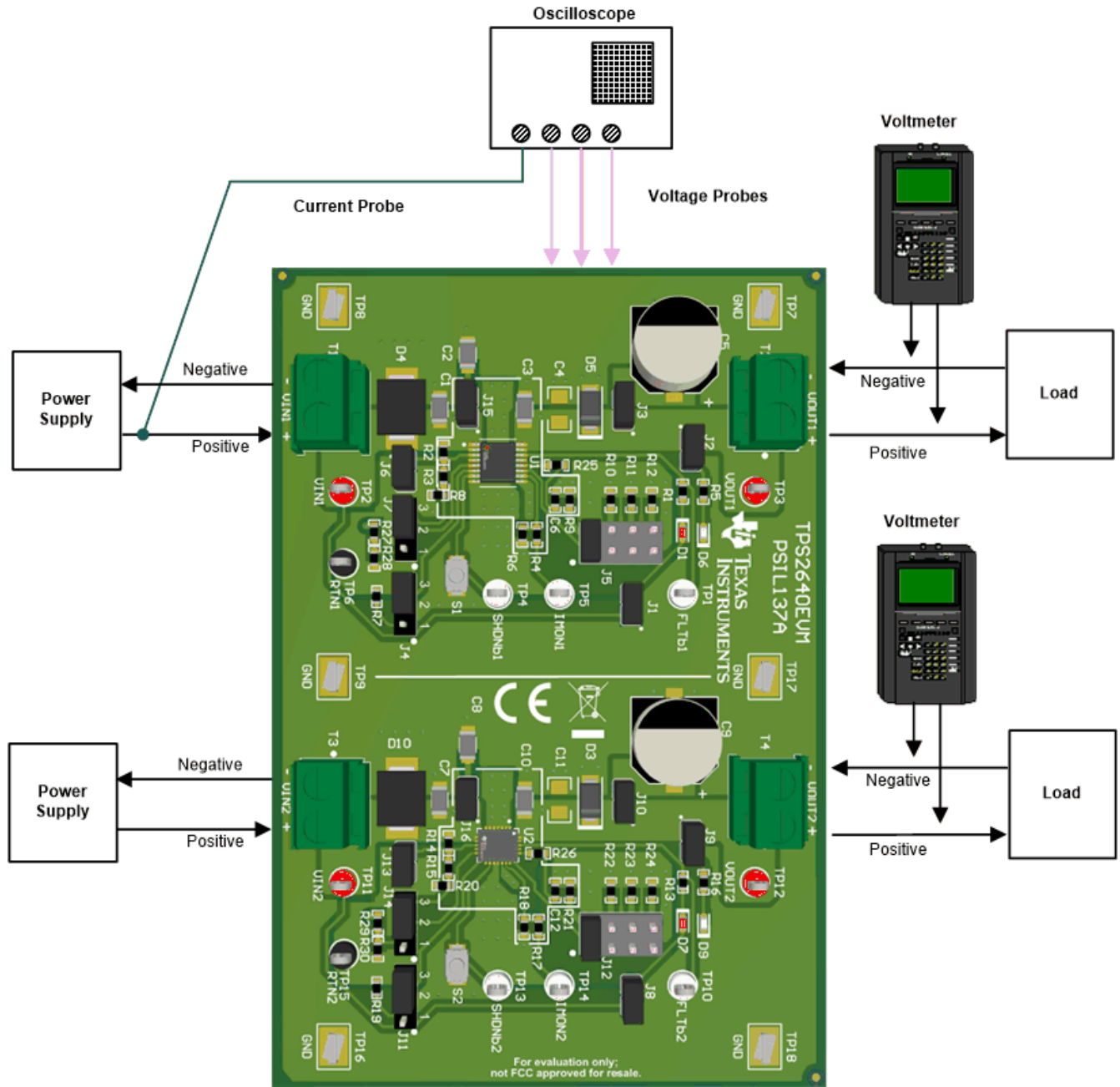


Figure 4-1. EVM Test Setup

4.4 Test Procedure

Note

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

4.4.1 Preliminary Tests

1. Turn on the power supply and set the output voltage and the current limit according to [Table 4-4](#).

Table 4-4. Power Supply Setting for the TPS2640EVM

EVM	Channel	Voltage Set Point	Power Supply Current Limit
TPS2640EVM	CH1	24 V	3 A
	CH2	24 V	3 A

2. Turn on the load and set the load resistance to $16 \Omega \pm 1 \Omega$.
3. Disable the power supply, load and hook up the TPS2640EVM assembly as shown in [Figure 4-1](#).
4. Make sure the default evaluation board jumper settings are as shown in [Table 4-5](#).

Table 4-5. Default Jumper Setting for the TPS2640EVM

	J1	J2	J3	J4	J5	J6	J7	J15
CH1	Install	Install	Open	2-3	1-2	Open	2-3	Install
	J8	J9	J10	J11	J12	J13	J14	J16
CH2	Install	Install	Open	2-3	1-2	Open	2-3	Install

5. Enable the power supply and the load.
6. Connect the negative probe of the DMM to TP7 or TP18 test points, the positive probe to the respective test points, and verify that the voltages shown in [Table 4-6](#) are obtained.

Table 4-6. TPS2640EVM DMM Readings at Different Test Points

Voltage Test on (CH1)	Measured Voltage Reading	Voltage Test on (CH2)	Measured Voltage Reading
VIN1 (TP2)	24 V \pm 1 V DC	VIN2 (TP11)	24 V \pm 1 V DC
VOUT1 (TP3)	24 V \pm 1 V DC	VOUT2 (TP12)	24 V \pm 1 V DC
IMON1 (TP5)	2.3 V \pm 0.2 V DC	IMON2 (TP14)	2.3 V \pm 0.2 V DC
FLTb1 (TP1)	22.6 V \pm 0.5 V DC	FLTb2 (TP10)	22.6 V \pm 0.5 V DC
SHDNb1 (TP4)	2.7 V \pm 0.5 V DC	SHDNb2 (TP13)	2.7 V \pm 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 24 V \pm 1 V.
8. Disable the power supply and the load.

4.4.2 Output Voltage Start-Up Time Test

Follow the instructions to verify the individual channels output voltage start-up time:

1. Set up the oscilloscope as listed in [Table 4-7](#).
2. Set the load resistance to $16\ \Omega \pm 1\ \Omega$ and the power supply voltage to 24 V.
3. Enable the load.
4. Enable the power supply and verify that the output voltage startup waveform is as shown in [Figure 4-2](#).

Table 4-7. TPS2640EVM Oscilloscope Setting for the Output Voltage Start-Up Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10 V / div	VOUT1 (TP3)	VOUT2 (TP12)
Channel 2 = 10 V / div	VIN1 (TP2)	VIN2 (TP11)
Channel 3 = 20 V / div	FLTb1 (TP1)	FLTb2 (TP10)
Channel 4 = 1 A / div	Input current into T1 +Ve wire	Input current into T3 +Ve wire
Trigger source = Channel 1		
Trigger level = 12 V \pm 1 V		
Trigger polarity = Rising		
Trigger mode = Single		
Time base	2 ms / div	

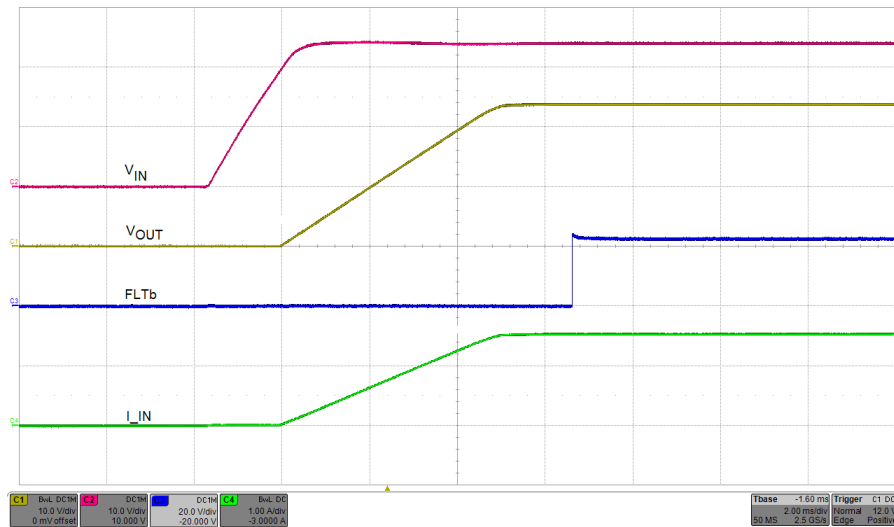


Figure 4-2. Output Voltage Start-Up Waveform

4.4.3 Current Limit and Fault Responses Test

Follow the instructions to verify the current limit and various fault response modes like auto-retry, latch and circuit breaker with auto-retry:

1. Set up the oscilloscope as listed in [Table 4-8](#).

Table 4-8. TPS2640EVM Oscilloscope Setting for the Current Limit Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10V / div	VOUT1 (TP3)	VOUT2 (TP12)
Channel 2 = 10V / div	VIN1 (TP2)	VIN2 (TP11)
Channel 4 = 2 A / div	Input current into T1 +Ve wire	Input current into T3 +Ve wire
Trigger source = Channel 2		
Trigger level = 12 V \pm 1V		
Trigger polarity = Rising		
Trigger mode = Single		
Time base	100 ms / div	

Note

Measuring the current limit value on the oscilloscope can easily cause \pm 10% error from the typical expected values as listed in [Table 4-9](#).

2. Set the current limit to 2.23 A by installing the J5/J12 jumper in position 1-2.
3. The jumper setting for different current limits is shown in [Table 4-9](#).
4. Set the current limit response to auto-retry by installing the J4/J11 jumper in position 2-3.

Table 4-9. TPS2640EVM Jumper Setting for Current Limits

CH1, CH2 Jumper Positions (J5, J12)	Load Current Limit (A)
1-2	2.23
3-4	1.5
5-6	1
7-8	0.2

5. Set the load resistance to $6 \Omega \pm 1 \Omega$ and the power supply voltage to 24 V.
6. Enable the load.

7. Enable the power supply and verify the current limit magnitude and auto-retry fault response waveform as shown in Figure 4-3.

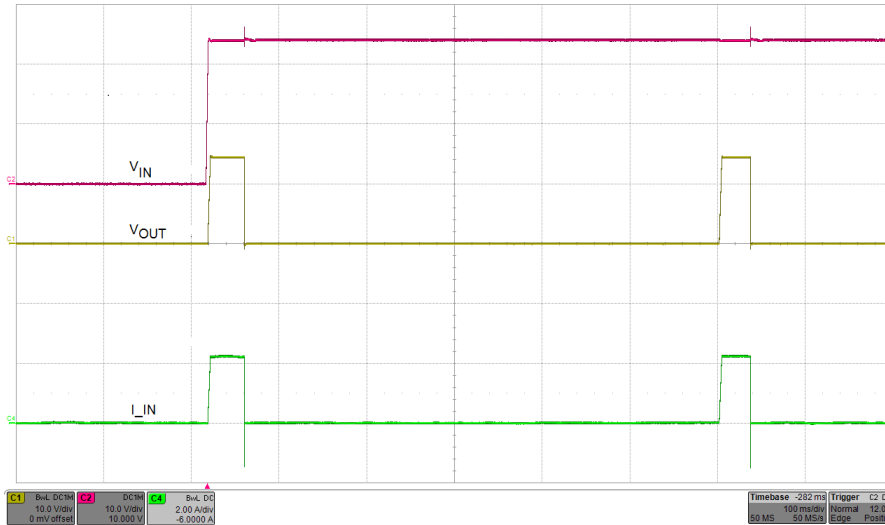


Figure 4-3. J5/J12 = 2-3 Position, Current Limit (2.23 A), Auto-Retry Mode

8. Disable the power supply.
9. Set the current limit response mode to latch-off by installing the J4/J11 jumper in the position 1-2.
10. Set the load resistance to $6 \Omega \pm 1 \Omega$ and enable the load.
11. Enable the power supply and verify the current limit magnitude the latch-off fault response waveform as shown in the Figure 4-4.

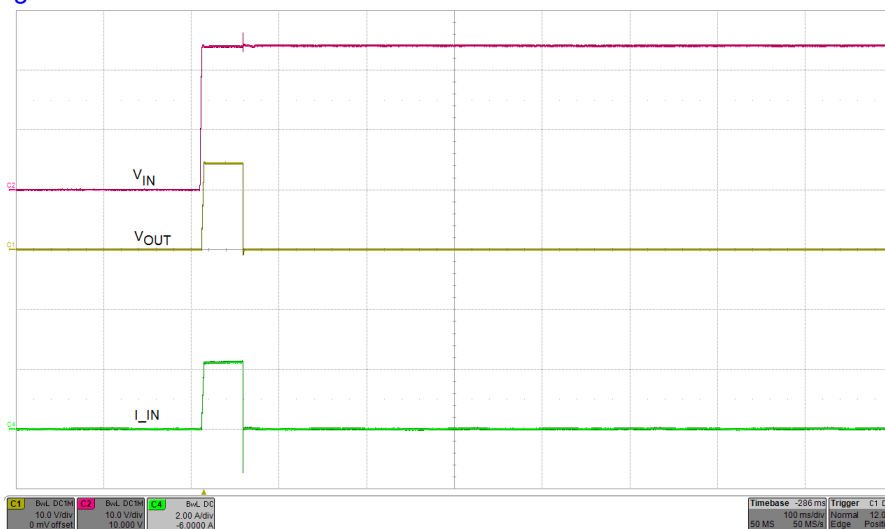


Figure 4-4. J5/J12 = 1-2 Position, Current Limit (2.23 A), Latch-Off Mode

12. Once the device is latched-off, either the power supply or the SHDNb should be recycled to re-enable it.
13. Change the load resistance to $16 \Omega \pm 1 \Omega$.

- Press and release the reset switch (S1/S2) to re-enable the device from latch-off mode and verify the recovery or restart waveform as shown in [Figure 4-5](#).

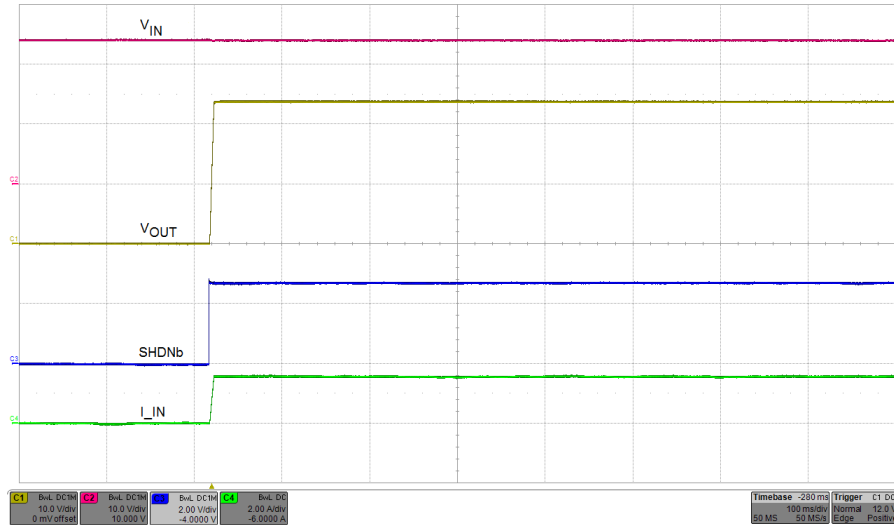


Figure 4-5. Restart From Latch-Off Mode

- Disable the power supply.
- Set the current limit response mode to circuit breaker with auto-retry by uninstalling the J4/J11 jumper.
- Set the load resistance to $6\ \Omega \pm 1\ \Omega$ and enable the load.
- Enable the power supply and verify the circuit breaker with auto retry fault response waveform as shown in [Figure 4-6](#).

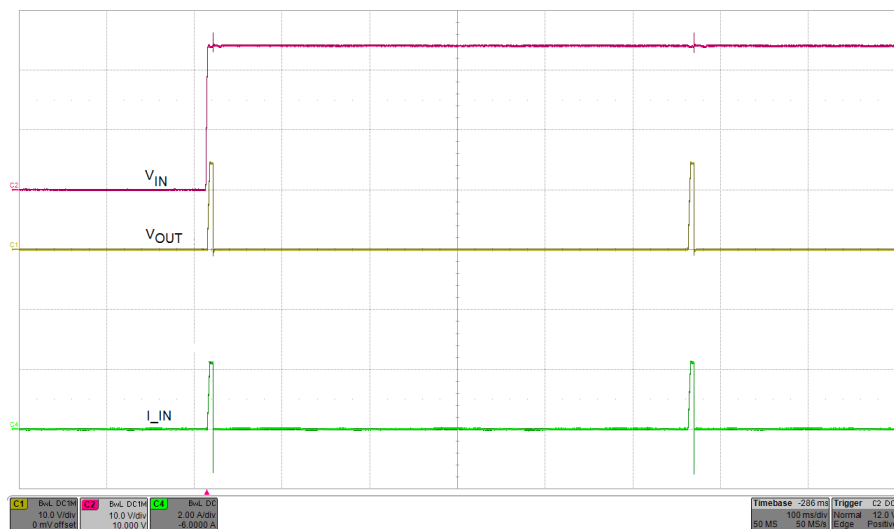


Figure 4-6. J5/J12 = Floating, Current Limit (2.23 A), Circuit Breaker With Auto-Retry Mode

4.4.4 Output Short-Circuit Protection Test

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

1. Set up the oscilloscope as listed in [Table 4-10](#).

Table 4-10. TPS2640EVM Output Short-Circuit Protection Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10 V / div	VOUT1 (TP3)	VOUT2 (TP12)
Channel 2 = 10 V / div	VIN1 (TP2)	VIN2 (TP11)
Channel 3 = 20 V / div	FLTb1 (TP1)	FLTb2 (TP10)
Channel 4 = 2 A / div	Input current into T1 +Ve wire	Input current into T3 +Ve wire
Trigger source = Channel 1		
Trigger level = 12 V \pm 1 V		
Trigger polarity = Falling		
Trigger mode = Single		
Time base	2 ms / div	

2. Set the load resistance to 16 Ω \pm 1 Ω and the power supply voltage to 24 V.
3. Enable the load and the power supply.
4. Use either wire or FET to short the output to ground and verify the output short-circuit response waveform as shown in [Figure 4-7](#).

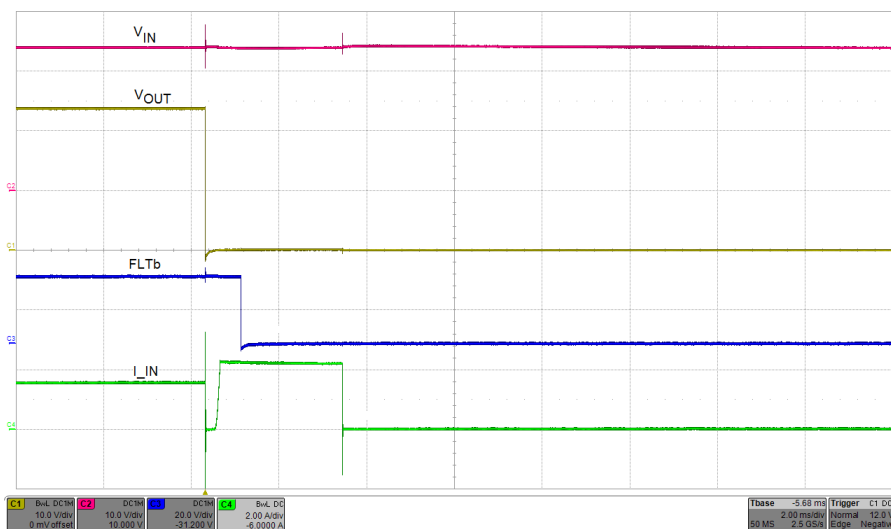


Figure 4-7. Output Short-Circuit Protection

4.4.5 Reverse Polarity Test

Follow the instructions to verify the reverse polarity protection feature of the device:

1. Set up the oscilloscope as listed in [Table 4-11](#).

Table 4-11. TPS2640EVM Reverse Polarity Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10 V / div	VOUT1 (TP3)	VOUT2 (TP12)
Channel 2 = 10 V / div	VIN1 (TP2)	VIN2 (TP11)
Trigger source = Channel 1		
Trigger level = $-12\text{ V} \pm 1\text{ V}$		
Trigger polarity = Falling		
Trigger mode = Single		
Time base	10 ms / div	

2. Set the power supply voltage to 42 V and disable the power supply.
3. Connect +ve terminal of the power supply to either T1/T3 –ve terminal, connect –ve terminal of the power supply to either T1/T3 +ve terminal.
4. Enable the power supply and verify the reverse polarity protection waveform as shown in [Figure 4-8](#).

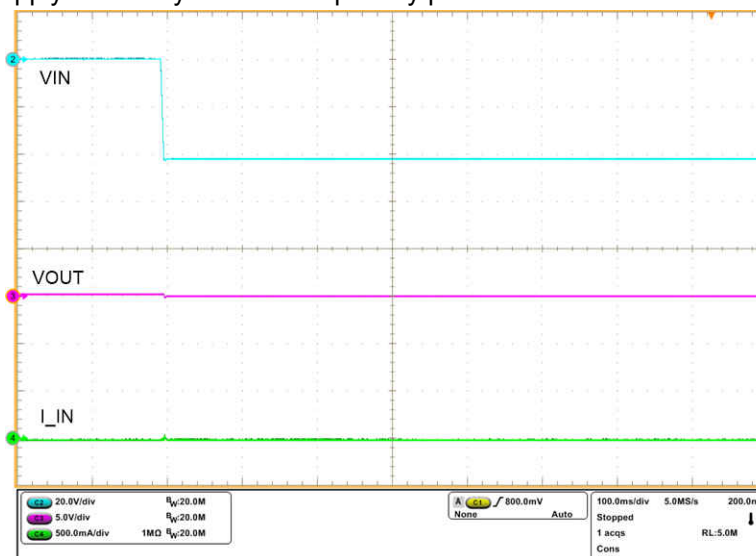


Figure 4-8. Reverse Polarity Protection

4.4.5.1 Overvoltage Clamp Response

Follow the instructions to verify the Overvoltage clamp response of the device:

1. Set J7 in 1-2 position
2. Set the power supply to 28 V and load of 1 A at the output.
3. Now apply transient input voltage (28 V to 40 V) for 20 ms and verify the Overvoltage clamp response as Figure 4-9 shows.

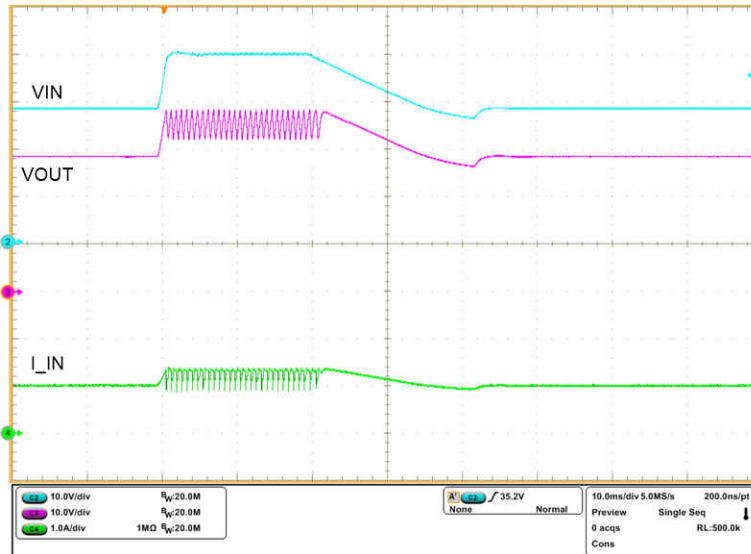


Figure 4-9. Overvoltage Clamp Response

5 EVM Board Assembly Drawings and Layout Guidelines

5.1 PCB Drawings

Figure 5-1 through Figure 5-3 show component placement and layout of the EVM.

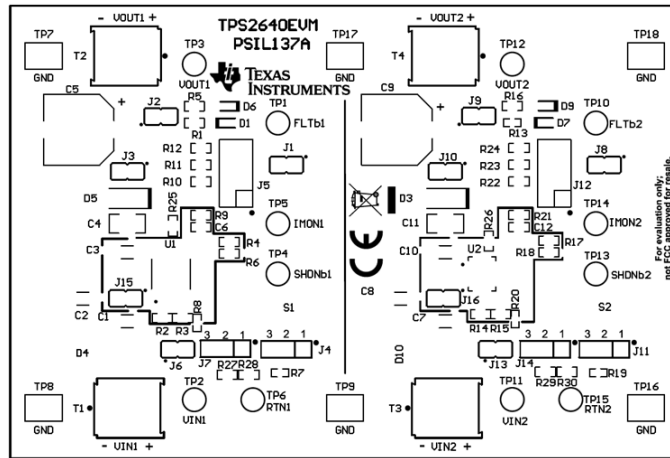


Figure 5-1. Top Side Placement

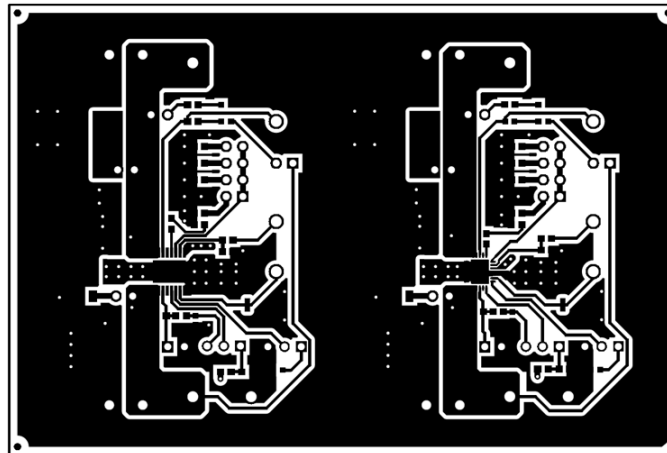


Figure 5-2. Top Layer

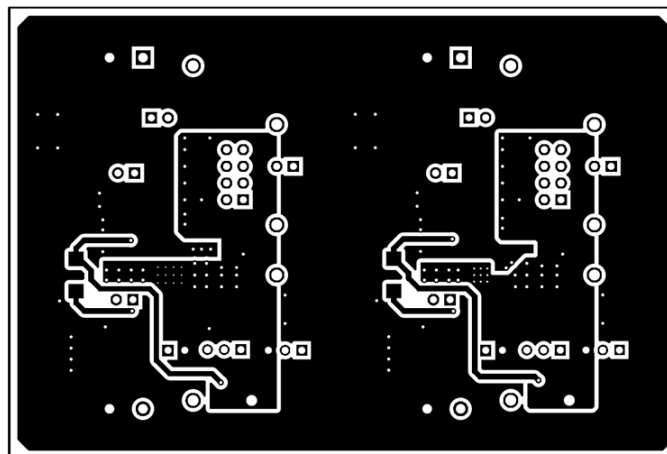


Figure 5-3. Bottom Layer

6 Bill Of Materials (BOM)

Table 6-1 displays the EVM BOM.

Table 6-1. TPS2640EVM Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number ⁽¹⁾	Alternate Manufacturer ⁽¹⁾
!PCB1	1		Printed Circuit Board		PSIL137	Any		
C1, C7	2	0.1uF	CAP, CERM, 0.1 uF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L2X7R2A104K160AA	TDK		
C2, C3, C8, C10	4	1uF	CAP, CERM, 1 µF, 100 V, ±10%, X7R, 1206	1206	CC1206KKX7R0BB105	Yageo America		
C5, C9	2	47uF	CAP, AL, 47 uF, 63 V, ±20%, SMD	SMT Radial G	EEETG1J470P	Panasonic		
C6, C12	2	0.022uF	CAP, CERM, 0.022 uF, 16 V, ±10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet		
D1, D7	2	Red	LED, Red, SMD	Red LED, 1.6x0.8x0.8mm	LTST-C190CKT	Lite-On		
D2, D8	2		Diode TVS Single Bi-Dir 36V 600W 2-Pin SMB	DO-214AA	SMBJ36CA	Littelfuse		
D3, D5	2	50V	Diode, Schottky, 50 V, 2 A, SMA	SMA	B250A-13-F	Diodes Inc.		
D4, D10	2	36V	Diode, TVS, Bi, 36 V, 58.1 Vc, SMC	SMC	SMCJ36CA	Littelfuse		
D6, D9	2	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On		
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M		
J1, J2, J3, J6, J8, J9, J10, J13, J15, J16	10		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
J4, J7, J11, J14	4		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions		
J5, J12	2		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions		
R1, R5, R13, R16, R25, R26	6	24.3k	RES, 24.3 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060324K3FKEA	Vishay-Dale		
R2, R14	2	825k	RES, 825 k, 1%, 0.1 W, 0603	0603	RC0603FR-07825KL	Yageo		
R3, R15	2	26.7k	RES, 26.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060326K7FKEA	Vishay-Dale		
R4, R17	2	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R6, R18	2	20.0k	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060320K0FKEA	Vishay-Dale		
R7, R19	2	402k	RES, 402 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603402KFKEA	Vishay-Dale		
R8, R20	2	30.1k	RES, 30.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060330K1FKEA	Vishay-Dale		
R9, R21	2	5.36k	RES, 5.36 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K36FKEA	Vishay-Dale		
R10, R22	2	8.06k	RES, 8.06 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06038K06FKEA	Vishay-Dale		

Table 6-1. TPS2640EVM Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number ⁽¹⁾	Alternate Manufacturer ⁽¹⁾
R11, R23	2	12.1k	RES, 12.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060312K1FKEA	Vishay-Dale		
R12, R24	2	60.4k	RES, 60.4 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060360K4FKEA	Vishay-Dale		
R27, R29	2	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo		
R28, R30	2	3.24k	RES, 3.24 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K24L	Yageo		
S1, S2	2		Switch, SPST-NO, 0.05 A, 12 VDC, SMT	3.9x2.9mm	SKRKAEE020	Alps		
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16	16	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, TP4, TP5, TP10, TP13, TP14	6	White	Test Point, TH, Multipurpose, White	Keystone5012	5012	Keystone	Equivalent	Any
TP2, TP3, TP11, TP12	4	Red	Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone		
TP6, TP15	2	Black	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone		
TP7, TP8, TP9, TP16, TP17, TP18	6	SMT	Test Point, SMT, Compact	Testpoint_Keystone_Compact	5016	Keystone	Equivalent	Any
U1	1		42-V, 2-A Industrial eFuse With Integrated Reverse Input Polarity Protection	HTSSOP16	TPS26400PWPR	Texas Instruments		
U2	1		42-V, 2-A Industrial eFuse With Integrated Reverse Input Polarity Protection	VQFN24	TPS26400RHFR	Texas Instruments		
C4, C11	0	1uF	CAP, CERM, 1 uF, 100 V, ±10%, X7R, 1206	1206	GRM31CR72A105KA01L	MuRata		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		

(1) Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

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