

TPS2663-166EVM: Evaluation Module for TPS2663xPWP and TPS1663xPWP

This user's guide describes the evaluation module (EVM) for the Texas instruments TPS2663x and TPS1663x eFuse in PWP packages. The document provides EVM configuration information and test setup details for evaluating the TPS26633 and TPS16630 devices. The EVM schematic, board layout, and bill of materials (BOM) are also included.

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1 Introduction

The TPS2663-166EVM allows reference circuit evaluation of TI's TPS26633 and TPS16630 eFuses. The TPS26633 device is a 4.5 V to 60 V, 6 A eFuse with overvoltage, undervoltage, short-circuit, and reverse current blocking protection, whereas the TPS16630 device is 4.5 V to 60 V, 6 A eFuse with overvoltage, undervoltage, and short-circuit protection.

1.1 EVM Features

TPS2663-166EVM features include:

- 4.5-V to 60-V operating voltage (without TVS on Input)
- 4.5 V to 33 V (For CH1 (TPS26633) with 33-V TVS on input for transient protection)
- 0.6-A to 6-A programmable current limit using onboard jumpers
- Adjustable output power limiting (For CH1 with the TPS26633 device)
- Adjustable inrush current for large capacitive loads
- Auto-retry or Latch Off MODE configuration using onboard jumpers
- Overvoltage and UVLO configuration using onboard jumpers
- LED status indication for $\overline{\text{FLT}}$ output and V_{OUT}

1.2 EVM Applications

- Factory automation and control
- Motor drives
- Active antenna Systems and Remote Radio Units.
- Industrial printers
- Electronic circuit breakers

2 Description

The TPS2663-166EVM enables evaluation of the TPS26633 and TPS16630 eFuses. This EVM has two channels: CH1 and CH2. CH1 is used with the TPS26633 device, whereas CH2 is used with the TPS16630 device. [Table 1](#) provides the operating range and jumper settings for this EVM. To test this EVM, setup the EVM as per the steps provided in [Section 5.5](#). Test procedure and results for this EVM are provided in [Section 6](#). To configure the EVM for another configuration (non-default), see [Table 4](#). To probe different signals on this EVM, see [Table 3](#). [Section 5](#) lists the equipment required to test this EVM. To connect a power supply and load to this EVM, see [Section 4.1](#).

Table 1. TPS2663-166EVM Operating Range and Jumper Settings

Part Number	EVM Function	V_{IN} Range (T1, T3)	I_{LIM} Pin Configuration (J4, J9)	MODE Configuration (J5, J10)
TPS2663-166EVM	4.5 V to 60 V, 6 A eFuse	• 4.5 V to 60 V • 4.5 V to 33 V (On CH1 with 33-V TVS)	0.6 A to 6 A	• Latch Off • Auto retry

3 Schematic

Figure 1 shows the schematic for the TPS2663-166EVM.

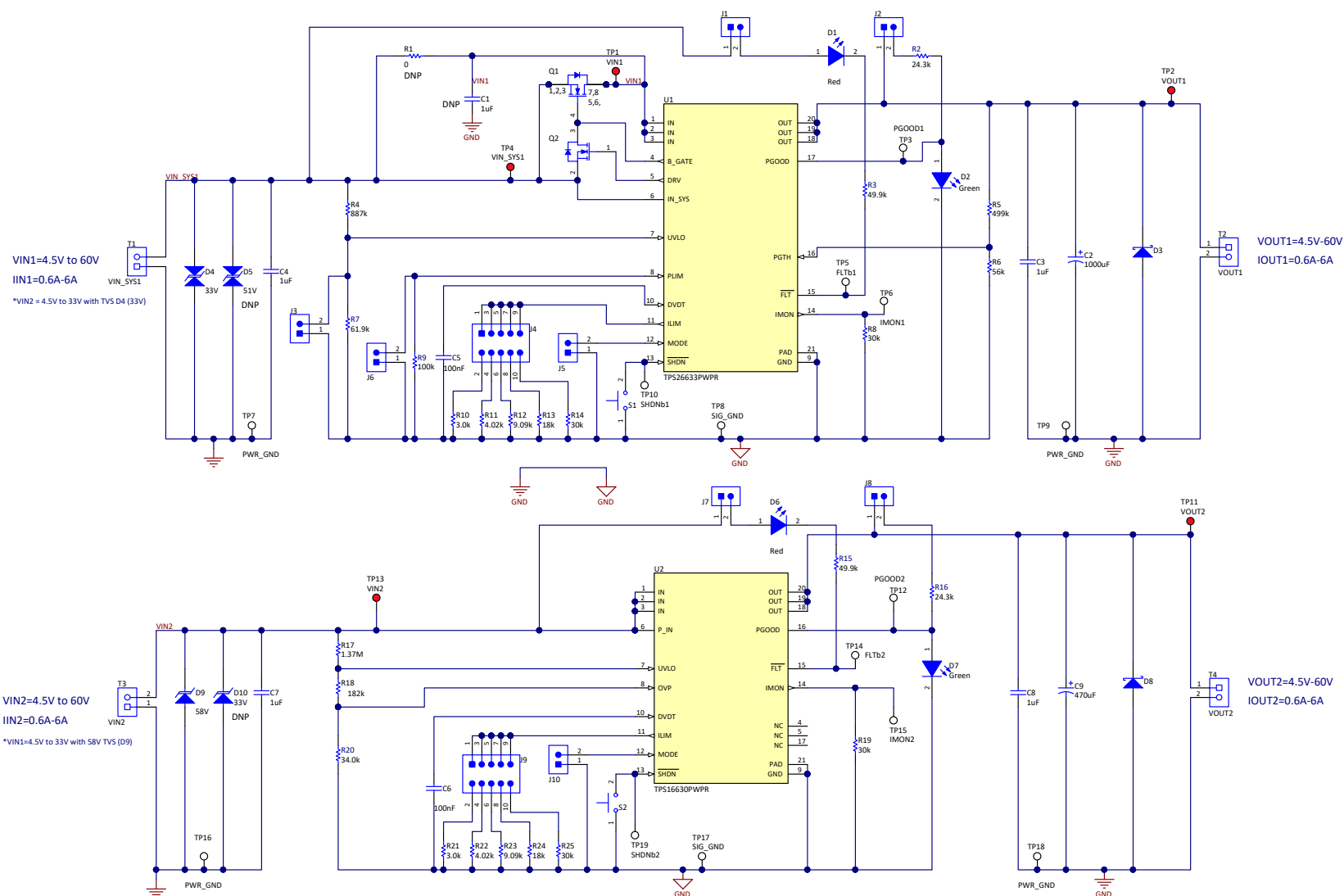


Figure 1. TPS2663-166EVM Schematic

4 Connector, Jumper, and LED Descriptions

4.1 Input and Output Connector Description

Table 2. Input and Output Connector Description

Connector	Label	Description
T1	VIN1	Power input connector for connecting the power supply for CH1 (TPS26633)
T2	VOUT1	Power output connector for connecting the load for CH1 (TPS26633)
T3	VIN2	Power input connector for connecting the power supply for CH2 (TPS16630)
T4	VOUT2	Power output connector for connecting the load for CH2 (TPS16630)

4.1.1 Test Points Description

Table 3. Test Points Description

Test Points	Label	Description
For CH1 (TPS26633)		
TP1	VIN1	Positive voltage input for CH1
TP2	VOUT1	Positive voltage output for CH1
TP3	PGOOD1	Power good output for CH1
TP4	VIN_SYS1	IN_SYS supply for CH1
TP5	FLTb1	FLT signal output for CH1
TP6	IMON1	Current monitoring signal for CH1
TP7	PWR_GND	Input power ground signal for CH1
TP8	SIG_GND	Signal ground for CH1
TP9	PWR_GND	Output power ground for CH1
TP10	SHDNb1	Shutdown input signal for CH1
For CH2 (TPS16630)		
TP11	VOUT2	Positive voltage output for CH2
TP12	PGOOD2	Power good output for CH2
TP13	VIN2	Positive voltage input for CH2
TP14	FLTb2	FLT signal output for CH2
TP15	IMON2	Current monitoring signal for CH2
TP16	PWR_GND	Input power ground signal for CH2
TP17	SIG_GND	Signal ground for CH2
TP18	PWR_GND	Output power ground for CH2
TP19	SHDNb2	Shutdown input signal for CH2

Table 4. Jumper Description

Jumper	Label	Description
For CH1 (TPS26633)		
J1	Pullup for $\overline{\text{FLT}}$ for CH1	This jumper is used for pulling up $\overline{\text{FLT}}$ to VIN_SYS1. OPEN: For pulling up $\overline{\text{FLT}}$ with any other voltage (like V _{IN}), open this jumper and connect pin 2 of J1 externally to the desired voltage (< 60 V). CLOSED: $\overline{\text{FLT}}$ is pulled up from VIN_SYS1.
J2	Pullup for PGOOD for CH1	This jumper is used for pulling up PGOOD for CH1 OPEN: For pulling up PGOOD with any other voltage (like V _{IN}), open this jumper and connect pin 2 of J2 externally to the desired voltage (< 60 V). CLOSED: PGOOD is pulled up from VOUT1.
J3	UVLO Configuration for CH1	To select factory select undervoltage trip level (15.46 V typical) or select external resistors OPEN: Resistors R4 and R7 set the UVLO trip level. CLOSED: Internal UVLO trip level is selected (15.46 V typical).
J4	I _{LIM} Configuration for CH1	This jumper sets the overcurrent limit: 1-2: I _{LIM} = 6 A 3-4: I _{LIM} = 4.5 A 5-6: I _{LIM} = 2 A 7-8: I _{LIM} = 1 A 9-10: I _{LIM} = 0.6 A
J5	MODE Configuration for CH1	This jumper configures the device mode for overcurrent and overload conditions. OPEN: Latch-Off (MODE = Open) CLOSED: Auto-retry (MODE = GND)
J6	PLIM Configuration for CH1	This jumper configures the power limiting for the device. OPEN: Resistor R9 sets the power limit. CLOSED: Power limiting is disabled.
For CH2 (TPS16630)		
J7	Pullup for $\overline{\text{FLT}}$ for CH2	This jumper is used for pulling up $\overline{\text{FLT}}$ to VIN2. OPEN: For pulling up $\overline{\text{FLT}}$ with any other voltage (like V _{IN}), open this jumper and connect pin 2 of J7 externally to the desired voltage (< 60 V). CLOSED: $\overline{\text{FLT}}$ is pulled up from VIN2.
J8	Pullup for PGOOD for CH2	This jumper is used for pulling up PGOOD for CH2 OPEN: For pulling up PGOOD with any other voltage (like V _{IN}), open this jumper and connect pin 2 of J8 externally to the desired voltage (< 60 V). CLOSED: PGOOD is pulled up from VOUT2.
J9	I _{LIM} Configuration for CH2	This jumper sets the overcurrent limit. 1-2: I _{LIM} = 6 A 3-4: I _{LIM} = 4.5 A 5-6: I _{LIM} = 2 A 7-8: I _{LIM} = 1 A 9-10: I _{LIM} = 0.6 A
J10	MODE Configuration for CH2	This jumper configures the device mode for overcurrent and overload conditions. OPEN: Latch-Off (MODE = Open) CLOSED: Auto-retry (MODE = GND)

5 Test Equipment and Setup

This section lists the required test equipment and provides instructions to set up the tests.

5.1 Power Supplies

Two adjustable power supplies 0-V to 60-V output, 0-A to 10-A output current limit.

5.2 Meters

Testing requires two digital multimeters (DMM).

5.3 Oscilloscope

A DPO2024 or equivalent, three 10× voltage probes, and a DC current probe.

5.4 Loads

Two resistive loads or an equivalent which can tolerate up to 10-A DC load at 60 V and is capable of the output short.

5.5 Test Setup

Before performing any of the tests listed in [Section 6](#), setup the EVM as per the following steps:

- Make sure that the jumper settings on the EVM are set to the default position as shown in [Table 5](#).
- Connect the power supply, load, oscilloscope, and voltmeter to the EVM as [Figure 2](#) shows.
- Set the power supply output to 0 V.
- Turn ON the power supply and set the power supply output to 24 V and current limit to 10 A.
- Turn OFF the power supply.

Table 5. Default Jumper Settings for TPS2663-166EVM

Jumper	For CH1 (TPS26633)					
	J1	J2	J3	J4	J5	J6
Position	Closed	Closed	Open	Closed between pin 1 and 2	Closed	Open
	For CH2 (TPS16630)					
	J7	J8	J9	J10		
Position	Closed	Closed	Closed between pin 1 and 2	Closed		

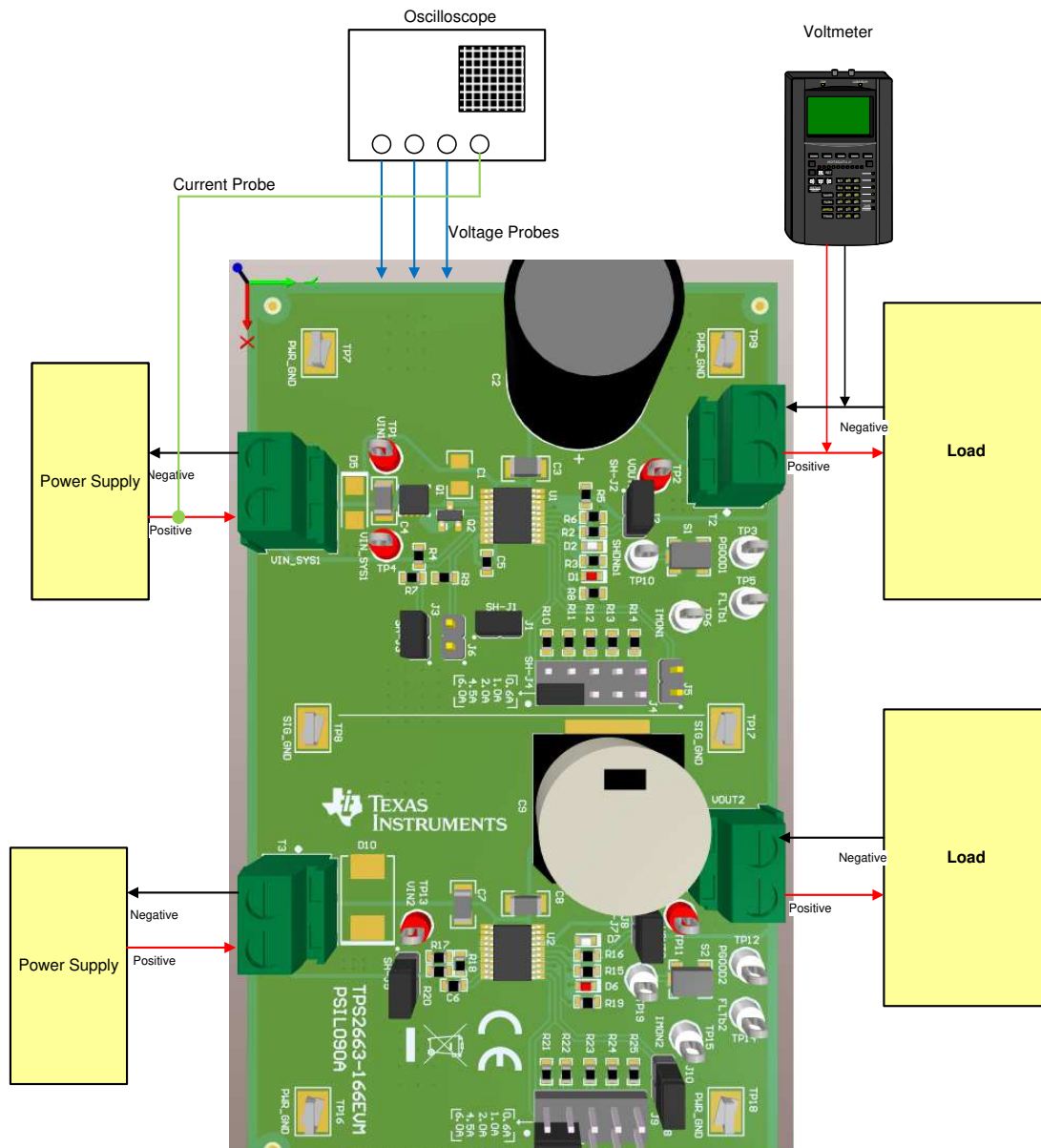


Figure 2. TPS2663-166 EVM Setup

6 Test Procedure and Results

6.1 Hot-plug and Start-up With 4.8 Ω Load

Use the following instructions to measure the output slew rate and input inrush current during start-up.

- Set the input supply voltage V_{IN} to 24 V and a current limit of 10 A. Enable the power supply.
- Connect a load of 4.8 Ω at output connector T2 for testing CH1 and T4 for testing CH2.
- Hot-plug the power supply at input connector T1 for testing CH1 and T3 for testing CH2.
- Observe the waveform at V_{IN} , V_{OUT} , $\overline{FLT}$, and I_{IN} with an oscilloscope to measure the output slew rate and rise time. The device starts with inrush current of 0.5 A and the output voltage reaches V_{IN} in 50 ms.

Figure 3 and Figure 4 show examples of inrush current during start-up on the TPS2663-166EVM.

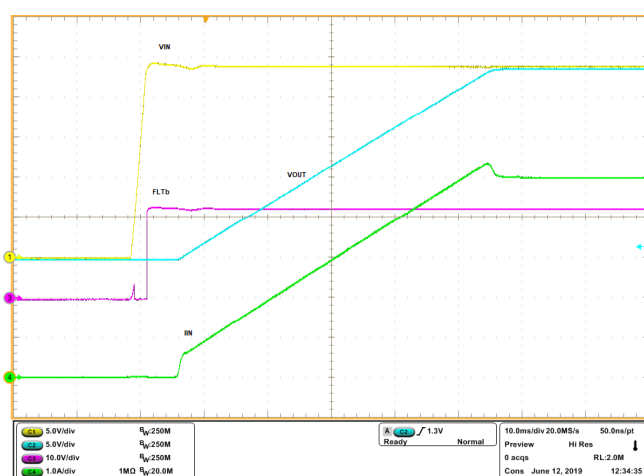


Figure 3. TPS2663-166EVM Startup for CH1 ($V_{IN} = 24$ V, $I_{LIM} = 6$ A, $R_{OUT} = 4.8$ Ω , MODE = GND)

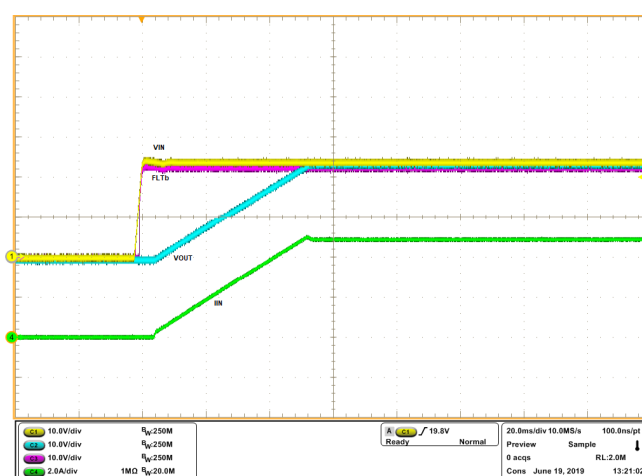


Figure 4. TPS2663-166EVM Startup for CH2 ($V_{IN} = 24$ V, $I_{LIM} = 6$ A, $R_{OUT} = 4.8$ Ω , MODE = GND)

6.2 Current Limit Test

Use the following instructions to perform the current limit test:

- Set the input supply voltage V_{IN} to 24 V and a current limit of 10 A and enable the power supply.
- Set the current limit to 4.5 A using jumper J4 for CH1 and jumper J9 for CH2.
- Connect the power supply at input connector T1 for testing CH1 and T3 for testing CH2. Enable the power supply output.
- Connect a load of $4.5\ \Omega$ (120 W) at output connector T2 for testing CH1 and T4 for testing CH2.
- Observe the waveform at V_{IN} , V_{OUT} , $\overline{FLT}$, and I_{IN} with an oscilloscope.
- The device limits the current to 4.5 A for a maximum duration of $t_{CL_PLIM(dly)}$ (162 ms), turns off the internal MOSFET, and auto-retries after a time of t_{TSD_retry} (648 ms).

Figure 5 and Figure 6 show examples of the current limit at 4.5 A for CH1 and CH2, respectively, on the TPS2663-166EVM.

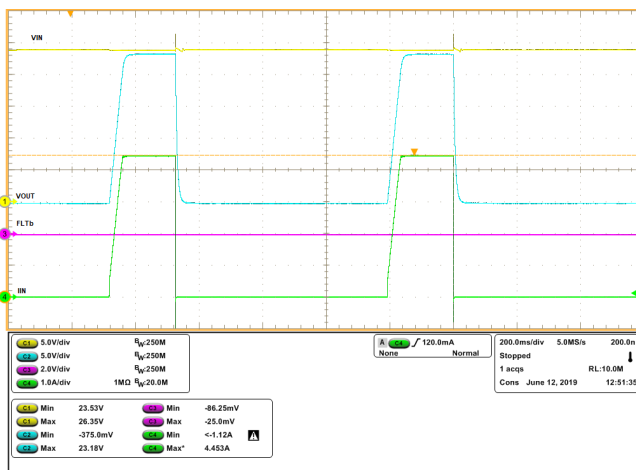


Figure 5. TPS2663-166EVM Current Limit Operation for CH1 ($V_{IN} = 24\text{ V}$, $I_{LIM} = 4.5\text{ A}$, $R_{OUT} = 4.5\ \Omega$, MODE = GND)

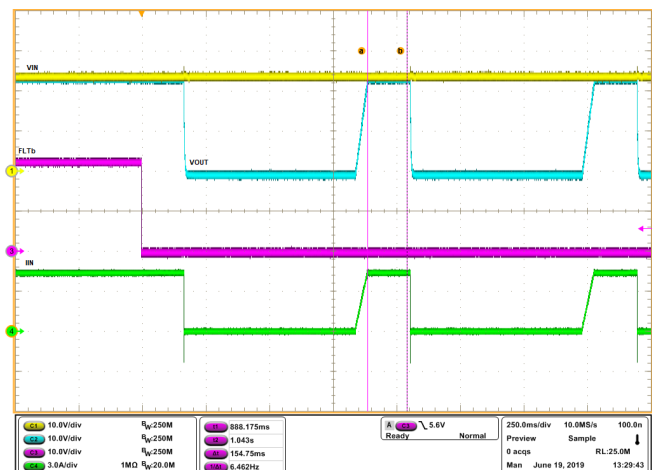


Figure 6. TPS2663-166EVM Current Limit Operation for CH2 ($V_{IN} = 24\text{ V}$, $I_{LIM} = 4.5\text{ A}$, $R_{OUT} = 4.5\ \Omega$, MODE = GND)

6.3 Output Hot-Short Test

Use the following instructions to perform the output Hot-Short test:

- Set the input supply voltage V_{IN} to 32 V and a current limit of 10 A and enable the power supply.
- Connect the power supply at input connector T1 for testing CH1 and T3 for testing CH2. Enable the power supply output.
- Short the output of the device at output connector T2 for testing CH1 and T4 for testing CH2.

NOTE: With the output powered up, shorting the output can lead to sparking at the output terminals. To minimize the sparking, uninstall capacitor C2 for CH1 and capacitor C9 for CH2.

Capacitors C2 and C9 were uninstalled for this test.

- Observe the waveforms of V_{IN} , V_{OUT} , and I_{IN} using an oscilloscope.

Figure 7 and Figure 8 show examples of output hot short on the TPS2663-166EVM. The device turns-off the internal MOSFET and disconnects the output from the input.

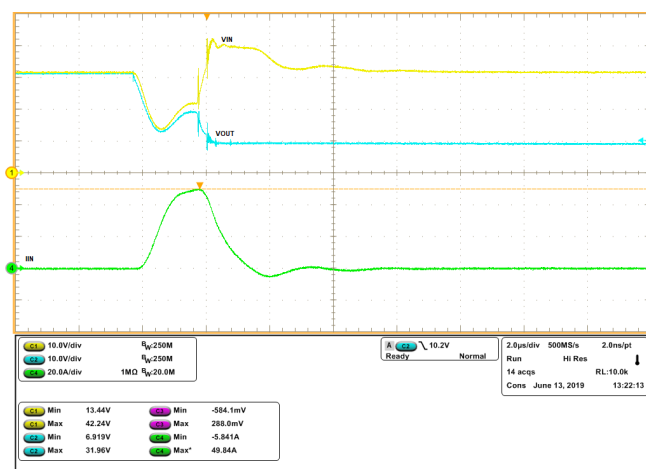


Figure 7. TPS2663-166EVM Output Hot Short for CH1 ($V_{IN} = 32$ V, $I_{LIM} = 6$ A, MODE = OPEN)

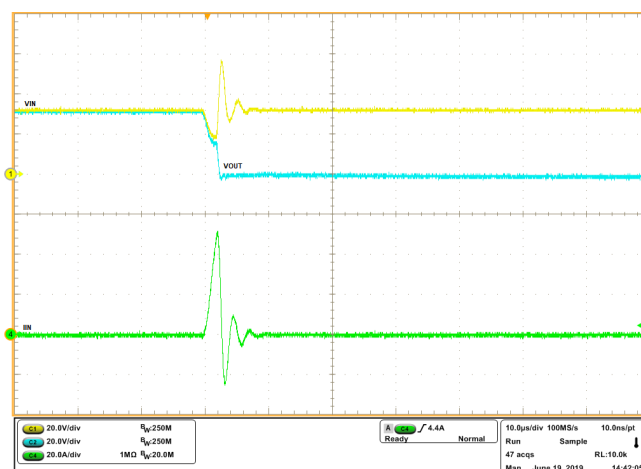


Figure 8. TPS2663-166EVM Output Hot Short for CH2 ($V_{IN} = 32$ V, $I_{LIM} = 6$ A, MODE = OPEN)

6.4 Reverse Input Polarity Test [TPS26633 Only]

Use the following instructions to perform the reverse input polarity test

- Set the input supply voltage V_{IN} to 32 V and a current limit of 10 A and enable the power supply.
- Connect the power supply output to the T1 terminal of the EVM in reverse polarity.
- Observe the waveforms of V_{IN} , V_{OUT} , and I_{IN} using an oscilloscope.

Figure 9 shows an example of reverse input polarity protection on the TPS2663-166EVM. The device turns-off the internal MOSFET and disconnects the output from the input.

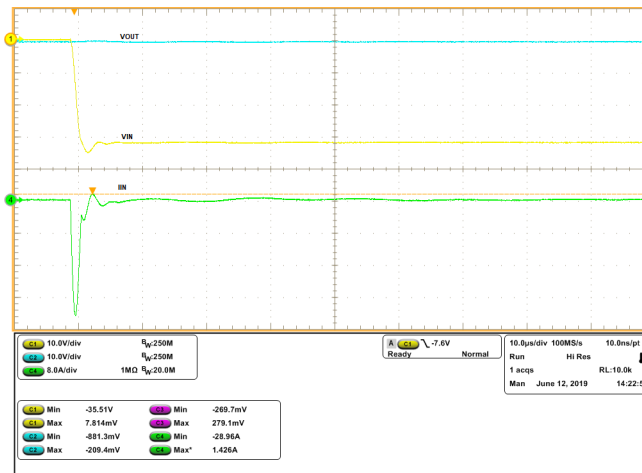


Figure 9. TPS2663-166EVM Reverse Input Polarity for CH1 ($V_{IN} = -32$ V, $I_{LIM} = 6$ A, MODE = GND)

6.5 Reverse Current Blocking Test [TPS26633 Only]

Use the following instructions to perform the reverse current blocking test:

- Set the input supply voltage V_{IN} to 32 V and a current limit of 10 A and enable the power supply.
- Connect the power supply output to terminal T2 of the EVM with the positive on pin 1 and the negative on pin 2.
- Observe the waveforms of V_{IN} , V_{OUT} , and I_{OUT} using an oscilloscope.

Figure 10 shows an example of the reverse current blocking protection on the TPS2663-166EVM.

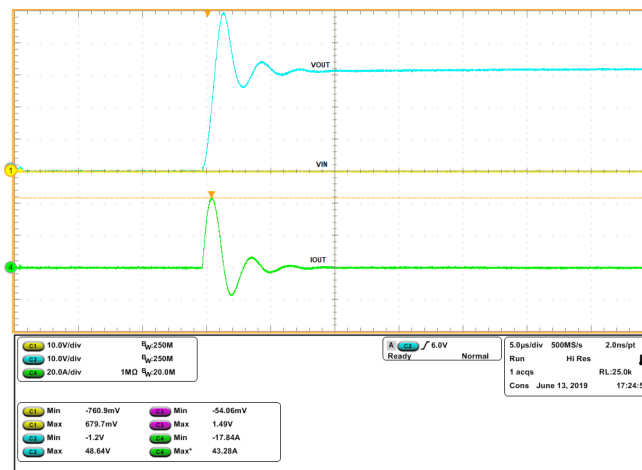


Figure 10. TPS2663-166EVM Reverse Current Blocking for CH1 ($V_{OUT} = 32$ V, $V_{IN} = 0$ V, $I_{LIM} = 6$ A, MODE = GND)

6.6 Overvoltage Clamping Test [TPS26633 Only]

Use the following instructions to perform the overvoltage clamping test:

- Set the input supply voltage V_{IN} to 35 V and a current limit of 10 A and enable the power supply.
- Connect the power supply output to the T1 terminal of the EVM.
- Connect a load of 25 Ω (50 W) at output terminal T2.
- Observe the waveforms of V_{IN} , V_{OUT} , $\overline{FLT}$, and I_{IN} using an oscilloscope.

Figure 11 shows an example of overvoltage clamping on the TPS2663-166EVM for CH1. The device clamps the voltage to $V_{(OVC)}$ voltage, turns off and retries.

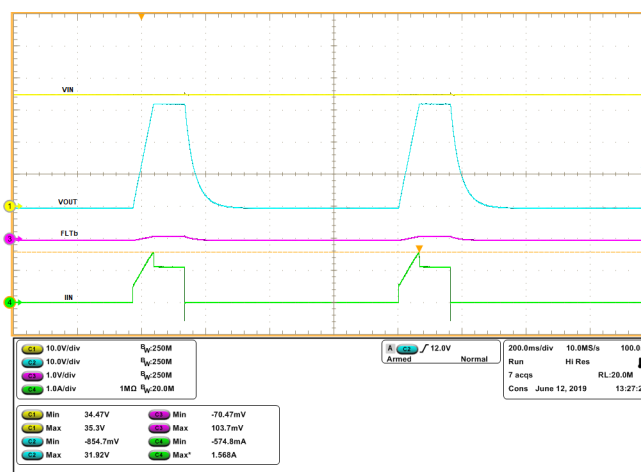


Figure 11. TPS2663-166EVM Overvoltage Clamping for CH1 ($V_{IN} = 35$ V, $I_{LIM} = 6$ A, MODE = GND)

7 Board Layout

Figure 12 and Figure 13 show the component placement of the EVM board. Figure 14 and Figure 15 show the PCB layout for the top and bottom layers of the EVM.

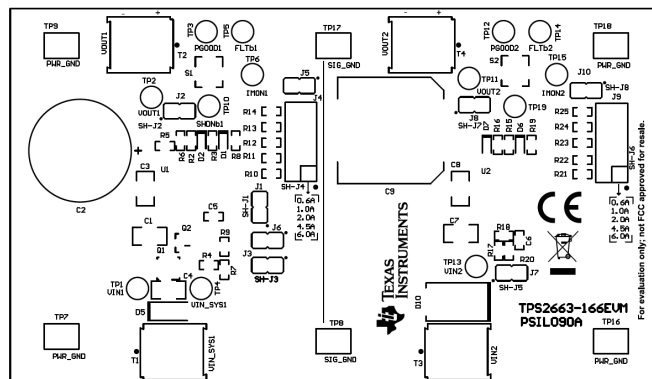


Figure 12. TPS2663-166EVM Top Overlay

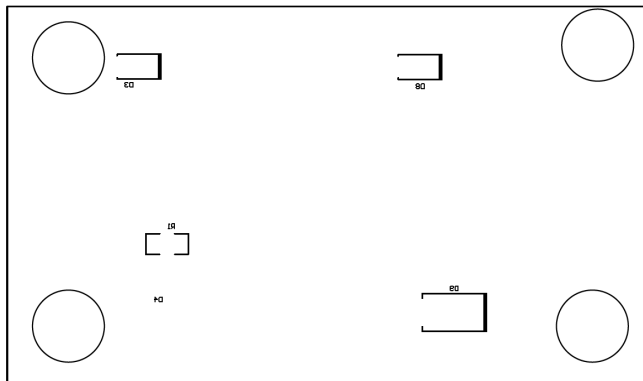


Figure 13. TPS2663-166EVM Bottom Overlay

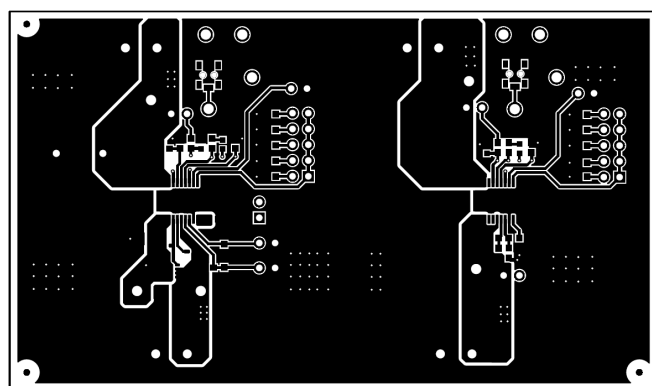


Figure 14. TPS2663-166EVM Top Layer

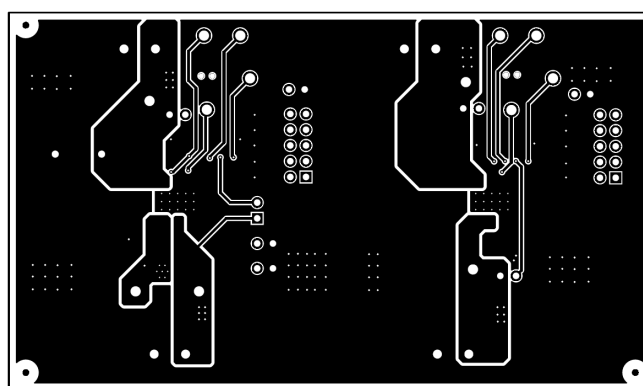


Figure 15. TPS2663-166EVM Bottom Layer

8 Bill of Materials

Table 6 lists the bill of materials for the TPS2663-166EVM.

Table 6. TPS2663-166EVM BOM

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed circuit board		PSIL090	Any
C2	1	1000 μ F	CAP, AL, 1000 μ F, 50 V, $\pm$ 20%, 0.034 Ω , AEC-Q200 Grade 2, TH	D16xL25	EEU-FC1H102	Panasonic
C3, C4, C7, C8	4	1 μ F	CAP, CERM, 1 μ F, 100 V, $\pm$ 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
C5, C6	2	0.1 μ F	CAP, CERM, 0.1 μ F, 10 V, $\pm$ 10%, X7R, 0603	0603	0603ZC104KAT2A	AVX
C9	1	470 μ F	CAP, AL, 470 μ F, 63 V, $\pm$ 20%, 0.11 Ω , SMD	LN0	EMVH630GDA471MLN0S	Chemi-Con
D1, D6	2	Red	LED, Red, SMD	Red LED, 1.6 $\times$ 0.8 $\times$ 0.8 mm	LTST-C190CKT	Lite-On
D2, D7	2	Green	LED, Green, SMD	1.6 $\times$ 0.8 $\times$ 0.8 mm	LTST-C190GKT	Lite-On
D3, D8	2	60 V	Diode, Schottky, 60 V, 2 A, SMB	SMB	B260-13-F	Diodes Inc.
D4	1	33 V	Diode, TVS, Bi, 33 V, 53.3 Vc, 1500 W, 29 A, SMC (No Polarity Mark)	SMC (No Polarity Mark)	SMCJ33CA-TR	STMicroelectronics
D9	1	58 V	Diode, TVS, Uni, 58 V, 93.6 Vc, SMC	SMC	SMCJ58A-13-F	Diodes Inc.
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 $\times$ 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J2, J3, J5, J6, J7, J8, J10	8		Header, 100 mil, 2 $\times$ 1, Gold, TH	Sullins 100 mil, 1 $\times$ 2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J4, J9	2		Header, 100 mil, 5 $\times$ 2, Tin, TH	Header, 5 $\times$ 2, 100 mil, Tin	PEC05DAAN	Sullins Connector Solutions
Q1	1	100 V	MOSFET, N-CH, 100 V, 50 A, DQG0008A (VSON-CLIP-8)	DQG0008A	CSD19537Q3	Texas Instruments
Q2	1	50 V	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	SOT-23	BSS138	Fairchild Semiconductor
R2, R16	2	24.3 k Ω	RES, 24.3 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060324K3FKEA	Vishay-Dale
R3, R15	2	49.9 k Ω	RES, 49.9 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
R4	1	887 k Ω	RES, 887 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603887KFKEA	Vishay-Dale
R5	1	499 k Ω	RES, 499 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EK4F4993V	Panasonic
R6	1	56 k Ω	RES, 56 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060356K0JNEA	Vishay-Dale
R7	1	61.9 k Ω	RES, 61.9 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060361K9FKEA	Vishay-Dale
R8, R14, R19, R25	4	30 k Ω	RES, 30 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060330K0JNEA	Vishay-Dale
R9	1	100 k Ω	RES, 100 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R10, R21	2	3.0 k Ω	RES, 3.0 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K00JNEA	Vishay-Dale
R11, R22	2	4.02 k Ω	RES, 4.02 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K02FKEA	Vishay-Dale
R12, R23	2	9.09 k Ω	RES, 9.09 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K09FKEA	Vishay-Dale
R13, R24	2	18 k Ω	RES, 18 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060318K0JNEA	Vishay-Dale
R17	1	1.37 Meg	RES, 1.37 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M37FKEA	Vishay-Dale
R18	1	182 k Ω	RES, 182 k Ω , 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603182KFKEA	Vishay-Dale
R20	1	34.0 k Ω	Test Point, Multipurpose, White, TH			
S1, S2	2		Switch, SPST-NO, Off-Mom, 0.05A, 12 VDC, SMD	3.9 $\times$ 2.9 mm	PTS820 J20M SMTR LFS	C&K Components
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8	8	1 $\times$ 2	Shunt, 100 mil, Flash Gold, Black	Closed Top 100 mil Shunt	SPC02SYAN	Sullins Connector Solutions
T1, T2, T3, T4	4		Terminal Block, 2 $\times$ 1, 5.08 mm, TH	10.16 $\times$ 15.2 $\times$ 9 mm	282841-2	TE Connectivity
TP1, TP2, TP4, TP11, TP13	5		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3, TP5, TP6, TP10, TP12, TP14, TP15, TP19	8		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
TP7, TP8, TP9, TP16, TP17, TP18	6		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		60-V, 6-A Power limiting, surge protection industrial eFuse, PWP0020T (HTSSOP-20)	PWP0020T	TPS26633PWPR	Texas Instruments
U2	1		60-V, 6-A eFuse with adjustable output power limiting, PWP0020T (HTSSOP-20)	PWP0020T	TPS16630PWPR	Texas Instruments
C1	0	1 μ F	CAP, CERM, 1 μ F, 100 V, $\pm$ 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
D5	0	51 V	Diode, TVS, Bi, 51 V, SMA	SMA	SMAJ51CA	Littelfuse
D10	0	33 V	Diode, TVS, Uni, 33 V, 53.3 Vc, 1500 W, 29 A, SMC	SMC	SMCJ33A-TR	STMicroelectronics
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R1	0	0	RES, 0, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20100000Z0EF	Vishay-Dale

9 Evaluating TPS26631 and TPS26636 on TPS2663-166EVM

Uninstall the device U1 (TPS26633) and install the TPS26631 or TPS26636 device on the board. With the TPS26631 device, close jumper J6. With this configuration, the TPS26631 device selects a factory set over-voltage protection trip level of $V_{(IN_SYS_OVP)}$.

Revision History

Changes from Original (August 2019) to A Revision	Page
• Updated Section 6.1 title	8
• Updated Section 9	15

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