User's Guide

TPS272C45 Evaluation Module

ABSTRACT

The TPS272C45EVM is a hardware evaluation module (EVM) used to enable hardware engineers to evaluate the full performance and functionality of the TPS272C45 industrial high side switch. The TPS272C45EVM contains everything needed to test and assess the TPS272C45 before designing it into part of a greater application's power system. The evaluation module is designed to either be used as a standalone board with an attached voltage supply and output load or in conjunction with an underlying Texas Instruments microcontroller by using the standardized BoosterPack headers. A wide range of application features such as current sensing, multiplexed current limiting, and transient suppression are enabled and visible through use of this evaluation module.

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Trademarks

1 Introduction

The Texas Instruments TPS272C45EVM is an evaluation module that is used to demonstrate and showcase all of the features of the underlying TPS272C45 industrial high side switch. This evaluation board provides a seamless way to connect a set of power supplies to the inputs of the TPS272C45, connect loads to the output channels, and switch on and off the device using the control pins of the chip itself. An on-board 3.3-V LDO is included on the EVM to simplify controlling signals to the TPS272C45 and easily assert and deassert logic signals by the use of a set of external hardware jumpers. Additionally this EVM includes BoosterPack headers allowing the user to easily connect the TPS272C45 high side switch to an underlying microcontroller and write software to control and configure the device.

Features of the TPS272C45EVM include:

- Multiplexed current limit configuration on ILIM1
- BoosterPack headers allowing power switch to be controlled by external microcontroller
- On-board 3.3-V LDO allowing for control signals to be manipulated by set of jumpers
- Ideal board layout and copper area for thermal performance
- Ability to support versions A, B, C, and D of the TPS272C45
- Optional footprint to populate external inductive clamping diodes (version C of TPS272C45)
- Optional footprint to populate TVS diode for Vdd input (version A of TPS272C45)

2 Compatibility Across Silicon Versions

The TPS272C45EVM is compatible across all versions of the TPS272C45. This compatibility includes the TPS272C45A with the external Vdd rail (A version), the TPS272C45B version without the Vdd rail (B version), the TPS272C45C with support for the external inductive loading diode (C version), and the TPS272C45D with fault output for individual channel (D version). By default, the A version of the silicon is populated on the EVM. The footprints among the A, B, C, and D versions of the TPS272C45 silicon are footprint compatible and can be interchanged by unpopulating the A version that ships default on the EVM and soldering, populating the desired version of the silicon.

The A, C and D version of the device includes the ability to power the digital logic of the TPS272C45 from an external Vdd pin. While the Vdd input pin exists on the A version of the TPS272C45 it does not exist in the B versions. When using the B versions of silicon on this EVM, disconnect the Vdd line (and associated jumper, *J17*) and ground the pin as this pin is classified as GND for B versions of the TPS272C45. Additionally with the A, C and D version of the silicon it is possible to solder a TVS diode to *D6* to filter out transients to the Vdd line. This TVS diode must have a reverse standoff voltage equal to the logic level of the voltage rail being fed into Vdd. For example, if the logic level is 5 V, then a SMAJ5.0CA diode is appropriate to filter any transients above 5 V.

When using the C version of the device, populate *D2*, *D3*, *D8*, and *D9* with the relevant diodes required for inductive loading. TI recommends the SMC series of diodes due to their ability to dissipate large energies and handle current required for discharging charged inductors during switch turn-off. These diodes must be chosen so that reverse standoff voltage falls within the nominal operating supply voltage of the device and anything above the breakdown voltage is considered a transient. The SMCJ48A-TR, for example, is able the absolute device max rating of 48 V and filter any transients above this level. More information about the transient protections provided by the EVM can be found in *Transient Protection*.

When using the D version of the device, make sure jumper *J23* is connected to the FLT1_IC position to get the Fault output for each channel.

A table of the versions of TPS272C45 and considerations that have to be taken can be found in Table 2-1.

Table 2-1. EVM Considerations Across Silicon Versions

TPS272C45 Version	Considerations
A	Default version populated on EVM. Follow desired settings from *Connection Descriptions*.
B	Unable to use external Vdd. Do not plug supply into *J6*. Do not populate *J17*. Do no populate TVS diode on *D6*.
C	Follow same guidance of A version. Populate inductive loading discharge diode on *D2*, *D3*, *D8*, and *D9*.
D	Follow same guidance of A version. Populate *J23* with jumper in position of FLT2_IC.

3 BoosterPack Operation

While the TPS272C45EVM can be used as a standalone evaluation board without the need of any external microcontroller, the EVM also comes populated with BoosterPack headers (*J1, J2, J3, J4*) to enable easy interface with a Texas Instruments microcontroller. The 40-pin headers of the BoosterPack headers are used, however all signals can be accessed using headers J1 and J2 enabling use with the 20-pin header. Additionally by populating jumper *J19* the user has the ability to power the underlying LaunchPad through the integrated 3.3-V LDO on the TPS272C45EVM. A list of pins connected to the BoosterPack header can be seen below in Table 3-1:

Table 3-1. Connected BoosterPack Header Pins on TPS272C45EVM

BoosterPack Pin	Function	Note
J1-1	3.3-V power rail	Disconnect *J19* if powering LaunchPad via USB.
J1-2	Current sensing through the SNS pin	Populate a Zener diode on *D7* if it is required to limit analog signal of pin
J1-5	DIA_EN pin used to enable diagnostics	Can be used to multiplex multiple TPS272C45 switches to one analog pin
J1-8	SEL pin used to change measurement reported on SNS pin	
J2-11	LATCH pin used to change fault behavior	
J2-12	ILIM1 pin used to enable a10-kΩ resistor *R13* for ILIM1	Active high. Do not enable at same time as J2-13.
J2-13	ILIM2 pin used to enable a 4.99-kΩ resistor *R14* for ILIM1	Active high. Do not enable as same time as J2-12.
J2-17	FLT pin used to detect faults	Open drain input. Pull-up source can be controlled using jumper *J18*.
J2-18	EN2 to enable VOUT2	Active high. Can be connected to PWM.
J2-19	EN1 to enable VOUT1	Active high. Can be connected to PWM.
J2-20	Module GND	Do not connect to IC ground if ground network is used

Note that for all IO and analog signals being attached to the BoosterPack, the relevant 4.7-kΩ protection resistors are populated in series with the pin.

To power the attached LaunchPad from the on-board LDO of the TPS272C45EVM, connect the jumper *J19*. Note that this feeds the output of the 3.3-V LDO on the TPS272C45EVM into the 3.3-V rail on the LaunchPad. If there is another power supply trying to power the LaunchPad (such as the integrated USB power on the LaunchPad itself) this can potentially cause issues with the separate power sources fighting for contention.

Jumpers *J8 through J12* are used to manually configure the control signals going into the TPS272C45. When using a microcontroller to control these signals these jumpers must be unpopulated to allow for the microcontroller to drive them high or low. Additionally the header labeled *J18* can be used to configure how the FAULT pin is pulled up. This pin is an open drain output used to report faults on the TPS272C45 such as overcurrent or open load. If *J18* is connected to the pin marked BP on the silkscreen the FAULT pin is pulled up through the 1-kΩ resistor *R9* to the 3.3-V rail of the BoosterPack. Similarly if the jumper labeled *J17* is connected to the BP pin the Vdd rail of the TPS272C45 is connected to the 3.3-V rail of the BoosterPack. If *J17* is populated to be fed from the LDO or BoosterPack, it cannot be supplied externally from the *J6* banana jack.

Note that one useful feature of the TPS272C45 EVM is the ability to sense the from the SNS pin of the TPS272C45 through the analog input of the microcontroller attached to the BoosterPack headers. A 1.0-kΩ resistor is connected to convert the current coming out of the SNS pin to a voltage, however care must be given to ensure that this value does not violate the input maximum of the microcontroller's analog input. To mitigate, a Zener diode can be soldered to *D7* (do not populate by default) to regulate the voltage going into the microncontroller's analog input.

4 TPS272C45EVM Schematic

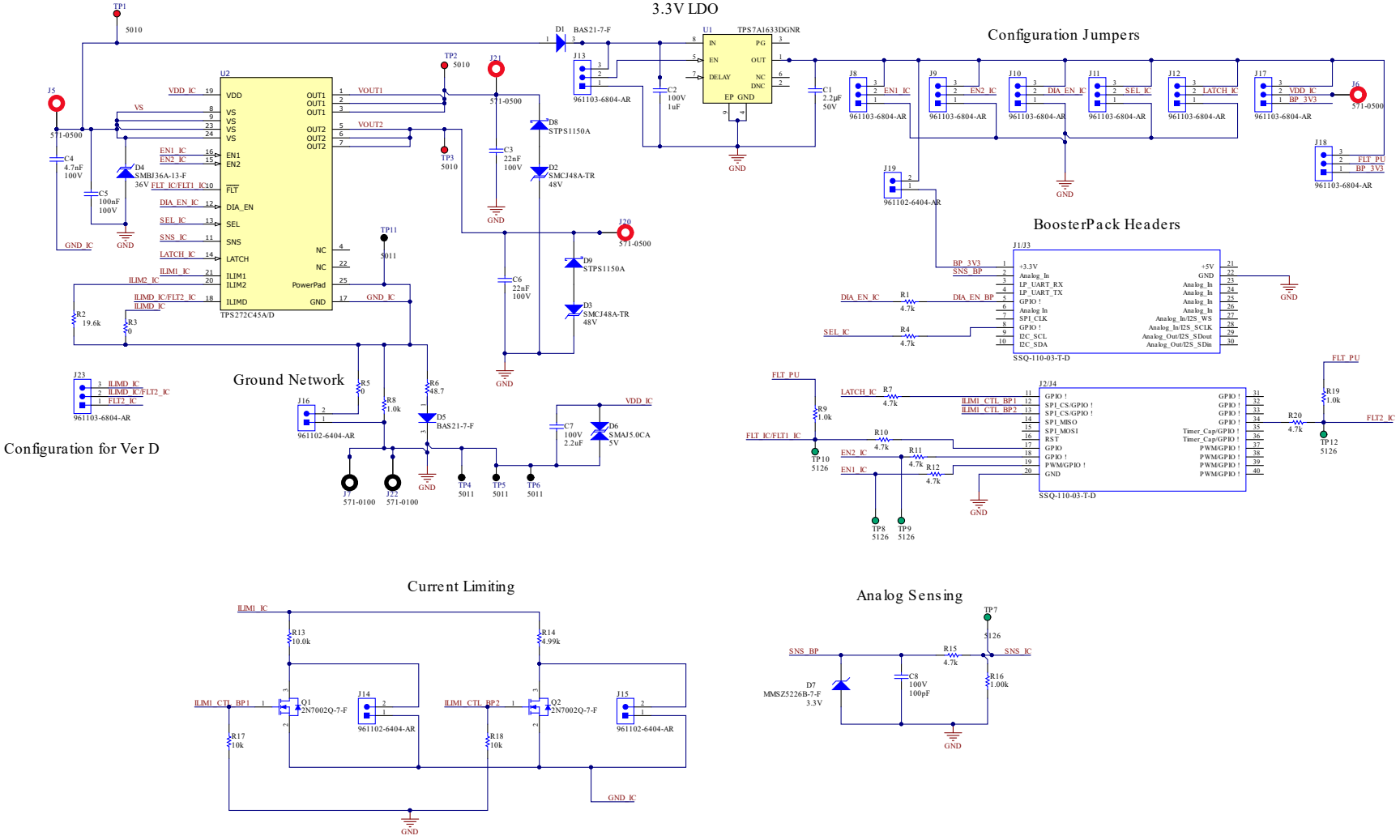

Figure 4-1. TPS272C45EVM Schematic Drawing

5 Connection Descriptions

Table 5-1 shows the test points populated on the board as well as the signal connectors.

Table 5-1. Connections and Test Points

Connector and Test Point	Description
J1 to J4	BOOST-XL headers to connect to Texas Instruments LaunchPad Ecosystem
J5, TP1	Supply voltage
J6	Supply rail for Vdd (A, C, D version of the TPS272C45 only)
J7, J22, TP4, TP5, TP6	Ground connections
TP7	Current sense output (SNS)
J20, TP3	Output voltage 2 (VOUT2)
J21, TP2	Output voltage 1 (VOUT1)
TP8	Enable for VOUT1 (EN1)
TP9	Enable for VOUT2 (EN2)
TP10	Shared fault line (FAULT)
TP11	IC Ground (IC_GND)

Table 5-2 shows the relevant configuration jumpers of the TPS272C45EVM as well as the associated values. Please refer to the TPS272C45 data sheet for detailed information on each pin's functionality.

Table 5-2. Jumper Configurations

Jumper	Function/Settings
J8	Controls EN1 and enables, disables VOUT1
J9	Controls EN1 and enables, disables VOUT2
J10	Sets DIA_EN and enables, disables diagnostics
J11	Controls the SEL pin to set which diagnostics are reported by the SNS pin
J12	Sets the functionality of the device during fault conditions via the LATCH pin
J13	Enables, disables the on-board 3.3-V LDO. Must be set to top position (marked on silk screen as 3.3-V LDO) to allow *J8* to *J12* to be high.
J14, J15	Controls which resistance value that is going into ILIM1. Only populate either *J14* or *J15* (not both) at a time. If *J14* is populated a 10-kΩ value is used and if *J15* is used a 4.99-kΩ value is used for ILIM1. If controlling from a from a microcontroller do not populate *J14* or *J15*.
J16	Controls whether or not to use the diode/resistor ground network for reverse current blocking. Populate jumper to bypass ground network.
J17	Selects if Vdd is being supplied by the BoosterPack or the on-board LDO. Do no populate if being supplied externally through *J6*.
J18	Controls if the FAULT line is being pulled up by the BoosterPack or the on-board LDO
J19	Connects the BoosterPack 3.3-V rail to the on-board LDO's 3.3-V output giving the ability to power the connected LaunchPad from the LDO.
J23	Configures pin 18 to be connected to ILIMD in A, B, C version or FLT1 in D version

6 TPS272C45EVM Assembly Drawings and Layout

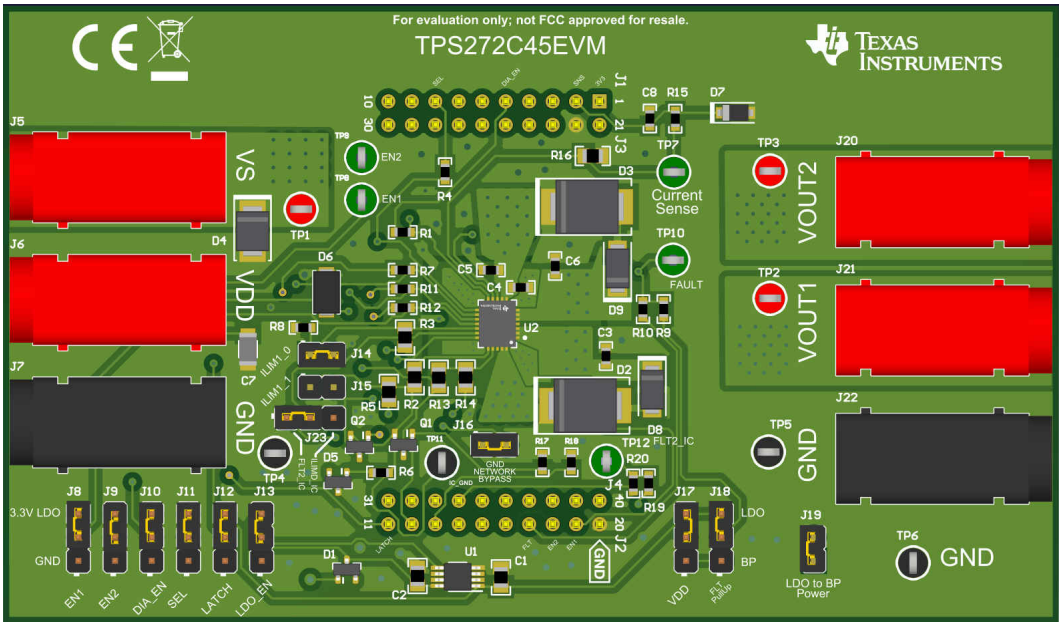

Figure 6-1. 3D Representation

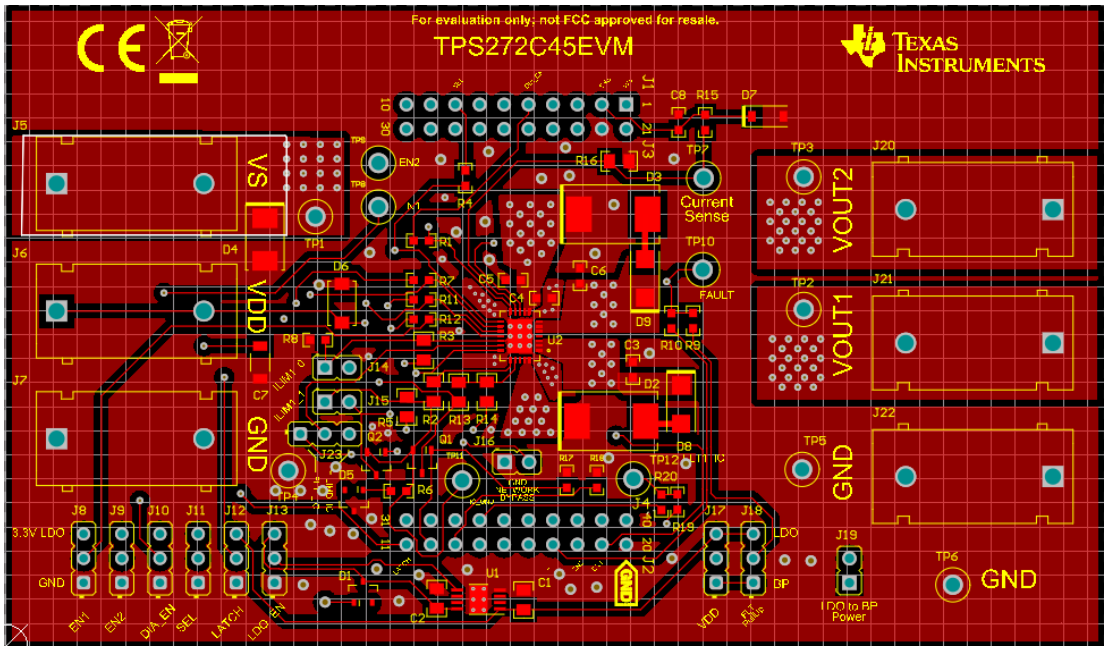

Figure 6-2. Top Layer

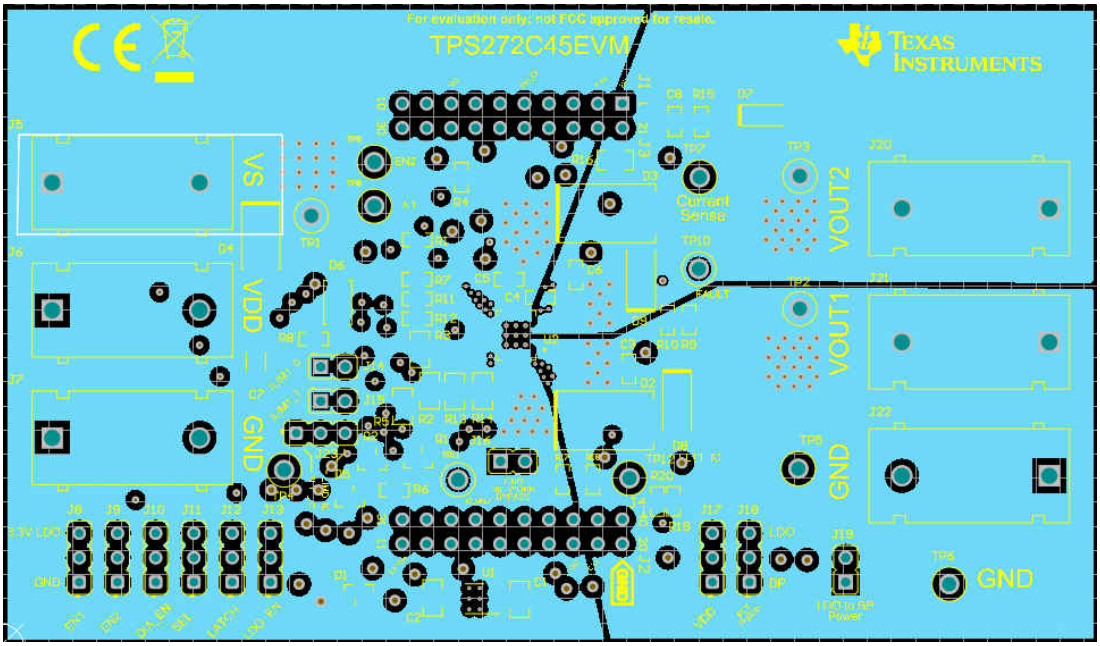

Figure 6-3. Power Layer

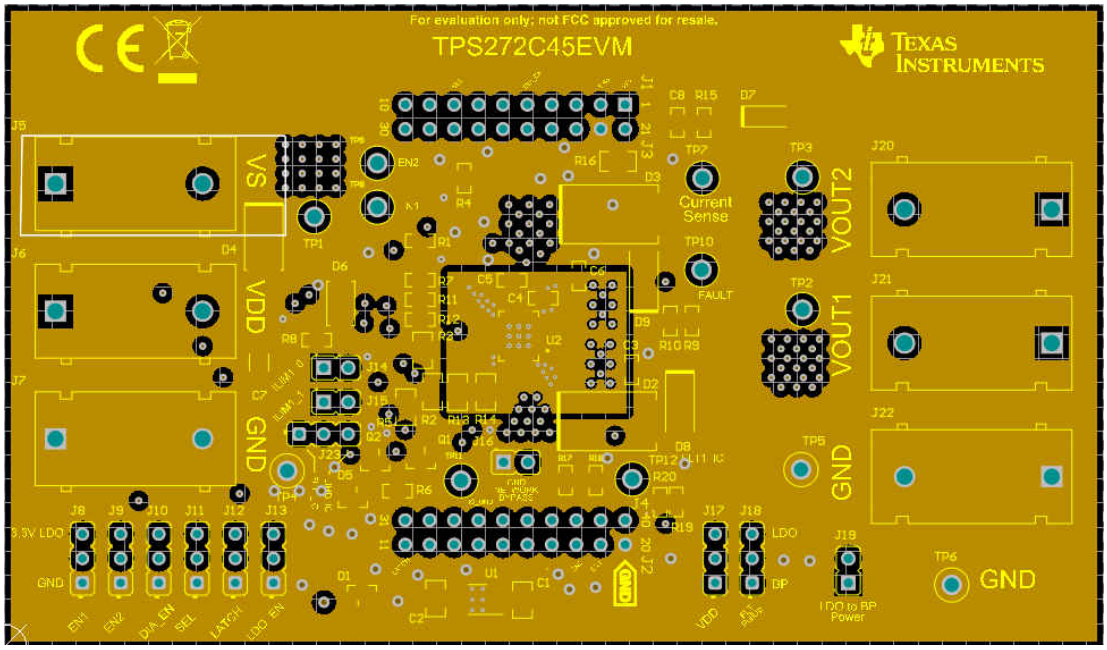

Figure 6-4. Ground Layer

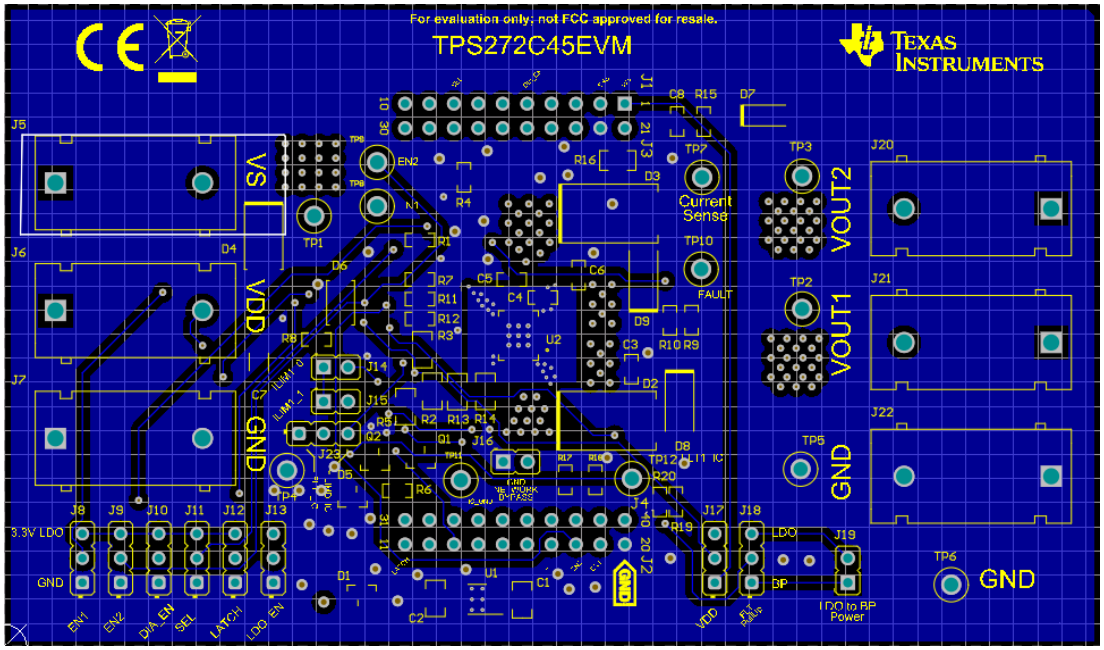

Figure 6-5. Bottom Layer

7 Current Limit Configuration

The TPS272C45EVM has the ability to configure both the ILIM1 and ILIM2 pins of the TPS272C45 to set a wide range of current limits that are custom tailored to the end design. Additionally the user is able to custom tailor the duration of time taken before the output current shuts off through the resistor connected to the ILIMD pin. The external current limits of the TPS272C45EVM are controlled by external resistors *R13* and *R14* (ILIM1), *R2* (ILIM2), and *R3* (ILIMD). Note that these resistors are populated in the 0805 package size allowing for easy soldering and desoldering.

The ILIM1 pin is configured in such a way that multiplexed current limits can be selected from an external microcontroller through the BoosterPack headers. This feature can seen below in Figure 7-1:

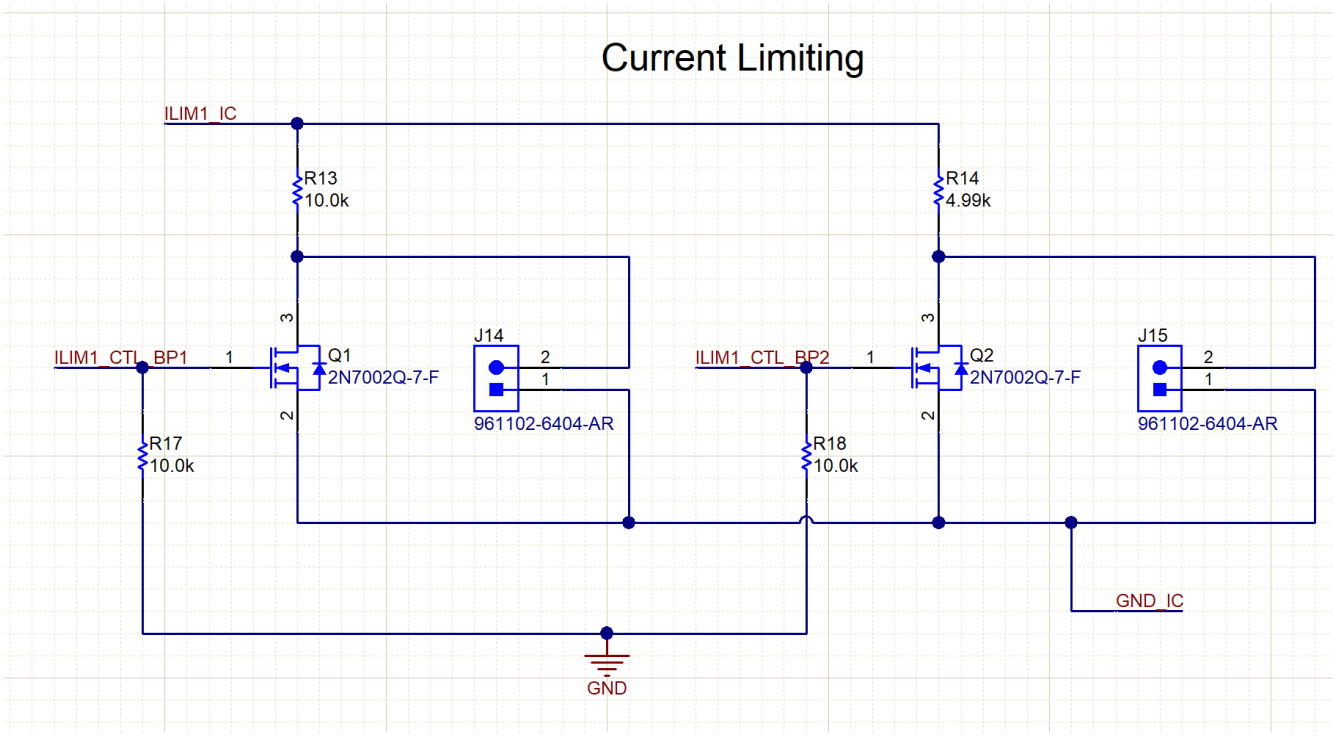

Figure 7-1. Multiplexed Current Limit

With this configuration, the user can choose to enable the MOSFET *Q1* if the 10.0-kΩ resistor is desired or enable the MOSFET *Q2* if the 4.99-kΩ resistor is desired. TI does not recommend to enable both channels simultaneously as this would parallel both of the resistors and add an undesired capacitance to the line. If multiplexing is not needed, the user can manually populate either the *J14* or *J15* jumpers. Please refer to the TPS272C45 data sheet for information on how to calculate delays from relevant resistor values.

8 Current Sense

The TPS272C45EVM has the ability to allow the user to sense the output current of the device through the SNS pin. This ability can be done by either:

- Connecting an external voltmeter to test point *TP7*
- Connecting an external microcontroller via the BoosterPack headers and sample/convert using the microcontroller's ADC

In the case that the microcontroller's ADC is sampling the SNS pin, it can required to populate a Zener diode on pin *D7* to regulate the maximum voltage going into the microcontroller's analog input. By default a 1-kΩ resistor is used as the SNS resistor (*R15*), however, depending on the ADC reference used on the microcontroller it can be desired to limit the voltage by use of the Zener diode. The *R15* pin's footprint is populated in a 0805 package to allow for easy soldering and desoldering.

9 Transient Protection

The TPS272C45EVM provides several footprints and populated components used to mitigate transient power events such as ESD, surges, and inductive load turn-offs. These protection mechanisms are provided in addition to the integrated transient mitigation features of the TPS272C45. Refer to the TPS272C45 data sheet on more information about the internal protections that the device provides.

The TPS272C45EVM provides the following transient protection features:

- Input TVS diode on VS (*D4*) to protect against upstream power events (populated)
- Optional external inductive load turn-off diode footprints on *D2*, *D3*, *D8*, and *D9* to provide a mechanism to discharge an inductive load if the internal clamp is not adequate (A, B or D versions of TPS272C45) or the clamp does not exist (C version of TPS272C45)
- Optional TVS diode footprint *D6* that provides input transient protection on Vdd (A or D version of TPS272C45 only)

10 Bill of Materials

Table 10-1 lists the TPS272C45 Bill of Materials.

Table 10-1. TPS272C45 Bill of Materials

Designator	Value	Description	Package Reference	Part Number	Manufacturer
C1	2.2 uF	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7R1H225K125AB	TDK
C2	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7S2A105K125AB	TDK
C3, C6	0.022 uF	CAP, CERM, 0.022 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A223K080AA	TDK
C4	4700 pF	CAP, CERM, 4700 pF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A472K080AA	TDK
C5	0.1 uF	CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCJ188R72A104KA01D	MuRata
C7	2.2 uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7S2A225K160AB	TDK
C8	100 pF	CAP, CERM, 100 pF, 100 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	GCM1885C2A101JA16D	MuRata
D1, D5	200 V	Diode, Switching, 200 V, 0.2 A, SOT-23	SOT-23	BAS21-7-F	Diodes Inc.
D4	36 V	Diode, TVS, Uni, 36 V, 58.1 Vc, SMB	SMB	SMBJ36A-13-F	Diodes Inc.
J1/J3, J2/J4		Receptacle, 2.54mm, 10x2, Tin, TH	10x2 Receptacle	SSQ-110-03-T-D	Samtec
J5, J6, J20, J21		Standard Banana Jack, insulated, 10A, red	571-0500	571-0500	DEM Manufacturing
J7, J22		Standard Banana Jack, insulated, 10A, black	571-0100	571-0100	DEM Manufacturing
J8, J9, J10, J11, J12, J13, J17, J18, J23		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	961103-6804-AR	3M
J14, J15, J16, J19		Header, 2.54mm, 2x1, TH	Header, 2.54mm, 2x1, TH	961102-6404-AR	3M
Q1, Q2	60 V	MOSFET, N-CH, 60 V, 0.115 A, AEC-Q101, SOT-23	SOT-23	2N7002Q-7-F	Diodes Inc.
R1, R4, R7, R10, R11, R12, R15, R20	4.7 k	RES, 4.7 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEYJ472V	Panasonic
R2	40.0 k	RES, 40.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080540K0FKEA	Vishay-Dale
R3, R5	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic
R6	48.7	RES, 48.7, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060348R7FKEA	Vishay-Dale
R8, R9, R19	1.0 k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RCA06031K00JNEA	Vishay-Dale

Table 10-1. TPS272C45 Bill of Materials (continued)

Designator	Value	Description	Package Reference	Part Number	Manufacturer
R13	10.0 k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF1002V	Panasonic
R14	4.99 k	RES, 4.99 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF4991V	Panasonic
R16	1.00 k	RES, 1.00 k, 1%, 0.25 W, 0805	0805	ERJ-P06F1001V	Panasonic
R17, R18	10.0 k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	M55342K12B10E0T	TT Electronics/IRC
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2, TP3		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP4, TP5, TP6, TP11		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP7, TP8, TP9, TP10, TP12		Test Point, Multipurpose, Green, TH	Green Multipurpose Testpoint	5126	Keystone
U1		Single Output LDO, 100 mA, Fixed 3.3 V Output, 3 to 60 V Input, with Enable and Power Good, 8-pin MSOP (DGN), -40 to 125 degC, Green (RoHS & no Sb/Br)	DGN0008C	TPS7A1633DGNR	Texas Instruments
U2		45-mΩ, 4-A, Dual-Channel Industrial Smart High-Side Switch with Diagnostics	PVQFN24	TPS272C45D	Texas Instruments
D2, D3	48 V	Diode, TVS, Uni, 48 V, 77.4 Vc, 1500 W, 20 A, SMC	SMC	SMCJ48A-TR	STMicroelectronics
D6	5 V	Diode, TVS, Bi, 5 V, 9.2 Vc, 400 W, 43.5 A, SMA (non-polarized)	SMA (non-polarized)	SMAJ5.0CA	Littelfuse
D7	3.3 V	Diode, Zener, 3.3 V, 500 mW, SOD-123	SOD-123	MMSZ5226B-7-F	Diodes Inc.
D8, D9	150 V	Diode, Schottky, 150 V, 1 A, SMA	SMA	STPS1150A	STMicroelectronics

11 Revision History

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

Changes from Revision * (December 2020) to Revision A (December 2021)	Page
• Added support for TPS272C45 version D	1
• Updated Figure 4-1	5
• Updated Figure 6-1 through Figure 6-5	7

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Last updated 10/2025