

## **TPS274160 Evaluation Module User's Guide**

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The TPS274160 evaluation module is designed to evaluate the TPS274160 integrated circuit. This user's guide provides the connectors and test point description, the schematic, bill of materials, and board layout of the EVM.

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## 1 Introduction

TI's TPS274160 evaluation module (EVM) contains a TPS274160 integrated circuit (IC), supporting quad-channel high-side switch applications. The purpose of this EVM is to facilitate evaluation of the TPS274160 for resistive, capacitive, and inductive load.

### 1.1 Description

The TPS274160 family is a fully-protected quad-channel, high-side power switch, with integrated NMOS power FET and charge pump.

Full diagnostics and high accuracy current sense features enable intelligent control of the load. The device diagnostic reporting has two versions to support both digital status output and analog current sense report. The diagnostics can be disabled for multiplexing the sense pin between different devices. Thermal shutdown behaviors as latch off or auto-retry are internally fixed in the part.

External programmable current limit improves the whole system's reliability by limiting the inrush or overload current.

### 1.2 Applications

This EVM is used in the following applications:

1. Multi-channel LED drivers, bulb drivers
2. Multi-channel high-side power switches
3. Multi-channel high-side relay drivers
4. PLC digital output drivers

### 1.3 Features

This EVM has the following features:

1. Operating Voltage 5 V– 36 V
2. Operating junction temperature, –40 to 150°C
3. Highly accurate current sense
4. Programmable current limit with external resistor
5. Multiplex high accuracy current sense or ST report
6. Tested according to IEC61000-4-2 and IEC61000-4-5
7. Ensured to survive DC-13 inductive load.

2 TPS274160 Schematic

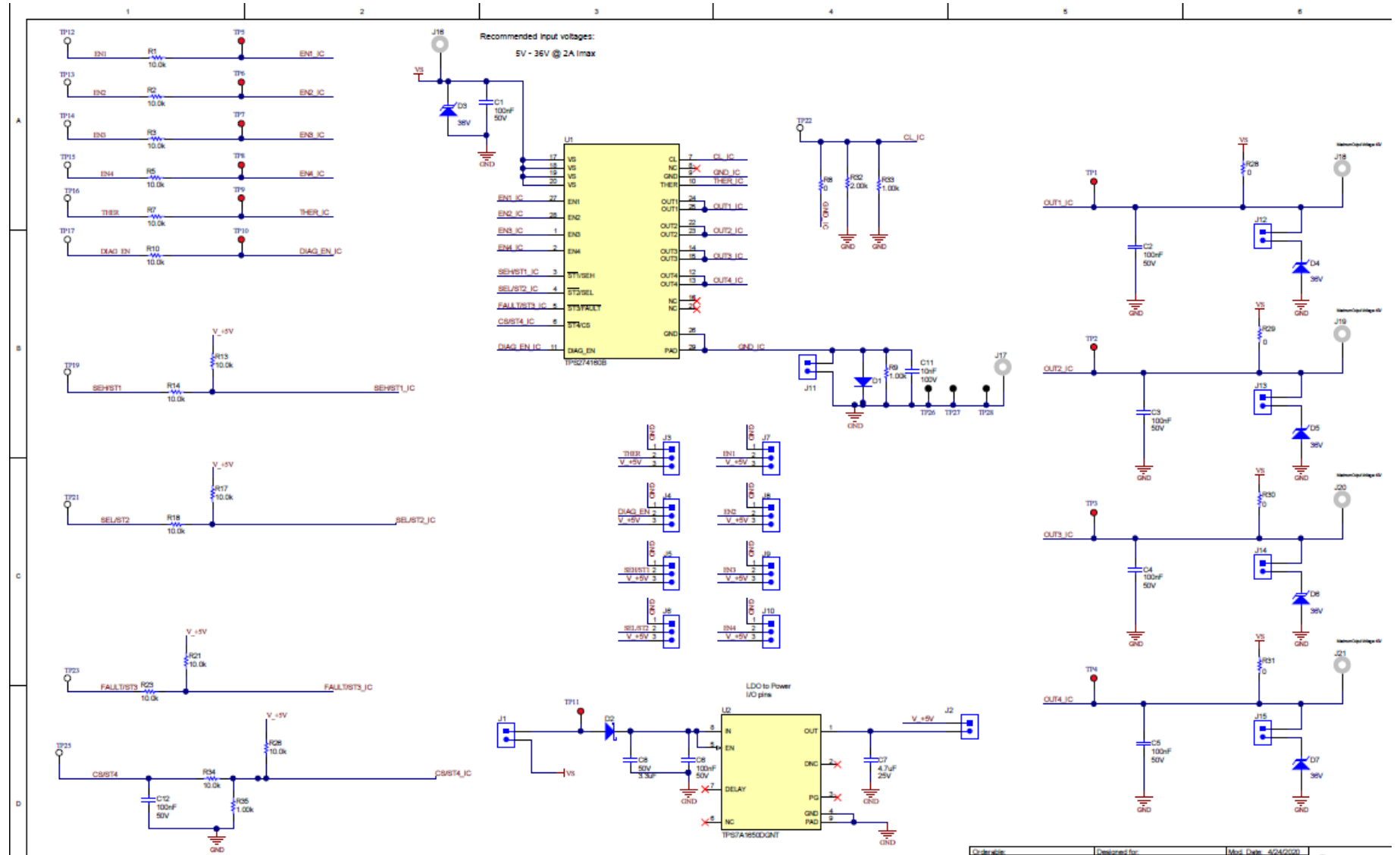


Figure 1. TPS274160EVM Schematic

### 3 Connection Descriptions

This section describes the connectors on the EVM as well and how to properly connect, set up, and use the TPS274160 EVM.

#### 3.1 Connectors

**VS** – The board's positive input supply voltage connector, the drain terminal of DMOS.

**GND** – The board's GND connector, the return connection to the input power supply.

**EN1** – The board's input connector; controls CH1 output. 3.3-V or 5-V control signal connection pin.

**EN2** – The board's input connector; controls CH2 output. 3.3-V or 5-V control signal connection pin.

**EN3** – The board's input connector; controls CH3 output. 3.3-V or 5-V control signal connection pin.

**EN4** – The board's input connector; controls CH4 output. 3.3-V or 5-V control signal connection pin.

**OUT1** – The board's CH1 output pin connector, the source terminal of DMOS.

**OUT2** – The board's CH2 output pin connector, the source terminal of DMOS.

**OUT3** – The board's CH3 output pin connector, the source terminal of DMOS.

**OUT4** – The board's CH4 output pin connector, the source terminal of DMOS.

**ST1** – The board's CH1 status output connector, only effective for version A.

**ST2** – The board's CH2 status output connector, only effective for version A.

**ST3** – The board's CH3 status output connector, only effective for version A.

**ST4** – The board's CH4 status output connector, only effective for version A.

**SEH** – The high-bit channel selection connector, combining with SEL to select which channel CS pin sense for, only effective for version B.

**SEL** – This is the low-bit channel selection connector, combining with SEH to select which channel CS pin sense for, only effective for version B.

**FAULT** – The board's states report connector, only effective for version B, can get the OR value for 4-CHs fault.

**CS** – The board's current sense output connector, only effective for version B.

**CL** – The board's current limit output connector.

**DIAG\_EN** – The board's DIAG\_EN input connector, 3.3-V or 5-V control signal connection pin.

**THER** – This is the thermal shutdown behavior control connector.

### 3.2 Jumpers

**J1** – This jumper connects VS to the input of the LDO.

**J2** – This jumper connects the output of the LDO to EN1, EN2, EN3, EN4, THER, DIAG\_EN, SEH/ST1, and SEL/ST2.

**J3** – Shorting pin 1 and pin 2 will connect THER to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to THER.

**J4** – Shorting pin 1 and pin 2 will connect DIAG\_EN to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to DIAG\_EN.

**J5** – Shorting pin 1 and pin 2 will connect SEH/ST1 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to SEH/ST1.

**J6** – Shorting pin 1 and pin 2 will connect SEL/ST2 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to SEL/ST2.

**J7** – Shorting pin 1 and pin 2 will connect EN1 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to EN1.

**J8** – Shorting pin 1 and pin 2 will connect EN2 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to EN2.

**J9** – Shorting pin 1 and pin 2 will connect EN3 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to EN3.

**J10** – Shorting pin 1 and pin 2 will connect EN4 to GND. Shorting pin 2 and pin 3 will connect 5V from the LDO output to EN4.

**J11** – Populating this jumper will tie IC\_GND of board GND with a diode in series with a 1k $\Omega$  resistor and 10nF capacitor.

**J12** – Populating this jumper will connect a TVS (SMBJ36A) diode from OUT1 to GND.

**J13** – Populating this jumper will connect a TVS (SMBJ36A) diode from OUT2 to GND.

**J14** – Populating this jumper will connect a TVS (SMBJ36A) diode from OUT3 to GND.

**J15** – Populating this jumper will connect a TVS (SMBJ36A) diode from OUT4 to GND.

#### 4 TPS274160 EVM Assembly Drawings and Layout

Figure 2 to Figure 5 show the design of the TPS274160 printed-circuit board (PCB). The EVM is designed using FR4 material, four-layer (2s2p), 2 x 70- $\mu\text{m}$  Cu in top and bottom layers, and 2 x 35- $\mu\text{m}$  Cu in internal plane layers. All components are in an active area on the top side and all active traces to the top and bottom layers to allow the user to easily view, probe, and evaluate. Moving components to both sides of the PCB offers additional size reduction for space-constrained systems.

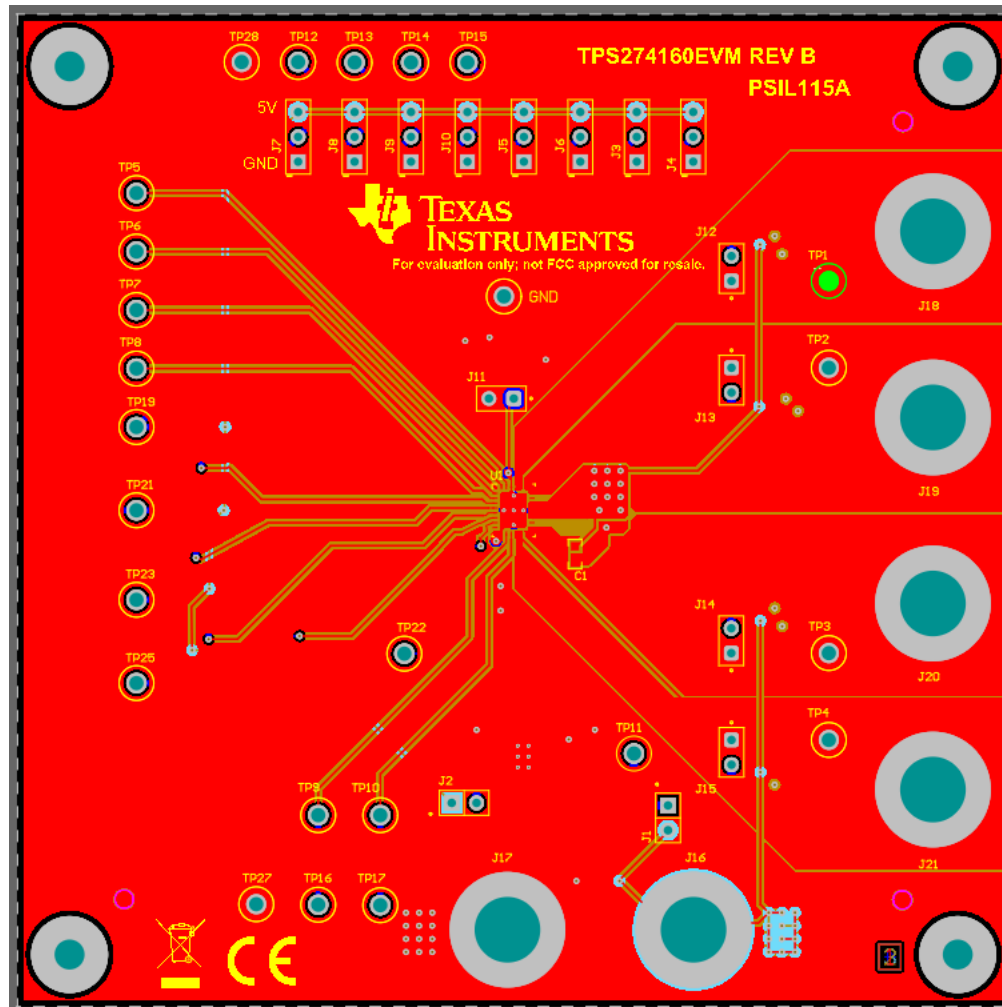


Figure 2. TPS274160EVM First Layer (Top View)

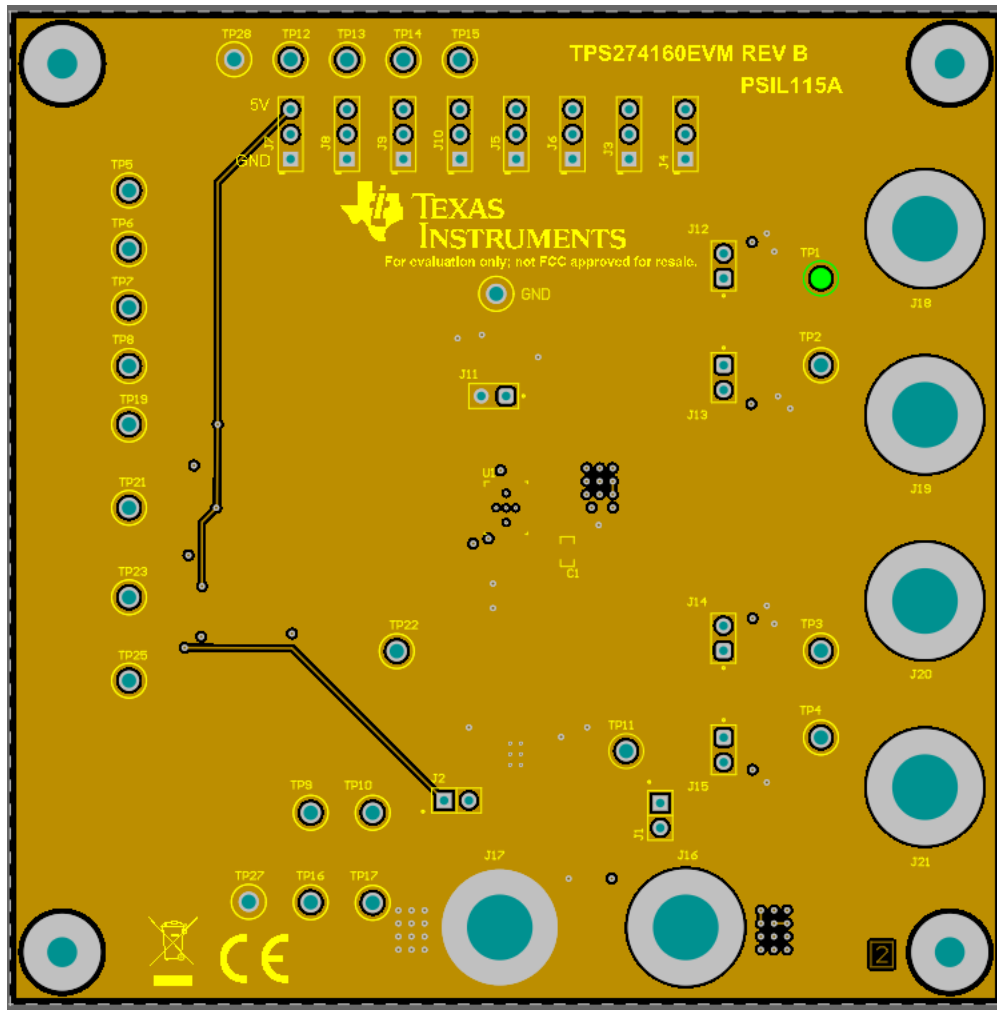


Figure 3. TPS274160EVM Second Layer GND (Top View)

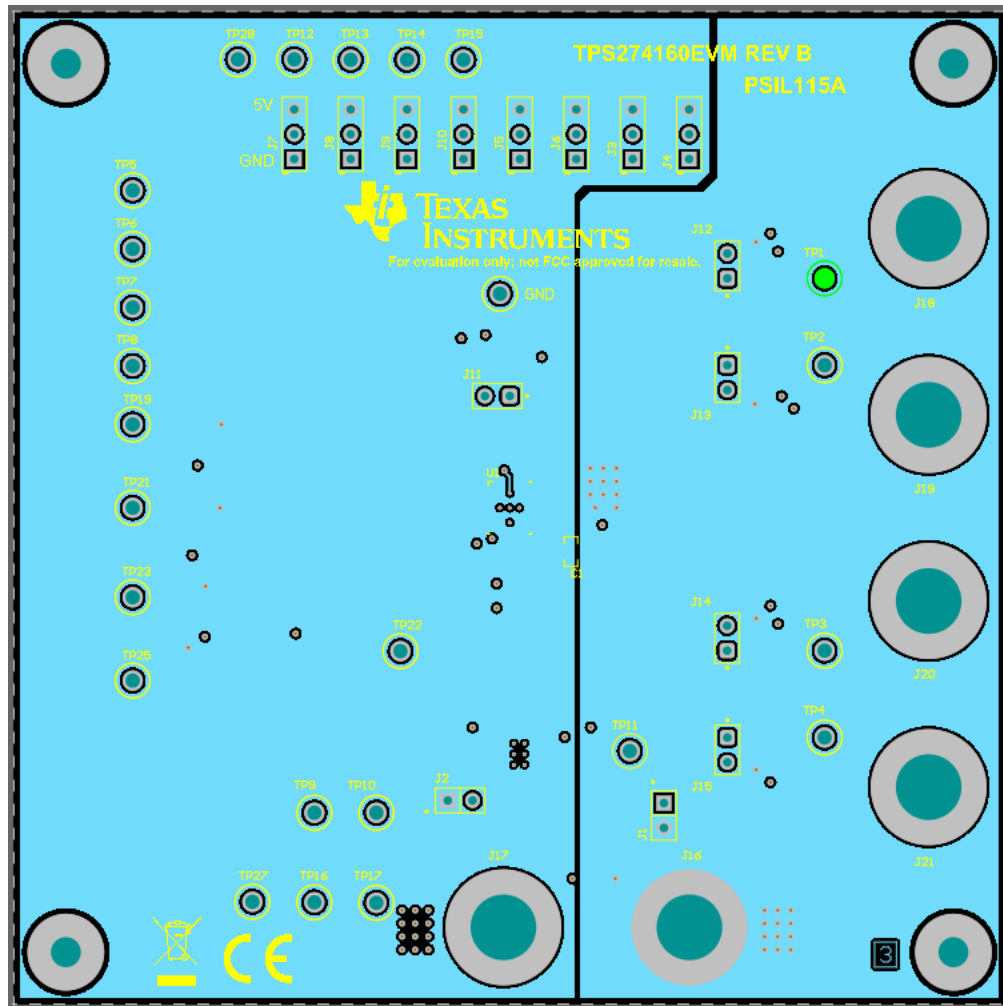


Figure 4. TPS274160EVM Third Layer Power Split (Top View)



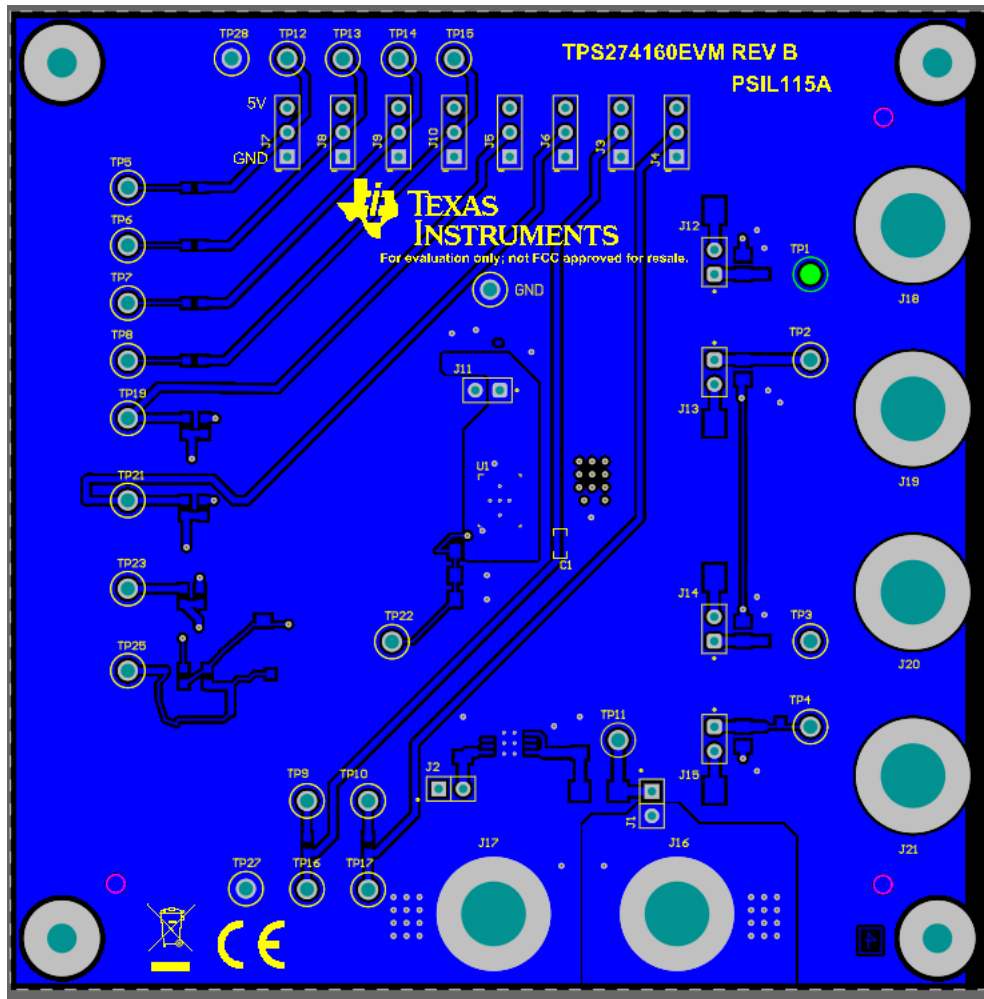


Figure 5. TPS274160EVM Bottom Layer (Top View)

## 5 Variable Resistor for CS and CL

### 5.1 Current Sense Resistor

For version B, high-accuracy current sensing allows better real-time monitoring effect and more accurate diagnostics without further calibration. It provides the real-time output current monitoring. A current mirror is used to source 1/K of the load current, and is reflected as  $V_{CS} = I_{CS} \times R_{CS}$ . Ensure the CS voltage is in the linear region (0–4 V) when in normal operation.

Also, when fault condition happens, it works as a diagnostics report pin. When open load/short to battery happen in on-state,  $V_{CS}$  almost equals to zero. When current limit, thermal shutdown/swing, open load/short to battery in off-state happen, the voltage is clamped at  $V_{CS,H}$ .

$$R_{CS} = \frac{V_{CS}}{I_{CS}} = \frac{V_{CS} \times K_{CS}}{I_{OUT}} \quad (1)$$

### 5.2 Current Limit Resistor

An external resistor is used to convert a proportional load current into a voltage, which is compared with an internal reference voltage. When the voltage on the CL pin exceeds the reference voltage, the current is clamped.

The inherent current limit ( $I_{lim,nom}$ ) is still present when using an external current limit. The smaller one of the internal or external set value decides the actual nominal current limit. If it is decided to not use an external programmable current, tie the CL pin to ground.

Equation 2 is the equation of the current limit resistor.

$$I_{CL} = \frac{V_{CL,th}}{R_{CL}} = \frac{I_{OUT}}{K_{CL}}$$

$$R_{CL} = \frac{V_{CL,th} \times K_{CL}}{I_{OUT}} \quad (2)$$

R32 is a 2k $\Omega$  resistor; R33 is a 1k $\Omega$  resistor, and R8 is a 0 $\Omega$  resistor. Populate/depopulate R8, R32, and R33 to vary CL. When 0 $\Omega$ , there is no external current limit function, the internal current limit is active.

## 6 Bill of Materials

Table 1 lists the EVM BOM.

**Table 1. Bill of Materials**

Designator	Comment	Description	Footprint	Quantity
C1	CC1206KRX7R9BB104	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 1206	1206	1
C2, C3, C4, C5, C6, C12	C0603C104K5RACAUTO	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	6
C7	CMP-0008515-2	CAP, CERM, 4.7 uF, 25 V, +/- 10%, X5R, 1206	1206	1
C8	C2012X5R1H335K125AB	CAP, CERM, 3.3 uF, 50 V, +/- 10%, X5R, 0805	0805_HV	1
C11	CMP-0007542-2	CAP, CERM, 0.01 uF, 100 V, +/- 5%, X7R, 0805	0805_HV	1
D1	BAS21-7-F	Diode, Switching, 200 V, 0.2 A, SOT-23	SOT-23L	1
D2	CMP-0028387-2	Diode, Schottky, 50 V, 1 A, SMA	SMA	1
D3, D4, D5, D6, D7	SMBJ36A-13-F	Diode, TVS, Uni, 36 V, 58.1 Vc, SMB	SMB	5
FID1, FID2, FID3, FID4, FID5, FID6	CMP-0077181-1	Fiducial mark. There is nothing to buy or mount.	Fiducial10-30	6
GND, OUT1, OUT2, OUT3, OUT4, VS	108-0740-001	Standard Banana Jack, Uninsulated, 15A	Johnson_108-0740-001	6
H1, H2, H3, H4	NY PMS 440 0025 PH	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	4
H5, H6, H7, H8	CMP-0003610-1	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone_1902C	4
J1	LDO_VBB	Header, 100mil, 2x1, Tin, TH	CONN_90120-0122	1
J2	LDO_PWR	Header, 100mil, 2x1, Tin, TH	CONN_90120-0122	1
J3	J_THER	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J4	J_DIAG_EN	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J5	J_SEH	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J6	J_SEL	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J7	J_EN1	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J8	J_EN2	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J9	J_EN3	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J10	J_EN4	Header, 100mil, 3x1, Tin, TH	TE_5-146278-3	1
J11	GND_BYPASS	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	1
J12	OUT1_DIODE	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	1
J13	OUT2_DIODE	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	1
J14	OUT3_DIODE	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	1
J15	OUT4_DIODE	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	1
R1, R2, R3, R5, R7, R10, R13, R14, R17, R18, R21, R23, R26	CMP-0021998-4	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	13
R8, R28, R29, R30, R31	PMR10EZPJ000	RES, 0, 0%, W, AEC-Q200 Grade 0, 0805	0805_HV	5
R9	CMP-0020951-3	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805_HV	1
R32	TNPW08052K00BEEA	RES, 2.00 k, 0.1%, 0.2 W, AEC-Q200 Grade 0, 0805	0805_HV	1
R33	RG2012P-102-B-T5	RES, 1.00 k, 0.1%, 0.125 W, 0805	0805_HV	1
R34	CRCW060310K0FKEA	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	1
R35	ERJ-P06F1001V	RES, 1.00 k, 1%, 0.25 W, 0805	0805_HV	1
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	SNT-100-BK-G	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	15
TP1	OUT1_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP2	OUT2_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP3	OUT3_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP4	OUT4_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP5	EN1_S	Test Point, Multipurpose, Red, TH	Keystone5010	1

**Table 1. Bill of Materials (continued)**

Designator	Comment	Description	Footprint	Quantity
TP6	EN2_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP7	EN3_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP8	EN4_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP9	THER_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP10	DIAG_EN_S	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP11	LDO_VS	Test Point, Multipurpose, Red, TH	Keystone5010	1
TP12	EN1	Test Point, Multipurpose, White, TH	Keystone5012	1
TP13	EN2	Test Point, Multipurpose, White, TH	Keystone5012	1
TP14	EN3	Test Point, Multipurpose, White, TH	Keystone5012	1
TP15	EN4	Test Point, Multipurpose, White, TH	Keystone5012	1
TP16	THER	Test Point, Multipurpose, White, TH	Keystone5012	1
TP17	DIAG_EN	Test Point, Multipurpose, White, TH	Keystone5012	1
TP19	SEH/ST1	Test Point, Multipurpose, White, TH	Keystone5012	1
TP21	SEL/ST2	Test Point, Multipurpose, White, TH	Keystone5012	1
TP22	CL	Test Point, Multipurpose, White, TH	Keystone5012	1
TP23	FAULT/ST3	Test Point, Multipurpose, White, TH	Keystone5012	1
TP25	CS/ST4	Test Point, Multipurpose, White, TH	Keystone5012	1
TP26, TP27, TP28	GND	Test Point, Multipurpose, Black, TH	Keystone5011	3
U1	TPS274160B	TPS274160B, RHF0028A (VQFN-28)	RHF0028A	1
U2	TPS7A1650DGNT	60V, 5uA Iq, 100mA Low-Dropout (LDO) Voltage Regulator With Enable and Power Good, DGN0008C (VSSOP-8)	DGN0008C_N	1

## Revision History

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

<b>Changes from Original (April 2020) to A Revision</b>	<b>Page</b>
• Changed 4V-48V to 5 V-36 V.....	2
• Changed schematic image.....	3
• Changed J12, J13, J14, and J15 descriptions .....	5
• Changed Figures 2-5 .....	6
• Changed SMBJ40A-13-F to SMBJ36A-13-F .....	11
• Changed Diode,TVS,Uni, 40 V, 64.5Vc, SMB to Diode, TVS, Uni, 36 V, 58.1 Vc, SMB .....	11

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