

EVM User's Guide: TPS281C100EVM

TPS281C100 Evaluation Module

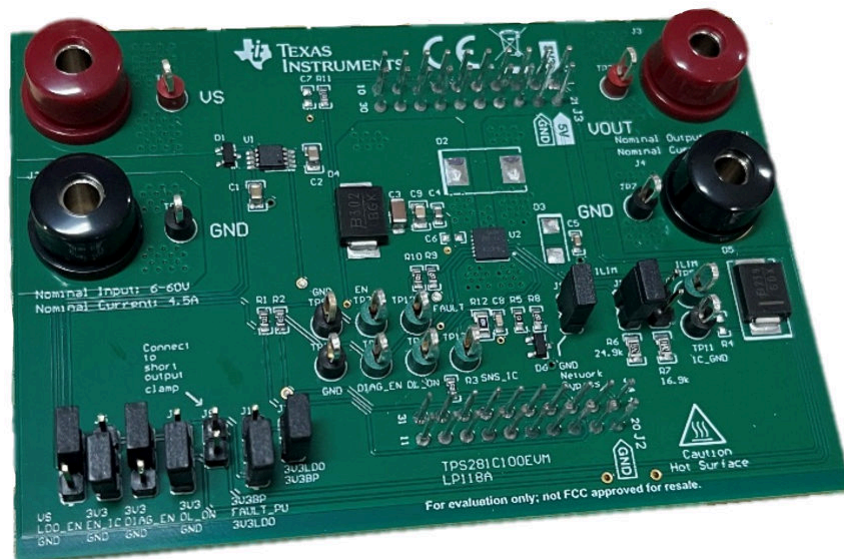


Description

The TPS281C100EVM is a hardware evaluation module (EVM) used to enable hardware engineers to evaluate the full performance and functionality of the TPS281C100 industrial high side switch. The TPS281C100EVM contains everything needed to test and assess the TPS281C100 before designing 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™ plug-in module headers. A wide range of application features such as digital output module, safe torque off (STO), and holding brake are enabled and visible through use of this evaluation module. This EVM is populated with the QFN version of TPS281C100.

Features

- Configurable current limit with fixed resistors
- Configurable current sense with fixed resistor
- BoosterPack plug-in module headers allowing power switch to be controlled by external microcontroller
- On-board 3.3-V LDO allowing for control signals to be manipulated by a set of jumpers
- Good board layout and copper area for thermal performance
- Jumper at the output to support different clamp configurations for inductive discharge
- Optional footprint to populate TVS diode for VDS clamp for faster inductive discharge



1 Evaluation Module Overview

1.1 Introduction

The Texas Instruments TPS281C100EVM is an evaluation module that is used to demonstrate and showcase all of the features of the underlying TPS281C100 industrial high side switch. This evaluation board provides a seamless way to connect a set of power supplies to the inputs of the TPS281C100, 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 TPS281C100 and easily assert and deassert logic signals by the use of a set of external hardware jumpers. Additionally, this EVM includes BoosterPack plug-in module headers allowing the user to easily connect the TPS281C100 high side switch to an underlying microcontroller and write software to control and configure the device.

1.2 Kit Contents

[Table 1-1](#) lists the contents of the EVM kit. Contact the Texas Instruments Product Information Center nearest if any component is missing.

Table 1-1. Kit Contents

Item	Quantity
TPS281C100EVM	1

1.3 Specification

The TPS281C100EVM is compatible with both the TPS281C100A and TPS281C100B device versions. [Table 1-2](#) shows the comparison across different device versions. Please note the TPS281C100EVM supports both versions, but has TPS281C100A populated. To evaluate the TPS281C100B, the TPS281C100A (U2) device has to be removed and the TPS281C100B device soldered down. Please refer to the device data sheet for more detailed specifications.

Table 1-2. Device Comparison

DEVICE VERSION	PART NUMBER	CURRENT LIMIT RANGE	INTEGRATED CLAMP FOR INDUCTIVE LOADS	INRUSH CURRENT PERIOD
A	TPS281C100A	1 A to 5 A (fixed 0.5A with ILIM short to GND)	Yes	Yes
B	TPS281C100B	1 A to 5 A (fixed 0.5A with ILIM short to GND)	Yes	No

1.4 Device Information

The TPS281C100 is a single channel smart high-side switch designed to meet the requirements of industrial control systems. The low RON(100 mΩ) minimizes device power dissipation, driving a wide range of output load current up to 4.5-A DC and the 60-V DC operation range improves system robustness.

The TPS281C100 device integrates protection features such as thermal shut down, output clamp, and current limit. These features improve system robustness during fault events such as short circuit. TPS281C100 implements an adjustable current limiting circuit that improves the reliability of the system by reducing inrush current when driving large capacitive loads and minimizing overload current. To drive high inrush current loads such as lamps or fast charging capacitive loads, TPS281C100 implements an inrush current time period with a higher level of allowed current.

The device also provides an accurate load current sense that allows for improved load diagnostics such as overload and open-load detection enabling better predictive maintenance.

Table 1-3. Device Information

Part Number	Package	Body Size (nom)
TPS281C100A	QFN (12)	4 mm × 4 mm

2 Hardware

2.1 BoosterPack™ Plug-in Module Operation

While the TPS281C100EVM can be used as a standalone evaluation board without the need of any external microcontroller, the EVM also comes populated with [BoosterPack plug-in module headers \(J15, J16\)](#) to enable easy interface with a Texas Instruments microcontroller. Additionally, by populating jumper *J14* the user has the ability to power the underlying LaunchPad™ development kit through the integrated 3.3-V LDO on the TPS281C100EVM. A list of pins connected to the BoosterPack plug-in module header can be seen below in [Table 2-1](#):

Table 2-1. Connected BoosterPack Plug-in Module Header Pins on TPS281C100EVM

BoosterPack Plug-in Module Pin	Function	Note
1	3.3-V power rail	Disconnect <i>J14</i> if powering LaunchPad development kit through USB.
5	FLT pin used to detect faults	Open drain input. Pullup source can be controlled using jumper <i>J12</i> .
6	Current sense output from IC	Current sense resistor is R12
38	Configure DIAG_EN	Make sure <i>J7</i> is not populated if using microcontroller output.
39	Configure EN_IC	Make sure <i>J6</i> is not populated if using microcontroller output.
40	Configure OL_IC	Make sure <i>J8</i> is not populated if using microcontroller output.

Note that for all IO and analog signals being attached to the BoosterPack plug-in module, the relevant 10-kΩ protection resistors are populated in series with the pin for reverse current protection.

To power the attached LaunchPad development kit from the on-board LDO of the TPS281C100EVM, connect the jumper *J14*. Note that this feeds the output of the 3.3-V LDO on the TPS281C100EVM into the 3.3-V rail on the LaunchPad development kit. If there is another power supply trying to power the LaunchPad development kit (such as the integrated USB power on the LaunchPad development kit itself), this can potentially cause issues with the separate power sources fighting for contention.

Jumpers *J6 through J8* are used to manually configure the control signals going into the TPS281C100. When using a microcontroller to control these signals, these jumpers must be unpopulated to allow for the microcontroller to drive them high or low.

For correct and accurate current sense, the maximum voltage out on the SNS pin is clamped to V_{SNSFH} internally, so there is no need for external clamp.

2.2 Connection Descriptions

[Table 2-2](#) shows the test points populated on the board as well as the signal connectors.

Table 2-2. Connections and Test Points

Connector and Test Point	Description
J1, TP1	Supply voltage VS
J3, TP2	Output voltage VOUT
J2, J4, TP7-TP10	System GND
TP3	ENABLE test point
TP4	DIAG_EN test point
TP5	ILIM test point
TP6	OL_ON test point
TP11	GND_IC test point
TP12	FAULT test point
TP13	SNS_IC test point

Table 2-3 shows the relevant configuration jumpers of the TPS281C100EVM as well as the associated values. Please refer to the TPS281C100 data sheet for detailed information on each pin's functionality.

Please note that a white mark on the jumper silkscreen is reflecting the position 1 of the jumper.

Table 2-3. Jumper Configurations

Jumper	Function, Settings
J5	Connect 1 and 2 to disable on-board LDO; connect 2 and 3 to enable on-board LDO.
J6	Connect 1 and 2 to pull ENABLE high using the on-board LDO; connect 2 and 3 to pull ENABLE low.
J7	Connect 1 and 2 to pull DIAG_EN high; connect 2 and 3 to pull DIAG_EN low.
J8	Connect 1 and 2 to pull OL_ON high; connect 2 and 3 to pull OL_ON low.
J9	Connect to keep output at 0 V during inductive turn-off; disconnect for TVS clamp to clamp the output (default to -10 V) during inductive turn-off.
J10	Connect the 24.9 k Ω resistor to ILIM pin. Resistor is paralleled if J11 is also connected.
J11	Connect the 16.9 k Ω resistor to ILIM pin. Resistor is paralleled if J10 is also connected.
J12	Connect 1 and 2 to use LDO for FAULT pullup; connect 2 and 3 to use BoosterPack plug-in module 3.3 V for FAULT pullup.
J13	Connect to bypass GND network. Disconnect to use GND network.
J14	Connect to power the BoosterPack plug-in module with LDO.

2.3 Best Practices



CAUTION

Hot surface. Contact can cause burns. Do not touch!

3 Hardware Design Files

3.1 Schematic

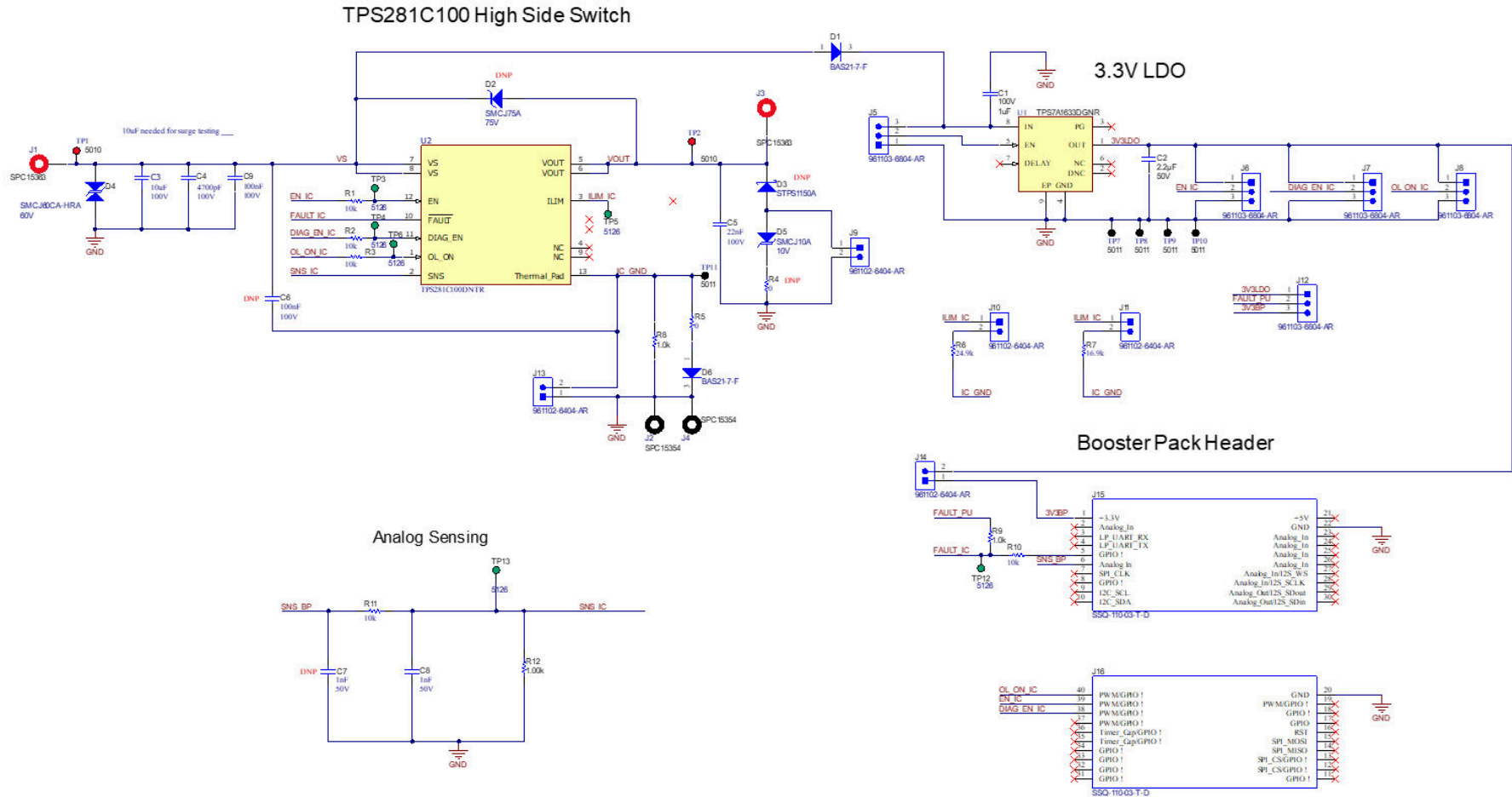


Figure 3-1. TPS281C100EVM Schematic Drawing

3.2 PCB Layouts

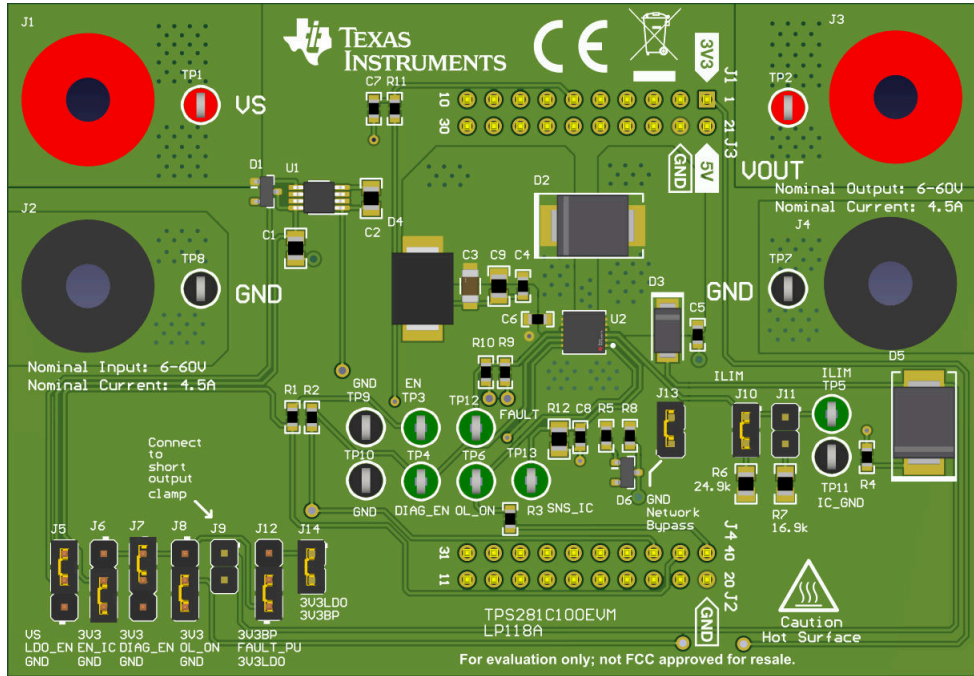


Figure 3-2. 3D Representation

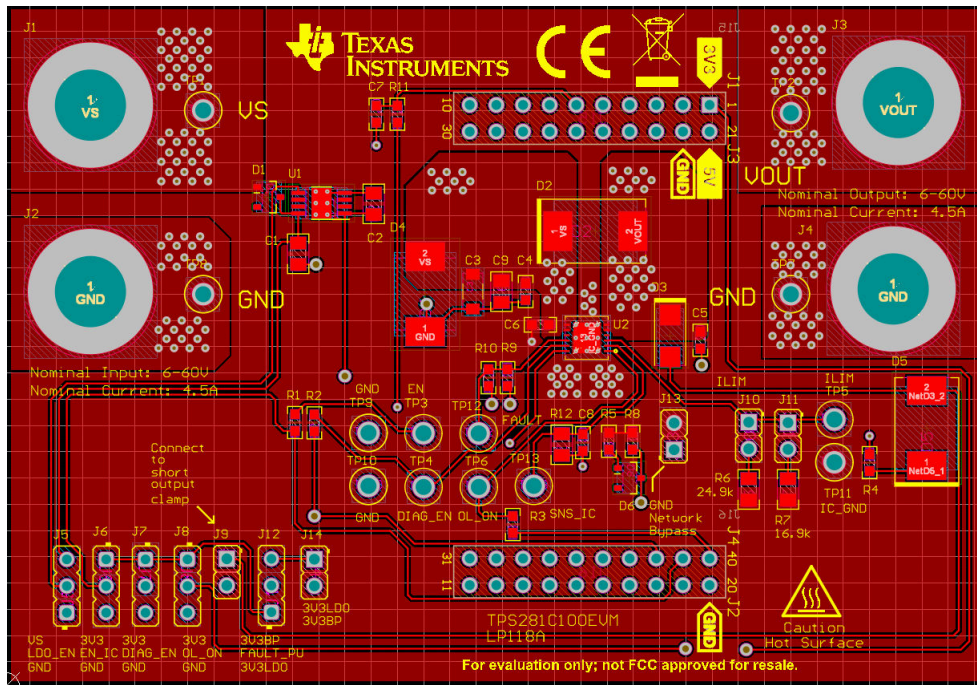


Figure 3-3. Top Layer

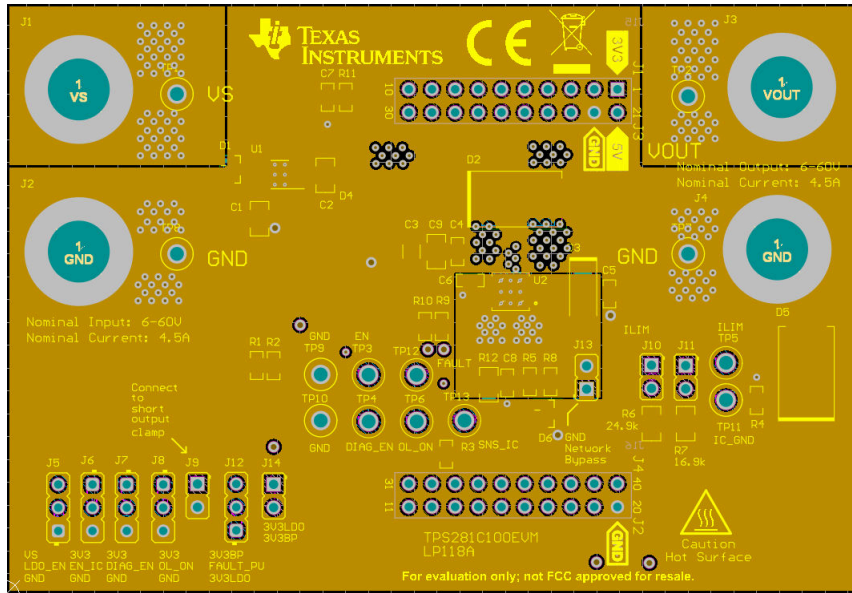


Figure 3-4. Ground Layer

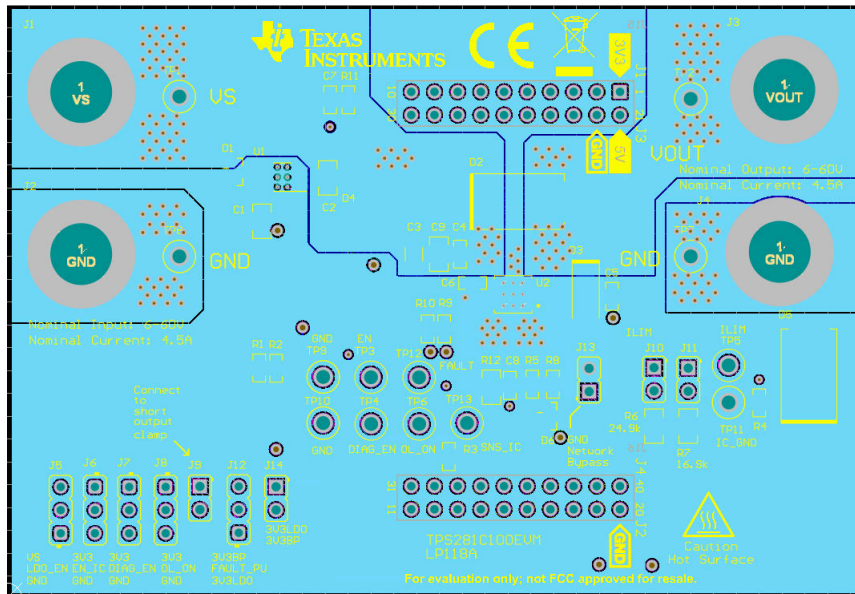


Figure 3-5. Power Layer

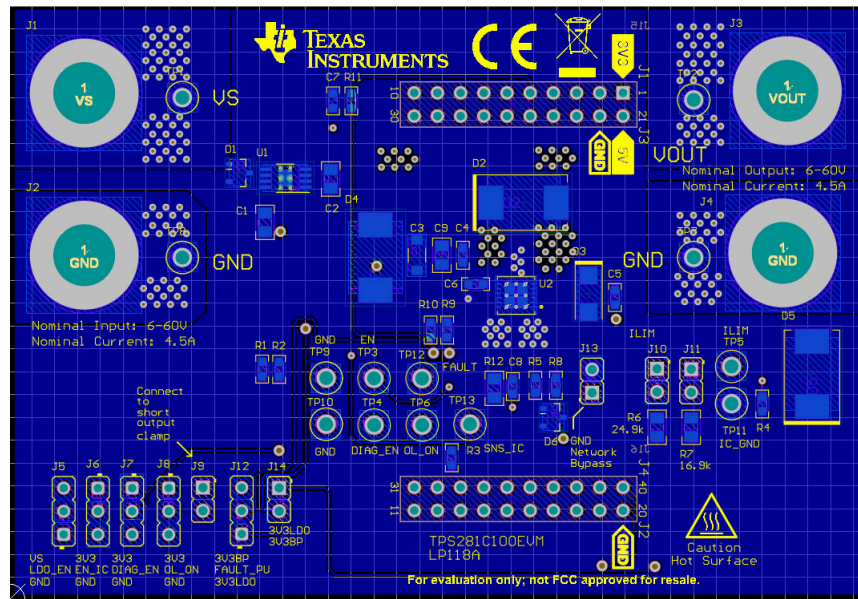


Figure 3-6. Bottom Layer

3.3 Bill of Materials

The table below lists the TPS281C100 Bill of Materials.

Table 3-1. TPS281C100 Bill of Materials

Designator	Description	Part Number	Manufacturer
C1	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	CGA4J3X7S2A105K125AB	TDK
C2	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J3X7R1H225K125AB	TDK
C3	10 μ F \pm 10% 100 V Ceramic Capacitor X6S 1206 (3216 Metric)	C3216X6S2A106K160AC	TDK
C4	CAP, CERM, 4700 pF, 100 V, +/- 5%, C0G/NP0, 0603	C0603C472J1GAC7867	Kemet
C5	CAP, CERM, 0.022 uF, 100 V, +/- 10%, X7R, 0603	C1608X7R2A223K080AA	TDK
C8	CAP, CERM, 1000 pF, 50 V, +/- 5%, X7R, AEC-Q200 Grade 1, 0603	C0603C102J5RACAUTO	Kemet
C9	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J2X7R2A104K125AA	TDK
D1, D6	Diode, Switching, 200 V, 0.2 A, SOT-23	BAS21-7-F	Diodes Inc.
D4	Diode, TVS, Bi, 60 V, 96.8 Vc, SMC (no polarity)	SMCJ60CA-HRA	Littelfuse
D5	Diode, TVS, Uni, 10 V, SMC	SMCJ10A	Bourns
J1, J3	BANANA JACK, SOLDER LUG, RED, TH	SPC15363	Tenma
J2, J4	BANANA JACK, SOLDER LUG, BLACK, TH	SPC15354	Tenma
J5, J6, J7, J8, J12	Header, 2.54mm, 3x1, Gold, TH	961103-6804-AR	3M
J9, J10, J11, J13, J14	Header, 2.54mm, 2x1, TH	961102-6404-AR	3M
J15, J16	Receptacle, 2.54mm, 10x2, Tin, TH	SSQ-110-03-T-D	Samtec
R1, R2, R3, R10, R11	RES, 10 k, 5%, 0.1 W, 0603	RC0603JR-0710KL	Yageo
R5	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R6	RES, 24.9 k, 0.5%, 0.1 W, 0805	RR1220P-2492-D-M	Susumu Co Ltd
R7	RES, 16.9 k, 0.5%, 0.1 W, 0805	RR1220P-1692-D-M	Susumu Co Ltd
R8, R9	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	RCA06031K00JNEA	Vishay-Dale
R12	RES, 1.00 k, 1%, 0.25 W, 0805	ERJ-P06F1001V	Panasonic
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP2	Test Point, Multipurpose, Red, TH	5010	Keystone
TP3, TP4, TP5, TP6, TP12, TP13	Test Point, Multipurpose, Green, TH	5126	Keystone
TP7, TP8, TP9, TP10, TP11	Test Point, Multipurpose, Black, TH	5011	Keystone

Table 3-1. TPS281C100 Bill of Materials (continued)

Designator	Description	Part Number	Manufacturer
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)	TPS7A1633DGNR	Texas Instruments
U2	60-V, 100-mΩ, Single-Channel Smart High-Side Switch	TPS281C100DNTR	Texas Instruments

4 Additional Information

Trademarks

BoosterPack™ and LaunchPad™ are trademarks of Texas Instruments.
All trademarks are the property of their respective owners.

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 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
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 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
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 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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- 4 *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
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