

EVM User's Guide: TPS1HTC100EVM

TPS1HTC100-Q1 Evaluation Module



Description

The TPS1HTC100EVM is a hardware evaluation module (EVM) used to enable hardware engineers to evaluate the full performance and functionality of the TPS1HTC100-Q1 automotive high side switch. This evaluation board provides a seamless way to connect a power supply to the input of the TPS1HTC100-Q1, connect a load to the output channel, and switch on and off the device using the control pins of the chip itself. The device integrates protection features such as thermal shut down, output clamp, and current limit.

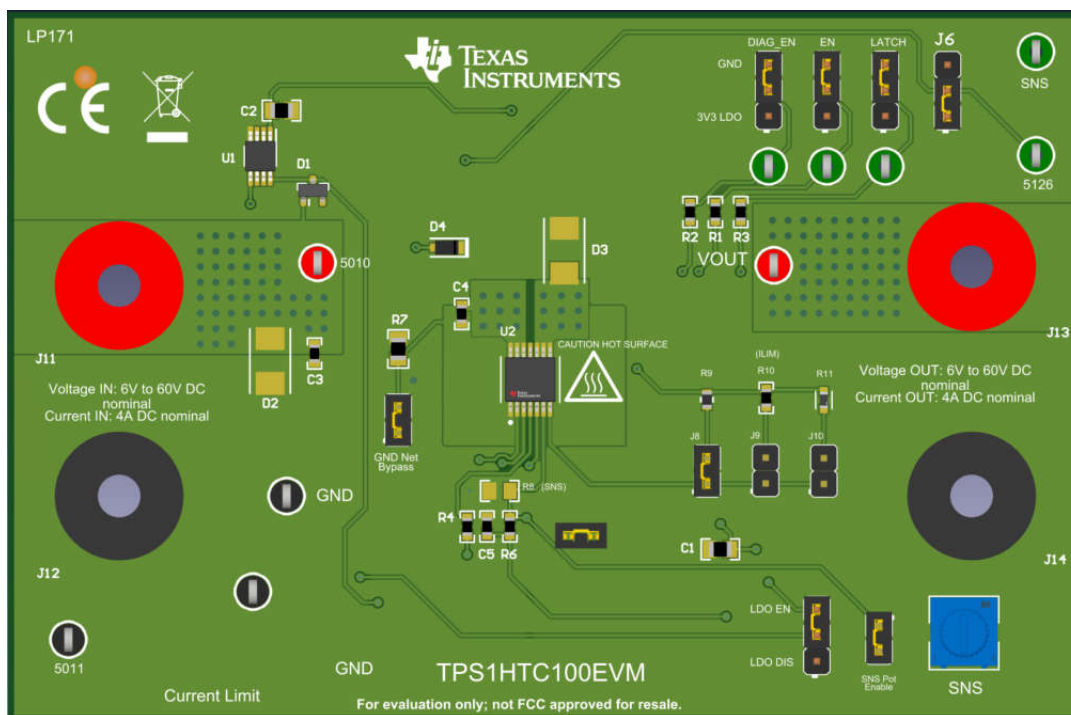
Features

- Standalone operation with standard bench equipment
- Wide operating voltage range: 6V to 60V
- 64V DC tolerance when disabled
- Low RON : 83mΩ typ, 180mΩ max
- Potentiometer for SNS resistor, allowing for easy configuration of external resistance values

- Improve system level reliability through adjustable current limiting: current limit 1A–7.3A
- Accurate Current Sensing: $\pm 5\%$ at 1A in standard mode
- Integrated inductive discharge clamp $>70V$
- Low standby current of $<0.5\mu A$
- Low quiescent current (I_q) of $<2mA$
- Functional safety capable
- Operating junction temperature, -40 to $125^\circ C$
- Input control 1.8V, 3.3V, and 5V logic compatible
- Integrated fault sense voltage scaling for ADC protection
- Open-load detection in off-state
- Thermal shutdown/swing detection
- 14-pin Thermally-enhanced HTSSOP package

Applications

- General resistive, inductive, and capacitive loads



3D View - Top

1 Evaluation Module Overview

1.1 Introduction

The TPS1HTC100EVM contains everything needed to test and assess the TPS1HTC100-Q1 before designing into part of a greater application power system. The evaluation module is designed to either be used as a standalone board with an attached voltage supply and output load. A wide range of application features such as current sensing, programmable current limiting, and transient suppression are enabled and visible through use of this evaluation module. Please place the module on a non-conductive surface before operation.

CAUTION



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

1.2 Kit Contents

Each evaluation module kit contains the following items:

- 1x TPS1HTC100EVM
- 1x EVM Disclaimer Read Me

1.3 Specification

The Texas Instruments' TPS1HTC100EVM is an evaluation module that is used to demonstrate and showcase all of the features of the underlying TPS1HTC100-Q1 automotive high side switch. An onboard 3.3V LDO is included on the EVM to simplify controlling signals to the TPS1HTC100-Q1 and easily assert and deassert logic signals by the use of a set of external hardware jumpers.

Features of the TPS1HTC100EVM include:

- Current limit options with selectable resistors
- Depopulated pads for custom configuration for SNS
- Onboard 3.3V LDO, allowing for control signals to be manipulated by set of jumpers
- Four-layer 2oz board layout and copper area for thermal performance
- Optional footprints for input TVS diodes to extend transient protection of the device

1.4 Device Information

TPS1HTC100-Q1

This device is the device under evaluation by using this EVM. TPS1HTC100-Q1 is a single channel smart high-side switch designed to meet the requirements of 24V automotive battery systems. The 83mΩ RON minimizes device power dissipation driving a wide range of output load current up to 4A DC and the 60V DC tolerance improves system robustness.

These features improve system robustness during fault events such as short circuit. TPS1HTC100-Q1 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, TPS1HTC100-Q1 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.

TPS1HTC100-Q1 is available in a small 14-pin, 5.0mm × 6.4mm HTSSOP leaded package with 0.65mm pin pitch minimizing the PCB footprint.

TPS7A1633

This LDO is used to provide an onboard 3.3V rail for easy use of the EVM out of the box.

2 Hardware

2.1 Connections and Test Points

Most connectors and test points are labeled with their functional names on the silk screen of the PCB and the actual component names are omitted to avoid clutter on the silk screen of the EVM. Likewise, jumpers are labeled to be self explanatory. The following tables contain a description of each test point and purpose.

Note, that by default the TPS1HTC100EVM comes configured for standalone operation.

Table 2-1. Connections and Test Points

Connector or Test Point	Description
J11, VBB test points	VBB input (supply).
J13, VOUT test points	VOUT output (from device).
J12, J14, GND test points	Ground connection (system ground).
DIAG_EN	Enable and disable diagnostics on the TPS1HTC100-Q1.
EN	Enable line for the TPS1HTC100-Q1.
LATCH	Controls latch functionality for the TPS1HTC100-Q1.
SNS	Current sense test point for the current sense output of the TPS1HTC100-Q1.
FAULT	Open-drain fault test point for the TPS1HTC100-Q1. Pullup source can be set to LDO using J6.

2.2 Jumper Information

Table 2-2. Jumper Configurations

Jumper	Function, Setting
J8, J9, J10	These jumpers are used to select the ILIM setting for the device. R9 select 10k, R10 selects 16.7k, and R11 selects 50k.
SNS pot enable	Enables the physical "SNS" potentiometer connected to the current sense output of the TPS1HTC100-Q1. Not populating this jumper defaults to the solder down pad, R8.
LDO_EN / LDO_DIS	Enables and disables the onboard 3.3V LDO.
J6 (fault pullup)	Configures where the fault pin is pulled up from. This jumper is either from the 3.3V LDO or GND.
DIAG_EN	Connects the TPS1HTC100-Q1's DIAG_EN signal to either the LDO 3.3V signal or ground.
EN	Connects the TPS1HTC100-Q1 EN signal to either the LDO 3.3V signal or ground.
LATCH	Connects the TPS1HTC100-Q1 LATCH signal to either the LDO 3.3V signal or ground.
GND net bypass	Bypasses the resistor and diode ground network and connects IC ground to system ground.

2.3 Current Limit and Current Sense Configuration

The current limit resistor connected to the ILIM pin configures the current limit of the TPS1HTC100-Q1 device. Based off the limit of this resistor, the allowed current that passes through the high side switch can be controlled. The TPS1HTC100EVM provides three different ways of configuring the effective value of the resistance on the ILIM pin:

- Connecting J8 for 10.0k Ω
- Connecting J9 for 16.7k Ω
- Connecting J10 for 50k Ω

See the [Section 2.2](#) for details on how to configure each one of these jumpers.

For the current sense resistance connected to the SNS pin, the *SNS Pot Enable* jumper controls the source. If this jumper is populated, then the SNS potentiometer is used to increase and decrease the resistance connected to the SNS pin. If this jumper is not populated, then the solder down pad, R8, must be used to provide the necessary resistance value. The output of the SNS pin of TPS1HTC100-Q1 is an analog current that is a representation of the load current going through the switch. The purpose of the sense resistor is to convert this current into a voltage so that an ADC can convert into a value for a microcontroller to use. For the TPS1HTC100EVM, the voltage across the sense resistor can either be read externally through the SNS test point.

2.4 Transient Protection

The TPS1HTC100EVM 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 TPS1HTC100-Q1. Refer to the TPS1HTC100-Q1 data sheet for more information about the internal protections that the device provides.

The TPS1HTC100EVM provides the following transient protection features:

- Input TVS diode on VS (D2) to protect against upstream power events (not populated)
- Optional external inductive load turn-off diode footprints on D3 to provide a mechanism to discharge an inductive load if the internal clamp is not adequate (not populated)

3 Hardware Design Files

3.1 Schematic

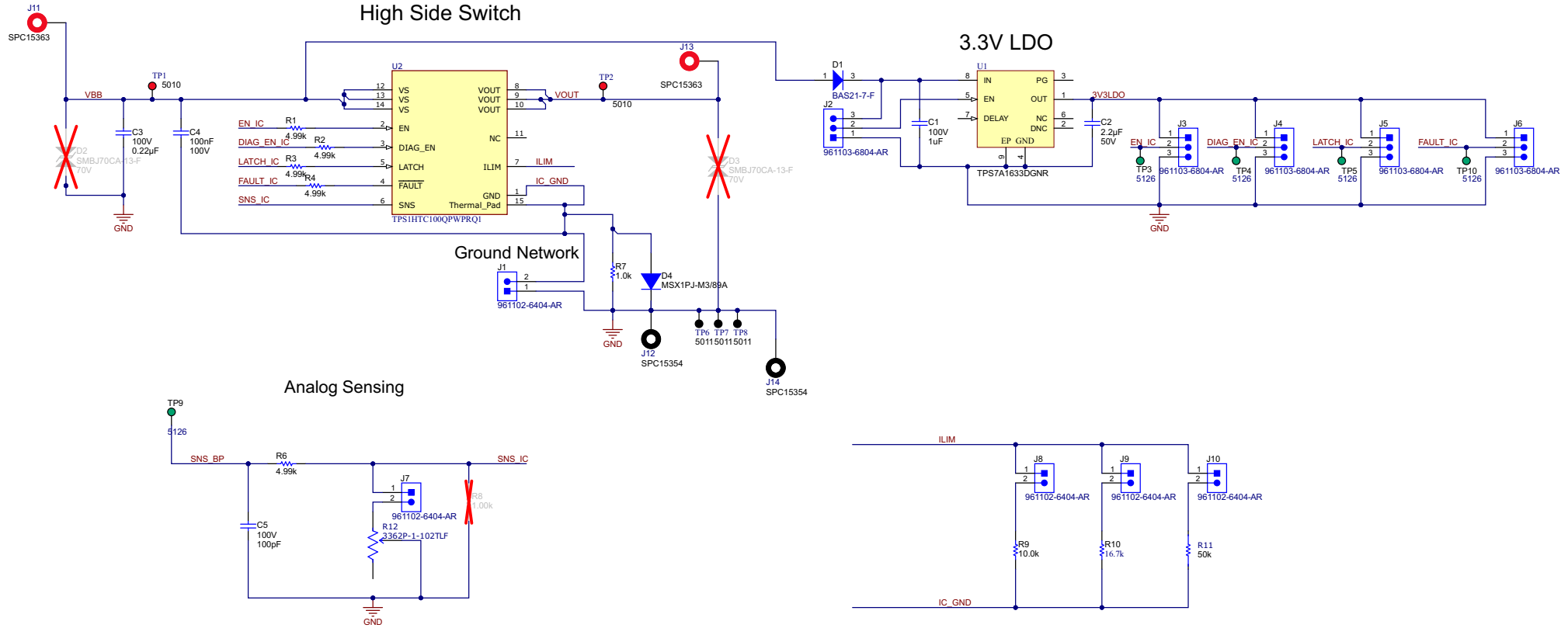


Figure 3-1. TPS1HTC100EVM Schematic

3.2 PCB Layouts

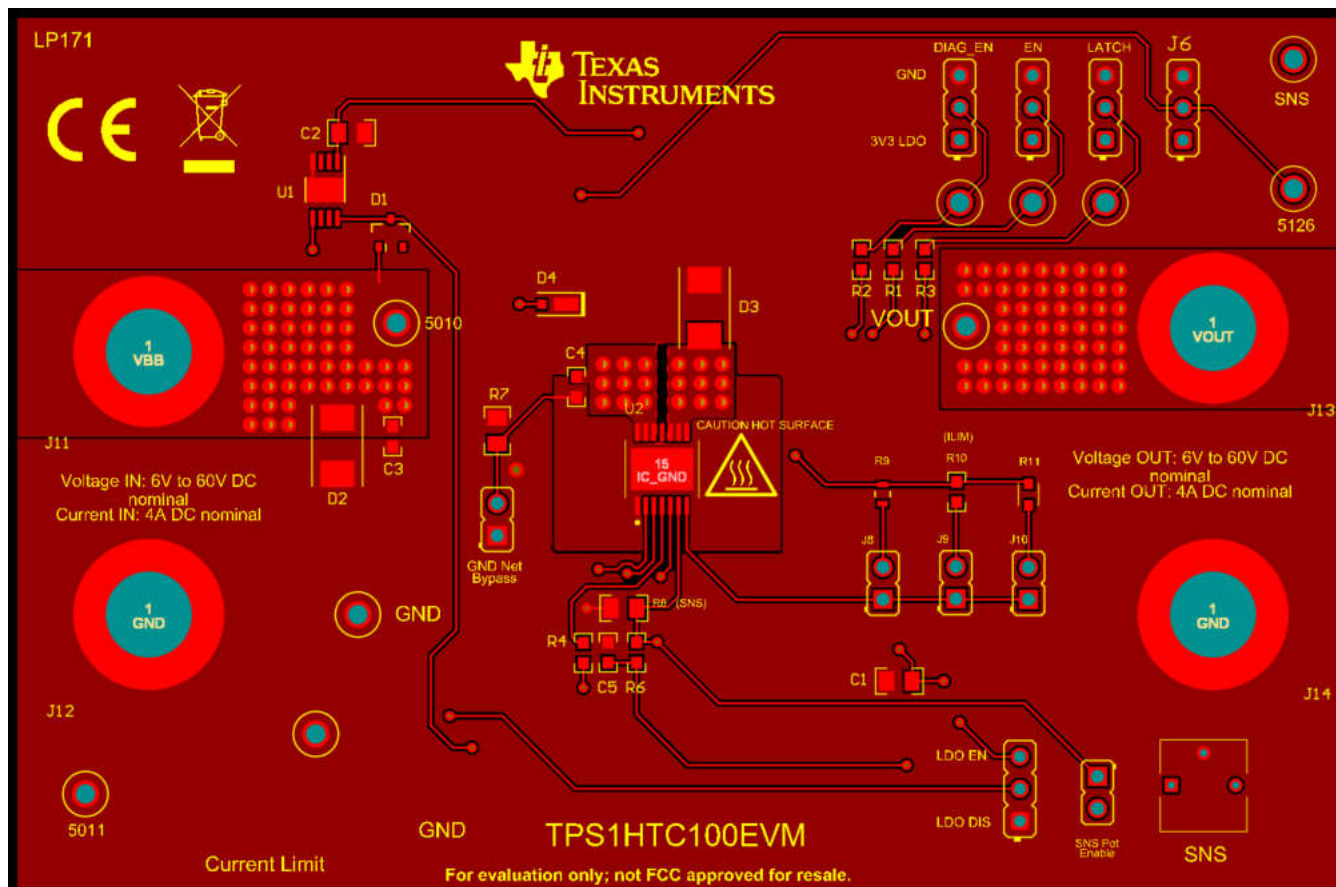


Figure 3-2. Top Layer

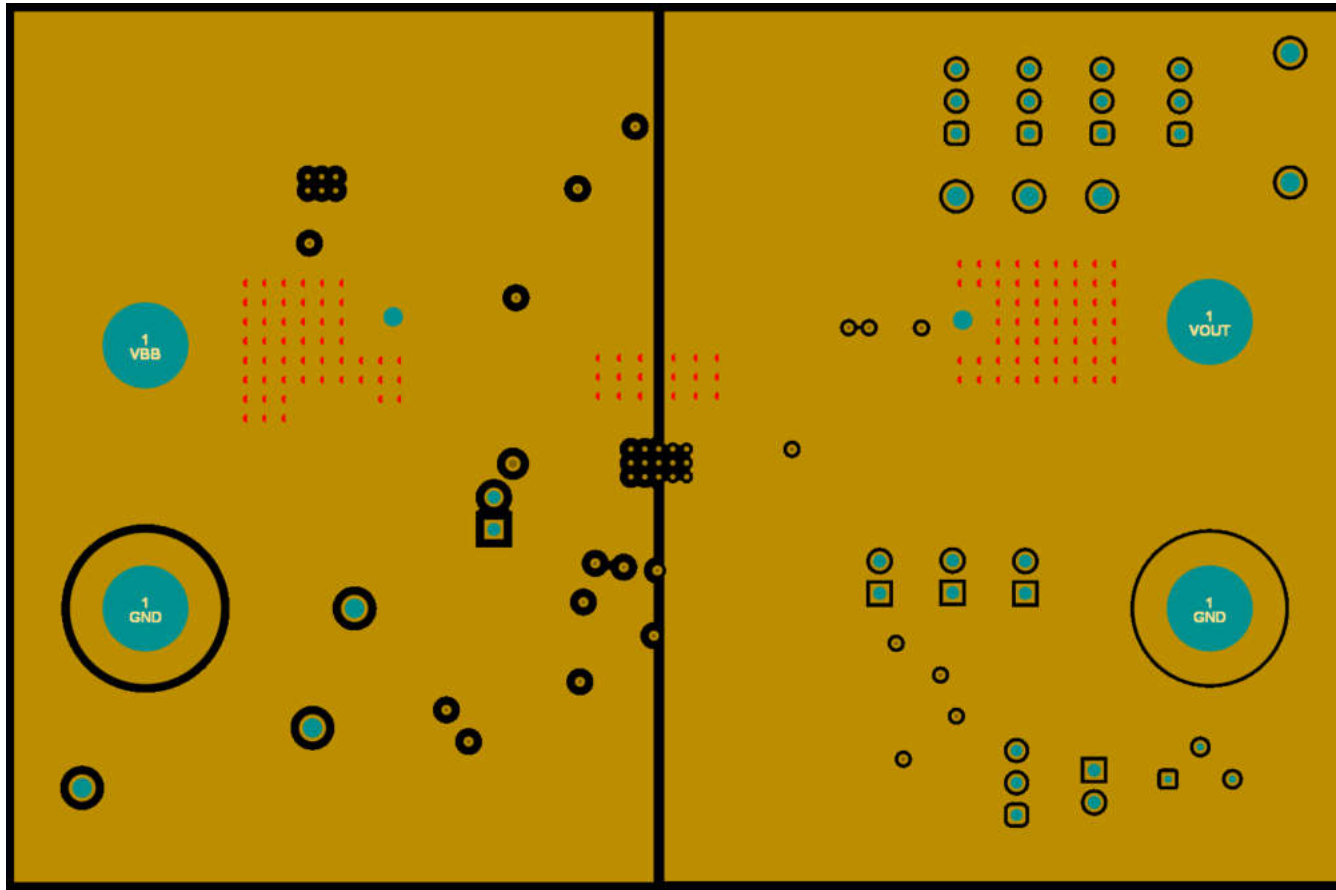


Figure 3-3. Power Layer

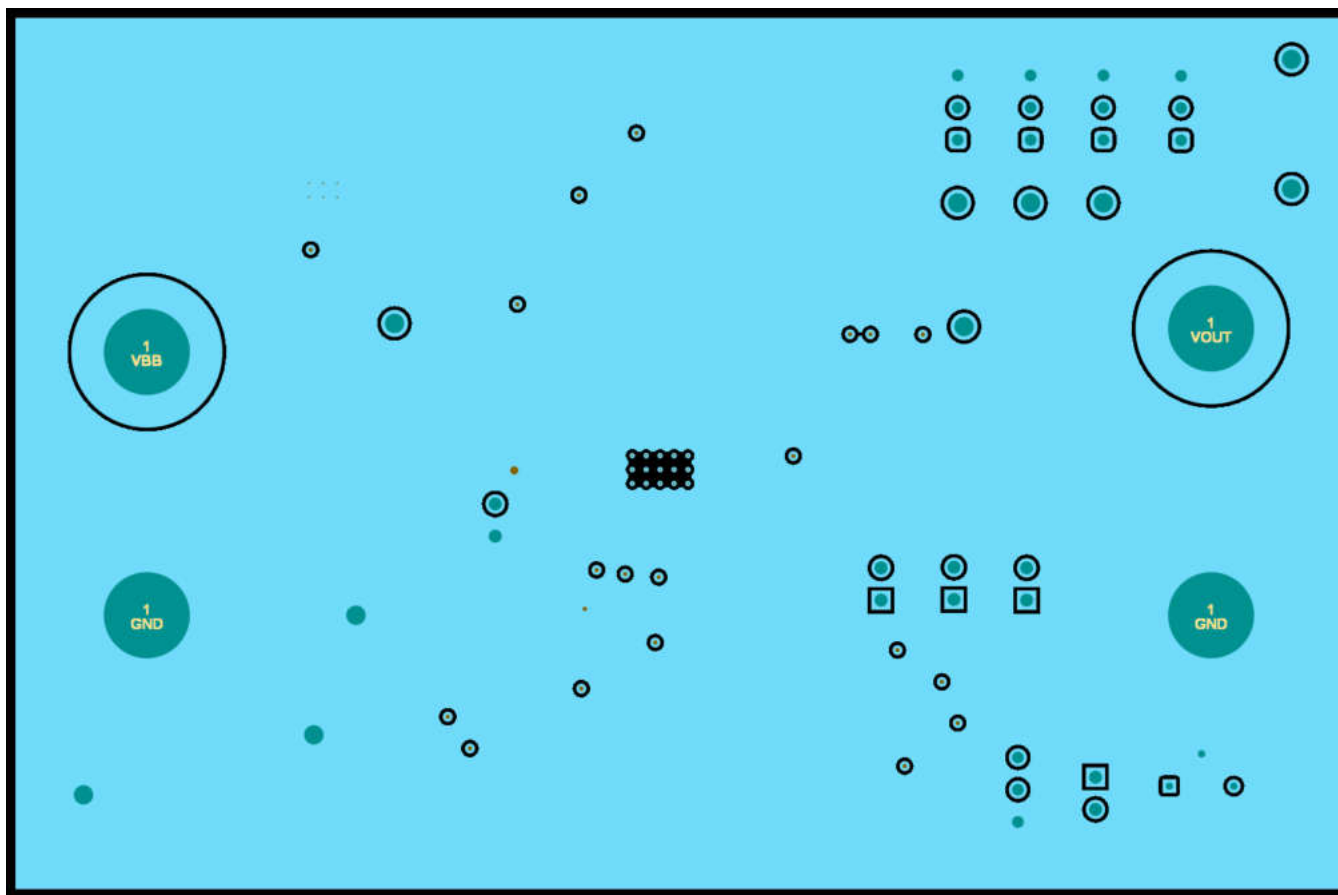


Figure 3-4. Ground Layer

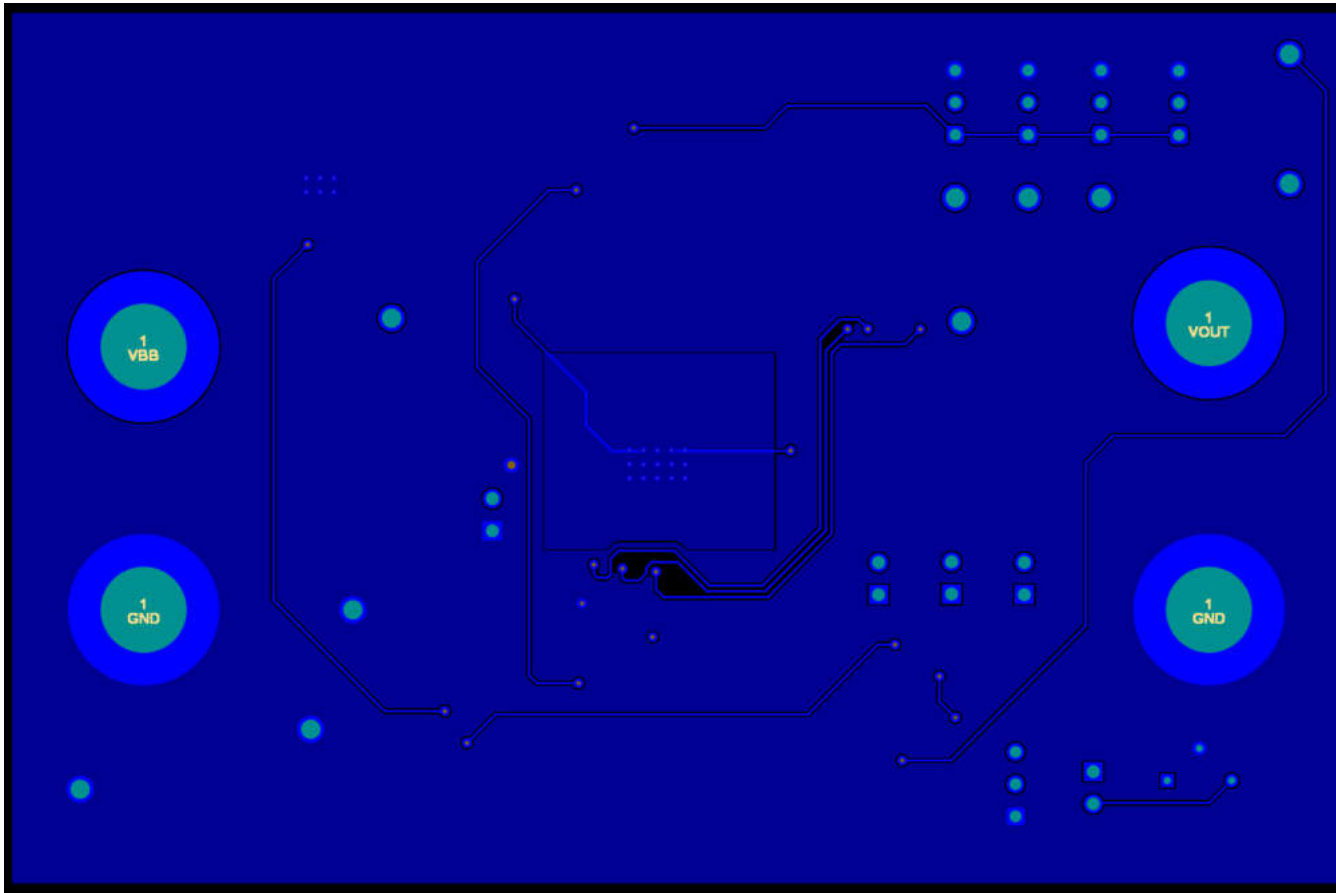


Figure 3-5. Bottom Layer

3.3 Bill Of Materials

Table 3-1 lists the bill of materials.

Table 3-1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	PartNumber	Manufacturer
C1	1	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7S2A105K125A B	TDK
C2	1	2.2uF	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J3X7R1H225K125 AB	TDK
C3	1	0.22uF	CAP, CERM, 0.22 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603	0603	HMK107C7224KAHTE	Taiyo Yuden
C4	1	0.1uF	CAP, CERM, 0.1 uF, VAC/100 VDC, +/- 20%, X7R, AEC-Q200 Grade 1, 0603	0603	HMK107B7104MAHT	Taiyo Yuden
C5	1	100 pF	CAP, CERM, 100 pF, 100 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	GCM1885C2A101JA16D	MuRata
D1	1	200 V	Diode, Switching, 200 V, 0.2 A, SOT-23	SOT-23	BAS21-7-F	Diodes Inc.
D4	1	600 V	Diode, Standard Recovery Rectifier, 600 V, 1 A, MicroSMP	MicroSMP	MSX1PJ-M3/89A	Vishay-Semiconductor
J1, J7, J8, J9, J10	5		Header, 2.54mm, 2x1, TH	Header, 2.54mm, 2x1, TH	961102-6404-AR	3M
J2, J3, J4, J5, J6	5		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	961103-6804-AR	3M
J11, J13	2		BANANA JACK, SOLDER LUG, RED, TH	Red Insulated Banana Jack	SPC15363	Tenma
J12, J14	2		BANANA JACK, SOLDER LUG, BLACK, TH	Black Insulated Banana Jack	SPC15354	Tenma
R1, R2, R3, R4, R6	5	4.99k	RES, 4.99 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K99FKEA	Vishay-Dale
R7	1	1.0k	RES, 1.0 k, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEYJ102V	Panasonic
R9	1	10.0k	RES, 10.0 k, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW060310K0BEEA	Vishay-Dale
R10	1	16.7k	RES, 16.7k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0716K7L	Yageo America
R11	1	50k	High Precision-High Stability Chip Resistor Thin Film 0603 50kOhm 0.1% Paper T/R	0603	RT0603BRD0750KL	Yageo
R12	1	1k	1 kOhms 0.5W, 1/2W PC Pins Through Hole Trimmer Potentiometer Cermet 1 Turn Top Finger Adjustment	PTH_POT_6MM6_6MM99	3362P-1-102TLF	Bourns

Table 3-1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	PartNumber	Manufacturer
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP2	2		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3, TP4, TP5, TP9, TP10	5		Test Point, Multipurpose, Green, TH	Green Multipurpose Testpoint	5126	Keystone
TP6, TP7, TP8	3		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		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	1		30-mΩ, 24-V, 6-A Single-Channel Automotive Smart High-Side Switch	HTSSOP14	TPS1HTC100QPWPRQ1	Texas Instruments
D2, D3	0	70 V	Diode, TVS, Bi, 70 V, SMB	SMB	SMBJ70CA-13-F	Diodes Inc.
R8	0	1.00k	RES, 1.00 k, 1%, 0.25 W, 0805	0805	ERJ-P06F1001V	Panasonic
R11	0	59.0k	RES, 59.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF5902V	Panasonic

4 Additional Information

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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.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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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.

-
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.
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