

TPS61290x Boost Converter With Bypass Mode Evaluation Module



Description

The TPS61290EVM is designed to demonstrate the features and functionality of the TPS61290x device, which is a high-performance, high-efficiency, synchronous boost converter with bypass mode and I²C interface. The factory default settings of the TPS61290EVM allow the operation with an input voltage range from 1.8V to 5.2V.

Get Started

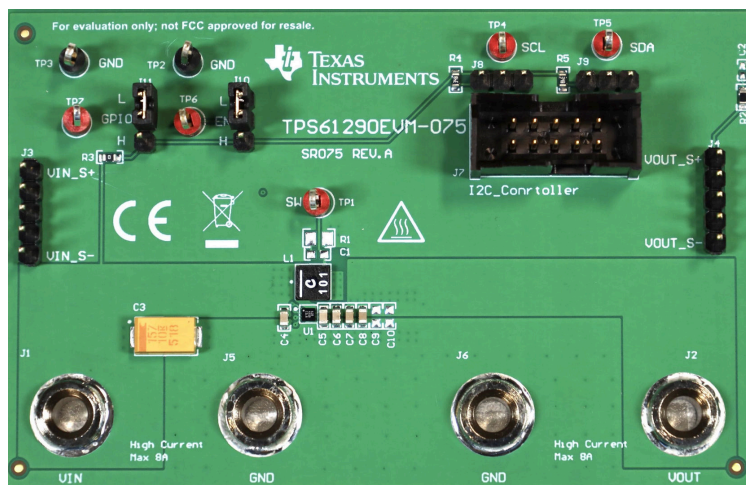
1. Order the EVM at [ti.com](https://www.ti.com).
2. Read the user's guide carefully.
3. Prepare the bench setup per instructions. Take precautions to prevent damage by ESD when handling the EVM.
4. Power up the EVM by following the recommended steps.
5. Run tests and measurements. Take cautions of high voltage and hot temperature produced by the EVM during test.

Features

- Wide input and output voltage range
- I²C interface
- Programmable output voltage from 2.35V to 5.5V with 50mV step
- Programmable average input current limit up to 11A with 500mA step
- High efficiency and good load transient performance
- Forced bypass function
- Output discharge function
- Programmable PFM and FPWM mode at light load

Applications

- [Mobile phone](#)
- [Tablets](#)
- 2G, 3G, 4G mini-module data card
- Satellite communication
- Audio power amplifier




TPS61290EVM

1 Evaluation Module Overview

1.1 Introduction

This EVM is designed for 1.8V to 5.2V input voltage and 3.4V output voltage applications. The EN jumper (J10) controls the ON and OFF of the device. The GPIO jumper (J11) controls I²C address. This EVM has test points of TP1 for SW voltage. The output voltage can be modified by I²C for other application conditions as per the datasheet.

This user's guide describes the characteristics and operation of the evaluation module TPS61290EVM. This document provides instructions on how to use the evaluation module. Throughout this document, the terms of evaluation board, evaluation module, and EVM are synonymous with the TPS61290EVM. This document also includes a schematic, reference printed circuit board (PCB) layout, and a complete bill of materials (BOM).

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

1.2 Kit Contents

Table 1-1 lists the contents of the EVM kit.

Table 1-1. EVM Kit Contents

ITEM	QUANTITY
TPS61290EVM	1

1.3 Specification

Table 1-2 provides a summary of the TPS61290EVM performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1-2. Performance Specification Summary

PARAMETER	TEST CONDITION	RECOMMENDED VALUE	UNIT
Input voltage		1.8 – 5.2	V
Output voltage		2.35 – 5.5	V
Maximum output current	$V_{IN} \geq 2.5V, V_{OUT} = 3.4V, L = 100nH$	6	A
	$V_{IN} \geq 2.5V, V_{OUT} = 5.0V, L = 220nH$	4	A

For the TPS61290x converter, TI recommends to use inductors from the following different suppliers.

Table 1-3. List of Inductors

SERIES	L (nH)	DIMENSIONS (in mm)	DC INPUT CURRENT LIMIT SETTING	MANUFACTURER
HTTP20121B-R11MSR	110	2.0 × 1.2 × 1.2 maximum height	≤ 11.0A	Cyntec
HTTP20160H-R11MSIR	110	2.0 × 1.6 × 0.8 maximum height	≤ 10.5A	Cyntec
HTTY2016FE-R10MSIR	100	2.0 × 1.6 × 0.65 maximum height	≤ 10.0A	Cyntec
XGL4012-101	100	4.0 × 4.0 × 1.2 maximum height	≤ 21.5A	Coilcraft
XGL3512-101	100	3.5 × 3.2 × 1.2 maximum height	≤ 15.2A	Coilcraft
XGL3520-101	100	3.5 × 3.2 × 2.0 maximum height	≤ 15.9A	Coilcraft

Table 1-3. List of Inductors (continued)

SERIES	L (nH)	DIMENSIONS (in mm)	DC INPUT CURRENT LIMIT SETTING	MANUFACTURER
XGL4012-221	220	4.0 × 4.0 × 1.2 maximum height	≤ 14.4A	Coilcraft
XGL4012-251	250	4.0 × 4.0 × 1.2 maximum height	≤ 13.3A	Coilcraft
XGL3512-201	200	3.5 × 3.2 × 1.2 maximum height	≤ 10.0A	Coilcraft
XGL3520-201	200	3.5 × 3.2 × 2.0 maximum height	≤ 11.4A	Coilcraft
XGL3520-301	300	3.5 × 3.2 × 2.0 maximum height	≤ 9.7A	Coilcraft

1.4 Device Information

The TPS61290x device provides a power supply design for products powered by either by a Li-Ion, Nickel-Rich, Silicon Anode, or LiFePO4 battery. The voltage range is optimized for single-cell portable applications like in smartphones or tablet PCs. Used as a high-power pre-regulator, the device extends the battery run-time and overcomes input current and voltage limitations of the powered system. With a wide input voltage range of 1.8V to 5.5V, the device supports applications powered by Li-Ion batteries with extended voltage range. The output voltage can be programmed by I2C up to 5.5V. During operation, when the battery is at a good state-of-charge, a low-ohmic, high-efficient integrated pass-through path (from a by-pass FET) connects the battery to the powered system. If the battery gets to a lower state of charge and the voltage becomes lower than the desired minimum system voltage, the device seamlessly transits into boost mode to uses the full battery capacity.

The TPS61290x offers a very small design size with a 16-ball WCSP package.

2 Hardware

2.1 Modification

This EVM requires an appropriate I²C interface, such as the TI [USB2ANY](#), to configure the TPS61290x. The external components can be changed by the user according to the real application.

2.2 Connector, Test Point, and Jumper Descriptions

This section describes how to properly connect, set up, and use the TPS61290EVM.

2.2.1 Connector and Test Point Descriptions

This EVM includes I/O connectors and test points as shown in [Table 2-1](#). The power supply must be connected to input connectors J1 and J5. The load must be connected to output connectors J2 and J6.

Table 2-1. Connectors and Test Points

REFERENCE DESIGNATOR	DESCRIPTION
J1	Input voltage positive connection
J5	Input voltage return connection
J3	Input voltage sense connection
J2	Output voltage connection
J6	Output voltage return connection
J4	Output voltage sense connection
J7	I ² C USB2ANY connector

2.2.2 Jumper Configuration

2.2.2.1 J10 (ENABLE)

The J10 jumper enables the device. By default, this jumper is set to the OFF position. Put this jumper in the ON position to enable the device.

2.2.2.2 J11 (I²C Target Address Selection)

The J11 jumper is for the I²C target address selection. By default, this jumper is set to the L position and device I²C target address is 75H. Place a jumper across GPIO and H to set the I²C target address to 76H. Leave a jumper floating to set the I²C target address to 77H.

2.3 Test Procedure

1. Set the power supply current limit to 11A. Set the power supply to approximately 2.7V. Turn off the power supply. Connect the positive output of the power supply to J1 and the negative output to J5.
2. Connect the load to J2 for the positive connection and connect the load J6 for the negative connection.
3. Turn on the power supply.
4. Set the J10 jumper across EN and H. Enable the IC with the GUI. The default output voltage is 3.4V.
5. Set the output voltage to the target value on the GUI user interface page.
6. Slowly increase the load while monitoring the output voltage between J2 and J6. The output voltage must remain in regulation when the load current is lower than 4A.
7. Slowly sweep the input voltage from 2.7V to 3.4V. The output voltage must remain in regulation when the load current is lower than the maximum load current specified in [Table 1-2](#).
8. Turn off the load and power supply.

3 Software

3.1 Software User Interface

3.1.1 Install USB2ANY Explorer

Download and install the USB2ANY explorer from [USB2ANY](#). Upgrade the firmware version to 2.8.2.0.

3.1.2 GUI Installation

A graphical user interface (GUI) is available on the [TI developer zone](#). The GUI allows simple and convenient programming of the device through the TI USB2ANY device.

1. Download the zip file for the desired platform.
2. Download GUI Composer Runtime.
3. Extract the zip folder and install the GUI.
4. Run through the installation steps. The installation wizard shows a prompt for GUI Composer Runtime. This action is done automatically.
5. Open the GUI.

3.1.3 Interface Hardware Setup

Connect the USB2ANY adapter to a PC using the supplied USB cable. Connect the TPS61290EVM connector J7 to the USB2ANY adapter using the supplied 10-pin ribbon cable. The connectors on the ribbon cable are keyed to prevent incorrect installation.

Figure 3-1 shows a quick connection overview.

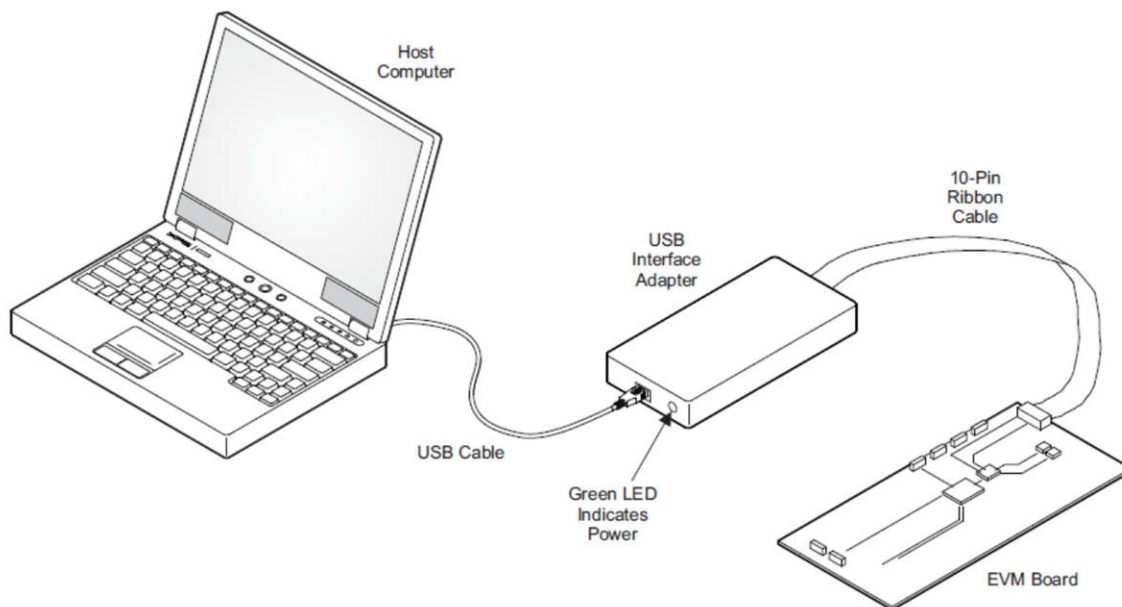


Figure 3-1. Quick Connection Overview

3.1.4 User Interface Operation

The TPS61290EVM board can be enabled for operation by the following steps:

1. Set J10 to the ON position. Turn on the power supply.
2. Open the GUI.
3. Select the *Auto Connect* button on the bottom left corner of the page on the target address widget ([Figure 3-2](#)). This action automatically checks for target addresses (0x75, 0x76, 0x77) and connects the GUI with the device.



Figure 3-2. GUI Auto Connect Button

4. Select the *Start* button. This button shows the GUI user interface of the TPS61290EVM ([Figure 3-3](#)).

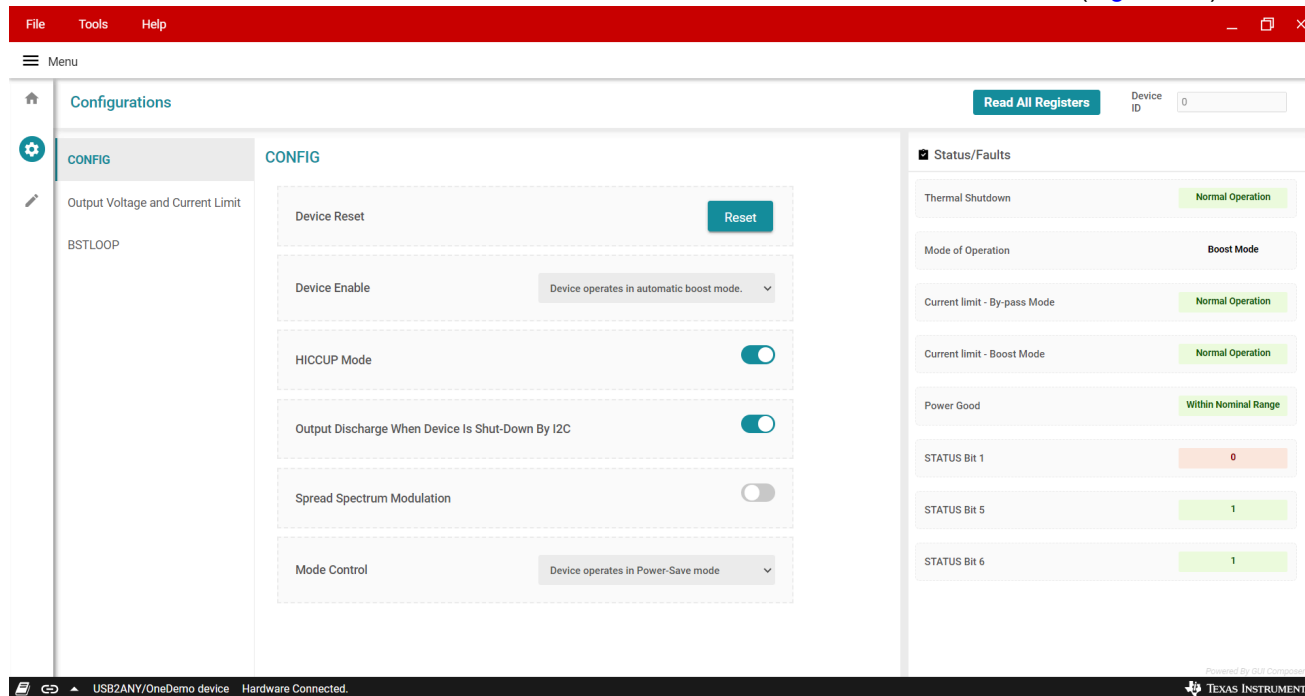
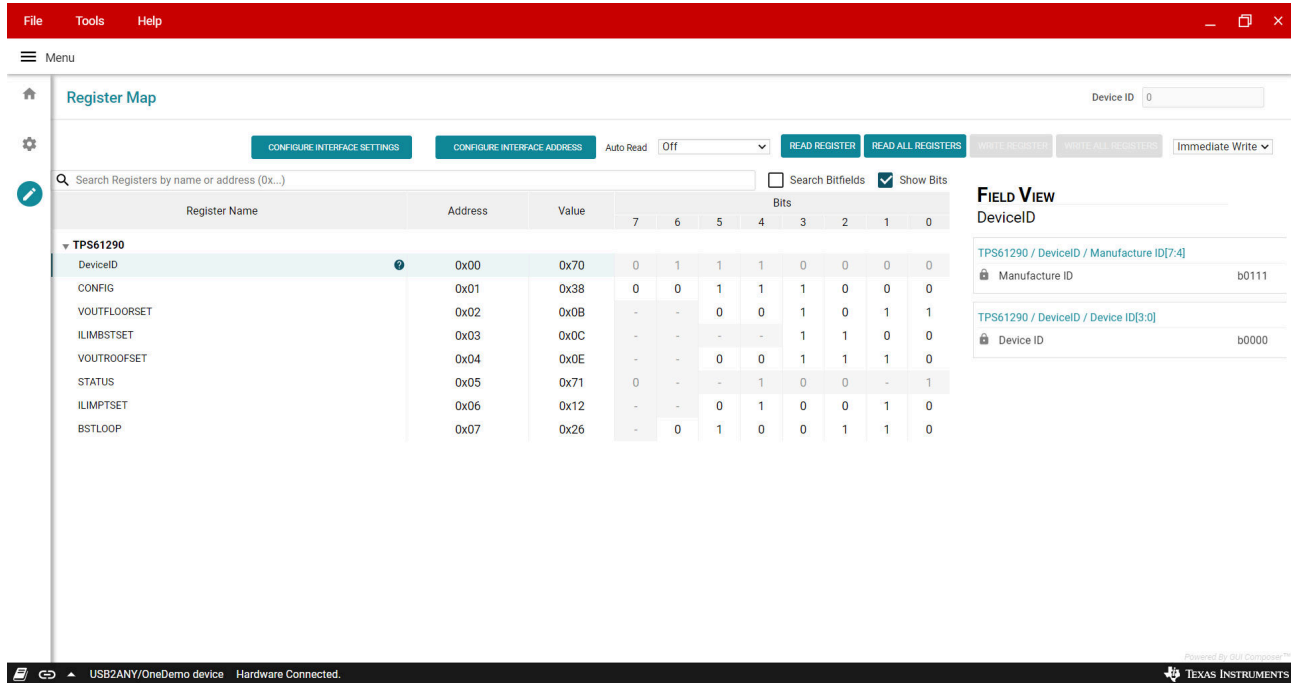


Figure 3-3. GUI User Interface of TPS61290EVM

3.1.5 Register Map Screen

The *Register Map* screen shows a register-wise view of all parameters. Here, single registers can be read or written to the device (if applicable). See also [TPS61290x 5.5V, 11A, Synchronous Boost Converter With Bypass Mode, I2C Interface, and Fast Transient Response](#) for a detailed description of the TPS61290 registers.



The screenshot displays the 'Register Map' GUI for a TPS61290 device. The interface includes a menu bar (File, Tools, Help), a search bar for registers, and a table of registers. The 'FIELD VIEW' panel on the right shows the bit fields for 'DeviceID' and 'Manufacture ID'.

Register Name	Address	Value	7	6	5	4	3	2	1	0
DeviceID	0x00	0x70	0	1	1	1	0	0	0	0
CONFIG	0x01	0x38	0	0	1	1	1	0	0	0
VOUTFLOORSET	0x02	0x0B	-	-	0	0	1	0	1	1
ILIMBSTSET	0x03	0x0C	-	-	-	-	1	1	0	0
VOUtroofSET	0x04	0x0E	-	-	0	0	1	1	1	0
STATUS	0x05	0x71	0	-	-	1	0	0	-	1
ILIMPTSET	0x06	0x12	-	-	0	1	0	0	1	0
BSTLOOP	0x07	0x26	-	0	1	0	0	1	1	0

FIELD VIEW

DeviceID

TPS61290 / DeviceID / Manufacture ID[7:4]

Manufacture ID: b0111

TPS61290 / DeviceID / Device ID[3:0]

Device ID: b0000

Figure 3-4. GUI Register Map Screen

4 Hardware Design Files

This section provides the TPS61290EVM schematic, board layout, and bill of materials (BOM).

4.1 Schematic

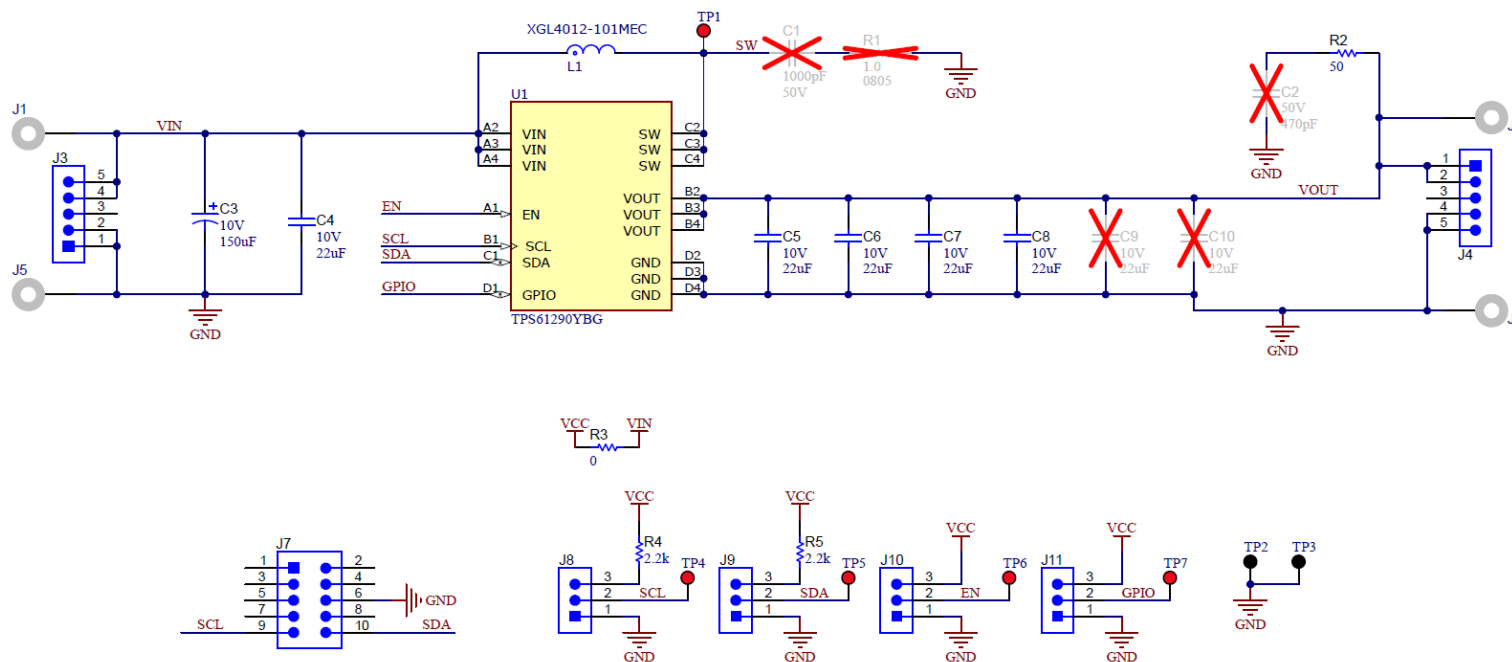


Figure 4-1. TPS61290EVM Schematic

4.2 PCB Layouts

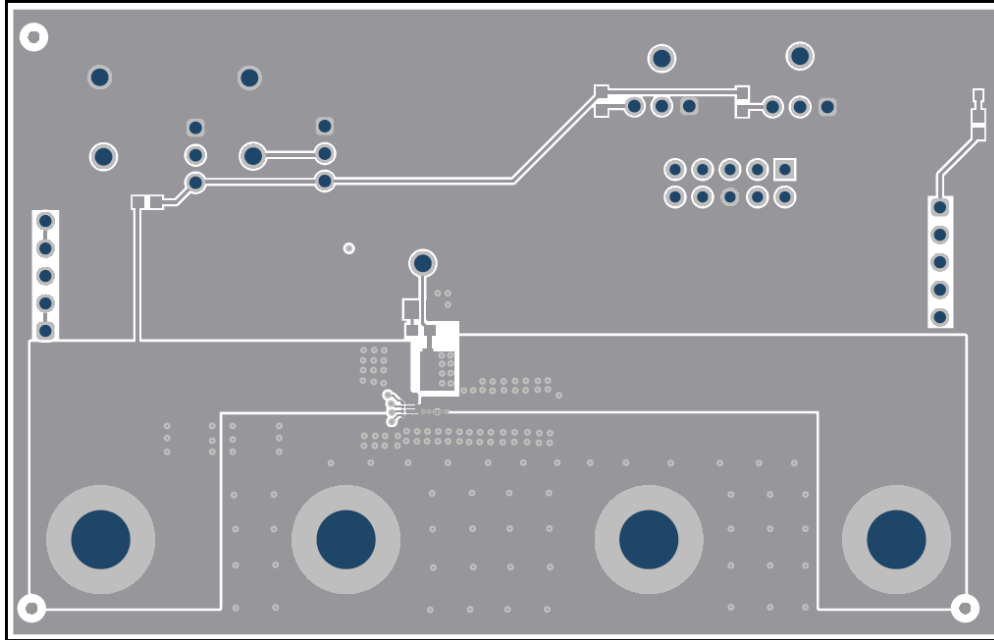


Figure 4-2. TPS61290EVM Top-Side Layout

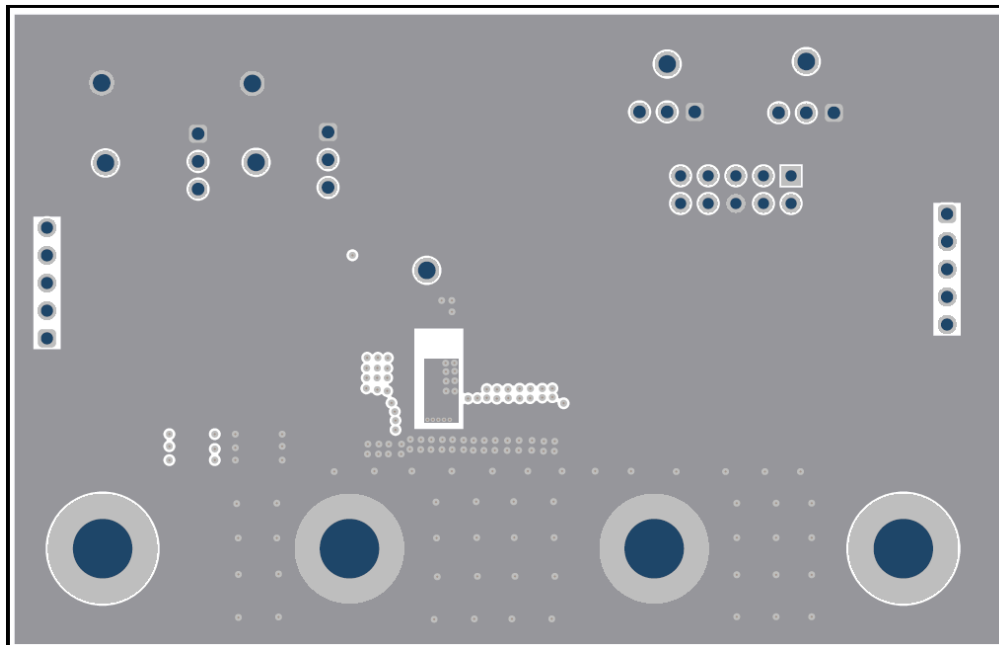


Figure 4-3. TPS61290EVM Inner Layer1

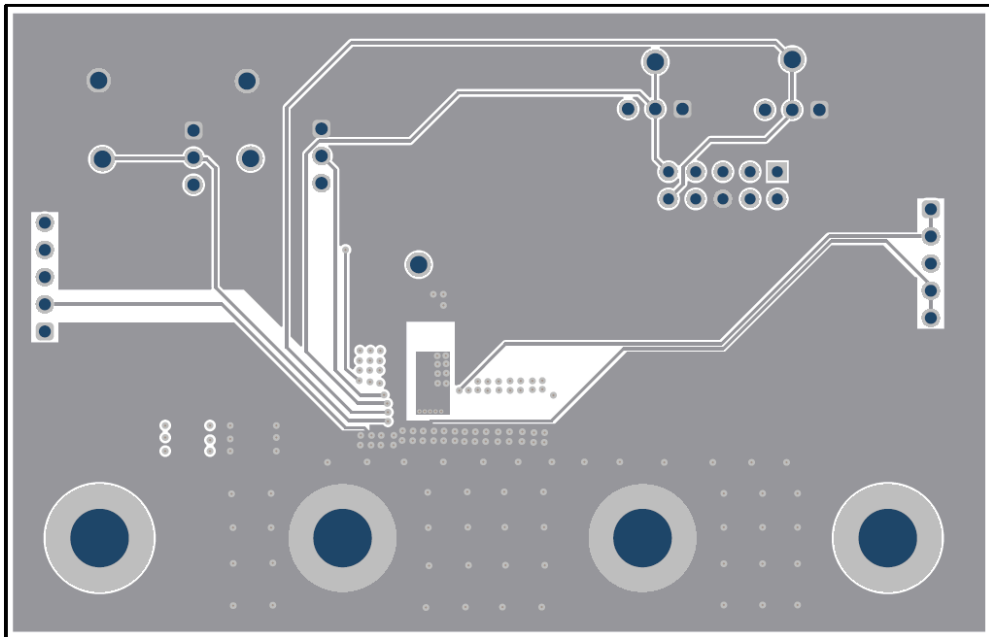


Figure 4-4. TPS61290EVM Inner Layer2

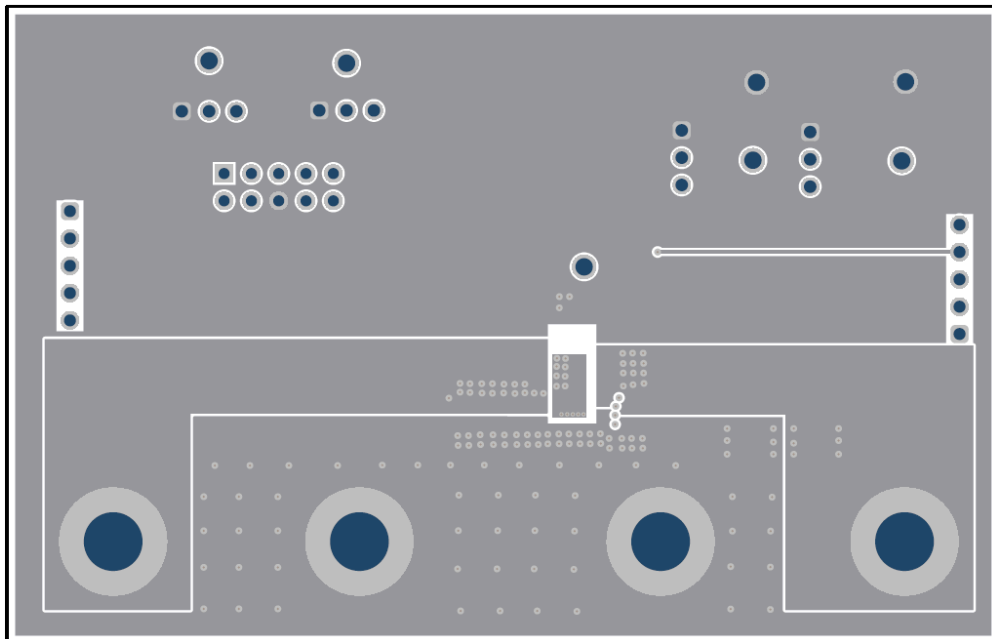


Figure 4-5. TPS61290EVM Bottom-Side Layout

4.3 Bill of Materials

Table 4-1. Bill of Materials

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE	PART NUMBER	MANUFACTURER
C3	1	150uF	CAP, TA, 150uF, 10V, +/- 10%, 0.1ohm, SMD	7343-31	T495D157K010ATE100	Kemet
C4, C5, C6, C7, C8	5	22uF	CAP, CERM, 22uF, 10V, +/- 20%, X5R, 0603	0603	GRM187R61A226ME15D	MuRata
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J1, J2, J5, J6	4		Standard Banana Jack, Uninsulated, 6.73mm	Standard Banana Jack, Uninsulated, 6.73mm	575-6	Keystone
J3, J4	2		Header, 2.54mm, 5x1, Gold, TH	Header, 2.54mm, 5x1, TH	61300511121	Würth Elektronik
J7	1		Header (shrouded), 100mil, 5x2, Gold, TH	5x2 Shrouded header	5103308-1	TE Connectivity
J8, J9, J10, J11	4		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Würth Elektronik
L1	1	0.1uH	100nH Shielded Molded Inductor 19.7A 2.9mOhm Max 1616 (4040 Metric)	SMT_IND_4MM0_4M M0	XGL4012-101MEC	Coilcraft
R2	1	50	RES, 50, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW060350R0FKEA	Vishay-Dale
R3	1	0	RES, 0, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R4, R5	2	2.2k	RES, 2.2k, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06032K20JNEA	Vishay-Dale
SH-JP1, SH-JP2	2	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP4, TP5, TP6, TP7	5		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP2, TP3	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	1		Wide-Voltage Battery Front-End DC/DC Converter for Single-Cell Li-Ion, Ni-Rich, Si-Anode Applications	DSBGA16	TPS61290YBG	Texas Instruments
C1	0	1000pF	CAP, CERM, 1000pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	GCM1885C1H102JA16D	MuRata
C2	0	470pF	CAP, CERM, 470pF, 50V, +/- 5%, C0G/NP0, 0402	0402	GRM1555C1H471JA01D	MuRata
C9, C10	0	22uF	CAP, CERM, 22uF, 10V, +/- 20%, X5R, 0603	0603	GRM187R61A226ME15D	MuRata
R1	0	1	RES, 1.0, 5%, 0.125W, AEC-Q200 Grade 0, 0805	0805	CRCW08051R00JNEA	Vishay-Dale

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
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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.
 - 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/llds/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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3. 技術基準適合証明を取得後ご使用いただく。

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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/llds/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.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
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