EVM User's Guide: TPS55289Q1EVM-011

TPS55289-Q1 Buck-Boost Converter Evaluation Module

Description

The TPS55289-Q1 integrates four MOSFETs providing a compact design for a variety of applications and is optimized for converting battery voltage into power supply rails. Through the I^{2}C interface, the output voltage can be programmed from 0.8V to 22 V with 10 mV step and the output current limit is programmable up to 6.35A with 50 mA step, which is a good choice for USB Power Delivery (USB PD) applications. The TPS55289-Q1 has adjustable external loop compensation, programmable switching frequency, optional spread spectrum and rich protection features. All these features bring flexibility and design optimization for overall performance, as well as BOM optimization and design cost.

Get Started

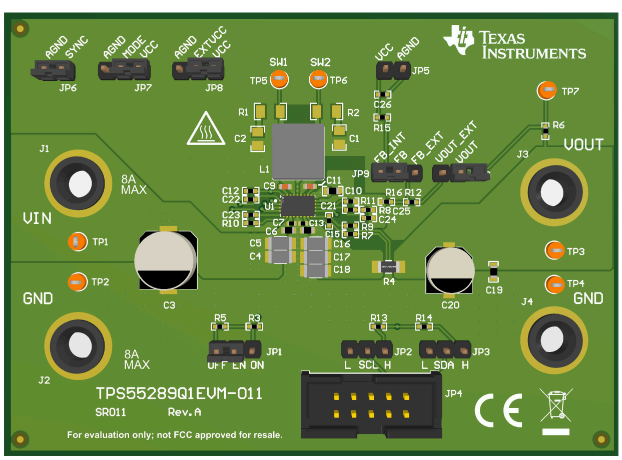
1. Order the EVM at ti.com.
2. Read the user's guide carefully.
3. Prepare the bench setup per instructions. Take precautions to prevent damage by ESD when handling the EVM.
4. Power up the EVM by following the recommended steps.
5. Run tests and measurements. Take cautions of high voltage and hot temperature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

Features

- Wide input and output voltage range
- Programmable power supply (PPS) support
- I^{2}C interface
- Programmable output voltage from 0.8V to 22 V with 10 mV step
- Programmable output current limit up to 6.35A with 50 mA step
- Forced discharge function
- User flexibilities in optimizing loop compensation
- Programmable PFM and FPWM mode at light load
- Optional programmable spread spectrum
- Adjustable output voltage compensation for voltage droop over the cable
- Rich protection features
- Small solution-size

Applications

- Automotive USB charge
- Wireless charger
- Automotive media hub
- ADAS domain controller
- Automotive cluster display
- Headlight, rear light



Copyright © 2023 Texas Instruments Incorporated

1 Evaluation Module Overview

1.1 Introduction

The TPS55289Q1EVM-011 is designed to demonstrate the features and functionality of the TPS55289-Q1 device, which is a high-performance, high-efficiency synchronous buck-boost converter with I^2C interface. The TPS55289-Q1 also verifies safe operating with optional output current limit and hiccup-mode protection in sustained overload conditions. The operation status can be read through the I^2C interface to know if SCP/OCP/OVP is triggered.

This user's guide describes the characteristics and operation of the evaluation module TPS55289Q1EVM-011. 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 TPS55289Q1EVM-011. 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 details the contents of the EVM kit.

Table 1-1. EVM Kit Contents

ITEM	QUANTITY
TPS55289Q1EVM-011	1

1.3 Specification

Table 1-2 provides a summary of the TPS55289-Q1 EVM performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1-2. Performance Specification Summary

Parameter	Test Condition	Value	Unit
Input voltage		3.0–36	V
Output voltage		0.8–22	V
Maximum output current	V_{IN} ≥ 5 V, V_{OUT} = 10 V	3	A
	V_{IN} ≥ 6 V, V_{OUT} = 12 V		
	V_{IN} ≥ 12 V, V_{OUT} = 20 V		
Default switching frequency		400	kHz

Copyright © 2023 Texas Instruments Incorporated

1.4 Device Information

The TPS55289-Q1 is a synchronous buck-boost converter which integrates four MOSFET switches, providing a compact device for a variety of applications, especially for USB Power Delivery (USB PD) application. The device has up to 36 V input voltage capability. Through the I^2C interface, the output voltage can be programmed from 0.8V to 22 V with 10 mV step, and the output current limit can be programmed up to 6.35A with 50 mA step. The switching frequency is programmable from 200 kHz to 2.2 MHz by an external resistor and can be synchronized to an external clock. The spread spectrum function is optional to minimize peak EMI. The output over-voltage protection, average inductor current limit, cycle-by-cycle peak current limit, and output short circuit protection are provided. Refer to TPS55289-Q1 36-V, 8-A Buck-Boost Converter with I^2C Interface Data Sheet for more detailed information of the TPS55289-Q1 fully integrated buck-boost converter.

The factory default settings of the TPS55289Q1EVM allow the operation with an input voltage range from 3 V to 36 V. Fine-tuning of the output voltage can be realized by adjusting the internal reference voltage and feedback ratio. In addition, users can modify the EVM to adjust the switching frequency by changing resistor value at the FSW pin. To meet the current ripple requirement, the inductor also needs to change according to the switching frequency, as well as the external compensation parameter to obtain enough phase margin and gain margin.

Copyright © 2023 Texas Instruments Incorporated

2 Hardware

This section describes how to properly connect, set up, and use the TPS55289Q1EVM-011.

2.1 Modification

This EVM requires an appropriate I^2C interface, such as the TI USB2ANY, to configure the TPS55289-Q1. 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 TPS55289Q1EVM-011.

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 J2. The load must be connected to output connectors, J3 and J4.

Table 2-1. Connectors and Test Points

Reference Designator	Description
J1	Input voltage positive connection
J2	Input voltage return connection
J3	Output voltage connection
J4	Output voltage return connection
JP4	I^2C connector

2.2.2 Jumper Configuration

2.2.2.1 JP1 (ENABLE)

The JP1 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 JP6 (SYNC)

The JP6 jumper is for frequency dithering selection. Placing a jumper across JP6 disables the frequency dithering function. Leave JP6 open when using the frequency dithering function.

2.2.2.3 JP7 (I^2C Target Address Selection)

The JP7 jumper is for the I^2C target address selection. By default, this jumper is set to the VCC position and device I^2C target address is 74H. Place a jumper across MODE and AGND to set the I^2C target address to 75H.

2.2.2.4 JP8 (Internal or External VCC Selection)

The JP8 jumper is for the internal LDO or external VCC selection. By default, the jumper is set to the VCC position and the device selects an internal LDO as the VCC source.

To minimize the power dissipation of the internal LDO when both input voltage and output voltage are high, an external 5-V power supply can be applied at the VCC pin to supply the TPS55289-Q1. Place a jumper across EXTVCC and AGND to set the device VCC source externally. The external 5-V power supply must have at least 100-mA output current capability and must be within the 4.75-V to 5.5-V regulation range.

Copyright © 2023 Texas Instruments Incorporated

2.2.2.5 JP9 and JP10 (External Feedback and Internal Feedback Selection)

The JP9 jumper is for the external feedback or the internal feedback selection. By default, this jumper is set to the FB_INT position. Place this jumper in the FB_EXT position for the external output voltage feedback.

The JP10 jumper is for the external feedback connection. Place a jumper across JP10 when using external feedback. Leave JP10 open when using internal feedback.

When using external output voltage feedback, the output voltage is determined by Equation 1:

$$V_{OUT} = V_{REF}\, x \left(1 + \frac{R_{FB\_UP}}{R_{FB\_BT}}\right) \quad (1)$$

TI recommends to use 100 kΩ for the up resistor, R_{FB_UP}. The reference voltage, V_{REF}, at the FB/INT pin is programmable from 45 mV to 1.2 V by writing a 11-bit data into registers 00H and 01H.

2.3 Test Procedure

1. Set the power supply current limit to 10 A. Set the power supply to approximately 12 V. Turn off the power supply. Connect the positive output of the power supply to J1 and the negative output to J2.
2. Connect the load to J3 for the positive connection and connect the load J4 for the negative connection.
3. Turn on the power supply.
4. Set the JP1 jumper across EN and ON. Enable the IC with the GUI. The default output voltage is 5 V.
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 J3 and J4. The output voltage must remain in regulation when the load current is lower than 5 A.
7. Slowly sweep the input voltage from 5 V to 20 V. 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. Then, turn on the load to discharge the output capacitors.

Copyright © 2023 Texas Instruments Incorporated

3 Software

3.1 Software User Interface

3.1.1 Install USB2ANY Explorer

Download and install the USB2ANY explorer from http://www.ti.com/tool/USB2ANY. Upgrade the firmware version to 2.8.2.0.

3.1.2 GUI Installation

A graphical user interface (GUI) is available from on www.dev.ti.com. 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 is done automatically.
5. Open the GUI – TPS55289-Q1.

3.1.3 Interface Hardware Setup

Connect the USB2ANY adapter to your PC using the supplied USB cable. Connect the TPS55289Q1EVM connector JP4 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.

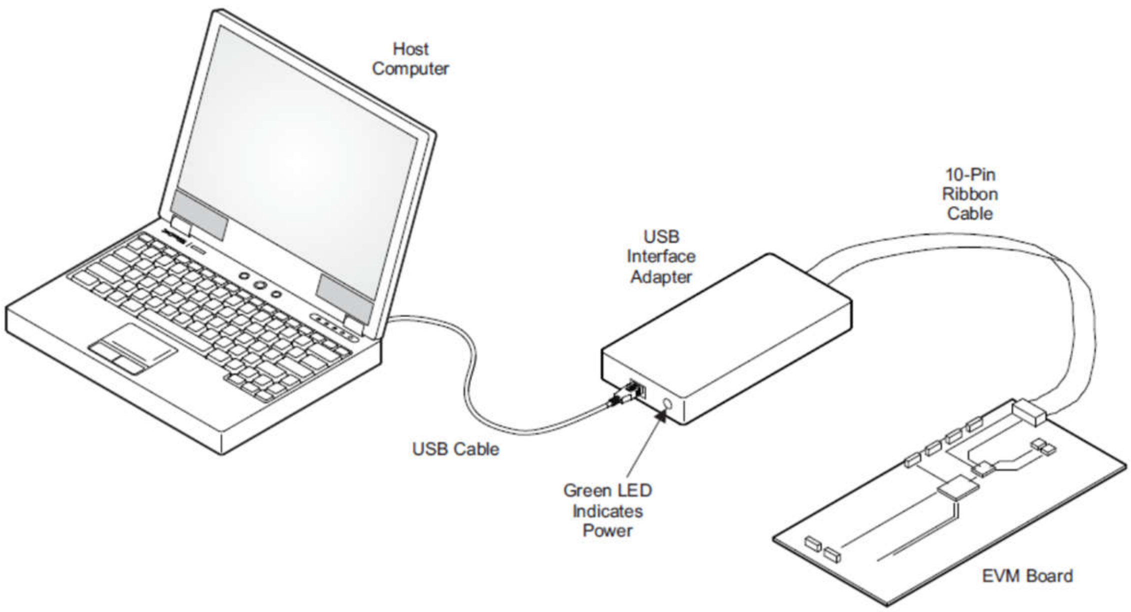


Figure 3-1. Quick Connection Overview

3.1.4 User Interface Operation

The TPS55289Q1EVM board can be enabled to work by the following steps:\.

1. Set JP1 to the ON position. Turn on the power supply.
2. Open the TPS55289Q1EVM GUI.
3. Click the auto connect button on the target address widget (Figure 3-2). This automatically checks for target addresses (0x74, 0x75) and connect the GUI with the device. After the GUI and device are connected, the GUI reads all eight registers and shows a notification (Figure 3-3).

Copyright © 2023 Texas Instruments Incorporated

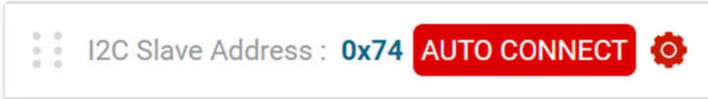


Figure 3-2. GUI Auto Connect Button

Figure 3-3. GUI Auto Connect Notification

4. Click the start button. This shows the GUI user interface of TPS55289Q1EVM-011 (Figure 3-4).

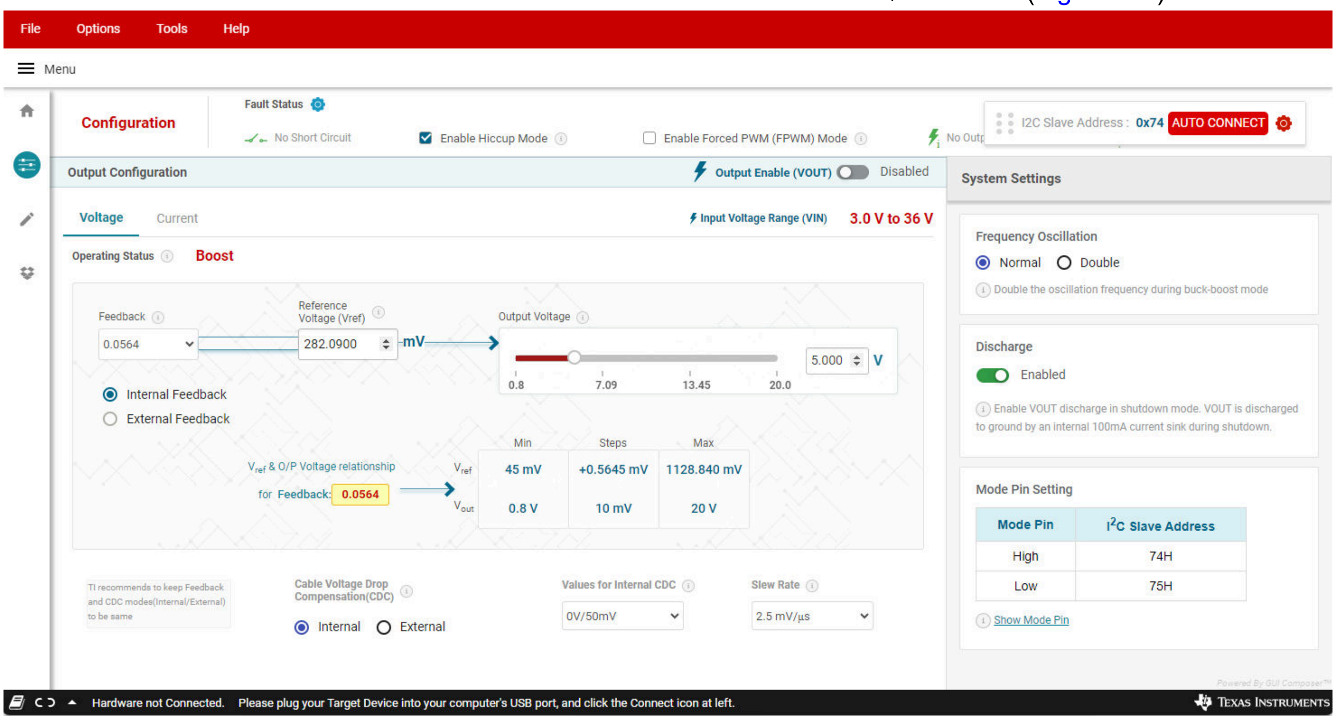


Figure 3-4. GUI User Interface of TPS55289Q1EVM-011

5. Click the Enable button (Figure 3-5). The default output voltage is 5 V.

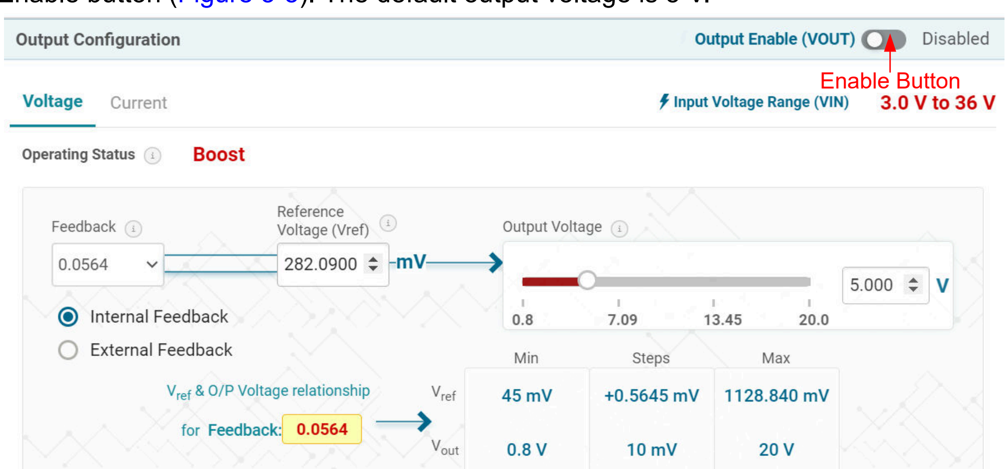


Figure 3-5. ENABLE Button

Copyright © 2023 Texas Instruments Incorporated

6. Set the output voltage, current limit point, and so forth according to the design target. If the maximum load current is ≥ 5 A, then uncheck the *Enable Current Limit* check box or increase the current limit value (Figure 3-6).

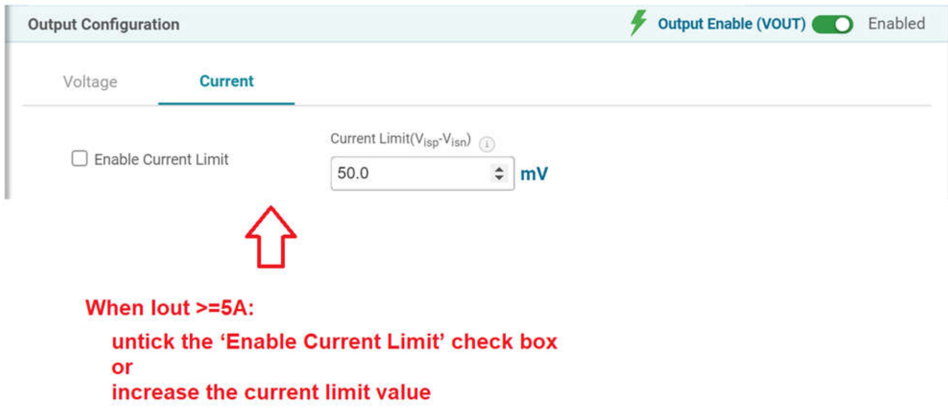


Figure 3-6. Output Current Limit Point Setting

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). Refer to the *TPS55289-Q1 36-V, 8-A Buck-Boost Converter with I²C Interface Data Sheet* for a detailed description of the TPS55289-Q1 registers.

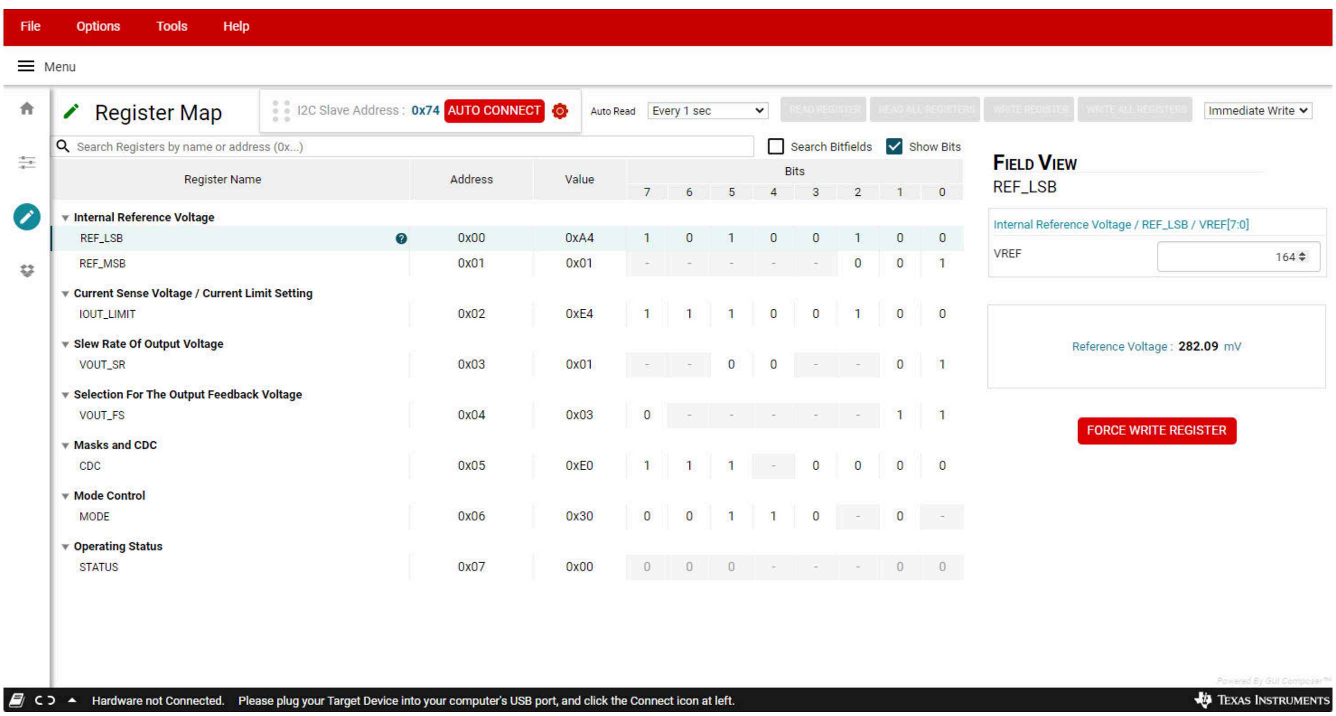


Figure 3-7. GUI Register Map Screen

Copyright © 2023 Texas Instruments Incorporated

4 Hardware Design Files

This section provides the TPS55289Q1EVM-011 schematic, board layout and bill of materials (BOM).

4.1 Schematic

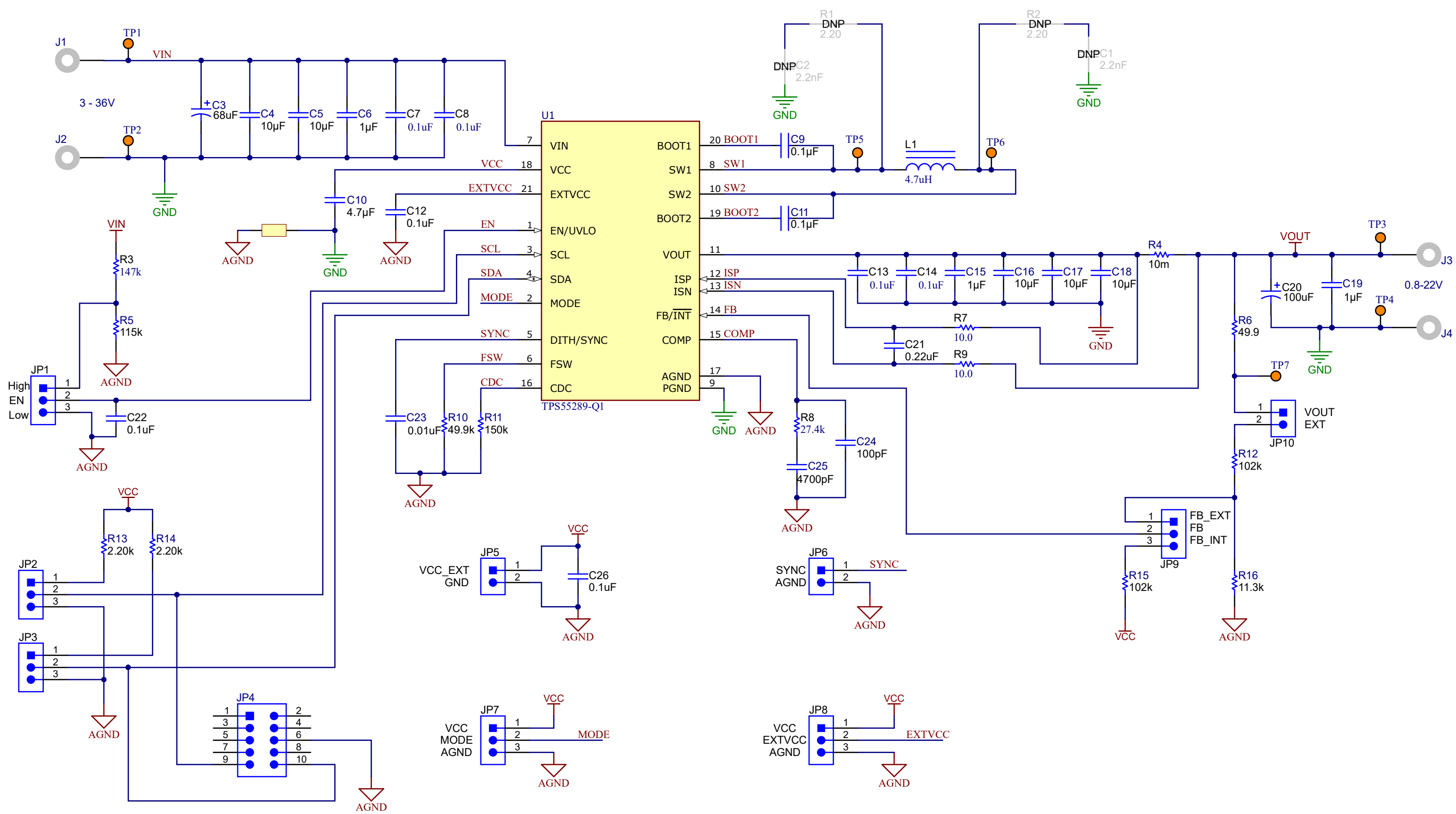


Figure 4-1. TPS55289Q1EVM-011 Schematic

Copyright © 2023 Texas Instruments Incorporated

4.2 PCB Layouts

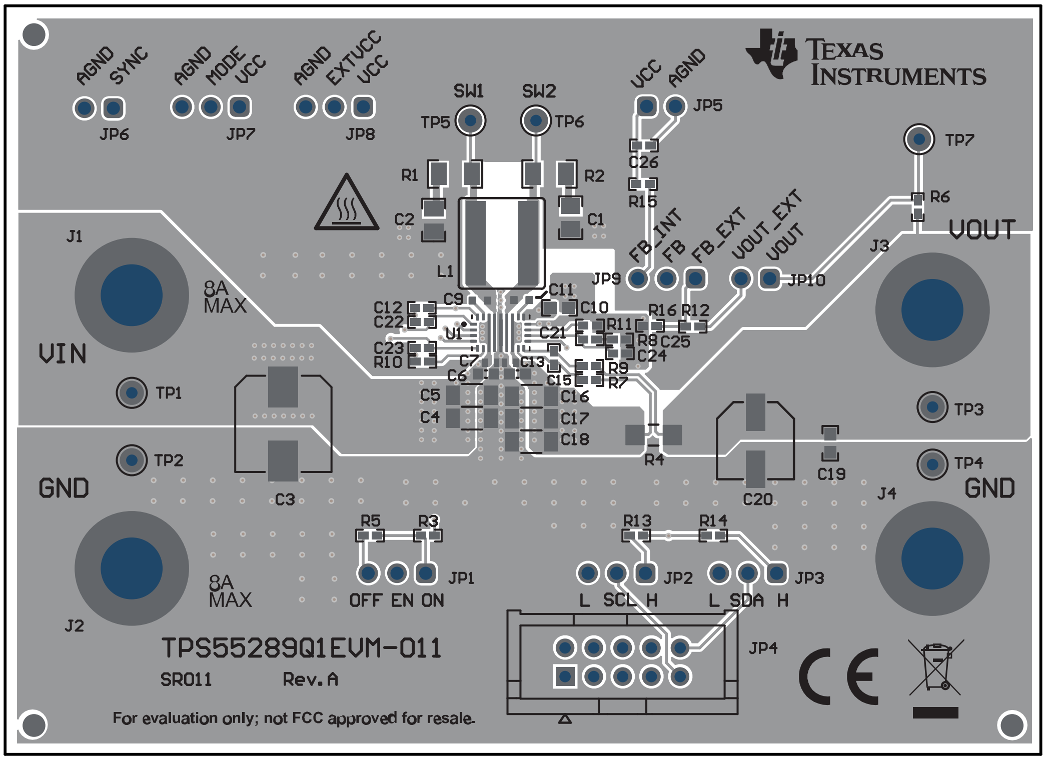


Figure 4-2. TPS55289Q1EVM-011 Top-Side Layout

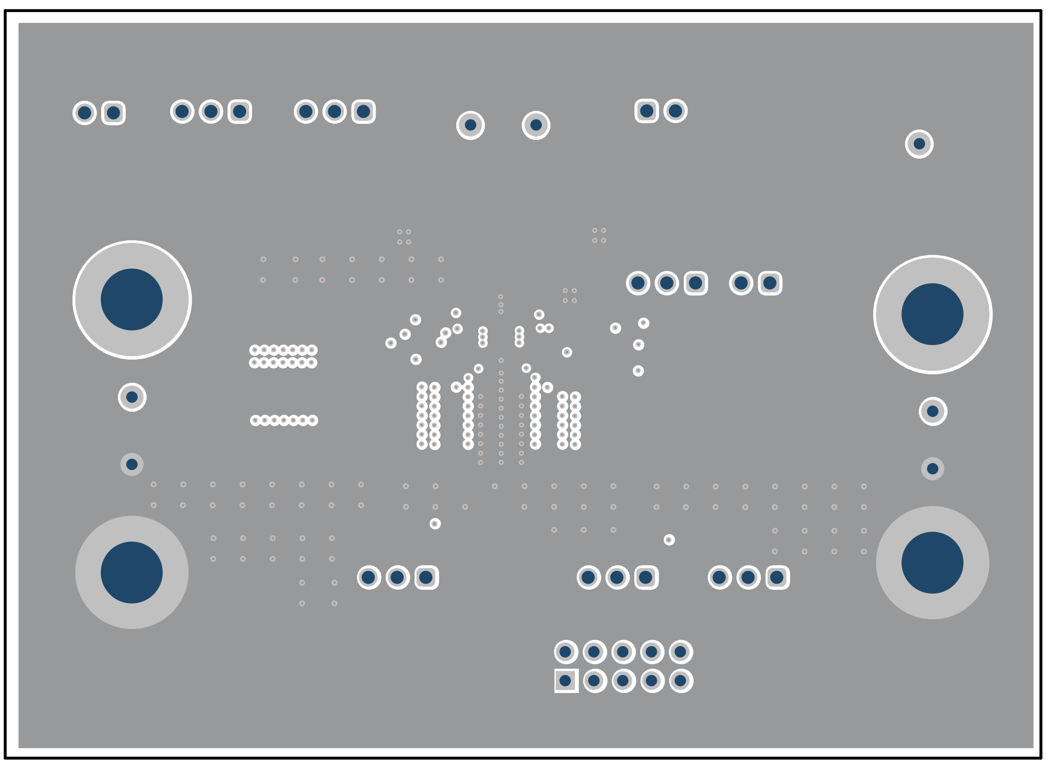


Figure 4-3. TPS55289Q1EVM-011 Inner Layer1

Copyright © 2023 Texas Instruments Incorporated

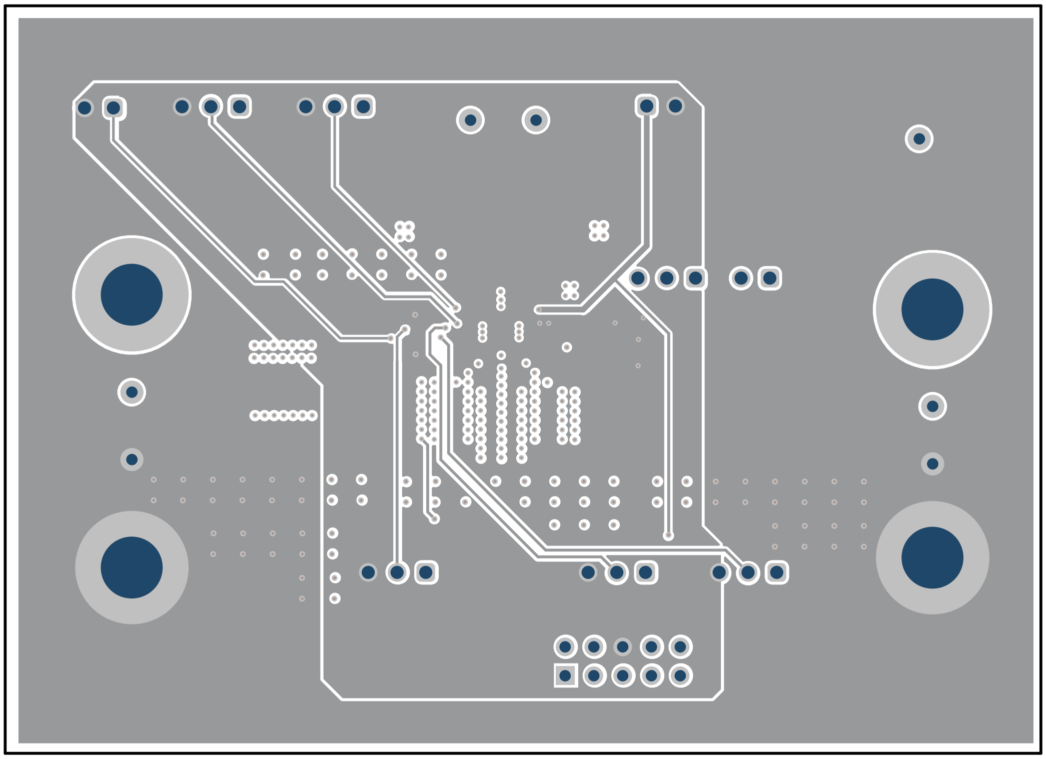


Figure 4-4. TPS55289Q1EVM-011 Inner Layer2

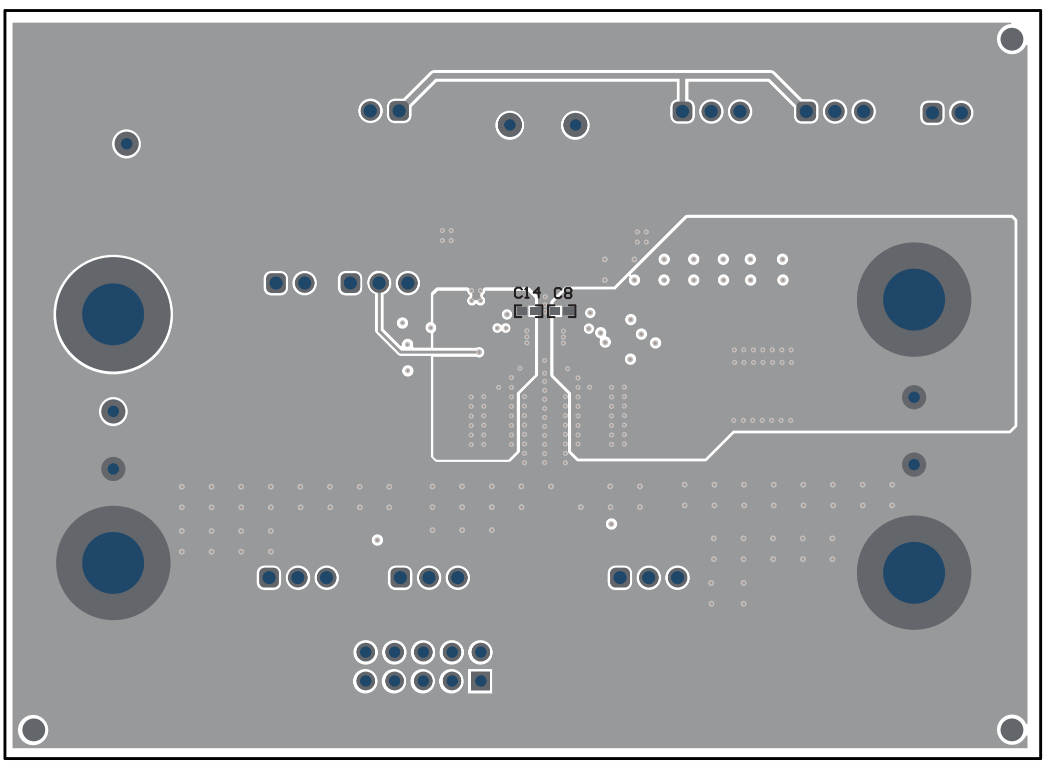


Figure 4-5. TPS55289Q1EVM-011 Bottom-Side Layout

Copyright © 2023 Texas Instruments Incorporated

4.3 Bill of Materials

Table 4-1. Bill of Materials

Designator	Qty	Value	Description	Package	Part Number	Manufacturer
C3	1	68uF	CAP, Polymer Hybrid, 68 uF, 50 V, +/- 20%, 30 ohm, 8x10 SMD	8x10	EEHZA1H680P	Panasonic
C4, C5, C16, C17, C18	5	10uF	CAP, CERM, 10 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L1X7R1H106K160AC	TDK
C6, C15, C19	3	1uF	CAP, CERM, 1 µF, 50 V,+/- 20%, X5R, AEC-Q200 Grade 3, 0603	0603	GRT188R61H105ME13D	MuRata
C7, C8, C13, C14	4	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 20%, X7R, 0402	0402	GRM155R71H104ME14D	MuRata
C9, C11	2		0.1µF ±10% 50 V Ceramic Capacitor X8L 0603 (1608 Metric)	0603	GCM188L81H104KA57D	Murata Electronics North America
C10	1	4.7uF	CAP, CERM, 4.7 µF, 16 V,+/- 10%, X5R, AEC-Q200 Grade 3, 0603	0603	GRT188R61C475KE13D	MuRata
C12, C21, C22, C26	4	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H104K050BB	TDK
C20	1	100uF	CAP, AL, 100 uF, 35 V, AEC-Q200 Grade 2, SMD	D6.3xL5.8mm	EEHZK1V101XP	Panasonic
C23	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H103K050BB	TDK
C24	1	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	CGA2B2C0G1H101J050BA	TDK
C25	1	4700 pF	CAP, CERM, 4700 pF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B2X7R1H472K050BA	TDK
FID4, FID5, FID6	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J1, J2, J3, J4	4		Standard Banana Jack, Uninsulated, 6.73mm	Standard Banana Jack, Uninsulated, 6.73mm	575-6	Keystone
JP1, JP2, JP3, JP7, JP8, JP9	6		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
JP4	1		Header (shrouded), 100mil, 5x2, Gold, TH	5x2 Shrouded header	5103308-1	TE Connectivity
JP5, JP6, JP10	3		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
L1	1	4.7uH	Inductor, Shielded, Composite, 4.7 uH, 13.6 A, 0.01 ohm, SMD	7.2x7x7.5mm	XAL7070-472MEB	Coilcraft
R3	1	147k	RES, 147 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402147KFKED	Vishay-Dale
R4	1		10 mOhms ±1% 1W Chip Resistor 1206 (3216 Metric) Automotive AEC-Q200, Current Sense, Moisture Resistant Metal Element	1206	CRF1206-FZ-R010ELF	Bourns

Copyright © 2023 Texas Instruments Incorporated

Table 4-1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package	Part Number	Manufacturer
R5	1	115k	RES, 115 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402115KFKED	Vishay-Dale
R6	1	49.9	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040249R9FKED	Vishay-Dale
R7, R9	2	10	RES, 10.0, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210R0FKED	Vishay-Dale
R8	1	27.4k	RES, 27.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040227K4FKED	Vishay-Dale
R10	1	49.9k	RES, 49.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040249K9FKED	Vishay-Dale
R11	1	150k	RES, 150 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402150KFKED	Vishay-Dale
R12, R15	2	102k	RES, 102 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402102KFKED	Vishay-Dale
R13, R14	2	2.20k	RES, 2.20 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20FKED	Vishay-Dale
R16	1	11.3k	RES, 11.3 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040211K3FKED	Vishay-Dale
SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6	6		Shunt, 100mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
TP1, TP2, TP3, TP4, TP5, TP6, TP7	7		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone Electronics
U1	1		36-V, 8-A Buck-boost Converter with I2C Interface	VQFN21	TPS55289-Q1	Texas Instruments
C1, C2	0	2200 pF	CAP, CERM, 2200 pF, 250 V, +/- 10%, X7R, 0805	0805	GRM21AR72E222KW01D	MuRata
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R1, R2	0	2.2	RES, 2.20, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8RQF2R2V	Panasonic

Copyright © 2023 Texas Instruments Incorporated

5 Additional Information

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2023 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated