TPS65653-Q1 EVM user's guide

This user's guide describes the characteristics, operation, and use of the TPS65653-Q1 evaluation module (EVM). This user's guide includes a *Evaluation Board Schematic* and *Bill of Materials (BOM)*.

Caution	Caution Hot surface. Contact may cause burns. Do not touch

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Trademarks

1 Related Documentation from Texas Instruments

TPS65653-Q1 data sheet and TPS6565342-Q1 technical reference manual.

2 FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user, at their own expense, will be required to take whatever measures may be required to correct this interference.

3 If You Need Assistance

Contact your local TI sales representative.

Using the TPS65653-Q1 Evaluation Module

1 Introduction

The Texas Instruments TPS65653-Q1 evaluation module (EVM) help designers evaluate the operation and performance of the TPS65653xx-Q1 devices. The TPS65653-Q1 is designed to meet the power-management requirements of the latest processor and platform needs in automotive camera and radar applications. These devices contain two step-down DC-DC converters, and a general-purpose digital-output signal. The device is controlled by an I^2C-compatible serial interface.

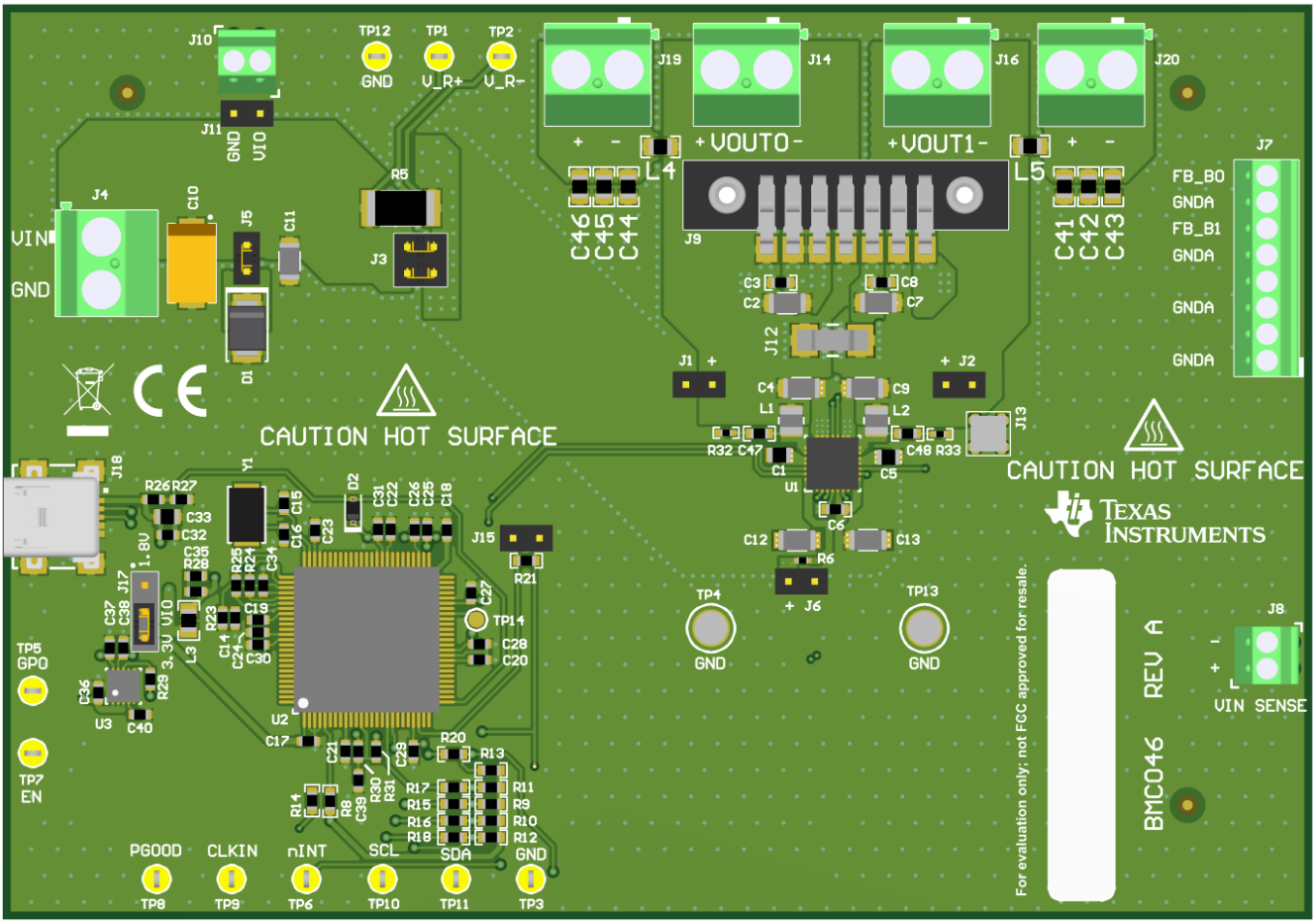

Figure 1. TPS65653-Q1 EVM

2 Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up, and use the TPS65653-Q1 EVM.

Many of the components on the TPS65653-Q1 EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

On opening the TPS65653-Q1 EVM package, ensure that these items are included:

- TPS65653Q1EVM evaluation board
- USB cable

If any of the items are missing, contact the closest Texas Instruments Product Information Center to inquire about a replacement.

2.1 Input/Output Connector Description

The description of the main connectors on the EVM board are as follows:

- Connector J4 is the power input terminal for the EVM board. The terminal block provides a power (VIN) and ground (GND) connection to allow the user to attach the EVM to a cable harness.
- Connector J14 is the regulated output voltage of the BUCK0 converter. The terminal block provides a power (+) and ground (–) connection to allow the user to attach the EVM to a cable harness for connecting a load.
- Connector J19 is also a regulated output voltage of the BUCK0 converter, with additional capacitors and inductors available for LC filtering. The terminal block provides a power (+) and ground (–) connection to allow the user to attach the EVM to a cable harness for connecting a load.
- Connector J16 is the regulated output voltage of the BUCK1 converter. The terminal block provides a power (+) and ground (–) connection to allow the user to attach the EVM to a cable harness for connecting a load.
- Connector J20 is also a regulated output voltage of the BUCK1 converter, with additional capacitors and inductors available for LC filtering. The terminal block provides a power (+) and ground (–) connection to allow the user to attach the EVM to a cable harness for connecting a load.
- Use connector J7 to sense V_{OUT} from BUCK0 and BUCK1.
- Use connector J6 tor sensing input voltage to both regulators BUCK0, and BUCK1.
- Connector J18 is for connecting USB cable to EVM board. It is compatible with a Mini USB Type B receptacle.

2.2 Software Installation

The EVM is controlled through a graphical user interface (GUI) software. The software communicates with the EVM through an available USB port. The minimum hardware requirements for the EVM software are:

- IBM PC-compatible computer running a Microsoft Windows® XP or newer operating system
- Available USB port
- Mouse

The latest downloadable software is available at http://www.ti.com/tool/TPS65653Q1EVM. Download the zip file onto your local hard drive, and then unzip this folder. Connect the EVM to the PC with the USB cable. Refer to Figure 1.

1. With the power supply disconnected from the EVM unit, open the un-zipped folder and click on the TPS65653_installer.exe file to start the software.
2. On the evaluation software window bottom left corner, you should see text “Hardware connected”. Refer to Figure 2.

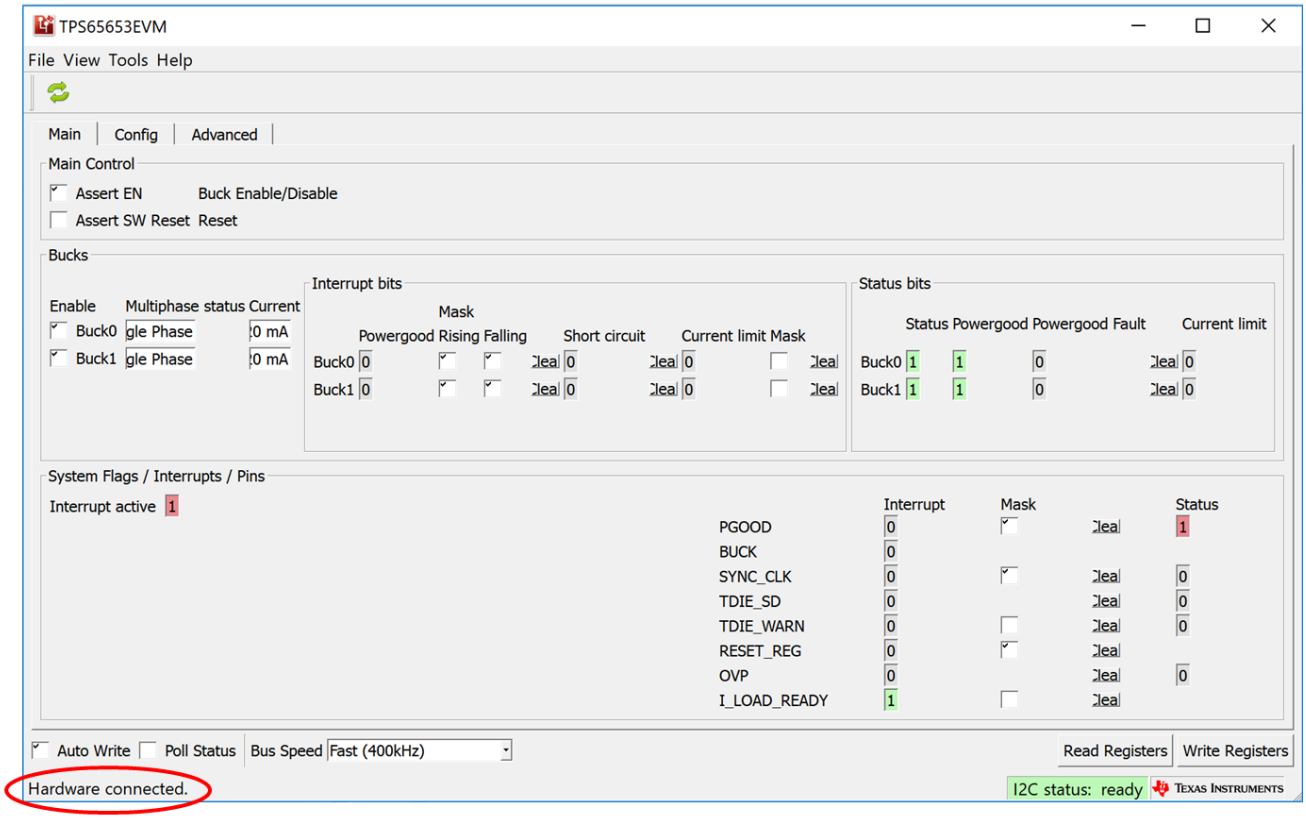

Figure 2. Evaluation Software GUI When EVM is Connected to the PC using USB Cable

2.3 Power Supply Setup

A bench-top DC power supply is needed to power up the EVM. For full-load testing of the TPS65653Q1EVM, a DC-power supply capable of at least 8 A and 4 V is required. 4 A is suggested as a practical minimum for partial load. The power supply is connected to the EVM using connector J4. The power supply and cabling must present low impedance to the UUT; the length of power supply cables must be minimized. Remote sense, using connector J8, can be used to compensate for voltage drops in the cabling.

With the power supply disconnected from the EVM, set the supply to 3.7-V DC and the current limit to 4 A, minimum. Set the power supply output OFF. Connect the positive terminal (+) of the power supply to VIN and negative terminal (–) to GND on the EVM (J5 power-in terminal block). Check that jumpers on the board are set as shown in (factory default jumper configuration).

Set power supply output ON, and then continue with the following steps:

1. Click on Assert EN check box. See marking 1 in Figure 3..
2. Click on Read Registers button (marking 2 in Figure 3). User should see “I2C Status: ready” message on the green background next to the Read Registers button.

The EVM is now ready for testing with default register settings loaded.

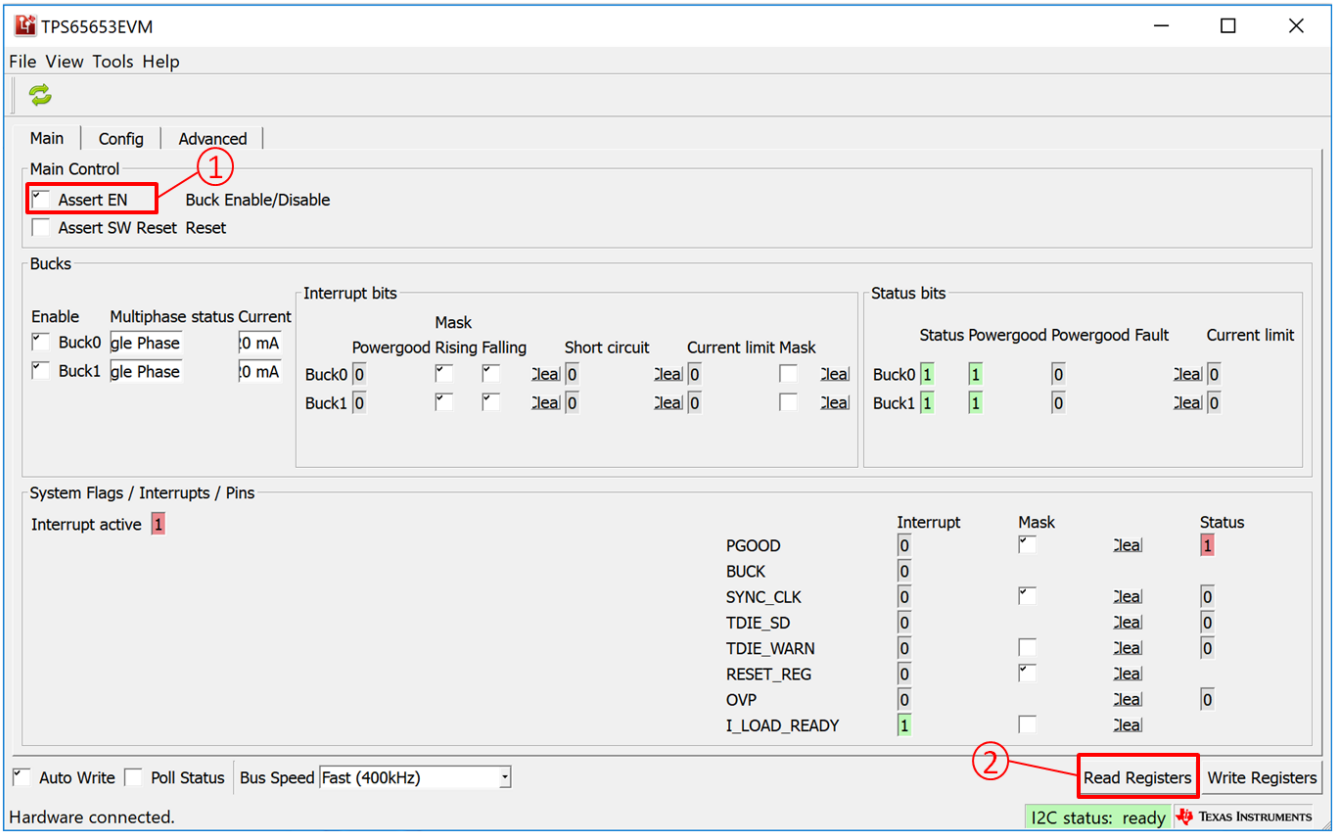

Figure 3. Evaluation Software GUI Showing Steps Needed to Power up the TPS65653-Q1

2.4 Notes on Efficiency Measurement Procedure

Output Connections: An appropriate electronic load or high-power system source meter instrument, specified for operation down to 700 mV, is desirable for loading the EVM. The maximum load current is specified as 8 A. Be sure to choose the correct wire size when attaching the electronic load. A wire resistance that is too high causes a voltage drop in the power distribution path, which becomes significant compared to the absolute value of the output voltage. Connect an electric load to J14 or J16. It is advised that, prior to connecting the load, it be set to sink 0 A to avoid power surges or possible shocks.

Voltage drop across the PCB traces yield inaccurate efficiency measurements. For the most accurate voltage measurement at the EVM, use J6 to measure the input voltage and J7 to measure the output voltage.

To measure the current flowing to/from the UUT, use the current meter of the DC power supply/electric load as long as it is accurate. Some power source ammeters may show offset of several milliamps and thus yields inaccurate efficiency measurements. In order to perform very accurate I_Q measurements on the EVM, disconnect input protective Zener diode D1 by removing the shunt J5 from the board. When connected, this diode will cause some leakage, especially at high VIN voltages.

3 GUI Overview

The evaluation software has the following tabs: Main, Config, and Advanced. The three tabs together provide the user access to the whole register map of the TPS65653 devices.

3.1 Main Tab

The Main tab has the elemental controls for the EVM and provides a view of the chip status. Starting from top, the main controls are:

- Assert EN: This checkbox asserts logic high level voltage to the TPS65653 EN pin. Asserting EN may enable the Buck regulator(s) depending on the register settings.
- Assert SW Reset: To perform a complete SW reset to the chip, click this checkbox. See the TPS65653 data sheet for explanation of various reset scenarios.

The "Bucks" section provides enable controls and status information for bucks as follows:

- Enable check boxes provide enable/disable control for all bucks.
- The “Current” field provides approximate level of load current on each buck.

The "System Flags / Interrupts / Pins" section as well as the "Interrupt bits" and the "Status bits" sections give data on system faults and warnings. If the interrupt is set for any reason the Interrupt field shall show ‘1’ on red background. The flag causing the interrupt will also be set on the Main tab. Interrupts on TPS65653 can only be cleared by writing '1' to associated registers. Any individual flag can be cleared by clicking the "Clear" button next to each flag. Some of the flags also have a mask bit. If "Mask" check-box of certain flag is checked, the interrupt is not generated. The "Status" bits will show the current status of the faults.

At the bottom of the GUI window is the "Auto Write" checkbox. If "Auto Write" is checked (default) any checking, un-checking or pull-down menu selections will immediately launch I2C writes to the chip register(s). If not checked, the user can update the chip registers to correspond the configuration selected on the GUI by clicking "Write Registers".

If "Poll Status" is selected the software sends a query to the TPS65653 device at a fixed interval in order to detect the status of the chip, including operation mode and load current. If not selected, user can read the registers by clicking "Read Registers".

3.2 Other Tabs and Menus

The "Tools" pulldown menu hosts another way of accessing the TPS65653 registers. The "Direct Register Access" tool can be used to read or write any register. When using direct register access, un-checking the “Poll Status” check-box is recommended. This way the GUI only does the reads and writes commanded from the direct access dialog.

The "Config" and "Advanced" tabs provide the user with pulldown menus and check-boxes for the part of the register space that is not covered by the Main tab, such as output voltage control. These controls are self-explanatory. Please refer to the TPS65653 datasheet for explanation of the functions.

3.3 Console

To show or hide the console, toggle the option in the View pulldown menu. The console can be used to access any of the TPS65653 registers. Registers can be read or written simply by referring to the logical registers by their name.

The console supports use of scripts. If a text file containing commands supported by the console is stored in the same folder as the evaluation software executable, then the script can be launched from the console by typing the text file name, like script.txt.

4 Board Layout

This section describes the board layout of the TPS65653-Q1. See the TPS65653 data sheet for specific PCB layout recommendations. The board is constructed on a 4-layer PCB. Figure 4 shows the top view of the entire board. Routing is mostly done on top and bottom layers. Top layer contains the copper areas connecting the VOUT pads of the inductors and output capacitors together and to the load terminals. 2nd layer is the ground plane and 3rd layer contains the VIN copper area and copper areas for the VOUT nets. Also the bottom layer contains large copper area filled with ground. Input capacitors are placed as close as possible to the TPS65653 device for keeping the critical VIN and GND traces short. Output capacitors and inductors are placed around the input capacitors.

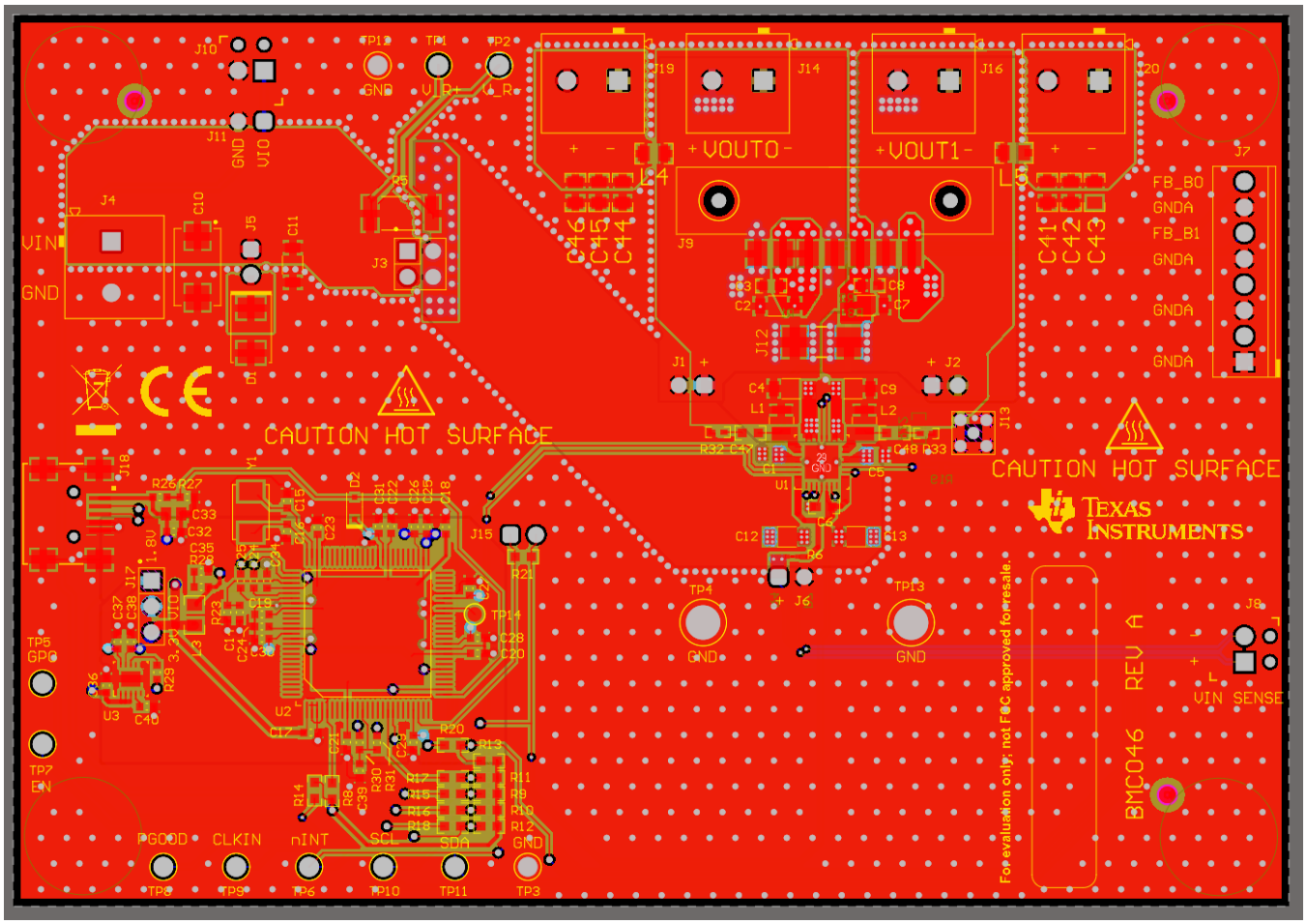

Figure 4. TPS65653-Q1 Board Layout

5 Evaluation Board Schematic

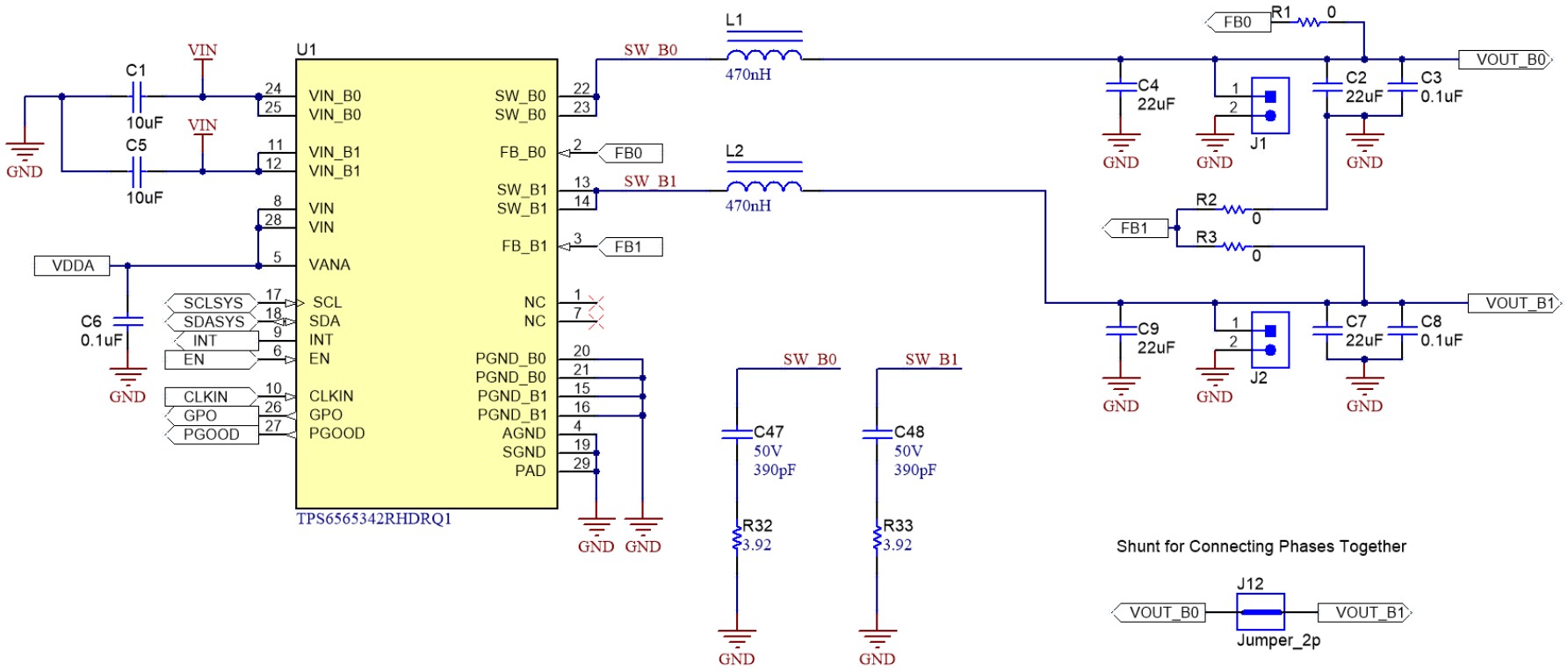

Figure 5. EVM Schematic

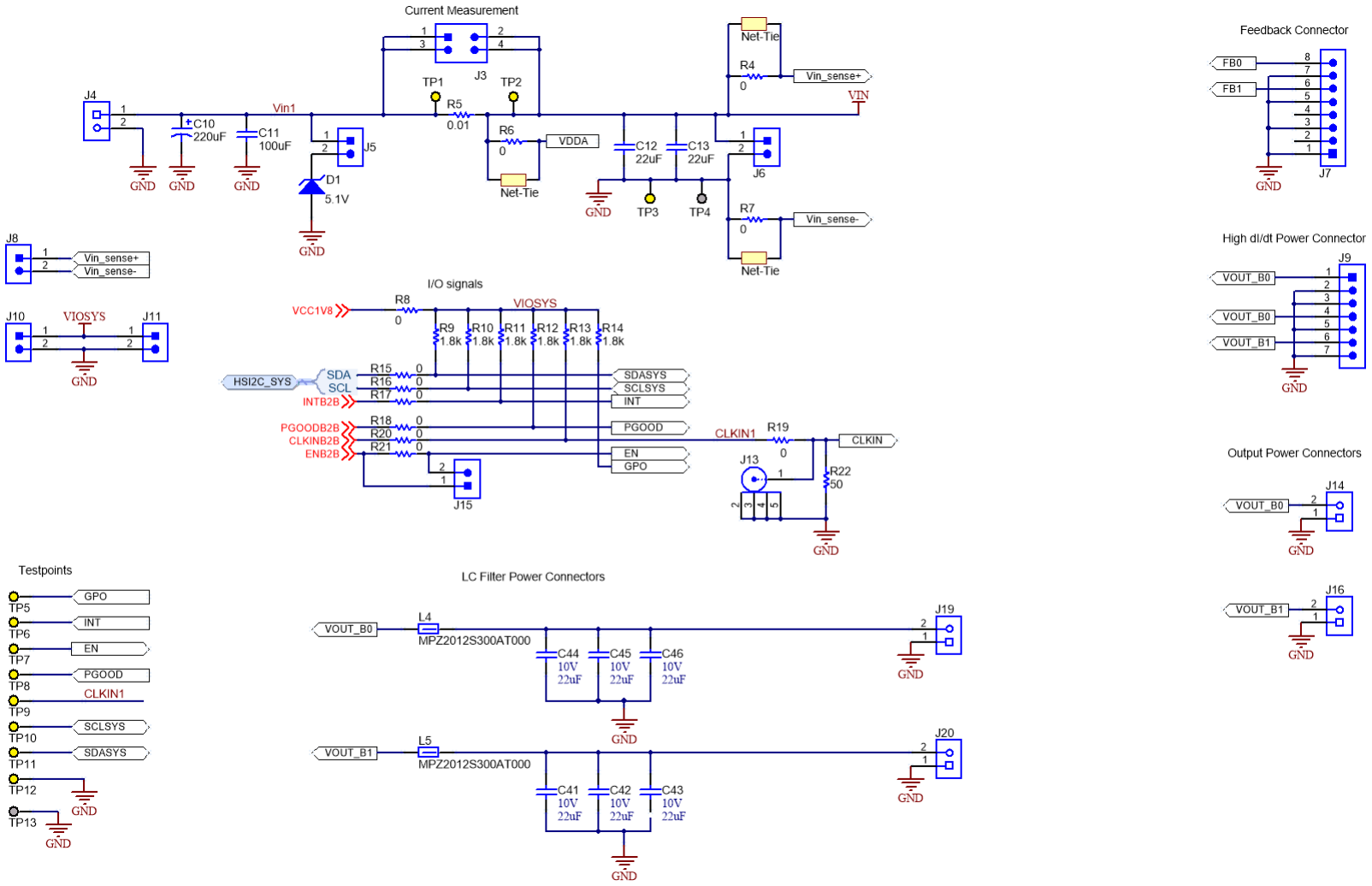

Figure 6. EVM Connectors

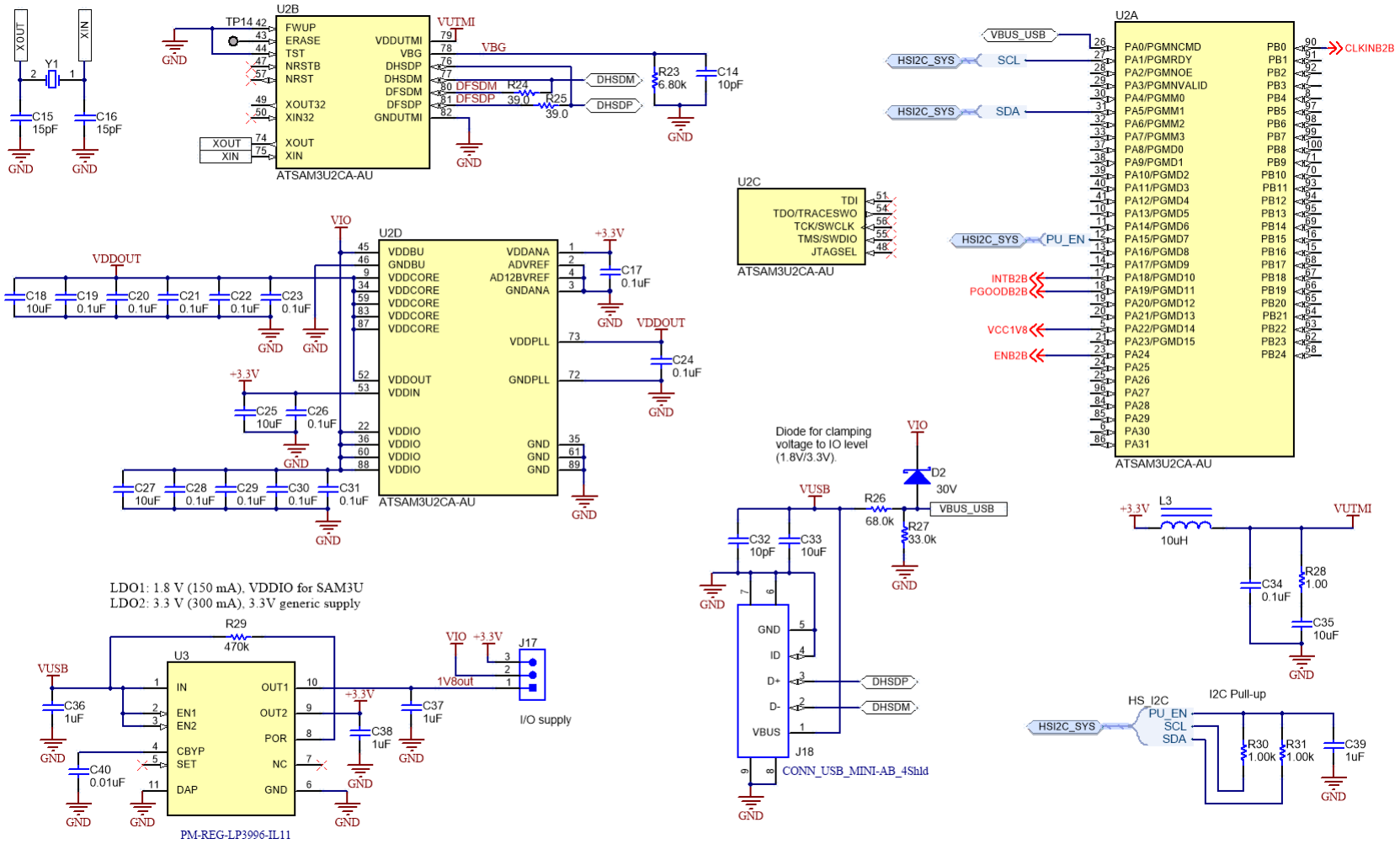

Figure 7. EVM I2C Interface

6 Bill of Materials

Quantity	Designator	Description	PartNumber	Manufacturer
1	!PCB1	Printed Circuit Board	BMC046	Any
2	C1, C5	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	GCM21BR71A106KE22L	MuRata
1	C10	CAP, TA, 220 uF, 10 V, +/- 10%, 0.05 ohm, SMD	TPSD227K010R0050	AVX
1	C11	CAP, CERM, 100 uF, 6.3 V, +/- 20%, X5R, 1206	GRM31CR60J107ME39L	MuRata
2	C14, C32	CAP, CERM, 10 pF, 100 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	GCM1885C2A100JA16D	MuRata
2	C15, C16	CAP, CERM, 15 pF, 100 V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	GCM1885C2A150JA16D	MuRata
4	C18, C25, C27, C35	CAP, CERM, 10 uF, 16 V, +/- 20%, X5R, 0603	GRM188R61C106MAALD	MuRata
6	C2, C4, C7, C9, C12, C13	CAP, CERM, 22 uF, 10 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	GCM31CR71A226KE02	MuRata
16	C3, C6, C8, C17, C19, C20, C21, C22, C23, C24, C26, C28, C29, C30, C31, C34	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	GCM188R71H104KA57D	MuRata
1	C33	CAP, CERM, 10 uF, 16 V, +/- 10%, X5R, 0805	GRM21BR61C106KE15L	MuRata
4	C36, C37, C38, C39	CAP, CERM, 1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71E105KA64D	MuRata
1	C40	CAP, CERM, 0.01 uF, 50 V, +/- 5%, C0G/NP0, 0603	GRM1885C1H103JA01D	MuRata
6	C41, C42, C43, C44, C45, C46	CAP, CERM, 22 uF, 10 V, +/- 20%, X7S, 0805	C2012X7S1A226M125AC	TDK
2	C47, C48	CAP, CERM, 390 pF, 50 V, +/- 10%, X7R, 0603	C0603C391K5RACTU	Kemet
1	D1	Diode, Zener, 5.1 V, 5 W, SMB	SMBJ5338B-TP	Micro Commercial Components
1	D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT42WS-7-F	Diodes Inc.
0	FID1, FID2, FID3, FID4, FID5, FID6	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
4	H1, H2, H3, H4	Bumpon, Hemisphere, 0.44 X 0.20, Clear	SJ-5303 (CLEAR)	3M
1	H5	CABLE MINI USB 5PIN 1M 2.0 VERS	AK672M/2-1-R	Assman WSW
3	J1, J2, J5, J6, J11, J15	Header, 100 mil, 2 x 1, Gold, TH	TSW-102-07-G-S	Samtec
0	J12	JUMPER TIN SMD	S1911-46R	Harwin
0	J13	Connector, MMCX,Vertical RCP 6GHz, 50Ohm, TH	135-9701-201	Cinch Connectivity
1	J17	Header, 100 mil, 3 x 1, Gold, TH	HTSW-103-07-G-S	Samtec
1	J18	Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	1734035-2	TE Connectivity
1	J3	Header, 100 mil, 2 x 2, Gold, TH	TSW-102-07-G-D	Samtec
5	J4, J14, J16, J19, J20	Terminal Block, 5.08 mm, 2 x 1, TH	1715721	Phoenix Contact
1	J7	Terminal Block, 8 x 1, 2.54 mm, TH	1725711	Phoenix Contact

2	J8, J10	Terminal Block, 100 mil, 2 x 1, 6 A, 63 V, TH	1725656	Phoenix Contact
0	J9	Connector, 7 pos, 2.54 mm, R/A, SMT	OPP-07-01-T-S-M	Samtec
2	L1, L2	Inductor, Shielded, 470 nH, 4.7 A, 0.021 ohm, SMD	DFE252012PD-R47M	MuRata Toko
1	L3	Inductor, Wirewound, Ferrite, 10 uH, 0.12 A, 0.5 ohm, SMD	LB2012T100KR	Taiyo Yuden
2	L4, L5	Ferrite Bead, 30 ohm @ 100 MHz, 6 A, 0805	MPZ2012S300AT000	TDK
1	LBL1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10	Brady
3	R1, R3, R19	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2GE0R00X	Panasonic
0	R2, R18, R20	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
0	R22	RES, 50, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060350R0FKEA	Vishay-Dale
1	R23	RES, 6.80 k, 1%, 0.1 W, 0603	RC0603FR-076K8L	Yageo
2	R24, R25	RES, 39.0, 1%, 0.1 W, 0603	RC0603FR-0739RL	Yageo
1	R26	RES, 68.0 k, 1%, 0.1 W, 0603	RC0603FR-0768KL	Yageo
1	R27	RES, 33.0 k, 0.1%, 0.1 W, 0603	RG1608P-333-B-T5	Susumu Co Ltd
1	R28	RES, 1.0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031R00JNEA	Vishay-Dale
1	R29	RES, 470 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603470KJNEA	Vishay-Dale
2	R30, R31	RES, 1.02 k, 1%, 0.1 W, 0603	RC0603FR-071K02L	Yageo
2	R32, R33	RES, 3.92, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04023R92FKED	Vishay-Dale
0	R4, R6, R7	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0ED	Vishay-Dale
1	R5	RES, 0.01, 1%, 3 W, 2512	CRA2512-FZ-R010ELF	Bourns
5	R8, R15, R16, R17, R21	RES, 0.005, 1%, 0.25 W, AEC-Q200 Grade 1, 0603	ERJ3LWFR005V	Panasonic
3	'R9, R10, R11, R12, R13, R14	RES, 1.8 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031K80JNEA	Vishay-Dale
4	SH-J1, SH-J2, SH-J3, SH-J4	Shunt, 2mm, Gold plated, Black	2SN-BK-G	Samtec
11	TP1, TP2, TP3, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	Test Point, Miniature, Yellow, TH	5004	Keystone
2	TP4, TP13	Terminal, Turret, TH, Double	1502-2	Keystone
1	U1	Dual Buck Converters for Radar Applications, RHD0028W (VQFN-28)	TPS6565342RHDRQ1	Texas Instruments
1	U2	AT91SAM ARM-based Flash MCU, LQFP100	ATSAM3U2CA-AU	Atmel
1	U3	Dual Linear Regulator with 300 mA and 150 mA Outputs and Power-On-Reset, 10-pin LLP, Pb-Free	LP3996SD-1833/NOPB	Texas Instruments
1	Y1	Crystal, 12 MHz, 12pF, SMD	CX5032GB12000H0PESZZ	AVX

Revision History

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

Changes from Original (February 2017) to A Revision	Page

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