TUSB4020BPHP Evaluation Module

This document describes how to use and configure the TUSB4020BPHP evaluation module (EVM). Also included in this user's guide are set up and installation instructions, a troubleshooting section, the bill of materials (BOM), and the EVM schematics.

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1 Introduction

The Texas Instruments TUSB4020B evaluation module is a functional board design of a single device that implements a USB 2.0 hub. The EVM can support USB 2.0 (HS, FS, and LS) operation on its USB ports. This EVM is intended for use in evaluating system compatibility, developing optional EEPROM firmware, and validating interoperability. This EVM also acts as a hardware reference design for any implementation of the TUSB4020B.

Upon request, layout files for the EVM can be provided to illustrate techniques used to route the differential pairs, use of split power planes, placement of filters and other critical components, and methods used to achieve length matching of critical signals.

NOTE: The EVM accommodates various lab test components, actual production implementations can be much smaller.

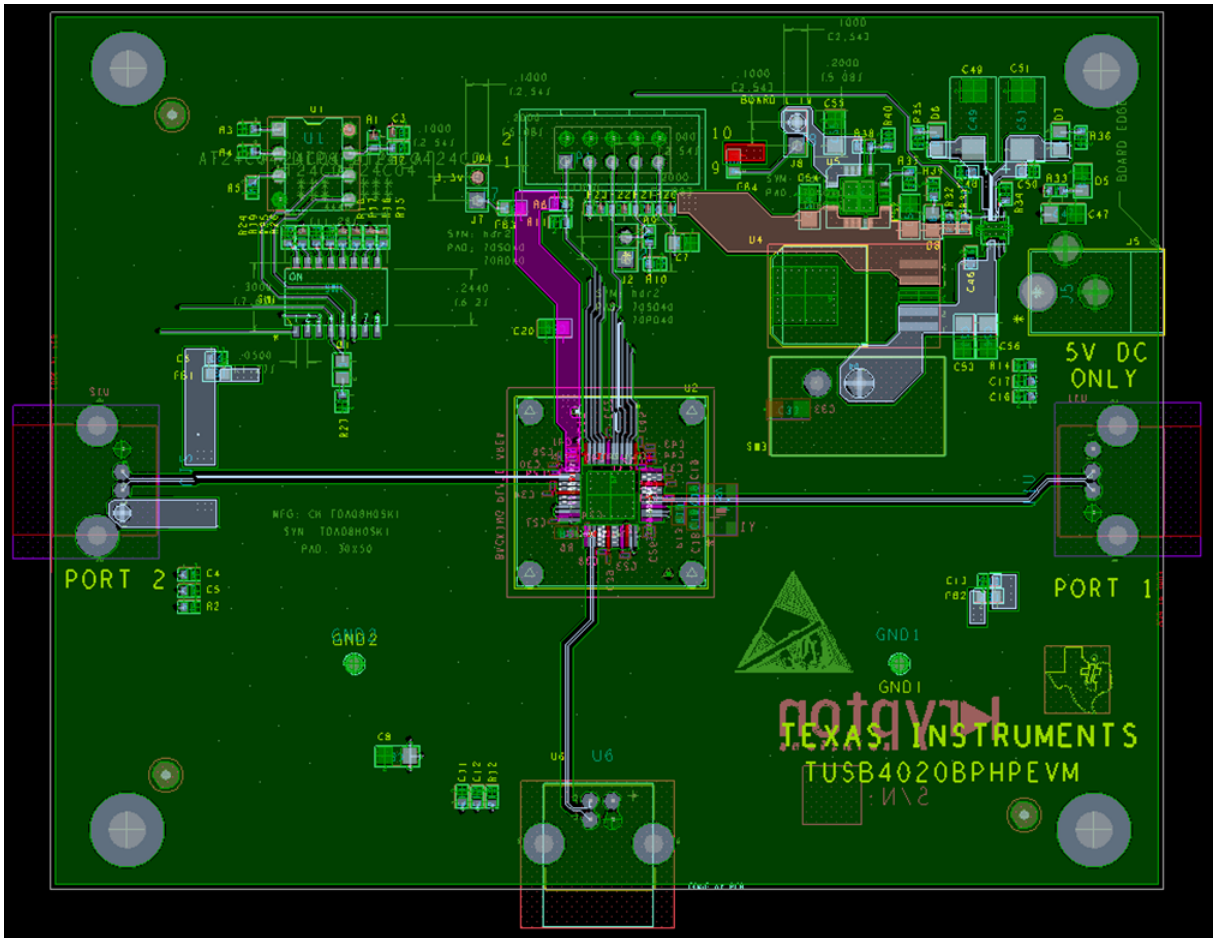


Figure 1. TUSB4020B EVM Top Layer Layout

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2 Hardware Overview

The TUSB4020B EVM board hardware can be divided into six functional areas:

2.1 TUSB4020BPHP

The TUSB4020B EVM (U2 on the schematic) operates as a functional interconnect between an upstream connection to a USB host or hub and up to two directly connected downstream devices or hubs. More devices and hubs can be supported if arranged in tiers. The TUSB4020B is capable of supporting operation at High-Speed (HS), Full Speed (FS) or Low Speed (LS). In general, the speed of the upstream connection of the TUSB4020B EVM limits the downstream connections to that speed (HS and FS) or lower.

The TUSB4020B requires a 24-MHz low ESR crystal, Y1 with a 1-MΩ feedback resistor. The crystal should be fundamental mode with a load capacitance of 12 pF – 24 pF and a frequency stability rating of ±100 PPM or better. To ensure a proper startup oscillation condition, a maximum crystal equivalent series resistance (ESR) of 50 Ω is recommended.

The TUSB4020B can also use an oscillator or other clock source. When using an external clock source such as an oscillator, the reference clock should have ±100 PPM (or better) frequency stability and have less than 50-ps absolute peak-to-peak jitter (or less) than 25-ps peak-to-peak jitter after applying the USB 3.0 jitter transfer function.

2.2 USB Port Connectors

VBUS is received from the upstream host or hub on J3. The TUSB4020B is configured as a self-powered hub, so there is not any significant current draw by the EVM from VBUS. The TUSB4020B does monitor the VBUS input after filtering through a resistor divider network of a 90.9-kΩ, 1% resistor, R9, and a 10-kΩ, 1% resistor, R10. VBUS cannot be directly connected to the TUSB4020B device. A bulk capacitor of at least 1 µF is required on the upstream port VBUS input to comply with the USB specification. The TUSB4020BEVM uses a 10-µF capacitor, C8.

VBUS, sourced by the 5-V wall power input, J5, is provided to the downstream port connectors. The USB 2.0 specification limits the current consumption of a USB 2.0 device to 500 mA at 5 V. The current limiting parameter of the TPS2561 device, U3, is configured to 2.2 A to avoid any spurious overcurrent events due to bus-powered HDD spin-up power fluctuations or unnecessary limiting during USB charging. A production implementation could place stricter limits on this power consumption. An overcurrent event on any of the downstream port connectors will be reported to the TUSB4020B via the OVERCURxZ inputs.

2.2.1 USB Port Connector – Noise Filtering

Each downstream VBUS output has a 150-µF bulk capacitor (C49, C51) as recommended by the TPS2561 data manual (SLVS930) to prevent in-rush current events on the downstream devices. In addition, there are ferrite beads and small capacitors on the VBUS lines to reduce noise and address ESD/EMI concerns.

The TUSB4020BEVM also implements optional isolation using two small noise filtering capacitors and a 1-MΩ resistor between the earth ground of each connector and the digital ground of the EVM, this is not a requirement but should be used if ground isolation is desired.

2.3 Optional Serial EEPROM

Each TUSB4020BEVM is equipped with an onboard EEPROM/socket placeholder, U1. A small I2C EEPROM can be installed to set the configuration registers as defined in the TUSB4020B data manual. In its default setting, the EVM does not have an EEPROM installed and instead uses the configuration inputs to determine any optional settings of the TUSB4020B.

The EEPROM interface defaults to programmable (not write-protected) so that any installed EEPROM's contents may be modified to test various settings. If an EEPROM data change is required, the values may be changed using the register access methods outlined in the TUSB4020B data sheet (#NUM#). In addition, a Microsoft® Windows® based EEPROM utility is available upon request.

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2.4 Power

The TUSB4020B EVM operates from the power provided by a 5-V wall power adapter, J5, not bus power supplied by a USB host. It is recommended to use a wall power adapter that is capable of sourcing 4 A to 5 A because the hub must be able to source significant power on its downstream ports (500 mA per port).

The TUSB4020B EVM uses a single channel LDO voltage regulator to drop 5 V to 3.3 V. The TPS7A4533, U4, is a 1.5-A output linear regulator (SLVS720). The 1.1-V core voltage required by the TUSB4020B is sourced by the 3.3-V rail to reduce unnecessary heat dissipation. The TPS74801, U5, is a 1.5-A output single channel LDO linear regulator (SBVS074). Both regulators require few external passive components and are appropriately rated for heat dissipation.

2.5 Hub Configuration

The TUSB4020BEVM can be configured by setting several inputs to the TUSB4020B that are sampled at power-on reset or using an optional serial EEPROM or SMBUS host. A production implementation without EEPROM or SMBUS could either rely on the default internal pull-up or pull-down resistor for each configuration input or override it with an external pull-up or pull-down resistor. The settings can be modified using SW1 on the EVM. Descriptions of the possible configuration changes are included in the Configuration Switch section.

2.6 Optional Circuitry

The TUSB4020B EVM design implements a variety of LEDs, none of which are required by the USB specification. The LEDs are provided for easier testing and debug.

- D1 – Indicates that the upstream USB port is connected at High-Speed
- D5 – Indicates that 5 V is being applied to the TUSB4020B EVM
- D6 – Indicates downstream USB port 1 power is on
- D7 – Indicates downstream USB port 2 power is on
- D8 – Indicates BOARD_3P3V is active

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3 Hardware Set Up

3.1 Configuration Switch

The TI TUSB4020BEVM has a set of switches to facilitate configuration changes. Changing these switch settings without a complete understanding of the result is not recommended. Configuration inputs are only read by the TUSB4020B during power on reset, changing the switch settings while the EVM is powered on will have no effect. Please refer to the EVM schematic in Appendix B for additional information.

The switch definitions are as follows, with the standard setting in parenthesis:

SW1_1 (on): FULLPWRMGMTZ_SMBA1_SS Switch. The TUSB4020B has an internal pull up on this terminal, so the TUSB4020B defaults to a non full power management mode. If the switch is set to the ON position, the terminal is pulled low and full power management mode is enabled. This means that the TUSB4020B reports that it supports downstream port power switching in the USB descriptors it sends to the USB host. Since the TUSB4020B EVM does implement downstream port power switching, full power management mode should be enabled.

SW1_2 (off): PWRCTL_POL_SS_DN1 Switch. The TUSB4020B has an internal pull down on this terminal, so port power control polarity defaults to active high. If the switch is set to the ON position, the terminal is pulled high and the port power control polarity changes to active low.

SW1_3 (off): SMBUSz_SS_DN2 Switch. The TUSB4020B has an internal pull up on this terminal, so I2C interface mode is enabled by default. If the switch is set to the ON position, the terminal is pulled low and SMBUS mode is enabled.

SW1_4 (on): GANGED_SMBA2_HS Switch. The TUSB4020B has an internal pull up on this terminal, so ganged mode is enabled by default. If the switch is set to the ON position, the terminal is pulled low and individual port power control mode is enabled. Since the TUSB4020B EVM does implement individual port power controls, this terminal should be set high.

SW1_5 (off): SCL_SMBCLK_SSCDIS Switch. The TUSB4020B has an internal pull down on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, a pull-up resistor is connected to the serial clock terminal to indicate that an I2C EEPROM may be attached (along with a pull-up resistor on SDA).

SW1_6 (off): SDA_SMBDAT_U1U2DIS Switch. The TUSB4020B has an internal pull down on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, a pull-up resistor is connected to the serial clock terminal to indicate that an I2C EEPROM may be attached (along with a pull-up resistor on SCL).

SW1_7 (off): PWRCTL1_BATEN1 Switch. The TUSB4020B has an internal pull down on this terminal, so USB Battery Charging mode on Port 1 is disabled by default. If the switch is set to the ON position, the terminal is pulled high and battery charging is enabled on downstream port 1.

SW1_8(off): PWRCTL2_BATEN2 Switch. The TUSB4020B has an internal pull down on this terminal, so the USB Battery Charging mode on Port 2 is disabled by default. If the switch is set to the ON position, the terminal is pulled high and battery charging is enabled on downstream port 2.

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4 EVM Installation

Install the EVM with the following steps:

1. Attach a 5-V, 3-A wall power source to J5. LEDs D8 and D5 should be lit.
2. Attach a USB cable between J3 and a USB host. LEDs D1, D6, and D7 should be lit.

5 Troubleshooting

Use the following to troubleshoot issues:

Case 1: One or more device functions are “banged out” in Device Manager.

- Make sure that the latest updates are installed for the operating system
- Make sure that the latest drivers are installed for the host controller

Case 2: The EVM does not work at all.

- Verify that all switches are in their default state and the EVM is powered on with a 5-V source with adequate current to support any bus-powered devices (3A+)
- If installed, remove the serial EEPROM from the EEPROM socket. The EVM does not require an EEPROM to operate.
- In the case where a 12-V power supply has been attached to the EVM, the fault is non-recoverable

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TUSB4020BPHP EVM Bill of Materials

This appendix contains the TUSB4020BPHP EVM BOM.

Table 1. EVM Bill of Materials

Item	QTY	Reference	Part	Manufacturer	Part Number	Pkg	Description
1	2	C7,C20	1uF	TDK	C2012X7R1A105K	805	CAP CER 1.0UF 10V X7R 10% 0805
2	3	C4,C12,C16,	0.001uF	TDK	C1005X7R1H102K	402	CAP CER 1000PF 50V X7R 10% 0402
3	8	C21,C26,C27,C30,C34, C37,C40,C43	0.001uF	TDK	C0603X7R1E102K	201	CAP CER 1000PF 25V 10% X7R 0201
4	8	C22,C24,C28,C31,C35, C38,C41,C44	0.01uF	TDK	C0603X5R1A103K	201	CAP CER 10000PF 10V 10% X5R 0201
5	9	C3,C5,C6,C11,C13,C17 , C46,C48,C50	0.1uF	Yageo	CC0402KRX5R6BB104	402	CAP CERAMIC .1UF 10V X5R 0402
6	8	C23,C25,C29,C32,C36, C39,C42,C45	0.1uF	TDK	C0603X5R0J104M	201	CAP CER .10UF 6.3V X5R 0201
7	2	C18,C19	18pF	AVX	04025A180JAT2A	402	CAP CERM 18PF 5% 50V NP0 0402
8	8	C8,C33,C47,C52,C53,C 54,C55, C56	10uF	Murata Electronics	GRM31CR61C106KC31L	1206	CAPACITOR CERM 10UF 16V 10% SMD
9	2	C49,C51	150uF	Kemet	B45197A2157K409 (Tantalum)	7343	CAP TANT 150UF 10V 10% LOESR SMD
10	8	R1,R8,R20,R21,R22,R2 3, R37,	NOPOP			402	NOPOP
11	5	D1,D5,D6,D7,D8	LED Green 0805	Lite On	LTST-C171GKT	805	LED GREEN CLEAR THIN 0805 SMD
12	4	FB1,FB2,FB3,FB4	220 @ 100MHZ Ferrite Bead	Murata	BLM18PG221SN1D	603	FERRITE CHIP 220 OHM 1400MA 0603
13	1	SW1	8-POS 50-MIL SMT	C&K Components	SD08H0SBR		SWITCH DIP SPST SEALED 8POS SMD
14	1	U6	USB 2.0 Type B USB-Shield	Amphenol	UE27BC54130		USB RCPT GOLD TYPE B R/A
15	2	U11,U12	USB 2.0 Type A USB-Shield	Amphenol	UE27AC54100		USB RCPT GOLD TYPE B R/A
16	1	J5	2.1mm x 5.5mm DC Power Jack	CUI Inc.	PJ-202AH (PJ-002AH)	2.1mm x 5.5mm	CONN PWR JACK 2.1X5.5MM HIGH CUR
17	4	R2,R12,R13,R14	1M	Rohm Semiconductor	MCR01MZPJ105	402	RES 1.0M OHM 1/16W 5% 0402 SMD
18	1	R9	90.9K 1%	Rohm Semiconductor	MCR01MZPF9092	402	RES 90.9K OHM 1/16W 1% 0402 SMD
19	2	R31,R32	10K	Rohm Semiconductor	MCR01MZPJ103	402	RES 10K OHM 1/16W 5% 0402 SMD
20	1	R10	10K 1%	Rohm Semiconductor	MCR01MZPF1002	402	RES 10K OHM 1/16W 1% 0402 SMD
21	9	R15,R16,R17,R18,R19, R24, R25,R26,R27	4.7K	Vishay / Dale	CRCW04024K70FKED	402	RES 4.70K OHM 1/16W 1% 0402 SMD
22	5	R3,R4,R5,R7,R11	1K	Rohm Semiconductor	MCR01MZPJ102	402	RES 1.0K OHM 1/16W 5% 0402 SMD
23	4	R33,R35,R36,R39	330	Rohm Semiconductor	MCR01MZPJ331	402	RES 330 OHM 1/16W 5% 0402 SMD
24	1	R34	25.5K	Panasonic - ECG	ERJ-2RKF2552X	402	RES 25.5K OHM 1/10W 1% 0402 SMD
25	1	R38	1.87K	Vishay / Dale	CRCW04021K87FKED	402	RES 1.87K OHM 1/16W 1% 0402 SMD
26	1	R40	4.99K	Vishay / Dale	CRCW04024K99FKED	402	RES 4.99K OHM 1/16W 1% 0402 SMD
27	1	U2	TUSB4020B	Texas Instruments	TUSB4020B	48QFP	

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Table 1. EVM Bill of Materials (continued)

Item	QTY	Reference	Part	Manufacturer	Part Number	Pkg	Description
28	1	U1	AT24C04 Socket	TE Connectivity	AT24C04A-10PU-1.8 / 2-641260-1	8DIP / 8SOIC SOCKET	CONN IC SOCKET 8POS DIP TIN
29	1	U3	TPS2561DRC-USB Power Switch	Texas Instruments	TPS2561DRC	10SON	
30	1	U4	TPS7A4533 - 3.3V Voltage Regulator	Texas Instruments	TPS7A4533KTT	DDPAK-5	
31	1	U5	TPS74801RGW - 1.1V Voltage Regulator	Texas Instruments	TPS74801RGW	20VQFN	
32	1	Y1	ECS-24MHZ Crystal	ECS	ECX-53B (ECS-240-20-30B-TR)	5.0mm x 3.2mm	CRYSTAL 24.000 MHZ 20PF SMD
33	1	JP1	Conn 2x5 shroud - NOPOP				
34	1	R6	9.53K 1%	Rohm Semiconductor	MCR01MRTF9531	402	RES 9.53K OHM 1/16W 1% 0402 SMD
35	2	GND1,GND2	TEST POINT - NOPOP				NOPOP
36	1	J2,J7,J8	Header 1x2	3M	961102-6404-AR		CONN HEADER VERT SGL 2POS GOLD
37	1	SW3	L101_switch	C&K Components	L101011MS02Q		SLIDE SWITCH SPST

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TUSB4020BPHP EVM Schematics

This appendix contains the TUSB4020BPHP schematic.

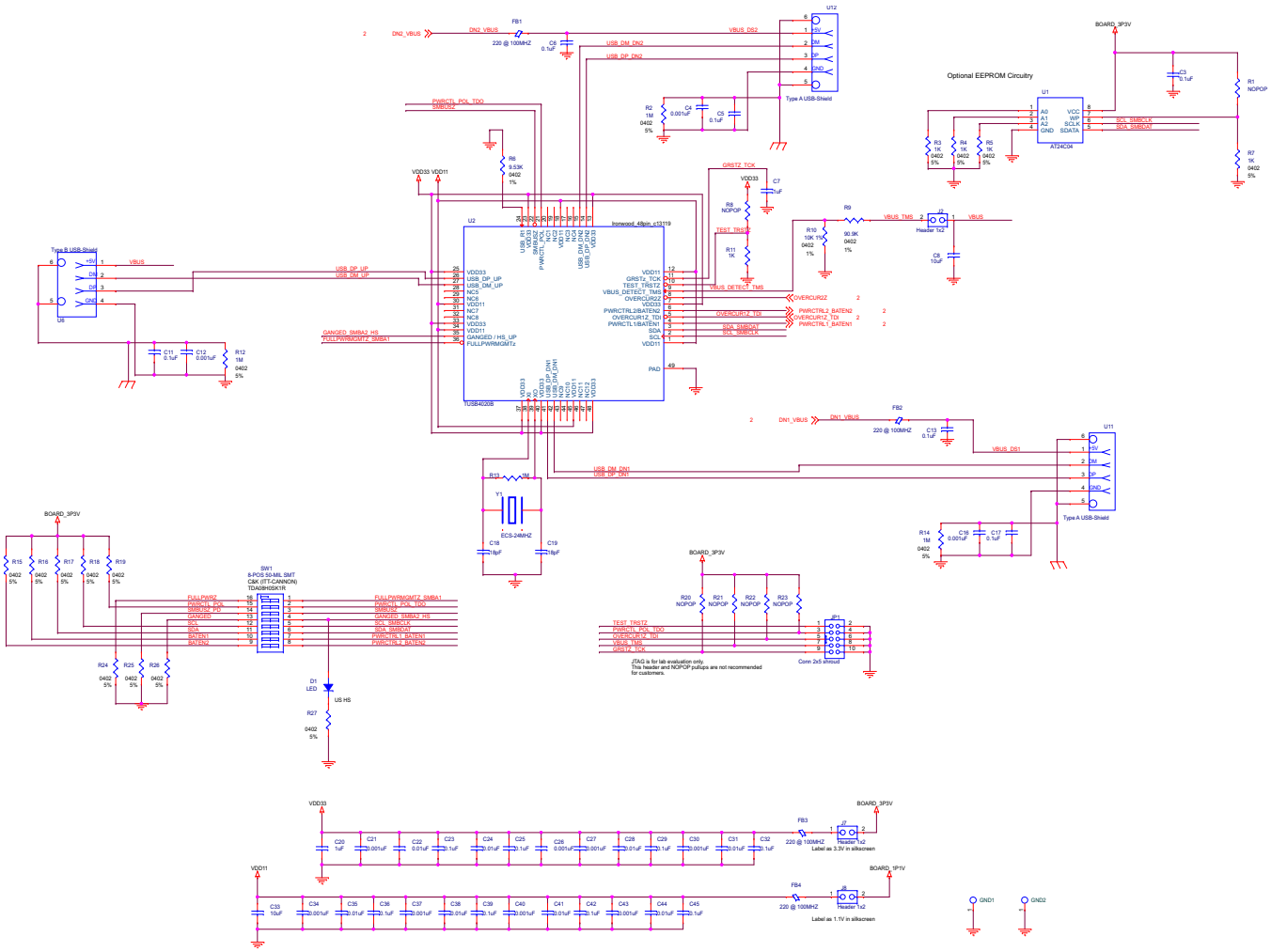


Figure 2. TUSB4020B PHP EVM Schematic

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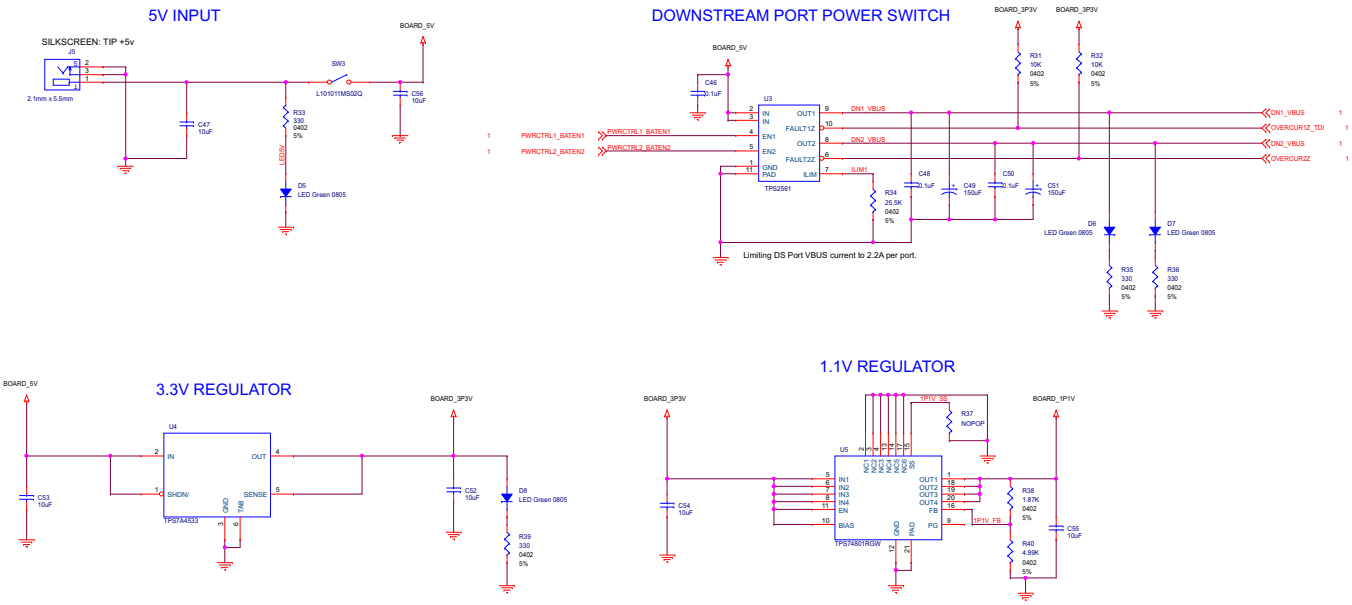


Figure 3. EVM Power Schematic

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      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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*

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http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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:*

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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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