TUSB8041RGC REVD Evaluation Module

The Texas Instruments TUSB8041RGC REVD evaluation module (EVM) is a functional board design of a single device that implements both a USB 3.0 hub and a USB 2.0 hub. The EVM can support both SuperSpeed (SS) and 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 TUSB8041.

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1 Introduction

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.

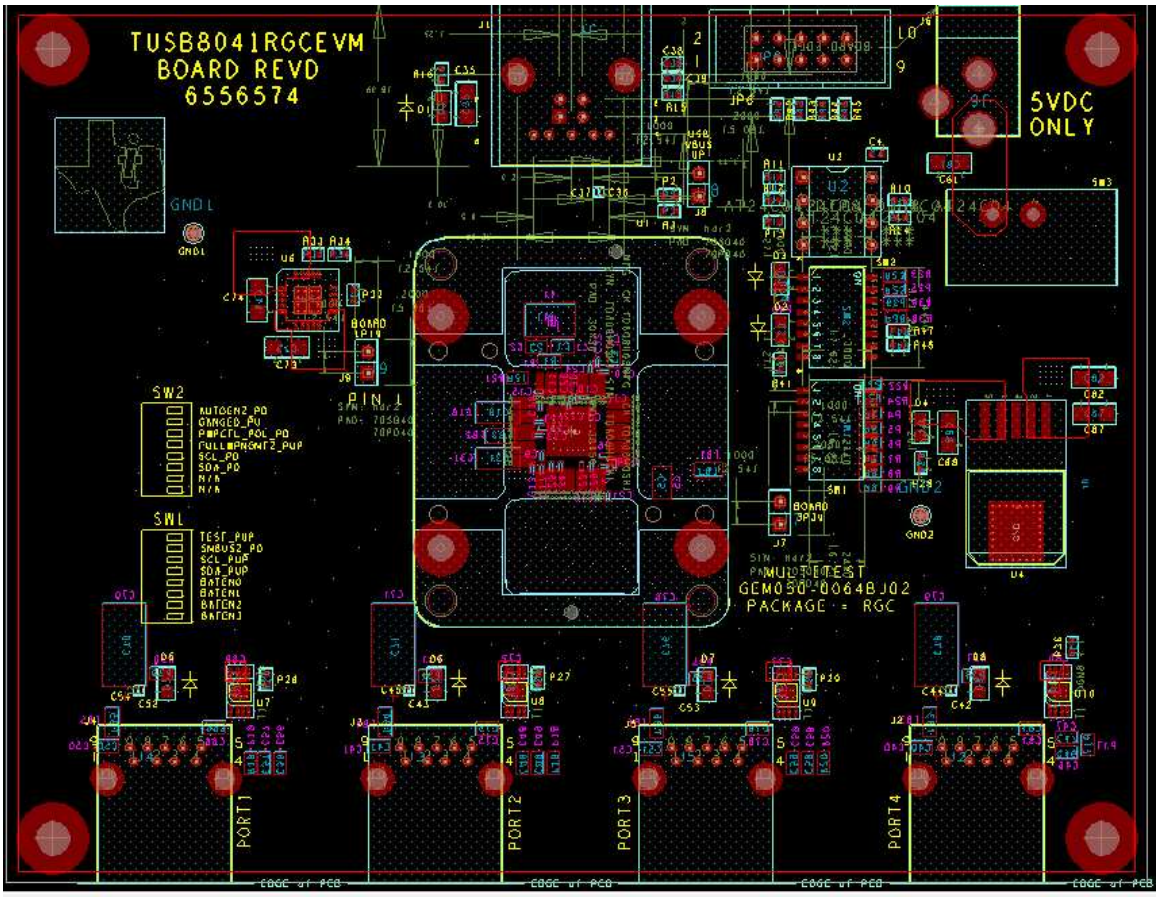


Figure 1. TUSB8041 REVD EVM Top Layer Layout

2 Hardware Overview

The TUSB8041 EVM board hardware can be divided into the following functional areas:

2.1 TUSB8041RGC

The TUSB8041 on the TUSB8041 EVM (U1 on the schematic) operates as a functional interconnect between an upstream connection to a USB host or hub and up to four directly connected downstream devices or hubs. More devices and hubs can be supported if arranged in tiers. The TUSB8041 is capable of supporting operation at USB SuperSpeed (SS), high-speed (HS), full speed (FS), or low speed (LS). In general, the speed of the upstream connection of the TUSB8041 EVM limits the downstream connections to that speed (SS, HS, and FS), or lower.

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The TUSB8041 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 to 24 pF and a frequency stability rating of ±100 PPM or better. To ensure a proper startup oscillation condition, TI recommends a maximum crystal equivalent series resistance (ESR) of 50 Ω.

The TUSB8041 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

The TUSB8041 EVM is equipped with five standard 9-pin USB 3.0 port connectors. One of these five connectors, J1, is a Type B connector designed to interface with an upstream USB host or hub. The remaining connectors, J2, J3, J4, and J5, are Type A connectors for connection to downstream devices or hubs. Standard size connectors were used on the EVM design, but USB micro connectors can be used if desired.

The USB ports can be attached through a standard USB cable to any USB 3.0 or legacy USB host, hub, or device. The TUSB8041 will automatically connect to any upstream USB 3.0 host or hub at both SS and HS. Using a legacy USB cable between the TUSB8041 EVM and a USB 3.0 host or hub forces it to HS operation. The same is true if a legacy USB cable is used between the TUSB8041 EVM and a downstream SS-capable device; operation will be limited to USB 2.0 HS.

2.3 USB Port Connector – Power

VBUS is received from the upstream host or hub on J1. The TUSB8041 is configured as a self-powered hub, so there is not any significant current draw by the EVM from VBUS. The TUSB8041 does monitor the VBUS input after filtering through a resistor divider network of a 90.9-kΩ, 1% resistor, R2, and a 10-kΩ, 1% resistor, R3. VBUS cannot be directly connected to the TUSB8041 device. A bulk capacitor of at least 1 µF is required on the upstream port VBUS input to comply with the USB specification. The TUSB8041EVM uses a 10-µF capacitor, C35.

VBUS, sourced by the 5-V wall power input, J6, is provided to the downstream port connectors. The USB 3.0 specification limits the current consumption of a USB 3.0 device to 900 mA at 5 V. The current limiting parameter of the TPS2001C devices, U7, U8, U9, and U10, is 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 TUSB8041 through the OVERCURxZ inputs.

2.4 USB Port Connector – Noise Filtering

Each downstream VBUS output has a 150-µF bulk capacitor (C70, C71, C76, C79) as recommended by the TPS2001C data manual 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 TUSB8041EVM 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.

Note that the series capacitors implemented on the SS TX pairs are incorporated to satisfy the USB 3.0 requirement that differential links be AC coupled on the transmit pair.

2.5 Optional Serial EEPROM

Each TUSB8041EVM is equipped with an onboard EEPROM/socket placeholder, U2. A small I2C EEPROM can be installed to set the configuration registers as defined in the TUSB8041 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 TUSB8041.

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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 TUSB8041 data sheet. In addition, a Windows® based EEPROM utility is available upon request.

2.6 Power

The TUSB8041 EVM operates from the power provided by a 5-V wall power adapter, J5, not bus power supplied by a USB host. TI recommends to use a wall power adapter that is capable of sourcing 2 to 3 A because the hub must be able to source significant power on its downstream ports (900 mA per port).

The TUSB8041 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 TUSB8041 is sourced by the 3.3-V rail to reduce unnecessary heat dissipation. The TPS74801, U6, 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.

2.7 Hub Configuration

The TUSB8041EVM can be configured by setting several inputs to the TUSB8041 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 pullup or pulldown resistor for each configuration input or override it with an external pullup or pulldown resistor. The settings can be modified using SW1 and SW2 on the EVM. Descriptions of the possible configuration changes are included in a later section.

2.8 Optional Circuitry

The TUSB8041 EVM design implements a variety of LEDs, none of which are required by the USB specification. They are provided to make testing and debugging easier.

- D1 – indicates that the upstream USB port is connected at HS.
- D2 – indicates that the downstream USB port 2 is connected at SS.
- D3 – indicates that the downstream USB port 1 is connected at SS.
- D4 – indicates that the upstream USB port is connected at SS.
- D5 – indicates that 5 V is being applied to the TUSB8041 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.

The switches (SW1, SW2, and SW3) and headers (J7, J8, J9, JP6) present on the TUSB8041 EVM are intended only for lab evaluation and are not required for production designs.

3 Hardware Setup

3.1 Configuration Switch

The TI TUSB8041EVM has a set of switches to facilitate configuration changes. TI does not recommend changing these switch settings without a complete understanding of the result. Configuration inputs are only read by the TUSB8041 during power-on reset, changing the switch settings while the EVM is powered on will have no effect. For additional information, refer to the EVM schematic in Section B.1.

The switch definitions are as follows in Table 1.

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Table 1. Switch Definitions

Switch	Standard Setting	Definition
SW1_1	Off	TEST_TRSTz Switch The TUSB8041 has an internal pulldown on this terminal. If the switch is set to the ON position, the terminal is pulled high and test mode is enabled. This is a production test mode only.
SW1_2	Off	SMBUSz Switch The TUSB8041 has an internal pullup on this terminal, so I^2C 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_3	Off	SCL_SMBCLK Switch The TUSB8041 has an internal pulldown on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, a pullup resistor is connected to the serial clock terminal to indicate that an I^2C EEPROM may be attached (along with a pullup resistor on SDA).
SW1_4	Off	SDA_SMBDAT Switch The TUSB8041 has an internal pulldown on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, a pullup resistor is connected to the serial clock terminal to indicate that an I^2C EEPROM may be attached (along with a pullup resistor on SCL).
SW1_5	Off	PWRON1_BATEN1 Switch. The TUSB8041 has an internal pulldown 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_6	Off	PWRON2_BATEN2 Switch The TUSB8041 has an internal pulldown on this terminal, so 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.
SW1_7	Off	PWRON3_BATEN3 Switch The TUSB8041 has an internal pulldown on this terminal, so USB battery charging mode on Port 3 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 3.
SW1_8	Off	PWRON4_BATEN4 Switch The TUSB8041 has an internal pulldown on this terminal, so USB battery charging mode on Port 4 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 4.
SW2_1	Off	AUTOENz Switch The TUSB8041 has an internal pullup on this terminal, so auto mode is disabled by default. If the switch is set to the ON position, the terminal is pulled low and automatic charging mode is enabled on any port that has battery charging enabled.
SW2_2	Off	GANGED_HS_UP Switch The TUSB8041 has an internal pulldown on this terminal, so ganged mode is disabled by default. If the switch is set to the ON position, the terminal is pulled high and ganged port power control mode is enabled. Because the TUSB8041 EVM does implement individual port power controls, this terminal should be set low.
SW2_3	Off	PWRCTL_POL Switch The TUSB8041 has an internal pullup 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 low and the port power control polarity changes to active low.
SW2_4	Off	FULLPWRMGMTZ_SS_UP Switch The TUSB8041 has an internal pulldown on this terminal, so the TUSB8041 defaults to a full power management mode. If the switch is set to the ON position, the terminal is pulled high and full power management mode is disabled. Because the TUSB8041 EVM does implement downstream port power switching, full power management mode should be left enabled.
SW2_5	Off	SCL_SMBCLK PD Switch The TUSB8041 has an internal pulldown on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, an external pulldown resistor is connected to the serial clock terminal for test purposes.
SW2_6	Off	SDA_SMBDAT PD Switch The TUSB8041 has an internal pulldown on this terminal, so the serial EEPROM/SMBUS interface is disabled. If the switch is set to the ON position, an external pulldown resistor is connected to the serial clock terminal for test purposes.

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3.2 EVM Installation

To install the EVM, perform the following steps:

1. Attach a 5-V 3-A wall power source to J5. LED D5 should be lit.
2. Turn on switch SW3, LED D8 should be lit.
3. Attach a USB cable between J3 and a USB host. LEDs D6 and D7 should be lit.
   (a) If the TUSB8041EVM is attached to a USB 3.0 host, D1 and D4 should be lit.
   (b) If the TUSB8041EVM is attached to a USB 2.0 host, D1 should be lit.

3.3 Troubleshooting

Case 1: Device function or 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 (3 A+).
- If installed, remove the serial EEPROM from the EEPROM socket. The EVM does not require an EEPROM to operate.
- Make sure shunts are installed on J7, J8, and J9.
- In the case where a 12-V power supply has been attached to the EVM, the fault is non-recoverable.

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Appendix A

A.1 TUSB8041RGC REVD EVM Bill of Materials

This appendix contains the TUSB8041RGC REVD EVM BOM.

Table 2. TUSB8041 QFN Lab EVM Bill Of Materials: Texas Instruments, CCI/ICP

Item	Quantity	Reference	Part	Manufacturer	Part Number	Package
1	1	C5	1uF	TDK	C2012X7R1A105K	805
2	1	C3	1uF	Samsung	CL05B105KQ5NQNC	402
3	5	C39,C47,C49,C57,C59	0.001uF	TDK	C1005X7R1H102K	402
4	9	C6,C9,C12,C15,C19,C22,C25,C28,C32	0.001uF	TDK	C0603X7R1E102K030BA	201
5	9	C7,C10,C13,C16,C20,C23,C26,C29,C33	0.01uF	Yageo	CC0201KRX7R7BB103	201
6	18	C4,C38,C40,C41,C46,C48,C50,C51,C56,C58,C66,C69,C72,C75,C77,C78,C80,C81	0.1uF	Yageo	CC0402KRX5R6BB104	402
7	19	C8,C11,C14,C17,C21,C24,C27,C30,C34,C36,C37,C42,C43,C44,C45,C52,C53,C54,C55	0.1uF	TDK	C0603X5R0J104M	201
8	2	C1,C2	18pF	AVX	04025A180JAT2A	402
9	9	C18,C31,C35,C61,C67,C68,C73,C74	10uF	Murata Electronics	GRM31CR61C106KC31L	1206
10	4	C70,C71,C76,C79	150uF	Kemet	B45197A2157K409 (Tantalum)	7343
11	6	R10,R32,R42,R43,R44,R45	NOPOP			402
12	8	D1,D2,D3,D4,D5,D6,D7,D8	LED Green 0805	Lite On	LTST-C171GKT	805
13	5	FB1,FB3,FB4,FB5,FB6	220 @ 100MHZ Ferrite Bead	Murata	BLM18PG221SN1D	603
14	2	SW1,SW2	8-POS 50-MIL SMT	C&K Components	SD08H0SBR	
15	1	J1	USB3_TYPEB_CONNECTOR	Amphenol	GSB321131HR	9_RA_TH_B
16	4	J2,J3,J4,J5	USB3_TYPEA_CONNECTOR	Amphenol	GSB311131HR	9_RA_TH_A
17	1	J6	2.1mm x 5.5mm DC Power Jack	CUI Inc.	PJ-202AH (PJ-002AH)	2.1mm x 5.5mm
18	6	R1,R15,R17,R18,R19,R20	1M	Rohm Semiconductor	MCR01MZPJ105	402
19	1	R2	90.9K 1%	Rohm Semiconductor	MCR01MZPF9092	402
20	4	R26,R27,R29,R36	10K	Rohm Semiconductor	MCR01MZPJ103	402
21	1	R3	10K 1%	Rohm Semiconductor	MCR01MZPF1002	402
22	4	R6,R7,R8,R9	4.7K	Rohm Semiconductor	MCR01MZPJ472	402
23	14	R4,R5,R11,R12,R13,R14,R22,R23,R24,R25,R38,R39,R46, R47	1K	Rohm Semiconductor	MCR01MZPJ102	402
24	8	R16,R28,R30,R31,R35,R37,R40,R41	330	Rohm Semiconductor	MCR01MZPJ331	402
25	1	R33	1.87K	Vishay / Dale	CRCW04021K87FKED	402
26	1	R34	4.99K	Vishay / Dale	CRCW04024K99FKED	402

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Table 2. TUSB8041 QFN Lab EVM Bill Of Materials: Texas Instruments, CCI/ICP (continued)

Item	Quantity	Reference	Part	Manufacturer	Part Number	Package
27	1	R21	9.53K 1%	Rohm Semiconductor	MCR01MRTF9531	402
28	1	U1	TUSB8041 - USB 3.0 Hub	Texas Instruments	TUSB8041	64QFN
29	1	U2	AT24C04 I2C EEPROM	Atmel	AT24C04A-10PI-1.8	8DIP
30	4	U7,U8,U9,U10	TPS2001C	Texas Instruments	TPS2001CDGN	8DGN
31	1	U4	TPS7A4533 - 3.3V Voltage Regulator	Texas Instruments	TPS7A4533KTT	DDPAK-5
32	1	U6	TPS74801RGW - 1.1V Voltage Regulator	Texas Instruments	TPS74801RGW	20VQFN
33	1	Y1	ECS-24MHZ Crystal	ECS	ECX-53B (ECS-240-20-30B-TR)	5.0mm x 3.2mm
34	4		PCB Feet	3M		
35	1	FB2	0 ohm			603
36	1	JP6	Conn 2x5 shroud - NO POP	3M	2510-6003UB	HDR5X2 M 0.1" TH
37	3	J7,J8,J9	Header 1x2	3M	961102-6404-AR	HDR2X1 M 0.1" TH
38	1	SW3	Power Switch - L101011MS02Q	C&K Components	L101011MS02Q	SPST
39	2	GND1, GND2	NOPOP			

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Appendix B

B.1 TUSB8041RGC REVD EVM Schematics

This appendix contains the TUSB8041RGC REVD EVM schematics.

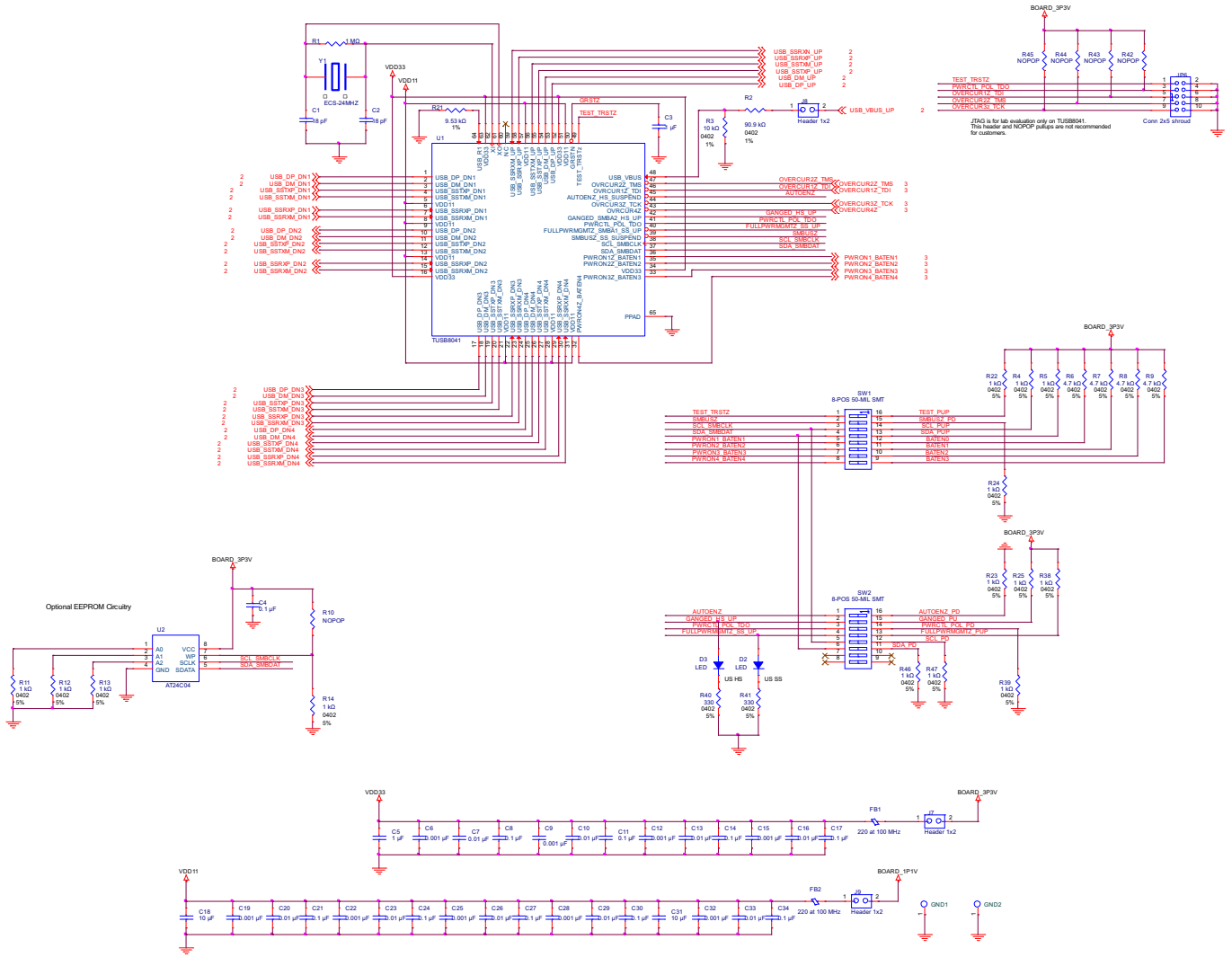


Figure 2. TUSB8041RGC REVD EVM Top Layer Layout

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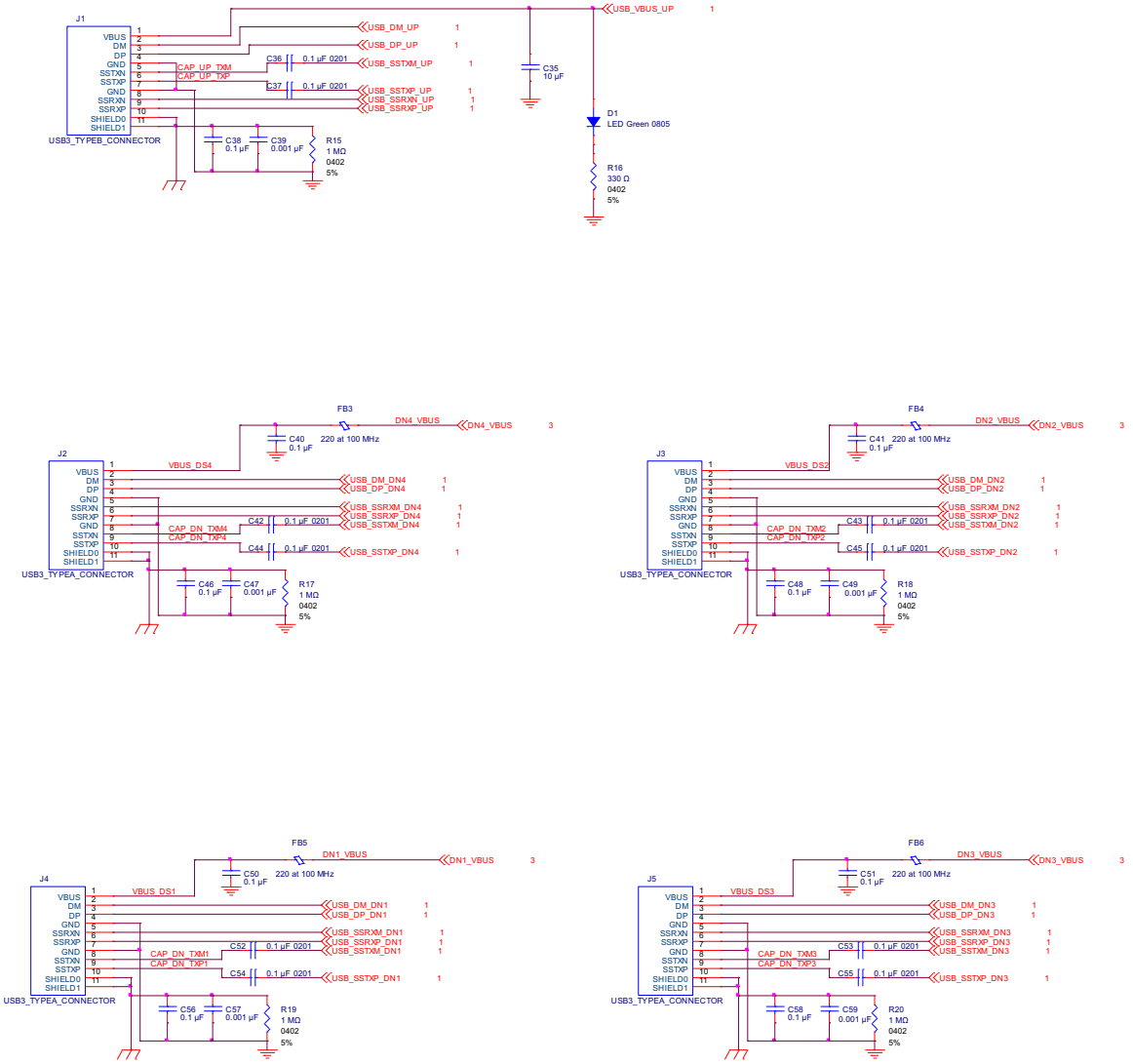


Figure 3. USB Port Connections

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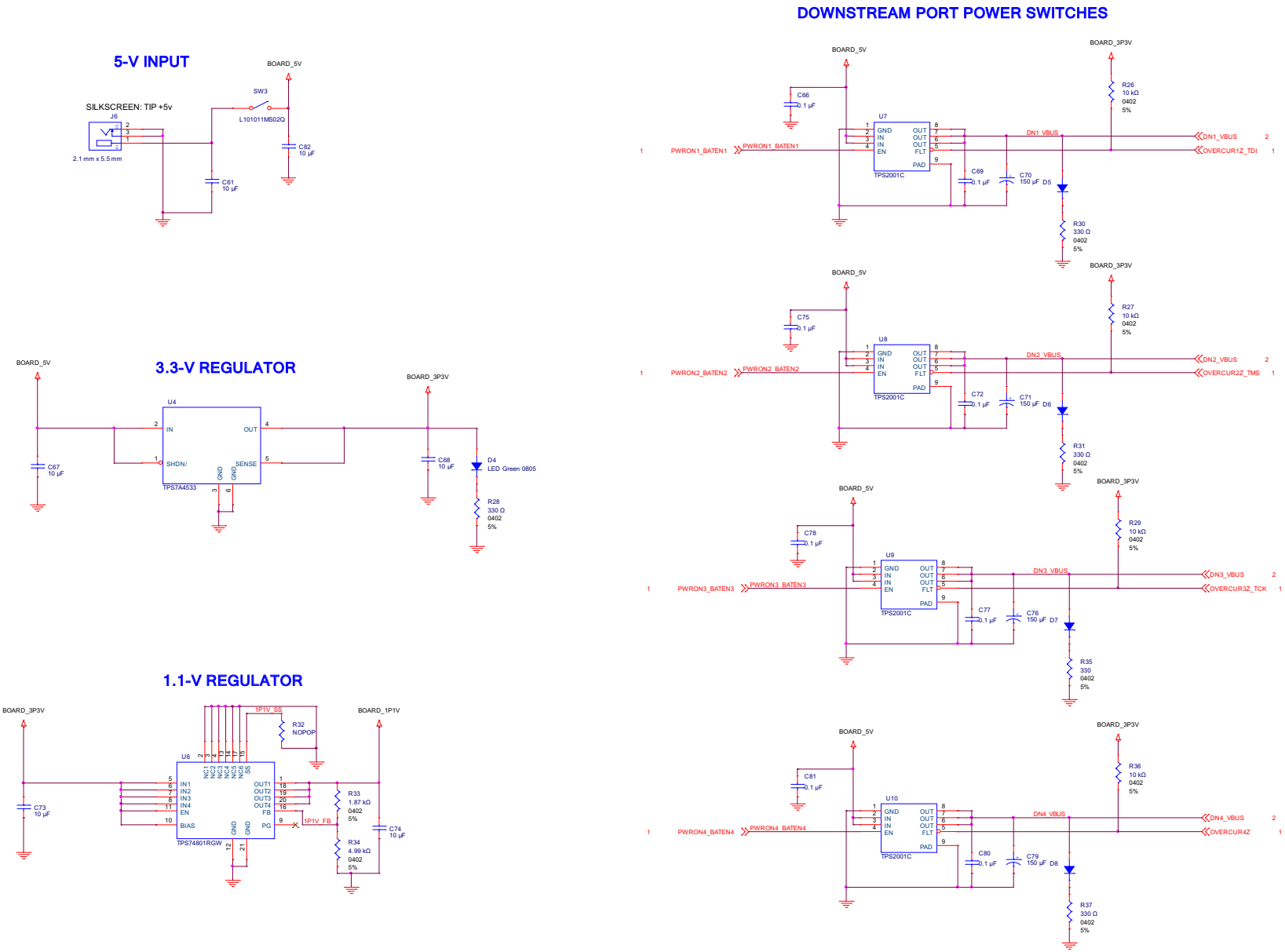


Figure 4. Power

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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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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 its own expense.

FCC Interference Statement for Class B EVM devices

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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-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.

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.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in 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.

http://www.tij.co.jp

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