TUSB4041PAP Evaluation Module

This user's guide describes the characteristics, hardware overview and set up, installation, and use of the TUSB4041PAP Evaluation Module (EVM). A complete schematic diagram and bill of materials (BOM) are included in this document.

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1 Introduction

The Texas Instruments TUSB4041PAP 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 TUSB4041.

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.

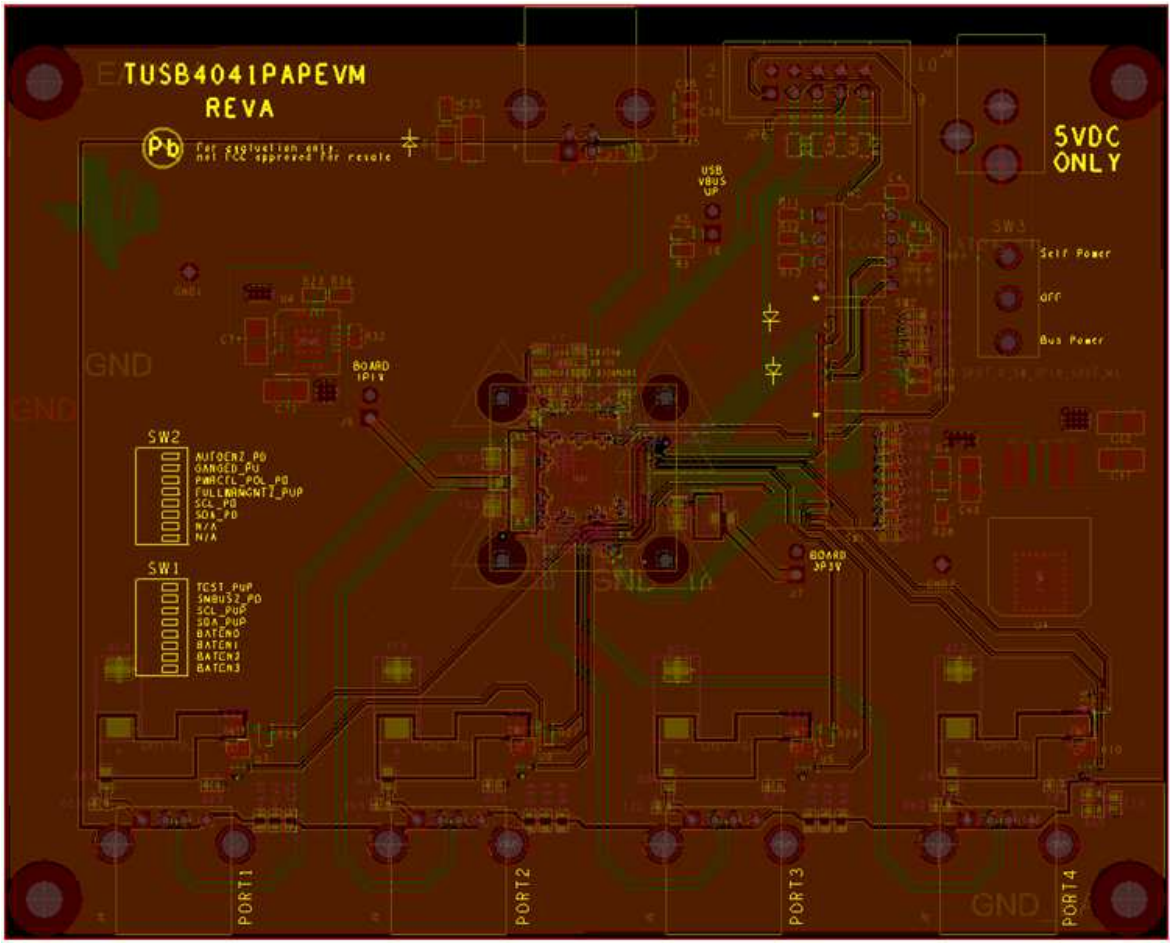


Figure 1. TUSB4041PAPEVM Top Layer Layout

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2 Hardware Overview

The TUSB4041PAPEVM board hardware can be divided into six functional areas:

2.1 TUSB4041PAP

The TUSB4041PAPEVM (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 TUSB4041 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 TUSB4041PAPEVM limits the downstream connections to that speed (HS and FS) or lower.

The TUSB4041 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 TUSB4041 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 TUSB4041PAPEVM is equipped with five standard USB2.0 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 via a standard USB cable to any USB 2.0 host, hub, or device. The TUSB4041 will automatically connect to any upstream USB 2.0 host or hub at HS.

2.2.1 USB Port Connector - Power

VBUS is received from the upstream host or hub on J1. The TUSB4041 can be configured as a self-powered or bus-power hub, just setting SW3 in the required option.

When the EVM is set for self-power there is not any significant current draw by the EVM from VBUS. The TUSB4041 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 TUSB4041 device. A bulk capacitor of at least 1 μF is required on the upstream port VBUS input to comply with the USB specification. The TUSB4041PAPEVM 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 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 TPS2001C device, U7, 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 TUSB4041 via the OVERCURxZ inputs.

2.2.2 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 (SLVSAU6) 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 TUSB4041PAPEVM 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.

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2.3 Optional Serial EEPROM

Each TUSB4041PAPEVM is equipped with an onboard EEPROM/socket placeholder, U2. A small I^2C EEPROM can be installed to set the configuration registers as defined in the TUSB4041 data manual (SLLSEK3A). 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 TUSB4041.

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 TUSB4041 data sheet. In addition, a Microsoft® Windows® based EEPROM utility is available upon request.

2.4 Power

The TUSB4041PAPEVM operates from the power provided by a 5-V wall power adapter, J6, or 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 TUSB4041PAPEVM 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 TUSB4041 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.

2.5 Hub Configuration

The TUSB4041PAPEVM can be configured by setting several inputs to the TUSB4041 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 over-ride 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 Section 3.1.

2.6 Optional Circuitry

The following list provides the optional circuitry available on the TUSB4041PAPEVM:

- D4 – Indicates BOARD_3P3V is active
- The switch (SW1, SW2) and headers (J8, JP6) provided on the TUSB4041PAPEVM are intended for lab evaluation only and are not required for production designs.

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3 Hardware Set Up

3.1 Configuration Switch

The TI TUSB4041PAPEVM 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 TUSB4041 during power on reset, changing the switch settings while the EVM is powered on will have no effect. Please refer to the EVM schematics for additional information (included in the appendix).

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

SW1_1 (off): TEST_TRSTZ. This pin is reserved for factory test.

SW1_2 (off): SMBUSz Switch. The TUSB4041 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 TUSB4041 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 TUSB4041 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): PWRCTL1_BATEN1 Switch. The TUSB4041 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): PWRCTL2_BATEN2 Switch. The TUSB4041 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): PWRCTL1_BATEN1 Switch. The TUSB4041 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): PWRCTL2_BATEN2 Switch. The TUSB4041 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 (on): AUTOENZ Switch. Automatic charge mode enable/HS suspend status The value of the pin is sampled at the deassertion of reset to determine if automatic mode is enabled as follows:

0 = Automatic mode is enabled on ports that are enabled for battery charging when the hub is unconnected. Note that CDP is not supported on Port 1 when operating in automatic mode.

1 = Automatic mode is disabled.
This value is also used to set the autoEnz bit in the Battery Charging Support Register. After reset, this signal indicates the high-speed USB suspend status of the upstream port if enabled through the Additional Feature Configuration Register. When enabled, a value of 1 indicates the connection is suspended.

SW2_2 (on): GANGED_HS_UP Switch. The TUSB4041 has an internal pulldown on this terminal, so individual port power control mode is enabled by default. If the switch is set to the ON position, the terminal is pulled high and ganged mode is enabled. Since the TUSB4041PAPEVM does implement individual port power controls, this terminal should be set low.

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SW2_3 (off): PWRCTL_POL_TDO Switch. The TUSB4041 has an internal pulldown 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.

SW2_4 (on): FULLPWRMGMTZ. The TUSB4041 has an internal pulldown on this terminal, so the TUSB4041 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. In full power management mode, the TUSB4041 reports that it supports downstream port power switching in the USB descriptors it sends to the USB host. Since the TUSB4041PAPEVM implements downstream port power switching, full power management mode should be enabled.

SW2_5 (off): SCL_SMBCLK Switch. The TUSB4041 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).

SW2_6 (off): SDA_SMBDAT Switch. The TUSB4041 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).

SW2_7 (NC): Not connected

SW2_8 (NC): Not connected

4 EVM Installation

To install the EVM, perform the following steps:

1. Attach a 5-V, 3-A wall power source to J6. LEDs D4 should be lit.
2. Attach a USB cable between J4 and a USB host. LEDs D1, should be lit.

5 Troubleshooting

Case 1: Device function(s) 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.
- In the case where a 12-V power supply has been attached to the EVM, the fault is non-recoverable.

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A.1 TUSB4041PAPEVM Bill of Materials

This appendix contains the TUSB4041PAPEVM BOM.

Table 1. TUSB4041PAPEVM BOM

Item	Qty	Reference	Part	Manufacturer	Part Number
1	2	C1,C2	18pF	AVX	04025A180JAT2A
2	1	C3	1uF	Samsung	CL05B105KQ5NQNC
3	18	C4,C38,C40,C41,C46,C48,C50,C51,C56,C58,C66,C69,C72,C75,C77,C78,C80,C81	0.1uF	Yageo	CC0402KRX5R6BB104
4	1	C5	1uF	TDK	CL21B105KPFNNNE
5	11	C6,C9,C12,C15,C19,C22,C25,C28,C32,C83,C86	0.001uF	TDK	C0603X7R1E102K030BA
6	11	C7,C10,C13,C16,C20,C23,C26,C29,C33,C85,C88	0.01uF	Yageo	CC0201KRX7R7BB103
7	11	C8,C11,C14,C17,C21,C24,C27,C30,C34,C84,C87	0.1uF	TDK	C0603X5R0J104M
8	8	C18,C31,C35,C67,C68,C73,C74,C82	10uF	Murata Electronics	GRM31CR71C106KAC7L
9	5	C39,C47,C49,C57,C59	0.001uF	TDK	C1005X7R1H102K
10	4	C70,C71,C76,C79	150uF	Kemet	T495D157K010ATE100
11	2	D1,D4	LED Green 0805	Lite On	LTST-C171GKT
12	6	FB1,FB2,FB3,FB4,FB5,FB6	220 @ 100MHZ	Murata	BLM18PG221SN1D
13	2	GND1,GND2	TEST POINT	Wurth Electronics Inc	61300111121
14	1	JP6	Conn 2x5 shroud	3M	N2510-6002-RB
15	1	J1	Type B USB-Shield	FCI	61729-1011BLF
16	4	J2,J3,J4,J5	Type A USB-Shield	TE Connectivity AMP Connectors	292303-1
17	1	J6	2.1mm x 5.5mm	CUI Inc.	PJ-202AH (PJ-002AH)
18	3	J7,J8,J9	Header 1x2	3M	961102-6404-AR
19	6	R1,R15,R17,R18,R19,R20	1M	Rohm Semiconductor	MCR01MZPJ105
20	1	R2	90.9K	Rohm Semiconductor	RMCF0402FT90K9
21	5	R3,R26,R27,R29,R36	10K	Rohm Semiconductor	MCR01MZPF1002
22	14	R4,R5,R11,R12,R13,R14,R22,R23,R24,R25,R38,R39,R46,R47	1K	Rohm Semiconductor	MCR01MRTJ102
23	4	R6,R7,R8,R9	4.7K	Rohm Semiconductor	MCR01MZPJ472
24	0	R10,R32,R42,R43,R44,R45	10K NOPOP	Rohm Semiconductor	MCR01MZPF1002
25	2	R16,R28	330	Rohm Semiconductor	MCR01MZPJ331
26	1	R21	9.53K	Rohm Semiconductor	MCR01MRTF9531
27	1	R33	1.87K	Vishay / Dale	CRCW04021K87FKED
28	1	R34	4.99K	Vishay / Dale	CRCW04024K99FKED
29	2	SW1,SW2	8-POS 50-MIL SMT	C&K Components	TDA08H0SB1R
30	1	SW3	MS13ANW03	NKK Switches	MS13ANW03
31	1	U1	TUSB4041	Texas Instruments	TUSB4041IPAP
32	1	U2	24AA04-I/P	Microchip Technology	24AA04-I/P
33	1	U4	TPS7A4533	Texas Instruments	TPS7A4533KTT
34	1	U6	TPS74801RGW	Texas Instruments	TPS74801RGW
35	4	U7,U8,U9,U10	TPS2001C	Texas Instruments	TPS2001CDGN
36	1	Y1	ECS-24MHZ	ECS	ECS-240-20-30B-TR

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A.2 TUSB4041PAPEVM Schematics

Figure 2 through Figure 4 illustrate the TUSB4041PAPEVM schematics.

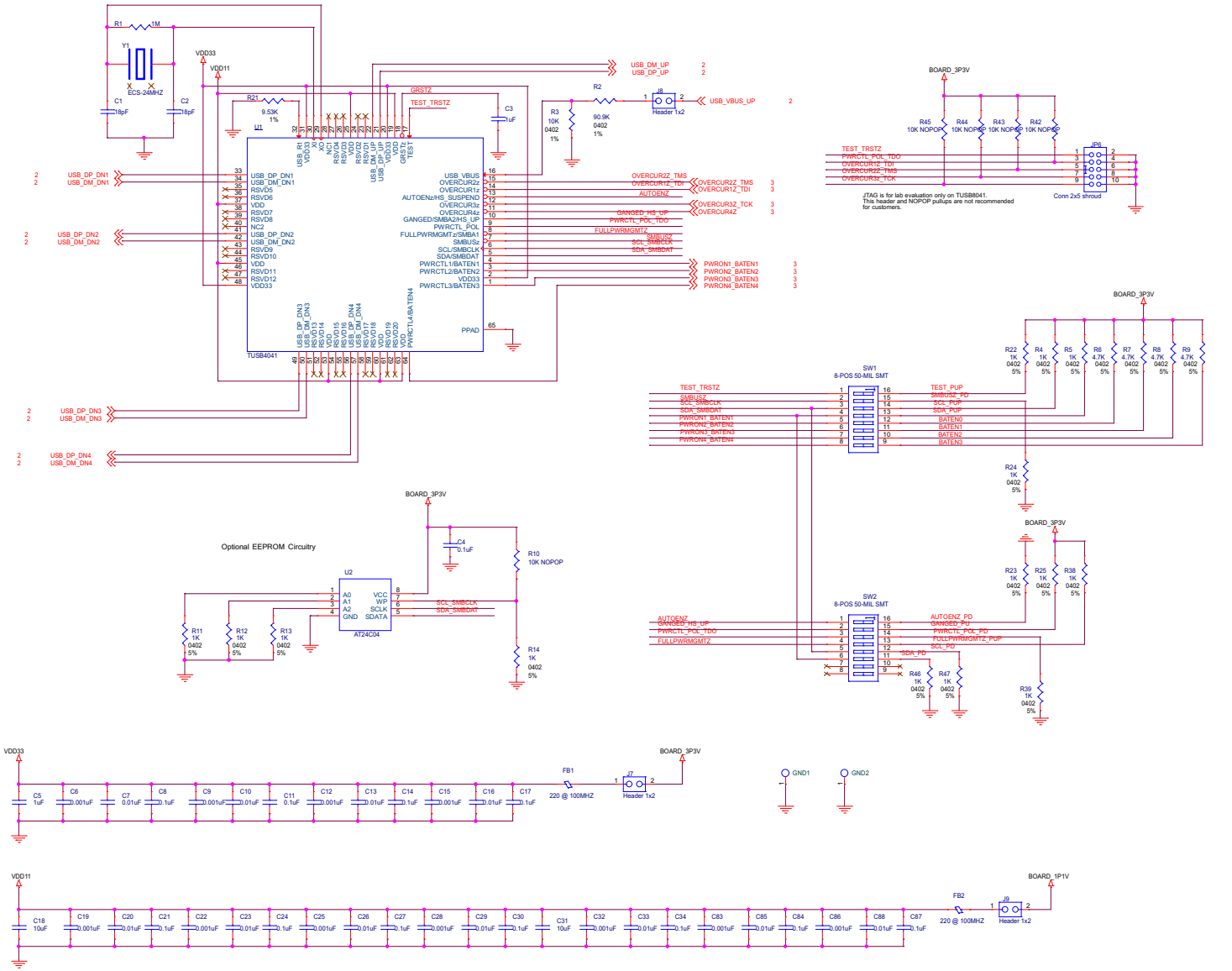


Figure 2. TUSB4041PAPEVM Schematics

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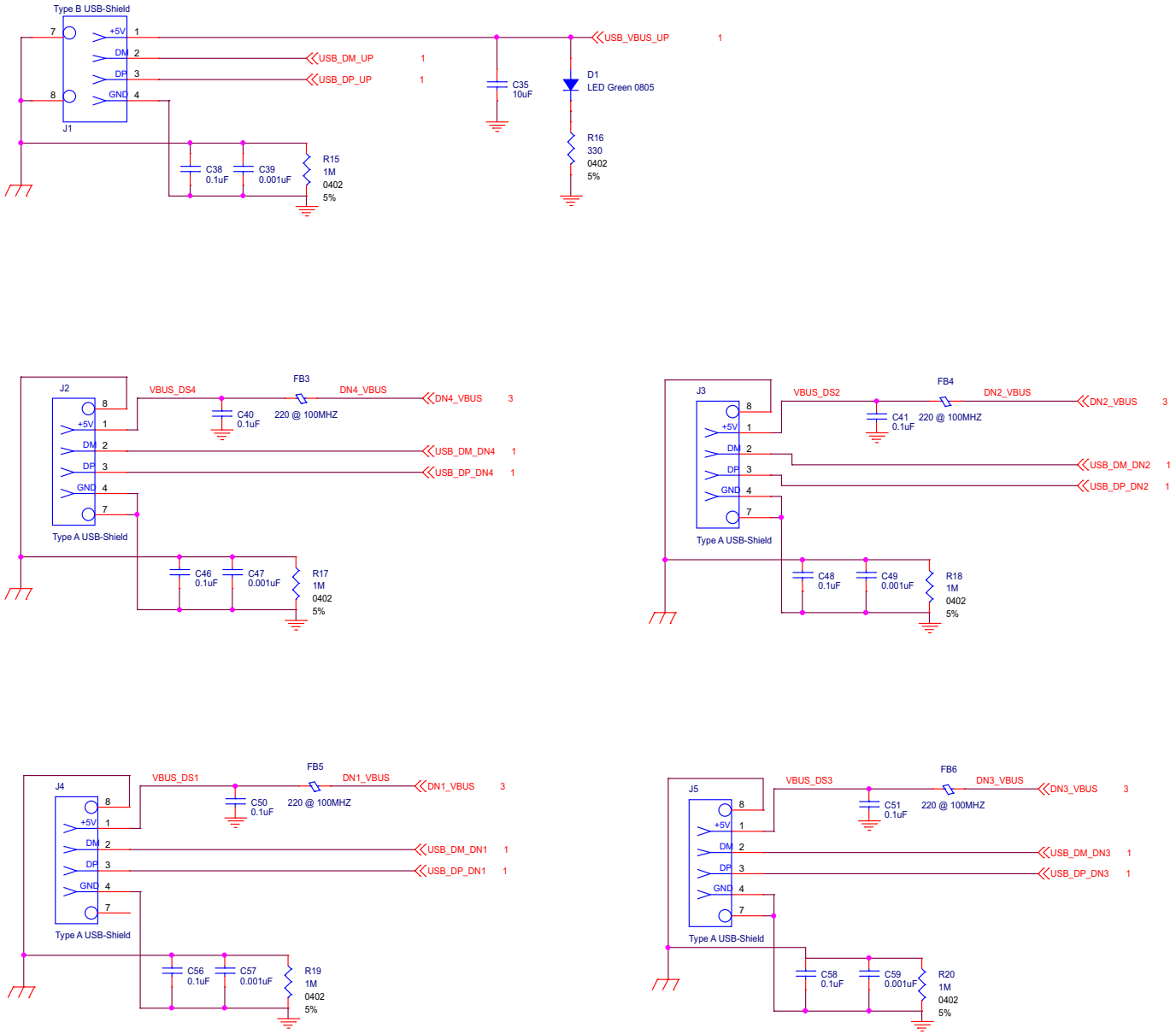


Figure 3. TUSB4041PAPEVM USB2 Connector Schematics

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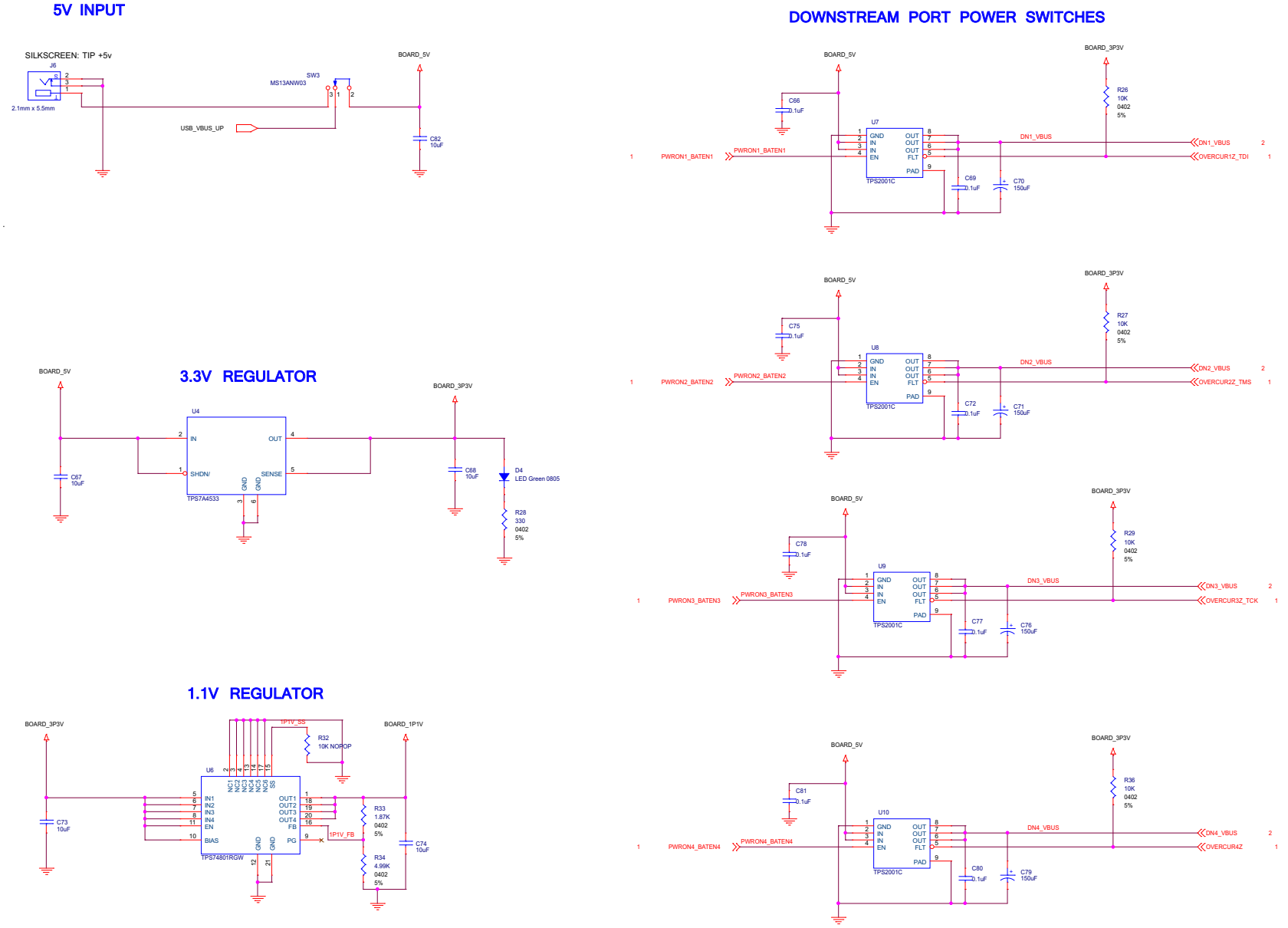


Figure 4. TUSB4041PAPEVM Power Schematics

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Revision History

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

Changes from Original (September 2015) to A Revision	Page
• Changed SW2_2 and SW2_4 descriptions	5

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NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION 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/lsds/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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。
上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

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
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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

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.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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