The Texas Instruments TUSB8020BPHP REVA evaluation module 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 TUSB8020B.

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. TUSB8020B REVA Top Layer Layout
Hardware Overview

The TUSB8020B EVM board hardware is divided into the following functional areas:

1. **TUSB8020BPHP**
   
The TUSB8020B on the TUSB8020B 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 TUSB8020B 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 TUSB8020B EVM limits the downstream connections to that speed (SS, HS, and FS) or lower.

   The TUSB8020B 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 TUSB8020B 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. **USB Port Connectors**
   
The TUSB8020B EVM is equipped with three standard nine pin USB 3.0 port connectors. One of these three connectors, J3, is a Type B connector designed to interface with an upstream USB host or hub. The remaining connectors, J1 and J4, 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. It is also possible to implement a legacy USB connector on one or more of the downstream ports if SuperSpeed operation is not desired.

   The USB ports can be attached via a standard USB cable to any USB 3.0 or legacy USB host, hub or device. The TUSB8020B automatically connects to any upstream USB 3.0 host or hub at both SuperSpeed and High-Speed. Using a legacy USB cable between the TUSB8020B EVM and a USB 3.0 host or hub forces it to High-Speed operation. The same is true if a legacy USB cable is used between the TUSB8020B EVM and a downstream SuperSpeed capable device: operation is limited to USB 2.0 High-Speed.

2.1 **USB Port Connector - Power**
   
   VBUS is received from the upstream host or hub on J3. The TUSB8020B is configured as a self-powered hub, so there is not any significant current draw by the EVM from VBUS. The TUSB8020B 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 TUSB8020B device. A bulk capacitor of at least 1 μF is required on the upstream port VBUS input to comply with the USB specification. The TUSB8020BEVM uses a 10-μF capacitor, C8.

2.2 **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 TUSB8020BEVM 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.

Please 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.

3 Optional Serial EEPROM

Each TUSB8020BEVM 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 TUSB8020B data sheet (SLLSEF6). 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 TUSB8020B.

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 TUSB8020B data sheet. In addition, a Microsoft® Windows® based EEPROM utility is available upon request.

4 Power

The TUSB8020B EVM operates from the power provided by a 5-V wall power adapter, J5, not bus power supplied by a USB host. TI recommends using a wall power adapter that is capable of sourcing 2 A to 3 A because the hub must be able to source significant power on its downstream ports (900 mA per port).

The TUSB8020B 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 TUSB8020B 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.

5 Hub Configuration

The TUSB8020BEVM can be configured by setting several inputs to the TUSB8020B 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 Switches section.

6 Optional Circuitry

The TUSB8020B EVM design implements a variety of LEDs, none of which are required by the USB specification. They are provided to make testing and debug easier.

- D1 – Indicates that the upstream USB port is connected at High-Speed.
- D2 - Indicates that the downstream USB port 2 is connected at SuperSpeed.
- D3 – Indicates that the downstream USB port 1 is connected at SuperSpeed.
- D4 – Indicates that the upstream USB port is connected at SuperSpeed.
- D5 – Indicates that 5 V is being applied to the TUSB8020B 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 and SW3) and headers (J2, J7, J8, JP1) present on the TUSB8020B EVM are intended for lab evaluation only and are not required for production designs.
1 Configuration Switches

The TI TUSB8020BEVM 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 TUSB8020B during power on reset, changing the switch settings while the EVM is powered on has no effect. 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 TUSB8020B has an internal pull up on this terminal, so the TUSB8020B 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 TUSB8020B reports that it supports downstream port power switching in the USB descriptors it sends to the USB host. Since the TUSB8020B EVM does implement downstream port power switching, enable full power management mode.

**SW1_2 (off):** PWRCTL_POL_SS_DN1 Switch. The TUSB8020B 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 TUSB8020B 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 TUSB8020B 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 TUSB8020B EVM does implement individual port power controls, this terminal should be set high.

**SW1_5 (off):** SCL_SMBCLK Switch. The TUSB8020B 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 Switch. The TUSB8020B 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 data 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 TUSB8020B 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 TUSB8020B has an internal pull down 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.
2 EVM Installation

Install the EVM using the following steps:

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

3 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.
• Make sure shunts are installed on J2, J7, and J8.
• In the case where a 12-V power supply has been attached to the EVM, the fault is non-recoverable.
# Appendix A  TUSB8020BPHPEVM Bill of Materials

Table 1 contains the BOM for the EVM.

## Table 1. TUSB8020BPHPEVM Bill of Materials

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Appendix B  Schematics

Figure 2 and Figure 3 contain the schematics for this EVM.

Figure 2. TUSB8020BPHPEVM Schematic
Figure 3. TUSB8020BPHPEVM Power Schematic
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10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.

11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.

12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable EVM user's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using EVM's schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 and/or use of EVMs. User’s indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user’s product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.
Texas Instruments Incorporated (TI) evaluation boards, kits, and/or modules (EVMs) and/or accompanying hardware that is marketed, sold, or loaned to users may or may not be subject to radio frequency regulations in specific countries.

General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 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. 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 déposables

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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No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have not been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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