# TUSB2077A 7-Port Hub for the Universal Serial Bus With Optional Serial EEPROM Interface

## 1 Features

- Fully Compliant With the USB Specification as a Full-Speed Hub: TID #20240226
- Integrated USB Transceivers
- 3.3-V Low-Power ASIC Logic
- Two Power Source Modes
  - Self-Powered Mode Supporting Seven Downstream Ports
  - Bus-Powered Mode Supporting Four Downstream Ports
- All Downstream Ports Support Full-Speed and Low-Speed Operations
- Power Switching and Overcurrent Reporting Is Provided Ganged or Per Port
- Supports Suspend and Resume Operations
- Suspend Status Pin Available for External Logic Power Down
- Supports Custom Vendor ID and Product ID With External Serial EEPROM
- 3-State EEPROM Interface Allows EEPROM Sharing
- Push-Pull Outputs for $\overline{\text{PWRON}}$ Eliminate the Need for External Pullup Resistors
- Noise Filtering on $\overline{\text{OVRCUR}}$ Provides Immunity to Voltage Spikes
- Supports 6-MHz Operation Through a Crystal Input or a 48-MHz Input Clock
- New Functional Pins Introduced to Reduce the Board Material Cost
  - 3 LED Indicator Control Outputs Enable Visualized Monitoring of 6 Different Hub/Port Status (HUBCFG, PORTPWR, PORTDIS)
  - Output Pin Available to Disable External Pullup Resistor on DP0 for 15 ms After Reset or After Change on $\overline{\text{BUSPWR}}$ and Enable Easy Implementation of Onboard Bus/Self-Power Dynamic Switching Circuitry
- No Special Driver Requirements; Works Seamlessly With Any Operating System With USB Stack Support
- Available in 48-Pin LQFP Package
- JEDEC Descriptor S−PQFP−G for Low-Profile Quad Flatpack (LQFP).

## 2 Applications

- Computer Systems
- Docking Stations

## 3 Description

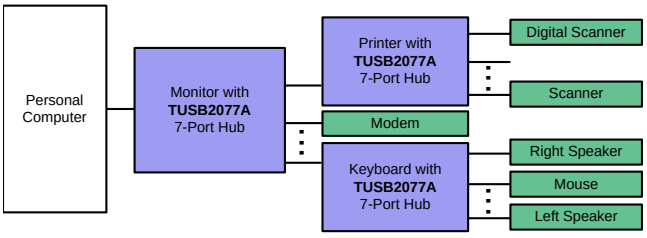
The TUSB2077A hub is a 3.3-V CMOS device that provides up to seven downstream ports in compliance with the USB 2.0 specification. Because this device is implemented with a digital state machine instead of a microcontroller, no software programming is required. Fully compliant USB transceivers are integrated into the ASIC for all upstream and downstream ports. The downstream ports support full-speed and low-speed devices by automatically setting the slew rate according to the speed of the device attached to the ports. The configuration of the $\overline{\text{BUSPWR}}$ terminal selects either the bus-powered or self-powered mode. The introduction of the DP0 pull-up resistor disable terminal, DP0PUR, makes it much easier to implement an onboard bus/self-power dynamic-switching circuitry. The three-LED indicator control output pins also enable the implementation of visualized status monitoring of the hub and its downstream ports. With these new function pins, the end equipment vendor can considerably reduce the total board cost while adding additional product value.

**Device Information**[1]

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TUSB2077A | LQFP (48) | 7.00 mm × 7.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

**USB-Tiered Configuration Example**



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## 4 Revision History

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

| Changes from Revision E (September 2013) to Revision F | Page |
|---|---|
| • Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section | 1 |

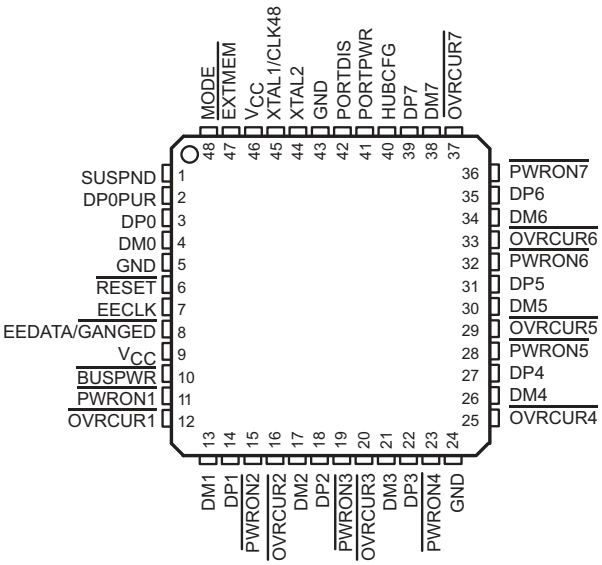
## 5 Description (Continued)

The $\overline{\text{EXTMEM}}$ pin (pin 47) enables or disables the optional EEPROM interface. When $\overline{\text{EXTMEM}}$ is high, the vendor and product IDs (VID and PID) use defaults, such that the message displayed during enumeration is General Purpose USB Hub.

The TUSB2077A supports bus-powered and self-powered modes. External power-management devices, such as the TPS2044, are required to control the 5-V power source switching (on/off) to the downstream ports and to detect an overcurrent condition from the downstream ports individually or ganged. An individually port power controlled hub switches power on or off to each downstream port as requested by the USB host. Also when an individually port power controlled hub senses an overcurrent event, only power to the affected downstream port will be switched off. A ganged hub switches on power to all its downstream ports when power must be on for any port. The power to the downstream ports is not switched off unless all ports are in a state that allows power to be removed. Also, when a ganged hub senses an overcurrent event, power to all downstream ports will be switched off.

# 6 Pin Configuration and Functions

**PT Package**
**48-Pin LQFP**
**Top View**




NC - No internal connection

## Pin Functions

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| BUSPWR | 10 | I | Power source indicator. BUSPWR is an active-low input that indicates whether the downstream ports source their power from the USB cable or a local power supply. For the bus-power mode, this terminal must be pulled low, and for the self-powered mode, this terminal must be pulled to 3.3 V. Input must not change dynamically during operation. |
| DM0 | 4 | I/O | Root port USB differential data minus. DM0 paired with DP0 constitutes the upstream USB port. |
| DM1 | 13 | I/O | USB differential data minus. DM1–DM7 paired with DP1–DP7 support up to four downstream USB ports. |
| DM2 | 17 | | |
| DM3 | 21 | | |
| DM4 | 26 | | |
| DM5 | 30 | | |
| DM6 | 34 | | |
| DM7 | 38 | | |
| DP0 | 3 | I/O | Root port USB differential data plus. DP0 paired with DM0 constitutes the upstream USB port. |
| DP1 | 14 | I/O | USB differential data plus. DP1–DP7 paired with DM1–DM7 support up to four downstream USB ports. |
| DP2 | 18 | | |
| DP3 | 22 | | |
| DP4 | 27 | | |
| DP5 | 31 | | |
| DP6 | 35 | | |
| DP7 | 39 | | |
| DP0PUR | 2 | O | Pullup resistor connection. When a system reset happens (RESET being driven to low, but not USB reset) or any logic level change on BUSPWR terminal, DP0PUR output is inactive (floating) until the internal counter reaches a 15-ms time period. After the counter expires, DP0PUR is driven to the VCC (3.3 V) level thereafter until the next system reset event occurs or there is a BUSPWR logic level change. |
| EECLK | 7 | O | EEPROM serial clock. When EXTMEM is high, the EEPROM interface is disabled. The EECLK terminal is disabled and must be left floating (unconnected). When EXTMEM is low, EECLK acts as a 3-state serial clock output to the EEPROM with a 100-µA internal pulldown. |
| EEDATA/GANGED | 8 | I/O | EEPROM serial data/power-management mode indicator. When EXTMEM is high, EEDATA/GANGED selects between ganged or per-port power overcurrent detection for the downstream ports. When EXTMEM is low, EEDATA/GANGED acts as a serial data I/O for the EEPROM and is internally pulled down with a 100-µA pulldown. This standard TTL input must not change dynamically during operation. |

**Pin Functions (continued)**

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| $\overline{\text{EXTMEM}}$ | 47 | I | When $\overline{\text{EXTMEM}}$ is high, the serial EEPROM interface of the device is disabled. When $\overline{\text{EXTMEM}}$ is low, pins 7 and 8 are configured as the clock and data terminals of the serial EEPROM interface, respectively. |
| GND | 5, 24, 43 | | GND pins must be tied to ground for proper operation. |
| HUBCFG(1) | 40 | O | Hub configured. Used to control LED indicator. When the hub is configured, HUBCFG is high, which can be used to turn on a green LED. When the hub is not configured, HUBCFG is low, which can be used to turn on a red LED. |
| MODE | 48 | I | Mode select. When MODE is low, the APLL output clock is selected as the clock source to drive the internal core of the chip and 6-MHz crystal or oscillator can used. When MODE is high, the clock on XTAL1/CLK48 is selected as the clock source and 48-MHz oscillator or other onboard clock source can be used. |
| $\overline{\text{OVRCUR1}}$ | 12 | I | Overcurrent input. $\overline{\text{OVRCUR1}}$–$\overline{\text{OVRCUR7}}$ are active low. For per-port overcurrent detection, one overcurrent input is available for each of the seven downstream ports. In the ganged mode, any $\overline{\text{OVRCUR}}$ input may be used and all $\overline{\text{OVRCUR}}$ pins must be tied together. $\overline{\text{OVRCUR}}$ terminals are active low inputs with noise filtering logic. |
| $\overline{\text{OVRCUR2}}$ | 16 | | |
| $\overline{\text{OVRCUR3}}$ | 20 | | |
| $\overline{\text{OVRCUR4}}$ | 25 | | |
| $\overline{\text{OVRCUR5}}$ | 29 | | |
| $\overline{\text{OVRCUR6}}$ | 33 | | |
| $\overline{\text{OVRCUR7}}$ | 37 | | |
| PORTPWR(1) | 41 | O | Any port powered. Used to control LED indicator. When any port is powered on, PORTPWR is high, which can be used to turn on a green LED. When all ports are off, PORTPWR is low, which can be used to turn on a red LED. |
| PORTDIS(1) | 42 | O | No ports disabled. PORTDIS is used for LED indicator control. When no port is disabled, PORTDIS is high, which can be used to turn on a green LED. When any port is disabled, PORTDIS is low, which can be used to turn on a red LED. |
| $\overline{\text{PWRON1}}$ | 11 | O | Power-on/-off control signals. $\overline{\text{PWRON1}}$–$\overline{\text{PWRON7}}$ are active low, push-pull outputs that enables the external power switch device. Push-pull outputs eliminate the pullup resistors which open-drain outputs require. However, the external power switches that connect to these terminals must be able to operate with 3.3-V inputs because these outputs cannot drive 5-V signals. |
| $\overline{\text{PWRON2}}$ | 15 | | |
| $\overline{\text{PWRON3}}$ | 19 | | |
| $\overline{\text{PWRON4}}$ | 23 | | |
| $\overline{\text{PWRON5}}$ | 28 | | |
| $\overline{\text{PWRON6}}$ | 32 | | |
| $\overline{\text{PWRON7}}$ | 36 | | |
| $\overline{\text{RESET}}$ | 6 | I | $\overline{\text{RESET}}$ is an active low TTL input with hysteresis and must be asserted at power up. When $\overline{\text{RESET}}$ is asserted, all logic is initialized. Generally, a reset with a pulse width between 100 µs and 1 ms is recommended after 3.3-V $V_{CC}$ reaches its 90%. Clock signal has to be active during the last 60 µs of the reset window. |
| SUSPND | 1 | O | Suspend status. SUSPND is an active high output available for external logic power-down operations. During the suspend mode, SUSPND is high. SUSPND is low for normal operation. |
| $V_{CC}$ | 9, 46 | | 3.3-V supply voltage |
| XTAL1/CLK48 | 45 | I | Crystal 1/48-MHz clock input. When MODE is low, XTAL1/CLK48 is a 6-MHz crystal input with 50% duty cycle. An internal APLL generates the 48-MHz and 12-MHz clocks used internally by the ASIC logic. When MODE is high, XTAL1/CLK48 acts as the input of the 48-MHz clock and the internal APLL logic is bypassed. |
| XTAL2 | 44 | O | Crystal 2. XTAL2 is a 6-MHz crystal output. This pin must be left open when using an oscillator. |

(1) All LED controls are 3-stated during low-power suspend.

# 7 Specifications

## 7.1 Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage(2) | | –0.5 | 3.6 | V |
| $V_I$ | Input voltage | | –0.5 | $V_{CC}$ + 0.5 | V |
| $V_O$ | Output voltage | | –0.5 | $V_{CC}$ + 0.5 | V |
| $I_{IK}$ | Input clamp current | $V_I$ < 0 V or $V_I$ < $V_{CC}$ | | ±20 | mA |
| $I_{OK}$ | Output clamp current | $V_O$ < 0 V or $V_O$ < $V_{CC}$ | | ±20 | mA |
| $T_A$ | Operating free-air temperature | | 0 | 70 | °C |
| $T_{stg}$ | Storage temperature | | –65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage levels are with respect to GND.

## 7.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1) | ±4000 | V |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C101 (2) | ±1500 | |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## 7.3 Recommended Operating Conditions

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 3 | 3.3 | 3.6 | V |
| $V_I$ | Input voltage, TTL/LVCMOS (1) | 0 | | $V_{CC}$ | V |
| $V_O$ | Output voltage, TTL/LVCMOS (2) | 0 | | $V_{CC}$ | V |
| $V_{IH(REC)}$ | High-level input voltage, signal-ended receiver | 2 | | $V_{CC}$ | V |
| $V_{IL(REC)}$ | Low-level input voltage, signal-ended receiver | | | 0.8 | V |
| $V_{IH(TTL)}$ | High-level input voltage, TTL/LVCMOS (1) | 2 | | $V_{CC}$ | V |
| $V_{IL(TTL)}$ | Low-level input voltage, TTL/LVCMOS (1) | 0 | | 0.8 | V |
| $T_A$ | Operating free-air temperature | 0 | | 70 | °C |
| $R_{(DRV)}$ | External series, differential driver resistor | | 22 | | Ω |
| $f_{(OPRH)}$ | Operating (dc differential driver) high speed mode | | | 12 | Mb/s |
| $f_{(OPRL)}$ | Operating (dc differential driver) low speed mode | | | 1.5 | Mb/s |
| $V_{ICR}$ | Common mode, input range, differential receiver | 0.8 | | 2.5 | V |
| $t_t$ | Input transition times, TTL/LVCMOS (1) | 0 | | 25 | ns |
| $T_J$ | Junction temperature (3) | 0 | | 115 | °C |

(1) Applies for input and bidirectional buffers.
(2) Applies for output and bidirectional buffers.
(3) These junction temperatures reflect simulated conditions. Absolute maximum junction temperature is 150°C. The customer is responsible for verifying junction temperature.

## 7.4 Thermal Information

| THERMAL METRIC (1) | | TUSB2077A PT (LQFP) 48 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 66.2 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 21.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 37.8 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 0.9 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 31.4 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | — | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

## 7.5 Electrical Characteristics

over recommended ranges of operating free-air temperature and supply voltage (unless otherwise noted)

| PARAMETER | | | TEST CONDITION | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{OH}$ | High-level output voltage | TTL/LVCMOS | $I_{OH}$ = –4 mA | $V_{CC}$ – 0.5 | | V |
| | | USB data lines | $R_{(DRV)}$ = 15 kΩ to GND | 2.8 | | |
| | | | $I_{OH}$ = –12 mA (without $R_{(DRV)}$) | $V_{CC}$ – 0.5 | | |
| $V_{OL}$ | Low-level output voltage | TTL/LVCMOS | $I_{OL}$ = 4 mA | | 0.5 | V |
| | | USB data lines | $R_{(DRV)}$ = 1.5 kΩ to 3.6 V | | 0.3 | |
| | | | $I_{OL}$ = 12 mA (without $R_{(DRV)}$) | | 0.5 | |
| $V_{IT+}$ | Positive input threshold | TTL/LVCMOS | | | 1.8 | V |
| | | Single-ended | 0.8 V ≤ $V_{ICR}$ ≤ 2.5 V | | 1.8 | |
| $V_{IT–}$ | Negative-input threshold | TTL/LVCMOS | | 0.8 | | V |
| | | Single-ended | 0.8 V ≤ $V_{ICR}$ ≤ 2.5 V | 1 | | |
| $V_{hys}$ | Input hysteresis(1) ($V_{T+} – V_{T–}$) | TTL/LVCMOS | | 0.3 | 0.7 | mV |
| | | Single-ended | 0.8 V ≤ $V_{ICR}$ ≤ 2.5 V | 300 | 500 | |
| $I_{OZ}$ | High-impedance output current | TTL/LVCMOS | V = $V_{CC}$ or GND(2) | | ±10 | µA |
| | | USB data lines | 0 V ≤ $V_O$ ≤ $V_{CC}$ | | ±10 | |
| $I_{IL}$ | Low-level input current | TTL/LVCMOS | $V_I$ = GND | | –1 | µA |
| $I_{IH}$ | High-level input current | TTL/LVCMOS | $V_I$ = $V_{CC}$ | | 1 | µA |
| $z_{0(DRV)}$ | Driver output impedance | USB data lines | Static $V_{OH}$ or $V_{OL}$ | 7.1 | 19.9 | Ω |
| $V_{ID}$ | Differential input voltage | USB data lines | 0.8 V ≤ $V_{ICR}$ ≤ 2.5 V | 0.2 | | V |
| $I_{CC}$ | Input supply current | | Normal operation | | 40 | mA |
| | | | Suspend mode | | 1 | µA |

(1) Applies for input buffers with hysteresis.
(2) Applies for open-drain buffers.

## 7.6 Differential Driver Switching Characteristics (Full-Speed Mode)

over recommended ranges of operating free-air temperature and supply voltage, $C_L$ = 50 pF (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $t_r$ | Transition rise time for DP or DM | See Figure 1 and Figure 2 | 4 | 20 | ns |
| $t_f$ | Transition fall time for DP or DM | See Figure 1 and Figure 2 | 4 | 20 | ns |
| $t_{(RFM)}$ | Rise/fall time matching(1) | ($t_r$/$t_f$) × 100 | 90% | 110% | |
| $V_{O(CRS)}$ | Signal crossover output voltage(1) | | 1.3 | 2.0 | V |

(1) Characterized only. Limits are approved by design and are not production tested.

## 7.7 Differential Driver Switching Characteristics (Low-Speed Mode)

over recommended ranges of operating free-air temperature and supply voltage, $C_L$ = 50 pF (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $t_r$ | Transition rise time for DP or DM(1) | $C_L$ = 200 pF to 600 pF, See Figure 1 and Figure 2 | 75 | 300 | ns |
| $t_f$ | Transition fall time for DP or DM(1) | $C_L$ = 200 pF to 600 pF, See Figure 1 and Figure 2 | 75 | 300 | ns |
| $t_{(RFM)}$ | Rise/fall time matching(1) | ($t_r$/$t_f$) × 100 | 80% | 120% | |
| $V_{O(CRS)}$ | Signal crossover output voltage(1) | $C_L$ = 200 pF to 600 pF | 1.3 | 2.0 | V |

(1) Characterized only. Limits are approved by design and are not production tested.

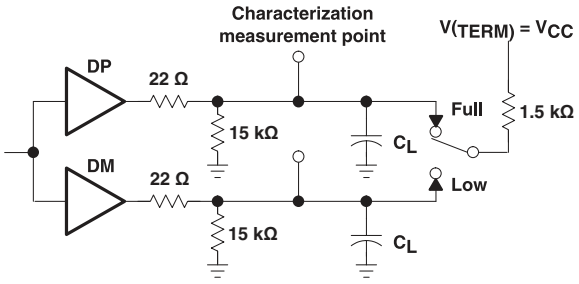
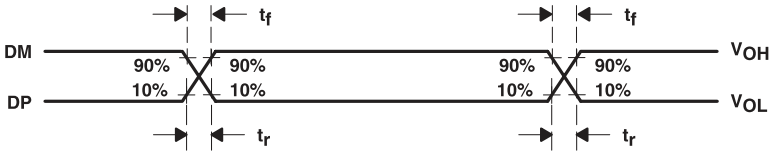



**Figure 1. Differential Driver Switching Load**




NOTE: The $t_r/t_f$ ratio is measured as $t_{r(DP)}/t_{f(DM)}$ and $t_{r(DM)}/t_{f(DP)}$ at each crossover point.

**Figure 2. Differential Driver Timing Waveforms**

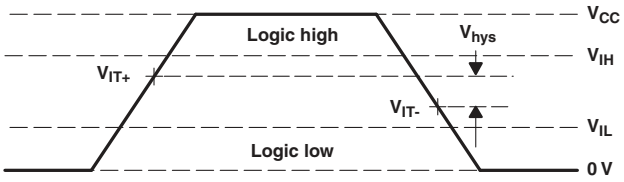



**Figure 3. Single-Ended Receiver Input Signal Parameter Definitions**

## 7.8 Typical Characteristics

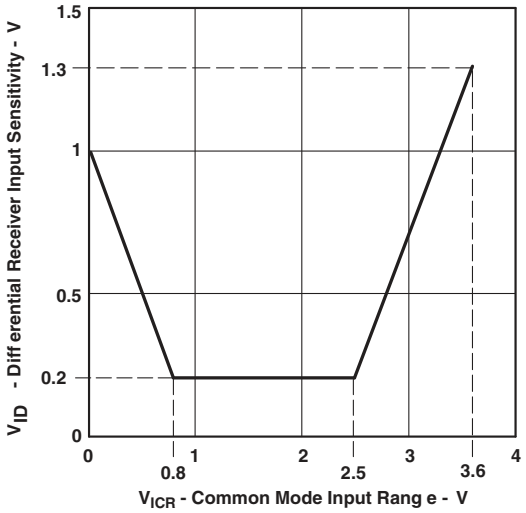


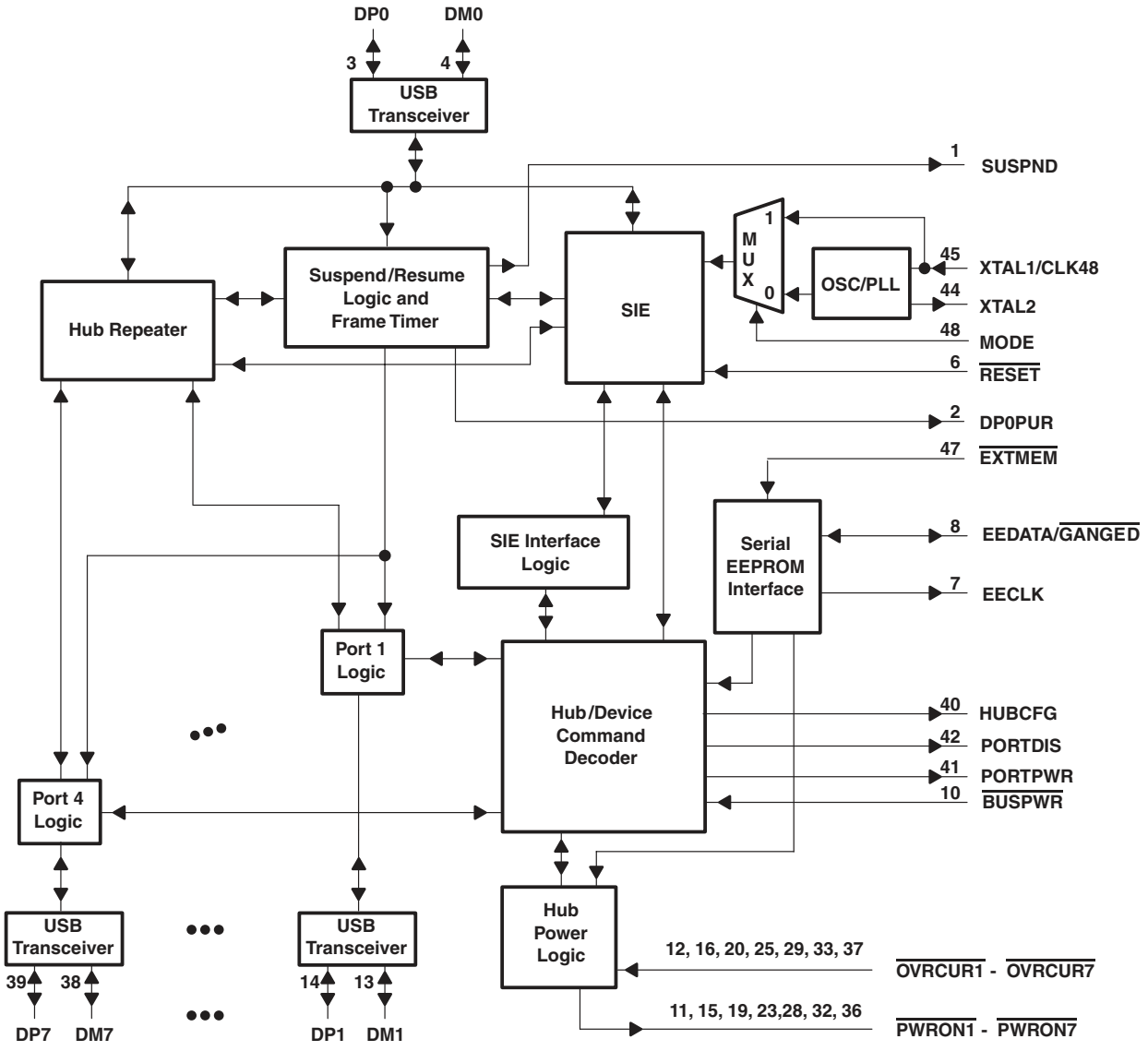

**Figure 4. Differential Receiver Input Sensitivity vs Common Mode Input Range**

# 8 Detailed Description

## 8.1 Overview

The TUSB2077A hub is a 3.3-V CMOS device that provides up to seven downstream ports in compliance with the USB 2.0 specification. Because this device is implemented with a digital state machine instead of a microcontroller, no software programming is required. Fully compliant USB transceivers are integrated into the ASIC for all upstream and downstream ports. The downstream ports support full-speed and low-speed devices by automatically setting the slew rate according to the speed of the device attached to the ports.

## 8.2 Functional Block Diagram



## 8.3 Feature Description

### 8.3.1 USB Power Management

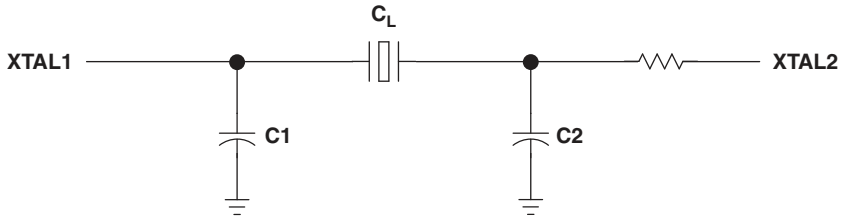
The TUSB2077A supports both bus-powered and self-powered modes. External power-management devices, such as the TPS2044, are required to control the 5-V power source switching (on/off) to the downstream ports and to detect an overcurrent condition from the downstream ports individually or ganged. Outputs from external power devices provide overcurrent inputs to the TUSB2077A $\overline{\text{OVRCUR}}$ pins in case of an overcurrent condition, the corresponding $\overline{\text{PWRON}}$ pins are disabled by the TUSB2077A. In the ganged mode, all $\overline{\text{PWRON}}$ signals transition simultaneously, and any $\overline{\text{OVRCUR}}$ input can be used. In the nonganged mode, the $\overline{\text{PWRON}}$ outputs and $\overline{\text{OVRCUR}}$ inputs operate on a per-port basis.

Both bus-powered and self-powered hubs require overcurrent protection for all downstream ports. The two types of protection are individual-port management (individual-port basis) or ganged-port management (multiple-port basis). Individual-port management requires power-management devices for each individual downstream port, but adds robustness to the USB system because, in the event of an overcurrent condition, the USB host only powers down the port that has the condition. The ganged configuration uses fewer power management devices and thus has lower system costs, but in the event of an overcurrent condition on any of the downstream ports, all the ganged ports are disabled by the USB host.

Using a combination of the $\overline{\text{BUSPWR}}$ and EEDATA/$\overline{\text{GANGED}}$ inputs, the TUSB2077A supports four modes of power management: bus-powered hub with either individual-port power management or ganged-port power management, and the self-powered hub with either individual-port power management or ganged-port power management. Texas Instruments supplies the complete hub solution because we offer this TUSB2077A along with the power-management devices needed to implement a fully USB compliant system.

### 8.3.2 Clock Generation

The TUSB2077A provides the flexibility of using either a 6-MHz or a 48-MHz clock. The logic level of the MODE terminal controls the selection of the clock source. When MODE is low, the output of the internal APLL circuitry is selected to drive the internal core of the chip. When MODE is high, the XTAL1 input is selected as the input clock source and the APLL circuitry is powered down and bypassed. The internal oscillator cell is also powered down while MODE is high. For 6-MHz operation, TUSB2077A requires a 6-MHz clock signal on XTAL1 terminal (with XTAL2 for a crystal) from which its internal APLL circuitry generates a 48-MHz internal clock to sample the data from the upstream port. For 48-MHz operation, the clock cannot be generated with a crystal, using the XTAL2 output, because the internal oscillator cell only supports the fundamental frequency. If low-power suspend and resume are desired, a passive crystal or resonator must be used, although the hub supports the flexibility of using any device that generates a 6-MHz clock. Because most oscillators cannot be stopped while power is on, their use prohibits low-power suspend, which depends on disabling the clock. When the oscillator is used, by connecting its output to the XTAL1 terminal and leaving the XTAL2 terminal open, its TTL output level cannot exceed 3.6 V. If a 6-MHz oscillator is used, it must be stopped at logic low whenever SUSPND is high. For crystal or resonator implementations, the XTAL1 terminal is the input and the XTAL2 terminal is used as the feedback path. A sample crystal tuning circuit is shown in Figure 5.




NOTE: This figure assumes a 6-MHz fundamental crystal that is parallel loaded. The component values of C1, C2, and $R_d$ are determined using a crystal from Fox Electronics – part number HC49U-6.00MHz 30\50\0±70\20, which means ±30 ppm at 25°C and ±50 ppm from 0°C to 70°C. The characteristics for the crystal include a load capacitance ($C_L$) of 20 pF, maximum shunt capacitance ($C_o$) of 7 pF, and the maximum ESR of 50 Ω. In order to insure enough negative resistance, use C1 = C2 = 27 pF. The resistor $R_d$ is used to trim the gain, and $R_d$ = 1.5 kΩ is recommended.

**Figure 5. Crystal Tuning Circuit**

## 8.4 Device Functional Modes

### 8.4.1 Vendor ID and Product ID With External Serial EEPROM

The $\overline{\text{EXTMEM}}$ (pin 47) enables or disables the optional EEPROM interface. When $\overline{\text{EXTMEM}}$ is high, the vendor and product IDs (VID and PID) use defaults, such that the message displayed during enumeration is General Purpose USB Hub. For this configuration, pin 8 functions as the GANGED input pin and EECLK (pin 7) is unused. If custom VID and PID descriptors are desired, the $\overline{\text{EXTMEM}}$ must be tied low ($\overline{\text{EXTMEM}}$ = 0) and a SGS Thompson M93C46 EEPROM, or equivalent, stores the programmable VID, PID, and GANGED values. For this configuration, pin 7 and 8 function as the EEPROM interface signals with pin 7 as EECLK and pin 8 as EEDATA, respectively. A block diagram example of how to connect the external EEPROM if a custom product ID and vendor ID are desired is shown in Figure 6.

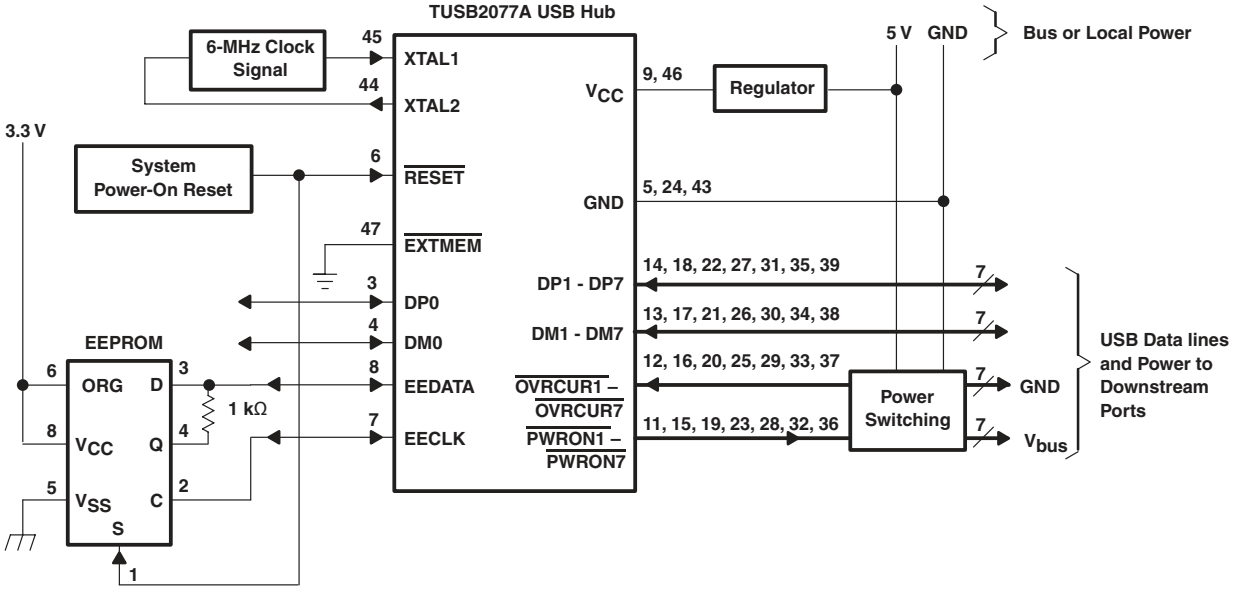



**Figure 6. Typical Application of the TUSB2077A USB Hub**

## 8.5 Programming

An SGS Thompson M93C46 EEPROM, or equivalent, stores the programmable VID and PID. When the EEPROM interface is enabled ($\overline{\text{EXTMEM}}$ = 0), the EECLK and EEDATA are internally pulled down (100 µA) inside the TUSB2077A. The internal pulldowns are disabled when the EEPROM interface is disabled ($\overline{\text{EXTMEM}}$ = 1).

The EEPROM is programmed with the three 16-bit locations as shown in Table 1. Connecting terminal 6 of the EEPROM high (ORG = 1) organizes the EEPROM memory into 64×16-bit words.

**Table 1. EEPROM Memory Map**

| ADDRESS | D15 | D14 | D13 | D12–D8 | D7–D0 |
|---|---|---|---|---|---|
| 00000 | 0 | $\overline{\text{GANGED}}$ | 00000 | 00000 | 00000000 |
| 00001 | VID High-byte | | | | VID Low-byte |
| 00010 | PID High-byte | | | | PID Low-byte |
| | XXXXXXXX | | | | |

The D and Q signals of the EEPROM must be tied together using a 1-kΩ resistor with the common I/O operations forming a single-wire bus. After system power-on reset, the TUSB2077A performs a one-time access read operation from the EEPROM if the $\overline{\text{EXTMEM}}$ terminal is pulled low and the chip select(s) of the EEPROM is connected to the system power-on reset. Initially, the EEDATA terminal is driven by the TUSB2077A to send a start bit (1) which is followed by the read instruction (10) and the starting-word address (00000). Once the read instruction is received, the instruction and address are decoded by the EEPROM, which then sends the data to the output shift register. At this point, the hub stops driving the EEDATA terminal and the EEPROM starts driving. A dummy (0) bit is then output and the first three 16-bit words in the EEPROM are output with the most significant bit (MSB) first.

The output data changes are triggered by the rising edge of the clock provided by the TUSB2077A on the EECLK terminal. The SGS-Thompson M936C46 EEPROM is recommended because it advances to the next memory location by automatically incrementing the address internally. Any EEPROM used must have the automatic internal address advance function. After reading the three words of data from the EEPROM, the TUSB2077A puts the EEPROM interface into a high-impedance condition (pulled down internally) to allow other logic to share the EEPROM. The EEPROM read operation is summarized in Figure 7. For more details on EEPROM operation, refer to *SGS-Thompson Microelectronics M93C46 Serial Microwire Bus EEPROM* data sheet.

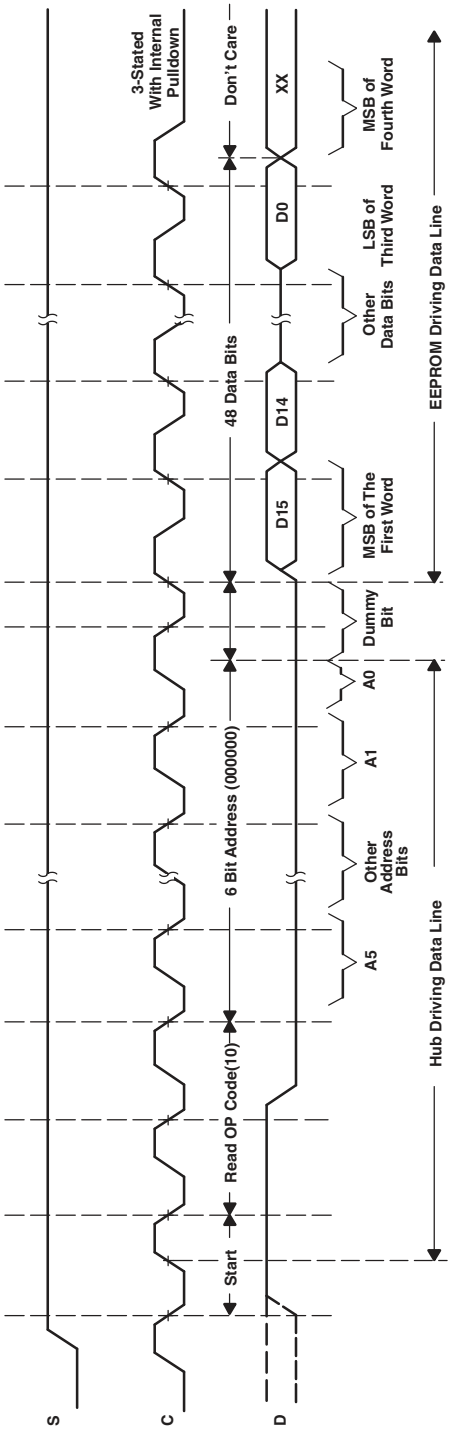



**Figure 7. EEPROM Read Operation Timing Diagram**

# 9 Application and Implementation

**NOTE**

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## 9.1 Application Information

A major advantage of USB is the ability to connect 127 functions configured in up to 6 logical layers (tiers) to a single personal computer.

Another advantage of USB is that all peripherals are connected using a standardized four-wire cable that provides both communication and power distribution. The power configurations are bus-powered and self-powered modes. The maximum current that may be drawn from the USB 5-V line during power up is 100 mA. For the bus-powered mode, a hub can draw a maximum of 500 mA from the 5-V line of the USB cable. A bus-powered hub must always be connected downstream to a self-powered hub unless it is the only hub connected to the PC and there are no high-powered functions connected downstream. In the self-powered mode, the hub is connected to an external power supply and can supply up to 500 mA to each downstream port. High-powered functions may draw a maximum of 500 mA from each downstream port and may only be connected downstream to self-powered hubs. Per the USB specification, in the bus-powered mode, each downstream port can provide a maximum of 100 mA of current, and in the self-powered mode, each downstream port can provide a maximum of 500 mA of current.

## 9.2 Typical Application

A common application for the TUSB2077A is as a self-powered USB hub product. The product is powered by an external 5-V DC Power adapter. In this application, using a USB cable TUSB2077A's upstream port is plugged into a USB Host controller. The downstream ports of the TUSB2077A are exposed to users for connecting USB cameras, keyboards, printers, and so forth.

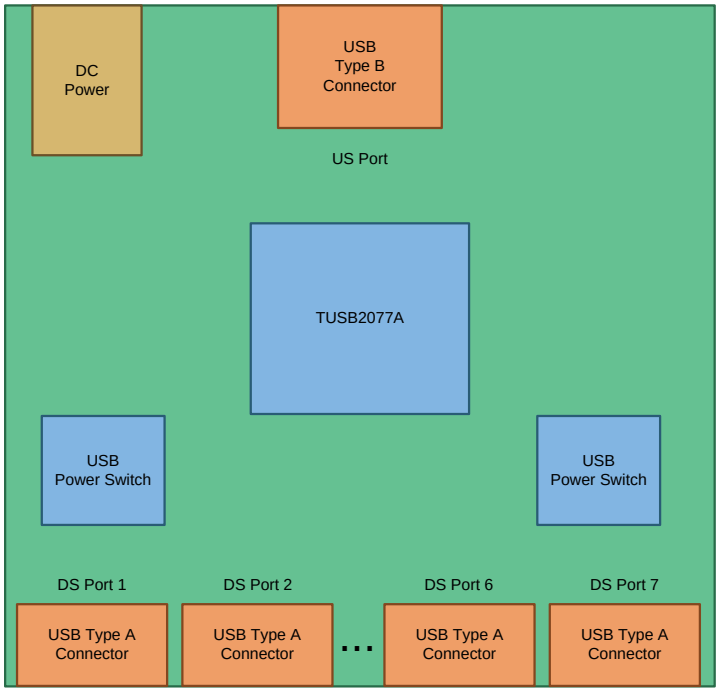



**Figure 8. Self-Powered USB Hub Product**

## Typical Application (continued)

### 9.2.1 Design Requirements

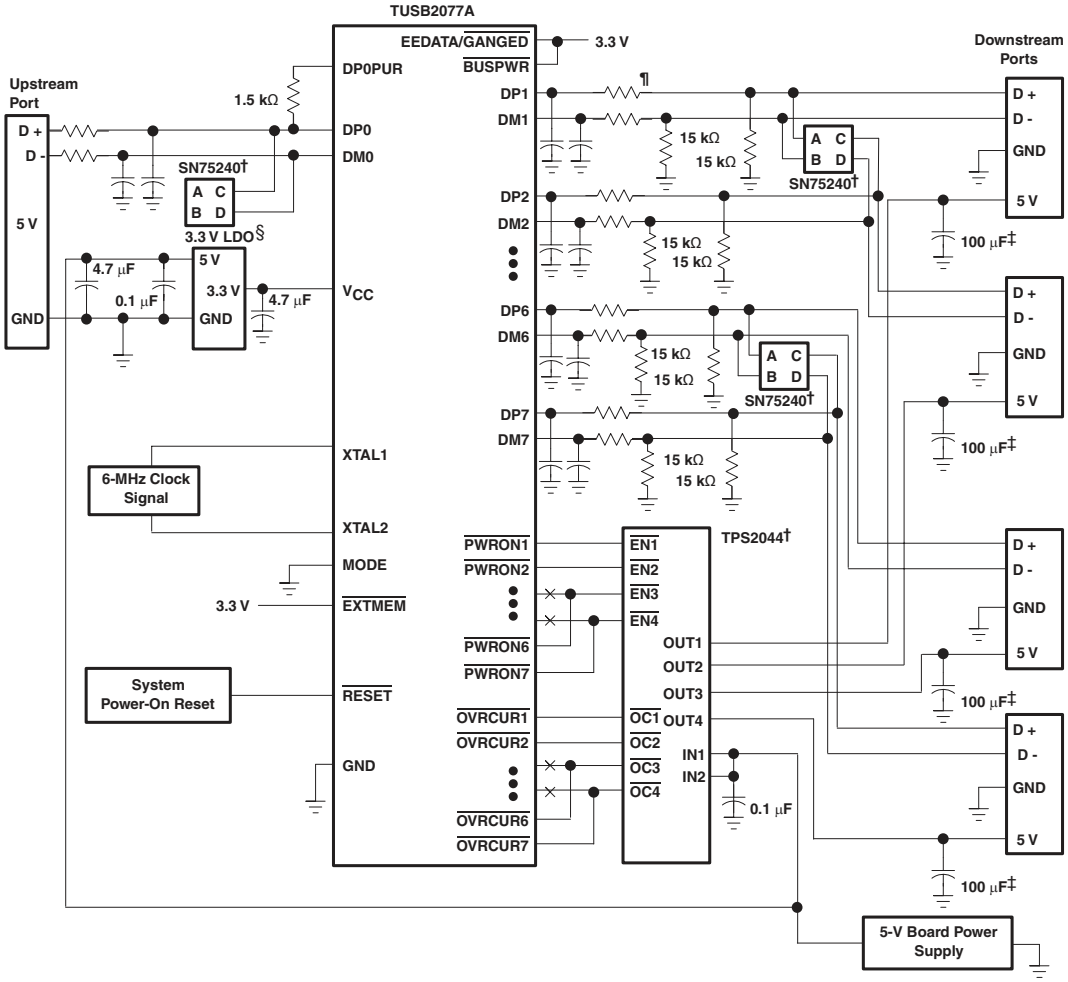
For this example, use the parameters listed in Table 2.

**Table 2. Design Parameters**

| DESIGN PARAMETERS | VALUE |
|---|---|
| $V_{CC}$ Supply | 3.3 V |
| Downstream Ports | 7 |
| Power Management | Individual Port |
| Clock Source | 6-MHz Crystal |
| External EEPROM | No |
| Power Source Mode | Self-Powered |

### 9.2.2 Detailed Design Procedure

In a self-powered configuration, the TUSB2077A can be implemented for individual-port power management when used with the TPS2044 because it is capable of supplying 500 mA of current to each downstream port and can provide current limiting on a per-port basis. When the hub detects a fault on a downstream port, power is removed from only the port with the fault and the remaining ports continue to operate normally. Self-powered hubs are required to implement overcurrent protection and report overcurrent conditions. The SN75240 transient suppressors reduce inrush current and voltage spikes on the data lines.




NOTES: † TPS2042 and SN75240 are Texas Instruments devices. Two TPS2042 devices can be substituted for the TPS2044.
‡ 120 µF per hub is the minimum required per the USB specification. However, TI recommends a 100-µF, low ESR, tantalum capacitor per port for immunity to voltage droop.
§ LDO is a 5-V-to-3.3-V voltage regulator. TPS76333 from Texas Instruments can be used.
¶ All USB DP, DM signal pairs require series resistors of approximately 27Ω to ensure proper termination. An optional filter capacitor of about 22 pF is recommended for EMI suppression. This capacitor, if used, must be placed between the hub terminal and the series resistor, as per section 7.1.6 of the USB specification.

**Figure 9. TUSB2077A Self-Powered Hub, Individual-Port Power-Management Application**

### 9.2.3 Application Curve

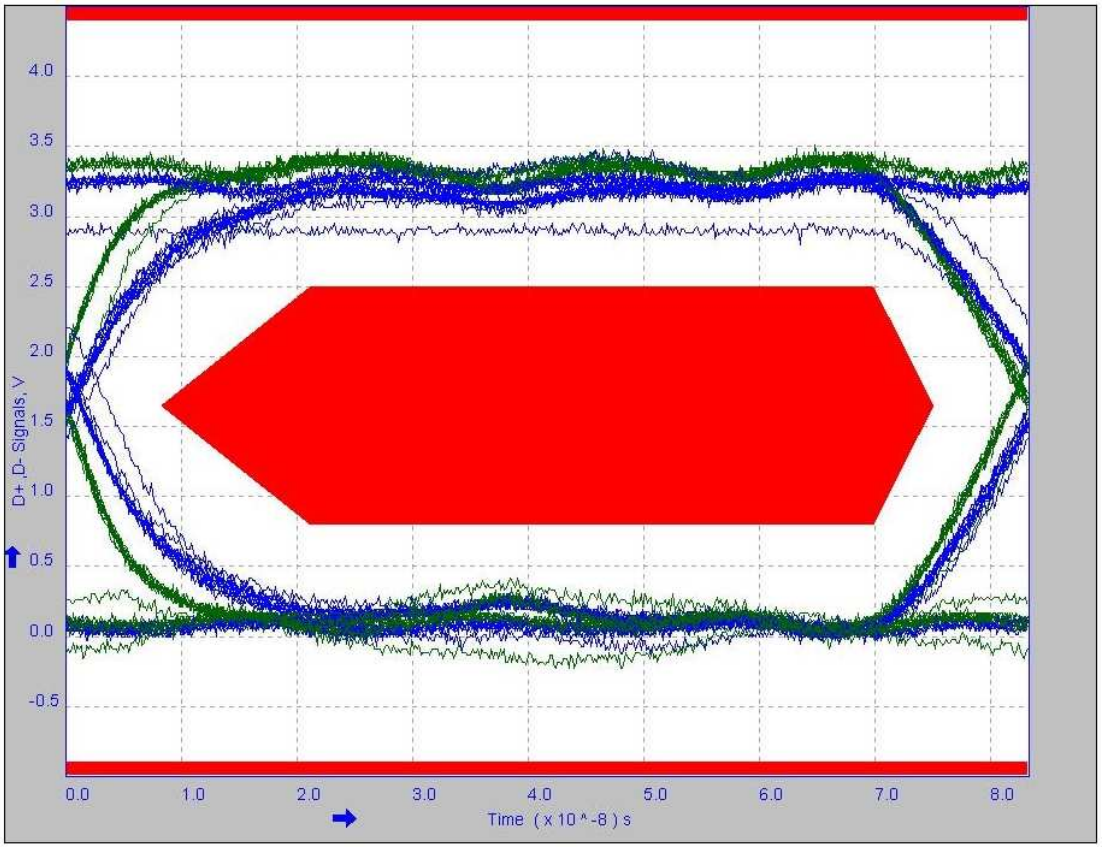



**Figure 10. Downstream Port**

## 10 Power Supply Recommendations

### 10.1 TUSB2077A Power Supply

$V_{CC}$ should be implemented as a single power plane.

- The $V_{CC}$ pins of the TUSB2077A supply 3.3-V power rail to the I/O of the TUSB2077A. This power rail can be isolated from all other power rails by a ferrite bead to reduce noise.
- All power rails require a 10-µF capacitor or 1-µF capacitors for stability and noise immunity. These bulk capacitors can be placed anywhere on the power rail. The smaller decoupling capacitors should be placed as close to the TUSB2077A power pins as possible with an optimal grouping of two of differing values per pin.

### 10.2 Downstream Port Power

- The downstream port power, VBUS, must be supplied by a source capable of supplying 5 V and up to 500 mA per port. Downstream port power switches can be controlled by the TUSB2077A signals. It is also possible to leave the downstream port power always enabled.
- A large bulk low-ESR capacitor of 22 µF or larger is required on each downstream port's VBUS to limit in-rush current.
- The ferrite beads on the VBUS pins of the downstream USB port connections are recommended for both ESD and EMI reasons. A 0.1-µF capacitor on the USB connector side of the ferrite provides a low impedance path to ground for fast rise time ESD current that might have coupled onto the VBUS trace from the cable.

# 11 Layout

## 11.1 Layout Guidelines

### 11.1.1 Placement

1. A 0.1-µF should be placed as close as possible on $V_{CC}$ power pin.
2. The ESD and EMI protection devices (if used) should also be placed as possible to the USB connector.
3. If a crystal is used, it must be placed as close as possible to the XTAL1 and XTAL2 pins of the TUSB2077A.
4. Place voltage regulators as far away as possible from the TUSB2077A, the crystal, and the differential pairs.
5. In general, the large bulk capacitors associated with the power rail should be placed as close as possible to the voltage regulators.

### 11.1.2 Differential Pairs

1. Must be designed with a differential impedance of 90 Ω ±10%.
2. Route all differential pairs on the same layer adjacent to a solid ground plane.
3. Do not route differential pairs over any plane split.
4. Adding test points will cause impedance discontinuity and will therefore negative impact signal performance. If test points are used, they should be placed in series and symmetrically. They must not be placed in a manner that causes stub on the differential pair.
5. Avoid 90-degree turns in trace. The use of bends in differential traces should be kept to a minimum. When bends are used, the number of left and right bends should be as equal as possible and the angle of the bend should be ≥ 135 degrees. This will minimize any length mismatch causes by the bends and therefore minimize the impact bends have on EMI.
6. Minimize the trace lengths of the differential pair traces. The maximum recommended trace length for USB 2.0 differential pair signals is 8 inches. Longer trace lengths require very careful routing to assure proper signal integrity.
7. Match the etch lengths of the differential pair traces. The USB 2.0 differential pairs should not exceed 50 mils relative trace length difference.
8. Minimize the use of vias in the differential pair paths as much as possible. If this is not practical, make sure that the same via type and placement are used for both signals in a pair. Any vias used should be placed as close as possible to the TUSB2077A device.
9. Do not place power fuses across the differential pair traces.

### 11.1.3 Ground

TI recommends using only one board ground plane in the design. This provides the best image plane for signal traces running above the plane. The thermal pad of the TUSB2077A and any of the voltage regulators should be connected to this plane with vias. An earth or chassis ground is implemented only near the USB port connectors on a different plane for EMI and ESD purposes.

## 11.2 Layout Example

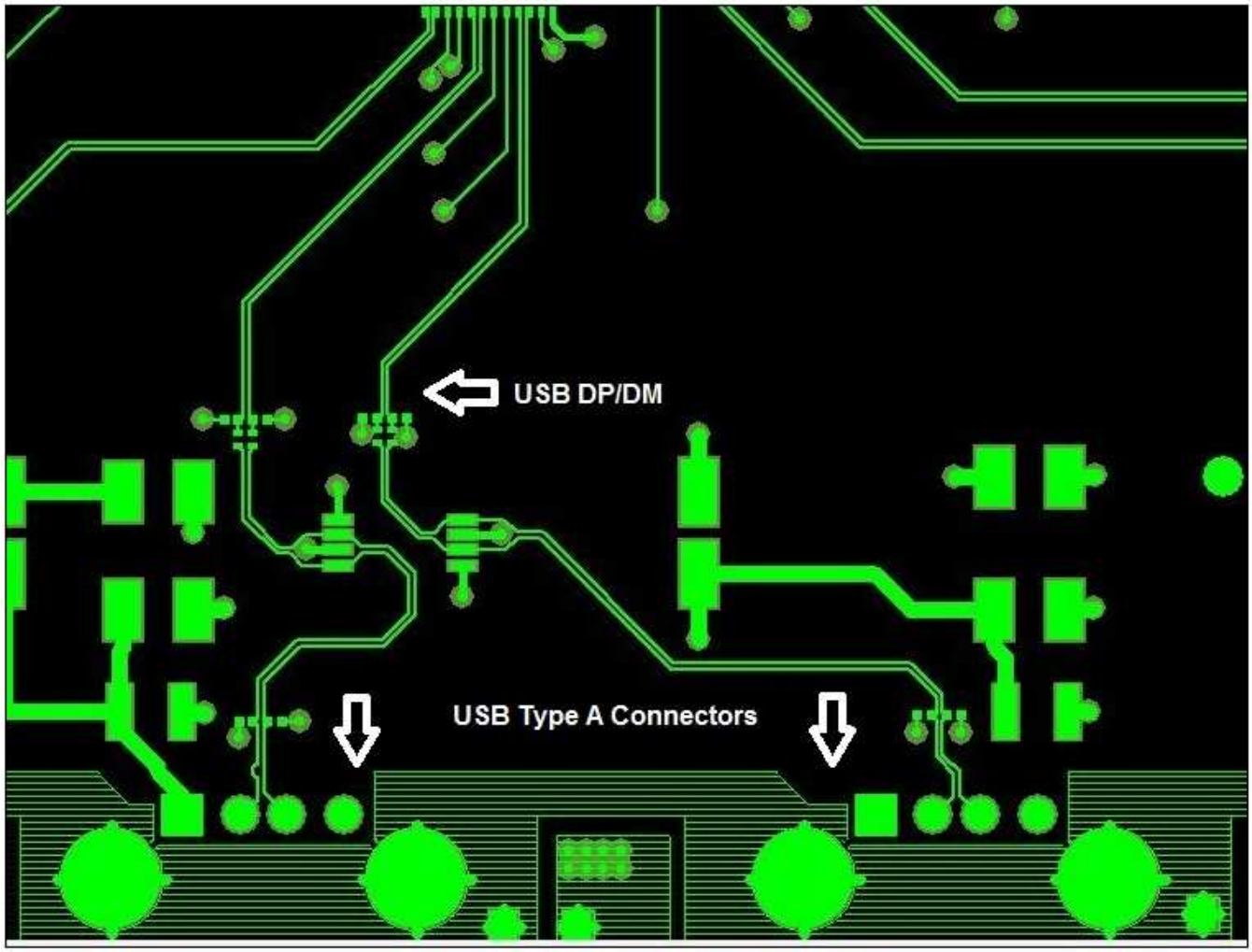



**Figure 11. TUSB2077 Layout Example**

# 12 Device and Documentation Support

## 12.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

**TI E2E™ Online Community** ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

## 12.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

## 12.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## 12.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

# 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB2077APT | ACTIVE | LQFP | PT | 48 | 250 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | 0 to 70 | TUSB2077A | Samples |
| TUSB2077APTR | ACTIVE | LQFP | PT | 48 | 1000 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | 0 to 70 | TUSB2077A | Samples |
| TUSB2077APTRG4 | ACTIVE | LQFP | PT | 48 | 1000 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | 0 to 70 | TUSB2077A | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

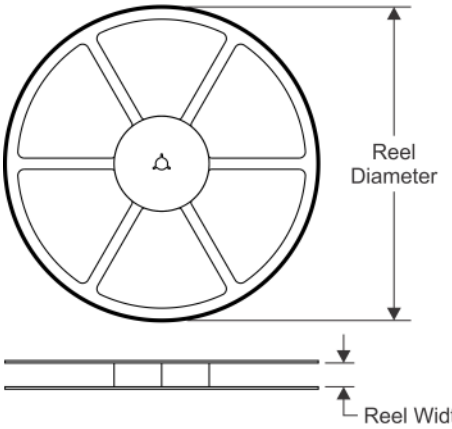
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

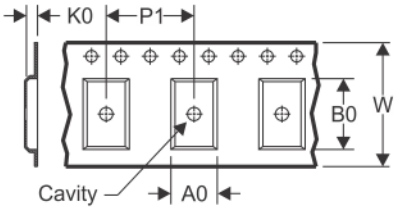
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

REEL DIMENSIONS

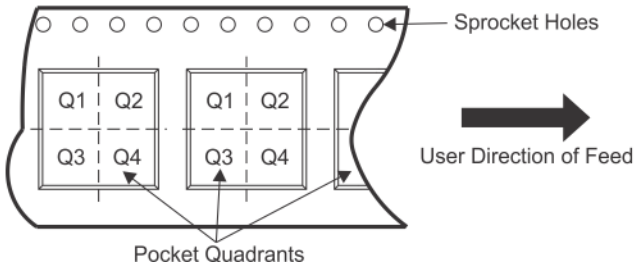



TAPE DIMENSIONS




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

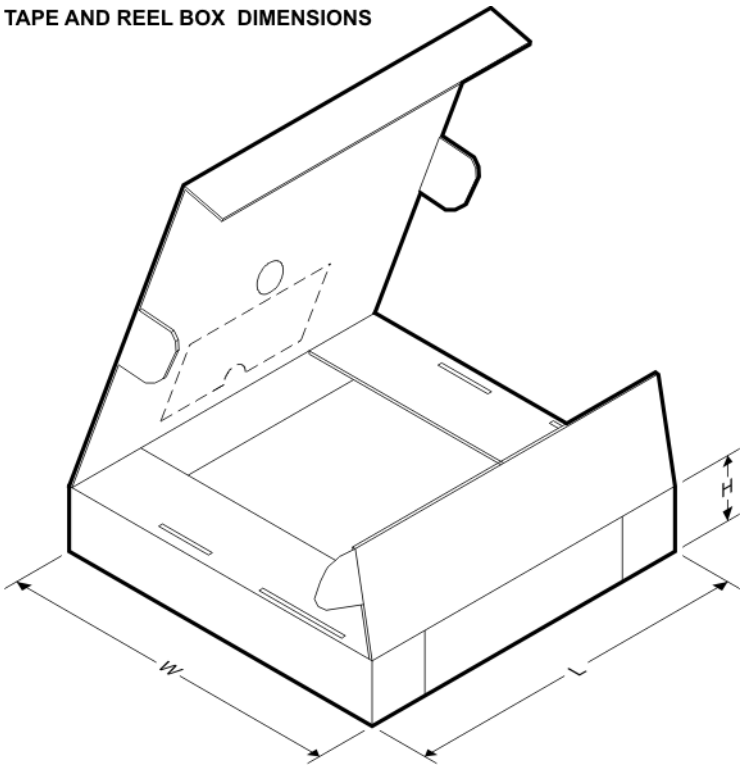
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB2077APTR | LQFP | PT | 48 | 1000 | 330.0 | 16.4 | 9.6 | 9.6 | 1.9 | 12.0 | 16.0 | Q2 |

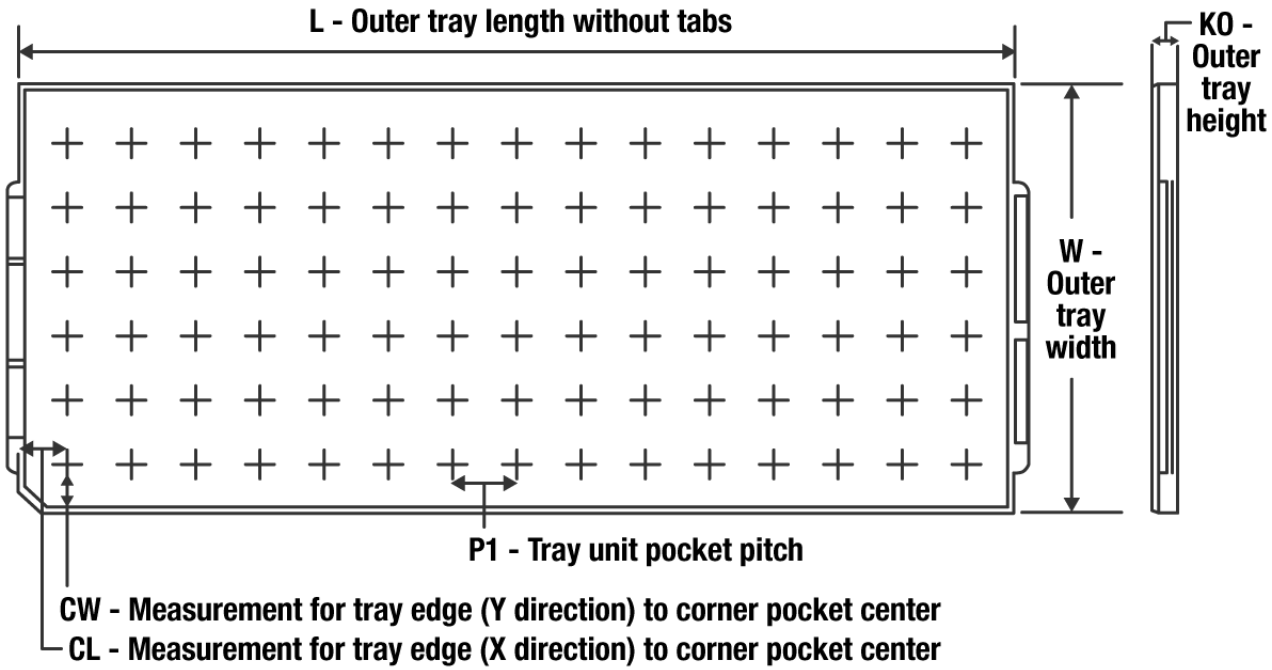
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TUSB2077APTR | LQFP | PT | 48 | 1000 | 336.6 | 336.6 | 31.8 |

## TRAY




Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

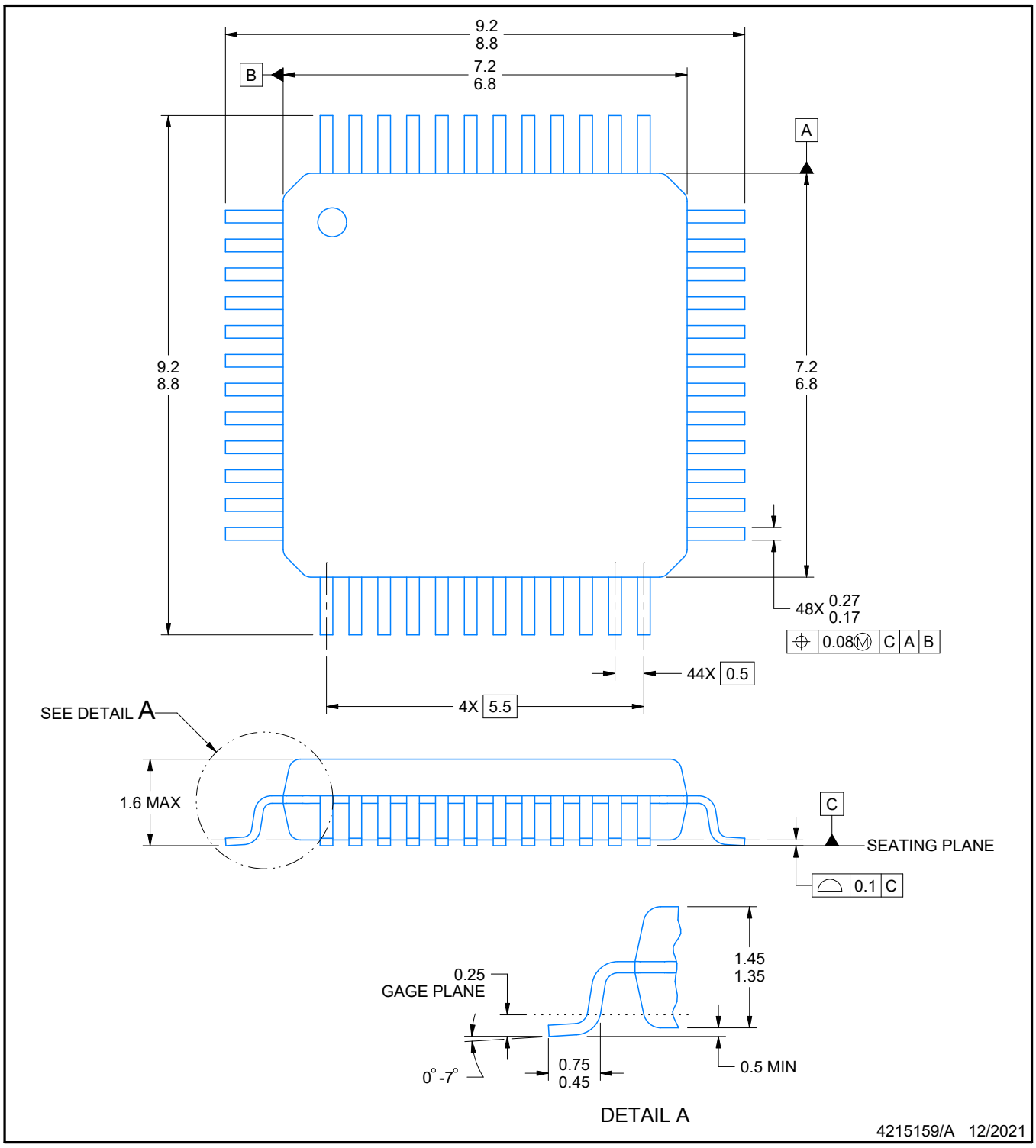
| Device | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB2077APT | PT | LQFP | 48 | 250 | 10 x 25 | 150 | 315 | 135.9 | 7620 | 12.2 | 11.1 | 11.25 |

# PACKAGE OUTLINE

## PT0048A

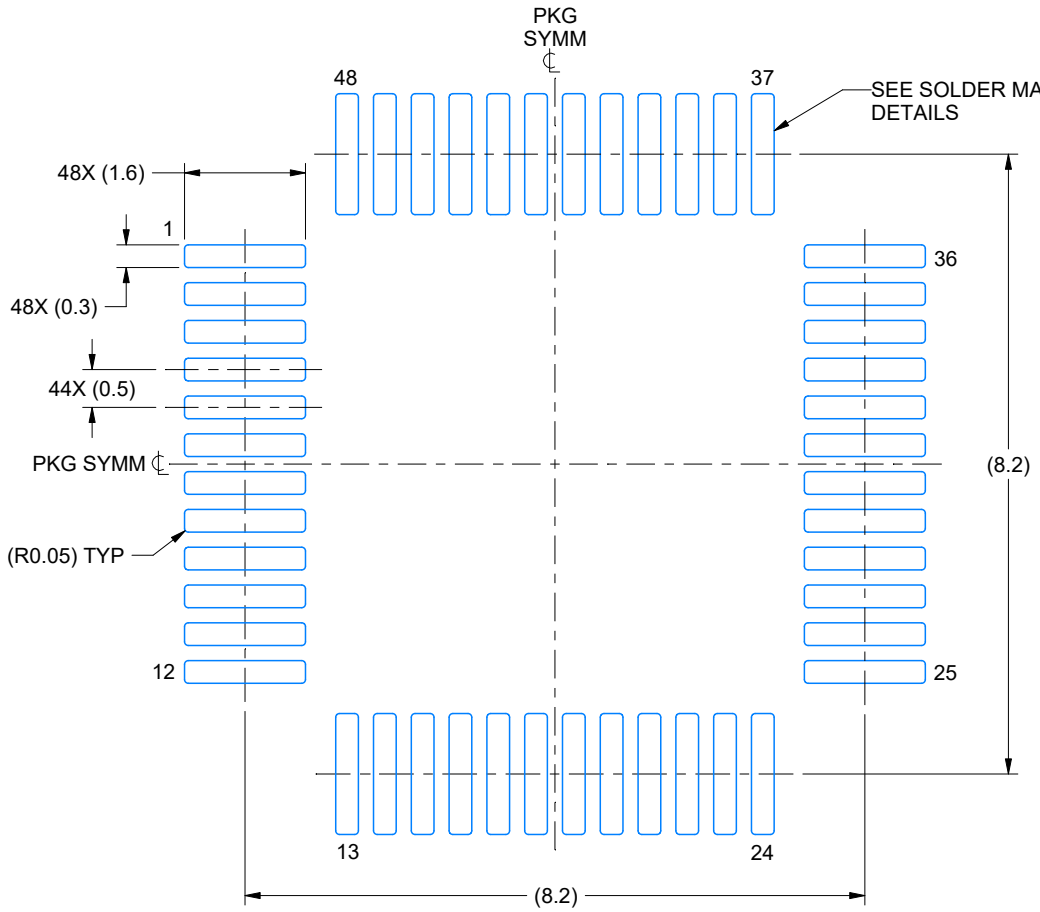
## LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK

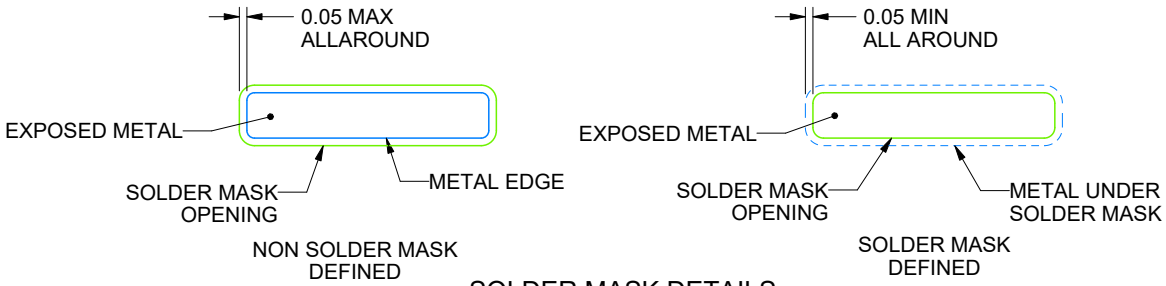



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MS-026.
4. This may also be a thermally enhanced plastic package with leads conected to the die pads.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE 10.000

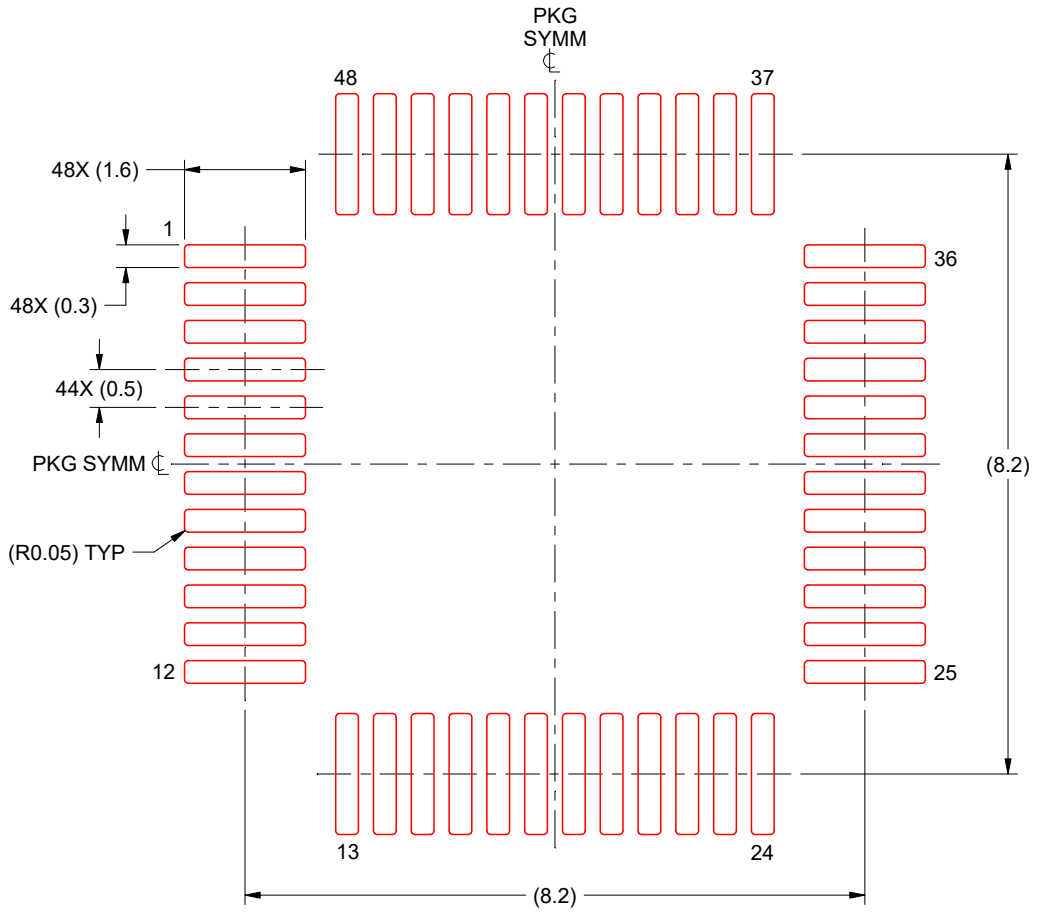



SOLDER MASK DETAILS

4215159/A 12/2021

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 10X

4215159/A 12/2021

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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