TEXAS INSTRUMENTS

**TUSB322I**

SLLSEO5C –OCTOBER 2015–REVISED MAY 2017

# TUSB322I USB Type-C™ Configuration Channel Logic and Port Control with VCONN

## 1 Features

- USB Type-C™ Specification 1.1
- Backward Compatible with USB Type-C Specification 1.0
- Supports Up to 3 A of Current Advertisement and Detection
- Mode Configuration
  - Host Only – DFP/Source (I$^2$C Mode only)
  - Device Only – UFP/Sink (I$^2$C Mode only)
  - Dual Role Port – DRP
- Channel Configuration (CC)
  - Attach of USB Port Detection
  - Cable Orientation Detection
  - Role Detection
  - Type-C Current Mode (Default, Medium, High)+u
- V$_{BUS}$ Detection
- I$^2$C or GPIO Control
- VCONN Support for Active Cables
- Cable Detection and Direction Control for External Switches
- Role Configuration Control through I$^2$C
- Supply Voltage: 4.5 V to 5.5 V
- Low Current Consumption
- Industrial Temperature Range of –40 to 85°C

## 2 Applications

- Host, Device, Dual Role Port Applications
- Mobile Phones
- Tablets and Notebooks
- USB Peripherals

## 3 Description

The TUSB322I device enables USB Type-C ports with the configuration channel (CC) logic required for Type-C ecosystems. The TUSB322I device uses the CC pins to determine port attach and detach, cable orientation, role detection, and port control for Type-C current mode. The TUSB322I device can be configured as a downstream facing port (DFP), upstream facing port (UFP), or a dual role port (DRP), making the TUSB322I device ideal for any application.

The TUSB322I device alternates configuration as a DFP or UFP according to the Type-C Specifications. The CC logic block monitors the CC1 and CC2 pins for pullup or pulldown resistances to determine when a USB port has been attached, the orientation of the cable, and the role detected. The CC logic detects the Type-C current mode as default, medium, or high depending on the role detected. V$_{BUS}$ detection is implemented to determine a successful attach in UFP and DRP modes. The TUSB322I will supply VCONN when an active cable is detected.
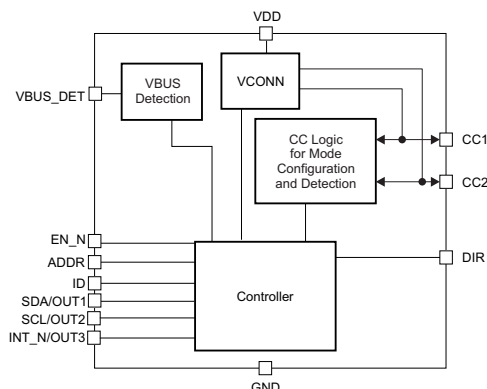
The device operates over a wide supply range and has low-power consumption. The TUSB322I device is available in industrial temperature ranges.

### Device Information[1]

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TUSB322I | X2QFN (12) | 1.60 mm × 1.60 mm |

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

### Simplified Schematic



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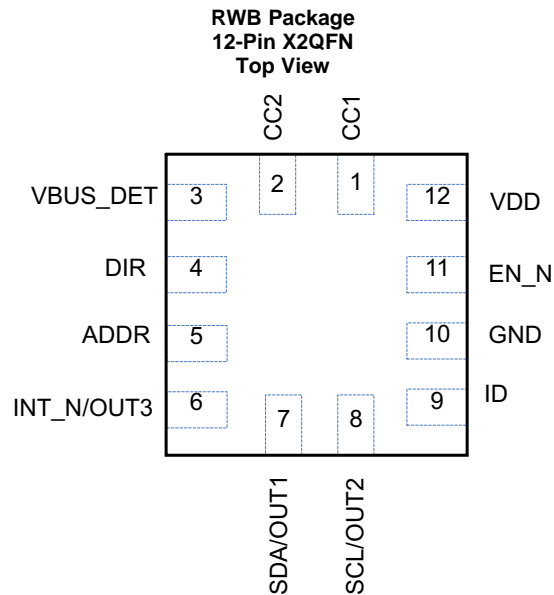
### Sample Applications

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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 B (September 2016) to Revision C** | **Page** |
|---|---|

* Changed $R_{VBUS}$ values From: MIN = 891, TYP = 900, MAX = 909 KΩ To: MIN = 855, TYP = 887, MAX = 920 KΩ ........... 6

| **Changes from Revision A (May 2016) to Revision B** | **Page** |
|---|---|

* Changed pins CC1 and CC2 values From: MIN = –0.3 MAX = $V_{DD}$ + 0.3 To: MIN –0.3 MAX = 6 in the *Absolute Maximum Ratings* ..................................................................................................................................................................... 4

| **Changes from Original (October 2015) to Revision A** | **Page** |
|---|---|

* Added Shutdown current consumption to *Electrical Characteristics* table. ................................................................. 5

# 5 Pin Configuration and Functions

**RWB Package**
**12-Pin X2QFN**
**Top View**



## Pin Functions

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| CC1 | 1 | I/O | Type-C configuration channel signal 1 |
| CC2 | 2 | I/O | Type-C configuration channel signal 2 |
| VBUS_DET | 3 | I | 5-V to 28-V $V_{BUS}$ input voltage. $V_{BUS}$ detection determines UFP attachment. One 900-k$\Omega$ external resistor required between system $V_{BUS}$ and VBUS_DET pin. |
| DIR | 4 | O | DIR of plug. The open drain output indicates the detected plug orientation: Type-C plug position 2 (H); Type-C plug position 1 (L). |
| ADDR | 5 | I | Tri-level input pin to indicate I$^2$C address or GPIO mode:<br>H - I$^2$C is enabled and I$^2$C 7-bit address is 0x67.<br>NC - GPIO mode (I$^2$C is disabled)<br>L - I$^2$C is enabled and I$^2$C 7-bit address is 0x47.<br>ADDR pin should be pulled up to $V_{DD}$ if high configuration is desired |
| INT_N/OUT3 | 6 | O | The INT_N/OUT3 is a dual-function pin. When used as the INT_N, the pin is an open drain output in I$^2$C control mode and is an active low interrupt signal for indicating changes in I$^2$C registers. When used as OUT3, the pin is in audio accessory detect in GPIO mode: no detection (H), audio accessory connection detected (L). |
| SDA/OUT1 | 7 | I/O | The SDA/OUT1 is a dual-function pin. When I$^2$C is enabled (ADDR pin is high or low), this pin is the I$^2$C communication data signal. When in GPIO mode (ADDR pin is NC), this pin is an open drain output for communicating Type-C current mode detect when the TUSB322I device is in UFP mode: default current mode detected (H); medium or high current mode detected (L). |
| SCL/OUT2 | 8 | I/O | The SCL/OUT2 is a dual function pin. When I$^2$C is enabled (ADDR pin is high or low), this pin is the I$^2$C communication clock signal. When in GPIO mode (ADDR pin is NC), this pin is an open drain output for communicating Type-C current mode detect when the TUSB322I device is in UFP mode: default or medium current mode detected (H); high current mode detected (L). |
| ID | 9 | O | Open drain output; asserted low when the CC pins detect device attachment when port is a source (DFP), or dual-role (DRP) acting as source (DFP). |
| GND | 10 | G | Ground |
| EN_N | 11 | I | EN_N. Active low enable. |
| $V_{DD}$ | 12 | P | Positive supply voltage |

Product Folder Links: *TUSB322I*

# 6 Specifications

## 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

|  |  | MIN | MAX | UNIT |
|---|---|---|---|---|
| Supply voltage | $V_{DD}$ | −0.3 | 6 | V |
| Control pins | ADDR, ID, DIR, INT_N/OUT3, EN_N | −0.3 | $V_{DD}$ + 0.3 | V |
| | CC1, CC2 | −0.3 | 6 | |
| | SDA/OUT1, SCL/OUT2 | −0.3 | $V_{DD}$ + 0.3 | |
| | VBUS_DET | −0.3 | 4 | |
| Storage temperature, $T_{stg}$ | | −65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.

## 6.2 ESD Ratings

|  |  |  | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[1] | ±3000 | 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.

## 6.3 Recommended Operating Conditions

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

|  |  |  | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | | 4.5 | 5 | 5.5 | V |
| $V_{BUS}$ | System $V_{BUS}$ voltage | | 4 | 5 | 28 | V |
| VCONTROL | DC voltage range for control lines: ADDR, ID, DIR, INT_N/OUT3, SDA/OUT1, SCL/OUT2, EN_N, CC1, and CC2. | | 0 | | 5.5 | V |
| | DC voltage range for VBUSDET | | 0 | | 4 | V |
| VCONN | Supply for active cable (With $V_{DD}$ at 5 V) | | 4.75 | | 5.5 | V |
| $T_A$ | Operating free-air temperature | TUSB322I | −40 | 25 | 85 | °C |

## 6.4 Thermal Information

| THERMAL METRIC[1] | | TUSB322I RWB (X2QFN) 12 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 169.3 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 68.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 83.4 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 2.2 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 83.4 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | N/A | |

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

## 6.5 Electrical Characteristics

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

| | PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Power Consumption** | | | | | | |
| $I_{SHUTDOWN\_UFP}$ | Leakage current when VDD is supplied but the device is not enabled. (VDD = 5 V, EN_N = H) | | | 0.04 | | µA |
| $I_{UNATTACHED\_UFP}$ | Current consumption in unattached mode when port is unconnected and waiting for connection. ($V_{DD}$ = 5 V, ADDR = NC, MODE_SELECT = 2'b01) | | | 70 | | µA |
| $I_{ACTIVE\_UFP}$ | Current consumption in active mode. ($V_{DD}$ = 5 V, ADDR = NC, MODE_SELECT = 2'b01) | | | 70 | | µA |
| **CC1 and CC2 Pins** | | | | | | |
| $R_{CC\_DB}$ | Pulldown resistor when in dead-battery mode. | | 4.1 | 5.1 | 6.1 | kΩ |
| $R_{CC\_D}$ | Pulldown resistor when in UFP or DRP mode. | | 4.6 | 5.1 | 5.6 | kΩ |
| $V_{UFP\_CC\_USB}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising default current source capability. | | 0.25 | | 0.61 | V |
| $V_{UFP\_CC\_MED}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising medium (1.5 A) current source capability. | | 0.7 | | 1.16 | V |
| $V_{UFP\_CC\_HIGH}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising high (3 A) current source capability. | | 1.31 | | 2.04 | V |
| $V_{TH\_DFP\_CC\_USB}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising default current source capability. | | 1.51 | 1.6 | 1.64 | V |
| $V_{TH\_DFP\_CC\_MED}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising medium current (1.5 A) source capability. | | 1.51 | 1.6 | 1.64 | V |
| $V_{TH\_DFP\_CC\_HIGH}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising high current (3.0 A) source capability. | | 2.46 | 2.6 | 2.74 | V |
| $V_{TH\_AC\_CC\_USB}$ | Voltage threshold for detecting a active cable attach when configured as a DFP and advertising default current source. | | 0.15 | 0.2 | 0.25 | V |
| $V_{TH\_AC\_CC\_MED}$ | Voltage threshold for detecting a active cable attach when configured as a DFP and advertising medium current (1.5 A) source. | | 0.35 | 0.4 | 0.45 | V |
| $V_{TH\_AC\_CC\_HIGH}$ | Voltage threshold for detecting a active cable attach when configured as a DFP and advertising high current (3.0 A) source. | | 0.76 | 0.8 | 0.84 | V |
| $I_{CC\_DEFAULT\_P}$ | Default mode pullup current source when operating in DFP or DRP mode. | | 64 | 80 | 96 | µA |
| $I_{CC\_MED\_P}$ | Medium (1.5 A) mode pullup current source when operating in DFP or DRP mode. | | 166 | 180 | 194 | µA |
| $I_{CC\_HIGH\_P}$ | High (3 A) mode pullup current source when operating in DFP or DRP mode.[(1)] | | 304 | 330 | 356 | µA |
| **Control Pins: EN_N, ADDR, INT/OUT3, DIR, ID** | | | | | | |
| $V_{IL}$ | Low-level control signal input voltage, (EN_N, ADDR) | | | | 0.4 | V |
| $V_{IM}$ | Mid-level control signal input voltage (ADDR) | | $0.28 \times V_{DD}$ | | $0.56 \times V_{DD}$ | V |
| $V_{IH}$ | High-level control signal input voltage (EN_N, ADDR) | | $V_{DD} - 0.3$ | | $V_{DD}$ | V |
| $I_{IH}$ | High-level input current | | −20 | | 20 | µA |
| $I_{IL}$ | Low-level input current | | −10 | | 10 | µA |
| $I_{ID\_LEAKAGE}$ | Current leakage on ID pin. | $V_{DD}$ = 0 V; ID = 5 V | | | 10 | µA |
| $R_{EN\_N}$ | Internal pull-up resistance for EN_N. | | | 1.1 | | MΩ |
| $R_{pu}$ | Internal pullup resistance (ADDR) | | | 588 | | kΩ |
| $R_{pd}$ | Internal pulldown resistance (ADDR) | | | 1.1 | | MΩ |
| $V_{OL}$ | Low-level signal output voltage (open-drain) (INT_N/OUT3, ID) | $I_{OL}$ = −1.6 mA | | | 0.4 | V |

(1)   $V_{DD}$ must be 3.5 V or greater to advertise 3 A current.

## Electrical Characteristics (continued)

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $R_{p\_ODext}$ | External pullup resistor on open drain IOs (INT_N/OUT3, ID) | | | 200 | | kΩ |
| $R_{p\_TLext}$ | Tri-level input external pullup resistor (ADDR) | | | 4.7 | | kΩ |
| **I²C - SDA/OUT1, SCL/OUT2 can operate from 1.8 or 3.3 V (±10%) when ADDR pin is low or high. [2]** | | | | | | |
| $V_{DD\_I2C}$ | Supply range for I²C (SDA/OUT1, SCL/OUT2) | | 1.65 | 1.8 | 3.6 | V |
| $V_{IH}$ | High-level signal voltage | | 1.05 | | | V |
| $V_{IL}$ | Low-level signal voltage | | | | 0.4 | V |
| $V_{OL}$ | Low-level signal output voltage (open drain) | $I_{OL}$ = −1.6 mA | | | 0.4 | V |
| **VBUS_DET IO Pins (Connected to System V$_{BUS}$ signal)** | | | | | | |
| $V_{BUS\_THR}$ | $V_{BUS}$ threshold range | | 2.95 | 3.3 | 3.8 | V |
| $R_{VBUS}$ | External resistor between $V_{BUS}$ and VBUS_DET pin | | 855 | 887 | 920 | KΩ |
| $R_{VBUS\_PD}$ | Internal pulldown resistance for VBUS_DET | | | 95 | | KΩ |
| **DIR pin (Open Drain IO)** | | | | | | |
| $V_{OL}$ | Low-level signal output voltage | $I_{OL}$ = −1.6 mA | | | 0.4 | V |
| **VCONN** | | | | | | |
| $R_{ON}$ | On resistance of the VCONN power FET | | | | 1.25 | Ω |
| $V_{TOL}$ | Voltage tolerance on VCONN power FET | | | | 5.5 | V |
| $V_{PASS}$ | Voltage to pass through VCONN power FET | | | | 5.5 | V |
| $I_{VCONN}$ | VCONN current limit; VCONN is disconnected above the value | | 225 | 300 | 375 | mA |
| $C_{BULK}$ | Bulk capacitance on VCONN; placed on $V_{DD}$ supply | | 10 | | 200 | uF |

(2)   When using 3.3 V for I²C, customer must ensure V$_{DD}$ is above 3.0 V at all times.

## 6.6   Timing Requirements

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| **I²C (SDA, SCL)** | | | | | |
| $t_{SU:DAT}$ | Data setup time | 100 | | | ns |
| $t_{HD;DAT}$ | Data hold time | 10 | | | ns |
| $t_{SU:STA}$ | Set-up time, SCL to start condition | 0.6 | | | µs |
| $t_{HD:STA}$ | Hold time, (repeated) start condition to SCL | 0.6 | | | µs |
| $t_{SU:STO}$ | Set up time for stop condition | 0.6 | | | µs |
| $t_{VD;DAT}$ | Data valid time | | | 0.9 | µs |
| $t_{VD;ACK}$ | Data valid acknowledge time | | | 0.9 | µs |
| $t_{BUF}$ | Bus free time between a stop and start condition | 1.3 | | | µs |
| $f_{SCL}$ | SCL clock frequency; I²C mode for local I²C control | | | 400 | kHz |
| $t_r$ | Rise time of both SDA and SCL signals | | | 300 | ns |
| $t_f$ | Fall time of both SDA and SCL signals | | | 300 | ns |
| $C_{BUS\_100KHZ}$ | Total capacitive load for each bus line when operating at ≤ 100 KHz | | | 400 | pF |
| $C_{BUS\_400KHZ}$ | Total capacitive load for each bus line when operating at 400 KHz. | | | 100 | pF |

Product Folder Links: *TUSB322I*

## 6.7 Switching Characteristics

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{CCCB\_DEFAULT}$ | Power on default of CC1 and CC2 voltage debounce time | DEBOUNCE register = 2'b00 | | 168 | | ms |
| $t_{VBUS\_DB}$ | Debounce of VBUS_DET pin after valid $V_{BUS\_THR}$ | | | 2 | | ms |
| $t_{DRP\_DUTY\_CYCLE}$ | Power-on default of percentage of time DRP advertises DFP during a $T_{DRP}$ | DRP_DUTY_CYCLE register = 2'b00 | | 30% | | |
| $t_{DRP}$ | The period TUSB322I in DFP mode completes a DFP to UFP and back advertisement. | | 50 | 75 | 100 | ms |
| $t_{I2C\_EN}$ | Time from EN_N low and $V_{DD}$ active to I$^2$C access available | | | | 100 | ms |
| $t_{SOFT\_RESET}$ | Soft reset duration | | 26 | 49 | 95 | ms |
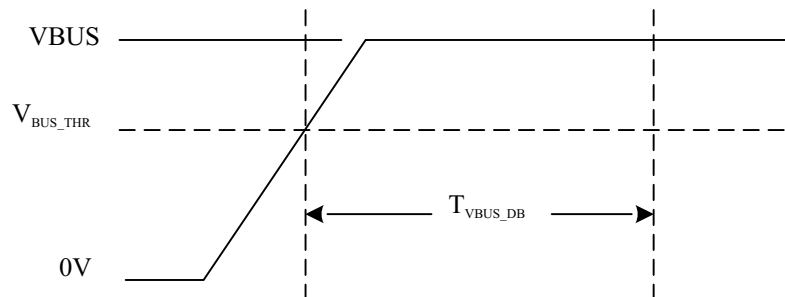


**Figure 1.  VBUS Detect and Debounce**

Product Folder Links: *TUSB322I*

# 7 Detailed Description

## 7.1 Overview

The USB Type-C ecosystem operates around a small form factor connector and cable that is flippable and reversible. Due to the nature of the connector, a scheme is required to determine the connector orientation. Additional schemes are required to determine when a USB port is attached and the acting role of the USB port (DFP, UFP, DRP), as well as to communicate Type-C current capabilities. These schemes are implemented over the CC pins according to the USB Type-C specifications. The TUSB322I device provides Configuration Channel (CC) logic for determining USB port attach and detach, role detection, cable orientation, and Type-C current mode. The TUSB322I device also contains several features such as VCONN sourcing, USB3.1 mux direction control, mode configuration, and low standby current, all of which make the TUSB322I device ideal for source or sinks in USB2.0 or USB3.1 applications.

## 7.2 Functional Block Diagram
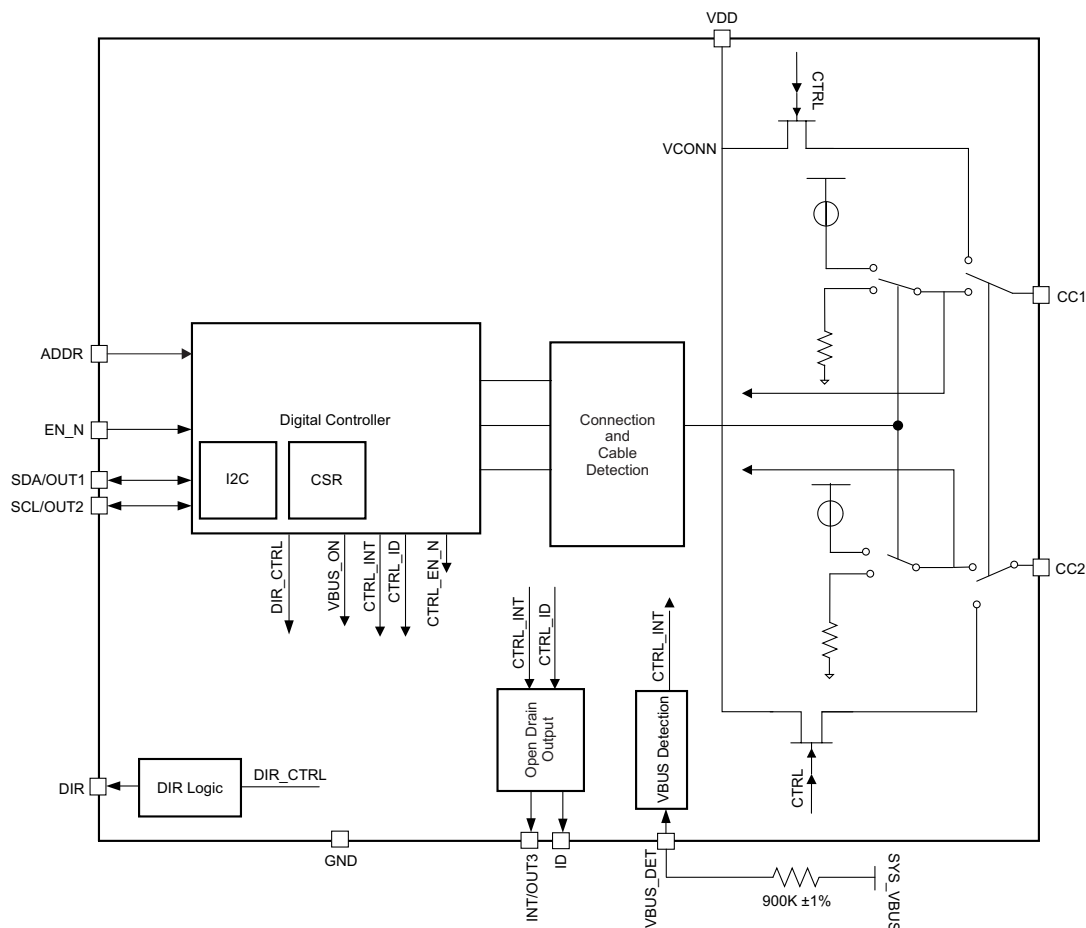


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## 7.3 Feature Description

### 7.3.1 Cables, Adapters, and Direct Connect Devices

*Type-C Specification 1.1* defines several cables, plugs, and receptacles to be used to attach ports. The TUSB322I device supports all cables, receptacles, and plugs. The TUSB322I device does not support any USB feature which requires USB Power Delivery communications over CC lines, such as e-marking or alternate mode.

## Feature Description (continued)

### 7.3.1.1 USB Type-C Receptacles and Plugs

Below is list of Type-C receptacles and plugs supported by the TUSB322I device:
- USB Type-C receptacle for USB2.0 and USB3.1 and full-featured platforms and devices
- USB full-featured Type-C plug
- USB2.0 Type-C plug

### 7.3.1.2 USB Type-C Cables

Below is a list of Type-C cables types supported by the TUSB322I device:
- USB full-featured Type-C cable with USB3.1 full-featured plug
- USB2.0 Type-C cable with USB2.0 plug
- Captive cable with either a USB full-featured plug or USB2.0 plug

### 7.3.1.3 Legacy Cables and Adapters

The TUSB322I device supports legacy cable adapters as defined by the Type-C Specification. The cable adapter must correspond to the mode configuration of the TUSB322I device.



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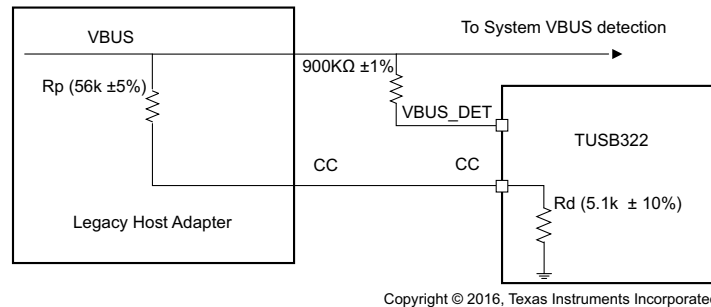
**Figure 2. Legacy Adapter Implementation Circuit**

### 7.3.1.4 Direct Connect Devices

The TUSB322I device supports the attaching and detaching of a direct-connect device.

### 7.3.1.5 Audio Adapters

Additionally, the TUSB322I device supports audio adapters for audio accessory mode, including:
- Passive Audio Adapter
- Charge Through Audio Adapter

### 7.3.2 Port Role Configuration

The TUSB322I default operation is dual-role port (DRP). The TUSB322I will always default to DRP operation anytime EN_N is asserted from high to low or I2C_SOFT_RESET bit is set. But the TUSB322I can be configured as DFP-only or UFP-only through changing the default state of the MODE_SELECT register. DFP-only and UFP-only mode is not available in GPIO mode. Table 1 lists the supported features in each mode:

## Feature Description (continued)

**Table 1. Supported Features for the TUSB322I Device by Mode**

| SUPPORTED FEATURES | DFP-Only | UFP-Only | DFP |
|---|---|---|---|
| Port attach and detach | Yes | Yes | Yes |
| Cable orientation (through I²C) | Yes | Yes | Yes |
| Cable orientation through DIR pin | Yes | Yes | Yes |
| Current advertisement | Yes | — | Yes (DFP) |
| Current detection | — | Yes | Yes (UFP) |
| Accessory modes (audio and debug) | Yes | Yes | Yes |
| Active cable detection | Yes | — | Yes (DFP) |
| Try.SRC | — | — | Yes (DFP) |
| Try.SNK | — | — | Yes (UFP) |
| VCONN | Yes | — | Yes (DFP) |
| I²C / GPIO | Yes | Yes | Yes |
| Legacy cables | Yes | Yes | Yes |
| $V_{BUS}$ detection | — | Yes | Yes (UFP) |

### 7.3.2.1 Downstream Facing Port (DFP) - Source

The TUSB322I device can be configured as a DFP-only device by changing the MODE_SELECT register default setting. In DFP mode, the TUSB322I device constantly presents Rps on both CC. In DFP mode, the TUSB322I device initially advertises default USB Type-C current. The Type-C current can be adjusted through I²C if the system is required to increase the amount advertised. The TUSB322I device adjusts the Rps to match the desired Type-C current advertisement. As a DFP, the TUSB322I monitors the voltage level on CC pins looking for the Rd termination of a UFP. When a UFP is detected and TUSB322I is in the Attached.SRC state, the TUSB322I will supply VCONN on the CC pin that has Ra.

The following list describes the steps for enabling DFP-only.

1. Write a 1'b1 to DISABLE_TERM register (address 0x0A bit 0)

2. Write a 2'b10 to MODE_SELECT register (address 0x0A bits 5:4)

3. Write a 1'b0 to DISABLE_TERM register (address 0x0A bit 0)

When configured as a DFP, the TUSB322I can operate with older USB Type-C 1.0 devices except for a USB Type-C 1.0 DRP device. The TUSB322I cannot operate with a USB Type-C 1.0 DRP device. The limitation is a result of a backwards compatibility problem between USB Type-C 1.1 DFP and a USB Type-C 1.0 DRP.

### 7.3.2.2 Upstream Facing Port (UFP) - Sink

The TUSB322I device can be configured as a UFP-only by changing the MODE_SELECT register default setting. In UFP mode, the TUSB322I device constantly presents pulldown resistors (Rd) on both CC pins. The TUSB322I device monitors the CC pins for the voltage level corresponding to the Type-C mode current advertisement by the connected DFP. The TUSB322I device debounces the CC pins and wait for $V_{BUS}$ detection before successfully attaching. As a UFP, the TUSB322I device detects and communicates the advertised current level of the DFP to the system through the I²C CURRENT_MODE_DETECT register once in the Attached.SNK state.

Steps for enabling UFP-only:

1. Write a 1'b1 to DISABLE_TERM register (address 0x0A bit 0).

2. Write a 2'b01 to MODE_SELECT register (address 0x0A bits 5:4)

3. Write a 1'b0 to DISABLE_TERM register (address 0x0A bit 0).

### 7.3.2.3 Dual Role Port (DRP)

The TUSB322I default operation is a dual-role port controller. As a DRP, the TUSB322I can operate as a UFP (sink) or a DFP (source). In DFP mode, the TUSB322I toggles between presenting as a DFP (Rp on both CC pins) and presenting as a UFP (Rd on both CC pins).

When presenting as a DFP, the TUSB322I monitors the voltage level on the CC pins looking for the Rd termination of a UFP. When a UFP is detected and TUSB322I is in the Attached.SRC state, the TUSB322I will pull the ID pin low to indicate to the system the port is attached to a sink (UFP). Additionally, when a UFP is detected, the TUSB322I will supply VCONN on the unconnected CC pin if Ra is also detected. In DFP mode, the TUSB322I will initially advertise default USB Type-C current. The Type-C Current can be adjusted through I2C if the system wishes to increase the amount advertised. TUSB322I will adjust the Rps to match the desired Type-C Current advertisement. In GPIO mode, the TUSB322I will only advertise default Type C current.

When presenting as a UFP, the TUSB322I monitors the CC pins for the voltage level corresponding to the Type-C mode current advertisement by the connected DFP. The TUSB322I will debounce the CC pins and wait for VBUS detection before successfully attaching. As a UFP, the TUSB322I will detect and communicate the DFP's advertised current level to the system through the OUT1 and OUT2 GPIOs (if in GPIO mode) or through the I2C CURRENT_MODE_DETECT register once in the Attached.SNK state.

The TUSB322I supports two optional Type-C DRP features called Try.SRC and Try.SNK. Products supporting dual-role functionality can have a requirement to be a source (DFP) or a sink (UFP) when connected to another dual-role capable product. For example, a dual-role capable notebook can be used as a source when connected to a tablet, or a cell phone could be a sink when connected to a notebook or tablet. When standard DRP products (products which don't support either Try.SRC or Try.SNK) are connected together, the role (UFP or DFP) outcome is not predetermined. These two optional DRP features provide a means for dual-role capable products to connect to another dual-role capable product in the role desired. Try.SRC and Try.SNK are only available when TUSB322I is configured in I2C mode. When operating in GPIO mode, the TUSB322I will always operate as a standard DRP.

The Try.SRC feature of the TUSB322I device provides a means for a DRP product to connect as a DFP when connected to another DRP product that doesn't implement Try.SRC. When two products which implement Try.SRC are connected together, the role outcome of either UFP or DFP is the same as a standard DRP. Try.SRC is enabled by changing I2C register SOURCE_PREF to 2'b11. Once the register is changed to 2'b11, the TUSB322I will always attempt to connect as a DFP when attached to another DRP capable device.

### 7.3.3 Type-C Current Mode

When a valid cable detection and attach have been completed, the DFP has the option to advertise the level of Type-C current a UFP can sink. The default current advertisement for the TUSB322I device is 500 mA (for USB2.0) or 900 mA (for USB3.1). If a higher level of current is available, the I2C registers can be written to provide medium current at 1.5 A or high current at 3 A. When the CURRENT_MODE_ADVERTISE register has been written to advertise higher than default current, the DFP adjusts the Rps for the specified current level. If a DFP advertises 3 A, it ensures that the $V_{DD}$ of the TUSB322I device is 3.5 V or greater. Table 2 lists the Type-C current advertisements in GPIO an I2C modes.

**Table 2. Type-C Current Advertisement for GPIO and I²C Modes**

| TYPE-C CURRENT | | GPIO MODE (ADDR PIN IN NC) | | I²C MODE (ADDR PIN H, L) | |
| --- | --- | --- | --- | --- | --- |
| | | UFP IN DRP MODE | DFP IN DRP MODE | UFP | DFP |
| Default | 500 mA (USB2.0) 900 mA (USB3.1) | Current mode detected and output through OUT1 / OUT2 | Only advertisement | Current mode detected and read through I²C register | I²C register default is 500 or 900 mA |
| Medium - 1.5 A | | | N/A | | Advertisement selected through writing I²C register |
| High - 3 A | | | | | |

### 7.3.4 Accessory Support

The TUSB322I device supports audio and debug accessories in UFP, DFP mode and DRP mode. Audio and debug accessory support is provided through reading of I²C registers. Audio accessory is also supported through GPIO mode with INT_N/OUT3 pin (audio accessory is detected when INT_N/OUT3 pin is low).

### 7.3.4.1 Audio Accessory

Audio accessory mode is supported through two types of adapters. First, the passive audio adapter can be used to convert the Type-C connector into an audio port. To effectively detect the passive audio adapter, the TUSB322I device must detect a resistance that is less than Ra on both of the CC pins.

Secondly, a charge through audio adapter can be used. The primary difference between a passive and charge through adapter is that the charge through adapter supplies 500 mA of current over VBUS. The charge through adapter contains a receptacle and a plug. The plug acts as a DFP and supplies $V_{BUS}$ when the plug detects a connection.

When the TUSB322I device is configured in GPIO mode, OUT3 pin determines if an audio accessory is connected. When an audio accessory is detected, the OUT3 pin is pulled low.

### 7.3.4.2 Debug Accessory

Debug is an additional state supported by USB Type-C. The specification does not define a specific user scenario for this state, but the end user could use debug accessory mode to enter a test state for production specific to the application. Charge through debug accessory is not supported by TUSB322I when in DRP or UFP mode. The TUSB322I when configured as a DFP-only or as a DRP acting as a DFP will detect a debug accessory which presents Rd on both CC1 and CC2 pins. The TUSB322I will set ACCESSORY_CONNECTED register to 3'b110 to indicate a UFP debug accessory. The TUSB322I when configured as a UFP-only or as a DRP acting as a UFP will detect a debug accessory which presents Rp on both CC1 and CC2 pins. The TUSB322I will set ACCESSORY_CONNECTED register to 3b'111 to indicate a DFP debug accessory.

### 7.3.5 I²C and GPIO Control

The TUSB322I device can be configured for I²C communication or GPIO outputs using the ADDR pin. The ADDR pin is a tri-level control pin. When the ADDR pin is left floating (NC), the TUSB322I device is in GPIO output mode. When the ADDR pin is pulled high or pulled low, the TUSB322I device is in I²C mode.

All outputs for the TUSB322I device are open drain configuration.

The OUT1 and OUT2 pins are used to output the Type-C current mode when in GPIO mode. Additionally, the OUT3 pin is used to communicate the audio accessory mode in GPIO mode. Table 3 lists the output pin settings. See for more information on the pins and their uses.

**Table 3. Simplified Operation for OUT1 and OUT2**

| OUT1 | OUT2 | DESCRIPTION |
|---|---|---|
| H | H | Default current in unattached state |
| H | L | Default current in attached state |
| L | H | Medium current (1.5 A) in attached state |
| L | L | High current (3.0 A) in attached state |

When operating in I²C mode, the TUSB322I device uses the SCL and SDA lines for clock and data and the INT_N pin to communicate a change in I²C registers, or an interrupt, to the system. The INT_N pin is pulled low when the TUSB322I device updates the registers with new information. The INT_N pin is open drain. The INTERRUPT_STATUS register will be set when the INT_N pin is pulled low. To clear the INTERRUPT_STATUS register, the end user writes to I²C.

When operating in GPIO mode, the OUT3 pin is used in place of the INT_N pin to determine if an audio accessory is detected and attached. The OUT3 pin is pulled low when an audio accessory is detected.

**NOTE**

When using the 3.3-V supply for I²C, the end user must ensure that the $V_{DD}$ is 3 V and above. Otherwise the I²C can back power the device.

### 7.3.6 V_BUS Detection

The TUSB322I device supports $V_{BUS}$ detection according to the Type-C Specification. $V_{BUS}$ detection is used to determine the attachment and detachment of a UFP and to determine the entering and exiting of accessary modes. $V_{BUS}$ detection is also used to successfully resolve the role in DRP mode.

The system $V_{BUS}$ voltage must be routed through a 900-kΩ resistor to the VBUS_DET pin on the TUSB322I device.

### 7.3.7 Cable Orientation and External MUX Control

The TUSB322I device has the ability to control an external/discrete MUX using the DIR pin. The TUSB322I detects the cable orientation by monitoring the voltage on the CC pins. When a voltage level within the proper threshold is detected on CC1, the DIR pin is pulled low. When a voltage level within the proper threshold is detected on CC2, the DIR is pulled high. The DIR pin is an open drain output. The I$^2$C communicates the cable orientation status for the TUSB322I device.

### 7.3.8 VCONN Support for Active Cables

The TUSB322I device supplies VCONN to active cables when configured in DFP mode or in DRP acting as a DFP mode. VCONN is provided only when the unconnected CC pin is terminated to a resistance, Ra, and after a UFP is detected and the Attached.SRC state is entered. When in DFP mode or in DRP acting as a DFP mode, a 5-V source must be connected to the VDD pin of the TUSB322I device after Attached.SRC. VCONN is supplied from VDD through a low resistance power FET out to the unconnected CC pin. VCONN is removed when a detach event is detected and the active cable is removed.

## 7.4 Device Functional Modes

The TUSB322I device has four functional modes. Table 4 lists these modes:

**Table 4. USB Type-C States According to TUSB322I Functional Modes**

| MODES | GENERAL BEHAVIOR | MODE | STATES[1] |
|---|---|---|---|
| Unattached | USB port unattached. ID, PORT operational. I$^2$C on. | UFP-Only | Unattached.SNK |
| | | | AttachWait.SNK |
| | | DRP | Toggle Unattached.SNK → Unattached.SRC |
| | | | AttachedWait.SRC or AttachedWait.SNK |
| | | DFP-Only | Unattached.SRC |
| | | | AttachWait.SRC |
| Active | USB port attached. All GPIOs operational. I$^2$C on. | UFP-Only | Attached.SNK |
| | | | Audio Accessory |
| | | | Debug Accessory |
| | | DRP | Attached.SNK |
| | | | Attached.SRC |
| | | | Audio accessory |
| | | | Debug accessory |
| | | DFP-Only | Attached.SRC |
| | | | Audio accessory |
| | | | Debug accessory |
| Dead battery | No operation. $V_{DD}$ not available. | DRP | Default device state to UFP/SNK with Rd. |
| Shutdown | No operation. $V_{DD}$ available and EN_N pin high | DRP | Default device state to UFP/SNK with Rd. |

(1)  Required; not in sequential order.

### 7.4.1 Unattached Mode

Unattached mode is the primary mode of operation for the TUSB322I device, because a USB port can be unattached for a lengthy period of time. In unattached mode, $V_{DD}$ is available, and all IOs and I$^2$C are operational. After the TUSB322I device is powered up, the part enters unattached mode until a successful attach has been determined. Initially, right after power up, the TUSB322I device comes up as an Unattached.SNK. The TUSB322I device toggles between the UFP and the DFP if configured as a DRP.

### 7.4.2 Active Mode

Active mode is defined as the port being attached. In active mode, all GPIOs are operational, and $I^2C$ is read / write (R/W). When in active mode, the TUSB322I device communicates to the AP that the USB port is attached. This communication happens through the ID pin if TUSB322I is configured as a DFP or DRP connect as source. If TUSB322I is configured as a UFP or a DRP connected as a sink, the OUT1/OUT2 and INT_N/OUT3 pins are used. The TUSB322I device exits active mode under the following conditions:

- Cable unplug
- $V_{BUS}$ removal if attached as a UFP
- Dead battery; system battery or supply is removed
- EN_N is floated or pulled high.

### 7.4.3 Shutdown Mode

Shutdown mode for TUSB322I is defined as follows:

- Supply voltage available and EN_N pin is high or floating.
- EN_N pin has internal pullup resistor
- The TUSB322I device is off, but still maintains the Rd on the CC pins.

### 7.4.4 Dead Battery Mode

During dead battery mode, $V_{DD}$ is not available. CC pins always default to pulldown resistors in dead battery mode. Dead battery mode means:

- TUSB322I in UFP with 5.1 k$\Omega$ ± 20% Rd; cable connected and providing charge
- TUSB322I in UFP with 5.1 k$\Omega$ ± 20% Rd; nothing connected (application could be off or have a discharged battery)

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**NOTE**

When $V_{DD}$ is off, the TUSB322I non-failsafe pins (DIR, VBUS_DET, ADDR, OUT[3:1] pins) could back-drive the TUSB322I device if not handled properly. When necessary to pull these pins up, TI recommends pulling up DIR, ADDR, and INT_N/OUT3 to the device's $V_{DD}$ supply. The VBUS_DET must be pulled up to $V_{BUS}$ through a 900-k$\Omega$ resistor.

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## 7.5 Programming

For further programmability, the TUSB322I device can be controlled using I$^2$C. The TUSB322I device local I$^2$C interface is available for reading/writing after T$_{I2C\_EN}$ when the device is powered up. The SCL and SDA terminals are used for I$^2$C clock and I$^2$C data respectively. If I$^2$C is the preferred method of control, the ADDR pin must be set accordingly.

**Table 5. TUSB322I I$^2$C Addresses**

| TUSB322I I$^2$C Target Address | | | | | | | |
|---|---|---|---|---|---|---|---|
| ADDR pin | Bit 7 (MSB) | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 (W/R) |
| H | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0/1 |
| L | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0/1 |

The following procedure should be followed to write to TUSB322I I$^2$C registers:

1. The master initiates a write operation by generating a start condition (S), followed by the TUSB322I 7-bit address and a zero-value R/W bit to indicate a write cycle
2. The TUSB322I device acknowledges the address cycle
3. The master presents the sub-address (I$^2$C register within the TUSB322I device) to be written, consisting of one byte of data, MSB-first
4. The TUSB322I device acknowledges the sub-address cycle
5. The master presents the first byte of data to be written to the I$^2$C register
6. The TUSB322I device acknowledges the byte transfer
7. The master can continue presenting additional bytes of data to be written, with each byte transfer completing with an acknowledge from the TUSB322I device
8. The master terminates the write operation by generating a stop condition (P)

The following procedure should be followed to read the TUSB322I I$^2$C registers:

1. The master initiates a read operation by generating a start condition (S), followed by the TUSB322I 7-bit address and a one-value R/W bit to indicate a read cycle
2. The TUSB322I device acknowledges the address cycle
3. The TUSB322I device transmits the contents of the memory registers MSB-first starting at register 00h or last read sub-address+1. If a write to the T I$^2$C register occurred prior to the read, then the TUSB322I device starts at the sub-address specified in the write.
4. The TUSB322I device waits for either an acknowledge (ACK) or a not-acknowledge (NACK) from the master after each byte transfer; the I$^2$C master acknowledges reception of each data byte transfer
5. If an ACK is received, the TUSB322I device transmits the next byte of data
6. The master terminates the read operation by generating a stop condition (P)

The following procedure should be followed for setting a starting sub-address for I$^2$C reads:

1. The master initiates a write operation by generating a start condition (S), followed by the TUSB322I 7-bit address and a zero-value R/W bit to indicate a read cycle
2. The TUSB322I device acknowledges the address cycle
3. The master presents the sub-address (I$^2$C register within the TUSB322I device) to be read, consisting of one byte of data, MSB-first
4. The TUSB322I device acknowledges the sub-address cycle
5. The master terminates the read operation by generating a stop condition (P)

**NOTE**

If no sub-addressing is included for the read procedure, then the reads start at register offset 00h and continue byte-by-byte through the registers until the I$^2$C master terminates the read operation. If a I$^2$C address write occurred prior to the read, then the reads start at the sub-address specified by the address write.

## 7.6 Register Maps

### 7.6.1 CSR Registers

**Table 6. CSR Registers**

| Offset | Reset | Register Name | Section |
|---|---|---|---|
| 0x07 through 0x00 | [0x00, 0x54, 0x55, 0x53, 0x42, 0x33, 0x32, 0x32] | Device Identification | *Device Identification Register* |
| 0x08 | 0x00 | Connection Status | *Connection Status Register* |
| 0x09 | 0x20 | Connection Status and Control | *Connection Status and Control Register* |
| 0x0A | 0x00 | General Control | *General Control Register* |
| 0xA0 | 0x02 | Device Revision | *Device Revision Register* |

#### 7.6.1.1 Device Identification Register (offset = 0x07 through 0x00) [reset = 0x00, 0x54, 0x55, 0x53, 0x42, 0x33, 0x32, 0x32]

**Figure 3. Device Identification Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| | | | DEVICE_ID | | | | |
| | | | R-0 | | | | |

LEGEND: R = Read only; *-n* = value after reset

**Table 7. Device Identification Register Field Descriptions**

| Bit | Field | Type | Reset | Description |
|---|---|---|---|---|
| 7-0 | DEVICE_ID | R | | For the TUSB322I device these fields return a string of ASCII characters returning TUSB322I<br>Addresses 0x07 - 0x00 = {0x00, 0x54, 0x55, 0x53, 0x42, 0x33, 0x32, 0x32} |

#### 7.6.1.2 Connection Status Register (offset = 0x08) [reset = 0x00]

**Figure 4. Connection Status Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CURRENT_MODE_ADVERTISE | | CURRENT_MODE_DETECT | | ACCESSORY_CONNECTED | | | ACTIVE_CABLE_DETECTION |
| RW | | RU | | RU | | | RU |

LEGEND: R/W = Read/Write; R/U = Read/Update

**Table 8. Connection Status Register Field Descriptions**

| Bit | Field | Type | Reset | Description |
|---|---|---|---|---|
| 7-6 | CURRENT_MODE_ADVERTISE | R | 2'b00 | These bits are programmed by the application to raise the current advertisement from default.<br><br>00 – Default (500 mA / 900 mA) initial value at startup<br><br>01 – Mid (1.5 A)<br><br>10 – High (3 A)<br><br>11 – Reserved |
| 5-4 | CURRENT_MODE_DETECT | RU | 2'b00 | These bits are set when a UFP determines the Type-C Current mode.<br><br>00 – Default (value at start up)<br><br>01 – Medium<br><br>10 – Charge through accessory – 500 mA<br><br>11 – High |

Product Folder Links: *TUSB322I*

**Table 8. Connection Status Register Field Descriptions (continued)**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 3-1 | ACCESSORY_CONNECTED | RU | 2'b00 | These bits are read by the application to determine if an accessory was attached.<br><br>000 – No accessory attached (default)<br>001 – Reserved<br>010 – Reserved<br>011 – Reserved<br>100 – Audio accessory<br>101 – Audio charged thru accessory<br>110 – Debug accessory when TUSB322I is connected as a DFP.<br>111 – Debug accessory when TUSB322I is connected as a UFP. |
| 0 | ACTIVE_CABLE_DETECTION | RU | 1'b0 | This flag indicates that an active cable has been plugged into the Type-C connector. When this field is set, an active cable is detected. |

### 7.6.1.3   Connection Status and Control Register (offset = 0x09) [reset = 0x20]

**Figure 5.   Connection Status and Control Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| ATTACHED_STATE | | CABLE_DIR | INTERRUPT_STATUS | VCONN_FAULT | DRP_DUTY_CYCLE | | DISABLE_UFP_ACCESSORY |
| RU | | RU | RCU | RCU | RW | | RW |

LEGEND: R/W = Read/Write; R/U = Read/Update; R/C/U = Read/Clear/Update

**Table 9. Connection Status and Control Register Field Descriptions**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 7-6 | ATTACHED_STATE | RU | 2'b00 | This is an additional method to communicate attach other than the ID pin. These bits can be read by the application to determine what was attached.<br><br>00 – Not attached (default)<br>01 – Attached.SRC (DFP)<br>10 – Attached.SNK (UFP)<br>11 – Attached to an accessory |
| 5 | CABLE_DIR | RU | 1'b1 | Cable orientation. The application can read these bits for cable orientation information.<br><br>0 – CC1<br>1 – CC2 (default) |
| 4 | INTERRUPT_STATUS | RCU | 1'b0 | The INT pin is pulled low whenever a CSR changes. When a CSR change has occurred this bit should be held at 1 until the application clears it.<br><br>0 – Clear<br>1 – Interrupt (When INT_N is pulled low, this bit will be 1. This bit is 1 whenever any CSR are changed) |
| 3 | VCONN_FAULT | RCU | 1'b0 | VCONN_FAULT Bit is set whenever a VCONN over-current limit is triggered.<br><br>0 - No fault. (default)<br>1 - Interrupt (INT_N is asserted low) |

**Table 9. Connection Status and Control Register Field Descriptions (continued)**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 2-1 | DRP_DUTY_CYCLE | RW | 2'b00 | Percentage of time that a DRP advertises DFP during tDRP<br>00 – 30% (default)<br>01 – 40%<br>10 – 50%<br>11 – 60% |
| 0 | DISABLE_UFP_ACCESSORY | RW | 1'b0 | Setting this field will disable UFP accessory support.<br>0 – UFP accessory support enabled (Default)<br>1 – UFP accessory support disabled |

### 7.6.1.4 General Control Register (offset = 0x0A) [reset = 0x00]

**Figure 6. General Control Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| DEBOUNCE | | MODE_SELECT | | I$^2$C_SOFT_RESET | SOURCE_PREF | | DISABLE_TERM |
| RW | | RW | | RSU | RW | | RW |

LEGEND: R/W = Read/Write; R/S/U = Read/Set/Update

**Table 10. General Control Register Field Descriptions**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 7-6 | DEBOUNCE | RW | 2'b00 | The nominal amount of time the TUSB322I device debounces the voltages on the CC pins.<br>00 – 168ms (default)<br>01 – 118ms<br>10 – 134ms<br>11 – 152ms |
| 5-4 | MODE_SELECT | RW | 2'b00 | This register can be written to set the TUSB322I device mode operation. The ADDR pin must be set to I$^2$C mode.<br>00 – DRP mode (start from unattached.SNK) (default)<br>01 – UFP mode (unattached.SNK)<br>10 – DFP mode(unattached.SRC)<br>11 – DRP mode(start from unattached.SNK) |
| 3 | I$^2$C_SOFT_RESET | RSU | 1'b0 | This register resets the digital logic. The bit is self-clearing. A write of 1 starts the reset. The following registers can be affected after setting this bit:<br>CURRENT_MODE_DETECT<br>ACTIVE_CABLE_DETECTION<br>ACCESSORY_CONNECTED<br>ATTACHED_STATE<br>CABLE_DIR |
| 2-1 | SOURCE_PREF | RW | 2'b00 | This field controls the TUSB322I behavior when configured as a DRP.<br>00 – Standard DRP (default)<br>01 – DRP will perform Try.SNK<br>10 – Reserved<br>11 – DRP will perform Try.SRC |

**Table 10. General Control Register Field Descriptions (continued)**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 0 | DISABLE_TERM | RW | 1'b0 | This field will disable the termination on CC pins and transition the CC state machine to the disabled state.<br><br>0 – Termination enabled according TUSB322I mode of operation (default)<br><br>1 – Termination disabled and state machine held in disable state. |

### 7.6.1.5  Device Revision Register (offset = 0xA0) [reset = 0x02]

**Figure 7.  Device Revision Register**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| | | | REVISION | | | | |
| | | | R | | | | |

LEGEND: R = Read only

**Table 11. Device Revision Register Field Descriptions**

| Bit | Field | Type | Reset | Description |
|-----|-------|------|-------|-------------|
| 7-0 | REVISION | R | 'h02 | Revision of TUSB322I. Defaults to 0x02. |

# 8 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.

## 8.1 Application Information

The TUSB322I device is a Type-C configuration channel logic and port controller. The TUSB322I device can detect when a Type-C device is attached, what type of device is attached, the orientation of the cable, and power capabilities (both detection and broadcast). The TUSB322I device can be used in a source application (DFP) or in a sink application (UFP).

## 8.2 Typical Application

Product Folder Links: *TUSB322I*

## Typical Application (continued)

### 8.2.1  DRP in I²C Mode

Figure 8 shows the TUSB322I device configured as a DRP in I²C mode.
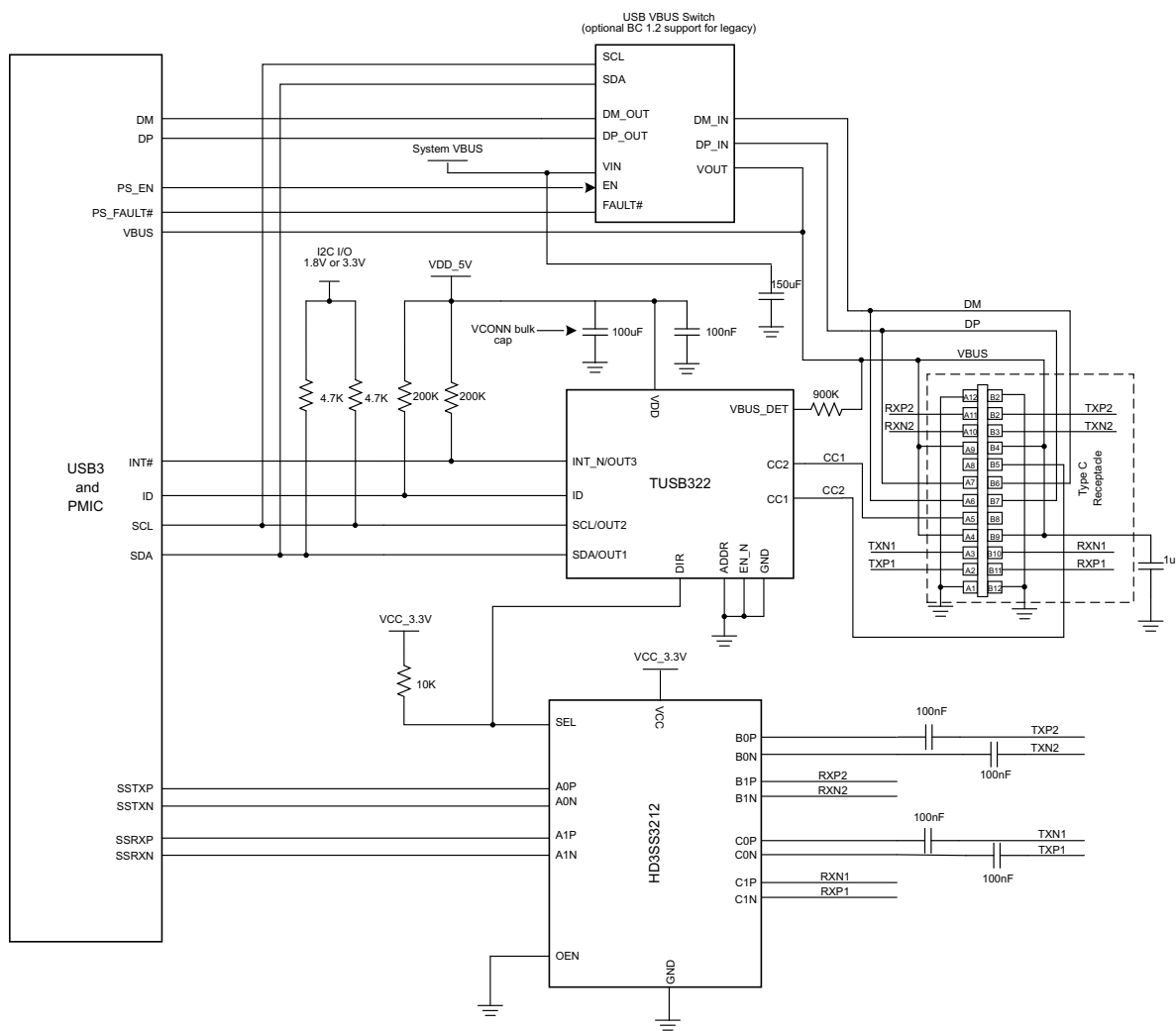


**Figure 8.  DRP in I²C Mode Schematic**

#### 8.2.1.1  Design Requirements

For the design example, use the parameters listed in Table 12.

**Table 12. Design Requirements for DRP in I²C Mode**

| DESIGN PARAMETER | VALUE |
|---|---|
| $V_{DD}$ (4.5 to 5.5 V) | 5 V |
| Mode (I²C or GPIO) | I²C<br>ADDR pin must be pulled down or pulled up |
| I²C address (0x67 or 0x47) | 0x47<br>ADDR pin must be pulled low or tied to GND |
| Type-C port type (UFP, DFP, or DRP) | DRP<br>MODE_SELECT register = 2'b00. |
| VCONN Support | Yes |

### 8.2.1.2  Detailed Design Procedure

The TUSB322I device supports a $V_{DD}$ in the range of 4.5 V to 5.5 V. In this particular use case, 5 V is connected to the $V_{DD}$ pin. Because VCONN support is required for a DRP, the 5 V on $V_{DD}$ meets the USB Type-C VCONN requirement of 4.75 V to 5.5 V. A 100-nF capacitor is placed near $V_{DD}$. Also, a 100-µF capacitor is used to meet the USB Type-C bulk capacitance requirement of 10 µF to 220 µF.

The TUSB322I device is placed into I²C mode by either pulling the ADDR pin high or low. In this case, the ADDR pin is tied to GND which results in a I²C address of 0x47. The SDA and SCL must be pulled up to either 1.8 V or 3.3 V. When pulled up to 3.3 V, the $V_{DD}$ supply must be at least 3 V to keep from back-driving the I²C interface.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB322I I²C registers occurs. This pin is an open drain output and requires an external pullup resistor. The pin should be pulled up to $V_{DD}$ using a 200-kΩ resistor.

The ID pin is used to indicate when a connection has occurred if the TUSB322I device is a DFP while configured for DRP. An OTG USB controller can use this pin to determine when to operate as a USB Host or USB Device. When this pin is driven low, the OTG USB controller functions as a host and then enables $V_{BUS}$. The Type-C standard requires that a DFP not enable $V_{BUS}$ until the $V_{BUS}$ is in the Attached.SRC state. If the ID pin is not low but $V_{BUS}$ is detected, then the OTG USB controller functions as a device. The ID pin is open drain output and requires an external pullup resistor. The ID pin should be pulled up to $V_{DD}$ using a 200-kΩ resistor.

The DIR pin is used to control the mux for connecting the USB3 SS signals to the appropriate pins on the USB Type-C receptacle. In this particular case, a HD3SS3212 is used as the mux. To minimize crossing in routing the USB3 SS signals to the USB Type C connector, the connection of CC1 and CC2 to the TUSB322I is swapped. When swapping the CC1 and CC2 connection, the CABLE_DIR register will also be reversed (0 = CC2 and 1 = CC1).

The VBUS_DET pin must be connected through a 900-kΩ resistor to $V_{BUS}$ on the Type-C that is connected. This large resistor is required to protect the TUSB322I device from large $V_{BUS}$ voltage that is possible in present day systems. This resistor along with internal pulldown keeps the voltage observed by the TUSB322I device in the recommended range.

The USB2 specification requires the bulk capacitance on $V_{BUS}$ based on UFP or DFP. When operating the TUSB322I device in a DRP mode, it alternates between UFP and DFP. If the TUSB322I device connects as a UFP, the large bulk capacitance must be removed.

**Table 13. USB2 Bulk Capacitance Requirements**

| PORT CONFIGURATION | MIN | MAX | UNIT |
|---|---|---|---|
| Downstream facing port (DFP) | 120 | | µF |
| Upstream facing port (UFP) | 1 | 10 | µF |

### 8.2.1.3  Application Curves
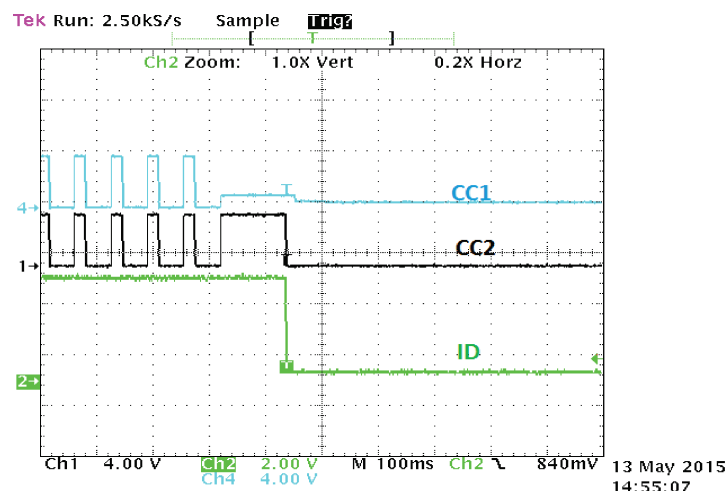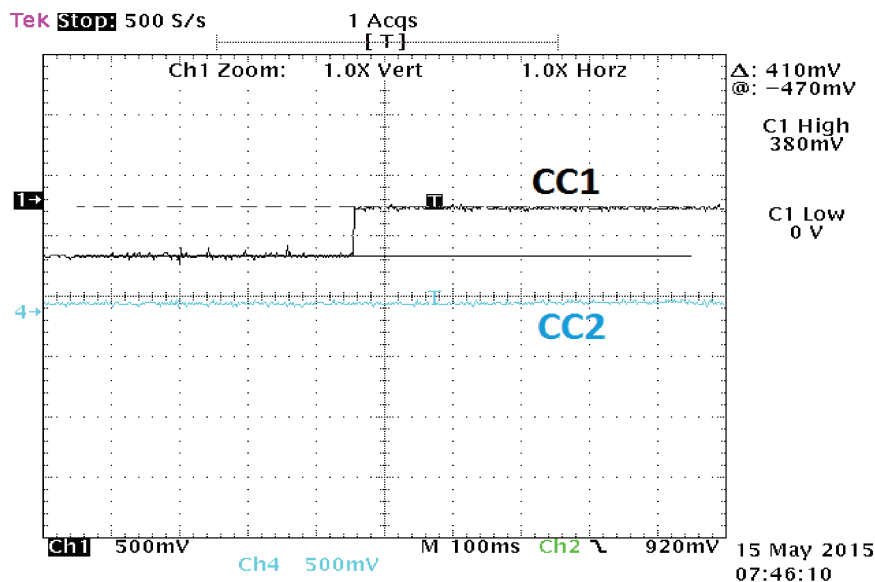


**Figure 9.  Application Curve for DRP in I²C Mode**

## 8.2.2 DFP in I²C Mode

Figure 10 shows the TUSB322I device configured as a DFP in I²C mode.



**Figure 10. DFP in I²C Mode Schematic**

### 8.2.2.1 Design Requirements

For the design example, use the parameters listed in Table 14:

**Table 14. Design Requirements for DFP in I²C Mode**

| DESIGN PARAMETER | VALUE |
|---|---|
| $V_{DD}$ (4.5 V to 5.5 V) | 5 V |
| Mode (I²C or GPIO) | I²C<br>ADDR pin must be pulled down or pulled up |
| I²C address (0x61 or 0x60) | 0x47<br>ADDR pin must be pulled low or tied to GND |
| Type-C port type (UFP, DFP, or DRP) | DFP<br>MODE_SELECT = 2'b10 |
| VCONN Support | Yes |

### 8.2.2.2 Detailed Design Procedure

The TUSB322I device supports a $V_{DD}$ in the range of 4.5 V to 5.5 V. In this particular case, $V_{DD}$ is set to 5 V. A 100-nF capacitor is placed near $V_{DD}$. Also, a 100-µF capacitor is used to meet the USB Type-C bulk capacitance requirement of 10 µF to 220 µF.

The TUSB322I device is placed into I²C mode by either pulling the ADDR pin high or low. In this particular case, the ADDR pin is tied to GND which results in a I²C address of 0x47. The SDA and SCL must be pulled up to either 1.8 V or 3.3 V. When pulled up to 3.3 V, the $V_{DD}$ supply must be at least 3 V to keep from back-driving the I²C interface.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB322I I²C registers occurs. This pin is an open drain output and requires an external pullup resistor. The pin should be pulled up to $V_{DD}$ using a 200-kΩ resistor.

The DIR pin is used to control the mux for connecting the USB3 SS signals to the appropriate pins on the USB Type-C receptacle. In this particular case, a HD3SS3212 is used as the mux. To minimize crossing in routing the USB3 SS signals to the USB Type C connector, the connection of CC1 and CC2 to the TUSB322I is swapped. When swapping the CC1 and CC2 connection, the CABLE_DIR register will also be reversed (0 = CC2 and 1 = CC1).

The Type-C port mode is determined by the state of the MODE_SELECT register. When the MODE_SELECT register is 2'b10, the TUSB322I device is in DFP mode. The TUSB322I will exit the DFP mode if the MODE_SELECT register is changed, I2C_SOFT_RESET is set, or EN_N pin is transitioned from high to low.

The VBUS_DET pin must be connected through a 900-kΩ resistor to $V_{BUS}$ on the Type-C that is connected. This large resistor is required to protect the TUSB322I device from large $V_{BUS}$ voltage that is possible in present day systems. This resistor along with internal pulldown keeps the voltage observed by the TUSB322I device in the recommended range.

The USB2 specification requires the bulk capacitance on $V_{BUS}$ based on UFP or DFP. When operating the TUSB322I device in a DFP mode, a bulk capacitance of at least 120 µF is required. In this particular case, a 150-µF capacitor was chosen.

### 8.2.2.3 Application Curves
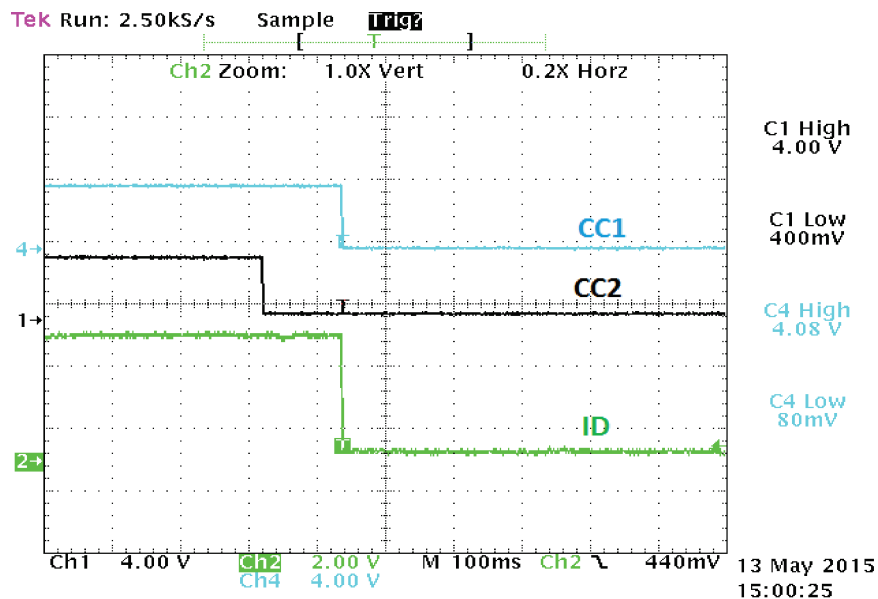


**Figure 11. Application Curve for DFP in I²C Mode**

## 8.2.3 UFP in I²C Mode

Figure 12 shows the TUSB322I device configured as a UFP in I²C mode.
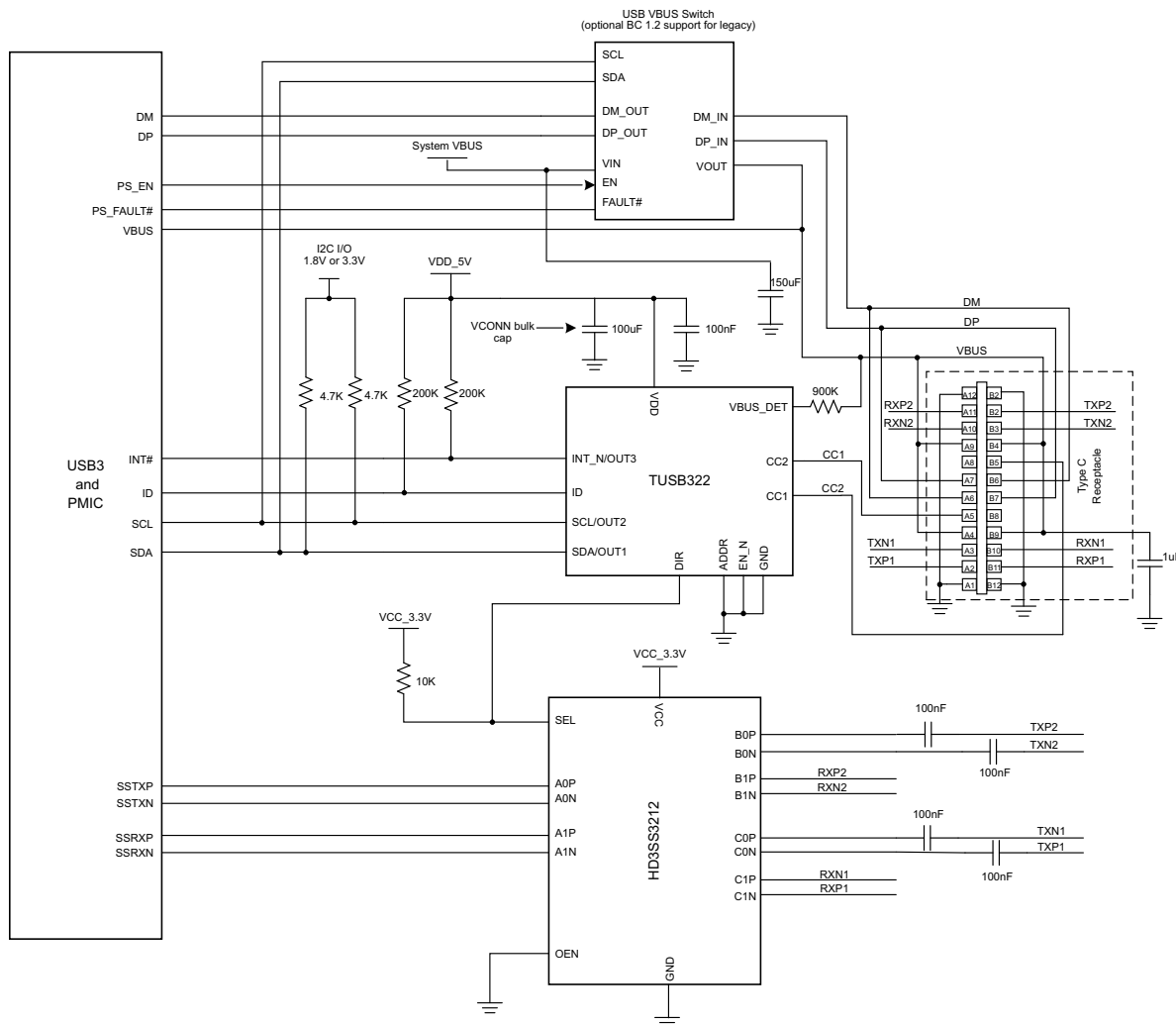


**Figure 12. UFP in I²C Mode Schematic**

### 8.2.3.1 Design Requirements

For the design example, use the parameters listed in Table 15:

**Table 15. Design Requirements for UFP in I²C Mode**

| DESIGN PARAMETER | VALUE |
|---|---|
| V_DD (4.5 V to 5.5 V) | 5 V |
| Mode (I²C or GPIO) | I²C<br>ADDR pin must be pulled down or pulled up |
| I²C address (0x61 or 0x60) | 0x47<br>ADDR pin must be pulled low or tied to GND |
| Type-C port type (UFP, DFP, or DRP) | UFP<br>MODE_SELECT = 2'b01 |
| VCONN Support | No |

### 8.2.3.2 Detailed Design Procedure

The TUSB322I device supports a $V_{DD}$ in the range of 4.5 V to 5.5 V. In this particular case, $V_{DD}$ is set to 5 V. A 100-nF capacitor is placed near $V_{DD}$.

The TUSB322I device is placed into I²C mode by either pulling the ADDR pin high or low. In this case, the ADDR pin is tied to GND which results in a I²C address of 0x47. The SDA and SCL must be pulled up to either 1.8 V or 3.3 V. When pulled up to 3.3 V, the $V_{DD}$ supply must be at least 3 V to keep from back-driving the I²C interface.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB322I I²C registers occurs. This pin is an open drain output and requires an external pullup resistor. The pin should be pulled up to $V_{DD}$ using a 200-kΩ resistor.

The DIR pin is used to control the mux for connecting the USB3 SS signals to the appropriate pins on the USB Type-C receptacle. In this particular case, a HD3SS3212 is used as the mux. To minimize crossing in routing the USB3 SS signals to the USB Type C connector, the connection of CC1 and CC2 to the TUSB322I is swapped. When swapping the CC1 and CC2 connection, the CABLE_DIR register will also be reversed (0 = CC2 and 1 = CC1).

The Type-C port mode is determined by the state of the MODE_SELECT register. When the MODE_SELECT register is 2'b01, the TUSB322I device is in UFP mode. The TUSB322I will exit the UFP mode if the MODE_SELECT register is changed, I2C_SOFT_RESET is set, or EN_N pin is transitioned from high to low.

The VBUS_DET pin must be connected through a 900-kΩ resistor to $V_{BUS}$ on the Type-C that is connected. This large resistor is required to protect the TUSB322I device from large $V_{BUS}$ voltage that is possible in present day systems. This resistor along with internal pulldown keeps the voltage observed by the TUSB322I device in the recommended range.

The USB2 specification requires the bulk capacitance on $V_{BUS}$ based on UFP or DFP. When operating the TUSB322I device in a UFP mode, a bulk capacitance between 1 µF to 10 µF is required. In this particular case, a 1-µF capacitor was chosen.

### 8.2.3.3 Application Curves



**Figure 13. Application Curve for UFP in I²C Mode**

## 8.3  Initialization Set Up

The general power-up sequence for the TUSB322I device (EN_N tied to GND) is as follows:

1. System is powered off (device has no $V_{DD}$). The TUSB322I device is configured internally in UFP mode with Rds on CC pins (dead battery).
2. $V_{DD}$ ramps – POR circuit.
3. $I^2C$ supply ramps up.
4. The TUSB322I device enters unattached.SNK and functions as a DRP. If DRP is not the desired mode of operation, then software must change MODE_SELECT register to desired mode (UFP or DFP).
5. The TUSB322I device monitors the CC pins as a DFP and $V_{BUS}$ for attach as a UFP.
6. The TUSB322I device enters active mode when attach has been successfully detected.

# 9  Power Supply Recommendations

The TUSB322I device has a wide power supply range from 4.5 to 5.5 V. The TUSB322I device can be run off of a system power such as a battery.

# 10  Layout

## 10.1  Layout Guidelines

1. An extra trace (or stub) is created when connecting between more than two points. A trace connecting pin A6 to pin B6 will create a stub because the trace also has to go to the USB Host. Ensure that:
   – A stub created by short on pin A6 (DP) and pin B6 (DP) at Type-C receptacle does not exceed 3.5 mm.
   – A stub created by short on pin A7 (DM) and pin B7 (DM) at Type-C receptacle does not exceed 3.5 mm.
2. A 100-nF capacitor should be placed as close as possible to the TUSB322I $V_{DD}$ pin.

## 10.2  Layout Example
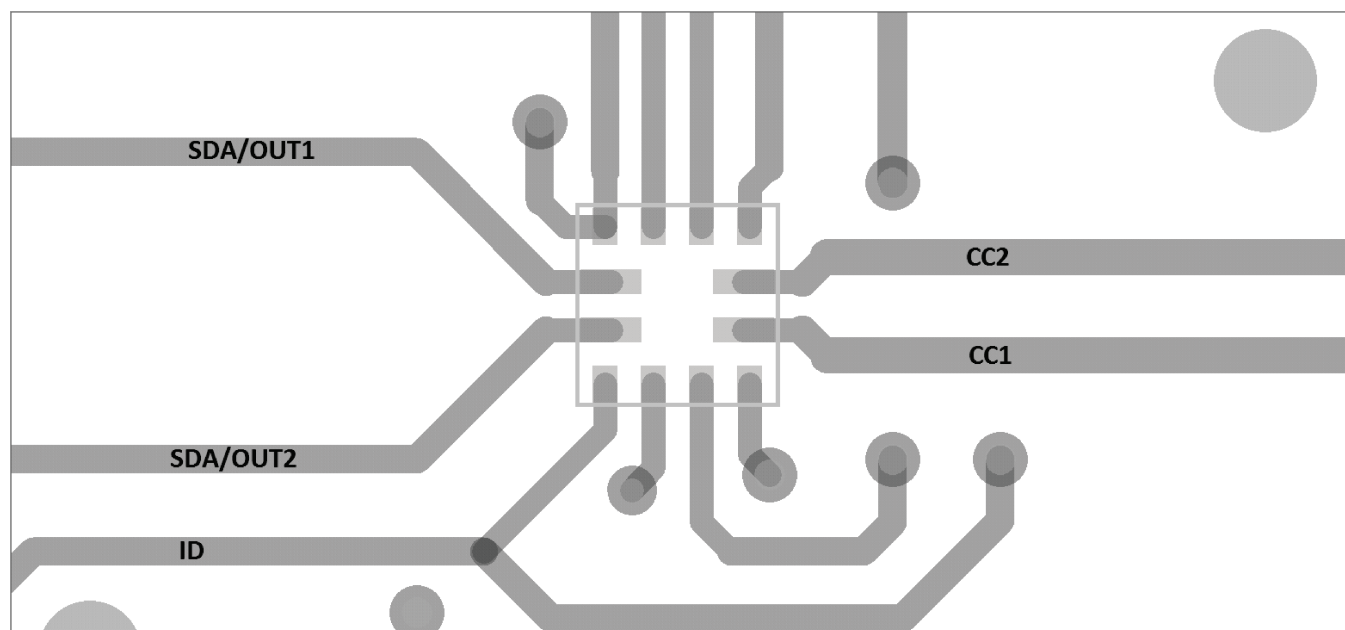


**Figure 14.  TUSB322I Layout**

# 11 Device and Documentation Support

## 11.1 Documentation Support

### 11.1.1 Related Documentation

For related documentation see the following:
* *Semiconductor and C Package Thermal Metrics* application report, SPRA953

## 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 11.3 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.

## 11.4 Trademarks

E2E is a trademark of Texas Instruments.
USB Type-C is a trademark of USB Implementers Forum.
All other trademarks are the property of their respective owners.

## 11.5 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.

## 11.6 Glossary

SLYZ022 — *TI Glossary*.
    This glossary lists and explains terms, acronyms, and definitions.

# 12 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/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB322IRWBR | ACTIVE | X2QFN | RWB | 12 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | 72 | 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)** Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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 |
|--------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TUSB322IRWBR | X2QFN | RWB | 12 | 3000 | 180.0 | 8.4 | 1.8 | 1.8 | 0.61 | 4.0 | 8.0 | Q2 |

**TAPE AND REEL BOX DIMENSIONS**

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TUSB322IRWBR | X2QFN | RWB | 12 | 3000 | 195.0 | 200.0 | 45.0 |
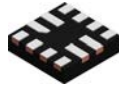
**PACKAGE OUTLINE**

PLASTIC QUAD FLATPACK - NO LEAD

B
1.65
1.55
A

PIN 1 INDEX AREA

1.65
1.55

0.4 MAX

C

SEATING PLANE

0.05 C

2X 1.2

SYMM

6X 0.4

3

6

2

7

SYMM

2X
0.4

1

8

8X 0.4
0.2

12

9

4X 0.6
0.4

12X 0.25
0.15

0.05
0.00

(0.13)
TYP

⊕ 0.07 Ⓜ C B A
0.05 Ⓜ C
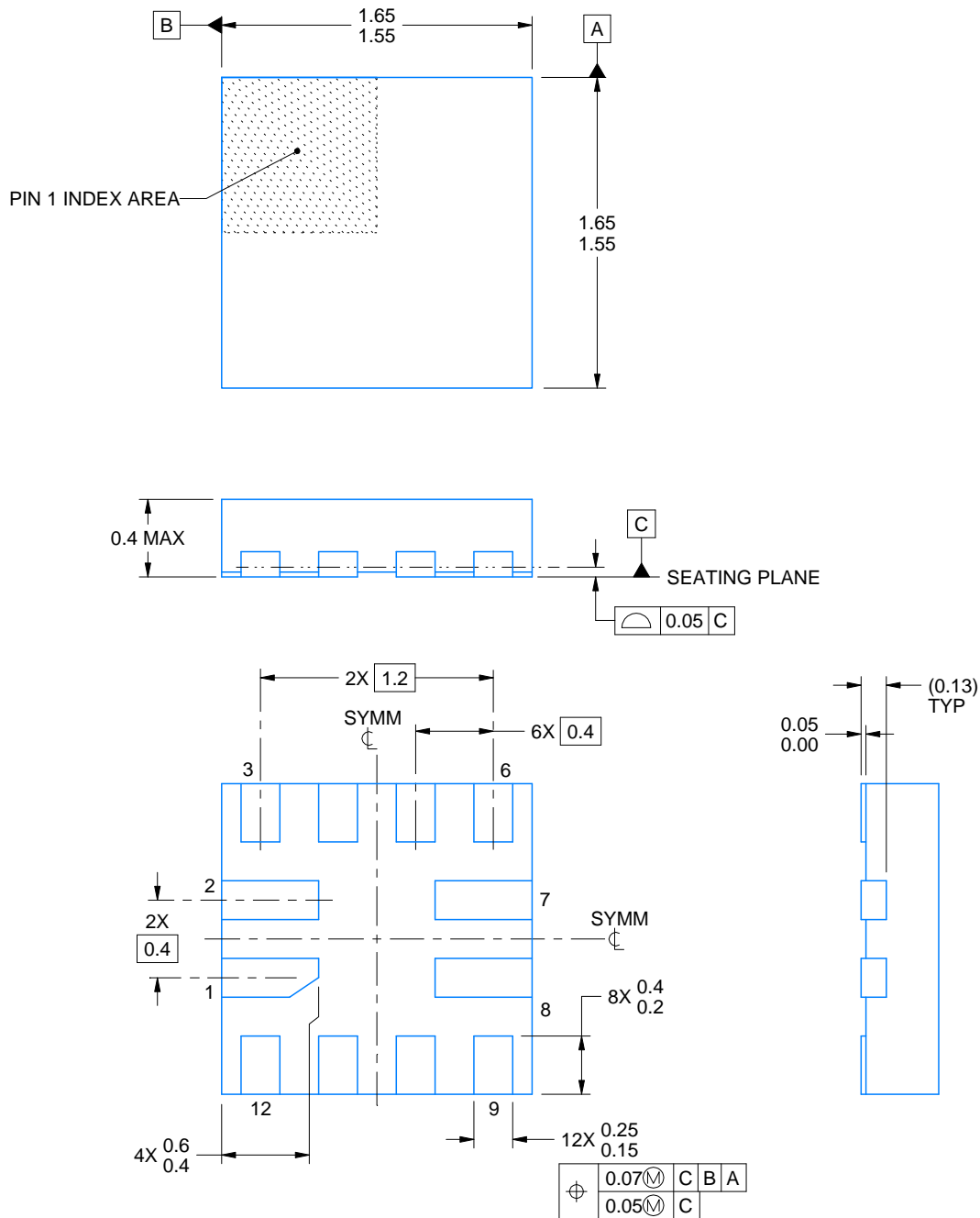
4221631/B   07/2017

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.

(1.3)

6X (0.4)

12

9

4X (0.7)

1

8

SYMM
℄

2X (0.4)

(1.5)

2

7

8X (0.5)

3

6

12X (0.2)

SYMM
℄

(R0.05) TYP

**LAND PATTERN EXAMPLE**
EXPOSED METAL SHOWN
SCALE:30X

0.05 MAX
ALL AROUND

METAL

EXPOSED METAL

SOLDER MASK
OPENING

NON SOLDER MASK
DEFINED
(PREFERRED)

0.05 MIN
ALL AROUND

SOLDER MASK
OPENING

EXPOSED METAL

METAL UNDER
SOLDER MASK

SOLDER MASK
DEFINED
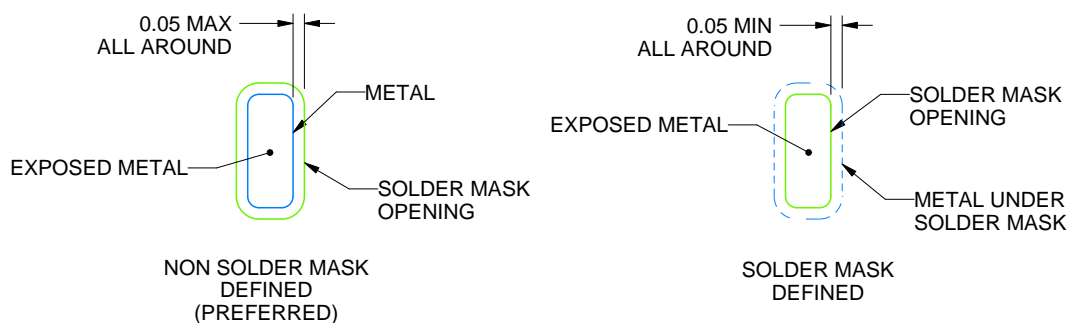
**SOLDER MASK DETAILS**

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NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

(1.3)

6X (0.4)

12

9

4X (0.67)

1

8

SYMM

(1.5)

2X (0.4)

2

7

8X
METAL

8X (0.5)

3

6

(R0.05) TYP

12X (0.2)

SYMM

**SOLDER PASTE EXAMPLE**
BASED ON 0.1 mm THICK STENCIL

PADS 1,2,7 & 8
96% PRINTED SOLDER COVERAGE BY AREA
SCALE:50X

4221631/B   07/2017

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

# IMPORTANT NOTICE