# TUSB321 VCONNによるUSB Type-C™構成チャネル・ロジックおよびポート制御

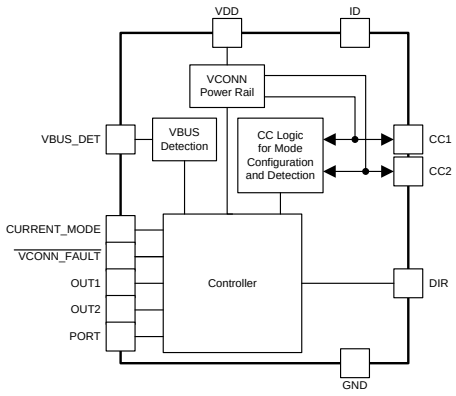
## 1 特長

- USB Type-C™仕様1.1
- USB Type-C仕様1.0と下位互換
- 専用の電流モード・ピンにより、最大3Aの電流アドバタイズメントが可能
- モード構成
  - ホストのみ - DFP (ソース)
  - デバイスのみ - UFP (シンク)
  - デュアル・ロール・ポート - DRP
- チャネル構成(CC)
  - USBポート接続の検出
  - ケーブルの向きの検出
  - ロール(役割)の検出
  - Type-C電流モード・アドバタイズメントおよび検出(デフォルト、中間、最大)
- $V_{BUS}$検出
- アクティブ・ケーブルでのVCONNサポート
- 外部スイッチのケーブルの検出と方向制御
- 電源電圧: 4.5V～5.5V
- 低い消費電流

## 2 アプリケーション

- ホスト、デバイス、デュアル・ロール・ポートのアプリケーション
- 携帯電話
- タブレットおよびノートブックPC
- USBペリフェラル

### 概略回路図






## 3 概要

TUSB321デバイスにより、USB Type-Cポートで、Type-Cエコシステムに必要な構成チャネル(CC)ロジックが使用可能になります。TUSB321デバイスはCCピンを使用して、ポートの取り付け/取り外し、ケーブルの方向、役割を検出し、Type-C電流モードのポート制御を行います。TUSB321デバイスは下流向けポート(DFP)、上流向けポート(UFP)、またはデュアル・ロール・ポート(DRP)に構成可能なため、あらゆるアプリケーションに適しています。

TUSB321デバイスがDRPとして構成されているとき、Type-Cの仕様に従ってDFPまたはUFPに構成が切り替わります。CCロジック・ブロックは、CC1およびCC2ピンのプルアップまたはプルダウン抵抗を監視し、USBポートへの接続、ケーブルの方向、および検出された役割を判定します。CCロジックは、検出された役割に応じて、Type-C電流モードをデフォルト、中、または高のいずれかとして検出します。UFPおよびDRPモードでの正しい接続を判定するため、$V_{BUS}$検出が実装されています。

このデバイスは、広い電源電圧範囲において、低い消費電力で動作します。

### 製品情報(1)

| 型番 | パッケージ | 本体サイズ(公称) |
|---|---|---|
| TUSB321 | X2QFN (12) | 1.60mm×1.60mm |

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。

### サンプル・アプリケーション

# 目次



## 4 改訂履歴

**Revision B (September 2016)** から **Revision C** に変更 **Page**

- 「*特長*」の「産業用温度範囲: -40～85℃」を削除 ... 1
- 「*概要*」から「TUSB321デバイスは産業用および商業用温度範囲で動作します」のテキストを削除 ... 1
- Changed pin VBUS_DET description From: 900-kΩ To: $R_{VBUS}$ in *Pin Functions* table. ... 3
- Changed $R_{VBUS}$ values From: MIN = 891, TYP = 900, MAX = 909 KΩ To: MIN = 855, TYP = 887, MAX = 920 KΩ ... 6
- Changed resister value From: 900 kΩ To: To: $R_{VBUS}$ in Figure 3 ... 8
- Changed resister value From: 900 kΩ To: To: $R_{VBUS}$ in *Functional Block Diagram* ... 9
- Changed From: The system $V_{BUS}$ voltage must be routed through a 900-kΩ resistor to the VBUS_DET pin .. To: The system $V_{BUS}$ voltage must be routed through a $R_{VBUS}$ resistor to the VBUS_DET pin .. in the *$V_{BUS}$ Detection* ... 11
- Added resister $R_{VBUS}$ in Figure 4 ... 14
- Added row for $R_{VBUS}$ to Table 4 ... 15
- Changed From: must be connected through a 900-kΩ resistor to $V_{BUS}$ on the Type-C... To: must be connected through a $R_{VBUS}$ resistor to $V_{BUS}$ on the Type-C .. in the *Detailed Design Procedure* ... 15

**Revision A (June 2015)** から **Revision B** に変更 **Page**

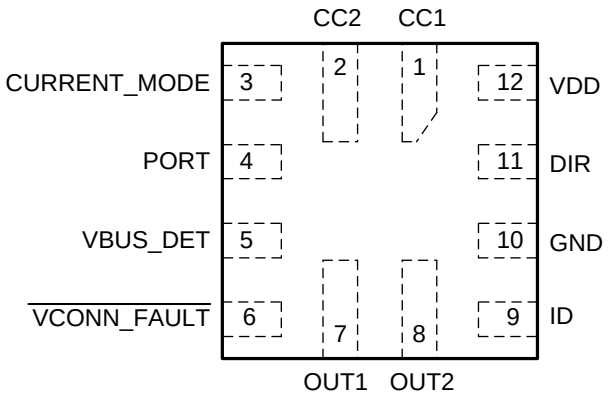
- Changed pins CC1 and CC2 values From: MIN = –0.3 MAX = $V_{DD}$ + 0.3 To: MIN –0.3 MAX = 6 in the *Absolute Maximum Ratings* ... 4

**2015年6月** 発行のものから更新 **Page**

- *デバイスのステータスを「製品プレビュー」から「量産データ」に* 変更 ... 1

# 5 Pin Configuration and Functions

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




**Pin Functions**

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| CC1 | 1 | I/O | Type-C configuration channel signal 1 |
| CC2 | 2 | I/O | Type-C configuration channel signal 2 |
| CURRENT_MODE | 3 | I | Advertise VBUS current. This 3-level input is used to control current advertisement in DFP mode or DRP mode connected as source. (See Table 2.)<br>L - Default Current. Pull-down to GND or leave unconnected.<br>M - Medium (1.5A) current. Pull-up to $V_{DD}$ with 500-kΩ resistor.<br>H - High (3.0A) current. Pull-up to $V_{DD}$ with 10-kΩ resistor. |
| PORT | 4 | I | Tri-level input pin to indicate port mode. The state of this pin is sampled when VDD is active.<br>H - DFP (Pull-up to $V_{DD}$ if DFP mode is desired)<br>NC - DRP (Leave unconnected if DRP mode is desired)<br>L - UFP (Pull-down or tie to GND if UFP mode is desired) |
| VBUS_DET | 5 | I | 5- to 28-V $V_{BUS}$ input voltage. $V_{BUS}$ detection determines UFP attachment. One $R_{VBUS}$ external resistor required between system $V_{BUS}$ and VBUS_DET pin. |
| $\overline{\text{VCONN\_FAULT}}$ | 6 | O | Open-drain output and is asserted low for $t_{FAULT}$ when VCONN over-current fault is detected. (See Figure 2.) |
| OUT1 | 7 | I/O | This pin is an open drain output for communicating Type-C current mode detect when the device is in UFP mode. Default current mode detected (H); medium or high current mode detected (L). (See Table 2.) |
| OUT2 | 8 | I/O | This pin is an open drain output for communicating Type-C current mode detect when the device is in UFP mode: default or medium current mode detected (H); high current mode detected (L). (See Table 2.) |
| 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 |
| DIR | 11 | O | DIR of plug. This open drain output indicates the detected plug orientation: Type-C plug position 2 (H); Type-C plug position 1 (L). |
| VDD | 12 | P | Positive supply voltage |

# 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 | PORT, CURRENT_MODE, ID, DIR, $\overline{\text{VCONN\_FAULT}}$ | –0.3 | $V_{DD}$ + 0.3 | V |
| | CC1, CC2 | –0.3 | 6 | |
| | OUT1, 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* may 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 may affect device reliability.

## 6.2 ESD Ratings

| | | VALUE | UNIT |
|---|---|---|---|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | ±7000 | 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 range | 4.5 | | 5.5 | V |
| $V_{BUS}$ | System $V_{BUS}$ voltage | 4 | 5 | 28 | V |
| VBUS_DET | VBUS_DET threshold voltage on the pin | | | 4 | V |
| VCONN | Supply for active cable (With $V_{DD}$ at 5 V) | 4.75 | | 5.5 | V |
| $T_A$ | Operating free air temperature range | 0 | 25 | 70 | °C |

## 6.4 Thermal Information

| THERMAL METRIC(1) | | 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.

## 6.5 Electrical Characteristics

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Power Consumption** | | | | | | |
| $I_{UNATTACHED\_UFP}$ | Current consumption in unattached mode when port is unconnected and waiting for connection. ($V_{DD}$ = 5 V, PORT = L) | | | 100 | | µA |
| $I_{ACTIVE\_UFP}$ | Current consumption in active mode. ($V_{DD}$ = 5 V, PORT = L) | | | 100 | | µA |
| **CC1 and CC2 Pins** | | | | | | |
| $R_{CC\_D}$ | Pulldown resistor when in UFP or DRP mode. | | 4.6 | 5.1 | 5.6 | kΩ |
| $V_{TH\_UFP\_CC\_USB}$ | Voltage threshold for detecting a DFP attach when configured as a UFP and DFP is advertising default current source capability. | | 0.15 | 0.2 | 0.25 | V |
| $V_{TH\_UFP\_CC\_MED}$ | Voltage threshold for detecting a DFP attach when configured as a UFP and DFP is advertising medium (1.5 A) current source capability. | | 0.61 | 0.66 | 0.7 | V |
| $V_{TH\_UFP\_CC\_HIGH}$ | Voltage threshold for detecting a DFP attach when configured as a UFP and DFP is advertising high (3 A) current source capability. | | 1.169 | 1.23 | 1.29 | 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 | 0.20 | 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 | 0.40 | 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 | 0.80 | 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: PORT, CURRENT_MODE, $\overline{\text{VCONN\_FAULT}}$, DIR, ID, OUT1, OUT2** | | | | | | |
| $V_{IL}$ | Low-level control signal input voltage, (PORT, CURRENT_MODE) | | | | 0.4 | V |
| $V_{IM}$ | Mid-level control signal input voltage (PORT, CURRENT_MODE) | | 0.28 × $V_{DD}$ | | 0.56 × $V_{DD}$ | V |
| $V_{IH}$ | High-level control signal input voltage (PORT, CURRENT_MODE) | | $V_{DD}$ - 0.3 | | | V |
| $I_{IH}$ | High-level input current | | –20 | | 20 | µA |
| $I_{IL}$ | Low-level input current | | –10 | | 10 | µA |
| $R_{pu}$ | Internal pullup resistance (PORT) | | | 588 | | kΩ |
| $R_{pd}$ | Internal pulldown resistance (PORT) | | | 1.1 | | MΩ |
| $R_{PD\_CUR}$ | Internal pulldown resistance for CURRENT_MODE pin | | | 275 | | kΩ |
| $V_{OL}$ | Low-level signal output voltage (open-drain) ($\overline{\text{VCONN\_FAULT}}$, ID, OUT1, OUT2) | $I_{OL}$ = –1.6 mA | | | 0.4 | V |
| $R_{p\_ODext}$ | External pullup resistor on open drain IOs ($\overline{\text{VCONN\_FAULT}}$, ID, OUT1, OUT2) | | | 200 | | kΩ |
| $R_{p\_TLext}$ | Tri-level input external pull-up resistor (PORT) | | | 4.7 | | kΩ |

(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 |
|---|---|---|---|---|---|---|
| $R_{p\_cm\_med}$ | External pull-up resistor on CURRENT_MODE pin to advertise 1.5-A current | | | 500 | | kΩ |
| $R_{p\_cm\_high}$ | External pull-up resistor on CURRENT_MODE pin to advertise 3.0-A current | | | 10 | | kΩ |
| **VBUS_DET IO Pins (Connected to System $V_{BUS}$ signal through external resistor)** | | | | | | |
| $V_{BUS\_THR}$ | $V_{BUS}$ threshold range | | 2.95 | 3.30 | 3.80 | 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 this value | | 200 | | | mA |
| $C_{BULK}$ | Bulk capacitance on VCONN; placed on $V_{DD}$ supply | | 10 | | 200 | µF |

## 6.6 Switching Characteristics

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

| PARAMETER | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| $t_{CCCB\_DEFAULT}$ | Power on default of CC1 and CC2 voltage debounce time | | 133 | | ms |
| $t_{VBUS\_DB}$ | Debounce of VBUS_DET pin after valid $V_{BUS\_THR}$ (See Figure 1.) | | 2 | | ms |
| $t_{DRP\_DUTY\_CYCLE}$ | Power-on default of percentage of time DRP advertises DFP during a $T_{DRP}$ | | 30% | | |
| $t_{DRP}$ | The period TUSB321 in DFP mode completes a DFP to UFP and back advertisement. | 50 | 75 | 100 | ms |
| $t_{FAULT}$ | $\overline{\text{VCONN\_FAULT}}$ asserted low time after VCONN over-current condition is detected. (See Figure 2.) | 7 | 10 | 13 | µs |

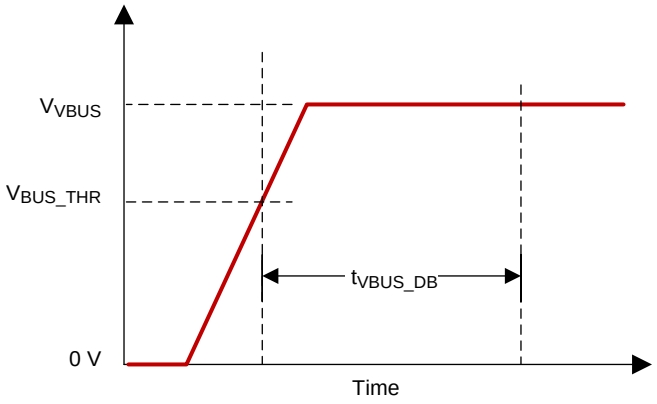



**Figure 1. VBUS Detect and Debounce**

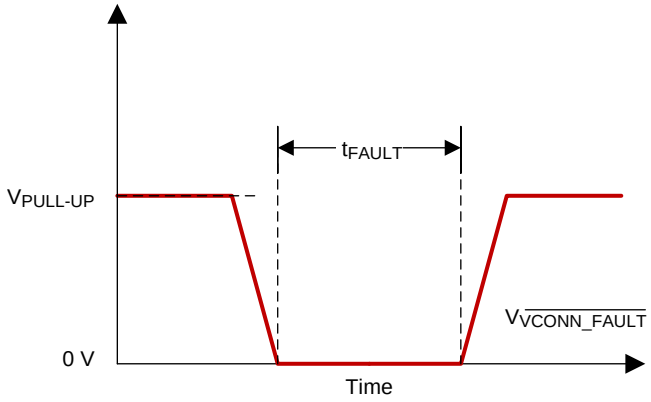



**Figure 2. $\overline{\text{VCONN\_FAULT}}$ Assertion Pulse Timing**

# 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. Because of the nature of the connector, a scheme is needed to determine the connector orientation. Additional schemes are needed 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 TUSB321 device provides Configuration Channel (CC) logic for determining USB port attach and detach, role detection, cable orientation, and Type-C current mode. The TUSB321 device also contains several features such as VCONN sourcing, USB3.1 MUX direction control, mode configuration and low standby current which make this device ideal for source or sinks in USB2.0 or USB3.1 applications.

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

*Type-C Specification 1.1* defines several cables, plugs and receptacles to be used to attach ports. The TUSB321 device supports all cables, receptacles, and plugs. The TUSB321 device does not support e-marking.

#### *7.1.1.1 USB Type-C Receptacles and Plugs*

Below is list of Type-C receptacles and plugs supported by the TUSB321 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

#### *7.1.1.2 USB Type-C Cables*

Below is a list of Type-C cables types supported by the TUSB321 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

#### *7.1.1.3 Legacy Cables and Adapters*

The TUSB321 device supports legacy cable adapters as defined by the Type-C Specification. The cable adapter must correspond to the mode configuration of the TUSB321 device.

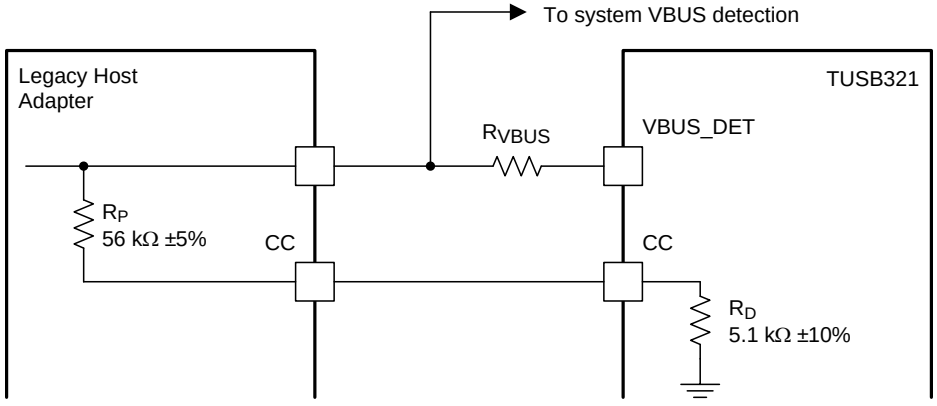
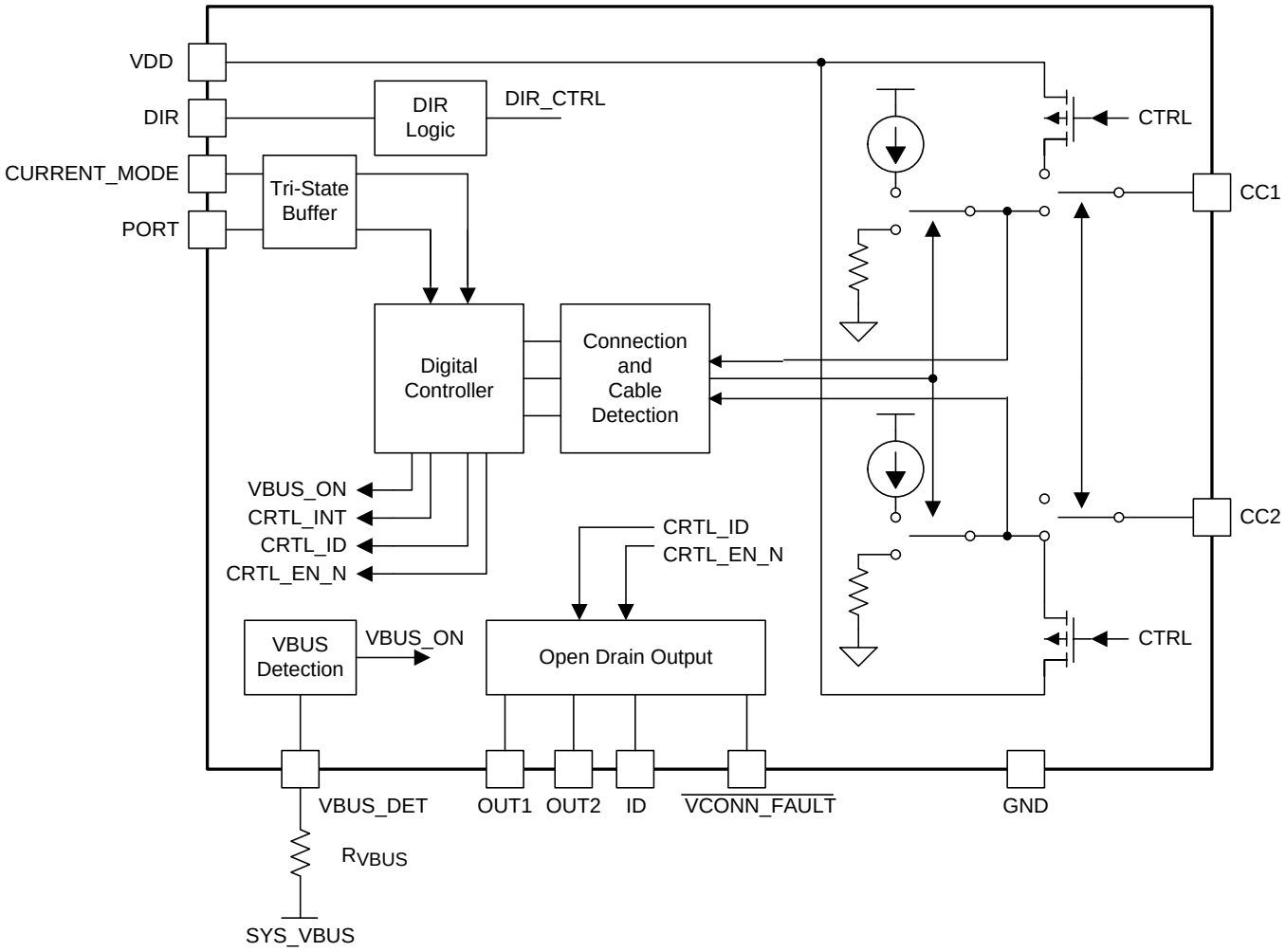



**Figure 3. Legacy Adapter Implementation Circuit**

#### *7.1.1.4 Direct Connect Devices*

The TUSB321 device supports the attaching and detaching of a direct-connect device.

## 7.2 Functional Block Diagram




## 7.3 Feature Description

### 7.3.1 Port Role Configuration

The TUSB321 device can be configured as a downstream facing port (DFP), upstream facing port (UFP), or dualrole port (DRP) using the tri-level PORT pin. The PORT pin should be pulled high to $V_{DD}$ using a pullup resistance, low to GND or left as floated on the PCB to achieve the desired mode. This flexibility allows the TUSB321 device to be used in a variety of applications. The TUSB321 device samples the PORT pin after reset and maintains the desired mode until the TUSB321 device is reset again. Table 1 lists the supported features in each mode:

## Feature Description (continued)

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

| PORT PIN / SUPPORTED FEATURES | HIGH (DFP ONLY) | LOW (UFP ONLY) | NC (DRP) |
|---|---|---|---|
| Port attach and detach | Yes | Yes | Yes |
| Cable orientation | Yes | Yes | Yes |
| Current advertisement | Yes | - | Yes (DFP) |
| Current detection | - | Yes | Yes (UFP) |
| Active cable detection | Yes | - | Yes (DFP) |
| VCONN | Yes | - | Yes (DFP) |
| Legacy cables | Yes | Yes | Yes |
| $V_{BUS}$ detection | - | Yes | Yes (UFP) |

#### *7.3.1.1 Downstream Facing Port (DFP) - Source*

The TUSB321 device can be configured as a DFP only by pulling the PORT pin high through a resistance to $V_{DD}$. In DFP mode, the TUSB321 device constantly presents Rps on both CC. In DFP mode, the TUSB321 device advertises USB Type-C current based on the state of the CURRENT_MODE pin.

When configured as a DFP, the TUSB321 can operate with older USB Type-C 1.0 devices except for a USB Type-C 1.0 DRP device. The TUSB321 can not operate with a USB Type-C 1.0 DRP device. This limitation is a result of backwards compatibility problem between USB Type-C 1.1 DFP and a USB Type-C 1.0 DRP.

#### *7.3.1.2 Upstream Facing Port (UFP) - Sink*

The TUSB321 device can be configured as a UFP only by pulling the PORT pin low to GND. In UFP mode, the TUSB321 device constantly presents pulldown resistors (Rd) on both CC pins. The TUSB321 device monitors the CC pins for the voltage level corresponding to the Type-C mode current advertisement by the connected DFP. The TUSB321 device debounces the CC pins and wait for $V_{BUS}$ detection before successfully attaching. As a UFP, the TUSB321 device detects and communicates the advertised current level of the DFP to the system through the OUT1 and OUT2 pins.

#### *7.3.1.3 Dual Role Port (DRP)*

The TUSB321 device can be configured to operate as a DRP when the PORT pin is left floated on the PCB. In DRP mode, the TUSB321 device toggles between operating as a DFP and a UFP. When functioning as a DFP in DRP mode, the TUSB321 device complies with all operations as defined for a DFP according to the Type-C Specification. When presenting as a UFP in DRP mode, the TUSB321 device operates as defined for a UFP according to the Type-C Specification.

### 7.3.2 Type-C Current Mode

The TUSB321 device supports both advertising and detection of Type-C current. When TUSB321 is a UFP or a DRP connected as a sink, the OUT1 and OUT2 pins are used to inform the system the detected USB Type-C current being broadcasted by the attached DFP. When TUSB321 device is a DFP or a DRP connected as a source, the CURRENT_MODE pin is used to advertise the USB Type-C current. The current advertisement for the TUSB321 device is 500 mA (for USB2.0) or 900 mA (for USB3.1) if CURRENT_MODE pin is left unconnected or pulled to GND. If a higher level of current is required, the CURRENT_MODE can be pulled up to VDD through a 500-kΩ resistor to advertise medium current at 1.5 A or pulled up to VDD through a 10-kΩ resistor to advertise high current at 3 A. Table 2 lists the Type-C current advertisements and detection.

**Table 2. Type-C Current Advertisement and Detection**

| TYPE-C CURRENT | | UFP or DRP acting as UFP Current Detection | DFP or DRP acting as DFP Current Advertisement |
|---|---|---|---|
| Default | 500 mA (USB2.0)<br>900 mA (USB3.1) | OUT1 = High<br>OUT2 = High (unattached) or Low (attached) | CURRENT_MODE = L |
| Medium - 1.5 A | | OUT1 = Low<br>OUT2 = High | CURRENT_MODE = M |
| High - 3 A | | OUT1 = Low<br>OUT2 = Low | CURRENT_MODE = H |

### 7.3.3 $V_{BUS}$ Detection

The TUSB321 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. $V_{BUS}$ detection is also used to successfully resolve the role in DRP mode.

The system $V_{BUS}$ voltage must be routed through a $R_{VBUS}$ resistor to the VBUS_DET pin on the TUSB321 device if the PORT pin is configured as a DRP or a UFP. If the TUSB321 device is configured as a DFP and only ever used in DFP mode, the VBUS_DET pin can be left unconnected.

### 7.3.4 Cable Orientation and External MUX Control

The TUSB321 device has the ability to control an external/discrete MUX using the DIR pin. The TUSB321 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. If the direction polarity of the external MUX is opposite of the TUSB321, the TUSB321 CC1/CC2 connection to USB Type-C receptacle can be reversed. The DIR pin is an open drain output.

### 7.3.5 VCONN Support for Active Cables

The TUSB321 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 TUSB321 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 TUSB321 device has two functional modes. Table 3 lists these modes:

**Table 3. USB Type-C States According to TUSB321 Functional Modes**

| MODES | GENERAL BEHAVIOR | PORT PIN | STATES (1) |
|---|---|---|---|
| Unattached | USB port unattached. ID, PORT operational. CC pins configure according to PORT pin. | UFP | Unattached.SNK |
| | | | AttachWait.SNK |
| | | DRP | Toggle Unattached.SNK → Unattached.SRC |
| | | | AttachedWait.SRC or AttachedWait.SNK |
| | | DFP | Unattached.SRC |
| | | | AttachWait.SRC |
| Active | USB port attached. All GPIOs operational. | UFP | Attached.SNK |
| | | DRP | Attached.SNK |
| | | | Attached.SRC |
| | | DFP | Attached.SRC |

(1) Required; not in sequential order.

### 7.4.1 Unattached Mode

Unattached mode is the primary mode of operation for the TUSB321 device, because a USB port can be unattached for a lengthy period of time. In unattached mode, $V_{DD}$ is available, and all IOs are operational. After the TUSB321 device is powered up, the part enters unattached mode until a successful attach has been determined. Initially, right after power up, the TUSB321 device comes up as an Unattached.SNK. The TUSB321 device checks the PORT pin and operates according to the mode configuration. The TUSB321 device toggles between the UFP and the DFP if configured as a DRP. The PORT pin is only sampled at reset or power up.

### 7.4.2 Active Mode

Active mode is defined as the port being attached. In active mode, all GPIOs are operational. When in active mode, the TUSB321 device communicates to the AP that the USB port is attached. This happens through the ID pin if TUSB321 is configured as a DFP or DRP connect as source. If TUSB321 is configured as a UFP or a DRP connected as a sink, the OUT1 and OUT2 pins are used. The TUSB321 device exits active mode under the following conditions:

- Cable unplug
- $V_{BUS}$ removal if attached as a UFP

# 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 TUSB321 device is a Type-C configuration channel logic and port controller. The TUSB321 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 TUSB321 device can be used in a source application (DFP) or in a sink application (UFP).

## 8.2 Typical Application

### 8.2.1 DFP Mode

Figure 4 shows the TUSB321 device configured as a DFP.

## Typical Application (continued)

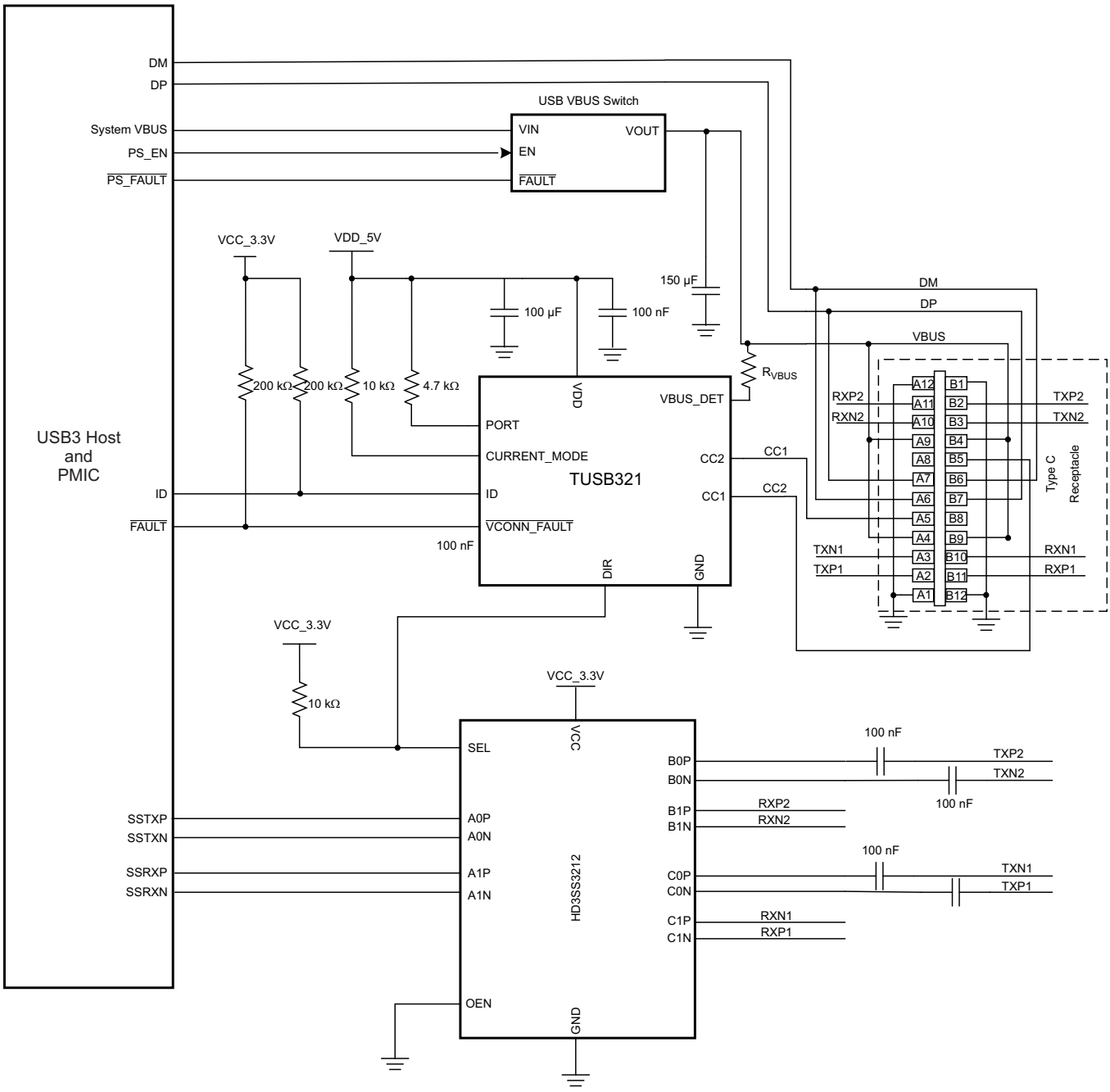



**Figure 4. DFP Mode Schematic**

## Typical Application (continued)

### 8.2.1.1 Design Requirements

For this design example, use the parameters listed in Table 4:

**Table 4. Design Requirements for DFP Mode**

| DESIGN PARAMETER | VALUE |
|---|---|
| $V_{DD}$ (4.5 V to 5.5 V) | 5 V |
| Type-C port type (UFP, DFP, or DRP) | DFP<br>PORT pin is pulled up |
| Advertised Type-C Current (Default, 1.5 A, 3.0 A) | 3.0 A |
| $R_{VBUS}$ (855-kΩ to 920-kΩ) | 900-kΩ |
| VCONN Support | Yes |

### 8.2.1.2 Detailed Design Procedure

The TUSB321 device supports a $V_{DD}$ in the range of 4.5 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 is used to meet the USB Type-C bulk capacitance requirement of 10 µF to 220 µF.

The TUSB321 current advertisement is determined by the state of the CURRENT_MODE pin. In this particular example, 3.0 A advertisement is desired so the CURRENT_MODE pin is pulled high to $V_{DD}$ through 10-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. In order to minimize crossing in routing the USB3 SS signals to the USB Type C connector, the connection of CC1 and CC2 to the TUSB321 is swapped.

The Type-C port mode is determined by the state of the PORT pin. When the PORT pin is pulled high, the TUSB321 device is in DFP mode.

The VBUS_DET pin must be connected through a $R_{VBUS}$ resistor to $V_{BUS}$ on the Type-C that is connected. This large resistor is required to protect the TUSB321 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 TUSB321 device in the recommended range.

The USB2 specification requires the bulk capacitance on $V_{BUS}$ based on UFP or DFP. When operating the TUSB321 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.

### 8.2.1.3 Application Curve

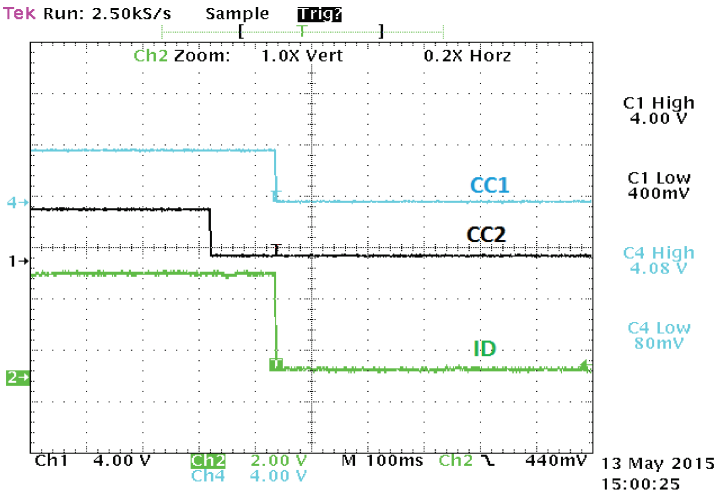



**Figure 5. Application Curve for DFP Mode**

### 8.3 Initialization Set Up

The general power-up sequence for the TUSB321 device is as follows:

1. System is powered off (device has no $V_{DD}$). The TUSB321 device is configured internally in UFP mode with Rds on CC pins.
2. $V_{DD}$ ramps – POR circuit.
3. The TUSB321 device enters unattached mode and determines the voltage level from the PORT pin. This determines the mode in which the TUSB321 device operates (DFP, UFP, DRP).
4. The TUSB321 device monitors the CC pins as a DFP and $V_{BUS}$ for attach as a UFP.
5. The TUSB321 device enters active mode when attach has been successfully detected.

## 9 Power Supply Recommendations

The TUSB321 device has a wide power supply range from 4.5 to 5.5 V. The TUSB321 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 TUSB321 $V_{DD}$ pin.

### 10.2 Layout Example

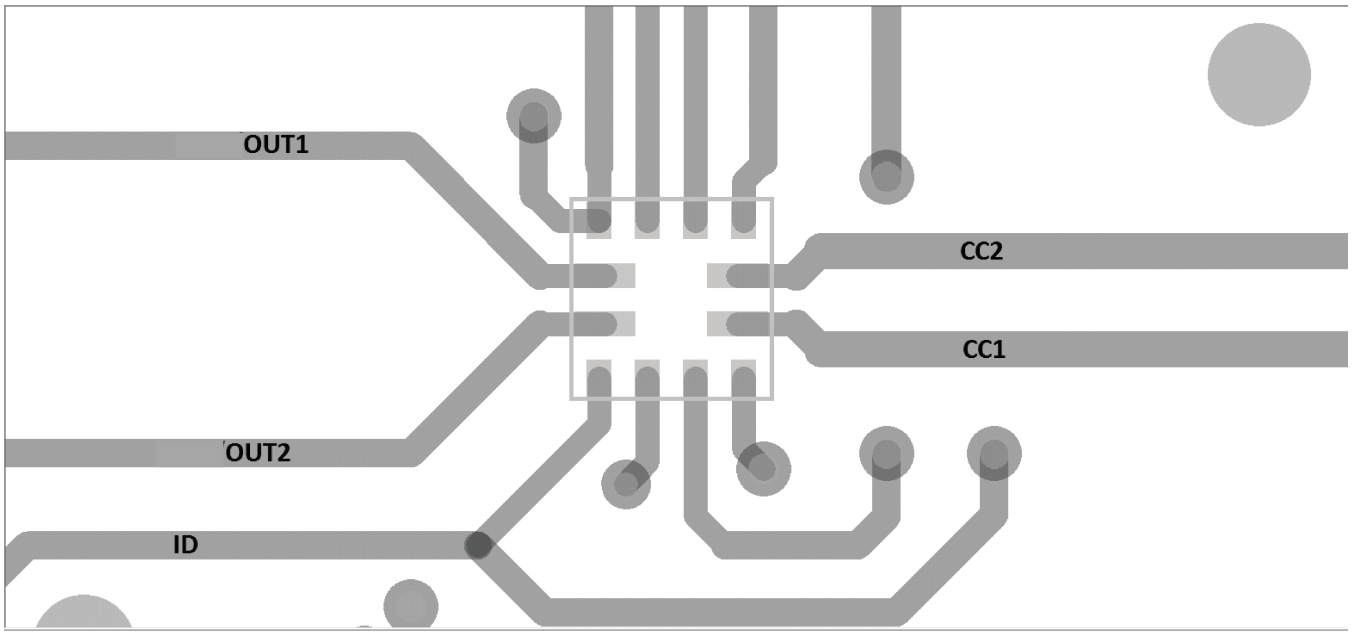



**Figure 6. TUSB321 Layout**

# 11 デバイスおよびドキュメントのサポート

## 11.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、ti.comのデバイス製品フォルダを開いてください。右上の隅にある「*通知を受け取る*」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

## 11.2 コミュニティ・リソース

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.

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## 11.5 Glossary

SLYZ022 — *TI Glossary*.

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

# 12 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB321RWBR | ACTIVE | X2QFN | RWB | 12 | 3000 | RoHS & Green | NIPDAU | Level-2-260C-1 YEAR | 0 to 70 | 21 | 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.

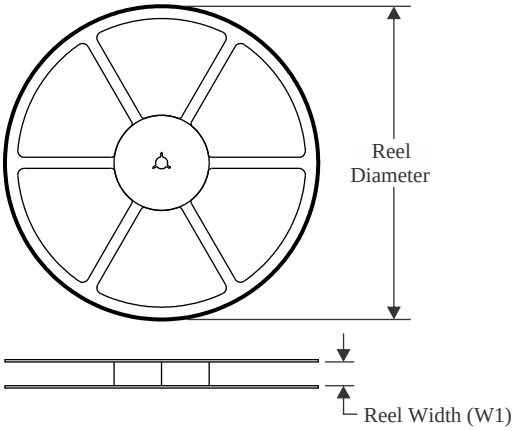
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

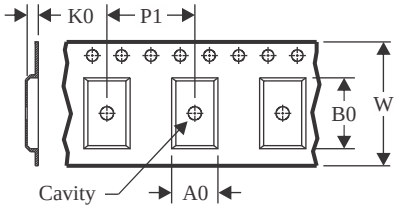
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

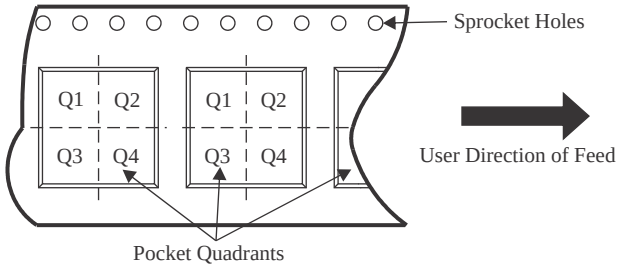



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

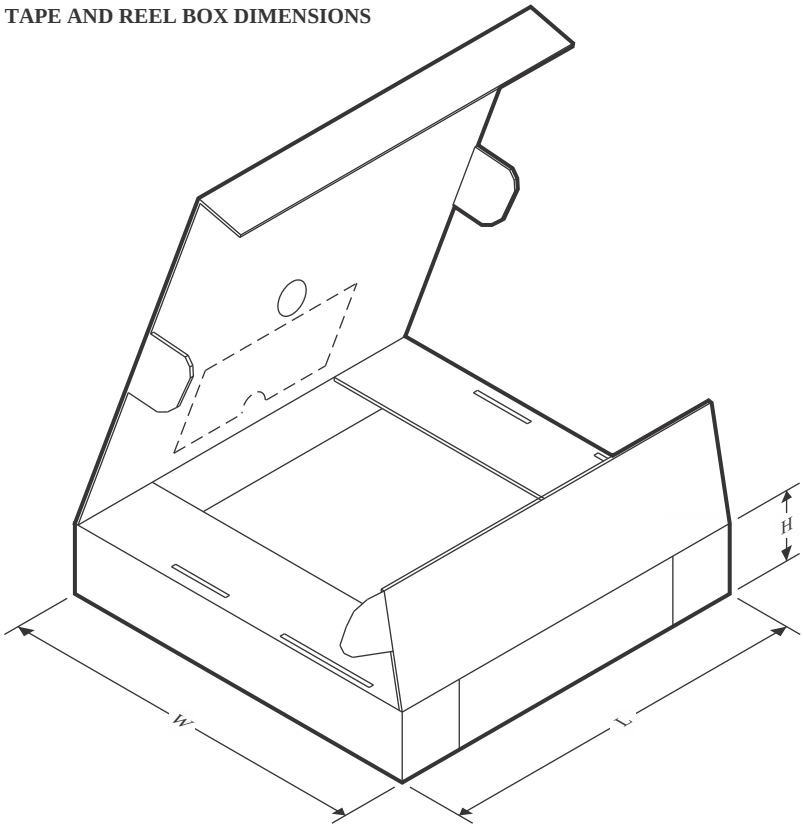
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUSB321RWBR | X2QFN | RWB | 12 | 3000 | 180.0 | 8.4 | 1.8 | 1.8 | 0.48 | 4.0 | 8.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

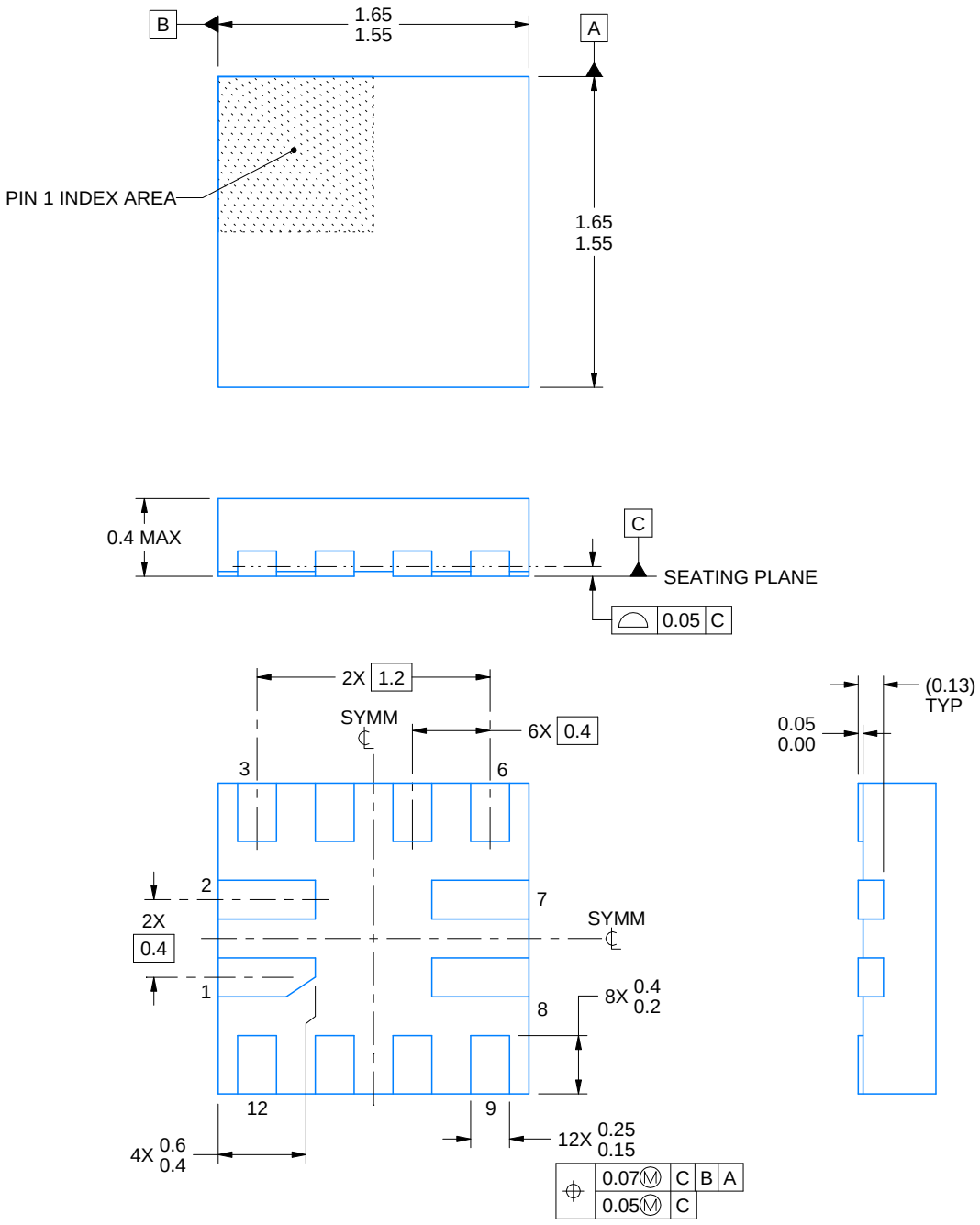
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TUSB321RWBR | X2QFN | RWB | 12 | 3000 | 210.0 | 185.0 | 35.0 |

# PACKAGE OUTLINE

## RWB0012A

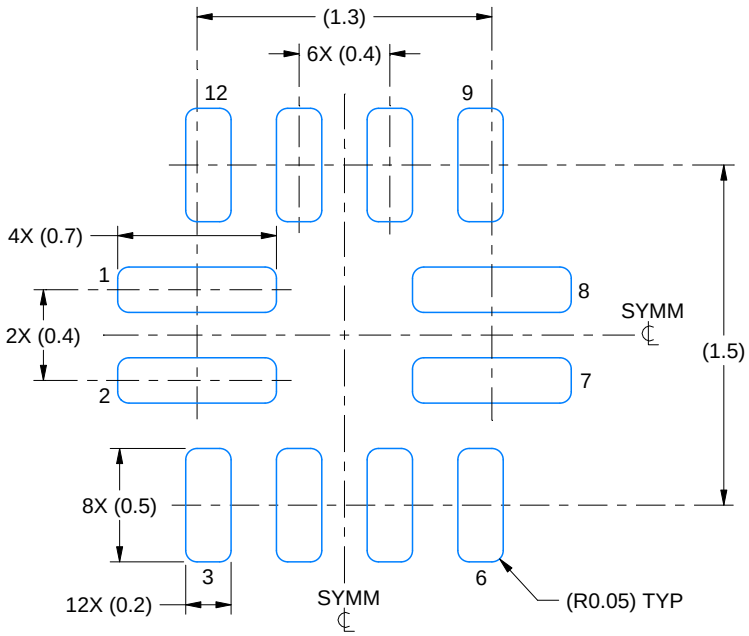
## X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

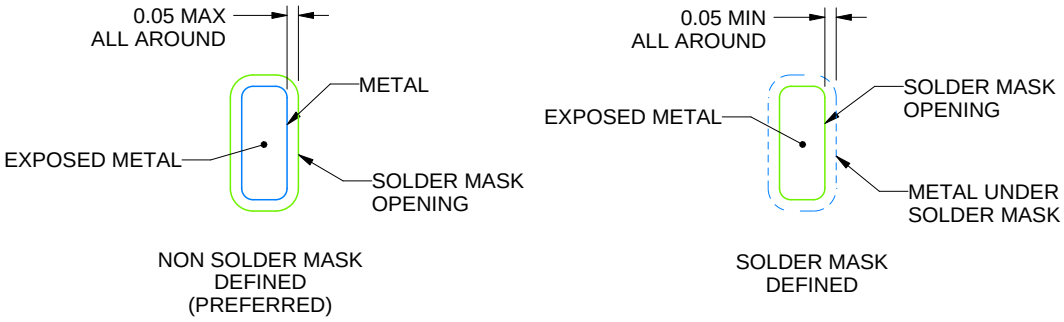



NOTES:

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.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:30X




SOLDER MASK DETAILS

4221631/B 07/2017

NOTES: (continued)

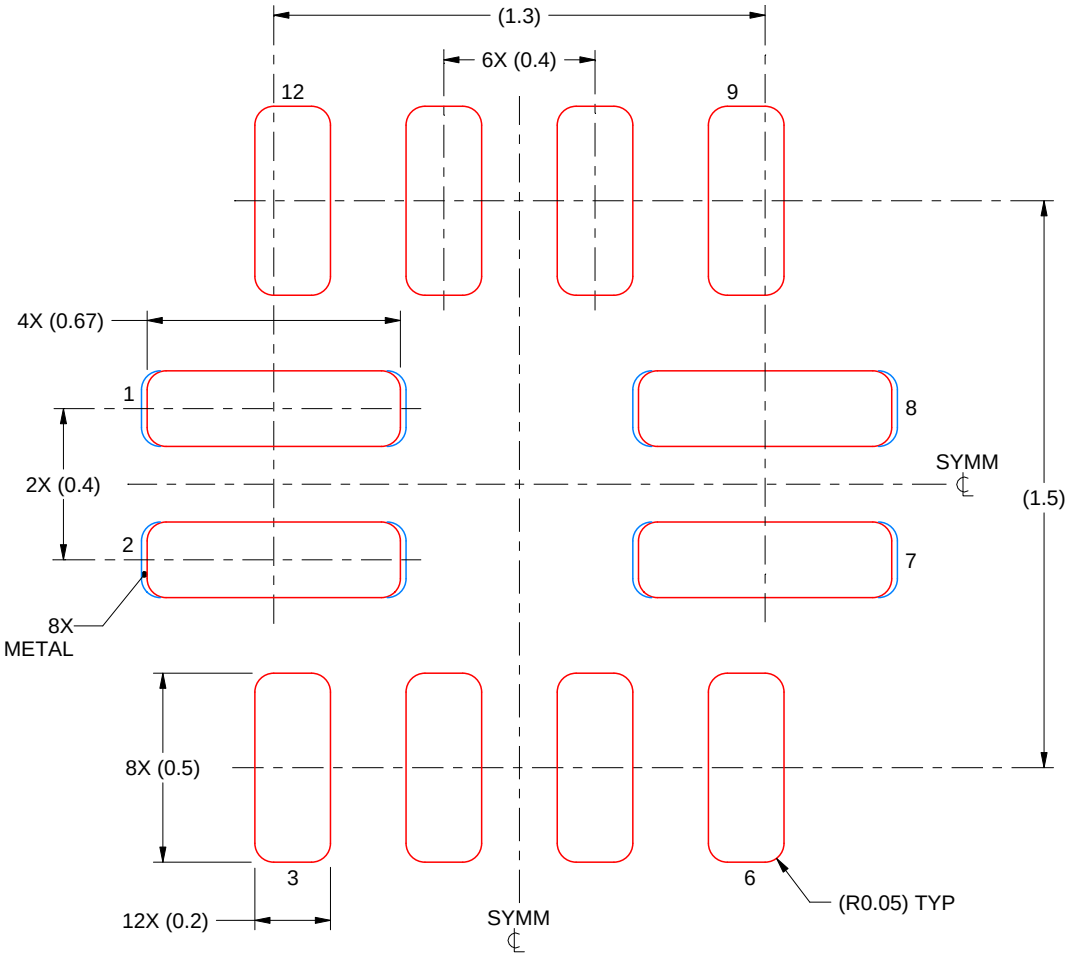
3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

# EXAMPLE STENCIL DESIGN

## RWB0012A

## X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




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.

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