TUSB321AI 支持 VCONN 的 USB Type-C 配置通道逻辑和端口控制

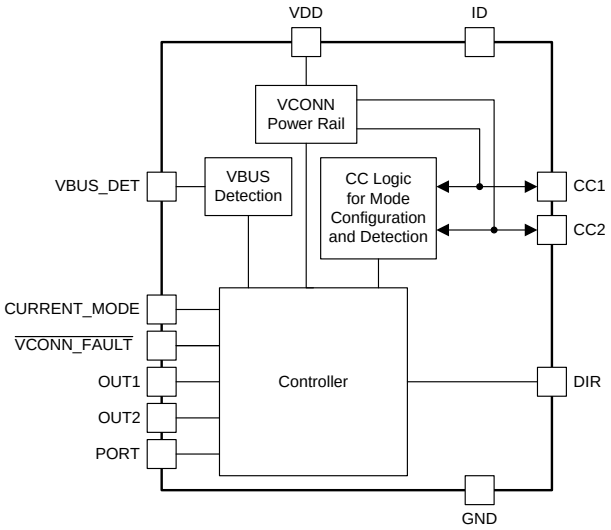
1 特性

- USB Type-C™ 规范 1.1
- 向后兼容 USB Type-C 规范 1.0
- 通过专用电流模式引脚支持高达 3A 的电流通告
- 模式配置
  - 仅主机 - 下行端口 (DFP)（供电设备）
  - 仅设备 – 上行端口 (UFP)（受电设备）
  - 双角色端口 – DRP
- 通道配置 (CC)
  - USB 端口连接检测
  - 电缆方向检测
  - 角色检测
  - Type-C 电流模式通告和检测（默认、中等和高）
- V_{BUS} 检测
- 针对有源电缆提供 VCONN 支持
- 外部开关电缆检测与方向控制
- 电源电压：4.5V 至 5.5V
- 低电流消耗
- 工业温度范围：–40°C 至 85°C

2 应用

- 主机、设备、双角色端口应用
- 移动电话
- 平板电脑和笔记本电脑
- USB 外设

简化电路原理图



3 说明

TUSB321AI 器件可在 USB Type-C 端口上实现 Type-C 生态系统所需的配置通道 (CC) 逻辑。 TUSB321AI 器件使用 CC 引脚来确定端口的连接状态和电缆方向，以及进行角色检测和 Type-C 电流模式控制。 TUSB321AI 器件可配置为下行端口 (DFP)、上行端口 (UFP) 或双角色端口 (DRP)，因此成为任何应用的理想选择。

根据 Type-C 规范，TUSB321AI 器件在配置为 DRP 时，会交替配置为 DFP 或 UFP。 CC 逻辑块通过监视 CC1 和 CC2 引脚上的上拉或下拉电阻，以确定何时连接了 USB 端口、电缆的方向以及检测到的角色。 CC 逻辑根据检测到的角色来确定 Type-C 电流模式为默认、中等还是高。 该逻辑通过实施 V_{BUS} 检测来确定端口在 UFP 和 DRP 模式下是否连接成功。

该器件能够在宽电源范围内工作，并且具有较低功耗。 TUSB321AI 器件适用于工业级和商业级温度范围。

器件信息(1)

部件号	封装	封装尺寸（标称值）
TUSB321AI	X2QFN (12)	1.60mm x 1.60mm

(1) 要了解所有可用封装，请见数据表末尾的可订购产品附录。

示例应用

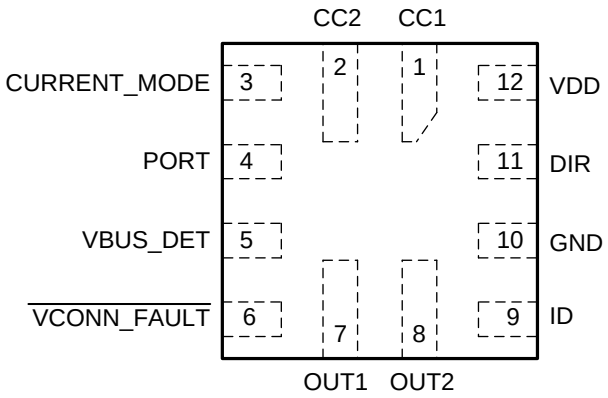
目录

4 修订历史记录

日期	修订版本	注释
2015 年 10 月	*	最初发布版本。

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.) L - Default Current. Pull-down to GND or leave unconnected. M - Medium (1.5A) current. Pull-up to V_{DD} with 500-kΩ resistor. 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. H - DFP (Pull-up to V_{DD} if DFP mode is desired) NC - DRP (Leave unconnected if DRP mode is desired) 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 900-kΩ 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 when VCONN over-current fault is detected.
OUT1	7	I/O	This pin is an open drain output for communicating Type-C current mode detect when the TUSB321AI 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 TUSB321AI 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	6.0	V
Control pins	CC1, CC2, PORT, CURRENT_MODE, ID, DIR, $\overline{\text{VCONN\_FAULT}}$	–0.3	V_{DD} + 0.3	V
	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)	±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
Supply voltage range, V_{DD}		4.5		5.5	V
System V_{BUS} voltage		4	5	28	V
DC Voltage range for VBUS_DET	VBUS_DET	0		4	V
DC Voltage range for control pins	ID, DIR, $\overline{\text{VCONN\_FAULT}}$, OUT1, OUT2, CURRENT_MODE, CC1, CC2, PORT	0		5.5	V
Supply for active cable (With V_{DD} at 5 V)	VCONN	4.75		5.5	V
Operating free air temperature, T_A		–40	25	85	°C

6.4 Thermal Information

THERMAL METRIC(1)		TUSB321AI 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
ψ_{JT}	Junction-to-top characterization parameter	2.2	°C/W
ψ_{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						
$I_{(UNATTACHED\_UFP)}$	Current consumption in unattached mode when port is unconnected and waiting for connection. (V_{DD} = 5 V, PORT = L)			70		µA
$I_{(ACTIVE\_UFP)}$	Current consumption in active mode. (V_{DD} = 5 V, PORT = L)			70		µA
CC1 and CC2 Pins						
$R_{(CC\_D)}$	Pulldown resistor when in UFP or DRP mode.		4.6	5.1	5.6	kΩ
R_{CC_DB}	Pulldown resistor when in dead-battery mode	VDD = 0V.	4.1	5.1	6.1	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.		0.70		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	0.20	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 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
$I_{ID\_LEAKAGE}$	Current leakage for ID pin.	V_{DD} = 0V; ID = 5V			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, DIR)	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 (VCONN_FAULT, ID, OUT1, OUT2, DIR)			200		kΩ
$R_{P(TLext)}$	Tri-level input external pull-up resistor (PORT)			4.7		kΩ
$R_{P(cm\_med)}$	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		891	900	909	KΩ
$R_{(VBUS\_PD)}$	Internal pulldown resistance for VBUS_DET			95		KΩ
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		225	300	375	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		168		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 TUSB321AI in DRP mode completes a DFP to UFP and back advertisement.	50	75	100	ms

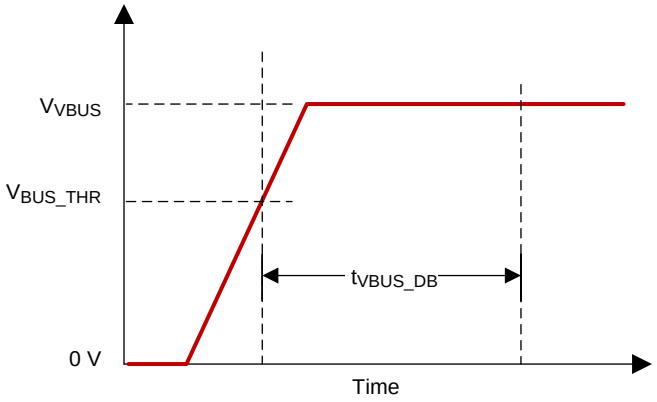


Figure 1. VBUS Detect and Debounce

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 TUSB321AI device provides Configuration Channel (CC) logic for determining USB port attach and detach, role detection, cable orientation, and Type-C current mode. The TUSB321AI 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 TUSB321AI device supports all cables, receptacles, and plugs. The TUSB321AI 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 TUSB321AI 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 TUSB321AI 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 TUSB321AI device supports legacy cable adapters as defined by the Type-C Specification. The cable adapter must correspond to the mode configuration of the TUSB321AI device.

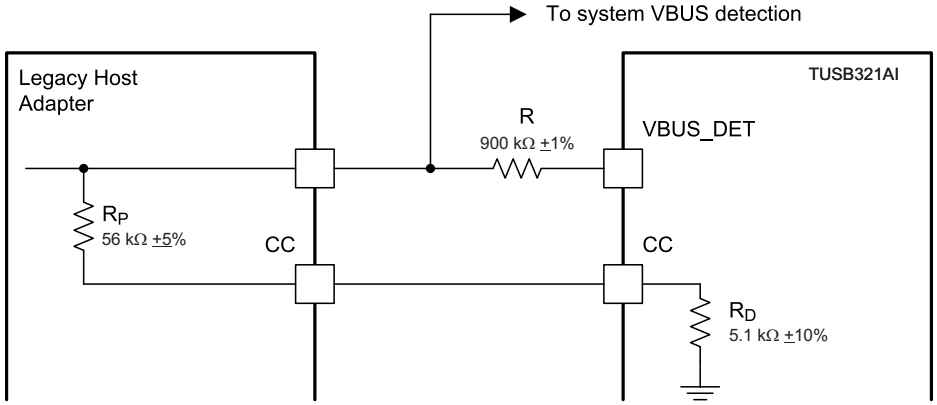
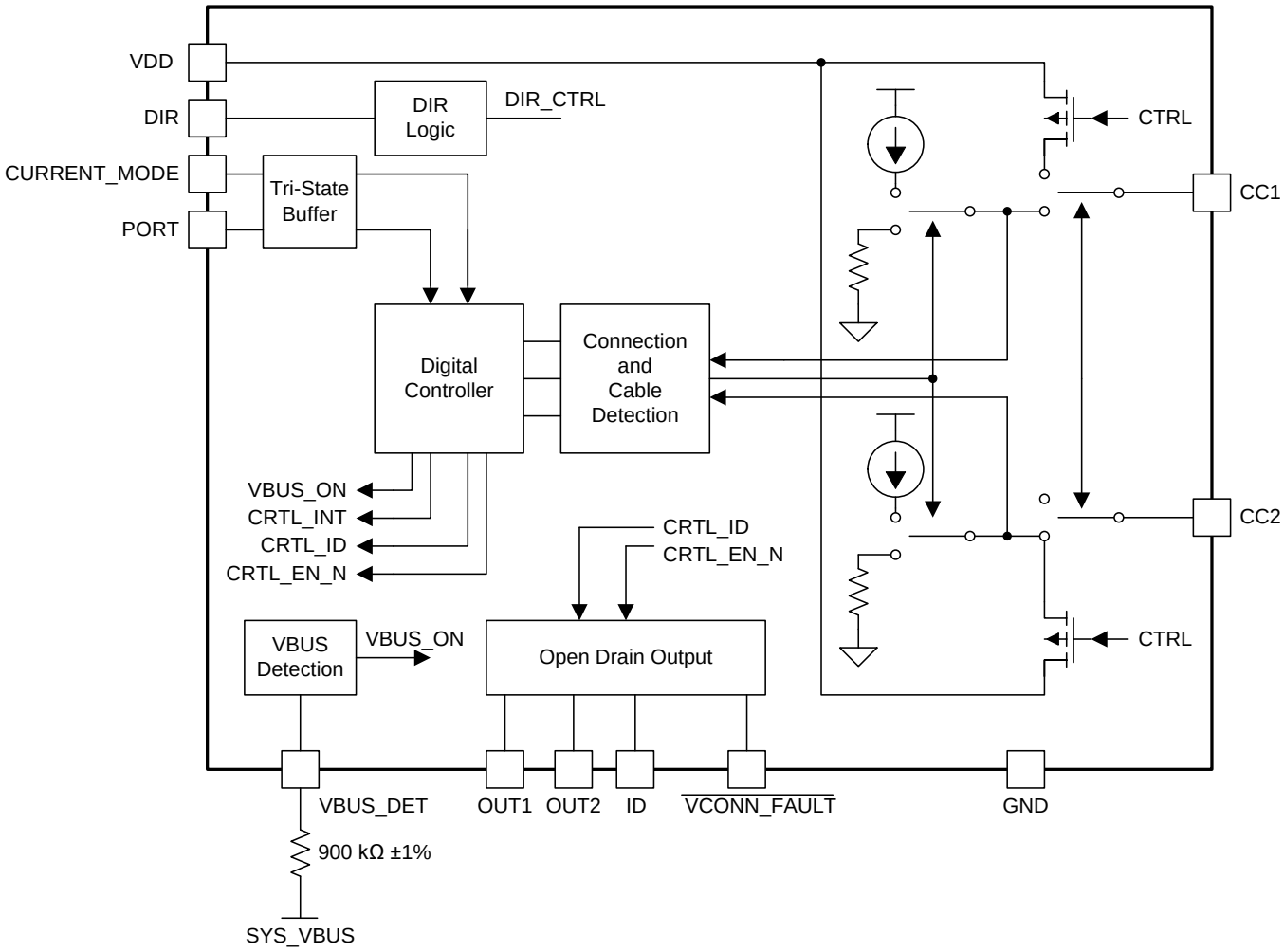


Figure 2. Legacy Adapter Implementation Circuit

7.1.1.4 Direct Connect Devices

The TUSB321AI 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 TUSB321AI 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 TUSB321AI device to be used in a variety of applications. The TUSB321AI device samples the PORT pin after reset and maintains the desired mode until the TUSB321AI device is reset again. Table 1 lists the supported features in each mode:

Feature Description (continued)

Table 1. Supported Features for the TUSB321AI 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 TUSB321AI device can be configured as a DFP only by pulling the PORT pin high through a resistance to V_{DD}. In DFP mode, the TUSB321AI device constantly presents Rps on both CC. In DFP mode, the TUSB321AI device advertises USB Type-C current based on the state of the CURRENT_MODE pin.

When configured as a DFP, the TUSB321AI can operate with older USB Type-C 1.0 devices except for a USB Type-C 1.0 DRP device. The TUSB321AI 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.

Please note that when TUSB321AI's V_{DD} supply is not active, Rd will be presented on both CC pins. This will cause another DRP or DFP device to detect the TUSB321AI as a UFP. When V_{DD} becomes active, the TUSB321AI will remove the Rd from CC pins and present Rp on both CC pins.

7.3.1.2 Upstream Facing Port (UFP) - Sink

The TUSB321AI device can be configured as a UFP only by pulling the PORT pin low to GND. In UFP mode, the TUSB321AI device constantly presents pulldown resistors (Rd) on both CC pins. The TUSB321AI device monitors the CC pins for the voltage level corresponding to the Type-C mode current advertisement by the connected DFP. The TUSB321AI device debounces the CC pins and wait for V_{BUS} detection before successfully attaching. As a UFP, the TUSB321AI 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 TUSB321AI device can be configured to operate as a DRP when the PORT pin is left floated on the PCB. In DRP mode, the TUSB321AI device toggles between operating as a DFP and a UFP. When functioning as a DFP in DRP mode, the TUSB321AI 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 TUSB321AI device operates as defined for a UFP according to the Type-C Specification.

7.3.2 Type-C Current Mode

The TUSB321AI device supports both advertising and detection of Type-C current. When TUSB321AI 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 TUSB321AI 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 TUSB321AI 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 V_{DD} through a 500-kΩ resistor to advertise medium current at 1.5 A or pulled up to V_{DD} 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) 900 mA (USB3.1)	OUT1 = High OUT2 = High (unattached) or Low (attached)	CURRENT_MODE = L
Medium - 1.5 A		OUT1 = Low OUT2 = High	CURRENT_MODE = M
High - 3 A		OUT1 = Low OUT2 = Low	CURRENT_MODE = H

7.3.3 V_{BUS} Detection

The TUSB321AI 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 900-kΩ resistor to the VBUS_DET pin on the TUSB321AI device if the PORT pin is configured as a DRP or a UFP. If the TUSB321AI 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 TUSB321AI device has the ability to control an external/discrete MUX using the DIR pin. The TUSB321AI 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 TUSB321AI, the 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 TUSB321AI 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 V_{DD} pin of the TUSB321AI device after Attached.SRC. VCONN is supplied from V_{DD} 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 TUSB321AI device has three functional modes. Table 3 lists these modes:

Table 3. USB Type-C States According to TUSB321AI 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
Dead Battery	No operation. V_{DD} not available	N/A	Default device state to UFP/SINK with Rd

(1) Required; not in sequential order.

7.4.1 Unattached Mode

Unattached mode is the primary mode of operation for the TUSB321AI 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 TUSB321AI device is powered up, the part enters unattached mode until a successful attach has been determined. Initially, right after power up, the TUSB321AI device comes up as an Unattached.SNK. The TUSB321AI device checks the PORT pin and operates according to the mode configuration. The TUSB321AI 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 TUSB321AI device communicates to the AP that the USB port is attached. This happens through the ID pin if TUSB321AI is configured as a DFP or DRP connect as source. If TUSB321AI is configured as a UFP or a DRP connected as a sink, the OUT1 and OUT2 pins are used. The TUSB321AI device exits active mode under the following conditions:

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

7.4.3 Dead Battery Mode

Dead battery mode is defined as V_{DD} not active. In this mode, CC pins always default to pull-down resistors. Dead battery means:

- TUSB321AI in UFP with 5.1 kΩ ±20% pull-down resistors

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 TUSB321AI device is a Type-C configuration channel logic and port controller. The TUSB321AI 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 TUSB321AI 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 3 shows the TUSB321AI device configured as a DFP.

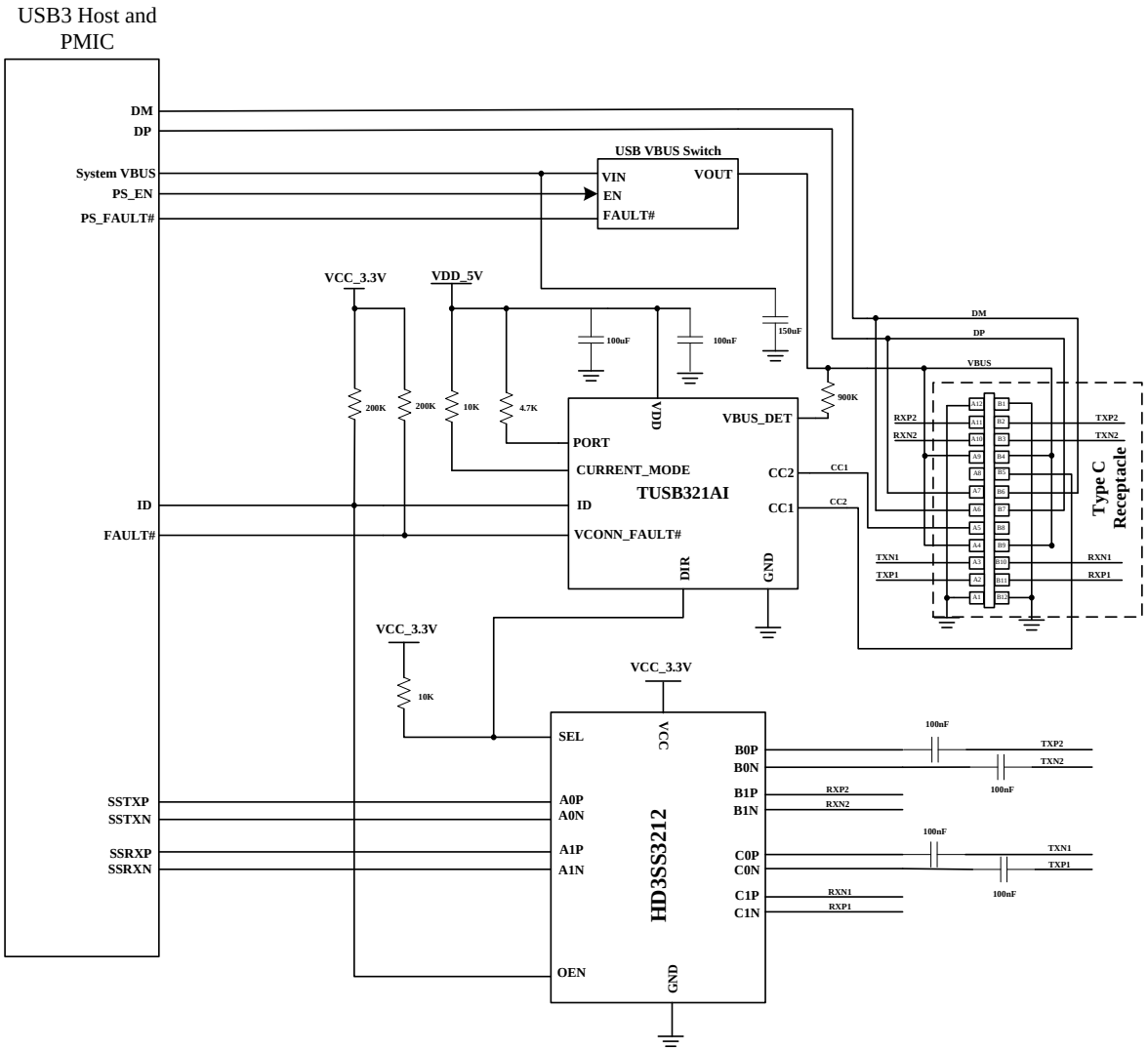


Figure 3. DFP Mode Schematic

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 PORT pin is pulled up
Advertised Type-C Current (Default, 1.5 A, 3 A)	3 A
VCONN Support	Yes

8.2.1.2 Detailed Design Procedure

The TUSB321AI 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 TUSB321AI current advertisement is determined by the state of the CURRENT_MODE pin. In this particular example, 3 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 USB 3.1 SS signals to the USB Type C connector, the connection of CC1 and CC2 to the TUSB321AI is swapped.

The Type-C port mode is determined by the state of the PORT pin. When the PORT pin is pulled high, the TUSB321AI device is in DFP mode.

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 TUSB321AI 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 TUSB321AI device in the recommended range.

The USB3.1 specification requires the bulk capacitance on V_{BUS} based on UFP or DFP. When operating the TUSB321AI 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

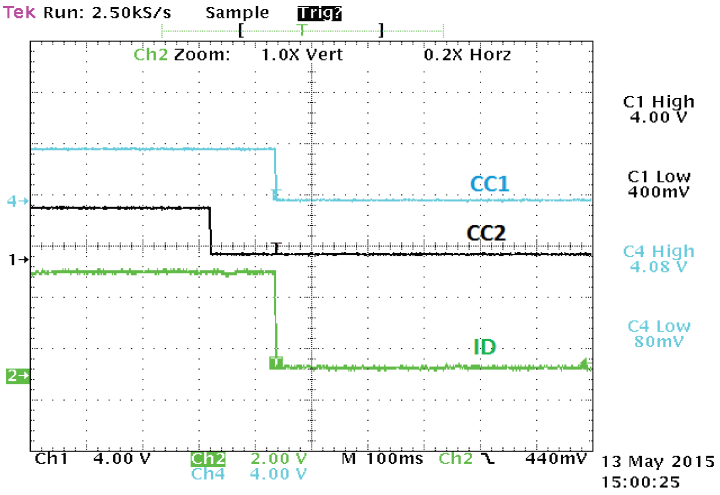


Figure 4. Application Curve for DFP Mode

8.3 Initialization Set Up

The general power-up sequence for the TUSB321AI device is as follows:

1. System is powered off (device has no V_{DD}). The TUSB321AI device is configured internally in UFP mode with Rds on CC pins.
2. V_{DD} ramps – POR circuit.
3. The TUSB321AI device enters unattached mode and determines the voltage level from the PORT pin. This determines the mode in which the TUSB321AI device operates (DFP, UFP, DRP).
4. The TUSB321AI device monitors the CC pins as a DFP and V_{BUS} for attach as a UFP.
5. The TUSB321AI device enters active mode when attach has been successfully detected.

9 Power Supply Recommendations

The TUSB321AI device has a wide power supply range from 4.5 to 5.5 V. The TUSB321AI 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 TUSB321AI V_{DD} pin.

10.2 Layout Example

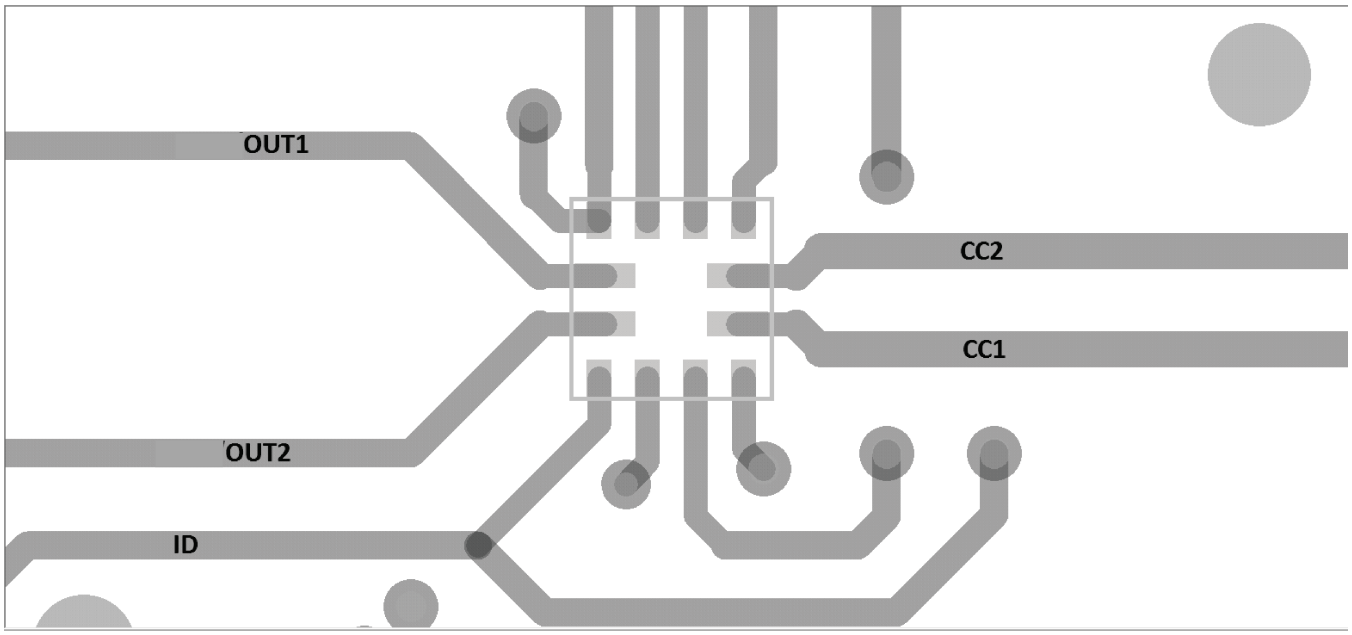


Figure 5. TUSB321AI Layout

11 器件和文档支持

11.1 文档支持

11.2 社区资源

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.

11.3 商标

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.

11.4 静电放电警告

这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。 这些信息是针对指定器件可提供的最新数据。 这些数据会在无通知且不对本文档进行修订的情况下发生改变。 欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TUSB321AIRWBR	Active	Production	X2QFN (RWB) | 12	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	7A
TUSB321AIRWBR.A	Active	Production	X2QFN (RWB) | 12	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	7A
TUSB321AIRWBRG4.A	Active	Production	X2QFN (RWB) | 12	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	7A

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

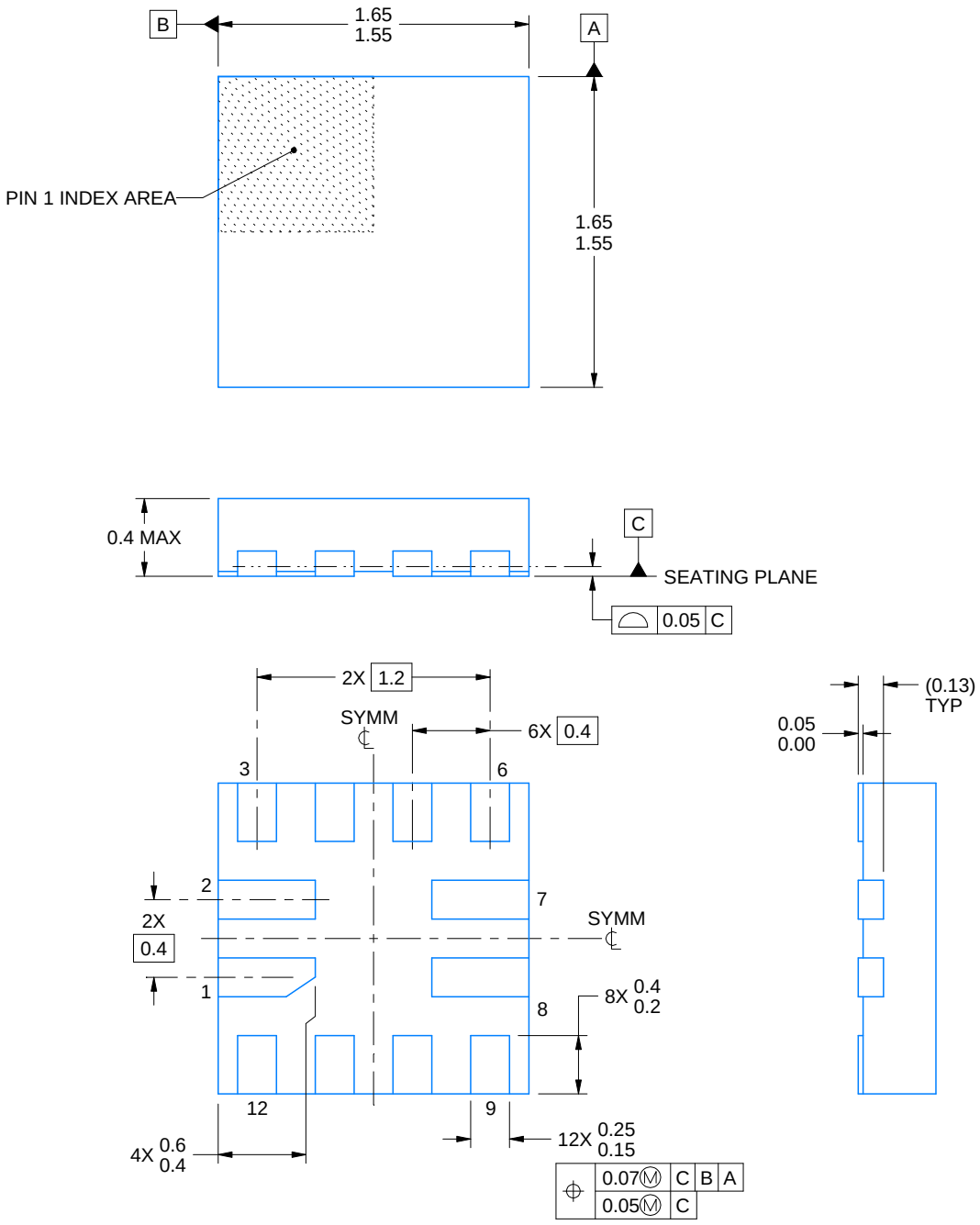
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

PACKAGE OUTLINE

RWB0012A

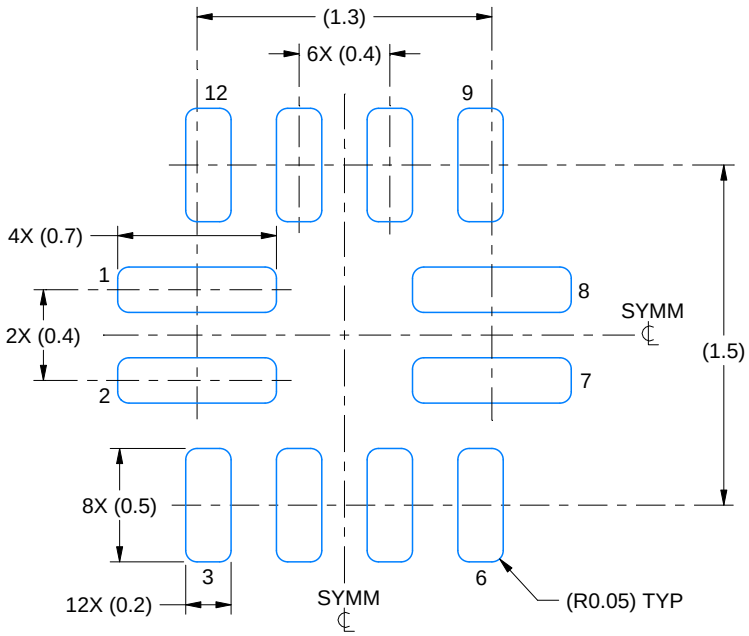
X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

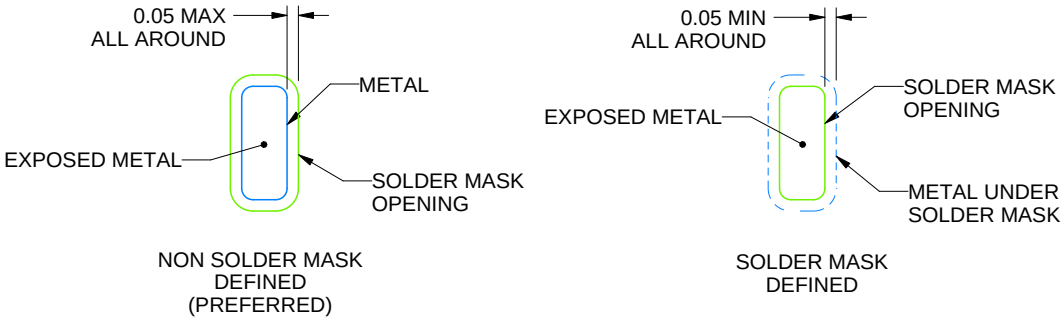


NOTES:

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)

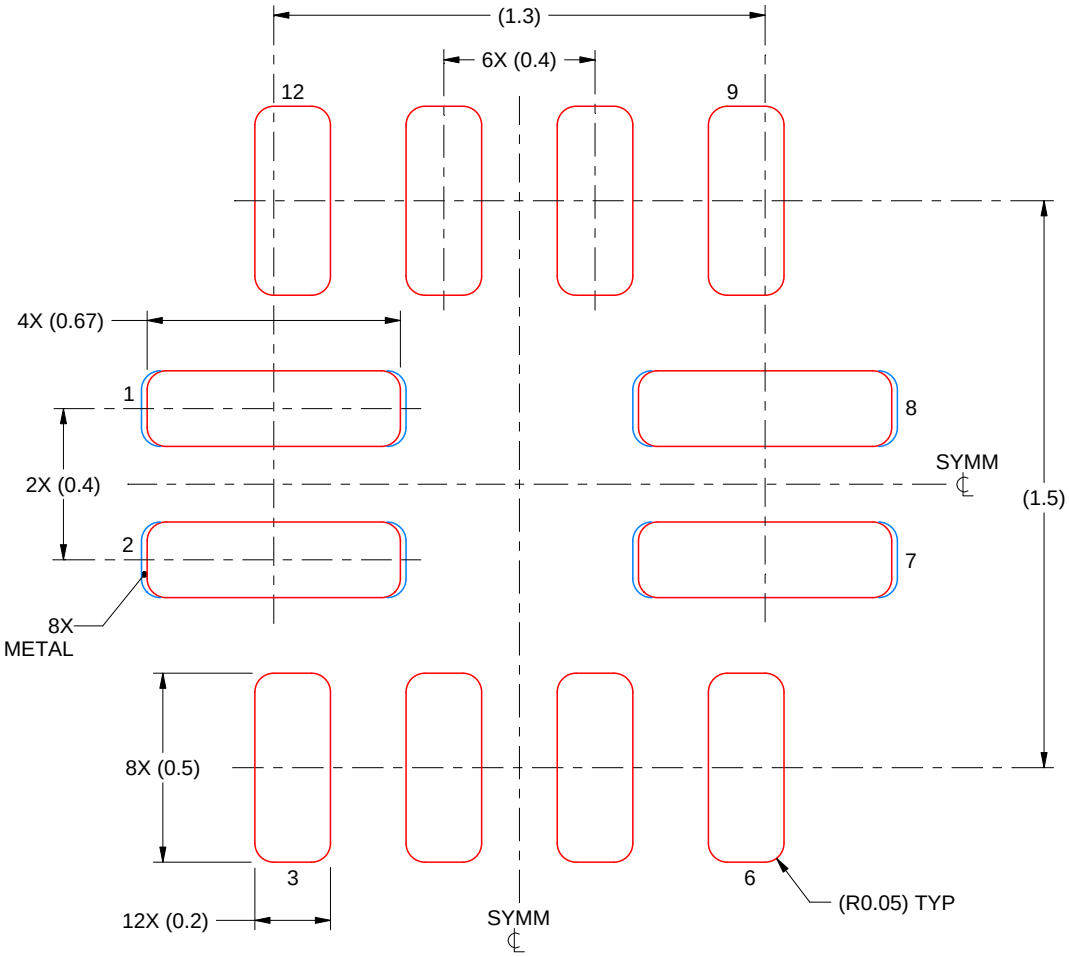
3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

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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