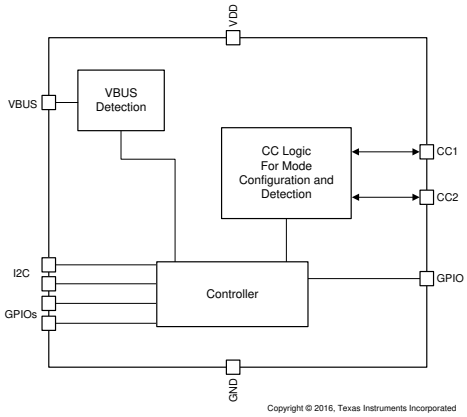
TUSB320 USB Type-C™ 配置通道逻辑和端口控制（）

1 特性

- USB Type-C™ 规范 1.1
- 向后兼容 USB Type-C 规范 1.0
- 支持高达 3A 的电流广播和检测
- 模式配置
  - 仅主机 - DFP（拉电流）
  - 仅器件 – UFP（灌电流）
  - 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（默认、中等和高）
- V_{BUS} 检测
- I^2C 或 GPIO 控制
- 通过 I^2C 实现角色配置控制
- 电源电压：2.7V 至 5V
- 低电流消耗
- 工业温度范围：–40°C 至 85°C

2 应用

- 主机、器件、双角色端口应用
- 手机
- 平板电脑和笔记本电脑
- USB 外设



简化版原理图

3 说明

TUSB320 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。TUSB320 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。TUSB320 器件可配置为下行端口 (DFP)、上行端口 (UFP) 或双角色端口 (DRP)，是任何应用的理想之选。

根据 Type-C 规范，TUSB320 器件会交替配置为 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来确定 USB 端口的连接时间、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。TUSB320 器件适用于工业级和商业级温度范围。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
TUSB320	X2QFN (12)	1.60mm × 1.60mm
TUSB320I	X2QFN (12)	1.60mm x 1.60mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。

示例应用

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4 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision E (May 2017) to Revision F (March 2022) — **Page**

- 更新了整个文档中的表格、图和交叉参考的编号格式 1
- 在整个数据表中将术语*主机*更改为*控制器*，以便与 MIPI I3C 规范和 NXP 的包容性语言项目保持一致 1
- Added the Junction Temperature to the *Absolute Maximum Ratings* section 5
- Changed the tCCCB_DEFAULT typical parameter from 168 ms to 133 ms 7
- Added *Functional Block Diagram* section 9

Changes from Revision D (October 2016) to Revision E (May 2017) — **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 C (September 2016) to Revision D (October 2016) — **Page**

- Changed text for Pin 7 in the *Pin Functions* table From: "default current mode detected (H); medium or high current mode detected (L)." To: "Refer to 表 7-3 for more details." 4
- Changed text for Pin 8 in the *Pin Functions* table From: "default or medium current mode detected (H); high current mode detected (L)." To: "Refer to 表 7-3 for more details." 4

Changes from Revision B (March 2016) to Revision C (September 2016) — **Page**

- Changed pins CC1 and CC2 values From: MIN = -0.3 MAX = V_{DD} + 0.3 To: MIN -0.3 MAX = 6 in the *节 6.1* ... 5

Changes from Revision A (June 2015) to Revision B (March 2016) — **Page**

- Added Note 1 and 2 to the *Pin Functions* table 4
- Changed the DESCRIPTION of pin EN_N pin in the *Pin Functions* table 4
- Changed the DESCRIPTION of pin V_{DD} in the *Pin Functions* table 4
- Changed the MIN, TYP, and MAX values for $V_{TH\_UFP\_CC\_USB}$, $V_{TH\_UFP\_CC\_MED}$, and $V_{TH\_UFP\_CC\_HIGH}$ in the *节 6.5* table 6
- Added Test Condition "See 图 6-1" to V_{BUS_THR} in the *节 6.5* 6

- Added Note 2 to the 节 6.5 table 6
- Updated 节 6.6 table with new values..... 7
- Added *Data hold time, Data valid time, Data valid acknowledge time*, and C_{bus_400kHz} values to 节 6.6 table.... 7
- Changed the 节 6.7 table 7
- Added Note: "SW must make sure..." to the Description of INTERRUPT_STATUS in 表 7-7 16
- Added text to list item 2 in the 节 8.3 section..... 27

Changes from Revision * (May 2015) to Revision A (June 2015)	Page
• 将 TUSB320 的器件状态从*产品预发布*更改为*量产数据*	1

5 Pin Configuration and Functions

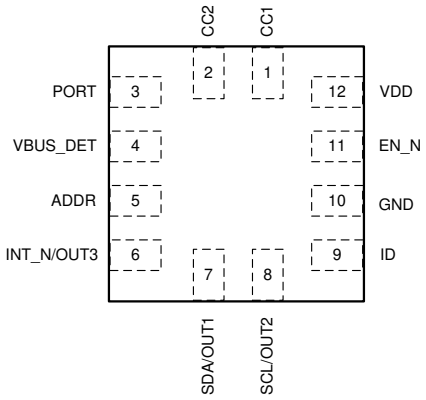

图 5-1. RWB Package, 12-Pin X2QFN (Top View)

表 5-1. Pin Functions

PIN		TYPE(3)	DESCRIPTION
NAME	NO.		
CC1	1	I/O	Type-C configuration channel signal 1
CC2	2	I/O	Type-C configuration channel signal 2
PORT(1)	3	I	Tri-level input pin to indicate port mode. The state of this pin is sampled when EN_N is asserted low and VDD is active. This pin is also sampled following a I2C_SOFT_RESET. 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(1)	4	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.
ADDR(1)	5	I	Tri-level input pin to indicate I^2C address or GPIO mode: H - I^2C is enabled and I^2C 7-bit address is 0x61. NC - GPIO mode (I^2C is disabled) L - I^2C is enabled and I^2C 7-bit address is 0x60. ADDR pin should be pulled up to V_{DD} if high configuration is desired
INT_N/OUT3(1)	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^2C control mode and is an active low interrupt signal for indicating changes in I^2C 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(1) (2)	7	I/O	The SDA/OUT1 is a dual-function pin. When I^2C is enabled (ADDR pin is high or low), this pin is the I^2C 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 TUSB320 device is in UFP mode: Refer to 表 7-3 for more details.
SCL/OUT2(1) (2)	8	I/O	The SCL/OUT2 is a dual function pin. When I^2C is enabled (ADDR pin is high or low), this pin is the I^2C 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 TUSB320 device is in UFP mode: Refer to 表 7-3 for more details.
ID(1)	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	Enable signal; active low. Pulled up to V_{DD} internally to disable the TUSB320 device. If controlled externally, must be held high at least for 50 ms after V_{DD} has reached its valid voltage level.
V_{DD}	12	P	Positive supply voltage. V_{DD} must ramp within 25 ms or less

(1) When V_{DD} is off, the TUSB320 non-failsafe pins (VBUS_DET, ADDR, PORT, ID, OUT[3:1] pins) could back-drive the TUSB320 device if not handled properly. When necessary to pull these pins up, it is recommended to pullup PORT, ADDR, INT_N/OUT3, and ID to the device V_{DD} supply. The VBUS_DET must be pulled up to VBUS through a 900-kΩ resistor.
(2) When using the 3.3 V supply for I^2C, the end user must ensure that the V_{DD} is 3 V and above. Otherwise the I^2C may back power the device.
(3) I = input, O = output, P = power

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, ADDR, ID, EN_N, INT_N/OUT3	-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
Junction temperature		-40	105	°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	2.7		5	V
V_{BUS}	System V_{BUS} voltage	4	5	28	V
VBUS_DET	VBUS_DET threshold voltage on the pin			4	V
T_A	TUSB320I Operating free air temperature range	-40	25	85	°C
	TUSB320 Operating free air temperature range	0	25	70	°C

6.4 Thermal Information

THERMAL METRIC(1)		TUSB320 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} = 4.5 V, EN_N = L, ADDR = NC, PORT = L)			100		µA
I_{ACTIVE_UFP}	Current consumption in active mode. (V_{DD} = 4.5 V, EN_N = L, ADDR = NC, PORT = L)			100		µA
$I_{SHUTDOWN}$	Leakage current when V_{DD} is supplied but the TUSB320 device is not enabled. (V_{DD} = 4.5 V, EN_N = H)				1.7	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 an 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 an 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 an 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 an 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 an 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 an UFP attach when configured as a DFP and advertising high current (3.0 A) source capability.		2.46	2.6	2.74	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, ADDR, INT/OUT3, EN_N, ID						
V_{IL}	Low-level control signal input voltage, (PORT, ADDR, EN_N)				0.4	V
V_{IM}	Mid-level control signal input voltage (PORT, ADDR)		0.28 × V_{DD}		0.56 × V_{DD}	V
V_{IH}	High-level control signal input voltage (PORT, ADDR, EN_N)		V_{DD} - 0.3			V
I_{IH}	High-level input current		–20		20	µA
I_{IL}	Low-level input current		–10		10	µA
R_{EN_N}	Internal pullup resistance for EN_N			1.1		MΩ
R_{pu} (2)	Internal pullup resistance (PORT, ADDR)			588		kΩ
R_{pd} (2)	Internal pulldown resistance (PORT, 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
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 (PORT, ADDR)			4.7		kΩ

6.5 Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I²C - SDA/OUT1, SCL/OUT2 can operate from 1.8 or 3.3 V (±10%)(3)						
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	See 图 6-1	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

(1) V_{DD} must be 3.5 V or greater to advertise 3 A current.
(2) Internal pullup and pulldown for PORT and ADDR are removed after the device has sampled EN = high or EN_N = low.
(3) 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_{BUF}	Bus free time between a stop and start condition	1.3			µs
$t_{VD;DAT}$	Data valid time			0.9	ns
$t_{VD;ACK}$	Data valid acknowledge time			0.9	ns
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

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	DEBOUCE register = 2'b00		133		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 during which the TUSB320 or the TUSB320I in DFP mode completes a DFP to UFP and back advertisement.		50	75	100	ms
t_{I2C_EN}	Time from TUSB320 EN_N low or TUSB320I EN high and V_{DD} active to I²C access available				100	ms
t_{SOFT_RESET}	Soft reset duration		26	49	95	ms

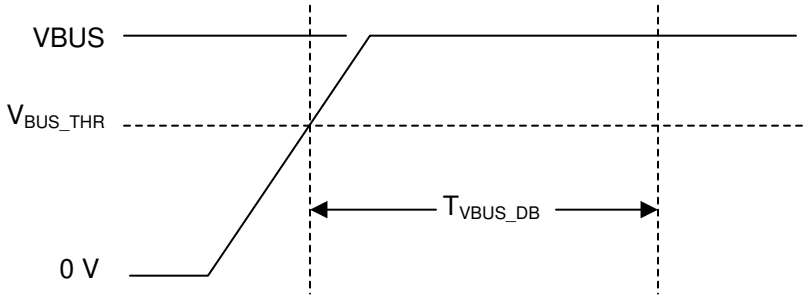

图 6-1. VBUS Detect and Debounce

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, and 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 TUSB320 device provides Configuration Channel (CC) logic for determining USB port attach and detach, role detection, cable orientation, and Type-C current mode. The TUSB320 device also contains several features such as mode configuration and low standby current which make this device ideal for source or sinks in USB 2.0 applications.

7.2 Functional Block Diagram

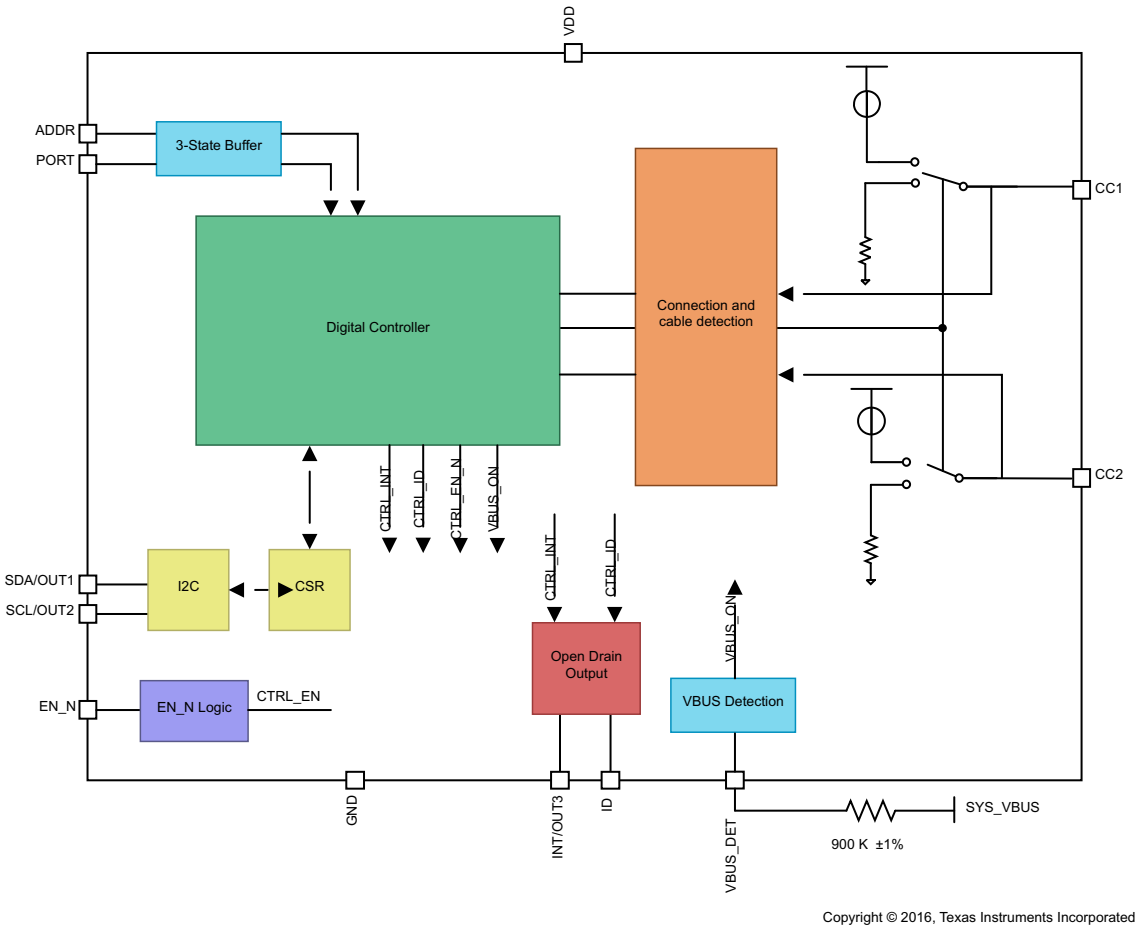

图 7-1. Functional Block Diagram of TUSB320

7.2.1 Cables, Adapters, and Direct Connect Devices

Type-C Specification 1.1 defines several cables, plugs and receptacles to be used to attach ports. The TUSB320 device supports all cables, receptacles, and plugs. The TUSB320 device does not support e-marking.

7.2.1.1 USB Type-C Receptacles and Plugs

Below is list of Type-C receptacles and plugs supported by the TUSB320 device:

- USB Type-C receptacle for USB 2.0 platforms and devices
- USB full-featured Type-C plug
- USB 2.0 Type-C plug

7.2.1.2 USB Type-C Cables

Below is a list of Type-C cable types supported by the TUSB320 device:

- USB full-featured Type-C cable
- USB 2.0 Type-C cable with USB 2.0 plug
- Captive cable with either a USB full-featured plug or USB 2.0 plug

7.2.1.3 Legacy Cables and Adapters

The TUSB320 device supports legacy cable adapters as defined by the Type-C specification. The cable adapter must correspond to the mode configuration of the TUSB320 device.

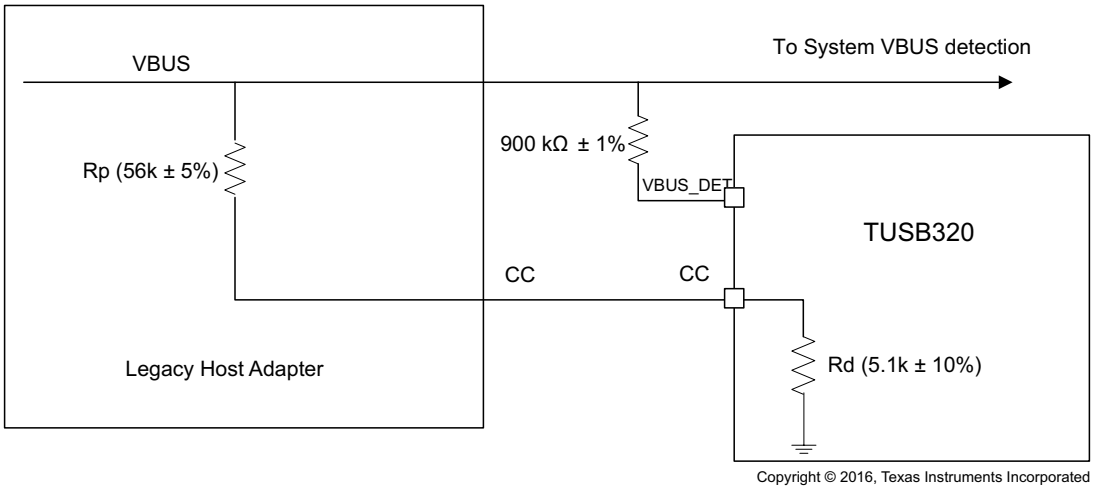

图 7-2. Legacy Adapter Implementation Circuit

7.2.1.4 Direct Connect Devices

The TUSB320 device supports the attaching and detaching of a direct-connect device.

7.2.1.5 Audio Adapters

Additionally, the TUSB320 device supports audio adapters for audio accessory mode, including:

- Passive audio adapter
- Charge through audio adapter

7.3 Feature Description

7.3.1 Port Role Configuration

The TUSB320 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 TUSB320 device to be used in a variety of applications. The TUSB320 device samples the PORT pin after reset and maintains the desired mode until the TUSB320 device is reset again. 表 7-1 lists the supported features in each mode.

表 7-1. Supported Features for the TUSB320 Device by Mode

PORT PIN / SUPPORTED FEATURES	HIGH (DFP ONLY)	LOW (UFP ONLY)	NC (DRP)
Port attach and detach	Yes	Yes	Yes
Cable orientation (through I^2C)	Yes	Yes	Yes
Current advertisement	Yes	—	Yes (DFP)
Current detection	—	Yes	Yes (UFP)
Accessory modes (audio and debug)	Yes	—	Yes
Active cable detection	Yes	—	Yes (DFP)
I^2C / GPIO	Yes	Yes	Yes
Legacy cables	Yes	Yes	Yes
V_{BUS} detection	—	Yes	Yes (UFP)

7.3.1.1 Downstream Facing Port (DFP) – Source

The TUSB320 device can be configured as a DFP only by pulling the PORT pin high through a resistance to V_{DD}. In DFP mode, the TUSB320 device constantly presents Rps on both CC. In DFP mode, the TUSB320 device initially advertises default USB Type-C current. The Type-C current can be adjusted through I^2C if the system needs to increase the amount advertised. The TUSB320 device adjusts the Rps to match the desired Type-C current advertisement. In GPIO mode, the TUSB320 device only advertises default Type-C current.

When configured as a DFP, the TUSB320 can operate with older USB Type-C 1.0 devices except for a USB Type-C 1.0 DRP device. The TUSB320 can not operate with a USB Type-C 1.0 DRP device. This limitation is a result of a backwards compatibility problem between USB Type-C 1.1 DFP and a USB Type-C 1.0 DRP.

7.3.1.2 Upstream Facing Port (UFP) – Sink

The TUSB320 device can be configured as an UFP only by pulling the PORT pin low to GND. In UFP mode, the TUSB320 device constantly presents pulldown resistors (Rd) on both CC pins. The TUSB320 device monitors the CC pins for the voltage level corresponding to the Type-C mode current advertisement by the connected DFP. The TUSB320 device debounces the CC pins and wait for V_{BUS} detection before successfully attaching. As an UFP, the TUSB320 device detects and communicates the advertised current level of the DFP to the system through the OUT1 and OUT2 GPIOs (if in GPIO mode) or through the I^2C CURRENT_MODE_DETECT register one time in the Attached.SNK state.

After initial connection, the advertised current by the connected DFP could change due to changes in its system power resource. For example, a DFP could advertise high current on initial connection but then decide to reduce to default current because user removed external power adapter from their notebook. Because the TUSB320 will only advertise on OUT1 and OUT2 the initial advertised current, it is recommend to monitor the advertised current through the TUSB320’s I2C interface from the CURRENT_MODE_DETECT register. System software must periodically perform a I2C_SOFT_RESET in order for the CURRENT_MODE_DETECT register to be updated based on the state of the CC pins.

7.3.1.3 Dual Role Port (DRP)

The TUSB320 device can be configured to operate as a DRP when the PORT pin is left floated on the PCB. In DRP mode, the TUSB320 device toggles between operating as a DFP and an UFP. When functioning as a DFP in DRP mode, the TUSB320 device complies with all operations as defined for a DFP according to the Type-C specification. When presenting as an UFP in DRP mode, the TUSB320 device operates as defined for an UFP according to the Type-C specification.

7.3.2 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 an UFP can sink. The default current advertisement for the TUSB320 device is 500 mA (for USB 2.0) or 900 mA (for USB 3.1). If a higher level of current is available, the I^2C 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 TUSB320 device is 3.5 V or greater. 表 7-2 lists the Type-C current advertisements in GPIO an I^2C modes.

表 7-2. Type-C Current Advertisement for GPIO and I^2C Modes

TYPE-C CURRENT		GPIO MODE (ADDR PIN IN NC)		I^2C MODE (ADDR PIN H, L)	
		UFP (PORT PIN L)	DFP (PORT PIN H)	UFP	DFP
Default	500 mA (USB 2.0) 900 mA (USB 3.1)	Current mode detected and output through OUT1 / OUT2	Only advertisement	Current mode detected and read through I^2C register	I^2C register default is 500 or 900 mA
Medium – 1.5 A			N/A		Advertisement selected through writing I^2C register
High – 3 A					

7.3.3 Accessory Support

The TUSB320 device supports audio and debug accessories in DFP mode and DRP mode. Audio and debug accessory support is provided through reading of I^2C 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).

7.3.3.1 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 TUSB320 device must detect a resistance < Ra on both of the CC pins.

Secondly, a charge through audio adapter may 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 supply V_{BUS} when the plug detects a connection.

When the TUSB320 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.

7.3.3.2 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 it is important because 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 TUSB320 when in DRP or UFP mode.

7.3.4 I^2C and GPIO Control

The TUSB320 device can be configured for I^2C 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 TUSB320 device is in GPIO output mode. When the ADDR pin is pulled high or pulled low, the TUSB320 device is in I^2C mode.

All outputs for the TUSB320 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. 表 7-3 lists the output pin settings. See the *Pin Functions* table for more information.

表 7-3. Simplified Operation for OUT1 and OUT2

OUT1	OUT2	ADVERTISEMENT
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 I^2C mode, the TUSB320 device uses the SCL and SDA lines for clock and data and the INT_N pin to communicate a change in I^2C registers, or an interrupt, to the system. The INT_N pin is pulled low when the TUSB320 device updates the registers with new information. The INT_N pin is open drain. The INTERRUPT_STATUS register should be set when the INT_N pin is pulled low. To clear the INTERRUPT_STATUS register, the end user writes to I^2C.

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.

备注

When using the 3.3 V supply for I^2C, the end user must ensure that the V_{DD} is 3 V and above. Otherwise the I^2C may back power the device.

7.3.5 V_{BUS} Detection

The TUSB320 device supports V_{BUS} detection according to the Type-C specification. V_{BUS} detection is used to determine the attachment and detachment of an 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 TUSB320 device if the PORT pin is configured as a DRP or an UFP. If the TUSB320 device is configured as a DFP and only ever used in DFP mode, the VBUS_DET pin can be left unconnected.

7.4 Device Functional Modes

The TUSB320 device has four functional modes. 表 7-4 lists these modes:

表 7-4. USB Type-C States According to TUSB320 Functional Modes

MODES	GENERAL BEHAVIOR	PORT PIN	STATES[1]
Unattached	USB port unattached. ID, PORT operational. I^2C on. 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. I^2C on.	UFP	Attached.SNK
		DRP	Attached.SNK
			Attached.SRC
			Audio accessory
			Debug accessory
		DFP	Attached.SRC
			Audio accessory
			Debug accessory
Dead battery	No operation. V_{DD} not available.	UFP/DRP/DFP	Default device state to UFP/SNK with Rd.

表 7-4. USB Type-C States According to TUSB320 Functional Modes (continued)

MODES	GENERAL BEHAVIOR	PORT PIN	STATES(1)
Shutdown	V_{DD} available. EN_N pin high.	UFP/DRP/DFP	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 TUSB320 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^2C are operational. After the TUSB320 device is powered up, the part enters unattached mode until a successful attach has been determined. Initially, right after power up, the TUSB320 device comes up as an Unattached.SNK. The TUSB320 device checks the PORT pin and operates according to the mode configuration. The TUSB320 device toggles between the UFP and the DFP if configured as a DRP. In unattached mode, I^2C can be used to change the mode configuration or port role if the board configuration of the PORT pin is not the desired mode. Writing to the I^2C MODE_SELECT register can override the PORT pin only in unattached mode. The PORT pin is only sampled at reset or power up. I^2C must be used after reset to change the device mode configuration.

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 TUSB320 device communicates to the AP that the USB port is attached. This happens through the ID pin if TUSB320 is configured as a DFP or DRP connect as source. If TUSB320 is configured as an UFP or a DRP connected as a sink, the OUT1/OUT2 and INT_N/OUT3 pins are used. The TUSB320 device exits active mode under the following conditions:

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

During active mode, I^2C cannot be used to change the mode configuration. This can only be done if TUSB320 is in an unattached state.

7.4.3 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:

- TUSB320 in UFP with 5.1-kΩ ± 20% Rd; cable connected and providing charge
- TUSB320 in UFP with 5.1-kΩ ± 20% Rd; nothing connected (application could be off or have a discharged battery)

Upon exiting dead battery mode (V_{DD} is active), the software must perform the following sequence in order for Rp to be presented on both CC pins:

1. Write a 0x04 to I^2C address 0x45.
2. Wait 30ms.
3. Write a 0x00 to I^2C address 0x45.

Between steps 1 and 3, the status flags will be set. The software must ignore these flags when performing the three steps.

备注

When V_{DD} is off, the TUSB320 non-failsafe pins (VBUS_DET, ADDR, PORT, ID, OUT[3:1] pins) could back-drive the TUSB320 device if not handled properly. When necessary to pull these pins up, it is recommended to pullup PORT, ADDR, INT_N/OUT3, and ID to the device’s V_{DD} supply. The VBUS_DET must be pulled up to V_{BUS} through a 900-kΩ resistor.

7.4.4 Shutdown Mode

Shutdown mode for TUSB320 device is defined as follows:

- Supply voltage available and EN_N pin is pulled high.
- EN_N pin has internal pullup resistor.
- The TUSB320 device is off, but still maintains the Rd on the CC pins.

7.5 Programming

For further programmability, the TUSB320 device can be controlled using I^2C. The TUSB320 device local I^2C 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^2C clock and I^2C data respectively. If I^2C is the preferred method of control, the ADDR pin must be set accordingly.

表 7-5. TUSB320 I^2C Addresses

TUSB320 I^2C 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	0	0	1	0/1
L	1	1	0	0	0	0	0	0/1

The following procedure should be followed to write to TUSB320 I^2C registers:

1. The controller initiates a write operation by generating a start condition (S), followed by the TUSB320 7-bit address and a zero-value R/W bit to indicate a write cycle
2. The TUSB320 device acknowledges the address cycle
3. The controller presents the sub-address (I^2C register within the TUSB320 device) to be written, consisting of one byte of data, MSB-first
4. The TUSB320 device acknowledges the sub-address cycle
5. The controller presents the first byte of data to be written to the I^2C register
6. The TUSB320 device acknowledges the byte transfer
7. The controller may continue presenting additional bytes of data to be written, with each byte transfer completing with an acknowledge from the TUSB320 device
8. The controller terminates the write operation by generating a stop condition (P)

The following procedure should be followed to read the TUSB320 I^2C registers:

1. The controller initiates a read operation by generating a start condition (S), followed by the TUSB320 7-bit address and a one-value R/W bit to indicate a read cycle
2. The TUSB320 device acknowledges the address cycle
3. The TUSB320 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^2C register occurred prior to the read, then the TUSB320 device starts at the sub-address specified in the write.
4. The TUSB320 device waits for either an acknowledge (ACK) or a not-acknowledge (NACK) from the controller after each byte transfer; the I^2C controller acknowledges reception of each data byte transfer
5. If an ACK is received, the TUSB320 device transmits the next byte of data
6. The controller terminates the read operation by generating a stop condition (P)

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

1. The controller initiates a write operation by generating a start condition (S), followed by the TUSB320 7-bit address and a zero-value R/W bit to indicate a read cycle
2. The TUSB320 device acknowledges the address cycle
3. The controller presents the sub-address (I^2C register within the TUSB320 device) to be read, consisting of one byte of data, MSB-first
4. The TUSB320 device acknowledges the sub-address cycle
5. The controller terminates the read operation by generating a stop condition (P)

备注

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^2C controller terminates the read operation. If a I^2C address write occurred prior to the read, then the reads start at the sub-address specified by the address write.

7.6 Register Maps

表 7-6. CSR Registers

ACCESS TAG	NAME	MEANING
R	Read	The field may be read by software.
W	Write	The field may be written by software.
S	Set	The field may be set by a write of one. Writes of zeros to the field have no effect.
C	Clear	The field may be cleared by a write of one. Writes of zeros to the field have no effect.
U	Update	Hardware may autonomously update this field.
NA	No Access	Not accessible or not applicable.

表 7-7. CSR Registers Bit Address and Description

ADDRESS	BIT(S)	BIT NAME	DESCRIPTION	ACCESS
0x00 – 0x07	7:0	DEVICE_ID	For the TUSB320 device these fields return a string of ASCII characters returning TUSB320 Addresses 0x07 - 0x00 = {0x00 0x54 0x55 0x53 0x42 0x33 0x32 0x30}	R

表 7-7. CSR Registers Bit Address and Description (continued)

ADDRESS	BIT(S)	BIT NAME	DESCRIPTION	ACCESS
0x08	7:6	CURRENT_MODE_ADVERTISE	These bits are programmed by the application to raise the current advertisement from default. 00 – Default (500 mA / 900 mA) initial value at startup 01 – Medium (1.5 A) 10 – High (3 A) 11 – Reserved	RW
	5:4	CURRENT_MODE_DETECT	These bits are set when an UFP determines the Type-C Current mode. 00 – Default (value at start up) 01 – Medium 10 – Charge through accessory – 500 mA 11 – High	RU
	3:1	ACCESSORY_CONNECTED	These bits are read by the application to determine if an accessory was attached. 000 – No accessory attached (default) 001 – Reserved 010 – Reserved 011 – Reserved 100 – Audio accessory 101 – Audio charged thru accessory 110 – Debug accessory 111 – Reserved	RU
	0	ACTIVE_CABLE_DETECTION	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.	RU

表 7-7. CSR Registers Bit Address and Description (continued)

ADDRESS	BIT(S)	BIT NAME	DESCRIPTION	ACCESS
0x09	7:6	ATTACHED_STATE	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. 00 – Not attached (default) 01 – Attached.SRC (DFP) 10 – Attached.SNK (UFP) 11 – Attached to an accessory	RU
	5	CABLE_DIR	Cable orientation. The application can read these bits for cable orientation information. 0 – CC1 1 – CC2 (default)	RU
	4	INTERRUPT_STATUS	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. 0 – Clear 1 – Interrupt (When INT_N is pulled low, this bit will be 1. This bit is 1 whenever any CSR are changed) Note: SW must make sure the INTERRUPT_STATUS has been cleared to zero. Rewrites to this register are needed for the INT_N to be correctly asserted for all interrupt events.	RCU
	3		Reserved	R
	2:1	DRP_DUTY_CYCLE	Percentage of time that a DRP advertises DFP during tDRP 00 – 30% (default) 01 – 40% 10 – 50% 11 – 60%	RW
	0		Reserved	R

表 7-7. CSR Registers Bit Address and Description (continued)

ADDRESS	BIT(S)	BIT NAME	DESCRIPTION	ACCESS
0x0A	7:6	DEBOUNCE	The nominal amount of time the TUSB320 device debounces the voltages on the CC pins. 00 – 133 ms (default) 01 – 116 ms 10 – 151 ms 11 – 168 ms	RW
	5:4	MODE_SELECT	This register can be written to set the TUSB320 device mode operation. The ADDR pin must be set to I^2C mode. If the default is maintained, the TUSB320 device operates according to the PORT pin levels and modes. The MODE_SELECT can only be changed when in the unattached state. 00 – Maintain mode according to PORT pin selection (default) 01 – UFP mode (unattached.SNK) 10 – DFP mode (unattached.SRC) 11 – DRP mode (start from unattached.SNK)	RW
	3	I^2C_SOFT_RESET	This resets the digital logic. The bit is self-clearing. A write of 1 starts the reset. The following registers maybe affected after setting this bit: CURRENT_MODE_DETECT ACTIVE_CABLE_DETECTION ACCESSORY_CONNECTED ATTACHED_STATE CABLE_DIR	RSU
	2:1		Reserved	R
	0		Reserved	R
0x45	7:3		Reserved	R
	2	DISABLE_RD_RP	When this field is set, Rd and Rp are disabled. 0 – Normal operation (default) 1 – Disable Rd and Rp	RW
	1:0		Reserved. For TI internal use only. Do not change default value.	RW

8 Application and Implementation

备注

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 TUSB320 device is a Type-C configuration channel logic and port controller. The TUSB320 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 TUSB320 device can be used in a source application (DFP) or in a sink application (UFP).

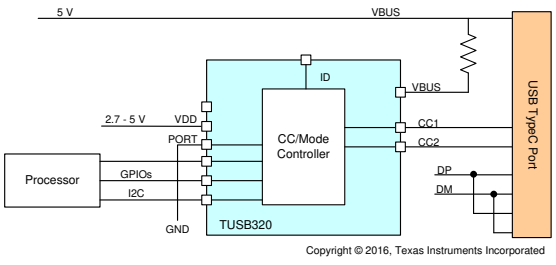

图 8-1. TUSB320 in UFP Mode Supporting Default Implementation

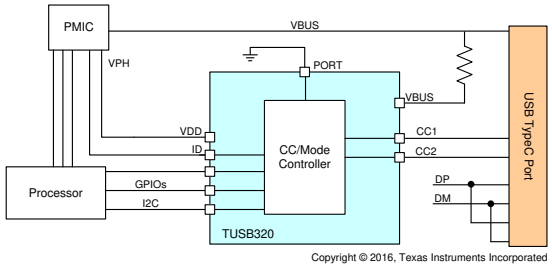

图 8-2. TUSB320 in UFP Mode Supporting Advanced Power Delivery

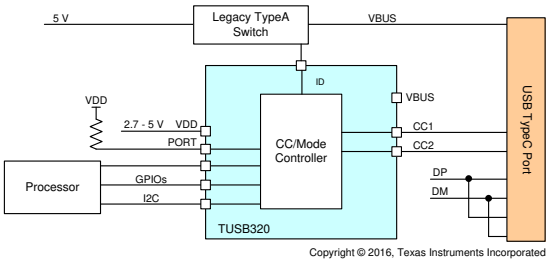

图 8-3. TUSB320 in DFP Mode Supporting Default Implementation

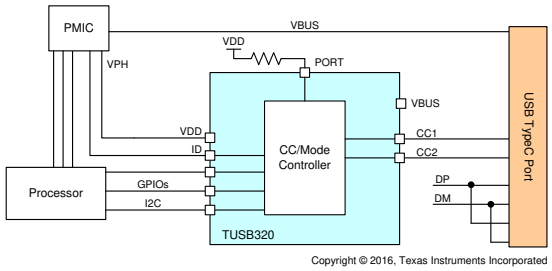

图 8-4. TUSB320 in DFP Mode Supporting Advanced Power Delivery

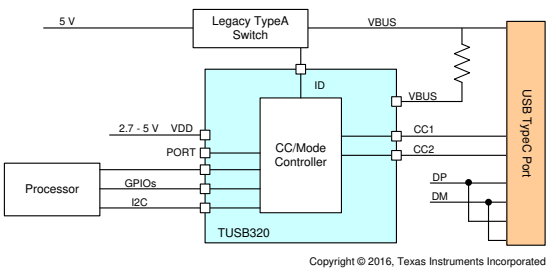

图 8-5. TUSB320 in DRP Mode Supporting Default Implementation

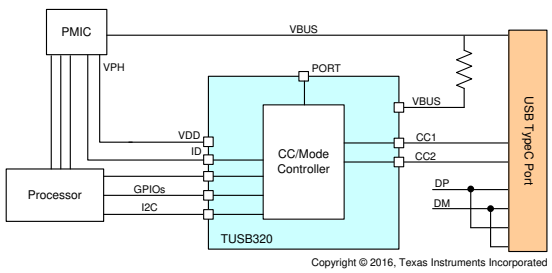

图 8-6. TUSB320 in DRP Mode Supporting Advanced Power Delivery

8.2 Typical Application

8.2.1 DRP in I²C Mode

图 8-7 shows the TUSB320 device configured as a DRP in I²C mode.

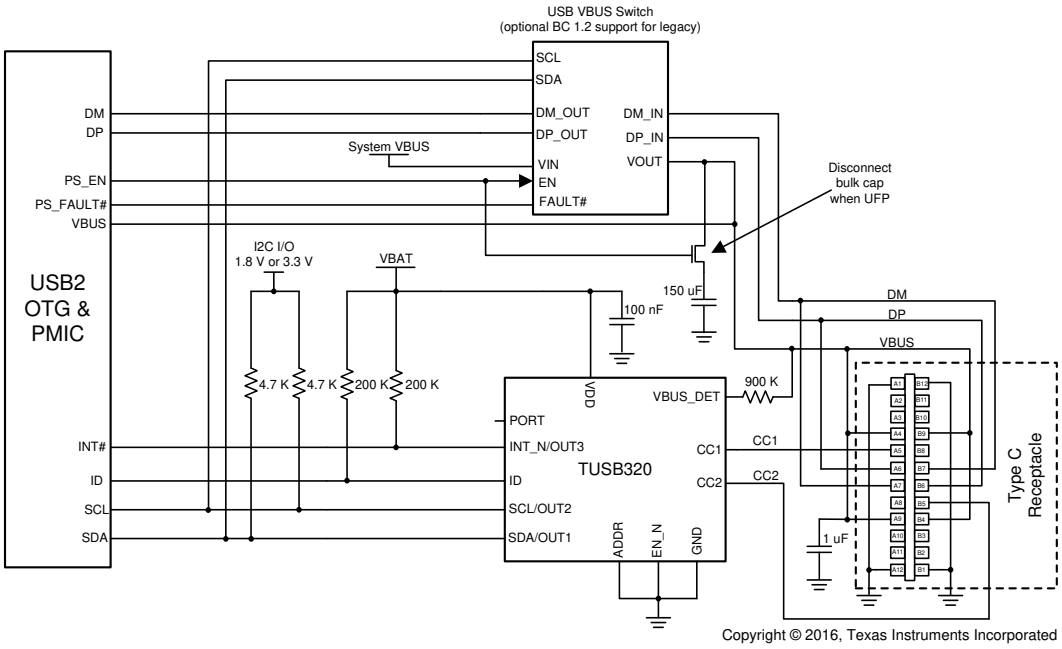

图 8-7. DRP in I²C Mode Schematic

8.2.1.1 Design Requirements

For this design example, use the parameters listed in 表 8-1:

表 8-1. Design Requirements for DRP in I²C Mode

DESIGN PARAMETER	VALUE
V_{DD} (2.75 V to 5 V)	VBAT (less than 5 V)
Mode (I²C or GPIO)	I²C ADDR pin must be pulled down or pulled up
I²C address (0x61 or 0x60)	0x60 ADDR pin must be pulled low or tied to GND
Type-C port type (UFP, DFP, or DRP)	DRP PORT pin is NC
Shutdown support (EN_N control)	No

8.2.1.2 Detailed Design Procedure

The TUSB320 device supports a V_{DD} in the range of 2.75 V to 5 V. In this particular use case, VBAT which must be in the required V_{DD} range is connected to the V_{DD} pin. A 100-nF capacitor is placed near V_{DD}.

The TUSB320 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 0x60. 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 TUSB320 device can enter shutdown mode by pulling the EN_N pin high, which puts the TUSB320 device into a low power state. In this case, external control of the EN_N pin is not implemented and therefore the EN_N pin is tied to GND.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB320 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 TUSB320 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 should not enable V_{BUS} until it is in the Attached.SRC state. If the ID pin is not low but V_{BUS} is detected, then OTG USB controller functions as a device. The ID pin is open drain output and requires an external pullup resistor. It should be pulled up to V_{DD} using a 200-kΩ resistor.

The Type-C port mode is determined by the state of the PORT pin. When the PORT pin is not connected, the TUSB320 device is in DRP mode. The Type-C port mode can also be controlled by the MODE_SELECT register through the I²C interface when the TUSB320 device is in the unattached state.

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 TUSB320 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 TUSB320 device in the recommended range.

The USB2 specification requires the bulk capacitance on V_{BUS} based on UFP or DFP. When operating the TUSB320 device in a DRP mode, it alternates between UFP and DFP. If the TUSB320 device connects as an UFP, the large bulk capacitance must be removed. The FET in 图 8-7 performs this task.

表 8-2. 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

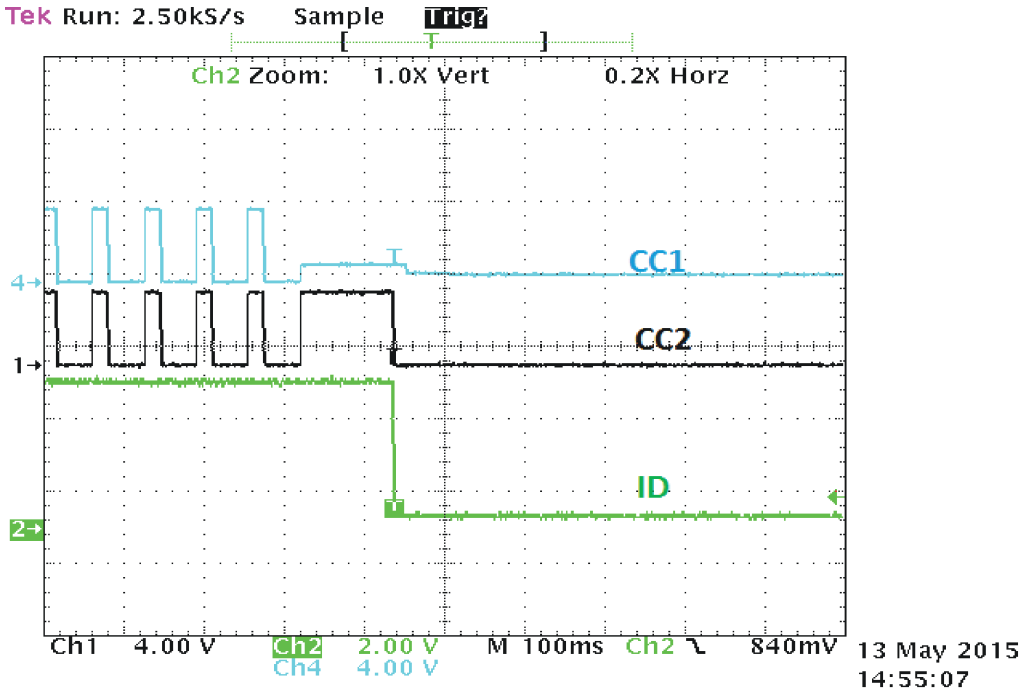

图 8-8. Application Curve for DRP in I²C Mode

8.2.2 DFP in I²C Mode

图 8-9 shows the TUSB320 device configured as a DFP in I²C mode.

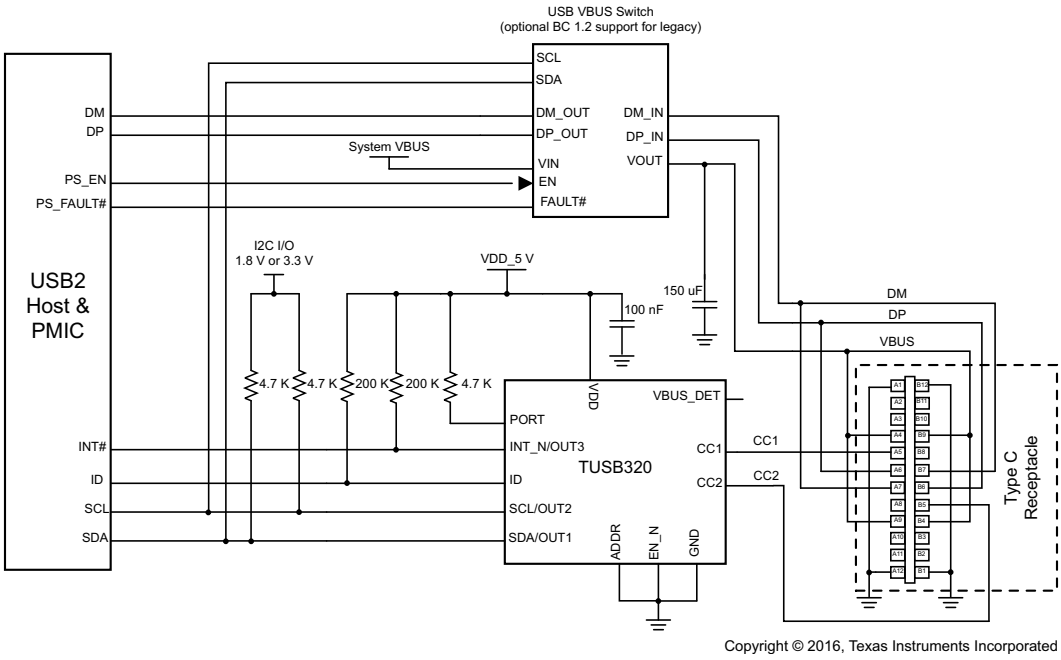

图 8-9. DFP in I²C Mode Schematic

8.2.2.1 Design Requirements

For this design example, use the parameters listed in 表 8-3:

表 8-3. Design Requirements for DFP in I²C Mode

DESIGN PARAMETER	VALUE
V_{DD} (2.75 V to 5 V)	5 V
Mode (I²C or GPIO)	I²C ADDR pin must be pulled down or pulled up
I²C address (0x61 or 0x60)	0x60 ADDR pin must be pulled low or tied to GND
Type-C port type (UFP, DFP, or DRP)	DFP PORT pin is pulled up
Shutdown support (EN_N Control)	No

8.2.2.2 Detailed Design Procedure

The TUSB320 device supports a V_{DD} in the range of 2.75 V to 5 V. In this particular case, V_{DD} is set to 5 V. A 100-nF capacitor is placed near V_{DD}.

The TUSB320 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 an I²C address of 0x60. 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 TUSB320 device can enter shutdown mode by pulling the EN_N pin high, which puts the TUSB320 device into a low power state. In this case, external control of the EN_N pin is not implemented and therefore the EN_N pin is tied to GND.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB320 I^2C 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 Type-C port mode is determined by the state of the PORT pin. When the PORT pin is pulled high, the TUSB320 device is in DFP mode. The Type-C port mode can also be controlled by the MODE_SELECT register through the I^2C interface when the TUSB320 device is in the unattached state.

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 TUSB320 device from the largest V_{BUS} voltage that is possible in present day systems. This resistor along with internal pulldown keeps the voltage observed by the TUSB320 device in the recommended range.

The USB2 specification requires the bulk capacitance on V_{BUS} based on UFP or DFP. When operating the TUSB320 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

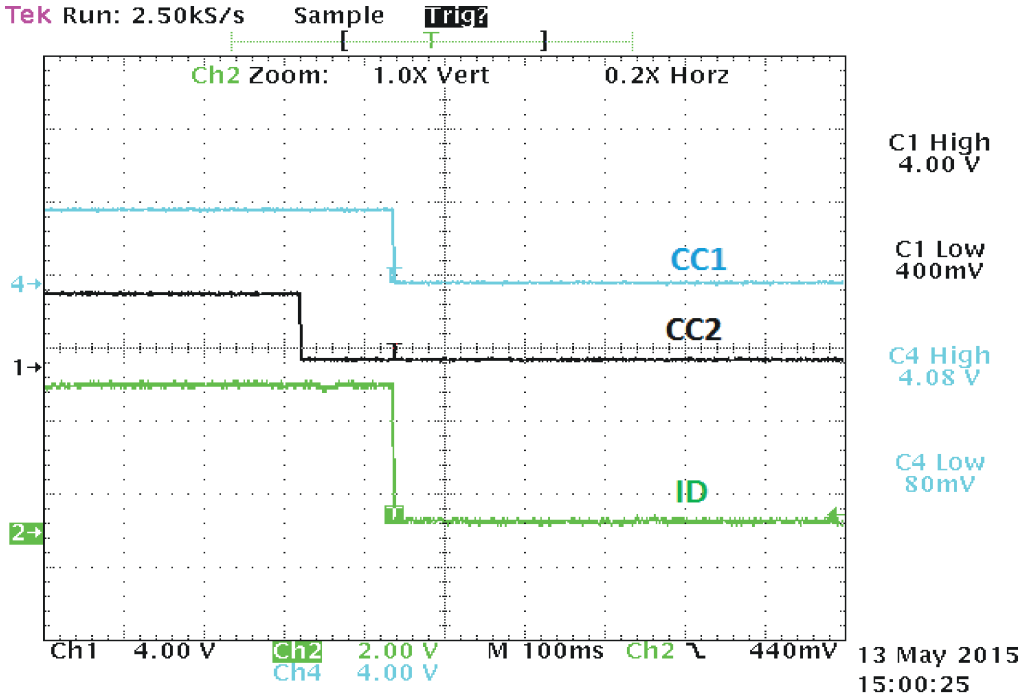

图 8-10. Application Curve for DFP in I^2C Mode

8.2.3 UFP in I²C Mode

图 8-11 shows the TUSB320 device configured as a DFP in I²C mode.

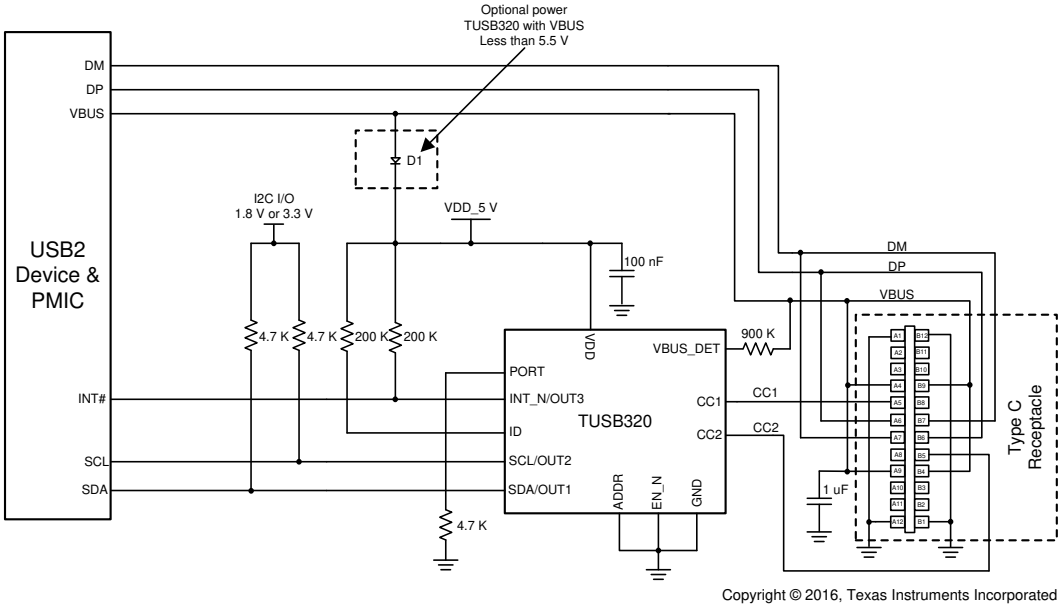

图 8-11. UFP in I²C Mode Schematic

8.2.3.1 Design Requirements

For this design example, use the parameters listed in 表 8-4:

表 8-4. Design Requirements for UFP in I²C Mode

DESIGN PARAMETER	VALUE
V_{DD} (2.75 V to 5 V)	5 V
Mode (I²C or GPIO)	I²C ADDR pin must be pulled down or pulled up
I²C address (0x61 or 0x60)	0x60 ADDR pin must be pulled low or tied to GND
Type-C port type (UFP, DFP, or DRP)	UFP PORT pin is pulled down
Shutdown support (EN_N control)	No

8.2.3.2 Detailed Design Procedure

The TUSB320 device supports a V_{DD} in the range of 2.75 V to 5 V. In this particular case, V_{DD} is set to 5 V. A 100-nF capacitor is placed near V_{DD}. If V_{BUS} is guaranteed to be less than 5.5 V, powering the TUSB320 device through a diode can be implemented.

The TUSB320 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 0x60. 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 TUSB320 device can enter shutdown mode by pulling the EN_N pin high, which puts the TUSB320 device into a low power state. In this case, external control of the EN_N pin is not implemented and therefore the EN_N pin is tied to GND.

The INT_N/OUT3 pin is used to notify the PMIC when a change in the TUSB320 I^2C 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 Type-C port mode is determined by the state of the PORT pin. When the PORT pin is pulled low, the TUSB320 device is in UFP mode. The Type-C port mode can also be controlled by the MODE_SELECT register through the I^2C interface when the TUSB320 device is in the unattached state.

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 TUSB320 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 TUSB320 device in the recommended range.

The USB2 specification requires the bulk capacitance on V_{BUS} based on UFP or DFP. When operating the TUSB320 device in an UFP mode, a bulk capacitance between 1 to 10 µF is required. In this particular case, a 1-µF capacitor was chosen.

8.2.3.3 Application Curves

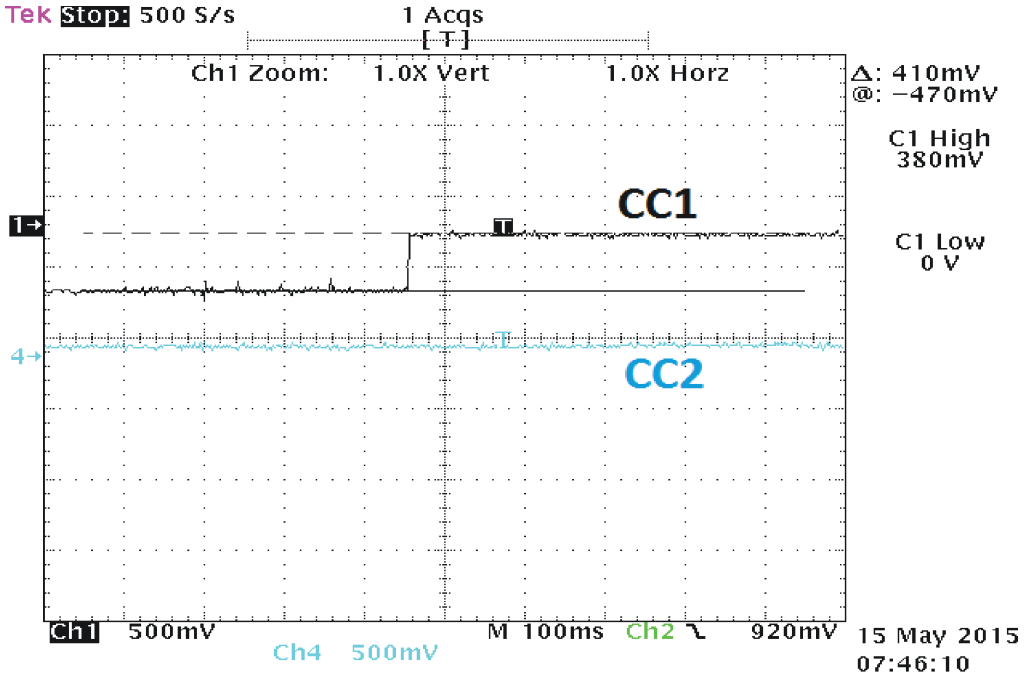

图 8-12. Application Curve for UFP in I^2C Mode

8.3 Initialization Set Up

The general power-up sequence for the TUSB320 device (EN_N tied to ground) is as follows:

1. System is powered off (device has no V_{DD}). The TUSB320 device is configured internally in UFP mode with Rds on CC pins (dead battery).
2. V_{DD} ramps – POR circuit. V_{DD} must ramp within 25 ms or less. IO pull-up power rail (for example, pull up on ID, INT, SCL, SDA, ADDR, and PORT) must ramp with V_{DD} or lag after V_{DD}.
3. I^2C supply ramps up.
4. The TUSB320 device enters unattached mode and determines the voltage level from the PORT pin. This determines the mode in which the TUSB320 device operates (DFP, UFP, and DRP).
5. The TUSB320 device monitors the CC pins as a DFP and V_{BUS} for attach as an UFP.
6. The TUSB320 device enters active mode when attach has been successfully detected.

9 Power Supply Recommendations

The TUSB320 device has a wide power supply range from 2.7 to 5 V, and can be powered by a battery system.

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 TUSB320 V_{DD} pin.

10.2 Layout Example

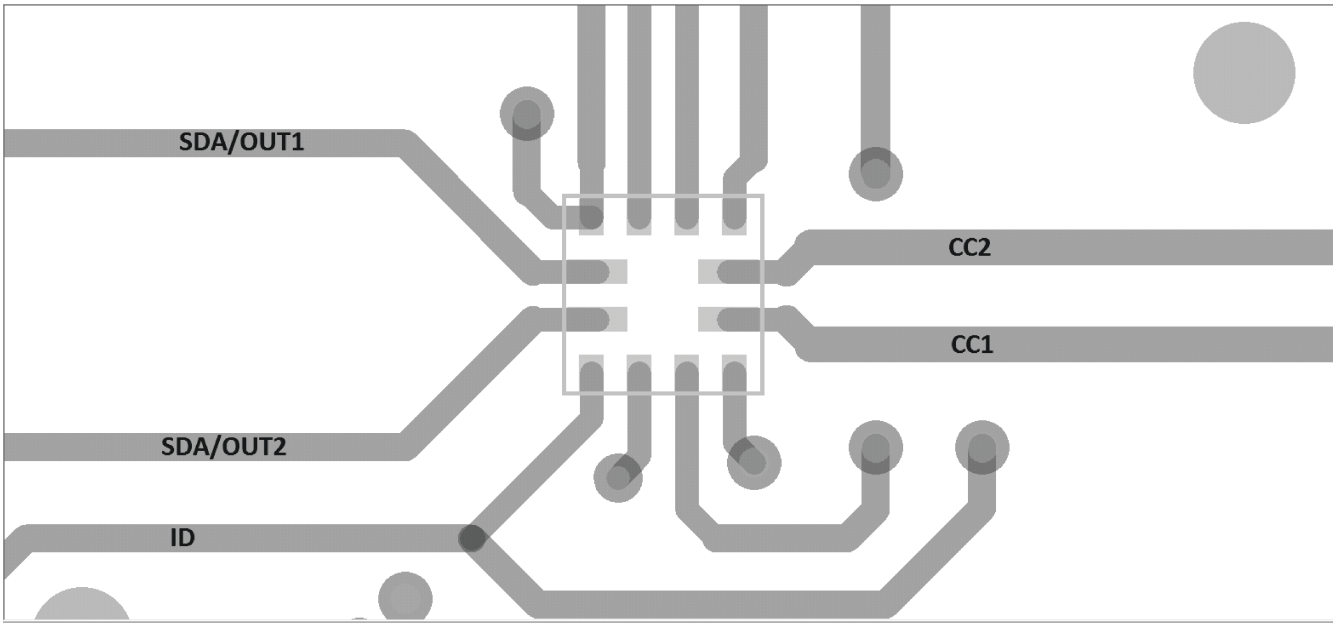

图 10-1. TUSB320 Layout

11 Device and Documentation Support

11.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 *订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

11.2 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

11.3 Trademarks

USB Type-C™ is a trademark of USB Implementers Forum.
TI E2E™ is a trademark of Texas Instruments.
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11.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.5 术语表

TI 术语表	本术语表列出并解释了术语、首字母缩略词和定义。

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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TUSB320IRWBR	ACTIVE	X2QFN	RWB	12	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	70	Samples
TUSB320RWBR	ACTIVE	X2QFN	RWB	12	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	0 to 70	20	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.

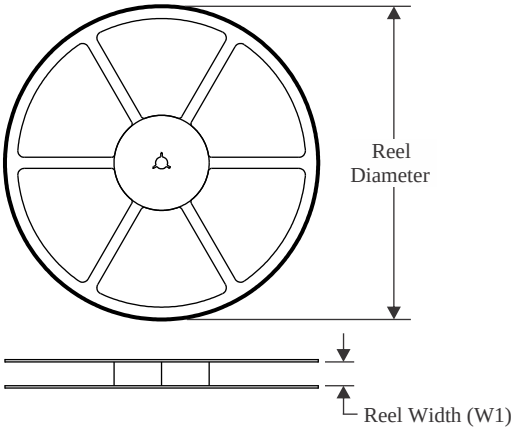
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

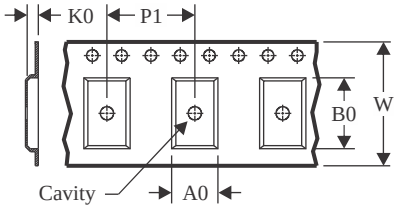
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

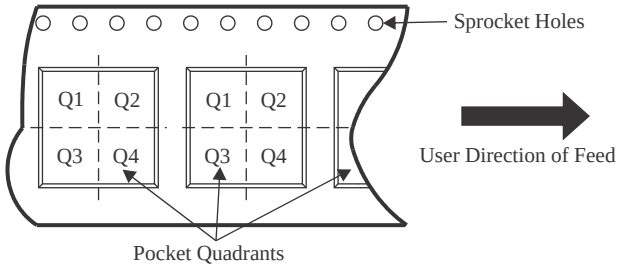


TAPE DIMENSIONS



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

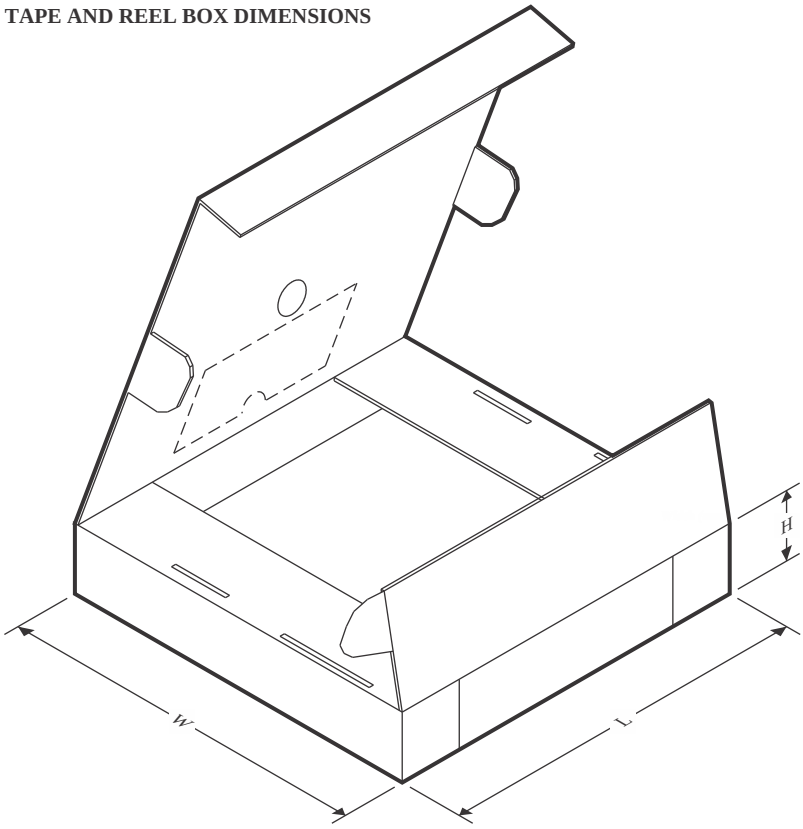
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TUSB320IRWBR	X2QFN	RWB	12	3000	180.0	8.4	1.8	1.8	0.48	4.0	8.0	Q2
TUSB320RWBR	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

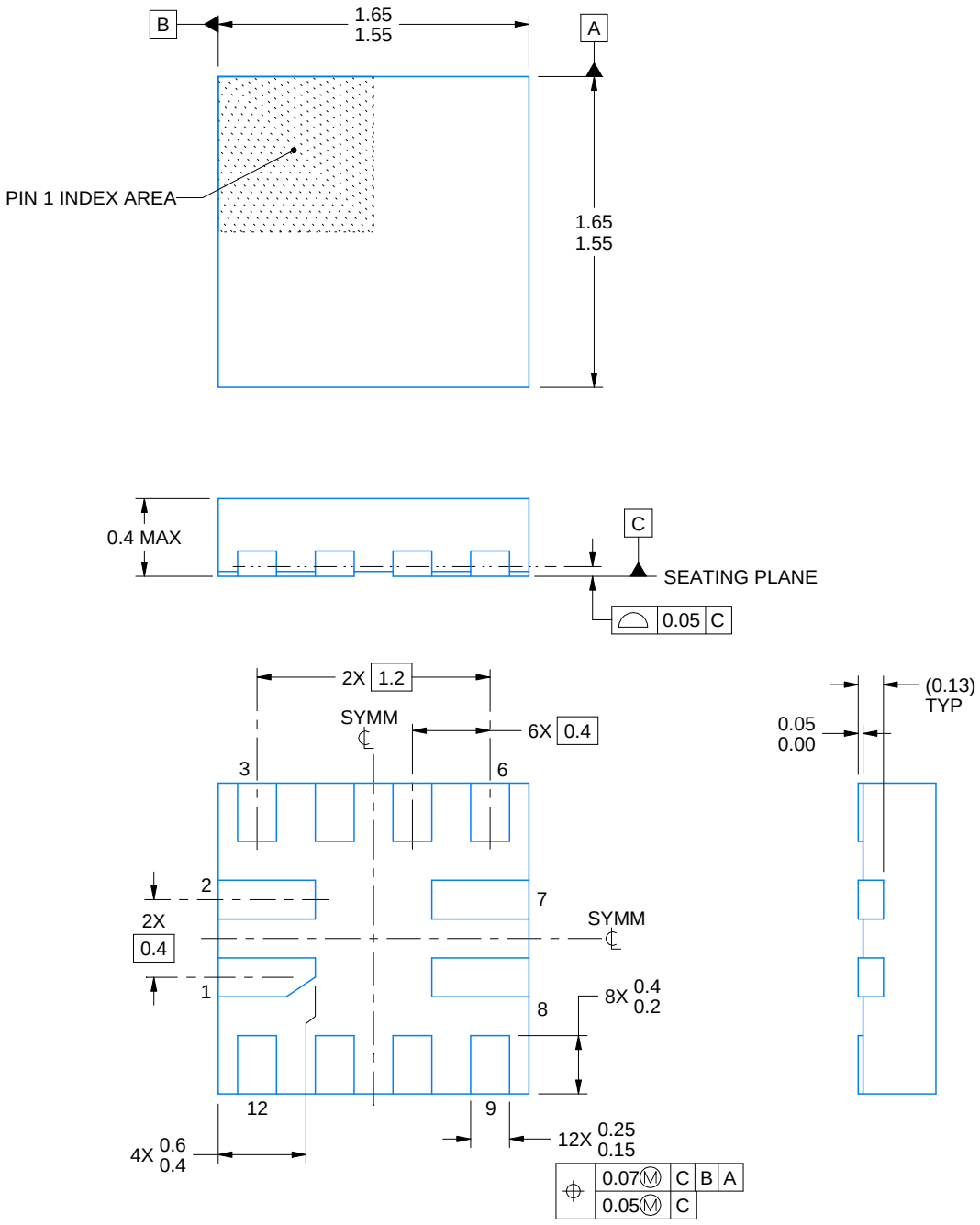
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TUSB320IRWBR	X2QFN	RWB	12	3000	210.0	185.0	35.0
TUSB320RWBR	X2QFN	RWB	12	3000	210.0	185.0	35.0

PACKAGE OUTLINE

RWB0012A

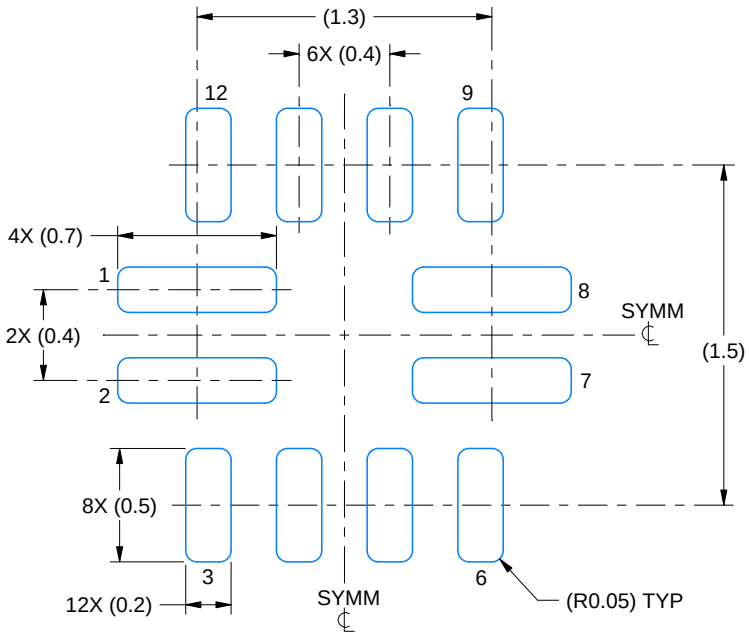
X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

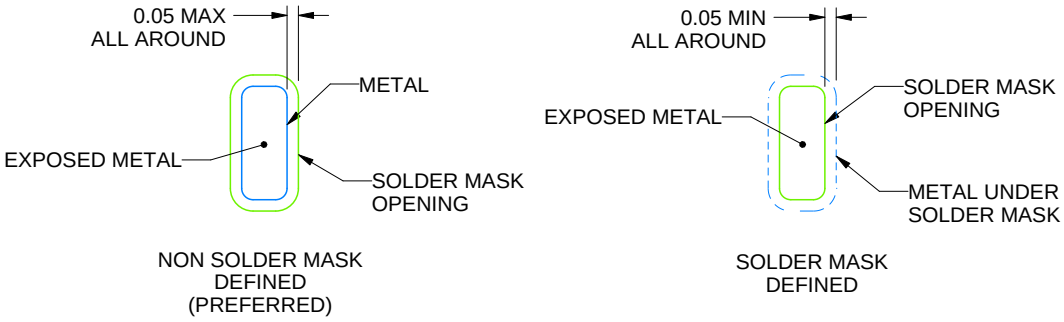


NOTES:

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)

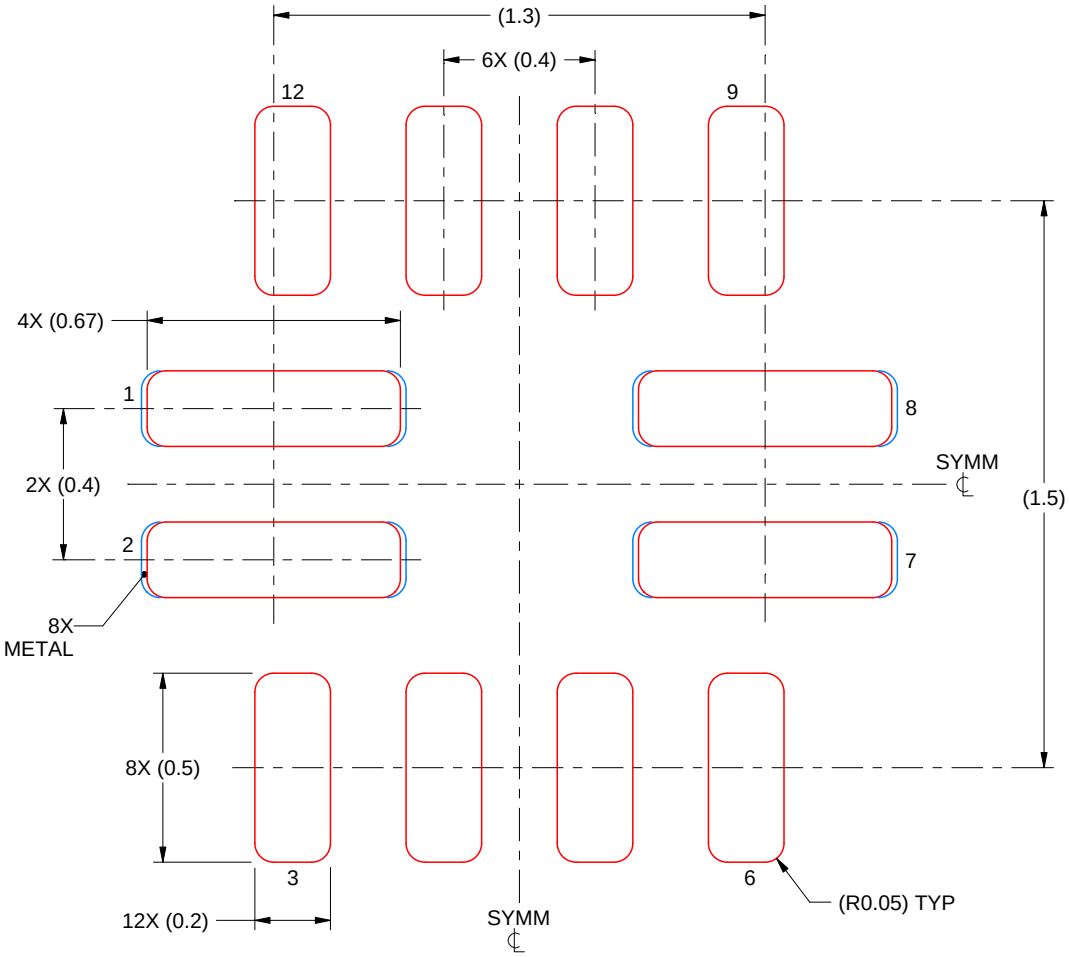
3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

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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