TUSB320, TUSB320I
SLLSEN9E—MAY 2015—REVISED MAY 2017

TUSB320 USB Type-C™ Configuration Channel Logic and Port Control

1 Features

- USB Type-C™ Specification 1.1
- Backward Compatible with USB Type-C Specification 1.0
- Supports Up to 3 A of Current Advertisement and Detection
- Mode Configuration
  - Host Only – DFP (Source)
  - Device Only – UFP (Sink)
  - Dual Role Port – DRP
- Channel Configuration (CC)
  - Attach of USB Port Detection
  - Cable Orientation Detection
  - Role Detection
  - Type-C Current Mode (Default, Medium, High)
- \( \textit{V_{BUS}} \) Detection
- \( \text{i}^2\text{C} \) or GPIO Control
- Role Configuration Control through \( \text{i}^2\text{C} \)
- Supply Voltage: 2.7 V to 5 V
- Low Current Consumption
- Industrial Temperature Range of –40 to 85°C

2 Applications

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

3 Description

The TUSB320 device enables USB Type-C ports with the configuration channel (CC) logic needed for Type-C ecosystems. The TUSB320 device uses the CC pins to determine port attach and detach, cable orientation, role detection, and port control for Type-C current mode. The TUSB320 device can be configured as a downstream facing port (DFP), upstream facing port (UFP) or a dual role port (DRP) making it ideal for any application.

The TUSB320 device alternates configuration as a DFP or UFP according to the Type-C Specifications. The CC logic block monitors the CC1 and CC2 pins for pullup or pulldown resistances to determine when a USB port has been attached, the orientation of the cable, and the role detected. The CC logic detects the Type-C current mode as default, medium, or high depending on the role detected. \( \textit{V_{BUS}} \) detection is implemented to determine a successful attach in UFP and DRP modes.

The device operates over a wide supply range and has low-power consumption. The TUSB320 device is available in industrial and commercial temperature ranges.

Device Information(1)

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUSB320</td>
<td>X2QFN (12)</td>
<td>1.60 mm × 1.60 mm</td>
</tr>
<tr>
<td>TUSB320I</td>
<td>X2QFN (12)</td>
<td>1.60 mm × 1.60 mm</td>
</tr>
</tbody>
</table>

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

Sample Applications

![Sample Applications Diagram]
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## 4 Revision History

<table>
<thead>
<tr>
<th>Changes from Revision D (October 2016) to Revision E</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed $R_{VBUS}$ values From: MIN = 891, TYP = 900, MAX = 909 KΩ To: MIN = 855, TYP = 887, MAX = 920 KΩ</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Changes from Revision C (September 2016) to Revision D</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 Table 3 for more details.”</td>
<td>4</td>
</tr>
<tr>
<td>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 Table 3 for more details.”</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Changes from Revision B (March 2016) to Revision C</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed pins CC1 and CC2 values From: MIN = –0.3 MAX = $V_{DD} + 0.3$ To: MIN –0.3 MAX = 6 in the Absolute Maximum Ratings</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Changes from Revision A (June 2015) to Revision B</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Note 1 and 2 to the Pin Functions table</td>
<td>4</td>
</tr>
<tr>
<td>Changed the DESCRIPTION of pin EN_N pin in the Pin Functions table</td>
<td>4</td>
</tr>
<tr>
<td>Changed the DESCRIPTION of pin $V_{DD}$ in the Pin Functions table</td>
<td>4</td>
</tr>
<tr>
<td>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 Electrical Characteristics table</td>
<td>6</td>
</tr>
<tr>
<td>Added Note 2 to the Electrical Characteristics table</td>
<td>6</td>
</tr>
<tr>
<td>Added Test Condition “See Figure 1” to $V_{BUS,THR}$ in the Electrical Characteristics</td>
<td>7</td>
</tr>
<tr>
<td>Updated Timing Requirements table with new values.</td>
<td>7</td>
</tr>
<tr>
<td>Added Data hold time, Data valid time, Data valid acknowledge time, and $C_{bus_{400kHz}}$ values to Timing Requirements table.</td>
<td>7</td>
</tr>
<tr>
<td>Changed the Switching Characteristics table</td>
<td>7</td>
</tr>
<tr>
<td>Added Note: “SW must make sure...” to the Description of INTERRUPT_STATUS in Table 7</td>
<td>17</td>
</tr>
</tbody>
</table>
Changes from Original (May 2015) to Revision A

- Added text to list item 2 in the *Initialization Set Up* section

- Changed device status of TUSB320 from *Product Preview* to *Production Data*
5 Pin Configuration and Functions

Pin Functions

<table>
<thead>
<tr>
<th>PIN</th>
<th>NO.</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC1</td>
<td>1</td>
<td>I/O</td>
<td>Type-C configuration channel signal 1</td>
</tr>
<tr>
<td>CC2</td>
<td>2</td>
<td>I/O</td>
<td>Type-C configuration channel signal 2</td>
</tr>
<tr>
<td>PORT(1)</td>
<td>3</td>
<td>I</td>
<td>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 VDD 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)</td>
</tr>
<tr>
<td>VBUS_DET(1)</td>
<td>4</td>
<td>I</td>
<td>5- to 28-V VBUS input voltage. VBUS detection determines UFP attachment. One 900-kΩ external resistor required between system VBUS and VBUS_DET pin.</td>
</tr>
<tr>
<td>ADDR(1)</td>
<td>5</td>
<td>I</td>
<td>Tri-level input pin to indicate I2C address or GPIO mode: H - I2C is enabled and I2C 7-bit address is 0x61. NC - GPIO mode (I2C is disabled) L - I2C is enabled and I2C 7-bit address is 0x60. ADDR pin should be pulled up to VDD if high configuration is desired</td>
</tr>
<tr>
<td>INT_N/OUT3(1)</td>
<td>6</td>
<td>O</td>
<td>The INT_N/OUT3 is a dual-function pin. When used as the INT_N, the pin is an open drain output in I2C control mode and is an active low interrupt signal for indicating changes in I2C registers. When used as OUT3, the pin is in audio accessory detect in GPIO mode: no detection (H), audio accessory connection detected (L).</td>
</tr>
<tr>
<td>SDA/OUT1(1)(2)</td>
<td>7</td>
<td>I/O</td>
<td>The SDA/OUT1 is a dual-function pin. When I2C is enabled (ADDR pin is high or low), this pin is the I2C 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 Table 3 for more details.</td>
</tr>
<tr>
<td>SCL/OUT2(1)(2)</td>
<td>8</td>
<td>I/O</td>
<td>The SCL/OUT2 is a dual function pin. When I2C is enabled (ADDR pin is high or low), this pin is the I2C 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 Table 3 for more details.</td>
</tr>
<tr>
<td>ID(1)</td>
<td>9</td>
<td>O</td>
<td>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).</td>
</tr>
<tr>
<td>GND</td>
<td>10</td>
<td>G</td>
<td>Ground</td>
</tr>
<tr>
<td>EN_N</td>
<td>11</td>
<td>I</td>
<td>Enable signal; active low. Pulled up to VDD internally to disable the TUSB320 device. If controlled externally, must be held high at least for 50 ms after VDD has reached its valid voltage level.</td>
</tr>
<tr>
<td>VDD</td>
<td>12</td>
<td>P</td>
<td>Positive supply voltage. VDD must ramp within 25 ms or less</td>
</tr>
</tbody>
</table>

(1) When VDD 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 VDD supply. The VBUS_DET must be pulled up to VBUS through a 900-kΩ resistor.

(2) When using the 3.3 V supply for I2C, the end user must ensure that the VDD is 3 V and above. Otherwise the I2C may back power the device.
6 Specifications

6.1 Absolute Maximum Ratings
over operating free-air temperature range (unless otherwise noted)\(^{(1)}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (V_{DD})</td>
<td>–0.3</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>Control pins PORT, ADDR, ID, EN_N, INT_N/OUT3</td>
<td>–0.3</td>
<td>(V_{DD} + 0.3)</td>
<td>V</td>
</tr>
<tr>
<td>CC1, CC2</td>
<td>–0.3</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>SDA/OUT1, SCL/OUT2</td>
<td>–0.3</td>
<td>(V_{DD} + 0.3)</td>
<td>V</td>
</tr>
<tr>
<td>VBUS_DET</td>
<td>–0.3</td>
<td>4</td>
<td>V</td>
</tr>
<tr>
<td>Storage temperature, (T_{stg})</td>
<td>–65</td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{(ESD)}) Electrostatic discharge</td>
<td>±7000</td>
<td>V</td>
</tr>
<tr>
<td>Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(^{(1)})</td>
<td>±7000</td>
<td>V</td>
</tr>
<tr>
<td>Charged-device model (CDM), per JEDEC specification JESD22-C101(^{(2)})</td>
<td>±1500</td>
<td>V</td>
</tr>
</tbody>
</table>

(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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{DD}) Supply voltage range</td>
<td>2.7</td>
<td>5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(V_{BUS}) System (V_{BUS}) voltage</td>
<td>4</td>
<td>5</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>VBUS_DET</td>
<td>–40</td>
<td>25</td>
<td>85</td>
<td>°C</td>
</tr>
<tr>
<td>(T_A)</td>
<td>0</td>
<td>25</td>
<td>70</td>
<td>°C</td>
</tr>
</tbody>
</table>

6.4 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(^{(1)})</th>
<th>TUSB320</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R_{JA}) Junction-to-ambient thermal resistance</td>
<td>169.3</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{JC(top)}) Junction-to-case (top) thermal resistance</td>
<td>68.1</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{WB}) Junction-to-board thermal resistance</td>
<td>83.4</td>
<td>°C/W</td>
</tr>
<tr>
<td>(\psi_{JT}) Junction-to-top characterization parameter</td>
<td>2.2</td>
<td>°C/W</td>
</tr>
<tr>
<td>(\psi_{JB}) Junction-to-board characterization parameter</td>
<td>83.4</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{JC(bot)}) Junction-to-case (bottom) thermal resistance</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

(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)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{UNATTACHED_UFP}$</td>
<td>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)</td>
<td>100</td>
<td></td>
<td></td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{ACTIVE_UFP}$</td>
<td>Current consumption in active mode. ($V_{DD} = 4.5\ V$, $EN_N = L$, ADDR = NC, PORT = L)</td>
<td>100</td>
<td></td>
<td></td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{SHUTDOWN}$</td>
<td>Leakage current when $V_{DD}$ is supplied but the TUSB320 device is not enabled. ($V_{DD} = 4.5\ V$, $EN_N = H$)</td>
<td></td>
<td></td>
<td>1.7</td>
<td>$\mu A$</td>
</tr>
</tbody>
</table>

CC1 and CC2 Pins

| $R_{CC\_DB}$ | Pulldown resistor when in dead-battery mode. | 4.1 | 5.1 | 6.1 | k$\Omega$ |
| $R_{CC\_D}$ | Pulldown resistor when in UFP or DRP mode. | 4.6 | 5.1 | 5.6 | k$\Omega$ |
| $V_{UFP\_CC\_USB}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising default current source capability. | 0.25 | 0.61 | | V |
| $V_{UFP\_CC\_MED}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising medium (1.5 A) current source capability. | 0.7 | 1.16 | | V |
| $V_{UFP\_CC\_HIGH}$ | Voltage level range for detecting a DFP attach when configured as a UFP and DFP is advertising high (3 A) current source capability. | 1.31 | 2.04 | | V |
| $V_{TH\_DFP\_CC\_USB}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising default current source capability. | 1.51 | 1.6 | 1.64 | V |
| $V_{TH\_DFP\_CC\_MED}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising medium current (1.5 A) source capability. | 1.51 | 1.6 | 1.64 | V |
| $V_{TH\_DFP\_CC\_HIGH}$ | Voltage threshold for detecting a UFP attach when configured as a DFP and advertising high current (3.0 A) source capability. | 2.46 | 2.6 | 2.74 | V |
| $I_{CC\_DEFAULT\_P}$ | Default mode pullup current source when operating in DFP or DRP mode. | 64 | 80 | 96 | $\mu A$ |
| $I_{CC\_MED\_P}$ | Medium (1.5 A) mode pullup current source when operating in DFP or DRP mode. | 166 | 180 | 194 | $\mu A$ |
| $I_{CC\_HIGH\_P}$ | High (3 A) mode pullup current source when operating in DFP or DRP mode. | 304 | 330 | 356 | $\mu A$ |

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) | $0.28 \times V_{DD}$ | $0.56 \times V_{DD}$ | | 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 | | $\mu A$ |
| $I_{IL}$ | Low-level input current | –10 | 10 | | $\mu A$ |
| $R_{EN\_N}$ | Internal pullup resistance for EN_N | 1.1 | | | M$\Omega$ |
| $R_{EN\_N\_PD}$ | Internal pulldown resistance (PORT, ADDR) | 588 | | | k$\Omega$ |
| $R_{EN\_N\_PD\_2}$ | Internal pulldown resistance (PORT, ADDR) | 1.1 | | | M$\Omega$ |
| $V_{OL}$ | Low-level signal output voltage (open-drain) (INT_N/OUT3, ID) | $I_{OL} = -1.6\ mA$ | | | V |
| $R_{PD\_Odrxt}$ | External pullup resistor on open drain IOs (INT_N/OUT3, ID) | 200 | | | k$\Omega$ |
| $R_{PD\_TRLKX}$ | Tri-level input external pullup resistor (PORT, ADDR) | 4.7 | | | k$\Omega$ |

(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.
Electrical Characteristics (continued)

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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DD,dc}$</td>
<td>Supply range for $V_{DD}$ (SDA/OUT1, SCL/OUT2)</td>
<td>1.65</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{HI}$</td>
<td>High-level signal voltage</td>
<td>1.05</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{IL}$</td>
<td>Low-level signal voltage</td>
<td></td>
<td>0.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{DL}$</td>
<td>Low-level signal output voltage (open drain)</td>
<td>$I_{DL} = -1.6$ mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{BUS}$ (SDA/OUT1, SCL/OUT2)</td>
<td>Operate from 1.8 or 3.3 V (±10%)</td>
<td>2.95</td>
<td>3.30</td>
<td>3.80</td>
<td>V</td>
</tr>
</tbody>
</table>

$V_{DD_{I2C}}$ Supply range for $I_{2C}$ (SDA/OUT1, SCL/OUT2)

(3) When using 3.3 V for $I_{2C}$, customer must ensure $V_{DD}$ is above 3.0 V at all times.

6.6 Timing Requirements

<table>
<thead>
<tr>
<th>$I_{2C}$ (SDA, SCL)</th>
<th>MIN</th>
<th>NOM</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{SU:DAT}$</td>
<td>Data setup time</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{HD:DAT}$</td>
<td>Data hold time</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{SU:STA}$</td>
<td>Set-up time, SCL to start condition</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{HD:STA}$</td>
<td>Hold time, (repeated) start condition to SCL</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{SU:STOP}$</td>
<td>Set up time for stop condition</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{BUF}$</td>
<td>Bus free time between a stop and start condition</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{VD:DAT}$</td>
<td>Data valid time</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{VD:ACK}$</td>
<td>Data valid acknowledge time</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f_{SCL}$</td>
<td>SCL clock frequency; $I_{2C}$ mode for local $I_{2C}$ control</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{R}$</td>
<td>Rise time of both SDA and SCL signals</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{F}$</td>
<td>Fall time of both SDA and SCL signals</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_{bus_{100kHz}}$</td>
<td>Total capacitive load for each bus line when operating at $\leq 100$ kHz</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_{bus_{400kHz}}$</td>
<td>Total capacitive load for each bus line when operating at $\leq 400$ kHz</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.7 Switching Characteristics

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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{CCCB_DEFAULT}$</td>
<td>Power on default of CC1 and CC2 voltage debounce time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{VBUS_DB}$</td>
<td>Debounce of $V_{BUS}$ pin after valid $V_{BUS_THR}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{DRP_DUTY_CYCLE}$</td>
<td>Power-on default of percentage of time DRP advertises DFP during a $t_{DRP}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{DRP}$</td>
<td>The period during which the TUSB320 or the TUSB320I in DFP mode completes a DFP to UFP and back advertisement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{NC_EN}$</td>
<td>Time from TUSB320 EN_N low or TUSB320I EN high and $V_{DD}$ active to $I_{2C}$ access available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{SOFT_RESET}$</td>
<td>Soft reset duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 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 USB2.0 applications.

Figure 2. Functional Block Diagram of TUSB320

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 TUSB320 device supports all cables, receptacles, and plugs. The TUSB320 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 TUSB320 device:
- USB Type-C receptacle for USB2.0 platforms and devices
- USB full-featured Type-C plug
- USB2.0 Type-C plug
Overview (continued)

7.1.1.2 USB Type-C Cables
Below is a list of Type-C cables types supported by the TUSB320 device:
• USB full-featured Type-C cable
• 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 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.

![Legacy Adapter Implementation Circuit](image)

Figure 3. Legacy Adapter Implementation Circuit

7.1.1.4 Direct Connect Devices
The TUSB320 device supports the attaching and detaching of a direct-connect device.

7.1.1.5 Audio Adapters
Additionally, the TUSB320 device supports audio adapters for audio accessory mode, including:
• Passive Audio Adapter
• Charge Through Audio Adapter

7.2 Feature Description

7.2.1 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. Table 1 lists the supported features in each mode:
Feature Description (continued)

Table 1. Supported Features for the TUSB320 Device by Mode

<table>
<thead>
<tr>
<th>PORT PIN</th>
<th>HIGH (DFP ONLY)</th>
<th>LOW (UFP ONLY)</th>
<th>NC (DRP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port attach and detach</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cable orientation (through I²C)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Current advertisement</td>
<td>Yes</td>
<td>-</td>
<td>Yes (DFP)</td>
</tr>
<tr>
<td>Current detection</td>
<td>-</td>
<td>Yes</td>
<td>Yes (UFP)</td>
</tr>
<tr>
<td>Accessory modes (audio and debug)</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Active cable detection</td>
<td>Yes</td>
<td>-</td>
<td>Yes (DFP)</td>
</tr>
<tr>
<td>I²C / GPIO</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Legacy cables</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VBUS detection</td>
<td>-</td>
<td>Yes</td>
<td>Yes (UFP)</td>
</tr>
</tbody>
</table>

7.2.1.1 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 VDD. In DFP mode, the TUSB320 device constantly presents Rp on both CC. In DFP mode, the TUSB320 device initially advertises default USB Type-C current. The Type-C current can be adjusted through I²C if the system needs to increase the amount advertised. The TUSB320 device adjusts the Rp 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.

7.2.1.2 Upstream Facing Port (UFP) - Sink

The TUSB320 device can be configured as a 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 VBUS detection before successfully attaching. As a 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 I²C 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.

7.2.1.3 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 a 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 a UFP in DRP mode, the TUSB320 device operates as defined for a UFP according to the Type-C Specification.
7.2.2 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 a UFP can sink. The default current advertisement for the TUSB320 device is 500 mA (for USB2.0) or 900 mA (for USB3.1). If a higher level of current is available, the I\(^2\)C 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. Table 2 lists the Type-C current advertisements in GPIO and I\(^2\)C modes.

<table>
<thead>
<tr>
<th>TYPE-C CURRENT</th>
<th>GPIO MODE (ADDR PIN IN NC)</th>
<th>I(^2)C MODE (ADDR PIN H, L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>500 mA (USB2.0) 900 mA (USB3.1)</td>
<td>Current mode detected and output through OUT1/OUT2</td>
</tr>
<tr>
<td>Medium - 1.5 A</td>
<td>Only advertisement</td>
<td>Current mode detected and read through I(^2)C register</td>
</tr>
<tr>
<td>High - 3 A</td>
<td>N/A</td>
<td>I(^2)C register default is 500 or 900 mA</td>
</tr>
</tbody>
</table>

7.2.3 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\(^2\)C 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).

7.2.3.1 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. In order 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.

7.2.3.2 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.

7.2.4 I\(^2\)C and GPIO Control

The TUSB320 device can be configured for I\(^2\)C 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\(^2\)C 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. Table 3 lists the output pin settings. See the Pin Functions table for more information.
Table 3. Simplified Operation for OUT1 and OUT2

<table>
<thead>
<tr>
<th>OUT1</th>
<th>OUT2</th>
<th>ADVERTISEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>H</td>
<td>Default Current in Unattached State</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Default Current in Attached State</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>Medium Current (1.5 A) in Attached State</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>High Current (3.0 A) in Attached State</td>
</tr>
</tbody>
</table>

When operating in I²C mode, the TUSB320 device uses the SCL and SDA lines for clock and data and the INT_N pin to communicate a change in I²C registers, or an interrupt, to the system. The INT_N pin is pulled low when the 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 I²C.

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

NOTE
When using the 3.3 V supply for I²C, the end user must ensure that the V_DD is 3 V and above. Otherwise the I²C may back power the device.

7.2.5 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 a UFP and to determine the entering and exiting of accessory 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 a 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.

7.3 Device Functional Modes
The TUSB320 device has four functional modes. Table 4 lists these modes:

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

<table>
<thead>
<tr>
<th>MODES</th>
<th>GENERAL BEHAVIOR</th>
<th>PORT PIN</th>
<th>STATES(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unattached</td>
<td>USB port unattached. ID, PORT operational. I²C on. CC pins configure according to PORT pin.</td>
<td>UFP</td>
<td>Unattached.SNK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DRP</td>
<td>Toggle Unattached.SNK → Unattached.SRC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AttachedWait.SRC or AttachedWait.SNK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DFP</td>
<td>Unattached.SRC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AttachWait.SRC</td>
</tr>
<tr>
<td>Active</td>
<td>USB port attached. All GPIOs operational. I²C on.</td>
<td>UFP</td>
<td>Attached.SNK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DRP</td>
<td>Attached.SNK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attached.SRC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DFP</td>
<td>Audio accessory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Debug accessory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attached.SRC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Audio accessory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Debug accessory</td>
</tr>
<tr>
<td>Dead battery</td>
<td>No operation. V_DD not available.</td>
<td>UFP/DRP/DFP</td>
<td>Default device state to UFP/SNK with Rd.</td>
</tr>
<tr>
<td>Shutdown</td>
<td>V_DD available. EN_N pin high.</td>
<td>UFP/DRP/DFP</td>
<td>Default device state to UFP/SNK with Rd.</td>
</tr>
</tbody>
</table>

(1) Required; not in sequential order.
7.3.1 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.

7.3.2 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 a 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 a 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 unattached state.

7.3.3 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-k$\Omega \pm 20\%$ Rd; cable connected and providing charge
- TUSB320 in UFP with 5.1-k$\Omega \pm 20\%$ 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 $R_P$ 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.

---

**NOTE**

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-k$\Omega$ resistor.

---

7.3.4 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
7.4 Programming

For further programmability, the TUSB320 device can be controlled using I\textsuperscript{2}C. The TUSB320 device local I\textsuperscript{2}C interface is available for reading/writing after $T_{\text{I2C,EN}}$ when the device is powered up. The SCL and SDA terminals are used for I\textsuperscript{2}C clock and I\textsuperscript{2}C data respectively. If I\textsuperscript{2}C is the preferred method of control, the ADDR pin must be set accordingly.

<table>
<thead>
<tr>
<th>Table 5. TUSB320 I\textsuperscript{2}C Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDR pin</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td>L</td>
</tr>
</tbody>
</table>

The following procedure should be followed to write to TUSB320 I\textsuperscript{2}C registers:
1. The master 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 master presents the sub-address (I\textsuperscript{2}C 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 master presents the first byte of data to be written to the I\textsuperscript{2}C register
6. The TUSB320 device acknowledges the byte transfer
7. The master may continue presenting additional bytes of data to be written, with each byte transfer completing with an acknowledge from the TUSB320 device
8. The master terminates the write operation by generating a stop condition (P)

The following procedure should be followed to read the TUSB320 I\textsuperscript{2}C registers:
1. The master 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\textsuperscript{2}C 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 master after each byte transfer; the I\textsuperscript{2}C master acknowledges reception of each data byte transfer
5. If an ACK is received, the TUSB320 device transmits the next byte of data
6. The master terminates the read operation by generating a stop condition (P)

The following procedure should be followed for setting a starting sub-address for I\textsuperscript{2}C reads:
1. The master 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 master presents the sub-address (I\textsuperscript{2}C 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 master terminates the read operation by generating a stop condition (P)

**NOTE**

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

### Table 6. CSR Registers

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

### Table 7. CSR Registers Bit Address and Description

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>BIT(S)</th>
<th>BIT NAME</th>
<th>DESCRIPTION</th>
<th>ACCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00 – 0x07</td>
<td>7:0</td>
<td>DEVICE_ID</td>
<td>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}</td>
<td>R</td>
</tr>
</tbody>
</table>
| 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 – Mid (1.5 A)  
10 – High (3 A)  
11 – Reserved  | RW     |
| 0x08    | 5:4   | CURRENT_MODE_DETECT   | These bits are set when a UFP determines the Type-C Current mode.  
00 – Default (value at start up)  
01 – Medium  
10 – Charge through accessory – 500 mA  
11 – High  | RU     |
| 0x08    | 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     |
| 0x08    | 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     |
Table 7. CSR Registers Bit Address and Description (continued)

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>BIT(S)</th>
<th>BIT NAME</th>
<th>DESCRIPTION</th>
<th>ACCESS</th>
</tr>
</thead>
</table>
| 0x00    | 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     |
| 0x09    | 5      | CABLE_DIR      | Cable orientation. The application can read these bits for cable orientation information.  
0 – CC1  
1 – CC2 (default) | RU     |
| 0x09    | 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    |
| 0x09    | 3      | Reserved       |                                                                                               | R      |
| 0x09    | 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     |
| 0x09    | 0      | Reserved       |                                                                                               | R      |
### Table 7. CSR Registers Bit Address and Description (continued)

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>BIT(S)</th>
<th>BIT NAME</th>
<th>DESCRIPTION</th>
<th>ACCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0A</td>
<td>7:6</td>
<td>DEBOUNCE</td>
<td>The nominal amount of time the TUSB320 device debounces the voltages on the CC pins.</td>
<td>RW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>00 – 133ms (default)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>01 – 116ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 – 151ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11 – 168ms</td>
<td></td>
</tr>
<tr>
<td>0x45</td>
<td>5:4</td>
<td>MODE_SELECT</td>
<td>This register can be written to set the TUSB320 device mode operation. The ADDR pin must be set to I(^2)C 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.</td>
<td>RW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>00 – Maintain mode according to PORT pin selection (default)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>01 – UFP mode (unattached.SNK)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 – DFP mode(unattached.SRC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11 – DRP mode(start from unattached.SNK)</td>
<td></td>
</tr>
<tr>
<td>0x45</td>
<td>3</td>
<td>I(^2)C_SOFT_RESET</td>
<td>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:</td>
<td>RSU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CURRENT_MODE_DETECT</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ACTIVE_CABLE_DETECTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ACCESSORY_CONNECTED</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ATTACHED_STATE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CABLE_DIR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:1</td>
<td>Reserved</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Reserved</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>7:3</td>
<td>Reserved</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>0x45</td>
<td>2</td>
<td>DISABLE_RD_RP</td>
<td>When this field is set, Rd and Rp are disabled.</td>
<td>RW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 – Normal operation (default)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 – Disable Rd and Rp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:0</td>
<td>Reserved</td>
<td>For TI internal use only. Do not change default value.</td>
<td>RW</td>
</tr>
</tbody>
</table>
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 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).

Figure 4. TUSB320 in UFP Mode Supporting Default Implementation

Figure 5. TUSB320 in UFP Mode Supporting Advanced Power Delivery

Figure 6. TUSB320 in DFP Mode Supporting Default Implementation

Figure 7. TUSB320 in DFP Mode Supporting Advanced Power Delivery
Application Information (continued)

Figure 8. TUSB320 in DRP Mode Supporting Default Implementation

Figure 9. TUSB320 in DRP Mode Supporting Advanced Power Delivery
8.2 Typical Application

8.2.1 DRP in I\textsuperscript{2}C Mode

Figure 10 shows the TUSB320 device configured as a DRP in I\textsuperscript{2}C mode.

![Figure 10. DRP in I\textsuperscript{2}C Mode Schematic](image)

8.2.1.1 Design Requirements

For this design example, use the parameters listed in Table 8:

<table>
<thead>
<tr>
<th>DESIGN PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V\textsubscript{DD} (2.75 V to 5 V)</td>
<td>VBAT (less than 5 V)</td>
</tr>
<tr>
<td>Mode (I\textsuperscript{2}C or GPIO)</td>
<td>I\textsuperscript{2}C</td>
</tr>
<tr>
<td>I\textsuperscript{2}C address (0x61 or 0x60)</td>
<td>0x60</td>
</tr>
<tr>
<td>Type-C port type (UFP, DFP, or DRP)</td>
<td>DRP</td>
</tr>
<tr>
<td>Shutdown support (EN_N control)</td>
<td>No</td>
</tr>
</tbody>
</table>

8.2.1.2 Detailed Design Procedure

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

The TUSB320 device is placed into I\textsuperscript{2}C mode by either pulling the ADDR pin high or low. In this case, the ADDR pin is tied to GND which results in a I\textsuperscript{2}C 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\textsubscript{DD} supply must be at least 3 V to keep from back-driving the I\textsuperscript{2}C 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 VDD 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 VBUS. The Type-C standard requires that a DFP not enable VBUS until it is in the AttachedSRC state. If the ID pin is not low but VBUS 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 VDD 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 VBUS on the Type-C that is connected. This large resistor is required to protect the TUSB320 device from large VBUS 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 VBUS 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 a UFP, the large bulk capacitance must be removed. The FET in Figure 10 performs this task.

<table>
<thead>
<tr>
<th>PORT CONFIGURATION</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream facing port (DFP)</td>
<td>120</td>
<td></td>
<td>µF</td>
</tr>
<tr>
<td>Upstream facing port (UFP)</td>
<td>1</td>
<td>10</td>
<td>µF</td>
</tr>
</tbody>
</table>

8.2.1.3 Application Curves

Figure 11. Application Curve for DRP in I²C Mode
8.2.2 DFP in \( \text{I}^2\text{C} \) Mode

Figure 12 shows the TUSB320 device configured as a DFP in \( \text{I}^2\text{C} \) mode.

![Figure 12. DFP in \( \text{I}^2\text{C} \) Mode Schematic](image)

8.2.2.1 Design Requirements

For this design example, use the parameters listed in Table 10:

<table>
<thead>
<tr>
<th>DESIGN PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{DD}} ) (2.75 V to 5 V)</td>
<td>5 V</td>
</tr>
<tr>
<td>Mode (( \text{I}^2\text{C} ) or GPIO)</td>
<td>( \text{I}^2\text{C} )</td>
</tr>
<tr>
<td>( \text{I}^2\text{C} ) address (0x61 or 0x60)</td>
<td>0x60</td>
</tr>
<tr>
<td>Type-C port type (UFP, DFP, or DRP)</td>
<td>DFP</td>
</tr>
<tr>
<td>Shutdown support (EN_N Control)</td>
<td>No</td>
</tr>
</tbody>
</table>

8.2.2.2 Detailed Design Procedure

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

The TUSB320 device is placed into \( \text{I}^2\text{C} \) mode by either pulling the ADDR pin high or low. In this particular case, the ADDR pin is tied to GND which results in a \( \text{I}^2\text{C} \) 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 \( V_{\text{DD}} \) supply must be at least 3 V to keep from back-driving the \( \text{I}^2\text{C} \) 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 \( \text{I}^2\text{C} \) registers occurs. This pin is an open drain output and requires an external pullup resistor. The pin should be pulled up to \( V_{\text{DD}} \) using a 200-k\( \Omega \) 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 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 DFP mode, a bulk capacitance of at least 120µF is required. In this particular case, a 150-µF capacitor was chosen.

### 8.2.2.3 Application Curves

![Application Curve for DFP in I²C Mode](image)

**Figure 13. Application Curve for DFP in I²C Mode**
8.2.3 UFP in I^2C Mode

Figure 14 shows the TUSB320 device configured as a DFP in I^2C mode.

![Diagram of TUSB320 device configuration](image)

**Figure 14. UFP in I^2C Mode Schematic**

8.2.3.1 Design Requirements

For this design example, use the parameters listed in Table 11:

<table>
<thead>
<tr>
<th>DESIGN PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{DD} (2.75 V to 5 V)</td>
<td>5 V</td>
</tr>
<tr>
<td>Mode (I^2C or GPIO)</td>
<td>I^2C</td>
</tr>
<tr>
<td>ADDR pin must be pulled down or pulled up</td>
<td></td>
</tr>
<tr>
<td>I^2C address (0x61 or 0x60)</td>
<td>0x60</td>
</tr>
<tr>
<td>ADDR pin must be pulled low or tied to GND</td>
<td></td>
</tr>
<tr>
<td>Type-C port type (UFP, DFP, or DRP)</td>
<td>UFP</td>
</tr>
<tr>
<td>PORT pin is pulled down</td>
<td></td>
</tr>
<tr>
<td>Shutdown support (EN_N control)</td>
<td>No</td>
</tr>
</tbody>
</table>

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 I^2C mode by either pulling the ADDR pin high or low. In this case, the ADDR pin is tied to GND which results in a I^2C 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 I^2C 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 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 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 UFP mode, a bulk capacitance between 1 to 10µF is required. In this particular case, a 1-µF capacitor was chosen.

### 8.2.3.3 Application Curves

![Application Curve for UFP in I²C Mode](image)

**Figure 15. Application Curve for UFP in I²C 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 (i.e. pull up on ID, INT, SCL, SDA, ADDR, PORT) must ramp with V_DD or lag after V_DD.
3. I2C 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, DRP).
5. The TUSB320 device monitors the CC pins as a DFP and V_BUS for attach as a 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. The TUSB320 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 TUSB320 V_DD pin.

10.2 Layout Example

![TUSB320 Layout Diagram](image-url)
11 Device and Documentation Support

11.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

<table>
<thead>
<tr>
<th>PARTS</th>
<th>PRODUCT FOLDER</th>
<th>SAMPLE &amp; BUY</th>
<th>TECHNICAL DOCUMENTS</th>
<th>TOOLS &amp; SOFTWARE</th>
<th>SUPPORT &amp; COMMUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUSB320</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
</tr>
<tr>
<td>TUSB320I</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
<td>Click here</td>
</tr>
</tbody>
</table>

11.2 Receiving Notification of Documentation Updates

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

11.3 Community Resources

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

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

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

11.4 Trademarks

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

11.5 Electrostatic Discharge Caution

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

11.6 Glossary

**SLYZ022 — TI Glossary.**

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

12 Mechanical, Packaging, and Orderable Information

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

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing Qty</th>
<th>PINS</th>
<th>Package Qty</th>
<th>Eco Plan</th>
<th>Lead/Ball Finish</th>
<th>MSL Peak Temp</th>
<th>Op Temp (°C)</th>
<th>Device Marking</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUSB320IRWBR</td>
<td>ACTIVE</td>
<td>X2QFN</td>
<td>RWB</td>
<td>12</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>NIPDAU</td>
<td>Level-2-260C-1 YEAR</td>
<td>-40 to 85</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>TUSB320RWBR</td>
<td>ACTIVE</td>
<td>X2QFN</td>
<td>RWB</td>
<td>12</td>
<td>3000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>NIPDAU</td>
<td>Level-2-260C-1 YEAR</td>
<td>0 to 70</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

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

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

**TAPE DIMENSIONS**

<table>
<thead>
<tr>
<th>A0</th>
<th>Dimension designed to accommodate the component width</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>Dimension designed to accommodate the component length</td>
</tr>
<tr>
<td>K0</td>
<td>Dimension designed to accommodate the component thickness</td>
</tr>
<tr>
<td>W</td>
<td>Overall width of the carrier tape</td>
</tr>
<tr>
<td>P1</td>
<td>Pitch between successive cavity centers</td>
</tr>
</tbody>
</table>

**REEL DIMENSIONS**

<table>
<thead>
<tr>
<th>Reel Diameter (mm)</th>
<th>Reel Width W1 (mm)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
<th>Pin1 Quadrant</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Reel Diameter (mm)</th>
<th>Reel Width W1 (mm)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
<th>Pin1 Quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUSB320IRWBR</td>
<td>X2QFN</td>
<td>RWB</td>
<td>12</td>
<td>3000</td>
<td>180.0</td>
<td>8.4</td>
<td>1.8</td>
<td>1.8</td>
<td>0.61</td>
<td>4.0</td>
<td>8.0</td>
<td>Q2</td>
</tr>
<tr>
<td>TUSB320RWBR</td>
<td>X2QFN</td>
<td>RWB</td>
<td>12</td>
<td>3000</td>
<td>180.0</td>
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<td>1.8</td>
<td>1.8</td>
<td>0.61</td>
<td>4.0</td>
<td>8.0</td>
<td>Q2</td>
</tr>
</tbody>
</table>

*All dimensions are nominal.*
## TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal*

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<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>RWB</td>
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<td>RWB</td>
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<td>3000</td>
<td>195.0</td>
<td>200.0</td>
<td>45.0</td>
</tr>
</tbody>
</table>
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.
NOTES: (continued)

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