

USB Type-C Configuration Channel (CC) Controller Selection Guide



Vishesh Pithadiya

ABSTRACT

This application note discusses the fundamentals of USB Type-C and the USB Type-C Configuration Channel (CC). Afterwards, this document provides insight into the CC designs that TI has to offer, as well as typical use cases for each part.

Table of Contents

1 Introduction	2
2 Detailed Description	8
3 Summary	10
4 References	11

Trademarks

All trademarks are the property of their respective owners.

1 Introduction

Common Terms and Definitions

Table 1-1. Common Terms and Definitions

Term	Definition
Differential signal	A signal that is transmitted using a pair of transmission lines. The transmitter sends data using two complementary, opposite-polarity signals on a pair of wires. The difference of these complementary signals is used to interpret the data at the receiver.
common mode voltage	The DC idle voltage of a link. The common mode voltage is the voltage of the link when no data is being transmitted
DC-coupling	DC coupling is when the common mode voltage of a link can be a non-zero value.
AC-coupling	AC coupling is when the common mode voltage of a link is 0V. This is typically done using AC coupling caps to block out DC voltages.
Full duplex	bidirectional communication across a single channel
half duplex	Unidirectional communication in two directions across two channels
GBPS	Giga bits per second.
CC	Configuration Channel
MUX	Multiplexer
source	Data/ power is transmitted from the source.
sink	Data/ power is received by the sink.
DFP	Downstream Facing Port
UFP	Upstream Facing Port
DRP	Dual-Role port
CC Controller	A CC controller is used to configure the orientation and power capabilities of the USB Type C link.
PD controller	Power Delivery controller. This type of controller typically integrates the functionality of the CC controller and PD functionality such as high-power capabilities and USB Type-C alternate modes.
PHY	Physical Layer. This includes all the hardware connections required for an interface.
AEQ Q100	Automotive qualification specification
try.SNK	A state in the USB Type-C state machine that allows for a DRP to prefer acting as a sink
try.SRC	A state in the USB Type-C state machine that allows for a DRP to prefer acting as a source

What is USB?

Universal Serial Bus, or USB is a serial protocol that allows for communication from a USB host to a USB device. This protocol was originally introduced in 1996 and today is one of the most popular communication protocols in the world. USB is used in applications ranging from mobile phones to electrical vehicles. Since 1996 there have been many updates and improvements to the protocol specification that led to its popularity. As shown in Table 1, the major revisions of the USB in use today are USB 2.0, USB 3.2, and USB 4.

Note: USB3.2 is an umbrella protocol that encompasses USB 3.0 (USB 3.2 Gen 1), and USB 3.1 (USB 3.2 Gen 2)

Table 1-2. Major USB Revisions and Data Communication Speeds Associated

USB Version			Symbol	Datarate
USB 2.0	LS	Low-Speed		1.5Mbps
	FS	Full-Speed		12Mbps
	HS	High-Speed		480Mbps
USB 3.2	Gen 1	SuperSpeed		5Gbps
	Gen 2	SuperSpeed 10Gbps		10Gbps
	Gen 2x2	SuperSpeed 20Gbps		20Gbps
USB 4				40Gbps

The latest revision of the USB is always backwards compatible with the previous iteration. This means a USB port supporting the newest revision, USB 4 with communication speeds of 40Gbps, is also required to support the oldest revision, USB 2.0 Low Speed with a communication speed of 1.5Mbps.

When USB transitioned from USB2 to USB3.x there was a major change in the physical characteristics of the USB port.

- In USB2.0 speeds all communication take place between a single DC-coupled differential pair utilizing half-duplex communication. (bidirectional communication across a single channel)
- In USB3.2 onwards communication takes place across two AC-coupled differential pairs allowing for full duplex communication. (unidirectional communication across two channels)

The USB specification also defines standard connectors associated with the USB protocol. The following diagram highlights the different USB connectors and footprints:

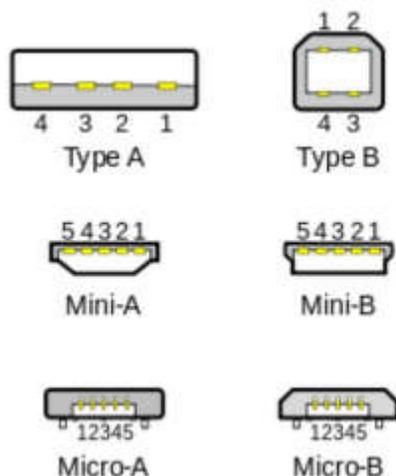


Figure 1-1. Typical USB 2.0 Connector Types

Here a link to the USB website for more details: <https://www.usb.org/documents>

What is USB Type-C and how is it different from previous USB Specifications?

The standard USB 2.0 type-A connector is symmetrical across the y-axis, so only one orientation of the USB connector can be plugged into a receptacle. The USB 2.0 connector has 4 pins.

- Vbus (5V Supply)
- D+ (Positive data input/ output for differential signaling)
- D- (Negative data input/ output for differential signaling)
- GND (Ground connection)

The following diagram shows what a standard USB 2.0 Type-A connector pinout looks like.

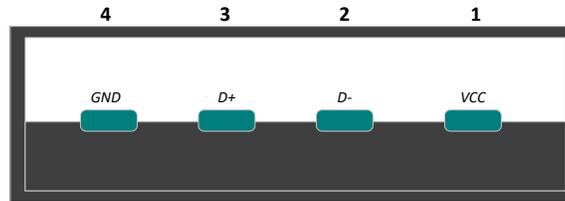


Figure 1-2. USB 2.0 Type-A Pinout

With the implementation of the full duplex USB 3.2 protocol some pins needed to be added to the USB connector. The addition of the differential pairs SSTX and SSRX allow for high speed communication while the D+ and D- pin remain for backwards compatibility. An example of a standard USB 3.2 Type-A connector is shown in Figure 1-3.

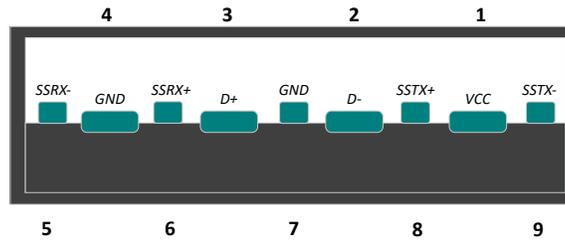


Figure 1-3. USB 3.2 Type-A Pinout

USB Type-C is a physical connector type that is symmetric across the x-axis and y-axis, meaning that there are two orientations of the cable that can be plugged into a receptacle. A USB device is required to function normally regardless of cable orientation; for this reason, the USB Type-C pinout includes a duplicate of each. The duplicate pins in a USB-C receptacle are shown in Figure 1-4

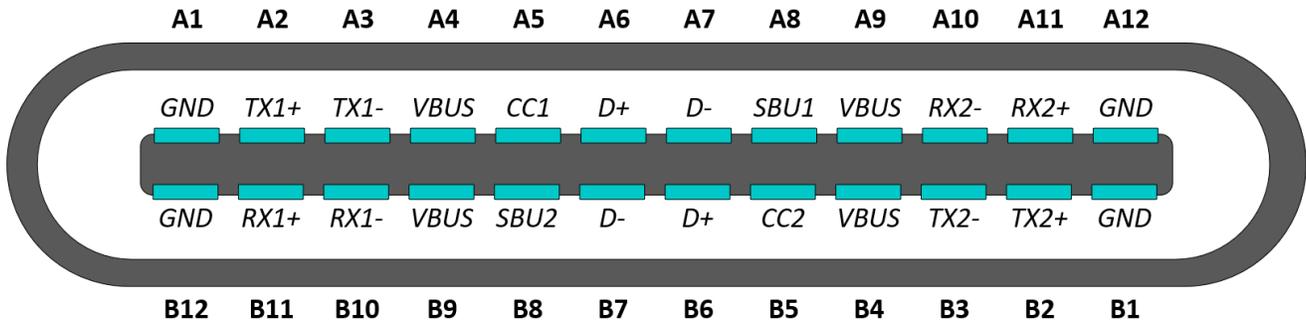


Figure 1-4. USB Type-C Pinout

Pins A5 and B5 of a Type-C receptacle are Configuration Channel (CC) pins.

How is the Configuration Channel (CC) implemented in USB Type-C?

The CC negotiation is one of the first steps of USB Type-C enumeration. The purpose of CC negotiation is threefold:

1. To determine the orientation of the USB Type-C connector
2. To negotiate the power sourcing and sinking capabilities between the host and device
3. To configure the system appropriately in alternate modes and debug modes

Determining the orientation of the USB Type-C controller is done by measuring the common mode of the CC pins. A standard representation of a USB Type-C CC connection is shown below.

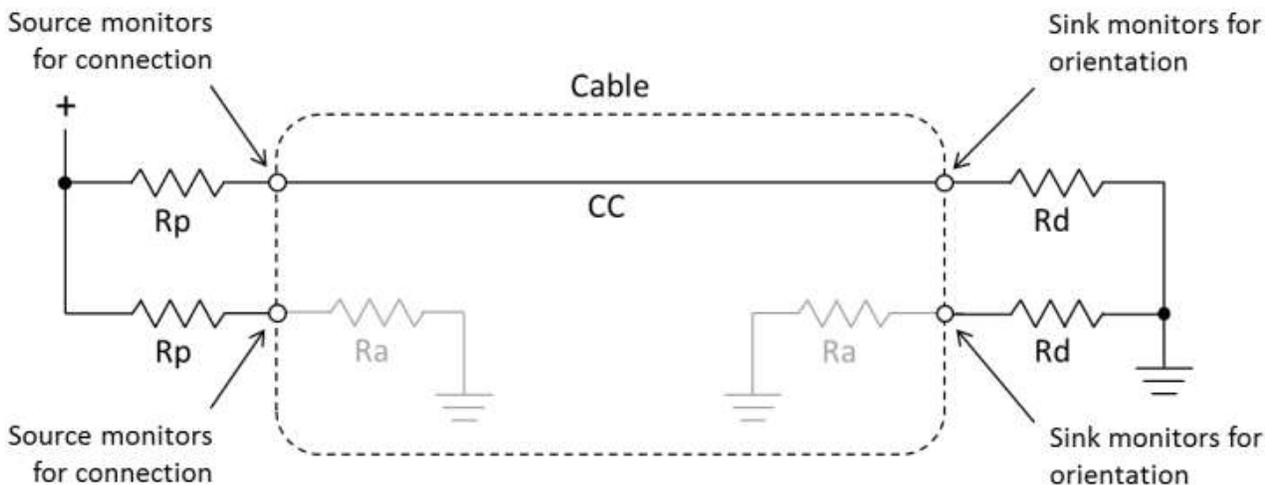


Figure 1-5. USB Type-C Pull-Up/ Pull-Down CC Model

In this image we see that the Source has pull up (PUP) resistors present on CC1 and CC2, these are defined to be R_p . The sink has pull down resistors (PDOWN) present on CC1 and CC2, these are defined to be R_d . R_a is a resistor internal to the cable which terminates the unused CC pins. When a USB Type-C cable is used to connect the Source and Sink ports, we see that one of the CC channels are connected to create a voltage divider network.

The Source and Sink are both monitoring the voltage seen on the CC pins. The CC voltage of the Source is at 3.3V when no connection is present. When a connection is made the CC voltage drops below 3.3V, and the Source knows a Sink is connected. Similarly, the CC voltage of the Sink is at 0V when no connection is present. When a connection is made, the CC voltage is pulled above 0V, so the Sink knows a Source is connected.

To clarify, two pull-up resistors are present on the source (R_p). Two pull-down resistors are present on the sink (R_d). A weak pulldown is present on all four pins of the USB Type-C cable (R_a). When the USB Type-C cable is plugged in, one pair of R_a and R_d is connected. This determines the orientation of the USB connection.

- If the change in voltage is detected on CC1, then the port determines the connection to be in the normal orientation. If the voltage change is detected on CC2 then the port determines the connection orientation in the flipped orientation. This is how the configuration channels are used to determine the orientation of the USB Type-C connector.

The pull-down values for the Sink is the same for all USB Type-C. However, the pull up values on the Source can be adjusted to change the common mode voltage of the CC pins between the DFP and UFP.

Different values of the DFP pull up resistors lead to different common mode voltages for the CC connection. This adjustable range of common mode voltages is used to determine the power capabilities of the connection. The following figures show the resistor values used to advertise 900mA, 1.5A, and 3A modes.

Source Advertisement	Current Source to 1.7 – 5.5 V	Resistor pull-up to 4.75 – 5.5 V	Resistor pull-up to 3.3 V ± 5%
Default USB Power	80 μ A ± 20%	56 k Ω ± 20% (Note 1)	36 k Ω ± 20%
1.5 A @ 5 V	180 μ A ± 8%	22 k Ω ± 5%	12 k Ω ± 5%
3.0 A @ 5 V	330 μ A ± 8%	10 k Ω ± 5%	4.7 k Ω ± 5%

Note 1: For *R_p* when implemented in the USB Type-C plug on a USB Type-C to **USB 3.1** Standard-A Cable Assembly, a USB Type-C to **USB 2.0** Standard-A Cable Assembly, a USB Type-C to **USB 2.0** Micro-B Receptacle Adapter Assembly or a USB Type-C captive cable connected to a USB host, a value of 56 k Ω ± 5% **shall** be used, in order to provide tolerance to IR drop on VBUS and GND in the cable assembly.

Note 2: Each value above is the total current or resistance into the Source CC pin including all leakage and parallel resistance.

Figure 1-6. R_p Resistor Values for CC Power Negotiation)

These different resistance values for R_p result in different ranges of common mode voltage for the CC voltage divider network. The resistor values in figure 4 relate directly to the voltages defined in figure 5. The voltages defined in the following table are detection thresholds for the USB Source.

	Minimum Voltage (V)	Maximum Voltage (V)
Connect Threshold <i>vCCRes-Rd-USB</i>	0.272	1.32 ⁽²⁾
Disconnect Threshold ² - <i>vRd-USB</i>	1.321	2.93 ⁽⁴⁾
Connect Threshold <i>vCCRes-Rd-1.5</i>	0.713	1.32 ⁽²⁾
Disconnect Threshold ¹ - <i>vRd-1.5</i>	1.440	2.44 ⁽⁴⁾
Connect Threshold <i>vCCRes-Rd-3.0</i>	0.88 ⁽²⁾	2.155
Disconnect Threshold ¹ - <i>vRd-3.0</i>	2.308	2.66 ⁽⁴⁾
<i>vCCRes-Ra-USB</i>	0 ⁽³⁾	0.143
<i>vCCRes-Ra-1.5</i>	0 ⁽³⁾	0.299
<i>vCCRes-Ra-3.0</i>	0 ⁽³⁾	0.617
Threshold between <i>vCCRes-Rd-USB</i> and <i>vCCRes-Ra-USB</i>	0.144	0.271
Threshold between <i>vCCRes-Rd-1.5</i> and <i>vCCRes-Ra-1.5</i>	0.300	0.712
Threshold between <i>vCCRes-Rd-3.0</i> and <i>vCCRes-Ra-3.0</i>	0.618	0.879

Note 1: Disconnect threshold should take *vOffset* into account. *vOffset* = 0.25 V is assumed here.
Note 2: Result is from the voltage clamp variance.
Note 3: Per Note 1 of Table 4-29, *R_a* minimum impedance may be less than *R_a(min)* when *V_{CONN}* is *not* applied.
Note 4: Considers *zOPEN* minimum.

Figure 1-7. CC Common Mode Voltage Detection Thresholds for 5V PUP CC Model

We observe that the voltage divider network of the CC can determine the orientation and power capabilities of the connection. We also observe that there are only three power modes available when determining power using the CC network.

- 5V/ 900mA (4.5W)
- 5V/ 1.5A (7.5W)
- 5V/ 3A (15W)

However, we know that USB Type-C have chargers that can charge at 50W+. How is this possible? Any power negotiation past 15W requires a PD controller. More information for these parts can be found [here](#).

The third function of the USB Tupe-C Configuration Channel (CC) is to configure the system appropriately into alternate modes and debug modes. Alternate mode configuration also requires a PD controller to communicate across the CC lines, and this function is not discussed in this document.

USB Type-C supports a variety of debug modes for a wide range of testing. These modes are optional, and not all UBS systems are required to support them. [Figure 1-8](#) shows the terminations seen by the USB source and the debug and accessory modes associated.

CC1	CC2	State	Position
Open	Open	Nothing attached	N/A
Rd	Open	Sink attached	①
Open	Rd		②
Open	Ra	Powered cable without Sink attached or for <i>Liquid Corrosion Mitigation Mode</i> attached (Appendix A)	①
Ra	Open		②
Rd	Ra	Powered cable with Sink, <i>VCONN-Powered Accessory (VPA)</i> , or <i>VCONN-Powered USB Device (VPD)</i> attached	①
Ra	Rd		②
Rd	Rd	<i>Debug Accessory Mode</i> attached (Appendix B)	N/A
Ra	Ra	<i>Liquid Corrosion Mitigation Mode</i> attached (Appendix A)	N/A

Figure 1-8. Expected CC Terminations and Debug Modes Associated

2 Detailed Description

This section of the document discusses what the CC controller portfolio of the USB team contains, and key differentiation criteria to help in the part selection process.

There are four main product families and three generations of parts in the CC controller portfolio. Figure 2-1 shows a visualization of the product families and the generations.

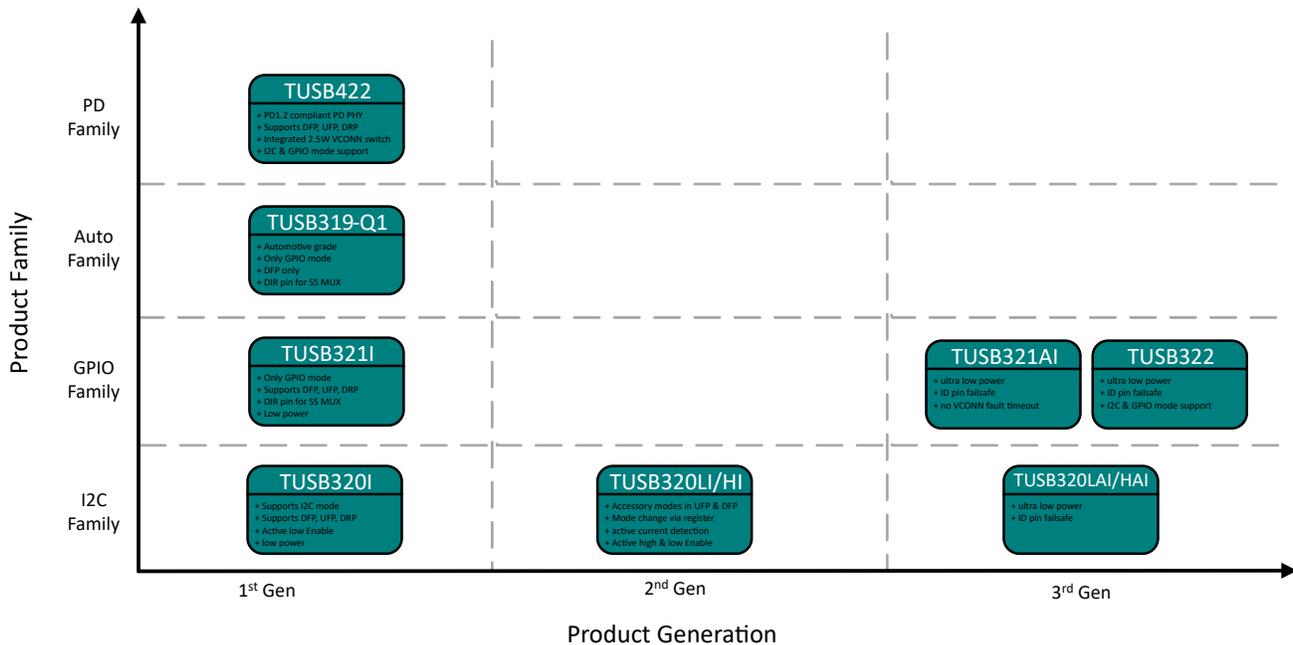


Figure 2-1. TI's Current CC Controller Portfolio

The four families of products can be divided based on the following identifiers:

1. **PD Family:** This family of products supports PD PHYs. The only part in this family is the TUSB422 which was released to be fully compliant with PD specification revision 1.2. For newer PD offerings, reach out to TI's PD controller team.
2. **Automotive Family:** The family of products that are AEQ Q100 qualified. The only part in this family of products is the TUSB319-Q1. This is a DFP only CC controller.
3. **GPIO Family:** This family of products were designed for GPIO applications. They are all designed with an external DIR which is used to control a USB Superspeed MUX. These parts are best designed for USB 3.x applications of a USB Type-C system. There are three parts in this family of products: TUSB321I, TUSB321AI, and TUSB322I.
4. **I2C Family:** This family of products are designed for I2C and GPIO applications. The products are designed to operate with USB 2.0 systems in GPIO mode as the products do not have an external DIR pin. However, in I2C mode these parts can operate in USB 2.0 and USB 3.x applications. These parts also provide the flexibility of an EN pin which can be active high or active low. The parts in this family are: TUSB230I, TUSB320LI, TUSB320HI, TUSB320LAI, and TUSB320HAI.

In addition to the four families of products, TI's CC controller portfolio can further be broken down into generations. The following figure highlights the key changes between generations. Keep in mind all three generations of products exist independently, meaning that a newer generation does not make older generations obsolete. The PD controller family is not included here as there is only one generation of the TUSB422.

Feature	First Generation		Second Generation		Third Generation				
	TUSB320	TUSB321	TUSB320LI	TUSB320HI	TUSB320LAI	TUSB320HAI	TUSB321A	TUSB322	HD3SS3220
VDD Range	2.7 V–5 V	4.5 V–5.5 V	2.7 V–5.5 V	2.7 V–5.5 V	2.7 V–5.5 V	2.7 V–5.5 V	4.5 V–5.5 V	4.5 V–5.5 V	Dual Supply: 5 V and 3.3 V
Enable Pin	Active Low	N/A	Active Low	Active Low	Active Low	Active High	N/A	Active Low	Active Low
Shutdown Current	0.46 μ A	N/A	0.46 μ A	0.46 μ A	0.37 μ A	0.37 μ A	N/A	0.37 μ A	5 μ A
UFP Active Current	100 μ A	100 μ A	100 μ A	100 μ A	70 μ A	70 μ A	70 μ A	70 μ A	700 μ A
Vconn 1-Watt Support	No	Yes	No	No	No	No	Yes	Yes	Yes
GPIO Mode	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
400-kHz I ² C support	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
UFP-only Support	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes With I2C	Yes
DFP-only Support	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes With I2C	Yes
DRP-only Support	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cable Orientation through DIR pin to control external MUX	No	Yes	No	No	No	No	Yes	Yes	Yes
Cable Orientation through I ² C register	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
ID pin Fail-Safe	No	No	No	No	Yes	Yes	Yes	Yes	Yes
VBUS Detection 4 V to 28 V	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integrated USB 3.1, 2:1 MUX	No	No External using HD3SS3212	No	No	No	No	No External using HD3SS3212	No External using HD3SS3212	Yes

Figure 2-2. Generational Breakdown of CC Controller Portfolio

Figure 2-3 provides a product selection flowchart that uses key device features to streamline part selection.

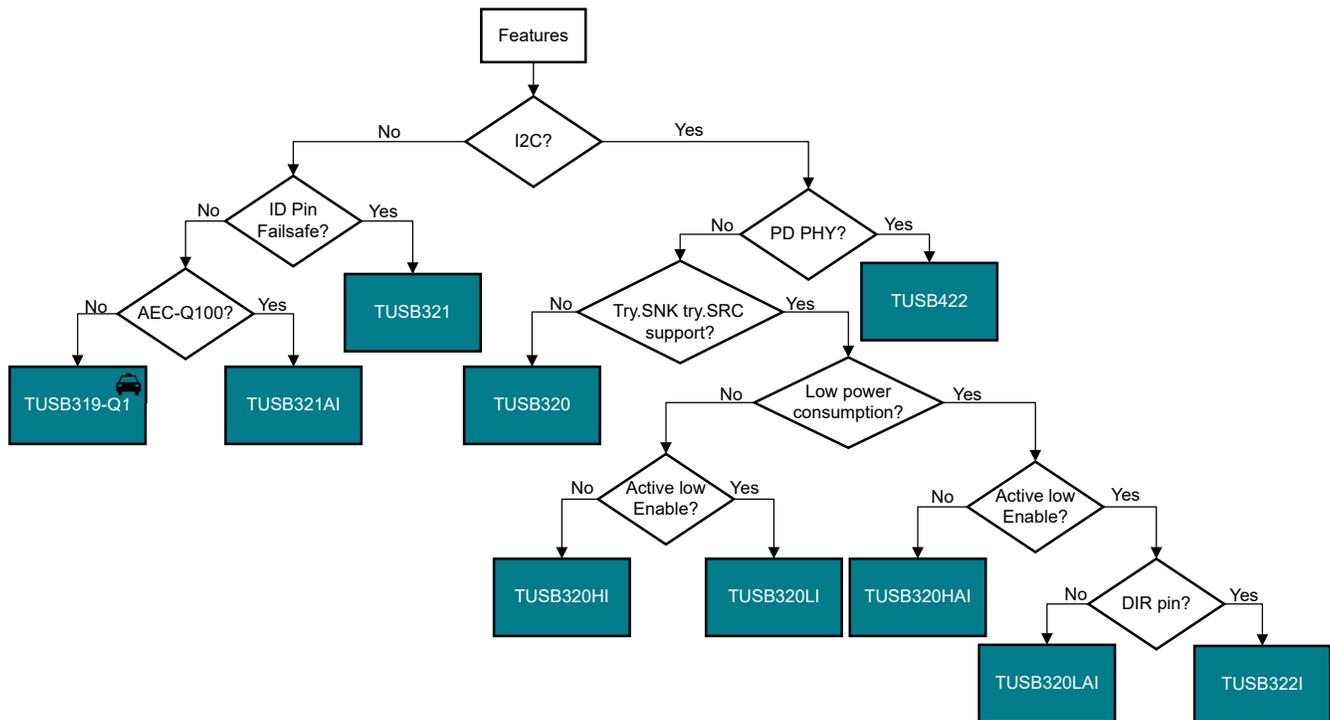


Figure 2-3. CC Controller Selection Flowchart

3 Summary

The CC controller portfolio covers many of the needs defined by the USB Type-C specification. Because of this coverage, there are currently no plans to expand this portfolio. If higher power, alternate mode functionality, or MCU functionality is needed please have a look at the [PD controller portfolio](#) on TI.com.

4 References

1. Texas Instruments, *Implementing USB Type-C® Using TI's Portfolio*, application note.
2. Texas Instruments, *Typical Application Issues for TUSB32x and HD3SS3220 CC Controller Devices*, application note.
3. USB, <https://www.usb.org>, webpage.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025