Application Report

Typical Application Issues for TUSB32x and HD3SS3220 CC Controller Devices

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ABSTRACT

This application note covers the main topics customers face when designing a USB Type-C® system with TI's CC controller. It summarizes the main differences between TI CC controller devices like the TUSB32x and HD3SS3220 as well as the difference between a Power Delivery (PD) controller and Configuration Channel (CC) controller. This information helps customer choose the best device for their system design.

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1 Introduction

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 USB Type-C current capabilities. These schemes are implemented over the CC pins according to the USB Type-C specifications. The TUSB32x devices provide CC logic for determining USB port attach and detach, role detection, cable orientation, and USB Type-C current mode.

The HD3SS3220 device has integrated USB 3.0, USB 3.1 SuperSpeed and SuperSpeed+ MUX with 2 channel 2:1 switching required to handle cable flips. The CC controller determines the orientation of the cable and controls the MUX selection. This application note describes the main issues customers may have when they design the USB Type-C application with a TI CC controller.

2 Differences for the TUSB32x and HD3SS3220 CC Controller Family

There are three generations of TUSB32x devices. Table 2-1 shows the major differences for the TI CC controller family.

Table 2-1. TI CC Controller Features

	First Generation		Second Generation		Third Generation				
Feature	**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 µA	N/A	0.46 µA	0.46 µA	0.37 µA	0.37 µA	N/A	0.37 µA	5 µA
UFP Active Current	100 µA	100 µA	100 µA	100 µA	70 µA	70 µA	70 µA	70 µA	700 µA
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^2C 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^2C 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

3 PD Controller versus CC Controller

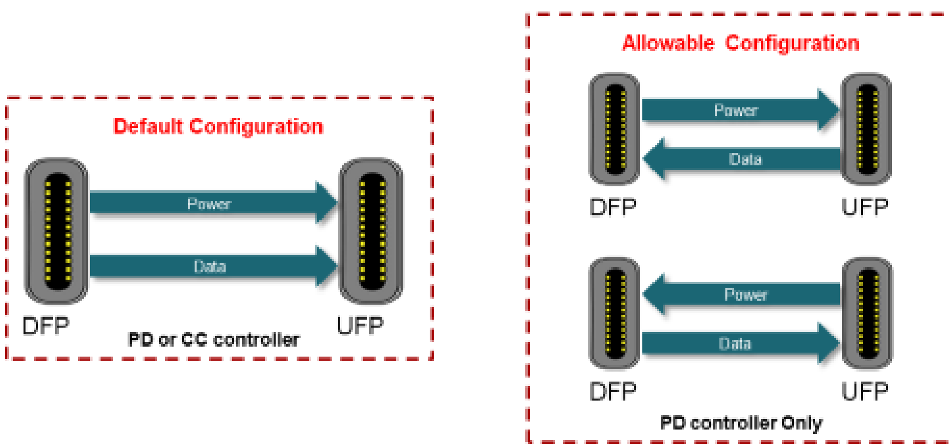
Customers often want to know what the major differences between a PD controller and a CC controller are and how to pick the right controller for their system.

Table 3-1 displays the comparison between the PD and CC controllers. When supporting charging greater than 15 W, a video alternate mode or power role and data role swap, a PD controller is required for your system.

Table 3-1. PD Controller versus CC Controller

USB Type-C®	PD Controller	CC Controller	Comments
Supports DFP, UFP, DRP Port Configurations	×	×	Supports both configuration and detection of USB Type-C ports. Includes Try.SNK and Try. SRC DRP ports
Supports up to 100-W Charging	×		Achieved by raising VBUS voltage and current maximum
Supports up to 15-W Charging	×	×	Achieved by raising VBUS current maximum to 3 A
Supports Video Alternate Modes	×		DP and HDMI video alternate modes supported
Supports Debug Alternate Modes and Audio Accessories	×	×	Allows for custom debug mode configuration and detection
Vconn Support	×	×	Used to power USB Type-C plug devices and active cables
Power Role Swap	×		Used to swap power provider and power consumer roles over Power Delivery messages
Data Role Swap	×		Used to swap USB host (DFP) and USB device (UFP) roles

Figure 3-1 shows the USB Type-C power and data role configurations. For a CC controller, power and data is configured from DFP to UFP. For a PD controller, power and data is configured either from DFP to UFP or from UFP to DFP.



USB Type-C power and data can flow independently.

Figure 3-1. USB Type-C® Power and Data Role Configuration

4 Power On Sequence and Power On Reset

This section describes the TUSB32x and HD3SS3220 devices.

4.1 TUSB32x Devices

There is a power switch in the TUSB320 which is controlled by the “en_n” signal. The chip is enabled when en_n = 0, and is disabled when en_n = 1. Power up sequence of en_n = 0 is shown in Figure 4-1: There is a voltage detector at the LDOS power supply. LDOS is not enabled until power and band gap is high enough, the DC threshold of this detector is around 2 V (3 V_{GS}). A digital reset signal “rstn_i_1p5v” is generated by a Power-On-Reset (POR) circuit that detects 1.5-V LDO output voltage, the threshold is typically 1.0 V.

After a digital reset, wait for 50 ms (typical) to ensure power is stable, then the eFuse values are read in and the other analog blocks are enabled as Figure 4-1 shows.

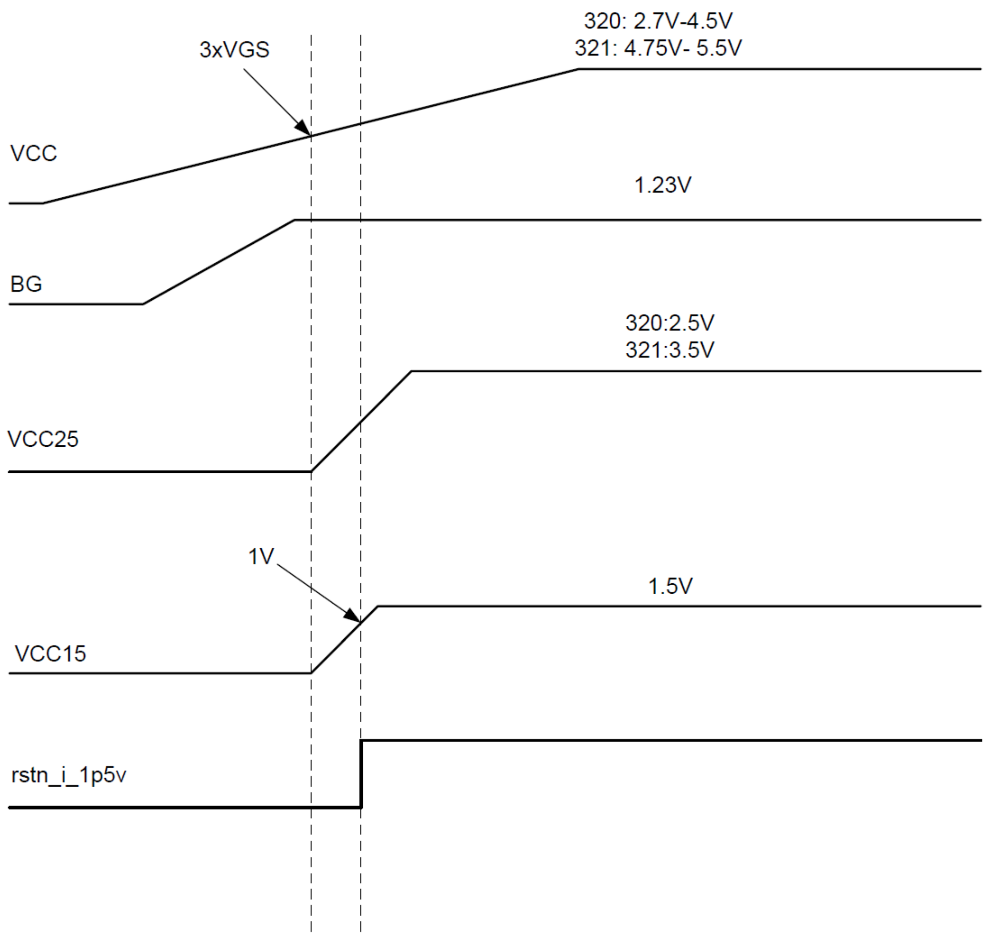


Figure 4-1. Power On Reset Timing of TUSB32x Devices

VCC must ramp within 25 ms or less. The EN_N pin can be shorted to GND. If controlled externally, EN_N must be held high at least for 50 ms after VCC has reached its valid voltage level.

4.2 HD3SS3220 Device

The HD3SS3220 has two power supplies: VDD5 and VCC33. The VDD5 supply powers the internal CC controller (TUSB320x) and also provides VCONN to either CC1 or CC2. The VCC33 powers the 2:1 MUX.

There are some non-fail-safe pins in HD3SS3220. If any of these non-fail-safe pins are pulled up to a supply other than VDD5, then the VDD5 supply must be powered up before the VCC33 supply, as depicted in Figure 4-2. ENn_CC can be shorted to GND.

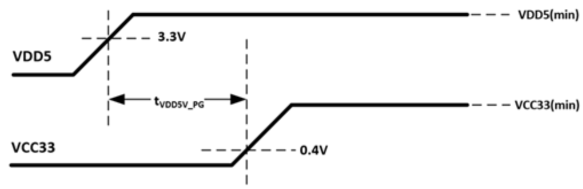


Figure 4-2. Power On Sequence of HD3SS3220

If it is not possible to power up VDD5 before VCC33, then the ENn_CC pin must be held high for at least 2 ms while both supplies are ramping and then asserted low after both supplies are stable as depicted in Figure 4-3.

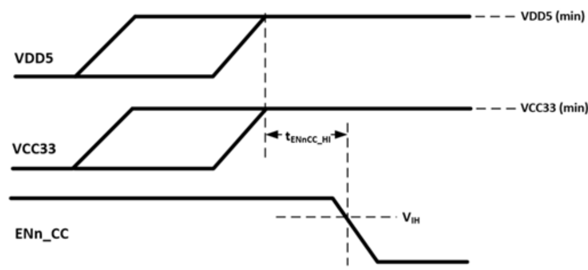


Figure 4-3. Power On Sequence of HD3SS3220 With ENn_CC

5 Non-Fail-Safe Pins

When VDD is off, the TUSB32x non-fail-safe pins (VBUS_DET, ADDR, PORT, ID, OUT[3:1] pins) could back-drive the TUSB320 device if not handled properly. When it is necessary to pull these pins up, it is recommended to pullup non-fail-safe pins to the VDD supply of the device. The VBUS_DET must be pulled up to VBUS through a 900-kΩ resistor.

When using the 3.3-V supply for I2C, the end user must ensure that the VDD is 3 V and above. Otherwise the I^2C may back power the device.

The HD3SS3220 non-fail-safe pins are the following: PORT, ADDR, SDA/OUT1, SCL/OUT2, INT_IN/OUT3,VCONN_FAULT_N, and DIR. If any of these non-fail-safe pins are pulled-up to a supply other than VDD5, then the VDD5 supply should be powered up before the VCC33 supply as depicted in Figure 4-2.

6 DFP and DRP Application

The TUSB32x and HD3SS3220 devices can be configured as a downstream facing port (DFP), upstream facing port (UFP), or dual role port (DRP) using the tri-level PORT pin. The PORT pin should be pulled high to VDD using a pullup resistance, low to GND, or left as floated on the PCB to achieve the desired mode, or by changing the MODE_SELECT register default setting with the PORT pin left floating with I^2C.

Upon detecting a UFP device, the CC controller keeps the ID pin high if VBUS is not at VSafe0V. Once VBUS is at VSafe0V, the HD3SS3220 asserts the ID pin low. This is done to enforce USB Type-C requirements that VBUS must be at VSafe0V before re-enabling VBUS. To meet this requirement, a VBUS switch is needed to control VBUS. Figure 6-1 is the typical DFP application with the VBUS switch.

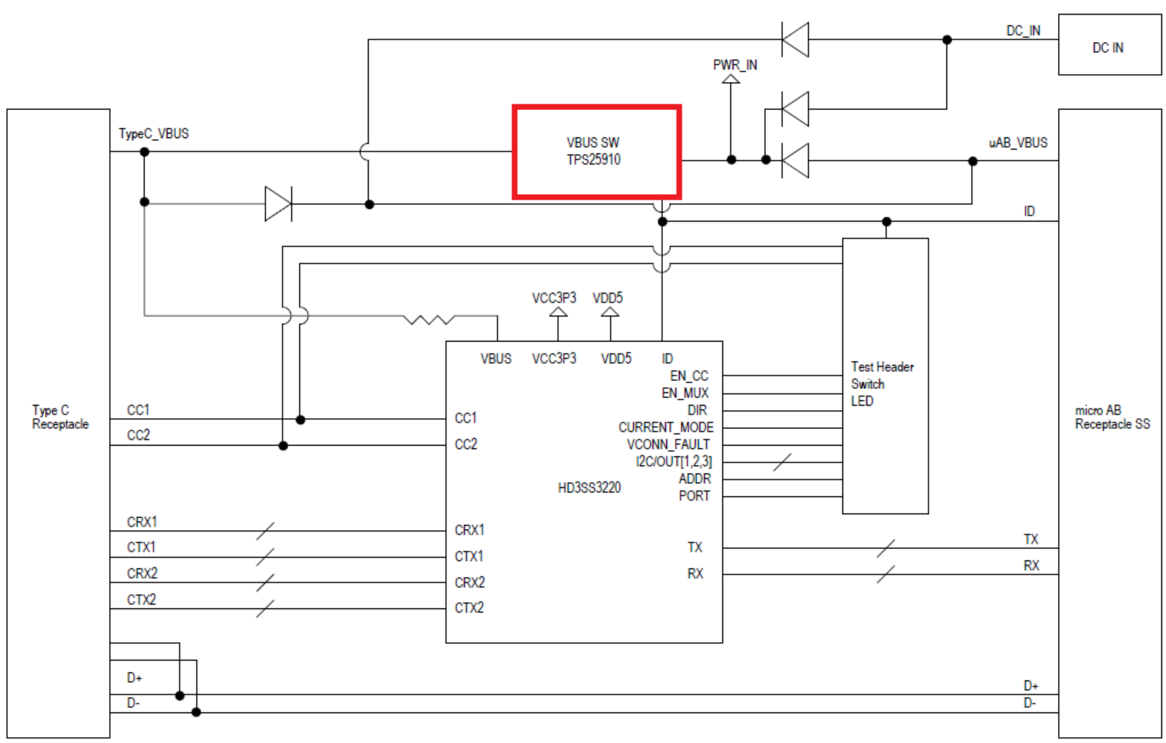


Figure 6-1. DFP Application With VBUS Switch

7 AC Coupling Capacitor Placement

Many interfaces require AC coupling between the transmitter and receiver. The 0402 capacitors are the preferred option to provide AC coupling; 0603 size capacitors also work.

When placing AC coupling capacitors, symmetric placement and a capacitor value of 0.1 µF is best. The value should match for the ±signal pair. Place them along the TX pairs on the system board, which are usually routed on the top layer of the board.

The AC coupling capacitors have several placement options. Because the switch requires a bias voltage, place the capacitors on one side of the switch. If they are placed on both sides of the switch, provide a biasing voltage.

In Figure 7-1, the host controller Vcm meets the MUX Vcm requirement, but end point Vcm does not meet the MUX Vcm requirement. An AC capacitor is placed between the MUX and Connector.

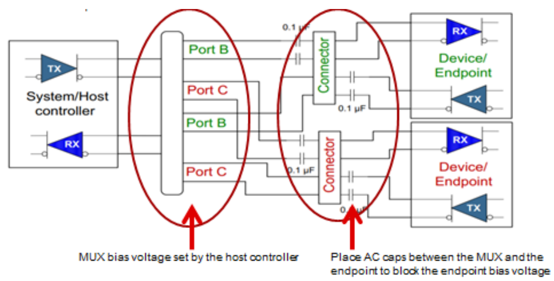


Figure 7-1. AC Capacitor Placed at Endpoint Side

In Figure 7-2, the host controller and endpoint Vcm meets the MUX Vcm requirement. MUX bias voltage is provided either by the host or the endpoint. An AC capacitor is placed by the host side.

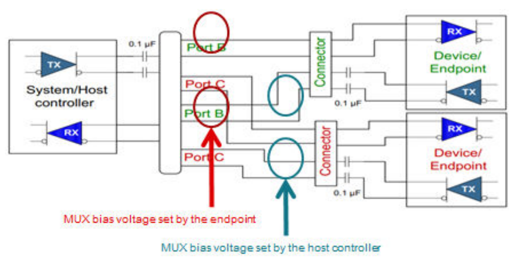


Figure 7-2. AC Capacitor Placed at Host Side

In Figure 7-3, the host controller and endpoint Vcm is outside the MUX Vcm requirement, an external biased voltage is required.

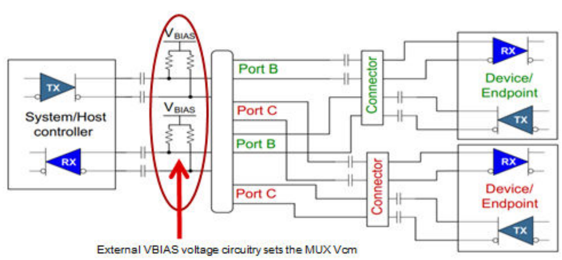


Figure 7-3. AC Capacitor Placed on Both Sides of MUX With External Bias

8 INT_N Bit Clear

In I^2C, INT_N is an active-low interrupt signal for indicating changes in I^2C registers. The INT_N pin is pulled low whenever a CSR changes. When a CSR change occurs this bit is held at 1 until the application clears it. A write "1" to bit 0x09 [4] clears the INT_N bit to low.

9 Summary

This technical article compares the differences between TI CC controller device families and between PD and CC controllers. Other typical customer questions regarding USB Type-C designs are discussed.