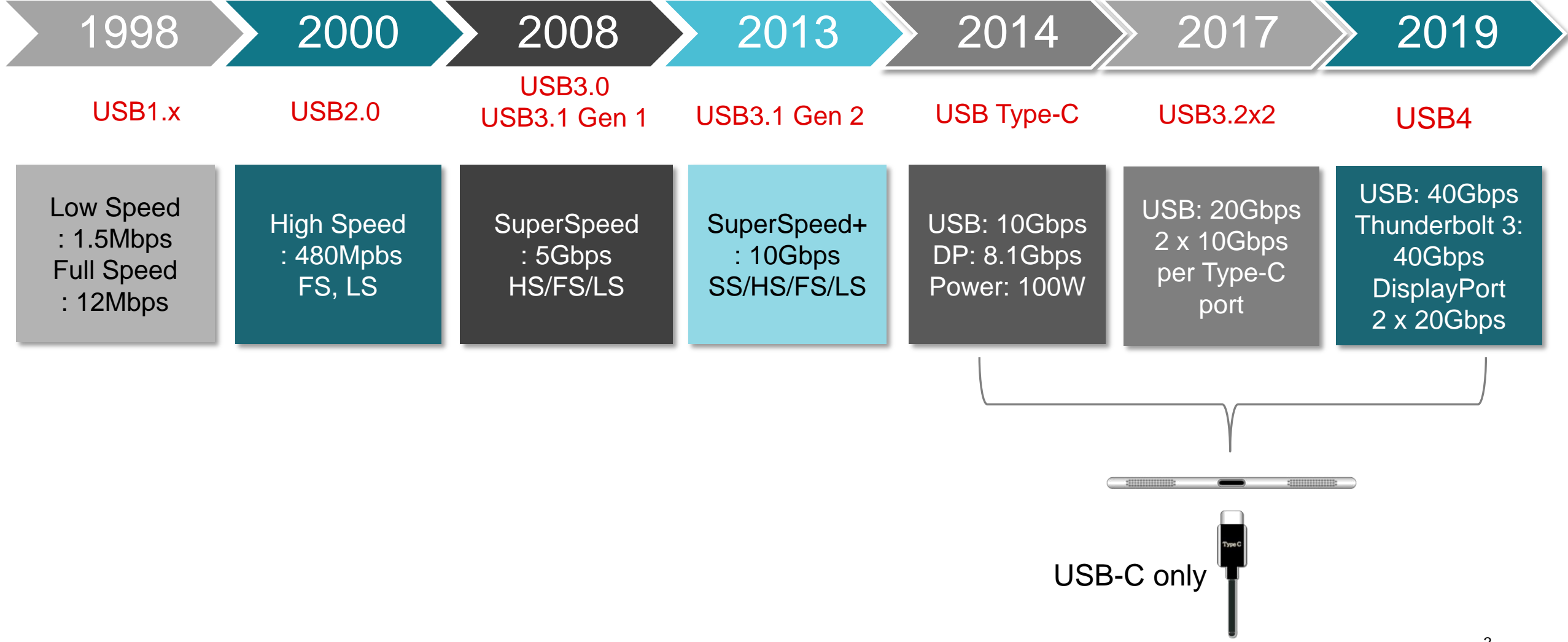


# USB Redriver and Type-C Solutions

**High Speed Signal Conditioning**

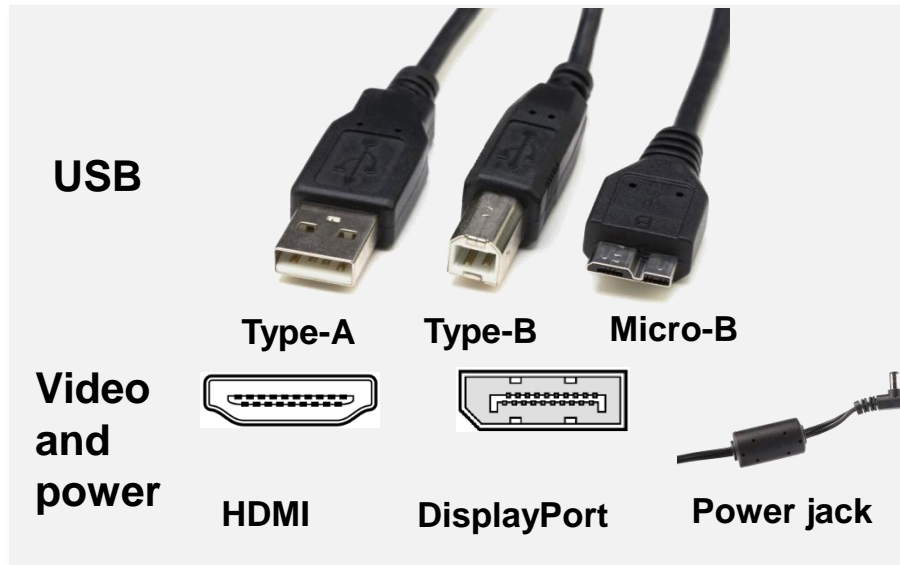
**Zhihong Lin**

# The evolution of USB

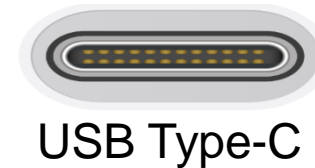


# USB Type-C: unified interface for data, video & power

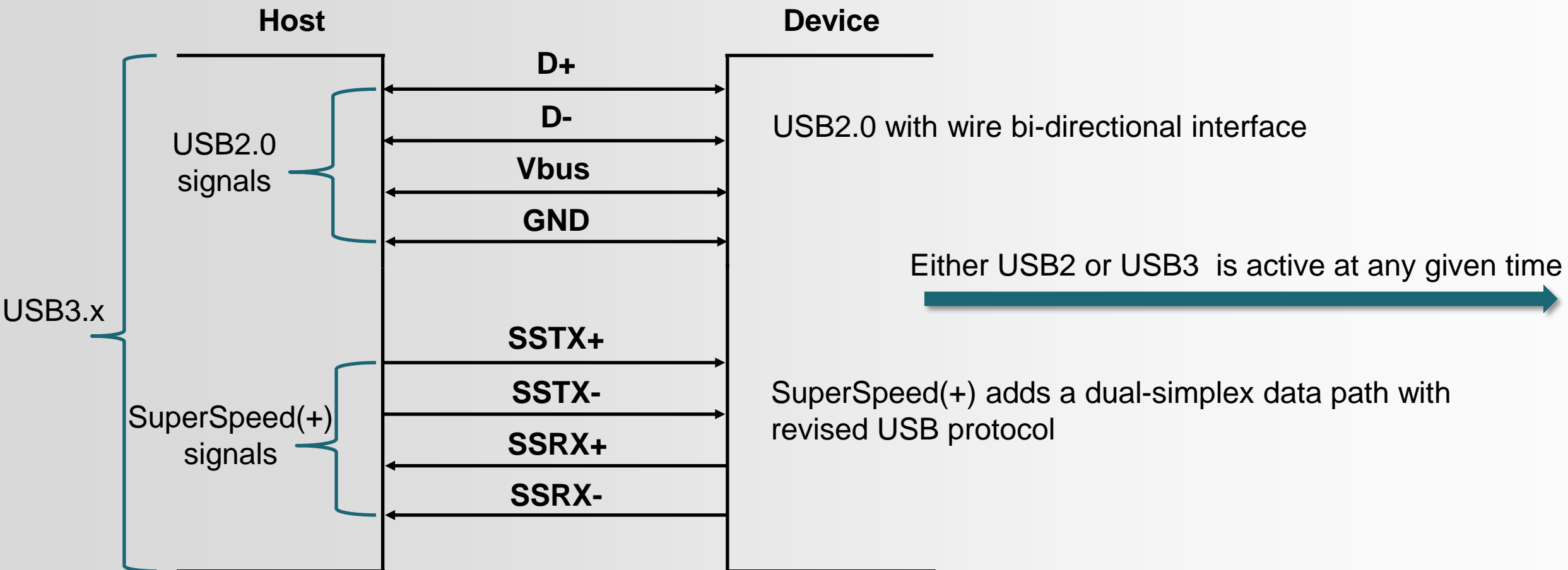
Type-C feature benefits	USB Type-C	USB Type-A or Type-B
Higher data throughput	Up to 40Gbps	Up to 10Gbps
Multiple protocols	USB, DisplayPort, Thunderbolt, HDMI...	USB data only
High power delivery	100W (up to 20V, 5A)	7.5W (up to 5V, 1.5A)



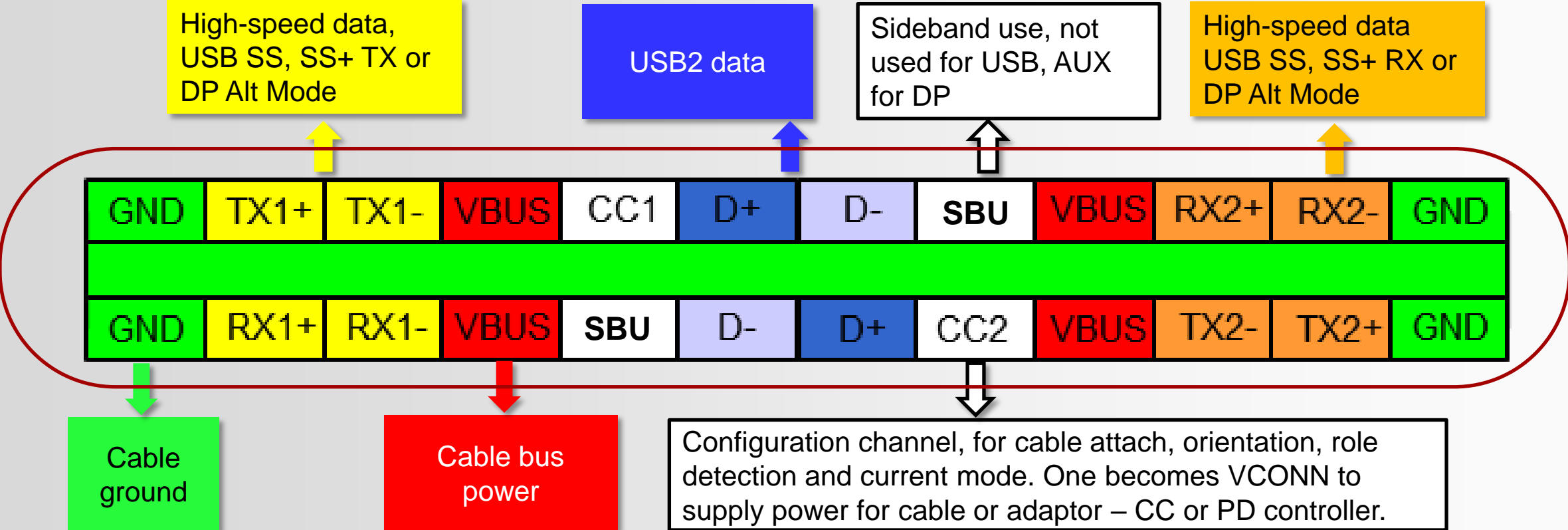
One size for all



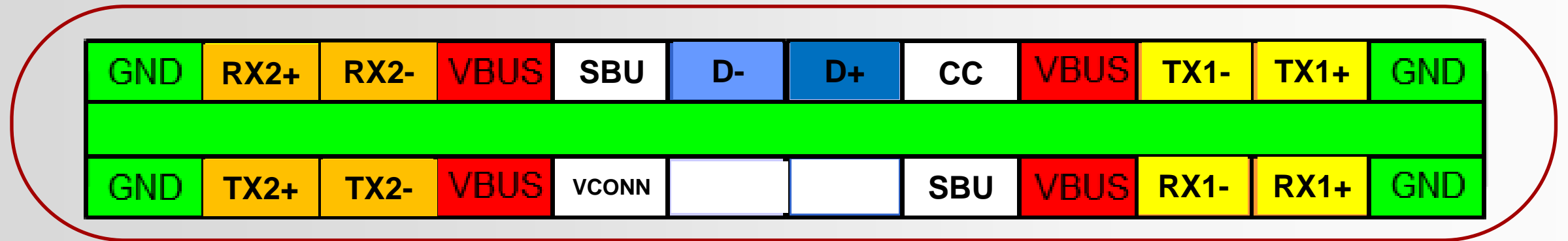
# The USB signal fundamentals



# USB Type-C flippable receptacle interface

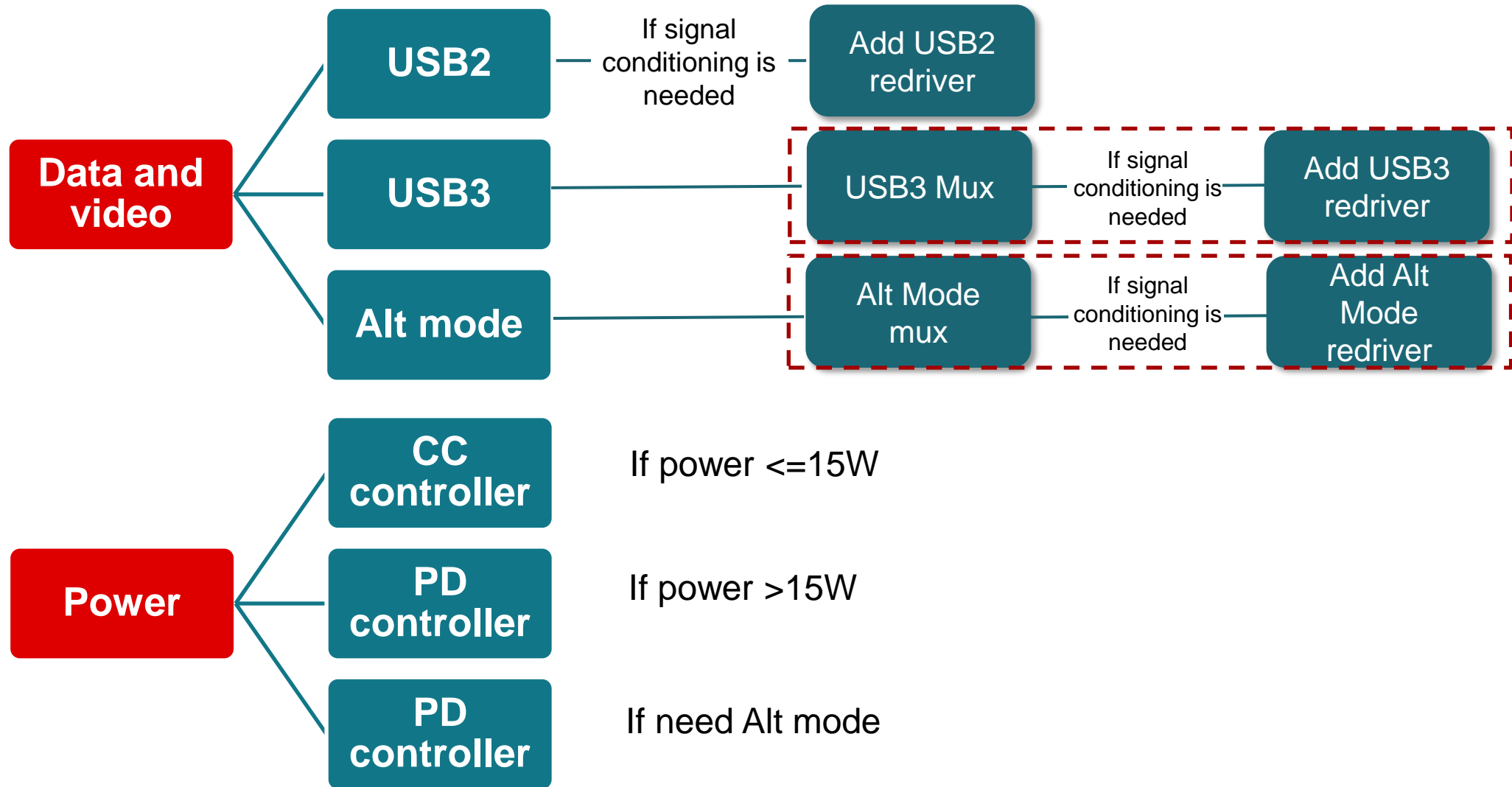


# USB Type-C plug interface

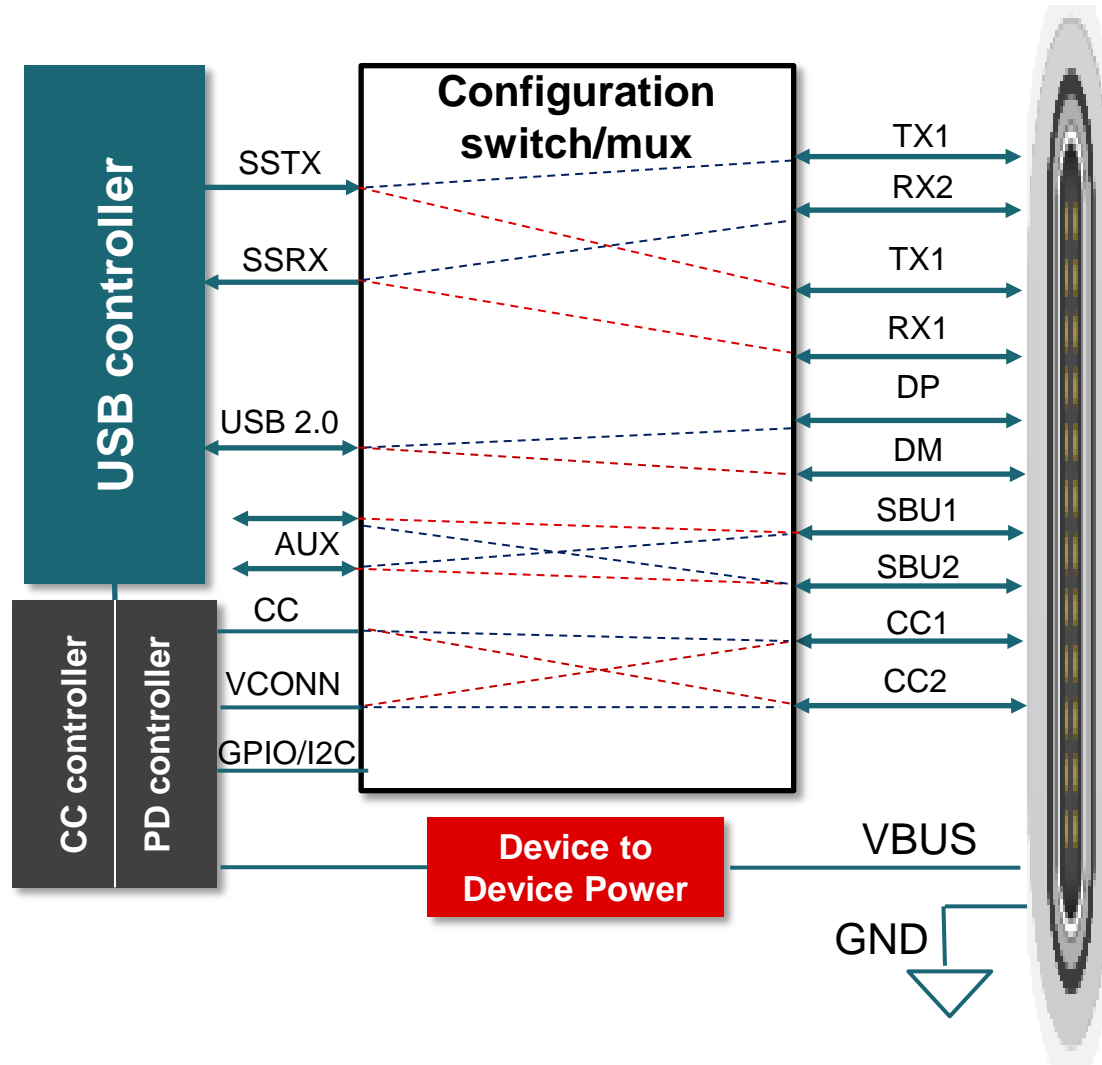


**Overview:** Conventionally, USB2 D+ and D- pins are stubbed at the PCB near the receptacle, so a mux is not required for USB2 interface.

# USB Type-C design considerations



# Enable USB Type-C flippable connector using configuration switch/mux



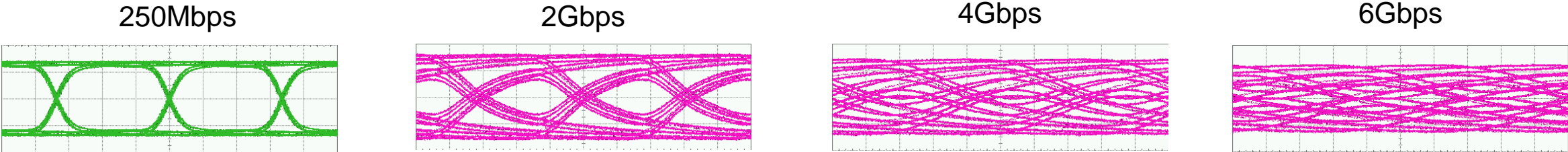
## Benefits:

- USB Type-C switch can reduce pin out and complexity in USB controller.
- Same switch required in both host and device.
- Switch can be integrated with USB signal conditioner and CC functions.
- SBU mux required for Alt Modes
- USB 2.0 mux optional.

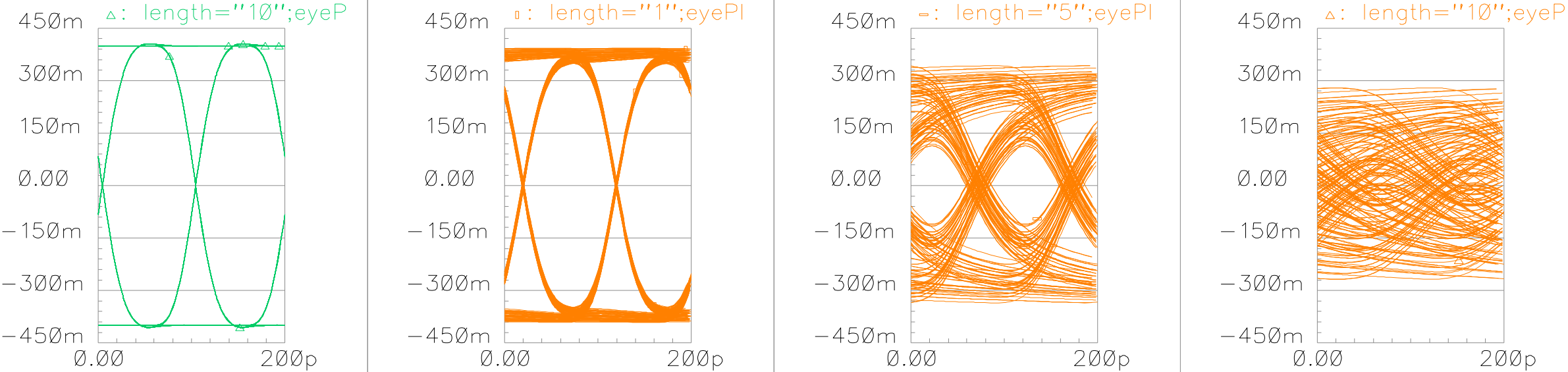


# Signal integrity challenges with high-speed signals

**Overview:** High-speed signals suffer signal integrity degradation over long PCB traces or cables



**Signal degradation with different data rate over 36-inch trace**



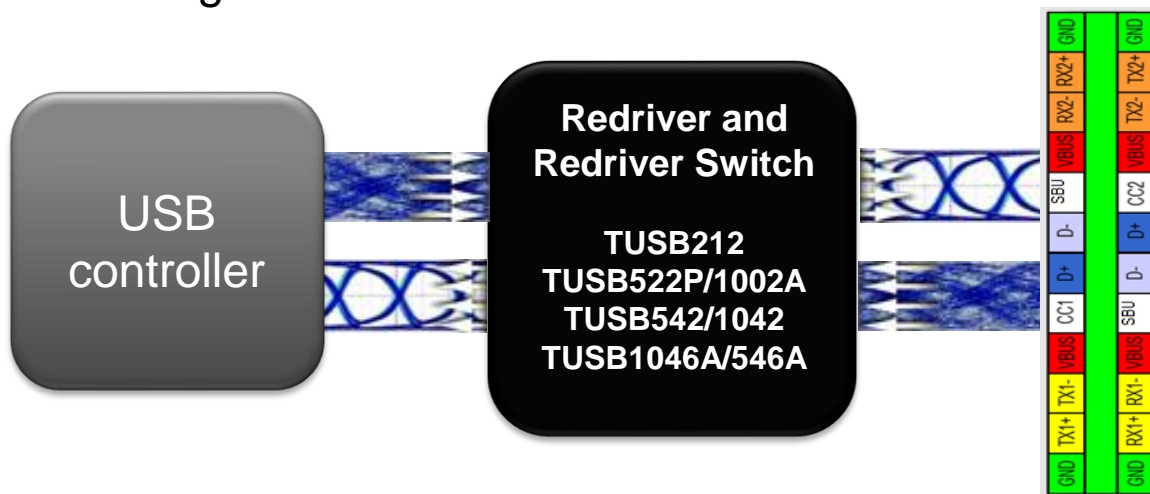
**10Gbps Signal degradation over different cable length**

# Improve USB Type-C signal quality using redrivers

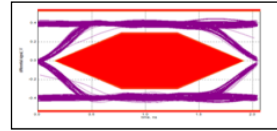
Gigabit signals are subject to signal integrity degradation due to long trace, cross connectors, long cable and capacitance lines

Redrivers enable better USB Type-C solution performance:

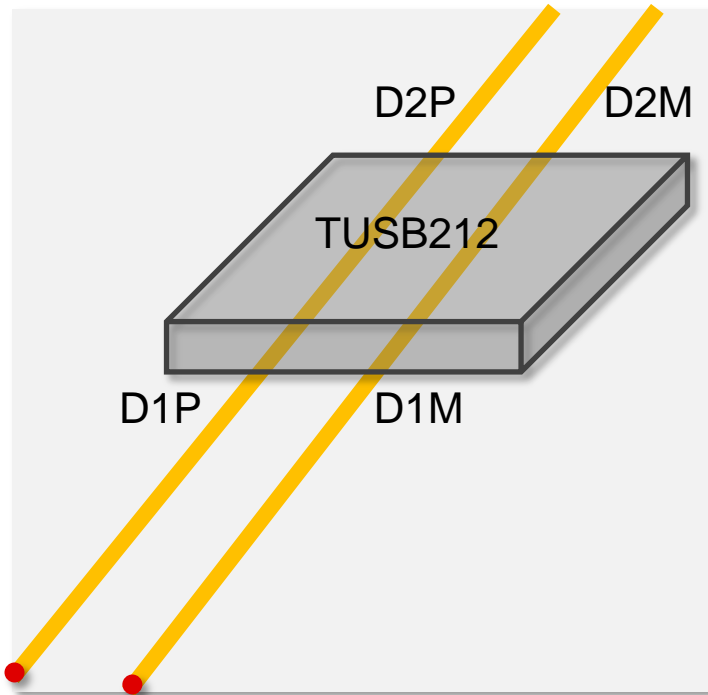
- Provides optimal equalization to compensate intersymbol interference.
- Improves signal quality, maintain signal integrity over long trace or cable.
- Enables design flexibility and improve system performance, help pass compliance.
- Enables broad range of interoperability.
- Extended distance signal can travel across cable or trace.



# USB2.0 redriver enable better system performance

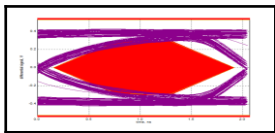


After



## TUSB212 Benefits

- Ultra-small package 1.6mm x 1.6mm
- Flow through PCB routing, **does not break DP/DM trace**
- Easy add-on to the PCB – **no board spin required**
- Improves signal quality over long trace or cable
- Enables better system interoperability with other USB2 devices – lower latency compared to retimer solutions,



Before

# TUSB212 non-disruptive flow through trace routing

## 10.2 Layout Example

### Risk Free Board Design

- Populate if signal conditioning needed
- DNP if no help needed! No need for board spin

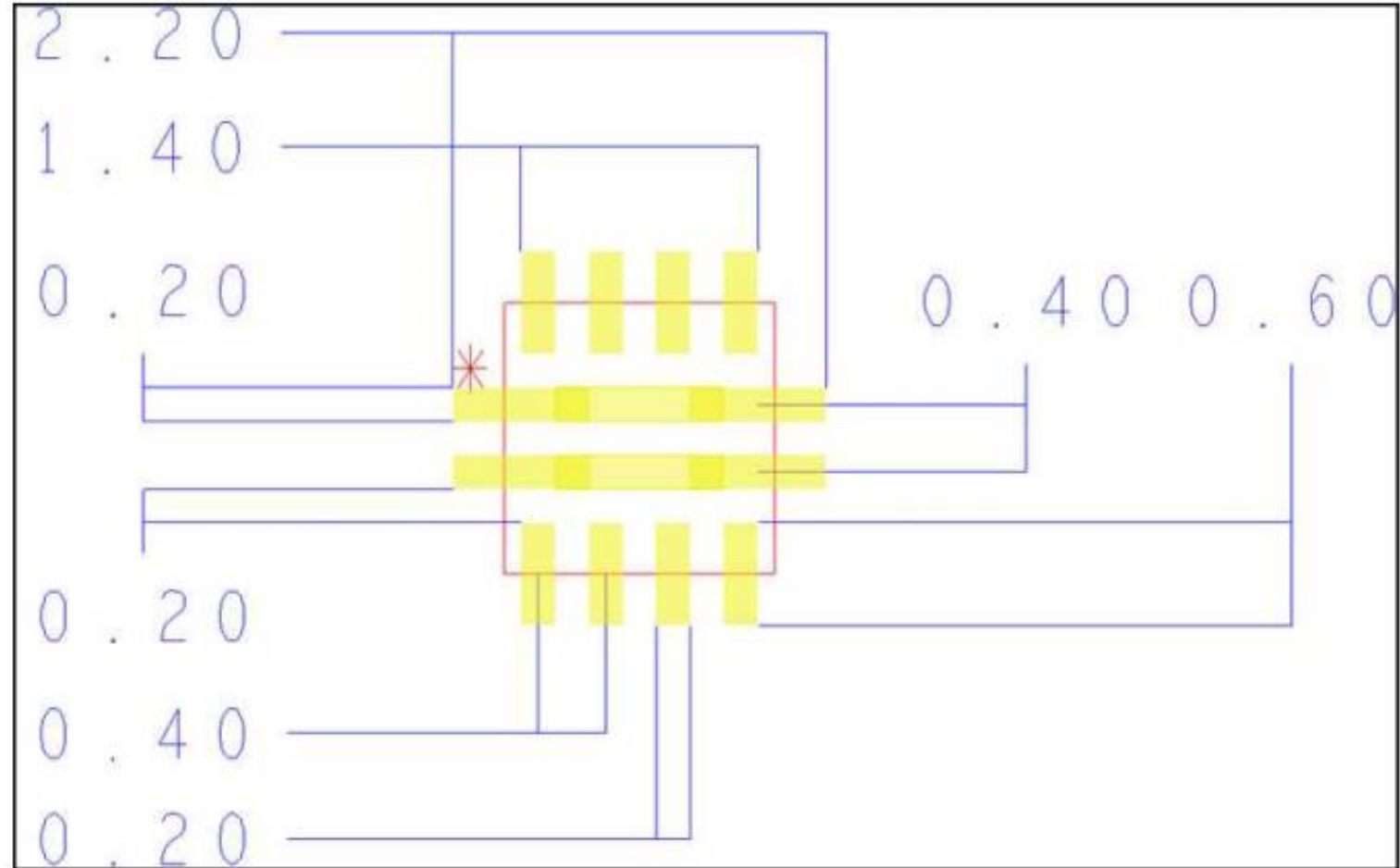
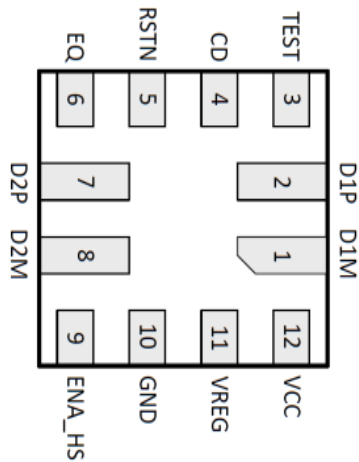
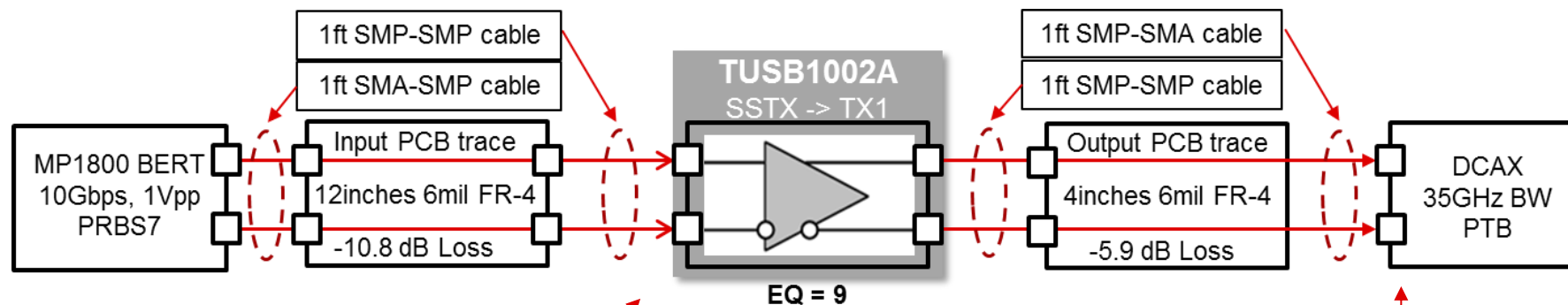
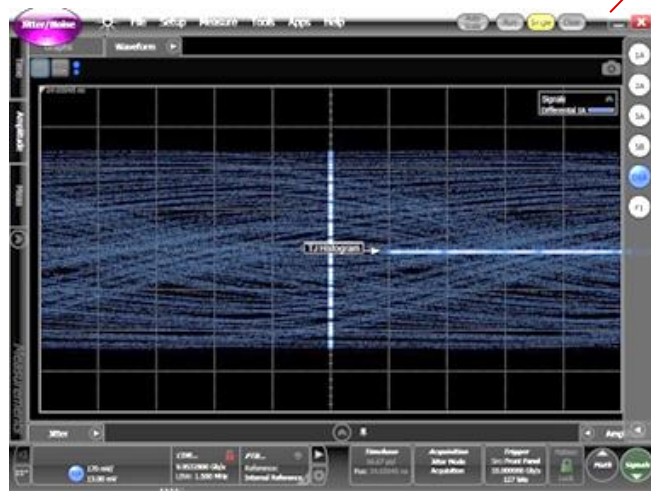


Figure 8. DP and DM Routing Underneath Device Package

# Use USB3 redriver to improve signal quality



Without redriver

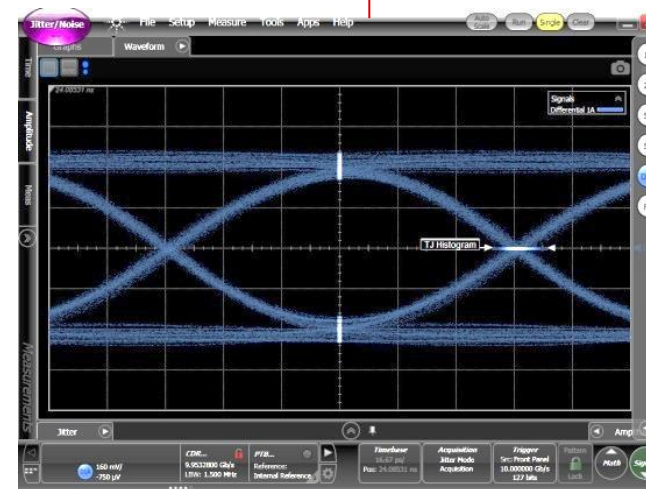


**TUSB1002A:**  
10Gbps, USB3, dual-  
channel redriver

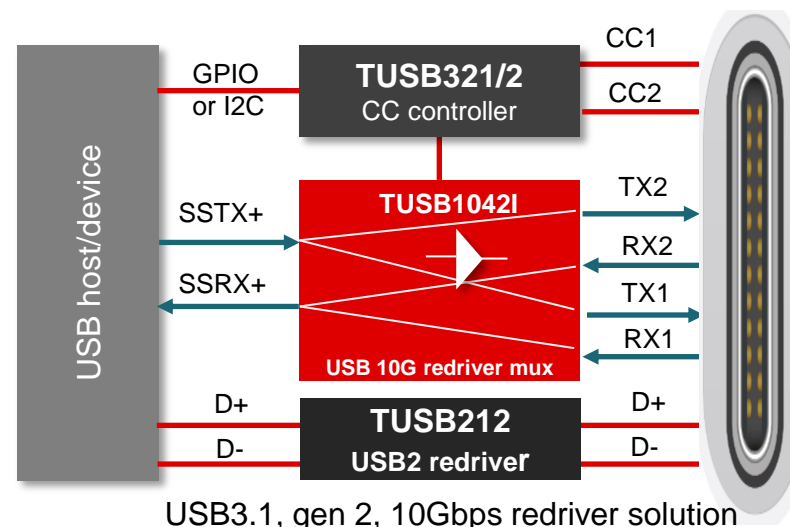
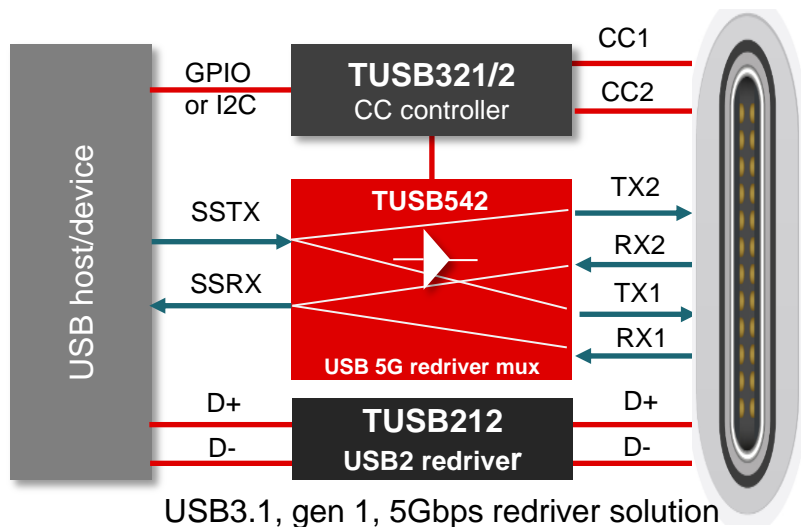
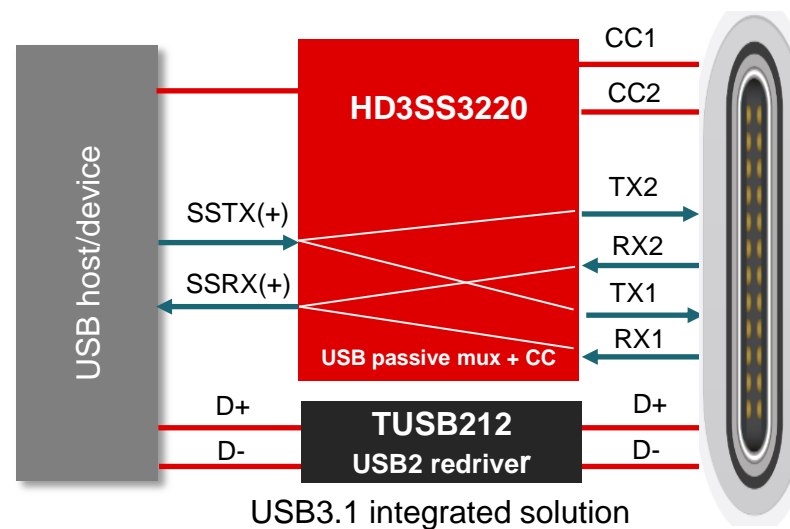
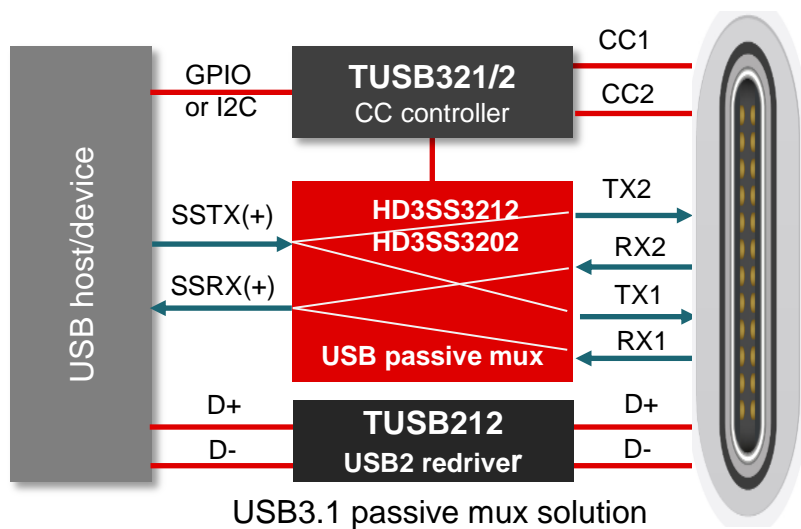
**TUSB522P:**  
5Gbps, USB3, dual-  
channel redriver

**TUSB501:**  
5Gbps, USB3, single-  
channel redriver

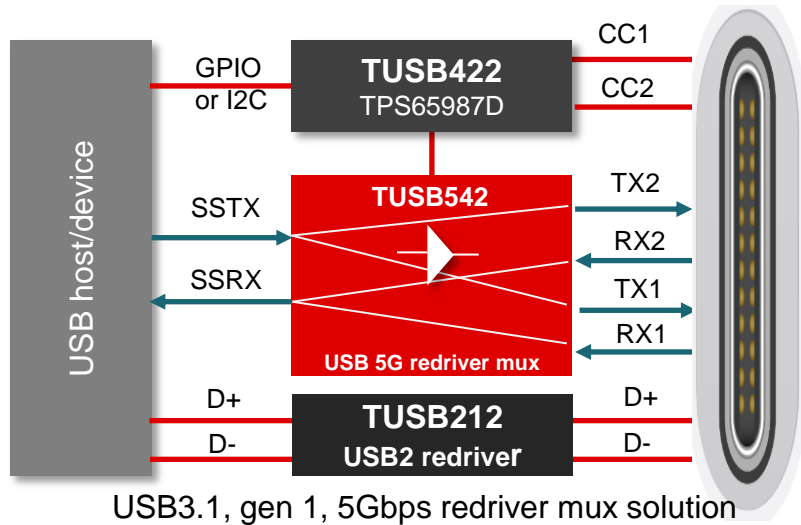
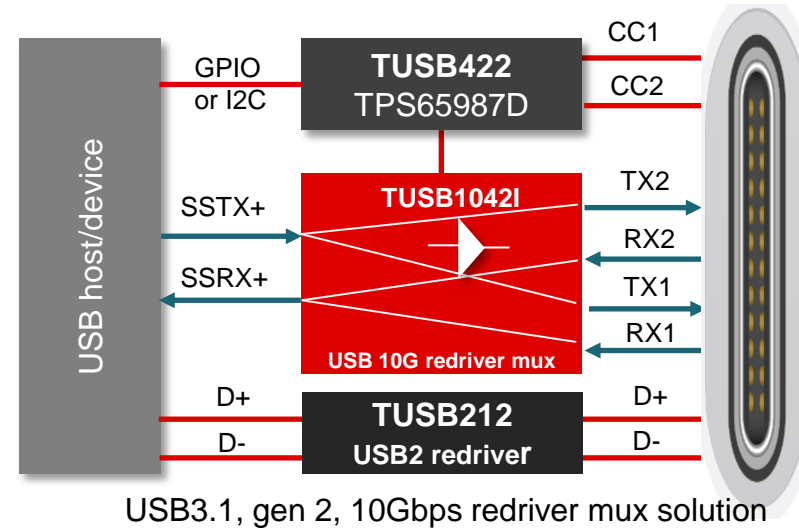
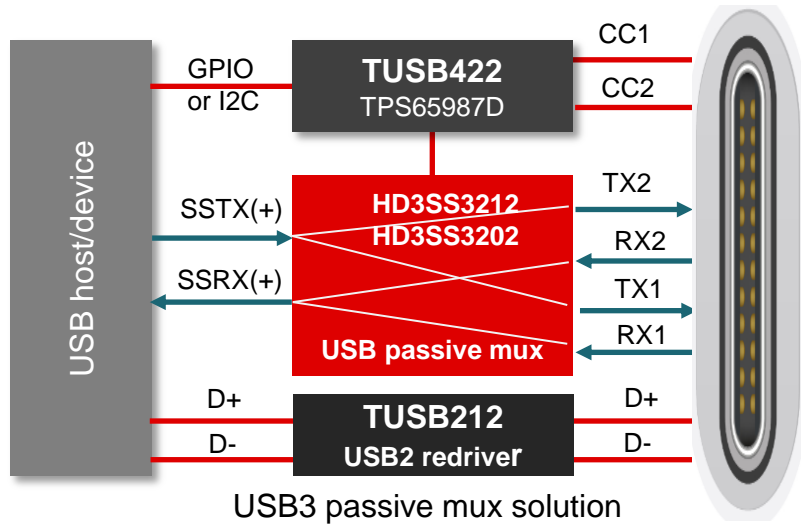
With redriver



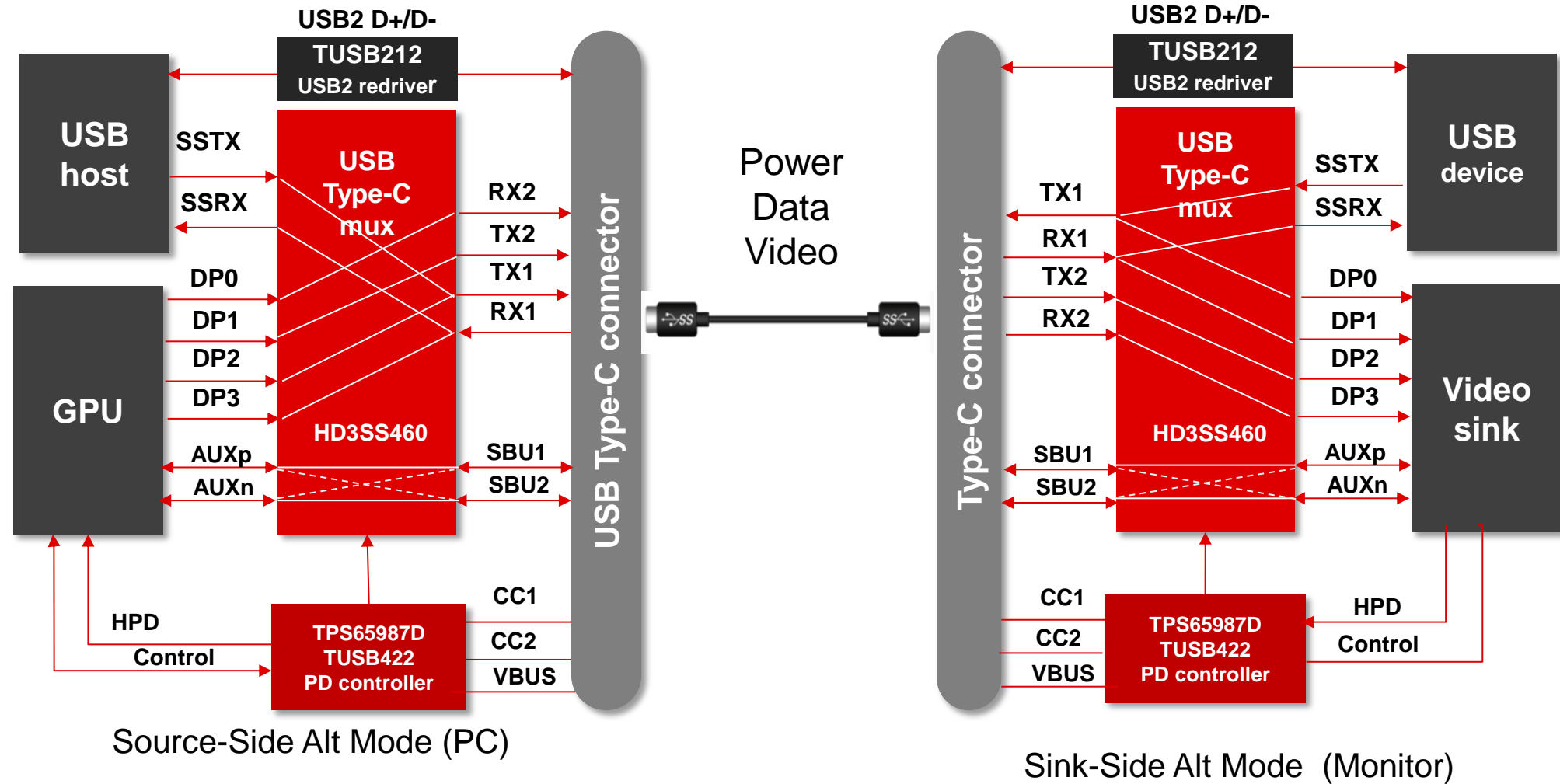
# USB Type-C data path options with $\leq 15W$ power



# USB Type-C data path options with >15W power

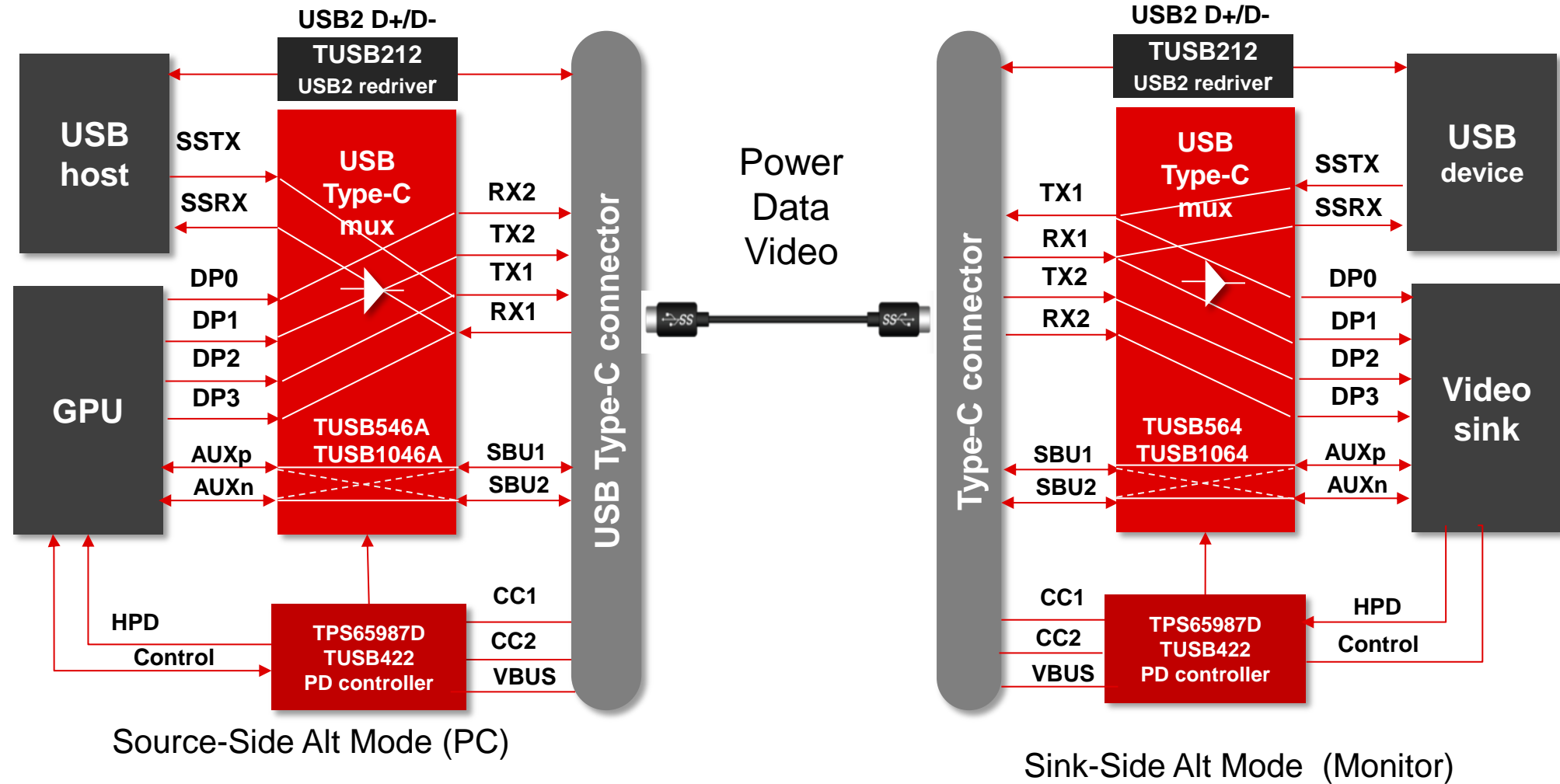


# DisplayPort over USB Type-C – passive solution



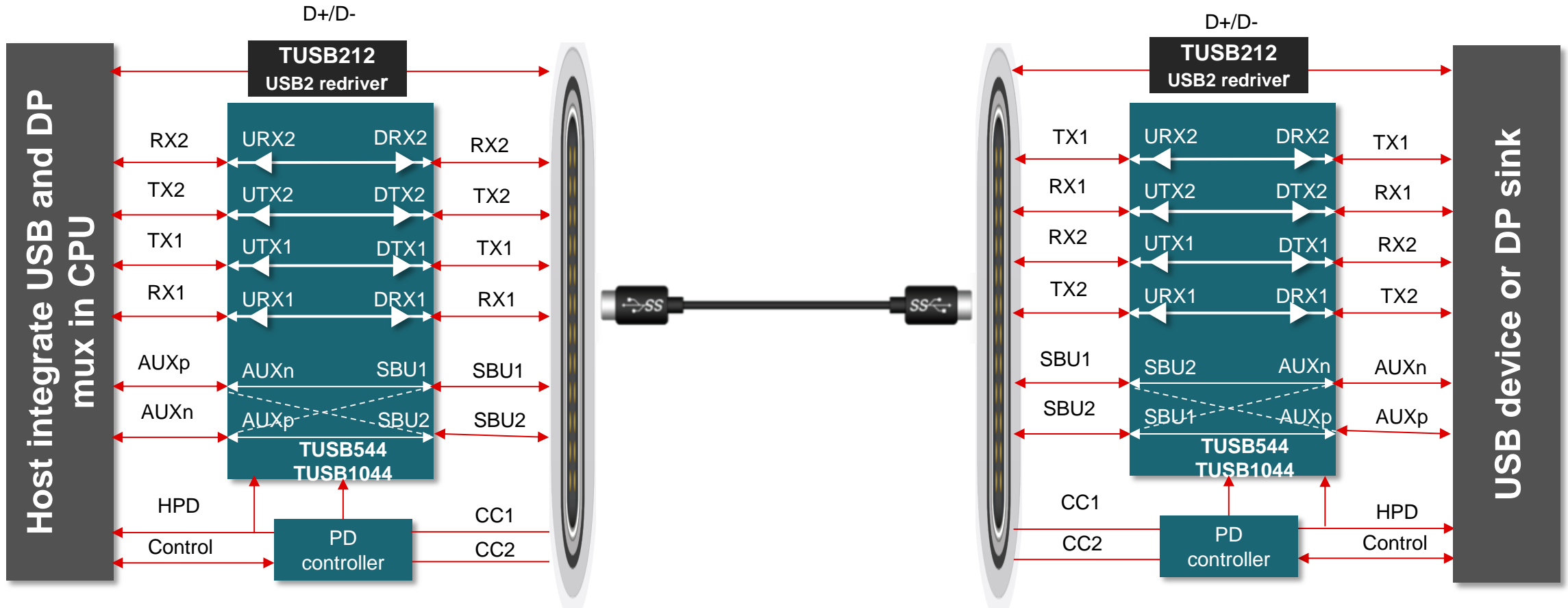


# DisplayPort over USB Type-C – redriver solution

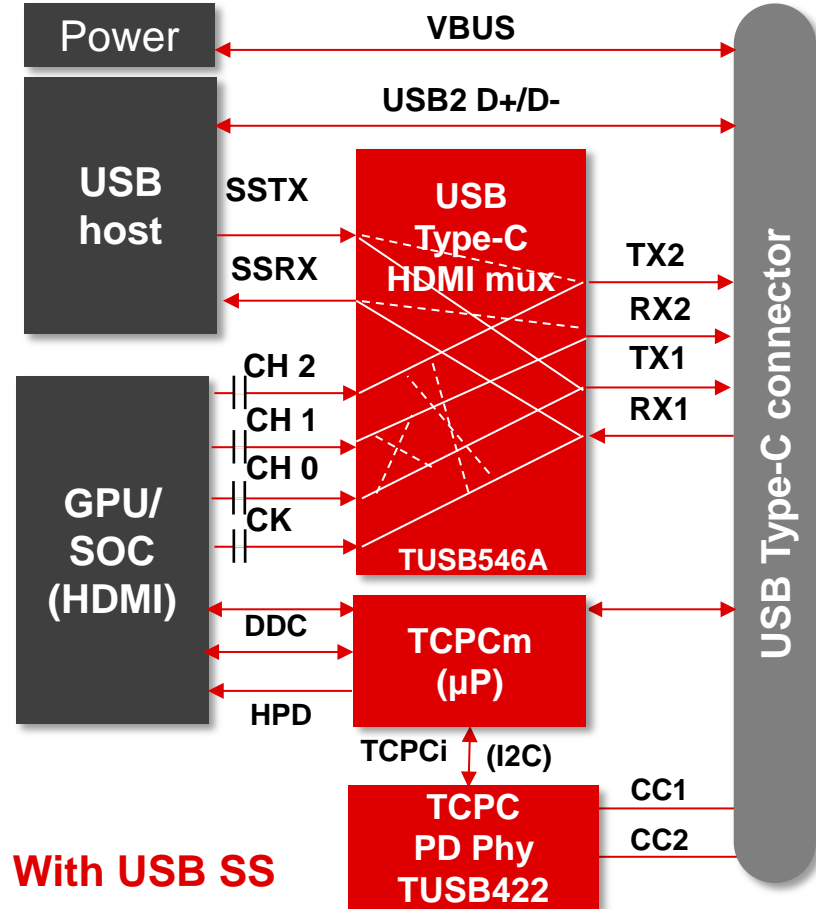


# USB Type-C Alt Mode bi-directional redriver

## TUSB544/1044

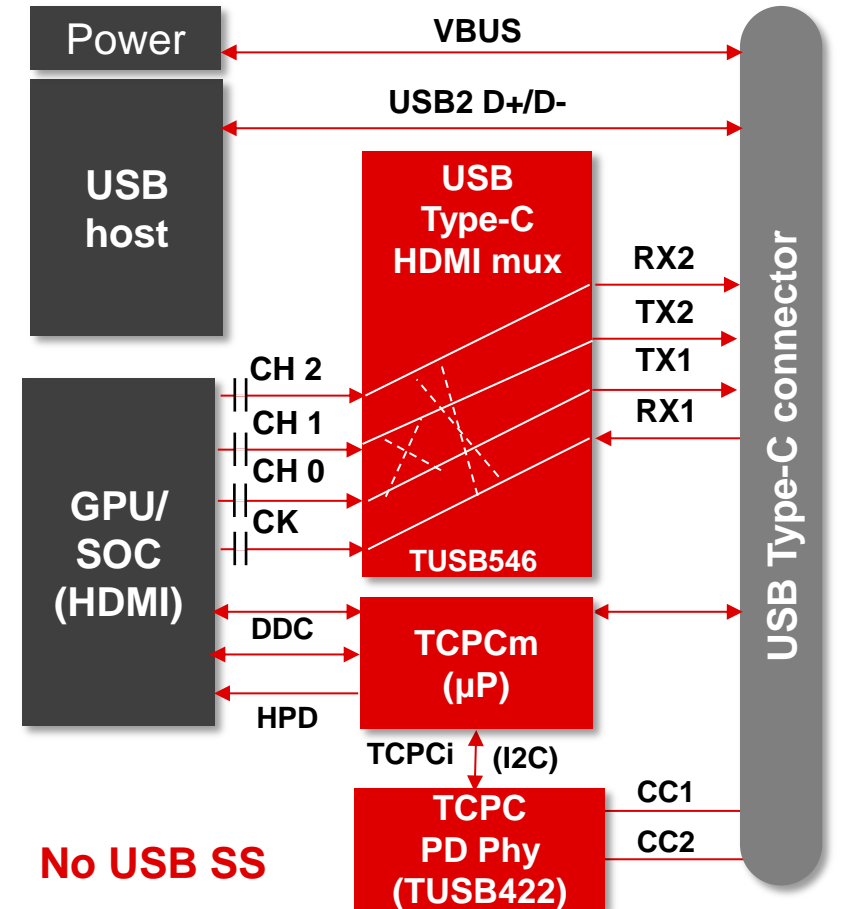


# HDMI over Type-C Alternate Mode

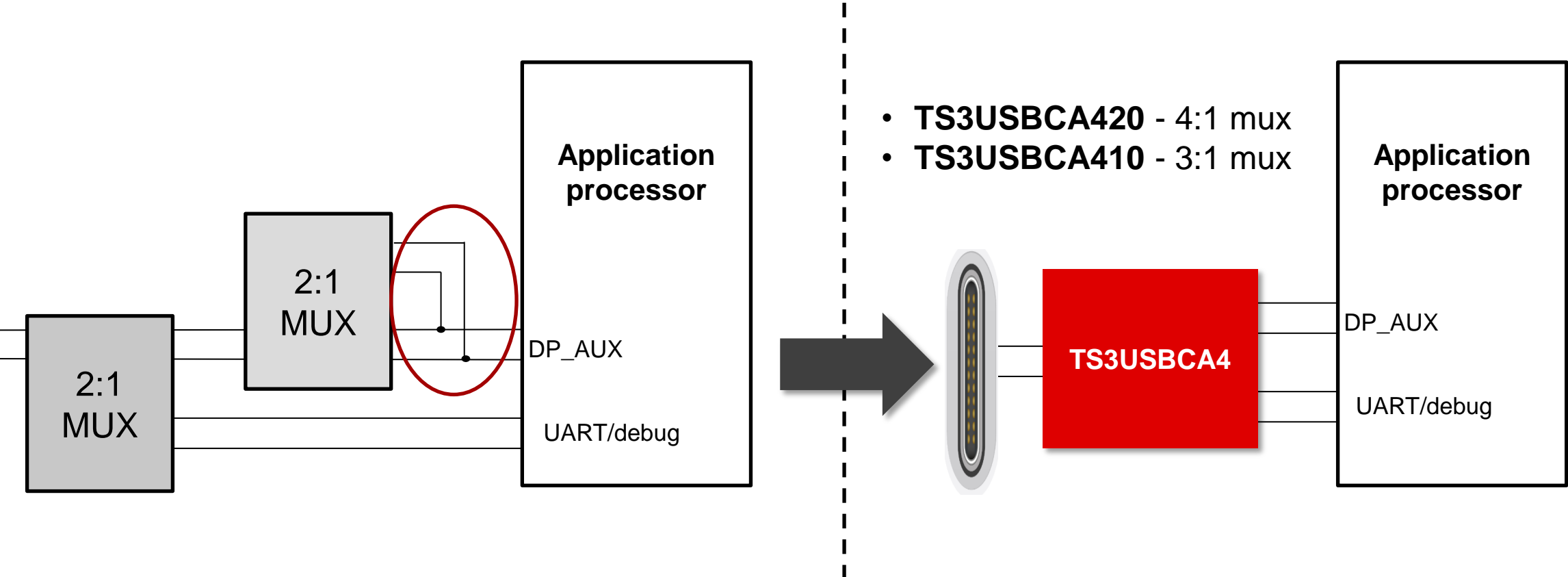


**TUSB546A**  
Type-C HDMI mux

- HDMI-only use case with or without USB SS - no DP support in same port.
- Must be AC-coupled at input of TUSB546A.
- TUSB546A AUX/SBU mux is not used.
  - Recommend external SBU mux if HEAC functions required.
- GPU/SOC has 50-Ω source termination to 3.3-V supply at output pins.

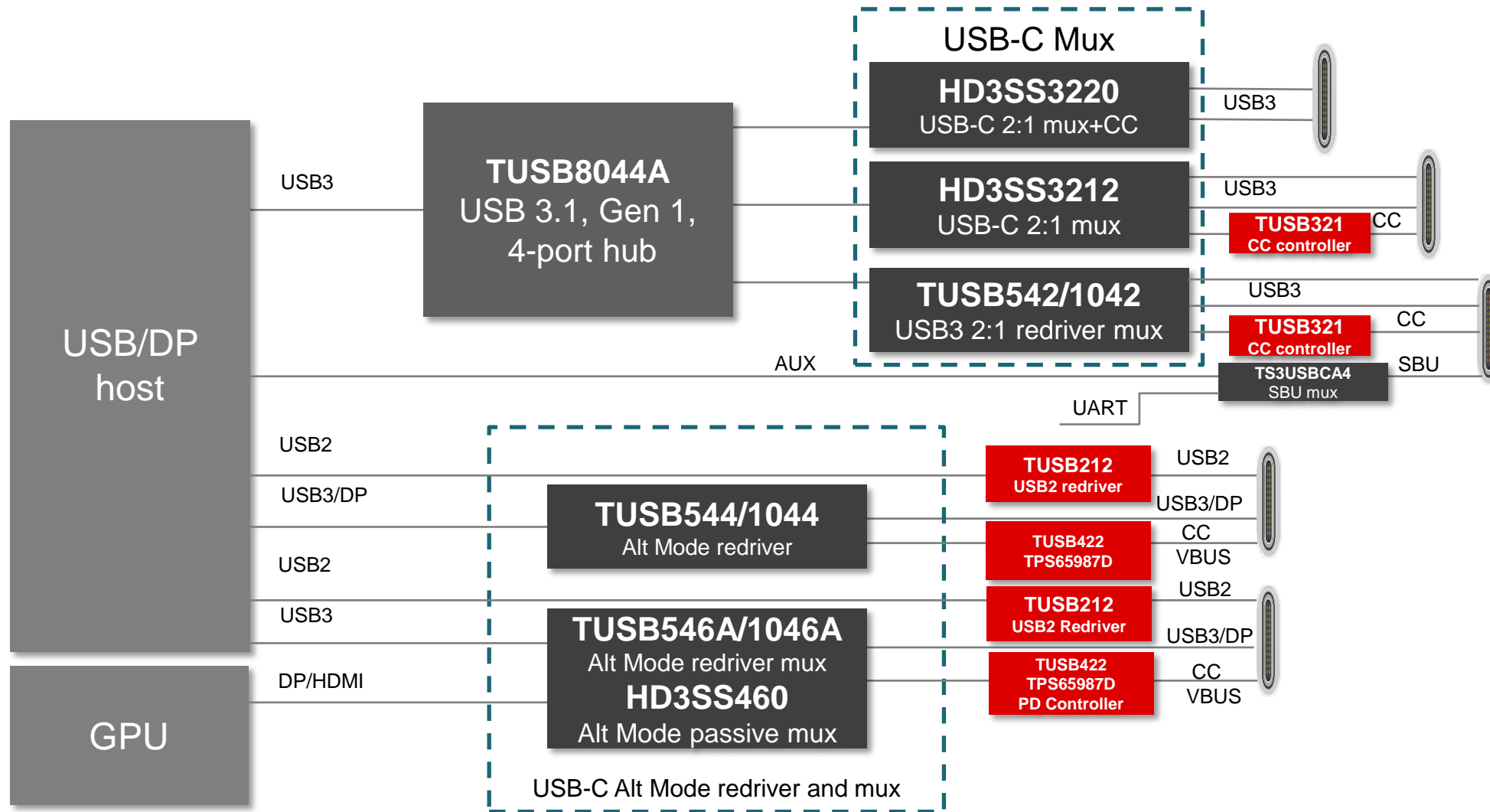


# SBU mux TS3USBCA4 – enabling easy polarity flip

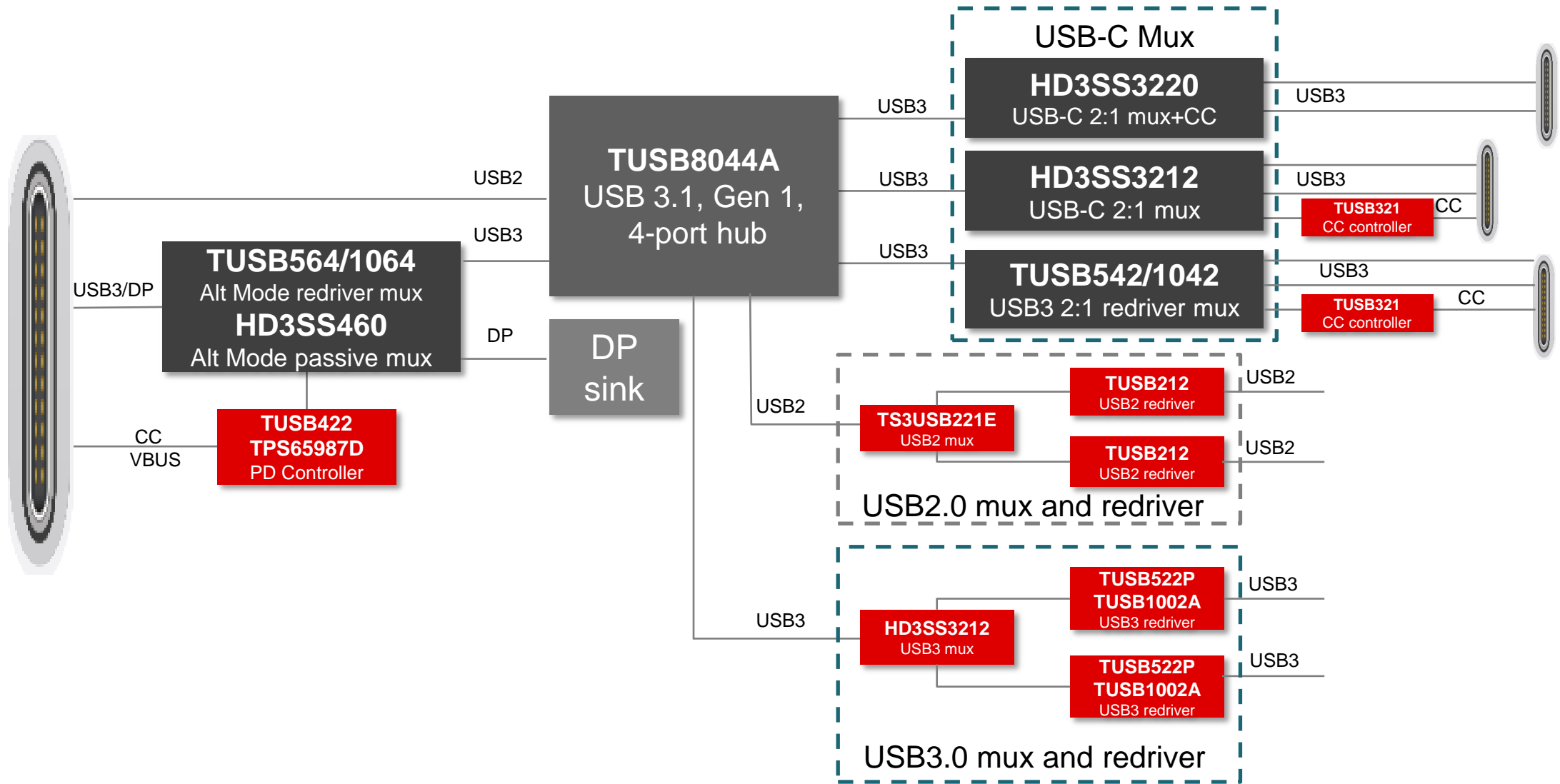


**Simplifying board layout and reduces solution size while also reducing BOM**

# USB Type-C building blocks - source



# USB Type-C building blocks - sink



# USB Type-C video application examples

PC & gaming



TUSB544/1044



Virtual reality

Docking



Mobile



Monitor

# USB Type-C mux solution selection guide

	HD3SS3212 HD3SS3202	HD3SS460	HD3SS3220	TUSB542	TUSB1042	TUSB546A	TUSB1046A	TUSB564	TUSB1064	TUSB544	TUSB1044
<b>Application</b>	Source, sink	Source, sink	Source, sink	Source, sink	Source, sink	Source	Source	Sink	Sink	Source, sink, cable	Source, sink, cable
<b>Data/video support</b>	SS+	SS, DP1.2a video	SS+	SS	SS+	SS DP1.4 video	SS+, DP1.4 video	SS, DP1.4 video	SS+, DP1.4 video	SS, DP1.4 video	SS+, DP1.4 video
<b>Alt Mode support</b>		✓				✓	✓	✓	✓	✓	✓
<b>Max data rate</b>	10Gbps	5.4Gbps	10Gbps	5Gbps	10Gbps	8.1Gbps	10Gbps	8.1Gbps	10Gbps	8.1Gbps	10.3Gbps
<b>High-speed lanes</b>	2	4	2	2	2	4	4	4	4	4	4
<b>X-point</b>		✓				✓	✓	✓	✓		
<b>Adaptive CM tracking</b>	✓	✓	✓								
<b>Redriving mux</b>				✓	✓	✓	✓	✓	✓	✓	✓
<b>Package (mmxmm)</b>	2.5x4.5 QFN 2.6x1.8 QFN	3.5x5.5 QFN	2.5x4.5 QFN	2x2.4 QFN	4x6 QFN	4x6 QFN	4x6 QFN	4x6 QFN	4x6 QFN	4x6 QFN	4x6 QFN
<b>Supply (V)</b>	3.3	3.3	5/3.3	1.8	3.3	3.3	3.3	3.3	3.3	3.3	3.3



# TIDA-01620 Type-C to DP reversible active dongle

## Features

- Bi-directional and reversible USB Type-C-to-DisplayPort active dongle.
- Support VESA DisplayPort Alt Mode to USB Type-C up to 8.1Gbps.
- UFP and DFP configuration with integrated USB billboard.
- Operates over entire VCONN range of 2.7V-to-5.5V.
- Supports up to 5 meters of DisplayPort cable.

## Applications

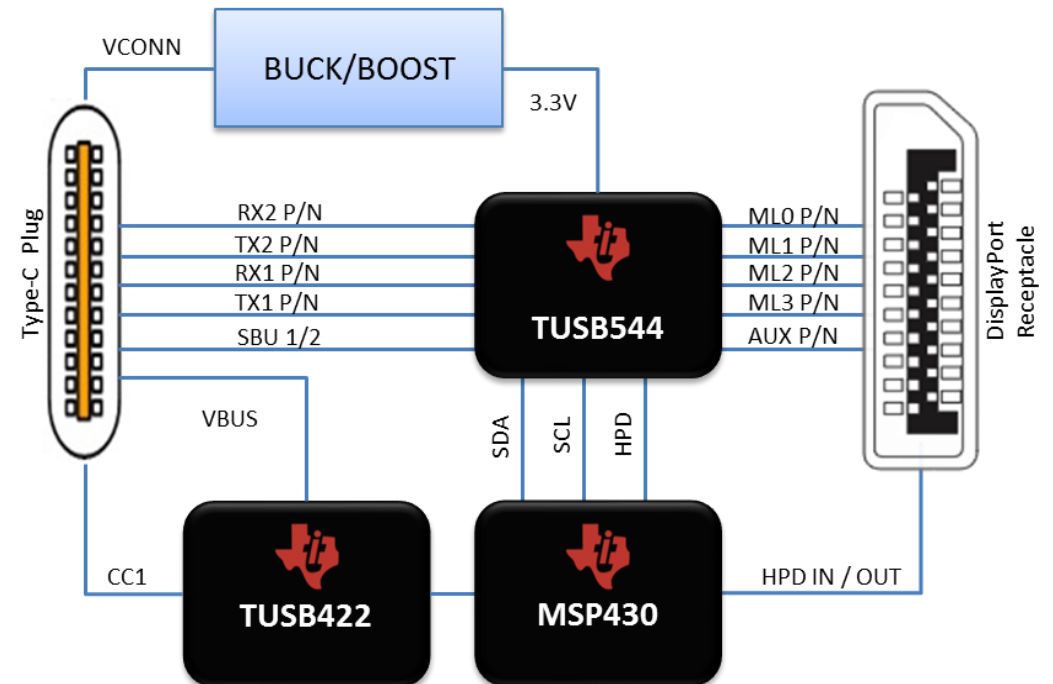
- USB Type-C to DP active cable
- USB Type-C to DP active dongle
- Docking

## Tools & resources

- [TIDA-01620 and/or Tools Folder](#)
- [Design guide](#)
- [Design files](#): schematics, BOM, gerbers, software, etc.
- [Device Datasheets:](#)
  - [TUSB544](#)
  - [TUSB422](#)
  - [MSP430](#)
  - [TPS63051](#)
  - [TPD4E02B04](#)
  - [TPD4E05U06](#)

## Benefits

- Improves and maintains signal quality over long cable.
- Enables legacy devices to inter-connect with USB Type-C devices.
- Enables bi-directional USB Type-C-to-DP active cable or converter.



# More technical resources

Title	Type	Link
How to select the right USB Type-C signal switch	Technical blog	<a href="http://e2e.ti.com/blogs_/b/analogwire/archive/2018/03/20/how-to-select-the-right-usb-type-c-signal-switches">http://e2e.ti.com/blogs_/b/analogwire/archive/2018/03/20/how-to-select-the-right-usb-type-c-signal-switches</a>
Why use a USB Type-C redriver in your personal electronics design?	Technical blog	<a href="http://e2e.ti.com/blogs_/b/analogwire/archive/2016/10/25/the-need-for-usb-type-c-redrivers">http://e2e.ti.com/blogs_/b/analogwire/archive/2016/10/25/the-need-for-usb-type-c-redrivers</a>
How to deliver clean USB Type-C Signal	Technical blog	<a href="http://e2e.ti.com/blogs_/b/analogwire/archive/2017/08/07/how-to-deliver-clean-usb-type-c-signals">http://e2e.ti.com/blogs_/b/analogwire/archive/2017/08/07/how-to-deliver-clean-usb-type-c-signals</a>
How to correct 10Gbps performance issues with a USB Type-C™ active redriver multiplexer	Technical blog	<a href="http://e2e.ti.com/blogs_/b/analogwire/archive/2016/12/01/how-to-correct-10gbps-performance-issues-with-a-usb-type-c-active-redirecter-multiplexer">http://e2e.ti.com/blogs_/b/analogwire/archive/2016/12/01/how-to-correct-10gbps-performance-issues-with-a-usb-type-c-active-redirecter-multiplexer</a>
Create an eye opening experience with 10G USB3 redriver	Technical blog	<a href="http://e2e.ti.com/blogs_/b/analogwire/archive/2018/07/12/eye-opening-experience-10g-usb3-redirecter">http://e2e.ti.com/blogs_/b/analogwire/archive/2018/07/12/eye-opening-experience-10g-usb3-redirecter</a>
How USB will enable the future of automotive infotainment	Technical blog	<a href="http://e2e.ti.com/blogs_/b/behind_the_wheel/archive/2015/10/08/usb-2-0-automotive-signal-conditioning?DCMP=tusb211&amp;HQS=hpa-int-hsi-tusb211-pr-blog-20151008-wwe">http://e2e.ti.com/blogs_/b/behind_the_wheel/archive/2015/10/08/usb-2-0-automotive-signal-conditioning?DCMP=tusb211&amp;HQS=hpa-int-hsi-tusb211-pr-blog-20151008-wwe</a>
Strengthening the USB Type-C signal chain through redrivers	White paper	<a href="http://www.ti.com/lit/wp/slly121/slly121.pdf">http://www.ti.com/lit/wp/slly121/slly121.pdf</a>
Low-cost implementation of USB Type-C	White paper	<a href="http://www.ti.com/lit/wp/slly016/slly016.pdf">http://www.ti.com/lit/wp/slly016/slly016.pdf</a>
Transitioning existing products from USB 2.0 OTG to USB Type-C	White paper	<a href="http://www.ti.com/lit/wp/slly017/slly017.pdf">http://www.ti.com/lit/wp/slly017/slly017.pdf</a>
Alternative Mode for USB Type-C: Going beyond USB	White paper	<a href="http://www.ti.com/lit/wp/slly021/slly021.pdf">http://www.ti.com/lit/wp/slly021/slly021.pdf</a>

# Helpful reference designs

Reference design title	Target applications	Link
<ol style="list-style-type: none"> <li>1) USB Type-C™ and Power Delivery Minidock With Video and Charging Support Reference Design</li> <li>2) USB Type-C HDD With USB Power Delivery Reference Design</li> <li>3) Type-C and Power Delivery Multiport Adapter</li> </ol>	<ul style="list-style-type: none"> <li>• Type-C docking stations</li> <li>• Video and power delivery over USB Type-C connections</li> <li>• Type-C HDD</li> <li>• Docking, monitors</li> </ul>	<ol style="list-style-type: none"> <li>1) <a href="http://www.ti.com/tool/TIDA-01243">http://www.ti.com/tool/TIDA-01243</a></li> <li>2) <a href="http://www.ti.com/tool/TIDA-00882">http://www.ti.com/tool/TIDA-00882</a></li> <li>3) <a href="http://www.ti.com/tool/TIDA-03027">http://www.ti.com/tool/TIDA-03027</a></li> </ol>
<ol style="list-style-type: none"> <li>1) Mobile Point of Sale (mPOS) Power Reference Design</li> <li>2) Type-C to DP Reversible Active Dongle</li> </ol>	<ul style="list-style-type: none"> <li>• Portable data terminals</li> <li>• Active cables, dongles</li> </ul>	<ol style="list-style-type: none"> <li>1) <a href="http://www.ti.com/tool/TIDA-00818">http://www.ti.com/tool/TIDA-00818</a></li> <li>2) <a href="http://www.ti.com/tool/TIDA-01620">http://www.ti.com/tool/TIDA-01620</a></li> </ol>
<ol style="list-style-type: none"> <li>1) USB Type-C Audio Adapter Accessory Mode Reference Design</li> <li>2) USB Type-A Plug to USB Type-C Receptacle SuperSpeed MUX With <b>DFP</b> Controller Reference Design</li> <li>3) USB Type-C Plug to USB Type-A Receptacle SuperSpeed MUX With <b>UFP</b> Controller Reference Design</li> </ol>	<ul style="list-style-type: none"> <li>• Smartphones</li> <li>• PCs and notebooks</li> <li>• USB Type-C Audio</li> </ul>	<ol style="list-style-type: none"> <li>1) <a href="http://www.ti.com/tool/TIDA-00565">http://www.ti.com/tool/TIDA-00565</a></li> <li>2) <a href="http://www.ti.com/tool/TIDA-00890">http://www.ti.com/tool/TIDA-00890</a></li> <li>3) <a href="http://www.ti.com/tool/TIDA-00891">http://www.ti.com/tool/TIDA-00891</a></li> </ol>
<ol style="list-style-type: none"> <li>1) 4 Port USB 3.0 Hub Reference Design</li> <li>2) 2 Port USB 3.0 Hub Reference Design</li> </ol>	<ul style="list-style-type: none"> <li>• Desktop and Notebook PCs</li> <li>• Enterprise servers</li> <li>• Workstations</li> </ul>	<ol style="list-style-type: none"> <li>1) <a href="http://www.ti.com/tool/TIDA-00288">http://www.ti.com/tool/TIDA-00288</a></li> <li>2) <a href="http://www.ti.com/tool/TIDA-00287">http://www.ti.com/tool/TIDA-00287</a></li> </ol>

**Thank you!**