Application Note

Type-C Alt Mode Application using TMUXHS4446 Crosspoint Multiplexer

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ABSTRACT

The TMUXHS4446 is high-speed bidirectional passive crosspoint switch that supports both USB3.2 Gen2 and DisplayPort 1.4 over a Type-C interface. This application report describes how to design a Type-C Alt Mode application with TMUXHS4446, for both source and sink application.

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Trademarks

1 Introduction

TMUXHS4446 is high-speed bidirectional 4:6 passive multiplexer developed with cutting-edge technology to support cost effective, high performance of DP 1.4/2.0 and USB 3.2 Gen 2 signals in type-C applications. This device is used to switch between USB 3.2 Gen2 SuperSpeed and DisplayPort 1.4/2.0 signals over a USB Type-C® interface. it also provides switching for the low-speed SBU signals typically used for DisplayPort auxiliary channels.

TMUXHS4446 can be used in many and various applications such as notebook, tablet, AIO, PC, monitor, HDTV, docking stations.

2 USB Type-C Alt Mode Application

2.1 What is Type-C Alt Mode?

The Type-C Alt Mode Specification, allows for protocols other than USB to be transferred over a USB connection, such as DisplayPort, HDMI, MHL, or Thunderbolt over the Type-C interface. Alternate Mode can be enabled only through a USB PD protocol handshake through structured vendor-defined messages (VDM) to discover, configure, and to enter or exit Alt Modes. Alternate Modes is highly flexible with multiple high-speed communication lanes and open SBU channels.

2.2 Why USB Type-C Alt Mode Need Multiplexer

Type-C Alt Mode requires multiplexers depending on the requirements of a particular Alt Mode standard, single or multiple protocols can reside over a single Type-C interface. For example, the Video Electronics Standards Association (VESA) DisplayPort Alt Mode on Type-C standard enables four lanes of DisplayPort, as well as simultaneous USB 3.2 and DisplayPort. With multiple protocol support and a flippable aspect of Type-C, multiplexing between different protocols is needed to connect video and data source to the appropriate destination.

On the source side, the multiplexer takes USB and DP lanes and switches them to the appropriate high-speed lanes. On the sink side, the multiplexer takes the four high-speed lanes from Type-C connector as input and then distributes the signal to the USB receiver or DP sink accordingly. Figure 2-1 shows the high level Alt Mode communication data path from source-to-sink, and multiplexer placement.

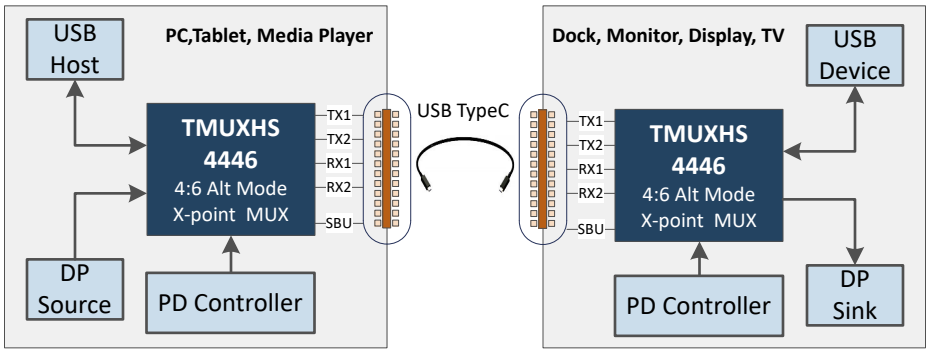

Figure 2-1. USB Type-C Source and Sink Applications

DisplayPort as Alt Mode DisplayPort is the most popular Alt Mode being used today that supports high-resolution video. A signal multiplexer is required to support four different signal configuration use cases to meet different application needs and the flip-ability of the Type-C connectors:

- One-port USB plus a two-lane DP for simultaneous data and video transfer
- One-port USB plus a two-lane DP with Type-C connector flip orientation
- Four-lane DP-only application
- Four-lane DP-only with Type-C connector flip orientation Additionally, DP auxiliary (AUX) signals use SBU1 and SBU2 signal pins, and the DP HPD signal is embedded into the USB PD message to enable the Type-C Alt Mode switch can be either a passive or redriver switch. A passive switch is bidirectional so that the switch can be placed on either the source or sink side.

2.3 When to Use Passive Multiplexer for Type-C Alt Mode application

The Type-C Alt Mode switch can be either a passive or redriver multiplexer. A passive switch is bidirectional so that the switch can be placed on either the source or sink side.

Other than the cost is much cheaper than redriver switch, the power consumption of TMUXHS4446 is only 2mW comparing to 0.5W power consumption for typical redriver switch.

3 Type-C Alt Mode Application with Passive Multiplexer TMUXHS4446

3.1 Type-C Alt Mode Source Application

Figure 3-1 is the typical Type-C Alt Mode source application like laptop, tablet and PC. TMUXHS4446 takes USB signal from USB host and DP signal from DP source and switches them to Type-C connector. Normally the Type-C port is configured as DRP or DFP, a Type-C monitor is connected to the DRP or DFP port by standand Type-C cable

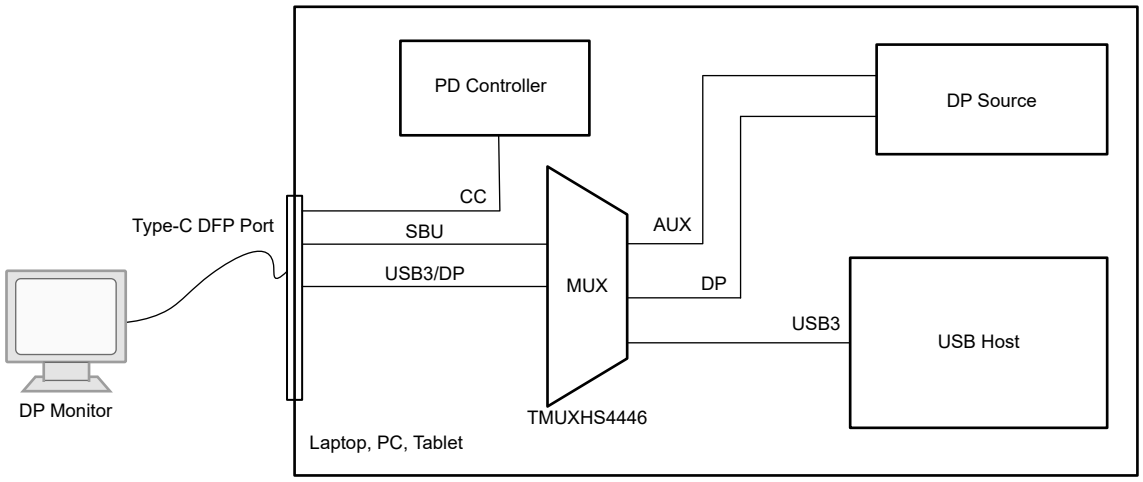

Figure 3-1. Type-C Alt Mode Source Application

3.2 Type-C Alt Mode Sink Application

Figure 3-2 is the typical Type-C Alt mode sink application like docking station. TMUXHS4446 takes signals from Type-C port and switches them out to DP sink device and USB hub device. Monitor can be connected though DP or HDMI output from MT hub and Mouse or keyboard can be connected to the USB ports from the USB hub.

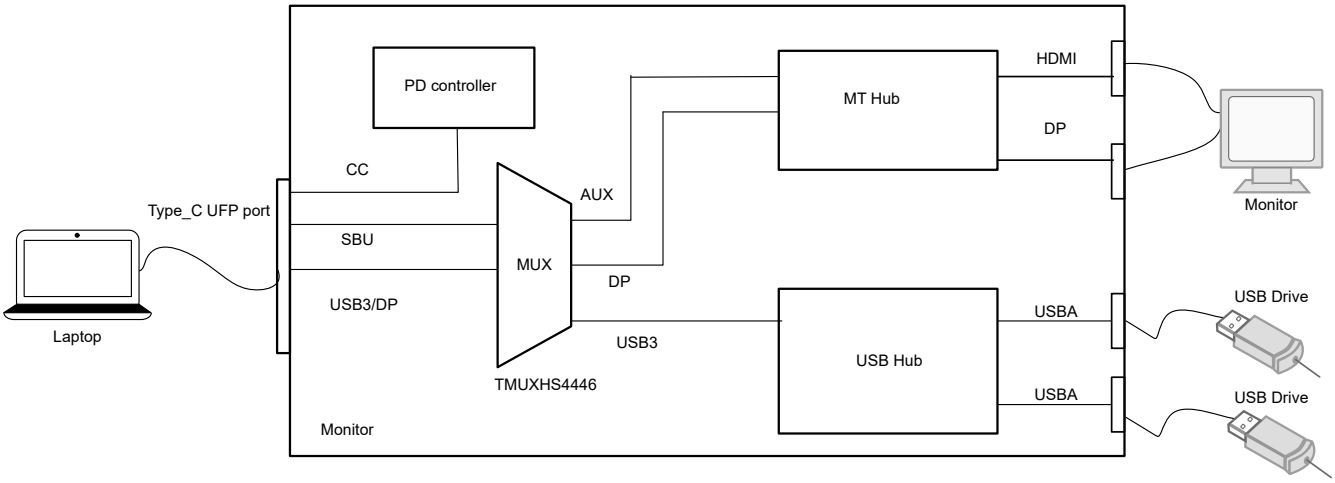

Figure 3-2. Typical Type-C Alt Mode Sink Application

3.3 Pin Assignment for Source and Sink Application

VESA defines different pin assignments on the USB Type-C connector when sending and receiving DisplayPort signaling. Six possible pin assignments are defined for USB Type-C configured to perform as a Display Source (DFP_D) – A, B, C, D, E, or F. Five possible pin assignments are defined for USB Type-C configured to perform as a Display Sink (UFP_D) – A, B, C, D, or E. Pin Assignments A, B, C, and D are intended for use with:

- USB Type-C to USB Type-C Cables
- Adapters from USB Type-C to other video standards such as VGA, DVI, HDMI.

Pin Assignments E and F are intended for use with adapters from USB Type-C to DisplayPort plugs or receptacles. For additional details on pin assignment, refer to the DP_Alt_Mode_on_USB_Type-C specification. Table 3-1 is the pin mapping table between TMUXHS4446 and Type-C receptacle for source and sink application.

Table 3-1. Pin Mapping Between TMUXHS4446 and Type-C Receptacle for Source and Sink Application

TMUXHS4446 Pin Number	TMUXHS4446 Pin Name	CC Receptacle Pin name for Source	CC Receptacle Pin name for Sink
33,34	CRX2	SSRX2	SSTX2
30,31	CTX2	SSTX2	SSRX2
27,28	CTX1	SSTX1	SSRX1
24,25	CRX1	SSRX1	SSTX1
22	SBU1	SBU1	SBU2
21	SBU2	SBU2	SBU1

4 PCB Design For TMUXHS4446

Before start PCB design for Type-C alt mode with TMUXHS4446, we need to get all insertion loss information of TMUXHS4446 mux, PCB board material used and dielectric constant of the material, Table 4-1 list the insertion loss information with FR4 material.

Table 4-1. Insertion Loss Budget for System

	1 in trace of FR4 PCB	TMUXHS4446	Max insertion loss allowed
Insertion loss at 5.4Gbps (DP1.2)	-0.77dB	-1.2dB	8 in FR4 trace
Insertion loss at 8Gbps (DP1.4)	-1.07dB	-1.4dB	
Insertion loss at 10Gbps (USB3.0)	-1.32dB	-1.6dB	Max 8.5dB allowed for SSTX or SSRX

For USB3.2 10Gbps, max allowed insertion loss for TX or RX is 8.5dB loss from USB3.2 host to type-C connector. So max trace length is about 5".

For DP 1.2 at 5.4Gbps , Intel recommends maximum 8” DP 1.2 trace without passive MUX . Recommended 1.2dB loss of mux is equal to 1.5 in of PCB trace. So max trace length of DP1.2 is about 6.5".

For DP1.4 at 8Gbps, recommend max trace length is about 4" based on Table 4-1

For PCB layout , the guideline is as follows:

- Minimize the trace length to prevent channel loss
- Don’t use EMI chokes, TMUXHS4446 is passive switch which has not having EMI issues
- Recommend 90 ohm differential impedance trace for differential DP and USB 3.0 signals
- The trace length miss-matching shall be less than 5 mils for the “+” and “–“
- Minimize the number of VIAS to prevent loss., No more than two VIAS on single trace from host to Type-C connector, adding ground VIAS next to the VIAS on the trace
- Route all high-speed differential pairs together symmetrically and parallel to each other
- Do not place probe or test points on any high-speed differential signal

For a comprehensive guide covering high-speed layout recommendations, see the High-Speed Interface Layout Guidelines application note.

5 Summary

This application note introduced what is USB Type-C® Alt mode and why crosspoint multiplexer is needed for Type-C Alt Mode. A Type-C Alt Mode source application and sink application are presented and PCB design guidelines are discussed.

6 References

- Texas Instruments, *TMUXHS4446 USB-C 10Gbps Alt Mode Crossbar Mux*, data sheet.
- Texas Instruments, *High-Speed Interface Layout Guidelines*, application note.

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