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# APPLICATION NOTE
# GLENAIR SUPERSPEED USB IMPLEMENTATION

WRITTEN BY: ____________________________________ DATE: _____________________
Lane Blackwell

APPROVED BY: ___________________________________ DATE: _____________________
Guido Hunziker

# REVISION HISTORY

| REVISION | DATE | REVISED PAGES | REVISIONS |
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| 1 | 7/5/2018 | | Engineering Release |
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# 1.0 Purpose

This document describes implementation of Glenair SuperSpeed USB cable assemblies.

# 2.0 Referenced Documents

| Document Number/Name | Description |
| --- | --- |
| 8572-0003 | CABLE ASSEMBLY, USB 3 TYP A PLUG, A REC, µB, OCHITO BLUE CONTACT TO USB 3 ASSY |
| 8572-0004 | OCHITO BLUE CONTACT, PRE-WIRED, PIN TO SOCKET SUPERSPEED USB WITH REDRIVER/EQUALIZER |
| 8572-0005 | OCHITO BLUE CONTACT TO USB 3 ASSY WITH REDRIVER/EQUALIZER USB 3 TYP A PLUG, A REC, B, µB |
| USB 3.1 Channel Loss Budgets | USB-IF Technical White Paper |

**Table 1. Reference Documents**

# 3.0 Responsibility

This document is the responsibility of the Engineering team.

# 4.0 SuperSpeed USB Implementation

## 4.1 Gender Selection Considerations in implementations using Ochito

The USB 3.1 specification offers gender specific cabling options to prevent cross connecting the SuperSpeed pairs in a transmission link. Introducing rugged military/aerospace connectors with Ochito contacts into the link opens up gender selections that would result in crossed connections (e.g. transmit to transmit instead of transmit to receive). The standard product offering from Glenair (PN# 8572-0003/4/5) restricts the Ochito gender choices so that links are compliant with the standard. Thus, Ochito pin contacts are only available on the host side, and the socket contacts are only available on the device side. Other gender options are available upon request, but a careful review of the wiring diagram is necessary.

## 4.2 Loss (Signal Integrity) Budget Considerations

Loss budgets play an important part in guaranteeing the interoperability of USB Super Speed components. In this section, we focus on the link loss budget, measured at the Nyquist frequency (-20dB max at 2.5GHz for USB 3.1 Gen 1). The following briefly discusses the loss budgets allocation for SuperSpeed Gen 1 as outlined in the USB-IF’s “USB 3.1 Channel Loss Budget”.

The original (2008) loss budget for the SuperSpeed Gen 1 channel is shown in Figure 1. There is a 10dB allowance for PCB routing on the host side (green, typically 10 inches maximum trace length), 7.5dB for the cable assembly (in red, typically 3meters of cable) and 2.5dB allocation for the PCB routing on the device side (in blue, 2 to 3 inch trace length).

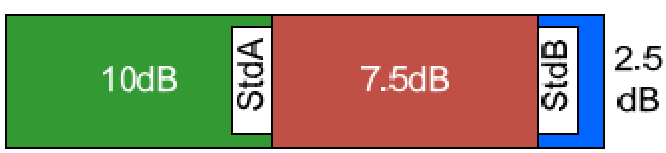


**Figure 1. Original SuperSpeed Gen 1 Loss Budget (from USB 3.1 Channel Loss Budgets).**

Subsequent revisions of the specification have generally kept the overall loss allowance. The advent of Micro B and Type C for small devices triggered a re-allocation of losses from the cables to the devices (smaller devices, few requiring the full 3 meters of cable).

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Rugged military and aerospace deployments are typically configured with additional connections and longer cable links. In some designs shorter traces can be implemented on the host side (for instance using a Glenair 858-025 transition adapter). In those situations, connector and cable insertion loss make up most of the overall assembly loss. The Glenair 963-110 USB 3.0 cable loss is -2.5 dB/m at 2.5GHz (-0.762 dB/ft ). The loss versus frequency is represented graphically in Figure. This shows that if the transition from board to cable occurs directly off the driver and amplification circuits, links as long as 6-7 meters could be achieved.

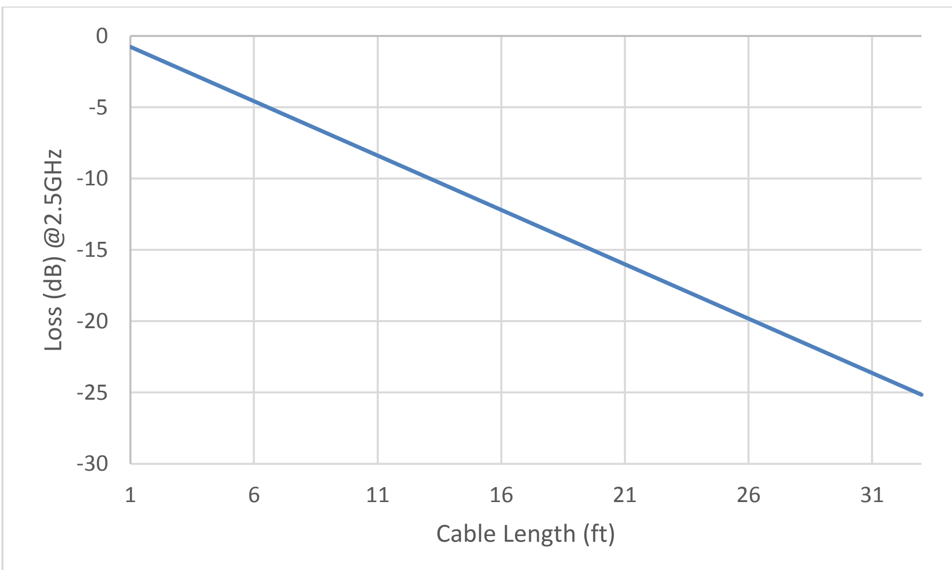


**Figure 2. Cable Insertion Loss per Foot**

In practice, a hard-wired link is highly unlikely, and the losses of the connectors must be taken into consideration. The typical insertion loss of a mated pair of Ochito Blue contacts (PN# 858-028 and 858-029) is approximately -0.3dB. A mated pair effectively reduces the cable length by approximately 0.2meters.

## 4.3 Re-driver Placement Considerations

Invalid cable design/construction is most likely to occur by not considering the full-link signal losses of concatenated assemblies. The insertion losses of the total channel can accumulate so that an active circuit is necessary to enhance signal quality. The active circuit (re-driver/ equalizer) uses equalization, pre-emphasis, and other technologies to adjust and correct for known channel losses at the transmitter and restore signal integrity at the receiver. The re-driver provides a gain of 15dB @ 2.5GHz. Thus, by placing the re-driver in the USB SuperSpeed signal path, a longer physical media link is achievable.

Generally, assemblies with a total length greater than 120 inches (10 ft.) but less than 283 (23.5 ft.) require a single booster. Assemblies with a length between 283 inches (23.5 ft.) and 396 inches (33 ft.) require two re-drivers. Although Glenair drawings 8572-0003 allow an arbitrary cable length, take care to consider total link length to determine if boosters are required.

Re-drivers must be distributed symmetrically along the length of the total link. For a single re-driver system, the re-driver is placed at the halfway point of the length. For a two re-driver system, the re-drivers are placed at 1/3 and 2/3 of the link length.

## 4.4 Power Considerations

IR losses over assembly links can limit available power at the device. According to the Universal Serial Bus 3.1 Specification, the voltage supplied at the connector of hub or root ports shall be between 4.75V to 5.25V and devices need to be operational with a minimum voltage of 4.00V. A best case voltage drop of 1.25V and a worst case voltage drop of 0.75V can be experienced over the total link.

Figure 2 shows the maximum current available for both the best and worst case in addition to a nominal supply voltage of 5V. The areas under each curve are valid operating zones for each case.

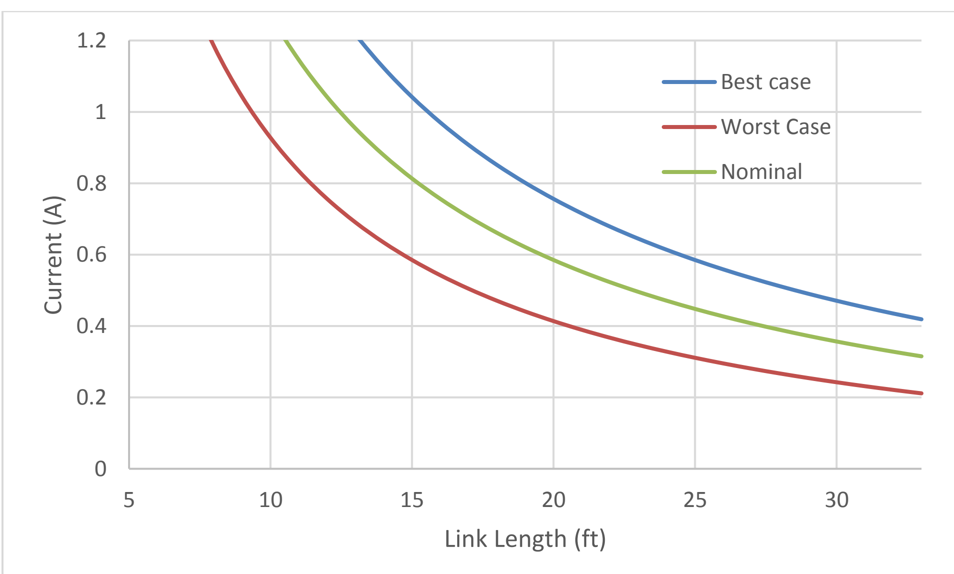


**Figure 2. Voltage Drop vs Link Length**

## 4.5 Example Case Studies

Four case studies serve to demonstrate the above concepts. Each case consists of a host chassis and a device chassis separated by a bulkhead. Four assemblies make up each host-to-device link. Two assemblies are six-inch jumpers from the host/device PCB. The other two assemblies vary in length case by case.

**Case 1:**

See the Case 1 Link Diagram in Figure 3 for link information. A three-foot assembly is required from the host chassis to the bulkhead and a five-foot assembly is required from the bulkhead to the device chassis. The total link is nine feet.

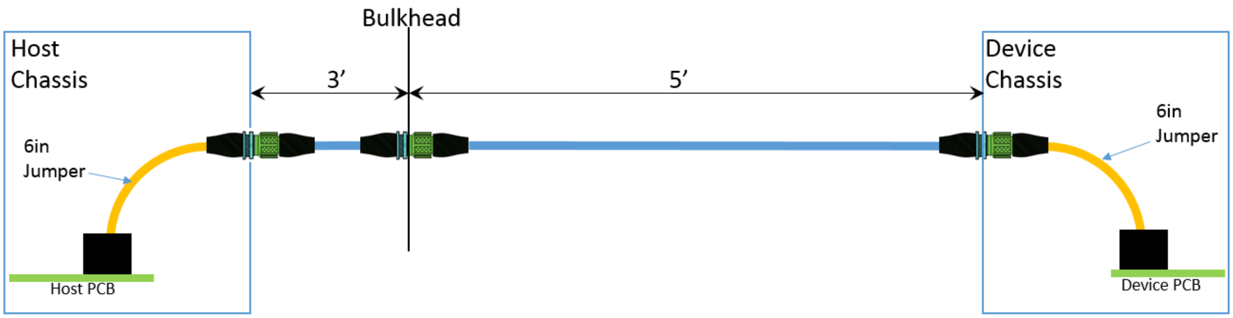


**Figure 3. Case 1 Link Diagram**

The insertion loss of the cable and Ochito mated pairs is approximately -7.75dB (9ft * -0.762 dB/ft + -0.3dB/mate * 3 mating pairs). This application is on the verge of requiring a re-driver. This application could feasibly supply 1A max to the end user (see Figure 2), but the current draw would max out the acceptable voltage drop of a 5V supply.

**Case 2:**

See the Case 2 Link Diagram in Figure 4 for link information. A three-foot assembly is required from the host chassis to the bulkhead and a fifteen-foot assembly is required from the bulkhead to the device chassis. The total link is nineteen feet.

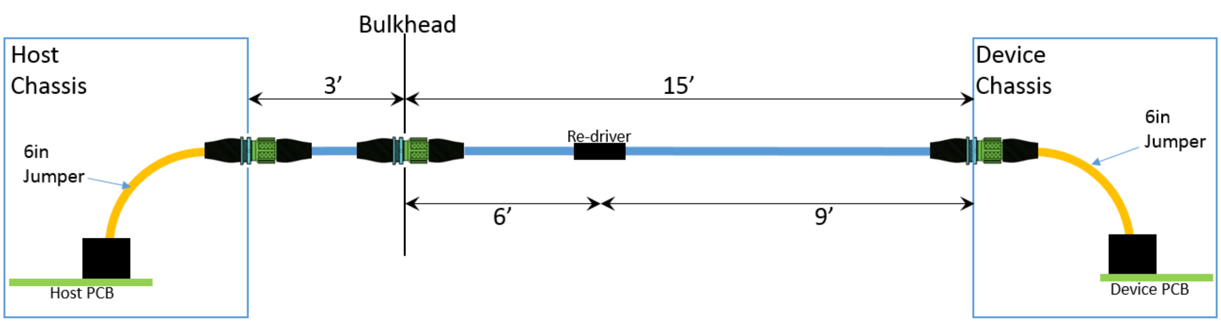


**Figure 4. Case 2 Link Diagram**

The insertion loss of the cable and Ochito mated pairs is approximately -15.4dB. This total link length requires a re-driver. The re-driver is placed mid-span (half-way) in the link. This link can provide a maximum of approximately 600mA of supply current at a nominal supply voltage of 5V (see Figure 2).

**Case 3:**
See the Case 3 Link Diagram in Figure 5 for link information. A three-foot assembly is required from the host chassis to the bulkhead and a twenty-three-foot assembly is required from the bulkhead to the device chassis. The total link is twenty-seven feet.

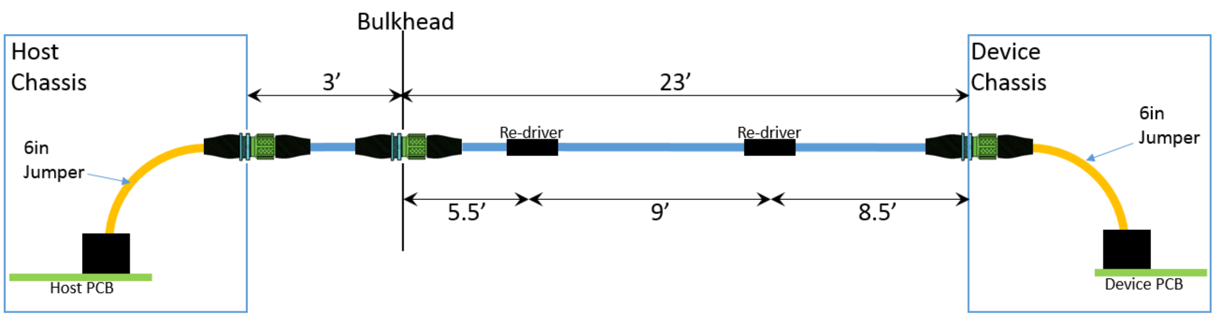


**Figure 5. Case 3 Link Diagram**

The insertion loss of the cable and Ochito mated pairs is approximately -21.5dB. This total length requires two re-drivers. The re-drivers are spaced evenly at 1/3 and 2/3 of the length of the total link (every nine feet). This link can provide a maximum of approximately 400mA of supply current at a nominal supply voltage of 5V (see Figure 2).

**Case 4:**
See the Case 4 Link Diagram in Figure 6 for link information. This is similar to the link setup as Case 3 but, in this case, a fifteen-foot assembly is required from the host chassis to the bulkhead and an eleven-foot assembly is required from the bulkhead to the device chassis. The total link is again twenty-seven feet.

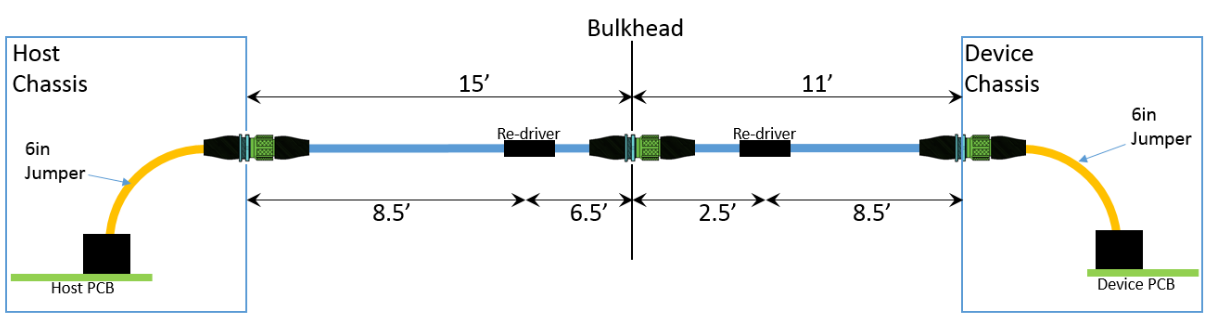


**Figure 6. Case 4 Link Diagram**

Again, this total link requires two re-drivers, but, in this case, the re-drivers are spread across two assemblies. Note that the re-drivers are still evenly spaced at 1/3 and 2/3 of the length of the total link (every nine feet). As in Case 3, this link can provide a maximum of approximately 400mA of supply current at a nominal supply voltage of 5V (see Figure 2).

## 4.6 Cross-Talk Considerations

The number of inter-connections can also be limited due to the signal reflection and the signal impairment by crosstalk from the mated connection connectors. Many inter-connections introduce more impedance discontinuity and hence cause more signal reflection and attenuate more transmitting signal. The added connections introduce more crosstalk and reduce the potential transmission bandwidth.

The following examples demonstrate the effects that multiple connections have on crosstalk.

Figure 7 shows a single continous link from host PCB to device PCB. Both PCBs utilize an Ochito PC tail connection in lieu of a standard USB connector.

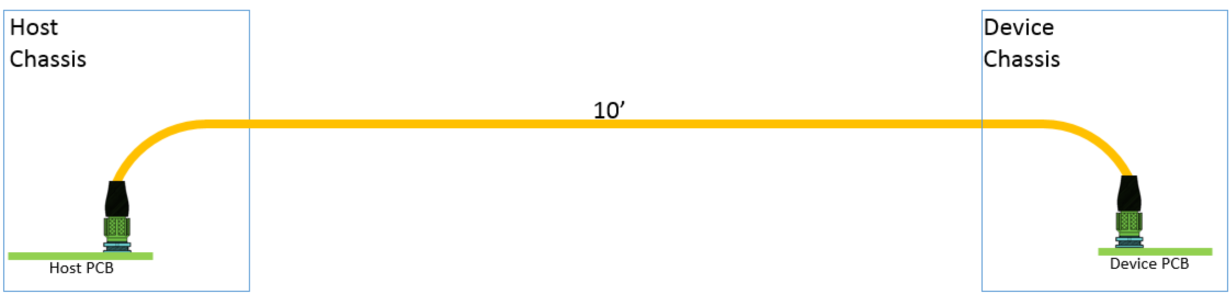


**Figure 7. Crosstalk Case 1 Diagram**

Simulation results of Crosstalk Case 1 is shown below in Figure 8.

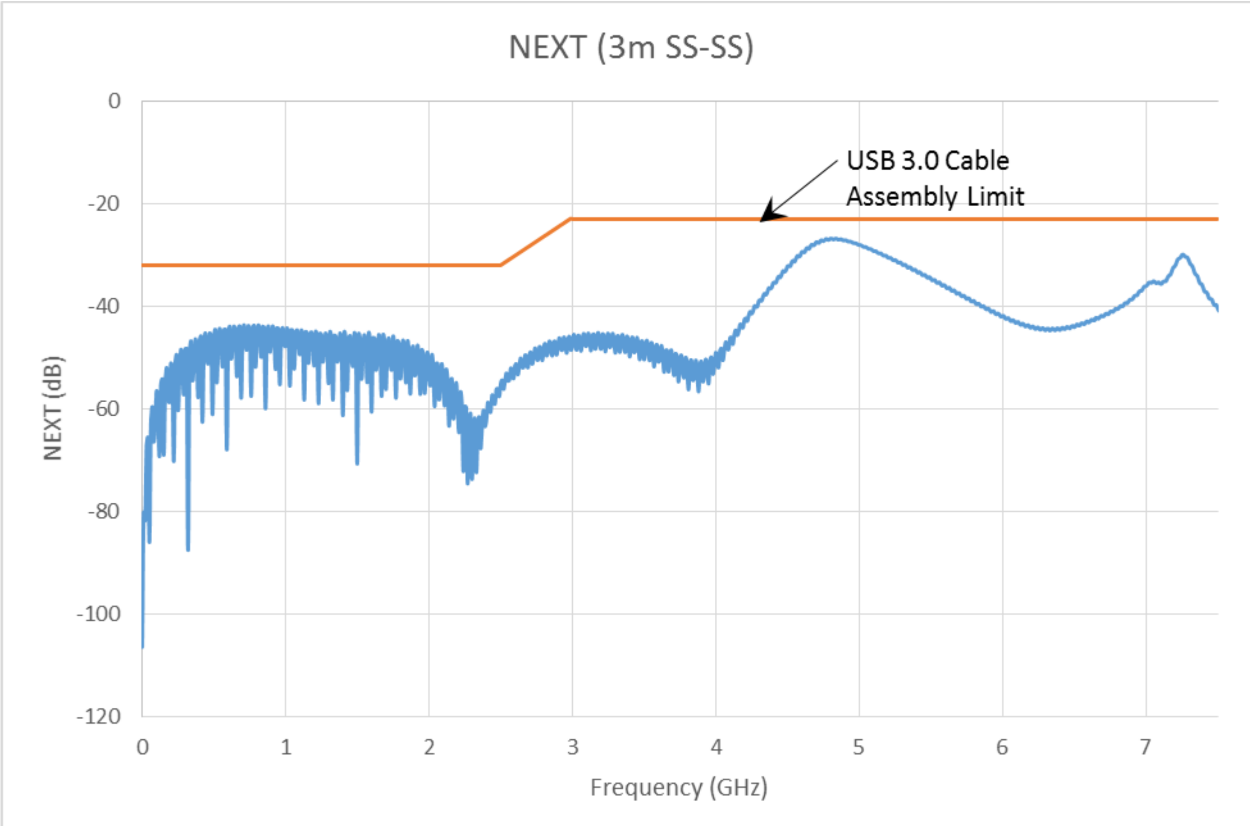


**Figure 8. NEXT Simulation Results for Crosstalk Case 1**

The next case, seen in Figure 9, extends the example of Case 1 above. In this case, standard USB connectors are used at the PCB and Ochito connectors are used to make chassis connctions at the Host Chassis and the Device Chassis.

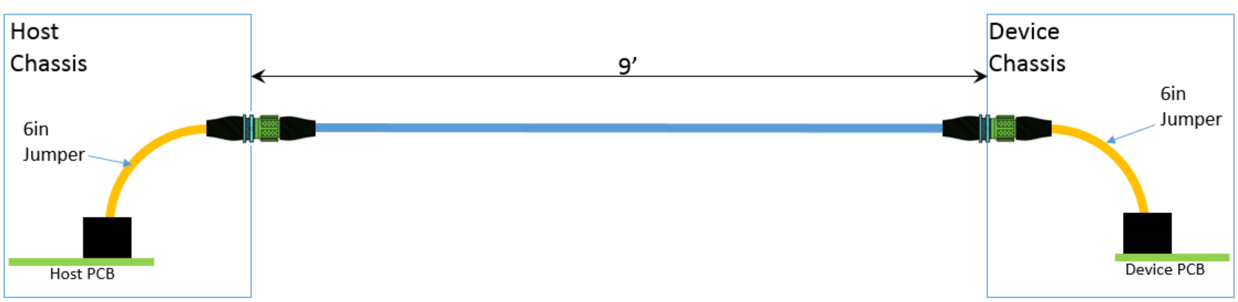


**Figure 9. Crosstalk Case 2 Diagram**

Simulation results of Crosstalk Case 2 is shown below in **Figure 10**.

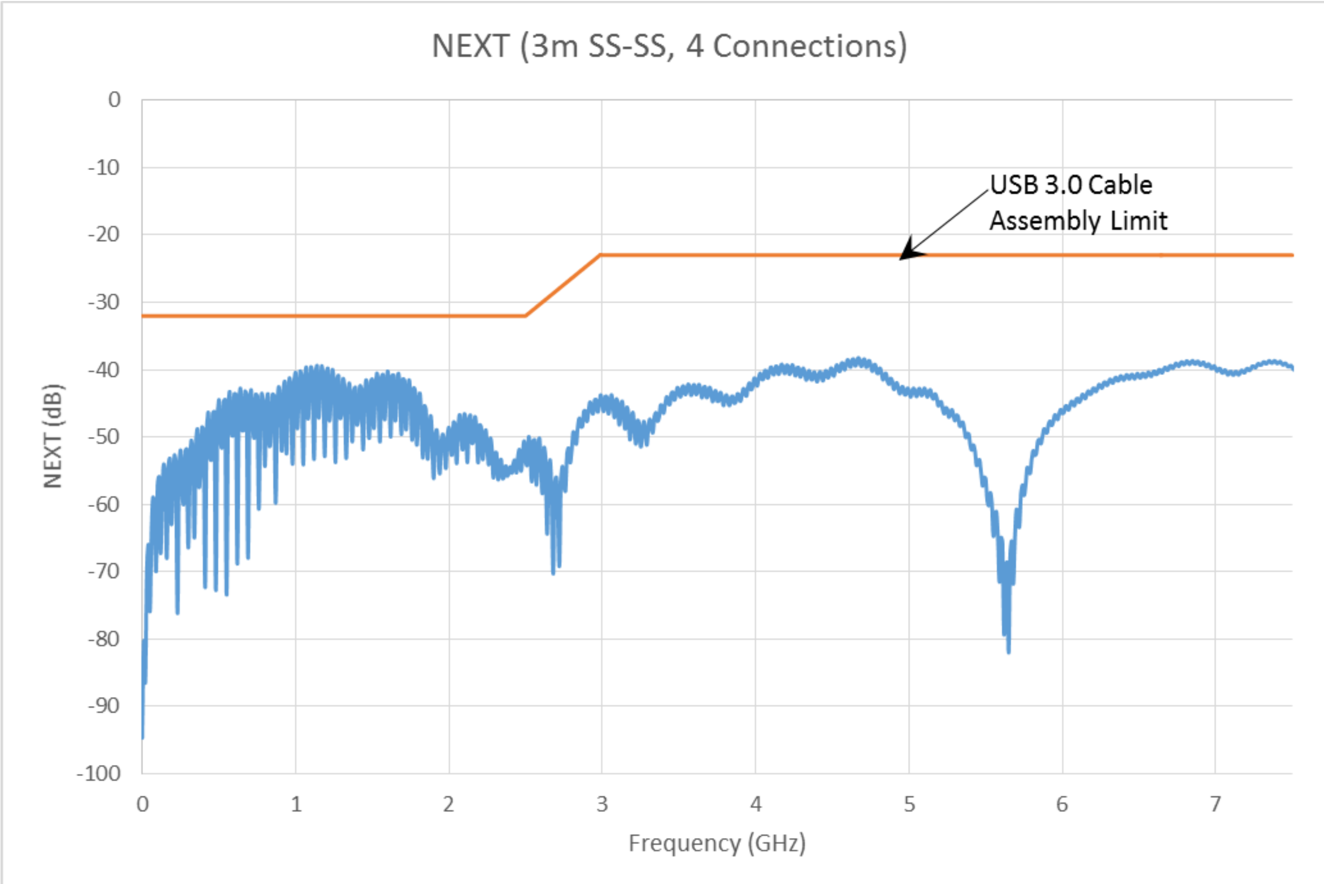


**Figure 10. NEXT Simulation Results for Crosstalk Case 2**

Crosstalk Case 3 adds two more Ochito connections to Crosstalk Case 2. See Figure 11.

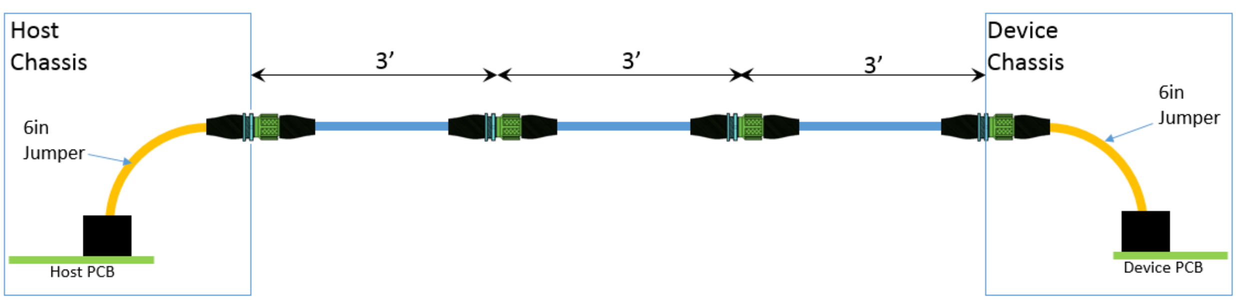


**Figure 11. Crosstalk Case 3 Diagram**

Simulation results of Crosstalk Case 2 is shown below **Figure 12**.

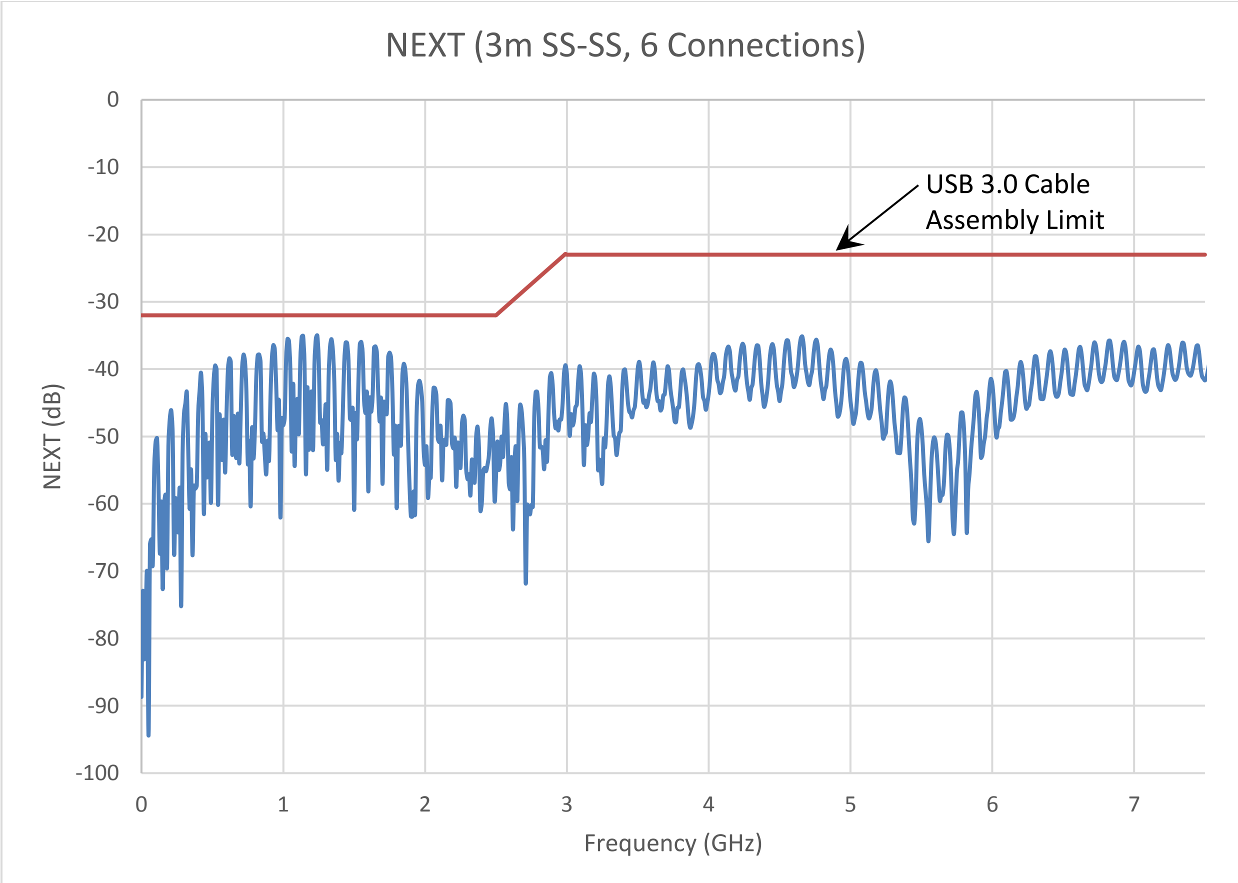


**Figure 12. NEXT Simulation Results for Crosstalk Case 3**

Table 2 summarizes the worst case NEXT margin for each of the above cases.

**Table 2. Worst Case NEXT Summary**

| Link Configuration | # Connection Points | Worst Case Margin (dB) |
|---|---|---|
| Direct 3 meter link | 2 | 11 dB |
| 3 meter link with Box I/O | 4 | 7.5 dB |
| 2 meter link with Box I/O and 2 break points | 6 | 3 dB |