infrastructure for a connected world

Calculating Your Insertion Loss Budget

WHITE PAPER

Introduction

Calculating an Insertion Loss Link Loss budget isn't a new topic. However, tolerances of Insertion Loss (IL) and Maximum Attenuation Allowance have become more important as the speed of data transmissions have grown throughout the years. All of these values are standards driven, available in ANSI/TIA-568-C.0 for performance and test requirements, and ANSI/TIA-568-C.3 for standards on fiber and connectors.

As an example, a 10G b/s fiber link in the data center over OM4 could easily reach 400m with a handful of mated pairs (defined as connector to patch panel, connector to cassette, or even splices with certain parameters for fiber type (ex, MMF) diameter (μm), wavelength (nm), maximum attenuation (dB/km), and modal bandwidth-length (MHz-km)).

With most data centers having 10 Gb/s uplinks in the rear view, and quickly surpassing 40 Gb/s, and now into 100 Gb/s and 400 Gb/s on the near horizon, there is less room for error for distance and performance as there was when data transmission speeds were 'lower'. Also, as data centers are physically getting larger, leaf-spine networks are sprawling, and lossless transport is needed for storage services, link channel design is a necessity. With the service life of the average fiber cable plant at around 20 years, a small amount of additional IL/attenuation at 40 Gb/s will make a gigantic difference in fiber application reach when speeds are approaching 400 or 800 Gb/s and beyond.

Testing the Link Per Standards

ANSI/TIA-568-C-0 provides the below Link Attenuation Allowance Calculation:

Link Attenuation Allowance (dB) = Cable Attenuation Allowance (dB) + Connector Insertion Loss Allowance (dB) + Splice Insertion Loss Allowance (dB)

Where: Cable Attenuation Allowance (dB) = Maximum Cable Attenuation Coefficient (dB/km) × Length (km) Connector Insertion Loss Allowance (dB) = Number of Connector Pairs × Connector Loss Allowance (dB) Splice Insertion Loss Allowance (dB) = Number of Splices × Splice Loss Allowance (dB)

Some examples include:

- **Cable Attenuation Allowance** = Max Cable Attenuation Coefficient
- **3.5dB/Km @ 850nm)** x Length (**.2Km**) x # of Connector Pairs (**2**) x Connector Pair Loss Allowance (**0.5dB**)
- **Connector Insertion Loss** 0.5dB x (ex: 2 connectors of Optimized IL Cassettes) = 1.0dB
- **Link Attenuation Allowance = 0.7dB** Cable Attenutation Allowance + **1.0dB** (Connector Insertion Loss Allowance) = **1.7dB Link Attenuation** for a **200m** Trunk with (**2**) Optimized IL Cassettes

Note: This is considered a 'worst-case scenario' per ANSI/TIA-568-C-0 standards-based values, which many contractors/installers will design with to ensure reach and performance of the intended application. The reality is most manufacturers components exceed the IL values for the intended performance category, Panduit included.

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Application Requirements vs. Testing to Standards

The issue with field testing is that the test value only provides a PASS/FAIL acknowledgement. This result gives no assurance that your intended application will provide the reach distance necessary to deliver data from end to end. As an example, the below image shows the distance with Loss Budget calculations. For 16 Gb/s Fibre Channel using OM4, you can expect 150m at 1.0dB connector loss, while 2.4dB loss will give about 50m of distance. While a PASS may have been seen from meeting loss budgets per standards, if the expectation was to get greater than 150m at 1.0dB loss, the only way to achieve this is now to lower the connector loss by moving to a greater performance option (for example, Standard IL to Optimized IL or Ultra IL performance).

Distance (m)/Loss Budget (dB)

	Connection Loss				
Fiber Type	**3.0dB**	**2.4dB**	**2.0dB**	**1.5dB**	**1.0dB**
M5F (OM4)		50/2.58	100/2.36	125/1.95	150/1.54
M5E (OM3)	NA	40/2.54	75/2.27	100/1.86	120/1.43
M5 (OM2)		NA	25/2.09	35/1.63	40/1.14

What's Next?

Design, design, design, and ensure you're futureproofing yourself. While Standard Insertion Loss/ Standard Performance components may be sufficient today, remember you're building for 15-20 years down the road. Servers come and go, as do switches, but does your cable plant? How are these calculations done?

As you can see having to re-calculate values based on distance, IL changes based on the performance levels of the fiber and the rest of the channel components, and adding additional connectors complicates these calculations immensely.

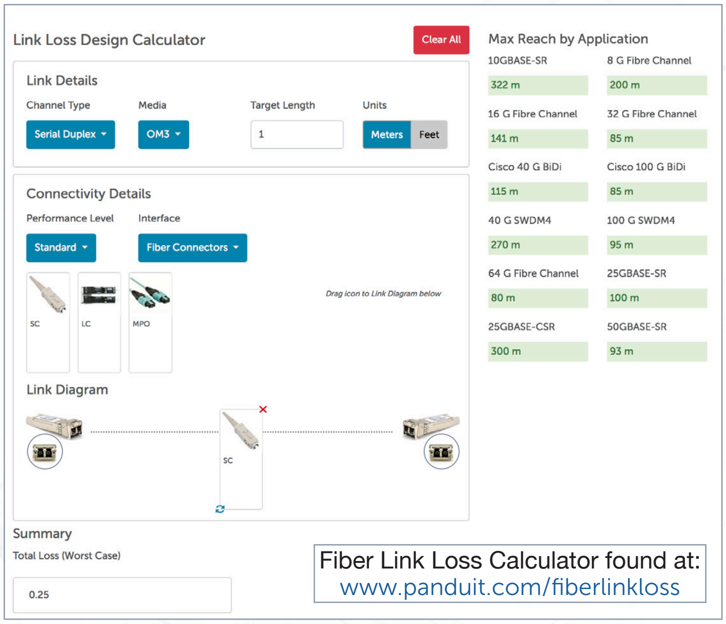
Note: As mentioned above, while these application reaches and distances are based on standards, the expectation is of better distances/performance in real-world implementation, assuming all installation standards for cleaning, bend radius, and OTDR testing is followed.

Panduit's Link Loss Calculator

Panduit has created a fiber link loss calculator to make the process of calculating Insertion Loss Link Loss to support your network designs.

The calculator is meant to assist during the network design phase to select the right fiber products based on the application. The calculator allows the user to easily toggle through performance levels of both fiber and components to ensure they choose the proper components for today's application, as well as futureproofing tomorrow's upgrades as network needs change.

This is not a Bill of Material generator, but as a review of intended channel components. The calculator is built to IEEE and ANSI standards for link loss. Users can expect better performance/distances and using this calculator will ensure the application will meet standards loss guidelines which is important for warranty purposes.



Fiber Link Loss Calculator found at:
www.panduit.com/fiberlinkloss

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Calculator Help Notes

1. This link loss calculator presents the application reach for multiple transceiver technologies based on fiber media selected and type of connectivity systems deployed in the channel (shown as the "link Diagram").
2. The calculation results are presented in two areas of the link calculator page.
    a. "Total Loss (Worst-case)" in the lower left represents the sum of the worst-case losses of all the mated pairs of connectors in the channel plus the fiber attenuation for the length of the channel.
    b. "Max Reach by Application" in the upper right on the page indicates the reach achievable based on the design instance (applicable transceivers and fiber/connectivity chosen). There is a highlight color overlaid in each transceiver reach result in this area that indicates 'Green' or 'Red' (Red showing that a channel based on your chosen design is not possible at any length).
3. The selection of "Channel Type" in the uppermost left corner of the page, limits the applicable transceiver selection to the type of transmission desired (serial duplex, parallel or hybrid serial duplex/parallel to support breakout applications). The images of the transceivers in the Link Diagram will change according to the channel type chosen.
4. Media selection enables the choice of fiber deployed in the link to all the popular multimode fibers and a general 'OS1/OS2' fiber.
5. Inputting a "Target Design Length" allows the user to use the calculator in a discrete mode to validate an existing design based on the total channel length (in either 'meters' or 'feet' units via the radio box located adjacent).
6. The "Connectivity Details" section allows the user to select the type of connectivity deployed (labelled in the 'interface' drop down menu) and the performance level of the connectivity deployed ('standard', 'optimized' or 'ultra').
7. Note that when multiple instances of connectivity are deployed into the Link Diagram, they will all be of the same performance level chosen (mixing & matching of connector grades is not possible).
8. Consult Panduit connectivity specification sheets to find out what Insertion loss values are associated with each connectivity system performance level (these vary depending on fiber type and connectivity style and are subject to change).
9. The 'Interface' drop down menu picks the family of connectivity you can deploy in the Link Diagram and shows an image of the types of connectivity in the family to the right of the drop down.
10. Once the "Link Details" and Connectivity Details" are completed by user input, a channel can be built by selecting the connectivity images (hovering over) and dragging them down into the area between the two transceivers facing each other in the link diagram.
    a. Please note that the image of the connectivity represents mated pairs of connectors (and the associated Insertion Loss with such). In other words, the image of a single connector under the "Fiber connectors" menu choice represents a **mated pair of connectors** (Connector, Adapter and Connector). There is no need to select two connectors onto the link diagram. Likewise, when selecting a plug and play module such as an MPO cassette, the menu choice represents the mated pair of LC duplex connectors on the front of the cassette along with the mated pair of MPO connectors on the rear of the cassette.
11. The RED button "Clear ALL" in the upper middle of the page allows the user to clear all the connectivity picks from the Link Diagram. Also, individual components can be removed from the diagram by clicking the RED 'X' in the connectivity image in the link.
12. To make the Link Diagram image truer to the direction of the actual deployment of the connectivity components in the channel, the image of the component deployed in the diagram can be flipped horizontal by clicking the lower left rotation "mini icon" on the image.

Fiber Link Loss Calculator found at:
www.panduit.com/fiberlinkloss

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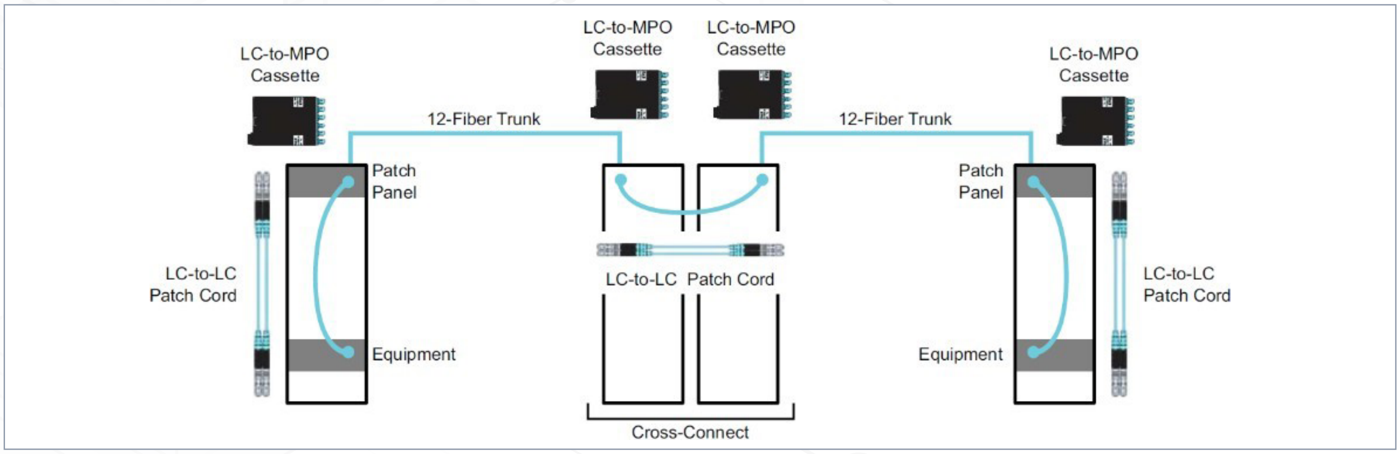
Example of Design through the Link Loss Calculator

A design for a cross connected plug and play system that needs to support 10 GBASE-SR and 16 G Fibre Channel on 90 meters of OMx fiber is shown below. This system is a 4 (four) MPO cassette system with cassettes deployed in switch EDAs at each end of the channel and a port replication cross connect somewhere in the middle. The 90 meters of fiber represents the worst-case sum of all fiber length in the channel including patch cords.



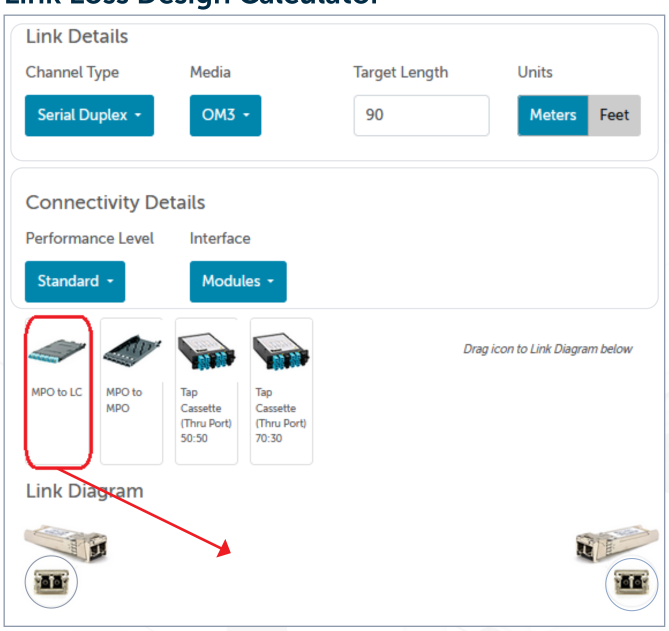
"Link Details" inputs:

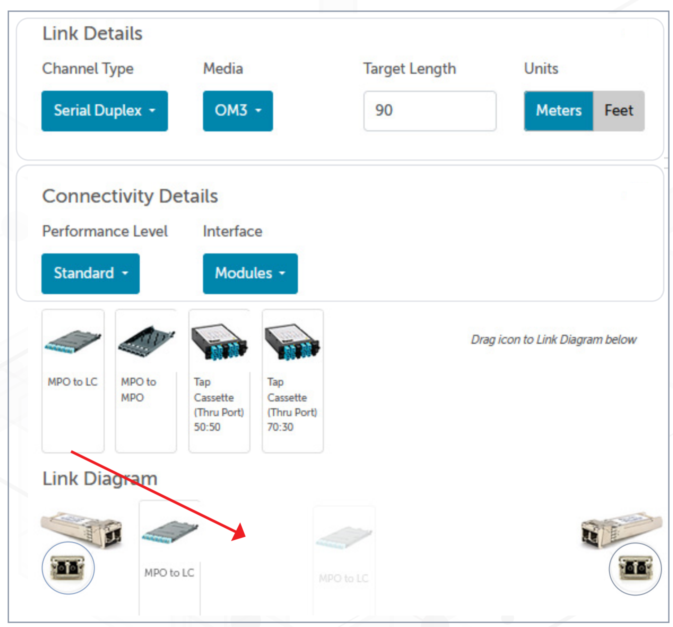
- The channel is a "Serial Duplex" channel
- As first pass we will try to build the channel with OM3 fiber
- Target Reach to 90 meters

"Connectivity Details" inputs:

- As first pass we will try to build the channel with 'Standard' performance level modules
- "MPO to LC" modules (icons) are picked and arranged onto the Link Diagram as below representing the 4 (four) MPO cassettes in the channel
- Hover over and click on the **MPO to LC** module as shown below in **RED**
- Once selected with your mouse, drag to the location between the duplex transceivers on the Link Diagram line

Link Loss Design Calculator

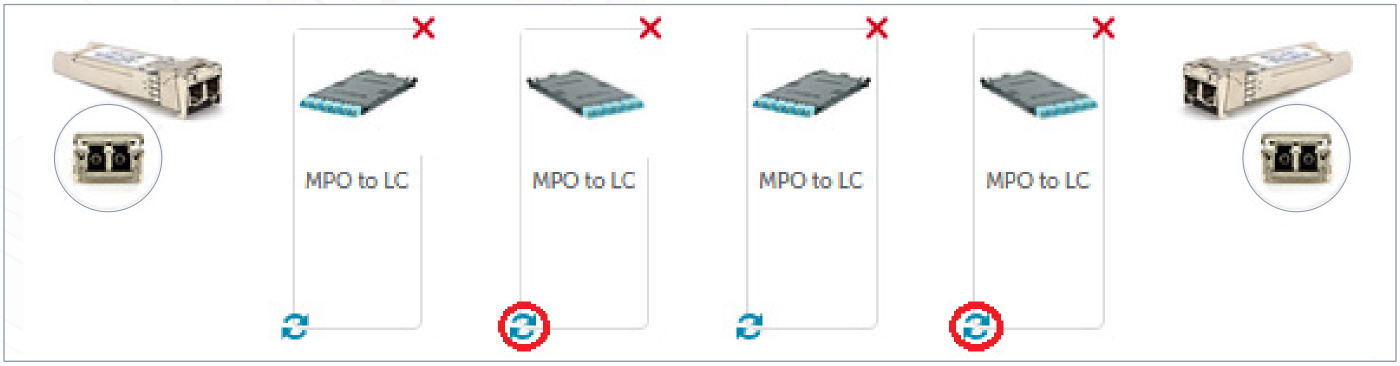




Example of Design through the Link Loss Calculator (Cont.)

- Repeat this process until there are 4 (four) MPO to LC Cassettes between the transceivers on the Link Diagram
- Re-arrange modules as below to represent the connectivity in the channel

Link Diagram



*Note: Image orientation can be flipped by clicking on the double-arrow icon under the image

Max Reach by Application

10GBASE-SR	8 G Fibre Channel
255 m	35 m
32 G Fibre Channel	Cisco 40 G BiDi
15 m	30 m
Cisco 100 G BiDi	40 G SWDM4
2 m	50 m
100 G SWDM4	64 G Fibre Channel
15 m	30 m
25GBASE-SR	25GBASE-CSR
64 m	100 m
50GBASE-SR	
5 m	

We can see from the "**Max Reach by Application**" area of the page, that the 10GBASE-SR application is supported, but for example the required 16G Fibre Channel application is not.

The normal approach to solve this (if at all possible), would be to update the inputs of the model to increase the performance level of the connectivity or the grade of multimode fiber selected (or both).

Any applications supported by the application connectivity methods selected will be shown, but if their distance supported is LESS than the target distance you selected (in this example 90m), they will be shown with a **RED** background.

Example: Cisco 40 G BiDi, 30m is a supported application, however the 30m maximum, based on 'worst-case scenario IL', is below the 90m Target Length application reach, therefore shown in red.

Note: Any application reach with a distance supported of ZERO will not be shown, which is why 16 G Fibre Channel is not visible.

Example of Design through the Link Loss Calculator (Cont.)

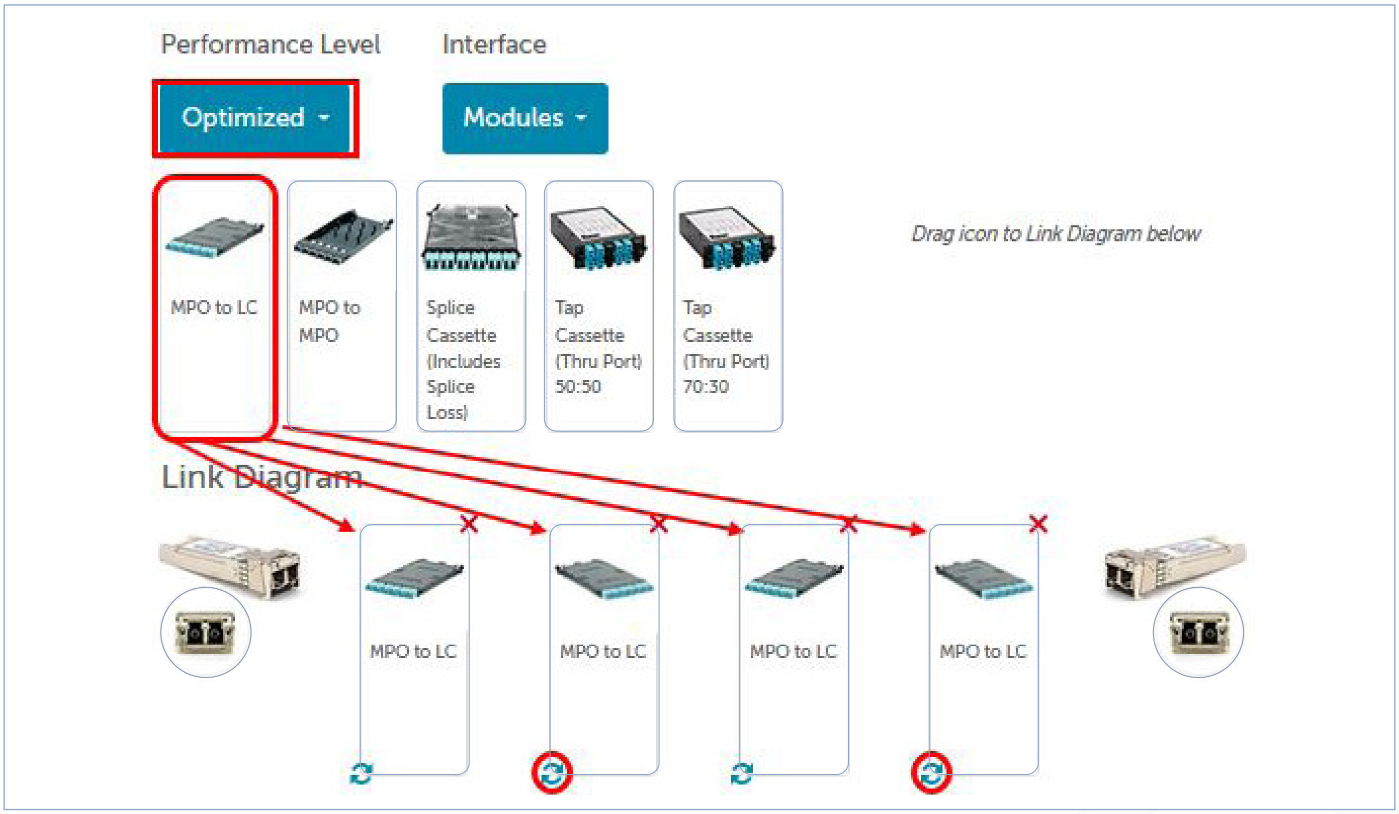
To change the level of Performance to see if you can get additional reach distance, select the dropdown for 'Performance Level' and change from 'Standard' to 'Optimized'. A message will be displayed stating you cannot mix differing performance levels. Select Clear and continue by selecting 'Optimized' Performance Level and re-create the Link Diagram.

Confirm Diagram Clear

Since connectors of differing performance levels cannot exist, the diagram must be cleared. Are you sure you want ot proceed?

Cancel | Clear

Link Loss Design Calculator



Optimized Reach by Application

10GBASE-SR	8 G Fibre Channel
285 m	125 m
16 G Fibre Channel	32 G Fibre Channel
75 m	60 m
Cisco 40 G BiDi	Cisco 100 G BiDi
85 m	50 m
40 G SWDM4	100 G SWDM4
210 m	60 m
64 G Fibre Channel	25GBASE-SR
60 m	84 m
25 GBASE-CSR	50 GBASE-SR
240 m	50 m

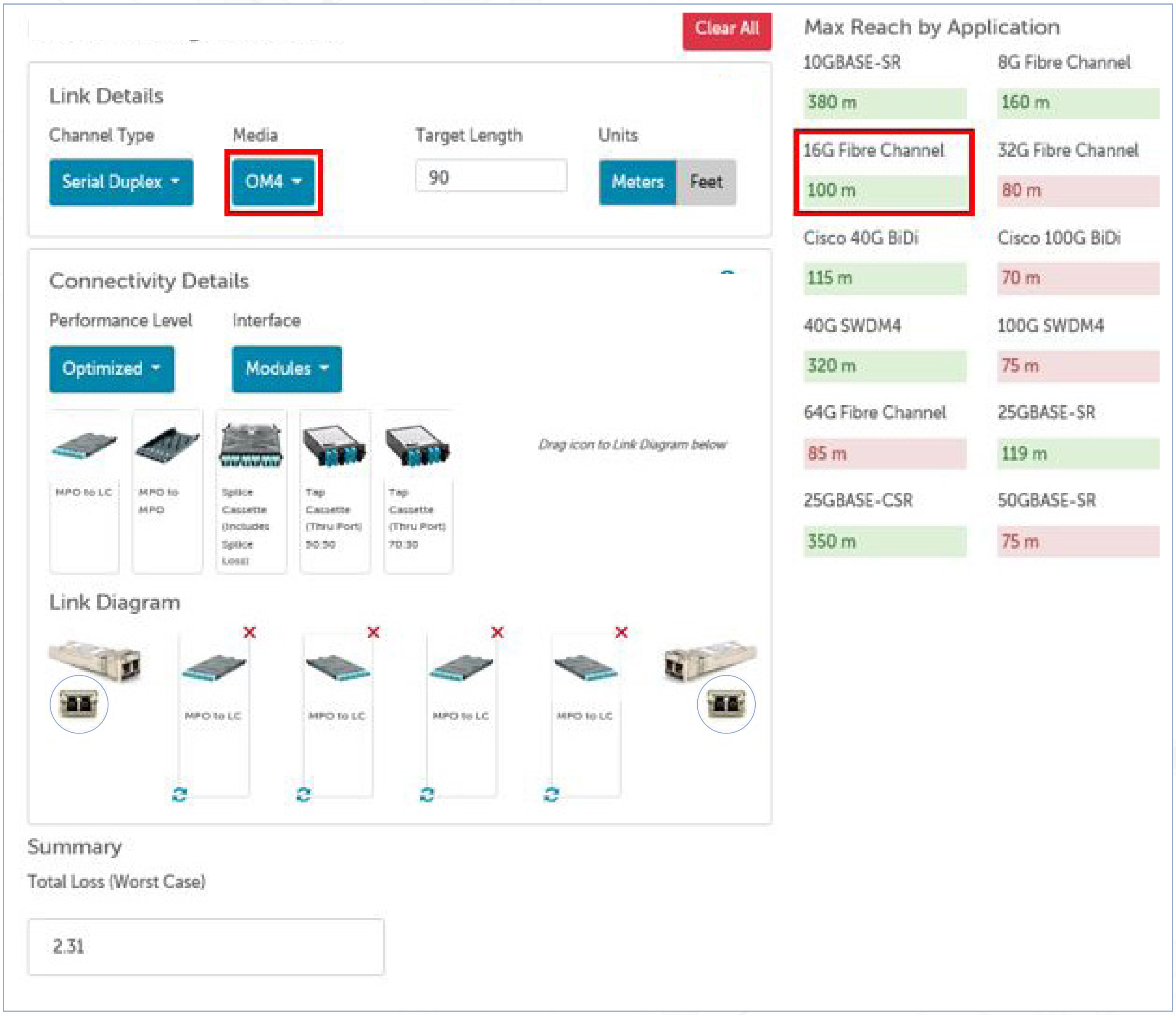
By changing the Level of performance of the connectivity to '**Optimized**' instead of standard (0.5dB maximum IL vs 0.75dB), we don't quite get to the required 90 meters of reach (it yields 75m), so the strategy here would be to upgrade the performance level of the multimode fiber media along with the enhanced connectivity performance.

When we do this, we can achieve a reach of 100 meters for 16 G Fibre Channel which satisfies the original requirement of a 90 meter channel.

Example of Design through the Link Loss Calculator (Cont.)

Shown is the image of changing Media type to ‘OM4’ from ‘OM3’, in addition to now having Optimized Performance Level as was changed above. When we do this, we can achieve a Channel Reach of 100 meters for 16 G Fibre Channel, which satisfies the original requirement of a 90 meter channel.

Link Loss Design Calculator



Note: The Total Loss (Worst-Case) value in the Summary field is achieved by adding the total Fibre Attenuation Loss (distance per km) and the Insertion Loss of the components, per standards. This value will give the Standards Based Loss, which is often higher than the measured value gained by completing OTDR-based testing.

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Since 1955, Panduit's culture of curiosity and passion for problem solving have enabled more meaningful connections between companies' business goals and their marketplace success. Panduit creates leading-edge physical, electrical, and network infrastructure solutions for enterprise-wide environments, from the data center to the telecom room, from the desktop to the plant floor. Headquartered in Tinley Park, IL, USA and operating in 112 global locations, Panduit's proven reputation for quality and technology leadership, coupled with a robust partner ecosystem, help support, sustain, and empower business growth in a connected world.

For more information

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