Application Note:
Design Considerations when using Passive Media Converters

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Product Line:
Fiber Optics

Part Numbers Affected:
OM1, OM2, OM3, OM4 products to be used in applications that extend beyond published Standards based length limitations.

APPLICATION

With today's need for ever-increasing data rates, existing physical infrastructure can often reveal challenges in keeping up with technology upgrades. While they are being phased out, many existing campus and inter-building backbone systems still rely on Multimode OM3 or lower fiber grades. While these fibers were sufficient for 1 Gb ethernet applications, 10 Gb or greater applications drive the need for modifications or upgrades to the physical cabling infrastructure.

IEEE 802.3 ethernet applications length limitations and maximum insertion loss for common duplex transceivers make common Ethernet Applications such as 10GBASE-SR, 40G BiDi and 100GBASE-SR4 unusable. Noteworthy is that no multimode Ethernet Applications above 100G utilize duplexed fibers. In addition, most of the multimode Ethernet Applications identified do not include OM1 and OM2 as an option. Current standards do not recognize these fiber grades for use in Data Center applications.

Passive Media Converters

A newer technology available is the implementation of Passive Media Converters. PMC's are non-powered (passive) single mode devices eliminating the modal dispersion that occurs over multimode fiber optic cabling. Existing multimode fiber is fusion spliced or mechanically mated to the multimode input fiber at the PMC device. At the remote end, an additional termination and PMC might be required. This effectively converts the signal to a single mode fiber transmission at the "last mile" prior to arriving at the recipient device.

While these devices have been proven to facilitate the transmission of data rates 10 Gb and beyond using SM transceivers to support a target Ethernet Application, there are factors to be evaluated when considering adding PMC's as an infrastructure solution.

One reason why PMCs are considered is to utilize existing pathway systems, especially those servicing a campus environment. New trenching, vault work, concrete cutting/coring can be cost prohibitive and removal of legacy cabling from these existing pathways can be time consuming, cause network downtime and potentially damage in-use cabling in the process.

Some manufacturers are claiming that a PMC is viable, lower-cost alternative to upgrading an existing multimode infrastructure or installing a new single-mode infrastructure to obtain higher performance or longer reach. Before adopting this technology, we believe there are several risk factors to consider before adopting including:

- Additional Insertion Loss in Channel
- Migration to Higher Data Rates
- Reduced Rack Density
- Cost
- Switch vendor warranty and support for non-standard cabling plant

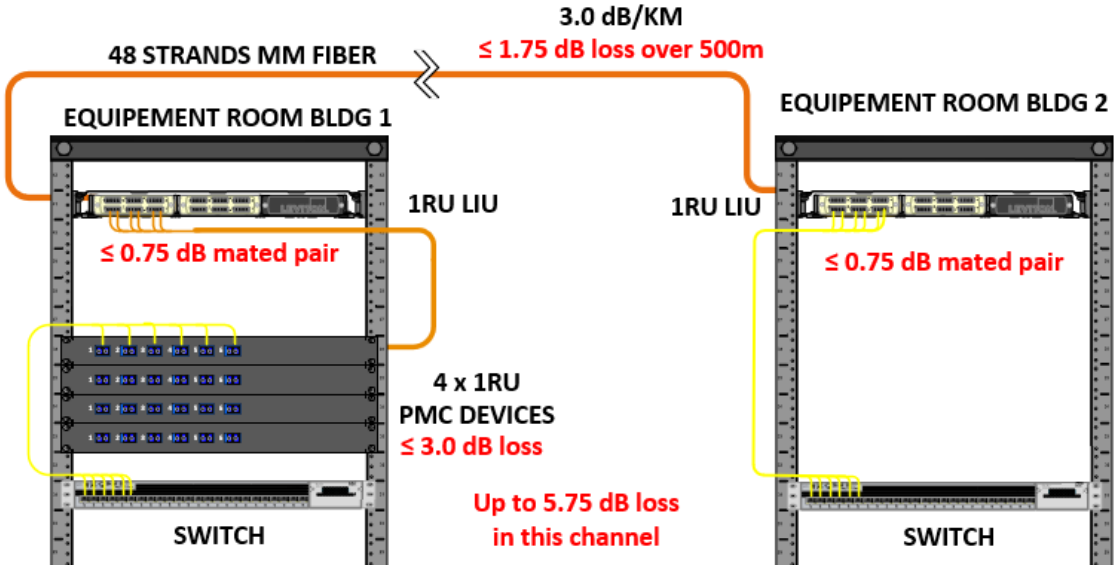
Additional Insertion Loss in Channel

Passive Media Converters use filters to perform the removal of modal dispersion that occurs in multimode fiber. Insertion loss occurs in these devices at up to 3 dB per connection. Single mode transceivers at lower data rates typically have sufficient headroom in receiver sensitivity. Four factors must be evaluated for this topic.

1. The number of connections in the channel. Each connection applies additional insertion loss.
2. Impact from the age and quality of the installation and connector end face cleanliness.
3. Lower loss requirements of higher data rate Ethernet and Fiber Channel Applications. The higher the data rate, the lower the allowable insertion loss and return loss.
4. Several of the potential 100, 200, and 400 Gb solutions require more than 2 strands of fiber using either MTP/MPO or duplexed connector types to support QSFP-DD or OSFP transceiver ports respectively.

Transceiver	Form Factor	Fiber Type	Distance (Meters)	# of Fibers	Conn. Type	Max Channel Loss in dB
10GBASE-L	SFP+	OS2	10,000	2	LC	6.2
25GBASE-LR	SFP, SFP28	OS2	10,000	2	LC	4.8
40G-LR4	QSFP+	OS2	10,000	2	LC	6.7
100GBASE-CWDM4	QSFP28	OS2	2000	2	LC	5.0
100GBASE-LR4	CFP2/CPAK/QSFP28	OS2	10,000	2	LC	6.3
100GBASE-PSM4	QSFP28	OS2	500	8	12F MTP	3.3
200GBASE-FR4	QSFP28?	OS2	2000	2	LC	4.0
400GBASE-DR4	OSFP28, QSFP-DD	OS2	500	8	12F MTP	3.0
400GBASE-FR8	OSFP28	OS2	2000	2	LC	4.0

As you can see, 100GBASE-PSM4 requires both 8 fibers and has a maximum allowable loss of 3.3 dB. The accumulated channel loss over MM fiber can easily approach or exceed the functional limits of several longer reach and/or higher data rate Ethernet Applications. In example application below, the total channel loss would be 5.75 dB – well over the budget of 3.3 dB.



Depending on the length of the overall channel, a second far end PMC device may be required. This also adds additional loss against the transceiver maximum allowable limit.

Migration to Higher Data Rates

As companies and campus environments see increased bandwidth requirements, they will likely need a network strategy to migrate to speeds higher than their existing infrastructure supports. As identified in the insertion loss factors above, the loss budget of channel is reduced at the higher data rates. When higher data rate applications like,100Gb/s are required, the existing cabling infrastructure may be insufficient and need to be upgraded anyway.

Reduced Rack Density

Real Estate is a high commodity in many telecommunications rooms and rack/cabinet spaces. PMC devices add required rack unit space and often have very low port density to facilitate the transition that occurs in the device. Port density is commonly as low as 12 fibers per RU. As the logical option would be to patch or splice from the existing infrastructure to the PMC, additional rack space beyond what was already installed is required. For example, a 48-strand campus backbone cable that already consumes 1 RU of rack space would require an **additional 4RU** of space for the PMC devices as shown above. Space is also required for any splicing that occurs to mate the existing infrastructure to the PMC input fibers. This can cause severe impact on available space for the operational, mission critical and revenue generating active hardware these passive cabling systems service.

Cost

There are obviously additional costs incurred with adding PMC. A 12-fiber PMC device can cost as much as $10,000. In addition, there will likely be additional costs incurred during installation to purchase or rent specific BER test equipment that is required to certify the installation in order to get a system warranty from the manufacturer. If BERT testing produces a failure, the system may not be warrantable causing potential need to re-cable. While the incurred costs of successfully adding PMCs could solve short term issues, it might not address longer-term issues that would again require re-cabling.

Switch Vendor Support for Non-Standard Cabling Plant

A multi-million dollar investment to upgrade the speed of your network switches may not be supported or warranted if there are any compatibility issues with the old fiber cabling in use with a PMC device. It is undetermined if transmission over multimode fiber will meet recommended IEEE and MSA transceiver performance requirements for data rates greater than 100Gb/s as they are just now becoming available. Switch provisioning and network troubleshooting may need to be supported from resources other than your switch vendor.

THE LEVITON RECOMMENDATION

Single mode is the best overall solution

While the addition of PMC devices may be the only cost or downtime effective option to mimic single-mode fiber, these should only be considered as a last resort. The cost of adding these devices can be significant when looking at the decreased IL headroom towards the link loss budget, consumption of critical rack space and potential functional limit when migrating to future data date applications.

While replacing the multimode cabling infrastructure with single mode is a capital cost today, it corrects and eliminates all the issues addressed in this Applications Note and provides essentially limitless distance and data throughput in the passive optical cabling infrastructure moving forward.

For more information on the Leviton family of fiber optic products and solutions, please go to www.leviton.com

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