Elimination of Field Testing for HyperReach™ Solution

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Executive summary

Current best practices in the installation of fiber optic cabling solutions recommend field testing for polarity, channel continuity, and insertion loss after the system is fully installed. When terminating or splicing optical fiber in the field, it is essential to validate the installer properly ordered the fibers when splicing or polished properly when terminating the fiber connectors. However, when using a factory preterminated fiber cabling solution that is fully contained in a pulling apparatus, data shows the risk of improper polarity, continuity, or insertion loss is eradicated. For this reason, this paper argues that field testing certain preterminated solutions is not required to ensure a high quality installation.

Introduction

A well-designed and installed structured cabling solution will survive many network hardware upgrade cycles with little or no modifications. Preterminated fiber optic cabling solutions are typically deployed in data centers to reduce installation time and eliminate potential debris during the installation process from terminating fiber optic connectors or splicing the optical fibers.

The viaPhoton Fiber Trunk Module™ solution consists of factory-terminated fiber cables housed inside a module with shuttered ports or dust caps. The module is inserted into a protective case for ease of installation in the field. While field testing of non-preterminated solutions needs to be performed to ensure continuity, correct polarity, and end-to-end insertion loss, field testing of specific preterminated solutions is not required as the final factory testing ensures compliance across each of those key quality metrics. Data shows that the engineered design of the FTM and end-of-line functional testing of the module ensures zero failures of the installed solution when field tested. Therefore, the viaPhoton Fiber Trunk Module™ (FTM) solution does not require field testing to provide full warranty.

Objective / Mission

In just the last decade, data center networking has evolved architectures, topologies, transport technologies, and data rates. Data center architectures have moved from traditional three-tiered to Spine/Leaf, which is the most commonly employed today. Further, the three-tier CLOS architecture is being deployed in the proliferating machine learning (ML) data center environments. ML-focused data centers are utilizing additional transport technologies – RDMA over Infiniband (IB) and RDMA over Converged Ethernet (RoCE). Data rates have increased from 10Gbps to 400Gbps for traditional cloud computing deployments, and those rates are increasing to 800Gbps to support ML workloads.

These changes have solidified fiber optic cabling as the medium necessary to support data center connectivity between servers and switch fabrics. Optical fiber cables are necessary to achieve transmissions speeds up to 800Gbps or higher for distances greater than fifteen meters; copper Direct Attached Cable (DAC) cannot supply connectivity at that bandwidth over longer distances. Conversely, optical fiber can support up to 500m for connectivity within a data center and even greater distances for data center interconnects, a 33x increase in potential distance and immeasurably greater design flexibility for data center networking fabrics. As architectures and use cases for compute are evolving, design flexibility is a critical consideration.

The reliance on fiber cabling and connectivity is exponentially greater for machine learning applications. AI/ML training workloads can run for weeks or even months—all for a single large language model (LLM). They run on a fully interconnected cluster of Graphic Processing Units (GPUs) where a connectivity failure can halt the entire process resulting in having to start the training over again. Even relatively minor latency within the fabric can add days or weeks when its effects are multiplied over the duration of the training project.
In the past, fiber optic cabling was spliced or terminated in the data center to provide connectivity between zones. The process was slow and error-prone; success was highly labor-dependent, relying on the execution and experience of the technician.

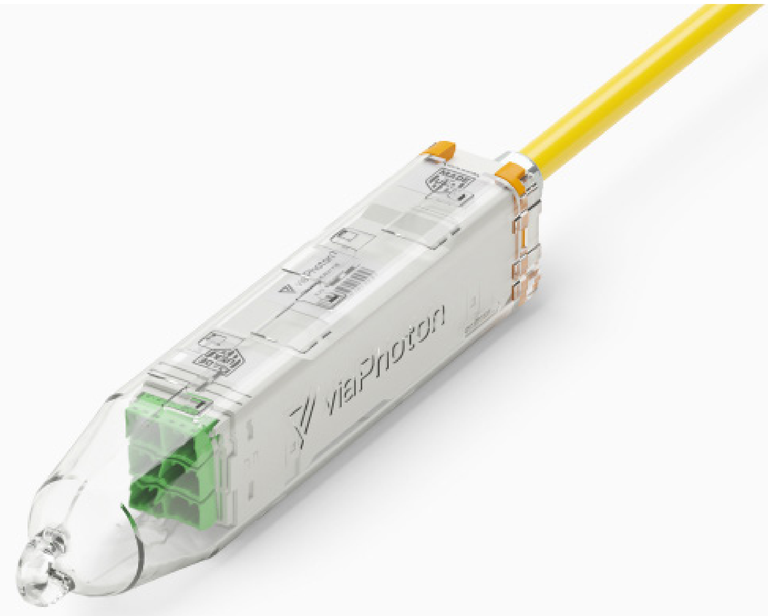
MPO Adapter Panel - Pulling sock

Once terminated, the connectors still had to be placed in proper position in the panel apparatus to ensure proper polarity.

Field testing fiber optic cabling solutions is a process that is done to ensure the continuity, polarity, and end-to-end insertion loss of the cabling solution being installed. Errors were typically found during this phase. Remediation ranged from simple fiber position swapping to maintain polarity or—in the worst case—the connector would have to be removed and re-terminated. Once fixed, some tests would be re-run to ensure quality, inflating the time and cost for deploying data centers. Fiber optic testing in the field is a time-consuming process usually involving multiple technicians in the field to perform. Optical loss test sets (OLTS) require a light source or permanent link on one side of the fiber channel and a power meter on the other side measuring light loss, or insertion loss. Sufficiently sophisticated OLTS equipment will also verify proper polarity and continuity of the installed fiber. In a typical hyperscale machine learning data center, there can be up to 500,000 fiber terminations in a single cluster. Testing the installation can take multiple crews days or weeks to perform.

As new data center buildouts have accelerated to meet rising demand for specialized compute, the labor market for these skilled technicians has tightened dramatically. The market forces of expansion, complexifying technical architectures, and access to sufficiently experienced labor are profoundly at-odds.

Pre-terminated cabling systems were developed to reallocate the terminating



viaPhoton - Fiber Trunk Module™ (FTM)

burden from a less-than-ideal environment to a centralized facility with proper lighting, equipment, and skilled technicians. Factory calibrated, robust test equipment is also used to ensure proper polarity and continuity of the trunk cables. The trunks were then shipped to the field location where the technicians installed the solutions. The technicians would unpack the cables and install the trunk connectors into panels and test for proper polarity or for damage due to installation. Testing is absolutely recommended when field installing trunk cables into adapter panels in the data center environment.

Installation quality and fitness are further risked by the lack of native test equipment for the very small-form factor (VSFF) connectors introduced in the market in 2016. The VSFF connectors have now gained industry acceptance as designs have required higher data rates and denser connections to each rack. However, because initial adoption and rollout was slow, test equipment manufacturers were equally slow in spending resources developing the native test sets. Their speed to market does not match the current rate of adoption, leading to inferior testing setups for each individual fiber in a VSFF connector.

Recommendations / Solution

ANSI/TIA-568-C defines best practices for designing and installing fiber optic cabling and connectivity systems in data centers. Testing is recommended for the trunk and adapter solution because the connector end faces could be damaged or dirtied when installing them into a panel. Even microscopic debris can occlude the 8-12 nm core of a singlemode fiber and aggravate the quality of the connection and the data rate. This multi-step installation method also creates the risk for the technician to plug the connectors in the wrong position in the adapter or panel, ruining the polarity of the system.

As a radical improvement to that system design, fiber optic cabling systems which are factory terminated in an apparatus, with the connectors already terminated and installed into a module housing protecting the connectors, remove the risk of damage. Functional, end-of-line factory testing confirms the polarity, continuity, and insertion loss are all as-specified. For designs featuring a containment system for the modules that further protects it from damage or debris, all risk of contamination of the connectivity is eliminated.

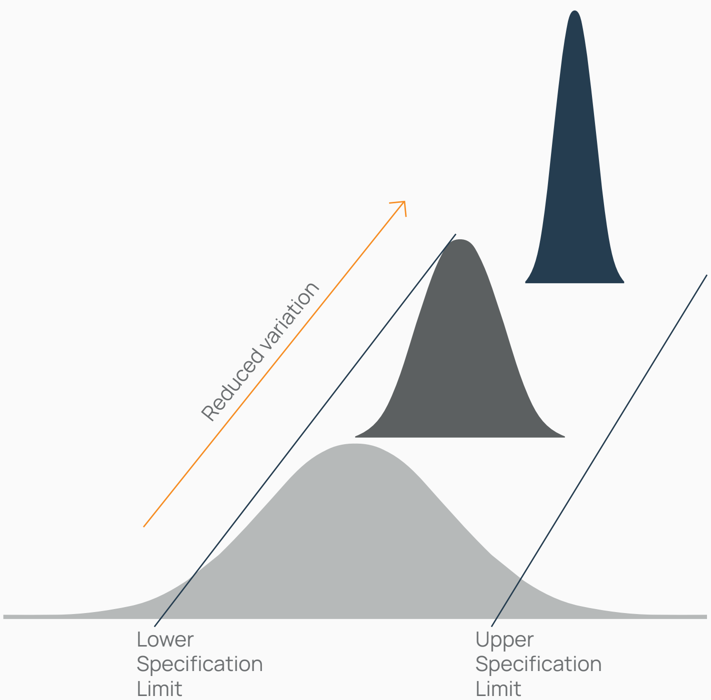
viaPhoton - HyperReach™ Fiber Trunk Module™ (FTM) Solution

The **viaPhoton HyperReach™ Fiber Trunk Module™ (FTM) solution** was developed with each of those core considerations: Factory termination, factory-installed connectors in a protective housing, installation containment, and full functional testing just before packaging with published, serialized test results. Because of these elements, the FTMs are a fully warrantied, factory-terminated solution with high optical performance and enables rapid installation without redundant field testing for polarity, continuity, and insertion loss. **The HyperReach™ FTM solution** uses a standard preterminated trunk. Rather than ship it to the data center location for the technician to install it in a panel adapter then into a panel, the trunk is installed into a module in the factory. The module is then inserted into a pulling apparatus that encapsulates the module for ease of pulling in the field. Once the **HyperReach™ FTM** is pulled to its destination, it is removed from the pulling apparatus and inserted into the panel. The preterminated connections are never exposed to risk of damage or debris particulates in the air. Because the solution was tested in the factory for polarity, continuity, and insertion loss, there is no need for further testing in the field.

Current data on this design has shown a 3.4 in 1,000,000 instances of failure in the field for polarity, continuity, or insertion loss in a 6 sigma model.

Methodology

The data for this publication was gathered from the Quality Management team at viaPhoton for all HyperReach FTM installations to date. The actual data was then extrapolated out to 6 sigma confidence level and reported.



Sigma Level	Defect per million opportunities (DPMO)	Yield
6	3.4	99.9997%
4	6,210	99.38%
2	308,538	69.15%

Results & Analysis

Based on the methodology referenced above, the results show a 3.4 in 1,000,000 failure rate for the HyperReach FTM solution in actual data center environments where installed.
The reasons for this are as follows:

The fibers are preterminated in the factory and tested for insertion loss.	The fibers are inserted into a coupler in an enclosed module and tested for polarity and continuity.	The module is fully encased in a pulling apparatus to minimize exposure to the construction environment.

The result shown after field installation and testing shows zero reported errors for issues with polarity, continuity or insertion loss. It is, therefore, recommended that field testing of the HyperReach FTM solution is not required to obtain a full limited lifetime warranty.

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