White Paper

Connectivity Solutions for Passive Optical LAN Installations
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Introduction

As enterprises begin to adopt Passive Optical LAN (POL) technology, they face a number of design and implementation challenges and choices. This paper reviews some of those challenges and offers solutions newly available in the marketplace.

Deciding on Fiber Termination Choices

When it comes to premises networks made of fiber, system integrators, installers and customers are faced with choosing between pre-terminated plug-and-play fiber assemblies or terminating the fibers to length on site during installation. 3M offers both solutions. To help customers make an informed choice about installation methods, this section reviews the latest technology and recent innovations in mechanical fiber connectivity.

In the last few years, innovative single-piece, field-installable fiber connectors, such as the 3M™ No Polish Connector and the 3M™ Crimplok™+ Connector, have been introduced. These fiber connectors use clever but inexpensive non-powered plastic tools to enable low-cost, quick and easy fiber connector terminations on site. Not only that, but they perform at specifications on par with those for fusion splicing or factory-terminated assemblies. See Figure A.

<table>
<thead>
<tr>
<th>3M™ No Polish SC/APC Connector 1.6 to 3.0 mm Jacket 8802-T/APC/FS/1.6-3</th>
<th>3M™ No Polish Connector SC/APC 8800-APC/FS</th>
<th>3M™ Crimplok™+ Connector 8700-APC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pre-polished ferrule</td>
<td>• Pre-polished ferrule</td>
<td>• No splice, gel or adhesive</td>
</tr>
<tr>
<td>• Low mean insertion loss of &lt;0.3 dB</td>
<td>• Low mean insertion loss of &lt;0.3 dB</td>
<td>• Fiber goes all the way through</td>
</tr>
<tr>
<td>• Reflection performance typ. -55 dB</td>
<td>• Reflection performance typ. -55 dB</td>
<td>• Optical performance from -40°F to 167°F</td>
</tr>
<tr>
<td>• For excellent side pull performance connectorize with 1.6 to 3.0 mm kink resistant cable.</td>
<td>• Bell-shaped boot helps keep fiber from kinking, even during side pull</td>
<td>• Reflection performance of &lt; -60 dB</td>
</tr>
<tr>
<td>• Provides on-site installation of 250 μm/900 μm singlemode fiber</td>
<td>• Provides on-site installation of 250 μm/900 μm singlemode fiber</td>
<td>• Provides on-site installation of 250 μm/900 μm singlemode fiber</td>
</tr>
<tr>
<td>• Low mean insertion loss of &lt; .2 dB</td>
<td>• Optical performance from -40°F to 167°F</td>
<td></td>
</tr>
</tbody>
</table>

Figure A
Gone are the days of lengthy procedures to secure the buffer/jacket and polish the end-face ferrule with size after size of lapping film in figure-eight motions in order to achieve just the right polish. Today, fiber terminations for in-building networks can be as easy as or easier than RJ-45 common copper cabling terminations. Previously, to obtain desired quality installations of fiber solutions, factory-terminated cable assemblies may have been the best way to go. 3M factory-made cable assemblies are pre-tested and delivered with factory quality systems and release specifications to attain consistent high quality performance. No doubt, some customers may still prefer this solution. Alternatively, if one did choose to terminate the fiber on site in the past, the only way to get the connector performance specifications desired in the field may have been to invest in expensive fusion splicing technology (with equipment prices ranging from $4,000 to $15,000 or more depending on the sophistication) as well as significant training commitment for personnel to operate the equipment.

However, today’s mechanical fiber connectors for on-site termination offer performance specifications to the same standards criteria of pre-terminated or fusion splice-on connectors.

3M mechanical fiber connectors enable the system integrator/installer a much lower investment in inventory, project management, and tooling and training for an overall total cost of ownership (TCO) benefit. Due to easy on-site fiber connectivity methods, the installer now has the same customizable installation capabilities as a copper-LAN and easy, quality termination methods for in-building fiber networks. (Pre-terminated fiber patch cords may still be used to connect the active equipment.)

Comparing alternative fiber network installation methods, new mechanical fiber connectivity solutions from 3M for easy on-site installation can yield quantifiable benefits over fuse-on connectors or pre-terminated factory assemblies, as shown in Figure B.

**Fiber Connectivity Technology Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Fuse-on Connectivity</th>
<th>Factory Assemblies</th>
<th>Mechanical Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tooling Investment</strong></td>
<td>High</td>
<td>None</td>
<td>Very Low</td>
</tr>
<tr>
<td><strong>Labor Cost/Skill Level</strong></td>
<td>High</td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Parts Costs</strong></td>
<td>Medium</td>
<td>High/Premium Price for Pre-terminated</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Inventory Costs</strong></td>
<td>Low/Connector Parts</td>
<td>High/Multiple Assembly Lengths</td>
<td>Low/Connector Parts</td>
</tr>
<tr>
<td><strong>Cable Management</strong></td>
<td>Custom Length</td>
<td>Extra Slack Storage</td>
<td>Custom Length</td>
</tr>
<tr>
<td><strong>Maintenance Costs</strong></td>
<td>High/labor, tooling</td>
<td>High/Time and Money if Any Part is Damaged</td>
<td>Very Low/100% Yield Possible</td>
</tr>
<tr>
<td><strong>Work Environment</strong></td>
<td>Affected by Humidity and Dust/ Power Required</td>
<td>Any Environment</td>
<td>Any Environment/ Non-powered</td>
</tr>
</tbody>
</table>

Figure B
An analysis of total installed costs between the three methods of fiber connectivity solutions for in-building networks shows that the mechanical connector solution offers a better up-front and installed cost than the fuse-on connector solution, and offers a similar up-front and a lower installed cost as the pre-terminated solution. (See Figure C & D).

**Total Up-front Expenditures**

![Figure C](image)

**Total Installed Cost Comparison per Drop Fiber Assembly**

![Figure D](image)

In comparing the installed cost of a single horizontal fiber to the work area, the Mechanical Connectors Solution #3 is determined to be the lowest total installed cost solution.

Another interesting comparison is between a singe-mode fiber-to-the-desktop POL installation (utilizing mechanical fiber termination methods) and a traditional copper-based LAN structured cabling solution. A passive
infrastructure cost analysis for a 1,000 gigabit Ethernet port configuration shows that a POL solution can cost up to 50 percent less in materials for the passive infrastructure (actual costs will depend on several factors, including material and configuration choices) compared to a traditional copper structured cabling installation. Labor expenditures related to the all-fiber premises cabling installation will be reduced significantly as well.

This is due to the following reasons:

- Singlemode fiber-to-the-desktop POL allows aggregated services over a single-fiber solution – gone are separate cables required for voice, video and data services, for example. Therefore, while typically two or more horizontal copper cables are needed to support multiple Ethernet connected devices in the work area, only a single fiber optic cable is needed for POL.

- Although fiber connectors are more costly than copper jacks, singlemode fiber cabling media itself is generally 20 to 50 percent less expensive than Category 6 or 6A copper structured cabling.

- The labor time required for the singlemode fiber-to-the-desktop installation and test certification of the installed fiber plant can be reduced significantly compared to the traditional copper structured cabling installation.

In addition to the near-term cost benefits mentioned above, the long-term benefits of investing in a fiber infrastructure should outweigh the traditional copper structured cabling solution. The installed singlemode fiber plant will generally outlast the copper infrastructure investment and can be used for generations of active electronics upgrades.

3M mechanical, manually installed splices and connectors offer the following features and benefits:

- Connector specifications of < 0.2 dB typical insertion loss and -60 dB reflectance.
- Splice specifications of < 0.07 dB typical insertion loss and better -65 dB reflectance.
- Splice installation time recorded at less than 30 seconds and connector installation recorded at less than three minutes (includes strip, cleave and clean fiber prep).
- A 100-percent yield is possible, minimizing costs in time and materials due to expensive defective scrap or yield issues.
- Non-powered, inexpensive plastic tooling provided free of charge with splices and connectors.
- Minimal training for installation and troubleshooting certification.
- One-piece splice/connector assembly (no more loose parts that can be lost).
Special Challenge of Below-the-ceiling Installations

Most POL projects may design and install the horizontal fiber cabling above the ceiling (located above the popular constructed tiled drop ceilings, for example) or below raised flooring, if present, there are some installations that may be particularly challenging to install cabling in these areas.

Some of the applications and opportunities for using a below-the-ceiling type of fiber distribution solution include:

- Retrofit buildings.
- Hard lid ceilings (no ceiling tiles, difficult to penetrate ceiling construction).
- Healthcare (costly and difficult process to “pop” a ceiling tile due to infection prevention procedures and “tenting” requirements).
- Older buildings with asbestos contamination.
- Buildings where access above the ceiling is costly and disruptive to the use of the building (e.g. hotels).
- Congested conduits or no access to above the ceiling or in-floor spaces.
- Historical buildings.
- High labor rate regions where fast and easy installation will substantially reduce the cost of installation.

For situations listed above, the methods used commonly to accommodate a below-the-ceiling application include plastic square latch molding, extra carpentry to cover the cable behind crown molding, and stapling the fiber to the wall. These methods require a labor-intensive, two-step installation process – hanging the raceway and then pulling the fiber through it – and the result is often visually unappealing. An easier, more aesthetically pleasing solution to the problem was required.

To solve this challenge, 3M developed the 3M Total Package. This group of new product innovations resolves the pain points faced by system integrators and contractors when trying to install fiber distribution in the horizontal. The 3M Total Package is anchored by the 3M™ One Pass Fiber Pathway and 3M™ One Pass Mini Fiber Pathway fiber distribution product.
The 3M One Pass Fiber Pathway and One Pass Mini Fiber Pathway offer the following benefits:

- Fast, easy, seamless installation.
- Low-profile design minimizes visual impact.
- Flexible – can be used in just about any building on a variety of surfaces.
- The total cost of install can be reduced by up to 35 percent for each floor compared to traditional methods.

The 3M™ One Pass Fiber Pathways are PVC (polyvinyl chloride) hollow ducts pre-loaded with 900 μm tight buffered, bend-insensitive fibers. They are backed with 3M proprietary adhesive with a removable liner. The hallway product contains six or 12 fibers and is available in 100, 200 or 300-foot reels. The 3M One Pass Mini Fiber Pathway for rooms and offices contains a single fiber and is available in 100 or 150-foot reels. The reel of fiber duct is applied with a rolling cart and a pole-top installation tool, which facilitates easy adhering to the wall as the installer walks along the wall. The roller tool is made of a lightweight pole, which threads the fiber pathways from the reel. It allows the installer to apply precisely the correct amount of pressure required to adhere the duct to the wall. Hence, the duct and fiber are installed at once in just one pass around the hallway or room perimeter.

Both pathways are available with one end pre-terminated to SC/APC-type individual fiber connectors. The hallway product is also available with an MPO multi-fiber (12-fiber) connector. The pathways enable quick plug-and-play capability at the fiber distribution enclosure where passive optical splitters or fiber interconnect may also be located for the POL solution. Figure E shows two people working together to install the One Pass Fiber Pathway. It literally takes only seconds to install the product along the length of a straight hallway. Once installed, the pathways can be painted to match a unique wall color if desired.
Once the 3M™ One Pass Fiber Pathway is installed in place along the hallway wall, a simple window-cut with a 3M tool is made to the duct wall to select a fiber inside for use. The small, cigar box-shaped 3M™ Surface-Mount Point-of-Entry Box is then placed over the window-cut, and the single fiber can be terminated within (using mechanical type connectors such as the 3M™ No Polish Connector or 3M™ Crimplok™+ SC/APC Connector). At this location, the installer can then route a single fiber from the duct directly through the wall and into an office/room on the other side.

In this office/room, a single fiber is routed and installed over to the work area location (close to where an ONT is placed) using the One Pass Mini Fiber Pathway. It can be thought of as a single fiber “tape.” It is small and non-obtrusive, and can be routed discretely to any ideal place on the wall where the 3M™ One Pass Mini Surface-Mount Wall Outlet is installed. The wall outlet provides the termination housing and slack storage for the last SC/APC adapter termination point, which then connects to an ONT with a 3M™ Fiber Patch Cord. To complete the end-to-end surface-mount installation, 3M accessories are available for the line which includes small plastic interior, exterior and planar corners to provide a professional customized installation appearance.

Where can the 3M One Pass Fiber Pathway products be utilized? Many types of venues can benefit from this unique fiber distribution offering for a below-the-ceiling solution including:

- Hotels
- High-rise buildings
- Higher education/ universities
- Healthcare facilities
- Manufacturing facilities

To learn more about 3M One Pass Fiber Pathways and the 3M Total Package, visit www.3M.com/OnePass.
Optimizing POL Topologies for Indoor Environments

When it comes to the indoor fiber network design and configuration of the passive infrastructure, system integrators, installers and end users/owners want a product that has been designed to best suit the application. Therefore, 3M has developed its Passive Optical LAN Solutions (POLS) with product components specifically designed to accommodate POL configurations for indoor environments. Backed by 50 years of telecommunications design expertise, 3M has created a POL portfolio that enables easy configuration, easy ordering and easy install as well as the highest performance specifications customers expect from 3M.

Since POL can accommodate a great deal of flexibility in the physical topology of the infrastructure (centralized fiber, telecom room or zone area configurations), 3M provides a wide array of easily configured products to optimize the installation and design. The port counts for distribution panels are specifically designed to accommodate optical splitter configurations, and the splitter modules and MPO modules are mix-and-match and compatible within various 3M fiber distribution enclosures (rack or wall-mount).

- The 3M POLS portfolio provides a complete end-to-end passive infrastructure solution, from the equipment room to the work areas and everywhere in between. Listed below are the major products included in the 3M POL portfolio:
  - 3M™ High Performance Fiber Cabling uses the latest in fiber optic technology to bring you bend radii specifications as low as 5 mm (ITU-T G.657.B.3) and plenty of options when it comes to cable construction, fiber count and performance.
  - 3M™ Passive Optical Splitters are designed to the highest industry standards (GR-1209/GR-1221) and optimally configured with port counts for POL and with pre-connectorized SC/APC connectors to enable easy interconnect or cross-connect configurations. Choose from rackmount pre-configured splitter shelves, mix-and-match splitter modules, or fiber enclosures with various configurations of pre-connectorized splitters already installed.
  - 3M™ MPO Fanout Modules are pre-connectorized multi-fiber modules with SC/APC breakout ports to make installations between risers or for zone solutions quick and easy. Use with 3M™ Pre-terminated Multi-fiber Trunk cable assemblies.
  - 3M™ Fiber Connectors. With millions sold worldwide, 3M mechanical fiber connectors like the No Polish Connector and the Crimplok+ Connector make fiber terminations even easier than those for copper structured cabling, saving you money on time and materials and reducing your total cost of ownership.
• 3M™ One Pass Fiber Pathways install quickly and discreetly below the ceiling and around the perimeter of walls so that fiber can be run almost anywhere in a variety of buildings.

• 3M zone area products optimize the passive configuration to reduce horizontal cabling cost and ease future maintenance (moves, adds and changes) costs for open office environments. The 3M zone area configurations can accommodate splitter distribution of up to 128 ports in 3RU.

Visit 3M.com/POLS for more information on the 3M POLS portfolio.

Protecting Your Future-ready Infrastructure Investment

Customers who are choosing to adopt POL are doing so for the many benefits and cost savings it provides, including the major advantage of owning a fiber cabling infrastructure that will be able to accommodate multiple generations of made, customers will want to rely on a cabling vendor that can stand behind the product solutions and stand the test of time.

With more than 100 years in business, you can count on 3M to protect your organization’s investment in the passive optical network infrastructure from end-to-end over its lifetime. 3M has created a 25-year warranty program designed to provide a long-term guarantee for the optical performance specifications of an installation completed by a certified installer. The program is offered at no added charge to the end user.

For more information about the 3M 25-year system warranty or for information on how to become a 3M certified integration professional/certified installer, please visit www.3M.com/Telecom.

*Graphs are for illustration purposes only. Actual costs will vary and will depend on several factors, including actual costs of materials and parts inventory, training, fiber termination kits and/or fusion splice equipment, install time and scrap/waste incurred.
Important Notice

All statements, technical information, and recommendations related to 3M’s products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product which are not contained in 3M’s current publications, or any contrary statements contained on your purchase order shall have no force or effect unless expressly agreed upon, in writing, by an authorized officer of 3M.

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