# Maintaining Proper Polarity for Modular Pre-terminated Fiber Systems

Rudolph A. Montgelas
Fiber Optic Senior Product Manager
Ortronics/Legrand

November, 2006

**Introduction**:

Optical communication systems provide a myriad of solutions for the many issues facing a communications network designer today. Most notably, the reduced cable diameters and increased connection densities offered by fiber links have proven to be extremely valuable in space-constrained installations, such as data centers, large enterprise equipment rooms, central offices, sub-floor spaces and cable pathways. Here, fiber optic cables significantly reduce congestion making it easier to organize equipment cable runs, as well as improving vital cooling airflow for servers and supporting equipment.

Because a typical fiber optic link requires two fibers for full duplex (two-way) communications, it is very important to ensure that the optical transceivers are connected properly at each end. Specifically, the optical light source (laser or LED) of the transmitter at one end of the link must be connected to the corresponding photo detector of the receiver at the other end. The task of ensuring that the transmitter is properly connected to the receiver is easier when the link involves only one fiber. However when the link contains two or more fibers, the situation is more complex. Bidirectional transmission, multiple connections and splices along the link further complicate the system design.

**Modular Fiber System Advantages:**

Modular pre-terminated fiber optic cabling systems are particularly useful in data center applications due to the high connection densities, superior optical performance of a factory terminated connection and the simplicity of a modular installation. These systems provide many advantages:

- ➢ Reduced
  - ✓ Labor costs
  - ✓ Congestion in cable pathways and spaces
  - ✓ On-site installation time
  - ✓ Security risk

- ➢ Increased
  - ✓ Optical port density
  - ✓ Component modularity
  - ✓ Optical performance and reliability
  - ✓ System interoperability

Pre-terminated fiber MTP®[1] /MPO optical cassettes and loose-tube or fiber ribbon backbone cables are the heart of a modular fiber system. The cassettes and cables typically support groups of full duplex fiber connections. The challenge for the network system designer becomes one of assuring the proper polarity of these array connections from end-to-end.

This white paper describes the methods defined in the ratified TIA/EIA (Telecommunications Industry Association/Electronic Industries Association) standard to assure correct polarity using MPO multi-fiber array connectors, cables and cassettes. Some advantages and disadvantages of the approved methods will also be highlighted.

**The Standards:**

The TR42.8 Technical Engineering Subcommittee of the TIA/EIA has developed a standard that addresses the polarity issues associated with multi-fiber array connections. This document is TIA-568-B.1-7 (hereafter referred to as the TIA standard). The document is available through the Internet for purchase as a reference document[2].

[1] MTP is a registered trademark of US Conec

[2] See the global.IHS.com website to purchase TIE/EIA documents

Currently, a new release of the TIA-568 Commercial Building Cabling Standard is under development as the TIA-568-C series of standards.  The fiber systems section of this series will be TIA-568-C.1 and it will include information on array system polarity along with a description of MPO array cables, duplex patch cords and array transitions.

**Connectivity Methods:**

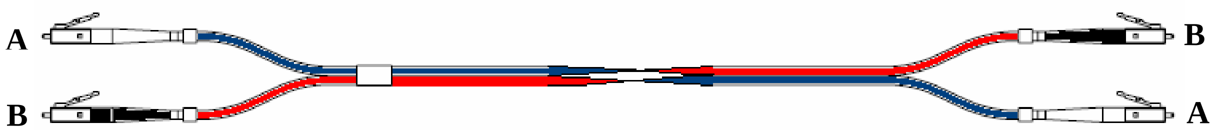
Two types of fiber links are outlined in the TIA standard: serial duplex pair connections and parallel optical connections.  This paper discusses the impact of polarity as it pertains to serial duplex pair connections. Parallel optical systems are not addressed in this document as they are not yet commonly deployed.

The TIA standard currently lists three connectivity methods for wiring point-to-point fiber links using array connections.  The three connectivity methods are designed to assure correct transceiver polarity.  These three methods assume one is working with a set of common patch cord, array cable and transition (fan-out harness) components.  Proper connectivity of these system components is crucial for correct link operation.  The TIA standard does not promote one method as a better choice than another.  However, the standard requires consistency to ensure correct operation.  In other words, once a particular connectivity method is selected, it should be used throughout the installation.  The selected cabling scheme should also adhere to one of the methods in the standard to maintain system compatibility and interoperability.  Selecting a proprietary connection method falling outside the definitions in the standard could result in a potential sole sourcing situation for the contractor and network designer.

**Fiber Patch cords:**

As previously mentioned, the TIA standard defines a set of common components that are used to complete an end-to-end fiber duplex pair connection.  At one end of the cable plant, patch cords connect terminal equipment to patch panels.  At the other end of the cable plant, patch cords connect workstation outlets to the end-user's equipment.

Two types of duplex fiber patch cords are defined in the TIA standard: A-to-A type shown in Figure 1 and A-to-B type shown in Figure 2.  They are commonly constructed from a figure-8 cross-section, duplex "zipcord" cable like the one shown in Figure 3.  Patch cords made with individual single fiber connectors at each end allow the flexibility for connections to be "swapped" when a polarity reversal is required. They also eliminate the need for a facility to stock both A-to-B and A-to-A type patch cords.  Patch cords manufactured with molded duplex connectors at each end do not provide this flexibility.




**A-to-A Patch Cord**
**Figure 1**


**A-to-B Patch Cord**
**Figure 2**

NetClear 50µm Laser Optimized LC Patch cord
Figure 3

**Connector Keying:**

Fiber optic connectors are typically "keyed" to maintain a repeatable position when they are mated to other connectors or to laser or LED receptacles mounted in active equipment. This is to assure consistent optical transmission performance. Multi-fiber connectors also have keys to maintain proper polarity. In the case of angle polished connectors, the keys also serve to assure that the factory polished angles, at the ferrule tip, will align properly when the connectors are mated together.

The keys on a multi-fiber array connector, such as an MPO, fit into keyed adapters for proper polarity, as well as for repeatable optical performance and angle polished inter-mateability.

**Modular fiber cassettes:**

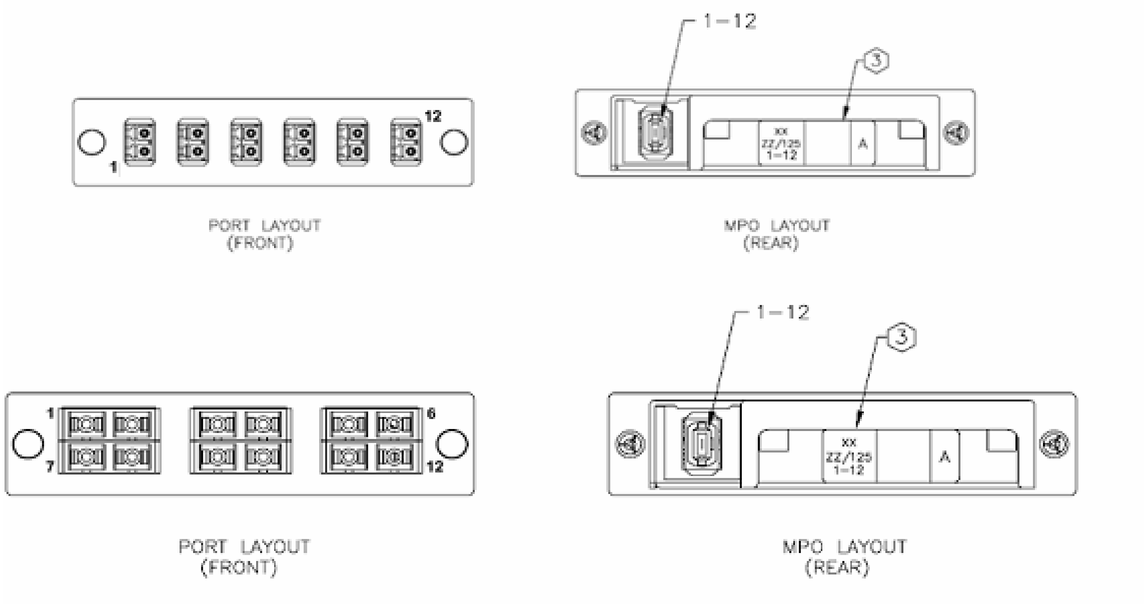
Modular fiber cassettes are enclosed units that contain 12 or 24–fiber factory terminated fan-outs inside. These cassettes serve to "transition" small diameter ribbon cables terminated with a MPO connector to the more common LC or SC interface used on the transceiver terminal equipment. The fan-outs typically incorporate SC, LC, ST-style or MT-RJ connectors plugged into adapters on the front side of the cassette and a MPO connector plugged into a MPO adapter mounted at the rear of the cassette. One or more MPO fan-out assemblies may be installed inside the cassette to connect up to two 12-fiber ribbon cables for a total of 24 fibers. Alignment pins are pre-installed in the MPO connector located inside the cassette. These pins precisely align the mating fibers in the MPO connectors at either end of the array cables that plug into the cassettes as illustrated in Figure 4.

Modular cassettes shown connected with a MPO array cable
Figure 4

The transition inside a cassette, the connector keying for the cassette and the corresponding MPO array cables are completely defined for all three connectivity methods listed in the TIA standard. A common transition, factory installed inside a cassette, is used for all of the three methods. The adapter mounted at the rear of a cassette defines it as either a **Method-A** or **Method-B** type cassette. The only difference between a Method-A and Method-B cassette is the orientation of the internal MPO connector with respect to the mating MPO array cable connector.

Method-A cassettes make a "key up" to "key down" connection between the internal MPO connector and the MPO array cable connector. Method-B cassettes make a "key up" to "key up" connection. **Note that a Method-B cassette will not allow single-mode angle polish mated pair connections due to the fact that the angles of the mating connectors are not complementary.** This prevents a Method-B cassette or adapter from being used in single-mode applications requiring low return losses, a significant limitation with Connectivity Method-B. The important thing to note is that Ortronics/Legrand cassettes are configured in accordance with the TIA Connectivity Method-A.

The front and rear adapter panels of Ortronics/Legrand cassettes are shown in Figure 5 below. The fiber positions are numbered on the front adapter ports, from 1 through 12. The corresponding MPO fiber positions are also indicated by a label located at the rear of the cassette. The fiber at position 1 is located next to a white mark on the side of the MPO adapter.

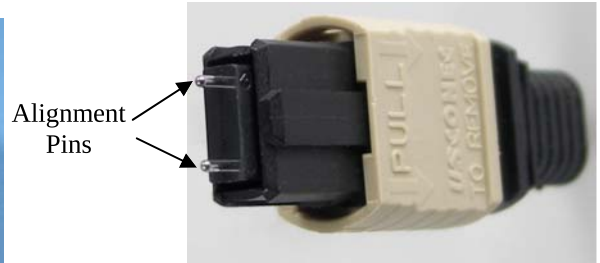



Ortronics/Legrand 12-fiber LC and SC Cassettes
Figure 5

**MPO Array Cables:**

Modular fiber cassettes are connected together with MPO-to-MPO ribbon backbone cables. The connectors on these cables do not contain alignment pins, but they do have mating alignment holes. The alignment pins are factory installed in the MPO fan-out connectors installed inside the cassette as shown in Figure 6.

MPO-to-MPO ribbon backbone
cable with dust caps

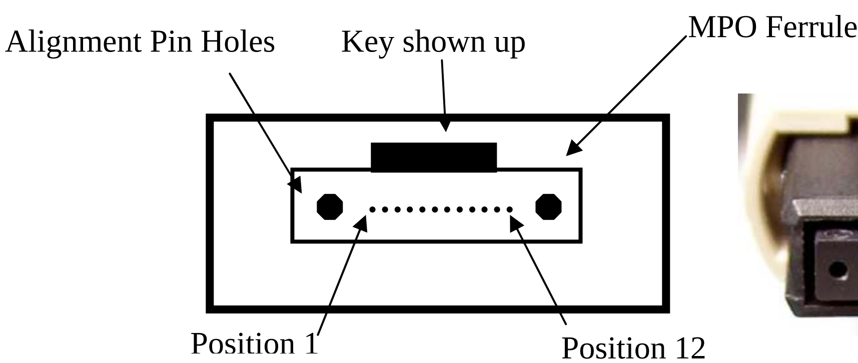


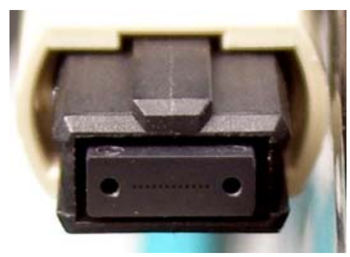

MPO connector with pins installed

MPO adapter shown with connector
installed inside the cassette

Figure 6

The fiber number is read 1 through 12 as viewed from the end of the MPO connector with the key facing upwards as shown in Figure 7.

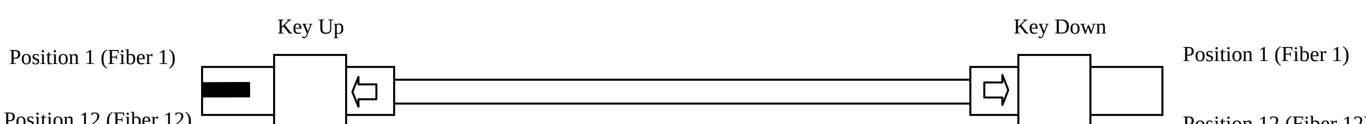


MPO plug fiber positions shown looking at the end of the ferrule with the key up

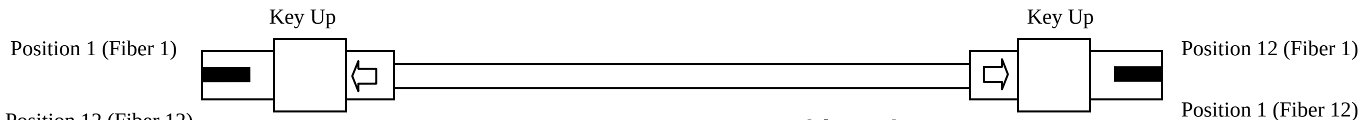
Figure 7

There are three different 12-fiber MPO-to-MPO ribbon backbone cables defined in the TIA standard. The three different cables: Types A, B and C are used for the three different connectivity Methods A, B and C respectively.



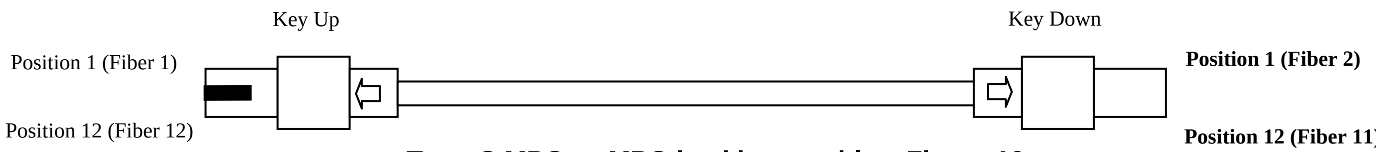

**Type-A MPO-to-MPO array cable – Figure 8**

For the Type-A array cable, the opposing connections at each end of the cable have the same fiber positions except that one end has the key oriented facing up and the other end has the key oriented facing down as shown in Figure 8.




**Type-B MPO-to-MPO array cable – Figure 9**

The Type-B array cable shown in Figure 9 has opposing connectors with both keys oriented facing up, however the fiber positions are reversed at each end i.e. the fiber at position 1 at one end is connected to position 12 in the connector at the opposing end.




**Type-C MPO-to-MPO backbone cable – Figure 10**

The Type-C array cable is shown in Figure 10, with the key facing up at one end and the key facing down at the other end, looks like the Type-A array cable. However, the cable is designed such that adjacent *pairs of fibers* are crossed from one end to the other. In this case, the fiber at position 1 on one end of the cable is shifted to position 2 at the other end of the cable. The fiber at position 2 at one end is shifted to position 1 at the opposite end etc.

**TIA Connectivity Methods**:

The patch cords, cassettes (transitions) and array cables previously described are used in specific combinations to form end-to-end full duplex fiber links. Each component of the total fiber cabling system is unique; underscoring the importance of assuring that the correct component is selected and used in the proper sequence.

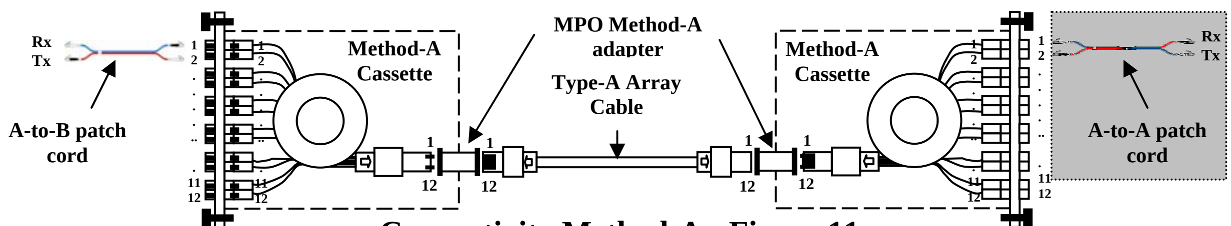
To illustrate how the components are used together, Table 1 shows the combinations of components necessary to assure correct transceiver polarity for the three connectivity methods defined in the TIA standard. It is important to note, that no matter which Method of the TIA standard is selected, there must be a pair-wise flipping (A-to-B polarity swap) that takes place at some point in the link. If the pair-wise flipping does not occur in the cassette (transition) then the pair-wise flipping must occur in the duplex patch cord or the MPO-to-MPO array cables and/or adapters. Table 1 illustrates where pair-wise flipping occurs in the link.

Figures 11 through 13 provide an illustration of the information shown in Table 1. The numbers shown next to the adapters on the outside of the cassette and the MPO connectors are fiber *port* designations. The numbers shown in **bold** next to the adapters on the inside of the cassette are *fiber number* designations. For further details and diagrams showing the approved Methods, refer to the TIA standard.

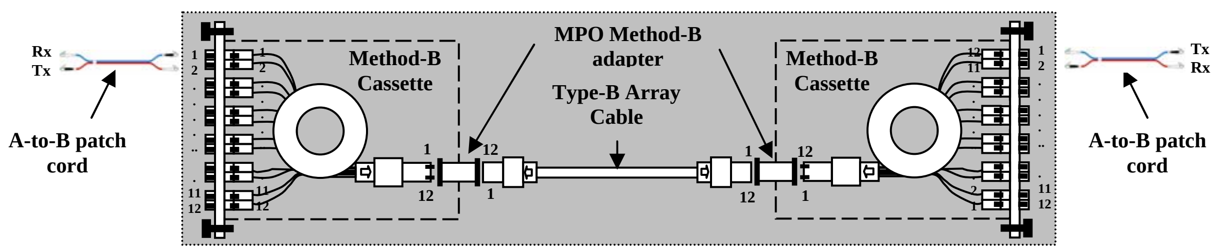
Table 1 - Components required for TIA Connectivity Methods

| TIA Connectivity Method | Patch cord type at one end of the link | MTP/MPO adapter type at the back of cassette | Array cable-to-cassette keying | Array Cable Type | MTP/MPO adapter type at the back of cassette | Array cable-to-cassette keying | Patch cord type at the other end of the link |
|---|---|---|---|---|---|---|---|
| **Method-A (Figure 11)** | A-to-B | A | Key Up to Key Down | A | A | Key Up to Key Down | ***A-to-A*** |
| **Method-B (Figure 12)** | A-to-B | ***B*** | ***Key Down to Key Down*** | ***B*** | ***B*** | ***Key Up to Key Up*** | A-to-B |
| **Method-C (Figure 13)** | A-to-B | A | Key Up to Key Down | ***C*** | A | Key Up to Key Down | A-to-B |

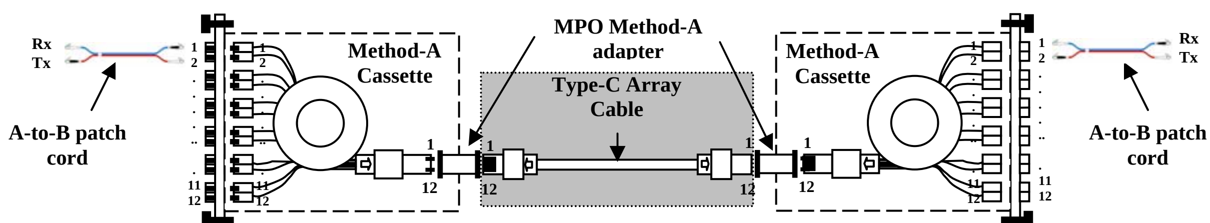
Note: Pair-wise flipping (A-to-B swap) occurs in the shaded component boxes marked in ***bold/Italics***




**Connectivity Method-A - Figure 11**




**Connectivity Method-B - Figure 12**




**Connectivity Method-C - Figure 13**

## Conclusions:

Modular cassette-based cabling technology offers many advantages facilitating high performance, rapid and error-free installation and reliable robust operation. The best way to maintain correct optical polarity in these systems is to select a standards-based approach and to adhere to it throughout an installation. Three Connectivity Methods are defined in the TIA/EIA 568-B.1-7 standard presenting the guidelines for maintaining polarity using array connections.

It is in the best interest of the installer and end-user to select modular optical fiber cassette based solutions that adhere to TIA standards. Proprietary non-standards based solutions will not assure interoperability. In addition, those solutions may not be compatible with commercially-based components designed to meet the TIA standards. Selecting modular fiber systems that comply with TIA standards can help to prevent costly troubleshooting and rework of the installed fiber cable plant. In addition, fiber network installers can be assured of a readily available product supply from multiple stocking supply sources with acceptable delivery lead times.

It is also very important for the installer, contractor, system architect and the end user to understand the implications of connecting a particular component into a full duplex fiber link. Incorrect connections that violate the proper polarity will result in a link failure and possibly damage to critical optoelectronic components. Normal network operation could be significantly delayed as a result. That is why it is important to know which standardized Connectivity Method has been specified for a particular modular fiber installation.

References: TIA/EIA 568-B.1 Standard Addendum 7