

Fiber Systems

Best Practices for Ensuring Polarity of Array-Based Fiber Optic Channels

White Paper



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Introduction

Data centers are the central location for data interchange and are found in enterprises, government offices, schools, universities, hospitals, and other networked server farms. The ease of turning nearly any location into an information interchange hub has been enabled by the development of array-based fiber optic cabling systems. Ribbon fiber cables, array-based fiber connectors, and packaged breakout assemblies (i.e., cassettes) provide modular small form factor connectivity and enable fast, reliable interconnection of fiber optic links in high-density data center environments.

Once the decision has been made to deploy array-based fiber connectivity, care must be taken to ensure the integrity of connections between the transmitting optical light source and the receiving photo detector. The matching of the transmit signal (Tx) to the receive equipment (Rx) at both ends of the fiber optic link is referred to as polarity. The objective of polarity is simple: provide transmit-to-receive connections across the entire fiber optic system in a consistent, standards-based manner.

Ensuring polarity of array-based systems requires careful planning. The end-user is best served by network designs that follow a single method that maintains polarity now over serial fiber channels and can migrate to parallel optics in support of very high data rates (40-100+ Gb/s) in the future. This paper describes recently published industry guidelines that address polarity across array-based fiber systems, and discusses the advantages and drawbacks of the three TIA/EIA recommended methods.

System Polarity and the Array-Based Fiber Channel

In any installation, it is important to ensure that the optical transmitter at one end is connected to the optical receiver at the other. Optical fiber links typically require two fibers to make a complete circuit. Optical transceivers have a transmit side and receive side, and typically employ a duplex fiber connector as the interface.

For traditional cabling systems using single fiber connectors, such as LC or SC, maintaining polarity is as simple as ensuring that the A side of one connector pair matches to the B side of the other connector pair in any patch cord or permanent link (Figure 1). This procedure is well documented in the TIA/EIA-568-B.1 *Commercial Building Telecommunications Cabling Standard*. Note “B” is the transmit signal and “A” is the receive signal. Maintaining polarity requires that the “B” transmit signal connects to the “A” receive signal.

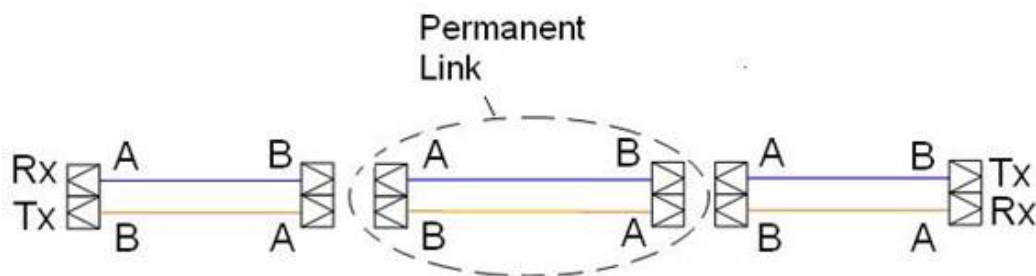


Figure 1. Example of Proper Polarity Over Single-Fiber Connectors

Responding to the growing adoption of fiber cabling based on array connectivity, TIA/EIA developed and published an addendum to the standards governing cabling systems. TIA/EIA-568-B.1 Addendum 7, *Guidelines for Maintaining Polarity Using Array Connectors*, outlines three recommended methods for assuring correct transmit-to-receive polarity over serial duplex fiber circuits using ribbon cables and array connectors. Since it is a guideline, the document does not promote one method as being the best. It also states that other methods may be available to establish correct polarity throughout installation and during subsequent maintenance, upgrades, and additions.

Ribbon cables and array connectors have introduced new complexities into the fiber installation process. To understand polarity and how to maintain it, the role and function of every part of the array-based fiber channel must be understood (see Figure 2), as each component of the channel has an impact on how polarity is maintained system-wide.

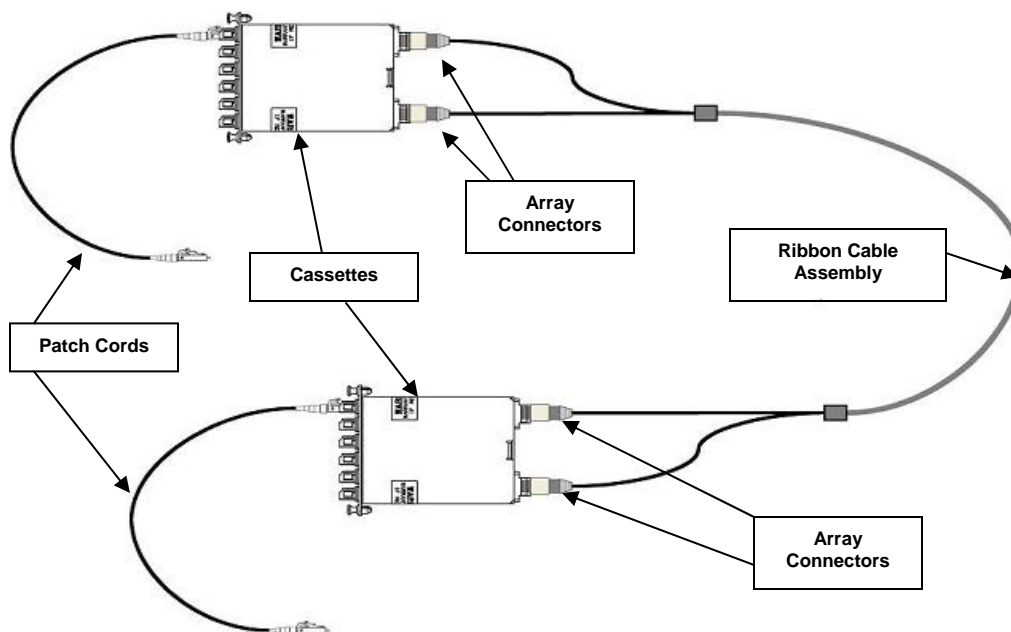
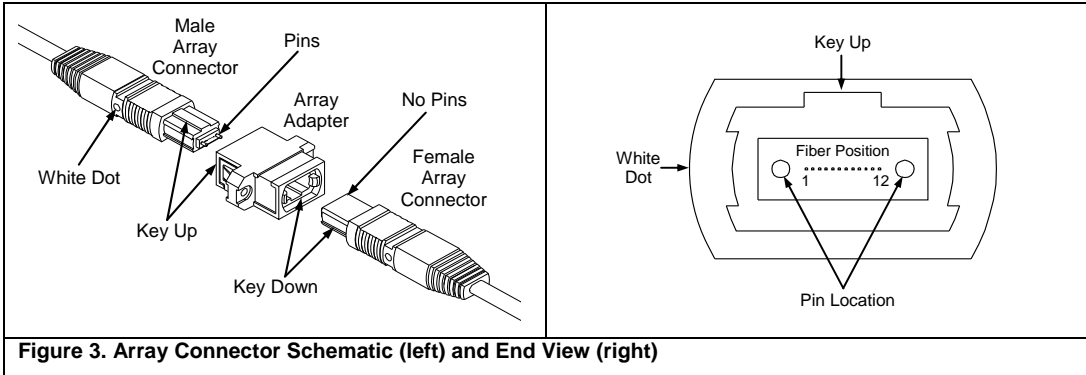


Figure 2. Example Array-Based Fiber Channel

Array Connectors. Special connectors have been developed for ribbon fiber cables that provide multi-fiber capability and high density in a unitary connector design (see Figure 3). These array connectors can house anywhere from 6 to 72 fibers, with 12-fiber arrays being the most common. The connectors have a pin-and-socket design to precisely align mating fibers. Cassettes and hydra cable assemblies are typically manufactured with a male (pinned) connector, and ribbon cable assemblies typically deploy a female (unpinned) connector.

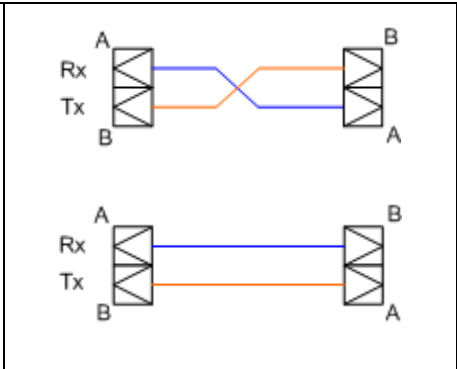
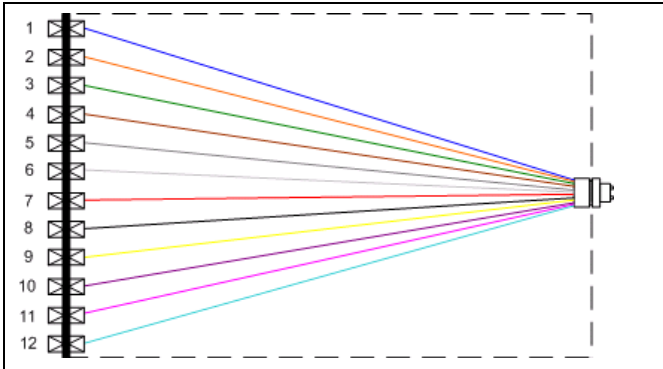
Most important for maintaining polarity, array connectors are keyed to ensure that proper endface orientation occurs. The “key” is a ridge on one surface of the array connector housing to ensure that the connector can only be joined in one orientation against the opposing connector. When looking at the endface of the connector, the key is in the “up” position and Fiber 1 is the far left fiber on the same side as the white dot on the connector (see Figure 3).



Cassettes. A cassette is a packaged, pre-terminated cabling assembly that transitions from small form factor ribbon-style fiber cables and array connectors to traditional single-fiber connectors (see Figure 4). The primary function of cassettes is to provide quick, scalable plug-in network deployment of up to 12 fiber ports (24 fibers) in a single assembly to support high-density applications. Array adapters at the rear of cassettes are also keyed to ensure proper orientation with keyed array connectors.

Patch Cords. Duplex patch cords used to complete serial duplex pair connections are available in two types (see Figure 5), depending on which polarity technique is used. The “A-to-B” patch cord connects position A on one end of the cord to position B on the other end; this is termed “straight-through” wiring. The “A-to-A” patch cord connects position A on one end of the cord to position A on the other end, and is known as “crossover” wiring.

Ribbon Cable Assemblies. Factory-assembled modular fiber cassettes are connected to one another with connectorized ribbon cables. Each 12-fiber ribbon (or “trunking”) cable translates into six 2-fiber serial optical circuits that require polarity management. Figure 6 shows the three fiber-and-connector trunk combinations described in TIA/EIA-568-B.1 Addendum 7 for polarity management when using fiber array cables; the chart indicates the transformation of fiber position along each circuit.



Understanding Array-Based Polarity

The basic strategy for designing polarity into an array-based serial duplex fiber optic system is to think of each ribbon cable as a series of two-fiber optical circuits that require polarity management. At some point along each circuit the fiber in odd-numbered array positions (i.e., the “transmit” position) must cross its duplex counterpart and end in an even-numbered position (i.e., the “receive” position) to achieve a Tx/Rx and Rx/Tx circuit rather than a non-functional Tx/Tx and Rx/Rx circuit.

This point of crossover is known as a “pair-wise flip” or, less commonly, as an “A-to-B polarity swap”. Regardless of the term used, the flip must occur at some point in every serial duplex link. Polarity methods differ, in essence, by the location of the pair-wise flip: Addendum 7 recommends that the flip be built into the duplex patch cords (Method A), array cables (Method C), or through a combination of cassette and trunk fiber transformation (Method B).

In array-based channels, the keys on connectors and adapters are used to establish the orientation of the fiber arrays in one connector relative to the array in the mating connector. The fiber numbering within a ribbon cable is also defined with respect to the key: fibers are numbered from left to right with the key facing up, as shown in Figure 6; this figure also indicates in matrix form the numerical alignment of a 12-fiber array under Addendum 7 Methods A, B, and C.

The following sections further define TIA/EIA polarity management methods, showing proper orientation of keys and the ribbon cable, cassette, and patch cords transformations necessary for each method.

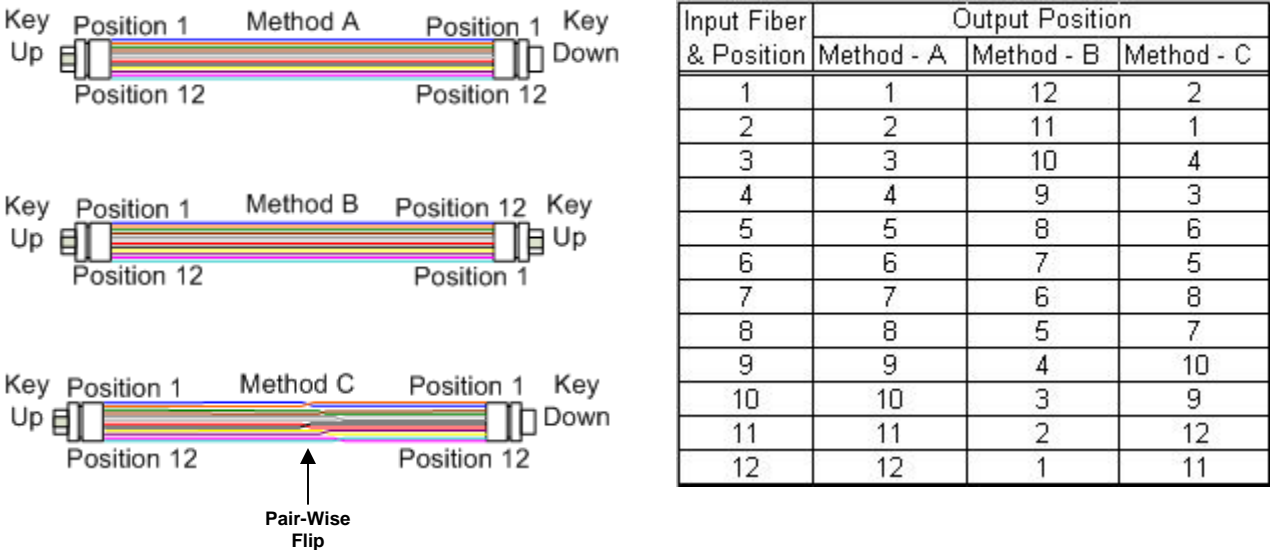


Figure 6. Array Connector Cables and Input-to-Output Fiber Mapping by Method

Method A

Method A employs Key Up to Key Down Adapters to link straight-through Key Up to Key Down ribbon cables to fiber cassettes (see Figure 7). This method maintains registration of Fiber 1 throughout the permanent link: Fiber 1 in the near-end cassette mates to Fiber 1 in the ribbon cable assembly, which mates to Fiber 1 in the remote cassette. The fiber circuit is completed by utilizing one flipped patch cord, either at the beginning or end of the permanent link, to move Fiber 1 into the Fiber 2 position at the face of the remote cassette to ensure proper Tx-Rx orientation.

The method requires two Method A cassettes, a Method A ribbon cable, an "A-to-A" patch cord at one end of the connection, and an "A-to-B" patch cord at the other end. *PANDUIT* recommends that the end user introduce the pair-wise flip consistently at the beginning or end of the channel for easier management. Patch cords with duplexing clips that hold connectors in place may be used rather than permanent molded assemblies. These clips open at the sides to permit installers to easily reverse or "swap" the order of connectors, so that the "A" cable becomes "B" when necessary to maintain polarity.

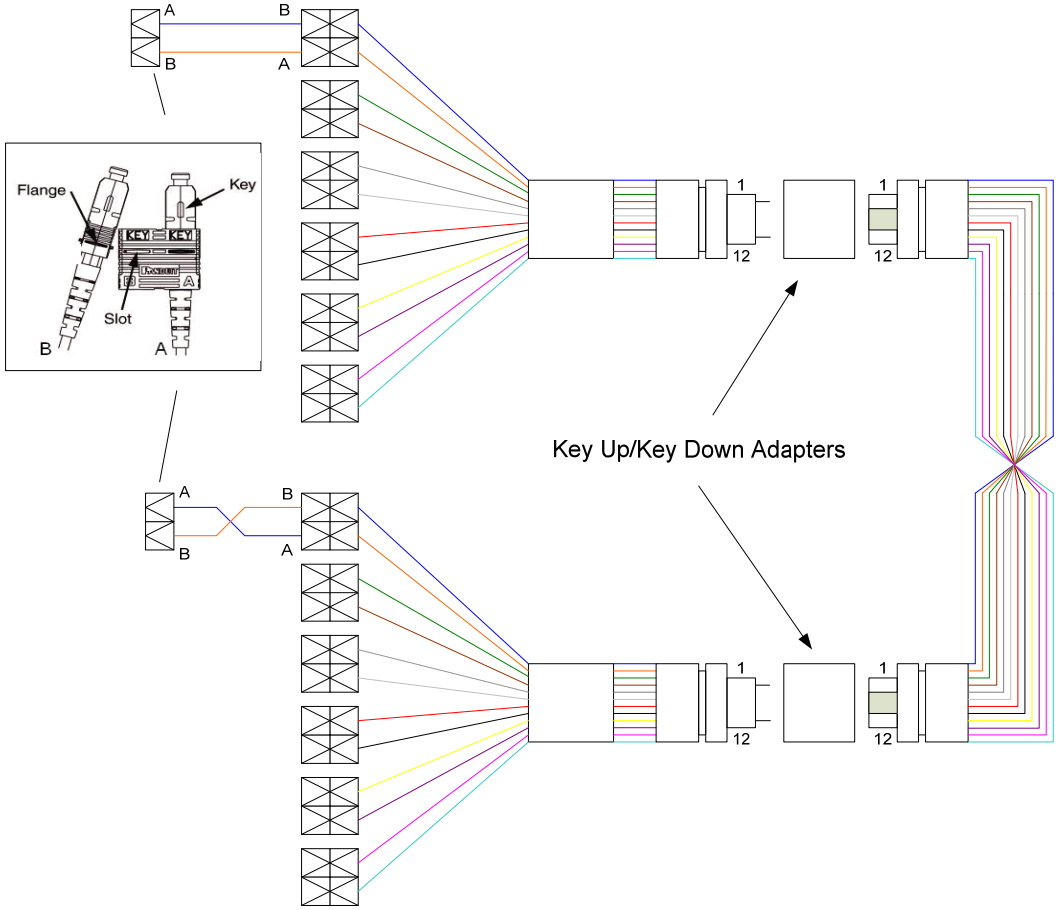


Figure 7. Polarity using Method A (inset shows polarity flip using patch cords with a duplexing clip)

Method B

Method B employs Key Up to Key Up Adapters to link straight-through Key Up to Key Up ribbon cables to fiber cassettes (see Figure 8). Method B cassettes are identical to Method A cassettes except that they use Key Up to Key Up adapters. The fiber channel is completed by flipping the second cassette (i.e., rotating it 180 degrees) and re-numbering it, and then utilizing straight “A-to-B” patch cords at the beginning and end of the link.

This type of mating results in an inversion of the entire numbered fiber array to achieve polarity, meaning that Fiber 1 (Tx) is mated with Fiber 12 (Rx), Fiber 2 (Rx) is mated with Fiber 11 (Tx), and so on. Therefore this particular method requires more in-depth planning than others to properly identify and manage the circuit inversions. Further, Method B does not support singlemode fiber deployments with standards-compliant connector endfaces because the angles of the mating connectors are not complimentary. However, an advantage of this method is that only one type of patch cord is used so patch cords do not need to be flipped.

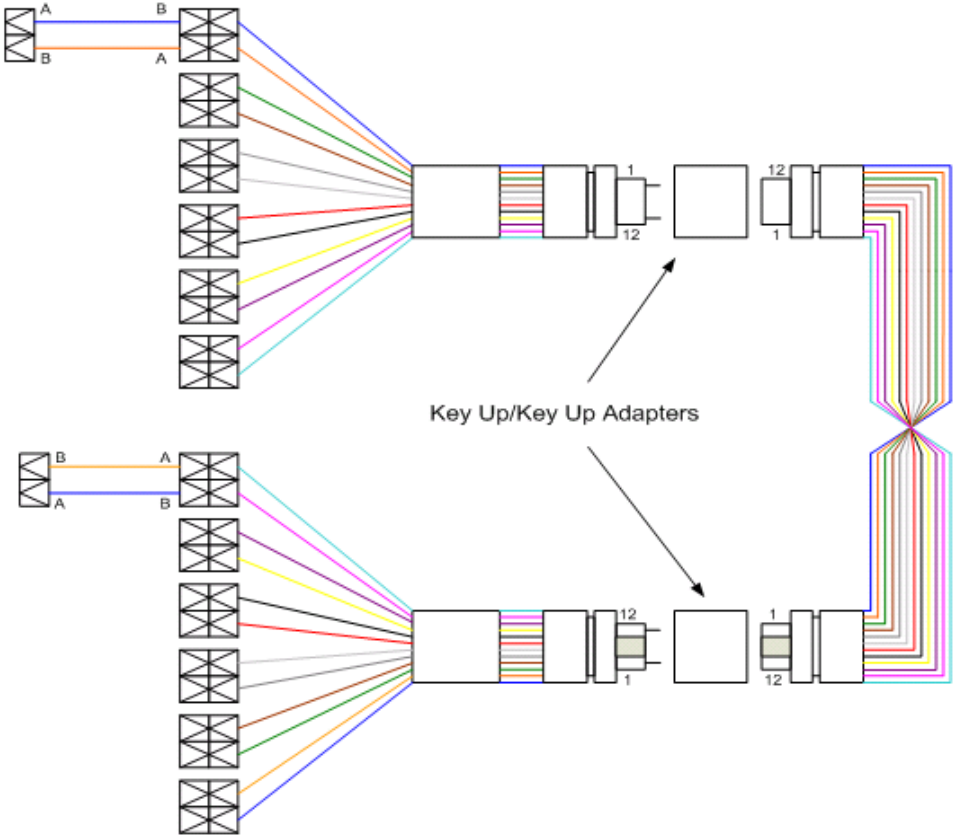


Figure 8. Polarity using Method B

Method C

Method C employs Key Up to Key Down Adapters to link a special Key Up to Key Down ribbon assembly to Method A cassettes (see Figure 9). In this method, polarity is achieved by using a ribbon cable that has the pair-wise flip built in to individual fiber pairs, and the fiber channel is completed by utilizing straight “A-to-B” patch cords at the beginning and end of the link. In essence, the only difference between this method and Method A is that the pair-wise flip occurs in the array cable itself rather than at the patch cords, so that odd-numbered Tx fibers leaving the near-end cassette are in even-numbered Rx positions when they arrive at the remote cassette.

Channels built with this method using one array cable may take the same time to deploy as channels built using other polarity methods. However, in longer channels that connect multiple array cords in sequence, the data center manager must keep close track of the number of array cables used in order to preserve the pair-wise flip, which results in more complex channel designs and longer maintenance times.

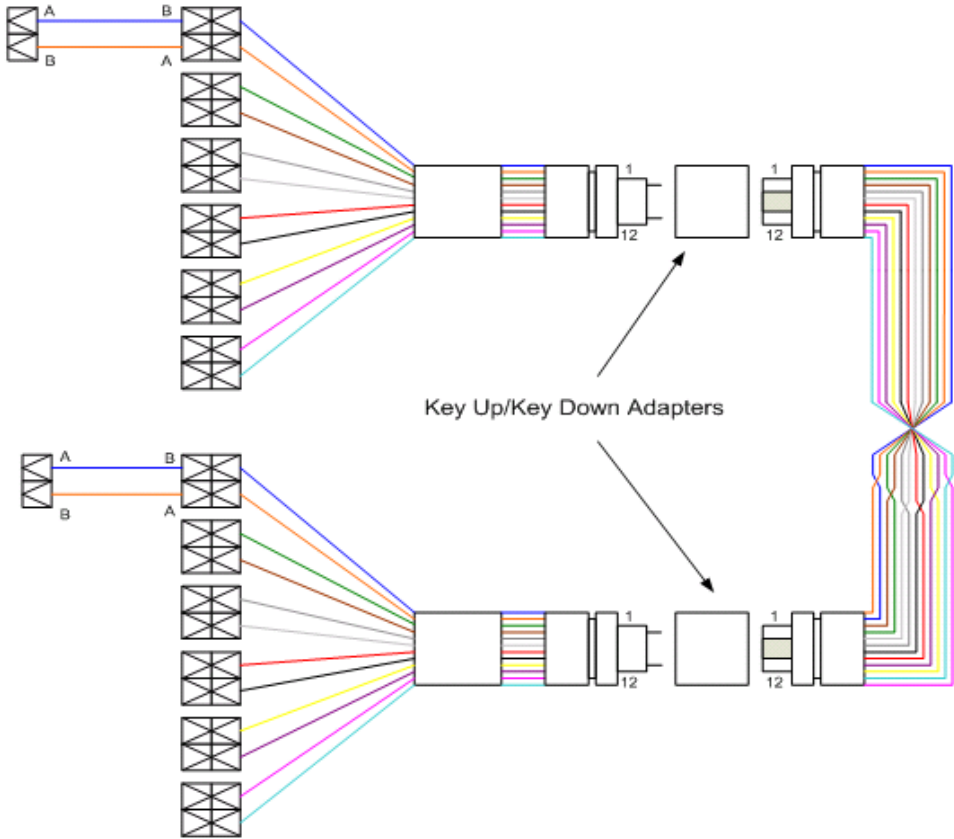


Figure 9. Polarity using Method C

Which Method?

In complex, high-density fiber installations, the advantages of array connectors can be lost if large-scale confusion and loss of local control result. Also, intermixing the components of these methods may result in incorrect polarity. So, with three guideline-recognized methods from which to choose, how should network stakeholders select the best method for ensuring polarity across their array-based fiber installation?

Table 1 summarizes the advantages and disadvantages of the three methods. The most critical consideration is to select one method and stick with it. As stated in TIA/EIA-568-B.1 Addendum 7: “The primary consideration faced by data center operators when choosing a method is ensuring that the same method is used throughout all of an operator’s installations.” Therefore, the method choice should be maintained consistently throughout the installation, and must be clearly communicated to all stakeholders.

PANDUIT endorses Method A as the most flexible and reliable method for the following reasons:

- Customers expect systems based on standards. Standards incorporate best practices and incorporate paths to upgrade as technology advances, so system investments are better protected from risk of obsolescence.
- Customers need flexibility. Method A provides the most flexible options for current system designs and includes an easy path to migrate to higher data rates via parallel optics.
- Customers should have the widest choice of installation and component vendors, rather than relying on vendors with proprietary solutions and technologists with specialist skills. Also, proprietary methods not based on TIA/EIA guidelines will neither assure future interoperability, nor availability of future product inventory at a time of greatest need.

Table 1. Analysis of TIA/EIA-568-B.1 Addendum 7 Fiber Polarity Methods

Method	Advantages	Disadvantages
A	<ul style="list-style-type: none"> • One cassette type, easy to produce and purchase • Multiple sources for components • Singlemode and multimode • Ribbon cables can be linked (need male/female connector) • Compatible with many legacy systems • Industry standard • Standard provides migration path to parallel optics 	<ul style="list-style-type: none"> • Requires pre-configured “A-to-A” patch cords, or field configuration of same
B	<ul style="list-style-type: none"> • Single source for components • “A-to-B” patch cord only • Industry standard • Standard provides migration path to parallel optics 	<ul style="list-style-type: none"> • Remote cassette must be flipped and re-labeled • Identification and maintenance of cassettes are different on each end • Multimode only • Not compatible with legacy systems • Ribbon cables can only be linked using less available (Key Up to Key Up) adapters (need male/female cord) • Fewest vendors
C	<ul style="list-style-type: none"> • One cassette type, easy to produce and purchase • Singlemode and multimode • Industry standard • “A-to-B” patch cord only 	<ul style="list-style-type: none"> • Less reliable than Method A • Specialized ribbon cable assembly • Does not support parallel optics • Not compatible with legacy systems • Less vendor support than Method A • Difficult to extend link

Conclusion

Ensuring fiber polarity over an array-based system requires a significant number of decisions early in the design process. The challenge for the system designer is ensuring that polarity of connections is observed from end to end, particularly in systems that contain many interconnect points. Constant attention is required to ensure that polarity decisions are adhered to by installers and other network stakeholders.

TIA/EIA-568-B.1 Addendum 7 provides guidance on three polarity management methods, so it is important to specify one method and implement it consistently in order to manage the risk associated with costly mistakes and re-work over the life of the installation. Method A is endorsed by *PANDUIT* because it provides the simplest deployment, works for singlemode and multimode fiber channels, supports network extensions, and is easily extendable to emerging parallel optics systems.

Array-based fiber optic cabling systems such as the *PANDUIT*[®] *QUICKNET*[™] Fiber Optic Cabling System enable faster implementation of scalable, high-density data center cabling deployments. *QUICKNET*[™] pre-terminated cassettes and cable assemblies improve on the time required for installation of fiber connections by reducing the number of laborious strand-to-strand connections, making deployment of high-speed network-cabled devices in data centers easier, faster, and more cost-effective.

When coupled with a consistent policy to ensure polarity across the hundreds or thousands of permanent links in today's data centers, pre-terminated solutions allow quick and scalable deployment. Data center designers can take advantage of array-based fiber optic systems while ensuring the widest choice in installation vendors, component manufacturers, and technology.

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