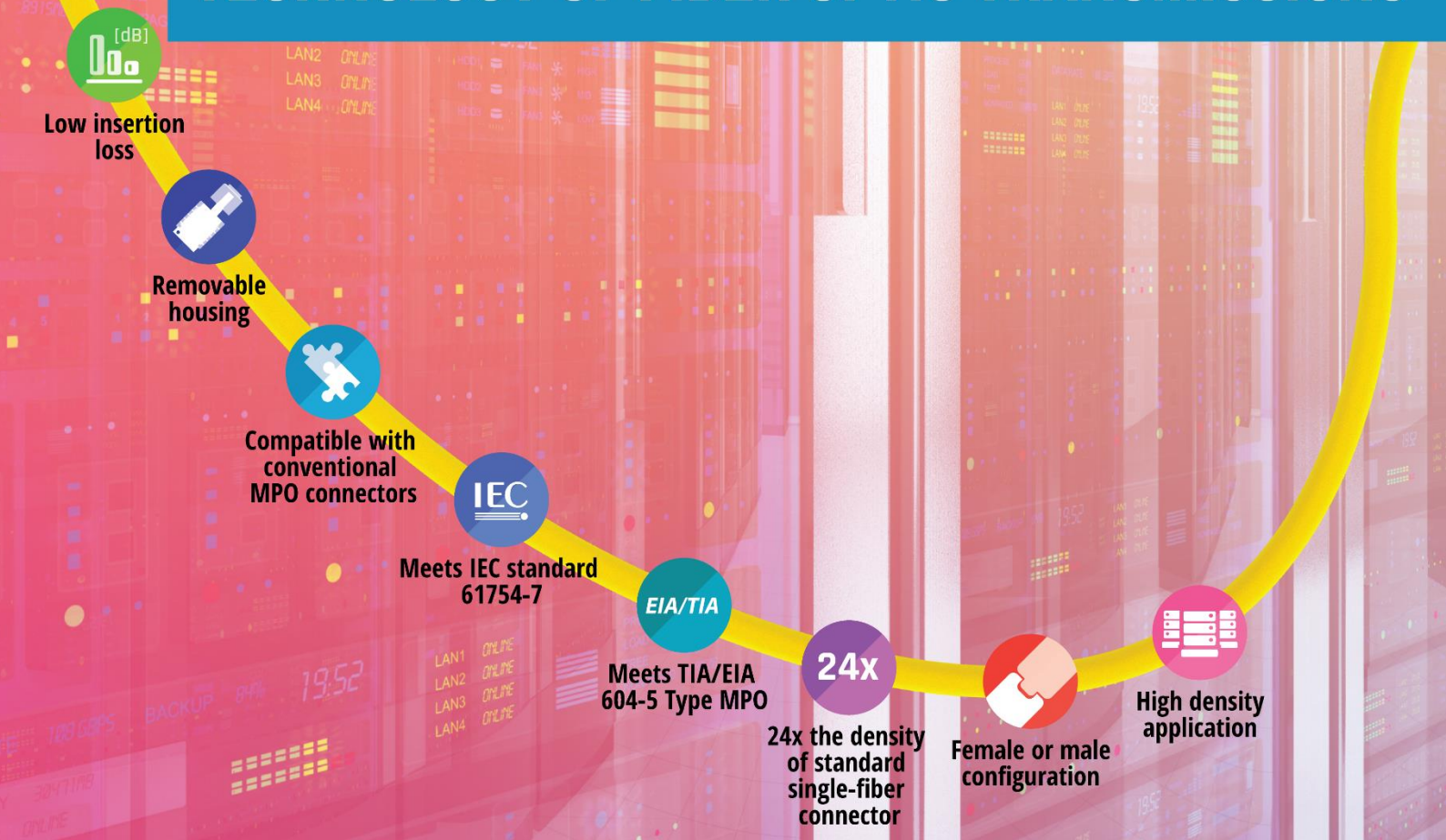
WHITE PAPER

MPO/MTP®

MPO/MTP MULTI-CHANNEL TECHNOLOGY OF FIBER OPTIC TRANSMISSIONS



MPO/MTP multi-channel technology of fiber optic transmissions

Contents

Target:	*Closer look at the issues related to the use of MPO/MTP multi-fiber connectors especially in the context of fiber optic multimode cables. Discussion and summary of the network topology using the above mentioned connectors.*
Applications:	*Data center/server rooms*
Technology:	*Multi-fiber optic connections*
Author:	*Mariusz Solski*
Published	*September 2016*

MPO/MTP multi-channel technology of fiber optic transmissions

1. What is MPO/MTP® connector?

World class MPO connector (Multi fiber Push On or Multi Path Push On) is a standarized connector in accordance with IEC 61754-7 and TIA/EIA 604-5 norms. It is a multi-fiber connector with up to 72 fibers which occupies the same amount of space as SC or LC duplex connectors. At present, however, the ones with 12 and 24 fibers are commonly used. MTP connectors are a subset of MPO ones and therefore, they don't only meet the necessary norms and requirements for MPO, but exceed them. MTP® connector is manufactured by US Conec, which is a world-leader in manufacturing of this type of connectors. FIBRAIN portfolio offers exclusively MPO connectors to produce its own product range. For the purpose of this article and facilitated reading I will use the MPO name. Nevertheless, please bear in mind that in FIBRAIN we use and deal with MPO/MTP® connectors.

1.1. Applications for MPO connectors

An unquestionable advantage of this type of connectors is their compact size and at the same time high capacity of data transmission. These features make the connector a perfect solution as it matches the present trend of increasing throughput using minimal space. The places for which already mentioned characteristics play an important role are data-processing centers (CPD or Data Center). Development of these connectors is closely related to development of 40G and 100G applications, which are more popular in CPD structures. Such transmissions are performed through various media both copper and fiber optic, including multimode and singlemode. The key element, which doesn't change, is the matter of maximum distances. The table below presents the basic info about the possibilities of the given 40G and 100G applications.

Protocol	Transmission Medium	Channel multiplication	Max distance
40GBASE-KR4	PCB (Trunk)	4x10Gb/s	N/D
100GBase-KR4	PCB (Trunk)	4x10Gb/s	N/D
40GBASE-CR4	Twinax	4x10Gb/s	7m
100GBASE-CR10	Twinax	10x10Gb/s	7m
100GBASE-CR4	Twinax	4x25Gb/s	7m
40GBase-T	4 twisted pair cable cat. 8		30m
40GBASE-SR4	MM OM3	4x10Gb/s	100m
	MM OM4		150m
100GBASE-SR10	MM OM3	10x10Gb/s	100m
	MM OM4		150m
100GBASE-SR4	MM OM3	4x25Gb/s	100m
	MM OM4		150m
40GBASE-LR4	SM	4x10 Gb/s DWDM	10km
40GBASE-ER4	SM	4x10 Gb/s DWDM	40km
100GBASE-LR4	SM	4x25 Gb/s DWDM	10km
100GBASE-ER4	SM	4x25 Gb/s DWDM	40km

Data transmission application for 40G and 100G

The above-mentioned fiber optic applications are designed to multiply the transmission channels of 10G or 25G. In case of singlemode optical fibers, WDM technology is applied, which means that the signals are transmitted at different wavelengths, thus still to transmit the data only a single pair of fibers (Tx / Rx) is used. In the case of multimode, the situation is different. Since we can't use the WDM channels, thus the multiplication takes place through the separate fibers, which means the necessity of transmitting through the multiplied amount of fibers. Taking as example 40GBASE-SR4 and 100GBASE-SR4 we need to use 8 fibers (after 2 fibers per 10G or 25G), while in case of 40GBASE-SR10 it will be already up to 20 fibers (see a table above). The outcome is obvious, MPO connectors need to be used. Undoubtedly, this connection may be also used for a singlemode fiber connector, but in this case it will be possible mainly due to its compact size in relation to the amount of used fibers. If density doesn't play an important role at a given location, standard connector can be used, for example LC duplex in 40G or 100G transmissions.

2. Rules of parallel transmission

Construction of the MPO connector includes 12 rows of fibers that support data transmission. Connectors are available in the following options: 12,24,36 and 72, which means that within one connector there are respectively 1,2,3 and 6 rows of fibers. Another important thing to remember is that the MPO connectors have a "gender" – in other words are available in male or female versions, which means that they are equipped on both sides with two centering pins or corresponding centering. These elements are extremely important for achieving appropriate transmission parameters, because they are responsible for centralizing relation to each individual rows of fibers.

NEW

MTP® Trunk cables

- 12 or 24 fibers in one connector
- Designed for SM and MM application
- Small diameter of ruggedized round cables
  - 12F → Ø 3.0 mm cable diameter
  - 24F → Ø 3.5 mm cable diameter
- Provide quick connection for up to 24 optical fiber
- Color coded housings available to differentiate fiber type
- Removable housing for quick gender change
- Female and male configuration available
- Polarization version A, B or C
- Alignment achieved with high precision quide pins with elliptical shape to minimize ferrule debris
- Low insertion loss
- 100% optical measurements
- 100% interferometric measurements
- Ideal solution for high fiber count, multi-row applictions in array trunking, breakout modules

HIGH DENSITY APPLICATION

Available colors of connector housing

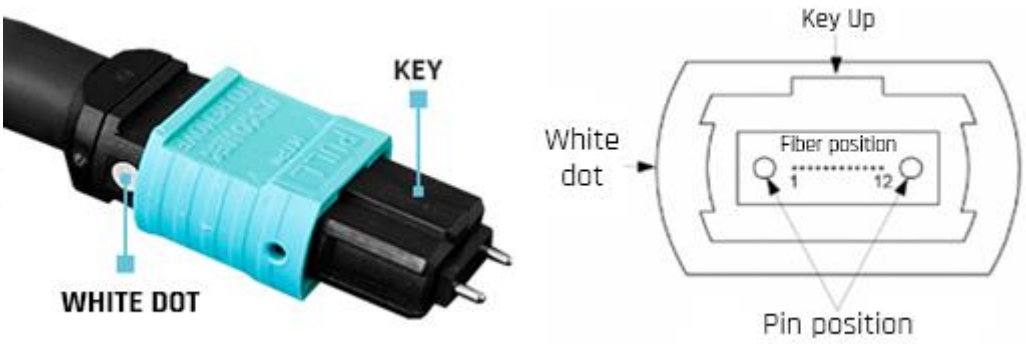
MTP® Fanouts – Direct Split

- This solution combine MTP® multi-fiber connectors with standard, single-fiber optic connectors
- Fanouting is made directly in the MTP® connector – without any additional furcation point
- Designed for SM and MM application, typically used in a 3U modular patch panel
- Wide range of single-fiber optic connectors, for example: LC, SC, E2000 with PC or APC polishing type
- Provide compact, cost effective solution for multi-fiber which require the MTP® hardware to be integrated with single-fiber connector assemblies
- Female or male configuration of MTP® connectors
- Low insertion loss
- Good value for money, the best price-quality ratio
- Different type of optical fiber available (G.652D, G.657, OM1, OM2, OM3 or OM4)

It is worth remembering that two female connectors can't be matched with each other (which would lead either to a very large attenuation or even lack of connection) or which is even worse two male connectors, as this in turn, may damage the connector.

Male/ females MPO connectors

Each connector is equipped with a protrusion- called a key, to which individual fibers are positioned. If we look at the connector from the front side and the key will up, then fiber no. 1 will be located on the left side while the fiber no. 12 on the right. It is essential to ensure proper polarity. Please bear in mind that the transmission which we can operate is full duplex, thus we transmit on one fiber, and receive on another one. Thus, the key factor is the connection in which Tx1 fiber on one side, is connected with the Rx1 fiber on the other (and vice versa), then Tx2 with Rx2 up to Tx12 and Rx12.

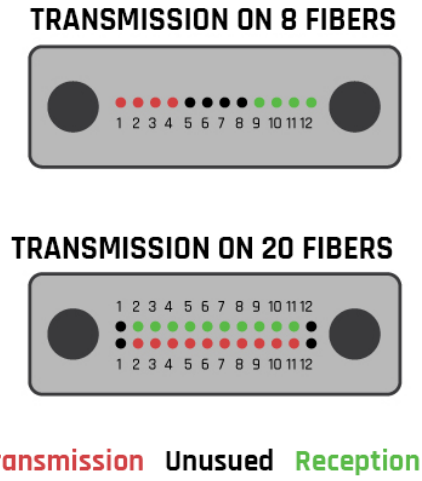


The position of key and fibers in MPO connector

If we go back to Table 1, we observe that the number of fibers depends mostly on the application. Thus, for example 100G applications, which are 100GBASE-SR10 and 100GBASE-SR4, differ in this respect diametrically, even though they provide the same bit rate. The first one will need approx. 20 fibers, while the other 8.

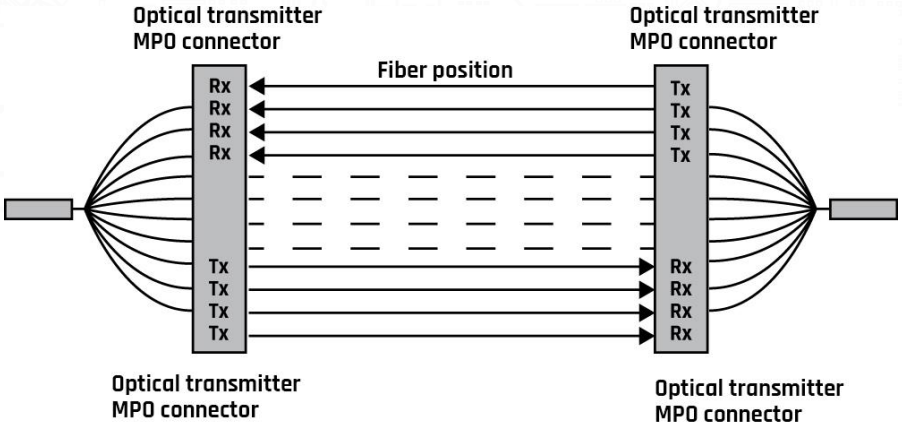
Consequently, if we want to support 100GBASE-SR10, then we will need to use a single cable terminated with 24-fiber MPO connector or alternatively 2 cables of 12 fibers each. For 100GBASE-SR4 just like for 40GBASE-SR4 one cable terminated with 12 MPO fibers will be enough. This is related to a bit rate of the multiplied channels – 10G or 25G per channel.

If the transmission part of the protocol needs 8 or 20 fibers and MPO connectors have 12 or 24 fiber, is easy to see that we will have some excess of fiber in relation to the needs (4 extra fibers). So which fibers will be used and which won't? This is shown in the scheme below::

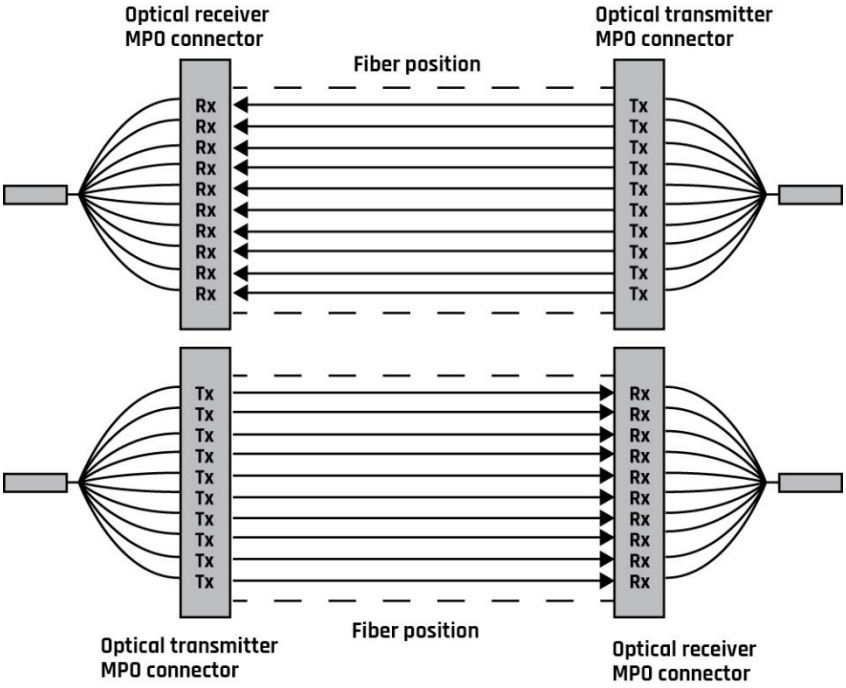


Well, if we support applications of 8-fiber (e.g. 40GBASE-SR4) we use 4 extreme fibers on each side while keeping in mind that 4 of fibers on the left (red) support the transmission and 4 on the right (green) reception. Also, in this case, 4 internal fibers remain unused.

For applications of 20-fiber (e.g. 100GBASE-SR10) we use ten internal fibers from each row. Whereas to transmit, we use 10 lower fibers and to receive 10 upper fibers. In this case, there are also 4 fibers that remain unused , but this time there are outer fibers - 2 on each side.



8-fiber parallel transmission



12-fiber parallel transmission

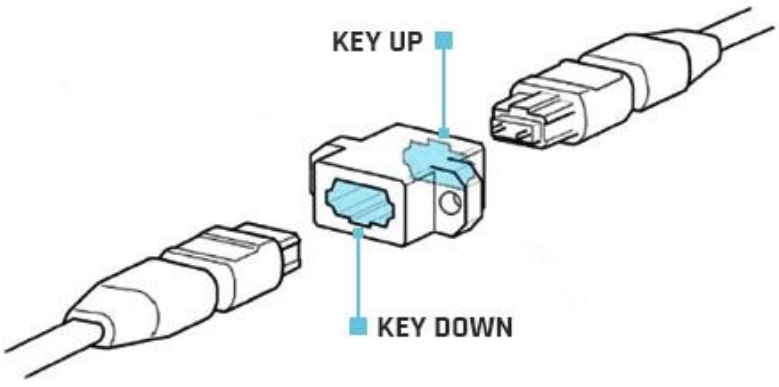
3. MPO components

Another aspect which I would like to discuss are the components. A proper selection of components will be a key to success that is obtaining uninterrupted transmission.

3.1. MPO adapters

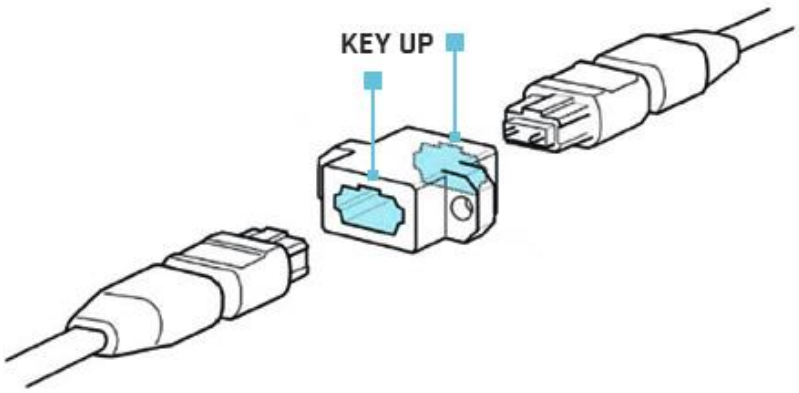
At the beginning I will describe adapters. I used the plural form on purpose, as in fact, we have two types of adapters which are type A of adapters, in other words „key up – key down". Both types are used to connect 2 MPO connectors, but in a different way:
Type A of adapters guarantee connecting of type A of connectors reversed to each other by 180 degrees. Consequently, fibers are connected 1:1 as shows the table below.

Connector 1	Connector 2
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12



Type B Adapter guarantees which are in a mirror image relative to each other. In this example the fibers will be connected to each other in the opposite direction to the original, as shows the table below::

Connector 1	Connector 2
1	12
2	11
3	10
4	9
5	8
6	7
7	6
8	5
9	4
10	3
11	2
12	1



3.2. MPO Pre-connectorized MPO cables

Certainly, both uplink and connector cables are another element. As MPO connectors can't be terminated manually, they need to be measured in advanced and be factory-made, then the installers get it. Generally, we can distinguish a few types of cables due to its structure and function. I would like to focus on three or even four, which play a significant role when obtaining proper polarity.

3.2.1. Uplink/patchcords

The difference between them is linked to the installation site. Uplinks are stretched between fiber optic module, whereas patchcords are used to connect the active device or the next network segment. In terms of the construction, these cables don't differ from each other, which of course doesn't mean that in every case these are the same cables. This is because they are characterized by a number of parameters, which we need to be aware of, and these are:

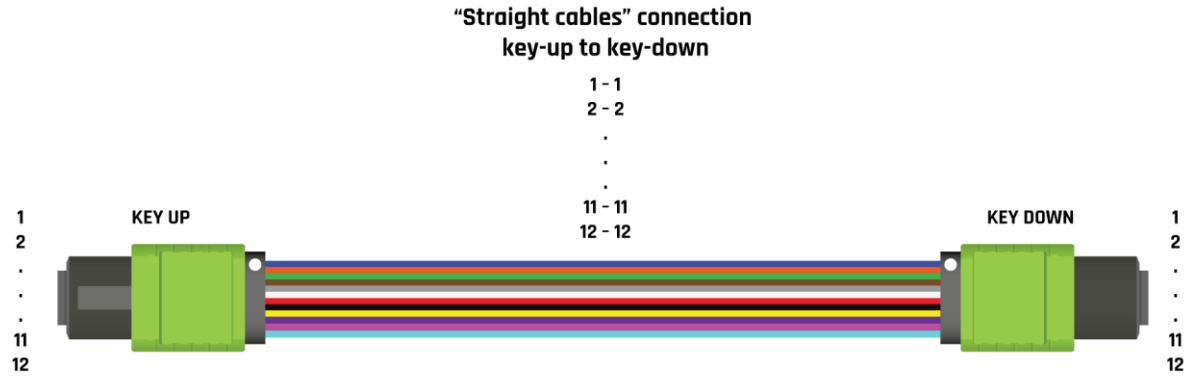
A) Type of a connector – male or female
B) Cable length
C) Fiber category (OM3, OM4, OS2)
D) Type

I would like to discuss the last point – type. We can distinguish 3 types of MPO cables:

- Type A
- Type B
- Type C

a) Type A (Key up - key down)

If we put a given cable on a table, so as the one side we will have key-up and on the other key-down. Then, the connections will be as below:

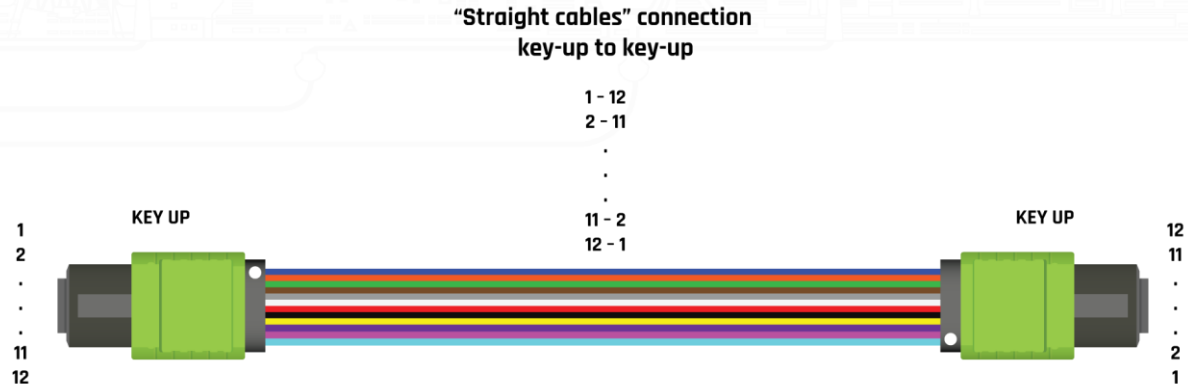


Furcation of a Type A cable

Similarly, as in case of adapters, also here we have connection 1:1

b) Type B (Key up - key up)

Now two connectors are facing one another with key up. The connections are shown below:

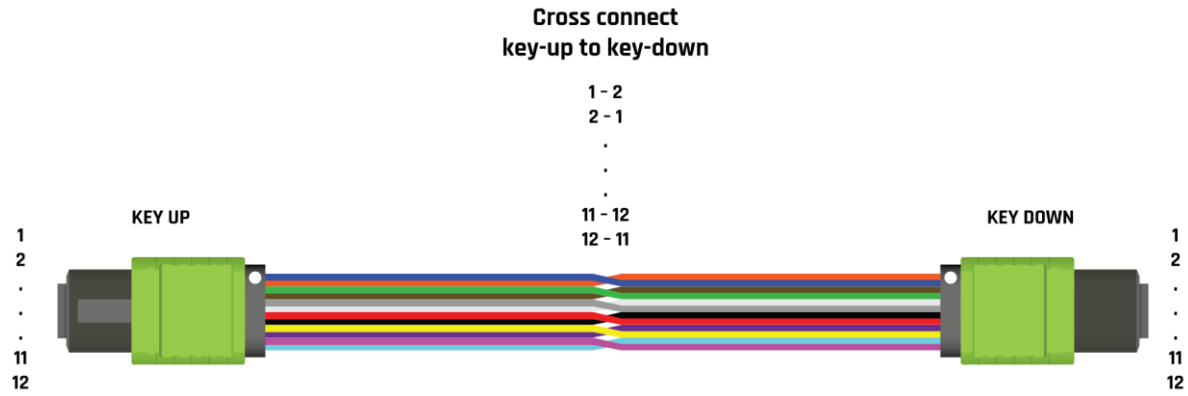


Furcation of a Type B cable

Again, by analogy with adapters we connect the given fibers „diagonally".

c) Type C

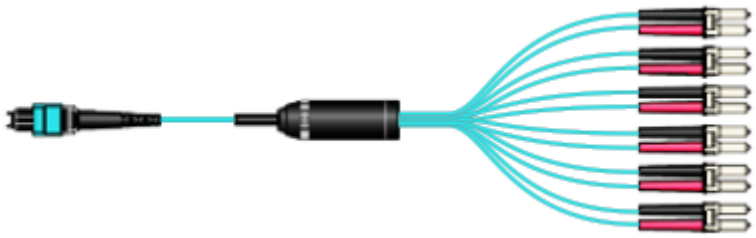
It' the first „cross" furcation as before the change was only in the order. Now we change the order in the given pairs (1 for 2, 2 for 1, 3 for 4, 4 for 3 etc.). Connectors are placed Key up – Key down.



Furcation of a Type C cable

3.2.2. Kable typu „harness"

These cables have on one side MPO connector while on the other, corresponding to the quantity of fibers in a cable, a number of standard S.C. or LC connectors.



Harness cable

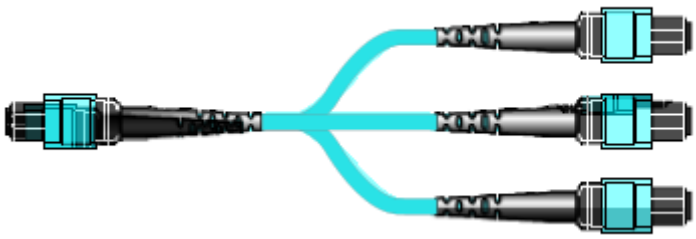
The trunk is a typical application for such cable. In a situation when you want to move the signal coming e.g. from 12 LC duplex ports rather than performing it through a separate pre-connectorized link or welded to a separate fiber optic module (occupying at least 1U in a rack), we can use harness cable on a single MPO adapter, and then MPO uplink. Certainly, such solution will save a lot of space in cabinets and cable ducts. Another way to use this type of cable is the reverse action. If we have an active device as MPO port, we can transmit the signal via a standard solution e.g. LC duplex. We need to connect the port in a switch with a standard panel, and a standard installation cable. This time we won't save place, but in turn, we can save ports in the router or switch.

3.2.3. Type „Y”

Cables Y-type play supporting role in relation to applications that we remember use 8 or 20 fibers. If today the user has in his CPD for example 40G links then he will need cabling based on the MPO 12 fiber. What will the user need to do if tomorrow he purchases 100G(100GBase-SR10) Network Interface Card and replaces them with the previous one? Of course, he will also need to replace the cabling that applied earlier for 40G (MPO 12 fiber) and pull through new cables terminated with MPO 24 - fiber. But it isn't cost-effective solution. Alternatively, he can use cables that have been already used and install additional cables necessary for having the connection. In the next step, he will have to join them only with the use of Y cable (see figure below). Cable Y at one end, two MPO connectors 12 and the fiber connector 1 MPO fiber 24 on the other. Now the user can enjoy the transmission of 100G through two links MTP with 12 fibers each.

Type „Y” Cable

At this point it is worth mentioning about less popular option of the cable Y that is 3 to 1. We bear in mind that applications don't use all the fibers in the MPO connector. At our disposal we have 12 or 24 fibers within the connector ,while we use 8 or 20 fibers each time, so all together there are 4 unused fibers. Why should we use them? If you have e.g. 3 ports 40G and each of them needs 8 fibers, they can all be transmitted over a single cable ended two rows, 24-fiber MPO connector. Now the economical use of our resources is undoubtedly very clear.



Triple branched cable

3.2.4. Duplex connector cables

These are standard patchcords, that seemingly have nothing to do with MPO connectors that are discussed here. Nothing could be further from the truth. This element will be always present in the duplex transmission, in other words, in all applications where the user will use the MPO cassettes. On one side of the cassette we have MPO, while on the other, e.g. 6 or 12 LC duplex. A proper selection of duplex connector cables will determine appropriate polarity that is Tx will be transmitted on the proper Rx or it won't.

These cables can be straight (A to B) or crossed (A to A) as the below schemes clearly show.

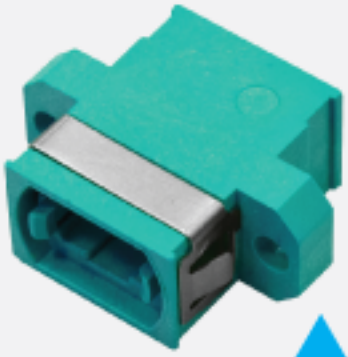
Straight cable A to B

Crossed cable A to A

3.3. MPO fiber optic cassettes

As for the definition of this element there is nothing overly complicated. Simplifying, it is a box representing a specific demarcation point between network segments. On the back it is equipped with one or two MPO connectors, while on the front of it will often have a proper number of LC connectors in the form of LC duplex or LC quad. The most important issue is to verify in what way the LC connectors at the front are connected to the connector / MPO connectors mounted at the back. This leads to the issue of polarity and possible scenarios of connections.

MTP® Fiber Optic Adapters



ONE-PIECE TECHNOLOGY

- Adapters provide quick connection of MTP®/MPO connectors – connection integrity is provided by adapter latches which are locked into place on the connectors by a spring loaded sliding mechanism
- One-piece design of adapter body – increased side loading performance
- Available in black, aqua, beige, violet magenta and green
- Flange or flangeless configuration
- Opposed key orientation - TIA 604-5D (on request aligned key orientation in gray housing color)
- Standard MTP footprint type (on request MTP adapters in SC footprint type available)

HIGH DENSITY APPLICATION

Applications

- Data Center Systems
- Array trunk cabling
- Dense interconnect for data center and telecommunication system
- Chassis-to-chassis connections
- Structured cabling per TIA-568-C

Features

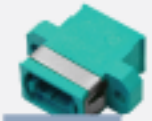
- Low insertion loss
- Meets IEC Standard 61754-7
- Meets TIA/EIA 604-5 Type MPO
- Push-pull mechanism provides quick connections

Available colors


SM APC


MM OM1


MM OM2


MM OM3


MM OM4

Ordering information

AD-MTP-SM-GR-F	FIBRAIN MTP SM adapter, flange, green housing, opposed key
AD-MTP-OM1-BG-F	FIBRAIN MTP OM1 adapter, flange, beige housing, opposed key
AD-MTP-OM2-BK-F	FIBRAIN MTP OM2 adapter, flange, black housing, opposed key
AD-MTP-OM3-AQ-F	FIBRAIN MTP OM3 adapter, flange, aqua housing, opposed key
AD-MTP-OM4-V-F	FIBRAIN MTP OM4 adapter, flange, violet housing, opposed key

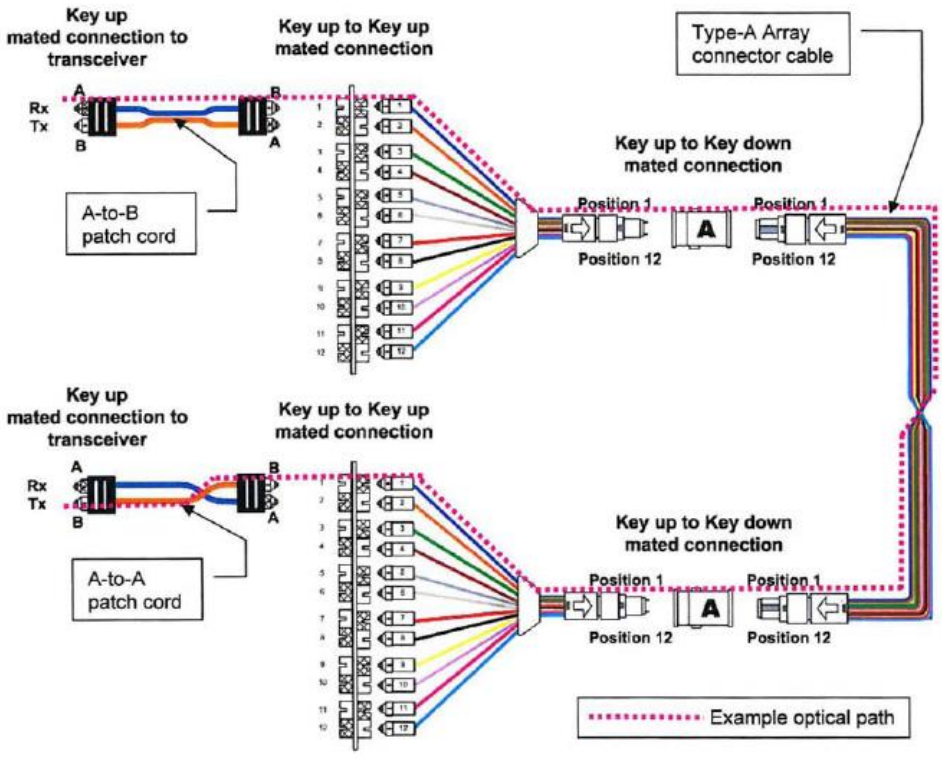
FIBRAIN

4. Connectivity methods

Let's start from the beginning or on what connections can be found in Data center today and what do we expect to see in the future? It depends on various factors such as for example CDP architecture CPD or even of its segments. Server – switch connections will be performed in a different way than router – router connections in the network. However, what we can identify as a rule, are duplex and parallel connections. We remember that duplex connections are based on a pair of fibers necessary for connections up to 10G and here the LC duplex connector will be the most desirable. We can't forget, however, that the IEEE is going to release 25G and in next year even 50G and protocols are to be duplex, it means that the LC is facing a fairly clear perspective, at least in the DC environment. But let's go back to the MPO. ANSI / TIA-568-C.0 norm clarified and organized some issues relating to duplex transmissions and parallel interface implemented by the ILO. 3 connection methods for duplex connections and 2 methods for parallel connections have been defined, and I will try to elaborate on them a bit later.

4.1. Connectivity method A for duplex signals

The following scheme provided by the aforementioned standard:



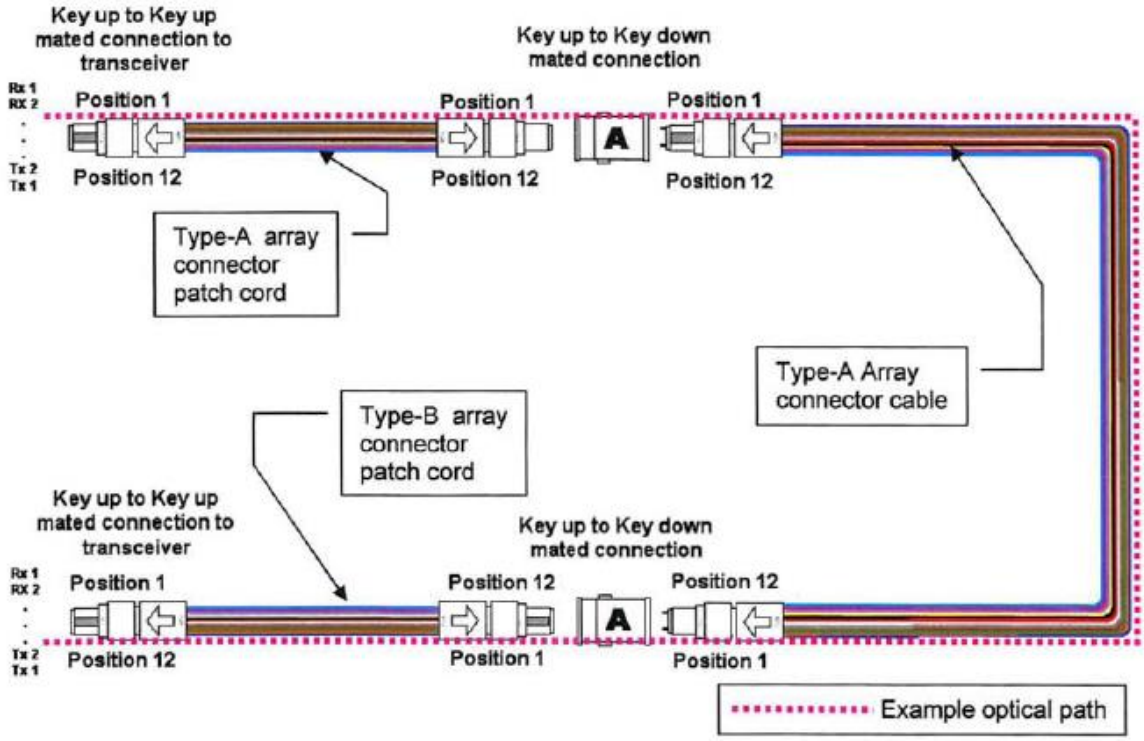
NOTE – The Type-A cable is illustrated with a twist.

The advantages of this method is undoubtedly the simplicity. As we can see, all the components are of type A (adapter and uplink), as well as fiber cassettes are the same on both sides. Also, the risk of making a mistake when ordering components and installation is little as we only need to remember that the connectors on the adapter MPO cassette on both sides are well matched in terms of gender (male/female) to the type of connectors on the uplink.

Problems may be caused by operation. Please note that the duplex connection cables are different on both sides. On one side it is a straight cable (A-to-B), on the other crossed cable (A-to-A). It follows, of course polarity. Let's analyze for example fiber path no.1 from one end to the other (it's dotted in the scheme). We can see that it goes straight. This is due to used components of type A, which, as we remember provide 1: 1 furcation over the entire length of the link. This means that the fiber no.1 goes on fiber no. 1 on the other side, that is, where the fiber is connected to the receiver Rx of the active device, thus it will go on the other side also to the receiver, which is obviously wrong. To make it right, we need to have cross on one side with the use of a connector cable A-to-A. For the user, this means so much, that it will always have to remember this and will be forced to keep on hand two types of connection cables instead of one.

4.2. Connectivity method A for parallel signals

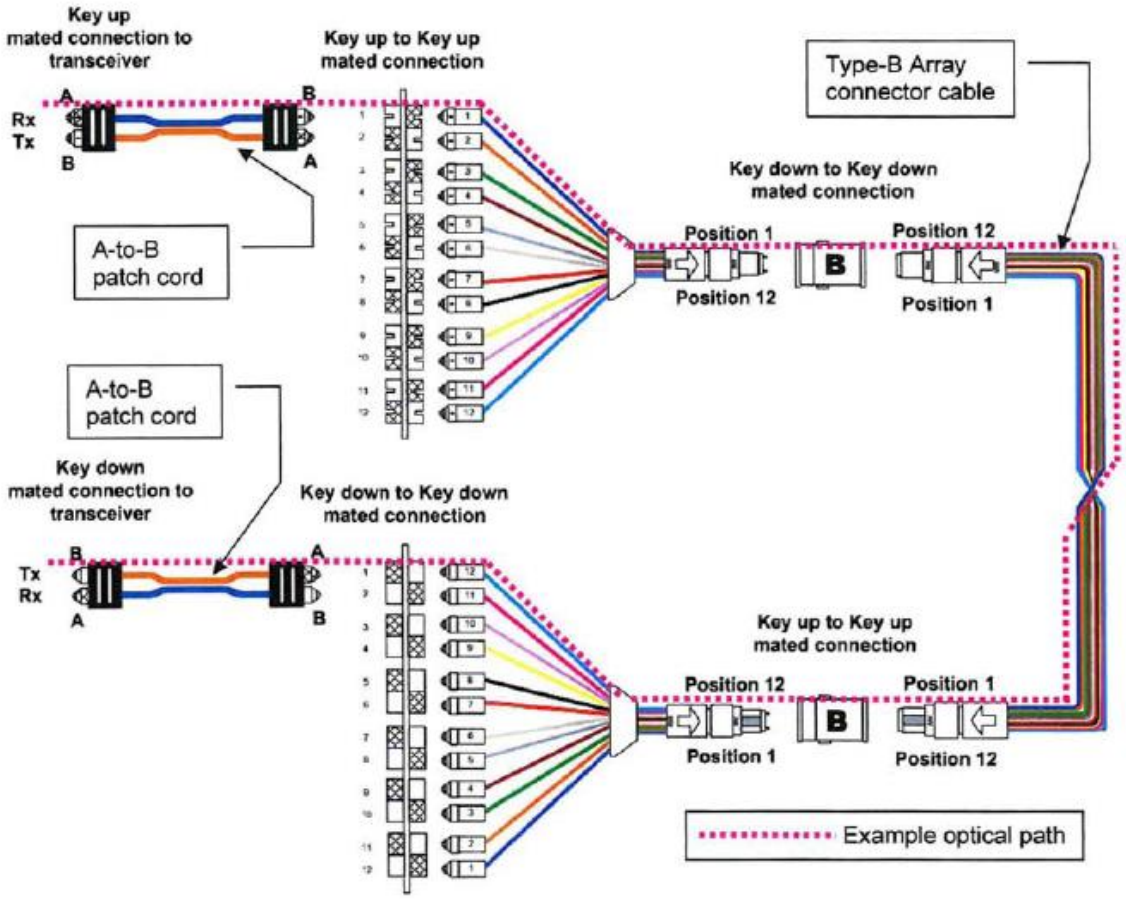
Below you can see the scheme of connections according to ANSI/TIA-568-C.0:



The installation requires the use of type A of adapters and uplink, but the connector cables, similarly as in case of duplex signal, differ from each other on both sides. On the one side we have type A of cable, while on the other B, thus Rx1 will get on Tx1 on the opposite side. The advantage of this method is the ability to support APC option of both multimode and singlemode fibers.

4.3. Connectivity method B for duplex signals

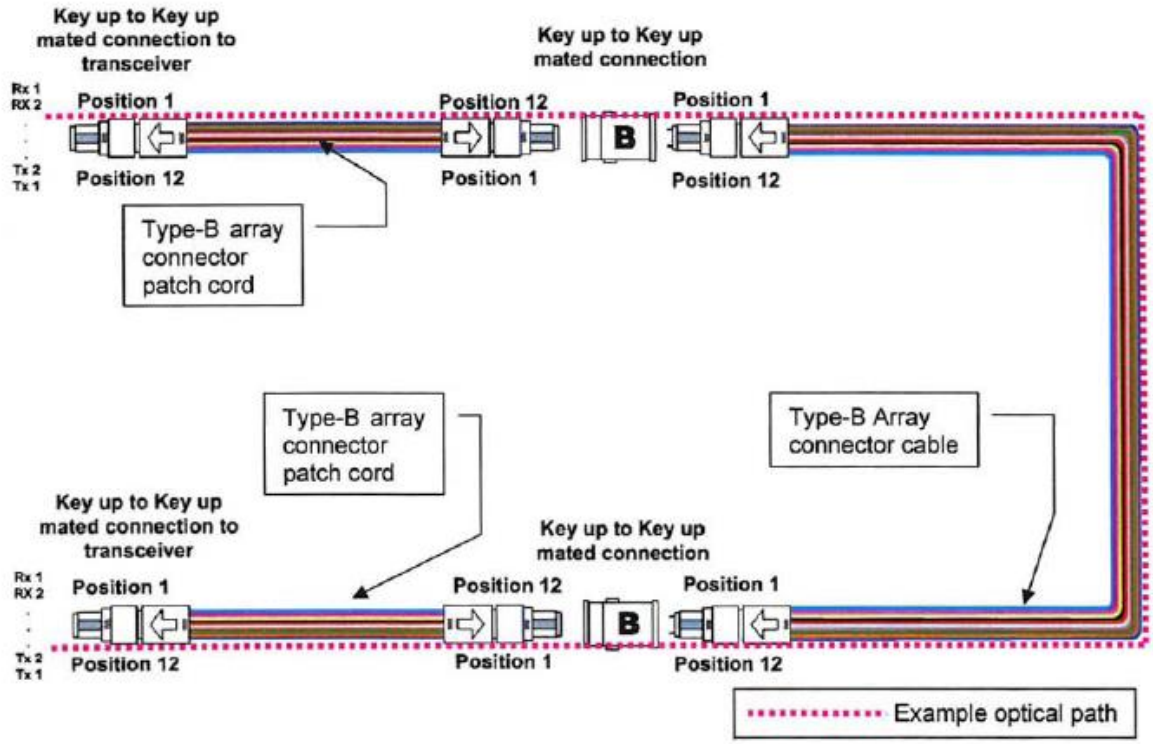
Installation scheme:



At first glance, method B solves the problem of the method of A associated with the need to use different patchcords on both ends. However, this convenience costs money. Please be aware that in method B, FO cassettes differ from each other on both ends. In fact, these cassettes are rotated relative to each other by 180 degrees without changing the numbering of ports. In method B, of course, adapters and uplink are of type B. This method essentially solves the problem of crossed cables but requires different cassettes, the second flaw is the lack of support for singlemode APC applications due to the design of adapters type B. It can literally cause that designers will have headache, especially with a number of MPO connections in the link, which requires great care in the design phase.

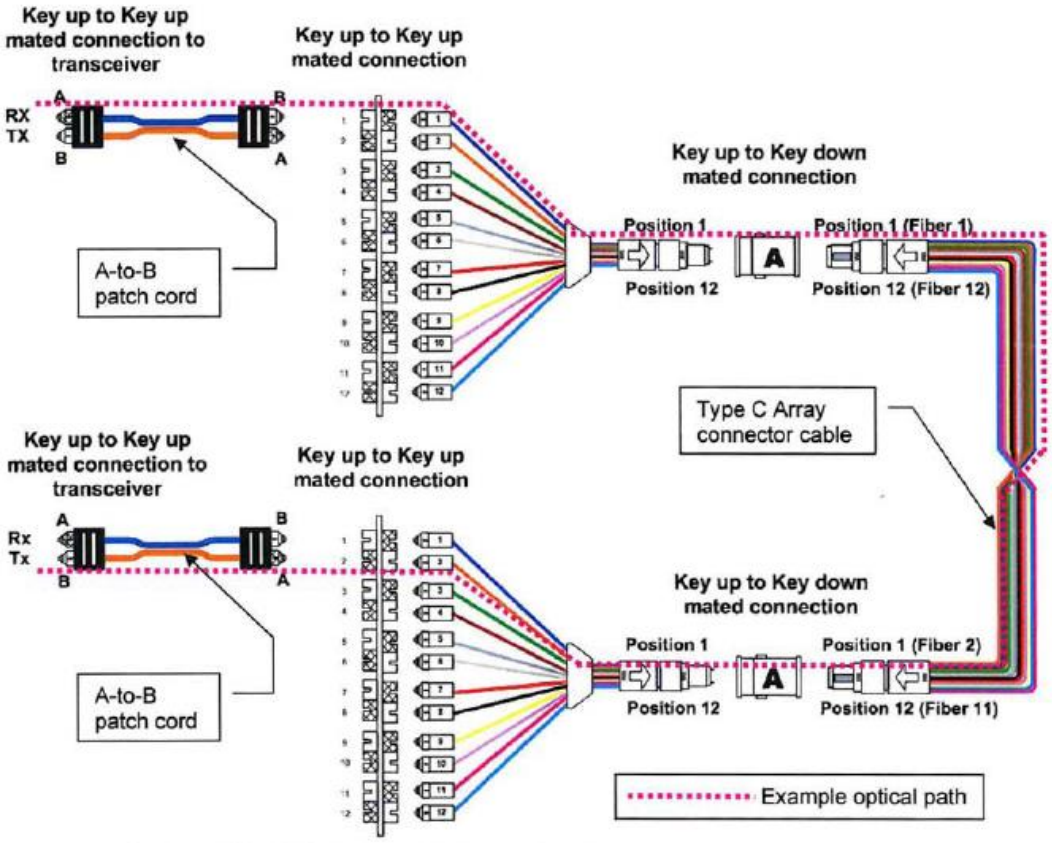
4.4. Connectivity method B for paralel signals

In this case, the point is very simple. Simply order all components marked as B and then connect with each other.The only drawback is the lack of support for APC singlemode fibers



4.5. Connectivity method C for duplex signals

The last method given by ANSI/TIA-568-C.0. However, in this method there isn't any problem with different patchcords on both end or the necessity to use various cassettes. These facilities were obtained by using a crossover uplink that is a cable of type C. Adapters required in this methd need to be of type A. Of course, in relation to the use of crossed cable of type C there is no possibility to change this method for parallel signals, which means that it eliminates the ability to migrate to 40 / 100G. Also, if the User is decided to support max. 10G (with the possiblity to 50G in the future), then this method is quite comfortable.



NOTE – The Type-C cable is illustrated with a twist.

5. Summary

At the end I would like to focus on one thing. Now, please pay attention to the migration of the duplex signal in parallel methods A and B. In other words, for the migration from 10G to 100G or 40. Well, actually, ANSI / TIA-568-C.0 nor is not taken into account. Why? Because the MPO uplink that are determined by the norm can differ. In case of duplex signals these cables are female while the male are parallel that eliminates migration.

In other words, if the user has done today his network based on the method A and tomorrow he wants to migrate to 40G application then in order to be compliant with ANSI / TIA-568-C.0 norm, he would have to replace the entire passive infrastructure. I strongly recommend to remember this information, especially network designers should keep it in mind. As Fibrain we recommend to use of the male cables in each case, for duplex signals too. This will facilitate operation in the event of migration, especially in the active devices where we always have male MPO port. This means that if you use the male uplink we will be able to apply female / female patchcords, otherwise it would mean the need to use female / male patchcords.

To sum up, MPO connector as the multi-fiber connector allows you to get reasonable saving of valuable space in CPD and server rooms. The main use of this connector would be in my mind multimode connection, but also in case of single-mode, the implementation of the MPO connector is justified and has a deep meaning. Undoubtedly, the key element is the network polarization which relates to proper understanding of the connectivity methods and individual components.