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Structured Cabling in Critical Infrastructures.

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Standards and Concepts.

Data Centers are critical and complex infrastructures that demand solutions from multiple providers and a variety of skills to manage. They must have very clear objectives that minimize any risks, making thorough planning essential. Effective operation and the best maintenance practices are also crucial. The ultimate goal is to achieve high availability while minimizing downtime

Fundamentals in Data Centers.

There are several things that are fundamental for a Data Center to make it highly reliable:

- Performance, efficiency, and high transmission speeds.
- High density and operational efficiency reduce the energy bill.
- Asset and capacity management (DCIM).
- Modular solutions to enable future growth without significant cambios.

Data Center Models

- Private companies and public administrations
- Internet (service providers and telecommunications operators)
- Colocation (manage physical space for their clients)
- Hosting (services to minimize investment in hardware and software, serving a variety of clients, owned by a service provider that sells data and Internet services, such as web hosting or VPN, to multiple clients).
- Hyperscale (providers of large-scale content).

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- To keep the equipment running reliably, even under the worst circumstances, all data centers are built with the following support infrastructures:
- Power supply and backup
- Temperature and environmental control
- Fire and smoke systems
- Physical security
- Connectivity to external networks
- NOC (Network Operations Center)
- Structured Cabling
- Grounding.

Main Standards for Data Centers

ANSI/TIA-942-B

Telecommunications Infrastructure Standard for Data Centers. Revision of 942-A

ANSI/BICSI 002-2019

Best Practices for Design and Implementation of Data Centers.

EN 50600-1

Information technology - Data center facilities and infrastructures - Part 1: General concepts..

ISO/IEC 11801-5:2017

Information technology - Generic cabling for customer premises - Part 5: Data Centres (formerly ISO/IEC 24764).

EN 50173-5:2018

Information technology - Generic cabling systems - Part 5: Data Center Spaces.

EN 50600-2-4:2015

Information Technology – Data Center Facilities and Infrastructures – Part 2-4: Telecommunications Cabling Infrastructure.

Estandars ANSI/TIA-942-B

In order to assist data centers in designing infrastructures that support current and future needs, the updated standard includes several substantial changes compared to the previous version.

It specifies the minimum requirements for the telecommunications infrastructure of the data center and computer room, including corporate data centers for single or multiple tenants. The topologies specified in this document apply to data centers of any size. Additionally, it provides recommendations for infrastructure classification regarding redundancy and availability, topologies, distances, cabling, requirements for physical construction, identification, and management.

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Requirements

Added Cat 8 Cabling.

Recommended cabling is CAT.6A or higher. The direct connection to the Zone Distribution Area (ZDA) has been reduced from 10 m to 7 m. The first step is to determine if the organization’s resources have the knowledge.

Preconnectorized Cabling

Recommendation for preconnectorized cabling. Add 16 and 32 Fiber MPO-style connectors as an additional connector type for the termination of more than two fibers. The 16 and 32 fiber connectors were standardized when ANSI/TIA-604-18 was published.

Identification, Routing, and Management.

Recommendations are included for the identification, routing, and management of cables, enabling the addition and removal of cables without disrupting adjacent connections

OM5 Cable

OM5 has been added as an allowed and recommended type of multimode optical fiber (broadband multimode fiber). The TIA-492.AAAE standard specifies OM5 fiber, designed to support short wavelength division multiplexing.

Others.

Coaxial cables ANSI/TIA-568.4-D and “F” type connectors can be used, with references made to other standards, including revisions, as well as temperature and humidity guidelines.

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Physical Infrastructure Requirements.

Main Spaces.

According to ANSI/TIA-942-B, the main spaces or areas of a Data Center are:

Entrance Room (ER)

The entrance room is a space for the interconnection between the structured cabling of the Data Center and the cabling coming from telecommunications operators.

Main Distribution Area (MDA)

It includes the Main Cross-Connect, which is the central distribution point for the structured cabling of the Data Center. It is a critical area where major maneuvers are performed.

Intermediate Distribution Area (IDA)

It is the space for the Intermediate Cross-Connect, which is the secondary distribution point for structured cabling in a server room. It is a critical area, similar to the MDA, where maneuvers are carried out from the server room where it is installed.

Horizontal Distribution Area (HDA)

It is used for the connection of equipment areas. It includes the Horizontal Cross-Connect (HC) and intermediate equipment.

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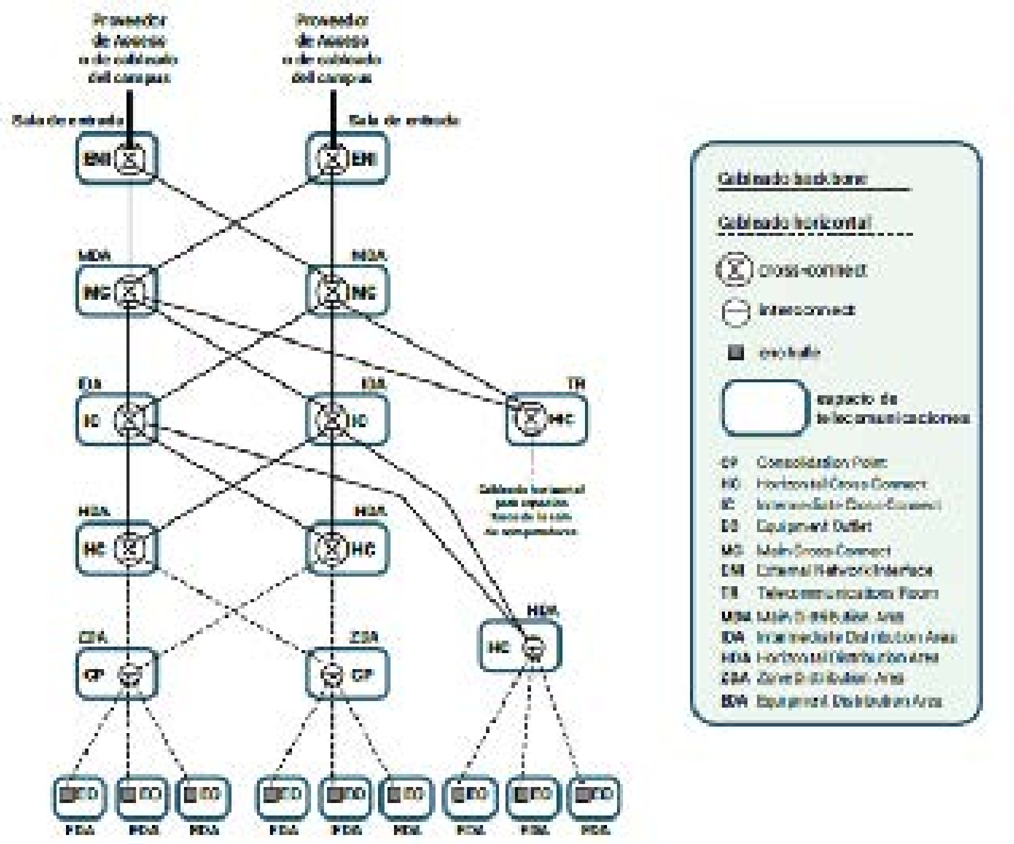
Zone Distribution Area (ZDA)

Optional point of interconnection for horizontal cabling. Positioned between the HDA and the EDA, it allows for quick and frequent configuration, often used in a raised floor installation. Adds flexibility to the Data Center.

Equipment Distribution Area (EDA)

Space for end equipment (servers, storage) and data or voice communication equipment (switches, hubs).



Functional Elements of Structure Cabling for Data Centers.

Levels or Tiers of a Data Center.

It is related to the levels of infrastructure availability.

- The tier classifications were originally defined by The Uptime Institute.
- Addresses critical data center systems.
- Critical systems may have different classifications.
- Classifications can be downgraded as the data center load increases over time.

Redundancy.

To reduce Data Center downtime and protect company data, redundancy is also a requirement outlined in the standard. Annex F of the ANSI/TIA-942-B standard establishes a set of rules for classifying a Data Center, called Rated. The classification considers four independent levels (rated) for Telecommunications, Electricity, Architecture, and Mechanical systems. These ratings are related to Data Center availability and may differ in each of the mentioned areas.

Source: ANSI/TIA-942-B

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The purpose of this topic is to maintain the essential features of the Data Center regarding its availability, reliability, security, resilience, and necessary redundancy for its classification. ANSI/TIA-942-B defines the following classifications:

- Data Center Level 1: Basic.
- Data Center Level 2: Redundant components.
- Data Center Level 3: Concurrently maintainable.
- Data Center Level 4: Fault-tolerant.

Level I - Basic

- Single path for power and cold distribution.
- No redundant components.
- May not have a raised floor.
- Susceptible to discontinuity due to both planned and unplanned activities.
- 28.8 hours of annual downtime.

Level II - Redundant Components

- Single path for power and cold distribution.
- Redundant components.
- Has a raised floor.
- Slightly less susceptible to discontinuities than Level I.
- 22.0 hours of annual downtime.

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Level III - Concurrently Maintainable

- Multiple power and cold distribution paths. Only 1 active path.
- Redundant components.
- Leaves margin for any planned infrastructure activity without interfering with server hardware operation.
- 1.6 hours of annual downtime.

Level IV - Fault Tolerant

- Multiple active power and cooling distribution paths.
- Redundant components.
- All server hardware must have dual power inputs.
- Could withstand at least one worst-case, unplanned failure or event with no impact on critical load.
- 0.4 hours of annual downtime.

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Data Center Tiers/Levels

RENDIMIENTO	TIER I	TIER II	TIER III	TIER IV
Disponibilidad	99,67%	99,79,749%	99,98%	100,00%
Tiempo parada (horas /año)	28,8	22,68	1,57	0,4
Centro de operaciones	No requerido	No requerido	Requerido	Requerido
Acceso redundante proveedor de servicios	No requerido	No requerido	Requerido	Requerido
Camino redundante de backbone	No	No	Si	Si
Cableado horizontal redundante	No	No	No	Opcional
UPS redundante	N	N+1	N+1	2N
Sistema supresor de gases	No	No	Clean agent FM200 Intergen	Clean agent FM200 Intergen

Telecommunications Requirement

- Cabling, racks, cabinets & pathways meet TIA-942 requirements.
- Has one entrance pathway from the access provider to the facility.
- Single pathway for all cabling.
- Recommended labeling according to ANSI/TIA/EIA-606-A and Annex B.

Level 2: Telecommunications Requirements

- All Level 1 requirements.
- Has 2 pathways from the access provider to the facilities.
- Routers & switches have both redundant power supplies and processors.
- Addresses vulnerability of service entrance to the building.

Level 3: Telecommunications Requirements

- All Level 2 requirements.
- Be served by at least 2 access providers.
- Secondary entrance room.
- Redundant backbone pathways.
- Multiple routers and switches for redundancy.
- Addresses vulnerability of a single access provider.

Level 4: Telecommunications Requirement

- All Level 3 requirements.
- Redundant backbone cabling.
- Backbone cabling must be ducted or have interlocking armor.
- Optional secondary distribution area.
- Optional redundant horizontal cabling.
- Addresses any vulnerability in the cabling infrastructure.

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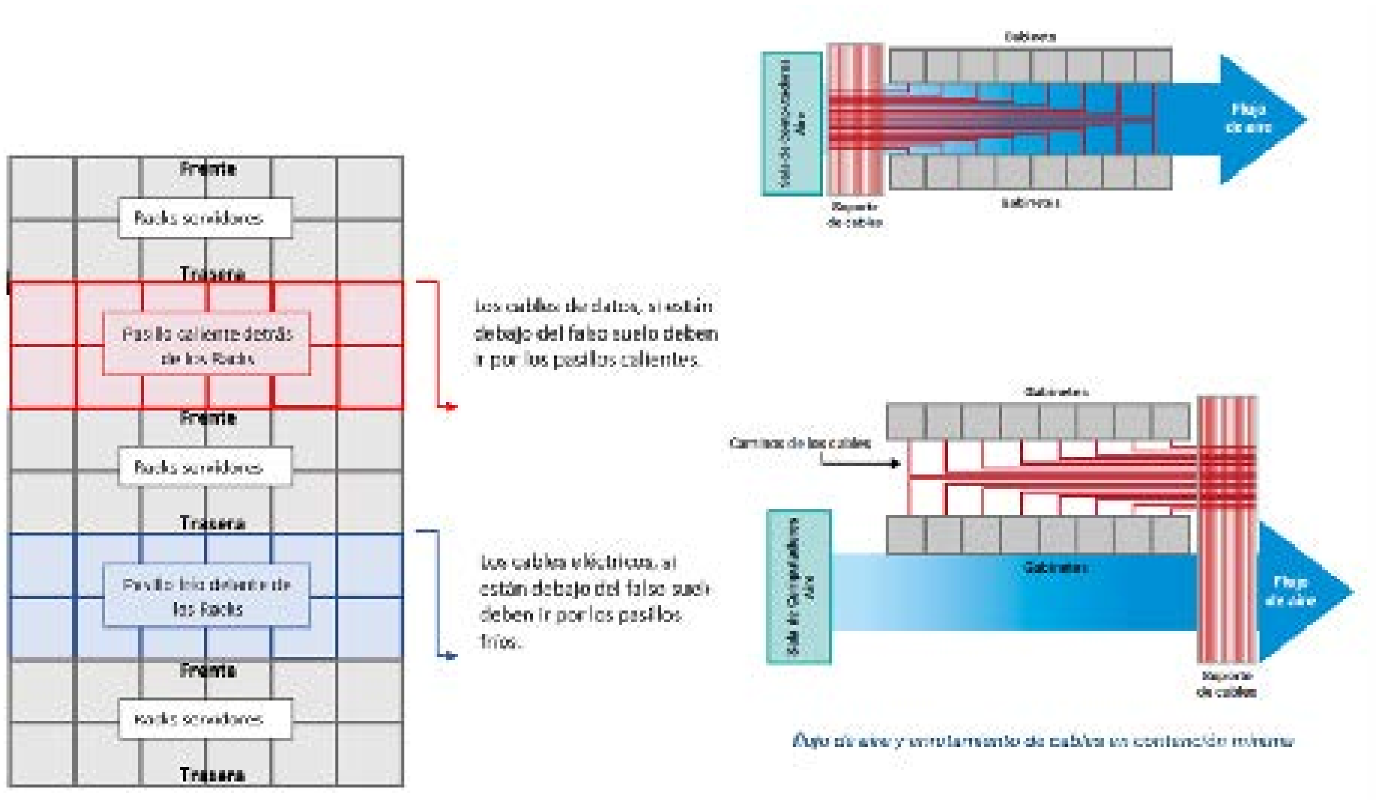
RENDIMIENTO	TIER I	TIER II	TIER III	TIER IV
Camino de entrega	1	1	1 Activo 1 Pasivo	2 Activos
Componentes redundantes	N	N+1	N+1	2(N+1) o S+S
Componentes redundantes	Tal vez ninguno	Sistemas	Sistemas, energía y algún otro	Todos
Proporción de espaco de soporte a suelo	20%	30%	80-90%	100%
Ultimos Watt/ft²	20-30	40-50	100-150	150+
Primer año de despliegue	1965	1970	1985	1995
Tiempo parada IT (horas/año)	28,8	22,68	1,57	0,4
Soporte de potencia	UPS	UPS+Gen	UPS+Gen	UPS+Gen
Critical path support requires	Shutdown	Shutdown	Auto	Auto
Coste por ft²	$450	$600	$900	$1.100

New Guidelines

The ANSI/TIA 942-B revision transformed sustainability and energy efficiency trends into clearer premises. Where there are racks and cabinets (especially cabinets with high thermal density), the goal is to judiciously save electrical power from PDUs and air conditioning, as illustrated below.

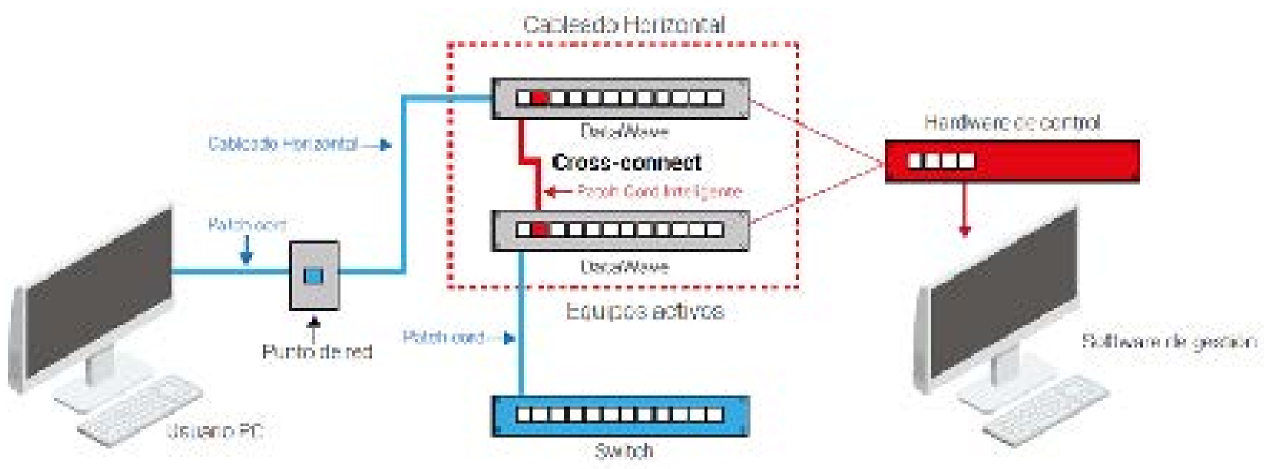


Recommendations on the channel position and organization of structured cabling.

Availability

In addition to the above criteria for redundancy in Data Centers, the following topics complement their availability assurance system according to the standards related in each topic (chapters ANSI/TIA-942-B):

- **Installation Requirements for Cabling:** ANSI/TIA-568.0-D installation requirements, in addition to the other clauses of this standard, must be followed to comply with applicable codes and regulations.
- **Cabling Performance Requirement:** Transmission performance requirements from ANSI/TIA-568.2-D, ANSI/TIA-568.3-D, and ANSI/TIA-568.4-D are the minimum requirements to be met.
- **Cabling for Wireless Access Points:** Cabling must be provided to service the wireless access network, in accordance with ANSI/TIA TSB-162-A.
- **Cabling for Distributed Antenna Systems:** Cabling for distributed antenna systems must follow the ANSI/TIA TSB-5018 guidelines.
- **PoE over Structured Copper Cabling:** Follow ANSI/TIA TSB-184-A guidelines. For this application, UL444 certified cables with PoE 100W support (IEEE 802.3bt, PoE Type 4, DC @ 100W) are available to support TVs and laptops.
- **Grounding and Bonding:** Grounding and other connections will meet ANSI/TIA-607-C requirements.
- **Firestopping:** Fire protection barriers or sealing must comply with ANSI/TIA-569-D and local regulations.
- **Physical Security**: Physical security of the telecommunications infrastructure must comply with ANSI/TIA-5017 requirements.



Intelligent Cabling System AIM

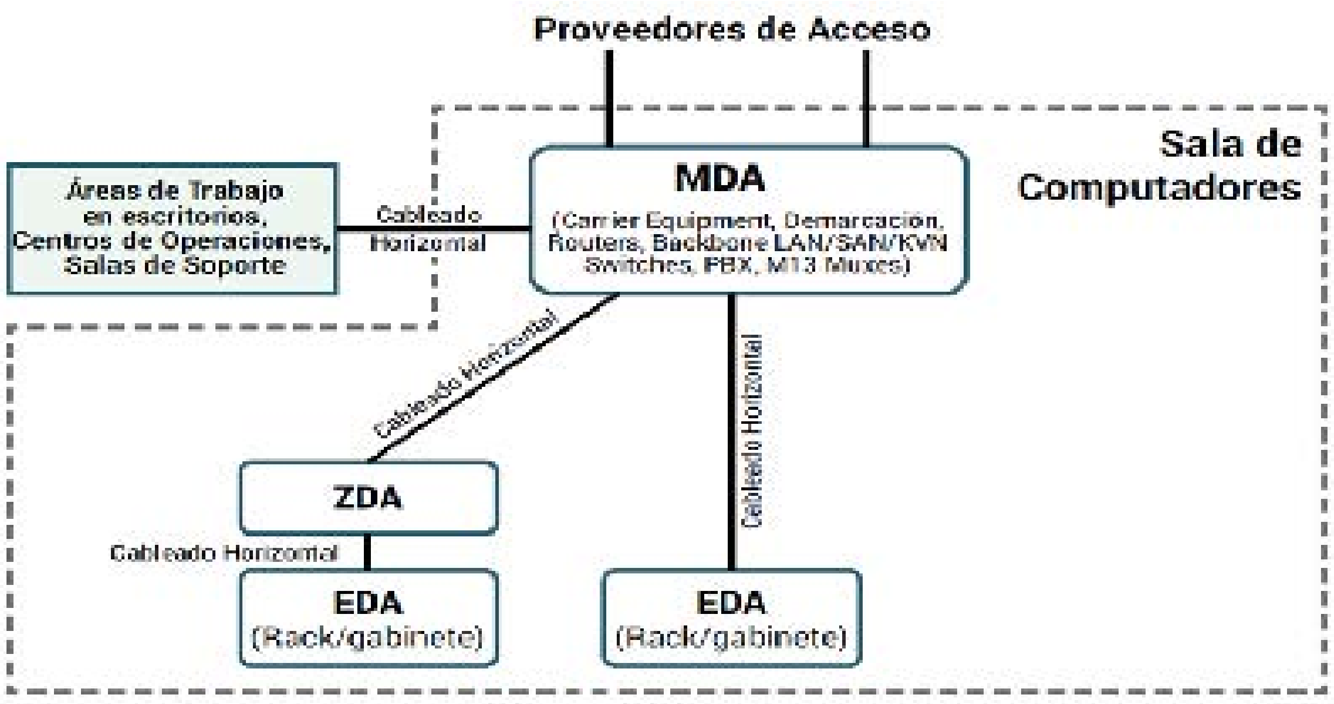
- **Management:** Telecommunications management must comply with the requirements of ANSI/TIA-606-C and also meet the requirements of AIM standards, namely:
    - **ANSI/TIA-5048:** Automated Infrastructure Management (AIM) Systems.
    - **ISO/IEC-18598:** Automated Infrastructure Management (AIM) Systems – Requirements, data Exchange and Applications.
    - These standards define the AIM system, its functions, security, assembly, hardware and software, as well as what its outputs should be and which systems it should integrate with, such as: Field Service systems, NOC, Inventory, Port Provisioning, etc.

Topologies

The standard presents three topologies according to the following schemes:

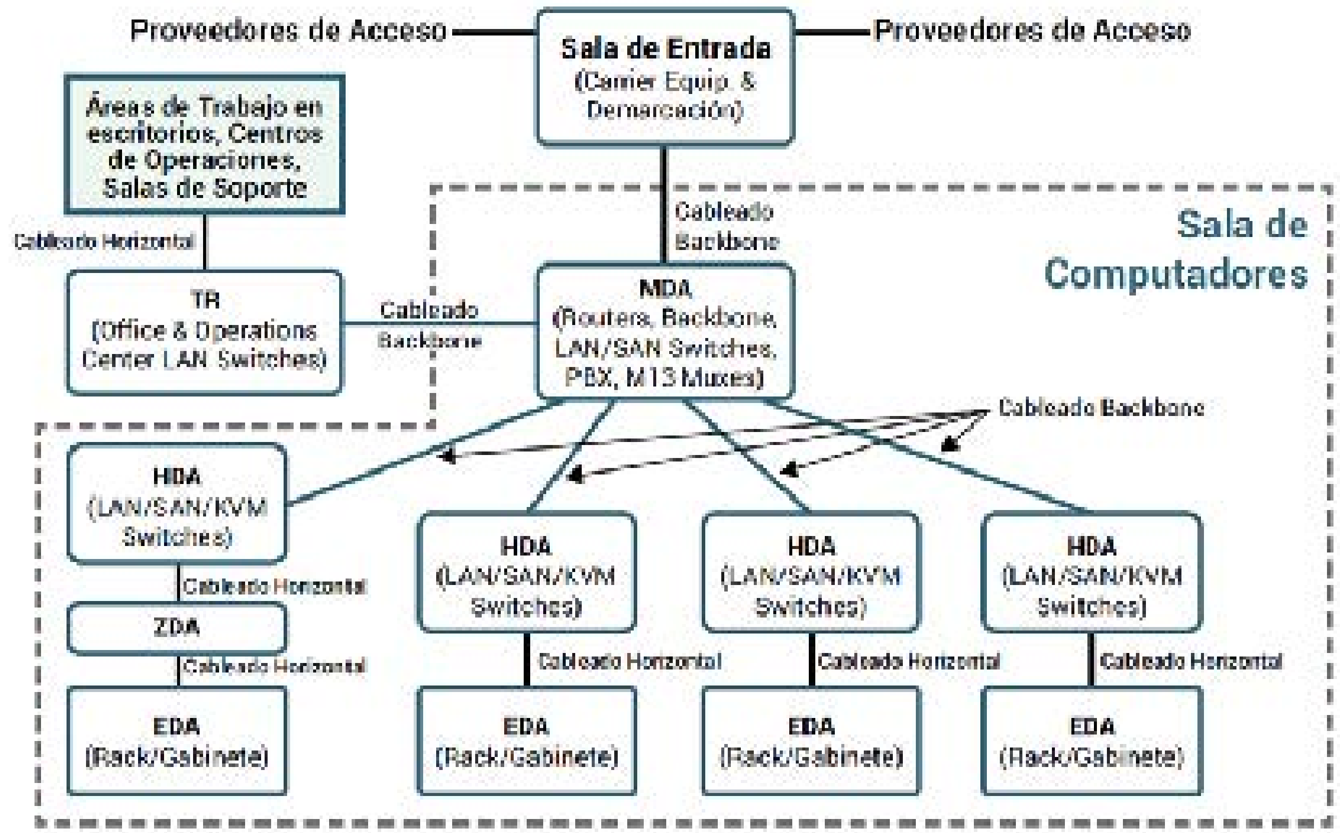
Reduced Topology

It has a single MDA that consolidates the main and horizontal cross-connect areas. The telecommunications room may also be consolidated into the MDA.



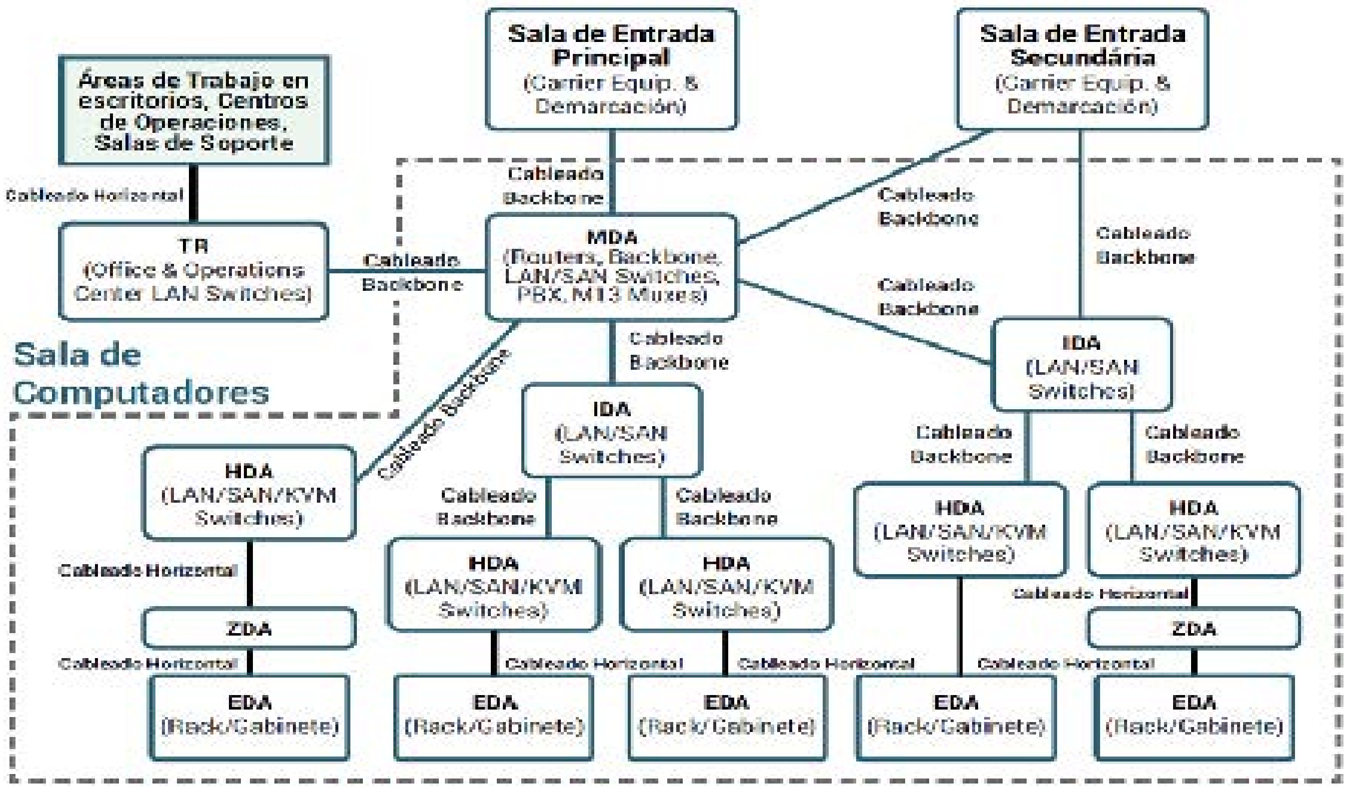
Basic Topology

It includes a single entrance room, one or more telecommunications rooms, an MDA, and multiple HDAs



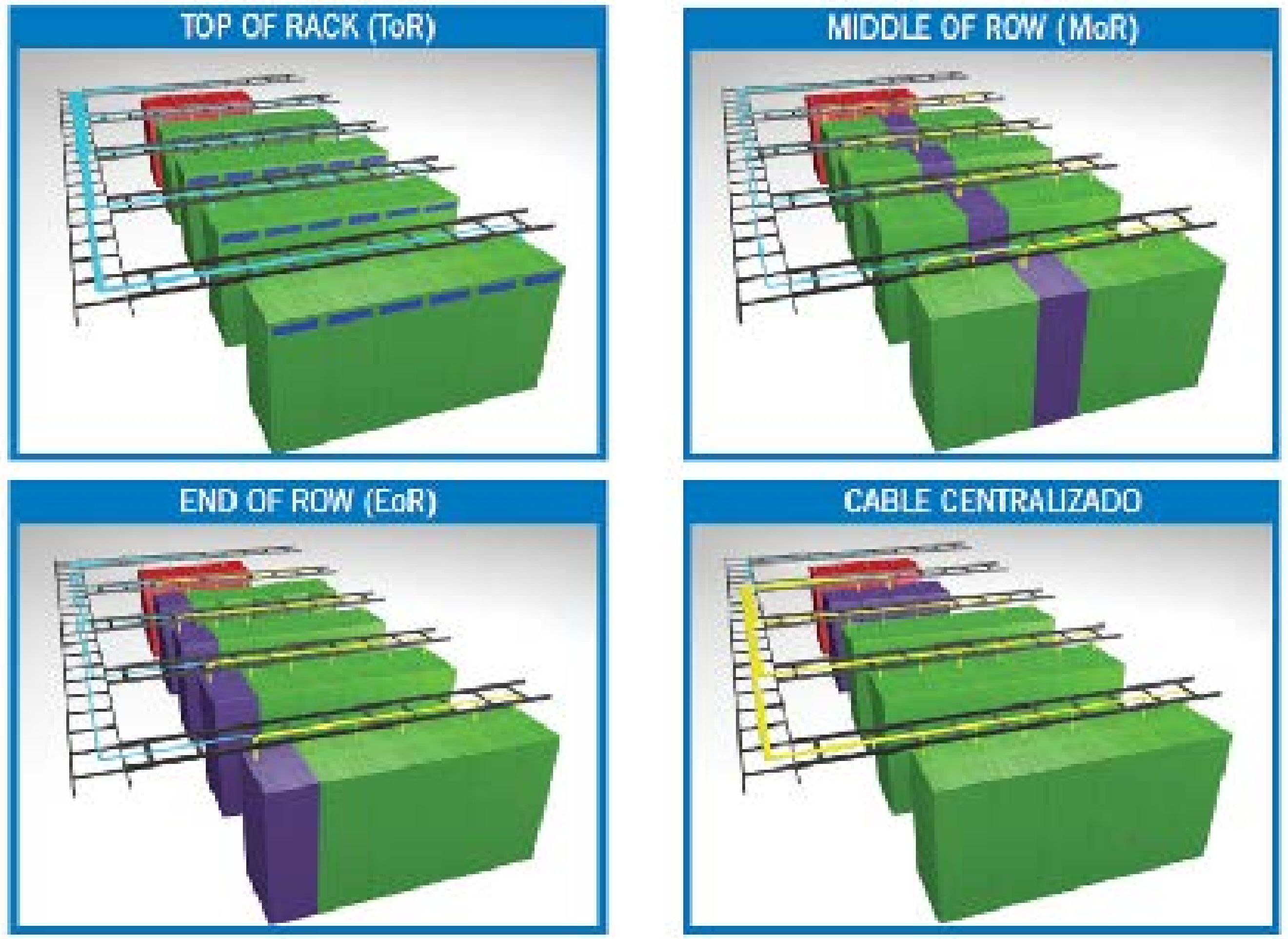
Distributed Topology

Los Grandes Data Centers que requieren áreas de Conexión cruzada Intermediarias (IDA), múltiples Salas de Telecomunicaciones y múltiples salas de entrada.



MDA-EDA Connection Topologies

To enable the connection of all existing equipment in the MDA area to the equipment in the EDA area, regardless of the size of the Data Center, various topologies can be employed, each with its own advantages and disadvantages. Below, you can review the details of the main topologies applied in current Data Centers.



Centralized Cabling

In the centralized or directly connected topology, in the main distribution area (MDA), there is a central network device, which is connected to the servers located in the equipment distribution area (EDA).

Advantages

- Lower cost than distributed architectures.
- Simple to design, implement, and maintain.
- Minimizes network bottlenecks.
- Optimized use of ports.
- Simplified device management.
- Greater flexibility for interconnection or cross-connection topologies.
- Centralized switches and other network equipment minimize the number of active equipment ports required for the project.
- Simplifies cable and active network equipment management.
- Enables intelligent monitoring and management systems (A.I.M.).
- Reduces the quantity of monitoring modules, management modules, and switch backbone ports: 'more capacity in fewer boxes.'
- Reduces power consumption, redundancy, and cooling requirements.
- Shortens equipment cable lengths, even if mirrored active ports exist for a cross-connection configuration.
- Optimal for implementing high-availability schemes (redundancy)

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Disadvantages

- High quantity of cables in the MDA.
- Overlaid cables in the MDA and in the main infrastructure.
- Challenges in infrastructure design due to high density of structured optical and copper cabling.
- Not scalable.
- More cross-connections to manage and maintain.
- Higher number of cabling links than other options (ToR or EoR/MoR)."

Top of Rack (ToR): Upper part of the Rack

In the Top of Rack (ToR) configuration, each equipment rack in the EDA has a network device (switch) positioned at its top. Connections to the servers are made directly from this switch using patch cables or active cables (AOC or DAC). Horizontal Distribution Area (HDA) is not used in this setup

Advantages

- Most of the time, it uses cabling more efficiently.
- Efficient use of space.
- Good scalability.
- Improved cable management.
- Easy interconnection of servers and ToR switches.
- Rapid addition of new equipment.
- Very low cable density, reducing the need for raised floor space.
- Quick installation.
- Reduces the space required for cable distribution racks.

Disadvantages

- Server interfaces and connection cables to ToR switches may not have an attractive cost-benefit ratio compared to structured cabling patch cords.
- More options for managing active network equipment.
- Traffic aggregation (aggregation or distribution switches).
- Higher number of Spanning Tree Protocol (STP) ports.
- Increased server-to-server traffic.
- Higher cost of assets (switches).
- Risks in thermal management.
- Creation of hotspots.
- Excess of network equipment and ports.
- Separate management and maintenance for each rack with ToR switch, increasing network complexity and reducing reliability.
- Limited flexibility for services offered by ToR switches.
- Network segmentation only through virtual means (VLAN, Fabric SAN), which may conflict with existing information security policies of the client.
- Additional requirements for cooling and power in each rack with ToR switch.
- Implementation of high availability schemes can be difficult and costly.
- Requires many redundant links and resources such as power supplies, management modules, and backbone ports.
- Unless networks are 100% integrated, they may need to be complemented with other cabling schemes for SAN, redundancies, consoles, security and management networks, etc.
- Does not allow for intelligent monitoring or management of cabling for server connections

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End of Row (EoR): End of the Row

The Horizontal Distribution Area (HDA) rack is centered in the row of server racks, and the horizontal network cabling reaches all EDA racks in an equidistant manner

Advantages

- M Fewer cables compared to the direct connection architecture between HDA and MDA.
- Very good scalability.
- Easy interconnection between servers and network devices.
- Quick insertion of new hardware into racks and the network.
- Very low cable density, reducing the space required in the infrastructure beneath the raised floor.
- Fast installation.
- Little space required in the cable distribution racks.
- Interfaces and activation cables (patch cords) for servers with a good cost-benefit ratio

Disadvantages

- Too many switches and distributed network ports throughout the Data Center.
- Separate management and maintenance for each EDA rack with ToR, leading to increased complexity and reduced network reliability.
- Limited flexibility for services offered by ToR switches.
- Network segmentation only through virtual means (VLAN, Fabric SAN), which may contradict existing security policies.
- Additional power and cooling needs per EDA rack.
- Implementation of high availability schemes (redundancy) becomes difficult and costly.
- Requires a large number of redundant links and resources, such as power supplies, management modules, and backbone ports

- Unless the networks are 100% integrated, they may need to be complemented with other cabling schemes for SAN, direct redundancies, consoles, security networks, etc.
- It does not allow for intelligent monitoring or management of cabling for server connections.”

Middle of Row (MoR)

The Horizontal Distribution Area (HDA) rack is centered in the row of server racks, and the horizontal network cabling reaches all EDA racks in an equidistant manner

Advantages

- Cables with shorter physical length.
- Lesser quantity of cables compared to direct connection architecture.
- Improved scalability.
- Relatively easy to implement server interconnection to network assets. Quick addition of new equipment.
- Very low cable density, reducing the need for space beneath the raised floor or in the infrastructure.
- Fast installation.
- Reduced space needed for cable distribution racks.
- Interfaces and server connection cables (patch cords) have a good cost-benefit ratio.
- Does not require as many network ports as in ToR architecture

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Disadvantages

- Higher cost of assets (switches) in the MoR rack.
- Increased management overhead.
- Significant excess of network equipment and ports.
- Separate management and maintenance for each rack group.
- Limited flexibility for services offered by the MoR switch.
- Network segmentation only through virtual means (VLAN, Fabric SAN), which may contradict existing information security policies.
- Additional cooling and power consumption needs for each rack group.

“he topologies define how the logical and physical links of network equipment will be for information traffic and equipment connections. In network architecture, it determines how the equipment will be connected, considering a layered approach for better management

Identification

Identification Scheme for the Raised Floor Space

The floor space must follow the data center grid. Most data centers will require at least two letters and two numerical digits to identify each 600 mm x 600 mm tile (or 2 feet x 2 feet). In such data centers, the letters will be AA, AB, AC… AZ, BA, BB, BC… and so forth.

Identification Scheme for Racks and Cabinets

All racks, cabinets, or enclosures should be labeled on the front and rear. In computer rooms with access floors, label cabinets and racks using the data center grid. Each rack and cabinet should have a unique identifier based on the coordinates of the floor tiles. If cabinets span more than one tile, the grid location for cabinets can be determined using the same corner on each cabinet (e.g., front-right corner). The numerical part of the ID will include leading zeros. Therefore, the cabinet whose front-right corner is on tile AJ05 will be labeled AJ05.

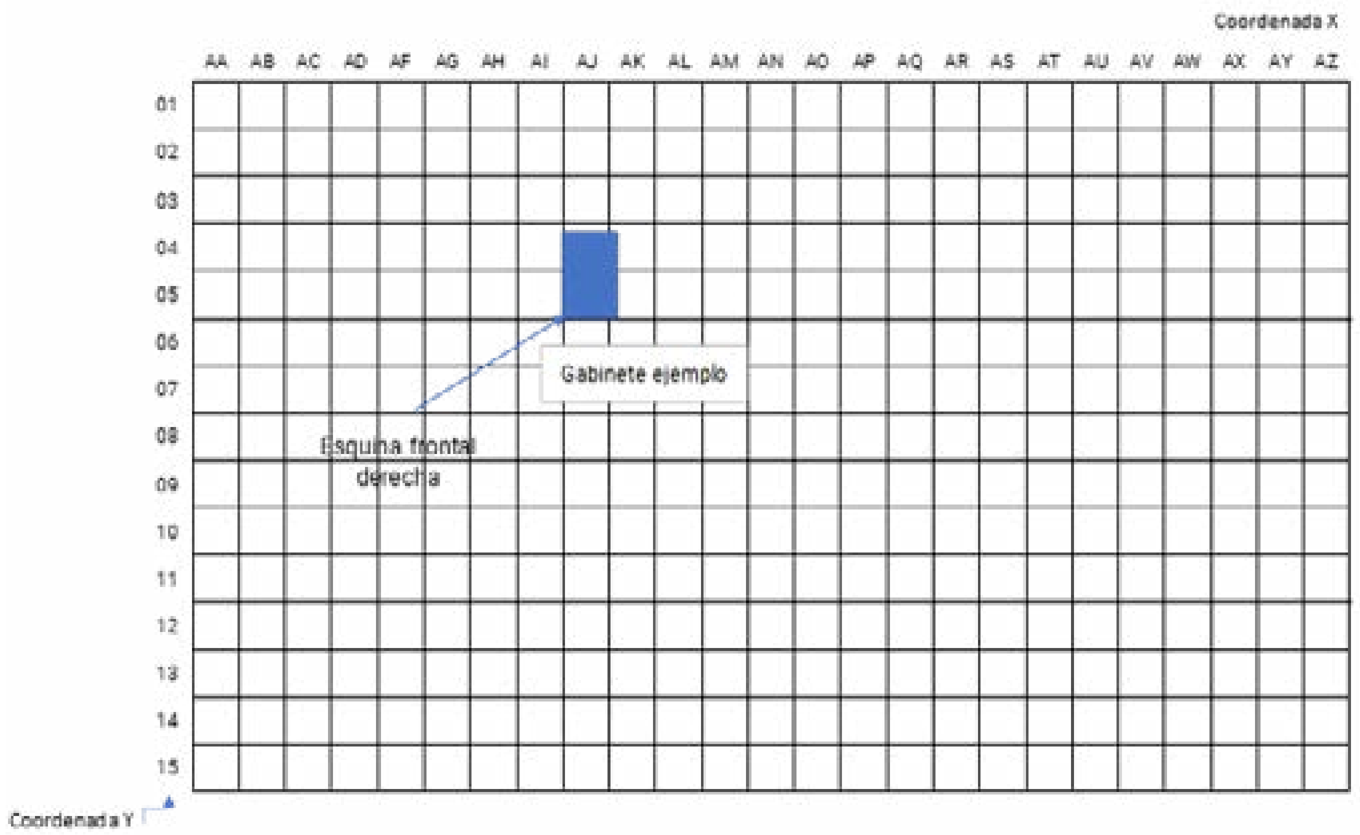
In multi-floor data centers, the floor number should be added as a prefix to the cabinet number. For example, 3AJ05 for the cabinet whose front-right corner is on tile AJ05 on the third floor of the data center. Below is a sample floor space management scheme

nx1Y1

Where:

n = When the data center space is present on more than one floor in a building, one or more numerical characters designate the floor where the space is located.

x1Y1 = One or two alphanumeric characters followed by two alphanumeric characters that designate the location on the floor space grid where the front-right corner of the rack or cabinet is situated. In the figure, the sample cabinet is located at AJ05



Example of Rack or Cabinet Labeling

In computer rooms without access floors, use the row number and position within the row to identify each rack and cabinet. Names and numbers of the cabinet or rack within the room

Identification Scheme for Patch Panels

Patch Panel Identifier

The identification scheme for patch panels should include the name of the cabinet or rack and one or more characters indicating the position of the patch panel in the cabinet or rack. Horizontal cable management panels do not count when determining the position of the patch panel. If a rack has more than 26 panels, two characters will be needed to identify the patch panel. Below is a sample patch panel management scheme:

x1y1-a

Where:

a = One or two characters designating the location of the patch panel within the cabinet or rack x1y1, starting from the top of the cabinet or rack. Refer to the figure for typical copper patch panel designation.

Patch Panel Port Identifier”

Two or three characters are used to specify the port number on the patch panel. Therefore, the fourth port on the second panel of cabinet 3AJ05 can be named 3AJ05-B04. Below is a sample patch panel port management scheme:

x1y1-an

Where:

n = One to three characters designating the port on a patch panel. For copper patch panels, two to three numeric characters. For fiber patch panels, one alphabetic character, identifying the connector panel within the patch panel, starting sequentially from ‘A’ excluding ‘I’ and ‘O’, followed by one or two numeric characters designating a fiber strand.

Connectivity Identifier Between Patch Panels

Patch panels should be labeled with the patch panel identifier and port identifiers, followed by the patch panel identifier and port identifiers of the connecting patch panels or outlets at the other end of the cables.

Below is a sample patch panel connectivity management scheme:

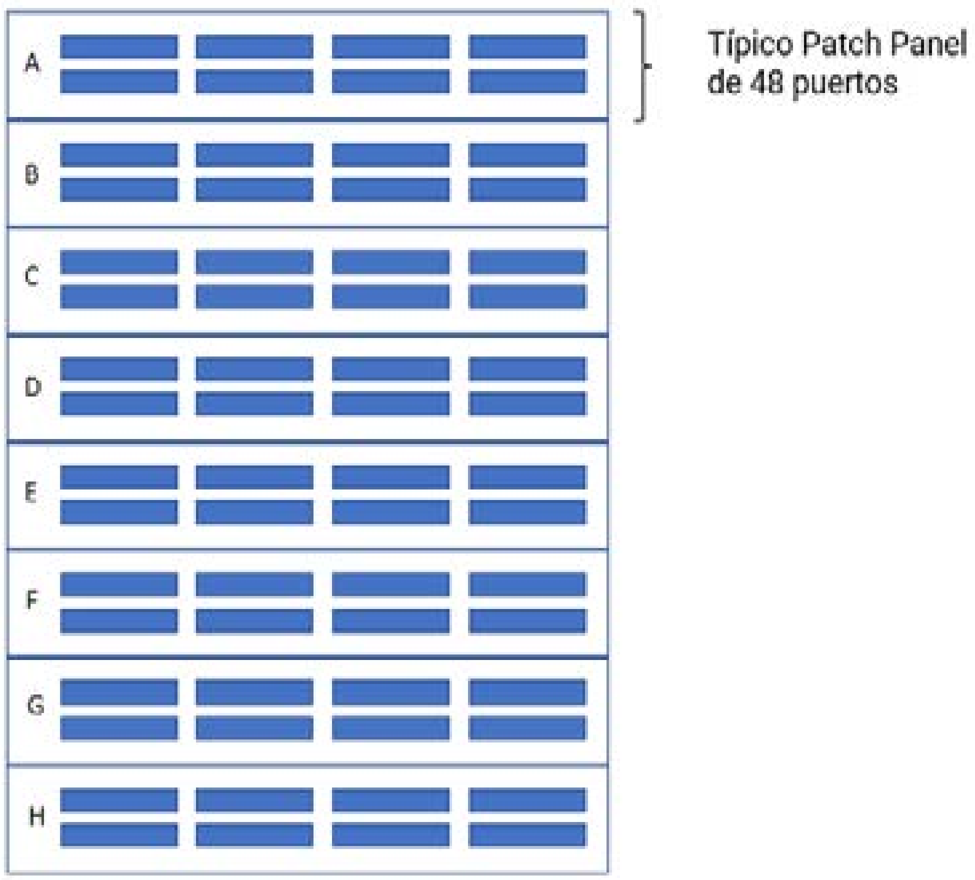
p1 to p2

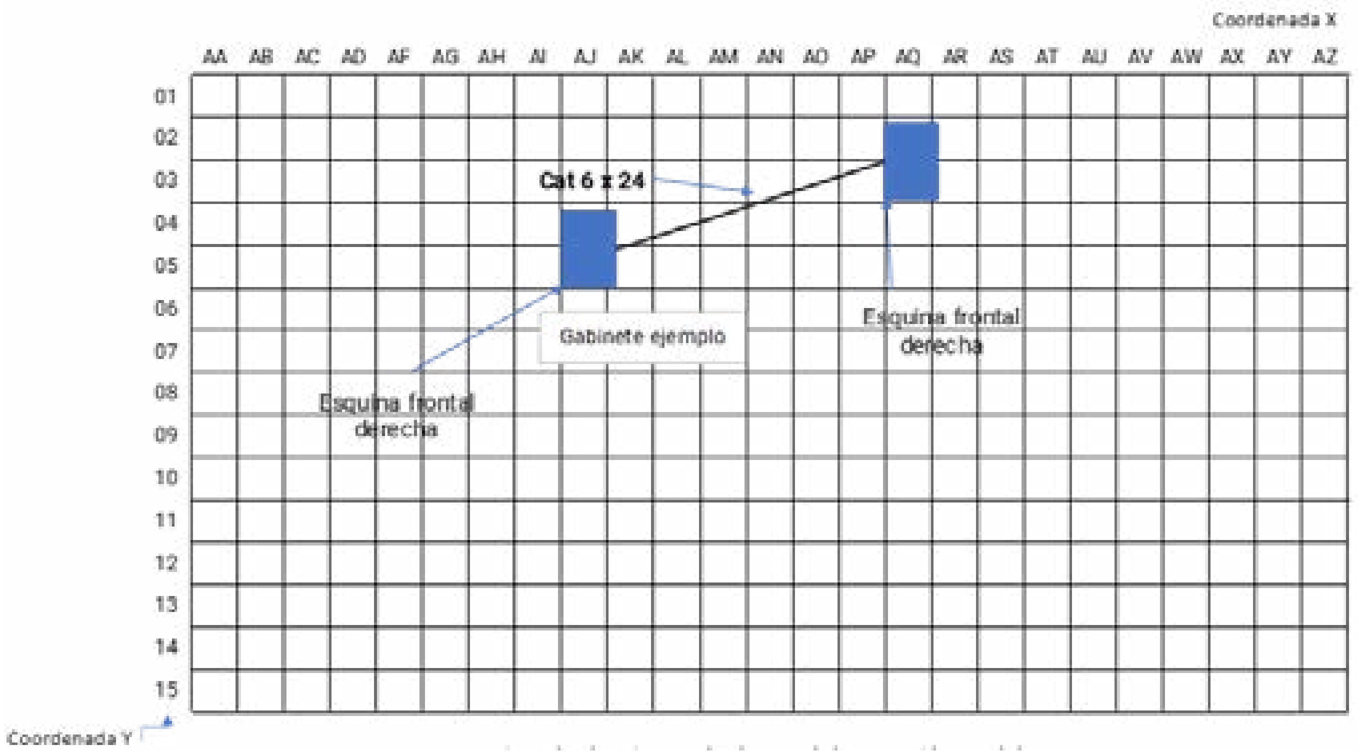
Where:

p1 = Near-end rack or cabinet, patch panel sequence, and port number range.

p2 = Far-end rack or cabinet, patch panel sequence, and port number range.

Consider supplementing ANSI/TIA/EIA-606-A cable labels with sequence numbers or other identifiers to simplify troubleshooting. For example, the 24-port patch panel with 24 Category 6 cables from MDA to HDA1 could include the above label but might also include the label ‘MDA to HDA1 Cat 6 UTP 1 - 24





Example of Modular Patch Panel Labeling:

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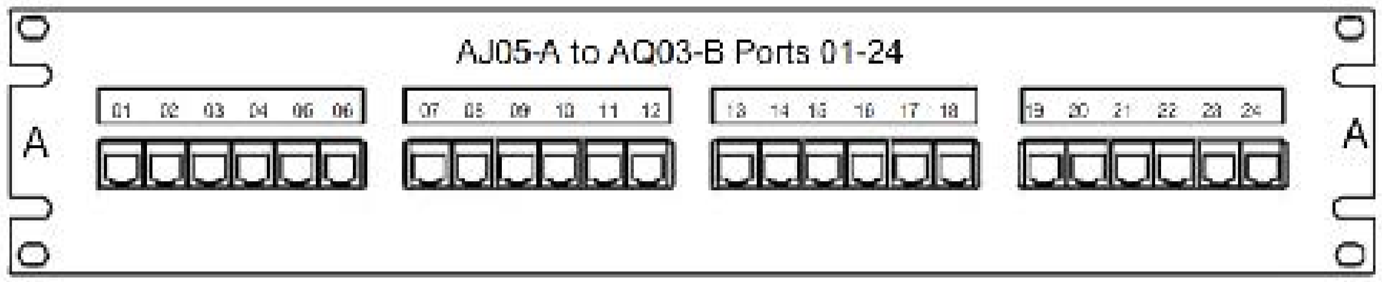
For example, the following figure displays a label for a 24-position modular patch panel with 24 Category 6 cables interconnecting cabinet AJ05 to AQ03 as shown in the previous figure.



Example of labeling for a modular patch panel 2

Cable and Patch Cord Identifier

Cables and patch cords should be labeled at both ends with the name of the connection on both ends of the cable. Consider color-coded patch cords by application and type. Below is a sample cable management and patch cord scheme.

p1n / p2n

Where:

p1n = Near-end rack or cabinet, patch panel sequence, and port designator assigned to that cable.

p2n = Far-end rack or cabinet, patch panel sequence, and port designator assigned to that cable. For example, the cable connected to the first position of the patch panel shown in the previous figure might have the following label: AJ05-A01 / AQ03-B01, and the same cable in cabinet AQ03 would have the following label: AQ03-B01 / AJ05-A01

Multifiber Connectivity Components

We live in a highly connected environment, generating a large volume of information, leading to growth in global network traffic as well as data storage in social networks, the Internet of Things, industry, among others. The Data Center must be prepared to support all this traffic, which tends to increase exponentially. The cabling infrastructure should use specific components, especially developed to handle the vast amount of data present in this environment.

In this chapter, we will explore the essential components for building a Data Center network infrastructure, their key parameters, and configurations.

Preconnectorized System Concepts

Structured cabling systems that employ factory preconnectorized cables are recommended for plug-and-play applications where ease of installation is paramount. Commonly used in optical channels, these systems allow for the assembly of channels without the need for splicing between components.

Primary Advantages:

- Flexibility and modularity, with optimized physical space utilization.
- Scalability and ease of expansion without degradation of quality.
- Quick and easy installation and reconfiguration.
- Simple handling, no special tools required.
- High performance in connections.
- Designed to support current and future data transmission rates

To ensure all the benefits offered by a preconnectorized system, it is essential to analyze the required topology and choose the correct components to meet the application requirements it will support.

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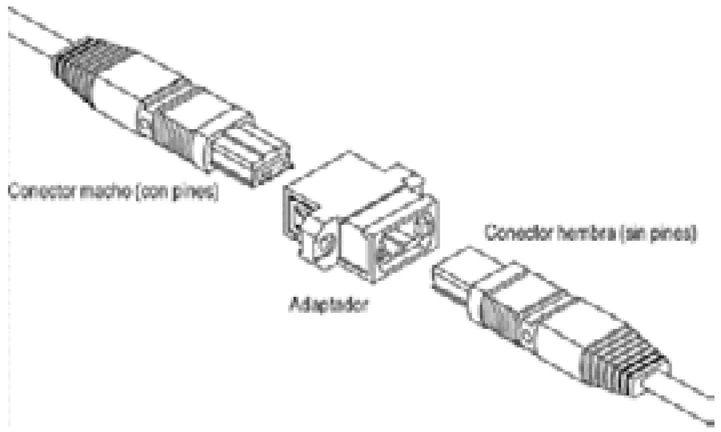
MPO Connector (Multi-Fiber Push-On)

Connectors, cables, and patch cords for two or more strands of optical fiber, also known as Array type (TIA). Standards for data centers ISO/IEC 24764 and ANSI/TIA-942-B specify MPO connectors for interfaces with more than two strands of optical fiber. They are multifiber optical connectors that can contain from 4 to 72 optical fibers in a single connector. Initially, their application aimed to optimize the optical backbone, replacing the need for multiple cables with one or two fibers. Currently, there is a new focus on developing applications for 40 Gbps and 100 Gbps, as well as new applications for 200 Gbps and 400 Gbps on multimode optical fibers and Transceivers with MPO connectors. Currently, the most widely used applications include connectors with 12 and 24 fibers. They are available in male (with guide pins) or female (without guide pins) versions, and there should always be a connection between a 'male' and a 'female' element

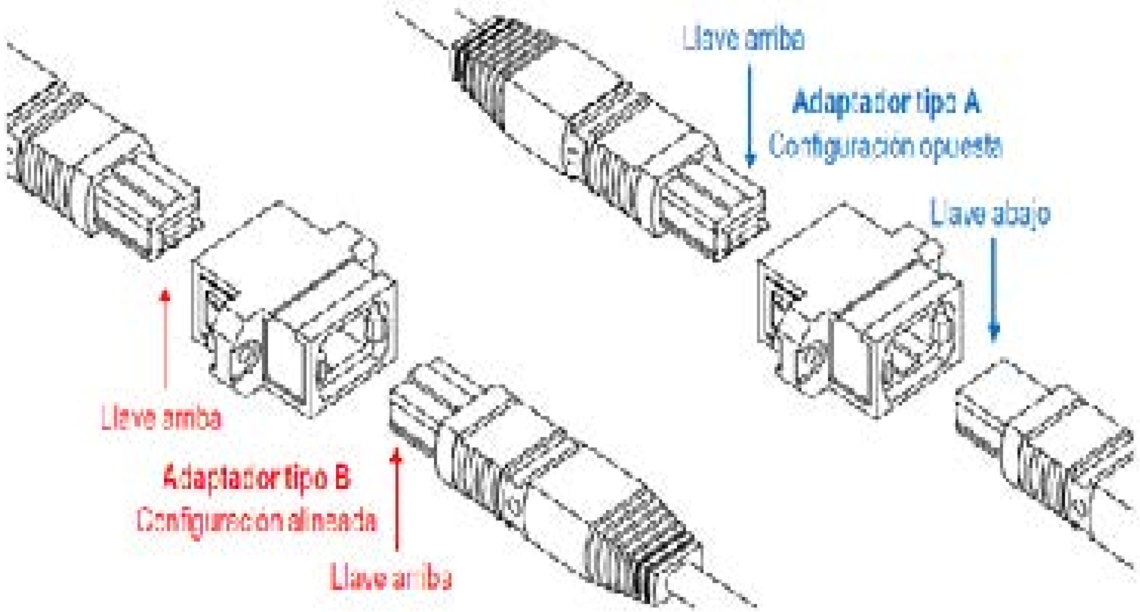


MPO Adapte

MPO adapters are elements that align between two MPO connectors. They have polarity according to the position of the connector's keying feature. Considering that MPO connectors must be compatible in gender and polarity, the correct operation of an MPO optical channel depends on the correct combination of these two variables to be functional.

To facilitate the design of the optical channel and ensure compatibility with legacy networks (which may have different gender and polarities than currently supplied products), the Universal MPO Connector has been developed. This connector allows you to change the gender of the connector from male to female and vice versa, as well as polarity, from key-up/key-up for changing the gender of the MPO Connector from male to female and vice versa.

In addition to the benefit of greater flexibility in the design and maintenance of MPO optical channels, there is a gain in the management of optical components due to the fewer number of required pieces



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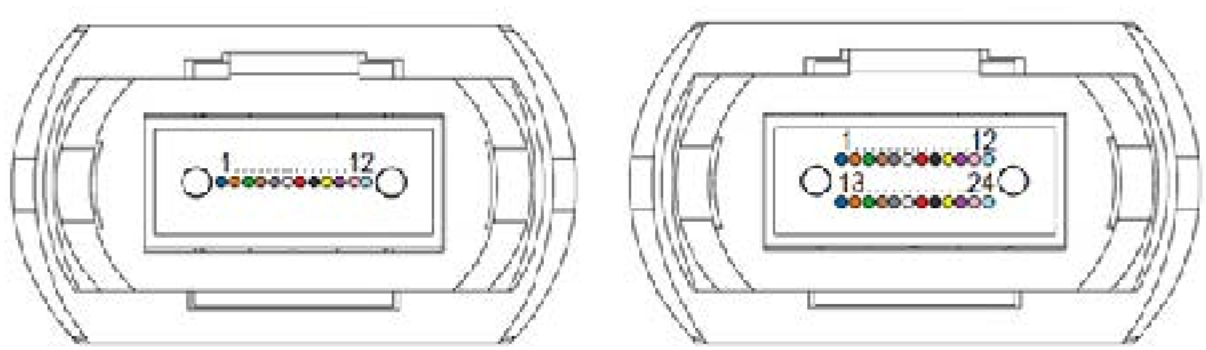
MPO Connector Standards

IEC 61754-7-1 (2014), Fibre optic connector interfaces – Part7-1: Type MPO connector family – One fiber row.

IEC 61754-7-2 (2014), Fibre optic connector interfaces – Part7-2: Type MPO connector family – Two fiber rows.

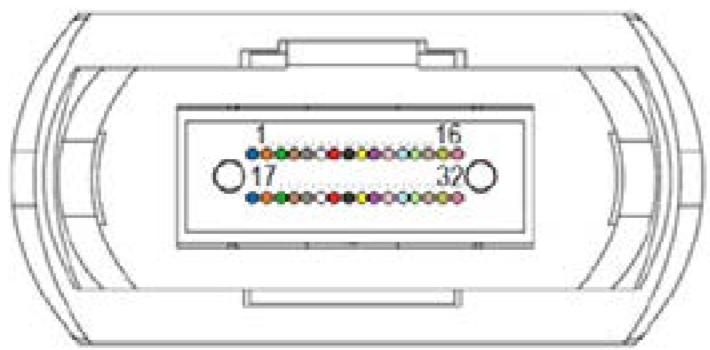
TIA-604-5-E (2015), FOCIS 5 Fiber Optic Connector Intermate ability Standard – Type MPO.



MPO-16

IEC CD 61754-7-3, Fibre optic connector interfaces - Part 7-3:Type MPO connector family - Two fiber rows 16 fiber wide

TIA-604-18 (2015), FOCIS 18 Fiber Optic Connector Intermate ability Standard - Type MPO-16 fiber.



MPO Connectors Base 8/12/16/24/32”

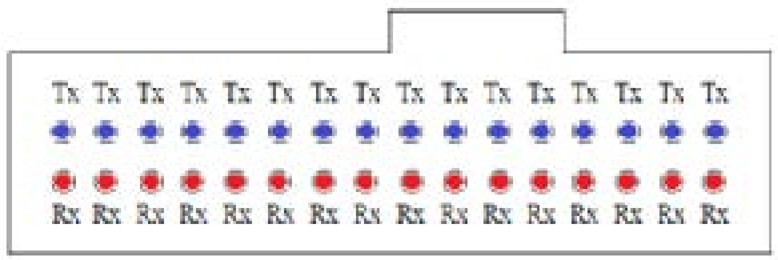
The development of equipment with MPO connectors has brought the possibility of parallel transmissions using multiple fibers. This optimizes the number of transceivers in equipment with higher transmission capacities. The use of MPO connectors with 12 and 24 optical fibers for parallel transmission of 8 fibers (4 transmitting fibers and 4 receiving fibers) and 20 fibers (10 transmitting fibers and 10 receiving fibers) respectively, ends up wasting resources, impacting infrastructure, and port density in IDFs (Internal Distribution Frames). Therefore, what is called Base 8 was generated with MPO connectors with 8 fibers.

In addition, there are other transmission standards for applications of 200Gbps and 400Gbps, and even 800Gbps, with connectors of 16 and 32 fibers that are being standardized.

Draf IEEE 802.3bs 400GBase-SR16

Optical Line Assignments.

The 16 transmission optical lines and 16 reception lines of 400GBASE-SR16 will occupy the positions shown in the figure when looking inside the MPO receptacle (MDI) with the connector’s slot function at the top. The interface contains 32 active lines. The transmission optical lines occupy the upper 16 positions. The reception optical lines occupy the lower 16 positions.

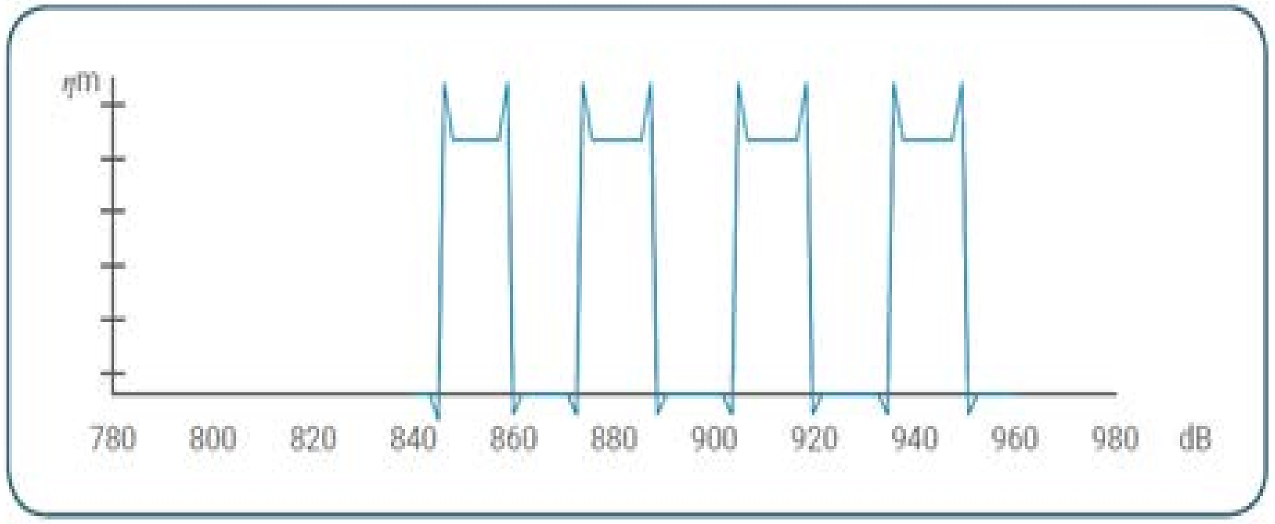


Until recently, OM3 and OM4 (optimized multimode fiber for laser [LOMMF]) were the primary choices for multimode fiber cabling to support 10G, 40G, and 100G Ethernet, InfiniBand, and Fibre Channel protocols.

However, as bandwidth requirements increase much faster than the VCSEL-based transceiver technology curve, it becomes more costly for optical fiber cabling systems to support the migration to next-generation Ethernet speeds. For example, in the IEEE 802.3bs draft standard, 400GBASE-SR16 has been specified to reuse 100GBASE-SR4 technology but requires a new MPO-32 connector instead of an MPO-12 connector (pictured above: 400GBASE-SR16 Interface (MPO-32)).

A potential alternative: wideband multimode fiber. Wideband multimode fiber (WBMMF) is an ANSI/TIA development that can cope with increasing data speeds and the infrastructure needed to support higher bandwidth. It uses wavelengths to increase the capacity of each fiber by at least a factor of four, allowing for at least a fourfold increase in data speed (or a fourfold reduction in the number of fibers needed to achieve a certain data speed—instead of using four independent fibers to transmit four optical signals, the signals can be sent over one fiber through four separate operational windows)

ANSI/TIA-492AAAE, the new wideband multimode fiber standard, was approved for publication in June 2016 after a 20-month industry study conducted by a special TIA working group within TR-42.11 (Optical Systems Subcommittee) and TR-42.12 (Cables and Optical Fiber Subcommittee). The International Organization for Standardization / International Electrotechnical Commission (ISO/IEC) has recently decided on the nomenclature for the wideband multimode fiber cable: OM5. This new fiber cable standard has already been mentioned by the IEEE 802.3 working group for the development of next-generation Ethernet standards



Multimode OM5 Fiber Transmission Windows"

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As the bandwidth of OM5 fiber increases, transmissions of 40 Gbps or 100 Gbps can be achieved over a single pair of fibers using different wavelengths (850 nm, 880 nm, 910 nm, and 940 nm). For example, a 100GBASE-SWDM4 application can perform four 25 Gbps transmissions over a pair of fibers at different wavelengths. This translates to a fourfold reduction in the amount of optical fiber required, less use of infrastructure, and ease of management.

In the future, it will also be possible to achieve speeds of 200 Gbps and 400 Gbps through a single pair of optical fibers. Undoubtedly, SWDM optical fiber technology opens new perspectives for the use of 40G, 100G, 200G, and 400G applications, with better utilization of infrastructure, equipment, and optimization of space in Data Centers. OM5 optical fiber confirms the trend of evolving transmission capacity for multimode fibers.

Fiber cable type ISO/IEC 11801	Glass fiber specification TIA-492AAAx	Core diameter (µm)	Max refractive index difference	Minimum modal bandwidth (MHz·Km)					Maximum glass fiber attenuation (dB/km) TIA-492AAAx IEC 60793-2-10				Maximum fiber cable attenuation (dB/km) TIA 568.3-D ISO/IEC 11801			IEEE 802.3 link Distance				
				Overfilled launch (OFL) bandwidth			Effective modal bandwidth									100-SR	10G-R	40G-SR4 & 100G-SR10	100G-SR4 & 400G-SR16	50G-SR & 200G-SR4*
				850nm	953nm	1300nm	850nm	953nm	850 nm	953 nm	1300 nm	1310 nm	850 nm	953 nm	1300 nm					
OM1	TIA-492AAAA	62.5	00.2	200		500			3.2			0.9	3.5		1.5	275m	33 m			
OM2	TIA-492AAAB	50	0.01	500		500			3			1	3.5		1.5	550m	82m			
OM3	TIA-492AAAC	50	0.01	1500		500	2000		2.5			0.8	3.0		1.5		300m	100m	70m	70m
OM4	TIA-492AAAD	50	0.01	3500		500	4700		2.5			0.8	3.0		1.5		400m	150m	100m	100m
OM5	TIA-492AAAE(WB MMF)	50	0.01	3500		500	4700	2470	2.5	1.8		0.8	3.0	2.3	1.5	no spec	400m	100m	100m	100m

Polarity

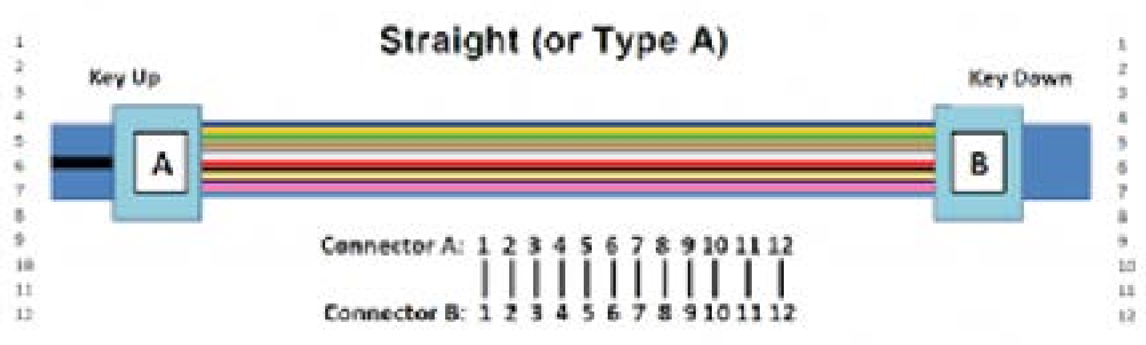
All optical connectivity methods share the same purpose: to create a communication path between the transmit port of one device and the receive port of another device. There are different ways to achieve this, but they are not interoperable. Therefore, careful selection is necessary, and the chosen pattern must be maintained throughout the installation's lifespan.

Below are the standards recognized by ANSI/TIA-568.3-D."

ANSI/TIA-568-C Standard

The ANSI/TIA-568-C standard recognizes three methods for configuring parallel transmission

TYPE A



MPO-MPO cables of TYPE A have fiber 1 at one end representing fiber 1 at the other end.

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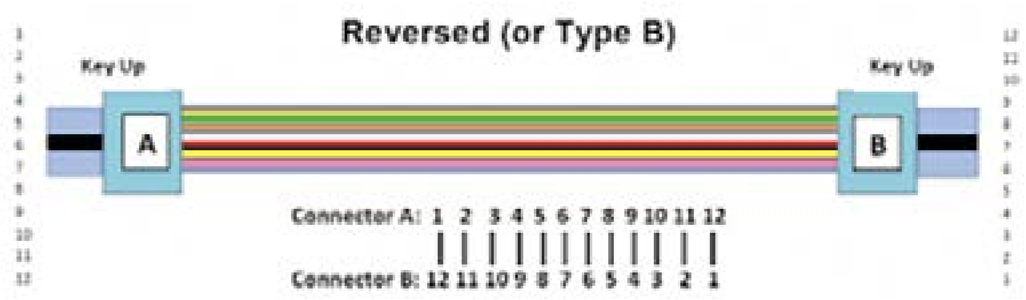
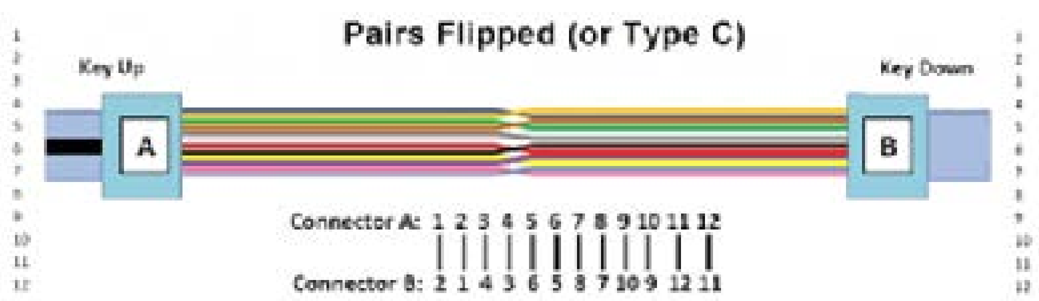
TYPE B



MPO-MPO cables of Type B have fiber 1 at one end representing fiber 12 at the other end. In this case, a complete inversion of fibers occurs

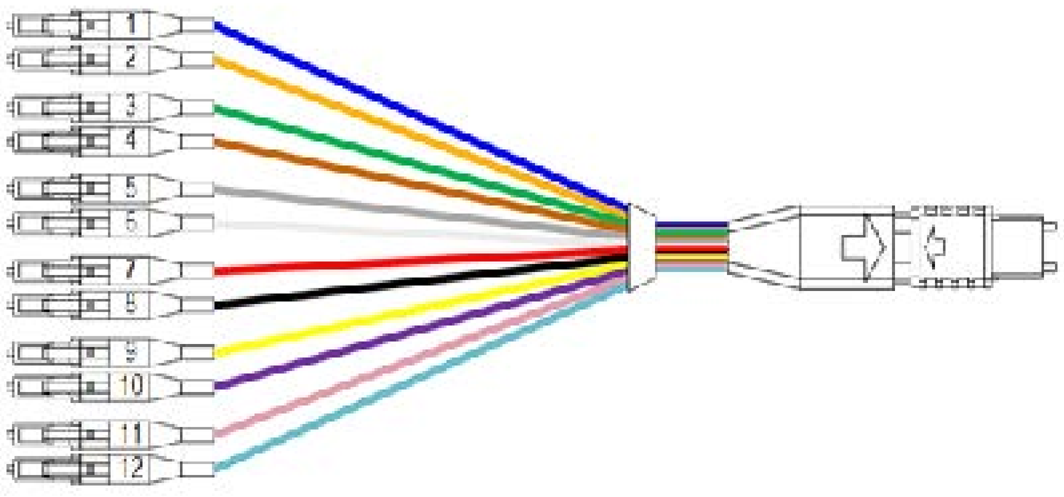
TYPE C

MPO-MPO cables of TYPE C have fiber 1 at one end representing fiber 2 at the other end. In this case, inversion occurs only on a 'pair' of fibers (i.e., fiber 1 and 2 are considered a pair of fibers, or an optical channel)

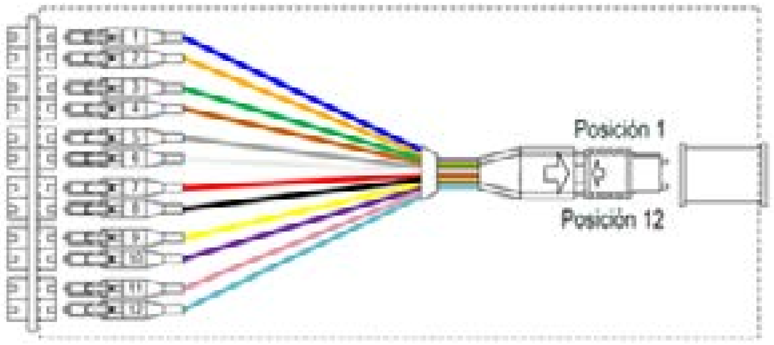


With all elements of Type B cabling, future network migrations from 1/10G to 40/100G or 200/400G, or future speeds, are simplified and, therefore, standard supply products can be applied. These include protocols not yet approved by the IEEE, such as 40G BiDi, 40G SWDM, and 100G SWDM, and new transmission protocols: 800 Gbps, 1.6 Tbps.

Conversion cable from duplex to multifiber



Duplex to multifiber conversion module



Method A Inversion in Cord. Requires different cords for both duplex and parallel channels.

Method B Module Inversion. Requires different modules for duplex channels. Ideal for supporting parallel channels.

Method C Trunk Inversion. Identical cords and modules for duplex channels and different cords for parallel channels.

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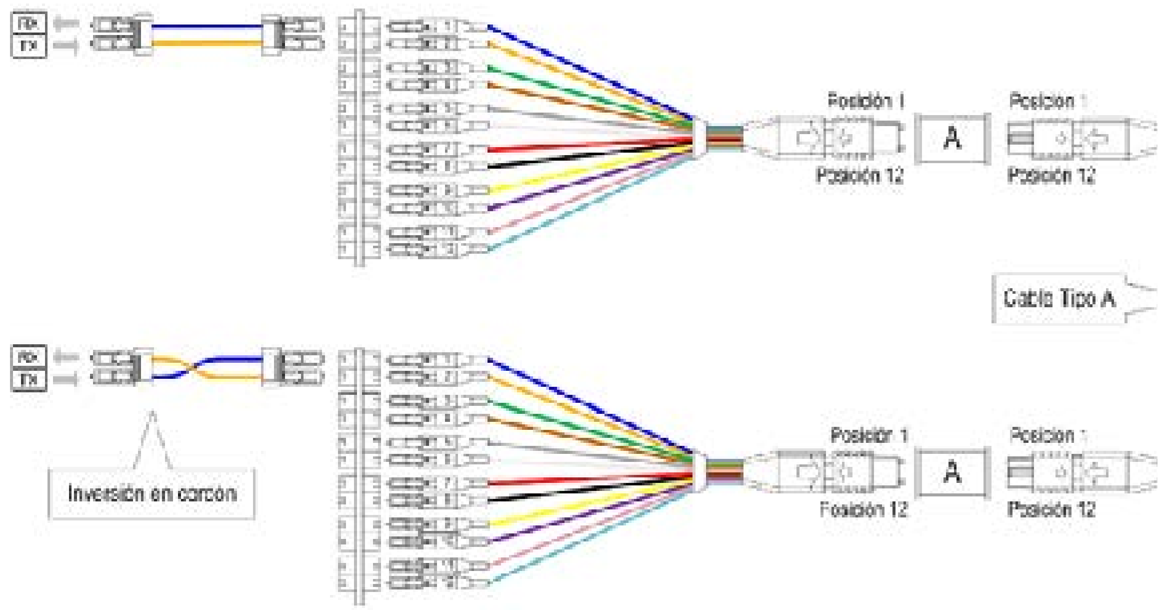
Components for Duplex Channels in Multifiber Links

MÉTODO	CORDONES	CONVERSIÓN	ADAPTADORES	CABLE
A	Uno A-B y Uno A-A	Estándar	Tipo A alineado	Tipo A
B	A-B	Uno estándar y otro con par invertido	Tipo B opuesto	Tipo B
C	A-B	Estándar	Tipo A alineado	Tipo C (par invertido)

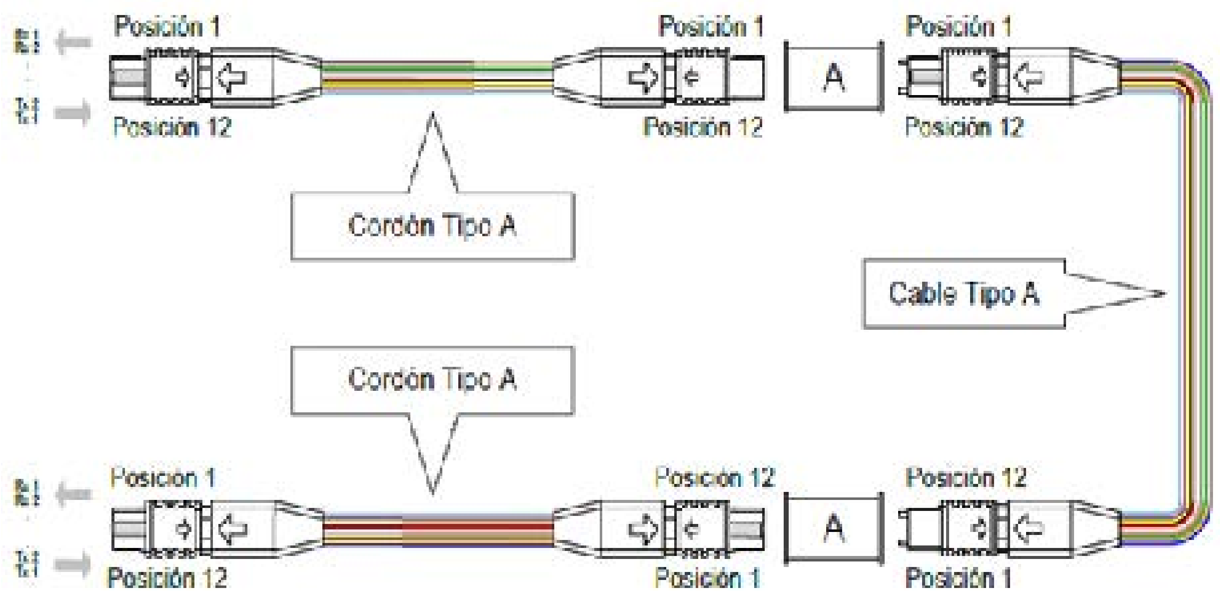
Components for Multifiber Channels

MÉTODO	CORDONES	ADAPTADORES	CABLE
A	Uno tipo A y uno Tipo B	Tipo A alineado	Tipo A
B	Tipo B	Tipo B opuesto	Tipo B
C	Uno Tipo B y uno Tipo C	Tipo A alineado	Tipo C (par invertido)

The polarity for duplex channels in the method.



Polarity for multifiber channels Method A



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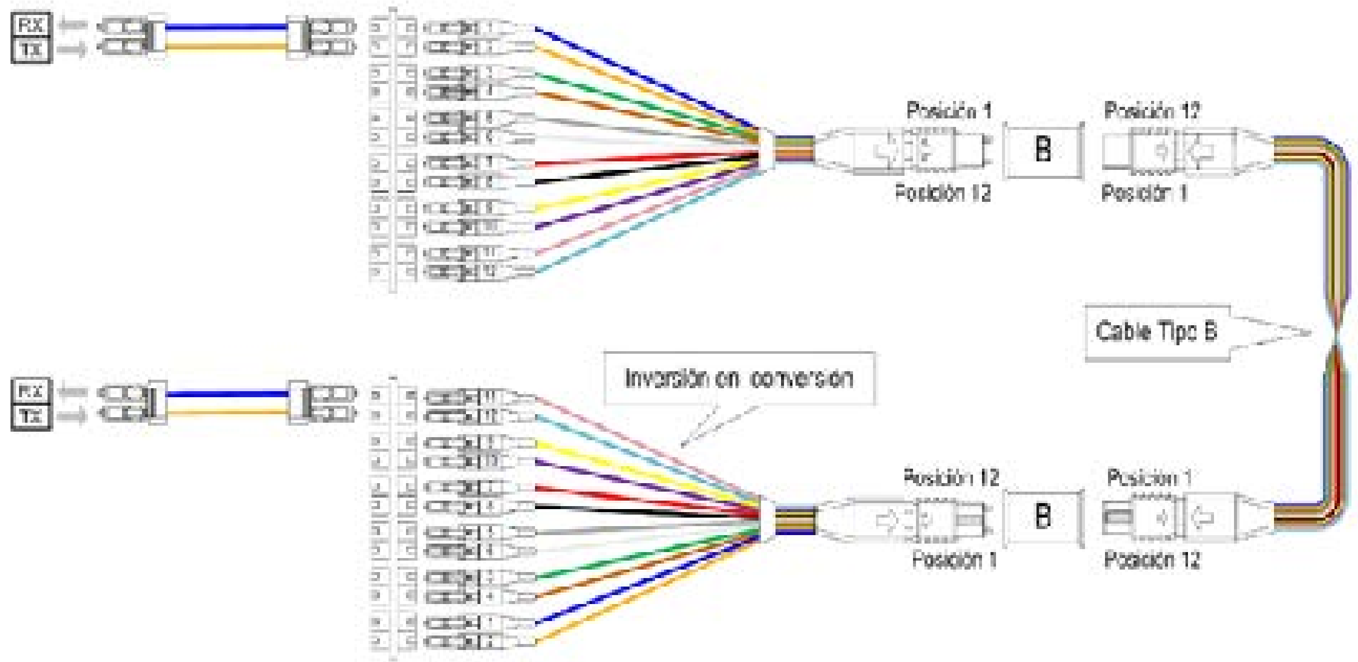
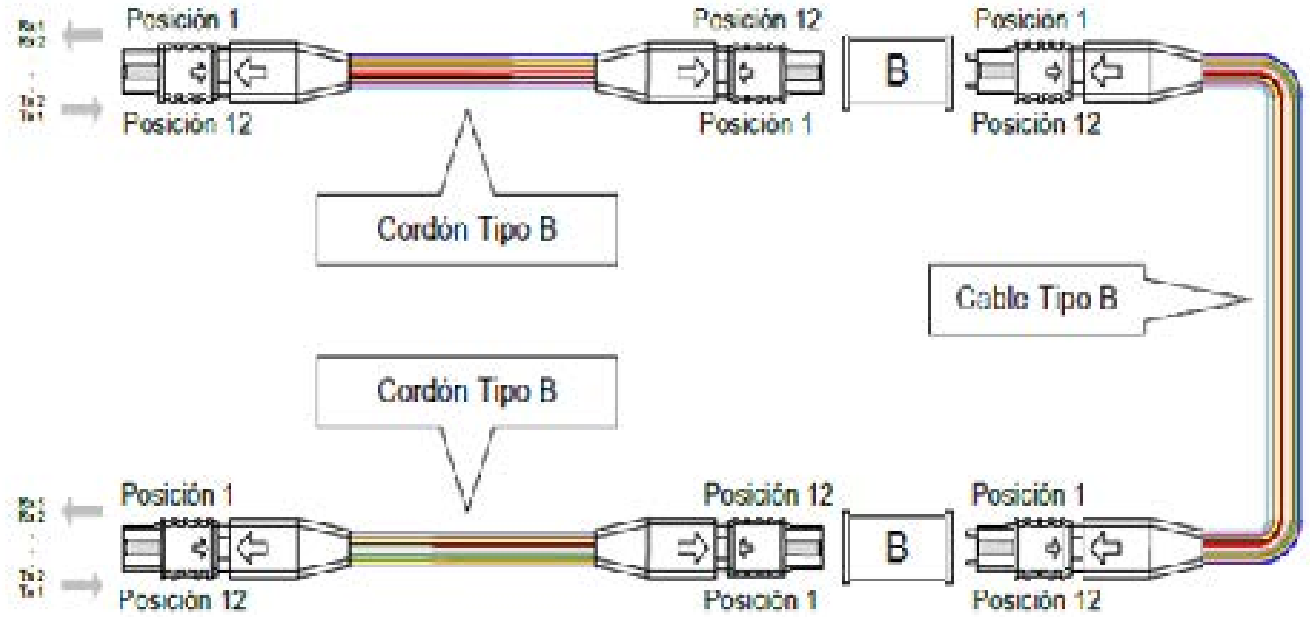
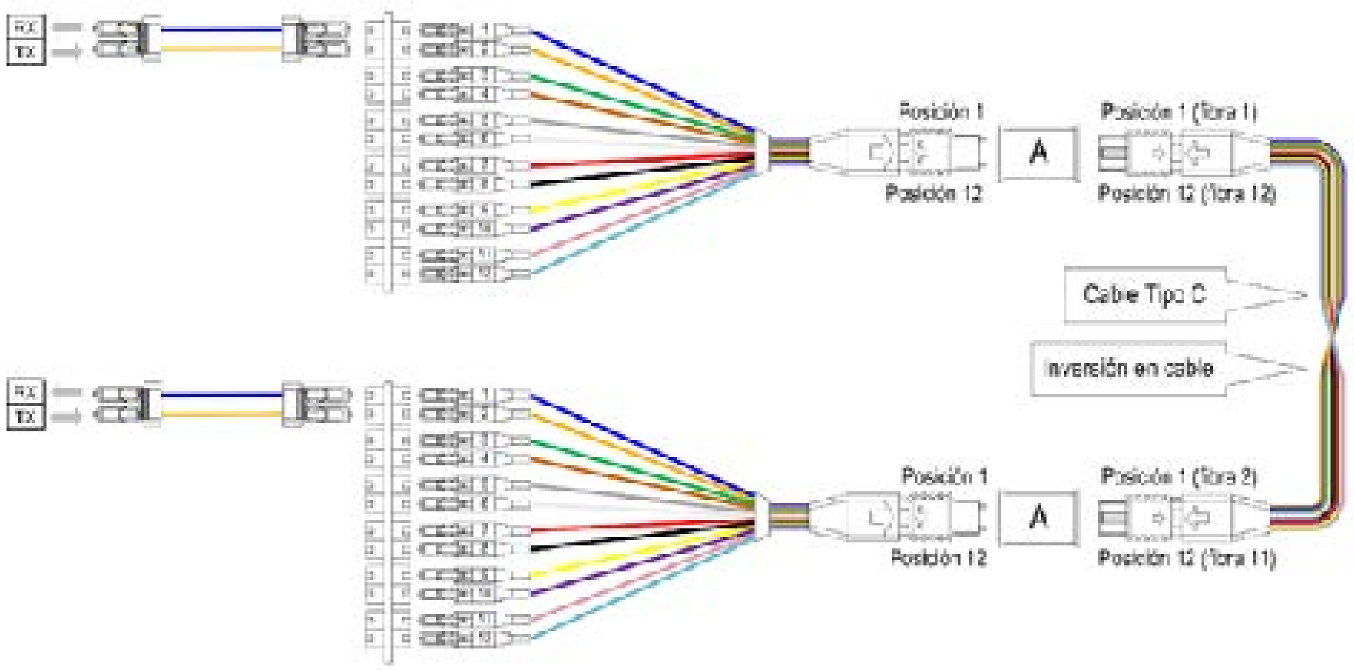
Polarity for duplex channels Method B



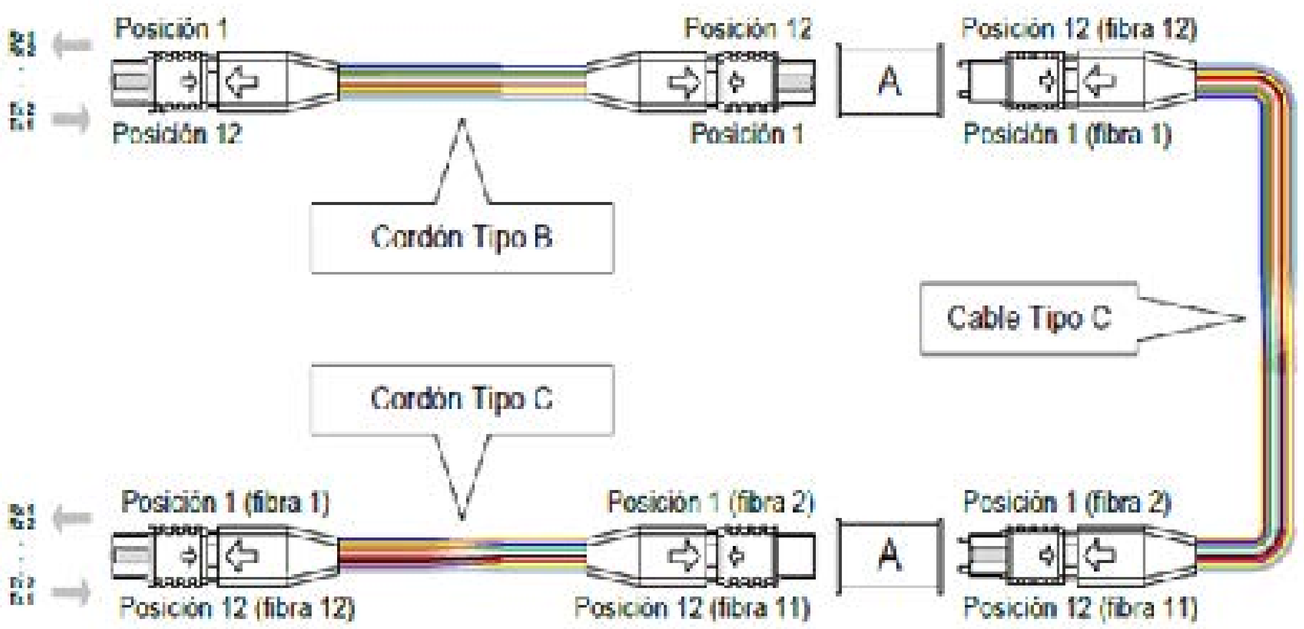
Polarity for multifiber channels Method B



Polarity for duplex channels Method C



Polarity for multifiber channels Method C



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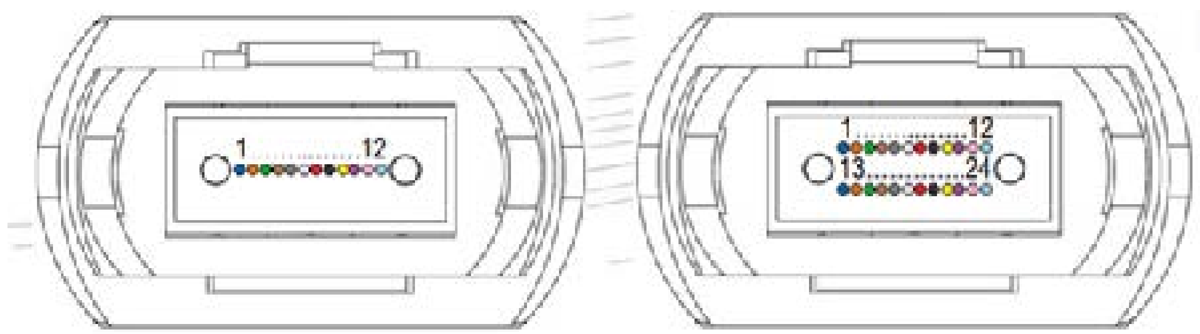
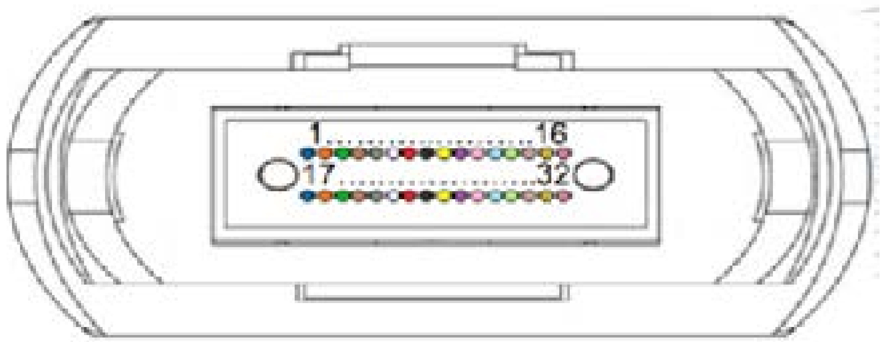
For channels with two or more connections, it is necessary to verify:

- The male/female standard for all MPO connections.
- The polarities of the products, considering that for 40G transmission, it is necessary to have an odd number or 100% of TYPE B components in the channel.
- Estimation of optical loss for the optical channel or Loss Budget, which is the sum of insertion losses (IL [dB]) of passive optical components present in the channel according to ANSI/TIA-568-3.D.

According to the ANSI/TIA-568-3.D standard representation, channels traveling through a pair of optical fibers, such as 1/10G/40G BiDi/40G SWDM4 (QSFP+) and 100GSWDM4 (QSFP28), can be configured as follows:



Bjumper



Type MPO connector family - Two fiber rows 16 fiber wide

Pre-connectorized Multifiber Solutions.

MPO (MTP) Trunk Cable and MPO to LC Module Solution, Ideal for Data Centers, Offers the Following Advantages:

- Consistency, uniformity, and termination quality
- 100% factory-terminated and tested
- No field termination required
- Reduces installation time
- Minimizes failures
- Seamless migration from 10G to 40G/100G

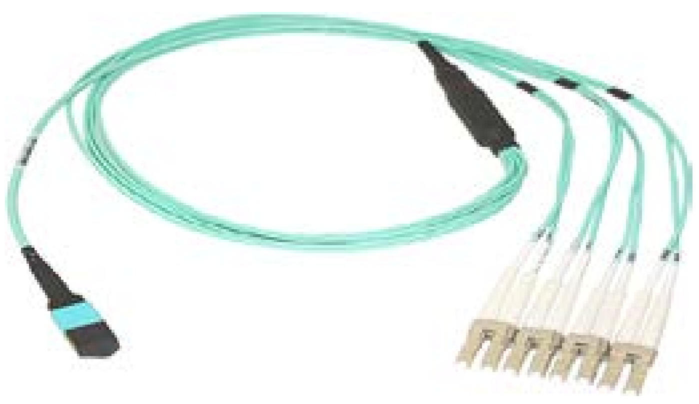


Illustration 24: MPO to 4 LC Duplex Patch Cord

MPO to MPO Patch Cord, OM4

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Fiber Optic Specifications

Categoría de fibra óptica	Longitud de onda (nm)	Atenuación máxima (dB/Km)	Ancho de Banda Modal Mínimo sobrellenado (MHZ-KM)	Ancho de Banda Modal Mínimo efectivo (MHZ-KM)
Multimodo OM3·50/125um	850 1300	3.5 1.5	1500 500	200 No Se requiere
Multimodo OM4 50/125 um	850 1300	3.5 1.5	3500 500	4700 No Se requiere
Multimodo OM5 50/125 um	850 953 1300	3.0 2.3 1.5	3500 1850 500	4700 2040
Monomodo OS1a	1310 1383 1550	1.0 1.0 1.0	– – –	– – –
Monomodo OS2	1310 1383 1550	0.4 0.4 0.4	– – –	– – –

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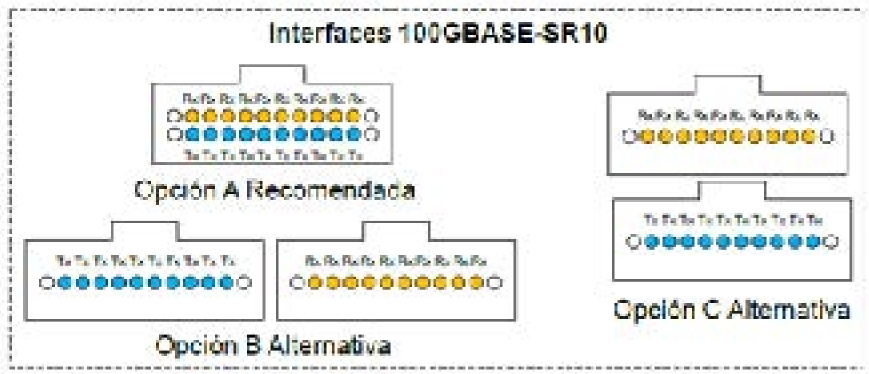
Ethernet Applications Support in Multimode Duplex Fiber Optic (FO)

Aplicación	Longitud de onda (nm)	OM1	OM2	OM3	OM4
1000BASE-SX	850	2.6 dB	3.6 dB	(Ver 1 GFC)	(Ver 1 GFC)
		275 m	550 m		
1000BASE-LX	1300	2.3	2.3 dB	2.3 dB	2.3 dB
		550 m	550 m	550 m	550 m
10GBASE-S	850	2.4 dB	2.3 dB	2.6 dB	2.9 dB
		33 m	82 m	300 m	400 m
10GBASE-LX4	1300	2.5 dB	2.0 dB	2.0 dB	2.0 dB
		300m	300 m	300 m	300 m
10GBASE-LRM	1300	1,9 dB	1.9 dB	1.9 dB	1.9 dB
		220 m	220 m	220 m	220 m
25GBASE-SR	850			1.8 dB	1.9 dB
				70 m	100 m

Bjumper

Ethernet Applications Support in Multimode Multifiber Fiber Optic (FO)

Aplicación	Longitud de onda	Nº Fibras	OM3	OM4
40GBASE-SR4	850 nm	8	1.9 dB	1.5 dB
			100 m	150 m
Multimodo OM4 50/125 um	850 nm	8	1.8 dB	1.9 dB
			70 m	100 m
Multimodo OM5 50/125 um	850 nm	20	1.9 dB	1.5 dB
			100 m	150 m



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Conversion Patch Cables

Enable higher density and lower loss than conversion modules

MTP 2:3 Patch Cord for 40GBASE-SR4 and 100GBASE-SR4”

Patch cord MTP 1:2 for 100GBASE-SR10” by “MTP 1:2 Patch Cord for 100GBASE-SR10”.

MTP to 4 LC Duplex Patch Cord (40G Link Aggregation)”.

Bjumper

Transition from 12 to 8 Fibers in MPO Connections”.

The 12-fiber MPO connectivity emerged in the mid-90s and contributed to the development of infrastructure in data centers. It is a divisible technology that supports duplex applications. However, the new SR4 and QSFP+/QSFP28 protocols are based on 8-fiber interfaces, NO 12.

- **40GBASE-SR4** (4 for transmission and 4 for reception at 10 Gb/s).
- **100GBASE-SR4** (4 for transmission and 4 for reception at 25 Gb/s).
- **Multimode and parallel single-mode** at speeds of 200G and 400G are also in development, based on an 8-fiber configuration.
- **Channels in current and emerging standards** from 10G to 400G are divided into either 2 or 8 fibers, NOT 12.

When using 12-fiber connectivity for 8-fiber applications, 33% of the fibers remain unused. To achieve 100% utilization with 12-fiber connectivity, conversion modules or patch cords of 2:3 (Two 12-fiber MPO connectors to three 8-fiber MPO connectors) are required.

Conversion modules or patch cords add complexity and attenuation to the link. Modules introduce more material and greater loss due to an extra connection.

When using 8 fibers or multiples of 8:

Advantages

- Achieve 100% fiber utilization without the need for complex and costly conversion cords or modules.
- Much better performance than conversion modules, which add higher attenuation to the channel, limiting the supported distance and the number of connections.
- Provides the simplest migration path from 10G to 40G/100G. Can be used in both duplex and parallel port applications