

TAP's

Advance Optical Modules

In Data Centers

Amphenol Network solutions

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Amphenol
NETWORK SOLUTIONS™

Introduction:

Security starts with visibility and optical TAPs (Test Access Points) or TAPs provide that visibility by permitting the replication of traffic on a network to a different route, which feeds a monitoring device, without any disruption to the network. This “mirror” traffic will provide visibility for troubleshooting the network, looking for malicious software or other threats.

Two ways of Tapping:

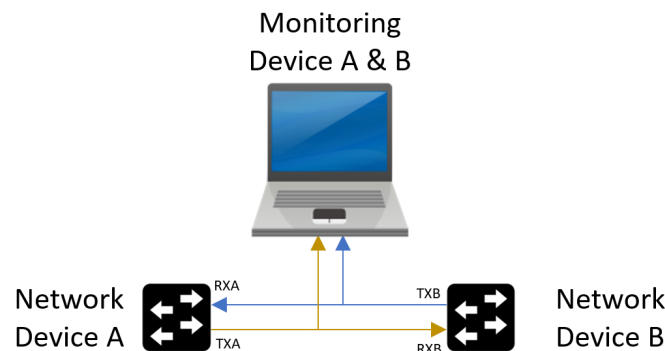
Span ports on switches vs optical taps

The usage of span ports for network visibility is cheap and quick to deploy. Unfortunately, there are trade-offs including a reduction in the port count, ports can be deactivated by software, and it cannot detect 100% errors. In addition, the usage of span ports compromise CPU usage, etc.

On the other hand, optical taps are passive, no power is required. Monitor ports and live ports can be configured as the customer requires (total front access, monitor and live ports or front monitor and live ports on the back etc.), 100% of errors are revealed, data can be routed to multiple tools, and they keep live network and monitoring network independent of each other. Cons to consider are the Capex cost and rack space required. Amphenol Network Solutions offers the best options available, of the highest density in the market (front and back of the chassis) to save rack space, with the most affordable price on the industry.

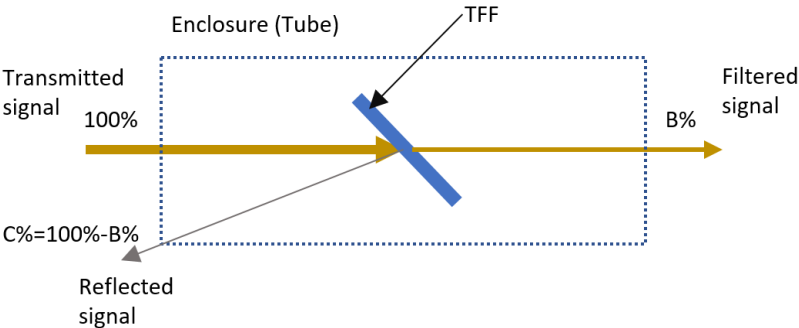
What is an Optical Tap?

A Test Access Port, or sometimes referred to as a Traffic Analysis Point, is an optical filter (physical device) connected between 2 network elements. This filter will take a certain amount of light and send it to a different port to be connected to a monitoring device. It will allow the communication flow without any disruption.



The picture above shows how communication works between the network elements A and B. Each element has 2 ports (TX, RX) that need to be connected to the opposite port on the other side (i.e. TXA -> RXB & TXB-> RXA). These connections are made with fiber optic cables and the optical filter (center of the picture) takes a percentage of the TXA & TXB light and sends it to the monitoring device. This is the basic concept of network monitoring. Datacenters are not as simple as this - the size and complexity of the newest architecture and protocols of connectivity such as Base 8, require more sophisticated planning to achieve a proper network monitoring design.

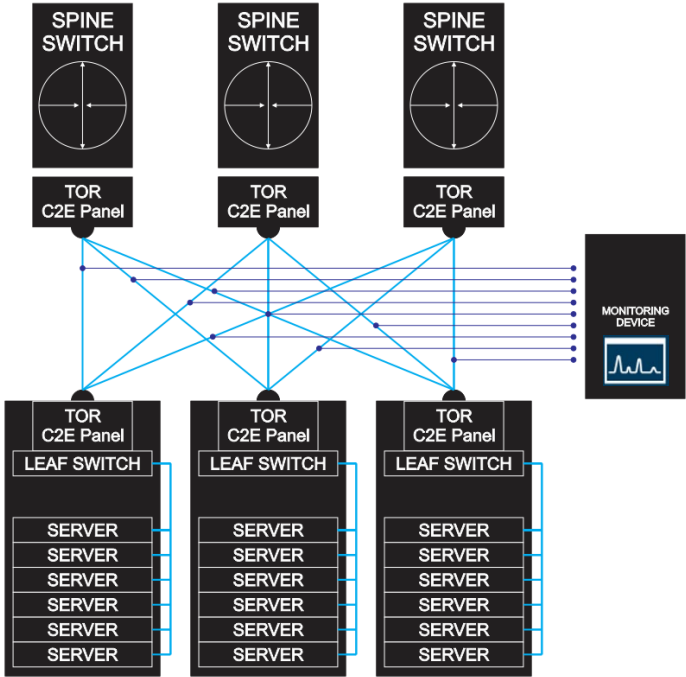
The technology used to create this type of hardware for multimode applications, is TFF (thin film filters). The name might sound familiar because of other applications such as WDM on single mode fiber. The reason for using TFFs is high bandwidth, and the speeds that this technology can support. TFFs are created by putting thin layers of material with special optical properties onto an optical-grade glass. In the WDM world, these layers are designed to filter, block or reflect certain light frequencies. In the tap world, these layers are designed to let most of the light to pass from point A to point B and reflect the desire amount of light to a different port (monitoring port).



As previously mentioned, there is no disruption in the communication, and the reflected signal is an exact copy of the information on the network. Ratios can vary depending on the customer needs, the most popular are: 50/50 and 70/30 (70% of the light going to the live network and 30% of the light on the reflected leg or monitor port). It is important to note that there will be intrinsic losses on the system. Therefore, it is not possible to achieve the 70% or the 30% of the total light on the ports - up to 5% of the total light will be dispersed. This is a known loss and is specified on each module and will not impact overall performance.

Hyperscale, datacenter and enterprise tapping

On a Spine & Leaf (S&L) architecture, is recommended to have the highest speed possible between Spine Switches and Leaf Switches (40G, 100G, 200G or even 400G) to support connectivity between the leaf switch and equipment. Leaf Switches linked to the servers are typically copper connections (DAC's) with a lower speed. Remember that certain amount of oversubscription is allowed, it does not have to be a 100G for 10x10G. The paths between the spine and leaf switches are where it is recommended to have network visibility. Below is a simplistic example of where to locate the taps.



Considerations for selecting optical taps

Tap's module selection will depend of the following primary factors:

1. Type of fiber
 - Single mode or multimode (OM3, OM4 or OM5)
2. Type of connector
 - LC or MPO
3. Optical Link Budget factors
 - Power Budget vs Loss Budget
 - Speed
 - Distance
 - Ratio
4. Architecture (TOR, EOR, MOR etc.)

1. Type of fiber

In the hyperscale world, big players who don't like to be limited by the relationship between speed and distance use Single Mode transceivers because of the range (tens of kilometers depending of the model) and virtually no speed limit (WDM). SMF pluggables used to be very expensive compared with similar Multimode options. Nowadays it is different. PSM4 transceivers with 500m reach can be found at very affordable prices.

Single mode connectivity is preferred in outside plant applications. In the enterprise and datacenter markets, where the connectivity is inside the plant, multimode fiber is the preferred way for connecting inside of the building. Transceivers using VCSEL's (vertical-cavity surface-emitting laser) are cheaper but distance limited - usually the paths need to be <150m (depending of the speed).

Bottom line, long distances inside the datacenter implicates more investment, therefore, more single mode fiber. Multimode fiber is a cost-effective solution recommended for shorter links.

2. Type of connector

There are many options in the market for connectors, the most popular are LCs and MPOs. The most important differentiation is an LC connector can be used for serial communication and an MPO connector for parallel communication.

LC connectors are simple to install, maintain, clean and identify. Serial protocols such as Wavelength Division Multiplexing uses LCs because multiple lines of modulated information can be sent over a single fiber (SMF). Multimode fiber also uses LC connectors, most of the time the communication is "single lambda, single line" which means, no modulation.



Fig. One strand of single mode fiber can carry many different modulated signals using WDM

In the MPO world things are different. The main difference is density. There are either 8, 12 or 24 fibers in the same space as 2 simplex LC connectors. Considering that the C2E can support 72 LC duplex ports in 1RU, by replacing the LC connectors with MPOs, the same panel can support up to 576, 864 or, theoretically, 1728 fibers in the same single unit of rack space.

The MPOs polarity must always be taken in account before installations. Cleaning MPO connectors can sometimes be a struggle because they utilize a single ferrule for multiple connections. Also, if one line goes wrong, the entire cable needs to be replaced. Despite these challenges with the MPO connectors, they are still the preferred way to interconnect high-end datacenters.

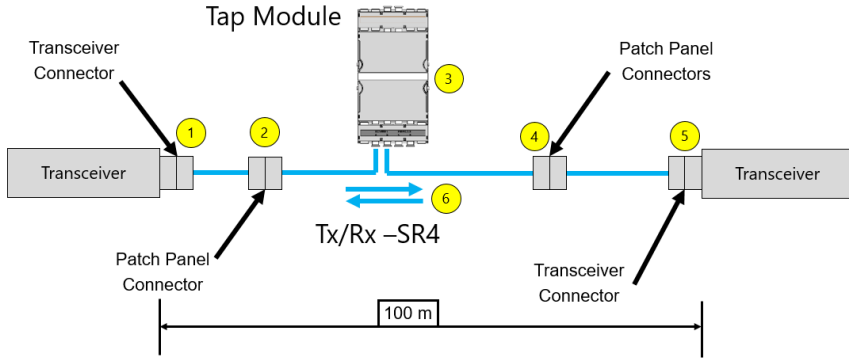
3. Optical Link Budget – *it is not in the scope of this present document to be meticulous about this topic because of the complexity*

The power budget can be obtained by taking the transmission power of the transceiver selected (0 dB), minus the RX sensitivity (i.e. - 8.2dB). The result, in this example, is an 8.2 dBm power budget. The connectivity between both transceivers (cable attenuation, connectors, splices and TAP modules) needs to ensure less than 8.2 dB of loss.

For each pair of connectors, a 0.2 dB loss for LC and 0.35 for MPO/MTP should be considered. Please note that these numbers refer to Ultra Low Loss versions. If standard connectors are used, the loss will be higher. Every pair of fusion spliced fibers will add 0.3 dB loss based on the standard EIA/TIA 568. However, some installation contractors will not approve any of their splices above 0.05 dB loss.

For the Amphenol Network Solutions SR4 taps, an IL of ≤ 2.40 dB on the live network and ≤ 6.40 dB on the monitor side needs to be considered in the design. Multimode cable and the attenuation/length relation, 0.35dB in this case (100m x 0.0035 dB loss (3.5 dB/Km in this case)), will affect the loss budget equation.

Link Budget Live Network

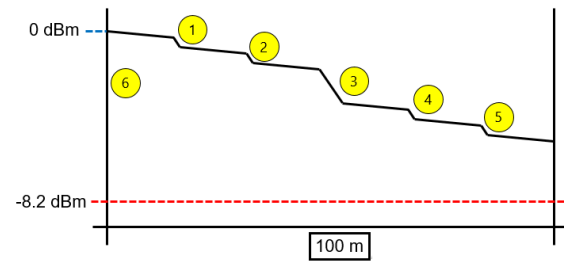


	Power dBm
Transceiver TX	0
Transceiver RX sensitivity	-8.2
Total Power Budget	8.2

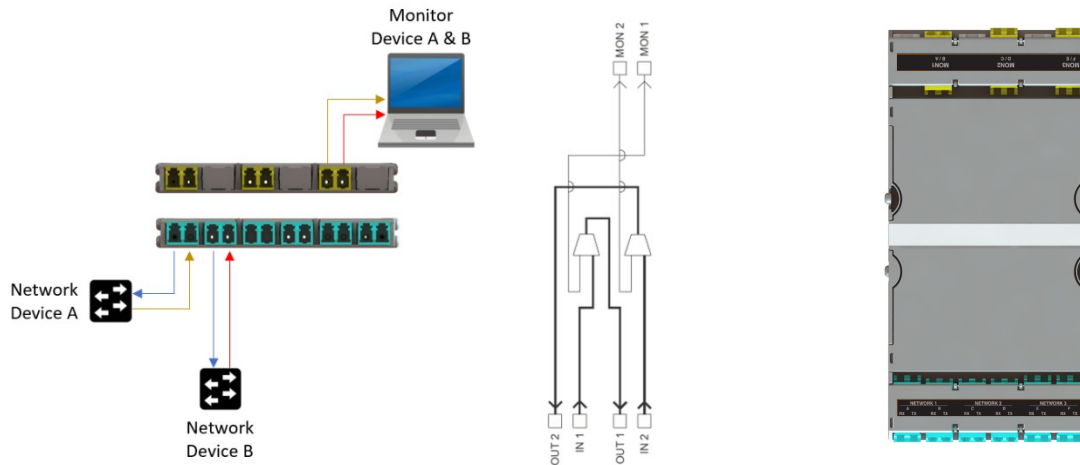
#	Component	Loss (dB)
1	Transceiver connector MPO	0.35
2	Patch Panel Connector MPO	0.35
3	Tap Cassette Live Port 70%	2.40
4	Patch Panel Connect MPO	0.35
5	Transceiver connector MPO	0.35
6	OM4 (100m)	0.35
Total loss budget		4.15

IL Specs (Tap only)		
70/30	Live IL (dB)	Mon IL (dB)
MAX	2.40	6.40

Power Budget dBm	Loss Budget dB	Link Budget dBm
8.2	4.15	4.05

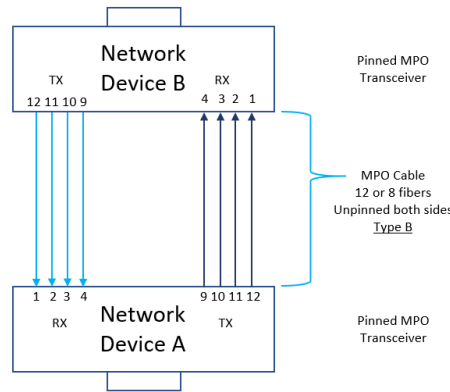


4. Configuration and wiring examples

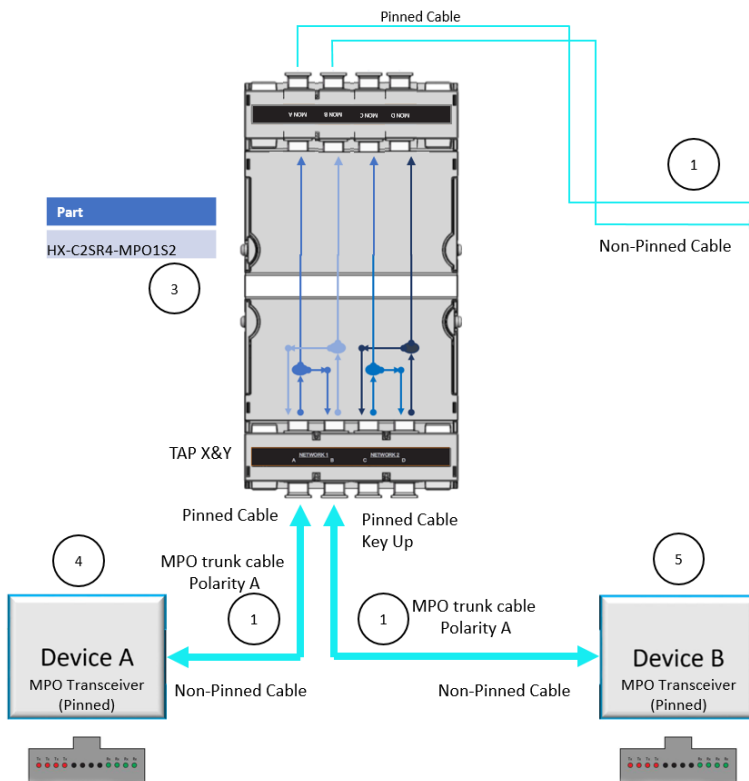


The system above shows a basic diagram of connecting a tap in the system (single lambda (wavelength) on a single fiber). The network device A transmits to the RX port on the network device B and TXB is connected to the RXA. This is done with 2 OM4 duplex jumpers on the front of Amphenol Tap. On the back, monitor outputs coming from the network devices A & B are connected to the monitor device. 100% of the traffic will be mirrored to the monitor port with no disruption on the live channels. In this specific case, 70% of the light is going from TXA & TXB to the correspondent RX on the other side, 30% is taken and transmitted to the monitor ports.

An MPO systems with SR4 protocol can be connected as shown. MPO connectors in this scenario have 12 fibers and only 8 are used, 4 for transmit and 4 to receive. The 4 center fibers are not used.

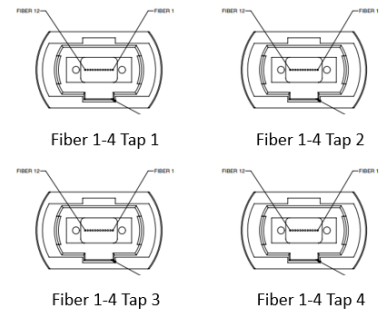


The connectivity between these two network devices is simple. Both transceivers are MPO connectors, male (or pinned), and the cable between them (in this case) is an MPO to MPO multimode cable, female (or unpinned) on both sides (type B). This paper will not dig in deep about polarity, but it will simplify the challenges on MPO systems.



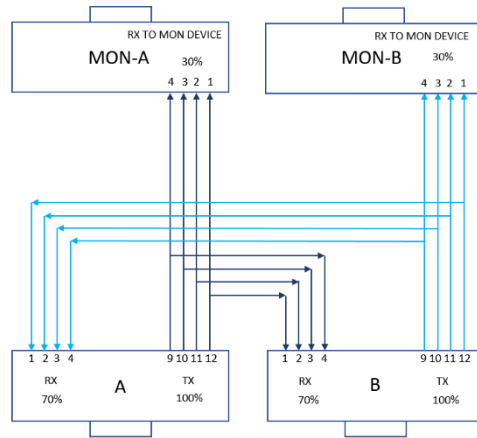
MON ports pinout

(All monitor output through ports 1-4)



Item no.	Device	Polarity	Pinned
1	MPO12 Trunk cable Amphenol	A	Side A Pinned (Male) to Cassette Side B Unpinned (Fem) to Network Device (SLX)
3	MPO SR4 Tap (Key Down) Amphenol	NA	Unpinned Both • network links MPOs • monitors MPOs
4	Network Device A (Key Up)	NA	Pinned
5	Network Device B (Key Up)	NA	Pinned
6	Monitoring System (Key Up) SLX	NA	Pinned

In the situation diagrammed above, the tap must be installed between 2 network elements. The Amphenol module HX-C2SR4-MPO1S2 used in this example has several interesting characteristics. First and foremost, all the MPO cables around the system are type A, so there is no need to manage polarity on this exercise. The Amphenol module could be considered type B (in theory) because it will allow the communication between both network devices with polarity A cables - one from Device A to the Tap and the other one from the Tap to the Device B. Traffic will be mirrored to the back of the module, again allowing the use of 2 MPO type A cables from the Mon A & Mon B of the module to the monitoring device.



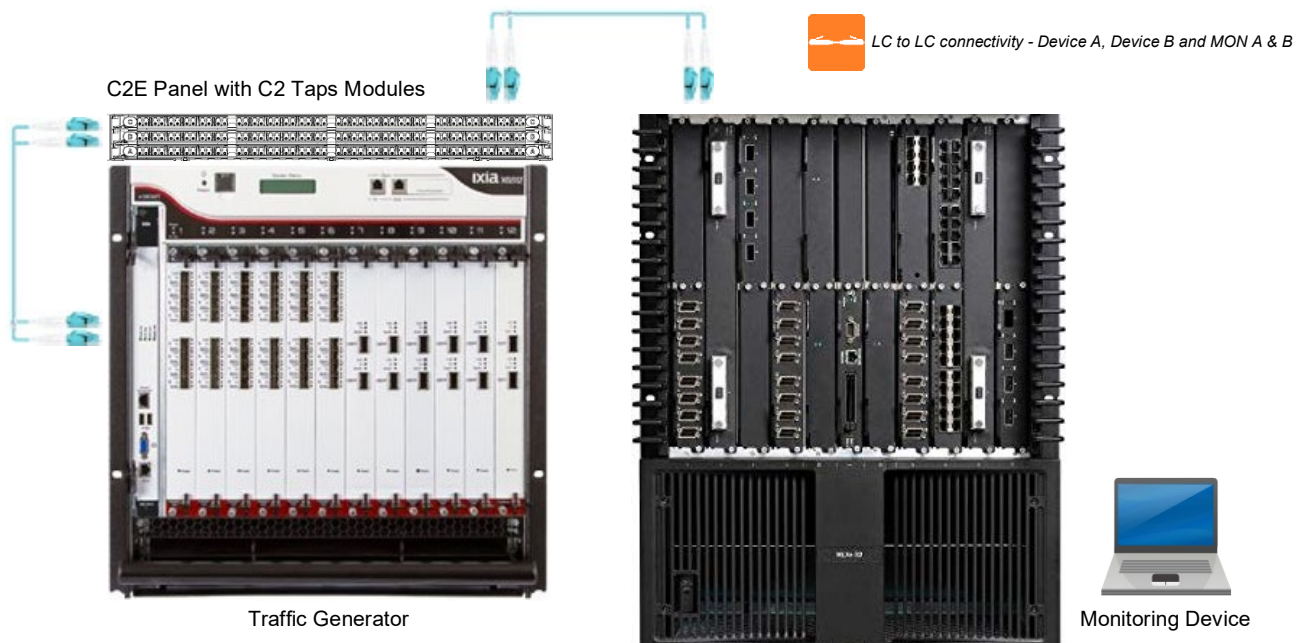
The image above shows how the schematic and the polarity are managed when only type A elements are required around the Amphenol tap module.

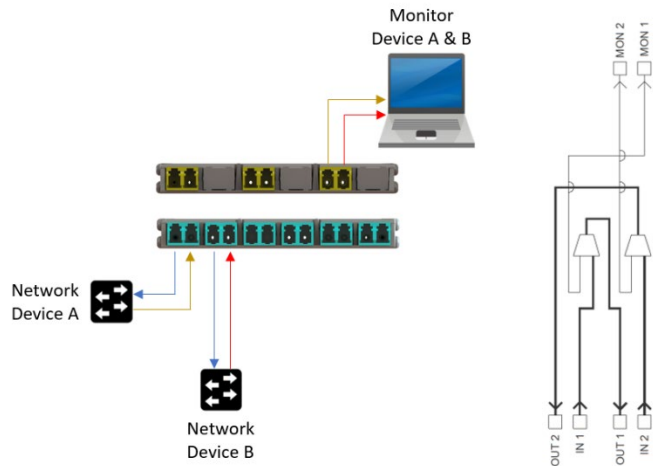
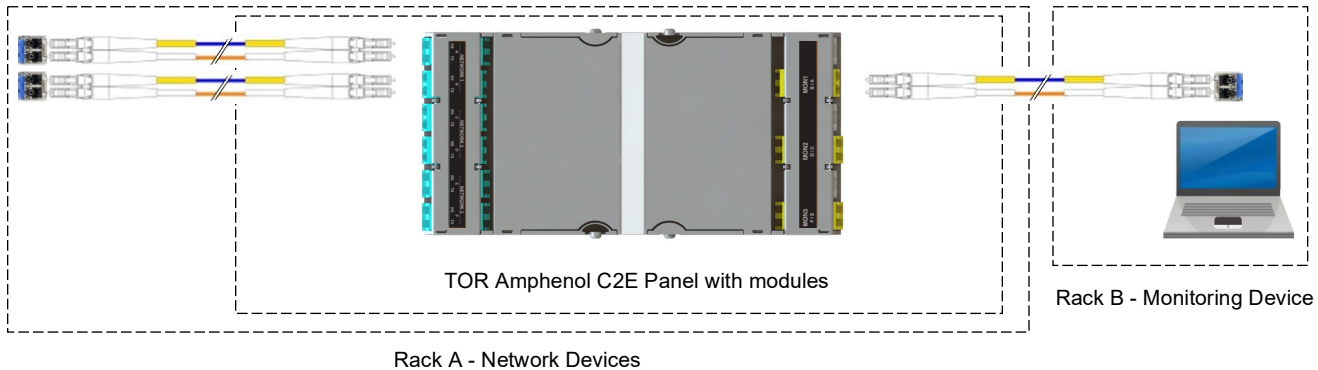
Separating the live network (front) from the monitor network (back) will avoid disruption caused by human errors. Installers working on the monitor side of the system will not be in contact with the live network. However, Amphenol has the capability to build TFA (total front access) modules for field implementations with no rear access on the rack.

Another important thing to note is that the MPO connectors on each cable need to be male (pinned) and the Amphenol module is all female connectors (unpinned).

a. Configuration 1 – LC to LC (Tap3 single module HX-TAP6-73MML)

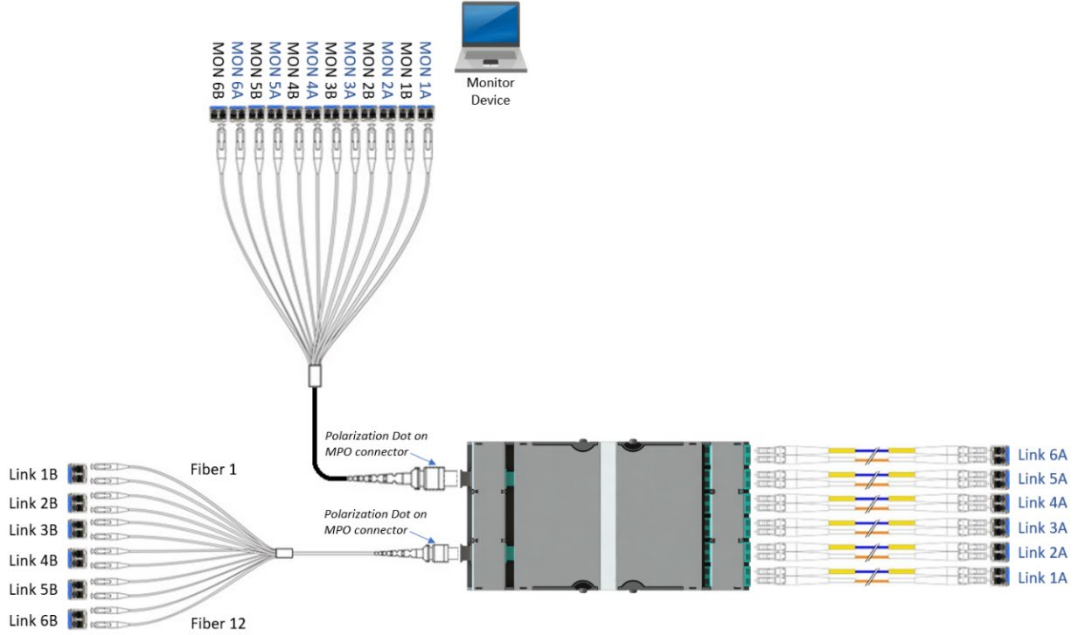
The configuration shown below was used in a customer's lab. A TOR (Top of Rack) C2E panel was used as a Patch/Tap connection between the 2 network elements (same rack) and the monitor signal was sent to a different rack. Short cables were used ($\leq 5m$) so the attenuation was negligible, and the traffic was 100% copied with C2 tap modules to the monitor device, which is receiving 30% of the signal.





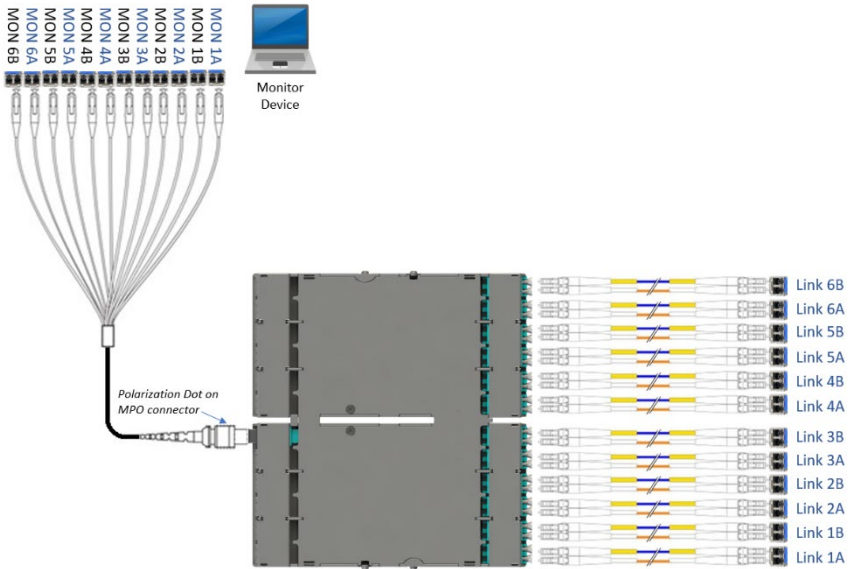
1.1. Configuration 2 – LC, LC and MPO (Tap6 single module HX-T6-73L-M2)

In the configuration below, network devices A and B can be on the same and/or different rack, doubling the density per 1RU and per module. This is preferred because of the cable consolidation of the MPO fanout cable and the monitoring device. Another difference with the previous configuration is the monitor cables are consolidated on a single 12-fiber MPO fan out cable from the TOR panel to the Monitor Rack. In the diagram below, the communication links are shown. Transceiver A1 is talking to B1, A2 to B2 and so on. The same is true for the corresponding monitor channel for each transceiver (MON 1A, 1B, 2A, 2B etc.).

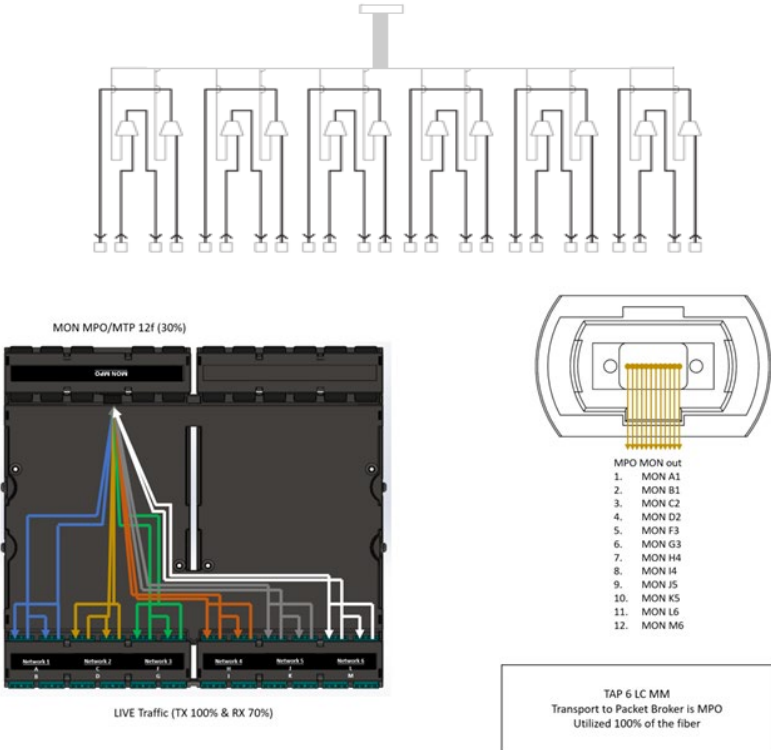


1.2. Configuration 3 – LC, LC and MPO (Tap6 dual module HX2-T6-73L-M1)

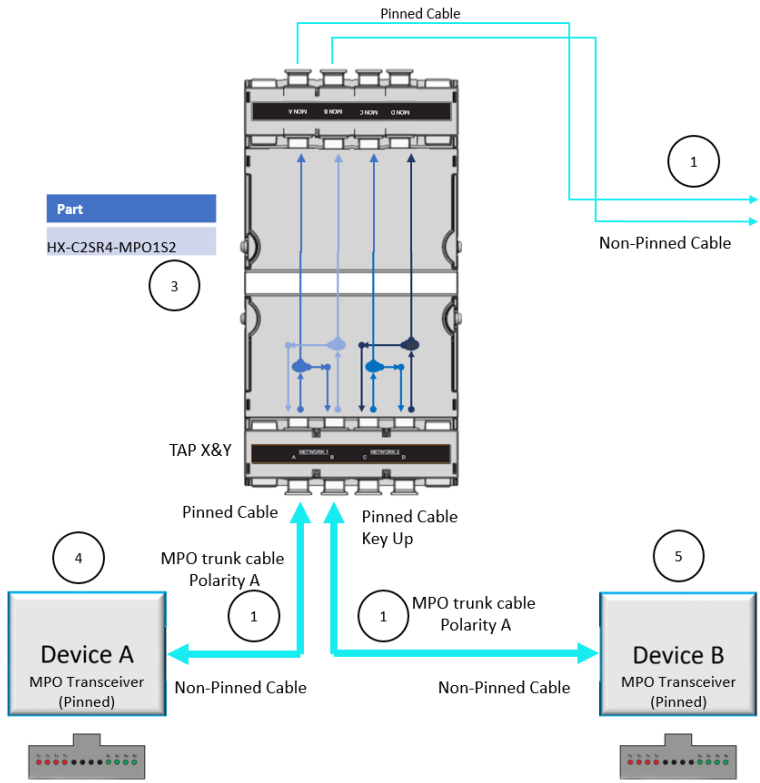
Introducing the C2 dual module, this configuration includes 6 Taps on each dual module (same density as the configuration 1), the benefits of this option are having both network devices on the same rack and sending the monitor signal to a different rack, consolidating fiber cabling on a MPO fanout cable to the monitoring device and breaking up into LC connectors.



Schematic:

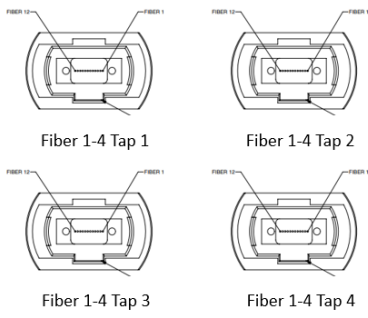


1.3. Configuration 4 – SR4 40G, 100G & 400G (HX-C2SR4-MPO1S2)

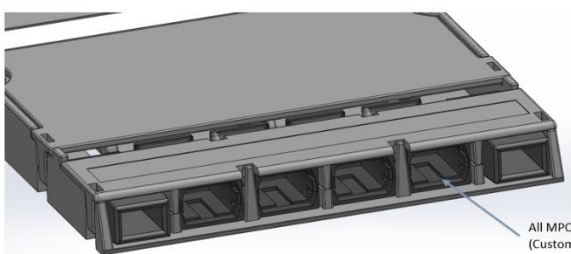
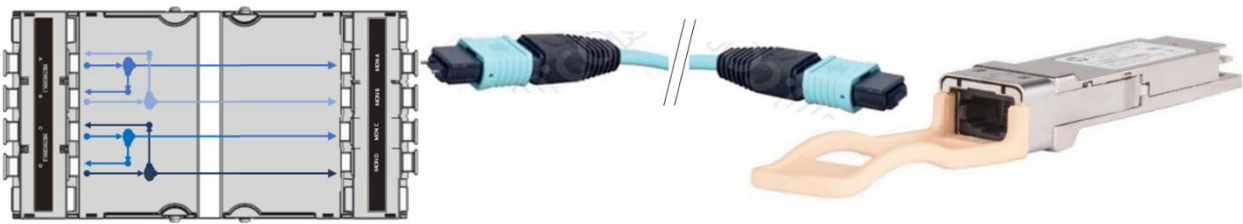


MON ports pinout

(All monitor output through ports 1-4)



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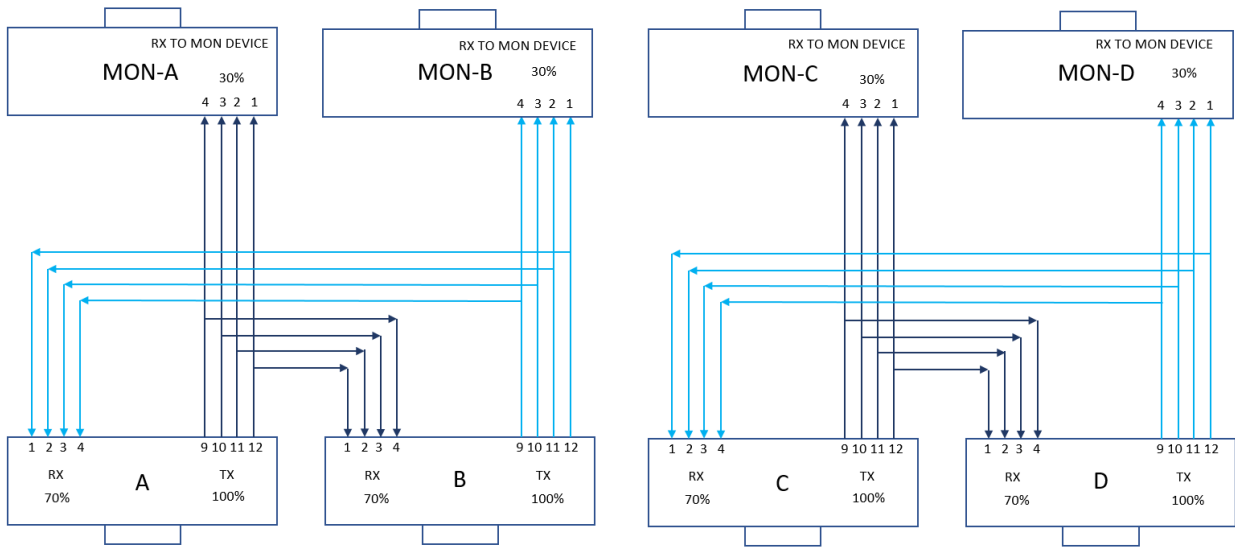


All MPOs on C2 Cassettes are key down (Customer facing)

- 1 MPO trunk cables must be:
- Pinned (male) connector on the TAP side
 - Unpinned (female) on the transceiver side
 - Type A

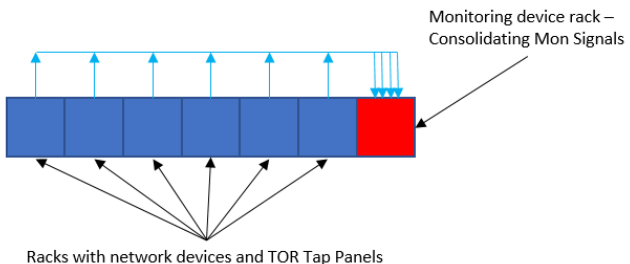
Note: Performance and optical specs on Telect TAPS HX-C2SR4-MPO1S2 & HX-C2SR4-MPO1S, are the same regardless the internal MPO connector gender

Schematic:

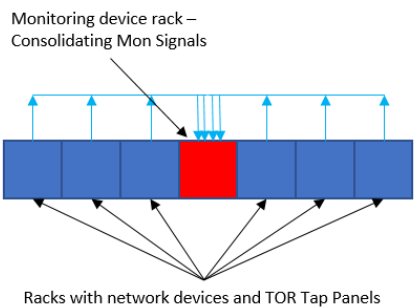


2. TAPs Architecture

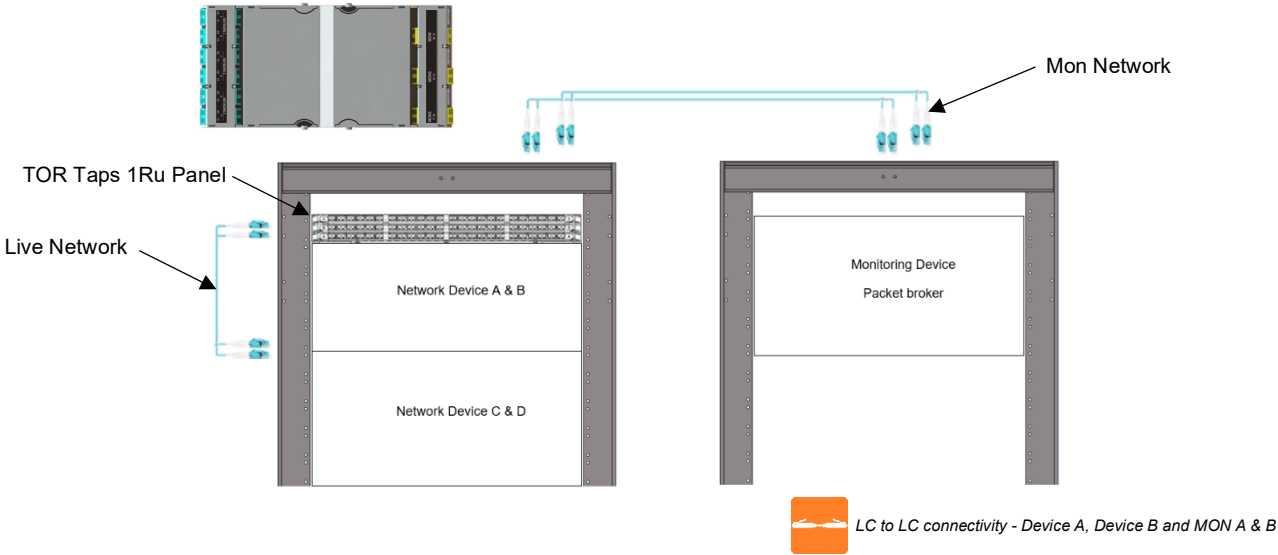
2.1. EOR (End of Row)



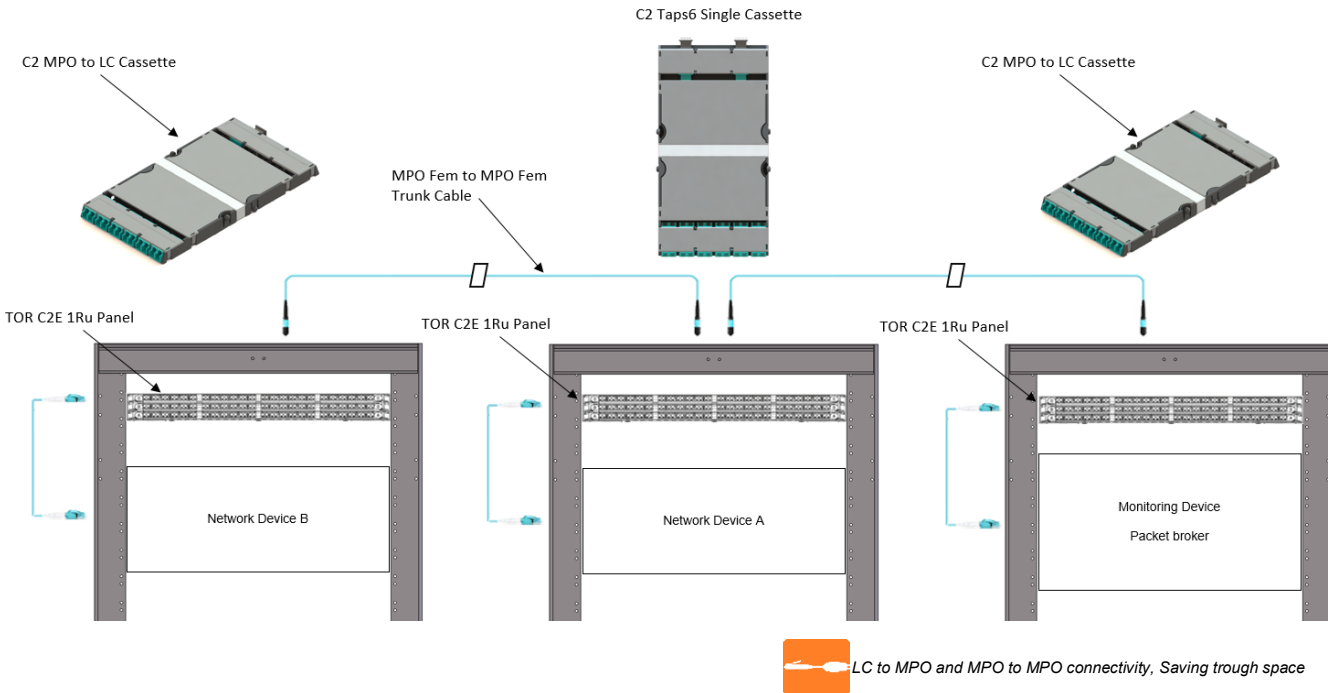
2.2. MOR (Middle of Row)



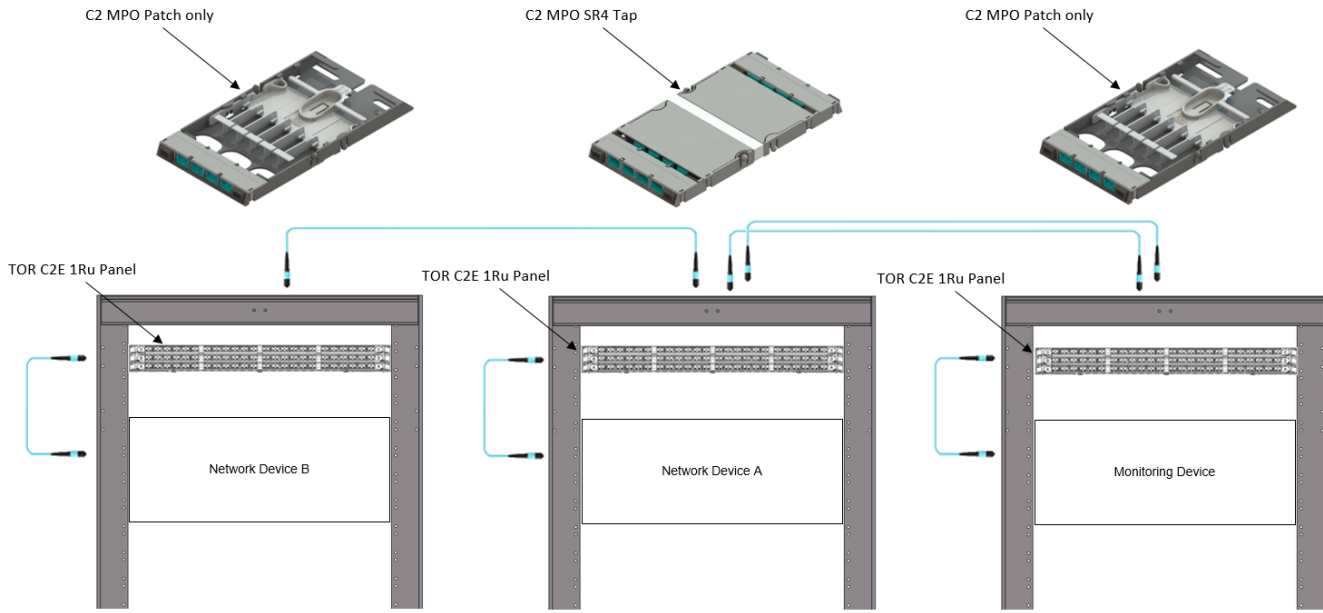
2.3. TOR (Top of rack) Patch, Live network (Devices A & B) within the same rack, monitoring device on a different rack (EOR or MOR)




2.4. TOR (Top of rack) Patch, Live network and monitoring device on a different rack (EOR or MOR)



2.5. TOR (Top of rack) Patch, Live network and monitoring device on a different rack (EOR or MOR)



 MPO to MPO Base 8 connectivity, Taps and Cross connect