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Network Solutions

White Paper

MPO Connector Basics and Best Practices

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Table of Contents

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Growth Brings New Opportunities

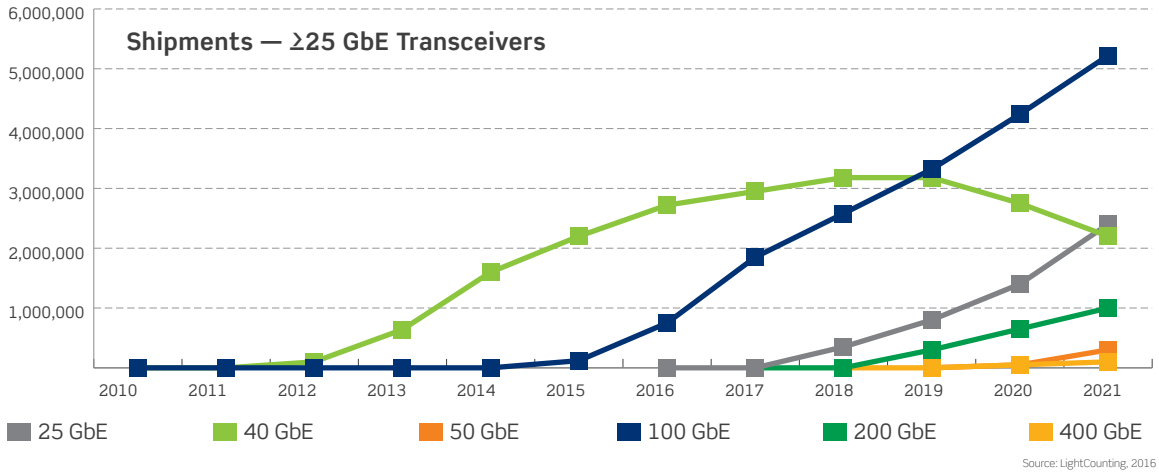
As the internet of things (IoT) continues to drive the need for additional bandwidth, higher speed and reduced latency is increasingly important. The adoption rate at which faster speeds and new transceiver form factors are being introduced into the market has ratcheted up exponentially over the past five years. As such, multi-fiber push on connectors or MPOs are becoming more and more relevant in data centers and enterprise networks.

In data centers, demand for 40 Gb/s reached its peak in 2018. Now, there's a significant growth pattern for 100 Gb/s, and parallel growth for 25 Gb/s lanes. Looking closer at the 100 Gb/s segment, 100GBASE-SR4 and 2 km reach transceivers make up the bulk of the 100 Gb/s demand.

The growth of 25 Gb/s and 100 Gb/s has a lot to do with the newer IEEE (Institute of Electrical and Electronics Engineers) and MSA (Multisource Agreement) specifications for 25 Gb/s lanes (IEEE 802.3bm, PSM4 and CWDM4). Previously, the preferred solution for 100 Gb/s was 10 Gb/s over 10 lanes (100GBASE-SR10), following the early IEEE 802.3ba specifications. But the adoption of 25 Gb/s per lane in IEEE 802.3bm has spurred the growth of newer 100 Gb/s solutions that are now on the market. Currently, there are quite a few 100 Gb/s transceivers that use MPO connectors.

The adoption rate of faster speeds and new transceiver form factors is accelerating quickly. With groups looking at developing 50 Gb/s and 100 Gb/s lanes for 400 and 800 Gb/s transceivers, network managers should be prepared to work with MPO connectors. Keep your cabling infrastructure flexible, as the adoption of next generation speeds is closer than you think and the number of options can make the path forward far from certain.

Dramatic Growth of 100 Gb/s Expected



Standards with MPO Connections

Although data centers are actively migrating to higher speeds, most enterprise data centers currently primarily use 10 Gb/s switches and 1 Gb/s servers. Cloud networks have operated at 40 Gb/s uplinks and 10 Gb/s at the server for the past several years. As pointed out earlier, these networks will move to 100 Gb/s uplinks and 25 Gb/s at the server as times goes on. The MPO connector has become the common interface for short reach 40 and 100 Gb/s transceivers.

Beyond the previously mentioned 100GBASE-SR4 and SR10, another popular specification option for 100 Gb/s

is 100GBASE-PSM4. It uses a parallel single mode fiber infrastructure to support reaches of at least 500 meters. It allows for support by multiple electrical form factors, including QSFP, CFP, and embedded optical engines.

But with the explosion of fiber growth, the cabling community has been scrambling for new standards to address higher data rates. With 200 Gb/s transceiver options, only two are available on the market today: 2x100-PSM4 single-mode and 2x100-SR4 multimode, as highlighted in below. These are proprietary options introduced by Cisco, and they both rely on 24-fiber MPO connectors.

Of the current 400 Gb/s transceivers that use MPO connections, single-mode 400G-DR4 and multimode 400G-SR4.2 will likely become the most common over the next several years. 400G-DR4 uses four optical channels (eight fibers), with each channel delivering 100 Gb/s. The 400G-SR4.2 BiDi solution, originally introduced by a manufacturer MSA, is currently in development by IEEE P802.3cm, with a target publication date in early 2020.

Transceivers That Require an MPO Connection

Optical Transceiver		IEEE Compliant	Switch Vendor	Form Factor	Fiber Type	Distance (meters)	# of fibers	Connector
40G	40G-SR4	Yes	All	QSFP+	OM3 / OM4	100 / 150	8	12F MPO
	40G-C / X / ESR4	No	Arista, Cisco, Juniper	QSFP+	OM3 / OM4	300 / 400	8	12F MPO
	40G-PLRL4	No	All	QSFP+	OS2	1,000	8	12F MPO
	4x10G-IR /LR	No	Juniper	QSFP+	OS2	1,000 / 2,000	8	12F MPO
	4x10G-LR	No	Cisco	QSFP+	OS2	10,000	8	12F MPO
	40G-PLR4	No	Arista	QSFP+	OS2	10,000	8	12F MPO
100G	100G-SR10	Yes	All	CFP / CFP2 / CPAK	OM3 / OM4	100 / 150	20	24F MPO
	100G-SR10 MXP	No	Arista	Embed. Optics	OM3 / OM4	100 / 150	24	24F MPO
	100G-XSR10	No	Arista	CFP2	OM3 / OM4	300 / 400	20	24 F MPO
	100G-SR4	Yes	All	QSFP28	OM3 / OM4	70 / 100	8	12F MPO
	100G-XSR4	No	Arista, Juniper	QSFP28	OM3 / OM4	300	8	12F MPO
	10x10-LR	No	Cisco	CPAK	OS2	1,000	20	24F MPO
	100G-PSM4	No	All	QSFP28	OS2	500	8	12F MPO

Optical Transceiver		IEEE Compliant	Switch Vendor	Form Factor	Breakout Option	Fiber Type	Distance (meters)	# of fibers	Connector
200G	200G-DR4	IEEE	None	TBD	Yes	OS2	500	8	12F MPO
	2X100G-PSM4	Prop.	Cisco	QSFP-DD	Yes	OS2	500	24	24F MPO
	200G-SR4	IEEE	None	TBD	Yes	OM3 / OM4 / OM5	70 / 100 / 100	8	12F MPO
	2X100G-SR4	Prop.	Cisco	QSFP-DD	Yes	OM3 / OM4 / OM5	70 / 100 / 100	24	24F MPO
400G	400G-DR4	IEEE	Arista, Cisco, Juniper	QSFP-DD, OSFP	Yes	OS2	500	8	12F MPO
	400G-XDR4 (DR4+)	Prop.	Arista, Juniper	QSFP-DD, OSFP	Yes	OS2	2,000	8	12F MPO
	2X200G-SR4	IEEE/ MSA	Cisco	QSFP-DD	Yes	OM3 / OM4 / OM5	70 / 100 / 150	8	12F MPO
	400G-SR4.2 (BD)	IEEE	Arista	OSFP	Yes	OM3 / OM4/OM5	70 / 100 / 100	16	16F / 24F MPO

As of December 2019

Distinguishing Between MPO and MTP

MPO or MTP (multi-fiber termination push-on) terminated cables are widely used in high-density environments. Often, the terms MPO and MTP are used interchangeably. However, there is a technical difference. MPO is a fiber connector type, while MTP is a registered trademark of an MPO connector manufactured by US Conec. All MTPs are MPOs but not all MPOs are MTPs. To the naked eye, there is little difference between the two connectors, and in cabling and transceiver interfaces, they are compatible with each other.

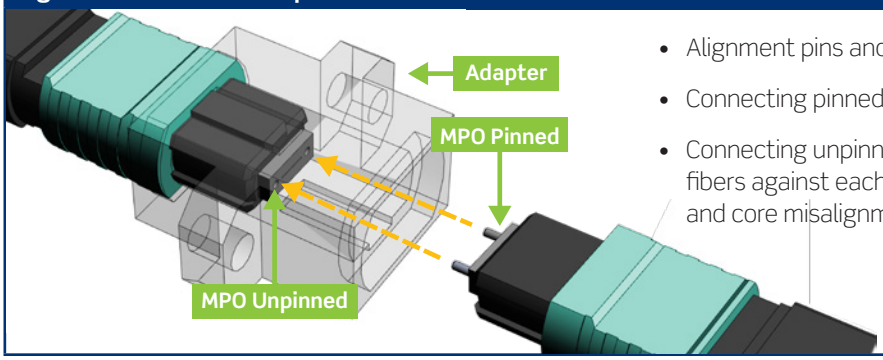
MPO Design: What You Need to Know

MPO connectors are typically available with 8, 12, or 24 fibers for common data center and LAN applications. Other fiber counts are available such as 32, 48, 60, or 72 fibers, but these are typically used for specialty super high-density multi-fiber arrays in large scale optical switches.

Unlike single-fiber connectors, which are all male, MPO connectors are either male (with alignment pins) or female (without alignment pins). In order to mate two MPO connectors together through an adapter, one connector must have pins and the other must be without pins (see Figure 1). The role of the alignment pins is to ensure that fibers are facing each other perfectly, ensuring successful mating.

MPO connectors are often color-coded to help contractors distinguish between the different fiber types and polish specifications for single-mode. MPO connectors are made for both single-mode and multimode multifiber cables. In single-mode OS2 applications, per Telecommunications Industry Association's (TIA) specification, the cable jacket is yellow. The connector color will vary depending on the connector type. Ultra Physical Contact (UPC) connectors will also be yellow, while Angled Physical Contact (APC) connectors are green. With multimode OM3/OM4, both MPO connectors and cable jacket will be aqua, per TIA specifications.

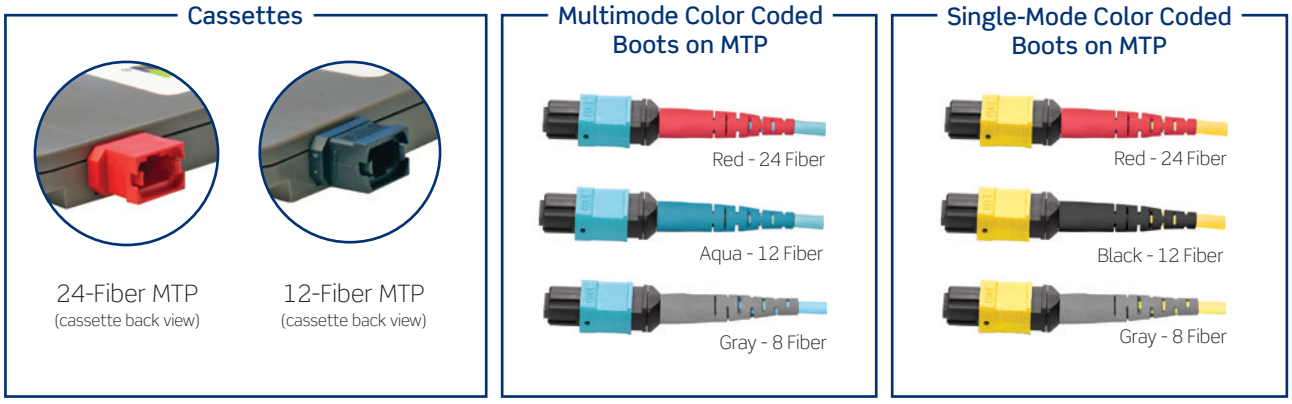
Figure 1: Pinned and Unpinned Connections



- Alignment pins and sockets ensure fiber cores align
- Connecting pinned to pinned can damage pins
- Connecting unpinned to unpinned can grind fibers against each other – creating damage and core misalignment

An added complexity of deploying MPO connectors is understanding the fiber count of the connectors you are trying to plug together. Because of the universal mating capability of some MPOs connectors, it is possible to connect a 12-Fiber MPO to a 24-fiber MPO. But doing so will not result in proper mating and can cause some confusion during moves adds or changes, or when new network installations are being connected to a legacy installation. Leviton introduced a color-coded boot to assist in this task (see Figure 2). On both single-mode and multimode connectors, a red boot indicates a 24-fiber connector, a 12-fiber connector is aqua on multimode connectors or black on single-mode connectors, and a gray boot denotes an 8-fiber connector. Similarly, for adapters, a red MTP adapter or coupler indicates a 24-fiber connector and black a 12-fiber connection.

Figure 2



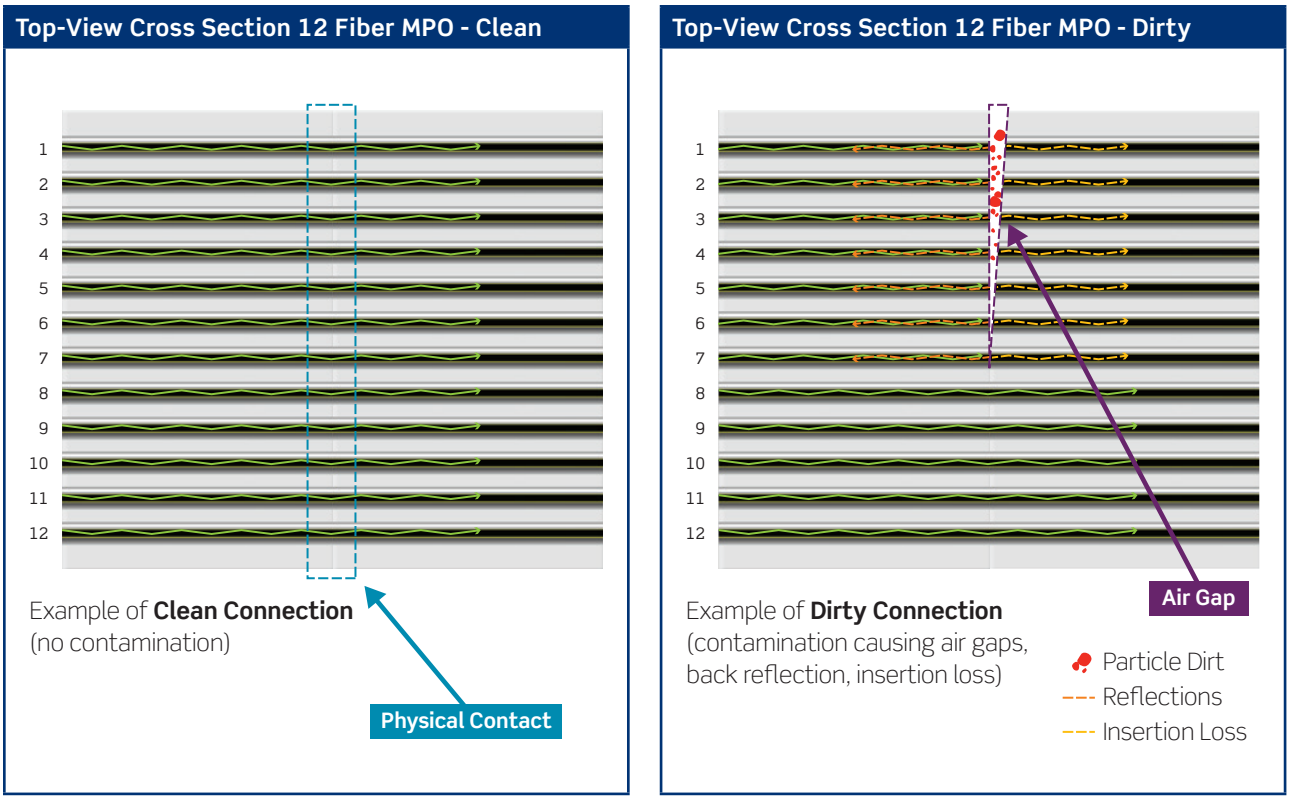
There are added levels of complexity to be aware of for some next generation transceivers using MPO connectors. In some transceiver specifications being developed for 400 Gb/s, new MPO connector options, such as 16-fiber and 32-fiber, are being developed. Connector manufacturers are working with design traits like off-setting the key to help avoid inadvertently mating the new options with legacy MPO connectors. To fit the extra four fibers between the alignment pins in the ferrule, the pin holes will also move closer to the edge of the connector. That means the new 16 and 32 fiber MPO cannot properly mate to an existing 8, 12, and 24 fiber connector.

Basics of Cleaning MPO Connections

A major consideration when using MPOs is they're notoriously more challenging to keep clean. The connector interface has many more fibers in it than the LC connector. Keeping 8, 12, or 24 fibers in a single connector end-face clean can be difficult.

However, it is essential that MPO connectors are kept clean. When clean, the cores can align, and the light gets through neatly and easily. But if dirt gets on the ferrule, the dirt particles will shatter and migrate throughout the ferrule end face when connection is trying to be achieved. The dirt creates air gaps, back reflection and insertion loss, as shown in Figure 3. If plugging into a transceiver (switch port), It becomes difficult for the transmitter to connect, and the life of the transceiver could be impacted.

Fortunately, the prescription for cleaning is simple: inspect before you connect. It is important to have a good visual inspection tool for the MPO connector. There are many inspection scope options available from the vendors of the optical test sets. Frequently used vendors include Fluke, Viavi, and Exfo. If the connector is clean after inspection, it is clean, go ahead and connect the MPO. If not, clean and then reinspect. For ceramic, single fiber ferrules, it is recommended that the cleaning process start with dry cleaning, and if anything is embedded, move to wet cleaning, and then finish with dry cleaning. With MPOs, wet cleaning is more often required to properly maintain a clean ferrule end face. As there are multiple fibers very closely positioned together, factors such as contaminants and static or humidity, which both attract contaminants to the surface, make uniform cleanliness more difficult to achieve. Wet cleaning should be performed with appropriate fiber cleaning solutions as even highly pure isopropyl alcohol can leave behind residue from water that does not evaporate. Applying a small amount of cleaning solution from a lint free wipe to the probe tip of a one-click MPO cleaning tool is a way to clean the connector end face of a pre-terminated cassette.



Polarity Considerations with MPOs

Achieving polarity is another challenge with MPOs. Polarity defines the direction of the light path or flow, such as the direction of an electrical current. In fiber optics, it's called the A-B-Cs of fiber polarity. To send data via light signals, a fiber optic link's transmit signal at one end of the cable must match the corresponding receiver at the other end. While this concept might seem simple, it becomes more complex with multi-fiber MPO cables and connectors. Industry standard TIA-568.3-D names three different polarity methods for MPOs: Method A, Method B, and Method C. Each method uses different types of MPO cables.

When examining 12 fiber configurations, Method A (or straight-through method) uses a key up connector on one end and a key down connector on the other end so that the fiber located in Position 1 arrives at Position 1 at the other end. Method B (inverted method) uses key up connectors on both ends to achieve the transceiver-receiver flip so that the fiber located in Position 1 arrives at Position 12 at the opposite end, the fiber located in Position 2 arrives at Position 11 at the opposite end, and so on. Method C (twisted pair method) uses a key up connector on one end and a key down on the other end like Method A, but the flip happens within the cable itself where each pair of fibers is flipped so that the fiber in Position 1 arrives at Position 2 at the opposite end, and the fiber in Position 2 arrives at Position 1.

While this may appear overwhelming on paper, it's not in practice. As long as contractors stick to just one polarity in planning, everything will be okay. Once a polarity plan is chosen, it's additionally important that polarity maintenance is consistently checked to make sure transmitters are transmitting to receivers and vice versa. This shouldn't be hard, but systems do need to be tested whenever they're configured or updated. There are several ways to check for polarity, and testing can be done on the trunk (installed portion of the link) or on the individual channels.

8-Fiber vs. 12-Fiber vs. 24-Fiber with MPO

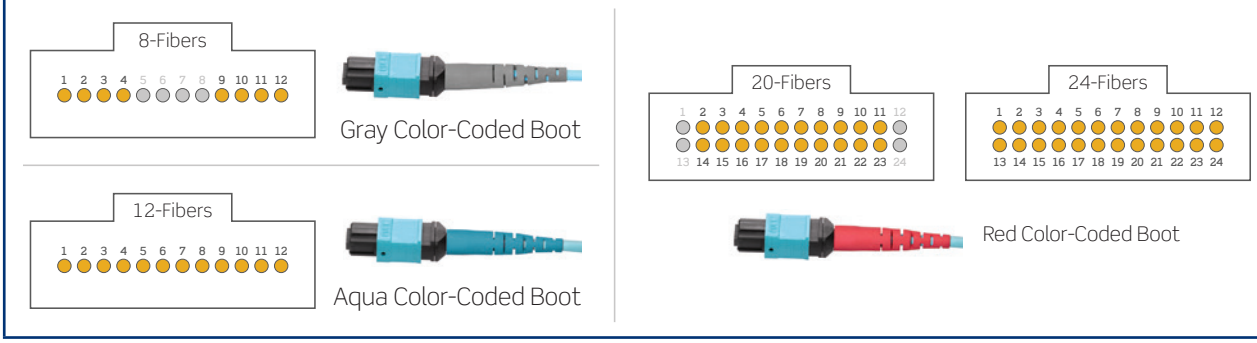
There are pros and cons to using 24-fiber cabling versus 12-fiber cabling. When it comes to density, 24-fiber cabling has an advantage over 12-fiber since higher density connectivity in the enclosure leaves more rack space for active equipment, reducing the total amount of rack space required for patching. With 24-fiber, enclosures can have twice as many connections with the same number of ports compared to 12-fiber.

Also, the opposite of density is congestion. The more connectivity that is run in the same footprint, the more crowded it will be in the rack or cabinet, again making 24-fiber cabling more advantageous since only half the number of cables are needed compared to 12-fiber. With reduced congestion also comes improved airflow and reduced cooling costs.

This is even more apparent in 8-fiber, parallel optic applications. A Base8 or 8-fiber cabling infrastructure actually uses 12-fiber MPO connectors to achieve 40, 100, 200, or 400 Gb/s channels. In these cases, only 8 of the 12 fibers are used, so a third of the connector capacity is dark or unused. This is highly inefficient and adds to the congestion of cable pathways and management solutions. In Base24 or 24-fiber cabling infrastructure, you get the flexibility to run three 8-fiber channels in one connector. This provides 100% fiber utilization in the connector, reduces cable tray congestion and ensures a strong return on your infrastructure investment.

The potential downside of 24-fiber is the additional planning required on the front end to ensure proper polarity and routing. However, manufacturers providing a 24-fiber solution will work with the network designers and administrators to ensure success. Data centers will need to inevitably upgrade their networks to accommodate 100, 200, and 400 Gb/s, and sticking to 12-fiber MPO configurations may actually be more challenging and expensive in the long-run, since switch speed upgrades and other network modifications are more difficult.

MPO Connectors in the Channel



In Closing

MPO connectors are the most likely method to get to 100, 200 and 400 Gb/s. If managers and contractors do not use MPOs, they're going to end up limiting themselves to either long-reach transceiver applications for single mode, or some type of WDM technology transceiver if they want to stick with LC connectivity on the fiber trunk or use long LC patch cords to connect transceiver ports, which do not provide a scalable and flexible structured cabling strategy. Getting started on using MPOs now will set organizations up for success as higher speeds through 40 and 100 Gb/s become the new norm in the enterprise. Cassettes are easily deployed to break the MPO fibers out to duplex LC pairs, while 1 Gb/s and 10 Gb/s are still in use. The MPO connector is a field-proven design that can support all the deployment scenarios. Using proper inspection tools and cleaning techniques will ensure the best network deployment and performance.

LEVITON®
Network Solutions

Today's networks must be fast and reliable, with the flexibility to handle ever-increasing data demands. Leviton can help expand your network possibilities and prepare you for the future. Our end-to-end cabling systems feature robust construction that reduces downtime, and performance that exceeds standards. We offer quick-ship make-to-order solutions from our US and UK factories. We even invent new products for customers when the product they need is not available. All of this adds up to the **highest return** on **infrastructure investment**.

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