APPLICATION NOTES

A Practical Guide to MPO Conversion and Aggregation Harnesses

Fiber Optic Cable Assemblies for High-Speed Network Migrations

As parallel-optic data rates increase to 100G, 200G, 400G, and beyond, MPO-based fiber systems must support higher lane counts and tighter polarity tolerances while preserving existing structured cabling investments. In these environments, conversion and aggregation harnesses are essential design elements, yet they are frequently misapplied due to confusion around lane redistribution, polarity methods, and transceiver architecture.

This application note provides a technical reference for MPO polarity management, fiber lane mapping, and harness selection in parallel-optic networks. It distinguishes clearly between conversion harnesses, which re-group and remap fiber lanes to align with differing transceiver lane architectures without changing total fiber count, and aggregation harnesses, which consolidate multiple independent links into a higher-density MPO trunk without lane redistribution.

Detailed examples and deployment scenarios illustrate how polarity method (A, B, or C), connector orientation, fiber count, and transceiver lane ordering interact at the system level. Emphasis is placed on identifying conditions that lead to TX-to-TX or RX-to-RX mapping, partial link failures, and other common field issues associated with improper harness specification.

By addressing these interactions explicitly, this document enables network designers and integrators to:

- Specify the correct harness topology based on optic lane architecture
- Maintain end-to-end polarity integrity across trunks, harnesses, and cassettes
- Reuse existing MPO backbone infrastructure during speed migrations
- Design scalable fiber systems that support phased upgrades with minimal rework

This application note is a practical engineering reference for specifying, deploying, and validating MPO conversion and aggregation harnesses in high-speed data center and enterprise network environments.

Introduction

As parallel-optic data rates increase to 100G, 200G, 400G, and beyond, fiber infrastructure must support higher lane counts, tighter polarity tolerances, and evolving transceiver architectures—often without replacing existing structured cabling. In these environments, MPO-based conversion and aggregation harnesses are critical design tools, but they are also among the most frequently misunderstood components in high-speed fiber systems.

Although conversion and aggregation harnesses may appear physically similar, they serve fundamentally different functions within the network. Conversion harnesses redistribute fiber lanes to align with transceiver lane architectures, while aggregation harnesses consolidate multiple independent links into high-density trunk infrastructure. Confusing these roles can result in lane misalignment, polarity errors, and complete link failure.

This application note is intended to support system-level fiber design decisions by explaining how MPO polarity methods, lane mapping, connector orientation, and fiber counts interact across trunks, harnesses, and transceivers. The sections that follow begin with the foundational technical variables—polarity and fiber mapping—before applying those principles to conversion and aggregation harness design and deployment.

Fiber Optic Cable Assemblies

MPO Conversion & Aggregation Harnesses

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MPO Conversion & Aggregation Harnesses

1.0 Key Technical Variables

Parameter	Options	Impact
Fiber Count	8F, 12F, 16F, 24F, 32F	Determines optics compatibility
Polarity	Type A, Type B, Type C	Determines Tx/Rx alignment
Gender	Pinned / non-pinned	Must mate properly
Polarity Method	Method A, B, C	System-level polarity design
Fiber Type	OM3, OM4, OM5, OS2	Distance & bandwidth
Key Orientation	Key-Up / Key-Down	Determines mapping orientation

1.1 Understanding MPO Polarity

At its core, polarity ensures that a transmitter (Tx) on one end of a link connects to a receiver (Rx) on the other. In duplex LC systems, this is simple. In MPO systems, polarity must be managed across multiple transmit and receive lanes simultaneously. A single polarity mismatch in an MPO system does not degrade performance—it prevents the link from coming up entirely.

Transmit (Tx) on one end connects to Receive (Rx) on the other end.

In duplex LC, this is simple (A to B).
In MPO (8–24 fibers), polarity must manage multiple Tx/Rx lanes simultaneously.

1.2 MPO Polarity Types (Connector Mapping)

◆ Type A (Straight Through) Illustration 1.31

- Key-up to key-down
- Fiber 1 → Fiber 1
- Fiber 12 → Fiber 12

Used in: Method A systems
Requires: Polarity flipped in cassette

End A (Key Up)   End B (Key Down)

1 2 3 ... 12 → 1 2 3 ... 12

Type B (Reversed) Illustration 1.31

- Key-up to key-up
- Fiber 1 → Fiber 12
- Fiber 12 → Fiber 1

Most common in data centers

End A (Key Up) End B (Key Up)

1 2 3 ... 12 ⟶ 12 11 10 ... 1

Used for:

- 40G SR4
- 100G SR4
- 400G SR8
- Direct optic-to-optic connections

This is the most common trunk type in modern parallel optics.

Type C (Pair Flipped) Illustration 1.33

- Key-up to key-down
- Adjacent fibers flipped in pairs

1↔2
3↔4
5↔6

Used in legacy duplex breakout systems.
Less common in modern high-speed data centers

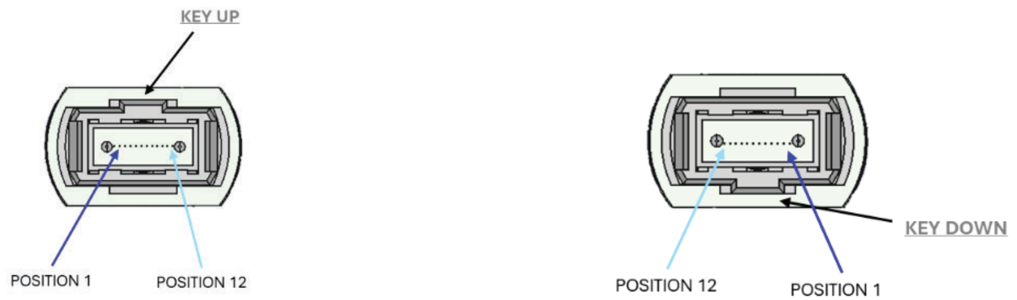
1.3 MPO Polarity Types & Configurations

Standard keying and fiber positions examples

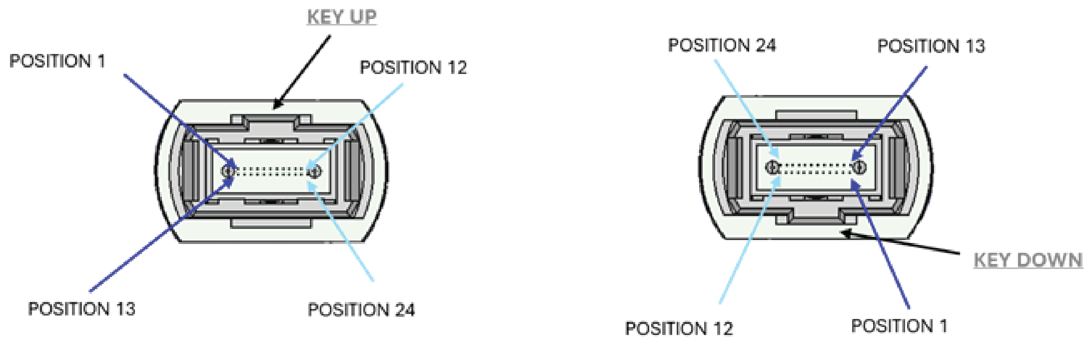
12F, KEY UP, with PINS, (MALE)

12F, KEY DOWN, without PINS (FEMALE)

Positions 1, 2, 3, etc., will always be the same, relative to the Key as shown



24F, KEY UP, without PINS, (FEMALE) 24F, KEY DOWN, with PINS (MALE)

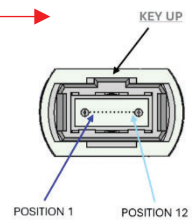


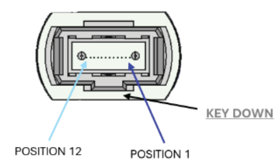
Polarity Types: A, B, & C

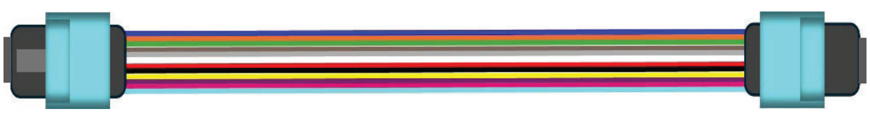
12 FIBER

	WIRING MAP	
	TYPE A	
J1		J2
1	BLUE	1
2	ORANGE	2
3	GREEN	3
4	BROWN	4
5	GRAY	5
6	WHITE	6
7	RED	7
8	BLACK	8
9	YELLOW	9
10	PURPLE	10
11	ROSE	11
12	AQUA	12

TYPE A: STRAIT THROUGH







24 FIBER

	WIRING MAP	
	TYPE A	
J1		J2
1	BLUE	13
2	ORANGE	14
3	GREEN	15
4	BROWN	16
5	GRAY	17
6	WHITE	18
7	RED	19
8	BLACK	20
9	YELLOW	21
10	PURPLE	22
11	ROSE	23
12	AQUA	24
13	BLUE/BLACK	1
14	ORANGE/BLACK	2
15	GREEN/BLACK	3
16	BROWN/BLACK	4
17	GRAY/BLACK	5
18	WHITE/BLACK	6
19	RED/BLACK	7
20	BLACK/BLACK	8
21	YELLOW/BLACK	9
22	PURPLE/BLACK	10
23	ROSE/BLACK	11
24	AQUA/BLACK	12

24 FIBER

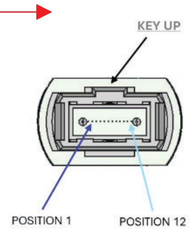
Examples: MPFF12OM4AP-5
MPMF24OM2AZ-3

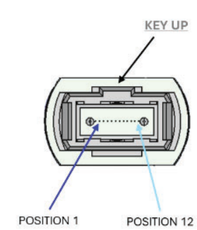
Illustration 1.31

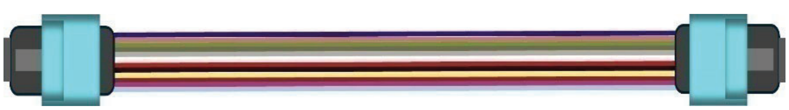
12 FIBER

	WIRING MAP	
	TYPE B	
J1		J2
1	BLUE	12
2	ORANGE	11
3	GREEN	10
4	BROWN	9
5	GRAY	8
6	WHITE	7
7	RED	6
8	BLACK	5
9	YELLOW	4
10	PURPLE	3
11	ROSE	2
12	AQUA	1

TYPE B: CROSSED







	WIRING MAP	
	TYPE B	
J1		J2
1	BLUE	12
2	ORANGE	11
3	GREEN	10
4	BROWN	9
5	GRAY	8
6	WHITE	7
7	RED	6
8	BLACK	5
9	YELLOW	4
10	PURPLE	3
11	ROSE	2
12	AQUA	1
13	BLUE/BLACK	24
14	ORANGE/BLACK	23
15	GREEN/BLACK	22
16	BROWN/BLACK	21
17	GRAY/BLACK	20
18	WHITE/BLACK	19
19	RED/BLACK	18
20	BLACK/BLACK	17
21	YELLOW/BLACK	16
22	PURPLE/BLACK	15
23	ROSE/BLACK	14
24	AQUA/BLACK	13

Examples: MPMM12OM4BR-10
MPMM24SMBR-10

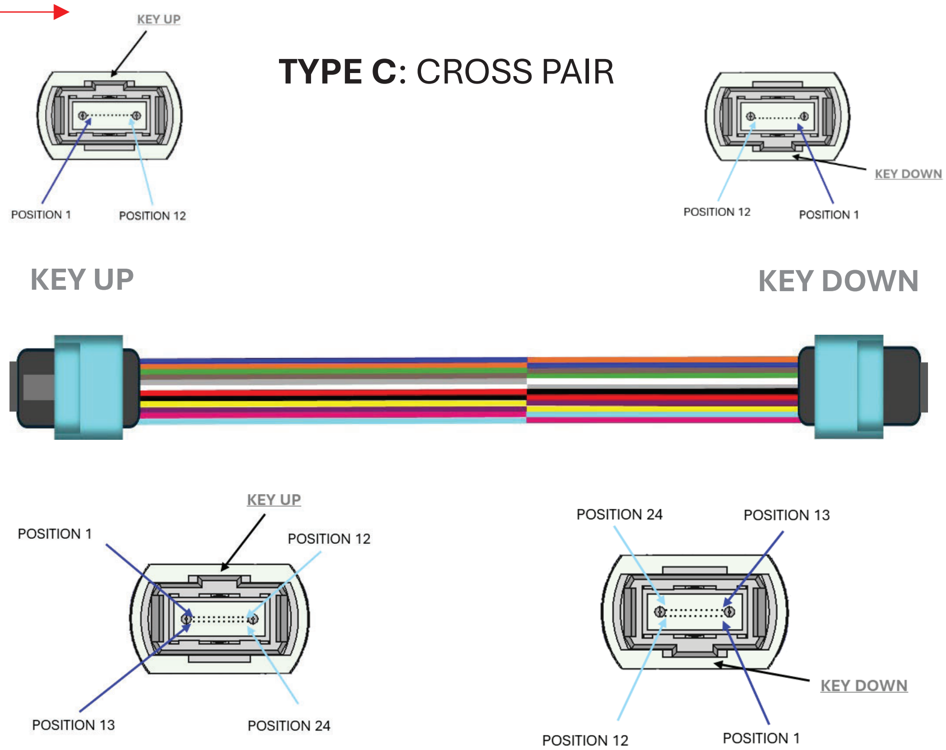
Illustration 1.32

24 FIBER

12 FIBER

	WIRING MAP	
	TYPE C	
J1		J2
1	BLUE	2
2	ORANGE	1
3	GREEN	4
4	BROWN	3
5	GRAY	6
6	WHITE	5
7	RED	8
8	BLACK	7
9	YELLOW	10
10	PURPLE	9
11	ROSE	12
12	AQUA	11

TYPE C: CROSS PAIR



	WIRING MAP	
	TYPE C	
J1		J2
1	BLUE	14
2	ORANGE	13
3	GREEN	16
4	BROWN	15
5	GRAY	18
6	WHITE	17
7	RED	20
8	BLACK	19
9	YELLOW	22
10	PURPLE	21
11	ROSE	24
12	AQUA	23
13	BLUE/BLACK	2
14	ORANGE/BLACK	1
15	GREEN/BLACK	4
16	BROWN/BLACK	3
17	GRAY/BLACK	6
18	WHITE/BLACK	5
19	RED/BLACK	8
20	BLACK/BLACK	7
21	YELLOW/BLACK	10
22	PURPLE/BLACK	9
23	ROSE/BLACK	12
24	AQUA/BLACK	11

24 FIBER

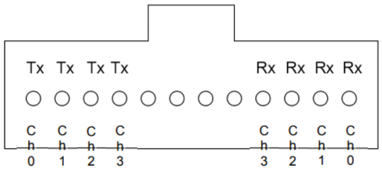
Illustration 1.33

1.4 MPO Fiber Mapping for Parallel Optics

Example: 100G SR4 (8-Fiber Active)

Uses fibers:

- 4 Tx
- 4 Rx
- Middle fibers unused (in 12F)



Typical mapping (Type B trunk):

Fiber Position	Function
1–4	Tx
9–12	Rx
5–8	Unused

Type B ensures Tx lanes hit Rx lanes on opposite device.

Example: 400G SR8 (16-Fiber)

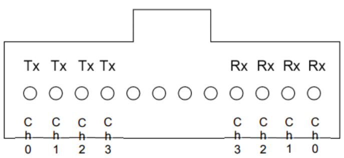
Fibers	Function
1–8	Tx
9–16	Rx

Requires:

- 16F MPO
- Type B polarity

Example: 400G DR4 (8-Fiber Singlemode)

Fibers	Function
1–4	Tx
9–12	Rx



Typically, OS2 with Type B mapping.

1.5 MPO Conversion Harness

Introduction

As data center and enterprise networks migrate from 10G to 25G, 40G, 100G, 200G, 400G and beyond, structured fiber systems must support higher density optics while maintaining polarity integrity, scalability, and signal performance.

Two critical components that enable this migration are:

- **Fiber Optic Conversion Harnesses**
- **Fiber Optic Aggregation Harnesses**

While they appear physically similar (MPO trunk splitting into multiple legs), their functional purpose in the network is fundamentally different.

This document explains:

- What each harness type does
- How they map lanes
- Optics compatibility (QSFP28, QSFP-DD, OSFP, SFP28, etc.)
- Deployment examples

1.6 Fiber Optic Conversion Harnesses

Definition

A **Conversion Harness** redistributes fiber lanes between different parallel optic formats. It changes fiber groupings to match lane architecture between transceivers.

Key concept: Lane rearrangement without changing total fiber count.

Conversion harnesses are introduced when existing backbone fiber no longer aligns with the lane architecture of newer transceivers. Rather than replacing structured cabling, these harnesses allow fiber lanes to be regrouped to match modern optics while preserving total fiber count.

1.7 What a Conversion Harness Does

Conversion harnesses:

- Convert 24F to 2×12F
- Convert 16F to 2×8F
- Convert 12F to 3×4F (less common)
- Maintain total fiber count
- Remap polarity and lane alignment

They are typically used during technological migrations.

1.8 Typical Applications

Example 1: 300G to 3×100G Conversion

Buffer Color	A	B	C	D
Blue	Position 1	Position 12		
Orange	Position 2	Position 11		
Green	Position 3	Position 10		
Brown	Position 4	Position 9		
Gray	Position 5		Position 12	
White	Position 6		Position 11	
Red	Position 7		Position 10	
Black	Position 8		Position 9	
Yellow	Position 9			Position 12
Violet	Position 10			Position 11
Rose	Position 11			Position 10
Aqua	Position 12			Position 9
Blue	Position 13	Position 4		
Orange	Position 14	Position 3		
Green	Position 15	Position 2		
Brown	Position 16	Position 1		
Gray	Position 17		Position 4	
White	Position 18		Position 3	
Red	Position 19		Position 2	
Black	Position 20		Position 1	
Yellow	Position 21			Position 4
Violet	Position 22			Position 3
Rose	Position 23			Position 2
Aqua	Position 24			Position 1

IE. Fiber mapping

Examples:

MPF24-MPF308OM3R-3

MPF24-MPF308OM5R-5

Full listing

- 1 × 24F MPO (300G parallel optic platform)
- Converts to 3 × 12F MPO (100G SR4 links)
- Total fiber count remains 24 fibers

Function:
The 24F trunk redistributes lanes into three independent 12F 100G channels. Each 12F output supports one 100G SR4 transceiver.

Used with:

- QSFP28 (100G SR4)
- QSFP-DD (300G parallel implementations)

Typical Deployment Scenario:
Used in data centers migrating high-density 24-fiber backbone infrastructure into multiple 100G leaf or spine ports without replacing trunk cabling.

Key Technical Note:
Fiber mapping must maintain correct TX/RX lane alignment across each 12F leg. Polarity method (A or B) must match the structured cabling system

Example 2: 120G to 3×40G Conversion

(2×12F to 3×8F Redistribution)

IE. Fiber Mapping

WIRING MAP					
J1	J2	J3	COLOR	J4	J5
12			BLUE	1	
11			ORANGE	2	
10			GREEN	3	
9			BROWN	4	
	12		GRAY	5	
	11		WHITE	6	
	10		RED	7	
	9		BLACK	8	
		9	YELLOW	9	
		10	PURPLE	10	
		11	ROSE	11	
		12	AQUA	12	
4			BLUE/BLACK		1
3			ORANGE/BLACK		2
2			GREEN/BLACK		3
1			BROWN/BLACK		4
	4		GRAY/BLACK		5
	3		WHITE/BLACK		6
	2		RED/BLACK		7
	1		BLACK / WHITE		8
		4	YELLOW/BLACK		9
		3	PURPLE/BLACK		10
		2	ROSE/BLACK		11
		1	AQUA/BLACK		12

WIRING MAP					
J1	J2	J3	COLOR	J4	J5
		12	BLUE		1
		11	ORANGE		2
		10	GREEN		3
		9	BROWN		4
	12		GRAY		5
	11		WHITE		6
	10		RED		7
	9		BLACK		8
12			YELLOW		9
11			PURPLE		10
10			ROSE		11
9			AQUA		12
		4	BLUE w/TRACER	1	
		3	ORANGE w/TRACER	2	
		2	GREEN w/TRACER	3	
		1	BROWN w/TRACER	4	
	4		GRAY w/TRACER	5	
	3		WHITE w/TRACER	6	
	2		RED w/TRACER	7	
	1		BLACK w/TRACER	8	
4			YELLOW w/TRACER	9	
3			PURPLE w/TRACER	10	
2			ROSE w/TRACER	11	
1			AQUA w/TRACER	12	

Examples:

MPM308-MPM212OM3Z-3

MPM308212SMR-5

**Note, both wire maps accomplish the same result, however different positions of J1, J2, J3.*

- 2 × 12F MPO inputs (total 24 fibers / 120G aggregate platform)
- Converts to 3 × 8F MPO outputs (40G SR4 links)
- Total fiber count remains 24 fibers

Function:
Two 12-fiber parallel groups are redistributed into three 8-fiber SR4 channels. This enables conversion between different parallel lane architectures while maintaining overall fiber count.

Used with:

- QSFP+ (40G SR4)
- QSFP28 (when used in mixed 40G/100G environments)

Typical Deployment Scenario:
Common in legacy 40G environments where existing 12F backbone infrastructure must be reallocated into 8F SR4 channels without replacing structured trunks.

Key Technical Note:
Because 8F SR4 uses only 8 active fibers (4 TX / 4 RX), unused fibers must be properly managed or parked depending on system design.

1.9 Technical Characteristics

Feature	Description
Fiber Count	Equal input/output total
Function	Lane remapping
Optic Type	Parallel optics
Polarity	Type A / Type B depending on system
Deployment	Switch-to-switch migration

2.0 Engineering Considerations

- Ensure lane alignment matches transceiver lane mapping
- Confirm polarity method (A/B/C)
- Verify fiber type (OM4, OM5, OS2)
- Validate insertion loss budget

2.1 When NOT to Use Conversion Harnesses

- Not used for traffic aggregation
- Not used to combine multiple switches into one port
- Not used to reduce fiber count

2.2 Fiber Optic Aggregation Harnesses

Definition

An **Aggregation Harness** consolidates multiple lower-speed duplex or parallel connections into a single high-density MPO port.

Key concept: Multiple independent links feeding one higher fiber count trunk.

Aggregation harnesses are often confused with conversion harnesses because they look similar physically. The key distinction is functional: aggregation harnesses do not rearrange lanes. Each breakout leg remains an independent link that is simply consolidated into a higher-density trunk.

2.3 What an Aggregation Harness Does

Example configurations:

- 24F MPO → 3×8F MPO
- 24F MPO → 6×LC duplex
- 12F MPO → 6×LC duplex

Unlike conversion harnesses, aggregation harnesses combine traffic paths physically.

2.4 Typical Applications

Example 1: 3×100G to 300G Aggregation

(24F to 3×8F Aggregation)

IE. Fiber Mapping

WIRING MAP

J1	COLOR	J2	J3	J4
1	BLUE	12		
2	ORANGE	11		
3	GREEN	10		
4	BROWN	9		
5	GRAY		12	
6	WHITE		11	
7	RED		10	
8	BLACK		9	
9	YELLOW			12
10	PURPLE			11
11	ROSE			10
12	AQUA			9
13	BLUE w/TRACER	1		
14	ORANGE w/TRACER	2		
15	GREEN w/TRACER	3		
16	BROWN w/TRACER	4		
17	GRAY w/TRACER		1	
18	WHITE w/TRACER		2	
19	RED w/TRACER		3	
20	BLACK w/TRACER		4	
21	YELLOW w/TRACER			1
22	PURPLE w/TRACER			2
23	ROSE w/TRACER			3
24	AQUA w/TRACER			4

Examples

MPF24308OM3R-CA-1

MPF24212SMR-CA-10

Function:
Three independent 100G SR4 links are physically consolidated into a single 24F backbone connection.

This is a true aggregation configuration — multiple parallel optic channels feeding a higher-density trunk infrastructure.

Used with:

- QSFP28 (100G SR4)
- QSFP-DD (in mixed-speed spine environments)

Typical Deployment Scenario:
Used in spine-leaf architectures where three 100G leaf connections are aggregated into a high-density 24-fiber backbone trunk feeding a core or spine switch.

Engineering Note:
Each 8F leg must maintain independent polarity alignment. No lane redistribution occurs — fibers remain grouped per SR4 channel.

Example 2: 2×200G to 400G Aggregation

(24F to 3×8F Physical Harness – 16 Active Fibers Used)

- 1 × 24F MPO trunk
- Breaks out to 3 × 8F MPO legs
- Two legs used for 200G SR8 (16 active fibers total)
- One 8F leg remains unused or reserved
- Total active fibers: 16

Examples

MPF24212SMR-CA-10

MPF24212OM3R-CA-5

Fiber Mapping

WIRING MAP			
J1	COLOR	J2	J3
	BLUE		
2	ORANGE	12	
3	GREEN	11	
4	BROWN	10	
5	GRAY	9	
6	WHITE		12
7	RED		11
8	BLACK		10
9	YELLOW		9
	PURPLE		
	ROSE		
	AQUA		
	BLUE w/TRACER		
14	ORANGE w/TRACER	1	
15	GREEN w/TRACER	2	
16	BROWN w/TRACER	3	
17	GRAY w/TRACER	4	
18	WHITE w/TRACER		1
19	RED w/TRACER		2
20	BLACK w/TRACER		3
21	YELLOW w/TRACER		4
	PURPLE w/TRACER		
	ROSE w/TRACER		
	AQUA w/TRACER		

Function:

Two independent 200G SR8 channels are consolidated into a 24F trunk infrastructure. Although the harness physically supports three 8F legs, only two are populated in this configuration.

This enables a migration path toward 400G-class infrastructure while preserving 24F structured cabling.

Used with:

- QSFP-DD (200G SR8)
- OSFP (400G platforms)

Typical Deployment Scenario:

Common in phased 400G deployments where backbone cabling is standardized on 24F, but active optics are operating at 2×200G.

Engineering Note:
When only 16 of 24 fibers are active:

- Unused fibers must be clearly identified
- Polarity must still match system method (A or B)
- Future scaling to full 24F utilization should be considered during design

Key Clarification

Aggregation harnesses:

- Do **not** redistribute lanes
- Do **not** change fiber count
- Simply consolidate multiple parallel links into a structured trunk

Improper polarity or incorrect trunk alignment will result in independent leg failures, even if only one breakout is misaligned.

2.5 Technical Characteristics

Feature	Description
Fiber Count	Higher on trunk side
Function	Traffic consolidation
Optic Type	Duplex or parallel
Deployment	Rack Aggregation

2.6 Engineering Considerations

- Each leg must maintain independent polarity
- Ensure no unintended lane cross-over
- Manage breakout mapping carefully
- Validate total insertion loss

2.7 Conversion vs Aggregation – Clear Comparison

Characteristic	Conversion Harness	Aggregation Harness
Fiber Count	Same total in/out	Higher on trunk side
Purpose	Lane redistribution	Traffic consolidation
Typical Use	200G → 2×100G	6×10G → 1×MPO trunk
Optics Migration	Yes	No
Reduces Ports	No	Yes

2.8 Data Center Deployment Example

Migration Scenario

A hyperscale data center upgrading from 100G to 400G:

- Existing 24F backbone
- Deploy 400G DR4 optics
- Use conversion harnesses to split lanes
- Use aggregation harnesses at rack level

This allows staged migration without replacing trunk infrastructure.

2.9 Polarity Considerations

MPO polarity methods define how fibers map from one end of a trunk to the other. Harnesses must match the polarity method of the structured cabling system.

Method A (Straight-Through)

- **Connector Orientation:** Key-Up to Key-Down
- **Fiber Mapping:** 1 → 1, 2 → 2, 3 → 3 … 12 → 12
- **Crossing Occurs:** In patch cords

Important: The trunk itself does not flip fiber numbering — it is straight through.

Method A is common in enterprise structured cabling systems.

Method B (Reversed / Flipped)

- **Connector Orientation:** Key-Up to Key-Up
- **Fiber Mapping:** 1 → 12, 2 → 11 … 12 → 1
- **Crossing Occurs:** Inside the trunk

Method B is very common in data center parallel optics environments (40G/100G SR4, 400G SR8, etc.).

Why This Matters for Harnesses

For Conversion Harnesses:

Lane alignment must match the optic's internal transmit/receive lane ordering.
If polarity is wrong, TX lanes land on TX lanes — no link.

For Aggregation Harnesses:

Each leg must maintain correct duplex polarity relative to the trunk.
If polarity is mismatched, individual breakout legs will fail.

Summary Table

Polarity Method	MPO Orientation	Fiber Mapping	Common Use
Method A	Key-Up to Key-Down	Straight (1→1)	Enterprise structured cabling
Method B	Key-Up to Key-Up	Reversed (1→12)	Parallel optics in data centers

Critical Engineering Rule

Polarity method must be defined at the system level before specifying harnesses.

The following engineering considerations determine whether a harness will function as intended once installed. Most field failures trace back to one of these items being overlooked during design or specification.

Harness polarity must match:

- Trunk polarity
- Cassette polarity (if used)
- Transceiver lane architecture

Failure to align polarity results in:

- Lane inversion
- TX-to-TX mapping
- RX-to-RX mapping
- Link failure