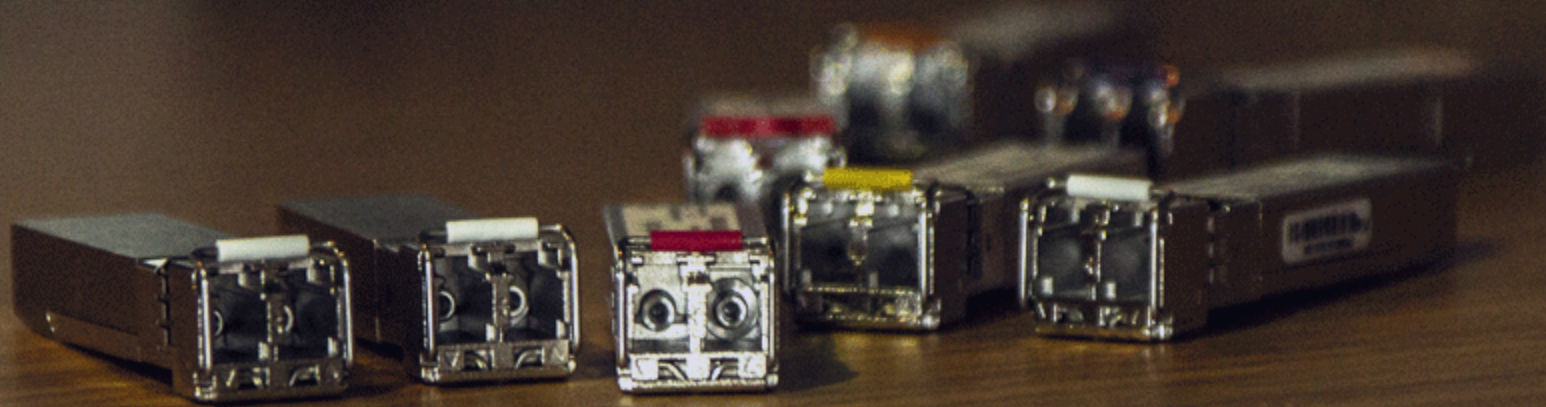
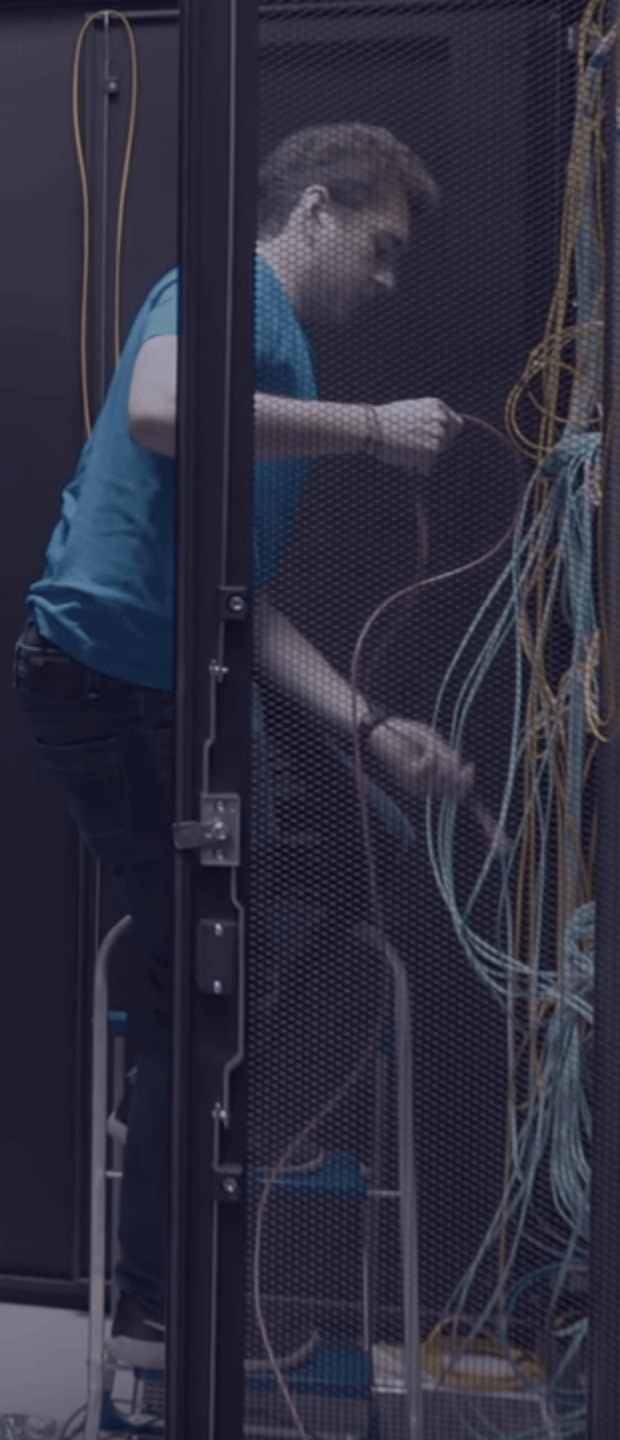


Un-amplified interconnect from 40G to 400G



40G interconnect



40G interconnect

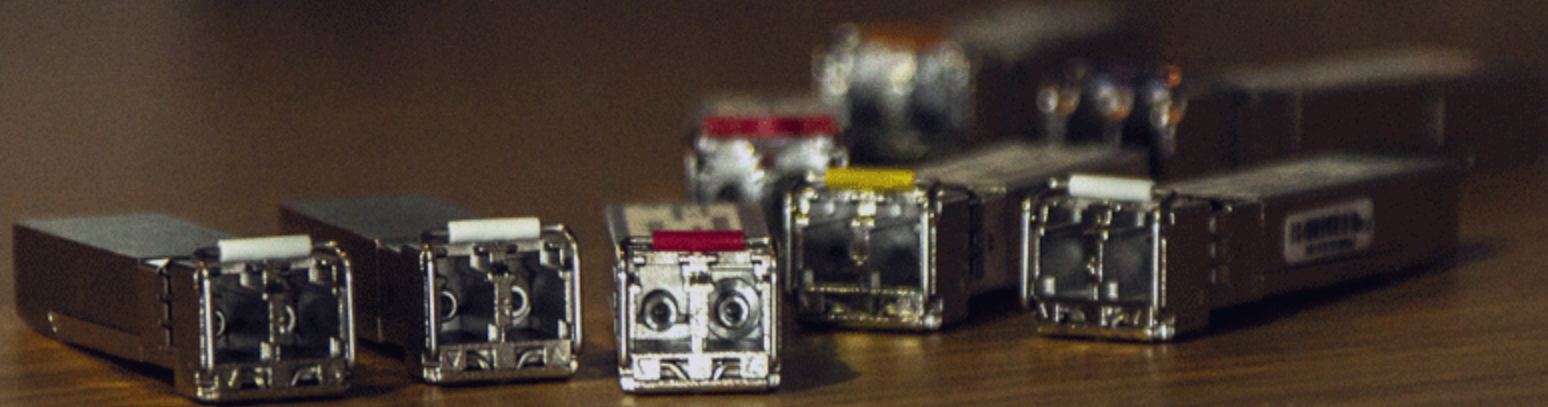
Two application options:

- 40G to 40G interconnect
- 40G to 4x 10G interconnect

Four technology options:

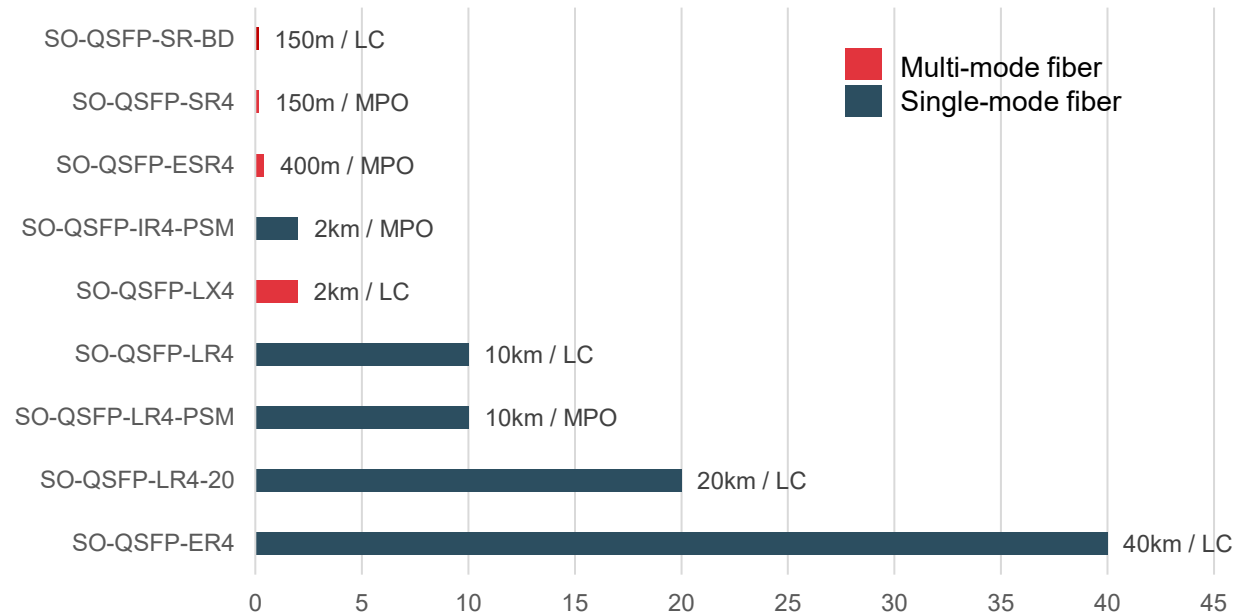
- Optical transceivers over Single-Mode fiber
- Optical transceivers over Multi-Mode fiber
- Direct Attach Cables (DAC)
- Active Optical Cables (AOC)

40G to 40G interconnect



40G to 40G interconnect

Optical QSFP+ transceivers



MPO8 connector



LC connectors

Transceivers with MPO connectors are using ribbon fiber cables.
Transceivers using LC connectors are using a fiber-pair cable.

MPO vs MTP: MTP (Multi-fiber Termination Push-on) is a registered trademark and design of UsConneq, and provides some performance advantages over a generic MPO connector.

40G to 40G interconnect

QSFP+ to QSFP+ Direct Attach Cables (DAC)



DAC cables are coax cables with mounted connectors that fit into a QSFP+ cage. Are available in active (up to 10m length) or passive versions (up to 5m length).

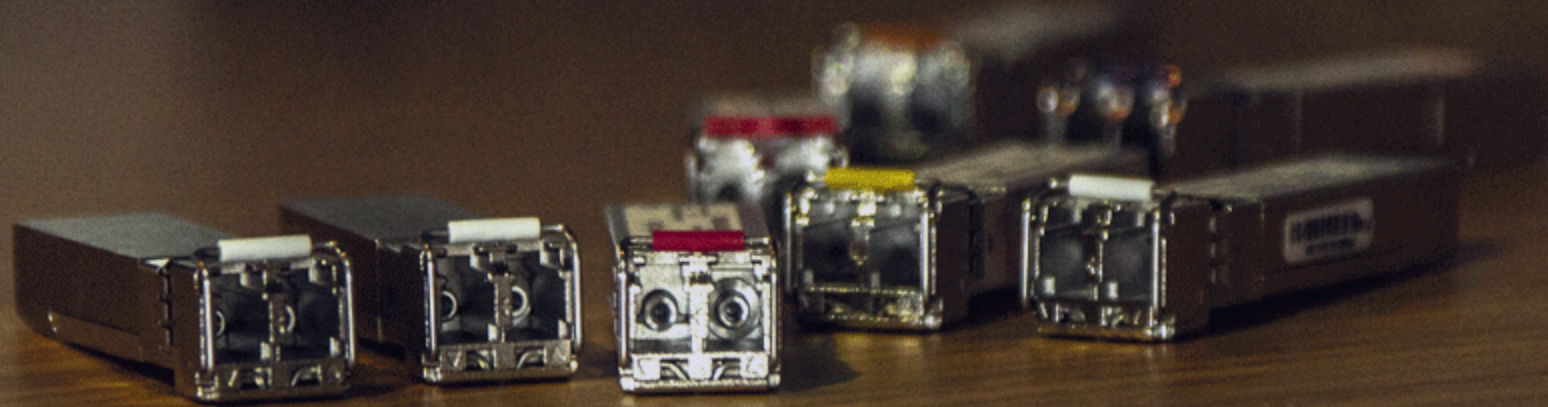
QSFP+ to QSFP+ Active Optical Cables (AOC)



AOC cables are optical QSFP+ transceivers with mounted Multi-mode fibers. The fibers cannot be unplugged from the transceivers. Are available up to 100m lengths.

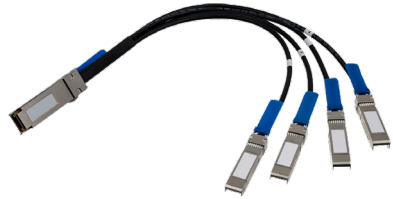
- Benefits:
- For intra- and inter-rack connections. Lower in cost vs optical transceivers.
 - Plug-and-play installation. Requires less skilled personnel since no cleaning of connectors is required, no optical power budget calculations needed.

40G to 4x 10G interconnect

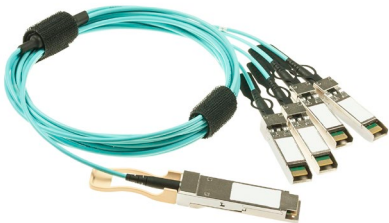


40G to 4x 10G interconnect

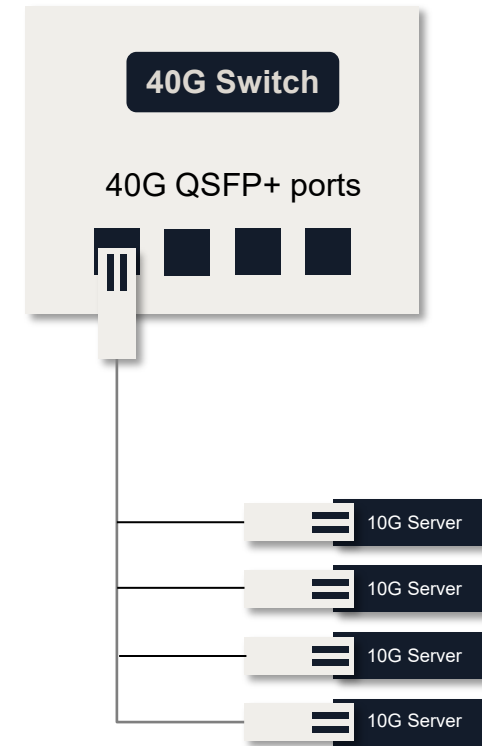
DAC or AOC cables:



QSFP+ to 4x SFP+ break-out DAC cables.
Are available in active (up to 10m length)
or passive versions (up to 5m length).



QSFP+ to 4x SFP+ break-out AOC cables.
Are available up to 100m length.



40G to 4x 10G interconnect

Optical transceivers and break-out patch cables:



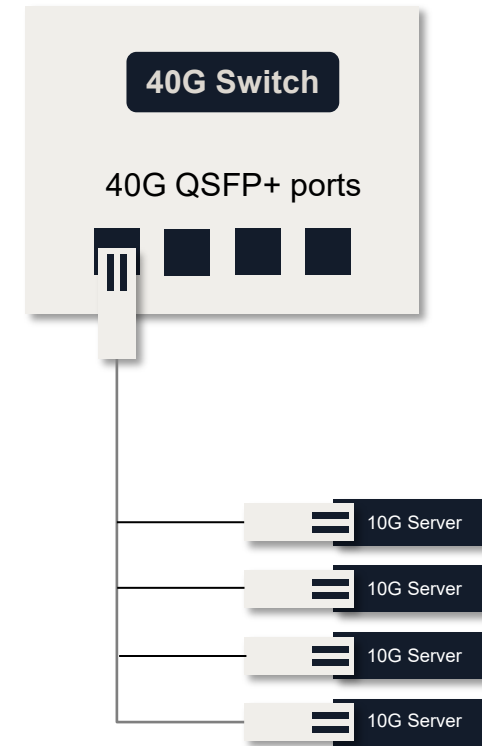
Using:

- MPO-based 40G transceiver
- MPO to LC break-out patch cable (SM or MM).
- 4x SFP+ transceivers

The 40G and the 10G transceivers need to have matching optical characteristics, such as:

SO-QSFP-SR4 and SO-SFP-10GE-SR (850nm, MM, 150m)

SO-QSFP-LR4-PSM and SO-SFP-10GE-LR (1310nm, SM, 10km)

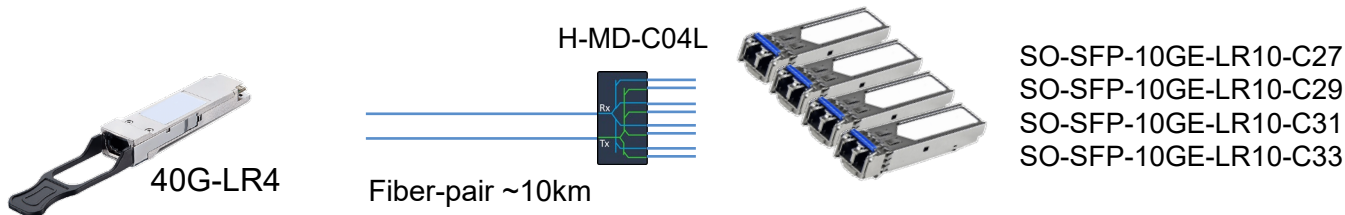


40G to 4x 10G interconnect

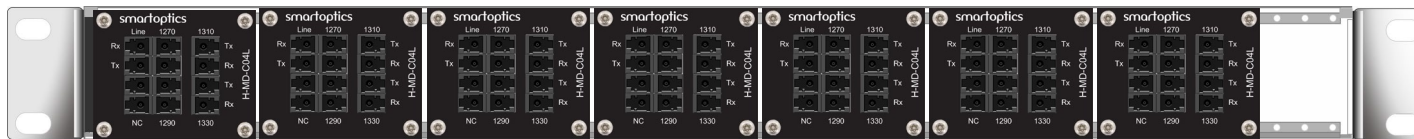
Optical transceivers and CWDM filters:

Using:

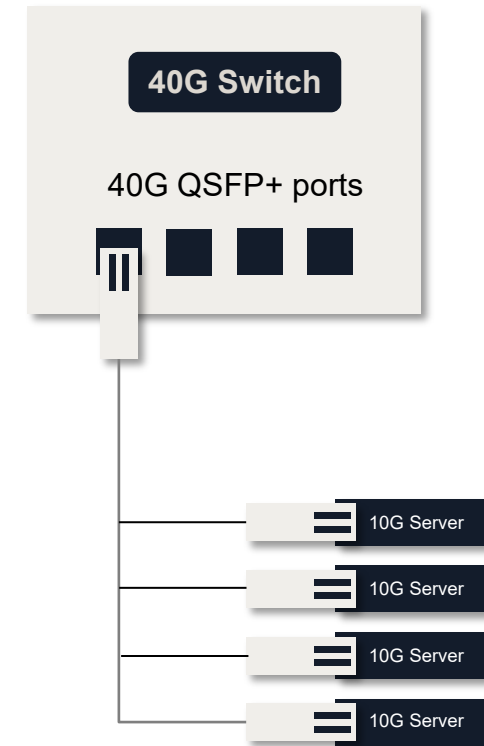
- 40G transceiver using CWDM lanes (SO-QSFP-LR4)
- Matching H-Series CWDM filter (H-MD-C04L)
- 4x SFP+ CWDM transceivers (SO-SFP-10GE-LR10-Cxx)
- LC patch cords



The H-MD-C04L filter matches the CWDM filter in the 40G transceiver



The H-Series filter enables up to 7 filters per 1RU.



40G products

QSFP+ Transceivers

SO-QSFP-SR4	QSFP+ 40GE 850nm MM 150m@OM4 MPO
SO-QSFP-ESR4	QSFP+, 40G eSR4, 850nm, 400m, MPO
SO-QSFP-SR-BD	QSFP+ 40GE BiDi dupl MM 150m@OM4
SO-QSFP-LX4	QSFP+ 40GE CWDM4 2km@SM 100m@OM3
SO-QSFP-LR4-PSM	QSFP+ 40GE 1310nm SM 10km MPO
SO-QSFP-LR4	QSFP+ 40GE LR4 OTN CWDM4 SM 10km
SO-QSFP-LR4-20	QSFP+ 40GE LR4-E SM 20km
SO-QSFP-ER4	QSFP+ 40GE CWDM4 SM 40km
SO-QSFP-IR4-PSM	QSFP+ 40GE IR4 SM 1310nm 2km MPO

DAC

QSFP+ to 4xSFP+ DAC, Passive

SO-QSFP-4SFP-PCUxM	QSFP+ to 4xSFP+, Direct Attach Cable (DAC), 40G to 10G Eth, AWG30/26, 1m to 5m, passive
--------------------	---

QSFP+ to 4xSFP+ DAC, Active

SO-QSFP-4SFP-ACUxM	QSFP+ to 4xSFP+, Direct Attach Cable (DAC), 40G to 10G Eth, AWG30/26, 3m to 10m, active
--------------------	---

QSFP+ to QSFP+ DAC, Passive

SO-QSFP-40G-PCUxM	QSFP+ to QSFP+, Direct Attach Cable (DAC), 40G Ethernet, AWG30/26, 1m to 5m, passive
-------------------	--

QSFP+ to QSFP+ DAC, Active

SO-QSFP-40G-ACUxM	QSFP+ to QSFP+, Direct Attach Cable (DAC), 40G Ethernet, AWG30/28, 3m to 10m, active
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AOC

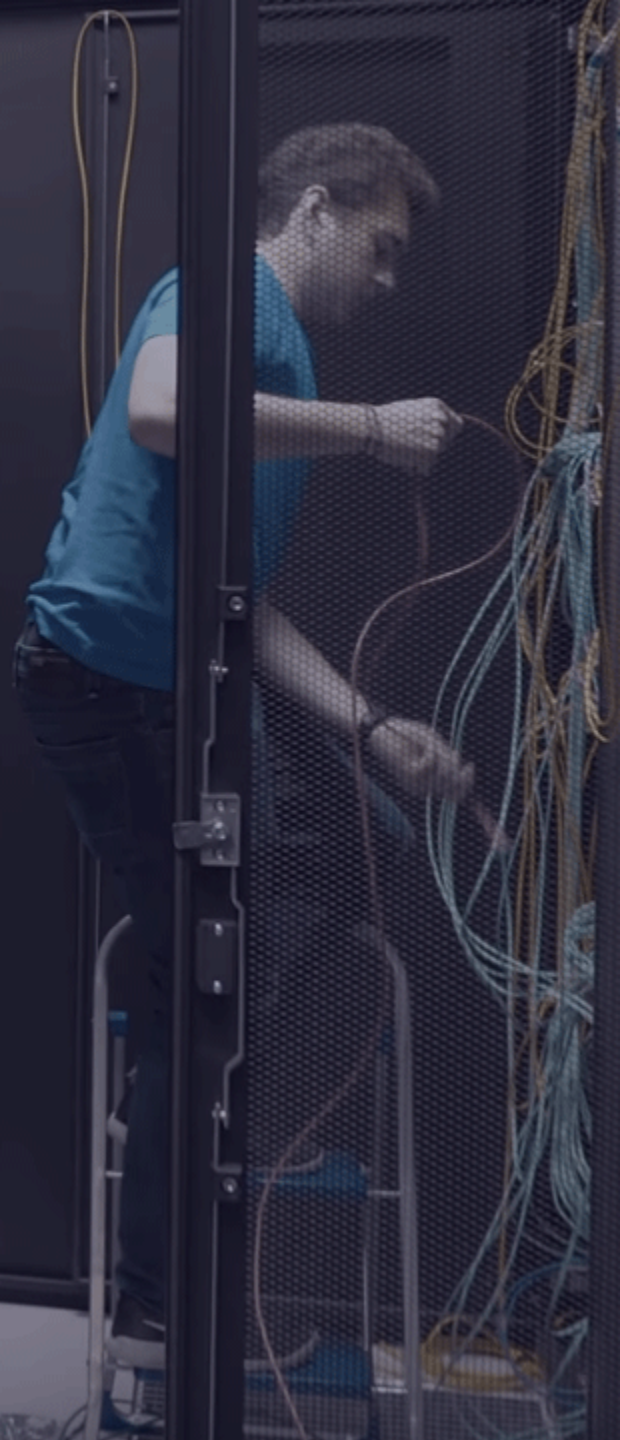
QSFP+ to 4xSFP+ AOC

SO-QSFP-4X10G-AOCxM	QSFP+ to 4xSFP+, Active Optical Cable (AOC), 40G to 10G Ethernet, 1m to 100m
---------------------	--

QSFP-QSFP AOC

SO-QSFP-40G-AOCxM	QSFP+, Active Optical Cable (AOC), 40G Ethernet, 1m to 100m
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100G interconnect



100G interconnect

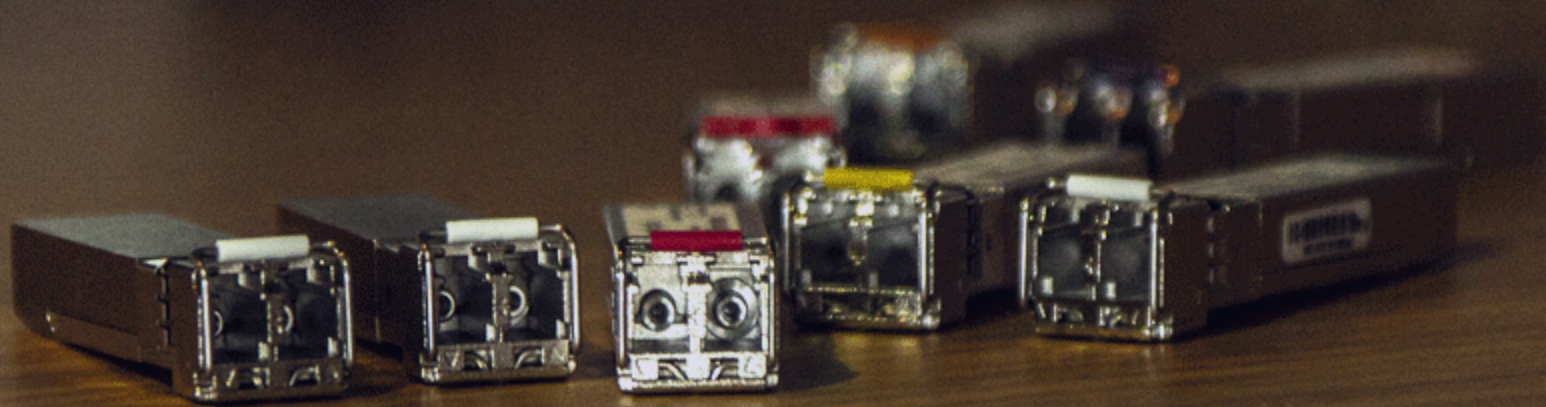
Two application options:

- 100G to 100G interconnect
- 100G to 4x 25G interconnect

Four technology options:

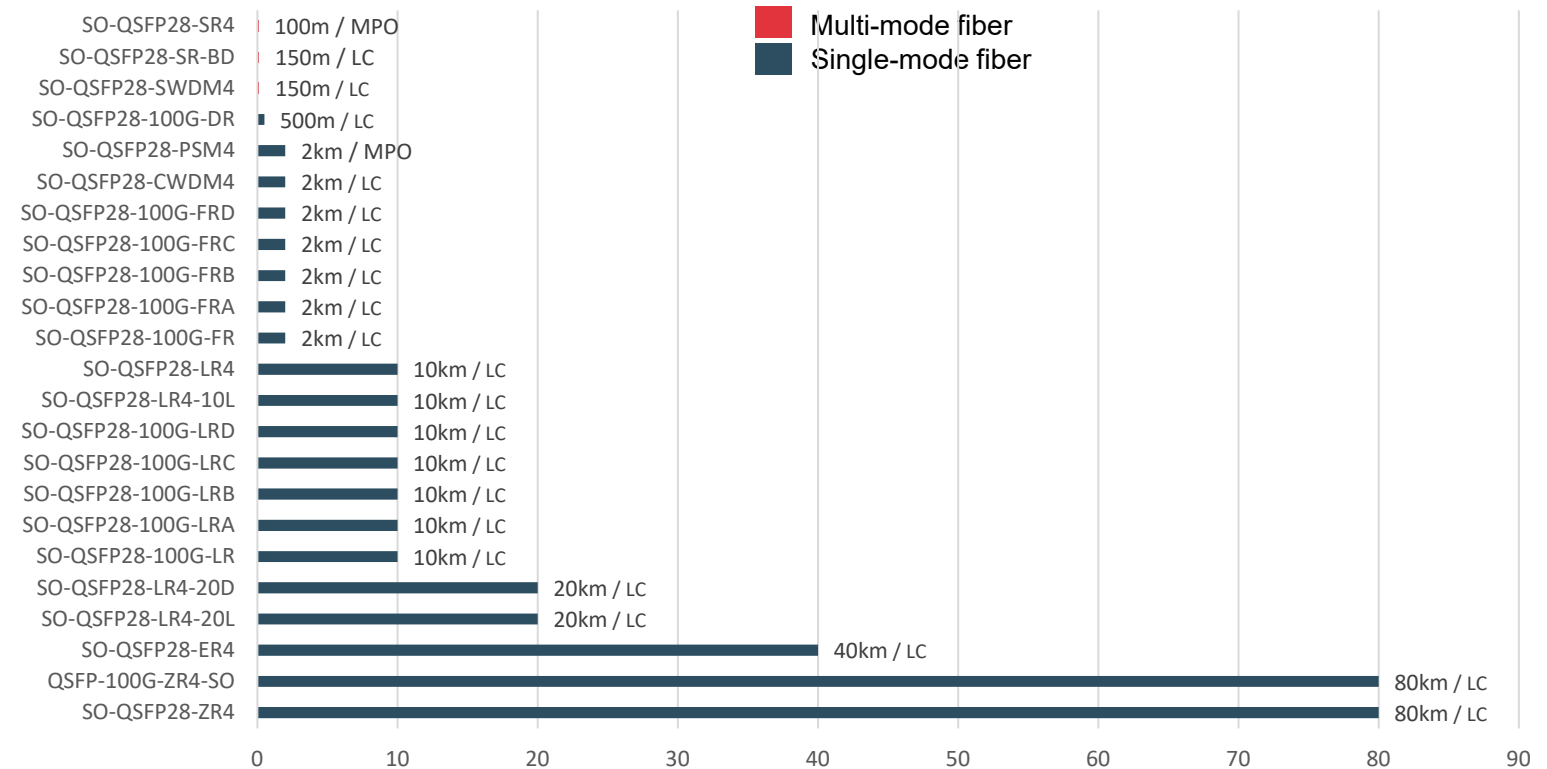
- Optical transceivers over Single-Mode fiber
- Optical transceivers over Multi-Mode fiber
- Direct Attach Cables (DAC)
- Active Optical Cables (AOC)

100G to 100G interconnect



100G to 100G interconnect

Optical QSFP28 transceivers



MPO8 connector



LC connectors

Transceivers with MPO connectors are using ribbon fiber cables.
Transceivers using LC connectors are using a fiber-pair cable.

MPO vs MTP: MTP (Multi-fiber Termination Push-on) is a registered trademark and design of UsConneq, and provides some performance advantages over a generic MPO connector.

100G to 100G interconnect

QSFP+ to QSFP+ Direct Attach Cables (DAC)



DAC cables are coax cables with mounted connectors that fit into a QSFP28 cage. Are available in passive versions up to 5m length.

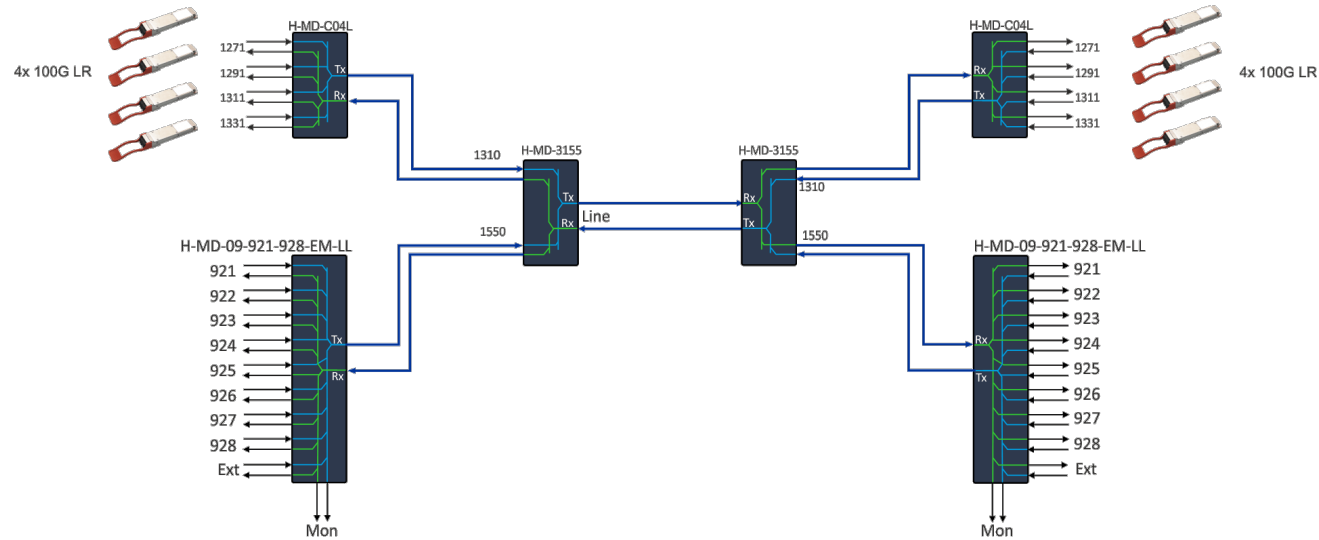
QSFP+ to QSFP+ Active Optical Cables (AOC)



AOC cables are optical QSFP28 transceivers with mounted Multi-mode fibers. The fibers cannot be unplugged from the transceivers. Are available up to 70m lengths.

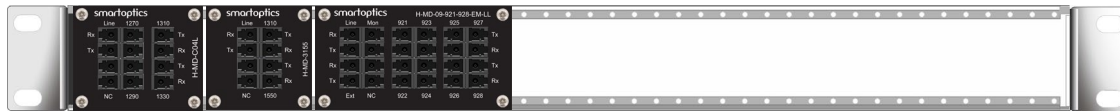
- Benefits:
- For intra- and inter-rack connections. Lower in cost vs optical transceivers.
 - Plug-and-play installation. Requires less skilled personnel since no cleaning of connectors is required, no optical power budget calculations needed.

100G to 100G interconnect example



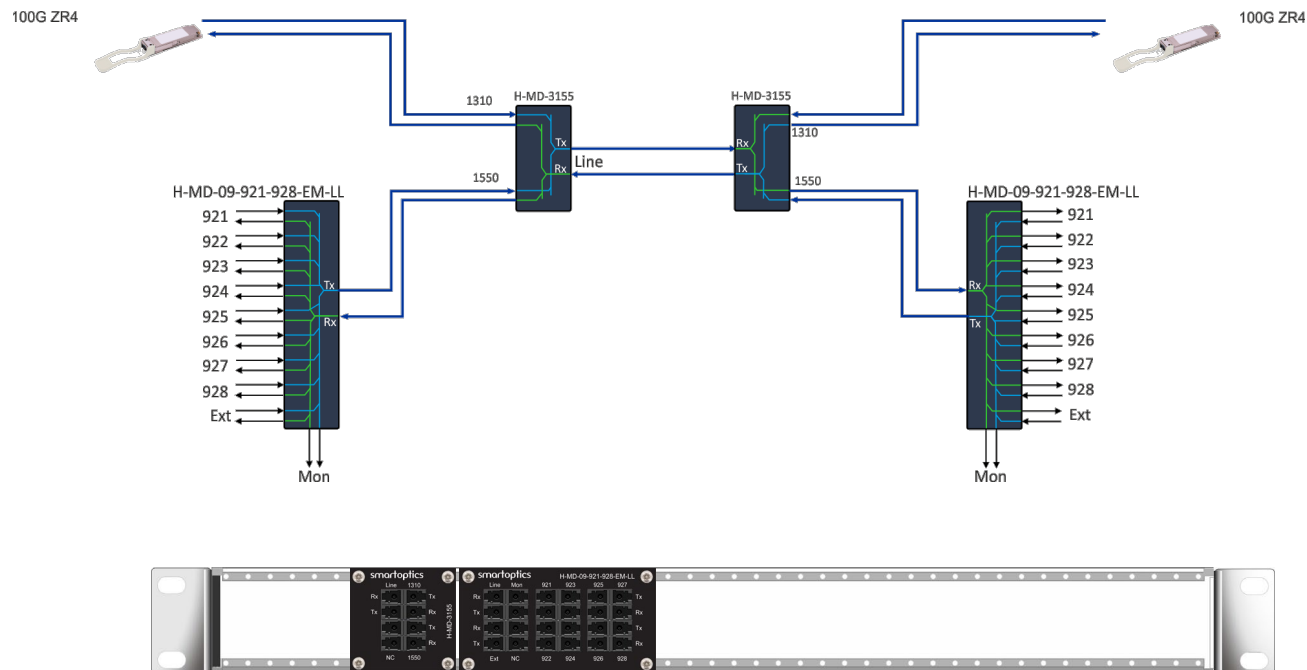
- 8x DWDM channels (e.g. 10G)
- 4x 100G CWDM channels

Distance is limited by power budget of the 100G-LR transceivers to about 6km.



The three H-Series filters occupies 150mm in the mounting brackets.

100G to 100G interconnect example



- 8x DWDM channels (e.g. 10G)
- 1x 100G ZR4 channel

The 100G ZR4 transceiver has 31dB power budget.

Connecting the 4 λ 100G-ZR4 to the 1310nm port will enable longer distances than the LR transceivers.

100G interconnect overview

For single 100G to 100G connections there are multiple MSA's and standards with overlapping distance capabilities.

QSFP28 Transceivers, Single lambda, Single rate

SO-QSFP28-100G-DR	QSFP28 100G Ethernet DR SM 1x 1311nm PAM4 500m 3dB LC
SO-QSFP28-100G-FR	QSFP28 100G Ethernet FR SM 1x 1311nm PAM4 2km 4dB LC
SO-QSFP28-100G-LR	QSFP28 100G Ethernet LR SM 1x 1311nm PAM4 10km 6.3dB LC



QSFP28 Transceivers, Single rate

SO-QSFP28-SR4	QSFP28, 100G Ethernet SR4, MM 4x 850nm, 100m, 4.3dB, MPO
SO-QSFP28-LR4-10L	QSFP28, 100G Ethernet LR4, SM 1296/1300/1305/1309nm, 10km, 6.3dB, LC
SO-QSFP28-LR4-20L	QSFP28, 100G Ethernet eLR4, SM, 1296/1300/1305/1309nm, 20km, 8.1dB, LC
SO-QSFP28-CWDM4	QSFP28, 100G Ethernet CWDM4, SM 1271/1291/1311/1331nm, 2km, 5dB, LC
SO-QSFP28-PSM4	QSFP28, 100G Ethernet PSM4, SM 4x 1310nm, 2km, 4.7dB, MPO
SO-QSFP28-ER4	QSFP28, 100G Ethernet ER4, SM 1296/1300/1305/1309nm, 40km, 18dB, LC
SO-QSFP28-SWDM4	QSFP28, 100G Ethernet SWDM4, MM, 850/880/910/940nm, 150m, 1.8dB, LC
SO-QSFP28-SR-BD	QSFP28, 100G Ethernet, BiDi, MM, 850nm / 910nm, 150m, 1.5dB, LC
SO-QSFP28-ZR4	QSFP28, 100G Ethernet ZR4, SM 1296/1300/1305/1309nm, 80km, 34dB, LC

QSFP28 Transceivers, Dual rate

SO-QSFP28-LR4	QSFP28, 100G Ethernet LR4, OTU4, SM 1296/1300/1305/1309nm, 10km, 6.3dB, LC
SO-QSFP28-LR4-20D	QSFP28, 100G Ethernet eLR4, OTU4 4I1 9D1F, SM, 1296/1300/1305/1309nm, 20km, 12dB, LC

100G interconnect overview

QSFP28 Transceivers, Single lambda, Single rate

SO-QSFP28-100G-DR	QSFP28 100G Ethernet DR SM 1x 1311nm PAM4 500m 3dB LC
SO-QSFP28-100G-FR	QSFP28 100G Ethernet FR SM 1x 1311nm PAM4 2km 4dB LC
SO-QSFP28-100G-LR	QSFP28 100G Ethernet LR SM 1x 1311nm PAM4 10km 6.3dB LC

} These are according to MSA



These are the "CWDM additions" intended for 400G break-out and 4ch 100G CWDM connections

SO-QSFP28-100G-FRA	QSFP28 100G Ethernet FR SM 1x 1271nm PAM4 2km 4dB LC
SO-QSFP28-100G-FRB	QSFP28 100G Ethernet FR SM 1x 1291nm PAM4 2km 4dB LC
SO-QSFP28-100G-FRC	QSFP28 100G Ethernet FR SM 1x 1311nm PAM4 2km 4dB LC
SO-QSFP28-100G-FRD	QSFP28 100G Ethernet FR SM 1x 1331nm PAM4 2km 4dB LC
SO-QSFP28-100G-LRA	QSFP28 100G Ethernet LR SM 1x 1271nm PAM4 10km 6.3dB LC
SO-QSFP28-100G-LRB	QSFP28 100G Ethernet LR SM 1x 1291nm PAM4 10km 6.3dB LC
SO-QSFP28-100G-LRC	QSFP28 100G Ethernet LR SM 1x 1311nm PAM4 10km 6.3dB LC
SO-QSFP28-100G-LRD	QSFP28 100G Ethernet LR SM 1x 1331nm PAM4 10km 6.3dB LC

100G interconnect overview



QSFP28 to QSFP28 DAC
100G to 100G

QSFP28-QSFP28 DAC, Passive

SO-QSFP28-PCUxM QSFP28 to QSFP28 Direct Attach Cable (DAC), 100G Ethernet, AWG30/26, 0.5m to 5m, passive

QSFP28-4xSFP28 DAC, Passive

SO-QSFP28-4SFP28-PCUxM QSFP28 to 4xSFP28 Direct Attach Cable (DAC), 100G Ethernet, AWG30/26, 1m to 5m, passive

QSFP28-QSFP28 AOC

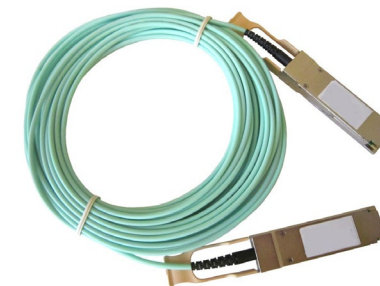
SO-QSFP28-AOCxM QSFP28 to QSFP28 Active Optical Cable (AOC), 100G Ethernet, 1m to 70m

QSFP28-4xSFP28 AOC

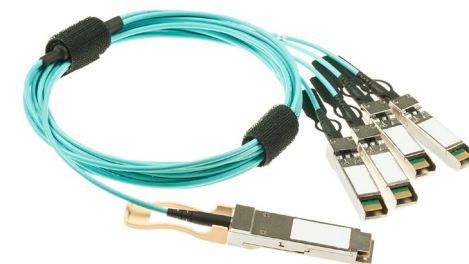
SO-QSFP28-4XSFP28-AOCxM QSFP28 to 4xSFP28, Active Optical Cable (AOC), 100G to 4x 25G Eth, 1m to 70m



QSFP28 to 4x SFP28 DAC
100G to 4x 25G



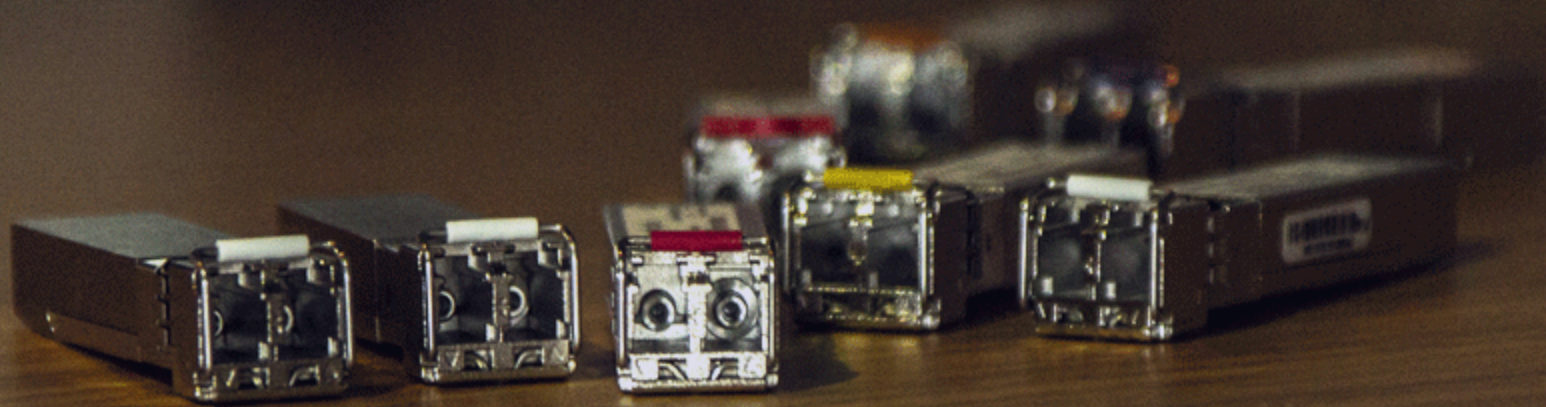
QSFP28 to QSFP28 AOC
100G to 100G



QSFP28 to 4x SFP28 AOC
100G to 4x 25G

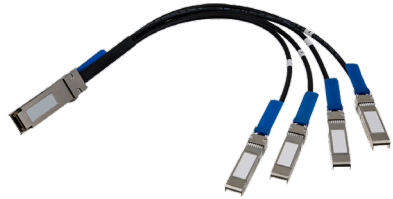
The thickness of the cable is defined by the AWG (American Wire Gauge) rating value.
As an example, an AWG26 DAC cable is thicker and heavier than the AWG30

100G to 4x 25G interconnect

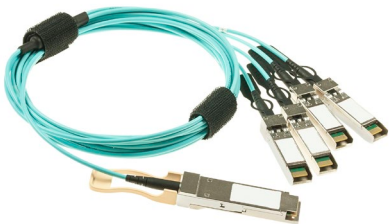


100G to 4x 25G interconnect

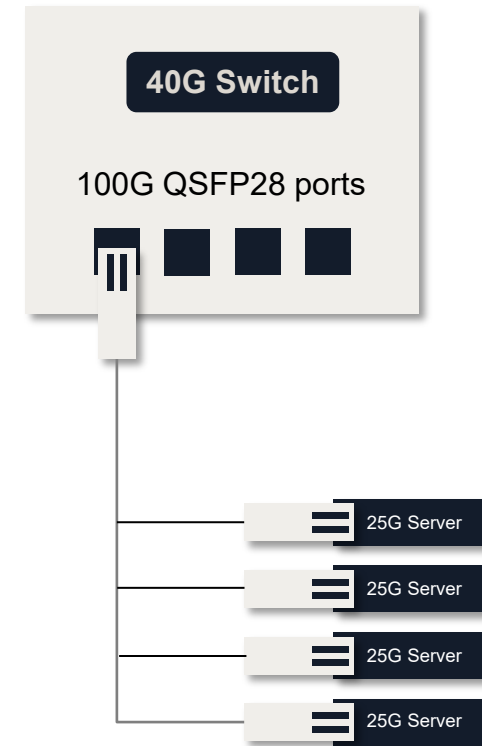
DAC or AOC cables:



QSFP28 to 4x SFP28 break-out DAC cables.
Are available in passive versions up to 5m length.

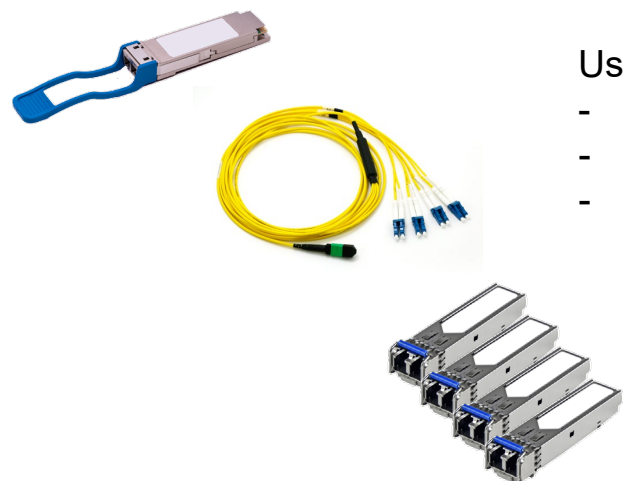


QSFP28 to 4x SFP28 break-out AOC cables.
Are available up to 70m length.



100G to 4x 25G interconnect

Optical transceivers and break-out patch cables:



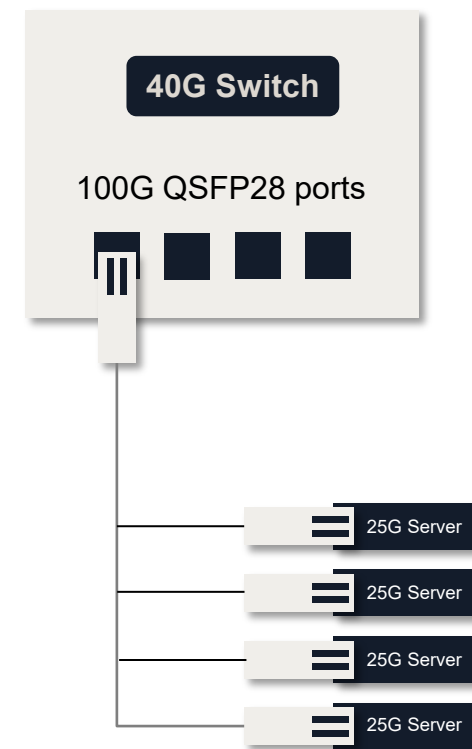
Using:

- MPO-based 100G transceiver
- MPO to LC break-out patch cable (SM or MM).
- 4x SFP28 transceivers

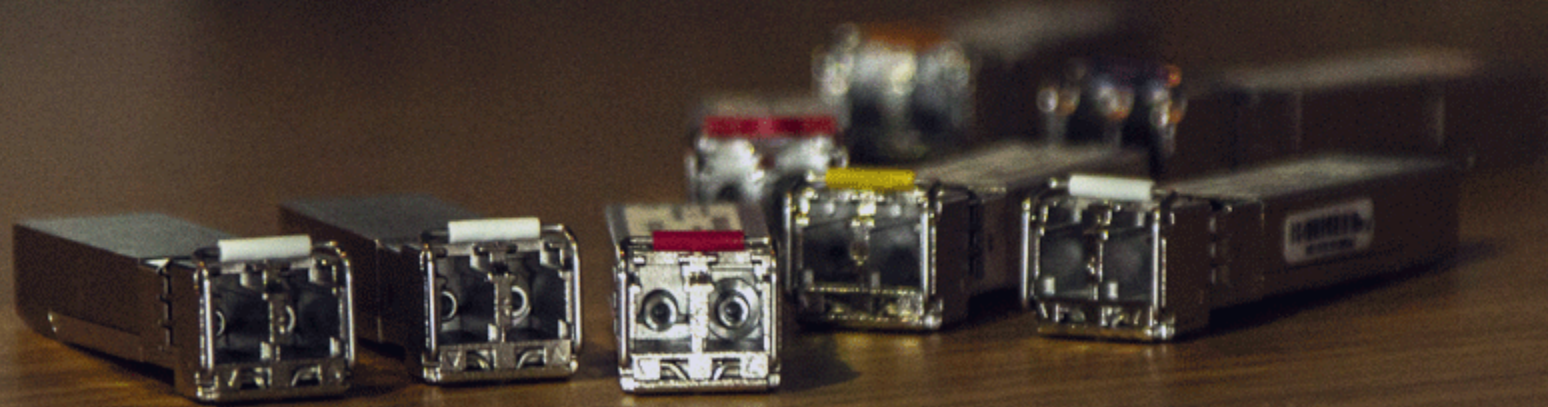
The 100G and the 25G transceivers need to have matching optical characteristics, such as:

SO-QSFP28-SR4 and SO-SFP28-SR (850nm, MM, ~100m)

SO-QSFP28-PSM4 and SO-SFP28-LR (1310nm, SM, ~2km, limited by the 100G transceiver)



400G interconnect



400G interconnect

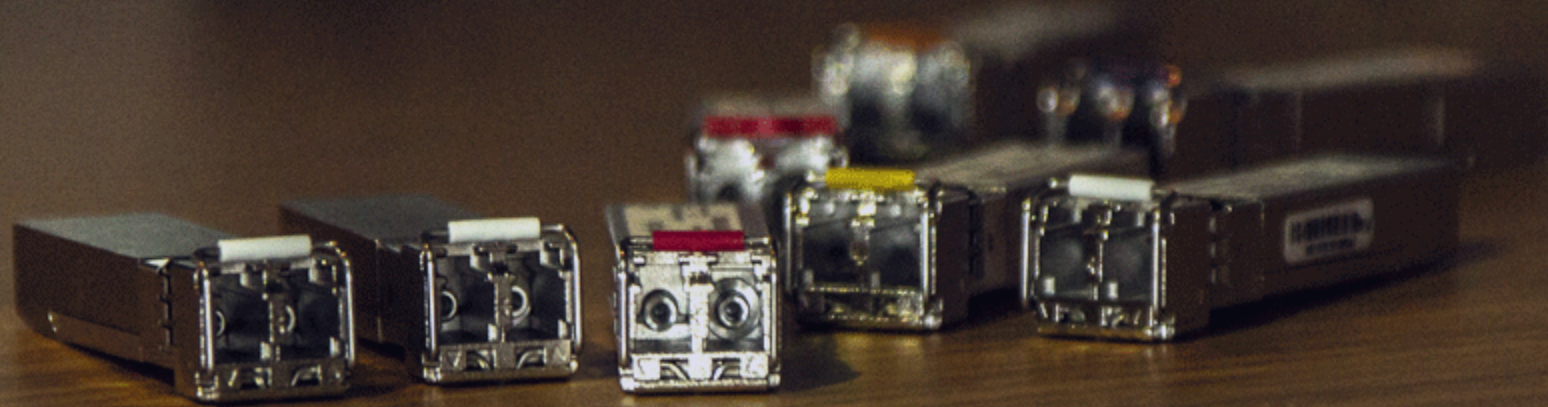
Two application options:

- 400G to 400G interconnect
- 400G to 4x 100G interconnect

Two technology options:

- Optical transceivers over Single-Mode fiber
- Active Optical Cables (AOC)

400G to 400G interconnect



400G to 400G interconnect

Optical QSFP-DD transceivers

400G-DR4



500m Ribbon-fiber

400G-FR4



2km Fiber-pair

400G-LR4



10km Fiber-pair

Note that CMIS3.0 and CMIS4.0 versions exist. Must be matched with host system.

QSFP-DD Transceivers, CMIS 3.0

SO-QSFP-DD-4C-DR4-M	QSFP-DD 400G-DR4 Ethernet, 4x100G-DR PAM4 CMIS3.0, 4x 1311nm 500m 3dB MPO12
SO-QSFP-DD-4C-FR4	QSFP-DD 400G-FR4 Ethernet, 4x100G-FR, PAM4 CMIS3.0, 1271nm/1291nm/1311nm/1331nm 2km 4dB LC
SO-QSFP-DD-4C-LR4	QSFP-DD 400G-LR4 Ethernet, 4x100G-LR, PAM4 CMIS3.0, 1271nm/1291nm/1311nm/1331nm 10km 6.3dB LC

QSFP-DD Transceivers, CMIS 4.0

SO-QSFP-DD-4C-DR4-4-M	QSFP-DD 400G-DR4 Ethernet, 4x100G-DR PAM4 CMIS4.0, 4x 1311nm 500m 3dB MPO12
SO-QSFP-DD-4C-FR4-4	QSFP-DD 400G-FR4 Ethernet, 4x100G-FR, PAM4 CMIS4.0, 1271nm/1291nm/1311nm/1331nm 2km 4dB LC
SO-QSFP-DD-4C-LR4-4	QSFP-DD 400G-LR4 Ethernet, 4x100G-LR, PAM4 CMIS4.0, 1271nm/1291nm/1311nm/1331nm 10km 6.3dB LC

400G to 400G interconnect

QSFP-DD AOC cables



1m to 30m length

CMIS 3.0 and CMIS 4.0 versions

400G-SR8; OM4 fiber cable with QSFP-DD "plug-ins"

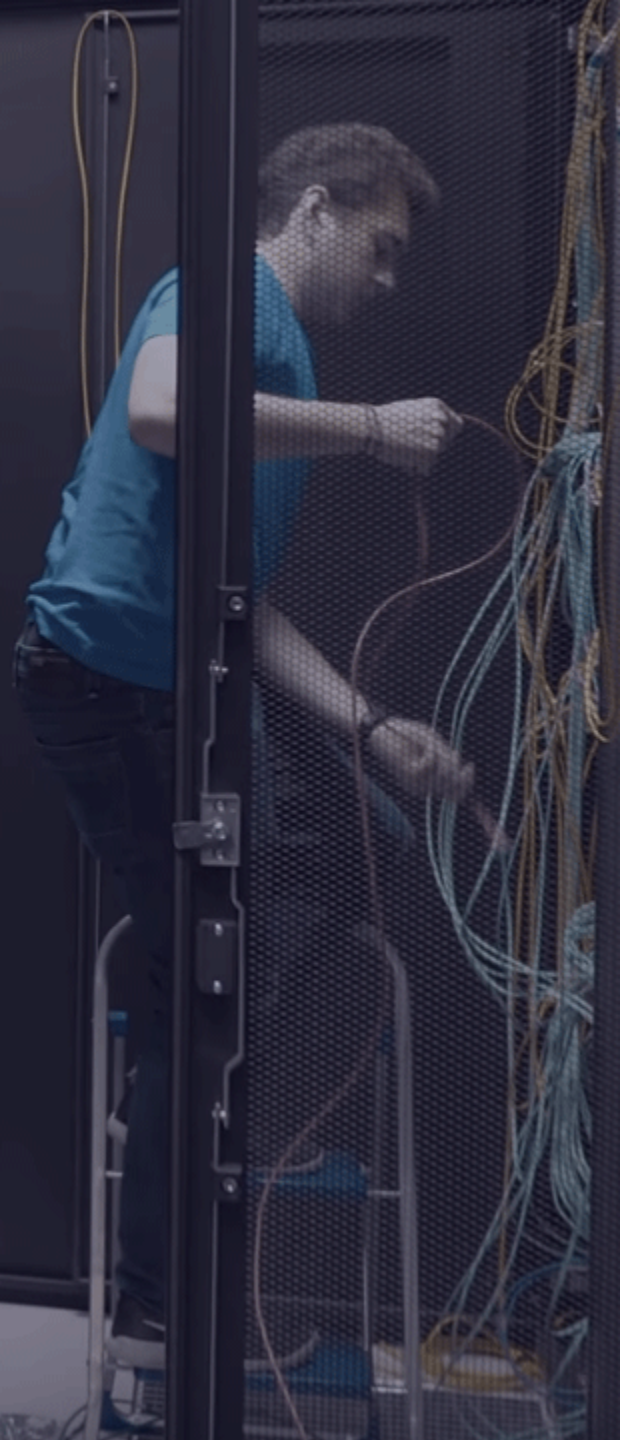
QSFP-DD AOC, CMIS 3.0

SO-QSFPDD-AOC01M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 1m
SO-QSFPDD-AOC03M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 3m
SO-QSFPDD-AOC05M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 5m
SO-QSFPDD-AOC07M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 7m
SO-QSFPDD-AOC10M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 10m
SO-QSFPDD-AOC15M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 15m
SO-QSFPDD-AOC20M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 20m
SO-QSFPDD-AOC30M	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS3.0 30m

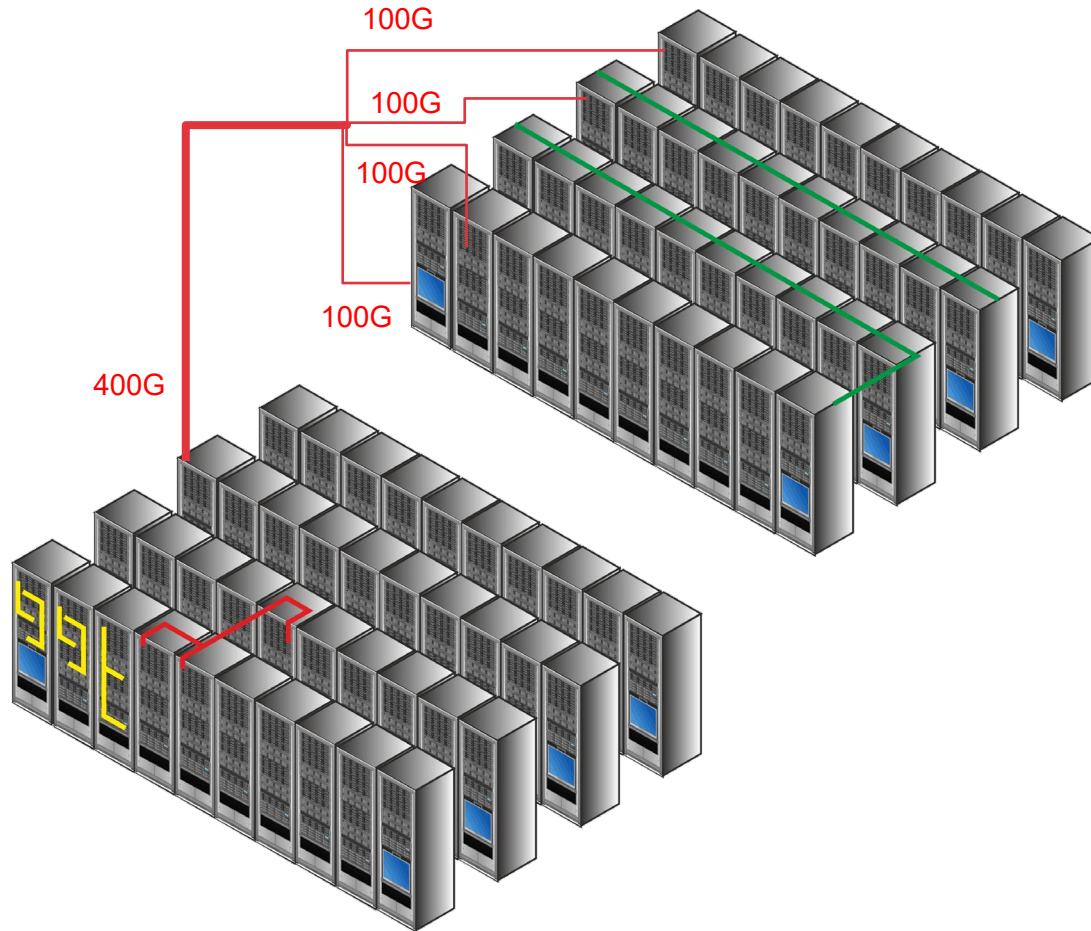
QSFP-DD AOC, CMIS 4.0

SO-QSFPDD-AOC01M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 1m
SO-QSFPDD-AOC03M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 3m
SO-QSFPDD-AOC05M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 5m
SO-QSFPDD-AOC07M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 7m
SO-QSFPDD-AOC10M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 10m
SO-QSFPDD-AOC15M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 15m
SO-QSFPDD-AOC20M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 20m
SO-QSFPDD-AOC30M-4	QSFP-DD 400G Ethernet-SR8, Active Optical Cable AOC MM CMIS4.0 30m

400G to 4x 100G interconnect



400G to 4x 100G break-out



Operator connecting @ 400G.

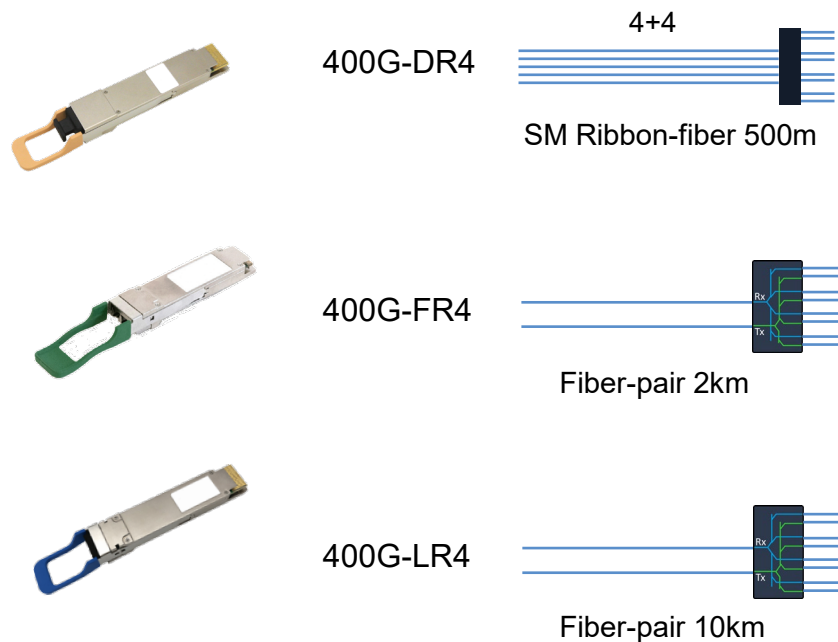
Multiple customers co-located or at remote Data Centers having 100G connections.

The single-lambda 100G –DR/-FR/-LR transceivers match the optical performance of the 400G –DR4/-FR4/-LR4 transceivers.

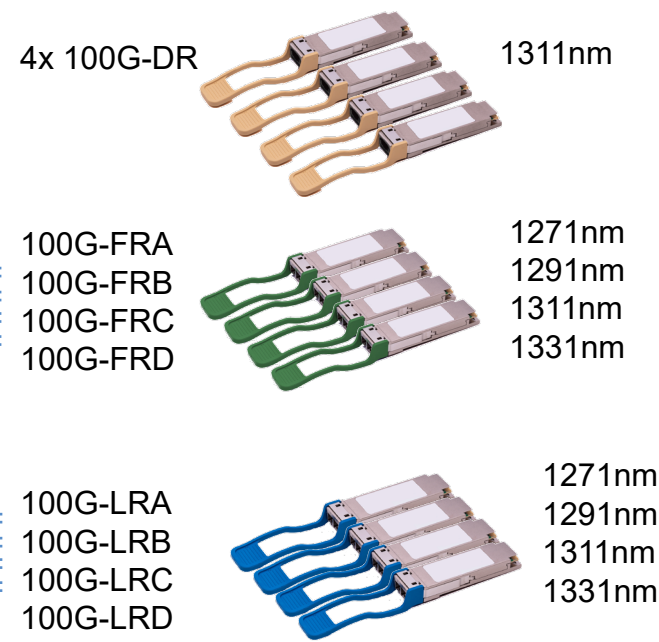
Three distance options,
- 500m
- 2km
- 10km

400G to 4x 100G breakout options

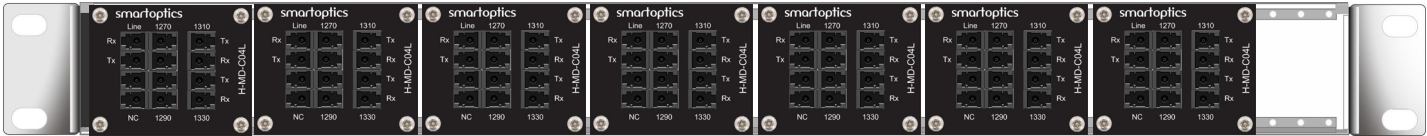
400G Transceivers



100G single-λ Transceivers



The H-MD-C04L filter matches the WDM filter in the transceiver



The H-Series filter enables up to 7 filters per 1RU.



smartoptics

