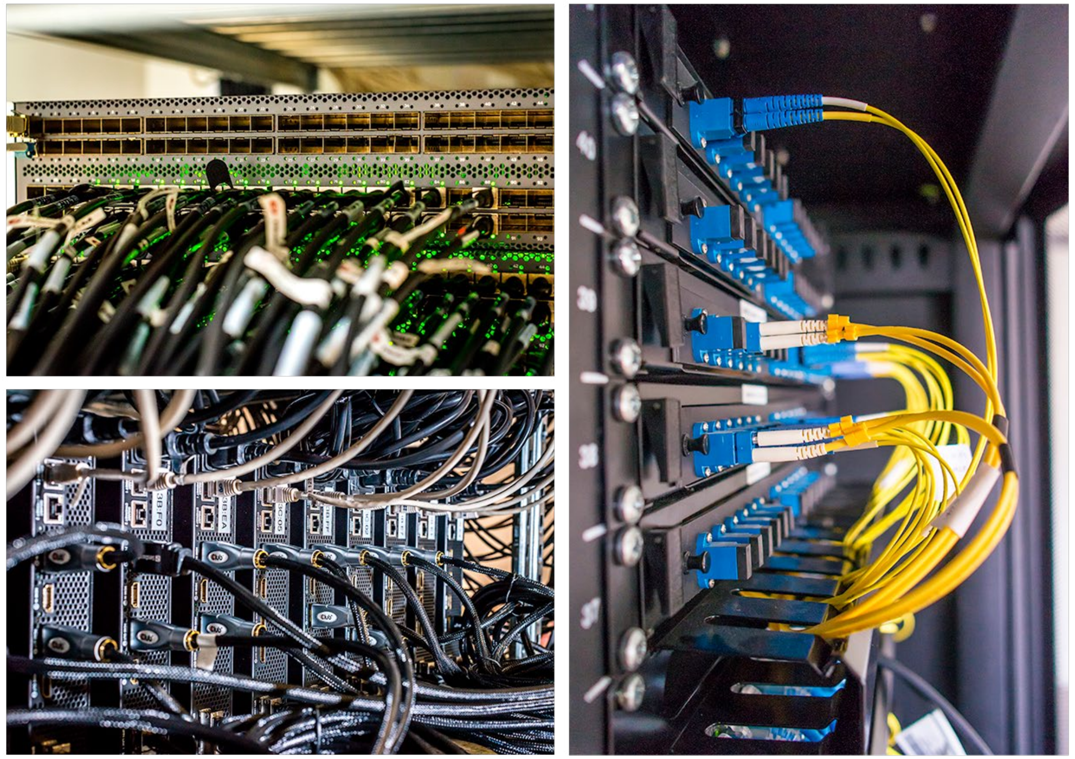
Application Notes



System Design Guide for UBEX

v2.4 23-05-2023

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Editor: Tamas Forgacs, Imre Mako

Contact Us

sales@lightware.com
+36 1 255 3800

support@lightware.com
+36 1 255 3810

Lightware Visual Engineering LLC.
Peterdy 15, Budapest H-1071, Hungary
www.lightware.com

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Disclaimer

> **ATTENTION!** Please note that **NOT all network switch types are tried out** and configured by the Lightware which are listed in this document. The endpoint numbers are calculated based on the data sheets from the provider. Network switches, which had already been **partially tested** and **configured for a user setup** by our engineers are marked on the data sheet page with the following stamp:

TESTED BY LIGHTWARE

2

Introduction

This chapter highlights the purpose of the document and gives a chance to get an overview into the world of UBEX network in the below listed sections:

- The Purpose of the Document
- About UBEX Technology
- UBEX Series Device Models
- Bandwidth Requirements of the Resolutions

2.1. The Purpose of the Document

The selection of the most appropriate Layer 3 (L3) network switch is one of the most important requirement in the AV system design procedure. The many parameters, running costs, requirements might make it difficult. This document summarizes the network switches of the market and collects the required accessories and costs incurred. Lightware believes the document helps designing the best available and cost-efficient UBEX matrix for our customers.

This application note contains the sections listed below:

- Connection guides and network related definitions with illustration photos;
- Summary tables of the L3 network switches with the maximum allowed endpoint devices grouped by the size of the business;
- Detailed list of the L3 network switches with all required UBEX AV system related parameters, accessories and other useful information.

2.2. About UBEX Technology

Lightware's most visionary development project is the UBEX (Ultra Bandwidth Extender) product family. This new optical solution allows 4K UHD@60Hz 4:4:4 uncompressed signal extension without latency. We use packet-based transmission instead of the conventional method.

We use standard, certificated 10 Gbps SFP+ optical modules which are plug and play, so they are swappable by the user. There could be either duplex multimode/singlemode modules (1–1 fiber for each direction per 10 Gbps link) or a bidirectional singlemode module (1 fiber for both direction per 10 Gbps link). The maximum distance is 400 m with multimode modules (OM4), and 10 km with short range singlemode modules, or 80 km with long range singlemode modules. In a typical application with standard, non-blocking 10 Gbps Ethernet switch it is necessary to use both directions of the link. Therefore the number of necessary fibers depend on the link speed and the optical module: for 10 Gbps 1 or 2 fibers, for 20 Gbps 2 or 4 fibers are needed. One of the primary advantages of the new architecture is scalability.

Matrix Management Unit

UBEX-MMU-X200 is a Matrix Management Unit (MMU) for the UBEX AV Over IP optical extender product line. With a standard Ethernet switch installed as a crosspoint, a virtual matrix can be created with UBEX devices connected to the IP network as input and output endpoints. The virtual matrix established requires to be managed and controlled by the MMU which is connected to the Ethernet switch.

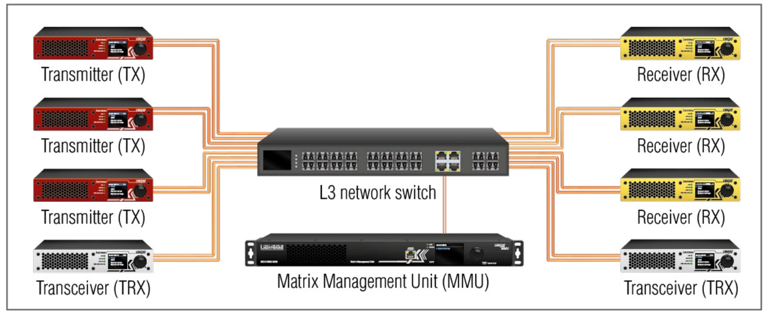
The MMU builds and constantly updates a database of the UBEX endpoints connected, displaying a traditional crosspoint view of the virtual matrix in the Lightware Device Controller (LDC) software, also displaying connected but inactive units.

The MMU displays information about endpoints and the overall virtual AV network, backup and restore functions are also provided to save and load the configuration. The MMU also manages the firmware upgrades of the connected endpoint UBEX devices, it is possible to initiate an update of the firmware on all UBEX units present in the network. Based on the communication with the UBEX endpoints, the MMU manages and supervises bandwidth use efficiency.

UBEX Application Modes

At first we need to clear up the application modes of the UBEX series devices. UBEX system has two main application modes:

- **EXTENDER application mode** - Point-to-point connection between a transmitter and a receiver, or between two transceiver endpoint devices;
- **MATRIX application mode** - Virtual A/V matrix with more transmitters, receivers, transceivers, and a Matrix Management Unit (MMU) which controls the A/V network.

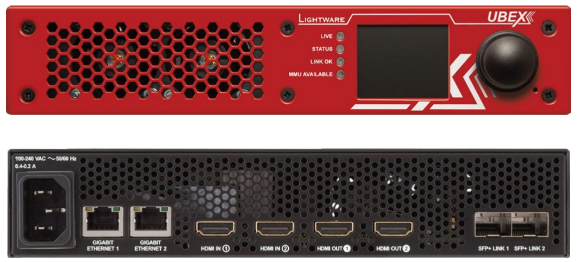


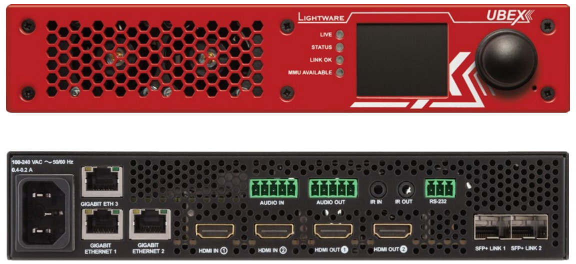
UBEX - Matrix application mode

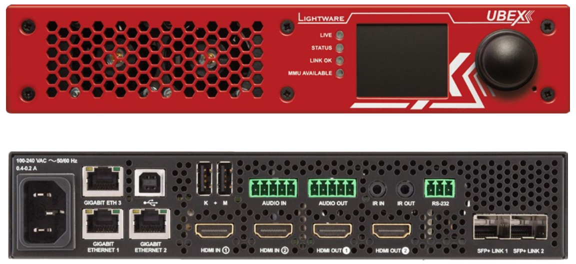
This application note is about the **Matrix application mode** only.

2.3. UBEX Series Device Models

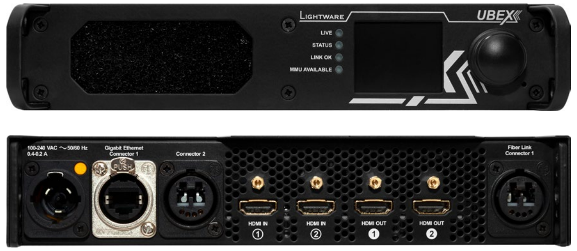
2.3.1. F-series Endpoint Models

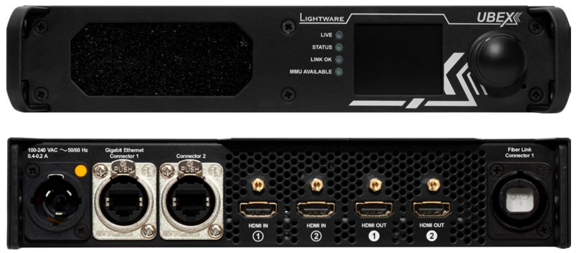
	**UBEX-PRO20-HDMI-F100** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps on two (or four) fibers; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream.

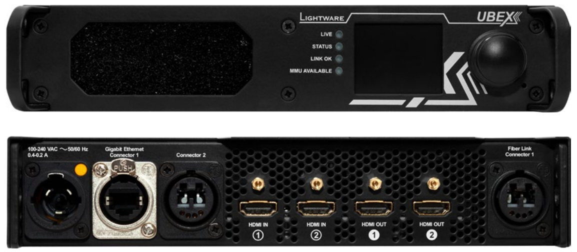
	**UBEX-PRO20-HDMI-F110** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps on two (or four) fibers; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, audio embedder and de-embedder function, RS-232 interface, Infrared interface.

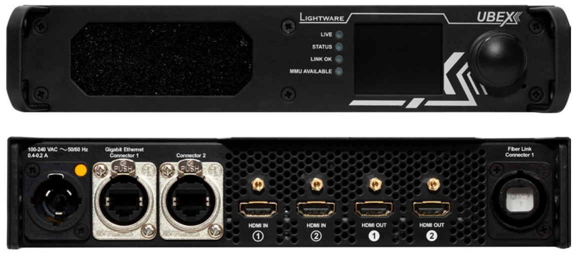
	**UBEX-PRO20-HDMI-F120** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps on two (or four) fibers; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, audio embedder and de-embedder function, RS-232 interface, Infrared interface, USB K+M.

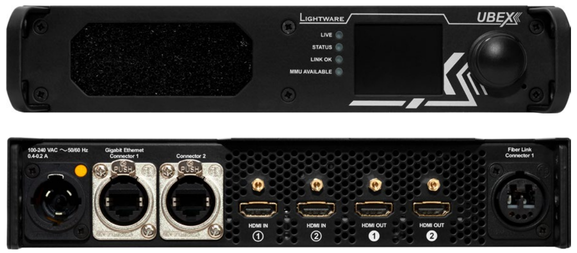
2.3.2. Rental (R-series) Endpoint Models

	**UBEX-PRO20-HDMI-R100 2xMM-2xDUO** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps designed for rental and professional users; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, including two 10G SFP+ multimode fiber modules with two Neutrik OpticalCON DUO connectors and EtherCON control port.

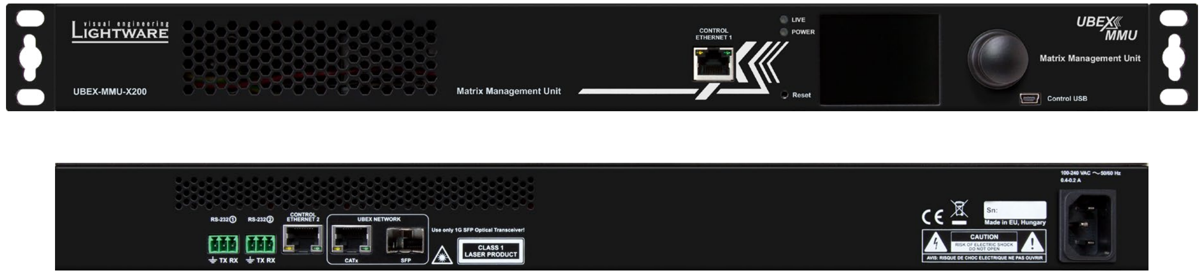
	**UBEX-PRO20-HDMI-R100 2xMM-QUAD** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps designed for rental and professional users; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, including two 10G SFP+ multimode fiber modules with one Neutrik OpticalCON QUAD connector and two EtherCON control ports.

	**UBEX-PRO20-HDMI-R100 2xSM-2xDUO** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps designed for rental and professional users; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, including two 10G SFP+ singlemode fiber modules with two Neutrik OpticalCON DUO connectors and EtherCON control port.

	**UBEX-PRO20-HDMI-R100 2xSM-QUAD** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps designed for rental and professional users; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, including two 10G SFP+ singlemode fiber modules with one Neutrik OpticalCON QUAD connector and two EtherCON control ports.

	**UBEX-PRO20-HDMI-R100 2xSM-BiDi-DUO** **Key features:** 4K UHD @ 60Hz 4:4:4 uncompressed AV over IP via 20 Gbps designed for rental and professional users; dual channel 4K transmitter, receiver or transceiver with scaling and multi stream, including two 10G BiDi SFP+ singlemode fiber modules with one Neutrik OpticalCON DUO connector and two EtherCON control ports.

2.3.3. Matrix Management Unit

	**UBEX-MMU-X200**
	Key features: Matrix Management Unit (MMU) for the UBEX AV over IP optical system, dynamic virtual matrix, video wall application, signal bandwidth management, centralized firmware upgrade for the endpoint devices, built-in web page.

2.4. Bandwidth Requirements of the Resolutions

2.4.1. Calculation Formula

The required bandwidth of a resolution can be calculated by a simple formula. Using the formula, the user can get the bandwidth requirement of any resolution. #bandwidth

[Horizontal pixels] x [Vertical pixels] x [Refresh rate] x [Color depth] x [Color sampling multiplier] x 1.08 = {Bandwidth}

The 1.08 multiplier is the overhead, which includes the data that is transmitted together with the AV signal.

Color Sampling Multiplier

The final result depends on the applied color sampling. In case of 4:4:4, the bandwidth is the same, so the multiplier will be 1. In case of 4:2:2 color sampling, the number will be the 66% of it; in case of 4:2:0, it is halved.

Color sampling	Color sampling multiplier
4:4:4	**1**
4:2:2	**0.66**
4:2:0	**0.5**

Let's see an example. Here is an one of the most used resolution: 4K UHD 60Hz 4:4:4 8bit/ch

The formula: 3840 x 2160 x 60 x 24 x 1 x 1.08 = 12,899,450,880 ≈ **12.9 Gbps**

Examples

The following examples show how it can be applied to it in the real life.

Resolution	Horizontal pixels	Vertical pixels	Refresh rate	Color depth	Color sampling multiplier	Overhead multiplier	Result	Bandwidth
1280x720@60Hz 4:4:4 10bit/ch	1280	720	60	30	1	1.08	1,791,590,400	**1.79 Gbps**
1600x1200@50Hz 4:4:4 8bit/ch	1600	1200	50	24	1	1.08	2,488,320,000	**2.49 Gbps**
1920x1080@60Hz 4:2:2 12bit/ch	1920	1080	60	36	0.66	1.08	3,192,614,093	**3.19 Gbps**
1920x1080@60Hz 4:4:4 8bit/ch	1920	1080	60	24	1	1.08	3,224,862,720	**3.23 Gbps**
2560x2048@60Hz 4:4:4 8bit/ch	2560	2048	60	24	1	1.08	8,153,726,976	**8.15 Gbps**
3840x2160@30Hz 4:4:4 12bit/ch	3840	2160	30	36	1	1.08	9,674,588,160	**9.67 Gbps**
4096x2160@30Hz 4:2:0 12bit/ch	4096	2160	30	36	0.5	1.08	5,159,780,352	**5.16 Gpbs**
4096x2160@30Hz 4:4:4 12bit/ch	4096	2160	30	36	1	1.08	10,319,560,704	**10.32 Gbps**
3840x2160@60Hz 4:4:4 8bit/ch	3840	2160	60	24	1	1.08	12,899,450,880	**12.9 Gbps**
4096x2160@60Hz 4:4:4 8bit/ch	4096	2160	60	24	1	1.08	13,759,414,272	**13.76 Gbps**

2.4.2. Table of the Most Used Resolutions

The following table contains the bandwidth requirement when transmitting one or two AV signals together. The table is grouped by resolution, color space, and color depth. The values are in **Gb/s**.

				Stream 1											
				No signal	1920x1080p60 (1080p)				3840x2160p30 (4K UHD 30)				3840x2160p60 (4K UHD 60)		
					YCbCr 4:2:2	RGB / YCbCr 4:4:4			YCbCr 4:2:2	RGB / YCbCr 4:4:4			YCbCr 4:2:0	YCbCr 4:2:2	RGB / YCbCr 4:4:4
					12 bit/ch	8 bit/ch	10 bit/ch	12 bit/ch	12 bit/ch	8 bit/ch	10 bit/ch	12 bit/ch	12 bit/ch	12 bit/ch	8 bit/ch
Stream 2	No signal			N/A	3.23	3.23	4.03	4.84	6.45	6.45	8.06	9.68	9.68	12.90	12.90
	1920x1080 60 Hz (1080p)	YCbCr 4:2:2	12 bit/ch	3.23	6.45	6.45	7.26	8.06	9.68	9.68	11.29	12.90	12.90	16.13	16.13
		RGB / YCbCr 4:4:4	8 bit/ch	3.23	6.45	6.45	7.26	8.06	9.68	9.68	11.29	12.90	12.90	16.13	16.13
			10 bit/ch	4.03	7.26	7.26	8.06	8.87	10.48	10.48	12.10	13.71	13.71	16.93	16.93
			12 bit/ch	4.84	8.06	8.06	8.87	9.68	11.29	11.29	12.90	14.51	14.51	17.74	17.74
	3840x2160 30 Hz (4K UHD 30)	YCbCr 4:2:2	12 bit/ch	6.45	9.68	9.68	10.48	11.29	12.90	12.90	14.51	16.13	16.13	19.35	19.35
		RGB / YCbCr 4:4:4	8 bit/ch	6.45	9.68	9.68	10.48	11.29	12.90	12.90	14.51	16.13	16.13	19.35	19.35
			10 bit/ch	8.06	11.29	11.29	12.10	12.90	14.51	14.51	16.13	17.74	17.74	20.97	20.97
			12 bit/ch	9.68	12.90	12.90	13.71	14.51	16.13	16.13	17.74	19.35	19.35	22.58	22.58
	3840x2160 60 Hz (4K UHD 60)	YCbCr 4:2:0	12 bit/ch	9.68	12.90	12.90	13.71	14.51	16.13	16.13	17.74	19.35	19.35	22.58	22.58
		YCbCr 4:2:2	12 bit/ch	12.90	16.13	16.13	16.93	17.74	19.35	19.35	20.97	22.58	22.58	25.80	25.80
		RGB / YCbCr 4:4:4	8 bit/ch	12.90	16.13	16.13	16.93	17.74	19.35	19.35	20.97	22.58	22.58	25.80	25.80

Legend:

🟩 < 10 Gbps 1 pc SFP+ module is enough for the transmission.

🟩 < 20 Gbps 2 pcs SFP+ modules are required for the transmission.

🟥 > 20 Gbps The transmission is not possible with 2 pcs SFP+ modules.

3

Definitions and Connection Guides

This chapter explaines the connection methods between the different interface ports of the network switches and the UBEX devices including definitions and real-life examples. The chapter includes the following sections:

- Endpoint Connection – SFP+ to SFP+
- Endpoint Connection – RJ45 to SFP+
- Endpoint Connection – QSFP+ / QSFP28 to SFP+
- MMU Connection – RJ45 to RJ45
- MMU Connection – SFP to RJ45
- MMU Connection – SFP to SFP
- MMU Connection – QSFP+ / QSFP28 to SFP / RJ45
- Connection between Network Switches – QSFP28 to QSFP28

3.1. Endpoint Connection – SFP+ to SFP+

The UBEX F-series endpoint devices are built with 2 pcs SFP+ slots so the most basic connection method between an L3 network switch and the endpoint devices is **SFP+ to SFP+**.

3.1.1. Definitions

SFP+

> DEFINITION: The enhanced small form-factor pluggable (**SFP+**) is an enhanced version of the SFP that supports data rates up to 10 Gbit/s.[1]

BiDi Modules

The single wavelength, bi-directional (BiDi) transceiver uses one fiber and one wavelength for simultaneous communication in both directions.[2] The advantage of this technology is that only one singlemode LC simplex fiber optical cable is needed for 10GbE data transmission.

Maximum Allowed Fiber-Optic Cable Length

The maximum allowed optical cable length depends of the installed SFP+ modules. Always check the specification of the optical modules before the fiber optical cabling.

Fiber-Optic Cables

> DEFINITION: A **fiber-optic cable**, also known as an **optical-fiber cable**, is an assembly similar to an electrical cable, but containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed. Different types of cable are used for different applications, for example, long distance telecommunication, or providing a high-speed data connection between different parts of a building.[3]

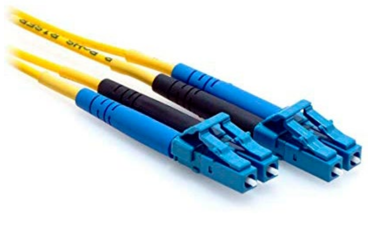
Multi-Mode Optical Fiber

Multi-mode optical fiber is a type of optical fiber mostly used for communication over short distances, such as within a building. Typical multi-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 400 meters (~1300 feet). Multi-mode fiber has a fairly large core diameter that enables multiple light modes to be propagated and limits the maximum length of a transmission link because of modal dispersion.[4]

Single-Mode Optical Fiber

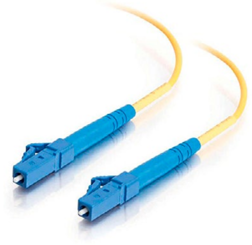
In fiber-optic communication, a **single-mode optical fiber** (SM) is an optical fiber designed to carry light only directly down the fiber - the transverse mode.[5] Typical single-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 10000 meters (~32800 feet).

Connector Types



LC duplex connector

Mostly used for SFP+ transceiver modules



LC simplex connector

Mostly used for SFP+ BiDi transceiver modules

DAC

A **Direct Attach Copper** cable or a **DAC** cable is a twinax copper cable that connects directly the ports (or line cards) within active equipment, such as switches, routers, servers or data storage devices, in a data network.[6]

There is 1G DAC cable, it can be used for the connection between the MMU and network switch; and there is 10G DAC cable, it can be used for the connection between the UBEX endpoint devices and network switch.

---

[1] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

[2] Source: http://www.fttxsfp.com/2019/05/09/the-principle-of-single-wavelength-bidi-transceiver/

[3] Source: https://en.wikipedia.org/wiki/Fiber-optic_cable

[4] Source: https://en.wikipedia.org/wiki/Multi-mode_optical_fiber

[5] Source: https://en.wikipedia.org/wiki/Single-mode_optical_fiber

[6] Source: https://www.completeconnect.co.uk/what-is-a-direct-attach-copper-dac-cable/

3.1.2. Connection Guide for Using SFP+ Modules

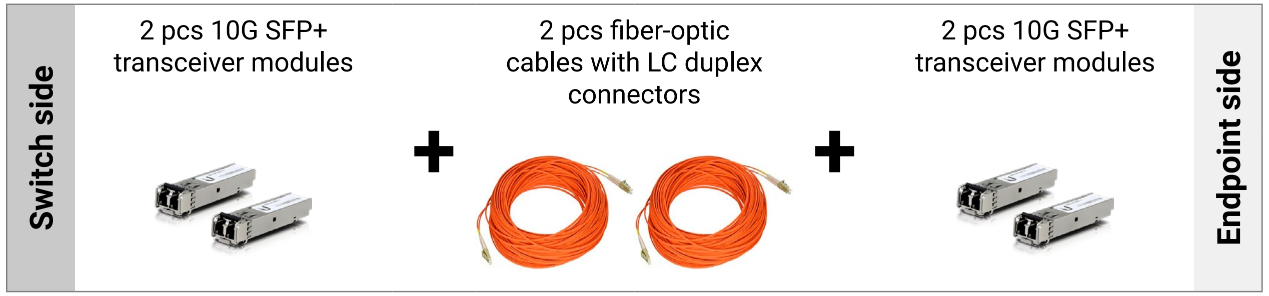
Advantage: the extension distance can be up to 400 m in case of multi-mode SFP+ modules and up to 10 km in case of single-mode SFP+ modules.

Disadvantage: using of SFP+ modules and fiber-optic cables is an expensive solution.

For 20GbE Data Transmission

20GbE bandwidth is required for one 4K 60Hz 4:4:4 signal transmission. In this case 2 pcs SFP+ slots per endpoint device are reserved in the network switch.

The list of the required network equipment **for one endpoint** is the following:


Switch side
2 pcs 10G SFP+ transceiver modules
+
2 pcs fiber-optic cables with LC duplex connectors
+
2 pcs 10G SFP+ transceiver modules
Endpoint side

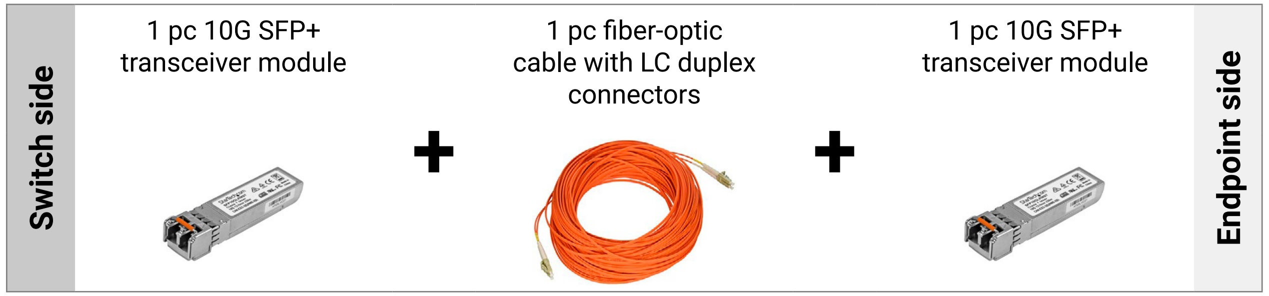
> **ATTENTION!** Always be sure the fiber-optic mode of the SFP+ modules and the cables are the same. Single-mode transceiver module is working with single-mode cable and multi-mode transceiver module works with single-mode cables only.

For 10GbE Data Transmission

10GbE bandwidth is required for one 4K 60Hz 4:2:2 signal transmission. In this case 1 pc SFP+ slot per endpoint device is reserved in the network switch.

With SFP+ Modules

The list of the required network equipment **for one endpoint** is the following:


Switch side
1 pc 10G SFP+ transceiver module
+
1 pc fiber-optic cable with LC duplex connectors
+
1 pc 10G SFP+ transceiver module
Endpoint side

> **ATTENTION!** Always be sure that fiber-optic mode of the SFP+ modules and the cables are same. Single-mode transceiver module is working with single-mode cable and multi-mode transceiver module works with single-mode cables only.

3.1.3. Connection Guide for Using DAC Cables

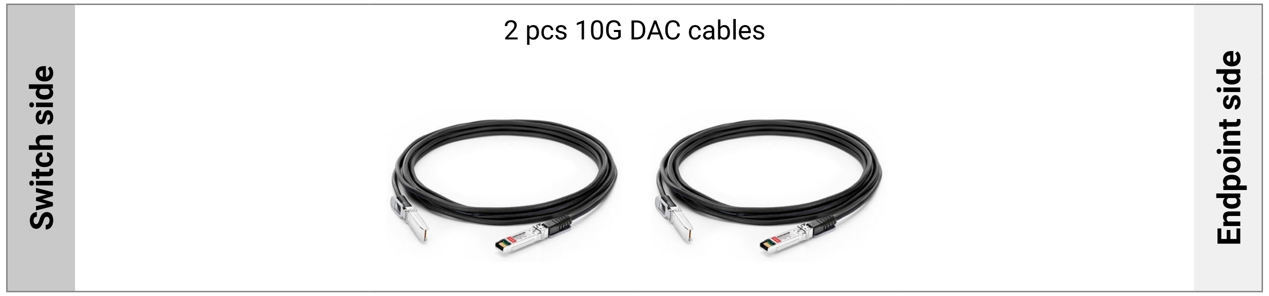
Advantage: using of DAC cables is a cost-efficient solution.

Disadvantage: the extension distance is up to 10 m only.

For 20GbE Data Transmission

20GbE bandwidth is required for one 4K 60Hz 4:4:4 signal transmission. In this case 2 pcs SFP+ slots per endpoint device are reserved in the network switch.

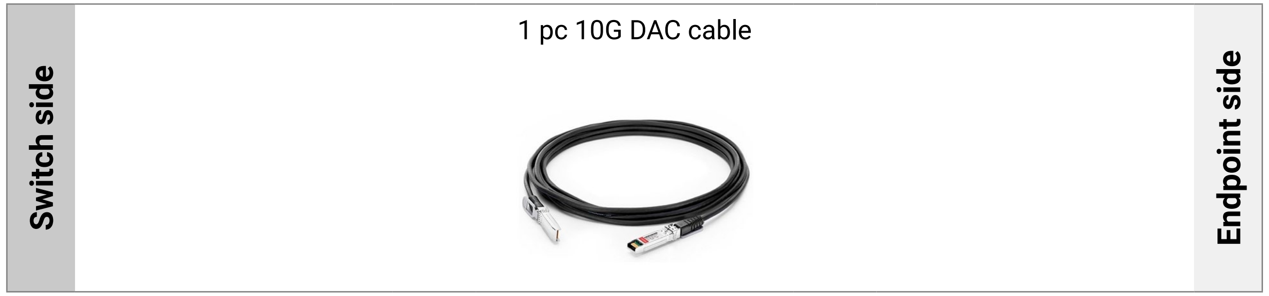
The list of the required network equipment **for one endpoint** is the following:


Switch side
2 pcs 10G DAC cables
Endpoint side

For 10GbE Data Transmission

10GbE bandwidth is required for one 4K 60Hz 4:2:2 signal transmission. In this case 1 pc SFP+ slot per endpoint device is reserved in the network switch.

The list of the required network equipment for **one endpoint** is the following:


Switch side
1 pc 10G DAC cable
Endpoint side

3.2. Endpoint Connection – RJ45 to SFP+

If the L3 network switch is built with 10G RJ45 copper ports, the endpoints can be connected to the switch using **SFP+ to RJ45** transceiver modules.

Advantage: use of CATx cables is a cost-efficient solution.

Disadvantage: the latency is higher than with the SFP+ (10GBASE-T latency is about 2.6 microseconds per link [8]) and the extension distance is up to 80 m only.

3.2.1. Definitions

SFP+ to RJ45

> DEFINITION: **SFP+ to RJ45** module, also known as copper SFP+, is a kind of hot-pluggable transceiver module. It supports 10 Gbps data rate over CAT5e, CAT6 or CAT7 cables with RJ45 connector interface. It allows communication over the twisted-pair copper cable.[8]

Maximum Allowed CATx Cable Length

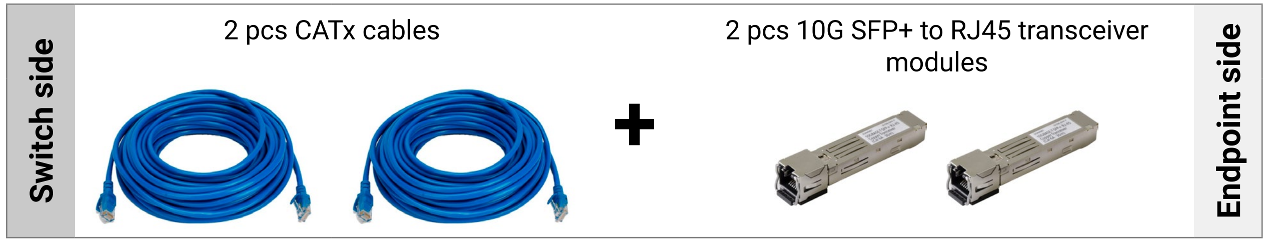
The maximum allowed CATx length depends of the installed SFP+ to RJ45 modules and the quality of the cables but it should be not longer than 80 m. Always check the specification of the module before the CATx cabling.

3.2.2. Connection Guide

For 20GbE Data Transmission

20GbE bandwidth is required for one 4K 60Hz 4:4:4 signal transmission. In this case 2 pcs 10G RJ45 ports per endpoint device are reserved in the network switch.

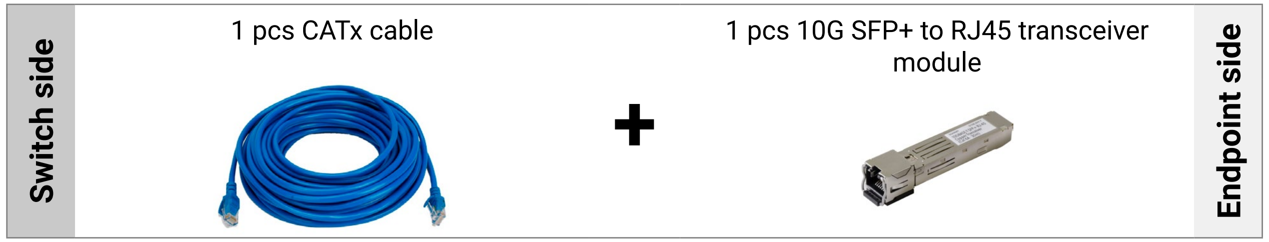
The list of the required network equipment **for one endpoint** is the following:



For 10GbE Data Transmission

10GbE bandwidth is required for one 4K 60Hz 4:2:2 signal transmission. In this case 1 pc 10G RJ45 port per endpoint device is reserved in the network switch.

The list of the required network equipment **for one endpoint** is the following:



3.3. Endpoint Connection – QSFP+ / QSFP28 to SFP+

This section is about how to connect the L3 network switch and the endpoint devices if the switch is built with 40G QSFP+ or 100G QSFP28 ports.

3.3.1. Definitions

QSFP+ MTP/MPO Modules

> DEFINITION: The small form-factor pluggable (SFP) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. A slightly larger sibling is the four-lane Quad Small Form-factor Pluggable (**QSFP**). The additional lanes allow for speeds 4 times their corresponding SFP. **QSFP+** is an evolution of QSFP to support four 10 Gbit/s channels carrying 10 Gigabit Ethernet, 10GFC FiberChannel, or QDR InfiniBand. The 4 channels can also be combined into a single 40 Gigabit Ethernet link. [9]

All QSFP+ transceiver modules mentioned in this document should be built with **MTP/MPO connector**.

> **ATTENTION!** The QSFP+ modules built with LC connectors cannot be used with breakout cables.

QSFP28 Slots

> DEFINITION: The small form-factor pluggable (SFP) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. A slightly larger sibling is the four-lane Quad Small Form-factor Pluggable (**QSFP**). The additional lanes allow for speeds 4 times their corresponding SFP. The **QSFP28** standard is designed to carry 100 Gigabit Ethernet, EDR InfiniBand, or 32G Fibre Channel. Sometimes this transceiver type is also referred to as "QSFP100" or "100G QSFP" for sake of simplicity.[9]

> **ATTENTION!** QSFP28 transceiver modules are not used for the connection with the UBEX endpoints. The allowed bandwidth rate of the QSFP28 ports can be downgraded from 100GbE to 40GbE in the most network switch models. After this setting the ports can be used with 40G QSFP+ transceiver modules or QSFP+ to 4x10G SFP+ breakout cables.

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[7] Source: http://www.fiber-optic-solutions.com/best-10g-solution-10gbase-t-sfp.html

[8] Source: http://www.fiber-optic-solutions.com/rj45-sfp-module.html

[9] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

QSFP+ to 4x10G SFP+ Breakout Cable

> DEFINITION: The **QSFP+ to 4x10G SFP+ breakout cables** are designed to split a single 40Gb QSFP+ interface into four (4) 10Gb SFP+ interfaces. The cable itself has a QSFP-shaped connector on one end and SFP-shaped connectors on the other end.[10]

Advantage: these connectors plug directly into the UBEX endpoint devices so there is no need for QSFP+ or SFP+ transceivers.

Disadvantage: the extension distance is short (in case of DAC is up to 7 m, in case of AOC is up to 30 m) and fixed.

There are two types of QSFP+ to 4x10G SFP+ breakout cables:

Direct Attach Copper (DAC)

Active Optical Cable (AOC)

MTP/MPO to LC Cables

> DEFINITION: SM or MM multi-fiber ribbon. Same ferrule as MT, but more easily reconnectable. Used for indoor cabling and device interconnections. **MTP** is a brand name for an improved connector, which is assembled with **MPO**.[11]

MTP/MPO harness cable is also known as fanout cable or breakout cable as it has a single MTP connector on one end and on the other end it breaks out into 6, 8, 12 or 24 connectors (LC, SC, ST, etc.). As one fiber patch cord contains two fibers for receiving and transmitting, a 8-fiber MTP-LC harness cable, for example, has 4 LC duplex connectors and a MTP connector at either end. Similarly, a 12-fiber MTP-LC harness cable has 6 LC duplex connectors and a MTP connector. MTP/MPO harness cable is usually deployed for 40G to 10G transmission and 100G to 25G transmission.[12]

SFP+

> DEFINITION: The enhanced small form-factor pluggable (**SFP+**) is an enhanced version of the SFP that supports data rates up to 10 Gbit/s.[13]

BiDi Modules

The single wavelength, bi-directional (BiDi) transceiver uses one fiber and one wavelength for a simultaneous communication in both directions.[14] The advantage of this technology is that only one singlemode LC simplex fiber optical cable is needed for 10GbE data transmission.

Maximum Allowed Fiber-Optic Cable Length

The maximum allowed optical cable length depends of the installed SFP+ modules. Always check the specification of the optical modules before the fiber optical cabling.

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[10] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

[11] Source: https://en.wikipedia.org/wiki/Optical_fiber_connector

[12] Source: http://www.fiber-optic-solutions.com/choose-mtpmpo-cable-10g40g100g-connections.html

Fiber-Optic Cables

> DEFINITION: A **fiber-optic cable**, also known as an **optical-fiber cable**, is an assembly similar to an electrical cable, but containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed. Different types of cable are used for different applications, for example, long distance telecommunication, or providing a high-speed data connection between different parts of a building.[15]

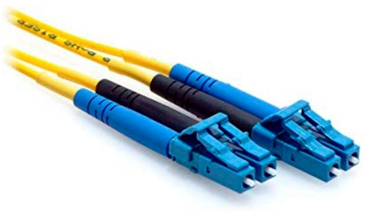
Multi-Mode Optical Fiber

Multi-mode optical fiber is a type of optical fiber mostly used for communication over short distances, such as within a building. Typical multi-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 400 meters (~1300 feet). Multi-mode fiber has a fairly large core diameter that enables multiple light modes to be propagated and limits the maximum length of a transmission link because of modal dispersion.[16]

Single-Mode Optical Fiber

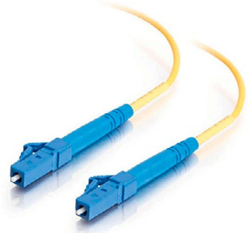
In fiber-optic communication, a **single-mode optical fiber** (SM) is an optical fiber designed to carry light only directly down the fiber - the transverse mode.[17] Typical single-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 10000 meters (~32800 feet).

Connector Types



LC duplex connector

Mostly used for SFP+ transceiver modules



LC simplex connector

Mostly used for SFP+ BiDi transceiver modules

Fiber Patch Panel

> DEFINITION: A fiber optic patch panel, also known as fiber distribution panel, serves as a convenient place to terminate all the fiber optic cable running from different rooms into the wiring closet and provides connection access to the cable's individual fibers. Fiber patch panels are termination units, which are designed with a secure, organized chamber for housing connectors and splice units. Fiber patch panels are available in rack mounted or wall mounted and are usually placed close to terminating equipment (within patch cable reach). Both types can house, organize, manage and protect fiber optic cable, splices and connectors. Rack mount panels also come in flat and angled versions.[18]

Using of fiber patch panel is required for the longer cable extension what the MTP/MPO to LC breakout cable can provide. The maximum cable length of the breakout cables is 5 m only but using of a patch panel the cable extension can be extended that the installed SFP+ modules in the endpoints allow (in case of multi-mode is up to 400 m, in case of single-mode is 10 km).

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[13] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

[14] Source: http://www.fttxsfp.com/2019/05/09/the-principle-of-single-wavelength-bidi-transceiver/

[15] Source: https://en.wikipedia.org/wiki/Fiber-optic_cable

[16] Source: https://en.wikipedia.org/wiki/Multi-mode_optical_fiber

[17] Source: https://en.wikipedia.org/wiki/Single-mode_optical_fiber

[18] Source: http://www.fiber-optic-equipment.com/fiber-optic-patch-panel-best-practices.html

3.3.2. Connection Guide for Using Fiber Patch Panel

Advantage: the extension distance can be up to 400 m in case of multi-mode SFP+ modules and up to 10 km in case of single-mode SFP+ modules.

Disadvantage: the network equipment for this solution is a expensive.

WARNING! In case of QSFP28 slots the port bandwidth rate downgrading setting to 40GbE is required.

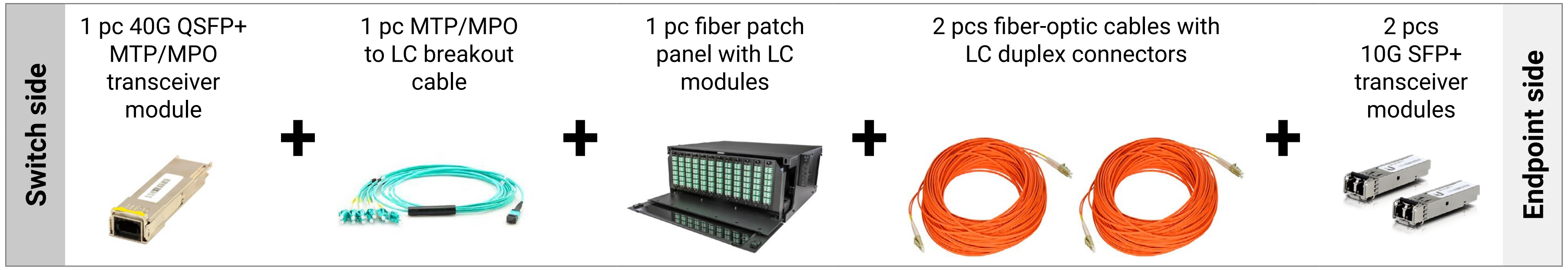
ATTENTION! Always be sure that fiber-optic mode of all required network equipment (QSFP+ module, QSFP+ to 4x10G SFP+ breakout cable, fiber patch panel (mainly the built-in fiber modules, fiber-optic cables and the SFP+ modules in the endpoint) is same. For example single-mode transceiver module works with single-mode cable and multi-mode transceiver module works with single-mode cables only.

ATTENTION! SFP+ **BiDi** modules cannot be connected to fiber patch panels.

For 20GbE Data Transmission

20GbE bandwidth is required for one 4K 60Hz 4:4:4 signal transmission.

The list of the required network equipment **for one endpoint** is the following:

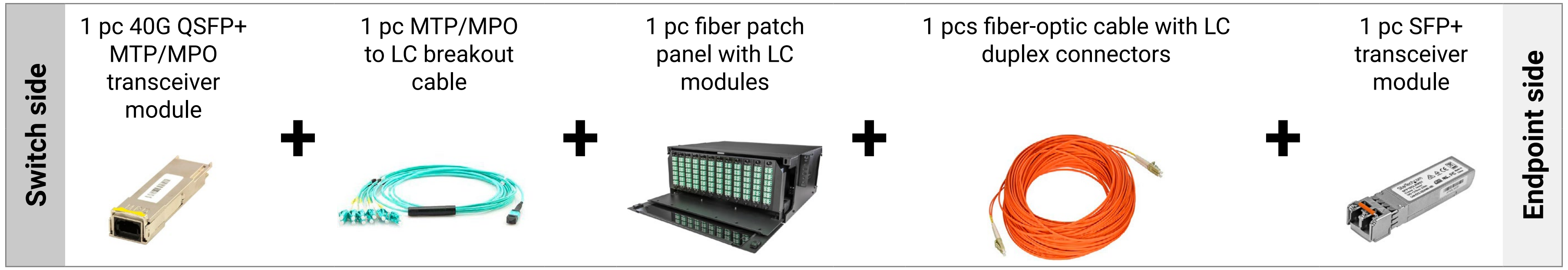

Switch side
1 pc 40G QSFP+ MTP/MPO transceiver module
+
1 pc MTP/MPO to LC breakout cable
+
1 pc fiber patch panel with LC modules
+
2 pcs fiber-optic cables with LC duplex connectors
+
2 pcs 10G SFP+ transceiver modules
Endpoint side

INFO: One QSFP+ with MTP/MPO connector, one MTP/MPO to LC cable and one fiber patch panel can serve **two endpoint devices** with 20GbE data transmission.

For 10GbE Data Transmission

10GbE bandwidth is required for one 4K 60Hz 4:2:2 signal transmission.

The list of the required network equipment **for one endpoint** is the following:


Switch side
1 pc 40G QSFP+ MTP/MPO transceiver module
+
1 pc MTP/MPO to LC breakout cable
+
1 pc fiber patch panel with LC modules
+
1 pcs fiber-optic cable with LC duplex connectors
+
1 pc SFP+ transceiver module
Endpoint side

INFO: One QSFP+ with MTP/MPO connector, one MTP/MPO to LC cable and one fiber patch panel can serve **four endpoint devices** with 10GbE data transmission.

3.3.3. Connection Guide for Using DAC/AOC Breakout Cables

Advantage: using of DAC/AOC cables is a cost-efficient solution.

Disadvantage: the extension distance is short (in case of DAC is up to 7 m, in case of AOC is up to 30 m) and fixed.

WARNING! In case of QSFP28 slots the port bandwidth rate downgrading setting to 40GbE is required.

For 20GbE Data Transmission

20GbE bandwidth is required for one 4K 60Hz 4:4:4 signal transmission.

The list of the required network equipment **for one endpoint** is the following:

Switch side
1 pc 40G QSFP+ DAC/AOC breakout cable
Endpoint side

INFO: One QSFP+ DAC/AOC cable can serve **two endpoint devices** with 20GbE data transmission.

For 10GbE Data Transmission

10GbE bandwidth is required for one 4K 60Hz 4:2:2 signal transmission.

The list of the required network equipment **for one endpoint** is the following:

Switch side
1 pc 40G QSFP+ DAC/AOC breakout cable
Endpoint side

INFO: One QSFP+ DAC/AOC cable can serve **four endpoint devices** with 10GbE data transmission.

3.4. MMU Connection – RJ45 to RJ45

The MMU needs 1GbE data rate and the most basic connection method with the network switch is the direct **RJ45 to RJ45** Ethernet.

The list of the required network equipment is the following:

Switch side

1 pc CATx cable

MMU side

3.5. MMU Connection – SFP to RJ45

If the network switch does not have RJ45 interface port but built with SFP/SFP+ slots, the MMU can be connected to it using an **SFP to RJ45** transceiver module.

3.5.1. Definitions

SFP

The small form-factor pluggable (**SFP**) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. It is a popular industry format jointly developed and supported by many network component vendors. The SFP interface supports data rates up to 1 Gbit/s. [19]

Maximum Allowed Optical Cable Length

The maximum allowed optical cable length depends of the installed SFP modules. Always check the specification of the optical modules before the fiber optical cabling.

SFP to RJ45

The small form-factor pluggable (**SFP**) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. **SFP to RJ45** module, also known as copper SFP, is a kind of hot-pluggable transceiver module. It supports 10/100/1000 Mbps data rate over CAT5e, CAT6 or CAT7 cables with RJ45 connector interface. It allows communications over the twisted-pair copper cable. [17]

3.5.2. Connection Guide

The list of the required network equipment is the following:

Switch side

1 pcs 1G SFP to RJ45 transceiver module

+

1 pcs CATx cable

MMU side

3.6. MMU Connection – SFP to SFP

If the network switch does not have RJ45 interface port but built with SFP/SFP+ slots, the MMU can be connected to the switch using SFP-SFP connection.

3.6.1. Definitions

SFP

The small form-factor pluggable (**SFP**) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. It is a popular industry format jointly developed and supported by many network component vendors. The SFP interface supports data rates up to 1 Gbit/s. [20]

Maximum Allowed Optical Cable Length

The maximum allowed optical cable length depends of the installed SFP modules. Always check the specification of the optical modules before the fiber optical cabling.

DAC

A **Direct Attach Copper** cable or a **DAC** cable is a twinax copper cable that connects directly the ports (or line cards) within active equipment, such as switches, routers, servers or data storage devices, in a data network. [21]

There is 1G DAC cable, it can be used for the connection between the MMU and network switch; and there is 10G DAC cable, it can be used for the connection between the UBEX endpoint devices and network switch.

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[19] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

[20] Source: https://en.wikipedia.org/wiki/Single-mode_optical_fiber

[21] Source: https://www.completeconnect.co.uk/what-is-a-direct-attach-copper-dac-cable/

Fiber-Optic Cables

> DEFINITION: A **fiber-optic cable**, also known as an **optical-fiber cable**, is an assembly similar to an electrical cable, but containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed. Different types of cable are used for different applications, for example, long distance telecommunication, or providing a high-speed data connection between different parts of a building.[22]

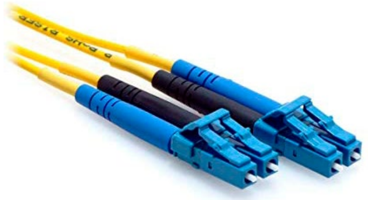
Multi-Mode Optical Fiber

Multi-mode optical fiber is a type of optical fiber mostly used for communication over short distances, such as within a building. Typical multi-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 400 meters (~1300 feet). Multi-mode fiber has a fairly large core diameter that enables multiple light modes to be propagated and limits the maximum length of a transmission link because of modal dispersion.[23]

Single-Mode Optical Fiber

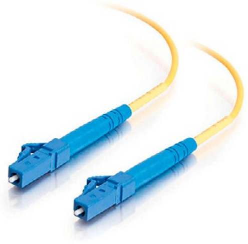
In fiber-optic communication, a **single-mode optical fiber** (SM) is an optical fiber designed to carry light only directly down the fiber - the transverse mode.[24] Typical single-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 10000 meters (~32800 feet).

Connector Types



LC duplex connector

Mostly used for SFP transceiver modules



LC simplex connector

Mostly used for SFP BiDi transceiver modules

3.6.2. Connection Guide for Using SFP Modules

Advantage: the extension distance can be up to 500 m in case of multi-mode SFP modules and up to 10 km in case of single-mode SFP modules.

Disadvantage: using of SFP modules and fiber-optic cables is an expensive solution.

The list of the required network equipment is the following:

Switch side	1 pc 1G SFP transceiver module 	+	1 pc fiber-optic cable with LC duplex connectors 	+	1 pc 1G SFP transceiver module 	**MMU side**

3.6.3. Connection Guide for Using DAC Cable

Advantage: using of DAC cables is a cost-efficient solution.

Disadvantage: the extension distance is up to 10 m only.

The list of the required network equipment is the following:

Switch side	1 pc 1G DAC cable 	**MMU side**

---

[22] Source: https://en.wikipedia.org/wiki/Fiber-optic_cable

[23] Source: https://en.wikipedia.org/wiki/Multi-mode_optical_fiber

[24] Source: https://en.wikipedia.org/wiki/Single-mode_optical_fiber

3.7. MMU Connection – QSFP+ / QSFP28 to SFP / RJ45

If the network switch does not have RJ45 interface port but built with 40G QSFP+ or 100G QSFP28 slots, the bandwidth rate should be converted to 1G by the following way described in this section.

3.7.1. Definitions

QSFP+ to 4x10G SFP+ Breakout Cable

> DEFINITION: The **QSFP+ to 4x10G SFP+ breakout cables** are designed to split a single 40Gb QSFP+ interface into four (4) 10Gb SFP+ interfaces. The cable itself has a QSFP-shaped connector on one end and SFP-shaped connectors on the other end.[25]

Advantage: these connectors plug directly into the UBEX endpoint devices so there is no need for QSFP+ or SFP+ transceivers.

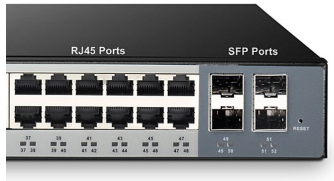
Disadvantage: the extension distance is short (in case of DAC is up to 7 m, in case of AOC is up to 30 m) and fixed.

There are two types of QSFP+ to 4x10G SFP+ breakout cables:

Direct Attach Copper (DAC)

Active Optical Cable (AOC)

Intermediate Network Switch


RJ45 Ports
SFP Ports

If the L3 network switch which serves the UBEX matrix has no 1G Ethernet connection possibility, an intermediate network switch should be installed between the switch and the MMU. The most important requirement of the switch is the device **should be built with SFP+ and SFP ports** or at least one of the SFP+ ports can be configured to **1GbE data rate**.

Standalone Media Rate Converter

If the L3 network switch which is served the UBEX matrix has no 1G Ethernet connection possibility, a standalone media rate converter can be installed between the switch and the MMU. It is available with 2 pcs SFP/SFP+ slots or SFP+ and RJ45 ports as well.

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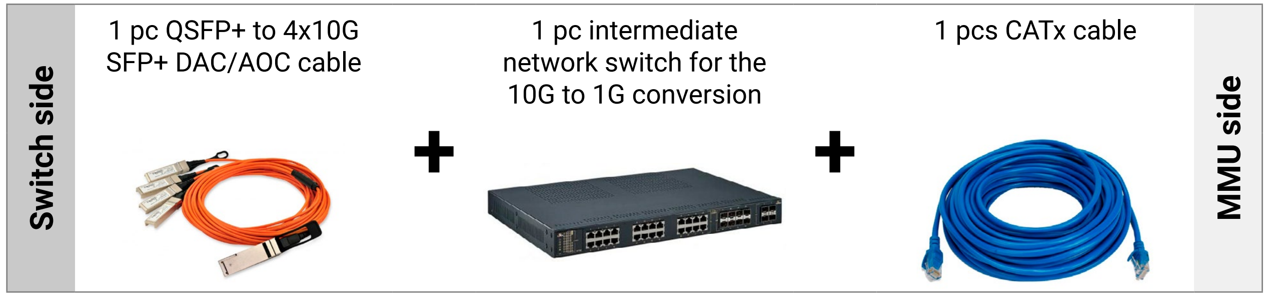
[25] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

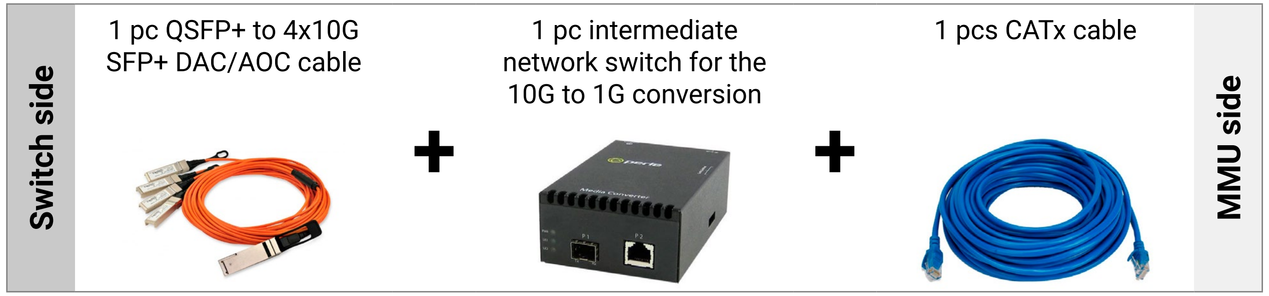
3.7.2. Connection Guide for Using Intermediate Network Switch

The list of the required network equipment is the following:


Switch side
1 pc QSFP+ to 4x10G SFP+ DAC/AOC cable
+
1 pc intermediate network switch for the 10G to 1G conversion
+
1 pcs CATx cable
MMU side

3.7.3. Connection Guide for Using Standalone Media Rate Converter

The list of the required network equipment is the following:


Switch side
1 pc QSFP+ to 4x10G SFP+ DAC/AOC cable
+
1 pc intermediate network switch for the 10G to 1G conversion
+
1 pcs CATx cable
MMU side

3.8. Connection between Network Switches – QSFP28 to QSFP28

The network switches can be connected to each other for expanding the number of connection possibilities. The type of connection between the switches can be stacked switches and leaf-and-spine deployment. This section describes the connection by 100GbE QSFP28 ports.

3.8.1. Definitions

QSFP28 Slots

DEFINITION: The small form-factor pluggable (SFP) is a compact, hot-pluggable optical module transceiver used for both telecommunication and data communication applications. A slightly larger sibling is the four-lane Quad Small Form-factor Pluggable (**QSFP**). The additional lanes allow for speeds 4 times their corresponding SFP. The **QSFP28** standard is designed to carry 100 Gigabit Ethernet, EDR InfiniBand, or 32G Fibre Channel. Sometimes this transceiver type is also referred to as "QSFP

QSFP28 AOC Cable

DEFINITION: **Active Optical Cables (AOC)** which using **QSFP28** standard are able to provide 100GbE data transmission per port between the network switches.

QSFP28 DAC Cable

DEFINITION: **Direct Attach Copper (DAC) cables** which using **QSFP28** standard are able to provide 100GbE data transmission per port between the network switches.

3.8.2. Connection Guide for Using QSFP28 AOC Cable

The list of the required network equipment **for 100GbE uplink** is the following:

Switch #1 side	1 pc 100G QSFP28 AOC cable 	**Switch #2 side**

ATTENTION! One AOC cable connection means 100GbE uplink between the network switches. When the required uplink is 200GbE, the required number of cables is two, and so on.

ATTENTION! Configuration of the switch ports which are wanted to be using as uplink ports is always required.

3.8.3. Connection Guide for Using QSFP28 DAC Cable

The list of the required network equipment **for 100GbE uplink** is the following:

Switch #1 side	1 pc 100G QSFP28 DAC cable 	**Switch #2 side**

ATTENTION! One DAC cable connection means 100GbE uplink between the network switches. When the required uplink is 200GbE, the required number of cables is two, and so on.

ATTENTION! Configuration of the switch ports which are wanted to be using as uplink ports is always required.

---

[26] Source: https://en.wikipedia.org/wiki/Small_form-factor_pluggable_ transceiver

4

Comparative Tables of the Network Switches

This chapter contains big data tables which summarize the most important parameters of the network switches regarding a UBEX AV system.

- Comparison of Switches – Interface Ports
- Comparison of Switches – Allowing Number of 20G Endpoints
- Comparison of Switches – Allowing Number of 10G Endpoints

4.1. Comparison of Switches – Interface Ports

Standalone Network Switches

	Network switch model	Interface ports				
		10GBASE-T RJ45 ports	10G SFP+ ports	25G SFP+ ports	40G QSFP+ ports	100G QSFP28 ports
Standalone switches	Ubiquiti EdgeSwitch 16 XG	4	12	-	-	-
	Netgear M4300-12X12F	12	12	-	-	-
	Netgear M4300-24XF	2	24	-	-	-
	Netgear M4300-24X24F	24	24	-	-	-
	Netgear M4300-48XF	2	48	-	-	-
	Netgear M4500-32C	-	-	-	-	32
	Netgear M4500-48XF8C	-	48	-	-	8
	Juniper QFX5100-48S	-	48	-	6	-
	Juniper QFX5100-96S	-	96	-	8	-
	Juniper QFX5110-48S	-	48	-	4	-
	Juniper QFX5110-32Q	-	-	-	32	-
	Juniper QFX5120-32C - Standalone Configuration	-	2	-	-	32
	Juniper QFX5120-48Y	-	48	-	8	-
	Juniper QFX5200-48Y	-	48	-	6	-
	Juniper QFX5200-32C	-	-	-	-	32
	Cisco Nexus 93360YC-FX2	-	96	-	-	12
	Cisco Nexus 9236C	-	-	-	-	36
	Cisco Nexus 9272Q	-	-	-	72	-
	Cisco Nexus 93180YC-EX - Standalone Configuration	-	48	-	-	6
	Mellanox SN2100	-	-	-	-	16
	Mellanox SN2010	-	18	-	-	4
	Mellanox SN2700	-	-	-	-	32
	Arista 7050SX3-48YC8	-	-	48	-	8

Modular Network Switches

	Network switch model	Interface ports			
		10GBASE-T RJ45 ports	10G SFP+ ports	40G QSFP+ ports	100G QSFP28 ports
Modular switches	Netgear M4300-96X ▪ installed with 12x APM408F expansion cards	-	96 (8 pcs percard)	-	-
	Cisco Nexus 9504 with N9K-X97160YC-EX Line Cards ▪ installed with 4x N9K-X97160YC-EX line cards	-	192 (48 pcs per card)	-	16 (4 pcs per card)
	Cisco Nexus 9504 with N9K-X9736C-FX Line Cards ▪ installed with 4x N9K-X9736C-FX line cards	-	-	-	144 (36 pcs per card)
	Cisco Nexus 9508 with N9K-X97160YC-EX Line Cards ▪ installed with 8x N9K-X97160YC-EX line cards	-	384 (48 pcs per card)	-	32 (4 pcs per card)
	Cisco Nexus 9508 with N9K-X9736C-FX Line Cards ▪ installed with 8x N9K-X9736C-FX line cards	-	-	-	288 (36 pcs per card)
	Cisco Nexus 9516 with N9K-X97160YC-EX Line Cards ▪ installed with 16x N9K-X97160YC-EX line cards	-	768 (48 pcs per card)	-	64 (4 pcs per card)
	Cisco Nexus 9516 with N9K-X9736C-FX Line Cards ▪ installed with 16x N9K-X9736C-FX line cards	-	-	-	576 (36 pcs per card)

4.2. Comparison of Switches – Allowing Number of 20G Endpoints

Number of Allowed Endpoint Devices with 20GbE Bandwidth **20GbE** bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots in the endpoint device			**Via SFP+ interface**	**Via RJ45 interface**	**Via QSFP+ / QSFP28 interface**	**ALTOGETHER**
Small business	1-30 endpoints	Ubiquiti EdgeSwitch 16 XG	6	1	-	**7**
		Netgear M4300-12X12F	6	5	-	**11**
		Netgear M4300-24XF	12	-	-	**12**
		Mellanox SN2010	8	-	8	**16**
		Netgear M4300-24X24F	12	11	-	**23**
		Netgear M4300-48XF	23	-	-	**23**
		Mellanox SN2100	-	-	30	**30**
Medium business	31-50 endpoints	Arista 7050SX3-48YC8	23	-	8	**31**
		Juniper QFX5110-48S	23	-	8	**31**
		Mellanox SN2700	-	-	31	**31**
		Cisco Nexus 93180YC-EX - Standalone Configuration	23	-	12	**35**
		Juniper QFX5100-48S	23	-	12	**35**
		Juniper QFX5200-48Y	23	-	12	**35**
		Netgear M4500-48XF8C	22	-	16	**38**
		Juniper QFX5120-48Y	23	-	16	**39**
		Juniper QFX5110-32Q	-	-	46	**46**
		Juniper QFX5200-32C	-	-	46	**46**
		Netgear M4300-96X	47	-	-	**47**
Big business	51-100 endpoints	Juniper QFX5100-96S	47	-	4	**51**
		Cisco Nexus 93180YC-EX - Two Stacked Switches Configuration	47	-	8	**55**
		Juniper QFX5120-32C - Standalone Configuration	-	-	62	**62**
		Netgear M4500-32C	-	-	62	**62**
		Cisco Nexus 9272Q	-	-	68	**68**
		Cisco Nexus 9236C	-	-	70	**70**
		Cisco Nexus 93360YC-FX2	47	-	24	**71**
		Juniper QFX5120-32C - Two Stacked Switches Configuration	-	-	80	**80**
		Cisco Nexus 9504 with N9K-X97160YC-EX Line Cards	85	-	-	**85**

Number of Allowed Endpoint Devices with 20GbE Bandwidth **20GbE** bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots in the endpoint device		**Via SFP+ interface**	**Via RJ45 interface**	**Via QSFP+ / QSFP28 interface**	**ALTOGETHER**
Corporate business 100+ endpoints	Juniper QFX5120-32C - 1 Spine 3 Leafs Configuration	-	-	120	**120**
	Juniper QFX5120-32C - 1 Spine 4 Leafs Configuration	-	-	160	**160**
	Cisco Nexus 9508 with N9K-X97160YC-EX Line Cards	191	-	-	**191**
	Cisco Nexus 9504 with N9K-X9736C-FX Line Cards	-	-	286	**286**
	Cisco Nexus 9516 with N9K-X97160YC-EX Line Cards	383	-	-	**383**
	Cisco Nexus 9508 with N9K-X9736C-FX Line Cards	-	-	574	**574**
	Cisco Nexus 9516 with N9K-X9736C-FX Line Cards	-	-	1150	**1150**

4.3. Comparison of Switches – Allowing Number of 10G Endpoints

Number of Allowed Endpoint Devices with 10GbE Bandwidth **10GbE** bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slots in the endpoint device		Via SFP+ interface	Via RJ45 interface	Via QSFP+ / QSFP28 interface	ALTOGETHER
Small business 1-30 endpoints	Ubiquiti EdgeSwitch 16 XG	12	3	-	**15**
	Netgear M4300-12X12F	12	11	-	**23**
	Netgear M4300-24XF	24	1	-	**25**
Medium business 31-50 endpoints	Mellanox SN2010	17	-	16	**33**
	Netgear M4300-24X24F	24	23		**47**
	Netgear M4300-48XF	47	-	-	**47**
Big business 51-100 endpoints	Mellanox SN2100	-	-	60	**60**
	Juniper QFX5110-48S	47	-	16	**61**
	Mellanox SN2700	-	-	62	**62**
	Arista 7050SX3-48YC8	47	-	16	**63**
	Cisco Nexus 93180YC-EX - Standalone Configuration	47	-	24	**71**
	Juniper QFX5100-48S	47	-	24	**71**
	Juniper QFX5200-48Y	47	-	24	**71**
	Netgear M4500-48XF8C	44	-	32	**76**
	Juniper QFX5120-48Y	47	-	32	**79**
	Juniper QFX5110-32Q	-	-	92	**92**
	Juniper QFX5200-32C	-	-	92	**92**
	Netgear M4300-96X	95	-	-	**95**

Number of Allowed Endpoint Devices with 10GbE Bandwidth **10GbE** bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slots in the endpoint device		**Via SFP+ interface**	**Via RJ45 interface**	**Via QSFP+ / QSFP28 interface**	**ALTOGETHER**
Corporate business 100+ endpoints	Juniper QFX5100-96S	95	-	8	**103**
	Cisco Nexus 93180YC-EX - Two Stacked Switches Configuration	95	-	16	**111**
	Netgear M4500-32C	-	-	124	**124**
	Juniper QFX5120-32C - Standalone Configuration	1	-	124	**125**
	Cisco Nexus 9272Q	-	-	136	**136**
	Cisco Nexus 9236C	-	-	140	**140**
	Cisco Nexus 93360YC-FX2	95	-	48	**143**
	Juniper QFX5120-32C - Two Stacked Switches Configuration	-	-	160	**160**
	Cisco Nexus 9504 with N9K-X97160YC-EX Line Cards	191	-	-	**191**
	Juniper QFX5120-32C - 1 Spine 3 Leafs Configuration	-	-	240	**240**
	Juniper QFX5120-32C - 1 Spine 4 Leafs Configuration	-	-	320	**320**
	Cisco Nexus 9508 with N9K-X97160YC-EX Line Cards	383	-	-	**383**
	Cisco Nexus 9504 with N9K-X9736C-FX Line Cards	-	-	572	**572**
	Cisco Nexus 9516 with N9K-X97160YC-EX Line Cards	767	-	-	**767**
	Cisco Nexus 9508 with N9K-X9736C-FX Line Cards	-	-	1148	**1148**
	Cisco Nexus 9516 with N9K-X9736C-FX Line Cards	-	-	2300	**2300**

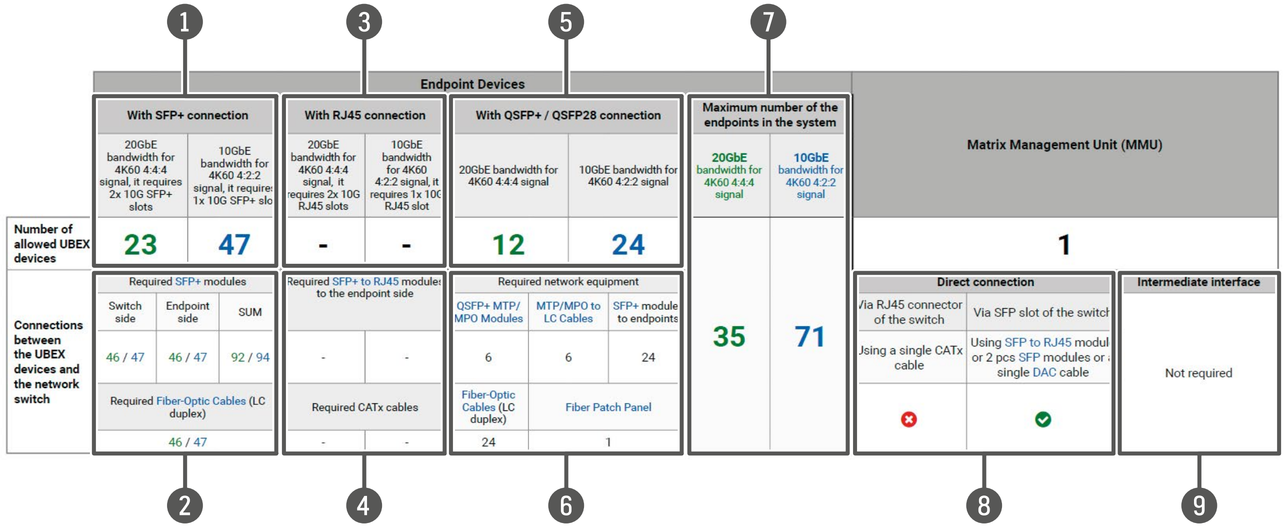
5

Network Switch Data Sheets for UBEX Systems

The following L3 network switch models are detailed in this section:

- Ubiquiti EdgeSwitch 16 XG
- Netgear M4300-12X12F
- Netgear M4300-24XF
- Netgear M4300-24X24F
- Netgear M4300-48XF
- Netgear M4300-96X
- Netgear M4500-32C
- Netgear M4500-48XF8C
- Juniper QFX5100-48S
- Juniper QFX5100-96S
- Juniper QFX5110-48S
- Juniper QFX5110-32Q
- Juniper QFX5120-32C - Standalone Configuration
- Juniper QFX5120-32C - Two Stacked Switches Configuration
- Juniper QFX5120-32C - 1 Spine 3 Leafs Configuration
- Juniper QFX5120-32C - 1 Spine 4 Leafs Configuration
- Juniper QFX5120-48Y
- Juniper QFX5200-48Y
- Juniper QFX5200-32C
- Cisco Nexus 93360YC-FX2
- Cisco Nexus 9236C
- Cisco Nexus 9272Q
- Cisco Nexus 93180YC-EX - Standalone Configuration
- Cisco Nexus 93180YC-EX - Two Stacked Switches Configuration
- Cisco Nexus 9504 with N9K-X97160YC-EX Line Cards
- Cisco Nexus 9504 with N9K-X9736C-FX Line Cards
- Cisco Nexus 9508 with N9K-X97160YC-EX Line Cards
- Cisco Nexus 9508 with N9K-X9736C-FX Line Cards
- Cisco Nexus 9516 with N9K-X97160YC-EX Line Cards
- Cisco Nexus 9516 with N9K-X9736C-FX Line Cards
- Mellanox SN2100
- Mellanox SN2010
- Mellanox SN2700
- Arista 7050SX3-48YC8

The Legend of the Data Sheet Tables



<table>
<tr><th></th><th colspan="8">Endpoint Devices</th><th colspan="2" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th></th><th colspan="2">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="2">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><th></th><th>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</th><th>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</th><th>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</th><th>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</th><th>20GbE bandwidth for 4K60 4:4:4 signal</th><th>10GbE bandwidth for 4K60 4:2:2 signal</th><th>20GbE bandwidth for 4K60 4:4:4 signal</th><th>10GbE bandwidth for 4K60 4:2:2 signal</th></tr>
<tr><td>Number of allowed UBEX devices</td><td>23</td><td>47</td><td>-</td><td>-</td><td>12</td><td>24</td><td rowspan="2">35</td><td rowspan="2">71</td><td colspan="2">1</td></tr>
<tr><td>Connections between the UBEX devices and the network switch</td><td colspan="2">Required SFP+ modules
Switch side
Endpoint side
SUM
46 / 47
46 / 47
92 / 94
Required Fiber-Optic Cables (LC duplex)
46 / 47</td><td colspan="2">Required SFP+ to RJ45 modules to the endpoint side
-
-
Required CATx cables
-
-</td><td colspan="2">Required network equipment
QSFP+ MTP/ MPO Modules
MTP/MPO to LC Cables
SFP+ module to endpoints
6
6
24
Fiber-Optic Cables (LC duplex)
Fiber Patch Panel
24
1</td><td>Direct connection
Via RJ45 connector of the switch
Via SFP slot of the switch
Using a single CATx cable
Using SFP to RJ45 modul or 2 pcs SFP modules or single DAC cable
✗
✓</td><td>Intermediate interface
Not required</td></tr>
</table>

For Endpoint Devices

① The two numbers mean the number of the allowed endpoint devices **via the 10G SFP+ interface ports** of the switch. **Green** means the 20GbE, **blue** means the 10GbE data transmission.

② The list of the required network equipment for the SFP+ connection (like a shopping list). **Green** numbers mean the 20GbE, **blue** numbers mean the 10GbE data transmission.

- **Switch side**: the number of SFP+ modules to the switch.
- **Endpoint side**: the number of SFP+ modules to the endpoints.
- **SUM**: the number of SFP+ modules altogether.

③ The two numbers mean the number of the allowed endpoint devices **via the 10G RJ45 copper interface ports** of the switch. **Green** means the 20GbE, **blue** means the 10GbE data transmission.

④ The list of the required network equipment for the RJ45 connection (like a shopping list). **Green** numbers mean the 20GbE, **blue** numbers mean the 10GbE data transmission.

- **Required SFP+ to RJ45 modules to the endpoint side**: the number of SFP+ to RJ45 modules to the endpoints.
- **Required CATx cables**: the number of CATx cables.

⑤ The two numbers mean the number of the allowed endpoint devices **via the 40G QSFP+** or **100G QSFP28 interface ports** of the switch. **Green** means the 20GbE, **blue** means the 10GbE data transmission.

For Endpoint Devices

⑥ The list of the required network equipment for the QSFP+ / QSFP28 connection (like a shopping list).

- **QSFP+ MTP/ MPO modules**: the number of QSFP+ modules to the switch.
- **MTP/MPO to LC cables**: the number of QSFP+ breakout cables to the QSFP+ modules.
- **SFP+ modules to endpoints**: the number of SFP+ modules to the endpoints.
- **Fiber-optic cables**: the number of fiber-optic cables between the patch panel and the endpoints.
- **Fiber Patch Panel**: the required fiber patch panel, please check the details by clicking on the text.

⑦ The two numbers mean the number of the allowed endpoint devices **via all interface ports** of the switch. **Green** means the 20GbE, **blue** means the 10GbE data transmission.

For MMU

⑧ The **direct connection indicators** shows the connection possibilities of the MMU where no needs any intermediate interface. It means in the practice the connection can be established using a single CATx cable, or using SFP modules and fiber-optic cables, etc.

⑨ If any **intermediate interface** is required for the MMU connection, it is described here. You can read more details about it by clicking on the links in the text.

5.1. Ubiquiti EdgeSwitch 16 XG

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><th colspan="16">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="6">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="6">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">6</td><td colspan="3">12</td><td>1</td><td>3</td><td colspan="3">-</td><td colspan="3">-</td><td rowspan="6">7</td><td rowspan="6">15</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><th colspan="2">Direct connection</th><th>Intermediate interface</th></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">12</td><td colspan="2">12</td><td colspan="2">24</td><td>2</td><td>3</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✓</td><td rowspan="2">Not required</td></tr>
<tr><td colspan="6">12</td><td>3</td><td>3</td><td colspan="2">-</td><td colspan="4">-</td></tr>
</table>

Links

Website:	https://www.ui.com/edgemax/edgeswitch-16-xg/
Data sheet:	https://dl.ubnt.com/datasheets/edgemax/EdgeSwitch_ES-16-XG_DS.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE

5.2. Netgear M4300-12X12F

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">6</td><td colspan="3">12</td><td>5</td><td>11</td><td colspan="3">-</td><td colspan="3">-</td><td rowspan="6">11</td><td rowspan="6">23</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">12</td><td colspan="2">12</td><td colspan="2">24</td><td>10</td><td>11</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✓</td><td rowspan="2">Not required</td></tr>
<tr><td colspan="6">12</td><td>10</td><td>11</td><td colspan="2">-</td><td colspan="4">-</td></tr>
</table>

Links

Website: https://www.netgear.com/support/product/M4300-12X12F.aspx

Data sheet: http://www.downloads.netgear.com/files/GDC/datasheet/en/M4300.pdf

5.3. Netgear M4300-24XF

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><th rowspan="3"></th><th colspan="12">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="4">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="4">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="2">12</td><td colspan="2">24</td><td>-</td><td>1</td><td colspan="2">-</td><td colspan="2">-</td><td rowspan="6">12</td><td rowspan="6">25</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td>24</td><td colspan="2">24</td><td>48</td><td>-</td><td>1</td><td>-</td><td colspan="2">-</td><td>-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">✓</td><td rowspan="2">Not required</td></tr>
<tr><td colspan="4">24</td><td>-</td><td>1</td><td>-</td><td colspan="3">-</td></tr>
</table>

Links

Website: https://www.netgear.com/business/products/switches/managed/m4300-24xf.aspx

Data sheet: http://www.downloads.netgear.com/files/GDC/datasheet/en/M4300.pdf

5.4. Netgear M4300-24X24F

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices										**Matrix Management Unit (MMU)**		
	With SFP+ connection			**With RJ45 connection**		**With QSFP+ / QSFP28 connection**			**Maximum number of the endpoints in the system**				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	**12**	**24**		**11**	**23**	**-**	**-**		**23**	**47**	**1**		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	24	24	48	22	23	-	-	-			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✓	Not required	
	24			22	23	-	-						

Links

Website:	https://www.netgear.com/business/products/switches/managed/M4300-24X24F.aspx
Data sheet:	http://www.downloads.netgear.com/files/GDC/datasheet/en/M4300.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE

5.5. Netgear M4300-48XF

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">23*</td><td colspan="3">47*</td><td>-</td><td>-</td><td colspan="3">-</td><td colspan="3">-</td><td rowspan="6">23*</td><td rowspan="6">47*</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">48</td><td colspan="2">48</td><td colspan="2">96</td><td>-</td><td>-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✓</td><td rowspan="2">Not required</td></tr>
<tr><td colspan="6">48</td><td>-</td><td>-</td><td colspan="2">-</td><td colspan="4">-</td></tr>
</table>

* The 47F, 47T, 48F and 48T ports are shared.

Links

Website:	https://www.netgear.com/support/product/m4300-48xf.aspx
Data sheet:	http://www.downloads.netgear.com/files/GDC/datasheet/en/M4300.pdf

5.6. Netgear M4300-96X

The Legend of the Data Sheet Tables

> INFO: Netgear M4300-96X is a modular network switch. The UBEX AV system related parameters below is valid with installed **12 pcs APM408F** 1G/10G SFP+ port expansion cards only.

UBEX System Related Parameters

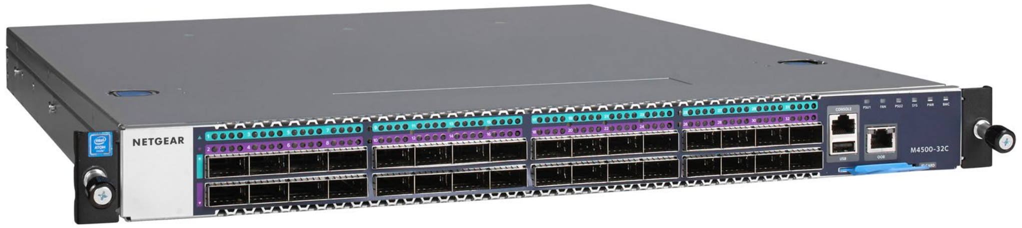
<table>
<tr><td rowspan="3"></td><td colspan="12">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="4">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="4">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="2">47</td><td colspan="2">95</td><td>-</td><td>-</td><td colspan="2">-</td><td colspan="2">-</td><td rowspan="6">47</td><td rowspan="6">95</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td>94 / 95</td><td colspan="2">94 / 95</td><td>188 / 190</td><td>-</td><td>-</td><td>-</td><td colspan="2">-</td><td>-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="4">94 / 95</td><td>-</td><td>-</td><td>-</td><td colspan="3">-</td></tr>
</table>

Links

Website: https://www.netgear.com/business/products/switches/managed/M4300-96X.aspx

Data sheet: http://www.downloads.netgear.com/files/GDC/datasheet/en/M4300.pdf

5.7. Netgear M4500-32C



The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td colspan="3">62</td><td colspan="3">124</td><td rowspan="6">62</td><td rowspan="6">124</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">32*</td><td colspan="2">32*</td><td colspan="2">124</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">❌</td><td rowspan="2">❌</td></tr>
<tr><td colspan="6">-</td><td>-</td><td>-</td><td colspan="2">124</td><td colspan="4">1</td></tr>
</table>

* 31 pcs QSFP+ MTP/MPO Modules and 31 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pc MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP+ port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website:	https://www.netgear.com/business/wired/switches/fully-managed/m4500-32c/
Data sheet:	https://www.netgear.com/media/M4500_tcm148-83958.pdf

5.8. Netgear M4500-48XF8C

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="12">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="4">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="4">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="2">22*</td><td colspan="2">44*</td><td>-</td><td>-</td><td colspan="2">16</td><td colspan="2">32</td><td rowspan="6">38</td><td rowspan="6">76</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td>44</td><td colspan="2">44</td><td>88</td><td>-</td><td>-</td><td>8</td><td colspan="2">8</td><td>32</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="4">44</td><td>-</td><td>-</td><td>32</td><td colspan="3">1</td></tr>
</table>

* The MMU requires 1 SFP port with 1 GbE connection but 4 ports together can be configured to 1 GbE speed so 44 SFP+ ports remains with 10 GbE network speed for the endpoint connections.

Links

Website:	https://www.netgear.com/business/wired/switches/fully-managed/m4500-48xf8c/
Data sheet:	https://www.netgear.com/media/M4500_tcm148-83958.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE

5.9. Juniper QFX5100-48S

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices								Matrix Management Unit (MMU)
	With SFP+ connection		With RJ45 connection		With QSFP+ / QSFP28 connection		Maximum number of the endpoints in the system		
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	
Number of allowed UBEX devices	23	47	-	-	12	24	35	71	1

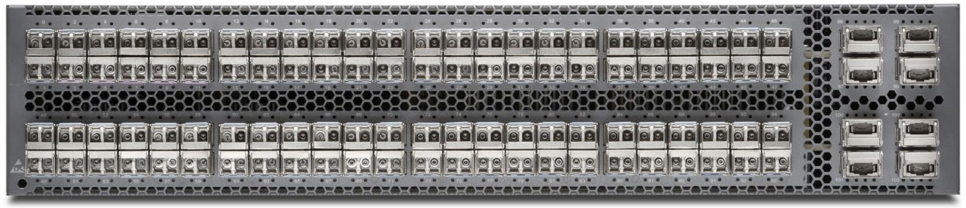
	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment			Direct connection		Intermediate interface
Connections between the UBEX devices and the network switch	Switch side	Endpoint side	SUM			QSFP+ MTP/MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints	Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	46 / 47	46 / 47	92 / 94	-	-	6	6	24	Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel		✗	✓	
	46 / 47			-	-	24	1				

Links

Website: https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5100/

Data sheet: https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000480-en.pdf

5.10. Juniper QFX5100-96S



The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">47</td><td colspan="3">95</td><td>-</td><td>-</td><td colspan="3">4*</td><td colspan="3">8*</td><td rowspan="6">51</td><td rowspan="6">103</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">94 / 95</td><td colspan="2">94 / 95</td><td colspan="2">188 / 190</td><td>-</td><td>-</td><td colspan="2">2</td><td colspan="2">2</td><td colspan="2">8</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="6">94 / 95</td><td>-</td><td>-</td><td colspan="2">8</td><td colspan="4">1</td></tr>
</table>

* The switch is built with 8 pcs 40GbE QSFP+ ports but only 2 pcs of them can be used with breakout cables due to port limitations.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5100/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000480-en.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.11. Juniper QFX5110-48S

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">23</td><td colspan="3">47</td><td>-</td><td>-</td><td colspan="3">8</td><td colspan="3">16</td><td rowspan="6">31</td><td rowspan="6">61</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">46 / 47</td><td colspan="2">46 / 47</td><td colspan="2">92 / 94</td><td>-</td><td>-</td><td colspan="2">4</td><td colspan="2">4</td><td colspan="2">16</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="6">46 / 47</td><td>-</td><td>-</td><td colspan="2">16</td><td colspan="4">1</td></tr>
</table>

Links

Website: https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5100/

Data sheet: https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000605-en.pdf

5.12. Juniper QFX5110-32Q

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><th colspan="16">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="6">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="6">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td colspan="3">46*</td><td colspan="3">92*</td><td rowspan="6">46</td><td rowspan="6">92</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><th colspan="2">Direct connection</th><th>Intermediate interface</th></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">24**</td><td colspan="2">24**</td><td colspan="2">92</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✖</td><td rowspan="2">✖</td></tr>
<tr><td colspan="6">-</td><td>-</td><td>-</td><td colspan="2">92</td><td colspan="4">1</td></tr>
</table>

* The switch is built with 32 pcs QSFP+ ports but only port 0-23 can be channelized into 4x10GbE ports, remaining ports are disabled due to port limitation.

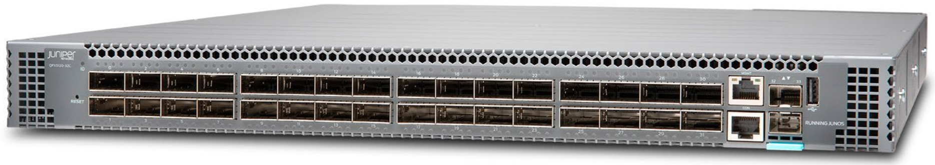
** 23 pcs QSFP+ MTP/MPO Modules and 23 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pc MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP+ port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5100/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000605-en.pdf

5.13. Juniper QFX5120-32C - Standalone Configuration

> INFO: This section is about the **standalone configuration** of the Juniper QFX5120-32C network switch.



The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="12">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="4">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="4">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="2">-</td><td colspan="2">1*</td><td>-</td><td>-</td><td colspan="2">62**</td><td colspan="2">124**</td><td rowspan="6">62</td><td rowspan="6">125</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td>1</td><td colspan="2">1</td><td>2</td><td>-</td><td>-</td><td>31</td><td colspan="2">31</td><td>124 / 125</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="4">1</td><td>-</td><td>-</td><td>62</td><td colspan="3">1</td></tr>
</table>

* The switch is built with 2 pcs SFP+ ports but one of the two is rquired for the MMU connection, thus, only one can be used for a 10GbE endpoint connection.

** The switch is built with 32 pcs QSFP28 ports but only port 0-30 can be channelized into 4x10GbE ports, remaining ports are disabled due to port limitation.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5120/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000639-en.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.14. Juniper QFX5120-32C - Two Stacked Switches Configuration

The Legend of the Data Sheet Tables

> INFO: This section is about **2 stacked** Juniper QFX5120-32C network switches configuration.

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><th colspan="16">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="6">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="6">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td colspan="3">80*</td><td colspan="3">160*</td><td rowspan="8">80</td><td rowspan="8">160</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="6">Not required</td></tr>
<tr><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">40</td><td colspan="2">40</td><td colspan="2">160</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="4">✗</td><td rowspan="4">✓</td></tr>
<tr><td colspan="6">-</td><td>-</td><td>-</td><td colspan="2">160</td><td colspan="4">1</td></tr>
<tr><td rowspan="2">Connections between the switches</td><td colspan="6" rowspan="2">-</td><td colspan="2" rowspan="2">-</td><td colspan="6">QSFP28 AOC Cable or QSFP28 DAC Cable</td></tr>
<tr><td colspan="6">8</td></tr>
</table>

* The uplink requires 8-8 pcs QSFP28 ports out of the 32, which means 800GbE uplink between the two switches. 20-20 pcs QSFP28 ports out of the remaining 24 can be used for the endpoint connection.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5120/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000639-en.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.15. Juniper QFX5120-32C - 1 Spine 3 Leafs Configuration

> INFO: This section is about the leaf-and-spine multi-chassis configuration of the Juniper QFX5120-32C network switches where are **1 spine switch** and **3 leaf switches**.

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices										**Matrix Management Unit (MMU)**		
	With SFP+ connection			**With RJ45 connection**		**With QSFP+ / QSFP28 connection**			**Maximum number of the endpoints in the system**				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	**-**	**-**		**-**	**-**	**120***	**240***		**120**	**240**	**1**		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	-	-	-	-	-	60	60	240			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✗	✓	
	-			-	-	240	1						
Connections between the switches	-			-		QSFP28 AOC Cable or QSFP28 DAC Cable							
						24							

* The uplink requires 8-8 pcs QSFP28 ports out of the 32 in case of each leaf switch, which means 800GbE uplink between the spine and leaf switches. 20-20 pcs QSFP28 ports out of the remaining 24 can be used for the endpoint connection.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5120/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000639-en.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.16. Juniper QFX5120-32C - 1 Spine 4 Leafs Configuration

> INFO: This section is about the leaf-and-spine multi-chassis configuration of the Juniper QFX5120-32C network switches where are **1 spine switch** and **4 leaf switches**.

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices										**Matrix Management Unit (MMU)**		
	With SFP+ connection			**With RJ45 connection**		**With QSFP+ / QSFP28 connection**			**Maximum number of the endpoints in the system**				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	-	-		-	-	**160***	**320***		**160**	**320**	**1**		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	-	-	-	-	-	80	80	360			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✗	✓	
	-			-	-	360	1						
Connections between the switches	-			-		QSFP28 AOC Cable or QSFP28 DAC Cable							
						32							

* The uplink requires 8-8 pcs QSFP28 ports out of the 32 in case of each leaf switch, which means 800GbE uplink between the spine and leaf switches. 20-20 pcs QSFP28 ports out of the remaining 24 can be used for the endpoint connection.

Links

Website:	https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5120/
Data sheet:	https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000639-en.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.17. Juniper QFX5120-48Y

The Legend of the Data Sheet Tables

UBEX System Related Parameters

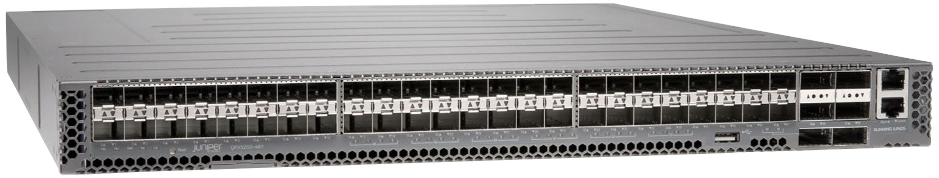
<table>
<tr><td></td><td colspan="10">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="3">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="3">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td>23</td><td colspan="2">47</td><td>-</td><td>-</td><td>16</td><td colspan="2">32</td><td rowspan="6">39</td><td rowspan="6">79</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="3">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="3">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td>Endpoint side</td><td>SUM</td><td>QSFP+ MTP/MPO Modules</td><td>MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td>46 / 47</td><td>46 / 47</td><td>92 / 94</td><td>-</td><td>-</td><td>8</td><td>8</td><td>32</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="3">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="2">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="3">46 / 47</td><td>-</td><td>-</td><td>32</td><td colspan="2">1</td></tr>
</table>

Links

Website: https://www.juniper.net/us/en/products-services/switching/qfx-series/qfx5120/

Data sheet: https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000639-en.pdf

5.18. Juniper QFX5200-48Y



The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices								Matrix Management Unit (MMU)
	With SFP+ connection		**With RJ45 connection**		**With QSFP+ / QSFP28 connection**		**Maximum number of the endpoints in the system**		
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal	
Number of allowed UBEX devices	**23**	**47**	**-**	**-**	**12**	**24**	**35**	**71**	**1**

Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment		
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints
	46 / 47	46 / 47	92 / 94	-	-	6	6	24
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel	
	46 / 47			-	-	24	1	

Direct connection		**Intermediate interface**
Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
✗	✓	

Links

Website: https://www.juniper.net/uk/en/products-services/switching/qfx-series/qfx5200/

Data sheet: https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000560-en.pdf

5.19. Juniper QFX5200-32C

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices										Matrix Management Unit (MMU)		
	With SFP+ connection			**With RJ45 connection**		**With QSFP+ / QSFP28 connection**			**Maximum number of the endpoints in the system**				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	**-**	**-**		**-**	**-**	**46***	**92***		**46**	**92**	**1**		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.
	-	-	-	-	-	24**	24**	92			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✖	✖	
	-			-	-	92	1						

* The switch is built with 32 pcs QSFP+ ports but only port 0-23 can be channelized into 4x10GbE ports, remaining ports are disabled due to port limitation.

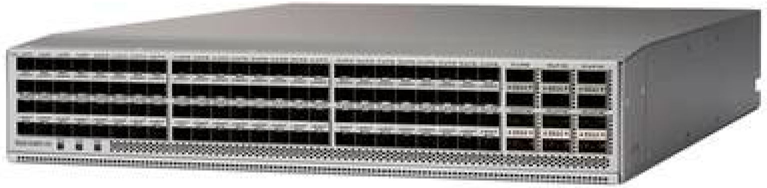
** 23 pcs QSFP+ MTP/MPO Modules and 23 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pc MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website: https://www.juniper.net/uk/en/products-services/switching/qfx-series/qfx5200/

Data sheet: https://www.juniper.net/assets/us/en/local/pdf/datasheets/1000560-en.pdf

5.20. Cisco Nexus 93360YC-FX2



The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td></td><th colspan="16">Endpoint Devices</th></tr>
<tr><td></td><th colspan="6">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="6">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">47</td><td colspan="3">95</td><td>-</td><td>-</td><td colspan="3">24</td><td colspan="3">48</td><td rowspan="6">71</td><td rowspan="6">143</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td></tr>
<tr><td colspan="2">94 / 95</td><td colspan="2">94 / 95</td><td colspan="2">188 / 190</td><td>-</td><td>-</td><td colspan="2">12</td><td colspan="2">12</td><td colspan="2">48</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td></tr>
<tr><td colspan="6">94 / 95</td><td>-</td><td>-</td><td colspan="2">48</td><td colspan="4">1</td></tr>
</table>

<table>
<tr><th colspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><td colspan="3">1</td></tr>
<tr><th colspan="2">Direct connection</th><th>Intermediate interface</th></tr>
<tr><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="3">Not required</td></tr>
<tr><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td>✗</td><td>✓</td></tr>
</table>

Links

Website: https://www.cisco.com/c/en/us/support/switches/nexus-93360yc-fx2-switch/model.html

Data sheet: https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-742282.html

5.21. Cisco Nexus 9236C

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><th colspan="12">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="4">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="4">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><th>Number of allowed UBEX devices</th><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">70</td><td colspan="2">140</td><td rowspan="6">70</td><td rowspan="6">140</td><td colspan="3">1</td></tr>
<tr><th rowspan="5">Connections between the UBEX devices and the network switch</th><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>-</td><td>-</td><td>-</td><td>36*</td><td colspan="2">36*</td><td>140</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">✖</td><td rowspan="2">✖</td></tr>
<tr><td colspan="4">-</td><td>-</td><td>-</td><td>140</td><td colspan="3">1</td></tr>
</table>

* 35 pcs QSFP+ MTP/MPO Modules and 35 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pc MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9236c-switch/index.html
Data sheet:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-735989.html

5.22. Cisco Nexus 9272Q

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices								
	With SFP+ connection		**With RJ45 connection**		**With QSFP+ / QSFP28 connection**		**Maximum number of the endpoints in the system**		**Matrix Management Unit (MMU)**
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal	
Number of allowed UBEX devices	-	-	-	-	68*	136*	68	136	1

	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment			**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints	Via RJ45 connector of the switch	Via SFP slot of the switch	Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.
Connections between the UBEX devices and the network switch	-	-	-	-	-	35**	35**	136	Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel		✖	✖	
	-			-	-	136	1				

* The switch is built with 72 pcs QSFP+ ports but only 35 can be channelized into 4x10GbE ports, remaining ports are disabled due to port limitation.

** 34 pcs QSFP+ MTP/MPO Modules and 34 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pc MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9272q-switch/index.html
Data sheet:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-735989.html

5.23. Cisco Nexus 93180YC-EX - Standalone Configuration

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">23</td><td colspan="3">47</td><td>-</td><td>-</td><td colspan="3">12</td><td colspan="3">24</td><td rowspan="6">35</td><td rowspan="6">71</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">46 / 47</td><td colspan="2">46 / 47</td><td colspan="2">92 / 94</td><td>-</td><td>-</td><td colspan="2">6</td><td colspan="2">6</td><td colspan="2">24</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="6">46 / 47</td><td>-</td><td>-</td><td colspan="2">24</td><td colspan="4">1</td></tr>
</table>

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-93180yc-ex-switch/index.html
Data sheet:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-742283.html
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE

5.24. Cisco Nexus 93180YC-EX - Two Stacked Switches Configuration

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><th colspan="16">Endpoint Devices</th><th colspan="3" rowspan="3">Matrix Management Unit (MMU)</th></tr>
<tr><th colspan="6">With SFP+ connection</th><th colspan="2">With RJ45 connection</th><th colspan="6">With QSFP+ / QSFP28 connection</th><th colspan="2">Maximum number of the endpoints in the system</th></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">47</td><td colspan="3">95</td><td>-</td><td>-</td><td colspan="3">8</td><td colspan="3">16</td><td rowspan="6">55</td><td rowspan="6">111</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">94 / 95</td><td colspan="2">94 / 95</td><td colspan="2">188 / 190</td><td>-</td><td>-</td><td colspan="2">4</td><td colspan="2">4</td><td colspan="2">16</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="6">94 / 95</td><td>-</td><td>-</td><td colspan="2">16</td><td colspan="4">1</td></tr>
</table>

Links

Website: https://www.cisco.com/c/en/us/products/switches/nexus-93180yc-ex-switch/index.html

Data sheet: https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-742283.html

Configuration steps for UBEX AV system: https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE

5.25. Cisco Nexus 9504 with N9K-X97160YC-EX Line Cards

The Legend of the Data Sheet Tables

> INFO: Cisco Nexus 9504 (N9K-C9504) is a modular network switch chassis. The UBEX AV system related parameters below is valid with **4 pcs N9K-X97160YC-EX** 48x10G SFP+ line cards only.

UBEX System Related Parameters

	Endpoint Devices										Matrix Management Unit (MMU)		
	With SFP+ connection			With RJ45 connection		With QSFP+ / QSFP28 connection			Maximum number of the endpoints in the system				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	85	191		-	-	-	-		85	191	1		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	190 / 191	190 / 191	380 / 382	-	-	-	-	-			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✗	✓	
	190 / 191			-	-	-	-						

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283
Data sheet of the chassis:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html
Data sheet of the cloud-scale line cards:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.26. Cisco Nexus 9504 with N9K-X9736C-FX Line Cards

> INFO: Cisco Nexus 9504 (N9K-C9504) is a modular network switch chassis. The UBEX AV system related parameters below is valid with **4 pcs N9K-X9736C-FX** 36x100G QSFP28 line cards only.

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices								Matrix Management Unit (MMU)
	With SFP+ connection		**With RJ45 connection**		**With QSFP+ / QSFP28 connection**		**Maximum number of the endpoints in the system**		
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal	
Number of allowed UBEX devices	-	-	-	-	286	572	286	572	1

	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment			**Direct connection**		**Intermediate interface**
Connections between the UBEX devices and the network switch	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints	Via RJ45 connector of the switch	Via SFP slot of the switch	Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.
	-	-	-	-	-	144*	144*	572	Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel		❌	❌	
	-			-	-	572	1				

* 143 pcs QSFP+ MTP/MPO Modules and 143 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pcs MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables. Ports 1 – 28 support 1 Gigabit Ethernet.

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283
Data sheet of the chassis:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html
Data sheet of the cloud-scale line cards:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.27. Cisco Nexus 9508 with N9K-X97160YC-EX Line Cards

The Legend of the Data Sheet Tables

> INFO: Cisco Nexus 9508 (N9K-C9508) is a modular network switch chassis. The UBEX AV system related parameters below is valid with **8 pcs N9K-X97160YC-EX** 48x10G SFP+ line cards only.

UBEX System Related Parameters

	Endpoint Devices										Matrix Management Unit (MMU)		
	With SFP+ connection			With RJ45 connection		With QSFP+ / QSFP28 connection			Maximum number of the endpoints in the system				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	**191**	**383**		**-**	**-**	**-**	**-**		**191**	**383**	**1**		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	382 / 383	382 / 383	764 / 766	-	-	-	-	-			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✗	✓	
	382 / 383			-	-	-	-						

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283
Data sheet of the chassis:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html
Data sheet of the cloud-scale line cards:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.28. Cisco Nexus 9508 with N9K-X9736C-FX Line Cards

> INFO: Cisco Nexus 9508 (N9K-C9508) is a modular network switch chassis. The UBEX AV system related parameters below is valid with `8 pcs N9K-X9736C-FX` 36x100G QSFP28 line cards only.

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices								**Matrix Management Unit (MMU)**
	With SFP+ connection		**With RJ45 connection**		**With QSFP+ / QSFP28 connection**		**Maximum number of the endpoints in the system**		
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal	
Number of allowed UBEX devices	**-**	**-**	**-**	**-**	**574**	**1148**	**574**	**1148**	**1**

Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment			**574**	**1148**	**Direct connection**		**Intermediate interface**
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.
	-	-	-	-	-	288*	288*	1148			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✖	✖	
	-			-	-	1148	1						

* 287 pcs QSFP+ MTP/MPO Modules and 287 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pcs MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables. Ports 1 – 28 support 1 Gigabit Ethernet.

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283
Data sheet of the chassis:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html
Data sheet of the cloud-scale line cards:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.29. Cisco Nexus 9516 with N9K-X97160YC-EX Line Cards

The Legend of the Data Sheet Tables

> INFO: Cisco Nexus 9516 (N9K-C9516) is a modular network switch chassis. The UBEX AV system related parameters below is valid with **16 pcs N9K-X97160YC-EX** 48x10G SFP+ line cards only.

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">383</td><td colspan="3">767</td><td>-</td><td>-</td><td colspan="3">-</td><td colspan="3">-</td><td rowspan="6">383</td><td rowspan="6">767</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Not required</td></tr>
<tr><td colspan="2">766 / 767</td><td colspan="2">766 / 767</td><td colspan="2">1532 / 1534</td><td>-</td><td>-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✓</td></tr>
<tr><td colspan="6">766 / 767</td><td>-</td><td>-</td><td colspan="2">-</td><td colspan="4">-</td></tr>
</table>

Links

Website: https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283

Data sheet of the chassis: https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html

Data sheet of the cloud-scale line cards: https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.30. Cisco Nexus 9516 with N9K-X9736C-FX Line Cards

The Legend of the Data Sheet Tables

> INFO: Cisco Nexus 9516 (N9K-C9516) is a modular network switch chassis. The UBEX AV system related parameters below is valid with **16 pcs N9K-X9736C-FX** 36x100G QSFP28 line cards only.

UBEX System Related Parameters

<table>
<tr><td></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td></td><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td></td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td colspan="3">1150</td><td colspan="3">2300</td><td rowspan="6">1150</td><td rowspan="6">2300</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">576*</td><td colspan="2">576*</td><td colspan="2">2300</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">❌</td><td rowspan="2">❌</td></tr>
<tr><td colspan="6">-</td><td>-</td><td>-</td><td colspan="2">2300</td><td colspan="4">1</td></tr>
</table>

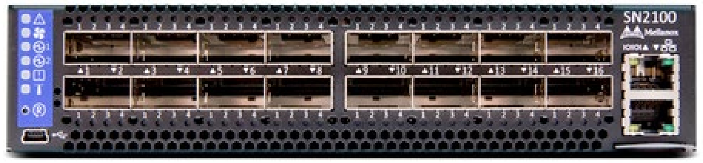
* 575 pcs QSFP+ MTP/MPO Modules and 575 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pcs MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables. Ports 1 – 28 support 1 Gigabit Ethernet.

Links

Website:	https://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html?dtid=osscdc000283
Data sheet of the chassis:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-729404.html
Data sheet of the cloud-scale line cards:	https://www.cisco.com/c/en/us/products/collateral/switches/nexus-9000-series-switches/datasheet-c78-736677.html

5.31. Mellanox SN2100

The Legend of the Data Sheet Tables



UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="16">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="6">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="6">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="3">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="3">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td colspan="3">30</td><td colspan="3">60</td><td rowspan="6">30</td><td rowspan="6">60</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="6">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="6">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td colspan="2">Switch side</td><td colspan="2">Endpoint side</td><td colspan="2">SUM</td><td colspan="2">QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td colspan="2">SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">16*</td><td colspan="2">16*</td><td colspan="2">60</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="6">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td colspan="2">Fiber-Optic Cables (LC duplex)</td><td colspan="4">Fiber Patch Panel</td><td rowspan="2">✗</td><td rowspan="2">✗</td></tr>
<tr><td colspan="6">-</td><td>-</td><td>-</td><td colspan="2">60</td><td colspan="4">1</td></tr>
</table>

* 15 pcs QSFP+ MTP/MPO Modules and 15 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pcs MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables.

Links

Website:	https://www.mellanox.com/ethernet/switches.php
Data sheet:	http://www.mellanox.com/related-docs/prod_eth_switches/PB_SN2100.pdf

5.32. Mellanox SN2010

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices										Matrix Management Unit (MMU)		
	With SFP+ connection			With RJ45 connection		With QSFP+ / QSFP28 connection			Maximum number of the endpoints in the system				
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot		20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal		20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal			
Number of allowed UBEX devices	8	17		-	-	8	16		16	33	1		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment					Direct connection		Intermediate interface
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints			Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	16 / 17	16 / 17	32 / 34	-	-	4	4	16			Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel				✗	✓	
	16 / 17			-	-	16	1						

Links

Website:	https://www.mellanox.com/ethernet/switches.php
Data sheet:	https://www.mellanox.com/related-docs/prod_eth_switches/PB_SN2010.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

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5.33. Mellanox SN2700

The Legend of the Data Sheet Tables

UBEX System Related Parameters

<table>
<tr><td rowspan="3"></td><td colspan="12">Endpoint Devices</td><td colspan="3" rowspan="3">Matrix Management Unit (MMU)</td></tr>
<tr><td colspan="4">With SFP+ connection</td><td colspan="2">With RJ45 connection</td><td colspan="4">With QSFP+ / QSFP28 connection</td><td colspan="2">Maximum number of the endpoints in the system</td></tr>
<tr><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot</td><td>20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots</td><td>10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot</td><td colspan="2">20GbE bandwidth for 4K60 4:4:4 signal</td><td colspan="2">10GbE bandwidth for 4K60 4:2:2 signal</td><td>20GbE bandwidth for 4K60 4:4:4 signal</td><td>10GbE bandwidth for 4K60 4:2:2 signal</td></tr>
<tr><td>Number of allowed UBEX devices</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>-</td><td colspan="2">31*</td><td colspan="2">62*</td><td rowspan="6">31</td><td rowspan="6">62</td><td colspan="3">1</td></tr>
<tr><td rowspan="5">Connections between the UBEX devices and the network switch</td><td colspan="4">Required SFP+ modules</td><td colspan="2" rowspan="2">Required SFP+ to RJ45 modules to the endpoint side</td><td colspan="4">Required network equipment</td><td colspan="2">Direct connection</td><td>Intermediate interface</td></tr>
<tr><td>Switch side</td><td colspan="2">Endpoint side</td><td>SUM</td><td>QSFP+ MTP/ MPO Modules</td><td colspan="2">MTP/MPO to LC Cables</td><td>SFP+ modules to endpoints</td><td>Via RJ45 connector of the switch</td><td>Via SFP slot of the switch</td><td rowspan="4">Intermediate Network Switch or a Standalone Media Rate Converter is required for the 10G to 1G conversion.</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>-</td><td>-</td><td>-</td><td>16**</td><td colspan="2">16**</td><td>62</td><td>Using a single CATx cable</td><td>Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable</td></tr>
<tr><td colspan="4">Required Fiber-Optic Cables (LC duplex)</td><td colspan="2">Required CATx cables</td><td>Fiber-Optic Cables (LC duplex)</td><td colspan="3">Fiber Patch Panel</td><td rowspan="2">❌</td><td rowspan="2">❌</td></tr>
<tr><td colspan="4">-</td><td>-</td><td>-</td><td>62</td><td colspan="3">1</td></tr>
</table>

* The switch is built with 32 pcs QSFP28 ports but only 16 can be channelized into 4x10GbE ports, remaining ports are disabled due to port limitation.

** 31 pcs QSFP+ MTP/MPO Modules and 31 pcs MTP/MPO to LC Cables are required for the endpoint connection and 1 pc QSFP+ module and 1 pcs MTP/MPO breakout cable is additionally required for the connection with the MMU. Where the MMU connects to the switch, the QSFP28 port should be channelized to 1GbE and no endpoint can be connected to the remained cables. Ports 1 – 28 support 1 Gigabit Ethernet.

Links

Website:	https://www.mellanox.com/ethernet/switches.php
Data sheet:	https://www.mellanox.com/related-docs/prod_eth_switches/PB_SN2700.pdf

5.34. Arista 7050SX3-48YC8

The Legend of the Data Sheet Tables

UBEX System Related Parameters

	Endpoint Devices							
	With SFP+ connection		With RJ45 connection		With QSFP+ / QSFP28 connection		Maximum number of the endpoints in the system	
	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G SFP+ slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G SFP+ slot	20GbE bandwidth for 4K60 4:4:4 signal, it requires 2x 10G RJ45 slots	10GbE bandwidth for 4K60 4:2:2 signal, it requires 1x 10G RJ45 slot	20GbE bandwidth for 4K60 4:4:4 signal	10GbE bandwidth for 4K60 4:2:2 signal	**20GbE** bandwidth for 4K60 4:4:4 signal	**10GbE** bandwidth for 4K60 4:2:2 signal
Number of allowed UBEX devices	**23**	**47**	**-**	**-**	**8***	**16***	**31**	**63**

	With SFP+ connection			With RJ45 connection		With QSFP+ / QSFP28 connection		
Connections between the UBEX devices and the network switch	Required SFP+ modules			Required SFP+ to RJ45 modules to the endpoint side		Required network equipment		
	Switch side	Endpoint side	SUM			QSFP+ MTP/ MPO Modules	MTP/MPO to LC Cables	SFP+ modules to endpoints
	46 / 47	46 / 47	92 / 94	-	-	4	4	16
	Required Fiber-Optic Cables (LC duplex)			Required CATx cables		Fiber-Optic Cables (LC duplex)	Fiber Patch Panel	
	46 / 47			-	-	16	1	

	Matrix Management Unit (MMU)		
Number of allowed UBEX devices	**1**		
Connections between the UBEX devices and the network switch	Direct connection		Intermediate interface
	Via RJ45 connector of the switch	Via SFP slot of the switch	Not required
	Using a single CATx cable	Using SFP to RJ45 module or 2 pcs SFP modules or a single DAC cable	
	✗	✓	

* The switch is built with 8 pcs 40GbE QSFP+ ports but only 4 pcs of them can be used with breakout cables due to port limitations.

Links

Website:	https://www.arista.com/en/products/7050x3-series
Data sheet:	https://www.arista.com/assets/data/pdf/Datasheets/7050X3-Datasheet.pdf
Configuration steps for UBEX AV system:	https://lightware.com/media/lightware/filedownloader/file/Application-Note/Installation_and_Network_Setup_Guide_for_UBEX.pdf

TESTED BY LIGHTWARE