visual engineering
LIGHTWARE

Application Notes

Installation and Network Setup Guide for UBEX

v2.5 30-10-2023

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Document Information

All presented functions refer to the indicated products. The descriptions have been made during testing these functions in accordance with the indicated firmware environment:

Item	Version
Firmware package - UBEX F-series / R-series enpoints	3.3.1
Firmware package - UBEX-MMU-X200	2.1.0

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Introduction

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

- About the Document
- About UBEX Technology

1.1. About the Document

The following chapters help for the integrators and our customers to install and configure an UBEX matrix in a newly installed or existing IT network system. The sections listed below are in the document:

- Hardware requirements
- UBEX network installation step by step
- Video network designing
- The required bandwidth of a stream by resolutions
- The steps of the network switch configuration in general terms
- The steps of the network switch configuration by switch models (for Ubiquiti, Netgear, Mellanox, Cisco and Juniper switch models)
- Useful tips & tricks for the best user experience
- UBEX Test Lab test cases, matrix architectures, and experiences

1.2. 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.

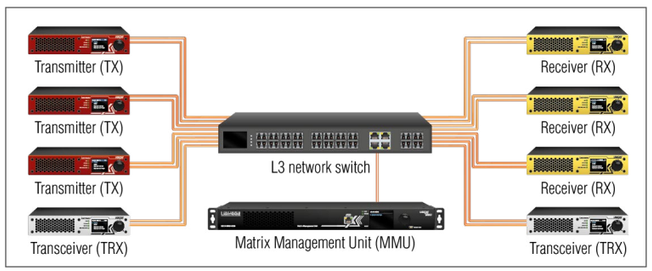
The MMU builds and constantly updates a database of the UBEX endpoints connected, displaying a traditional crosspoint view of the virtual matrix in the Lightware Device Controller (LDC) software, also displaying connected but inactive units.

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 AV matrix with more transmitters, receivers, transceivers and a Matrix Management Unit (MMU) which controls the AV network.



UBEX - Matrix application mode

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

Find more details about the UBEX Matrix application mode in the **user's manual** of the system:
https://lightware.com/media/lightware/filedownloader/file/User-Manual/UBEX_Matrix_UsersManual.pdf

2

Video Network Designing

This chapter gives useful practical advices to the network designers creating an effective and well-functioning UBEX AV network.

- First Steps
- Bandwidth Requirements
- 10 Gigabit Ethernet Designing
- Bandwidth Requirements of the Resolutions

2.1. First Steps

At first, the video network designer needs to decide what purpose needs to be satisfied with the video system - it will determine the size of the matrix and the type of the network switch. The size of the matrix primarily depends on the number of inputs and outputs. When the designer knows that, the choosing of the type of the switch can be started. The following table can help in that:

Business type	Sources / Destinations	Required UBEX devices		Required SFP+ ports in the switch	Required QSFP+ ports in the switch	Required SFP/ RJ45 ports in the switch	Recommended switch type	
		Endpoints (TX/RX/TRX)	MMU				Type	Example
Small business	up to 12 / 12	6	1	12	-	1	12-ports 10G (+1 1G SFP port for MMU) L3 managed switch	**Ubiquiti EdgeSwitch 16 XG** See also: Configuration Steps - Ubiquiti EdgeSwitch 16 XG
Medium business	up to 24 / 24	12	1	24	-	1	24-ports 10G (+1 1G SFP port for MMU) L3 managed switch	**Netgear M4300-24X24F** See also: Configuration Steps - Netgear M4300-24X24F
	up to 32 / 32	16	1	16	4	-	18-ports 10G and 4-ports 100G L3 managed switch	**Mellanox SN2010** See also: Configuration Steps - Mellanox SN2010
	up to 46 / 46	23	1	46	-	1	48-ports 10G (+1 1G SFP port for MMU) L3 managed switch	**Cisco Nexus 5548UP** See also: Configuration Steps - Cisco Nexus 5548UP **Cisco Nexus 93180YC-EX** See also: Configuration Steps - Cisco Nexus 93180YC-EX
Corporate business	up to 94 / 94	47	1	94	-	1	96-ports 10G (+1 1G SFP port for MMU) L3 managed switch	**Juniper QFX5100-96S** See also: Configuration Steps - Juniper QFX5100-96S
	100+ / 100+	up to 160	1	1	up to 32	-	More L3 switches in Leaf-and-spine deployment	**Juniper QFX5120-32C** See also: Configuration Steps - Juniper QFX5120-32C

Comparison table for video network designing

The Calculation

Let's see an example: the video network is designed for a small business calculated with maximum 6 source and 6 destination devices. The UBEX endpoint has 2 HDMI input ports and 2 HDMI output ports, so the network needs 3 transmitters for the 6 inputs and 3 receivers for the 6 outputs. It is 6 endpoints (the operation mode (TX, RX or TRX) does not matter, the UBEX endpoint can be configured freely anytime by the user), moreover the network needs one Matrix Management Unit (UBEX-MMU-X200) to control the UBEX network.

The endpoints require two SFP+ ports in the switch per unit, in summary, it is 12 ports in the case of six extenders. The video network requires a 12-port 10G L3 fully managed switch to ensure the stable data transmission for the UBEX system.

ATTENTION! The SFP+ ports must support 10 Gbps Ethernet.

In the case of corporate business, the UBEX system gives an opportunity building even an 100x100 video matrix. The transmitters, receivers, and transceivers can be variated dynamically because of the MMU is able to handle it in real time. An asymmetric AV matrix can also be built with UBEX endpoints, e.g. an 1x100 or 100x1 video system. The possibilities are only limited by imagination.

The Matrix Management Unit requires one RJ45 or SFP ports with 1 GbE support to the network switch. The MMU does not transmit a video, it controls the UBEX system only.

INFO: More details and technical information can be found about the AV network designing in our **System Design Guide for UBEX** documentation: https://lightware.com/media/lightware/filedownloader/file/Application-Note/System_Design_Guide_for_UBEX.pdf

Bandwidth Management

The next challenge of the video network designing is the bandwidth management. The next section describes how to calculate the required bandwidth based on the video resolution and refresh rate on the network and the general know-how of the bandwidth requirement calculation.

2.2. Bandwidth Requirements

The bandwidth calculation consists of two components:

- Required bandwidth of the streams (up to 2 streams per endpoint)
- Uplink bandwidth

The following sections give the details about these components.

2.2.1. Stream Bandwidth Requirements

UBEX transmitters have 2x HDMI 2.0 input ports which can receive two video streams for transmission to the receiver. The required bandwidth for the stream is calculated from the resolution, the color space, the refresh rate, and the loss ration of the video packeting (~3%).

Bandwidth Calculation

The correct formula:

$$X_{ACTIVE} \times Y_{TOTAL} \times fps \times ColorDepth \times VideoPacketizingLossRatio = \text{Total signal bandwidth}$$

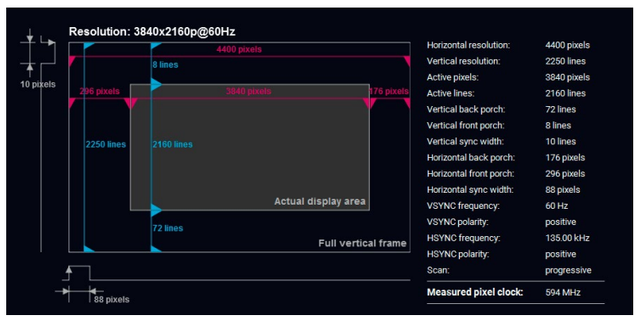
Parameters:

Parameter	Description	Example (4K UHD 60 Hz 24 bit)
X_{ACTIVE}	Number of the columns of the active resolution	3840
Y_{TOTAL}	Total number of the lines including the blanking area	2250
fps	Refresh rate	60 Hz
ColorDepth	Color depth	24 bit
VideoPacketingLossRatio	The ratio of the packet loss due to the packeting and the protocol	1.03684

For the exact calculation you should know the total resolution of the stream because the transmitted number of pixels are not equal with the active pixels which are finally displayed on the receiver side. The cause is the blanking area where the embedded audio and other information travels with the HDMI signal.

INFO: The bandwidth calculation in the case of the HDMI pipes count with the **peak bandwidth** which is the summary of the video burst.

If the stream information is unknown to the designer, to get the information of the active resolution the **Frame detector** of Lightware is a useful tool. The Frame detector is available in our control software, in the Lightware Device Controller (LDC), it can be downloaded from the website www.lightware.com.



Frame detector in the LDC software

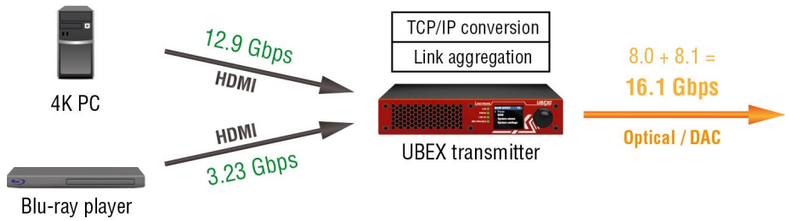
Let's see an example:

I want to transmit a UHD (3840x2160@60 Hz 24 bit) HDMI signal which is received on the HDMI input 1 port of the UBEX transmitter.

Based on the formula the calculation is the following:

3840 x 2250 x 60 x 24 x 1.03684 = 12 899 948 544 = **12.9 Gb/s**

This is the required bandwidth for the Stream 1 from the HDMI input 1 port. The HDMI input 2 receives an 1080p60 video, the required bandwidth is 3.23 Gb/s. The summary of the two values gives the final number of the required signal bandwidth for the video streams.



Bandwidth of the input streams for UBEX transmitter

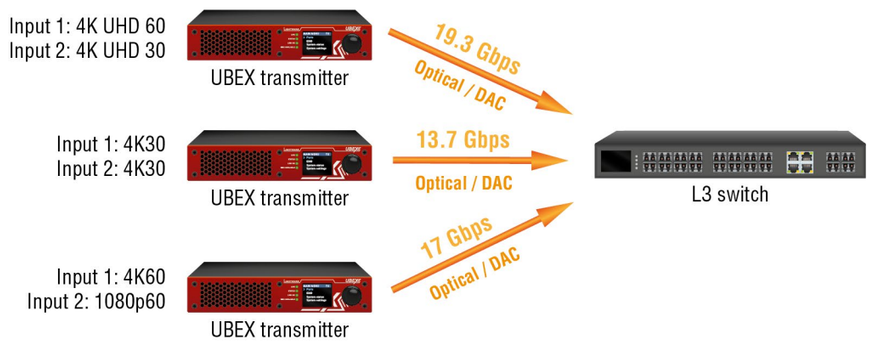
The signal bandwidth which is transmitted over the SFP+ ports is measured with the **average bandwidth** which counts with active resolution lines instead of the total resolution lines.

2.2.2. Endpoint Uplink Bandwidth Requirements

UBEX endpoints support video over an optical fiber SFP+ network connection up to 20 Gbps which means 2x 10 GbE SFP+ slots. The 20 GbE can ensure transmitting

- one 4K60 4:4:4 and one 4K30 4:4:4 signals, or
- 2x 4K60 4:2:2, or
- 2x 4K30 4:4:4 signals, or
- one 4K60 4:4:4 and one 1080p60 signals together and losslessly.

No compression, no latency, every single bit is received as it is transmitted.



2.3. 10 Gigabit Ethernet Designing

The video transmission is taken over the SFP+ interfaces which are required to build in 2x 10 Gigabit Ethernet connection between the UBEX transmitters and receivers. The fiber optical network solutions provide stable and trustworthy signal transmission in the video network. This section describes the details about the video matrix designing in the fiber optical network point of view.

2.3.1. Multimode Fiber

Multimode fiber is used in the LAN environment where distances between the rooms are 300 m or less.

The IEEE 802.3ae 10 Gigabit Ethernet specification includes a serial interface referred to as **10GBASE-SR** (the "S" stands for short wavelength) that is designed for 850 nm transmission on multimode fiber. The table below provides the wavelength, modal bandwidth, and operating distance for different types of multimode fiber operating at 10 Gbps.

Description	62.5 micron fiber		50 micron fiber		
Wavelength (nm)	850	850	850	850	850
Modal bandwidth (MHz*km)	160	200	400	500	2000
Operating range (m)	**2-26**	**2-33**	**2-66**	**2-82**	**2-400**

10GBASE-SR operating range for various multimode fiber sizes

To address the operating range concern, a new multimode fiber specification had to be created for 10GbE to achieve multimode fiber operating distances of 300 m (as specified in the TIA/EIA-568 and ISO/IEC 11801 cabling standards). This new fiber is referred to by some as "10 Gigabit Ethernet multimode fiber" and is an 850 nm, laser-optimized, 50/125 micron fiber with an effective modal bandwidth of 2000 MHz*km and is detailed in TIA-492AAAC. Its key difference, relative to legacy multimode fibers, are the additional requirements for DMD specified in TIA-492AAAC enabled by a new measurement standard for DMD (TIA FOTP-220). As shown in the table, this fiber can achieve 400 m of distance with a 10GBASE-SR interface. Many leading optical fiber vendors are actively marketing this new multimode fiber for 10GbE applications.

2.3.2. Singlemode Fiber

Singlemode fiber is used in the LAN environment where distances between the buildings are 80 km or less. Standard singlemode fiber can address nearly any application, depending on the level of cost and complexity that an operator is willing to employ. The latter issues become more significant as higher data rates, different wavelengths, and/or longer distances are adopted.

Attenuation

> DEFINITION: **Attenuation**: Reduction in transmitted optical power. Attenuation as a function of distance in optical fiber is logarithmic. Attenuation as a function of optical wavelength is dominated by the degree to which light is scattered by the molecular structure of the optical fiber ("Rayleigh scattering").

For short fiber spans, optical transmission at 1310 nm remains an appealing option due to the price and availability of lasers at this wavelength. Several factors drive consideration of transmission at higher wavelengths, however. At higher data rates, requirements on receiver sensitivity typically grow more stringent, requiring higher received optical powers to maintain low error rates. Due to relatively high fiber attenuation at 1310 nm (see the table on the right side), maximum allowable transmission distances are reduced at 1310 nm compared to 1550 nm. At extended distances, which exceed the allowable sensitivities of optical receivers, signals in the 1550 nm region can be optically amplified (usually with an EDFA) whereas optical amplification is not commonly available at 1310 nm. As a result, 1310 nm transmission requires electrical regeneration, which is fundamentally more expensive than optical amplification.

WaveLenght (nm)	Maximum fiber attenuation per IEC 60793-2 (dB/km)	Typical cabled attenuation (dB/km)
1310	0.40	0.35
1550	0.30	0.25

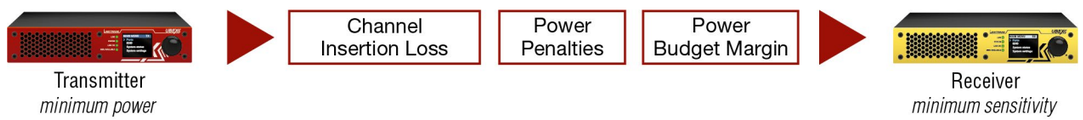
Attenuation of standard singlemode fiber at 1310 nm and 1550 nm

2.3.3. 10 Gigabit Ethernet Fiber Design Considerations

Key factors to consider in the design of 10 Gigabit Ethernet networks are:

- The network topology, including operating distances, splice losses and numbers of connectors (i.e. the link power budget).
- The fiber cabling type (i.e. singlemode or multimode fiber) and the performance at a specified wavelength. The performance is characterized by channel insertion loss (cabling attenuation), and modal bandwidth(for multimode fiber).
- The use of mode-conditioning patch cords if required. The 1310 nm CWDM solution, 10GBASE-LX4, requires the use of a mode-conditioning patch cord on multimode fiber to achieve its specified range of operating distances.
- The implementation of a cabling design, compatible with LED and laser-based Ethernet network devices, which will allow the integration of current LED based 10 Mbps and 100 Mbps networks and laser-based 1 Gbps and 10 Gbps networks.

When designing individual fiber links, the first step is the characterization of the link power budget. This value (expressed in dB) is specified in the 10GbE standard for each optical interface. Tables for all interfaces are shown in this section. The link power budget is calculated by taking the difference between the minimum transmitter power launched into the fiber, and the minimum receiver sensitivity (see the figure below). The receiver sensitivity is the minimum amount of power that is necessary to maintain the required signal-to-noise ratio over the specified operating conditions. The link power budget determines the amount of total loss due to attenuation and other factors that can be introduced between the transmitter and the receiver.



Link Power Budget = Minimum transmit power - Minimum receiver sensitivity

Link Power Budget

Link Power Budget

The 10 Gigabit Ethernet operating distances provided in the tables below are limited by the channel insertion loss, the cable bandwidth for multimode fiber, and the optical transceiver characteristics (i.e., PMD types). 10GBASE-ER distances greater than 30 km are considered “engineered links” because to support those distances the attenuation of the cable needs to be less than the maximum specified for standard singlemode fiber. Therefore, distances greater than 30 km for installed cabling should be “field-tested” for verification of conformance to the 11 dB channel insertion loss specification. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A/ method B and ANSI/TIA/EIA-526-7/ method A-1.

Parameters	10BASE-SR				
	62.5 micron MMF		50 micron MMF		
Modal Bandwidth at 850nm (MHz*km)	160	200	400	500	2000
Link power budget (dB)	7.3	7.3	7.3	7.3	7.3
Operating distance (m)	**26**	**33**	**66**	**82**	**400**
Channel insertion point (dB)[1]	1.6	1.6	1.7	1.8	2.6
Power penalty (dB) [2]	4.7	4.8	5.1	5.0	4.7

10GBASE-SR link power budget as per IEEE Draft P802.3ae/D5.0

[1] These channel insertion loss numbers are based on a wavelength of 850 nm.

[2] These power penalties are based on a wavelength of 840 nm.

Parameter	10BASE-LR
Link power budget (dB)	9.4
Operating distance (km)	**10**
Channel insertion point (dB) [3]	6.2
Power penalty (dB) [4]	3.2

10GBASE-LR link power budget as per IEEE Draft P802.3ae/D5.0

[3] These channel insertion loss numbers are based on a wavelength of 1310 nm.

[4] These power penalties are based on a wavelength of 1260 nm.

Parameter	10BASE-ER	
Link power budget (dB)	15.0	
Operating distance (km)	**30**	**40** [5]
Channel insertion point (dB) [6]	10.9	10.9
Power penalty (dB) [7]	3.6	4.1

10GBASE-ER link power budget as per IEEE Draft P802.3ae/D5.0

[5] Greater than 30 kilometers distance mandates an “engineered link” requiring “field testing” for verification of conformance to the 11 dB channel insertion loss specification. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A/method B and EANSI/TIA/EIA-526-7/ Method A1.

[6] These channel insertion loss numbers are based on a wavelength of 1550 nm.

[7] These power penalties are based on a wavelength of 1565 nm and other penalties.

Parameters	10BASE-LX4			
	62.5 micron MMF	50 micron MMF		SMF
Modal bandwidth as measured at 1300 nm (minimum, overfilled launch) (MHz*km)	500	400	500	-
Link power budget (dB)	7.5	7.5	7.5	8.2
Operating distance (m)	**300**	**240**	**400**	**10000**
Channel insertion point (dB) [8]	2.0	1.9	2.0	6.2
Power penalty (dB) [9]	5.0	5.5	5.5	1.9

10GBASE-LX4 link power budget as per IEEE Draft P802.3ae/D5.0

[8] These channel insertion loss numbers are based on a wavelength of 1300 nm for multimode and 1310 for single mode. An offset launch pad cord is assumed. The total insertion loss, when including the attenuation of the offset launch patch cord is allowed to be 0.5 dB higher than shown in the table.

[9] These power penalties are based on a wavelength of 1269 nm and other penalties.

Fiber	62.5 micron MMF		50 micron MMF			SMF
MHz*km	**160** [10]	**200**	**400**	**500**	**2000** [10]	**-**
SR/SW 850 nm	26 m	33 m	66 m	82 m	400 m	-
LR/LW 1310 nm	-	-	-	-	-	10 km
ER/EW 1550 nm	-	-	-	-	-	40 km
LX4 1310 nm	300m @ 500Mhz*km [11]		240 m	400 m	-	10 km

10GbE supported fiber and distances

[10] Commonly referred to as “FDDI Grade Fiber”.

[11] 62.5 micron multimode fiber has a model bandwidth of 500 Mhz*km at 1300 nm as opposed to 160 or 200 Mhz*km at 850nm.

> DEFINITION: **Modal Bandwidth**: Measure of the highest frequency signal that can be supported over a given distance of multimode fiber, as limited by modal dispersion. Modal bandwidth is typically expressed in MHz*km.

10GBASE-ER Link-loss Calculation

When designing 10GBASE-ER links greater than 30 km (i.e., the cable is not already installed) a cabling link-loss calculation, which is a simple arithmetic process, is used to make sure the combined loss of the cabling components in the link does not exceed the 11 dB channel insertion loss allocated for 10GBASE-ER. The cabling link-loss is calculated by adding the connector and splice loss to the cable loss. The cable attenuation for the link is calculated by multiplying the link distance by the loss per unit distance specified for the fiber (e.g., dB/km).

As shown in the table below (scenario 1) given a cable attenuation of 0.225 db/km, the cable attenuation for a 40 km link is 9 dB (40 km x 0.225 = 9 dB). Assuming 2 dB for singlemode fiber connector and splice losses the link-loss is 11 dB (9 dB + 2 dB = 11 dB); which is an allowable channel insertion loss for 10GBASE-ER and would insure that this link can achieve 40 km. A similar calculation can be done for scenario 2 and 3.

Parameter	Scenario 1	Scenario 2	Scenario 3
Channel insertion point	11 dB	11 dB	11 dB
Required attenuation loss	0.225 dB/km	0.225 dB/km	0.3 dB/km [12]
Connector and splice loss	2 dB	2 dB	2 dB
Maximum distance	**40 km**	**35 km**	**30 km**

10GBASE-ER link-loss calculation examples

[12] This is the maximum fiber attenuation allowed for standerd single mode fiber at 1550 nm as per IEC 60793-2. See the table in the Singlemode Fiber section for the details.

> INFO: The 10BASE-E channel shall have attenuation between 5 and 11 dB. If required an attenuator can be added to comply with this specification.

2.3.4. Conclusion

As with previous generations of Ethernet, 10 Gigabit Ethernet requires a network designer to thoroughly understand the capabilities of his/her fiber infrastructure. With 10GbE new challenges and considerations have emerged such as the effects of chromatic and polarization mode dispersion on signal integrity. In addition, decisions may have to be made regarding whether to use singlemode or multimode fiber. This paper has introduced some basic fiber related concepts and outlined some of the key points to understand and consider when designing a 10 Gigabit Ethernet network.

> DEFINITION: **Polarization Mode Dispersion (PMD)**: Difference in propagation velocity between different optical polarization states. An optical signal can be represented by two orthogonally polarized components, each of which will travel at different velocities due to inherent geometric flaws in a length of optical fiber. Since receivers used in optical communications do not discriminate between different polarization states, the two delayed polarization components will be mixed at the receiving end. This mainly applies to singlemode fiber.

Source: https://www.10gea.org/whitepapers/optical-fiber-and-10-gigabit-ethernet/

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	8 bit/ch	10 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	8.63	10.75	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	11.86	13.98	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	11.86	13.98	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	12.66	14.78	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	13.47	15.59	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	15.08	17.20	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	15.08	17.20	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	16.69	18.81	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	18.31	20.43	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	18.31	20.43	22.58	22.58
		YCbCr 4:2:2	8 bit/ch	8.63	11.86	11.86	12.66	13.47	15.08	15.08	16.69	18.31	18.31	17.26	19.38	21.53	21.53
			10 bit/ch	10.75	13.98	13.98	14.78	15.59	17.20	17.20	18.81	20.43	20.43	19.38	21.50	23.65	23.65
			12 bit/ch	12.90	16.13	16.13	16.93	17.74	19.35	19.35	20.97	22.58	22.58	21.53	23.65	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	21.53	23.65	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

Installation of the UBEX Matrix

This chapter introduces the hardware requirements of the UBEX matrix and lists the required capabilities of the network switch for the best AV performance:

- Hardware Requirements
- Ethernet Switch - Detailed Requirements
- Connections

3.1. Hardware Requirements

The UBEX AV network has the following hardware requirements.

Devices:

- **Layer 3 (L3) network switch**
  - 10 GbE support
  - IGMPv2 snooping
  - Non-blocking
  - VLAN support
  - Link Aggregation Control Protocol (LACP)
- **UBEX-MMU-X200 Matrix Management Unit**
- **UBEX endpoints (transmitters, receivers, and/or transceivers)**
  - UBEX-PRO20-HDMI-F100, -F110, -F120 and/or -R100 series

SFP+ modules:

- **SFP+ transceiver modules for the endpoints**
  - 1 (for 10G link) or 2 (for 20G link) modules per endpoint device
  - Singlemode or multimode
  - up to 10 GbE support
- **SFP+ transceiver modules for the L3 switch**
  - 2 modules per endpoint device
  - Singlemode or multimode
  - up to 10 GbE support
- **Singlemode or multimode fiber optical cables**
  - OM3 or OM4 is recommended

If the application does not require long cable extension, DAC cables can be applied instead of the SFP+ modules and optical cables.

DAC cables:

- **DAC cables**
  - 2 cables per endpoint device
  - up to 10 GbE support

3.2. Ethernet Switch - Detailed Requirements

In the virtual matrix architecture, a third-party switch is used to transfer IP packets. In connection with this switch, the following criteria must be met:

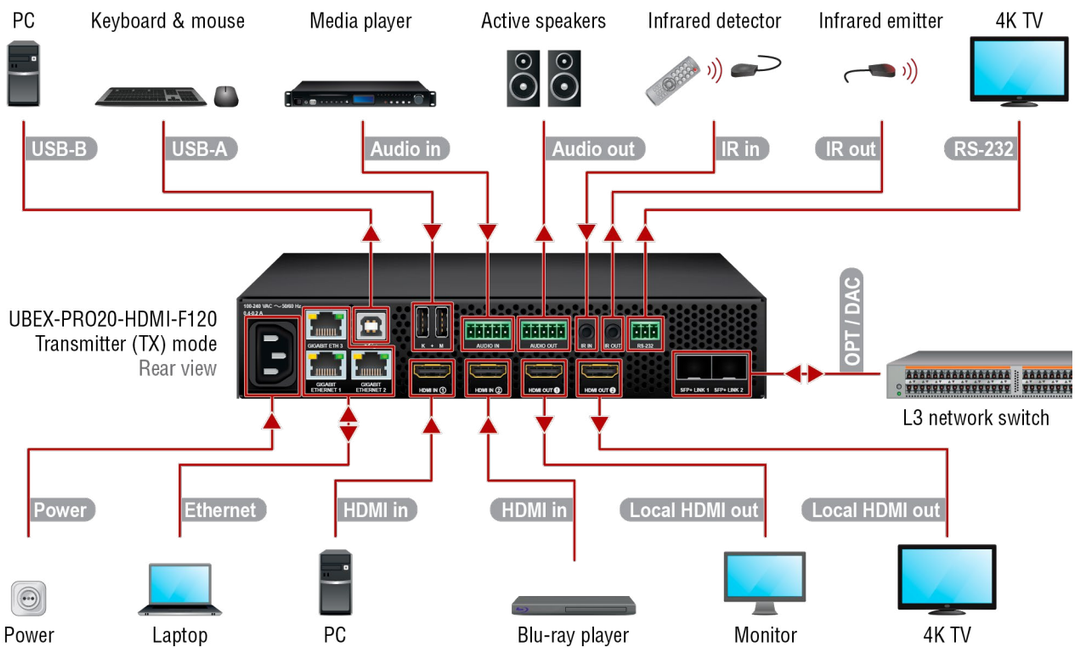
- **10 Gbps non-blocking switch** (capable of full bandwidth transmission between all ports)
- Supports IEEE Std. 802.3ad-2000 **Link Aggregation Control** Protocol, with **Link Aggregation Groups for each endpoint**.
- Supports Internet Group Management Protocol version 2 (RFC 2236) snooping.
- IPv4 (or Layer 2) Multicast Forwarding based on **IGMP v2 snooping**, with at least **16 addresses available for each endpoint**, e.g. 4096 IPv4 multicast addresses for 256 endpoints.
- Supports IEEE Std. 802.1Q VLAN tagging: **1 VLAN reserved for UBEX control and media transmission**, other(s) available for user traffic.

Optional Requirements:

- Supports IEEE Std. 802.1Q (formerly 802.1p) priority code point (**PCP**), and implements priority based queuing for at least 1 prioritized traffic class. This is required to guarantee uninterrupted media transmission regardless of the user traffic.
- Supports Link Layer Discovery Protocol (**LLDP**), in order to discover network topology.
- Supports IEEE Std. 802.1s (merged into IEEE Std. 802.1Q-2005) Multiple Spanning Tree Protocol (**MSTP**), in order to detect switching loops in VLAN's.

3.3. Connections

3.3.1. F-series Endpoints - Transmitter Operation Mode



Connections for the F120 model in transmitter operation mode

Changing the Operation Mode

The operation mode of the UBEX endpoint device can be changed using the following methods.

Before connecting the device to the network and the MMU:

- via **front panel LCD menu**;

After connecting the device to the network and the MMU:

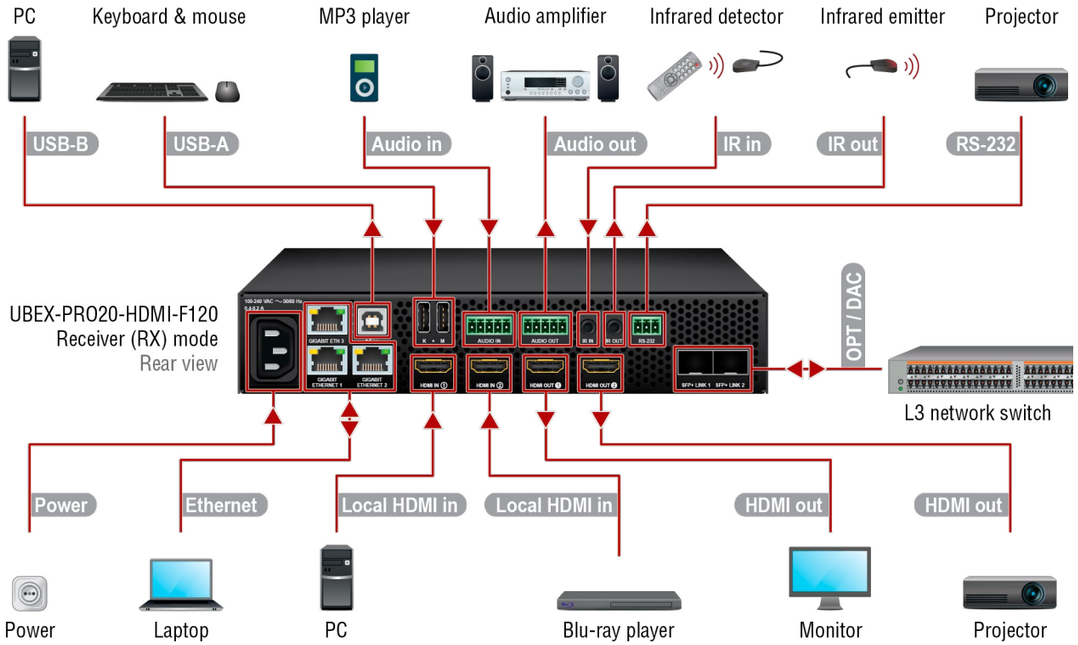
- via **Lightware Device Controller (LDC) software** in the Device map tool.

For all F-series models	OPT DAC	Connect singlemode or multimode (depends on the installed SFP+ modules) fiber optical cables or DAC cables between the transmitter and the Layer 3 (L3) network switch. The Matrix Mode is detected and applied automatically in the device once the MMU claims the endpoint.
	HDMI in	Connect the source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	Local HDMI out	Connect the local sink devices (e.g. monitor, 4K TV) to the HDMI output 1 and 2 ports by HDMI cables.
	Ethernet	Optionally connect the transmitter to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the transmitter first, then to the AC power socket.
For F110 and F120 models only	Audio in	Connect an audio source device (e.g. media player) to the audio input connector.
	Audio out	Connect an audio sink device (e.g. active speakers) to the audio output connector.
	IR in	Connect an Infrared detector unit to the IR IN connector for receiving Infrared input signal.
	IR out	Connect an Infrared emitter unit to the IR OUT connector for controlling third-party devices over Infrared signal.
	RS-232	Optionally for RS-232 extension: connect the controlled unit (e.g. 4K TV) to the RS-232 port of the device with a serial cable.
For F120 model only	USB-B	Optionally for USB HID extension: connect the transmitter to the computer by the USB-B cable.
	USB-A	Optionally for USB HID extension: connect the USB HID devices to the transmitter (preferably mouse and keyboard).

WARNING! User Ethernet is also transmitted over the SFP+ interface, so be sure not to create a network loop.

INFO: The HDMI output ports can be used as local output ports only when the device is configured as transmitter.

3.3.2. F-series Endpoints - Receiver Operation Mode



Connections for the F120 model in receiver operation mode

Changing the Operation Mode

The operation mode of the UBEX endpoint device can be changed using the following methods.

Before connecting the device to the network and the MMU:

- via **front panel LCD menu**.

After connecting the device to the network and the MMU:

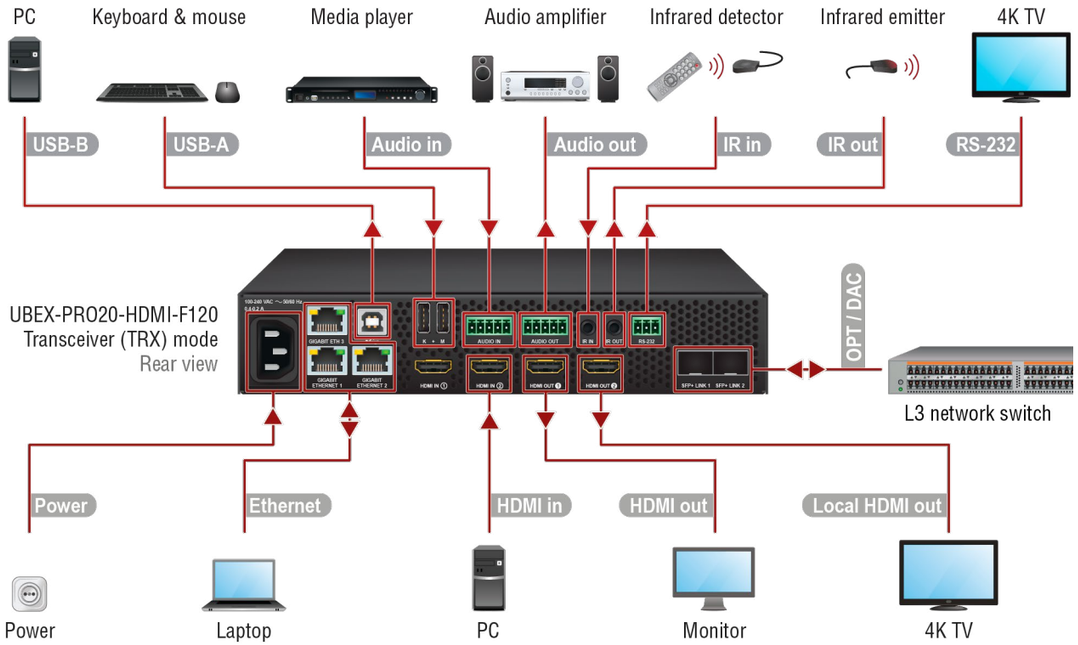
- via **Lightware Device Controller (LDC) software** in the Device map tool;
- via **LW3 protocol command.**

For all F-series models	OPT DAC	Connect singlemode or multimode (depends on the installed SFP+ modules) fiber optical cables or DAC cables between the receiver and the Layer 3 (L3) network switch. The Matrix Mode is detected and applied automatically in the device once the MMU claims the endpoint.
	Local HDMI in	Connect the local source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	HDMI out	Connect the sink devices (e.g. monitor, projector) to the HDMI output 1 and 2 ports by HDMI cables.
	Ethernet	Optionally connect the receiver to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the receiver first, then to the AC power socket.
For F110 and F120 models only	Audio in	Connect an audio source device (e.g. MP3 player) to the audio input connector.
	Audio out	Connect an audio sink device (e.g. audio amplifier) to the audio output connector.
	IR in	Connect an Infrared detector unit to the IR IN connector for receiving Infrared input signal.
	IR out	Connect an Infrared emitter unit to the IR OUT connector for controlling third-party devices over Infrared signal.
	RS-232	Optionally for RS-232 extension: connect the controlled unit (e.g. projector) to the RS-232 port of the device with a serial cable.
For F120 model only	USB-B	Optionally for USB HID extension: connect the receiver to the computer by the USB-B cable.
	USB-A	Optionally for USB HID extension: connect the USB HID devices to the receiver (preferably mouse and keyboard).

WARNING! User Ethernet is also transmitted over the SFP+ interface, so be sure not to create a network loop.

INFO: The HDMI input ports can be used as local input ports only when the device is configured as receiver.

3.3.3. F-series Endpoints - Transceiver Operation Mode



Connections for the F120 model in transceiver operation mode

Changing the Operation Mode

The operation mode of the UBEX endpoint device can be changed using the following methods.

Before connecting the device to the network and the MMU:

- via **front panel LCD menu**.

After connecting the device to the network and the MMU:

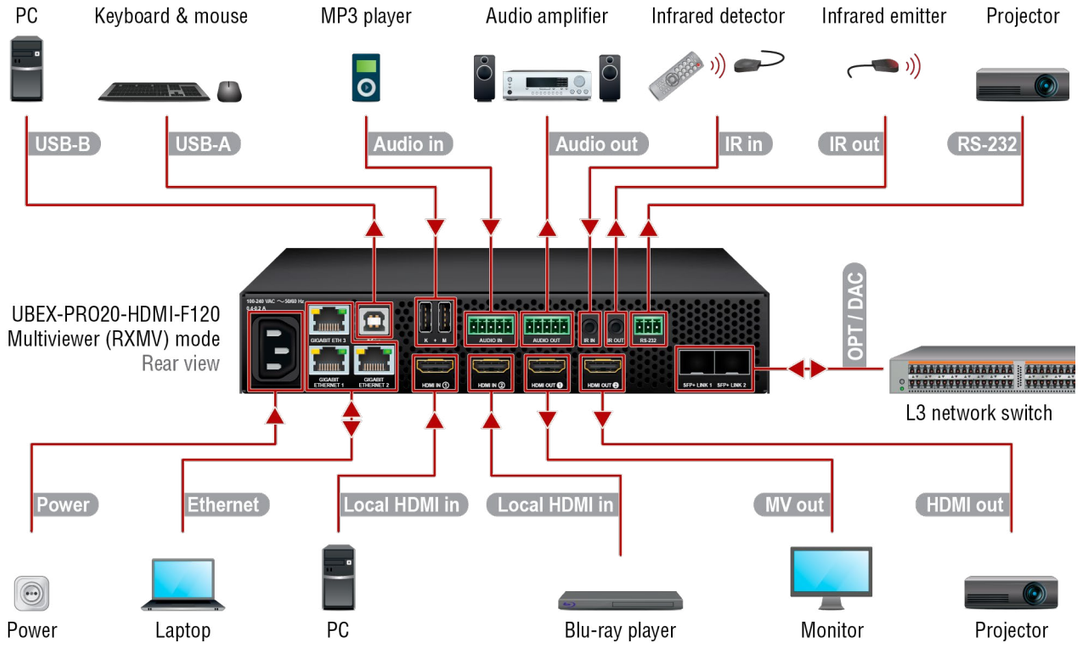
- via **Lightware Device Controller (LDC) software** in the Device map tool;
- via **LW3 protocol command.**

For all F-series models	OPT DAC	Connect singlemode or multimode (depends on the installed SFP+ modules) fiber optical cables or DAC cables between the transceiver and the Layer 3 (L3) network switch. The Matrix Mode is detected and applied automatically in the device once the MMU claims the endpoint.
	HDMI in	Connect the source device (e.g. PC) using the HDMI input 2 port by an HDMI cable.
	HDMI out	Connect a sink device (e.g. monitor) to the HDMI output 1 port by an HDMI cable.
	Local HDMI out	Connect a local sink device (e.g. 4K TV) to the HDMI output 2 port by an HDMI cable.
	Ethernet	Optionally connect the transceiver to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the transceiver first, then to the AC power socket.
For F110 and F120 models only	Audio in	Connect an audio source (e.g. media player) to the audio input connector.
	Audio out	Connect an audio sink device (e.g. audio amplifier) to the audio output connector.
	IR in	Connect an Infrared detector unit to the IR IN connector for receiving Infrared input signal.
	IR out	Connect an Infrared emitter unit to the IR OUT connector for controlling third-party devices over Infrared signal.
	RS-232	Optionally for RS-232 extension: connect the controlled unit (e.g. 4K TV) to the RS-232 port of the device with a serial cable.
For F120 model only	USB-B	Optionally for USB HID extension: connect the transceiver to the computer by the USB-B cable.
	USB-A	Optionally for USB HID extension: connect the USB HID devices to the transceiver (preferably mouse and keyboard).

WARNING! User Ethernet is also transmitted over the SFP+ interface, so be sure not to create a network loop.

INFO: The HDMI input 1 port cannot accept AV signal when the device is configured as transceiver.

3.3.4. F-series Endpoints - Multiviewer Operation Mode



Connections for the F120 model in multiviewer operation mode

Changing the Operation Mode

The operation mode of the UBEX endpoint device can be changed using the following methods.

Before connecting the device to the network and the MMU:

- via **front panel LCD menu**.

After connecting the device to the network and the MMU:

- via **Lightware Device Controller (LDC) software** in the Device map tool;
- via **LW3 protocol command.**

DIFFERENCE: The multiviewer operation mode for the endpoint devices is available only from endpoint firmware package **v3.2.0**.

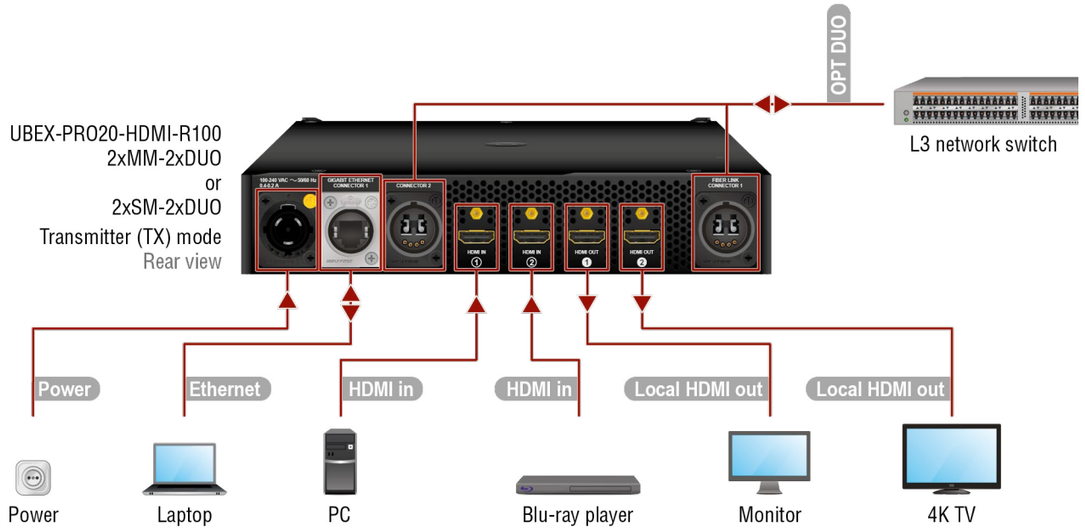
For all F-series models	OPT DAC	Connect singlemode or multimode (depends on the installed SFP+ modules) fiber optical cables or DAC cables between the multiviewer and the Layer 3 (L3) network switch. The Matrix Mode is detected and applied automatically in the device once the MMU claims the endpoint.
	Local HDMI in	Connect the local source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	MV out	Connect the multiviewer sink device (e.g. monitor) to the HDMI output 1 port by an HDMI cable.
	HDMI out	Connect a sink device (e.g. projector) to the HDMI output 2 port by an HDMI cable.
	Ethernet	Optionally connect the multiviewer to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the receiver first, then to the AC power socket.
For F110 and F120 models only	Audio in	Connect an audio source device (e.g. MP3 player) to the audio input connector.
	Audio out	Connect an audio sink device (e.g. audio amplifier) to the audio output connector.
	IR in	Connect an Infrared detector unit to the IR IN connector for receiving Infrared input signal.
	IR out	Connect an Infrared emitter unit to the IR OUT connector for controlling third-party devices over Infrared signal.
	RS-232	Optionally for RS-232 extension: connect the controlled unit (e.g. projector) to the RS-232 port of the device with a serial cable.
For F120 model only	USB-B	Optionally for USB HID extension: connect the multiviewer to the computer by the USB-B cable.
	USB-A	Optionally for USB HID extension: connect the USB HID devices to the multiviewer (preferably mouse and keyboard).

WARNING! User Ethernet is also transmitted over the SFP+ interface, so be sure not to create a network loop.

INFO: The HDMI input ports can be used as local input ports only when the device is configured as multiviewer.

3.3.5. R-series Endpoints - Transmitter Operation Mode

2xMM-2xDUO and 2xSM-2xDUO



2xMM-QUAD and 2xSM-QUAD

2xSM-BiDi-DUO

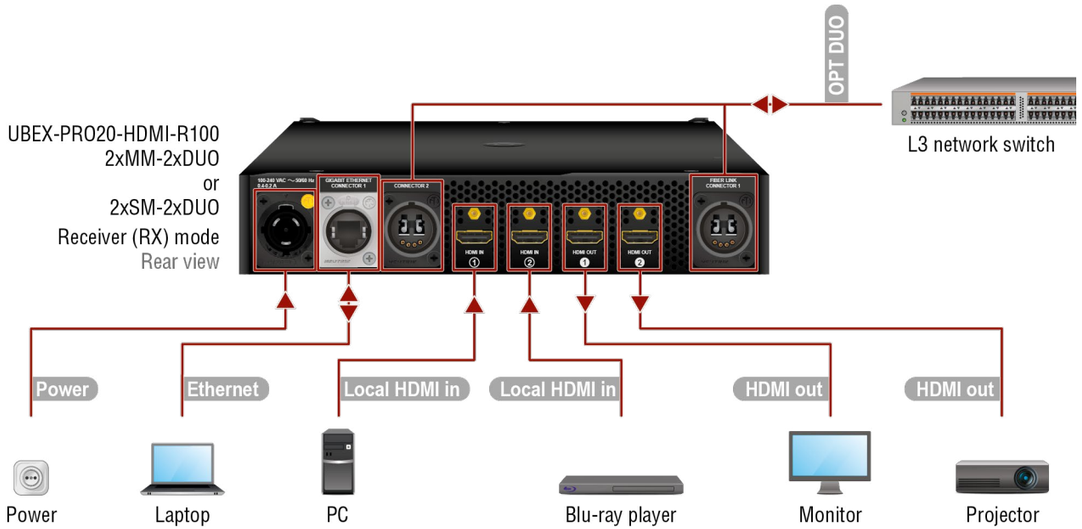
For all R-series models	HDMI in	Connect the source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	Local HDMI out	Connect the local sink devices (e.g. monitor, 4K TV) to the HDMI output 1 and 2 ports by HDMI cables. The ports transmit the original streams of the HDMI input ports.
	Ethernet	Optionally connect the transmitter to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the transmitter first, then to the AC power socket.
2xMM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **multimode** Neutrik opticalCON DUO or 4 pcs multimode LC fiber optical cables. *
2xMM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **multimode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **singlemode** Neutrik opticalCON DUO or 4 pcs singlemode LC fiber optical cables. *
2xSM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-BiDi-DUO	OPT BiDi DUO	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON DUO BiDi or 2 pcs singlemode LC fiber optical cables. * **The connector does not support the Neutrik opticalCON cross cable. Please use standard cable only.**

WARNING! User Ethernet is also transmitted over the fiber optical interface, so be sure not to create a network loop.

INFO: The HDMI output ports can be used as local output ports only when the device is configured as transmitter.

3.3.6. R-series Endpoints - Receiver Operation Mode

2xMM-2xDUO and 2xSM-2xDUO



2xMM-QUAD and 2xSM-QUAD

2xSM-BiDi-DUO

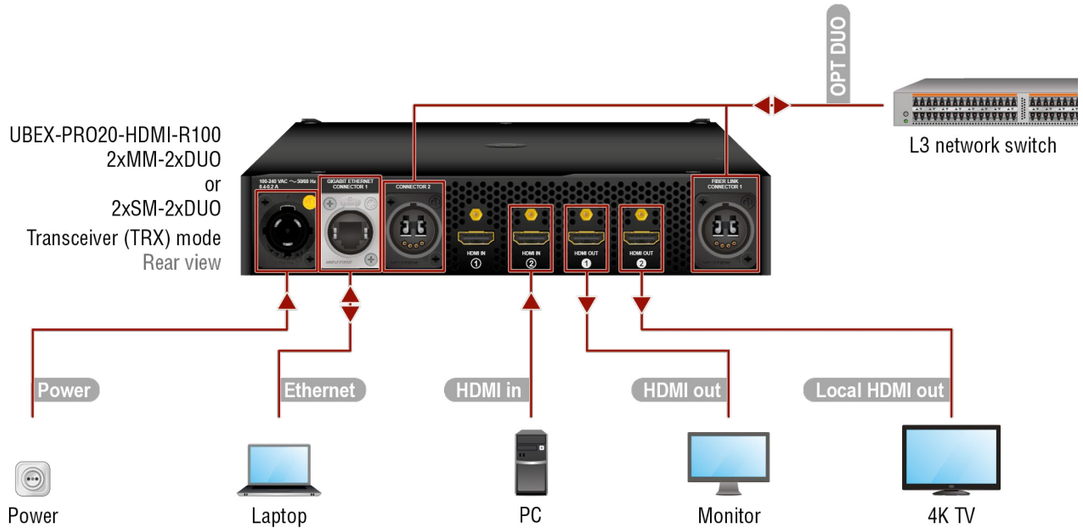
For all R-series models	Local HDMI in	Connect the local source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	HDMI out	Connect the sink devices (e.g. monitor, projector) to the HDMI output 1 and 2 ports by HDMI cables.
	Ethernet	Optionally connect the receiver to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the receiver first, then to the AC power socket.
2xMM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **multimode** Neutrik opticalCON DUO or 4 pcs multimode LC fiber optical cables. *
2xMM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **multimode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **singlemode** Neutrik opticalCON DUO or 4 pcs singlemode LC fiber optical cables. *
2xSM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-BiDi-DUO	OPT BiDi DUO	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON DUO BiDi or 2 pcs singlemode LC fiber optical cables. * **The connector does not support the Neutrik opticalCON cross cable. Please use standard cable only.**

WARNING! User Ethernet is also transmitted over the fiber optical interface, so be sure not to create a network loop.

INFO: The HDMI input ports can be used as local input ports only when the device is configured as receiver.

3.3.7. R-series Endpoints - Transceiver Operation Mode

2xMM-2xDUO and 2xSM-2xDUO



2xMM-QUAD and 2xSM-QUAD

2xSM-BiDi-DUO

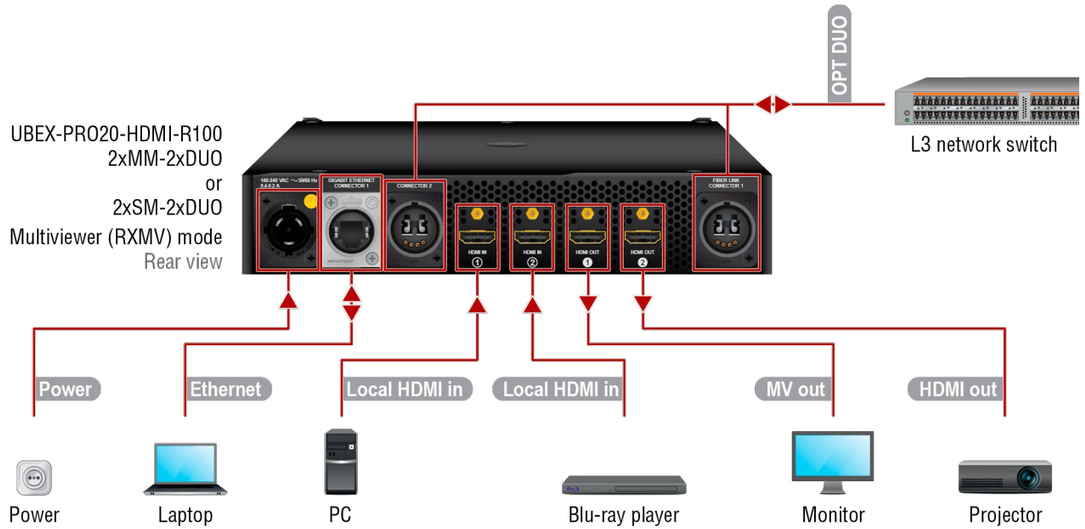
For all R-series models	HDMI in	Connect the source device (e.g. PC) using the HDMI input 2 port by an HDMI cable.
	HDMI out	Connect a sink device (e.g. monitor) to the HDMI output 1 port by an HDMI cable.
	Local HDMI out	Connect a local sink device (e.g. 4K TV) to the HDMI output 2 port by an HDMI cable. The port transmit the original stream of the HDMI in 2 port.
	Ethernet	Optionally connect the transceiver to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the transceiver first, then to the AC power socket.
2xMM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **multimode** Neutrik opticalCON DUO or 4 pcs multimode LC fiber optical cables. *
2xMM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **multimode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **singlemode** Neutrik opticalCON DUO or 4 pcs singlemode LC fiber optical cables. *
2xSM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-BiDi-DUO	OPT BiDi DUO	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON DUO BiDi or 2 pcs singlemode LC fiber optical cables. * **The connector does not support the Neutrik opticalCON cross cable. Please use standard cable only.**

WARNING! User Ethernet is also transmitted over the fiber optical interface, so be sure not to create a network loop.

INFO: The HDMI input 1 port cannot accept AV signal when the device is configured as transceiver.

3.3.8. R-series Endpoints - Multiviewer Operation Mode

2xMM-2xDUO and 2xSM-2xDUO



2xMM-QUAD and 2xSM-QUAD

2xSM-BiDi-DUO

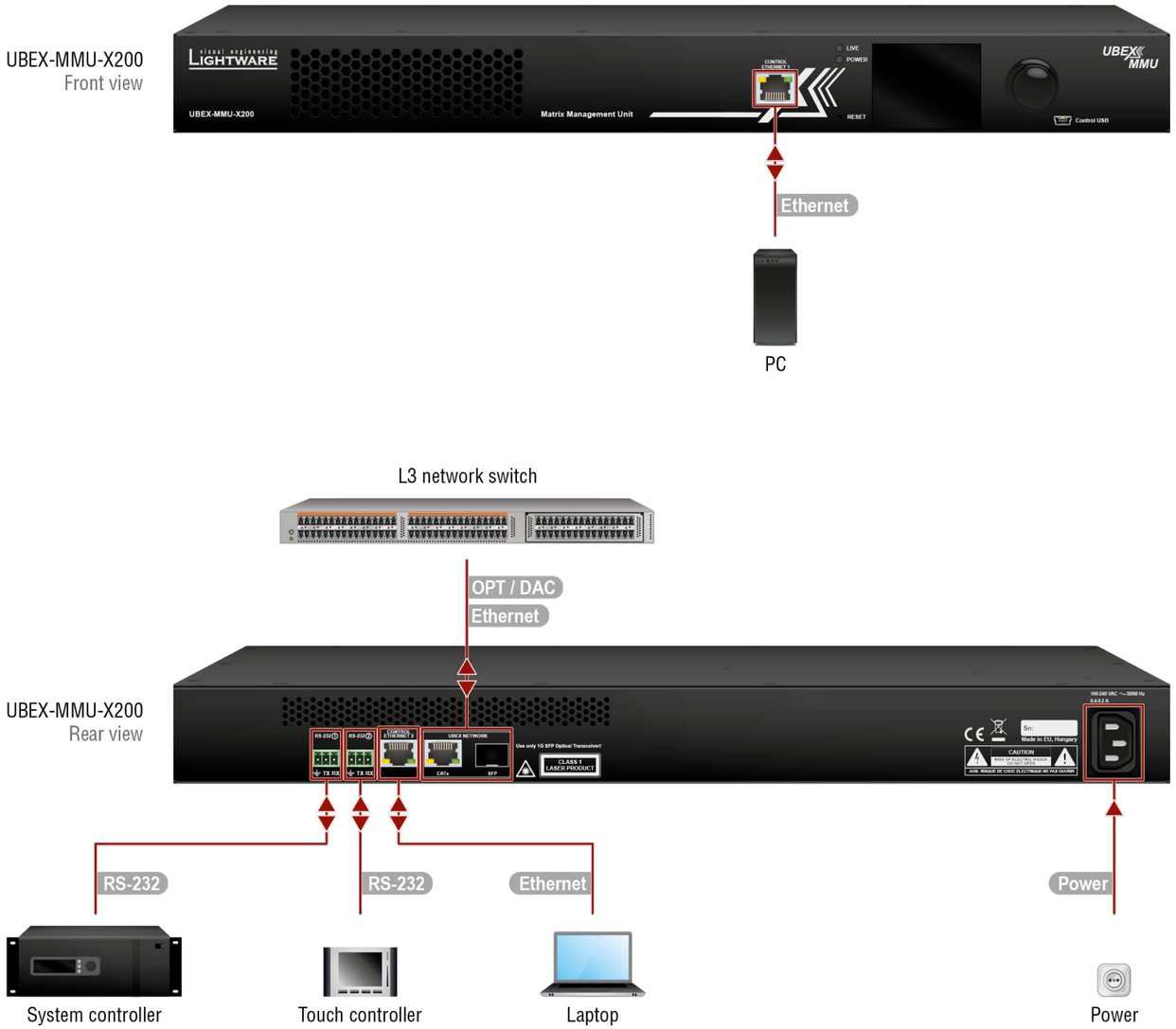
For all R-series models	Local HDMI in	Connect the local source devices (e.g. PC, Blu-ray player) using the HDMI input 1 and 2 ports by HDMI cables.
	MV out	Connect the multiviewer sink device (e.g. monitor) to the HDMI output 1 port by an HDMI cable.
	HDMI out	Connect a sink device (e.g. projector) to the HDMI output 2 port by an HDMI cable.
	Ethernet	Optionally connect the multivivewer to a LAN in order to control the device.
	Power	Connect the power adaptor to the AC input on the multivivewer first, then to the AC power socket.
2xMM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **multimode** Neutrik opticalCON DUO or 4 pcs multimode LC fiber optical cables. *
2xMM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **multimode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-2xDUO	OPT DUO	Connect the device and the L3 network switch by 2 pcs **singlemode** Neutrik opticalCON DUO or 4 pcs singlemode LC fiber optical cables. *
2xSM-QUAD	OPT QUAD	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON QUAD fiber optical cable. *
2xSM-BiDi-DUO	OPT BiDi DUO	Connect the device and the L3 network switch by a **singlemode** Neutrik opticalCON DUO BiDi or 2 pcs singlemode LC fiber optical cables. * **The connector does not support the Neutrik opticalCON cross cable. Please use standard cable only.**

WARNING! User Ethernet is also transmitted over the fiber optical interface, so be sure not to create a network loop.

DIFFERENCE: The multiviewer operation mode for the endpoint devices is available only from endpoint firmware package **v3.2.0**.

INFO: The HDMI input ports can be used as local input ports only when the device is configured as multiviewer.

3.3.9. Matrix Management Unit (MMU)



Connections for the UBEX-MMU-X200 Matrix Management Unit

OPT / DAC Ethernet

Two possibilities are available to connect the MMU to the Layer 3 (L3) network switch:

- **via Ethernet:** use the CATx port of the UBEX Network for the Ethernet connection between the devices, OR
- **via SFP port:**
  - use a singlemode or multimode (depends on the installed SFP **(not SFP+)** modules) fiber optical cables or DAC cables between the MMU and the Layer 3 (L3) network switch.
  - use CATx cable between the MMU and the Layer 3 (L3) network switch when RJ45 SFP **(not SFP+)** module is installed to the slot.

Ethernet

Connect a controller device (e.g. PC, laptop) to the MMU with a CATx cable for the connection to the LAN network.

RS-232

Optionally connect third-party controller devices (e.g. system controller, touch controller) with a serial cable via the RS-232 1 and 2 connectors.

Power

Connect the power adaptor to the AC input on the MMU first, then to the AC power socket.

INFO: The USB control function will be added by future firmware update.

4

Ethernet Switch Configuration

This chapter describes the steps of the configuration for the network switch in general terms:

- Link Aggregation (LAG)
- VLAN
- IGMPv2
- Optional Configuration

ATTENTION! The UBEX extenders do not support jumbo/giant frames.

4.1. Link Aggregation (LAG)

DEFINITION: The **Link Aggregation Group** (LAG) applies to various methods of combining (aggregating) multiple network connections in parallel in order to increase throughput beyond what a single connection could sustain.

Create Link Aggregation Groups (LAG's)/EtherChannels etc. for each port pair that is used for 20 GbE transmission. The bonding mode is dynamic: 802.3-ad LACP has to be enabled for each group.

4.2. VLAN

DEFINITION: A **virtual LAN** (VLAN) is any broadcast domain that is partitioned and isolated in a computer network at the data link layer (OSI layer 2). LAN is the abbreviation for local area network and in this context, virtual refers to a physical object recreated and altered by additional logic.

The UBEX network uses 802.1Q tagged frames with the VLAN ID of 286. This VLAN has to be available from each LAG, with tagged frames. The LAG's have to be in trunk mode (multiple VLAN's are available on UBEX devices, other VLAN's may be used with tagged or untagged frames).

The port where the MMU is connected is also a trunk port.

4.3. IGMPv2

DEFINITION: **IGMP snooping** is the process of listening to Internet Group Management Protocol network traffic. The feature allows a network switch to listen in on the IGMP conversation between hosts and routers.

IGMPv2 snooping has to be enabled for each LAG in this VLAN.

4.4. Optional Configuration

Enable Link Layer Discovery Protocol (**LLDP**) on all ports to access topology information in order to speed up your installation process.

5

Configuration Steps - Ubiquiti EdgeSwitch 16 XG

The following chapter describes and explains step-by-step the procedure of the configuration for the Ubiquiti EdgeSwitch 16 XG fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- First Steps
- Detailed Instructions
- Finalizing the Matrix

5.1. Description

This chapter helps you configure the Ubiquiti EdgeSwitch™ ES-16-XG fully managed switch for the UBEX matrix. This model of the Ubiquiti contains 12x 10G SFP+ slots which are enough to serve 6 UBEX endpoints and handle up to 12 source / destination devices. The switch is recommended for small businesses.

5.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Ubiquiti EdgeSwitch 16 XG	**1**	1.8.1 (or above)
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**6**	latest released firmware version

ATTENTION! Always check the firmware version of the network switch before starting the configuration. The required steps with older versions than v1.7.3 may differ from the following description.

5.3. First Steps

5.3.1. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

5.3.2. Installation of the Switch

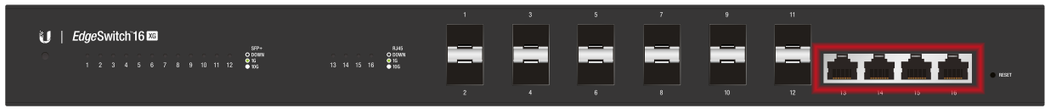
Download the user's manual for the EdgeSwitch 16 XG model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 12x 10GbE singlemode/multimode SFP+ transceiver modules and 12x singlemode/multimode fiber optical cables
- 12x 10GbE DAC cables

Step 3. Plug a CATx cable to the copper port (UBEX network) of the UBEX MMU and to one of the copper ports of the switch.



Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to one of the copper ports.

The factory default settings of the switch: **192.168.1.2**

Control Device Settings

Before connecting to the switch be sure the network settings of the operating system on your computer are correct. You need to set the following setting on the network card:

- IP address: must be in the in the same subnet : **192.168.1.x** with the subnet mask of 255.255.255.0)

ATTENTION! The copper ports of the switch accept 1000BaseT (1 Gbps) Ethernet connection only.

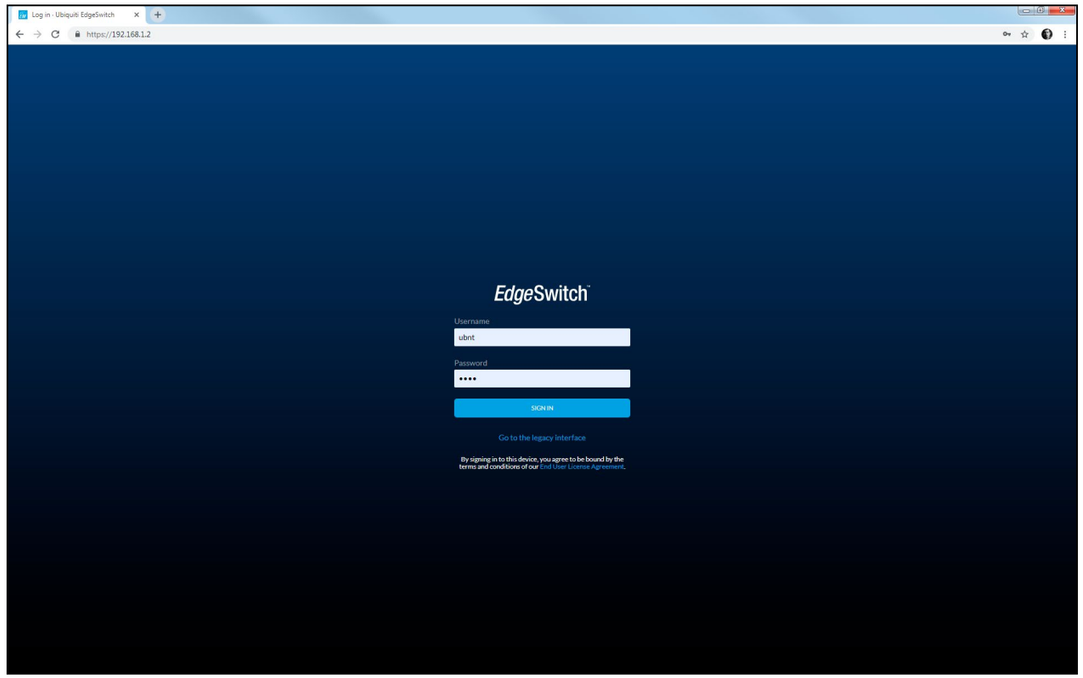
Step 5. Open a web browser on your computer and follow the configuration steps coming in the following section.

5.4. Detailed Instructions

5.4.1. Open a Web Browser

Open a web browser (e.g. Google Chrome) and enter the IP address of the switch. The login screen with the new interface appears.

You have to switch back to the legacy interface (old GUI) by clicking on the **Go to the legacy interface** link.

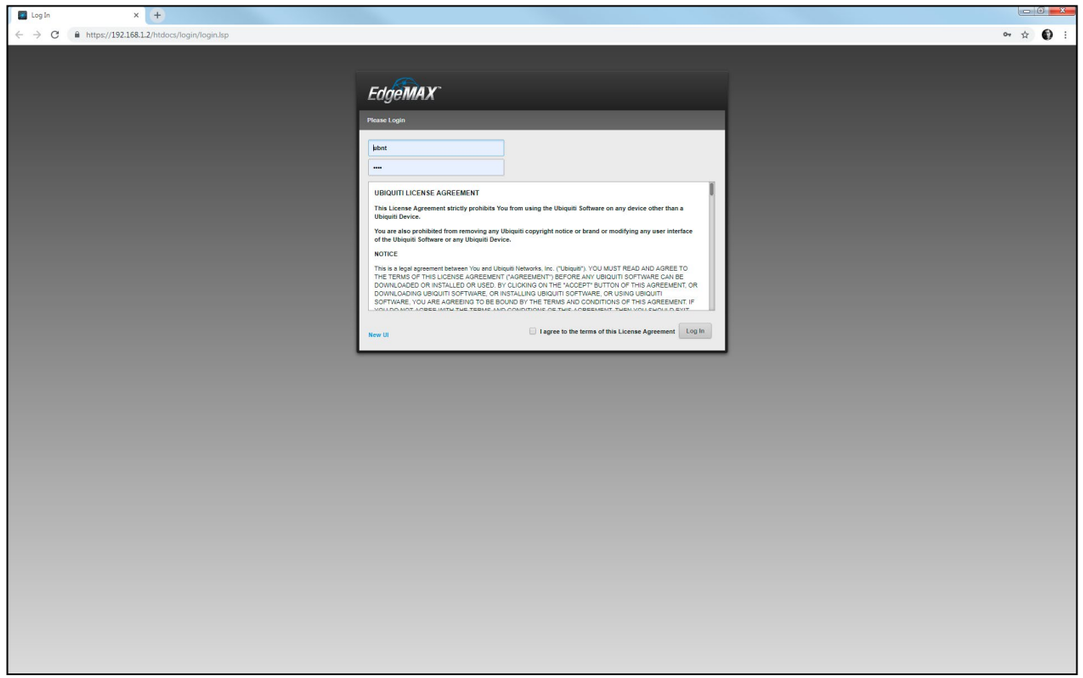


New GUI login screen of the switch

5.4.2. Login to the Switch

The login screen with the legacy interface appears. Enter the following parameters:

- **Username**: ubnt
- **Password**: ubnt



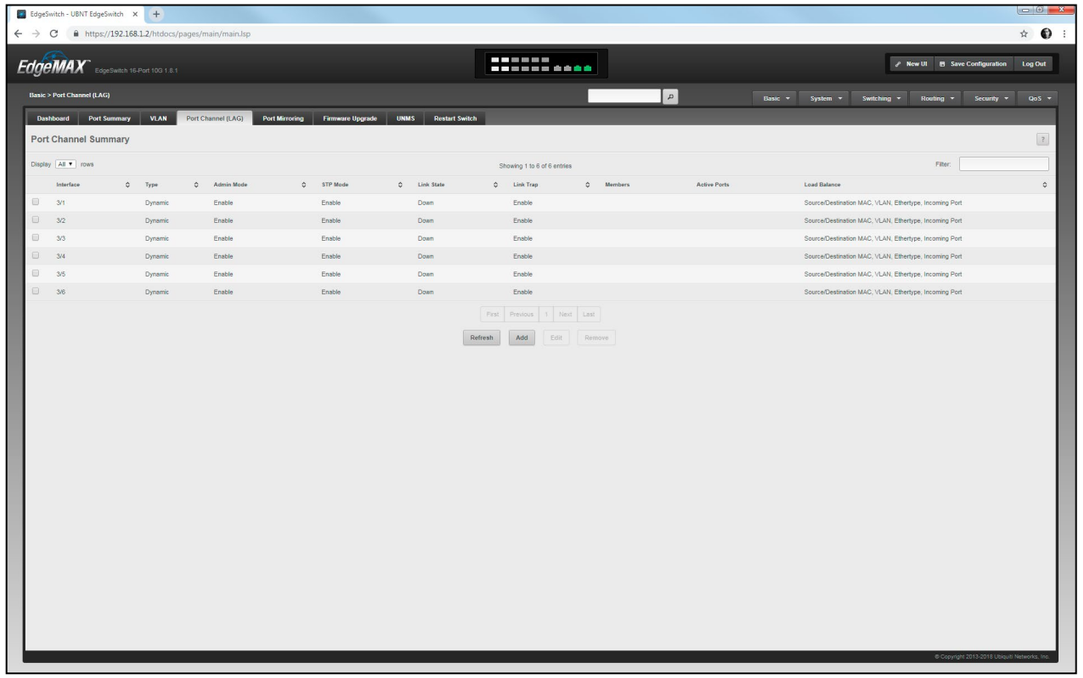
Legacy interface login screen of the switch

5.4.3. Creating LAGs

> DEFINITION: The **Link Aggregation Protocol** (LAG) applies to various methods of combining (aggregating) multiple network connections in parallel in order to increase throughput beyond what a single connection could sustain.

The UBEX endpoint devices use 2x SFP+ ports in the switch per unit. You need to create LAGs for each port pair. If the bandwidth of the connection is 10GbE (one SFP+ port is used only in the endpoint), you also need to create LAGs for each used port.

Navigate to the Basic -> **Port Channel (LAG)** submenu. All ports and the current LAG states are listed here.



LAG Configuration page with no configured LAGs

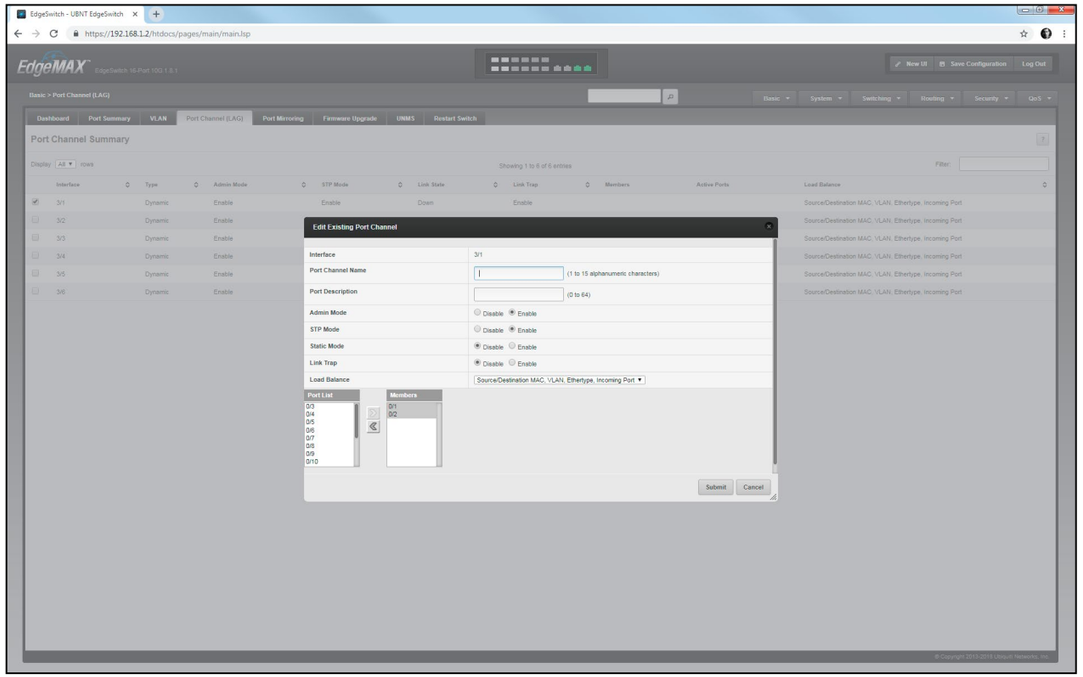
Creating LAGs

Select the port channels one by one and select the **Edit** menu. The editing window pops up, you need to add the 2 ports where the UBEX endpoints are connected to the switch and set the following values for the channel:

- Admin Mode: **Enable**
- STP Mode: **Enable**
- Static Mode: **Disable**
- Link Trap: **Disable**
- Load Balance: **Source/Destination MAC, VLAN, Ethertype, Incoming Port**

Port channel name and Port description can also be added but it is not obligatory.

When it is done, press the **Submit** button to save the configuration.



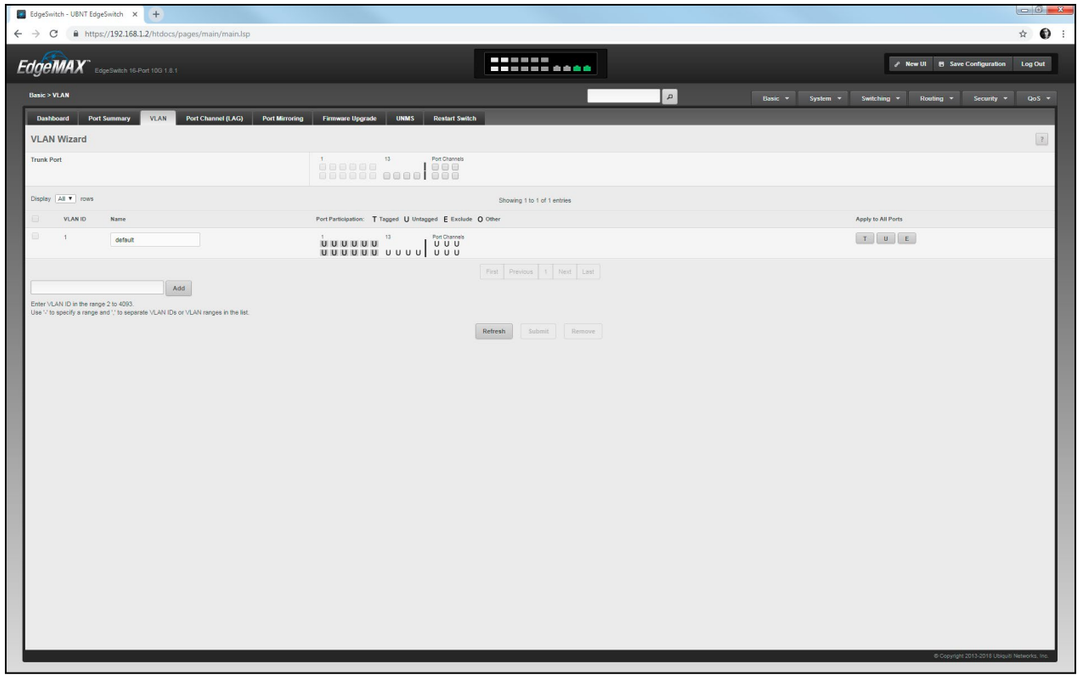
Edit Existing Port window

5.4.4. VLAN Configuration

> DEFINITION: A **virtual LAN** (VLAN) is any broadcast domain that is partitioned and isolated in a computer network at the data link layer (OSI layer 2). LAN is the abbreviation for local area network and in this context, virtual refers to a physical object recreated and altered by additional logic.

Create VLAN

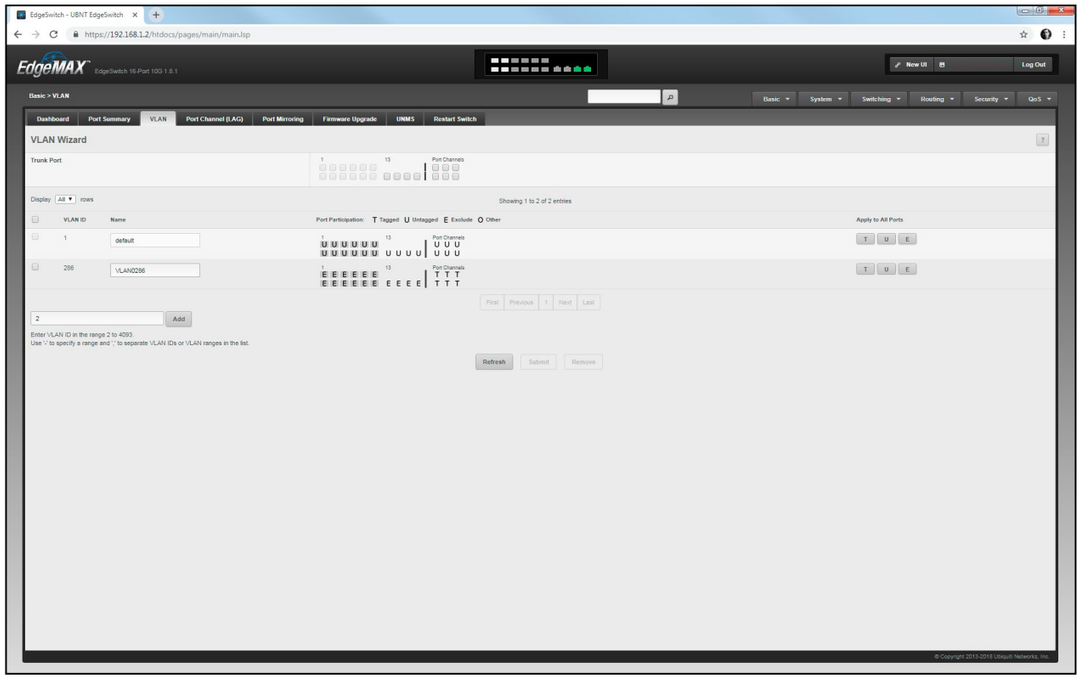
Navigate to the Basic -> **VLAN** submenu.



VLAN wizard page

Adding a New VLAN

Type to the VLAN ID the **286** and click on the **Add** button. The new VLAN appears with 286 ID. Change the port participation from Untagged (U) to **Tagged (T)** in the Port Channels section.



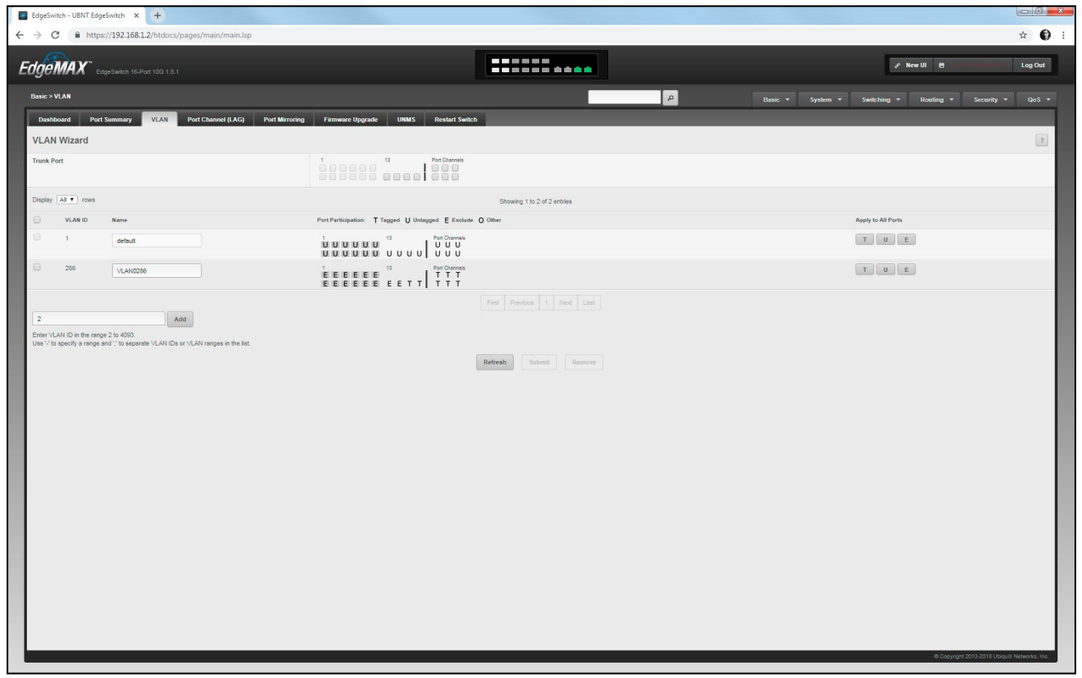
VLAN wizard page with the new VLAN

> **ATTENTION!** Do not enable **Trunk port** for the Port channels. If it is enabled, disable it.

Add the MMU's port to the UBEX VLAN

Change the port participation from Exclude (E) to **Tagged (T)** on the port where the MMU connects to the switch - this is the copper port 16 in our example. Also add the port where the control device (e.g. laptop) connects to the switch for enabling the user Ethernet - this is the copper port 15 in our example.

When it is done, press the **Submit** button to save the configuration.



VLAN wizard page with the final configuration

ATTENTION! Do not enable **Trunk port** for the Port channels. If it is enabled, disable it.

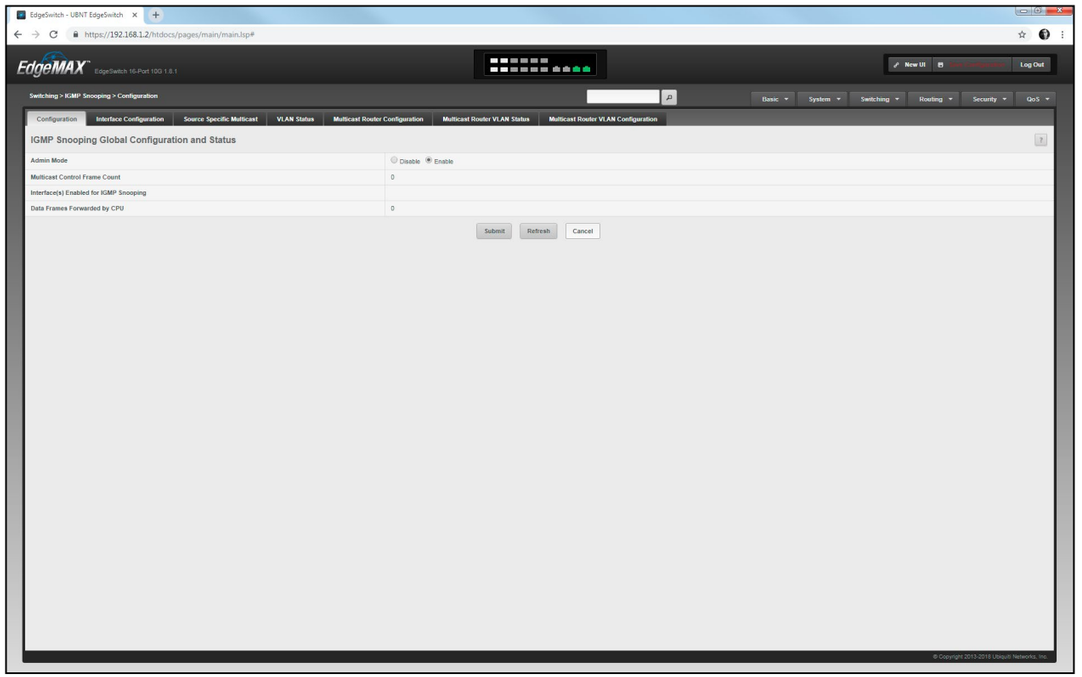
ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

5.4.5. IGMPv2 Snooping

> DEFINITION: **IGMP snooping** is the process of listening to Internet Group Management Protocol network traffic. The feature allows a network switch to listen in on the IGMP conversation between hosts and routers.

Configuration

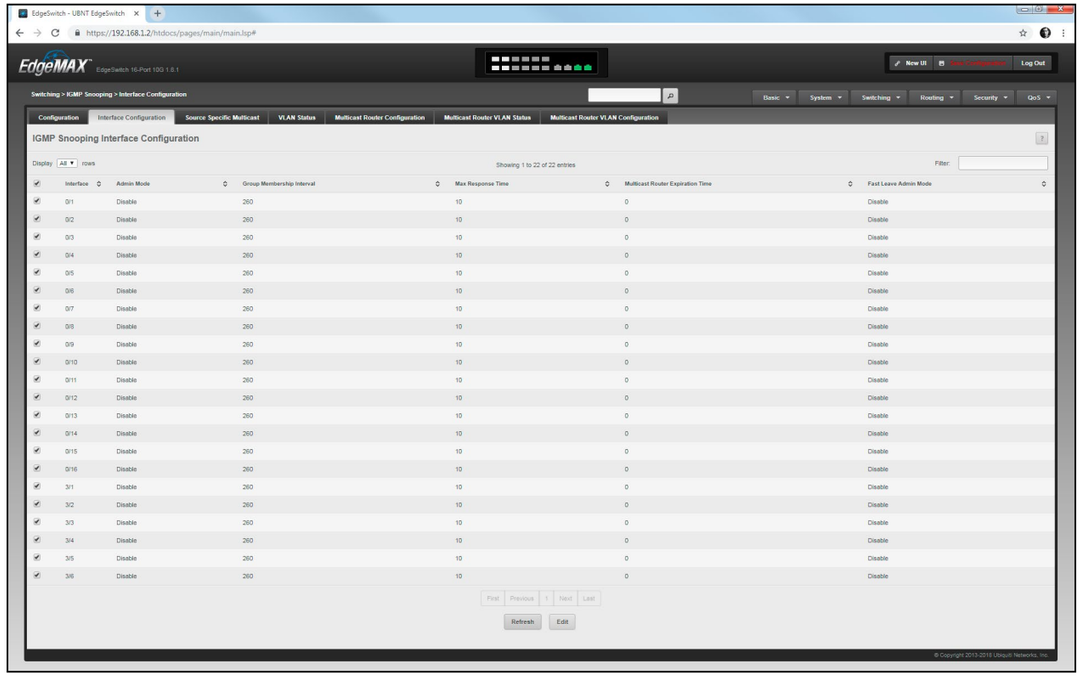
Navigate to the Switching -> IGMP Snooping -> **Configuration** submenu. Set the Admin Mode to **Enable**.



IGMP snooping configuration page

Interface Configuration

Go to the **Interface Configuration** tab. Set the **Display** to **All** rows and select all interfaces in the list. Select all ports and click on the **Edit** button.



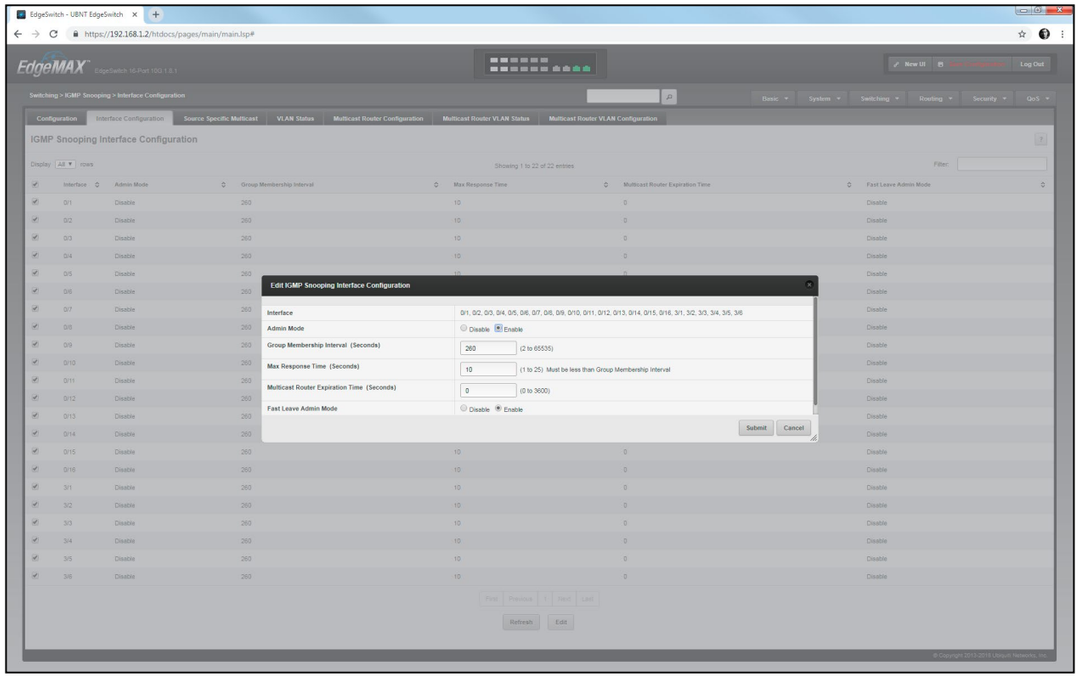
Interface configuration page

Editing the IGMP Snooping Interface Configuration

The IGMP snooping interface configuration editor appears in a new window. Set the following values for the interfaces:

- Admin Mode: **Enable**
- Group Membership Interval (Seconds): **260**
- Max Response Time (Seconds): **10**
- Multicast Router Expiration Time (Seconds): **0**
- Fast Leave Admin Mode: **Enable**

When it is done, press the **Submit** button to save the configuration.



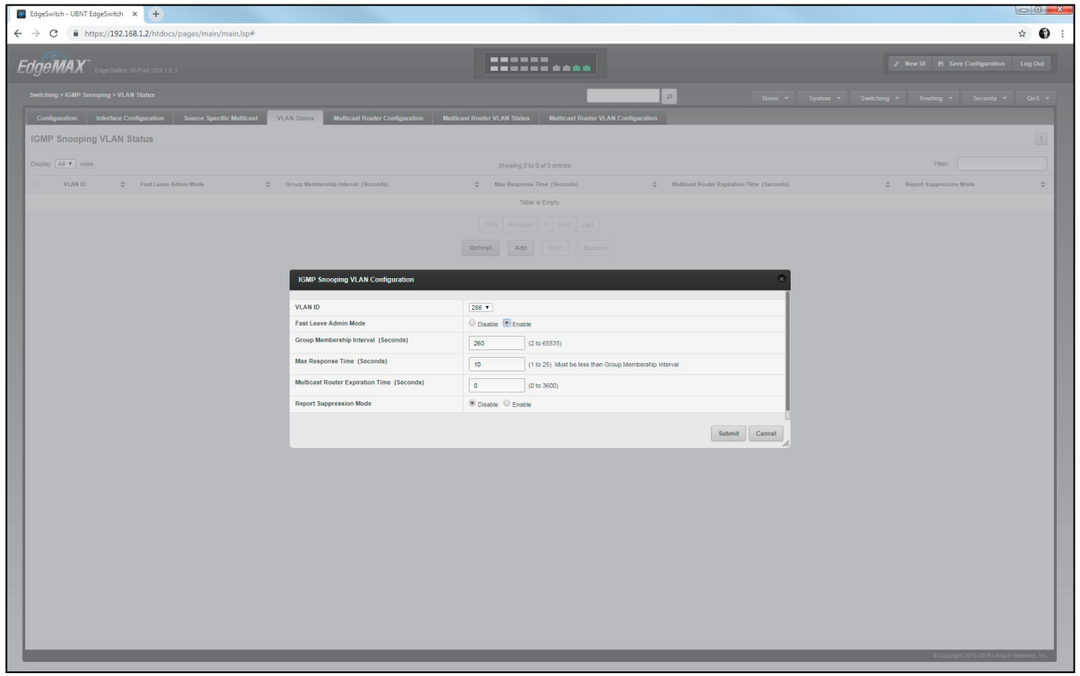
Interface configuration editor page

IGMP Snooping VLAN Configuration

Go to the **VLAN Status** tab. Click on the **Add** button to open the IGMP Snooping VLAN Configuration window. Select the **286** VLAN ID and set the following values:

- Fast Leave Admin Mode: **Enable**
- Group Membership Interval (Seconds): **260**
- Max Response Time (Seconds): **10**
- Multicast Router Expiration Time (Seconds): **0**
- Report Suppression Mode: Disable

When it is done, press the **Submit** button to save the configuration.



IGMP snooping VLAN configuration page

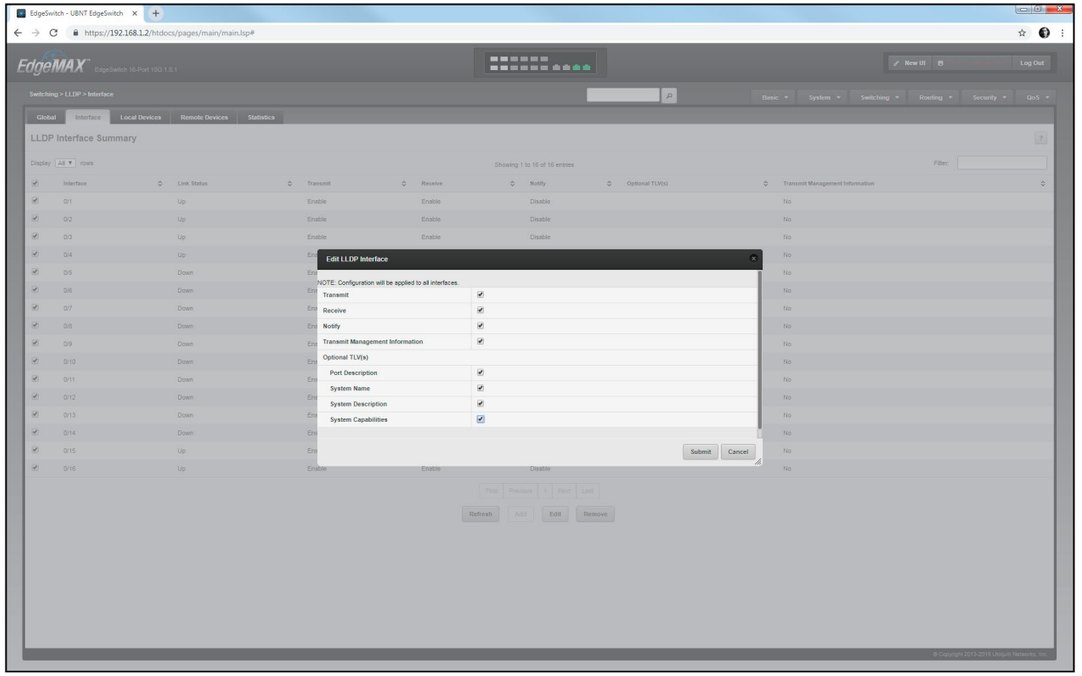
5.4.6. LLDP

> DEFINITION: The **Link Layer Discovery Protocol** (LLDP) is a vendor-neutral link layer protocol in the Internet Protocol Suite used by network devices for advertising their identity, capabilities, and neighbors on an IEEE 802 local area network, principally wired Ethernet.

Adding LLDP Interface

Navigate to the Switching -> LLDP ->**Interface** submenu. Select all interfaces and clicking on the **Edit** button opens the **Edit LLDP Interface** window. **Tick all settings** to enable them.

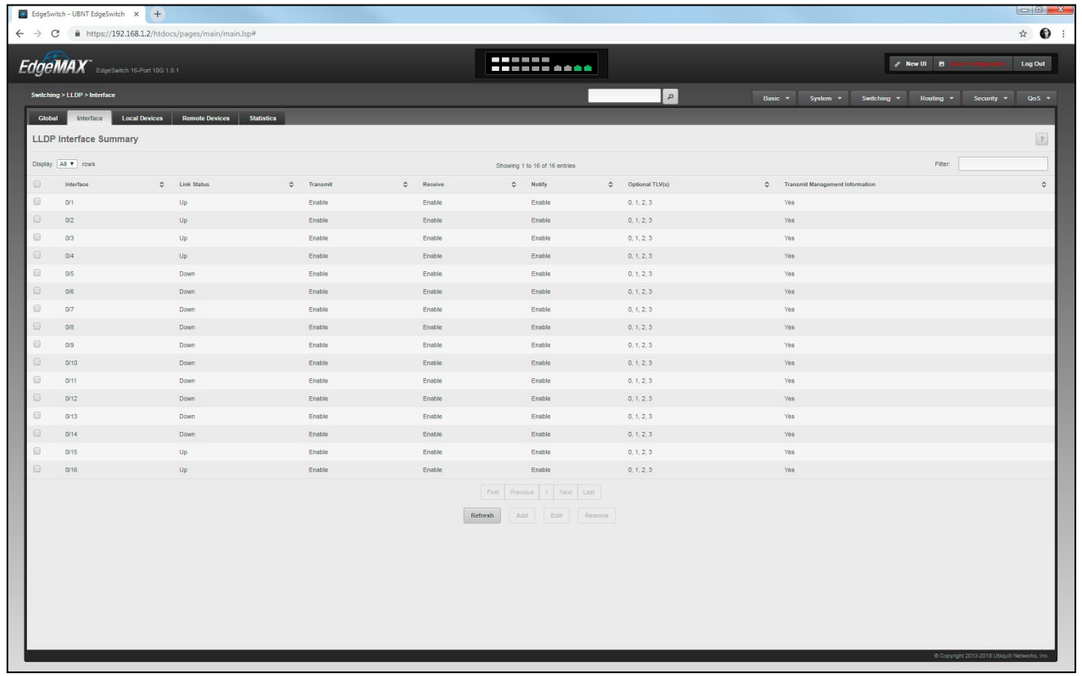
When it is done, press the **Submit** button to save the configuration.



Add LLDP Interface window

LLDP Interface Summary

After adding all interfaces you can check the list on the LLDP Interface Summary page.

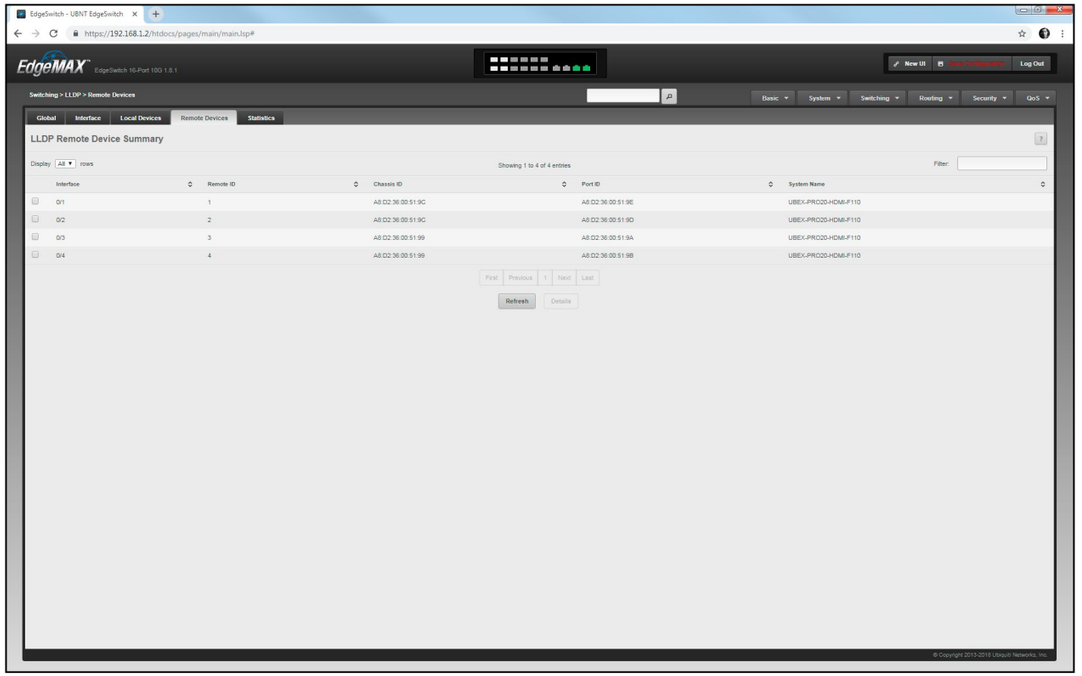


LLDP Interface Summary page

LLDP Remote Device Summary

Go to the **Remote Devices** tab.

After the UBEX endpoints and the MMU booted up you can check the presence of the devices in the LLDP Remote Device Summary page.

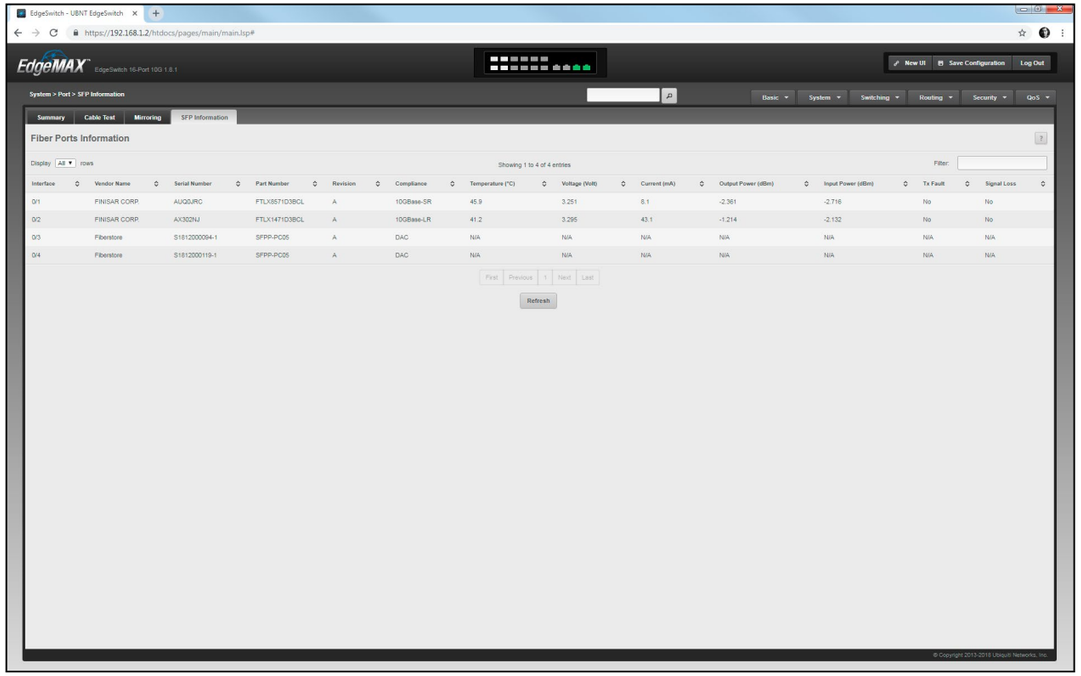


LLDP Remote Device Summary page

5.4.7. Port Transceiver Information

Navigate to the System -> Port -> **SFP information** submenu. You can check the connection interfaces by ports.

> TIPS AND TRICKS: this table can be used for debugging purpose as well. If you are sure that an SFP+ transceiver module or fiber optical cable or DAC cable is connected to a port but it is not in the table, might be the module or the cable has contact problem or it is faulty.

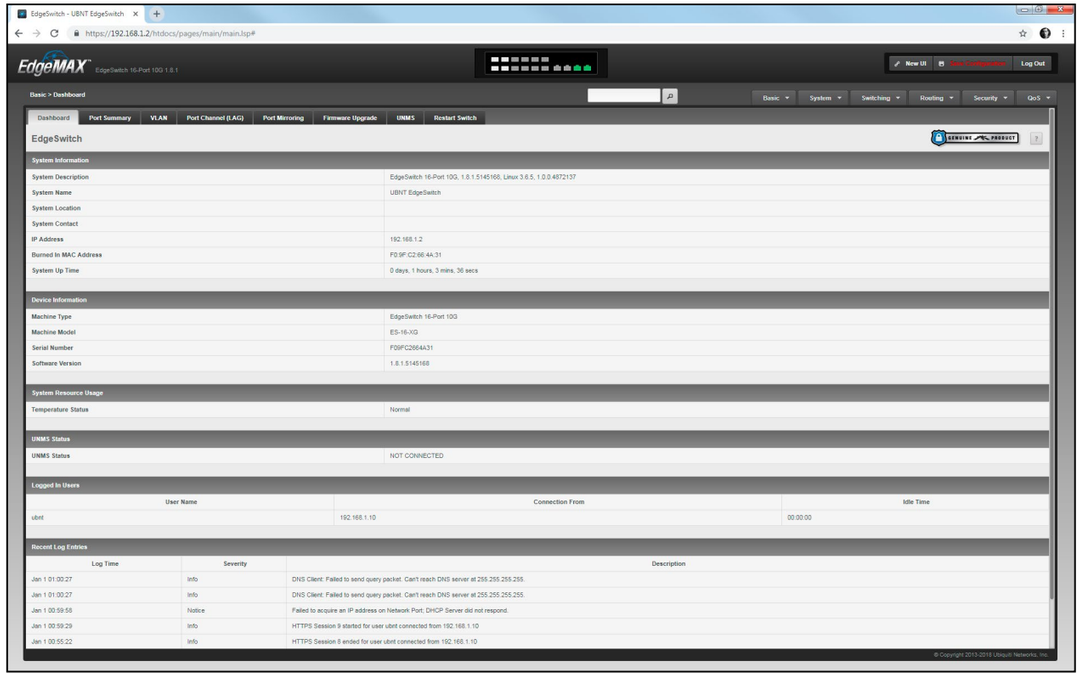


SFP information page

5.4.8. Save the Configuration

Click on the **Save Configuration** button on the upper right corner of the page to save the current configuration settings.

> **WARNING! Always save the configuration before power off the switch otherwise the settings will be lost.**



Dashboard page, the Save Configuration button on the upper right

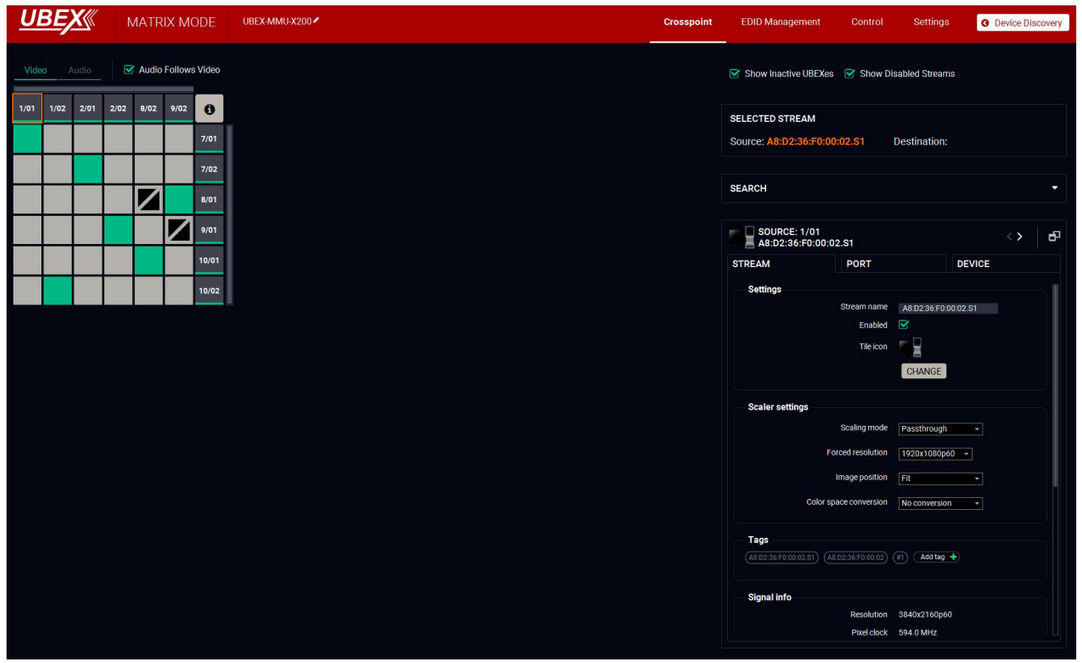
5.5. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

6

Configuration Steps - Netgear M4300-24X24F

The following chapter describes and explains step-by-step the procedure of the configuration for the Netgear M4300-24X24F fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- First Steps
- Detailed Instructions
- Finalizing the Matrix

6.1. Description

This chapter helps you configure the Netgear ProSAFE® M4300-24X24F managed switch for the UBEX matrix. This model of the Netgear contains 24x 10G SFP+ slots which are enough to serve 12 UBEX endpoints and handle up to 24 source / destination devices. The switch is recommended for medium businesses.

6.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Netgear M4300-24X24F	**1**	Firmware ver.: 12.0.2.9 Boot ver.: 1.0.0.8
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**12**	latest released firmware version

6.3. First Steps

6.3.1. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

6.3.2. Installation of the Switch

Download the user's manual for the M4300-24X24F model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

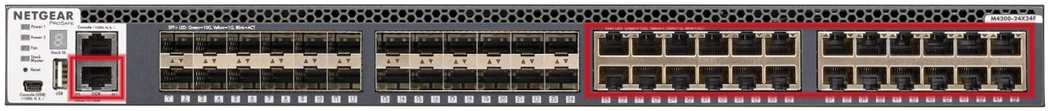
- 12x 10GbE singlemode/multimode SFP+ transceiver modules and 12x singlemode/multimode fiber optical cables
- 12x 10GbE DAC cables

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable
- 1x CATx cable

Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to one of the following ports:

- OOB port
- Any 10G copper port



The factory default settings of the switch:

- IP address of the OOB port: **192.168.0.239**
- IP address of the copper ports: **169.254.100.100**

Control Device Settings

Before connecting to the switch be sure the network settings of the operating system on your computer are correct. You need to set the following setting in the network card:

- IP address: must be in the in the same subnet : **192.168.0.x** with the subnet mask of 255.255.255.0

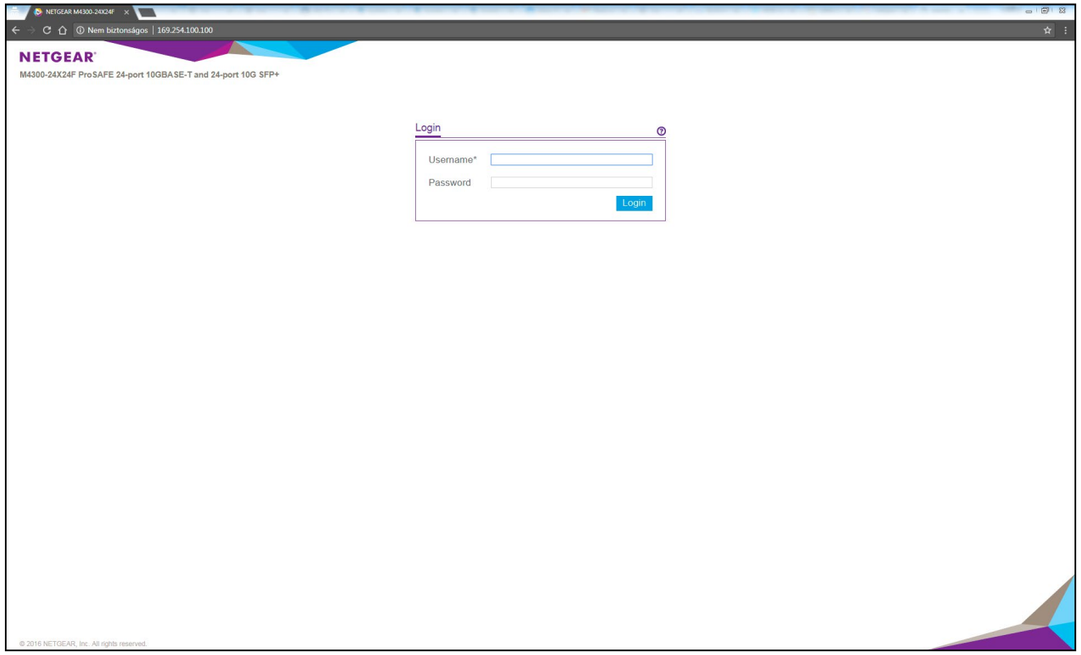
Step 5. Open a web browser on your computer and follow the configuration steps coming in the following section.

6.4. Detailed Instructions

6.4.1. Login to the Switch

Open a web browser (e.g. Google Chrome) and enter the IP address of the switch. The login screen appears. Enter the following parameters:

- **Username**: admin
- **Password**: (empty) - no password needed

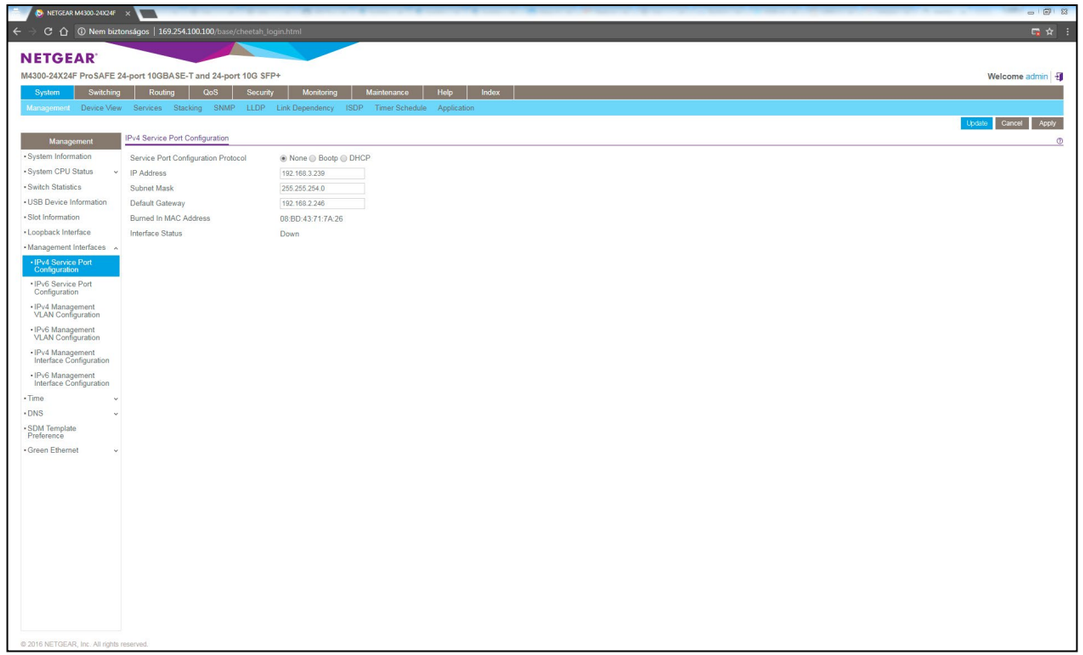


Login screen of the switch

6.4.2. IP Address Settings

You can change the default static IP address to any other one you want.

Navigate to the System -> Management -> Management Interfaces -> **IPv4 Service Port Configuration** -> submenu and check the **Service Port Configuration Protocol** to **None**. When it is done, press the **Update** button to save the configuration.



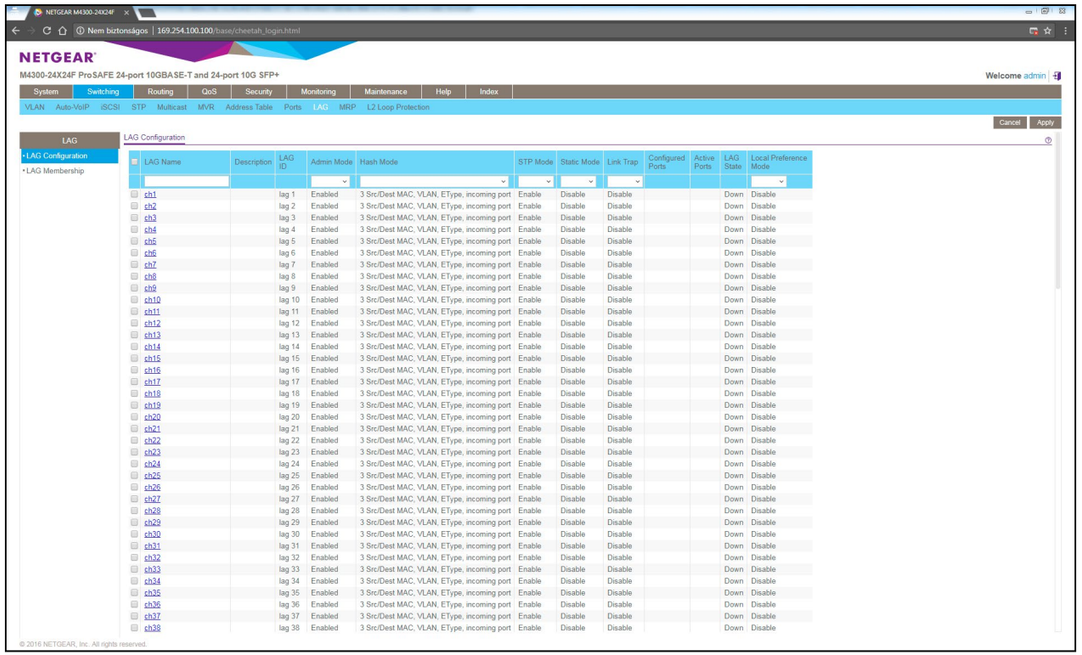
Port IP address settings page

6.4.3. Creating LAGs

> DEFINITION: The **Link Aggregation Protocol** (LAG) applies to various methods of combining (aggregating) multiple network connections in parallel in order to increase throughput beyond what a single connection could sustain.

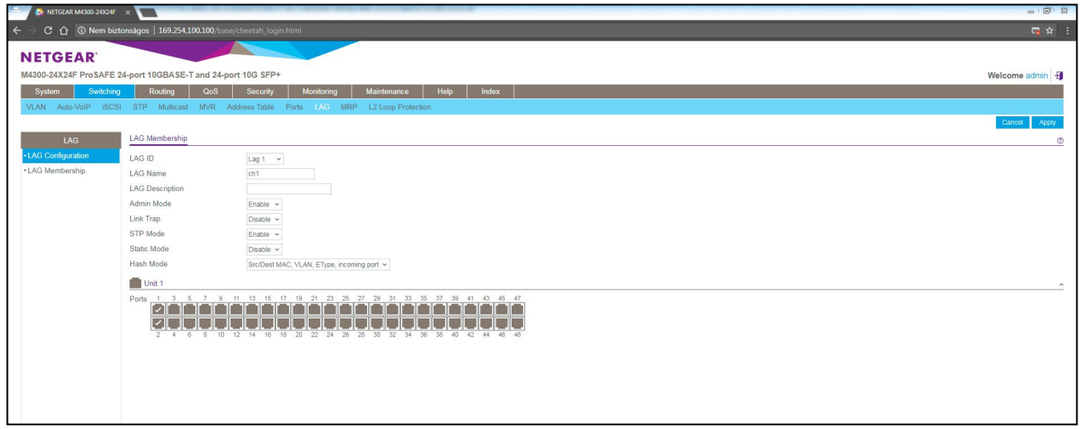
The UBEX endpoint devices use 2x SFP+ ports in the switch per unit. You need to create LAGs on the two ports.

Navigate to the Switching -> LAG -> **LAG Configuration** submenu. All ports and the current LAG states are listed here.



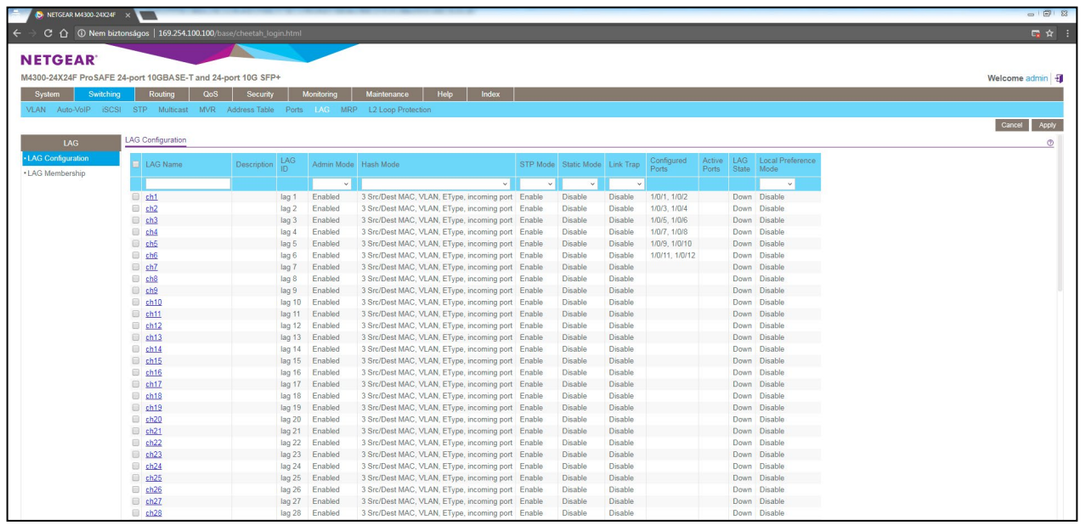
LAG Configuration page with no configured LAGs

Click on the first channel (**ch1**) to enter the LAG Membership settings page. Tick the two ports (where the two ports of the UBEX endpoint are connected to the switch) the graphic port table below. Press **Apply** when a LAG has been configured.



LAG Membership page

When all 6 LAGs for the 6 endpoints are created, check the configuration on the LAG Configuration Page in the **Configured Ports** section.

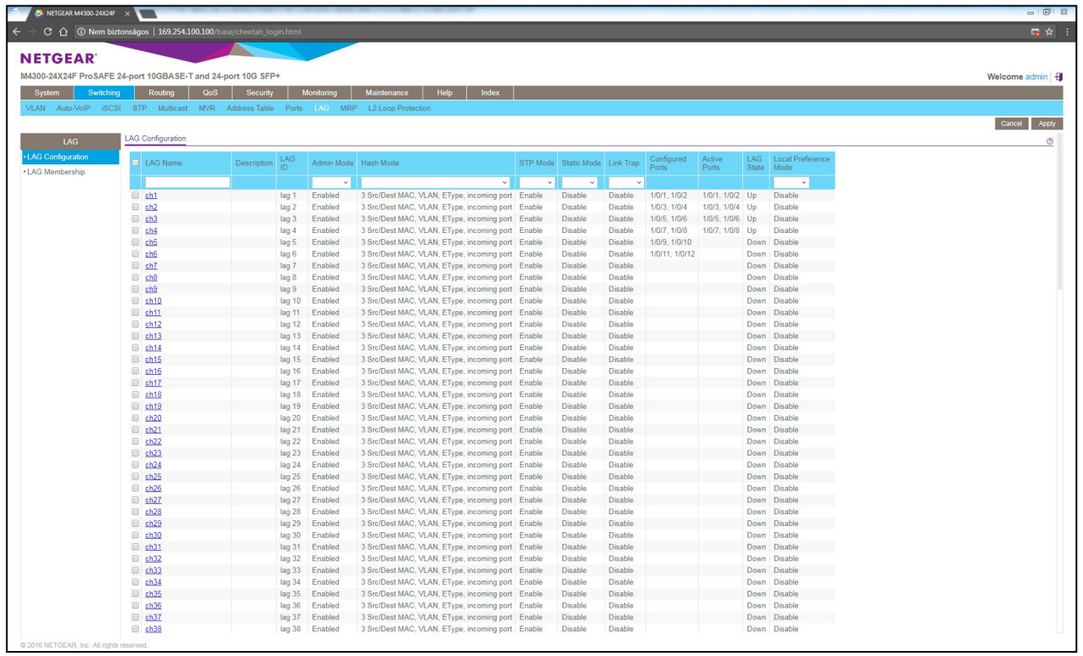


LAG Configuration page with six configured LAGs

Press the **Apply** button to save the configuration.

LAG Configuration Checking

Navigate to the Switching -> LAG -> **LAG Configuration** submenu. All ports and the current LAG states are listed here. Check the Configured Ports and Active Ports sections in the table.



LAG Configuration page

6.4.4. VLAN Configuration

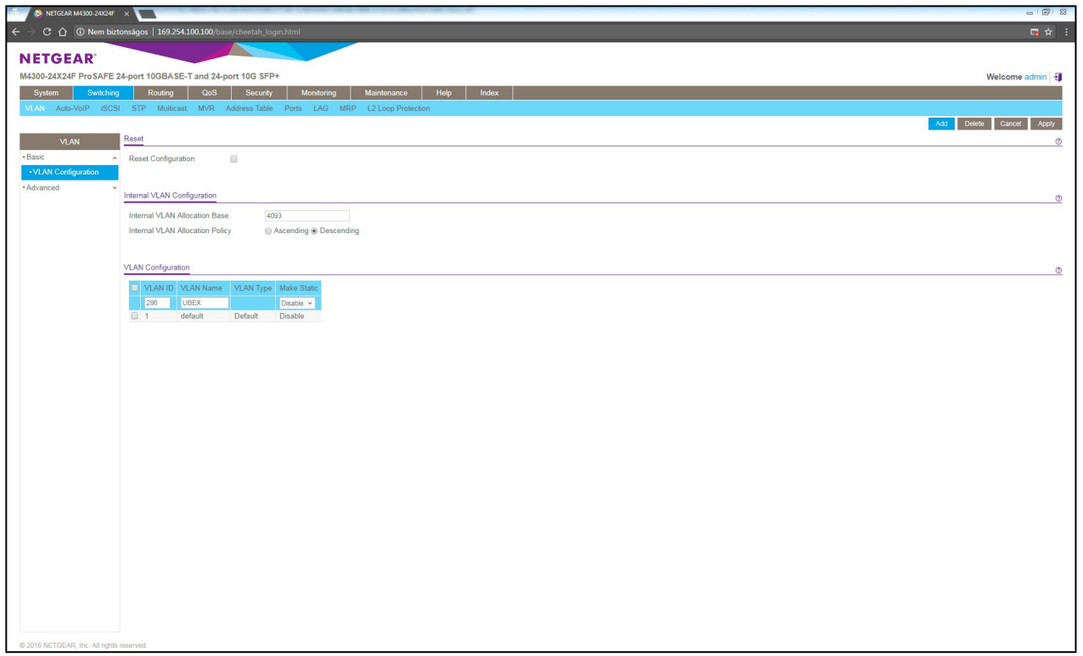
> DEFINITION: A **virtual LAN** (VLAN) is any broadcast domain that is partitioned and isolated in a computer network at the data link layer (OSI layer 2). LAN is the abbreviation for local area network and in this context, virtual refers to a physical object recreated and altered by additional logic.

Create VLAN

Navigate to the Switching -> VLAN -> Basic -> **VLAN Configuration** submenu. Create a VLAN and set the following values:

- VLAN ID: **286**
- VLAN Name: any unique name (e.g. UBEX)
- Make static: **Disable**

When it is done, press the **Add** button to save the configuration.



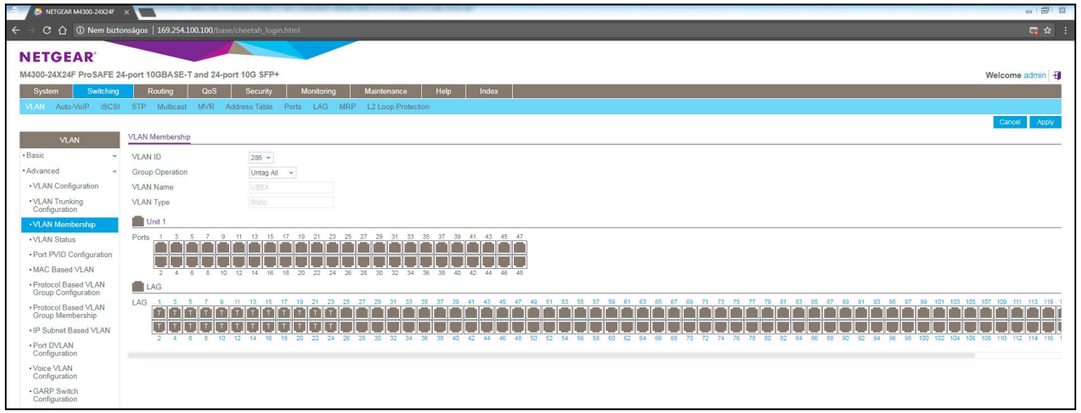
VLAN Configuration page

VLAN Membership

After that navigate to the Switching -> VLAN -> Advanced -> **VLAN Membership** submenu. Select the **286** in the VLAN ID menu.

Set all LAG's to **T** (Tagged). Also add the port where the control device (e.g. laptop) connects to the switch for enabling the user Ethernet.

When it is done, press the **Apply** button to save the configuration.

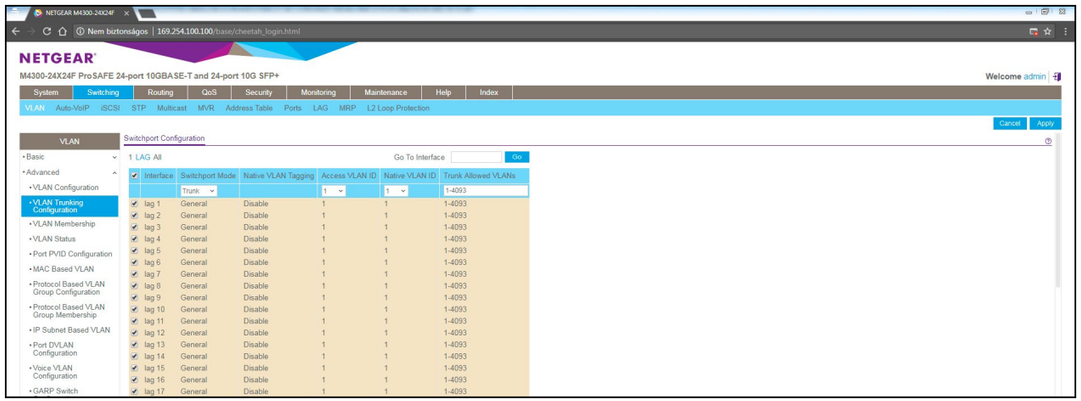


VLAN Membership page

> **ATTENTION!** Always make sure that the your uplink port is **not** the part of the VLAN 286.

VLAN Trunking Configuration

Go to the Switching -> VLAN -> Advanced -> **VLAN Trunking Configuration** submenu. Select all LAGs and set the Switchport Mode to Trunk. When it is done, press the **Apply** button to save the configuration.



VLAN Trunking Configuration page

6.4.5. IGMPv2 Snooping

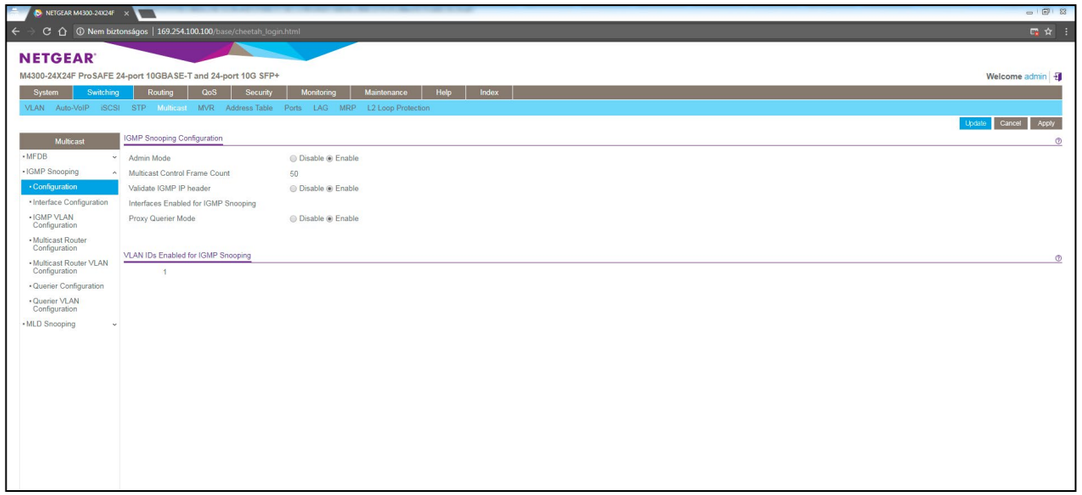
> DEFINITION: **IGMP snooping** is the process of listening to Internet Group Management Protocol network traffic. The feature allows a network switch to listen in on the IGMP conversation between hosts and routers.

Configuration

Navigate to the Switching -> Multicast -> IGMP Snooping -> **Configuration** submenu. Check the settings are set to the following values:

- Admin Mode: **Enable**
- Validate IGMP IP header: **Enable**
- Proxy Querier Mode: **Enable**

When it is done, press the **Update** button to save the configuration.



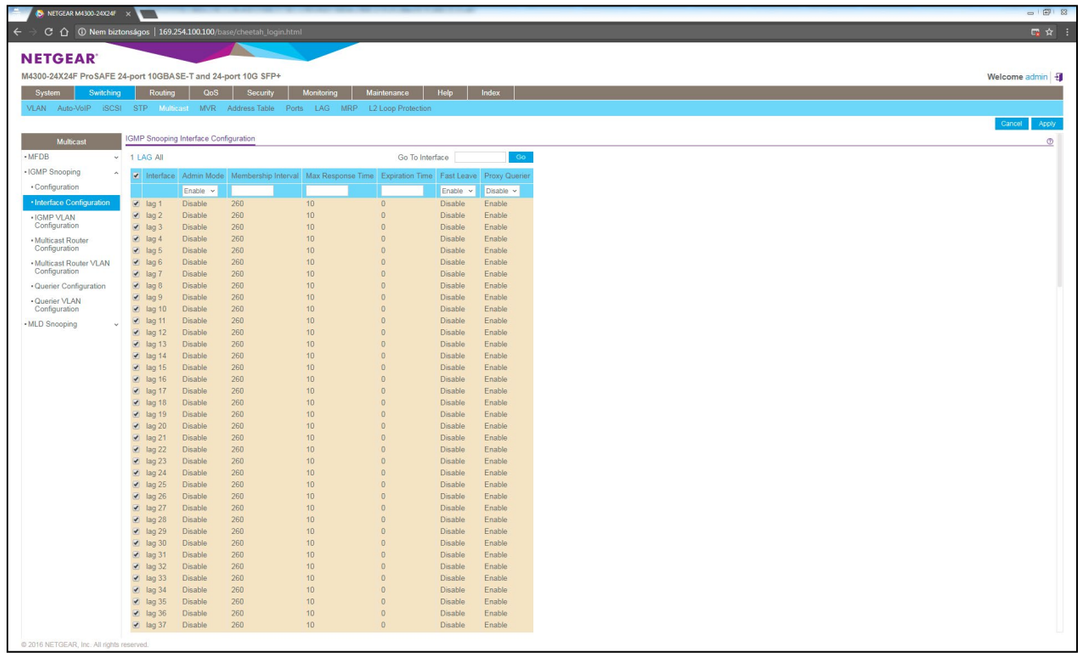
IGMP snooping configuration page

Interface Configuration

Go to the Switching -> Multicast -> IGMP Snooping -> **Interface Configuration** submenu. Select all LAGs and set the following values:

- Admin Mode: **Enable**
- Fast Leave: **Enable**
- Proxy Querier: **Disable**

When it is done, press the **Apply** button to save the configuration.



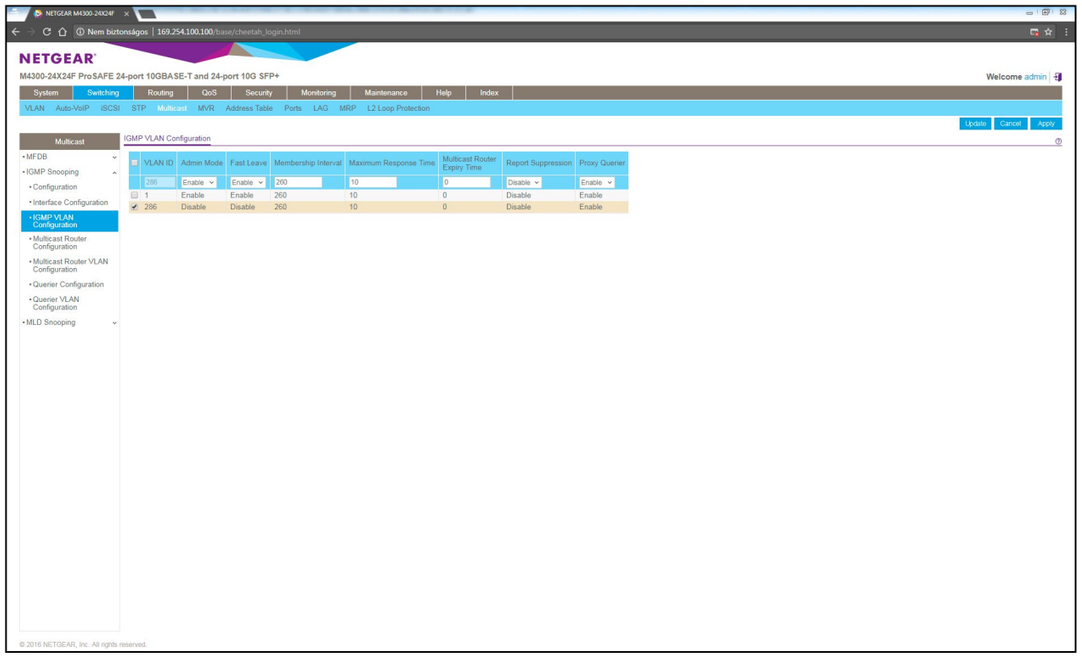
Interface Configuration Page

IGMP VLAN Configuration

Go to the Switching -> Multicast -> IGMP Snooping -> **IGMP VLAN Configuration** submenu. Select the 286 VLAN ID and set the following values:

- Admin Mode: **Enable**
- Fast Leave: **Enable**
- Membership Interval: **260**
- Maximum Response Time: **10**
- Multicast Router Expiry Time: **0**
- Report Suppression: **Disable**
- Proxy Querier: **Enable**

When it is done, press the **Apply** button to save the configuration.



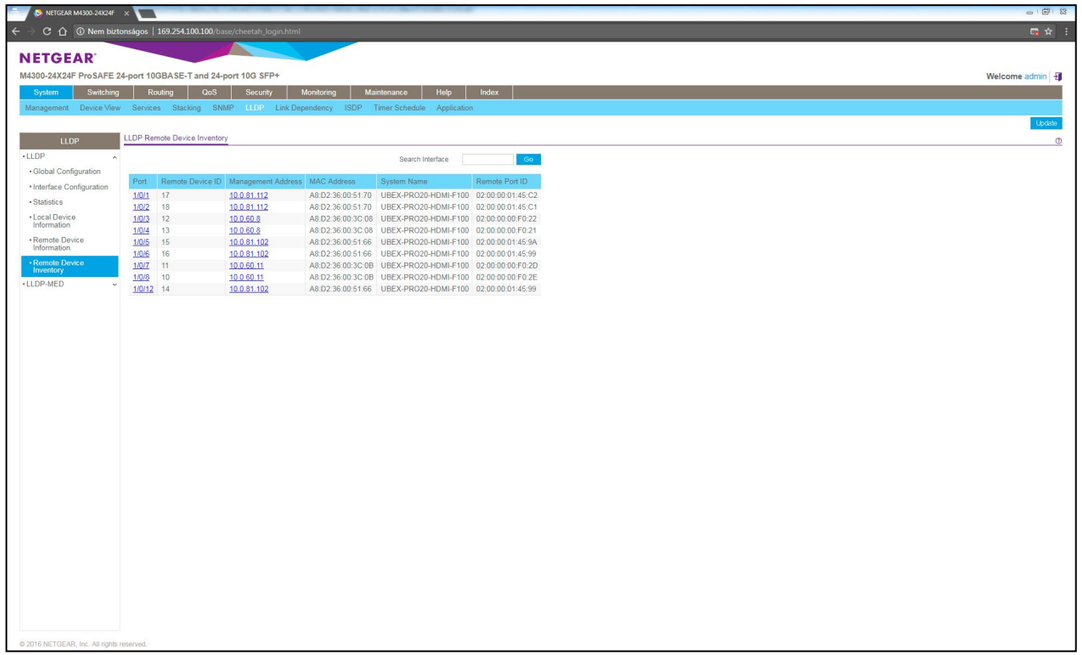
IGMP VLAN Configuration page

6.4.6. LLDP

> DEFINITION: The **Link Layer Discovery Protocol** (LLDP) is a vendor-neutral link layer protocol in the Internet Protocol Suite used by network devices for advertising their identity, capabilities, and neighbors on an IEEE 802 local area network, principally wired Ethernet.

Remote Device Inventory

Navigate to the System -> LLDP -> LLDP -> **Remote Device Inventory** submenu. Check the connected and explored devices by port or IP address.

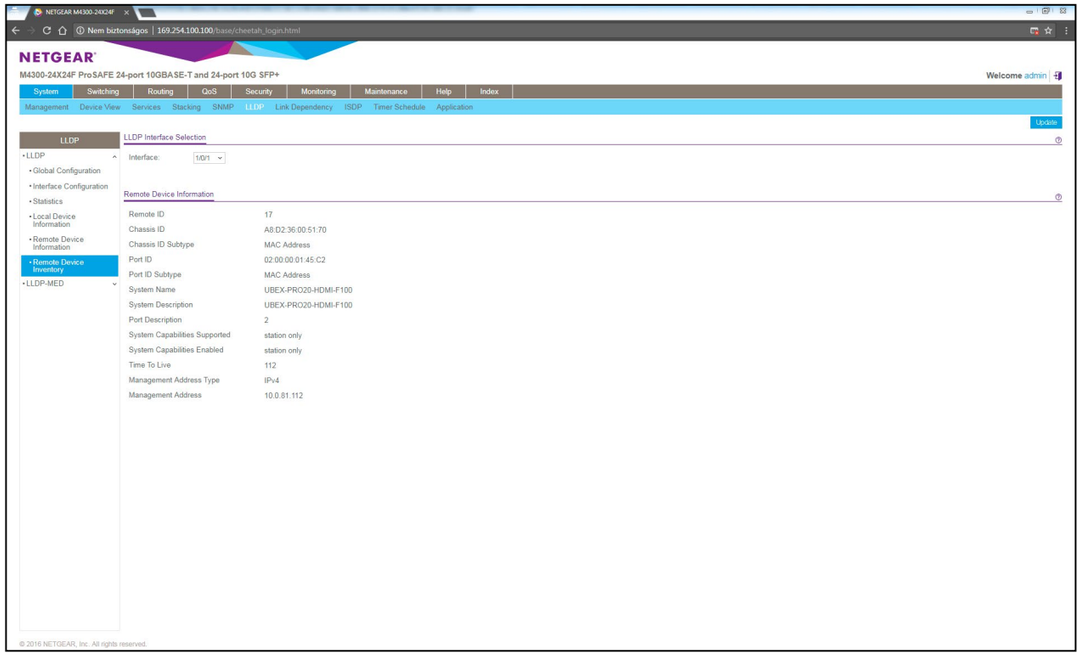


Remote Device Inventory page

> TIPS AND TRICKS: this table can be used for debugging purpose as well. If you are sure that a UBEX device is connected to a port but it is not in the table, check the SFP+ transceiver modules or the fiber optical connections or the DAC cable connections - might be the module or the cable has a contact problem or it is faulty.

Remote Device Information

Clicking on the **Port** opens the detailed information window about the remote device.

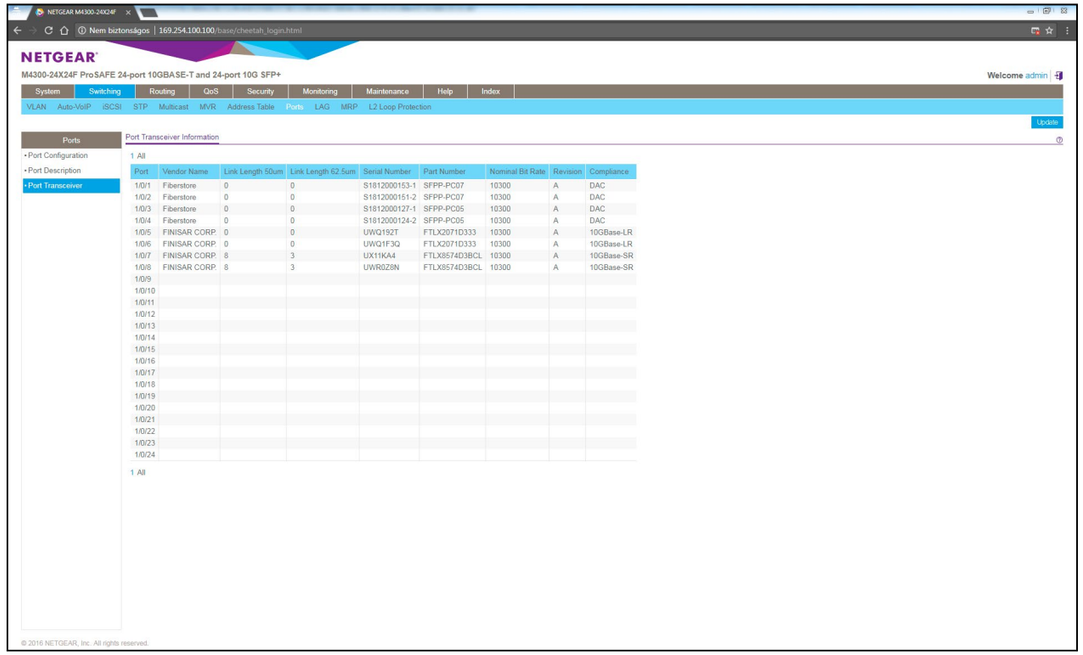


Remote Device Information page

6.4.7. Port Transceiver Information

Navigate to the Switching -> Ports -> **Port Transceiver** submenu. You can check the connection interfaces by ports.

> TIPS AND TRICKS: This table can be used for debugging purpose as well. If you are sure that an SFP+ transceiver module or DAC cable is connected to a port but it is not in the table, might be the module or the cable has contact problem or it is faulty.



Port Transceiver Information page

6.4.8. Adding the MMU to the VLAN Membership

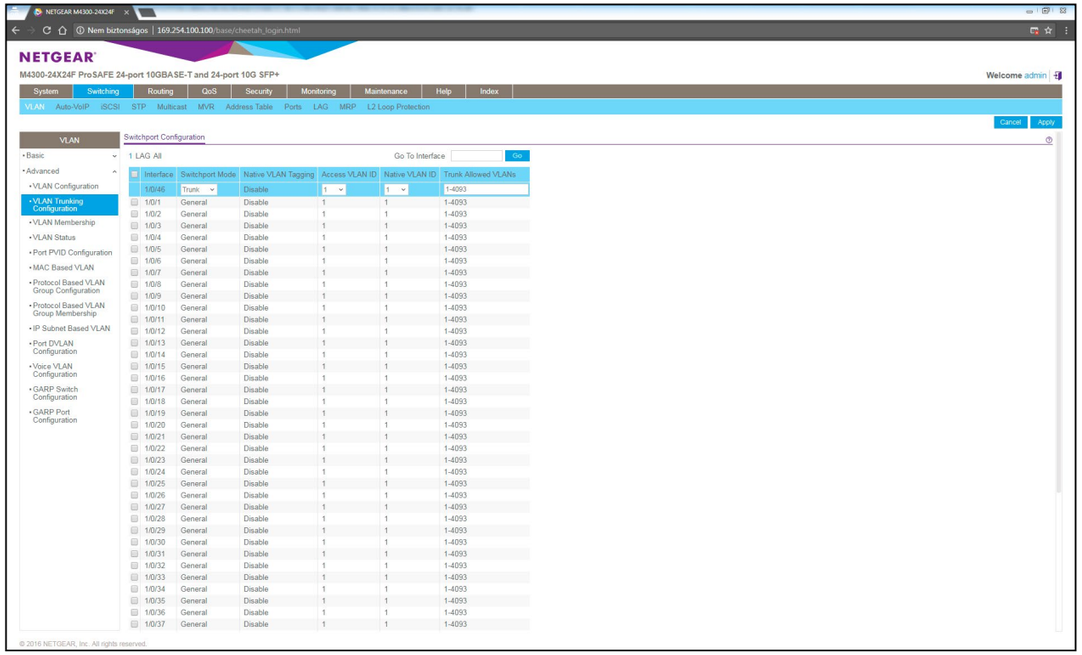
Once the MMU boots up and available, it is needed to be added to the VLAN membership.

Switchport Configuration

Navigate to the Switching -> VLAN -> Advanced -> **VLAN Trunking Configuration** submenu. Select the port of the MMU (e.g. 1/0/46) and set the following values:

- Switchport Mode: **Trunk**
- Access VLAN ID: **1**
- Native VLAN ID: **1**
- Trunk Allowed VLANs: **1-4093**

When it is done, press the **Apply** button to save the configuration.

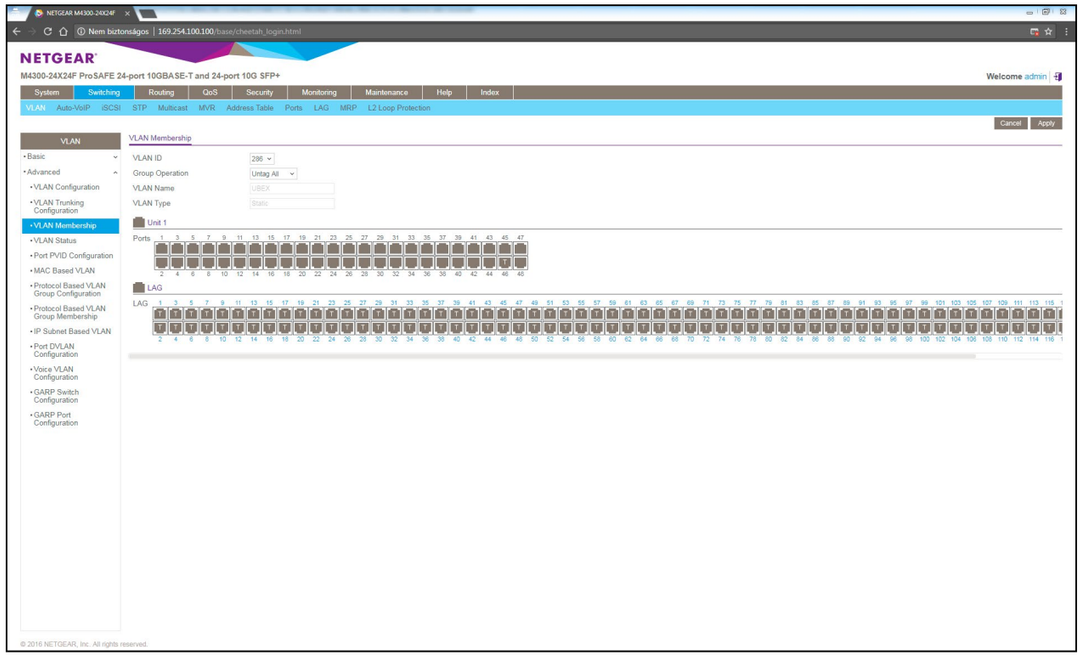


VLAN Trunking Configuration page

VLAN Membership

Go to the Switching -> VLAN -> Advanced -> **VLAN Membership** submenu. Select the **286 VLAN ID** and set all LAG's to **T** (Tagged). Select **the port in the Unit graphical layout** where the MMU is connected to the switch (e.g. 46).

When it is done, press the **Apply** button to save the configuration.

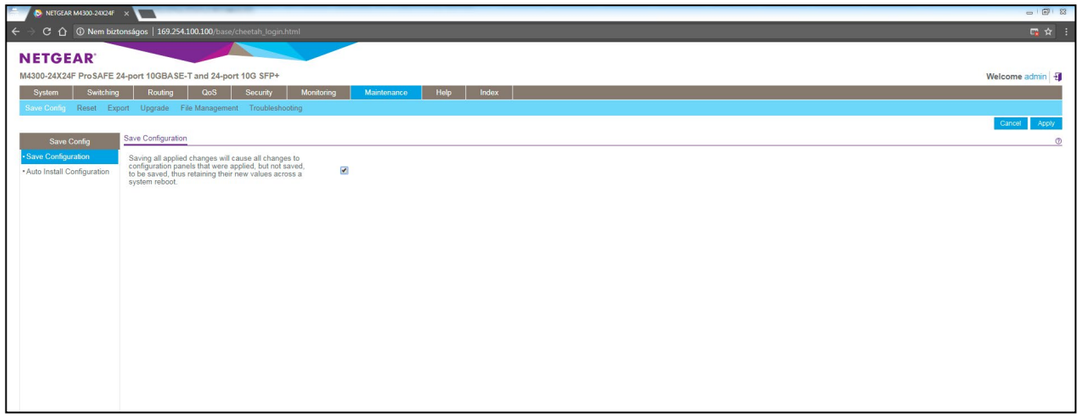


VLAN Membership page

6.4.9. Save the Configuration

Navigate to the Maintenance -> Save Config -> **Save Configuration** submenu. Tick the **Save Configuration** option and press the **Apply** button.

WARNING! Always save the configuration before power off the switch otherwise the settings will be lost.



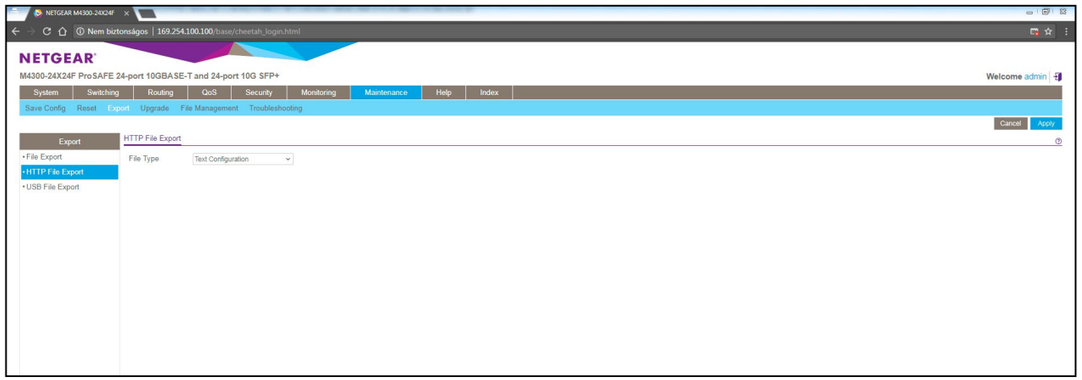
Save Configuration page

6.4.10. Export the Configuration

The configuration settings can be exported to a file and save to your local computer.

ATTENTION! This safety step is highly recommended to avoid any setting loss.

Navigate to the Maintenance -> Export -> **HTTP File Export** submenu. Select a file type (e.g. Text Configuration) and save the file to a computer.



Configuration file export page

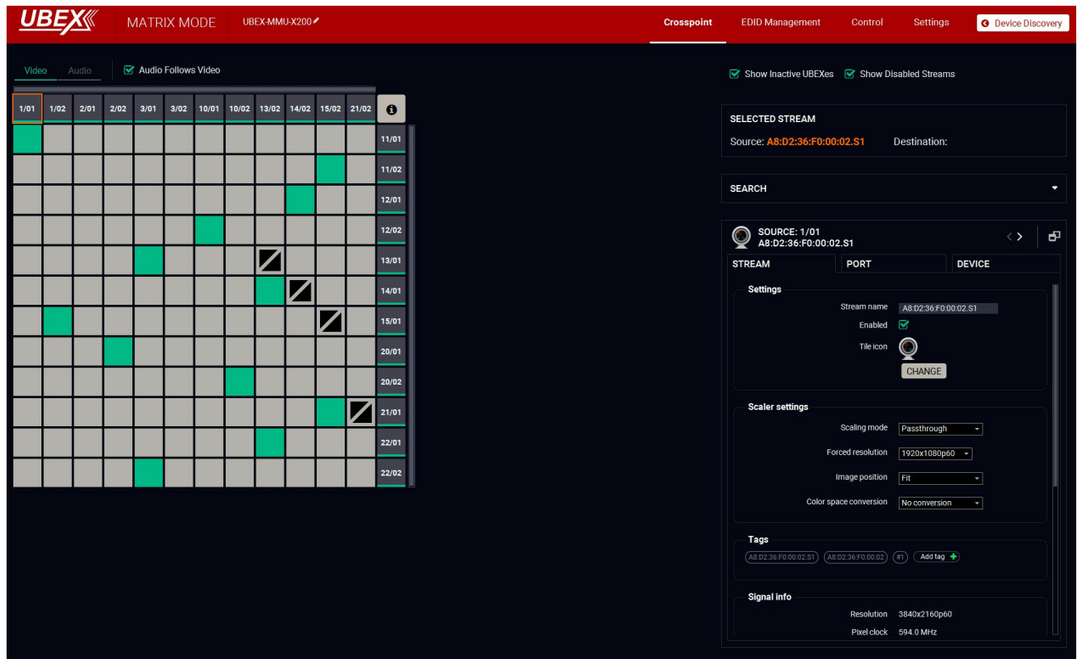
6.5. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

7

Configuration Steps - Netgear M4500-48XF8C

The following chapter describes and explains step-by-step the procedure of the configuration for the Netgear M4500-48XF8C fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- First Steps
- Detailed Instructions
- Troubleshooting Commands
- Finalizing the Matrix

7.1. Description

This chapter helps you configure the Netgear M4500-48XF8C managed switch for the UBEX matrix. The chassis of this model contains 48x 10G SFP+ and 8x QSFP28 port slots which are enough to serve 38 UBEX endpoints and an MMU and handle up to 76 source / destination devices. The switch is recommended for medium businesses.

7.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Netgear M4500-48XF8C	**1**	7.0.1.13
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**22**	latest released firmware version

7.3. First Steps

7.3.1. Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ-45 male-to-RS-232. Follow the instructions listed on the website of the vendor:

https://www.downloads.netgear.com/files/GDC/M4500/M4500_HIG_EN.pdf?_ga=2.102657221.59608736.1627454853-401644551.1627307319

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

7.3.2. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

7.3.3. Installation of the Switch

Download the user's manual for the M4500-48XF8C model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 44x 10GbE singlemode/multimode SFP+ transceiver modules and 22x singlemode/multimode fiber optical cables
- 44x 10GbE DAC cables

ATTENTION! Skip 4 ports for the 1 GbE connection of the MMU becasuse network speed setting is working a 4-port group only. For example if you want to connect the MMU to the last (48th) SFP+ port, the last 4 ports (45-46-47-48) should be dedicated for this purpose and no endpoint connections are allowed there.

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Plug the cables between the switch and the possible other switch for the outgoing data traffic.

Step 5. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port**:

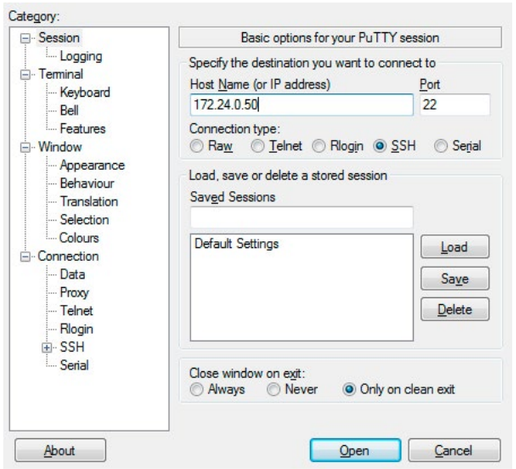
7.4. Detailed Instructions

7.4.1. Setting up the Control Device

The Netgear switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

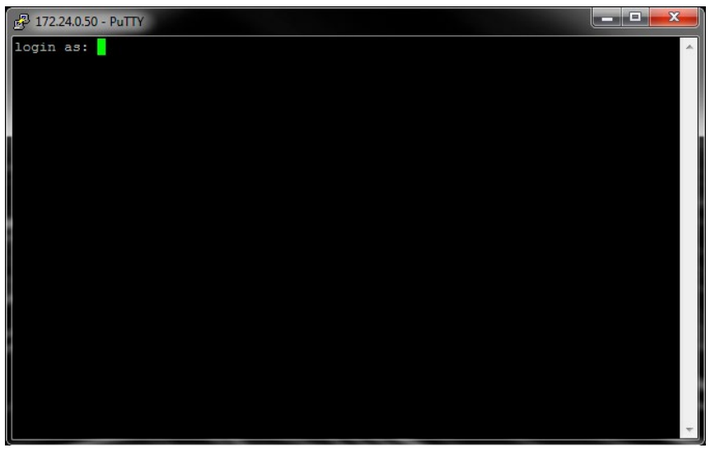
The IP address of the switch in our example: 172.24.0.50

Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



7.4.2. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

7.4.3. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by switch.

7.4.4. IP Address Setting

The Command

Type and apply the following commands:

```
serviceport protocol dhcp
exit
```

Explanation

The IP address of the switch have been set to DHCP (dynamic IP address) for the management port.

7.4.5. SSH Terminal-Line Access

If you need inbound SSH terminal-line authentication, you can configure and test SSH for outbound reverse Telnets through Putty or CLI.

The Command

Type and apply the following commands:

```
line vty
exit
line ssh
exit
```

7.4.6. VLAN Configuration

The Command

Type and apply the following commands:

```
vlan database
vlan 286
vlan name 286 "UBEX"
exit
```

Explanation

Registers VLAN number 286. Optionally a unique name can be added to the VLAN.

7.4.7. IGMP Fast-Leave Setting

The Command

Type and apply the following commands:

```
set igmp 1
set igmp 286
set igmp fast-leave 286
no set igmp fast-leave auto-assignment
exit
```

7.4.8. IGMP Snooping Configuration

The Command

Type and apply the following commands:

```
ip igmp snooping
ip igmp snooping querier
ip igmp snooping querier vlan 1
ip igmp snooping querier vlan election participate 1
ip igmp snooping querier vlan 286
ip igmp snooping querier vlan election participate 286
```

Explanation

Enables IGMPv2 Snooping in the VLAN 286.

ATTENTION! IGMP querier v2 is required configuration setting.

7.4.9. Interface Configuration for the MMU

The Command

Type and apply the following commands:

Port ID	Command (in this example)
Port 48	interface 0/48 port-mode 4x1G ip igmp snooping interfacemode ip igmp snooping fast-leave switchport allowed vlan add 286 switchport tagging 286 ip igmp version 2 exit

Explanation

The interface 0/48 is the last SFP28 port of the switch which is for the connection of the MMU. The speed of the port is set to 1 Gbit/s and added to the VLAN 286.

7.4.10. Port Channel Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port Channel Index	Command
Port Channel 1	interface port-channel 1 no staticcapability ip igmp snooping interfacemode ip igmp snooping fast-leave switchport allowed vlan add 286 switchport tagging 286 exit
Port Channel 2	interface port-channel 2 no staticcapability ip igmp snooping interfacemode ip igmp snooping fast-leave switchport allowed vlan add 286 switchport tagging 286 exit
...	...
Port Channel 22	interface port-channel 22 no staticcapability ip igmp snooping interfacemode ip igmp snooping fast-leave switchport allowed vlan add 286 switchport tagging 286 exit

Explanation

The ports between the 1 and 44 are grouped by pairs to port-channels, in this case between port-channel 1 to port-channel 22. They are set to trunk mode and the speed (10 Gbit/s) is automatically detected when an SFP+ transceiver module is plugged to the SFP+ slot of the switch

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

7.4.11. Interface Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command
Port 1	interface 0/1 port-mode 4x10G ip igmp snooping interfacemode ip igmp snooping fast-leave ip igmp version 2 exit
Port 2	interface 0/2 port-mode 4x10G ip igmp snooping interfacemode ip igmp snooping fast-leave ip igmp version 2 exit
...	...
Port 44	interface 0/44 port-mode 4x10G ip igmp snooping interfacemode ip igmp snooping fast-leave ip igmp version 2 exit

Explanation

The ports between interface 0/1 and interface 0/44 are the SFP+ ports where the UBEX endpoints are connected to the switch.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

7.4.12. Aggregated Ethernet Allocation

The Commands

Type and apply the following commands for the desired interface ports:

Port Channel Index	Command

Port Channel 1	`interface 0/1`
	`  channel-group 1 mode active`
	`  exit`
	`interface 0/2`
	`  channel-group 1 mode active`
	`  exit`

Port Channel 2
 	
...
	`interface 0/3`
	`  channel-group 2 mode active`
	`  exit`
	`interface 0/4`
	`  channel-group 2 mode active`
	`  exit`
	
	...

Port Channel 22	`interface 0/43`
	`  channel-group 22 mode active`
	`  exit`
	`interface 0/44`
	`  channel-group 22 mode active`
	`  exit`

Explanation

The aggregated Ethernet is set and finalized with these commands.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

7.5. Troubleshooting Commands

7.5.1. LLDP Activation

The Command

Type and apply the following command:

```
lldp run
```

7.5.2. Querying LLDP Partners

The Command

Type and apply the following command:

```
show lldp neighbors
```

Explanation

The query returns with the list of connected UBEX devices (which MAC address of the UBEX endpoint is on the ports of switch).

7.5.3. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lldp neighbors interface 0/1 detail
```

Explanation

The query returns with the details of the LLDP partner which is connected to the interface 0/1 port.

7.5.4. Switching on the Support for Unsupported SFP+ Modules

The Command

Type and apply the following command:

```
service unsupported-transceiver
```

ATTENTION! Always use high-quality SFP+ transceiver modules.

7.5.5. Querying the Status of the Interfaces

The Command

Type and apply the following command:

```
show interface status
```

7.5.6. Querying the Details of the Installed Transceiver Modules

The Command

Type and apply the following command:

```
show interface transceiver
```

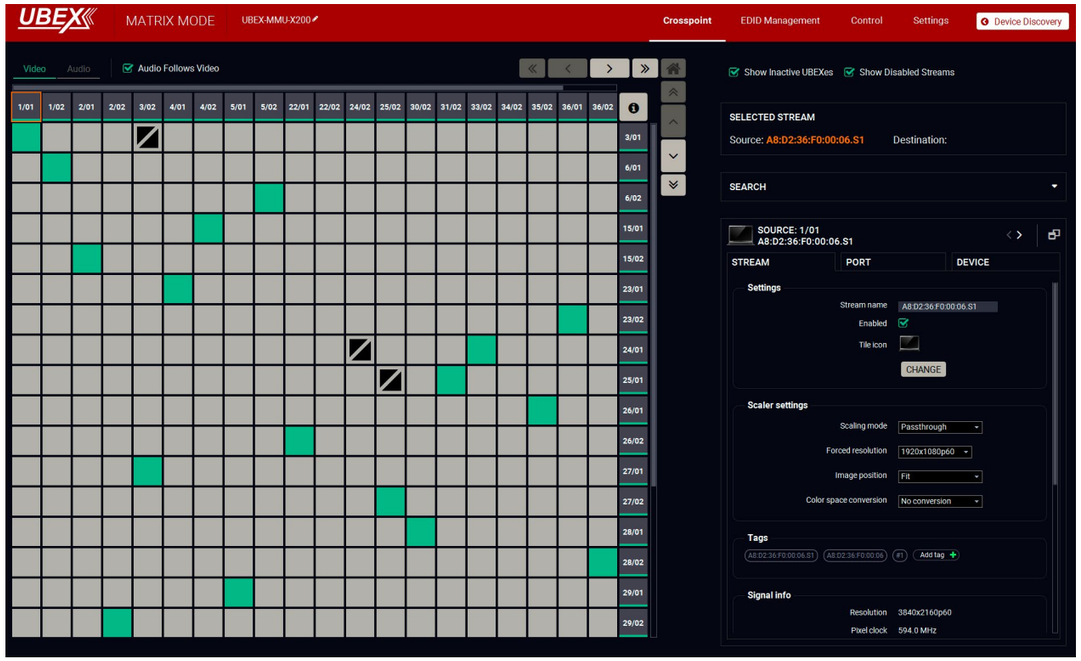
7.6. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

8

Configuration Steps - Cisco Nexus 5548UP

The following chapter describes and explains step-by-step the procedure of the configuration for the Cisco Nexus 5548UP fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- Cisco Requirements for the Switch Configuration
- First Steps
- Detailed Instructions
- Troubleshooting Commands
- Finalizing the Matrix

8.1. Description

This chapter helps you configure the Cisco Nexus 5548UP managed switch for the UBEX matrix. The base chassis of this model contains 32x 10G SFP+ slots and it can be expanded with +16 10G SFP+ ports with installing an expansion module. In this case the switch is enough to serve 23 UBEX endpoints and an MMU and handle up to 46 source / destination devices. The switch is recommended for medium businesses.

> INFO: The configuration steps of the **Cisco Nexus 5548P** and **5548UP** switches are exactly the same and can be applied for both models.

8.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Cisco Nexus 5548UP	**1**	7.3(0)N1(1)
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**23**	latest released firmware version

8.3. Cisco Requirements for the Switch Configuration

Cisco Certification Program

Configuring a Cisco network switch requires the knowledge of the Cisco's own software architecture, the Cisco IOS software. This is a command-based programming language which can be applied in the switch over terminal applications, for example Putty or CLI.

Step 1. Sign up for the **Cisco Training** to get the knowledge and skill to configure the switch. Visit the following website for the available Cisco trainings:
https://www.cisco.com/c/en/us/training-events/training-certifications/overview.html

Step 2. Configurator needs the **Routing and Switching** training course - here are the details about it:
https://www.cisco.com/c/en/us/training-events/training-certifications/training-catalog/routing-switching.html#~skills

Step 3. Complete the exam and get the Cisco Network Certification about the Routing and Switching Track:
https://www.cisco.com/c/en/us/training-events/training-certifications/certifications/entry/ccent.html

8.4. First Steps

8.4.1. Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor (PDF file):

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus5000/hw/installation/guide/nexus_5000_hig.pdf

Set an IP address for the Management Ethernet port (Mgmt 0) to be able to connect it and to set up the device for the UBEX network.

8.4.2. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

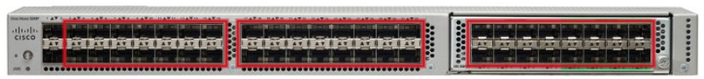
8.4.3. Installation of the Switch

Download the user's manual for the 5548UP model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 92x 10GbE singlemode/multimode SFP+ transceiver modules and 46x singlemode/multimode fiber optical cables
- 46x 10GbE DAC cables



Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port (Mgmt 0)**:

8.4.4. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus5000/sw/configuration/guide/cli/CLIConfigurationGuide/initconfig.html

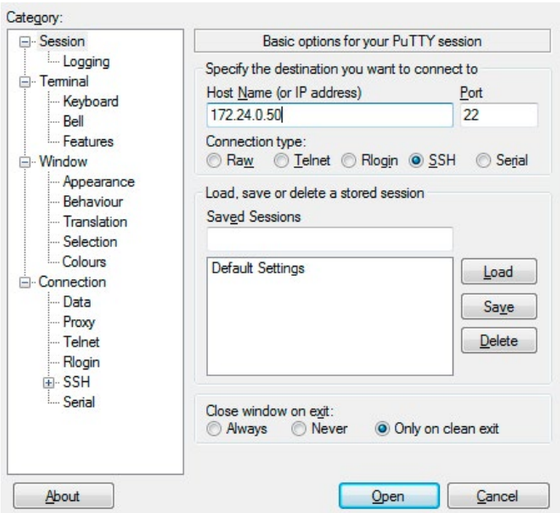
8.5. Detailed Instructions

8.5.1. Setting up the Control Device

The Cisco switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the switch in our example: 172.24.0.50

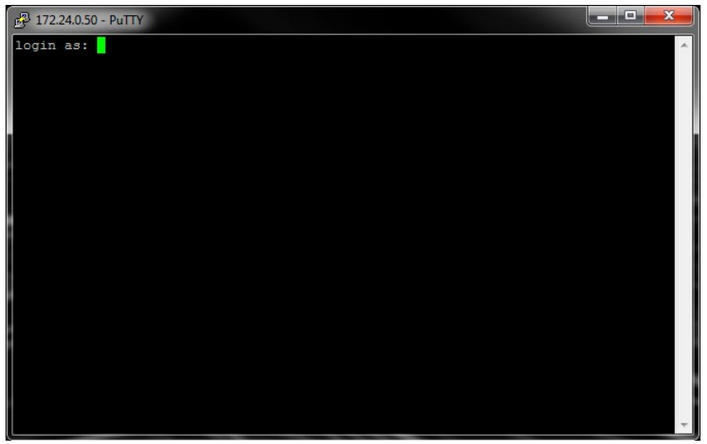
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

8.5.2. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

8.5.3. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by switch.

8.5.4. IP Address Setting

The Command

Type and apply the following commands:

```
interface mgmt0
     vrf member management
     ip address 172.24.0.50/16
     exit
```

Explanation

The IP address (172.24.0.50) and subnet mask (/16) of the switch have been set for the management port (Mgmt 0).

8.5.5. Default Gateway Setting

INFO: The command requires only in the case of the switch has to be accessed from different subnet.

The Command

Type and apply the following commands:

```
vrf context management
     ip route 0.0.0.0/0 172.24.0.1
     exit
```

8.5.6. Switching on the LACP, LLDP, and VLAN

The Command

Type and apply the following command:

```
feature telnet
feature lacp
feature lldp
feature interface-vlan
no lldp tlv-select management-address v6
lldp port-channel
```

8.5.7. VLAN and IGMPv2 Configuration

The Command

Type and apply the following commands:

```
vlan 1, 286
vlan configuration 286
     ip igmp snooping fast-leave
     ip igmp snooping version 2
     exit
```

Explanation

Registers VLAN number 1 and number 286. Enables IGMPv2 snooping in both VLANs.

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

8.5.8. Forwarding Options

The Command

Type and apply the following command:

```
port-channel load-balance src mac
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

8.5.9. Interface Configuration for the MMU

The Command

Type and apply the following commands:

Port ID	Command (in this example)

Port 1	`interface Ethernet1/1`
	`switchport`
	`switchport mode trunk`
	`switchport access vlan 286`
	`switchport trunk allowed vlan 1,286`
	`no shutdown`
	`exit`

Explanation

The Ethernet1/1 is the first SFP+ port of the switch which is for the connection of the MMU. Its speed is set to 1 Gbps (1000 = 1 GbE) and configured as a trunk port, thus has access to both of the configured VLAN's.

8.5.10. Port Channel Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port Channel Index	Command

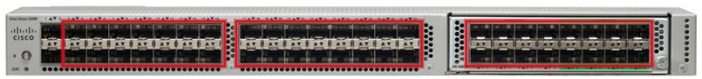
Port Channel 3	`interface port-channel1`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  speed 10000`
	`  exit`

Port Channel 4	`interface port-channel2`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  speed 10000`
	`  exit`

...	

Port Channel 48	`interface port-channel46`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  speed 10000`
	`  exit`

Explanation



The ports between the 3 and 48 are grouped by pairs to port-channels, in this case between port-channel 3 to port-channel 23.
They are set to trunk mode and speed to 10 Gbps (10000 = 10 GbE).

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

8.5.11. Interface Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command

Port 3	`interface Ethernet1/3`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

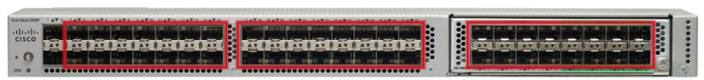
Port 4	`interface Ethernet1/4`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

...	

Port 47	`interface port-channel1/47`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 23 mode active`
	`  exit`

Port 48	`interface port-channel1/48`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 23 mode active`
	`  exit`

Explanation



The ports between the Ethernet1/3 and Ethernet1/48 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (10000 = 10 GbE).

The 'active' keyword means that the switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX devices.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch. In this case the **configure** command needs only once at the starting of the sequence.

8.6. Troubleshooting Commands

8.6.1. Querying LLDP Partners

The Command

Type and apply the following command:

```
show lldp neighbors
```

Explanation

The query returns with the list of connected UBEX devices (which MAC address of the UBEX endpoint is on the ports of switch).

8.6.2. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lldp neighbors interface ethernet 1/1 detail
```

Explanation

The query returns with the details of the LLDP partner which is connected to the Ethernet1/1 port.

8.6.3. Switching on the Support for Unsupported SFP+ Modules

The Command

Type and apply the following command:

```
no system default switchport shutdown
service unsupported-transceiver
```

8.6.4. Querying the Details of the Installed Transceiver Module

The Command

Type and apply the following command:

```
show interface transceiver
```

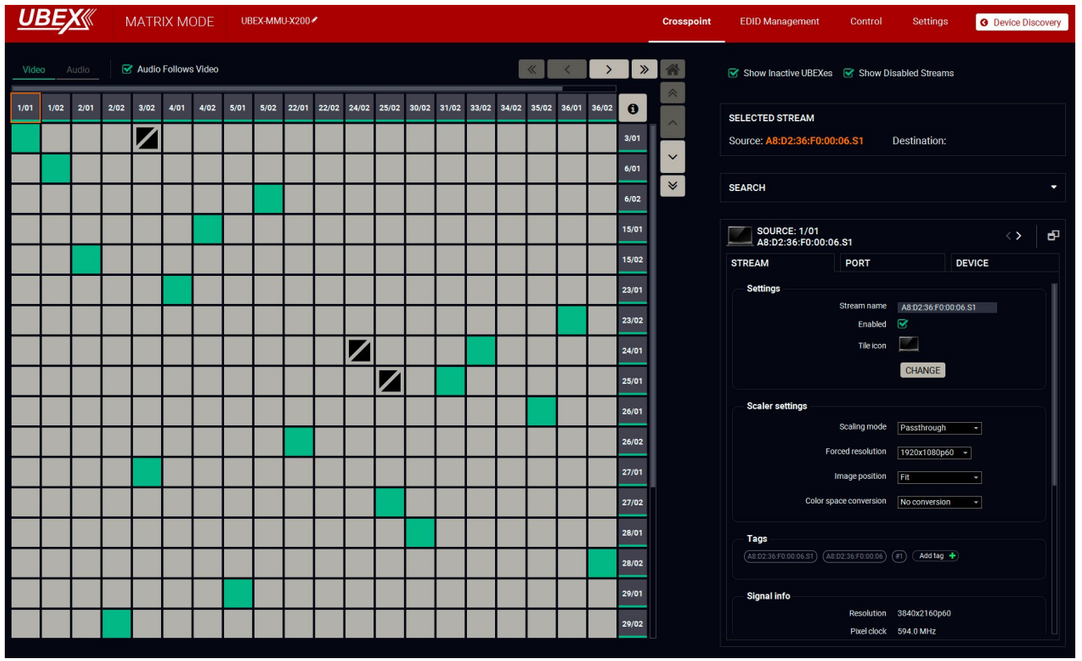
8.7. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

9

Configuration Steps - Cisco Nexus 93180YC-EX

The following chapter describes and explains step-by-step the procedure of the configuration for the Cisco Nexus 93180YC-EX fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- Cisco Requirements for the Switch Configuration
- Detailed Instructions - Standalone Configuration
- Detailed Instructions - Two Stacked Switches Configuration
- Troubleshooting Commands
- Finalizing the Matrix

9.1. Description

This chapter helps you configure the Cisco Nexus 93180YC-EX managed switch for the UBEX matrix. The chassis of this model contains 48x 10G SFP+ slots which are enough to serve 23 UBEX endpoints and an MMU and handle up to 46 source / destination devices. The switch is recommended for medium businesses.

ATTENTION! Endpoints require additional configuration settings in case of Cisco Nexus 93180YC-EX switch model for the switch can accept the maximum number of endpoints. The settings can be applied by Lightware developer team only.

The chapter describes two different configuration deployments:

- **Standalone configuration** - see details in the Setting up the Control Device section;
- **Two stacked network switches** - see details in the Detailed Instructions - Two Stacked Switches Configuration section.

9.2. The Configuration of the UBEX Matrix

9.2.1. Standalone Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Cisco Nexus 93180YC-EX	**1**	9.2(1)
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**23**	latest released firmware version

See the detailed configuration steps for this deployment in the Setting up the Control Device section.

9.2.2. Two Stacked Switches Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Cisco Nexus 93180YC-EX	**2**	9.2(1)
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**47**	latest released firmware version

See the detailed configuration steps for this deployment in the Detailed Instructions - Two Stacked Switches Configuration section.

9.3. Cisco Requirements for the Switch Configuration

Cisco Certification Program

Configuring a Cisco network switch requires the knowledge of the Cisco's own software architecture, the Cisco IOS software. This is a command-based programming language which can be applied in the switch over terminal applications, for example Putty or CLI.

Step 1. Sign up for the **Cisco Training** to get the knowledge and skill to configure the switch. Visit the following website for the available Cisco trainings:

https://www.cisco.com/c/en/us/training-events/training-certifications/overview.html

Step 2. Configurator needs the **Routing and Switching** training course - here are the details about it:

https://www.cisco.com/c/en/us/training-events/training-certifications/training-catalog/routing-switching.html#~skills

Step 3. Complete the exam and get the Cisco Network Certification about the Routing and Switching Track:

https://www.cisco.com/c/en/us/training-events/training-certifications/certifications/entry/ccent.html

9.4. Detailed Instructions - Standalone Configuration

9.4.1. First Steps

Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor (PDF file):

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/hw/n93180ycex_hig/guide/b_n93180ycex_nxos_mode_hardware_install_guide.pdf

Set an IP address for the Management Ethernet port (Mgmt 0) to be able to connect to it over SSH and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Switch

Download the user's manual for the Nexus 93180YC-EX model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 46x 10GbE singlemode/multimode SFP+ transceiver modules and 23x singlemode/multimode fiber optical cables
- 46x 10GbE DAC cables

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port (Mgmt 0)**:

9.4.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

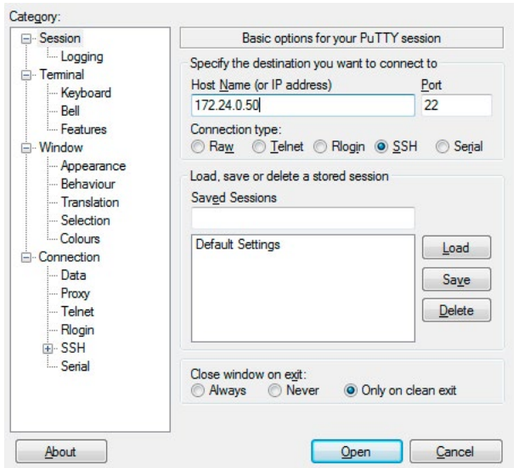
https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/sw/6-x/fundamentals/configuration/guide/b_Cisco_Nexus_9000_Series_NX-OS_Fundamentals_Configuration_Guide/b_Cisco_Nexus_9000_Series_NX-OS_Fundamentals_Configuration_Guide_chapter_0100.html

9.4.3. Setting up the Control Device

The Cisco switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the switch in our example: 172.24.0.50

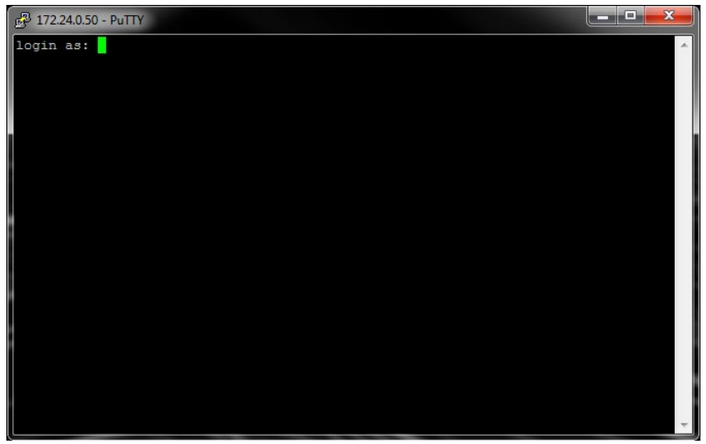
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

9.4.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

9.4.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by switch.

9.4.6. Setting up IP Address of the Switch

The Command

Type and apply the following commands:

```
interface mgmt0
     vrf member management
     ip address 172.24.0.50/24
     exit
```

Explanation

The IP address (172.24.0.50) and subnet mask (/24) of the switch have been set for the management port (Mgmt 0).

9.4.7. Default Gateway Setting

> INFO: The commands are required only in the case when the switch has to be accessed from different subnet.

The Command

Type and apply the following commands:

```
vrf context management
     ip route 0.0.0.0/0 172.24.0.1
     exit
```

9.4.8. Switching on the LACP, LLDP, and VLAN

The Command

Type and apply the following command:

```
feature telnet
feature lacp
feature lldp
feature interface-vlan
no lldp tlv-select management-address v6
lldp port-channel
```

9.4.9. VLAN and IGMPv2 Configuration

The Command

Type and apply the following commands:

```
vlan 1,286

vlan configuration 286
     ip igmp snooping fast-leave
     ip igmp snooping version 2
     exit
```

Explanation

Registers VLAN number 1 and number 286. Enables IGMPv2 snooping and the fast-leave feature which is required for the instant switching.

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

9.4.10. Forwarding Options

The Command

Type and apply the following commands:

```
port-channel load-balance src mac
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

9.4.11. Interface Configuration for the MMU

The Command

Type and apply the following commands:

Port ID	Command (in this example)
Port 1	interface Ethernet1/1 switchport switchport mode trunk switchport access vlan 286 switchport trunk allowed vlan 1,286 no shutdown exit

Explanation

The Ethernet1/1 is the first SFP+ port of the switch which is for the connection of the MMU. The port accepts **SFP+** and **SFP** transceiver modules either.

9.4.12. Port Channel Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired port channels:

Port Channel Index	Command
Port Channel 2	interface port-channel2 switchport switchport mode trunk switchport access vlan 286 exit
Port Channel 3	interface port-channel3 switchport switchport mode trunk switchport access vlan 286 exit
...	...
Port Channel 23	interface port-channel23 switchport switchport mode trunk switchport access vlan 286 exit

Explanation

The ports between the 3 and 48 are grouped by pairs to port-channels, in this case between port-channel 2 to port-channel 23.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

9.4.13. Interface Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command
Port 3	interface Ethernet1/3 switchport switchport mode trunk switchport access vlan 286 channel-group 1 mode active exit
Port 4	interface Ethernet1/4 switchport switchport mode trunk switchport access vlan 286 channel-group 1 mode active exit
...	...
Port 47	interface Ethernet1/47 switchport switchport mode trunk switchport access vlan 286 channel-group 23 mode active exit
Port 48	interface Ethernet1/48 switchport switchport mode trunk switchport access vlan 286 channel-group 23 mode active exit

Explanation

The ports between the Ethernet1/3 and Ethernet1/48 are the SFP+ ports where the UBEX endpoints are connected to the switch.

The 'active' keyword means that the switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX devices.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

9.5. Detailed Instructions - Two Stacked Switches Configuration

9.5.1. First Steps

Configuring the Switches

At first time the switch needs to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor (PDF file):

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/hw/n93180ycex_hig/guide/b_n93180ycex_nxos_mode_hardware_install_guide.pdf

Set an IP address for the Management Ethernet port (Mgmt 0) to be able to connect to it over SSH and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Switches

Download the user's manual for the Nexus 93180YC-EX model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch where **also the MMU will be connected to**:

- 46x 10GbE singlemode/multimode SFP+ transceiver modules and 23x singlemode/multimode fiber optical cables
- 46x 10GbE DAC cables

Step 3. Plug the cables between the UBEX endpoints and the switch where **the MMU will NOT be connected to**:

- 48x 10GbE singlemode/multimode SFP+ transceiver modules and 24x singlemode/multimode fiber optical cables
- 48x 10GbE DAC cables

Step 4. Plug the cables between the UBEX MMU and **one of the two switches** based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 5. Plug the cables between the two switches based on the following options.

- 4x 100GbE QSFP28 AOC cables
- 4x 100GbE QSFP28 DAC cables

Step 6. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port (Mgmt 0)**:

9.5.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

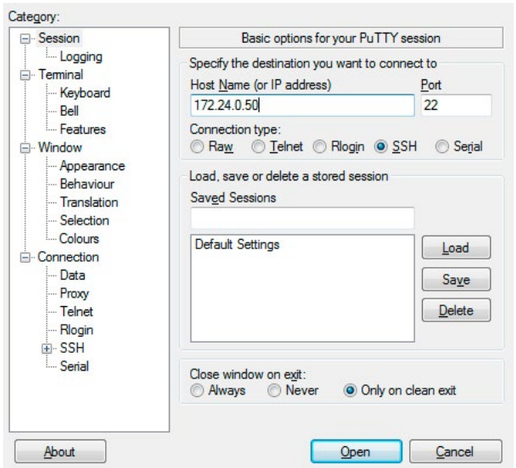
https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/sw/6-x/fundamentals/configuration/guide/b_Cisco_Nexus_9000_Series_NX-OS_Fundamentals_Configuration_Guide/b_Cisco_Nexus_9000_Series_NX-OS_Fundamentals_Configuration_Guide_chapter_0100.html

9.5.3. Setting up the Control Device

The Cisco switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP addresses of the switches in our example: 172.24.0.50 and 172.24.0.51

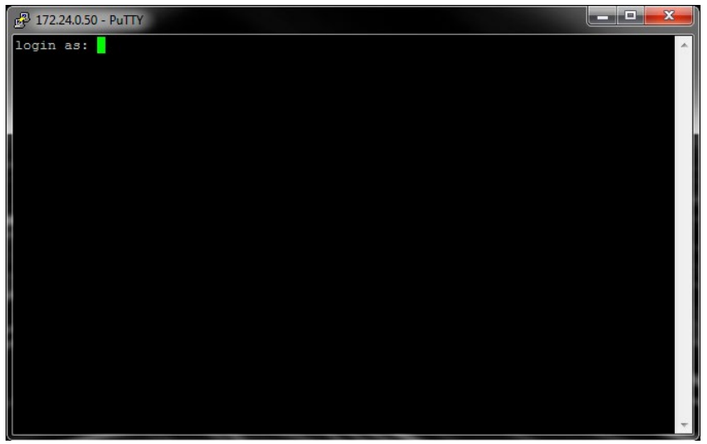
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

9.5.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

9.5.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by switch.

9.5.6. Setting up IP Addresses of the Switches

The Command

Type and apply the following commands for one of the switches:

```
interface mgmt0
     vrf member management
     ip address 172.24.0.50/24
     exit
```

Type and apply the following commands for the other switch:

```
interface mgmt0
     vrf member management
     ip address 172.24.0.51/24
     exit
```

Explanation

The IP addresses (172.24.0.50 and 172.24.0.51) and subnet mask (/24) of the switches have been set for their management ports (Mgmt 0).

9.5.7. Default Gateway Setting

> INFO: The commands are required only in the case when the switch has to be accessed from different subnet.

The Command

Type and apply the following commands:

```
vrf context management
     ip route 0.0.0.0/0 172.24.0.1
     exit
```

9.5.8. Switching on the LACP, LLDP, and VLAN

The Command

Type and apply the following command:

```
feature telnet
feature lacp
feature lldp
feature interface-vlan
no lldp tlv-select management-address v6
lldp port-channel
```

9.5.9. VLAN and IGMPv2 Configuration

The Command

Type and apply the following commands:

```
vlan 1,286
vlan configuration 286
     ip igmp snooping fast-leave
     ip igmp snooping version 2
     ip igmp snooping mrouter interface port-channel25
     exit
```

Explanation

Registers VLAN number 1 and number 286. Enables IGMPv2 snooping and the fast-leave feature which is required for the instant switching. *Port-channel25* is the uplink for the 400G connection between the two switches.

> **ATTENTION!** Always make sure that the your uplink port is **not** the part of the VLAN 286.

9.5.10. Forwarding Options

The Command

Type and apply the following commands:

```
port-channel load-balance src mac
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

9.5.11. Interface Configuration for the MMU

The Command

Type and apply the following commands:

Port ID	Command (in this example)

Port 1	`interface Ethernet1/1`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  switchport trunk allowed vlan 1,286`
	`  no shutdown`
	`  exit`

Explanation

The Ethernet1/1 is the first SFP+ port of the switch which is for the connection of the MMU. The port accepts **SFP+** and **SFP** transceiver modules either.

9.5.12. Port Channel Configuration for the Endpoints

The Commands

DIFFERENCE: The following commands belongs to the switch where the MMU also is connected.

Type and apply the following commands for the desired port channels:

Port Channel Index	Command

Port Channel 2	`interface port-channel2`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

Port Channel 3	`interface port-channel3`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

...	...

Port Channel 23	`interface port-channel23`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

Explanation

The ports between the 3 and 48 are grouped by pairs to port-channels, in this case between port-channel 2 to port-channel 23.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

The Commands

DIFFERENCE: The following commands belongs to the switch where the MMU is NOT connected.

Type and apply the following commands for the desired port channels:

Port Channel Index	Command

Port Channel 1	`interface port-channel1`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

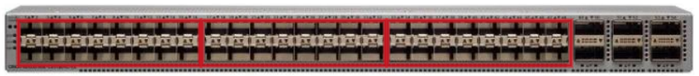
Port Channel 2	`interface port-channel2`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

...	...

Port Channel 24	`interface port-channel24`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  exit`

Explanation

The ports between the 1 and 48 are grouped by pairs to port-channels, in this case between port-channel 1 to port-channel 24.



TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

9.5.13. Interface Configuration for the Endpoints

The Commands

DIFFERENCE: The following commands belongs to the switch where the MMU also is connected.

Type and apply the following commands for the desired interface ports:

Port ID	Command

Port 3	`interface Ethernet1/3`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

Port 4	`interface Ethernet1/4`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

...	...

Port 47	`interface Ethernet1/47`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 23 mode active`
	`  exit`

Port 48	`interface Ethernet1/48`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 23 mode active`
	`  exit`

Explanation

The ports between the Ethernet1/3 and Ethernet1/48 are the SFP+ ports where the UBEX endpoints are connected to the switch.

The 'active' keyword means that the switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX devices.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

The Commands

> **DIFFERENCE:** The following commands belongs to the switch where the MMU is NOT connected.

Type and apply the following commands for the desired interface ports:

Port ID	Command

Port 1	`interface Ethernet1/1`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

Port 2	`interface Ethernet1/2`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 1 mode active`
	`  exit`

...	...

Port 47	`interface Ethernet1/47`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 24 mode active`
	`  exit`

Port 48	`interface Ethernet1/48`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  channel-group 24 mode active`
	`  exit`

Explanation

The ports between the Ethernet1/1 and Ethernet1/48 are the SFP+ ports where the UBEX endpoints are connected to the switch.

The 'active' keyword means that the switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX devices.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

9.5.14. Port Channel Configuration for the 400G Uplink

The Commands

Type and apply the following commands for the desired port channel:

Port Channel Index	Command

Port Channel 25	`interface port-channel25`
	`  switchport`
	`  switchport mode trunk`
	`  switchport access vlan 286`
	`  speed 100000`
	`  no negotiate auto`
	`  load-interval counter 1 5`
	`  exit`

Explanation

The QSFP28 ports between the 49 and 52 are grouped to one port-channel named *port-channel25*.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT). In this case the **configure** command needs only once at the starting of the sequence.

9.6. Troubleshooting Commands

9.6.1. Querying LLDP Partners

The Command

Type and apply the following command:

```
show lldp neighbors
```

Explanation

The query returns with the list of connected UBEX devices (which MAC address of the UBEX endpoint is on the ports of switch).

9.6.2. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lldp neighbors interface ethernet 1/1 detail
```

Explanation

The query returns with the details of the LLDP partner which is connected to the Ethernet1/1 port.

9.6.3. Switching on the Support for Unsupported SFP+ Modules

The Command

Type and apply the following command:

```
no system default switchport shutdown
service unsupported-transceiver
```

ATTENTION! Always use high-quality SFP+ transceiver modules.

9.6.4. Querying the Details of the Installed Transceiver Module

The Command

Type and apply the following command:

```
show interface transceiver
```

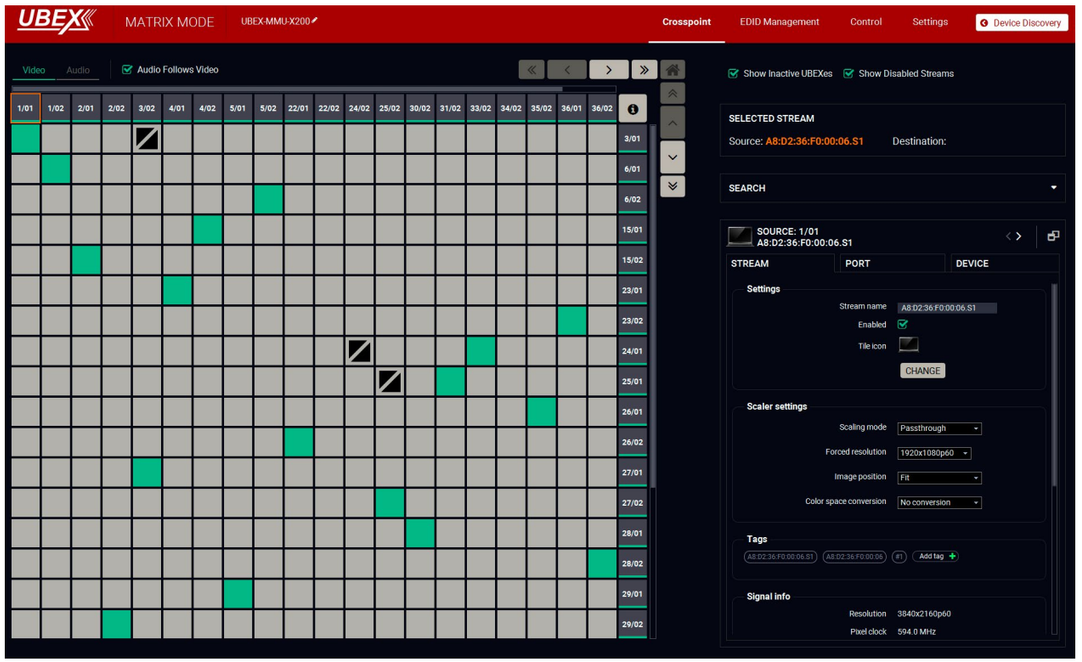
9.7. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

10

Configuration Steps - Juniper QFX5100-96S

The following chapter describes and explains step-by-step the procedure of the configuration for the Juniper QFX5100-96S fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- Juniper Requirements for the Switch Configuration
- First Steps
- Detailed Instructions
- Troubleshooting Commands
- Finalizing the Matrix

10.1. Description

This chapter helps you configure the Juniper QFX5100-96S managed switch for the UBEX matrix. This model of the Juniper contains 96x 10G SFP+ slots which are enough to serve 47 UBEX endpoints and an MMU and handle up to 94 source / destination devices. The switch is recommended for corporate businesses.

The configuration steps are compatible with the following switch models:

- Juniper QFX5100-48S
- Juniper QFX5110-48S
- Juniper QFX5100-96S
- Juniper QFX5110-96S

10.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Juniper QFX5100-96S	**1**	18.1R3-S4.2
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**47**	latest released firmware version

10.3. Juniper Requirements for the Switch Configuration

Juniper Networks Certification Program

Configuring a Juniper network switch requires the knowledge of the Juniper's own software architecture, the Junos OS. This is a command-based programming language which can be applied in the switch over terminal applications, for example Putty or CLI.

Step 1. Sign up for the **Juniper Training** to get the knowledge and skill to configure the switch. Visit the following website for the available Juniper trainings:

https://www.juniper.net/us/en/training/

Step 2. Configurator needs the **Enterprise Routing and Switching** training course - here are the details about it:

https://learningportal.juniper.net/juniper/user_activity_info.aspx?id=8057

Step 3. Complete the exam and get the Juniper Network Certification about the Enterprise Routing and Switching Track:

https://www.juniper.net/us/en/training/certification/certification-tracks/ent-routing-switching-track/?tab=jnciajunos

10.4. First Steps

10.4.1. Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/task/configuration/qfx5100-initial-configuration-cli.html

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

10.4.2. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

10.4.3. Installation of the Switch

Download the user's manual for the QFX5100/QFX5110 series model from the website of the vendor and follow the instructions.

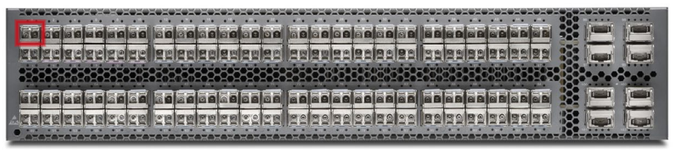
Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 94x 10GbE singlemode/multimode SFP+ transceiver modules and 94x singlemode/multimode fiber optical cables
- 94x 10GbE DAC cables

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable



Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port (C0)**:

10.4.4. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/task/configuration/qfx5100-initial-configuration-cli.html

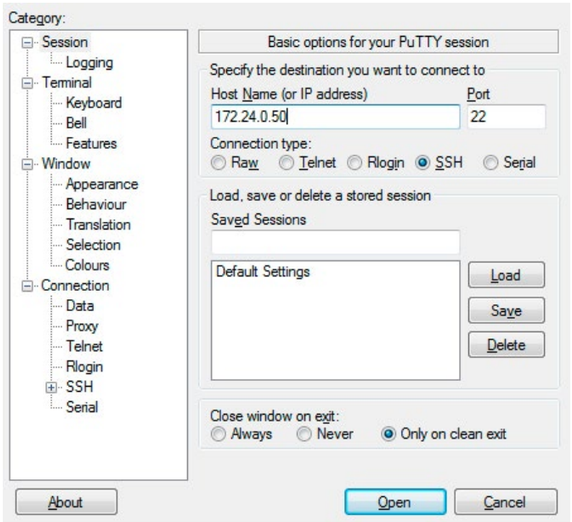
10.5. Detailed Instructions

10.5.1. Setting up the Control Device

The Juniper switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the switch in our example: 172.24.0.50

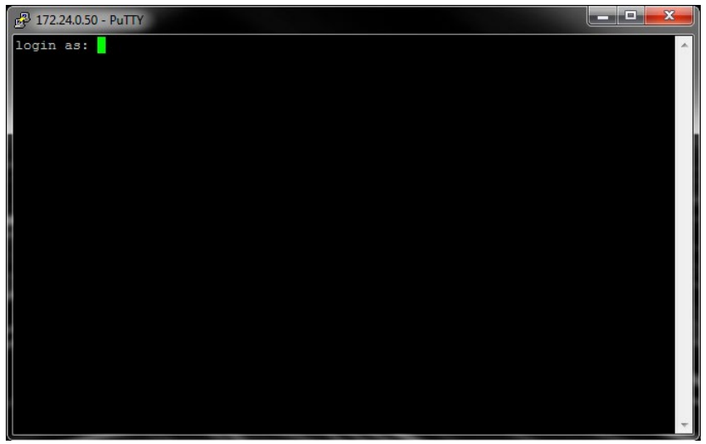
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

10.5.2. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

10.5.3. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by the switch.

10.5.4. Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 47
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected endpoint devices. It is 47 in our example.

10.5.5. Interface Configuration for the MMU and the Uplink

ATTENTION! The switch needs one of the interface configuration command sets (for 10 Gbps SFP+ modules **OR** 1 Gbps SFP modules). The **xe** or **ge** interface parameter will be accepted when SFP+ (xe) or SFP (ge) modules are inserted to the switch.

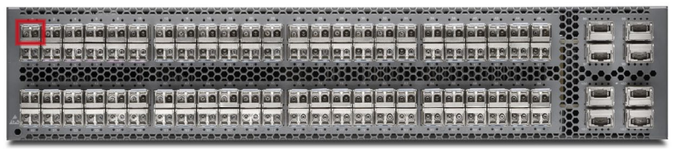
The Commands for 10 Gpbs SFP+ Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 0	edit interfaces xe-0/0/0 set native-vlan-id 1 edit unit 0 family ethernet-switching set interface-mode trunk set vlan members default set storm-control default exit exit

Explanation

The xe-0/0/0 is the SFP+ port of the switch and it is used for the "uplink" for the **user Ethernet connection** and for controlling the MMU. The link speed is applied to 10 Gbps (xe = 10 Gigabit Ethernet) automatically.



ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

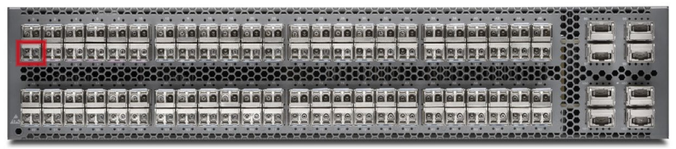
The Commands for 1 Gpbs SFP Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 1	edit interfaces ge-0/0/1 set native-vlan-id 1 edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all set storm-control default exit exit

Explanation

The ge-0/0/1 is the SFP+ port of the switch and it is used for the connection of the **MMU**. The link speed is applied to 1 Gbps (ge = 1 Gigabit Ethernet) automatically by the switch by the switch and the interfaces have membership to the all VLANs.



10.5.6. Interface Configuration for the Endpoints

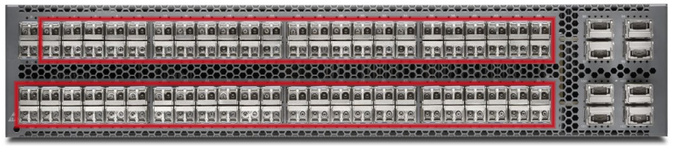
The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command
Port 2	`set xe-0/0/2 ether-options 802.3ad ae1`
Port 3	`set xe-0/0/3 ether-options 802.3ad ae1`
Port 4	`set xe-0/0/4 ether-options 802.3ad ae2`
Port 5	`set xe-0/0/5 ether-options 802.3ad ae2`
...	...
Port 94	`set xe-0/0/94 ether-options 802.3ad ae47`
Port 95	`set xe-0/0/95 ether-options 802.3ad ae47`

Explanation

The ports between the xe-0/0/2 and xe-0/0/94 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (xe = 10 GbE).



The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

10.5.7. Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command

ae0	`edit interfaces ae0`
	`  set native-vlan-id 1`
	`  set aggregated-ether-options lacp active`
	`  edit unit 0 family ethernet-switching`
	`  set interface-mode trunk`
	`  set vlan members all`
	`  exit`
	`exit`

ae1	`edit interfaces ae1`
	`  set native-vlan-id 1`
	`  set aggregated-ether-options lacp active`
	`  edit unit 0 family ethernet-switching`
	`  set interface-mode trunk`
	`  set vlan members all`
	`  exit`
	`exit`

...	...

ae47	`edit interfaces ae47`
	`  set native-vlan-id 1`
	`  set aggregated-ether-options lacp active`
	`  edit unit 0 family ethernet-switching`
	`  set interface-mode trunk`
	`  set vlan members all`
	`  exit`
	`exit`

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

10.5.8. Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
set enhanced-hash-key hash-mode layer2-header;
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

10.5.9. Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

10.5.10. IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave
```

10.6. Troubleshooting Commands

10.6.1. Enabling LLDP

The Command

Type and apply the following commands:

```
set protocols lldp interface all
```

Explanation

The LLDP setting is optional but it is helpful for further troubleshooting.

10.6.2. Querying LLDP Details

The Command

Type and apply the following command:

```
show lldp detail
```

Explanation

The query returns with the basic information about the LLDP.

10.6.3. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lldp neighbors xe-0/0/4
```

Explanation

The query returns with the details of the LLDP partner which is connected to the `xe-0/0/4` port.

10.6.4. Querying LLDP Statistics by Ports

The Command

Type and apply the following command:

```
show lldp statistics xe-0/0/4
```

Explanation

The query returns with the statistics of the LLDP partner which is connected to the `xe-0/0/4` port.

10.6.5. Verifying the Status of a LAG Interface

The Command

Type and apply the following command:

```
show interfaces ae0 terse
```

Explanation

The query returns with the status of the `ae0` LAG interface. When the link is **up**, the link aggregation (LACP) is working on the selected LAG interface.

10.6.6. Querying the Details of the Selected Interface Port

The Commands

Type and apply the following command:

```
show interfaces ge-0/0/1 detail
show interfaces xe-0/0/4 detail
```

Explanation

The query returns with the details of the `ge-0/0/1` and `xe-0/0/4` ports. The answers contain either that the inserted SFP / SFP+ module is supported or not by the switch.

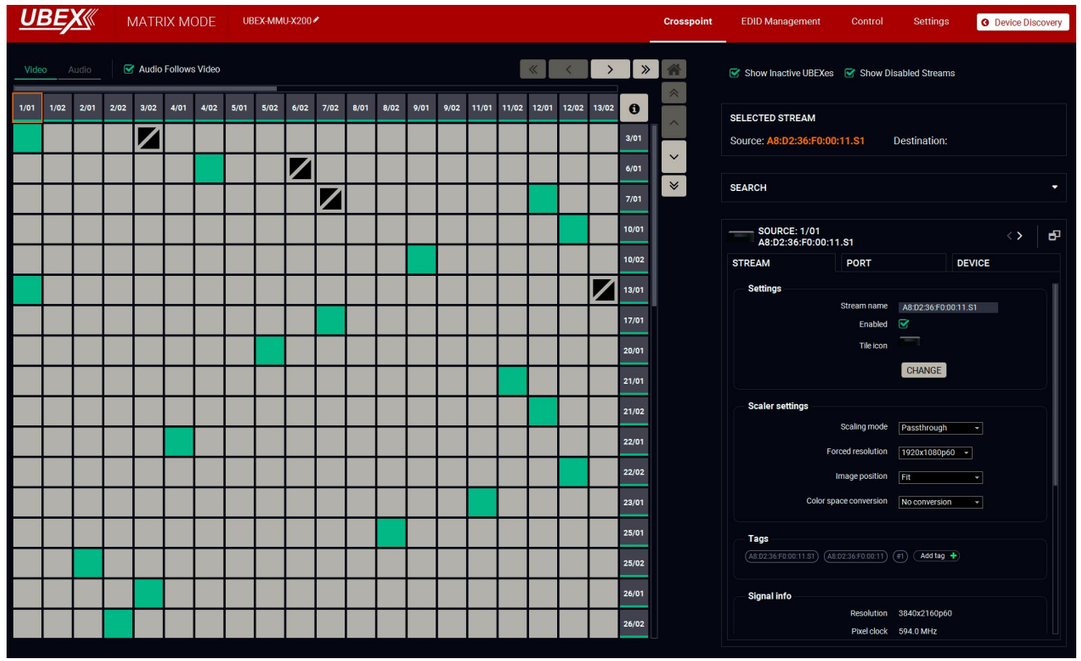
10.7. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

11

Configuration Steps - Juniper QFX5120-32C

The following chapter describes and explains step-by-step the procedure of the configuration for the Juniper QFX5120-32C fully managed network switch in four different configuration layouts:

- Description
- The Configuration of the UBEX Matrix
- Juniper Requirements for the Switch Configuration
- Detailed Instructions - Standalone Configuration
- Detailed Instructions - Two Stacked Switches Configuration
- Detailed Instructions - 1 Spine 3 Leaves Configuration
- Detailed Instructions - 1 Spine 4 Leaves Configuration
- Troubleshooting Commands
- Finalizing the Matrix

11.1. Description

This chapter helps you configure the Juniper QFX5120-32C managed switch for the UBEX matrix. The chassis of this model contains 2x 10G SFP+ slots and 32x 100G QSFP28 slots which are enough to serve 62 UBEX endpoints and an MMU and handle up to 124 source / destination devices in standalone configuration.

The chapter describes four different configuration deployments:

- **Standalone configuration** - see details in the Detailed Instructions - Standalone Configuration section;
- **Two stacked network switches** - see details in the Detailed Instructions - Two Stacked Switches Configuration section;
- **Leaf-and-spine deployment: 1 spine 3 leaves configuration** - see details in the Detailed Instructions - 1 Spine 3 Leaves Configuration section;
- **Leaf-and-spine deployment: 1 spine 4 leaves configuration** - see details in the Detailed Instructions - 1 Spine 4 Leaves Configuration section;

The switch is recommended for corporate businesses.

11.2. The Configuration of the UBEX Matrix

11.2.1. Standalone Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Juniper QFX5120-32C	**1**	20191212.201431_builder.r1074901
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**62**	latest released firmware version

See the detailed configuration steps for this deployment in the Detailed Instructions - Standalone Configuration section.

11.2.2. Two Stacked Switches Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Juniper QFX5120-32C	**2**	20191212.201431_builder.r1074901
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**80**	latest released firmware version

See the detailed configuration steps for this deployment in the Detailed Instructions - Two Stacked Switches Configuration section.

11.2.3. 1 Spine 3 Leaves Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Juniper QFX5120-32C	**4**	20191212.201431_builder.r1074901
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**120**	latest released firmware version

See the detailed configuration steps for this deployment in the Detailed Instructions - 1 Spine 3 Leaves Configuration section.

11.2.4. 1 Spine 4 Leaves Configuration

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Juniper QFX5120-32C	**5**	20191212.201431_builder.r1074901
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**160**	latest released firmware version

See the detailed configuration steps for this deployment in the Detailed Instructions - 1 Spine 4 Leaves Configuration section.

11.3. Juniper Requirements for the Switch Configuration

Juniper Networks Certification Program

Configuring a Juniper network switch requires the knowledge of the Juniper's own software architecture, the Junos OS. This is a command-based programming language which can be applied in the switch over terminal applications, for example Putty or CLI.

Step 1. Sign up for the **Juniper Training** to get the knowledge and skill to configure the switch. Visit the following website for the available Juniper trainings:

https://www.juniper.net/us/en/training/

Step 2. Configurator needs the **Enterprise Routing and Switching** training course - here are the details about it:

https://learningportal.juniper.net/juniper/user_activity_info.aspx?id=8057

Step 3. Complete the exam and get the Juniper Network Certification about the Enterprise Routing and Switching Track:

https://www.juniper.net/us/en/training/certification/certification-tracks/ent-routing-switching-track/?tab=jnciajunos

11.4. Detailed Instructions - Standalone Configuration

11.4.1. First Steps

Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-connecting-external.html

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Switch

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 32x 40GbE QSFP+ AOC breakout cables
- 32x 40GbE QSFP+ DAC breakout cables

ATTENTION! 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.

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port**:

11.4.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

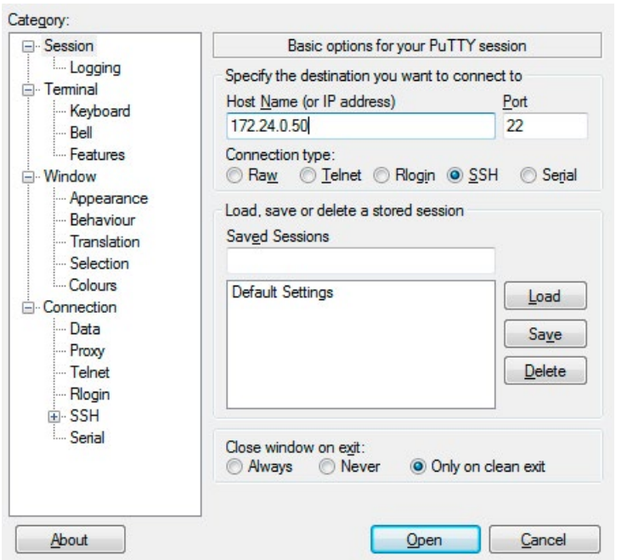
https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-initial-configuration.html

11.4.3. Setting up the Control Device

The Juniper switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

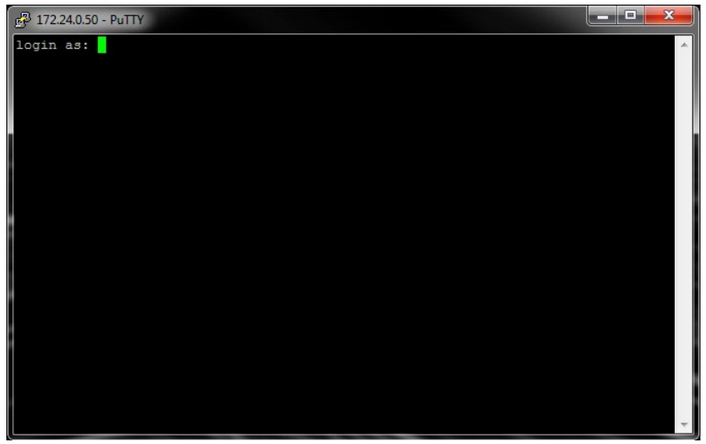
The IP address of the switch in our example: 172.24.0.50

Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



11.4.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

11.4.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by the switch.

11.4.6. Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 62
edit chassis fpc 0 pic 0
set port-range 0 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected endpoint devices. It is 62 in our example. The `channel-speed` parameter is set to 10G as a fixed parameter so the switch does not need to recognize it based on the break-out cable.

11.4.7. Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.4.8. SFP+ Interface Configuration for the MMU and the Uplink

> **ATTENTION!** The switch needs one of the interface configuration command sets (for 10 Gbps SFP+ modules **OR** 1 Gbps SFP modules). The **xe** or **ge** interface parameter will be accepted when SFP+ (xe) or SFP (ge) modules are inserted to the switch.

The Commands for 1 Gpbs SFP Modules

Type and apply the following commands:

Port ID	Command (in this example)

Port 32	`edit interfaces ge-0/0/32`
	`  set enable`
	`  edit unit 0 family ethernet-switching`
	`  set interface-mode trunk`
	`  set vlan members all`
	`  exit`
	`exit`

Explanation

The ge-0/0/32 is the SFP+ port of the switch and it is used for the connection of the **MMU**. The link speed is applied to 1 Gbps (ge = 1 Gigabit Ethernet) automatically by the switch by the switch and the interfaces have membership to the all VLANs.

The Commands for 10 Gpbs SFP+ Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 33	edit interfaces xe-0/0/33 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members default exit exit

Explanation

The xe-0/0/33 is the SFP+ port of the switch and it is used for the "uplink" for the **user Ethernet connection** and for controlling the MMU. The link speed is applied to 10 Gbps (xe = 10 Gigabit Ethernet) automatically.

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

11.4.9. Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
...	
ae61	edit interfaces ae61 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

11.4.10. Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 0	0/0	`delete interfaces xe-0/0/0:0 unit 0`
	0/1	`delete interfaces xe-0/0/0:1 unit 0`
	0/2	`delete interfaces xe-0/0/0:2 unit 0`
	0/3	`delete interfaces xe-0/0/0:3 unit 0`
...		
Port 30	30/0	`delete interfaces xe-0/0/30:0 unit 0`
	30/1	`delete interfaces xe-0/0/30:1 unit 0`
	30/2	`delete interfaces xe-0/0/30:2 unit 0`
	30/3	`delete interfaces xe-0/0/30:3 unit 0`

ATTENTION! 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.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.

11.4.11. Aggregated Ethernet Allocation

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 0	0/0	`set interfaces xe-0/0/0:0 ether-options 802.3ad ae0`
	0/1	`set interfaces xe-0/0/0:1 ether-options 802.3ad ae0`
	0/2	`set interfaces xe-0/0/0:2 ether-options 802.3ad ae1`
	0/3	`set interfaces xe-0/0/0:3 ether-options 802.3ad ae1`
...		
Port 30	30/0	`set interfaces xe-0/0/30:0 ether-options 802.3ad ae60`
	30/1	`set interfaces xe-0/0/30:1 ether-options 802.3ad ae60`
	30/2	`set interfaces xe-0/0/30:2 ether-options 802.3ad ae61`
	30/3	`set interfaces xe-0/0/30:3 ether-options 802.3ad ae61`

ATTENTION! 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.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The ports between the xe-0/0/0:0 and xe-0/0/30:3 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (xe = 10 GbE).

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

11.4.12. Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

11.4.13. LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.4.14. IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave
```

11.4.15. Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

11.5. Detailed Instructions - Two Stacked Switches Configuration

11.5.1. First Steps

Configuring the Switches

At first time the switches need to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-connecting-external.html

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Switches

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the two switches based on the following options:

- 8x 100GbE QSFP28 AOC cables
- 8x 100GbE QSFP28 DAC cables

Step 3. Plug the cables between the UBEX endpoints and both switches based on the following options:

- 20x 40GbE QSFP+ AOC breakout cables
- 20x 40GbE QSFP+ DAC breakout cables

Step 4. Plug the cables between the UBEX MMU and **one of the two switches** based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 5. Connect a control device (e.g. a laptop) to one of the two switches with a CATx cable to the **1000 Base-T management Ethernet port**:

11.5.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

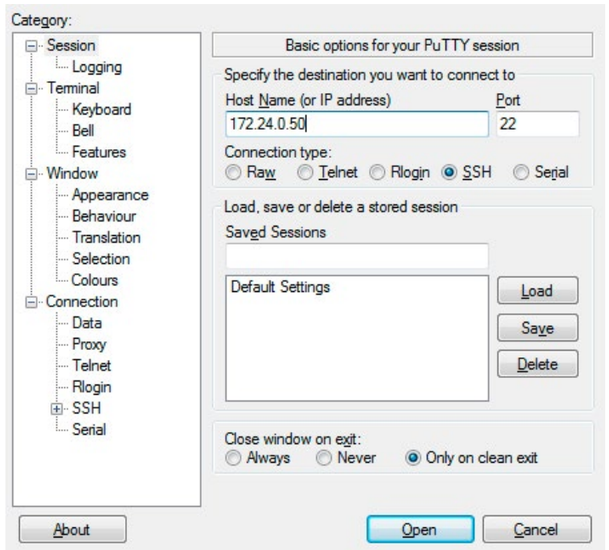
https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-initial-configuration.html

11.5.3. Setting up the Control Device

The Juniper switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

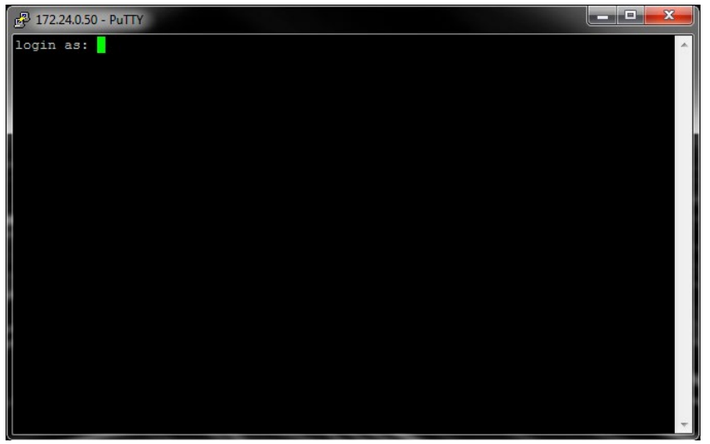
The IP addresses of the switches in our example: 172.24.0.50 and 172.24.0.51

Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



11.5.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

11.5.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by the switch.

11.5.6. Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 41
edit chassis fpc 0 pic 0
set port-range 8 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected endpoint devices (40) and the connected switches (1). It is 41 in our example.

ATTENTION! The setting needs to be applied on both switches with the same number.

11.5.7. Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.5.8. SFP+ Interface Configuration for the MMU and the Uplink

DIFFERENCE: These settings need to applied on one of the switches only.

ATTENTION! The switch needs one of the interface configuration command sets (for 10 Gbps SFP+ modules **OR** 1 Gbps SFP modules). The **xe** or **ge** interface parameter will be accepted when SFP+ (xe) or SFP (ge) modules are inserted to the switch.

The Commands for 1 Gpbs SFP Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 32	edit interfaces ge-0/0/32 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The ge-0/0/32 is the SFP+ port of the switch and it is used for the connection of the **MMU**. The link speed is applied to 1 Gbps (ge = 1 Gigabit Ethernet) automatically by the switch and the interfaces have membership to the all VLANs.

The Commands for 10 Gpbs SFP+ Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 33	edit interfaces xe-0/0/33 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members default exit exit

Explanation

The xe-0/0/33 is the SFP+ port of the switch and it is used for the "uplink" for the **user Ethernet connection** and for controlling the MMU. The link speed is applied to 10 Gbps (xe = 10 Gigabit Ethernet) automatically by the switch.

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

11.5.9. QSFP28 Interface Setting Erasure

The Commands

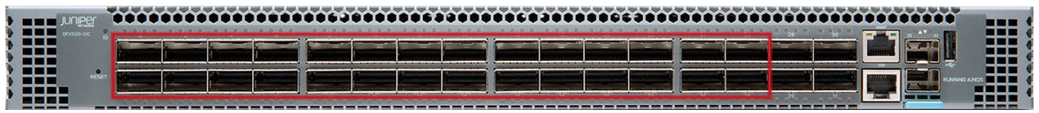
Type and apply the following commands for the desired interface ports:

Port ID	Command (in this example)
Port 0	`delete interfaces et-0/0/0 unit 0`
Port 1	`delete interfaces et-0/0/1 unit 0`
Port 2	`delete interfaces et-0/0/2 unit 0`
...	
Port 27	`delete interfaces et-0/0/27 unit 0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.



11.5.10. Split QSFP+ Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 8	8/0	`delete interfaces xe-0/0/8:0 unit 0`
	8/1	`delete interfaces xe-0/0/8:1 unit 0`
	8/2	`delete interfaces xe-0/0/8:2 unit 0`
	8/3	`delete interfaces xe-0/0/8:3 unit 0`
...		
Port 27	27/0	`delete interfaces xe-0/0/27:0 unit 0`
	27/1	`delete interfaces xe-0/0/27:1 unit 0`
	27/2	`delete interfaces xe-0/0/27:2 unit 0`
	27/3	`delete interfaces xe-0/0/27:3 unit 0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the split QSFP+ ports need to be deleted before the aggregated Ethernet allocation is set.

11.5.11. Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
...	...
ae40	edit interfaces ae40 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

11.5.12. Aggregated Ethernet Allocation for the Uplink between the Switches

The Commands for the 100 Gpbs QSFP28 Ports

Type and apply the following commands:

Port ID	Command (in this example)
Port 0	set interfaces et-0/0/0 ether-options 802.3ad ae0
Port 1	set interfaces et-0/0/1 ether-options 802.3ad ae0
...	...
Port 7	set interfaces et-0/0/7 ether-options 802.3ad ae0

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The QSFP28 ports between et-0/0/0 and et-0/0/7 are the 100GbE (et = 100 Gigabit Ethernet) interfaces of the switch for the connection with the other network switch. All of them are assigned to the ae0 aggregated Ethernet ID.

11.5.13. Aggregated Ethernet Allocation for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

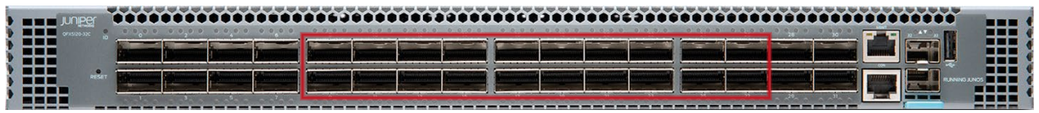
Port ID	Split part	Command
Port 8	8/0	`set interfaces xe-0/0/8:0 ether-options 802.3ad ae1`
	8/1	`set interfaces xe-0/0/8:1 ether-options 802.3ad ae1`
	8/2	`set interfaces xe-0/0/8:2 ether-options 802.3ad ae2`
	8/3	`set interfaces xe-0/0/8:3 ether-options 802.3ad ae2`
Port 9	9/0	`set interfaces xe-0/0/9:0 ether-options 802.3ad ae3`
	9/1	`set interfaces xe-0/0/9:1 ether-options 802.3ad ae3`
	9/2	`set interfaces xe-0/0/9:2 ether-options 802.3ad ae4`
	9/3	`set interfaces xe-0/0/9:3 ether-options 802.3ad ae4`
...		
Port 27	27/0	`set interfaces xe-0/0/27:0 ether-options 802.3ad ae39`
	27/1	`set interfaces xe-0/0/27:1 ether-options 802.3ad ae39`
	27/2	`set interfaces xe-0/0/27:2 ether-options 802.3ad ae40`
	27/3	`set interfaces xe-0/0/27:3 ether-options 802.3ad ae40`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch.

Explanation

The ports between the xe-0/0/8:0 and xe-0/0/27:3 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (xe = 10 GbE).

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.



INFO: The 800 GbE uplink between the switches makes the limitation that up to 40 pcs 20G UBEX endpoint devices can be connected the port 8-27. Thus, four QSFP28 ports (port 28-31) are unused in this deployment. However those ports can also be used for further endpoint connection if the sum of the data transmission is under 800 GbE. In this case the same settings can be applied on the unused ports. **The maximum 40 pcs endpoint connections guarantees the non-blocking operation of the UBEX matrix.**

11.5.14. Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links and the 800G uplink between the switches (load balancing).

11.5.15. LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.5.16. IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave interface ae0.0
multicast-router-interface
```

11.5.17. Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

11.6. Detailed Instructions - 1 Spine 3 Leaves Configuration

11.6.1. First Steps

Configuring the Switches

At first time the switches need to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-connecting-external.html

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Spine Switch

DIFFERENCE: The following instructions are regarding to the **spine** switch only.

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

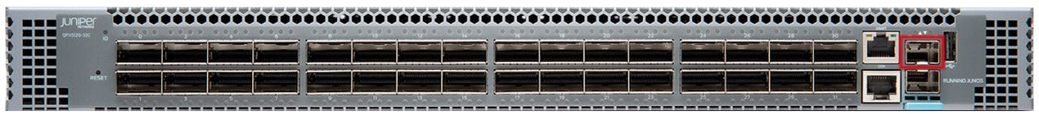
Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the spine and leaf switches based on the following options:

- 24x 100GbE QSFP28 AOC cables
- 24x 100GbE QSFP28 DAC cables

Step 3. Plug the cables between the UBEX MMU and one of the two switches based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable



Step 4. Connect a control device (e.g. a laptop) to one of the two switches with a CATx cable to the **1000 Base-T management Ethernet port**:

Installation of the Leaf Switches

DIFFERENCE: The following instructions are regarding to the **leaf** switches only.

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the spine and leaf switches based on the following options:

- 8x 100GbE QSFP28 AOC cables
- 8x 100GbE QSFP28 DAC cables

Step 3. Plug the cables between the UBEX endpoints and both switches based on the following options:

- 20x 40GbE QSFP+ AOC breakout cables
- 20x 40GbE QSFP+ DAC breakout cables

11.6.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-initial-configuration.html

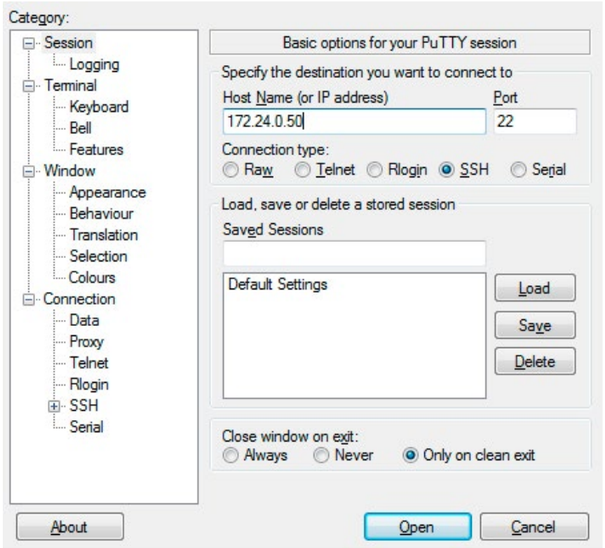
11.6.3. Setting up the Control Device

The Juniper switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the **spine** switch in our example: 172.24.0.50

The IP addresses of the **leaf** switches in our example: 172.24.0.51; 172.24.0.52; 172.24.0.53;

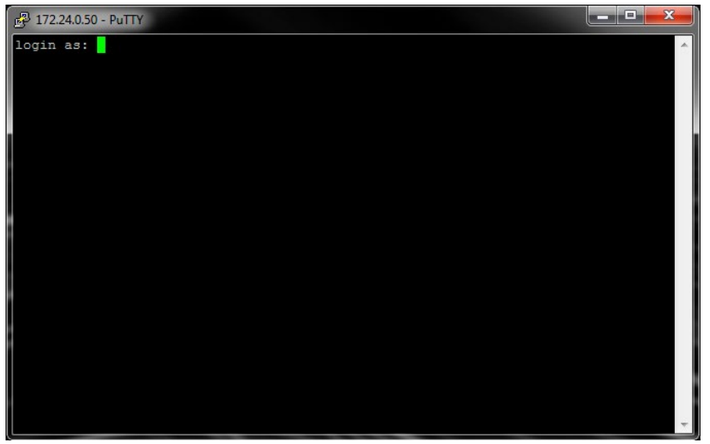
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

11.6.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

11.6.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by the switch.

<START OF THE SPINE SWITCH CONFIGURATION>

DIFFERENCE: The following setting is related to the **spine** switch configuration only.

11.6.6. SPINE - Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 3
edit chassis fpc 0 pic 0
set port-range 7 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected leaf switches. It is 3 in our example.

11.6.7. SPINE - Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.6.8. SPINE - SFP+ Interface Configuration for the MMU and the Uplink

ATTENTION! The switch needs one of the interface configuration command sets (for 10 Gbps SFP+ modules **OR** 1 Gbps SFP modules). The **xe** or **ge** interface parameter will be accepted when SFP+ (xe) or SFP (ge) modules are inserted to the switch.

The Commands for 1 Gpbs SFP Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 32	edit interfaces ge-0/0/32 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The ge-0/0/32 is the SFP+ port of the switch and it is used for the connection of the **MMU**. The link speed is applied to 1 Gbps (ge = 1 Gigabit Ethernet) automatically by the switch and the interfaces have membership to the all VLANs.

The Commands for 10 Gpbs SFP+ Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 33	edit interfaces xe-0/0/33 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members default exit exit

Explanation

The xe-0/0/33 is the SFP+ port of the switch and it is used for the "uplink" for the **user Ethernet connection** and for controlling the MMU. The link speed is applied to 10 Gbps (xe = 10 Gigabit Ethernet) automatically by the switch.

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

11.6.9. SPINE - Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae2	edit interfaces ae2 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

11.6.10. SPINE - Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command (in this example)
Port 0	delete interfaces et-0/0/0 unit 0
Port 1	delete interfaces et-0/0/1 unit 0
Port 2	delete interfaces et-0/0/2 unit 0
...	
Port 23	delete interfaces et-0/0/23 unit 0

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.

11.6.11. SPINE - Aggregated Ethernet Allocation

The Commands for the 100 Gpbs QSFP28 Ports

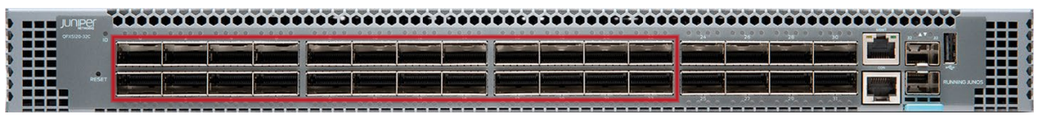
Type and apply the following commands:

Port ID	Command (in this example)
Port 0	`set interfaces et-0/0/0 ether-options 802.3ad ae0`
Port 1	`set interfaces et-0/0/1 ether-options 802.3ad ae0`
Port 2	`set interfaces et-0/0/2 ether-options 802.3ad ae0`
Port 3	`set interfaces et-0/0/3 ether-options 802.3ad ae0`
Port 4	`set interfaces et-0/0/4 ether-options 802.3ad ae0`
Port 5	`set interfaces et-0/0/5 ether-options 802.3ad ae0`
Port 6	`set interfaces et-0/0/6 ether-options 802.3ad ae0`
Port 7	`set interfaces et-0/0/7 ether-options 802.3ad ae0`
Port 8	`set interfaces et-0/0/8 ether-options 802.3ad ae1`
Port 9	`set interfaces et-0/0/9 ether-options 802.3ad ae1`
Port 10	`set interfaces et-0/0/10 ether-options 802.3ad ae1`
Port 11	`set interfaces et-0/0/11 ether-options 802.3ad ae1`
Port 12	`set interfaces et-0/0/12 ether-options 802.3ad ae1`
Port 13	`set interfaces et-0/0/13 ether-options 802.3ad ae1`
Port 14	`set interfaces et-0/0/14 ether-options 802.3ad ae1`
Port 15	`set interfaces et-0/0/15 ether-options 802.3ad ae1`
Port 16	`set interfaces et-0/0/16 ether-options 802.3ad ae2`
...	
Port 23	`set interfaces et-0/0/23 ether-options 802.3ad ae2`

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The QSFP28 ports between et-0/0/0 and et-0/0/23 are the 100GbE (et = 100 Gigabit Ethernet) interfaces of the switch for the connection with the other network switch. All of them are assigned to an aggregated Ethernet ID grouped by eight ports (it means 800GbE uplink for each leaf switch).



11.6.12. SPINE - Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally on the 3x 800G uplink between the switches (load balancing).

11.6.13. SPINE - LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.6.14. SPINE - IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave interface ae0.0
multicast-router-interface
```

11.6.15. SPINE - Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

<END OF THE SPINE SWITCH CONFIGURATION>

<START OF THE LEAF SWITCH CONFIGURATION>

DIFFERENCE: The following setting is related to the **leaf** switch configuration only. The configuration steps need to be applied on all three leaf switches.

11.6.16. LEAF - Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 41
edit chassis fpc 0 pic 0
set port-range 8 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected endpoint devices (40) and the connected spine switch (1). It is 41 in our example.

11.6.17. LEAF - Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.6.18. LEAF - Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
...	
ae40	edit interfaces ae40 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

11.6.19. LEAF - QSFP28 Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command (in this example)
Port 0	`delete interfaces et-0/0/0 unit 0`
Port 1	`delete interfaces et-0/0/1 unit 0`
Port 2	`delete interfaces et-0/0/2 unit 0`
...	
Port 27	`delete interfaces et-0/0/27 unit 0`

ATTENTION! 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.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.

11.6.20. LEAF - Split QSFP+ Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 8	8/0	`delete interfaces xe-0/0/8:0 unit 0`
	8/1	`delete interfaces xe-0/0/8:1 unit 0`
	8/2	`delete interfaces xe-0/0/8:2 unit 0`
	8/3	`delete interfaces xe-0/0/8:3 unit 0`
...		
Port 27	27/0	`delete interfaces xe-0/0/27:0 unit 0`
	27/1	`delete interfaces xe-0/0/27:1 unit 0`
	27/2	`delete interfaces xe-0/0/27:2 unit 0`
	27/3	`delete interfaces xe-0/0/27:3 unit 0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the split QSFP+ ports need to be deleted before the aggregated Ethernet allocation is set.

11.6.21. LEAF - Aggregated Ethernet Allocation for the Uplink between the Switches

The Commands for the 100 Gpbs QSFP28 Ports

Type and apply the following commands:

Port ID	Command (in this example)
Port 0	`set interfaces et-0/0/0 ether-options 802.3ad ae0`
Port 1	`set interfaces et-0/0/1 ether-options 802.3ad ae0`
...	
Port 7	`set interfaces et-0/0/7 ether-options 802.3ad ae0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The QSFP28 ports between et-0/0/0 and et-0/0/7 are the 100GbE (et = 100 Gigabit Ethernet) interfaces of the switch for the connection with the other network switch. All of them are assigned to the `ae0` aggregated Ethernet ID.

11.6.22. LEAF - Aggregated Ethernet Allocation for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 8	8/0	`set interfaces xe-0/0/8:0 ether-options 802.3ad ae1`
	8/1	`set interfaces xe-0/0/8:1 ether-options 802.3ad ae1`
	8/2	`set interfaces xe-0/0/8:2 ether-options 802.3ad ae2`
	8/3	`set interfaces xe-0/0/8:3 ether-options 802.3ad ae2`
Port 9	9/0	`set interfaces xe-0/0/9:0 ether-options 802.3ad ae3`
	9/1	`set interfaces xe-0/0/9:1 ether-options 802.3ad ae3`
	9/2	`set interfaces xe-0/0/9:2 ether-options 802.3ad ae4`
	9/3	`set interfaces xe-0/0/9:3 ether-options 802.3ad ae4`
...		
Port 27	27/0	`set interfaces xe-0/0/27:0 ether-options 802.3ad ae39`
	27/1	`set interfaces xe-0/0/27:1 ether-options 802.3ad ae39`
	27/2	`set interfaces xe-0/0/27:2 ether-options 802.3ad ae40`
	27/3	`set interfaces xe-0/0/27:3 ether-options 802.3ad ae40`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch.

Explanation

The ports between the xe-0/0/8:0 and xe-0/0/27:3 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (xe = 10 GbE).

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

INFO: The 800 GbE uplink between the switches makes the limitation that up to 40 pcs 20G UBEX endpoint devices can be connected the port 8-27. Thus, four QSFP28 ports (port 28-31) are unused in this deployment. However those ports can also be used for further endpoint connection if the sum of the data transmission is under 800 GbE. In this case the same settings can be applied on the unused ports. **The maximum 40 pcs endpoint connections guarantees the non-blocking operation of the UBEX matrix.**

11.6.23. LEAF - Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

11.6.24. LEAF - LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.6.25. LEAF - IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave
```

11.6.26. LEAF - Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

<END OF THE LEAF SWITCH CONFIGURATION>

11.7. Detailed Instructions - 1 Spine 4 Leaves Configuration

11.7.1. First Steps

Configuring the Switches

At first time the switches need to be configured locally by using the supplied RJ45 to DB9 adapter cable. Follow the instructions listed on the website of the vendor:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-connecting-external.html

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

Installation of the Spine Switch

DIFFERENCE: The following instructions are regarding to the **spine** switch only.

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the spine and leaf switches based on the following options:

- 32x 100GbE QSFP28 AOC cables
- 32x 100GbE QSFP28 DAC cables

Step 3. Plug the cables between the UBEX MMU and one of the two switches based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Connect a control device (e.g. a laptop) to one of the two switches with a CATx cable to the **1000 Base-T management Ethernet port**:

Installation of the Leaf Switches

DIFFERENCE: The following instructions are regarding to the **leaf** switches only.

Download the user's manual for the QFX5120 series model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the spine and leaf switches based on the following options:

- 8x 100GbE QSFP28 AOC cables
- 8x 100GbE QSFP28 DAC cables

Step 3. Plug the cables between the UBEX endpoints and both switches based on the following options:

- 20x 40GbE QSFP+ AOC breakout cables
- 20x 40GbE QSFP+ DAC breakout cables

11.7.2. Global Settings

See the details about the global settings of the switch on the website of the vendor and follow the instructions:

https://www.juniper.net/documentation/en_US/release-independent/junos/topics/topic-map/qfx5120-initial-configuration.html

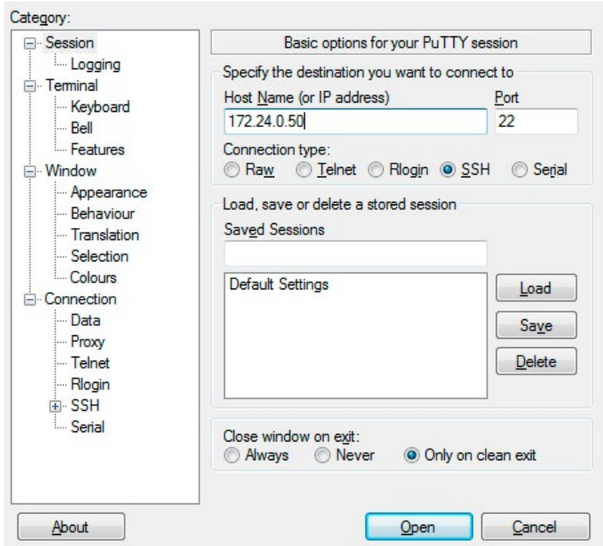
11.7.3. Setting up the Control Device

The Juniper switch can be configured by protocol commands only. You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the **spine** switch in our example: 172.24.0.50

The IP addresses of the **leaf** switches in our example: 172.24.0.51; 172.24.0.52; 172.24.0.53;

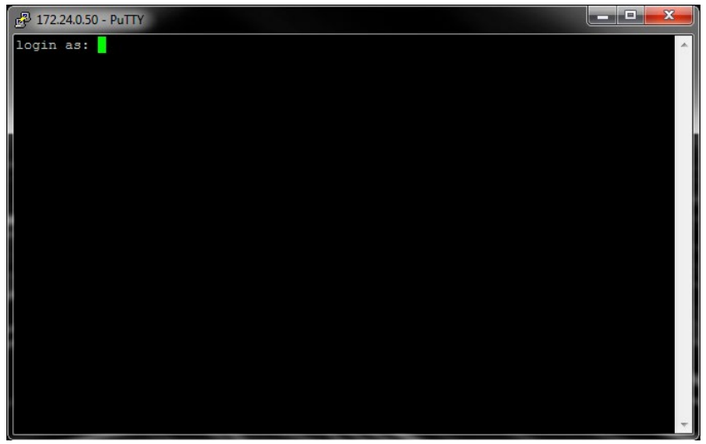
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

11.7.4. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password.



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

11.7.5. Entering to Configure Mode

The Command

Type and apply the following command:

```
configure
```

Explanation

The Configure mode is enabled and the configuration commands will be accepted by the switch.

<START OF THE SPINE SWITCH CONFIGURATION>

DIFFERENCE: The following setting is related to the **spine** switch configuration only.

11.7.6. SPINE - Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 3
edit chassis fpc 0 pic 0
set port-range 7 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected leaf switches. It is 3 in our example.

11.7.7. Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.7.8. SFP+ Interface Configuration for the MMU and the Uplink

ATTENTION! The switch needs one of the interface configuration command sets (for 10 Gbps SFP+ modules **OR** 1 Gbps SFP modules). The **xe** or **ge** interface parameter will be accepted when SFP+ (xe) or SFP (ge) modules are inserted to the switch.

The Commands for 1 Gpbs SFP Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 32	edit interfaces ge-0/0/32 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The ge-0/0/32 is the SFP+ port of the switch and it is used for the connection of the **MMU**. The link speed is applied to 1 Gbps (ge = 1 Gigabit Ethernet) automatically by the switch by the switch and the interfaces have membership to the all VLANs.

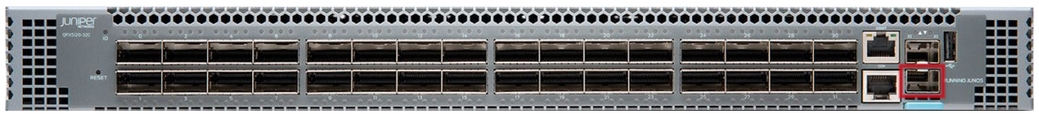
The Commands for 10 Gpbs SFP+ Modules

Type and apply the following commands:

Port ID	Command (in this example)
Port 33	edit interfaces xe-0/0/33 set enable edit unit 0 family ethernet-switching set interface-mode trunk set vlan members default exit exit

Explanation

The xe-0/0/33 is the SFP+ port of the switch and it is used for the "uplink" for the **user Ethernet connection** and for controlling the MMU. The link speed is applied to 10 Gbps (xe = 10 Gigabit Ethernet) automatically.



ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

11.7.9. SPINE - Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
...	
ae3	edit interfaces ae3 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

11.7.10. SPINE - Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command (in this example)
Port 0	`delete interfaces et-0/0/0 unit 0`
Port 1	`delete interfaces et-0/0/1 unit 0`
Port 2	`delete interfaces et-0/0/2 unit 0`
...	
Port 31	`delete interfaces et-0/0/31 unit 0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.

11.7.11. SPINE - Aggregated Ethernet Allocation for the Uplink between the Switches

The Commands for the 100 Gpbs QSFP28 Ports

Type and apply the following commands:

Port ID	Command (in this example)
Port 0	`set interfaces et-0/0/0 ether-options 802.3ad ae0`
Port 1	`set interfaces et-0/0/1 ether-options 802.3ad ae0`
Port 2	`set interfaces et-0/0/2 ether-options 802.3ad ae0`
Port 3	`set interfaces et-0/0/3 ether-options 802.3ad ae0`
Port 4	`set interfaces et-0/0/4 ether-options 802.3ad ae0`
Port 5	`set interfaces et-0/0/5 ether-options 802.3ad ae0`
Port 6	`set interfaces et-0/0/6 ether-options 802.3ad ae0`
Port 7	`set interfaces et-0/0/7 ether-options 802.3ad ae0`
Port 8	`set interfaces et-0/0/8 ether-options 802.3ad ae1`
...	
Port 15	`set interfaces et-0/0/15 ether-options 802.3ad ae1`
Port 16	`set interfaces et-0/0/16 ether-options 802.3ad ae2`
...	
Port 23	`set interfaces et-0/0/23 ether-options 802.3ad ae2`
Port 24	`set interfaces et-0/0/24 ether-options 802.3ad ae3`
...	
Port 31	`set interfaces et-0/0/31 ether-options 802.3ad ae3`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The QSFP28 ports between et-0/0/0 and et-0/0/31 are the 100GbE (et = 100 Gigabit Ethernet) interfaces of the switch for the connection with the other network switch. All of them are assigned to an aggregated Ethernet ID grouped by eight ports (it means 800GbE uplink for each leaf switch).

11.7.12. SPINE - Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally on the 4x 800G uplink between the switches (load balancing).

11.7.13. SPINE - LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.7.14. SPINE - IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave interface ae0.0
multicast-router-interface
```

11.7.15. SPINE - Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

<End of the SPINE Switch Configuration>

<START OF THE LEAF SWITCH CONFIGURATION>

DIFFERENCE: The following setting is related to the **leaf** switch configuration only. The configuration steps need to be applied on all three leaf switches.

11.7.16. LEAF - Aggregated Ethernet Interface Configuration

The Command

Type and apply the following commands:

```
set chassis aggregated-devices ethernet device-count 41
edit chassis fpc 0 pic 0
set port-range 8 31 channel-speed 10g
```

Explanation

This setting reserves the resources of the switch for it. The `device-count` parameter needs to be set to the number of the connected endpoint devices (40) and the connected spine switch (1). It is 41 in our example.

11.7.17. LEAF - Creating VLAN

The Command

Type and apply the following command:

```
set vlans ubex-vlan vlan-id 286
```

Explanation

The VLAN ID 286 has been created now.

11.7.18. LEAF - Aggregated Ethernet Settings

The Commands

Type and apply the following commands:

Aggregated Ethernet ID	Command
ae0	edit interfaces ae0 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
ae1	edit interfaces ae1 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit
...	...
ae40	edit interfaces ae40 set native-vlan-id 1 set aggregated-ether-options lacp active edit unit 0 family ethernet-switching set interface-mode trunk set vlan members all exit exit

Explanation

The aggregated Ethernet is set and finalized with these commands. The ae<x> increases till the last LAG interface.

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

11.7.19. LEAF - QSFP28 Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Command (in this example)
Port 0	delete interfaces et-0/0/0 unit 0
Port 1	delete interfaces et-0/0/1 unit 0
Port 2	delete interfaces et-0/0/2 unit 0
...	...
Port 27	delete interfaces et-0/0/27 unit 0

> TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the QSFP28 ports need to be deleted before the aggregated Ethernet allocation is set.

11.7.20. LEAF - Split QSFP+ Interface Setting Erasure

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 8	8/0	`delete interfaces xe-0/0/8:0 unit 0`
	8/1	`delete interfaces xe-0/0/8:1 unit 0`
	8/2	`delete interfaces xe-0/0/8:2 unit 0`
	8/3	`delete interfaces xe-0/0/8:3 unit 0`
...		
Port 27	27/0	`delete interfaces xe-0/0/27:0 unit 0`
	27/1	`delete interfaces xe-0/0/27:1 unit 0`
	27/2	`delete interfaces xe-0/0/27:2 unit 0`
	27/3	`delete interfaces xe-0/0/27:3 unit 0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The previous interface settings on the split QSFP+ ports need to be deleted before the aggregated Ethernet allocation is set.

11.7.21. LEAF - Aggregated Ethernet Allocation for the Uplink between the Switches

The Commands for the 100 Gpbs QSFP28 Ports

Type and apply the following commands:

Port ID	Command (in this example)
Port 0	`set interfaces et-0/0/0 ether-options 802.3ad ae0`
Port 1	`set interfaces et-0/0/1 ether-options 802.3ad ae0`
...	
Port 7	`set interfaces et-0/0/7 ether-options 802.3ad ae0`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

Explanation

The QSFP28 ports between et-0/0/0 and et-0/0/7 are the 100GbE (et = 100 Gigabit Ethernet) interfaces of the switch for the connection with the other network switch. All of them are assigned to the `ae0` aggregated Ethernet ID.

11.7.22. LEAF - Aggregated Ethernet Allocation for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port ID	Split part	Command
Port 8	8/0	`set interfaces xe-0/0/8:0 ether-options 802.3ad ae1`
	8/1	`set interfaces xe-0/0/8:1 ether-options 802.3ad ae1`
	8/2	`set interfaces xe-0/0/8:2 ether-options 802.3ad ae2`
	8/3	`set interfaces xe-0/0/8:3 ether-options 802.3ad ae2`
Port 9	9/0	`set interfaces xe-0/0/9:0 ether-options 802.3ad ae3`
	9/1	`set interfaces xe-0/0/9:1 ether-options 802.3ad ae3`
	9/2	`set interfaces xe-0/0/9:2 ether-options 802.3ad ae4`
	9/3	`set interfaces xe-0/0/9:3 ether-options 802.3ad ae4`
...		
Port 27	27/0	`set interfaces xe-0/0/27:0 ether-options 802.3ad ae39`
	27/1	`set interfaces xe-0/0/27:1 ether-options 802.3ad ae39`
	27/2	`set interfaces xe-0/0/27:2 ether-options 802.3ad ae40`
	27/3	`set interfaces xe-0/0/27:3 ether-options 802.3ad ae40`

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch.

Explanation

The ports between the xe-0/0/8:0 and xe-0/0/27:3 are the SFP+ ports where the UBEX endpoints are connected to the switch. They are set to 10 Gbps (xe = 10 GbE).

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

INFO: The 800 GbE uplink between the switches makes the limitation that up to 40 pcs 20G UBEX endpoint devices can be connected the port 8-27. Thus, four QSFP28 ports (port 28-31) are unused in this deployment. However those ports can also be used for further endpoint connection if the sum of the data transmission is under 800 GbE. In this case the same settings can be applied on the unused ports. **The maximum 40 pcs endpoint connections guarantees the non-blocking operation of the UBEX matrix.**

11.7.23. LEAF - Forwarding Options

The Commands

Type and apply the following commands:

```
set forwarding-options storm-control-profiles default all
edit forwarding-options enhanced-hash-key
    set hash-mode layer2-header
    set hash-parameters lag function crc32-lo
    set layer2 no-incoming-port
    set layer2 no-incoming-device
    set layer2 no-destination-mac-address
    set layer2 no-ether-type
exit
```

Explanation

The setting ensures that traffic is shared equally between the two aggregated links.

11.7.24. LEAF - LLDP Setting

The Commands

Type and apply the following commands:

```
set protocols lldp port-id-subtype interface-name interface all
set protocols lldp-med interface all
```

11.7.25. LEAF - IGMPv2 Setting

The Commands

Type and apply the following commands:

```
set protocols igmp-snooping vlan default
set protocols igmp-snooping vlan ubex-vlan immediate-leave
```

11.7.26. LEAF - Troubleshooting Commands

All related commands are listed in the Troubleshooting Commands section.

<END OF THE LEAF SWITCH CONFIGURATION>

11.8. Troubleshooting Commands

11.8.1. Enabling LLDP

The Command

Type and apply the following commands:

```
set protocols lldp interface all
```

Explanation

The LLDP setting is optional but it is helpful for further troubleshooting.

11.8.2. Querying LLDP Details

The Command

Type and apply the following command:

```
show lldp detail
```

Explanation

The query returns with the basic information about the LLDP.

11.8.3. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lldp neighbors et-0/0/4
```

Explanation

The query returns with the details of the LLDP partner which is connected to the `et-0/0/4` port.

11.8.4. Querying LLDP Statistics by Ports

The Command

Type and apply the following command:

```
show lldp statistics et-0/0/4
```

Explanation

The query returns with the statistics of the LLDP partner which is connected to the `et-0/0/4` port.

11.8.5. Verifying the Status of a LAG Interface

The Command

Type and apply the following command:

```
show interfaces ae0 terse
```

Explanation

The query returns with the status of the `ae0` LAG interface. When the link is **up**, the link aggregation (LACP) is working on the selected LAG interface.

11.8.6. Querying the Details of the Selected Interface Port

The Commands

Type and apply the following command:

```
show interfaces et-0/0/1 detail
```

```
show interfaces xe-0/0/32 detail
```

Explanation

The query returns with the details of the `et-0/0/1` and `xe-0/0/32` ports. The answers contain either that the inserted QSFP28 / QSFP+ / SFP / SFP+ module is supported or not by the switch.

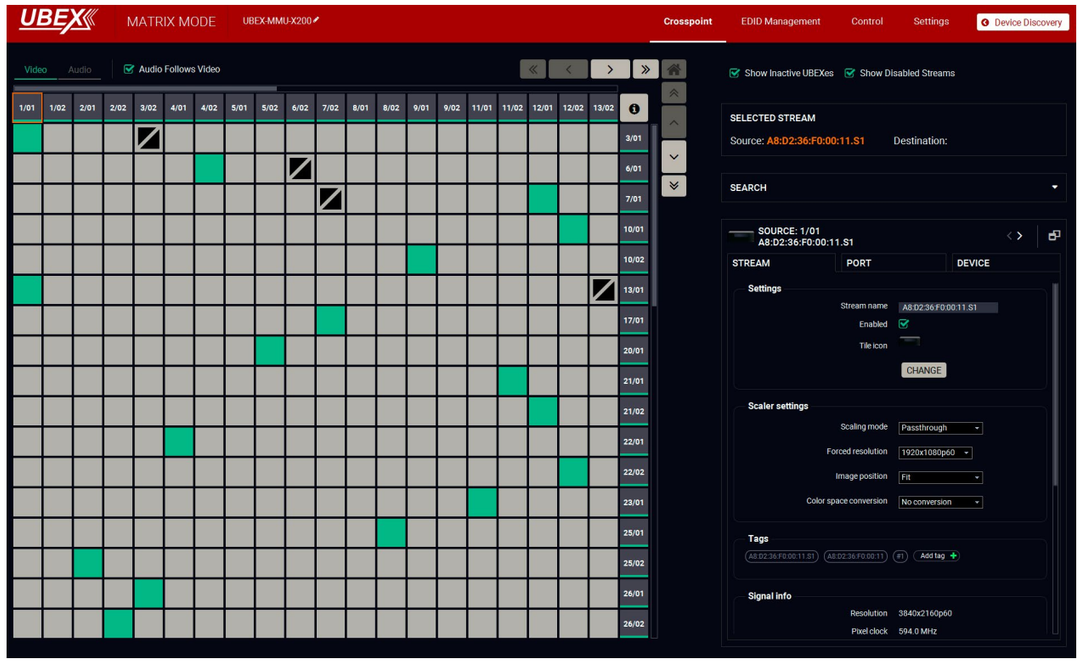
11.9. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

12

Configuration Steps - Mellanox SN2010

The following chapter describes and explains step-by-step the procedure of the configuration for the Mellanox SN2010 fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- First Steps
- Detailed Instructions
- Troubleshooting Commands
- Finalizing the Matrix

12.1. Description

This chapter helps you configure the Mellanox SN2010 managed switch for the UBEX matrix. The chassis of this model contains 18x 10G SFP+ slots and 4x 100G QSFP28 slots which are enough to serve 16 UBEX endpoints and an MMU and handle up to 32 source / destination devices. The switch is recommended for medium businesses.

12.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Mellanox SN2010	**1**	Onyx v3.8.1888
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**16**	latest released firmware version

12.3. First Steps

12.3.1. Configuring the Switch

At first time the switch needs to be configured locally by using the supplied console RJ45 adapter cable. Follow the instructions listed on the user manual of the vendor:

https://www.mellanox.com/files/doc-2020/onyx-eth-um.pdf

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

12.3.2. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

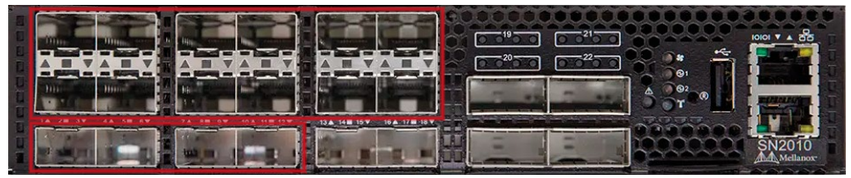
12.3.3. Installation of the Switch

Download the user's manual for the SN2010 model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

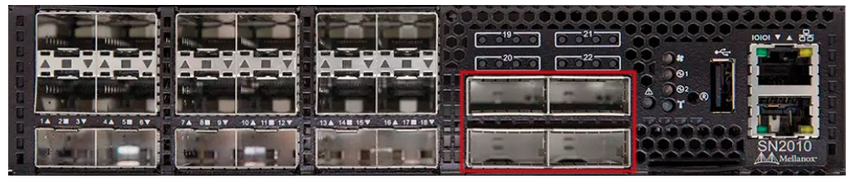
Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 16x 10GbE singlemode/multimode SFP+ transceiver modules and 16x singlemode/multimode fiber optical cables
- 16x 10GbE DAC cables



Step 3. Plug the cables between the UBEX endpoints and the switch based on the following options:

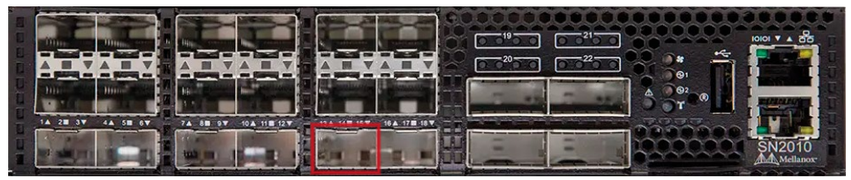
- 4x 40GbE QSFP+ AOC breakout cables
- 4x 40GbE QSFP+ DAC breakout cables



INFO: See more details about the connection possibilities for 40GbE QSFP+ slots in our **System Design Guide** document: https://lightware.com/media/lightware/filedownloader/file/Application-Note/System_Design_Guide_for_UBEX.pdf

Step 4. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable



Step 5. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **1000 Base-T management Ethernet port**:

12.4. Detailed Instructions

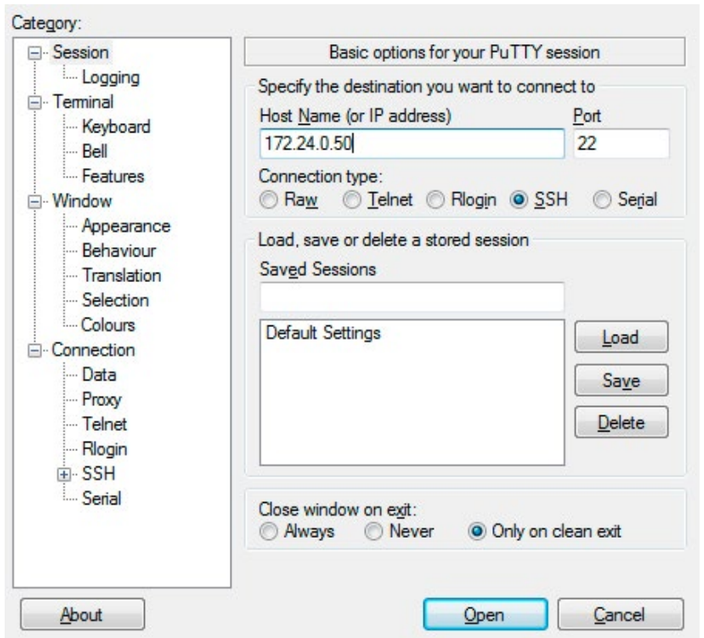
12.4.1. Setting up the Control Device

The Mellanox switch can be configured by protocol commands or by GUI. **The following instruction guide describes the protocol command method.**

You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the switch in our example: 172.24.0.50

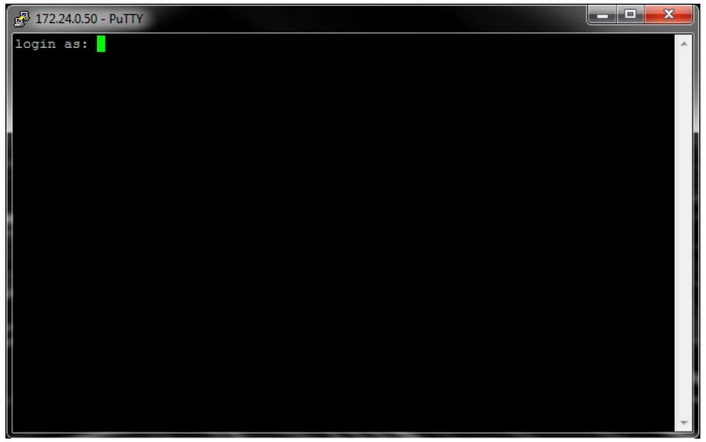
Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

12.4.2. Login to the Switch

Once the terminal window is opened, you can log in to the switch by the given user name and password (default user name: **admin**; default password: **admin**).



Login window in the Putty

After you logged in, the switch can be configured by protocol commands listed in the following sections.

12.4.3. Configuring the CLI Session

The Command

Type and apply the following command:

```
cli default prefix-modes enable
```

12.4.4. IP Address Setting

The Command

Type and apply the following commands:

```
no interface mgmt0 dhcp
interface mgmt0 ip address 172.24.0.50 /24
```

12.4.5. Default Gateway Setting

INFO: The command requires only in the case of the switch has to be accessed from different subnet.

The Command

Type and apply the following command:

```
ip route vrf default 0.0.0.0/0 172.24.0.1
```

12.4.6. QSFP+ Interface Split Configuration

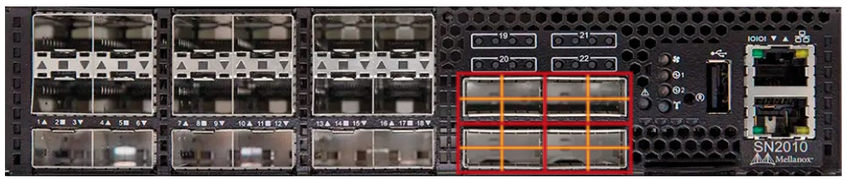
The Command

Type and apply the following commands:

Port ID	Command (in this example)
Port 19	`interface ethernet 1/19 module-type qsfp-split-4 force`
Port 20	`interface ethernet 1/20 module-type qsfp-split-4 force`
Port 21	`interface ethernet 1/21 module-type qsfp-split-4 force`
Port 22	`interface ethernet 1/22 module-type qsfp-split-4 force`

Explanation

The 40G QSFP+ slots need to be split to four 10G SFP+ slots for accepting the breakout cables and making connections with endpoint devices.



12.4.7. Switching on LACP

The Command

Type and apply the following command:

```
lacp
```

12.4.8. VLAN and IGMPv2 Configuration

The Command

Type and apply the following commands:

```
vlan 286
vlan 286 name "UBEX"
interface vlan 286
interface vlan 286 ip address 172.24.0.50/16 primary
ip igmp snooping unregistered multicast forward-to-mrouter-ports
ip igmp snooping version 2
ip igmp snooping
vlan 286 ip igmp snooping
vlan 286 ip igmp snooping querier query-interval 120
vlan 286 ip igmp snooping querier address 172.24.0.50
interface port-channel 1-16 ip igmp snooping fast-leave
```

Explanation

Registers VLAN number 286. Enables IGMPv2 snooping and the fast-leave feature which is required for the instant switching.

12.4.9. MTU Settings

The Command

Type and apply the following commands:

```
interface ethernet 1/1-1/18 mtu 9216 force
interface ethernet 1/1-1/2 mtu 9216 force
interface port-channel 1 mtu 9216 force
interface ethernet 1/19/1-1/19/4 mtu 9216 force
interface ethernet 1/20/1-1/20/4 mtu 9216 force
interface ethernet 1/21/1-1/21/4 mtu 9216 force
interface ethernet 1/22/1-1/22/4 mtu 9216 force
```

12.4.10. Creating Port Channels

The Command

Type and apply the following command:

```
interface port-channel 1-16
```

12.4.11. Interface Configuration for the MMU

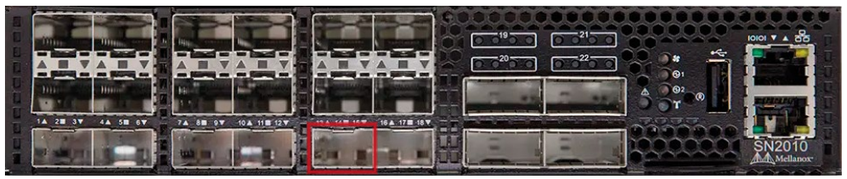
The Command

Type and apply the following commands:

```
interface ethernet 1/17 speed 1G force
interface ethernet 1/17 switchport mode hybrid
```

Explanation

The 1/17 port is an SFP+ port of the switch which are reserved for the connection of the MMU. The port accepts **SFP+** and **SFP** transceiver modules either. Connection with the MMU requires a 1GbE SFP transceiver module.



12.4.12. Interface Configuration for the Endpoints

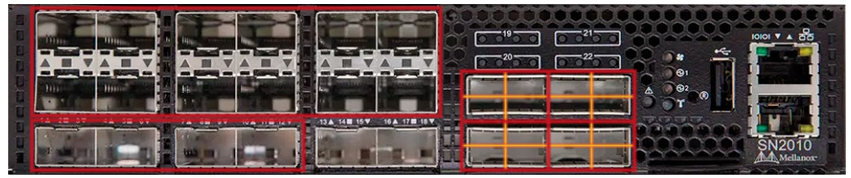
The Command

Type and apply the following commands for the desired interface ports:

```
interface ethernet 1/1-1/16 speed 10G force
interface ethernet 1/19/1-1/19/4 speed 10G force
interface ethernet 1/20/1-1/20/4 speed 10G force
interface ethernet 1/21/1-1/21/4 speed 10G force
interface ethernet 1/22/1-1/22/4 speed 10G force
```

Explanation

The Ethernet interfaces between 1/1 and 1/16 (SFP+ ports) are set to 10GbE transmission speed. The Ethernet interfaces between 1/19/1 and 1/22/4 are the split QSFP+ ports where the transmission speed is set to forced 10GbE.



12.4.13. Creating LAGs for the SFP+ Ports

The Command

Type and apply the following commands:

Channel group ID	Command (in this example)
Channel group 1	`interface ethernet 1/1-1/2 channel-group 1 mode active`
Channel group 2	`interface ethernet 1/3-1/4 channel-group 2 mode active`
	...
Channel group 8	`interface ethernet 1/15-1/16 channel-group 8 mode active`

Explanation

The SFP+ ports between the 1/1 and 1/16 are grouped by pairs to port channels, in this case between port-channel 1 to port-channel 8.

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

12.4.14. Creating LAGs for the QSFP+ Ports

The Command

Type and apply the following commands:

Channel group ID	Command (in this example)
Channel group 9	`interface ethernet 1/19/1-1/19/2 channel-group 9 mode active`
Channel group 10	`interface ethernet 1/19/3-1/19/4 channel-group 10 mode active`
...	
Channel group 16	`interface ethernet 1/22/3-1/22/4 channel-group 16 mode active`

Explanation

The QSFP+ ports between the 1/19/1 and 1/22/4 are grouped by pairs to port channels, in this case between port-channel 9 to port-channel 16.

The switch uses the IEEE 802.3ad-2005 Link Aggregation Control Protocol (in active mode) to combine 10G ports into 20G logical channels for the UBEX endpoint devices.

12.4.15. Port Channel Configuration for the Endpoints

The Commands

Type and apply the following commands for the desired interface ports:

Port channel ID	Command
Port channel 1	`interface port-channel 1 switchport mode trunk` `interface port-channel 1 description UBEX_LAG_1`
Port channel 2	`interface port-channel 2 switchport mode trunk` `interface port-channel 2 description UBEX_LAG_2`
...	
Port channel 16	`interface port-channel 16 switchport mode trunk` `interface port-channel 16 description UBEX_LAG_16`

12.4.16. Connecting the Port Channels to the VLAN

The Commands

Type and apply the following commands for the desired interface ports:

Port channel ID	Command
Port channel 1	`interface port-channel 1 switchport trunk allowed-vlan 286`
Port channel 2	`interface port-channel 2 switchport trunk allowed-vlan 286`
...	
Port channel 16	`interface port-channel 16 switchport trunk allowed-vlan 286`

12.4.17. Connecting the MMU to the VLAN

The Command

Type and apply the following commands:

```
interface ethernet 1/17 switchport hybrid allowed-vlan 286
```

ATTENTION! Always make sure that the your uplink port is **not** the part of the VLAN 286.

12.5. Troubleshooting Commands

12.5.1. Querying LLDP Partners

The Command

Type and apply the following command:

```
show lacp interfaces neighbor
```

Explanation

The query returns with the list of connected UBEX devices (which MAC address of the UBEX endpoint is on the ports of switch).

12.5.2. Querying LLDP Details by Ports

The Command

Type and apply the following command:

```
show lacp interfaces ethernet 1/1
```

Explanation

The query returns with the details of the LLDP partner which is connected to the Ethernet 1/1 port.

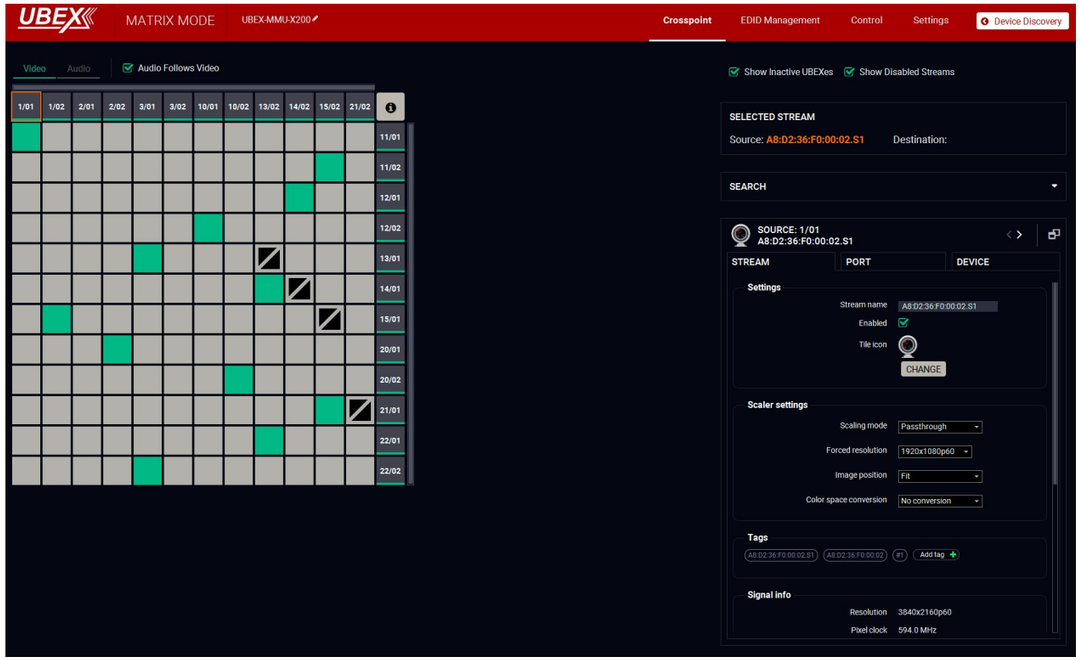
12.6. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

13

Configuration Steps - Arista 7050SX3-48YC8

The following chapter describes and explains step-by-step the procedure of the configuration for the Arista 7050SX3-48YC8 fully managed network switch:

- Description
- The Configuration of the UBEX Matrix
- First Steps
- Detailed Instructions
- Troubleshooting Commands
- Finalizing the Matrix

13.1. Description

This chapter helps you configure the Arista 7050SX3-48YC8 managed switch for the UBEX matrix. The chassis of this model contains 48x 25G/10G SFP+ and 8x QSFP28 port slots which are enough to serve 31 UBEX endpoints and an MMU and handle up to 62 source / destination devices. The switch is recommended for medium businesses.

ATTENTION! The switch supports **up to 64 pcs 10G connections**.

13.2. The Configuration of the UBEX Matrix

For the sake of simplicity the configuration steps of the switch are explained through a valid UBEX matrix example which contains:

Device	Pieces	Firmware version
Arista 7050SX3-48YC8	**1**	EOS-4.26.4M
UBEX-MMU-X200	**1**	latest released firmware version
UBEX F-series/R-series endpoints	**31**	latest released firmware version

13.3. First Steps

13.3.1. Configuring the Switch

At first time the switch needs to be configured locally by using the supplied RJ-45 male-to-DB-9 serial adapter. Follow the instructions listed on the website of the vendor:

https://www.arista.com/assets/data/pdf/qsg/qsg-books/QS_7050_1RU_Gen3.pdf

Set an IP address for the Management Ethernet port to be able to connect it and to set up the device for the UBEX network.

13.3.2. Installation of the UBEX Devices

The installation steps of the endpoint and the MMU devices can be found in the Connections section.

13.3.3. Installation of the Switch

Download the user's manual for the Arista 7050SX3-48YC8 model from the website of the vendor and follow the instructions.

Step 1. Install the switch correctly based on the instructions of the model.

Step 2. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 92x 10GbE singlemode/multimode SFP+ transceiver modules and 46x singlemode/multimode fiber optical cables
- 46x 10GbE DAC cables

Step 3. Plug the cables between the UBEX MMU and the switch based on the following options:

- 1x 1GbE singlemode/multimode SFP transceiver module and a singlemode/multimode fiber optical cable
- 1x 1GbE DAC cable

Step 4. Plug the cables between the UBEX endpoints and the switch based on the following options:

- 4x 40GbE QSFP+ AOC breakout cables
- 4x 40GbE QSFP+ DAC breakout cables

INFO: 4 pcs 100GbE QSFP28 ports out of the total 8 ones can be used for UBEX endpoint connections due to the port limitation of the switch.

Step 5. Connect a control device (e.g. a laptop) to the switch with a CATx cable to the **Management Ethernet port**:

13.4. Detailed Instructions

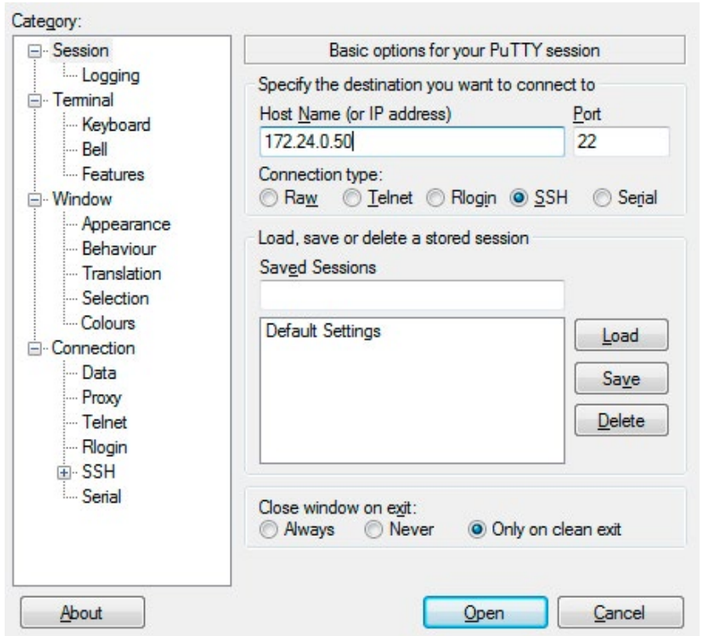
13.4.1. Setting up the Control Device

The Arista switch can be configured by protocol commands or by GUI. **The following instruction guide describes the protocol command method.**

You need to install a terminal application to your control device, for example **Putty** or **CLI**.

The IP address of the switch in our example: 172.24.0.50

Open the terminal application (e.g. Putty), add the IP address of the switch and open it.



Putty terminal window

13.4.2. Cancelling Zero Touch Configuration

This step initiates a switch reboot.

The Command

Type and apply the following command:

```
localhost>zerotouch cancel
```

After the switch boots, log into the switch again by typing admin at the login prompt.

The Command

Type and apply the following command:

```
localhost login:admin
```

13.4.3. Entering to Global Configuration Mode

The Commands

Type and apply the following commands:

```
localhost>enable
config
```

13.4.4. Assigning a Password

The Command

Type and apply the following command:

```
username admin secret mypassword
```

13.4.5. Enabling DHCP.

The Commands

Type and apply the following commands:

```
no ip routing
interface management 1
ip address dhcp
exit
```

13.4.6. Querying the IP Address of the Switch

The Command

Type and apply the following command:

```
show interfaces management 1
```

After the command runs, the actual IP address and the port number of the switch is revealed in the "Internet address is..." line.

13.4.7. Creating VLAN

The Command

Type and apply the following command:

```
vlan 286
    name UBEX
exit
```

Explanation

The VLAN ID 286 has been created now and named UBEX.

13.4.8. IGMPv2 Setting

The Commands

Type and apply the following commands:

```
ip igmp snooping vlan 286 querier
ip igmp snooping vlan 286 querier version 2
ip igmp snooping vlan 286 fast-leave
ip igmp snooping querier address 0.0.0.0
no ip igmp snooping vlan 1
ip igmp snooping restart query-interval 2
```

13.4.9. Load Balance Settings

The Commands

Type and apply the following commands:

```
port-channel load-balance trident fields mac src-mac
port-channel load-balance trident fields mac ingress-interface disabled
```

13.4.10. Spanning Tree Mode Setting

The Command

Type and apply the following command:

```
spanning-tree mode mstp
```

Multiple Spanning Tree (MST) was created to allow for multiple spanning tree topologies while preserving scalability. MST enables an administrator to map an arbitrary number of VLANs to a single MST instance, resulting in the minimum number of instances needed to satisfy a design.

13.4.11. Port Channel Configuration

The Commands

Type and apply the following commands for the desired port channels:

Port Channel Index	Command

Port Channel 1	`interface Port-Channel1`
	`  switchport trunk allowed vlan 1,286`
	`  switchport mode trunk`
	`  exit`

Port Channel 2	`interface Port-Channel2`
	`  switchport trunk allowed vlan 1,286`
	`  switchport mode trunk`
	`  exit`

...	...

Port Channel 32	`interface Port-Channel38`
	`  switchport trunk allowed vlan 1,286`
	`  switchport mode trunk`
	`  exit`

Explanation

Port channels between 1 and 38 is configured and VLAN 286 is applied on them.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

13.4.12. Interface Configuration for the Endpoints (SFP+ Ports)

The Commands

DIFFERENCE: The following commands belongs to the **SFP+** ports of the switch only.

Type and apply the following commands for the desired interface ports:

Channel-group Index	Command
Channel-group 1	interface Ethernet1 speed forced 10000full switchport mode trunk channel-group 1 mode active lacp timer fast exit
	interface Ethernet2 speed forced 10000full switchport mode trunk channel-group 1 mode active lacp timer fast exit
Channel-group 2	interface Ethernet3 speed forced 10000full switchport mode trunk channel-group 2 mode active lacp timer fast exit
	interface Ethernet4 speed forced 10000full switchport mode trunk channel-group 2 mode active lacp timer fast exit
...	...
...	...
Channel-group 23	interface Ethernet45 speed forced 10000full switchport mode trunk channel-group 23 mode active lacp timer fast exit
	interface Ethernet46 speed forced 10000full switchport mode trunk channel-group 23 mode active lacp timer fast exit

Explanation

The ports between the 1 and 46 are grouped by pairs to port-channels, in this case between channel-group 1 to channel-group 23.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

13.4.13. Interface Configuration for the MMU

The Commands

DIFFERENCE: The following commands belongs to the SFP+ ports of the switch only.

Type and apply the following commands for the desired interface ports:

```
interface Ethernet48
   speed forced 1000full
   switchport trunk allowed vlan 1,286
   switchport mode trunk
```

Explanation

Ethernet interface 48 is created to the port where the MMU is connected to the switch.

13.4.14. Interface Configuration for the Endpoints (QSFP28 Ports)

The Commands

DIFFERENCE: The following commands belongs to the **QSFP28** ports of the switch only.

The 40G QSFP28 slots need to be split to four 10G SFP+ slots for accepting the breakout cables and making connections with endpoint devices.

The ports are ordered to 2 pools:

- Pool1 consists of interfaces Ethernet1-24, 49/1 - 52/4
- Pool2 consists of interfaces Ethernet25-48, 53/1 - 56/4

Breakout of the 40G QSFP28 Ports

ATTENTION! Due to the port limition of the switch, only four QSFP28 ports out of the eight ones can be used for endpoint connections. The **Ethernet Port 49-50 and 53-54** are configured and to be split to four 10G SFP+ breakouts in our example.

The steps of the configuration in order of the success breakout procedure:

Step 1. Set to 10G the first interface of the Ethernet Port 49-50 and 53-54.

Channel-group Index	Command

Channel-group 25	`interface Ethernet49/1`
	`speed forced 10000full`
	`switchport mode trunk`
	`channel-group 25 mode active`
	`lacp timer fast`
	`exit`

Channel-group 27	`interface Ethernet50/1`
	`speed forced 10000full`
	`switchport mode trunk`
	`channel-group 27 mode active`
	`lacp timer fast`
	`exit`

Channel-group 29	`interface Ethernet53/1`
	`speed forced 10000full`
	`switchport mode trunk`
	`channel-group 29 mode active`
	`lacp timer fast`
	`exit`

Channel-group 31	`interface Ethernet54/1`
	`speed forced 10000full`
	`switchport mode trunk`
	`channel-group 31 mode active`
	`lacp timer fast`
	`exit`

Step 2. Save the recent configuration and reboot/restart the switch. The re-allocation of the interface ports will be set automatically.

```
copy running-config startup-config
reload
```

Step 3. Set to 10G the rest of the interface ports by the following commands:

Channel-group Index	Command
Channel-group 25	interface Ethernet49/2 speed forced 10000full switchport mode trunk channel-group 25 mode active lacp timer fast exit
Channel-group 26	interface Ethernet49/3 speed forced 10000full switchport mode trunk channel-group 26 mode active lacp timer fast exit
	interface Ethernet49/4 speed forced 10000full switchport mode trunk channel-group 26 mode active lacp timer fast exit
...	...
Channel-group 31	interface Ethernet54/2 speed forced 10000full switchport mode trunk channel-group 31 mode active lacp timer fast exit
Channel-group 32	interface Ethernet54/3 speed forced 10000full switchport mode trunk channel-group 32 mode active lacp timer fast exit
	interface Ethernet54/4 speed forced 10000full switchport mode trunk channel-group 32 mode active lacp timer fast exit

Step 4. Check the configuration with the following command:

```
show platform trident interface map full
```

Explanation

The 40G QSFP+ slots need to split to four 10G SFP+ slots for accepting the breakout cables and making connections with endpoint devices.

TIPS AND TRICKS: The recurring commands can be scripted (e.g. in Python) and run in batch in a capable terminal application (e.g. YAT).

13.4.15. LLDP Setting

The Commands

Type and apply the following commands:

```
lldp tlv transmit link-aggregation
hostname Arista-7050SX3
lldp run
```

13.5. Troubleshooting Commands

13.5.1. Enabling the Troubleshooting Commands

The Command

Type and apply the following command:

```
enable
```

After this command the following queries can be run on the switch.

13.5.2. Querying the IP Address of the Switch

The Command

Type and apply the following command:

```
show interfaces management 1
```

After the command runs, the actual IP address and the port number of the switch is revealed in the "Internet address is..." line.

13.5.3. Querying the Status of All Ports

The Command

Type and apply the following command:

```
show platform trident interface map full
```

The query returns the actual status of all ports of the switch and especially the right configuration of the 100G QSFP28 ports can be checked.

13.5.4. Querying the Local LLDP Parameters

The Command

Type and apply the following command:

```
show lldp local-info |no-more
```

13.5.5. Querying LLDP Partners

The Command

Type and apply the following command:

```
show lldp neighbors
```

Explanation

The query returns with the list of connected UBEX devices (which MAC address of the UBEX endpoint is on the ports of switch).

13.5.6. Querying LLDP Partners by Ports

The Command

Type and apply the following command:

```
show lldp neighbors Ethernet 1
```

Explanation

The query returns with the connected UBEX device (which MAC address of the UBEX endpoint is on the ports of switch).

13.5.7. Querying the Details of the Selected Interface Port

The Command

Type and apply the following command:

```
show interfaces Ethernet 1
```

13.5.8. Querying the Details of the Selected Port Channel

The Command

Type and apply the following command:

```
show interfaces port-Channel 1
```

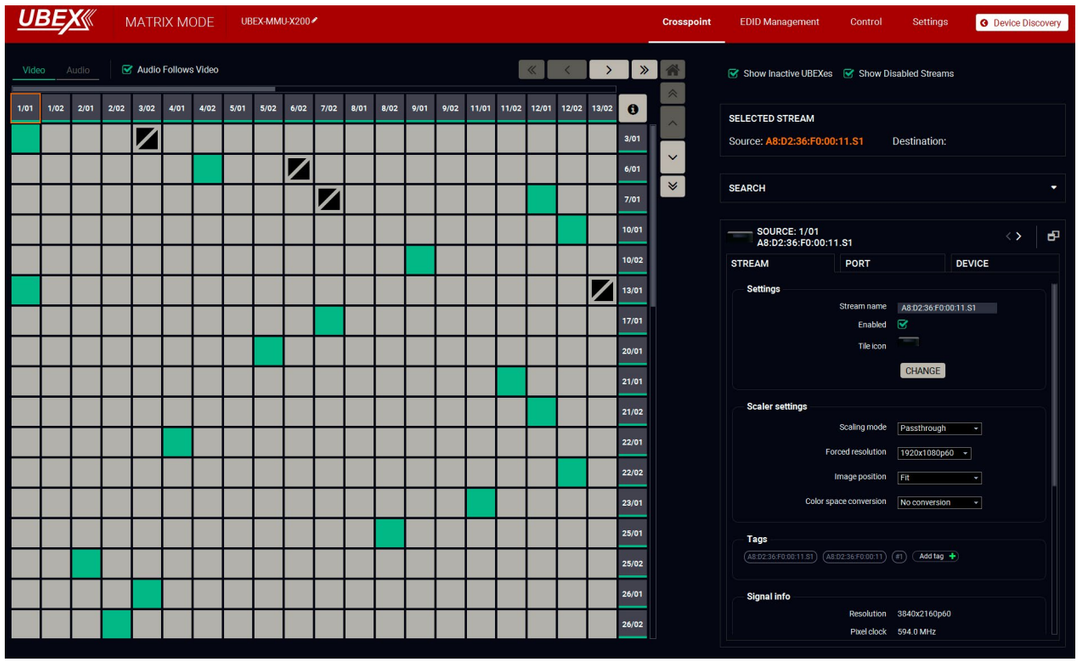
13.6. Finalizing the Matrix

The UBEX AV matrix is ready to use now.

The Lightware Device Controller software

Download the Lightware Device Controller (LDC) software from the website (www.lightware.com) to control the matrix. Install the software to a control system (e.g. a laptop). Establish the connection between the Matrix Management Unit (MMU) and the computer via Ethernet, or RS-232 interface.

Open the LDC and find the MMU in the Device discovery list. Double click on the name of the MMU to connect. The matrix crosspoint menu opens where you can configure the video system and see all information about the network.



LDC crosspoint menu

14

UBEX Test Lab

This chapter describes the experiences collected in our 24/7 testing laboratory using multifarious network environments and different AV equipments.

- Introduction
- The Concept
- The Elements of the Test
- The 10 GbE Matrix
- The 20 GbE Matrix

14.1. Introduction

We, at Lightware are proud of all advertised features and properties of our products are tested in our 24/7 laboratory to create perfect AV systems.

The UBEX matrix is one of the most complex AV product family which is developed by Lightware. The Test Engineering Team must specify complicated test cases with various AV peripheries and install the UBEX system into different network environments.

Hundreds of DAC cables run into the Juniper switches in the 24/7 testing room

UBEX Matrix Configurations

Two main UBEX matrix configurations were built and tested in the testing room beside of some smaller ones for special tester/developer jobs:

- **10 Gbps matrix**: stress test for the MMU in the matrix control point of view. See the layout of the architecture in The 10 GbE Matrix section.
- **20 Gbps matrix**: stress test for the MMU and the endpoint devices in the video transmission point of view. See the layout of the architecture in The 20 GbE Matrix section.

The third system was a simulated logical UBEX matrix which was run on a computer - it functioned as the control point beside of the real ones.

14.2. The Concept

The basic idea is building up a real matrix and a simulated one, both have exactly the same parameters. The two systems are controlled by the same LW3 commands in the same time. The answers of the commands are compared by the comparator software. If their status are not equal, one of the system has failure.

UBEX endpoints wait for the passed test result

All communication between the elements of the system is logged and analyzed after every test sequences. If the problem is deterministic, the failure status can be duplicated by resending the commands based on the system log files.

14.3. The Elements of the Test

More software elements have been made for the UBEX test which are done the bigger/smaller subtasks.

Test Case Commands

LW3 commands which modify the status of the MMU and the endpoints. See the details in the Test Cases section.

Message Repeater / Distributor

The component duplicates all test case commands - one is for the real UBEX matrix, another one is for simulated system.

MMU Model

The virtual Matrix Management Unit (MMU). Its functionality and features are similar like the real one but it is more simple because the persistence and the other network communication is unnecessary in the test point of view.

Endpoint Model

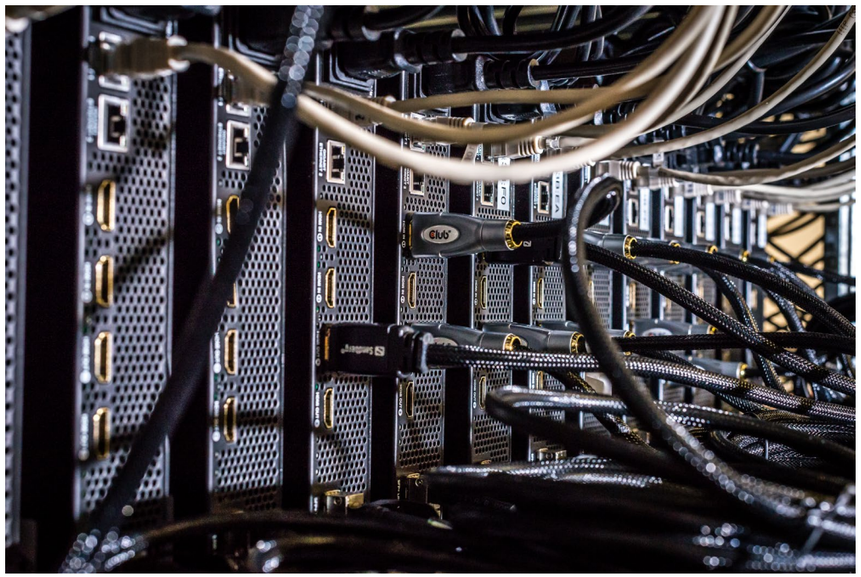
This component consists of a database which copies the internal states of a real endpoint, and some parts of its internal logic, that describes the connections between certain settings.

Comparator

The comparator queries the actual status of the MMU and compares it to the MMU model. In the case of difference the comparator notifies the test engineer about the catch.

Emulated Endpoint

LW3 servers which can model the entire functionality and the inner status of the real endpoint in the MMU point of view. Managing of the emulated endpoints can provide realistic stress test but they does not require building a physical network capable of video transmission.



One of the tested UBEX matrix under construction

Additional advantage of the emulated endpoints is that a special failure status can be generated as well. These cases help for the software developers preparing the UBEX devices for any specific situation in the future.

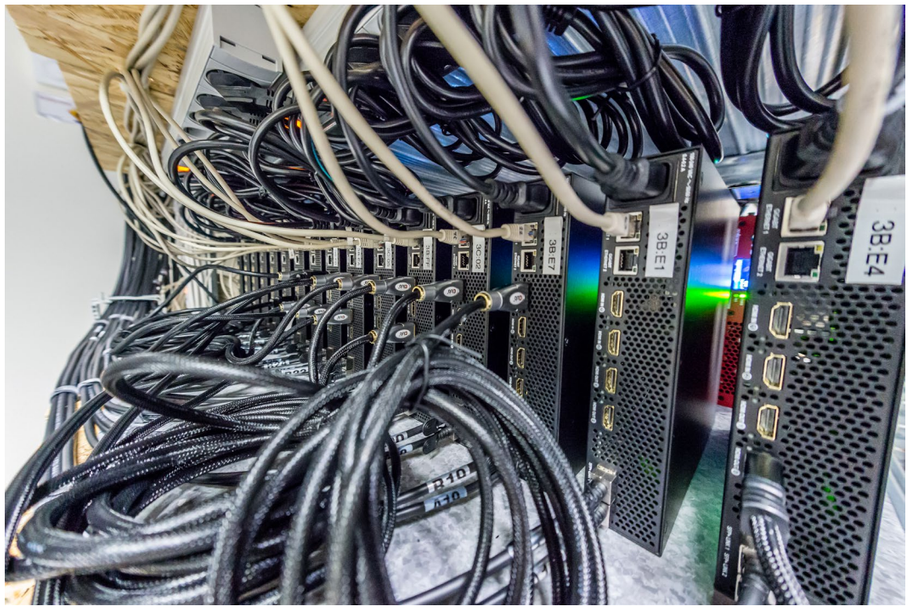
14.3.1. Test Cases

This section describes some significant test cases which were applied in the UBEX systems as listed above.

- **Restarting of the endpoints in random times**: the MMU must detect the disappearance of the devices from the network, must establish the connection as the endpoints are rebooted, and restore the last configuration for the right device.
- **Operation mode changing in random endpoints**: the MMU must configure the Device Map, must detect and invalidate the ceased video streams in the receivers, and must add the new streams to the crosspoints.
- **Virtual crosspoint status changing**: the MMU must set the source stream on the receiver based on the actual Device Map.

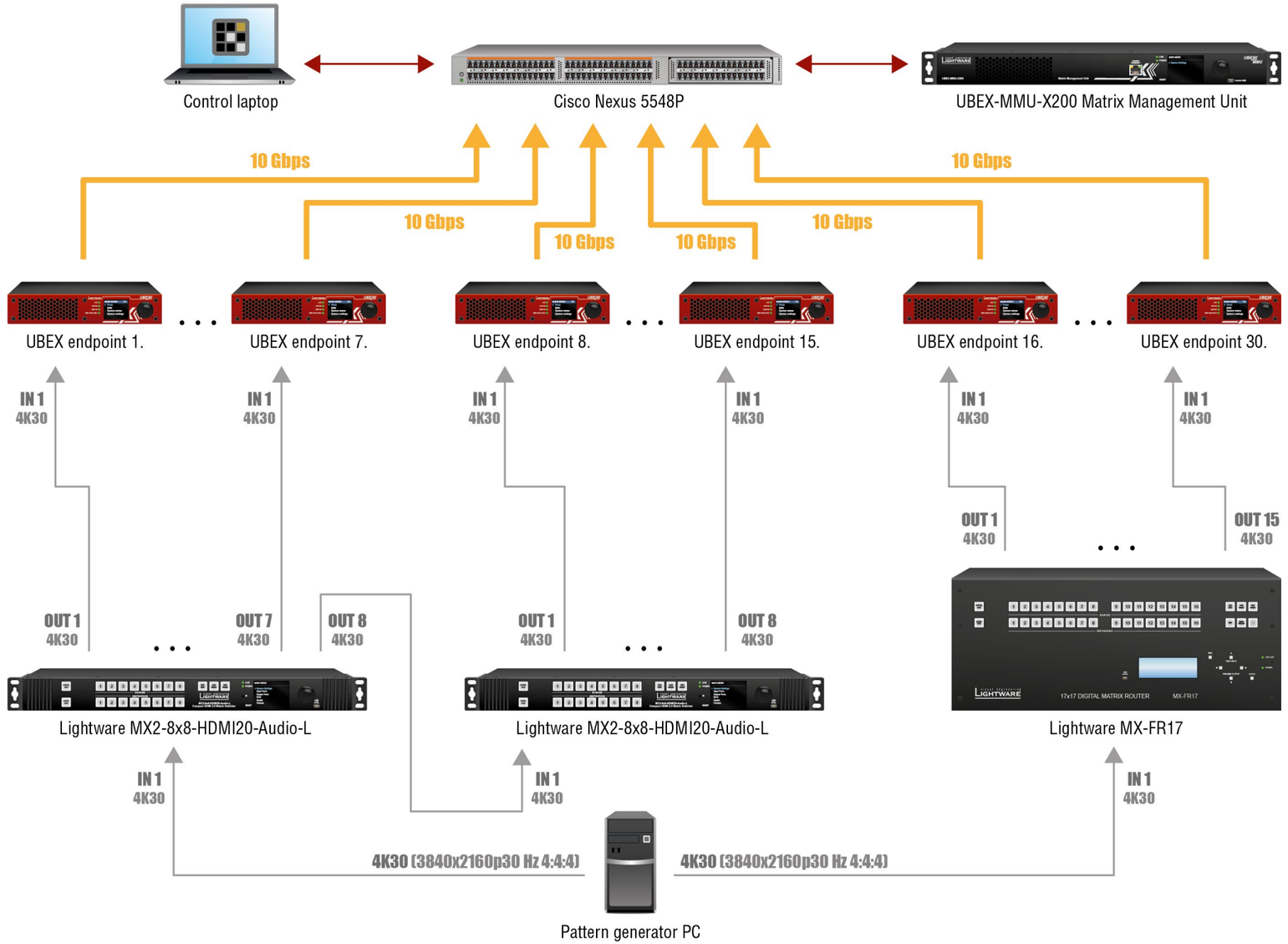
14.3.2. Self-Diagnostics

The firmwares of the MMU and the endpoints contain a self-diagnostic software as well. The log files which were created during the tests were saved and analyzed. This procedure helped for the software developers to find the causes of the temporary loss of functions and eliminate them.



Curly HDMI and DAC cables meanders between the endpoint devices

14.4. The 10 GbE Matrix



The 10 GbE UBEX test matrix

14.4.1. The Architecture of the Matrix

The matrix is built with 30 UBEX endpoints and a Matrix Management Unit (MMU). The network switch is a Cisco Nexus 5548P with 48 pcs 10GbE SFP+ ports. The matrix is controlled by the MMU, the control commands are sent from a laptop which runs the LDC software.

All UBEX endpoints receive **4K UHD 30** (3840x2160p30 Hz 4:4:4) video signal on their HDMI in 1 ports (the HDMI in 2 port is not used in this test). The source is a pattern generator PC which transmits 4K30 signal on both output ports. The HDMI signal is distributed by 2 pcs Lightware MX2-8x8-HDMI20-Audio-L matrix switcher and a Lightware MX-FR17 modular matrix switcher built with HDMI input and output I/O boards.

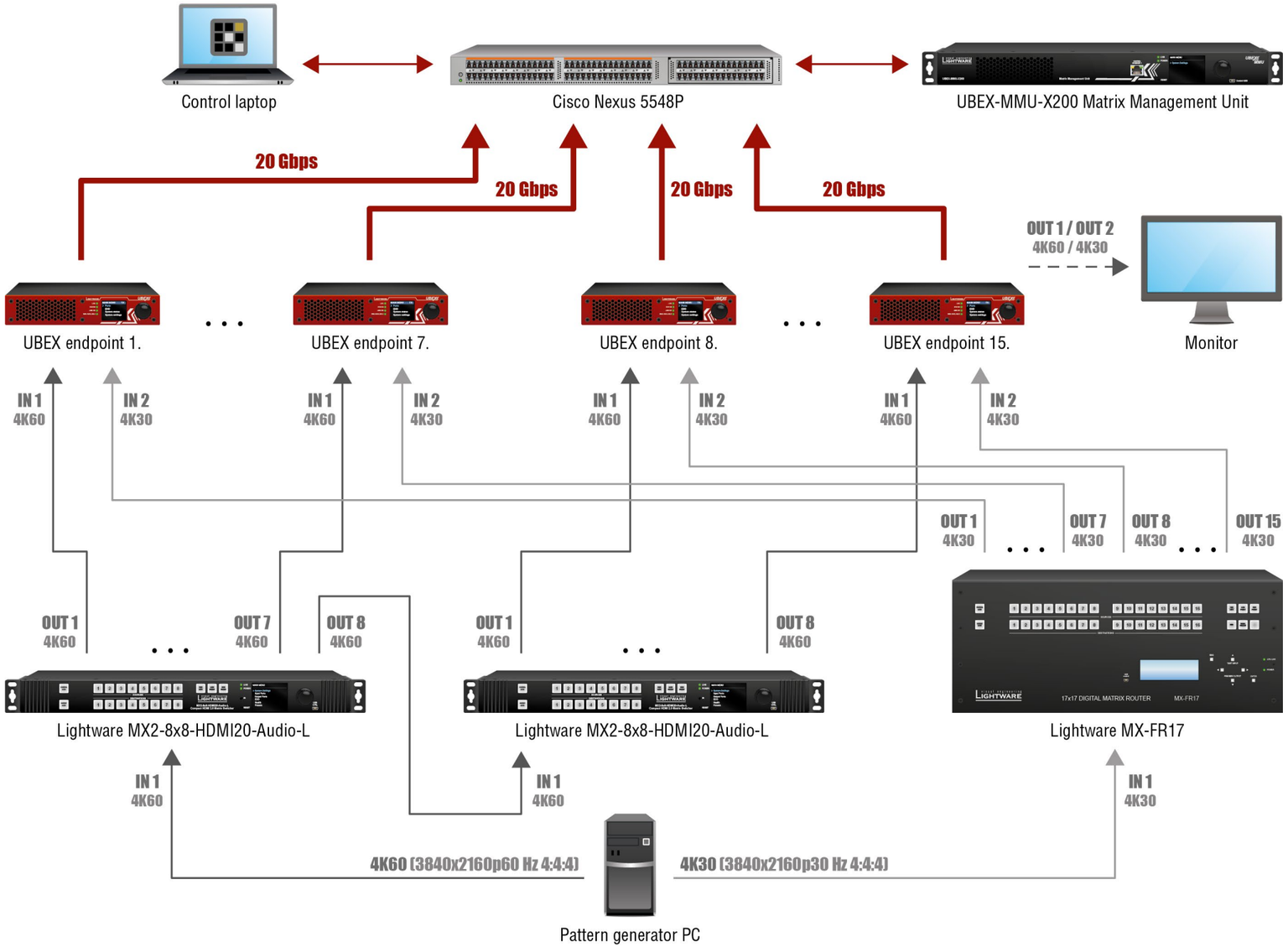
Each UBEX endpoint is installed with one 10 GbE SFP+ module or DAC cable which is enough to transmit the 4K30 signal.

14.4.2. Test Equipment

The following table lists the most important parts of the test equipment which are installed in the UBEX matrix.

Device	Pcs	Description
MX2-8x8-HDMI20-Audio-L	2	8x8 matrix switcher with HDMI 2.0 support
MX-FR17	1	Modular multimedia matrix switcher up to 16 inputs and 16 outputs
Cisco Nexus 5548P	1	Layer 3 managed switch with 32+16 10G SFP+ ports
Club 3D HDMI cable	33	Premium high speed HDMI 2.0 4K60Hz UHD cable, 5m
Finisar FTLX8571D3BCL	12	10Gb/s 850nm multimode SFP+ transceiver module
Finisar FTLX1471D3BCL	16	10Gb/s 1310nm singlemode SFP+ transceiver module
Fiberstore OM3 50/125	6	OM3 50/125 850nm multimode fiber optical cable with LC connectors, 5m
Prysmian Group Draka BendBright-XS 60019441	8	OS2 1310nm singlemode fiber optical cable with LC connectors, 15m
Fiberstore SFPP-PC05	16	10G SFP+ DAC cable, 5m

14.5. The 20 GbE Matrix



The 20 GbE UBEX test matrix

14.5.1. The Architecture of the Matrix

The matrix is built with 15 UBEX endpoints and a Matrix Management Unit (MMU). The network switch is a Cisco Nexus 5548P with 48 pcs 10GbE SFP+ ports. The matrix is controlled by the MMU, the control commands are sent from a laptop which runs the LDC software.

All UBEX endpoints receive a **4K UHD 60** (3840x2160p60 Hz 4:4:4) video signal on their HDMI in 1 ports and a **4K UHD 30** (3840x2160p30 Hz 4:4:4) video signal on their HDMI in 2 ports. The source is a pattern generator PC which transmits the 4K60 and 4K30 signal on the output ports. The HDMI signal is distributed by 2 pcs Lightware MX2-8x8-HDMI20-Audio-L matrix switcher and a Lightware MX-FR17 modular matrix switcher built with HDMI input and output I/O boards.

Each UBEX endpoint is installed with two 10 GbE SFP+ modules or DAC cables which are able to support the successful transmission of the 4K60 and 4K30 video signals together.

14.5.2. Test Equipment

The following table lists the most important parts of the test equipment which are installed in the UBEX matrix.

Device	Pcs	Description
MX2-8x8-HDMI20-Audio-L	2	8x8 matrix switcher with HDMI 2.0 support
MX-FR17	1	Modular multimedia matrix switcher up to 16 inputs and 16 outputs
Cisco Nexus 5548P	1	Layer 3 managed switch with 32+16 10G SFP+ ports
Club 3D HDMI cable	33	Premium high speed HDMI 2.0 4K60Hz UHD cable, 5m
Finisar FTLX8571D3BCL	20	10Gb/s 850nm multimode SFP+ transceiver module
Finisar FTLX1471D3BCL	8	10Gb/s 1310nm singlemode SFP+ transceiver module
Fiberstore OM3 50/125	10	OM3 50/125 850nm multimode fiber optical cable with LC connectors, 5m
Prysmian Group Draka BendBright-XS 60019441	4	OS2 1310nm singlemode fiber optical cable with LC connectors, 15m
Fiberstore SFPP-PC05	16	10G SFP+ DAC cable, 5m