MultiVES and miniVES

fiber optic network manual

V1.1

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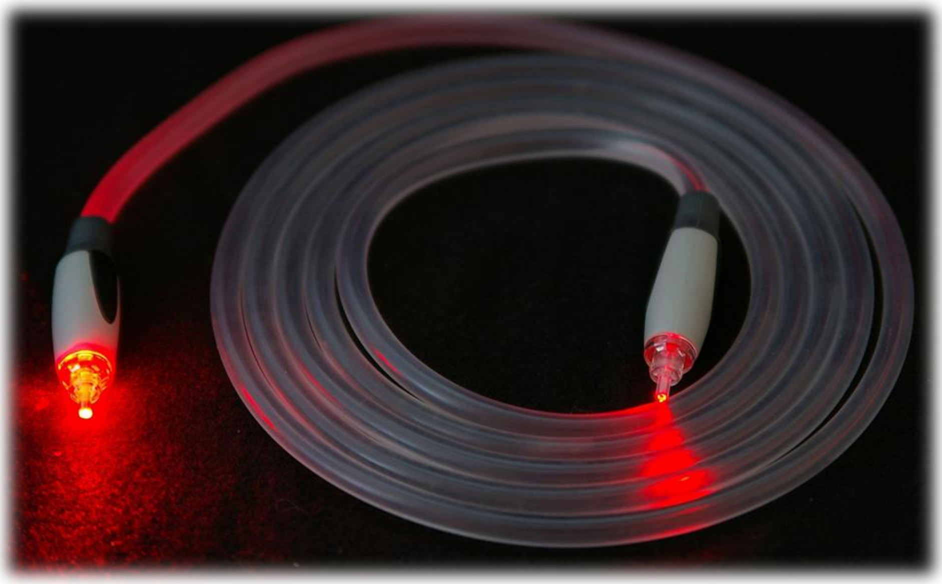
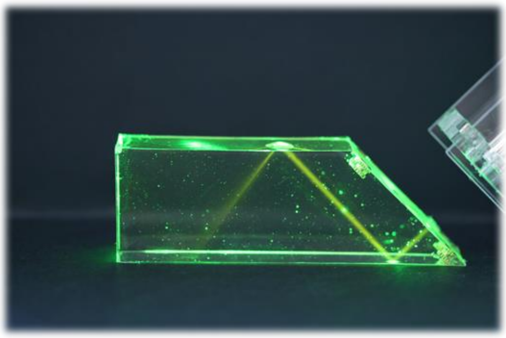
What is fiber optic cable?

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

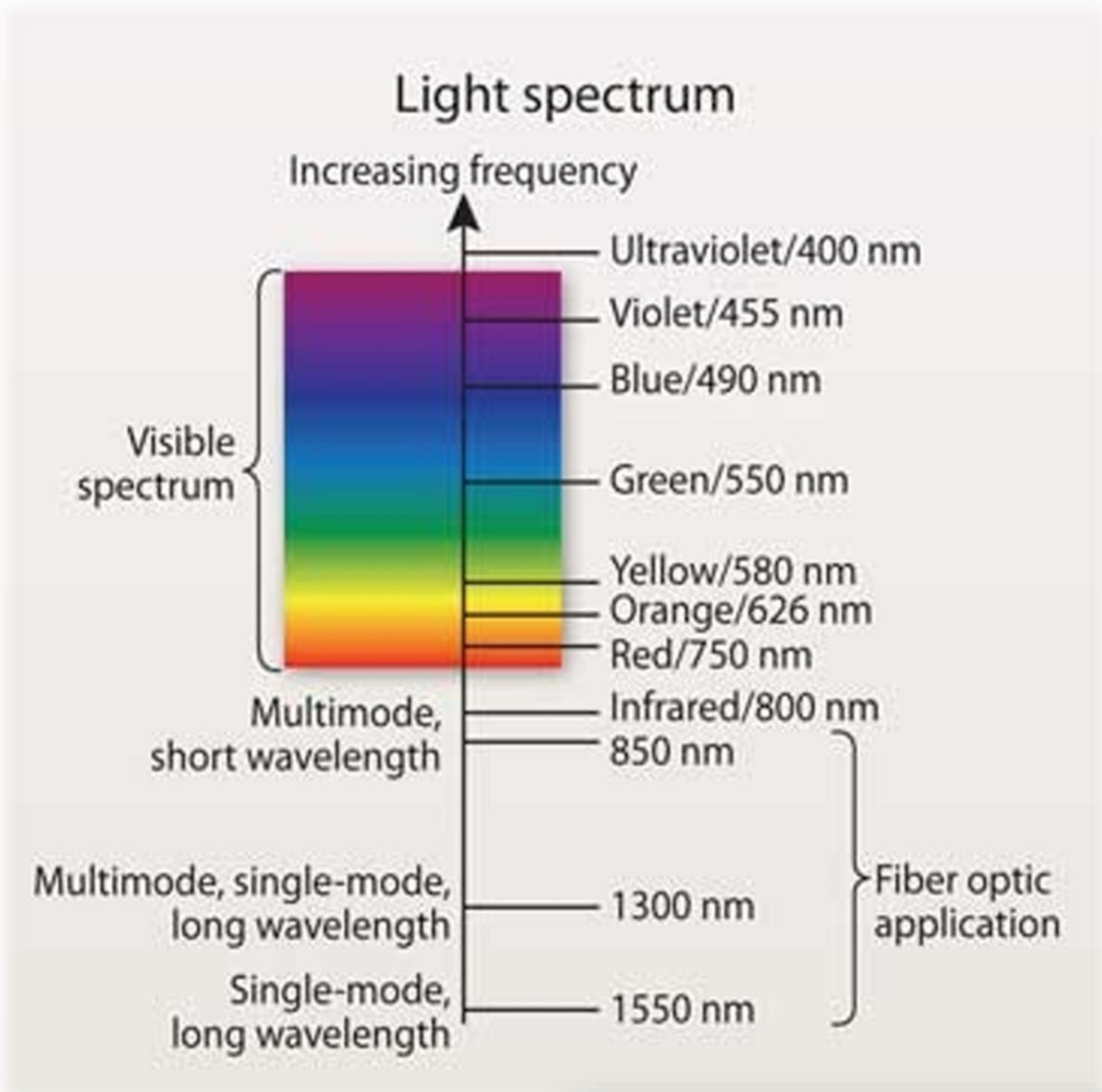
Fiber optic cable is used to transmit data by light impulses thru glass core in cable. Benefits of this technology are:

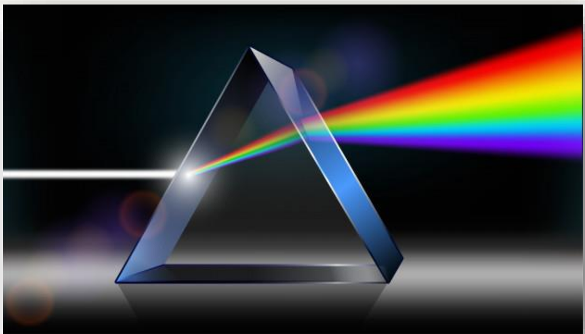
- No electromagnetic interference
- Data can be transmitted for over 160km on single connection
- Simplified wiring





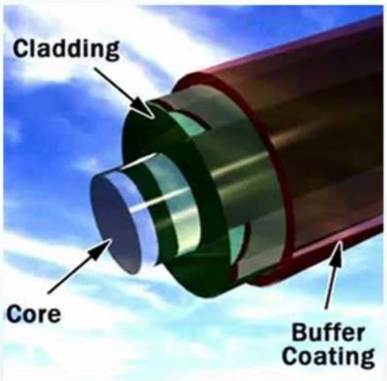
Fiber optic networks works is infrared wavelengths range, beyond the sensitivity of the human eye. Light in fiber optic cable cannot be seen by human eye

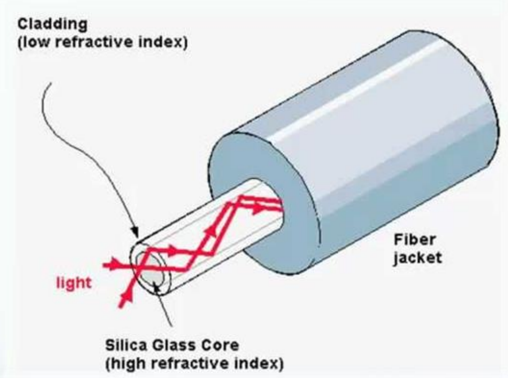




Fiber optic cable is constructed from glass core, glass cladding and coating, which protect fragile glass inside.

Structure of Optical Fiber

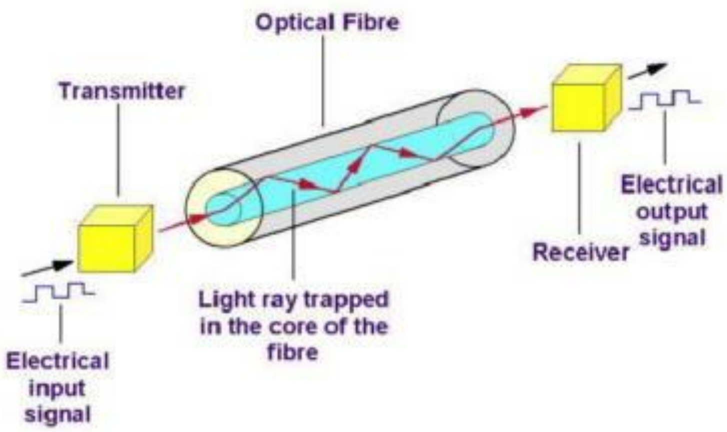




- Core – Higher refractive index
- Cladding – Lower refractive index
- Buffer Coating – Mechanical protection

Core is made from extremely pure fused silica, which provides very low optical loss on long distance transmission

Refractive index difference between core and cladding results as mirror-like surface, which reflect light inside with almost no loss.

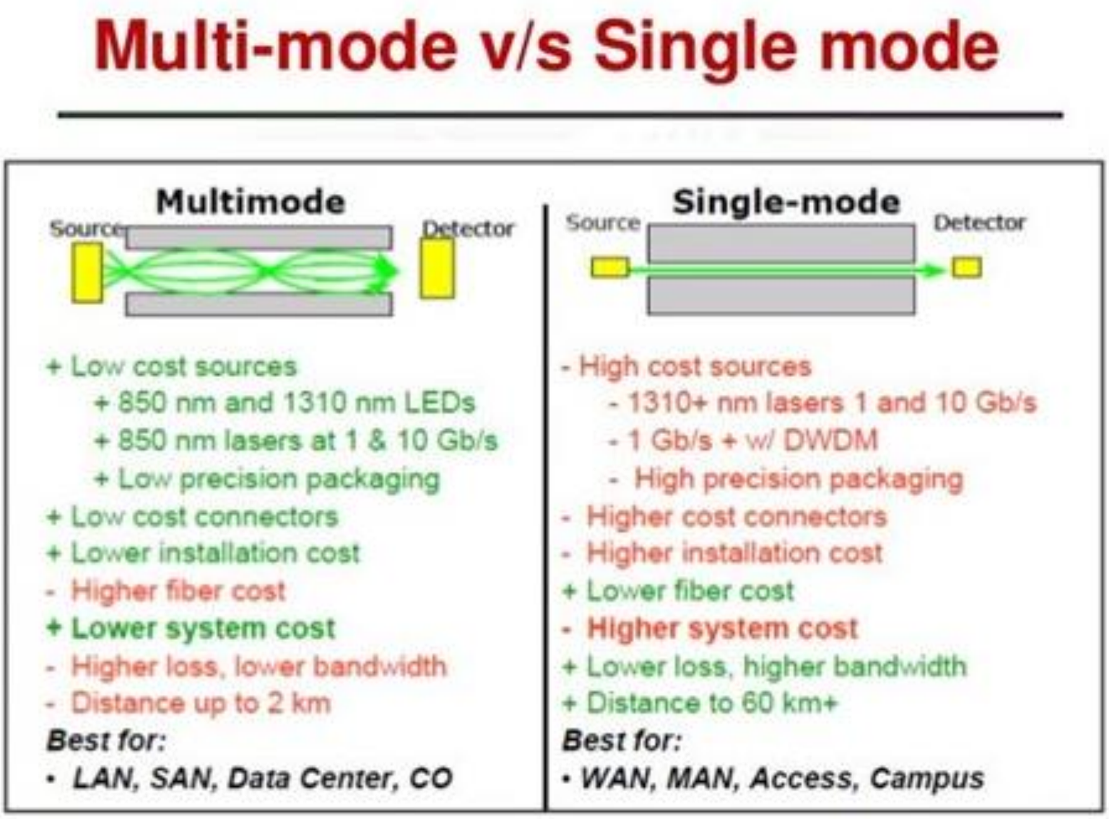


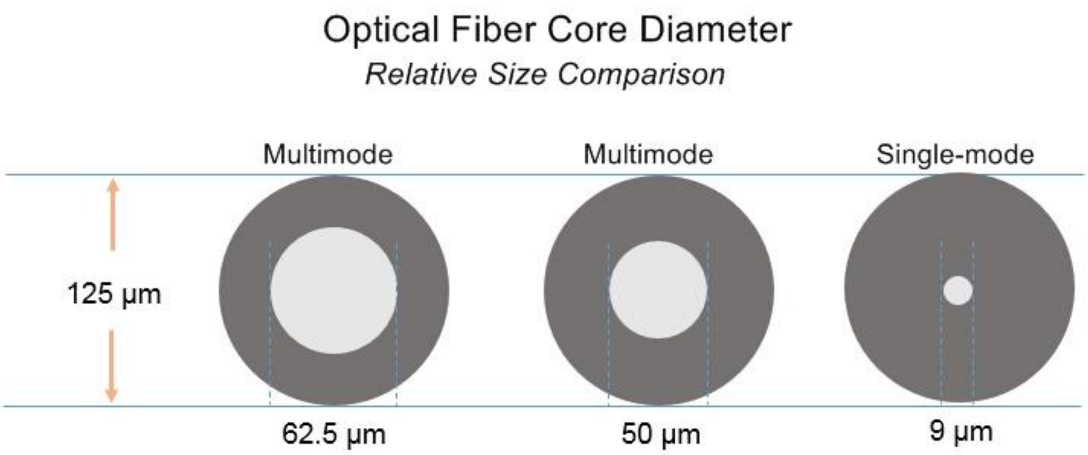
Fiber optic cable types

Fiber optic cables can be divided into two groups:

- Single mode fiber optic cable

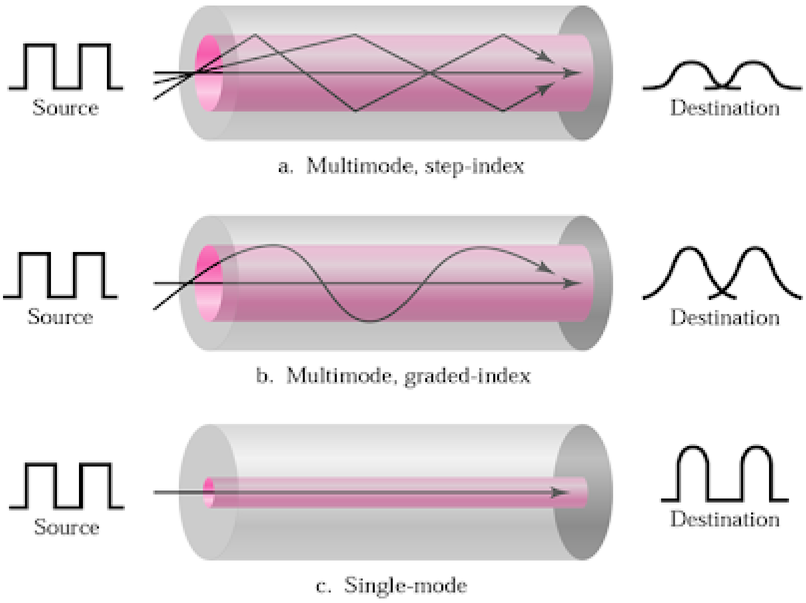
- Multi mode fiber optic cable





In multimode fiber optic connection, because of larger core diameter many light paths (rays) can be found inside. Because of slightly different paths, thus slightly different lengths, which light impulse have to travel, they will arrive with a shift in time

In destination point. Because of that signal will be naturally disrupted on longer distances – that is why multimode connection is often limited to 2km distance.

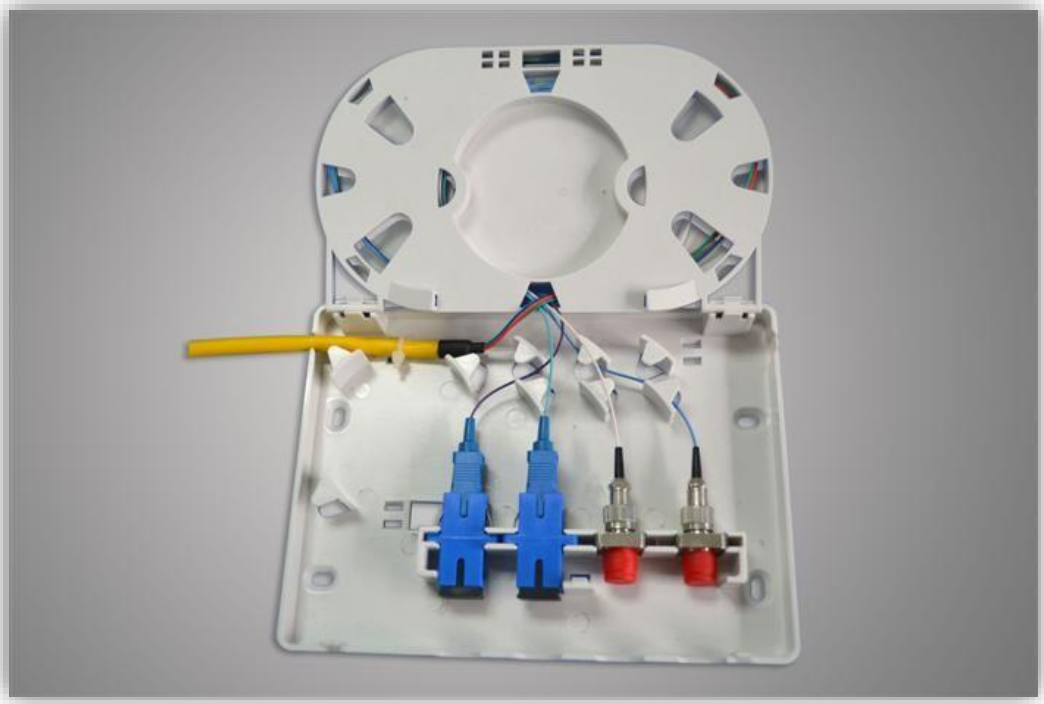


Single-mode connection can be used on longer distances because of lower signal distortion (lower signal loss)

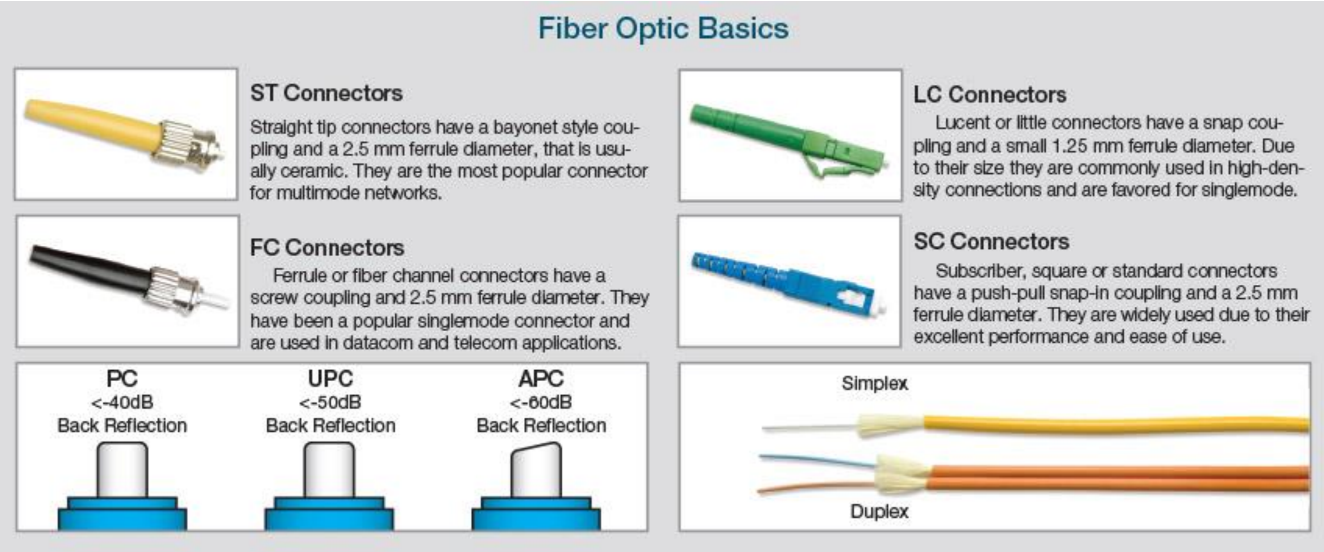
Patch cables

Fiber optic patch cables are used to connect SFP modules with other SFP modules,

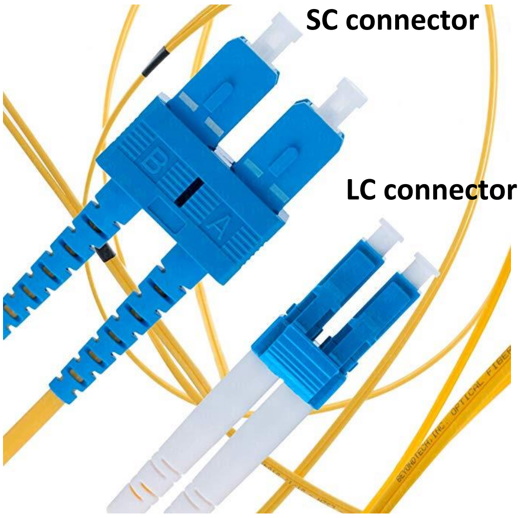
or with fiber optic connection box



Fiber optic connector types:

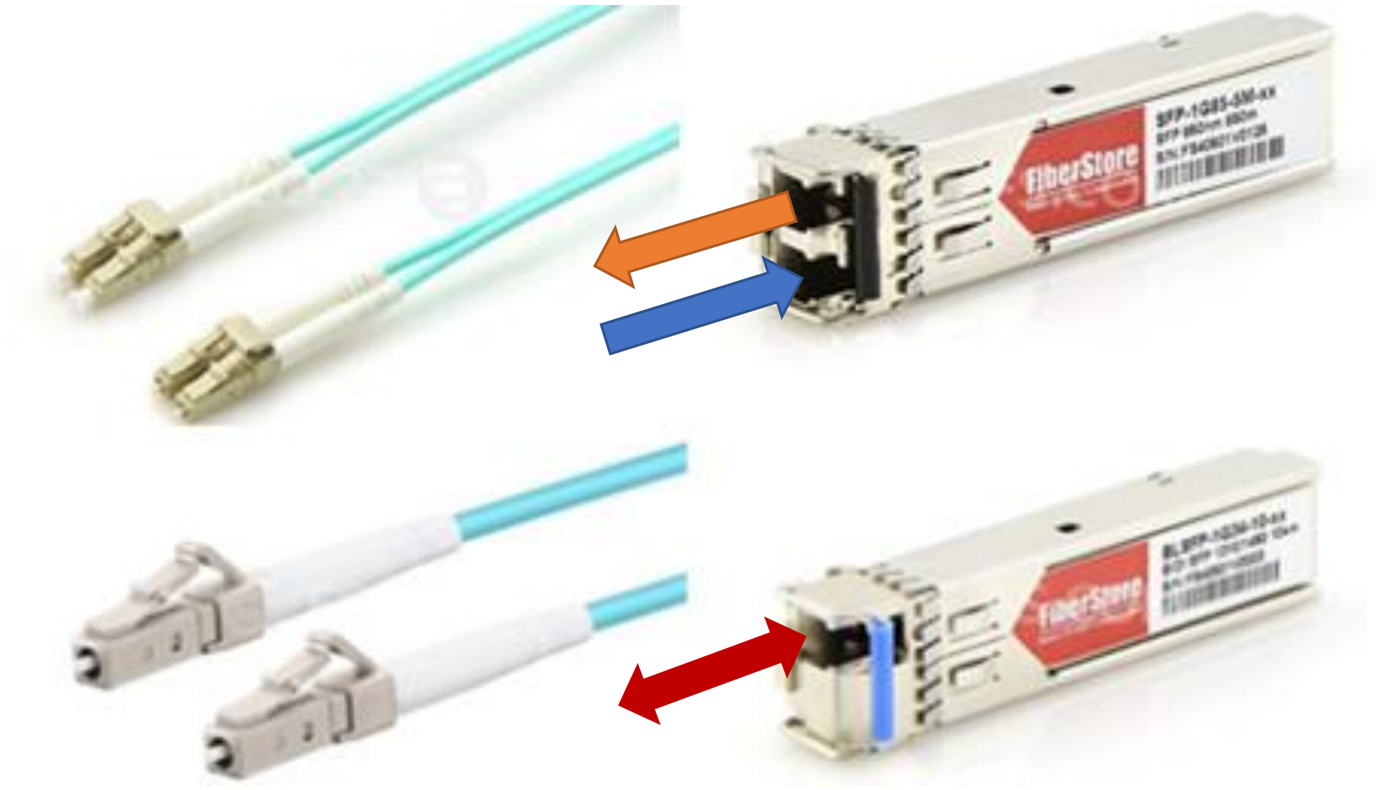


The most popular connectors are LC and SC.

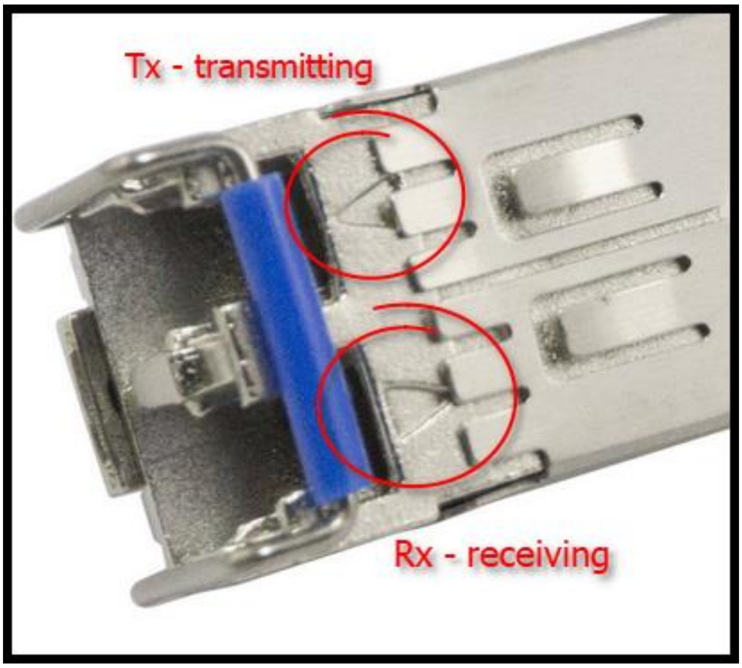


Full duplex SFP modules vs BiDi SFP modules

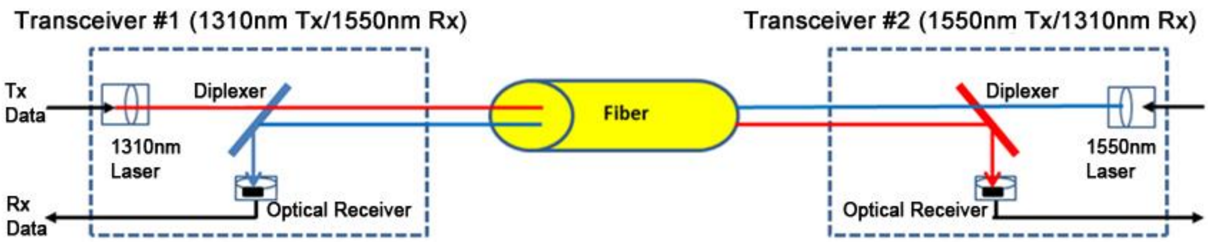
- Full duplex modules (separate Tx and Rx channel) are used mostly for multimode connection
- BiDi (bi-directional) SFP modules are used mostly for singlemode connection



Tx and Rx ports are marked on SFP module with triangle signs:



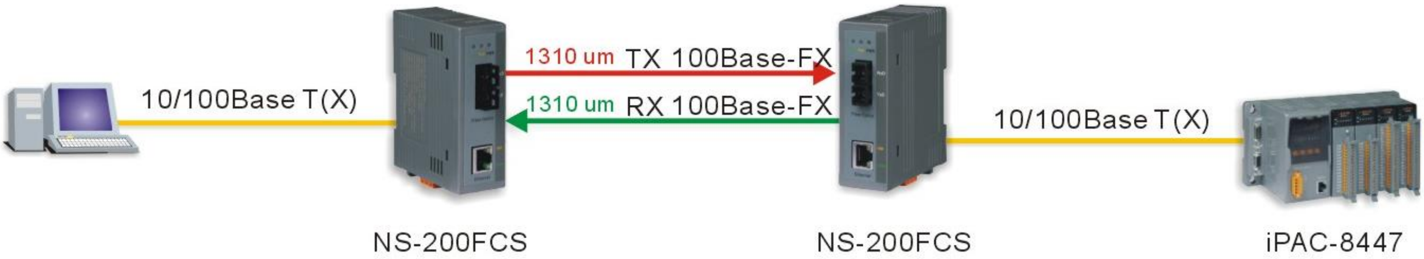
In single mode applications Tx and Rx are in one port. Because transmitting, and receiving data is accomplished in the same optical connection, SFP modules have to use different wavelength for Tx and different for Rx to avoid signal influence with each other.



Comparison between full-duplex and bi-directional connection:

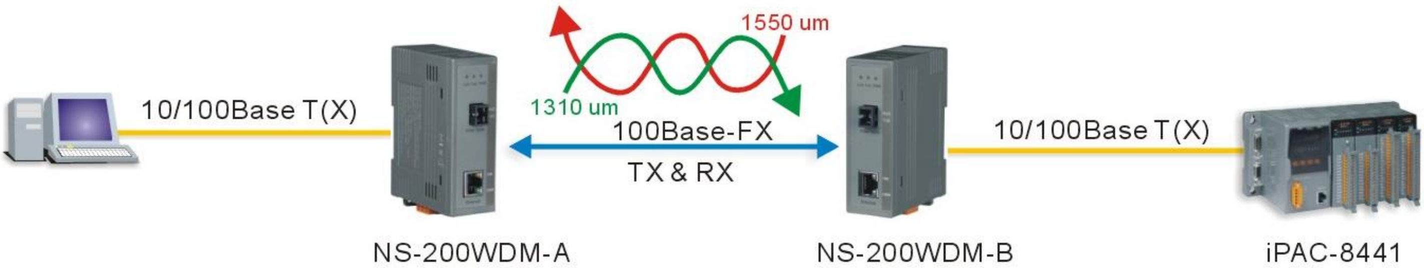
General Media Converter Solution

A general media converter requires a pair of fiber optic cables for data transmission and receiving.



Single-Strand Fiber Converter Solution

Wavelength Division Multiplexing (WDM) supports bi-directional data transmission and receiving using dual wavelengths (1310/1550 nm) over a single strand, of single-mode optical fiber.



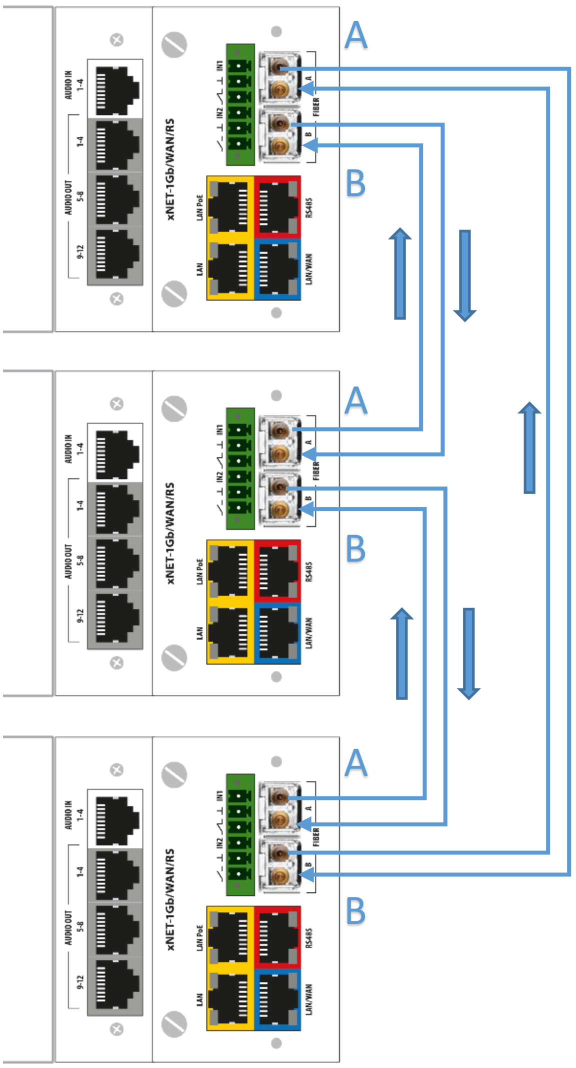
Available MultiVES network SFP modules types:

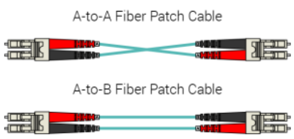
SF-MM31002D-GP	SFP Module, 1.25Gbps SX+ 1350nm LC DDM MMF 2km Multimode connection	
SF-SMS31WD020-GP	SFP Module, WDM 1.25Gbps Tx: 1310nm Rx: 1550nm SC SMF 20km Single mode connection	
SF-SMS55WD020-GP	SFP Module, WDM 1.25Gbps Tx: 1510nm Rx: 1350nm SC SMF 20km Single mode connection	Those modules have to be used in pairs! One pair = **1x SF-SMS31 + 1x SF-SMS55**
SFP-1GBT-06	SFP Module, 10/100/1000 Base-T UTP 100m For LAN Cat5e ring topology	

Fiber optic network construction

Multimode fiber optic network

Fiber optic network connection example using multimode **SF-MM31002D-GP** SFP modules and A-to-B Fiber Patch Cable. SFP module in port A in 1st control unit have to be connected to SFP module in port B in next control unit until whole ring-topology is closed



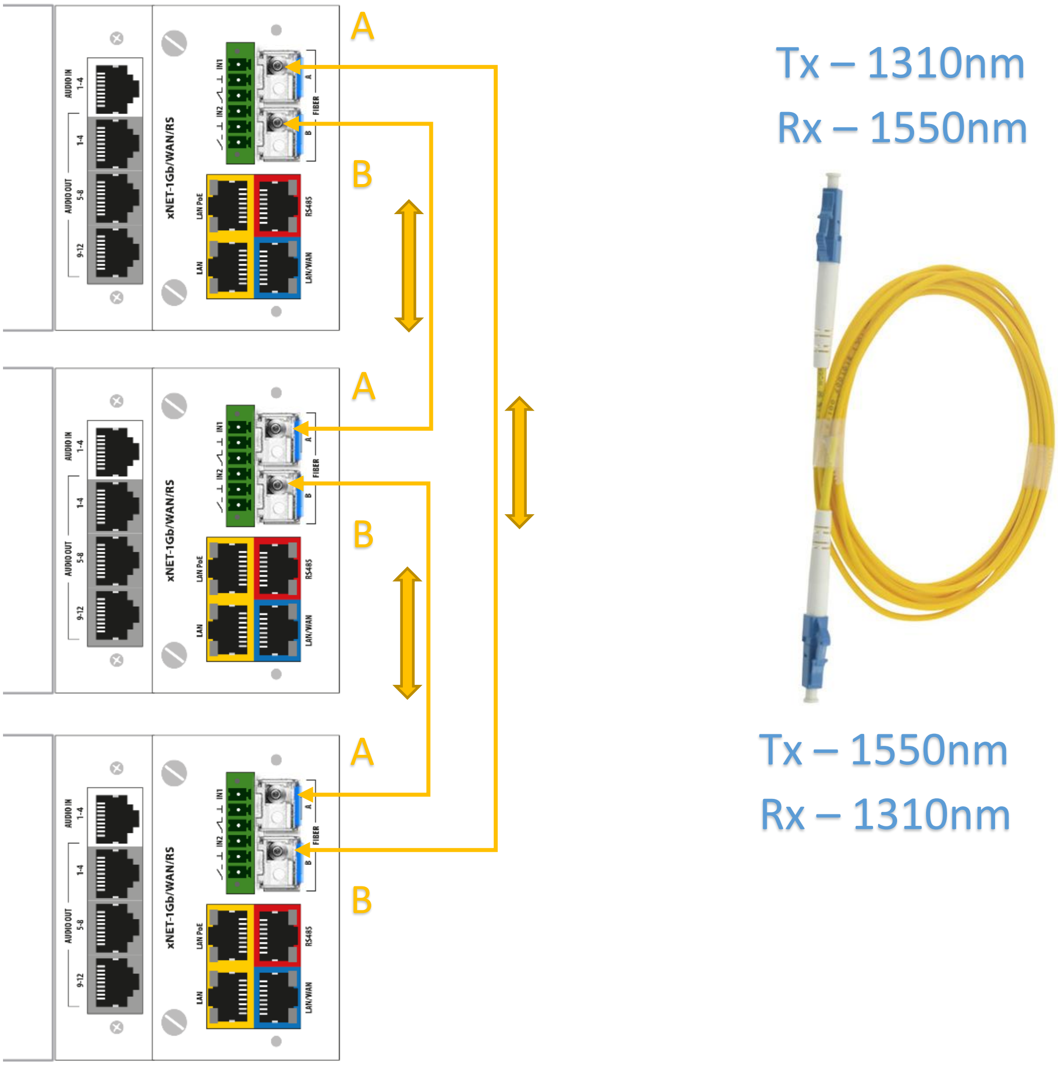


Single mode fiber optic network

Fiber optic network connection example using singlemode **SF-SMS31WD020-GP** and **SF-SMS51WD020-GP** pairs of SFP modules and single Fiber Patch Cable. SFP module in port A in 1st control unit have to be connected to SFP module in port B in next control unit until whole ring-topology is closed.

To simplify connection methodology:

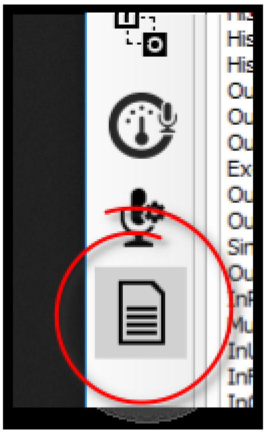
- **SF-SMS31WD020-GP** modules should be installed **in A ports**
- **SF-SMS51WD020-GP** modules should be installed **in B ports**



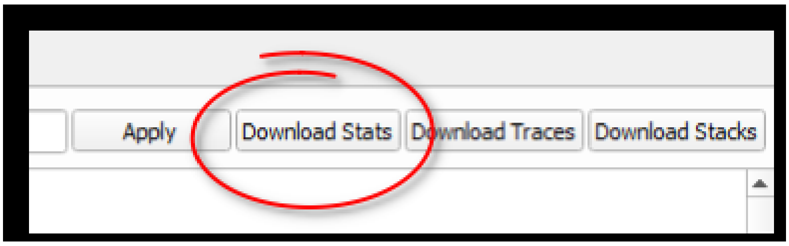
Fiber optic network diagnostics

All details regarding system network connection and possible problems can be found in Statistic report in Configurator, or in statistic files downloaded from system. To obtain statistic information connect with active system, choose device from which you would like to get network connection info and then use "Download Stats" button

1.

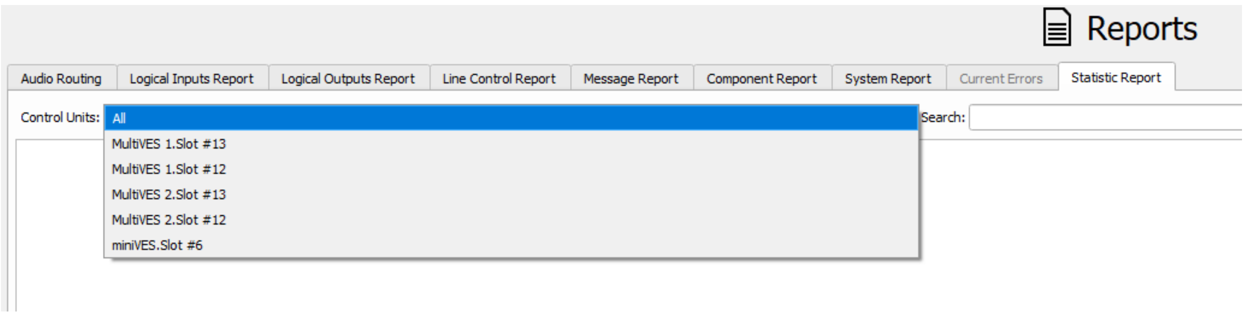


2.



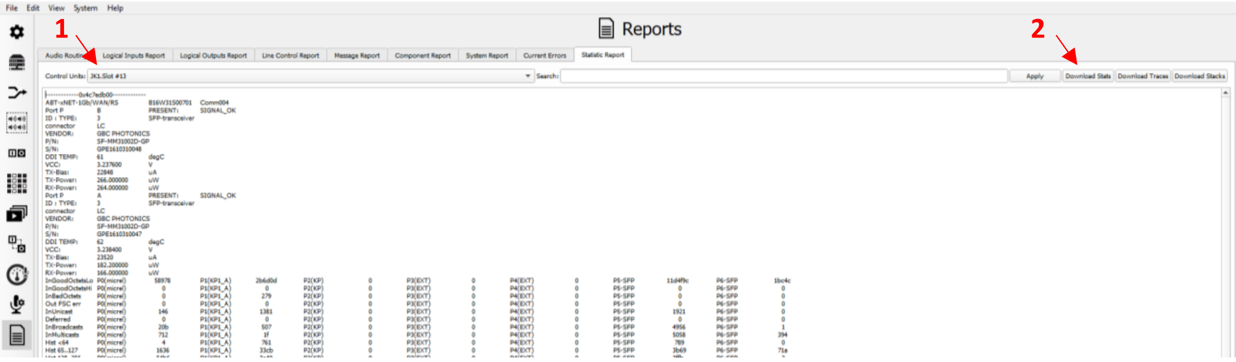
Selector software will download statistic files from Audio cards, Network cards and DFMS microphones.

3. Statistic information from different devices can be selected from dropdown list:

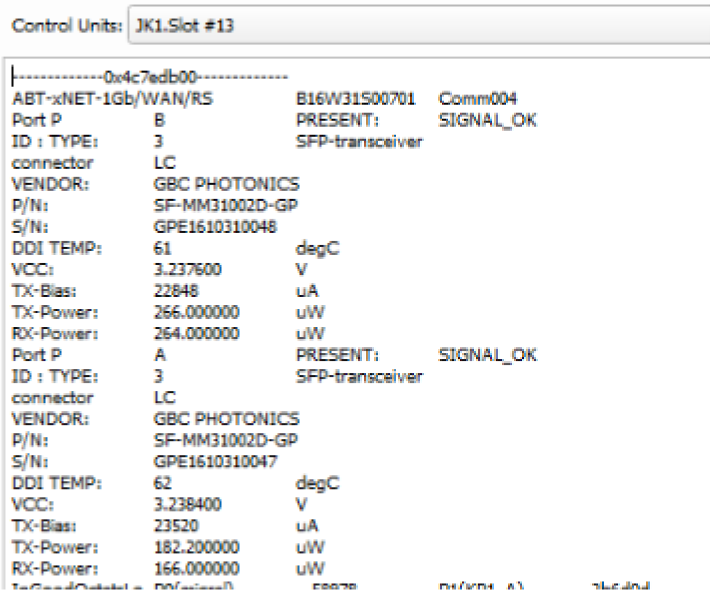


Where for MultiVES **Slot #13** is ABT-xNet – network card, Slot #12 is ABT-xAud - audio card and for miniVES **Slot #6** is Charger module

Relevant informations can be found in statistic information from xNet cards (**slot #13**) and charger modules (**Slot #6**)



Fiber optic connection information can be found on the top of download data:

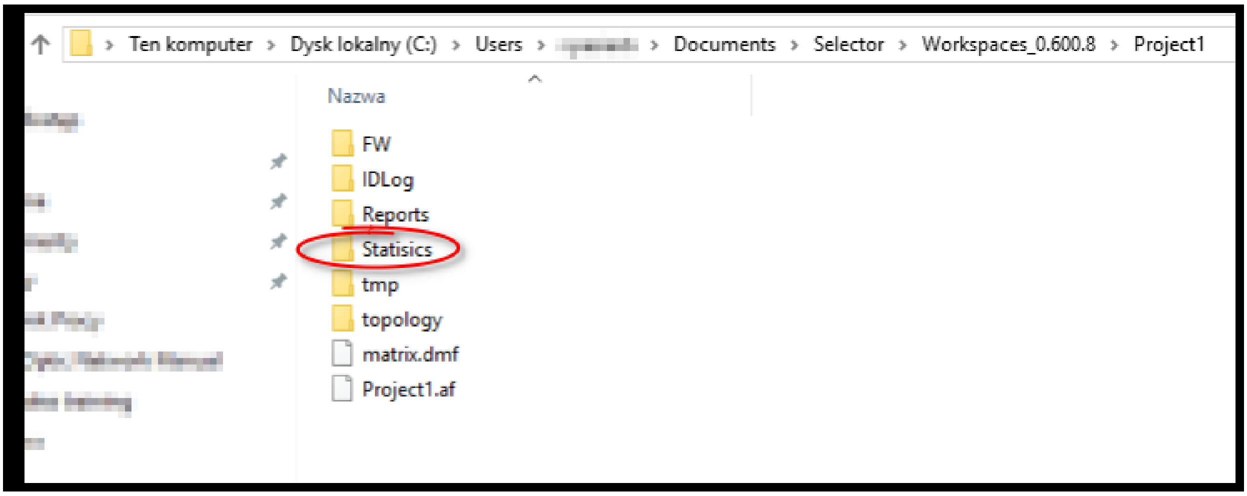


Control Units: JK1.Slot #13

|-------------0x4c7edb00-------------

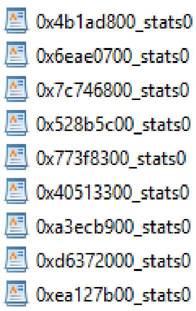
ABT-xNET-1Gb/WAN/RS		B16W31S00701	Comm004
Port P	B	PRESENT:	SIGNAL_OK
ID : TYPE:	3	SFP-transceiver	
connector	LC		
VENDOR:	GBC PHOTONICS		
P/N:	SF-MM31002D-GP		
S/N:	GPE1610310048		
DDI TEMP:	61	degC	
VCC:	3.237600	V	
TX-Bias:	22848	uA	
TX-Power:	266.000000	uW	
RX-Power:	264.000000	uW	
Port P	A	PRESENT:	SIGNAL_OK
ID : TYPE:	3	SFP-transceiver	
connector	LC		
VENDOR:	GBC PHOTONICS		
P/N:	SF-MM31002D-GP		
S/N:	GPE1610310047		
DDI TEMP:	62	degC	
VCC:	3.238400	V	
TX-Bias:	23520	uA	
TX-Power:	182.200000	uW	
RX-Power:	166.000000	uW	

If Selector software was not able to display all devices on list, all Statistic files can be found in Statistics folder in project workspace:



For fiber optic network diagnostic refer to files downloaded from network cards and DFMS microphones (if FO connection is used)

Example list of files that can be found in folder:



After opening file (Notepad++ is advised) in 1st text line component name, serial number and card name can be found:

0x528b5c00_stats0.txt

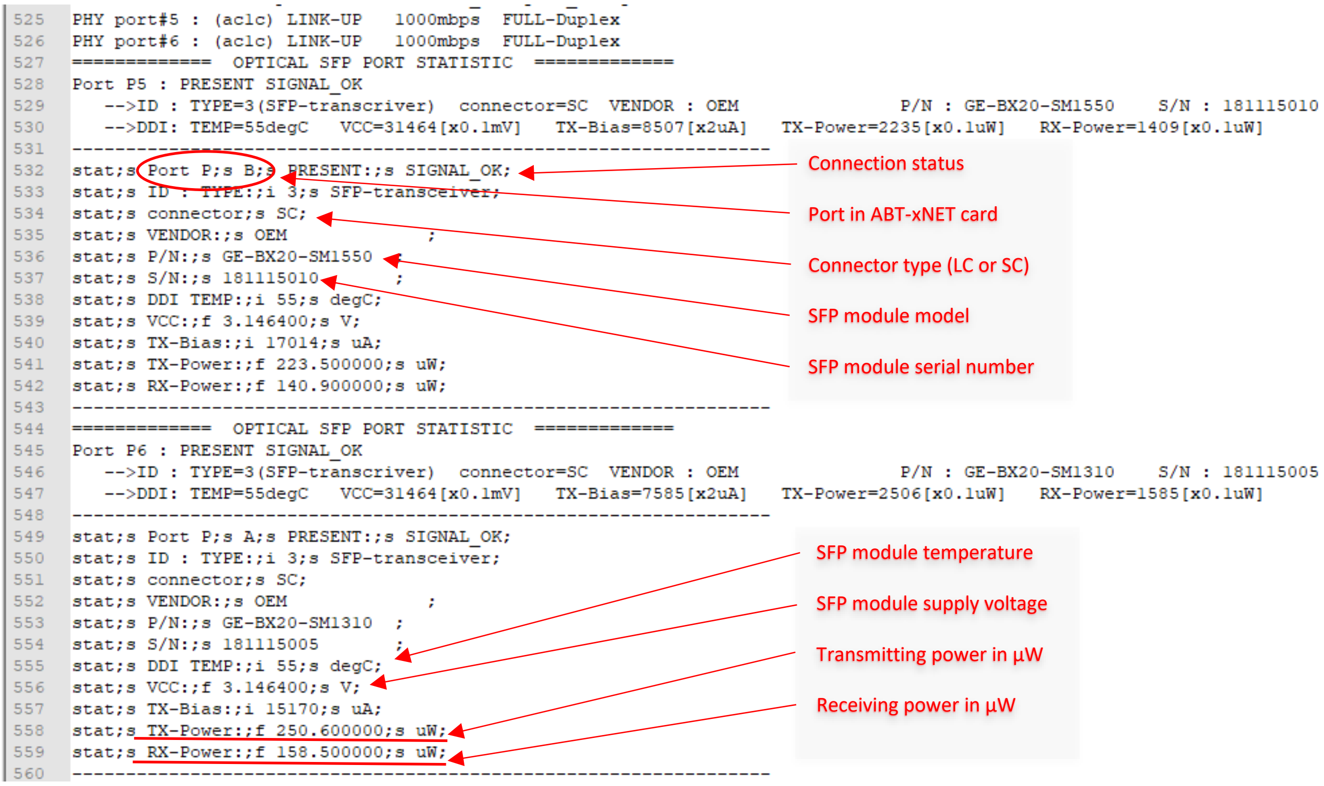
```
1   stat;s ABT-xNET-1Gb/WAN/RS;s B17W36S0[redacted];s Comm002;
2
3   SBRK: size:29114352, allocated:2928624 utilization:10%
4   Heap: total system allocated:2928624, unused chunks:1185 total allocated:1
5   Device Type:ABT-xNET-1Gb/WAN/RS Serial: B17W36S0[redacted] Board: ISA00020-01
6   MAC address: 02:00:00:ac:0a:89
7   IP address ln0(up): ip:10.10.0.54 nm:255.255.0.0 gw:10.10.0.1
8   IP address wn1(down): ip:0.0.0.0 nm:255.255.255.255 gw:0.0.0.0
9   DNS:208.067.222.222
10  FlashB_address: 0x1b050000, Image_checksumB: 0x0, Image_size: 0, FlashA_ad
11  EPOC time: 1543404936s 145ms
12  GMT   time: Wed Nov 28 11:35:36 2018
13  local time: Wed Nov 28 13:35:36 2018
14  Uptime: 960s 85ms
15  Build revision: 0.600.1, revSig: 0xa851476b, version: 29149696
16  Bootloader revision: 1.0.2, revSig: 0xfd35031a, version: 68443648
17  Watchdog state mask:fffffe active:fffffe
18  Topology ID:0x528b5c00, name:Comm002
```

Line 6: network card MAC address

Line 7: LAN connection IP address

Line 8: WAN connection IP address

For fiber optic connection statistics refer to OPTICAL SFP PORT STATISTIC section:




```
PHY port#5 : (aclc) LINK-UP   1000mbps  FULL-Duplex
PHY port#6 : (aclc) LINK-UP   1000mbps  FULL-Duplex
=============  OPTICAL SFP PORT STATISTIC  =============
Port P5 : PRESENT SIGNAL_OK
   -->ID : TYPE=3(SFP-transcriver)  connector=SC  VENDOR : OEM             P/N : GE-BX20-SM1550    S/N : 181115010
   -->DDI: TEMP=55degC   VCC=31464[x0.1mV]   TX-Bias=8507[x2uA]   TX-Power=2235[x0.1uW]   RX-Power=1409[x0.1uW]
-----------------------------------------------------------------
stat;s Port P;s B;s PRESENT:;s SIGNAL_OK;
stat;s ID : TYPE:;i 3;s SFP-transceiver;
stat;s connector;s SC;
stat;s VENDOR:;s OEM             ;
stat;s P/N:;s GE-BX20-SM1550  ;
stat;s S/N:;s 181115010       ;
stat;s DDI TEMP:;i 55;s degC;
stat;s VCC:;f 3.146400;s V;
stat;s TX-Bias:;i 17014;s uA;
stat;s TX-Power:;f 223.500000;s uW;
stat;s RX-Power:;f 140.900000;s uW;
-----------------------------------------------------------------
=============  OPTICAL SFP PORT STATISTIC  =============
Port P6 : PRESENT SIGNAL_OK
   -->ID : TYPE=3(SFP-transcriver)  connector=SC  VENDOR : OEM             P/N : GE-BX20-SM1310    S/N : 181115005
   -->DDI: TEMP=55degC   VCC=31464[x0.1mV]   TX-Bias=7585[x2uA]   TX-Power=2506[x0.1uW]   RX-Power=1585[x0.1uW]
-----------------------------------------------------------------
stat;s Port P;s A;s PRESENT:;s SIGNAL_OK;
stat;s ID : TYPE:;i 3;s SFP-transceiver;
stat;s connector;s SC;
stat;s VENDOR:;s OEM             ;
stat;s P/N:;s GE-BX20-SM1310  ;
stat;s S/N:;s 181115005       ;
stat;s DDI TEMP:;i 55;s degC;
stat;s VCC:;f 3.146400;s V;
stat;s TX-Bias:;i 15170;s uA;
stat;s TX-Power:;f 250.600000;s uW;
stat;s RX-Power:;f 158.500000;s uW;
-----------------------------------------------------------------
```

If connection is good, you will find SIGNAL_OK information

<u>Receiving power in µW is power received from SFP module on other side of fiber optic connection</u>

<u>Transmitting power (Tx) and receiving power (Rx) information is crucial to verify optical connection condition</u>

<u>Example:</u>

<u>Control unit 1, port A, Tx power - 225µW</u>

<u>Control unit 2, port B, Rx power - 150µW</u>

Optical Power Loss

In designing an optical link, the optical link loss budget must be calculated. This reflects the difference of power generated by the transmitter compared to the amount of light the receiver is set to receive. In calculating link loss budgets, first consider the output power of the transmitter. For example, most multimode transceivers have a minimum transmission value of -10dB; maximum receiver sensitivity is set at -17dB. The result is that in a multimode application, with a standard transceiver at 850nm, the dB budget is -7dB. This means that up to 7dB of power can be lost in the fiber optic cable and the receiver will still detect an optical signal.

The following table shows the percentage of power lost and its corresponding dB value. At -7dB, only 20% of power is received and yet the optical signal is received successfully. A theoretically perfect optical device would have no internal losses and would transmit 100% of the power, thus having 0dB.

Total signal loss should be no higher than -7dB to avoid possibility of loosing data packets and creating network instability.

For example:

Tx power on SFP module in A port is 250µW

Rx power (receiving) on SFP module in port B in next control unit is 150µW

Loss= (Tx/Rx) x 100%

Loss= (250/150) x 100% = 60%

60% power loss is equal to -4dB, which is acceptable as signal loss

DECIBEL TO POWER CONVERSIONS		
dB	Power Out as a % of Power In	% of Power Lost
.001	99.98%	.02%
.01	99.8%	.22%
.05	99%	1%
.1	98%	2%
.2	95.5%	4.5%
.3	93%	7%
.4	91%	9%
.5	89%	11%
.6	87%	13%
.7	85%	15%
.8	83%	17%
.9	81%	19%
1	79%	21%
2	63%	37%
3	50%	50%
4	40%	60%
5	32%	68%
6	25%	75%
7	20%	80%
8	16%	84%
9	12%	88%
10	10%	90%
11	8%	92%
12	6.3%	93.7%
13	5%	95%
14	4%	96%
15	3.2%	96.8%
16	2.5%	97.5%
17	2%	98%
18	1.6%	98.4%
19	1.3%	98.7%
20	1%	99%
25	0.3%	99.7%
30	0.1%	99.9%
40	0.01%	99.99%
50	0.001%	99.999%

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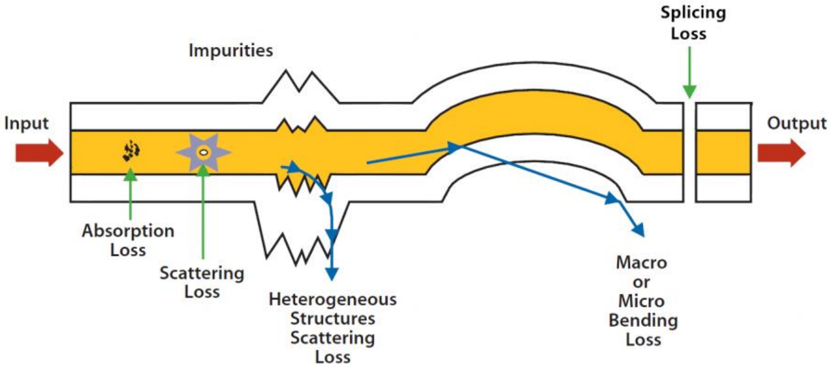
Fiber optic problems that can influence optical signal loss:

- **Glass core absorption**
- **Scattered core**
- **Uneven core surface**
- **To aggressive bends**
- **Spliced core**
- **Broken core**



A basic guideline for loss measurements is to estimate the loss using these approximate values:

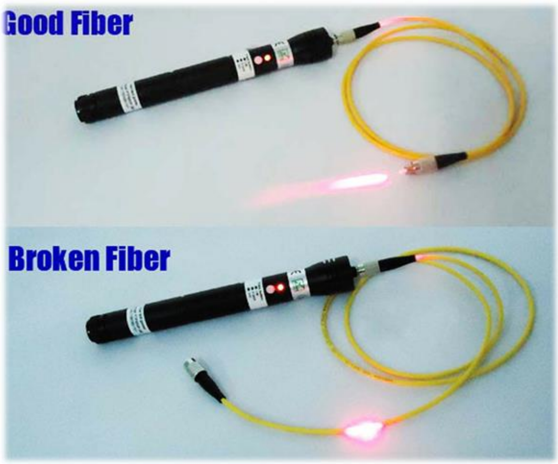
Connector loss: 0.5 dB per mated pair
Splice loss: 0.2 dB per splice

Typical fiber loss:
Multimode: 3 dB/km @ 850 nm, 1 dB/km @ 1300 nm
Singlemode: 0.4 dB/km @ 1300 nm, 0.3 dB/km @ 1550 nm

For example: a 1.5 km multimode link with 3 connections @ 1300 nm:
Loss = (1.5 km X 1 dB/km) + (3 conn X 0.5 dB)
Loss = 1.5 dB + 1.5 dB = 3 dB

Tools that are used for fiber optic network testing:

For simple fiber optic core continuity testing a visual fault locator can be used. This device transmits visible red laser light, which should pass thru fiber optic link.



If FO is damaged, light will escape from core thru FO coating. This tool also can be helpful in fiber cable assigning

For advanced FO testing a FO meter with separate light source is used. This set allows to measure FO connection total loss on different light wavelengths.