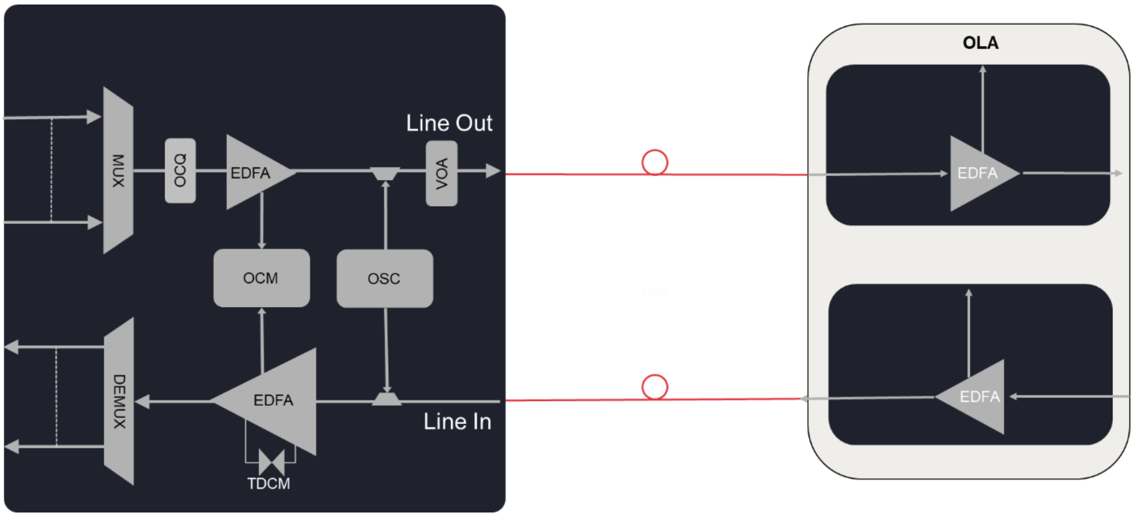
smartoptics

DCP-Amplified links Installation manual

User Manual

dcp-release-12.0.1



The specifications and information within this manual are subject to change without further notice. All statements, information and recommendations are believed to be accurate but are presented without warranty of any kind. Users must take full responsibility for their application of any products.

Contents

1 Introduction

1.1 General

This installation guide details how to install DWDM equipment in the DCP platform. It also contains design rules for the different types of application. The guide involves the following products:

Product	Description
DCP-F-R22	2-port ROADM, EDFA amplifier with 22 dB Gain, 2-Port Optical Channel Monitor, 1RU plug-in unit, with support for 2 x Passive Plug-in Modules (PPM's)
DCP-F-A22	EDFA amplifier with 22 dB Gain, 1RU plug-in unit, with support for 2 x Passive Plugin Modules (PPM's)
DCP-F-DE22	Dual Equalizer, EDFA amplifier with 22 dB Gain, 2-Port Optical Channel Monitor, 1RU plug-in unit, with support for 2 x Passive Plug-in Modules (PPM's)
DCP-M series	Multi-format 40 channel DWDM open line system

The different kind of applications that will be covered are:

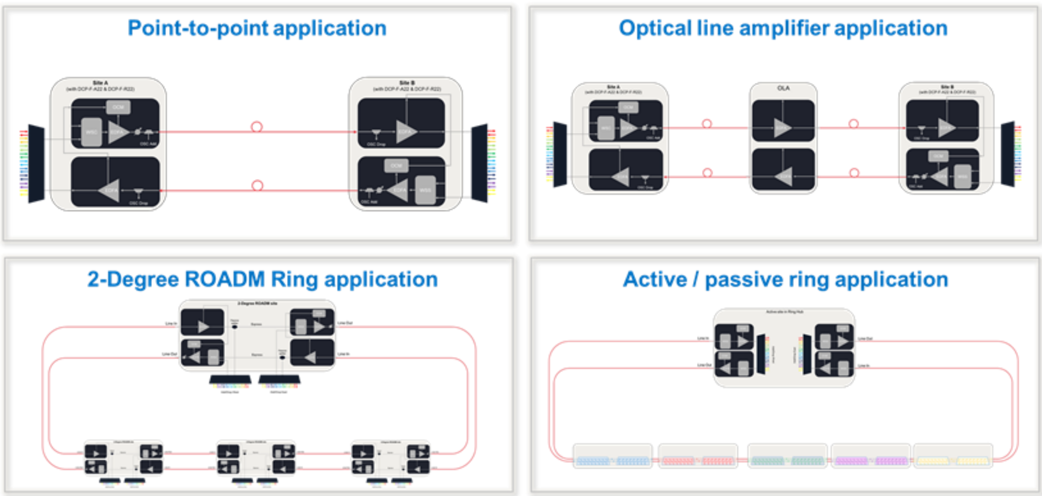


Figure 1: Application scenarios

1.2 In commercial confidence

The manual is provided in commercial confidence and shall be treated as such.

1.3 Document Revision History

Revision	Date	Description of changes
8.1.1 A	2023-06-20	Release version for R8.1.1
8.1.3 A	2023-08-22	No update
8.1.4 A	2023-10-11	No update
8.1.5 A	2023-11-01	No update
8.1.6 A	2023-11-20	No update
8.1.7 A	2024-01-04	No update
9.0.1 A	2024-01-19	No update
10.0.1 A	2024-07-03	Updates related to DCP-R-34D-CS
10.0.2 A	2024-09-05	No update
11.0.1 A	2024-12-12	No update
11.1.1 A	2025-01-23	No update
11.3.1 A	2025-04-22	No update
12.0.1 A	2025-06-23	No update

2 Safety Precaution

For precautions regarding electrical safety, protection against electrostatic discharge and site requirements, please see the installation manuals for DCP-2 and DCP-M respectively.

2.1 General Safety Precautions

The following are the general safety precautions:

The equipment should be used in a restricted access location only.

No internal settings, adjustments, maintenance, and repairs may be performed by the operator or the user; such activities may be performed only by skilled service personnel who are aware of the hazards involved.

Always observe standard safety precautions during installation, operation and maintenance of this product.

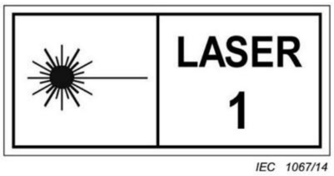
2.2 Laser Safety Classification

The DCP-2 complies with Class 1. The incorporated laser has a divergent beam, operates within the wavelength span of 1530 – 1563 nm and has a maximum output of +20 dBm.

The DCP-M complies with Class 1. The incorporated laser has a divergent beam, operates within the wavelength span of 1504 – 1563 nm and has a maximum output of +20 dBm.

The following warning applies to Class 1 laser products.

Invisible Laser Radiation: Do not view directly with optical instruments.



Class 1 Laser Warning.

Laser Safety Statutory Warning and Operating Precautions

All personnel involved in equipment installation, operation, and maintenance must be aware that the laser radiation is invisible. Therefore, the personnel must strictly observe the applicable safety precautions and in particular, must avoid looking straight into optical connectors, either directly or using optical instruments.

In addition to the general precautions described in this section, be sure to observe the following warnings when operating a product equipped with a laser device. Failure to observe these warnings could result in fire, bodily injury, and damage to the equipment.

Warning: To reduce the risk of exposure to hazardous radiation:

Do not try to open the enclosure. There are no user serviceable components inside.

Do not operate controls, adjust, or perform procedures to the laser device other than those specified herein.
Allow only authorized service technicians to repair the unit.

3 Applications

3.1 Point-to-Point

In one of the simplest applications, Point-to-Point networks are linear setups characterized by a single-span fiber link with a fixed set of DWDM channels that needs to be transported between the two sites. Depending on distance/attenuation between the sites

3.1.1 Pre-Amp

The pre-amplifier increases the transmission distance and is used to amplify the optical signal to the required level to ensure that it can be detected by the transceiver. Dispersion compensation is recommended to be positioned after the pre-amplifier to achieve the best OSNR performance.

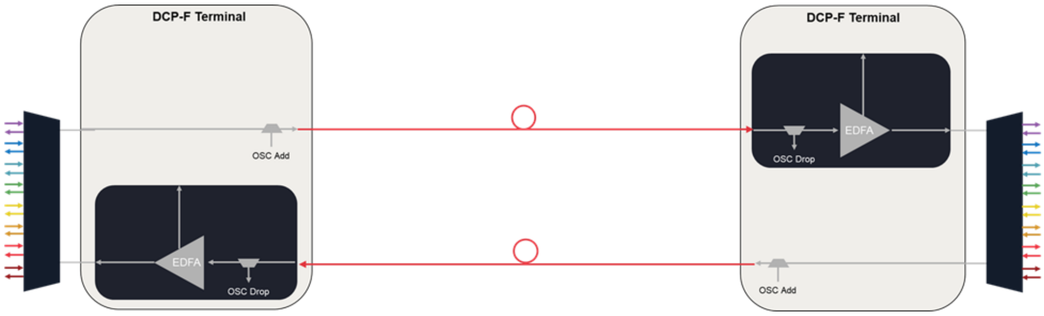


Figure 2: Pre-amp only, point-to-point link with DCP-F-A22

3.1.2 Booster

The booster amplifier increases the transmission distance by adding little optical noise to the system and maintaining a high optical signal to noise ratio, OSNR.

Booster amplifiers are preferably selected if the noise characteristic is unknown of the receiver. Dispersion compensation is recommended to be positioned in front of the Booster. When the DCP-F-R22 is used as a booster it equalizes the optical spectral of the incoming wavelengths prior to amplification and transportation over the fiber.

In a similar way the DCP-F-DE22 can be used in a booster configuration to also provide equalization in the receive direction. Note however that the allowed span loss will be a couple of dB shorter due to the insertion loss of the receiving direction WSS.

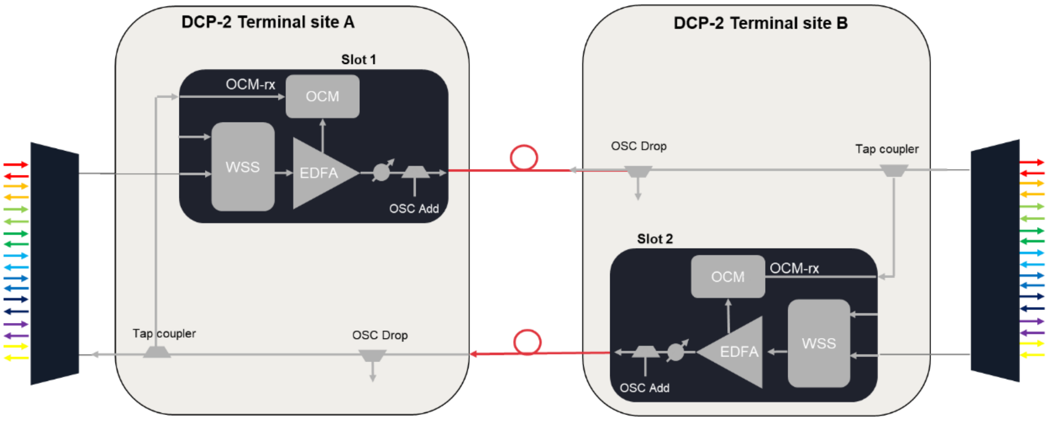


Figure 3: Booster only, point-to-point link with DCP-F-R22

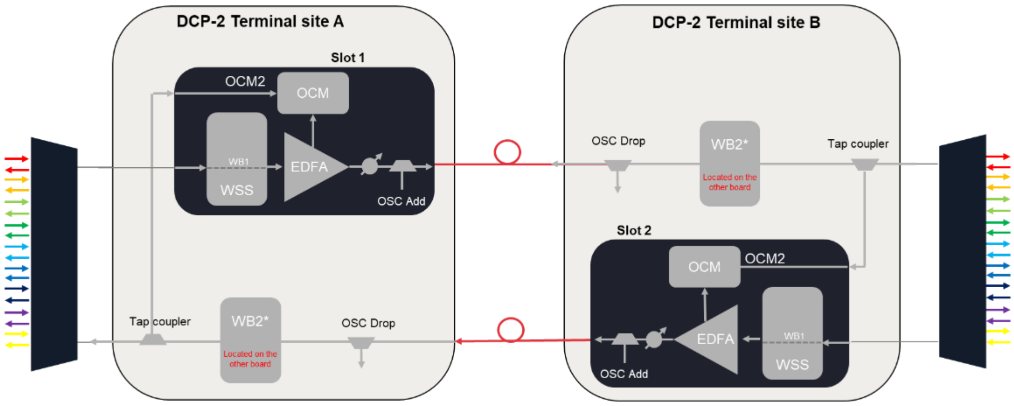


Figure 4: Booster only, point-to-point link with DCP-F-DE22

3.1.3 Booster & Pre-Amp

By using both booster and pre-amplifiers it is possible to achieve maximum transmission distance between 2 sites. The DCP-F-R22 or DCP-F-DE22 are recommended to be used as a booster as it equalizes the optical spectral of the incoming wavelengths prior to amplification and transportation over the fiber by using the integrated Optical Channel Monitor (OCM) to monitor the Tx spectrum. The DCP-F-A22 is used as pre-amp and patching the DCP-F-A22 Optical Channel Monitor Tx port to DCP-F-R22/DE22 integrated OCM Rx port enables the monitoring of the Rx spectrum.

When the DCP-F-DE22 is be used in a booster and preamp configuration together with DCP-F-A22 the solution provides equalization in both directions. As in the booster only configuration the insertion loss of the WSS will decrease the allowed span loss a little bit in receive direction compared to a DCP-F-R22 solution.

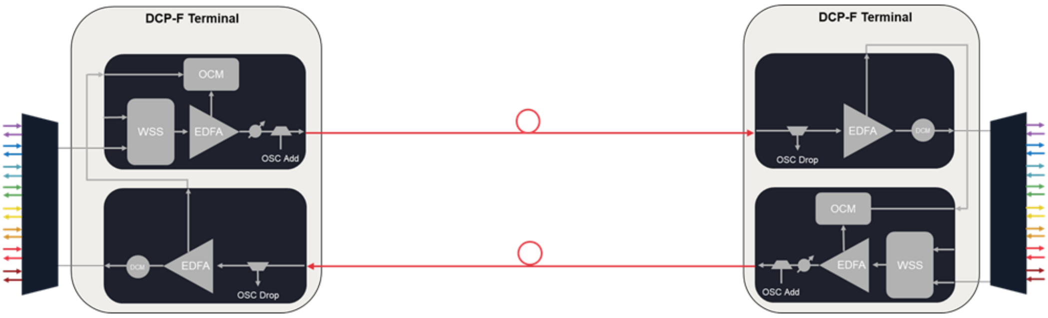


Figure 5: Pre-amp & Booster, point-to-point link with DCP-F-A22 and DCP-F-R22.

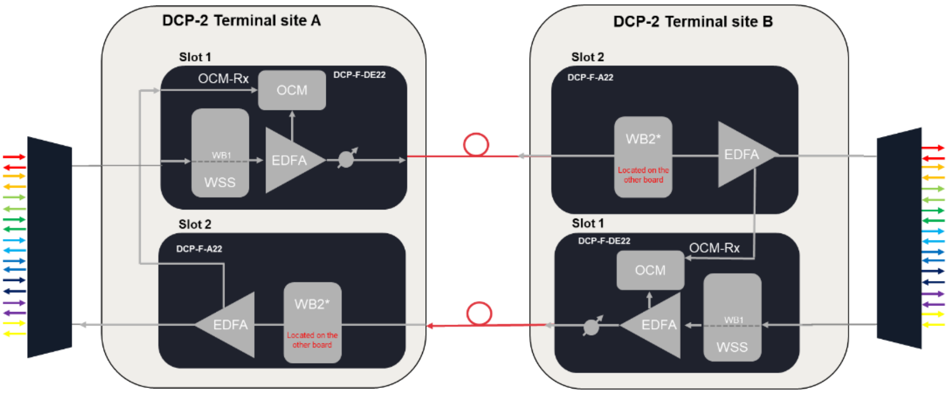


Figure 6: Pre-amp & Booster, point-to-point link with DCP-F-A22 and DCP-F-DE22.

3.2 Optical line amplifiers

The optical line amplifiers are used when both a booster and pre-amplifier is not enough due to the distance and optical loss. For these longer distances the DCP-F-A22 and its integrated Erbium-Doped Fiber Amplifier (EDFA) is an efficient tool for amplification and signal regeneration. The total distance possible to bridge and the maximum distance between amplifiers is dependent on the modulation format used for the line system. The DCP-F-A22 used as optical line amplifier is compatible with any other combination of DCP-F-R22, DCP-F-DE22 or a member of DCP-M family.

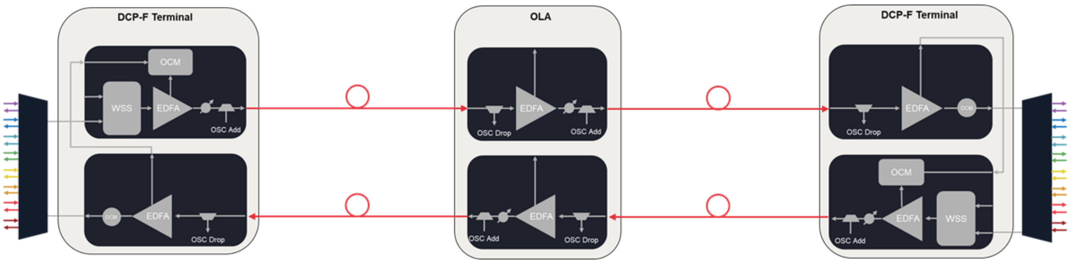


Figure 7: DCP-F-A22 as optical line amplifier with DCP-F units

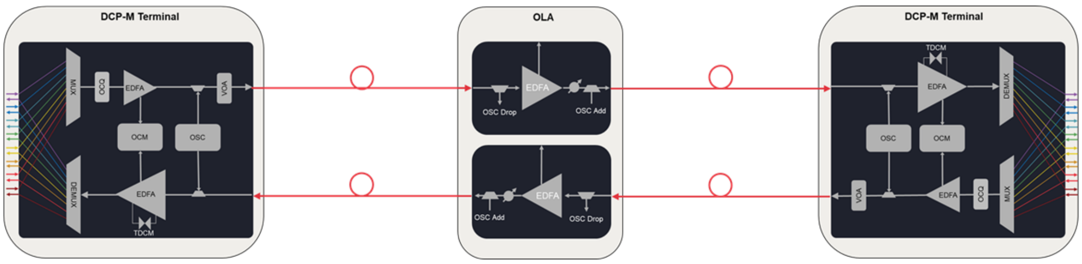


Figure 8: DCP-F-A22 as optical line amplifier together with DCP.M units

3.2.1 Line Equalizing

To support extended reach and eliminate channel power disparity it is recommended to use DCP-F-DE22/DCP-F-A22 combo as the line amplifier after 8 spans as it will perform equalization on the individual wavelengths and remove degradation due to amplifier gain variations or fiber tilt loss. Where equalization is required its recommended to place the combination on the spans with lower loss.

The recommendation of equalization after 8 spans is to be regarded as a rule of thumb. Depending on the overall combination of spans and amplifiers it is possible that the equalization is necessary after shorter number of spans.

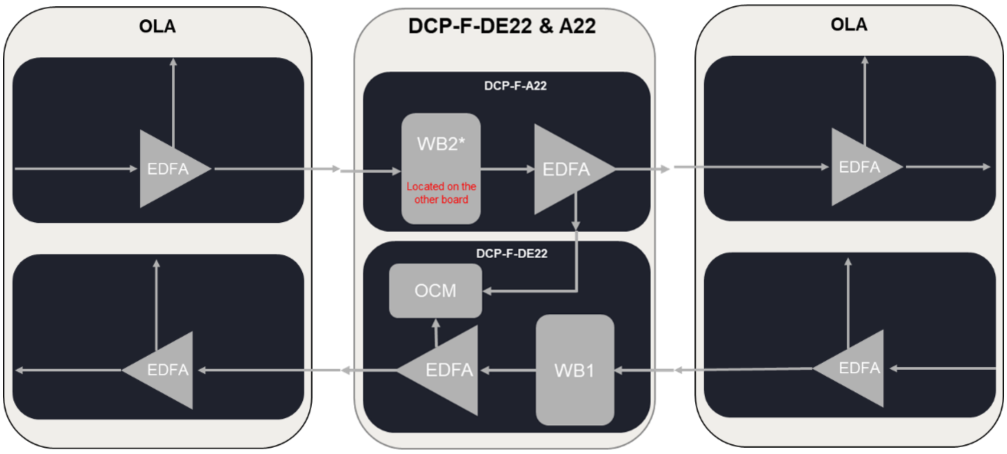


Figure 9: DCP-F-DE22/A22 combo as optical line amplifier with equalization

When connecting a DCP-F-DE22/DCP-F-A22 combo, see below for clarification:

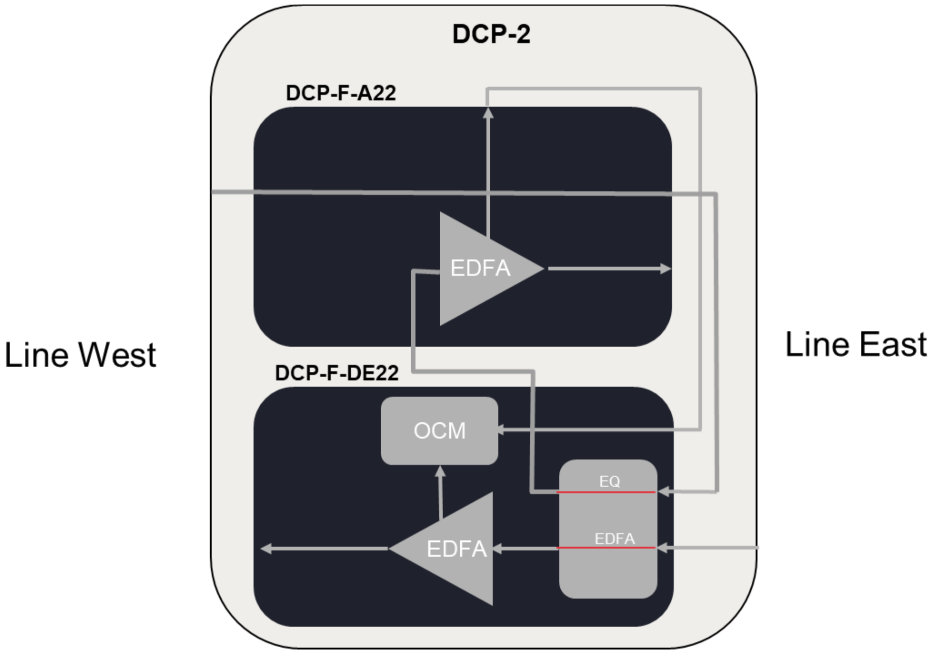


Figure 10: DCP-F-DE22/A22 combo connections

From Line West; Line is connected to EQ Rx on DE22. From EQ Tx to EDFA Rx on A22 and from EDFA Tx on A22 to Line East. OCM Tx on A22 is connected to OCM Rx on DE22.

From Line East; Line is connected to EDFA Rx on DE22. From EDFA Tx to Line East.

Observe that Line West and East can both be fiber lines when it is a line amplifier, but this equalizer configuration can also be used at terminal sites. In this case either of Line West or Line East will be connected to a mux and demux.

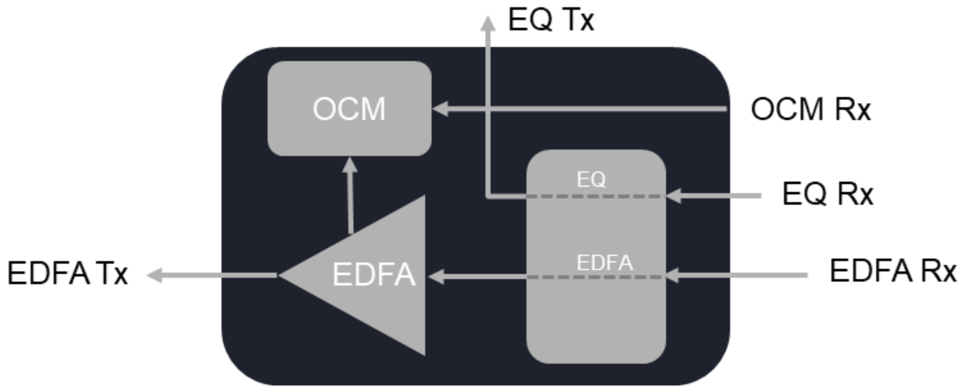


Figure 11: DCP-F-DE22/A22 connections.

3.2.2 2-degree DCP-F ROADM

2-degree DCP-F ROADMs, a standard building block of a metro access ring, are easily configured by combing one DCP-F-A22 and one DCP-F-R22 for each signal direction, i.e. using one 1U chassis with two active units per degree.

A 2-degree also has two Mux/Demux modules - one for each degree. A wavelength can only be connected to the Mux/Demux port that is on the same degree. For example, a wavelength received on the east facing units can only be terminated on the east facing Mux/Demux module.

With a 2-degree ROADM network element, a passthrough wavelength can easily be provisioned between West and East signal directions.

The received signals on the “West” fiber path is first amplified via the DCP-F-A22 before being connected to PPM-OCU-50-50 100% port.

One of the 50% ports is then connected to the express Rx on the “East” DCP-F-R22 where the WSS controls which EDFA Rx or Express Rx wavelengths are routed to the “East” line-out port.

The second 50% port is connected to the local add/drop/demux lines rx port where all wavelengths received on the line-in port are visible on the drop port,

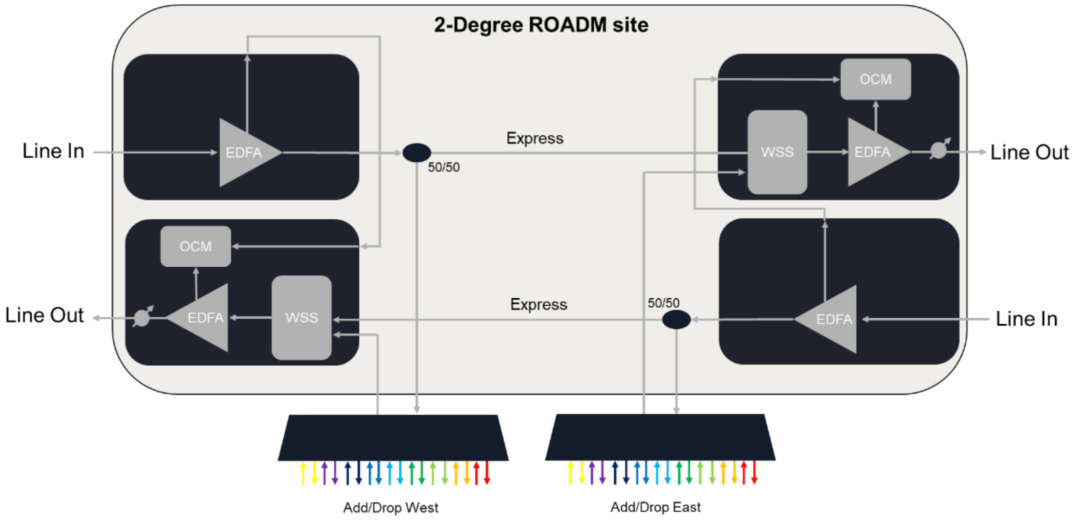


Figure 12: 2 degree ROADM Site with preamplifier

3.3 Active/Passive

It is often desirable to use passive optical multiplexers in parts of the metro access network. The multiplexers are then typically deployed in a chain and at various distances from the active node, hence the signal strength will vary for different sets of wavelengths, emanating from different multiplexers. The DCP-F-DE22/A22 combo can be used for spectral equalization of incoming wavelengths from the passive multiplexers before the EDFA amplifier as well as for power balancing of the outgoing signal to the passive multiplexers, ensuring optimal performance of the optical links.

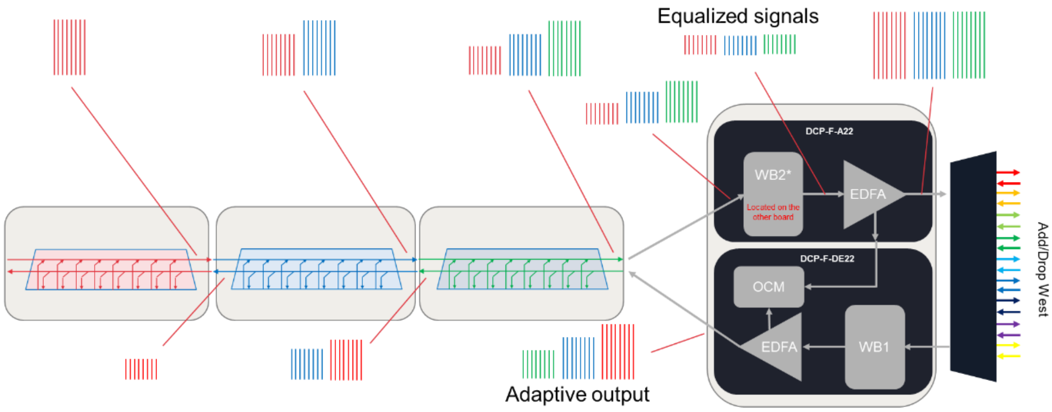


Figure 13: Active/Passive chain configuration application

As a topology example, the illustration below shows how to create a hybrid active/passive access ring using the DCP-F-DE22, DCP-F-A22 and H-series multiplexers. The H-series multiplexers are installed in manholes, on poles or at other industrial temperature (-40 °C to +85 °C) locations without any need for external power, and the optical channels are then conveniently aggregated at one single active site.

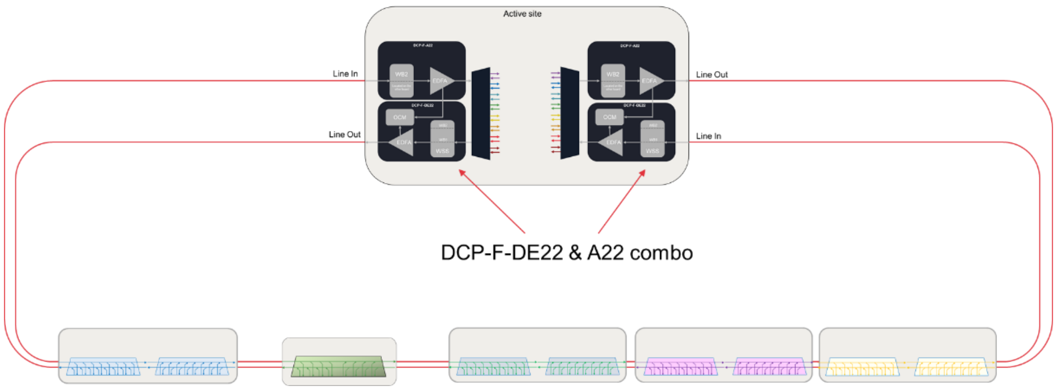


Figure 14: Active/Passive ring with DCP-F-DE22, DCP-F-A22 at one active site and remote signal aggregation with the H-series Passive Optical Networking Platform

3.4 DCP-R ROADMs

3.4.1 DCP-R-9D-CS

In networks with meshed and ring topology it is often required to route wavelengths over different paths. This can easily be done with ROADMs where it is possible to cross connect the individual wavelengths remotely via the WSS (wavelength selective switch) ports. For multiple degrees it is required to have multiple WSS ports.

The DCP-R-9D-CS product offers a “ROADM on a blade” solution with everything needed for one ROADM degree in a 1RU chassis. This chassis has front to back air flow and can use AC or DC power. The power and FAN units are redundant and can be replaced. They are accessed from the rear side of the chassis.

Figure 15: Chassis front view of DCP-R-9D-CS

The blade contains a twin 9D Flexgrid WSS, booster and pre-amplifier, a 40ch mux/demux with 80GHz BW, a VOA for the line side and OSC filters.

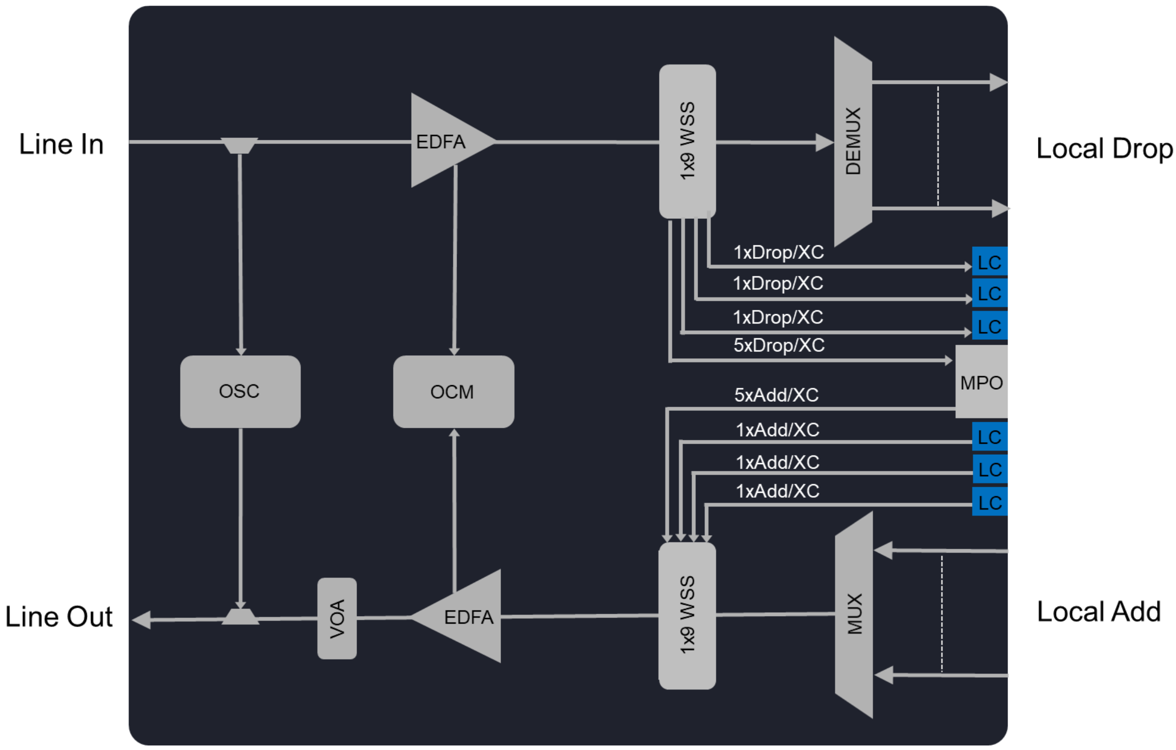


Figure 16: Functional diagram of DCP-R-9D-CS

There are several advantages to have all the components integrated in a 1RU chassis are, e.g. same box and same functionality in all nodes, only one spare part, easy fibre management, minimal external patching and faster installation etc.

3.4.2 DCP-R-34D-CS

The DCP-R-34D-CS product is a “ROADM on a blade” solution with everything needed for one ROADM degree in a 1RU chassis. This unit is optimized for transport of coherent services that will not require tunable dispersion compensation, but it can also be used for other services if external dispersion compensation is used.
DCP-R-34D-CS can be used in ROADM configurations up to 12 degrees.

This chassis has front to back air flow and can use AC or DC power. The power and FAN units are redundant and can be replaced. They are accessed from the rear side of the chassis.

Figure 17: Chassis front view of DCP-R-34D-CS

The DCP-R-34D-CS contains a twin 1x34 Flexgrid WSS, OCM, booster and pre-amplifier, a VOA for the line side and OSC filters. The OSC channel uses a pluggable SFP to support different distances. The OSC port can also use special SFPs for combined OSC+OTDR functionality.

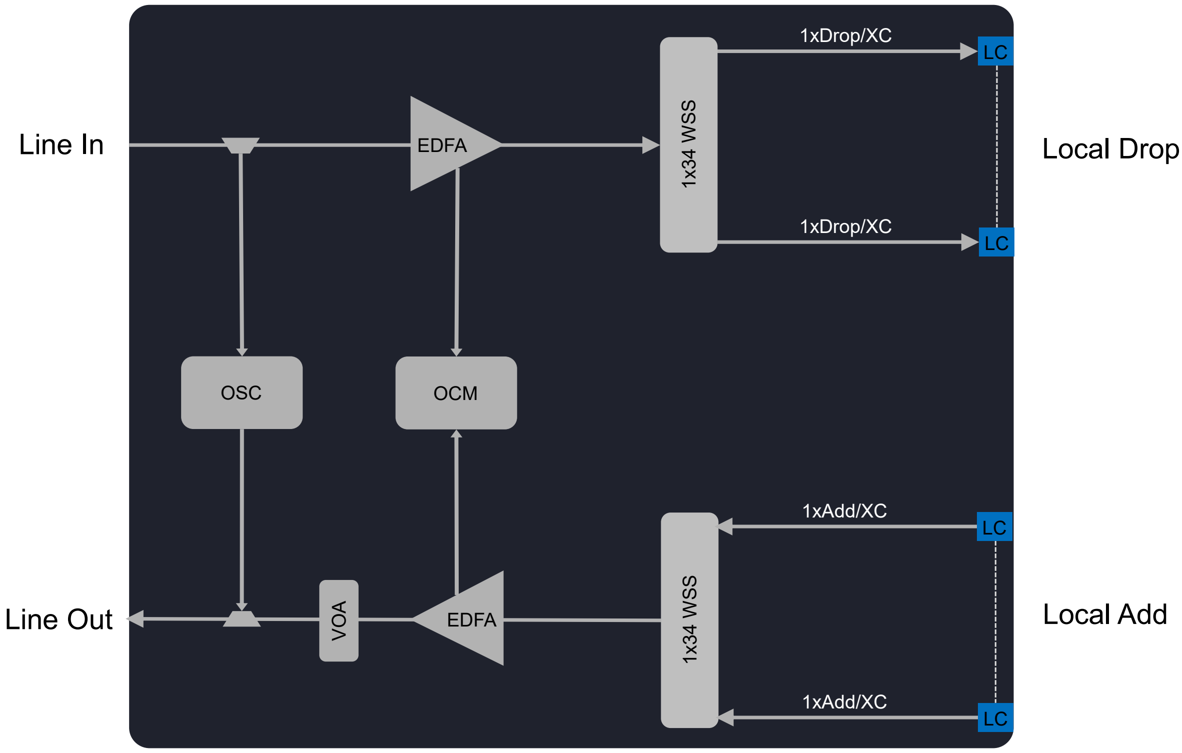


Figure 18: Functional diagram of DCP-R-34D-CS

4 Prerequisites

4.1 Variable optical attenuator, VOA

Besides gain, an amplifier is also characterized by the range of supported input and output optical power levels. To ensure proper network performance a Variable Optical Attenuator (VOA) can be used to attenuate and balance the optical line signals. The DCP-F allows VOA-SFP´s to be installed into the DCP-F SFP ports. Upon electrical power loss the VOA is set to max attenuation, i.e. “dark mode” and during normal operation the attenuation can be set between 0 to 20dB.

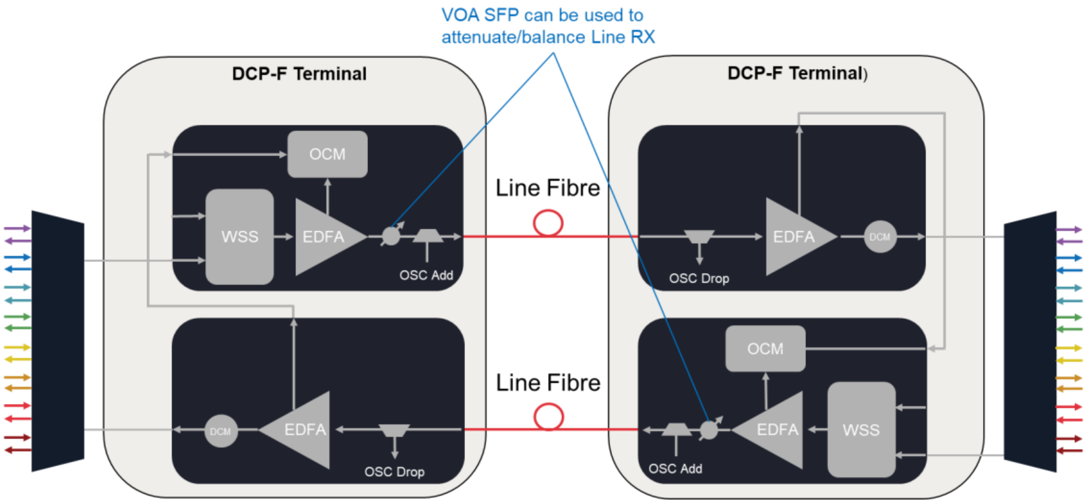


Figure 19: Variable Optical Attenuator

In optical transmission there is a phenomenon, non-linear effects, that can reduce the quality of transmission. High power levels into the fiber leads to more non-linear effects. It is therefore important that the VOA is placed at the booster transmit as shown in the picture above. Reducing power levels before going into the fiber is vital when minimizing non-linear effects in the fiber. If the VOA is placed on the receive side, high optical power is sent into the fiber and the attenuation is made after this effect has already occurred. In the DCP-M the line VOA is integrated within the unit on the transmit side and does not need to be externally added.

4.2 Channel power CLI terminology

DCP products have two types of channel power settings:

Target output power – This configuration means that the channel power after line VOA is configured. Currently used in DCP-M systems.

Wanted output power – This configuration means that the channel power before line VOA (directly after booster) is configured. Currently used in DCP-F systems.

4.3 DCP-M automation modes

The DCP-M has 2 automation modes; *embedded* and *managed*.

The embedded mode is only for point-to-point configurations and has completely self regulated operation. In this mode it is possible to set the running parameters through the command "chpowerlevel".

Embedded automation mode:

Chpowerlevel -> PAM4 (default, automatic, optimized for PAM4 traffic)

Chpowerlevel -> nonPAM4 (for systems running without PAM4 signals, automatic)

Chpowerlevel -> Manual (Automatic, but Booster Tx target and Preamp Tx Target are set by user). Booster Tx target power is set as value directly out of booster (before line VOA attenuation).

The **managed automation mode** for DCP-M means that line regulation is no longer self-regulating and the desired channel target power is configured by the user. Managed automation mode is required when connecting between the DCP-M and DCP-F families. The target output power is set as mentioned in previous chapter after (including) line VOA attenuation.

4.4 Optical connections

4.4.1 Connections with OSC filter PPM-AD1-1510-2F

The OSC filter in PPM formfactor should be connected as the picture below.

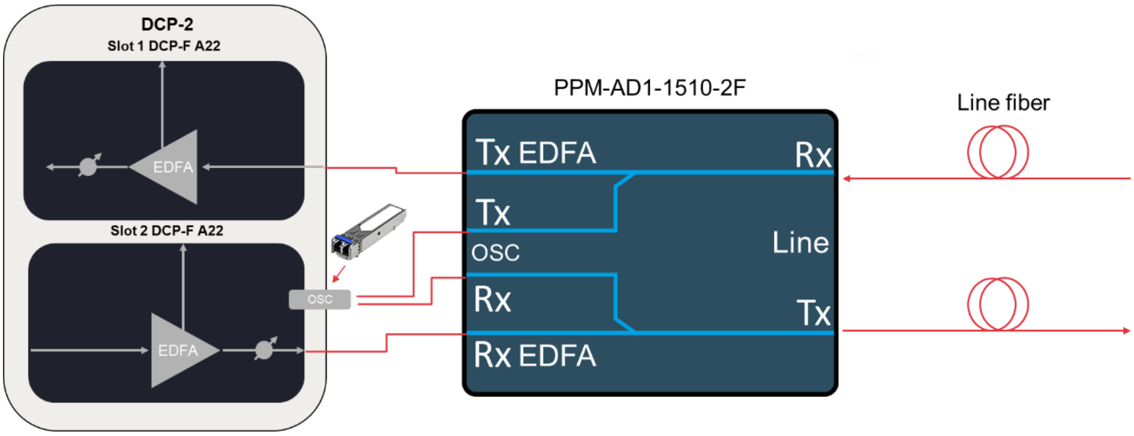


Figure 20: Connections between the OSC filter, EDFA and Line In each direction "Line" should always be facing the line fiber. EDFA ports should always be facing the DWDM amplifying equipment, which can be a DCP-F-A22, DCP-F-R22 or DCP-F-DE22. The OSC ports should be connected to the OSC transceiver transmit and receive.

4.4.2 Connections without OSC filter

If the OSC filter is not used connections should be as the picture below.

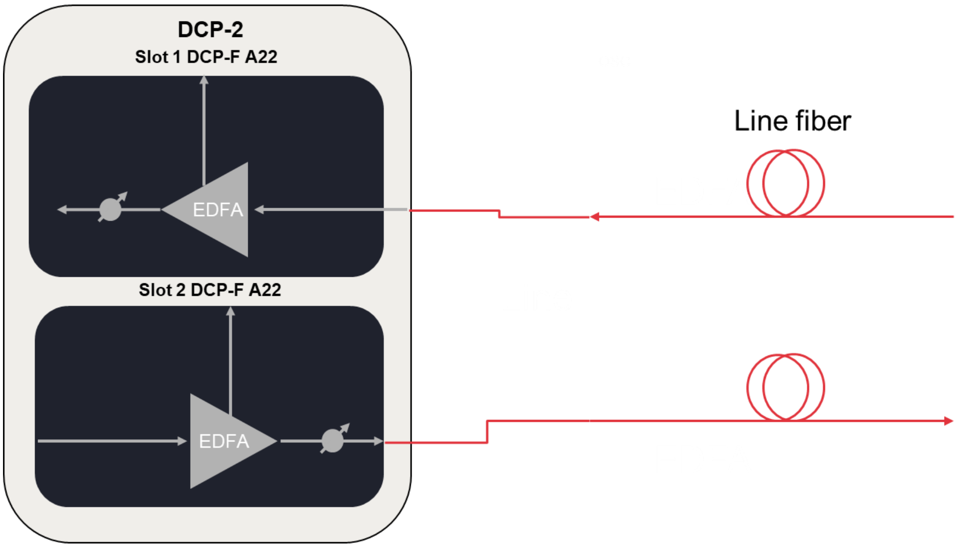


Figure 21: Connections between the EDFAs and Line fiber.

In each direction EDFA Tx and Rx in each direction is connected directly to the line fiber. If a line SFP-VOA is used it is placed between EDFA Tx port and line fiber.

5 Installation & commissioning

General remark: The installation values in this chapter are for 40 channel systems.

5.1 Booster installation

The booster is defined as the first amplifier connected right after the transmitting multiplexer.

5.1.1 DCP-M as booster

When using the DCP-M as a booster supporting 40 channels, the line power is set by using the target output power command in CLI in managed automation mode. The unit will strictly keep this value and not adapt based on changes in link loss. See Figure 22:

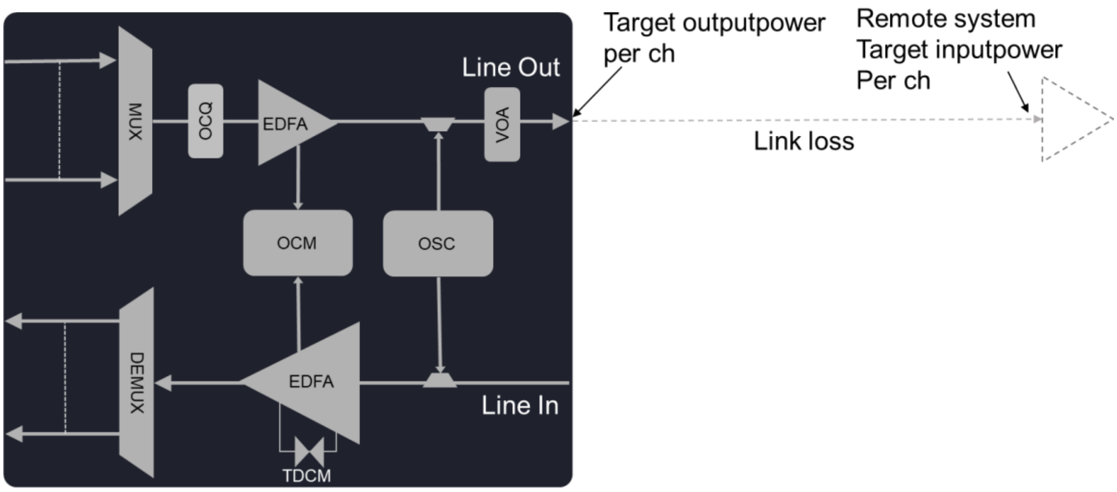


Figure 22: Definition explanation of Target output power and Remote system Target input power

The link loss can be obtained by using the function OSC linkview. and combining the loss value from the *show osclinkview* command and the insertion loss for the PPM modules (e.g. OSC, DCM, couplers, etc) that are not in the OSC path.

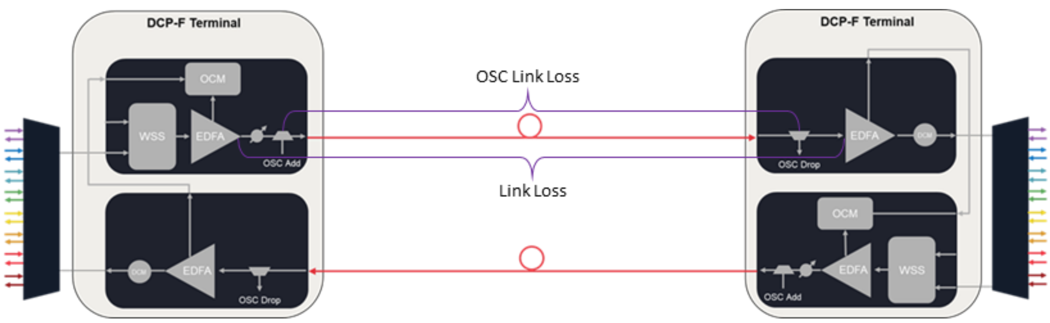


Figure 23: Link Loss Defined

The target output power is determined by the following formula:

Target output power (dBm) = Remote system target input power (dBm) + Link loss (dB

For DCP products find the remote system target input power in below table:

Remote system Model PN	Remote system target input power (dBm/ch)
DCP-M40	-18.5
DCP-F-A22	-18
DCP-F-R22 (EDFA Rx)	-11
DCP-F-DE22 (EDFA Rx)	-11
DCP-F-DE22/A22 (EQ Rx)	-11
DCP-F-R22 (Express Rx)	-5

Table 1: Remote system target input power per system type

5.1.2 DCP-F-R22 or DCP-F-DE22 as booster

The DCP-F-R22 or DCP-F-DE22 can be used as a booster.

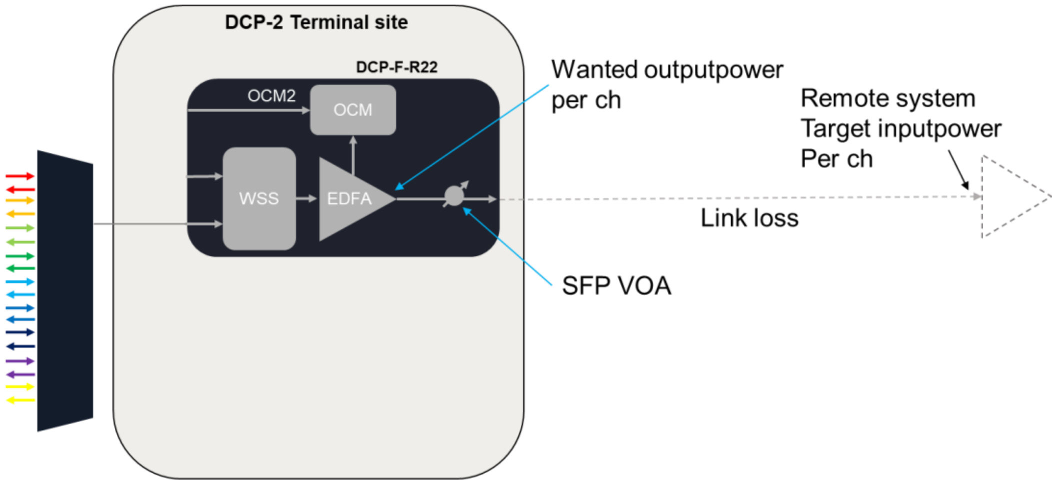


Figure 24: DCP-F-R22 as a booster with definitions

First find out the wanted power level per channel on the system. This can be found by setting max number on channels on the DCP-F unit. Then the expected wanted power for this channel amount is set as default. It can also be found out using Appendix A and the Tx power levels for 1 channel. Then note the expected loss on the fiber in transmit direction. Observe that this link loss is including OSC filter loss. The link loss can be obtained by using the function OSC linkview. If exact loss is not known either connect OSC first and use osclinkview or calculate an approximate value by using 0.25 dB/km. See Figure 23: Link Loss Defined.

Use the applicable remote system target input power as explained in the previous chapter Table 1.

Observe that the above table is valid for 40 channels. If you are using another channel amount in the system you are installing, find appropriate value in Appendix B.

Calculate the SFP VOA setting based on the expected link loss The following equation should be fulfilled:

SFP VOA setting (dB) = Wanted output power (dBm) - Link loss (dB) - Remote system target input power (dBm)

The link loss value in the above calculation includes: OSC link loss, Insertion loss through PPM modules that are not in OSC path, i.e. dispersion compensating modules, couplers etc.

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be removed.

5.1.2.1 DCP-F-R22 or DCP-F-DE22 EDFA port

For installation steps see below:

1. Connect all fibers as designed.

With OSC Filter: See Figure 20 for connections

   a. Connect Mux Tx to EDFA Rx.
   b. Connect EDFA Tx port to SFP-VOA Rx (if applicable).
   c. Connect EDFA Tx or SFP-VOA Tx (if applicable) to EDFA Rx on OSC filter.
   d. Connect OSC transceiver to OSC filter.
   e. Connect Line fibers to ”Line” on OSC filter.

Without OSC Filter: See Figure 21 for connections

   a. Connect Mux Tx to EDFA Rx.
   b. Connect EDFA Tx to SFP-VOA Rx (if applicable).
   c. Connect EDFA-Tx or SFP-VOA-Tx (if applicable) to the line fibers.

2. Set the max number of channels that the system is designed for. Wanted power default should be according to Tx power levels in Appendix A, 1 channel.
3. Set VOA attenuation to the calculated value.
4. Make sure that the channels to be added are added on the right port for DCP-F-R22 (edfa-rx or express-rx) on DCP-F-R22. On DCP-F-DE22 the channels to be added should have portmode “on” on the edfa and eq port respectively.
5. Set admin status up on EDFA and SFP VOA.
6. Insert the channels into the mux as designed. The channels will be automatically regulated.
7. If any channel is not detected follow the steps below:
   a. Confirm that the laser is enabled on the source.
   b. If the channel is still not detected lower the default WSS attenuation as explained in DCP-F user manual. It is possible to change individual channels default attenuation as well as groups.

c. As a rule of thumb, lower the default attenuation as much as needed for detection then reduce the setting another 3 dB for margin. The default attenuation is set per port (edfa-rx, express-rx) on DCP-F-R22 and per optical channel (och) on DCP-F-DE22.

8. Check power levels at EDFA Tx that they are expected and compare Tx power levels in Appendix A, 1 channel.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is required.

5.1.2.2 DCP-F-DE22/A22 Combo EQ port

For clarification on how to connect a DE22/A22 combo please see Figure 10 and Figure 11.

Installation steps:

1. Connect all fibers as designed.

With OSC Filter**:** See Figure 20 for connections

a. Connect Mux Tx to DE22 EQ Rx.
b. Connect DE22 EQ Tx to A22 EDFA Rx.
c. Connect A22 EDFA Tx to SFP-VOA Rx (if applicable).
d. Connect A22 EDFA Tx or SFP-VOA Tx (if applicable) to OSC filter EDFA Rx.
e. Connect OSC transceiver to OSC filter.
f. Connect Line fibers to ”Line” on OSC filter.
g. Connect A22 OCM Tx to DE22 OCM Rx.

Without OSC Filter: See Figure 21 for connections

a. Connect Mux Tx to DE22 EQ Rx.
b. Connect DE22 EQ Tx to A22 EDFA Rx.
c. Connect A22 EDFA Tx to SFP-VOA Rx (if applicable).
d. Connect A22 EDFA Tx or SFP-VOA Tx (if applicable) to line fibers.
e. Connect A22 OCM Tx to DE22 OCM Rx.

2. Make sure the combinedMode on the DCP-F-DE22 is set to “enabled”.
3. On the EQ interface set the maximum number of channels that the system is designed for. The default channel power will be automatically set.
4. Make sure that all the channels that are added to the system has port mode “on”.
5. Set admin status to EDFA up on A22.
6. Insert the channels into the mux as designed. The channels will be automatically regulated.
7. If any channel is not detected follow the steps below:

a. Confirm that the laser is enabled on the source. If the input port is connected to a line confirm that the light is coming into the port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.

b. If the channel is still not detected lower the default WSS attenuation as explained in DCP-F user manual. It is possible to change individual channels default attenuation as well as groups.

c. As a rule of thumb, lower the default WSS attenuation as much as needed for detection then reduce the setting another 3 dB for margin.

8. Check power levels at OCM Rx that they are as expected and compare Tx power levels in Appendix A, 1 channel.
9. Set VOA attenuation to the calculated value above.
10. Set admin status up on SFP VOA.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is required.

5.1.3 DCP-F-A22 as booster

The DCP-F-A22 can be used as a booster.

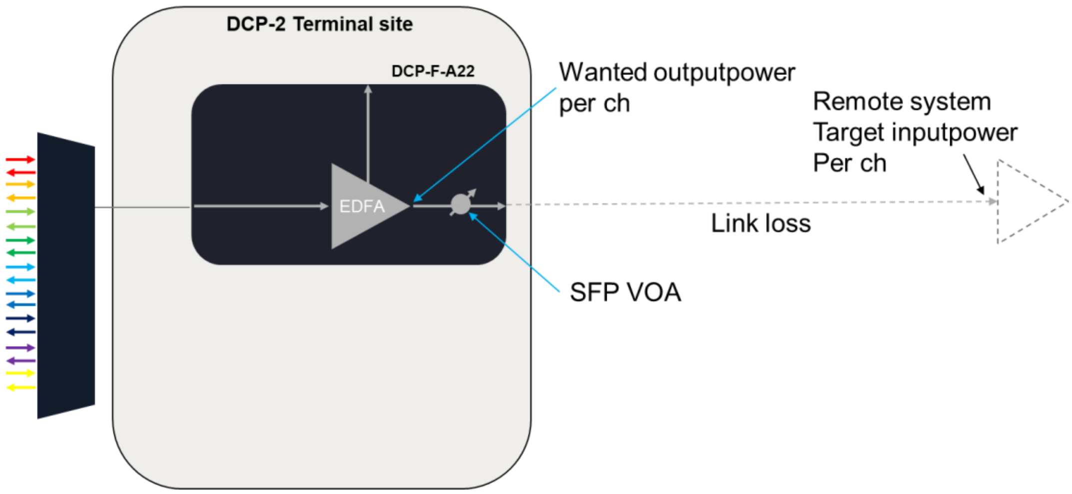


Figure 25: DCP-F-A22 as a booster with definitions

First find out the wanted power level per channel on the system by looking in the table in Appendix A and the Tx power levels for 1 channel. Then note the expected loss on the fiber in transmit direction. Observe that this link loss is including OSC filter loss. The link loss can be obtained by using the function OSC linkview. If exact loss is not known either connect OSC first and use CLI command osclinkview or calculate an approximate value by using 0.25 dB/km. See Figure 23: Link Loss Defined.

Use the applicable remote system target input power:

Remote system Model PN	Remote system target input power (dBm/ch)
DCP-F-A22	-18
DCP-F-R22 (EDFA Rx)	-11
DCP-F-DE22 (EDFA Rx)	-11
DCP-F-DE22/A22 (EQ Rx)	-11
DCP-F-R22 (Express Rx)	-5

Table 2: Remote system target input power for DCP-F system

Note that the above table is valid for 40 channels. If you are using another channel amount in the system you are installing, find appropriate value in Appendix B.

Wanted output power can be found in Appendix A, for 1 channel, depending on channel configuration.

Calculate the SFP VOA setting based on the expected link loss. The following equation should be fulfilled:

SFP VOA setting (dB) = Wanted output power (dBm) - Link loss (dB) - Remote system target input power (dBm)

The link loss value in the above calculation includes: OSC link loss, Insertion loss through PPM modules that are not in OSC path, i.e. dispersion compensating modules, couplers etc.

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be removed.

For installation steps see below:

1. Connect all fibers as designed.

With OSC Filter**:** See Figure 20 for connections

   a. Connect Mux Tx to EDFA Rx.
   b. Connect EDFA Tx port to SFP-VOA Rx (if applicable).
   c. Connect EDFA TX or SFP-VOA Tx (if applicable) to EDFA Rx on OSC filter.
   d. Connect OSC transceiver to OSC filter.
   e. Connect Line fibers to ”Line” on OSC.

Without OSC Filter: See Figure 21 for connections

   a. Connect Mux Tx to EDFA Rx.
   b. Connect EDFA Tx to SFP-VOA Rx (if applicable).
   c. Connect EDFA-Tx or SFP-VOA-Tx (if applicable) to the line fibers.

2. Set SFP VOA attenuation on the transmit side to the calculated value above.
3. Set admin status up on EDFA and SFP VOA.

4. Use fixed attenuators on the client laser to achieve the correct power levels at EDFA Rx and EDFA Tx port.
    a. Rx power levels in Appendix A can be used for the added amount of channels.
    b. (Recommended) A spectrum analyzer can be used at OCM Tx to measure the EDFA Tx channel power. Add 20dB to the read channel power value on analyzer to get the actual EDFA Tx channel power. Compare to Tx power levels in Appendix A, for 1 channel.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is needed.

5.1.4 Booster only configuration

If the system only has a booster amplifier the installation procedure is the same as for other booster configurations except that the Remote system target input power is different.

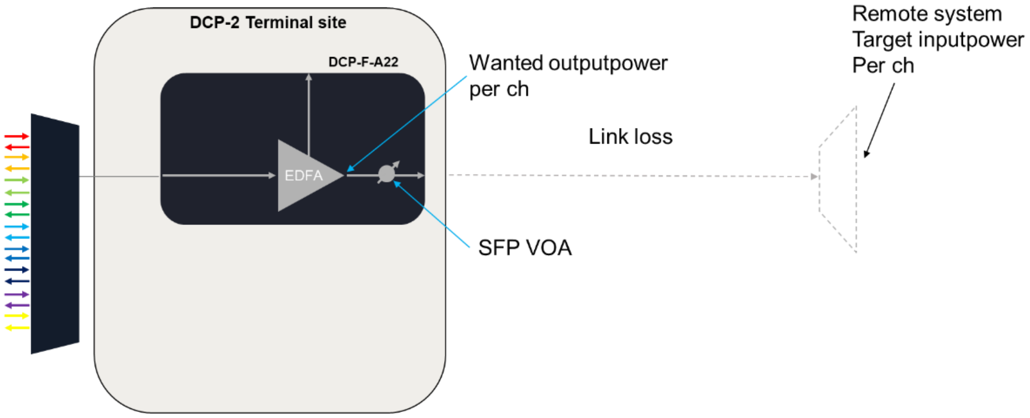


Figure 26: DCP-F-A22 as a booster only with definitions

In this case Remote system target input power will consist of the overload input power threshold of the transceivers used. If more than one type of transceivers are used the highest overload threshold should be used. Also the link loss value should include the drop insertion loss on the remote side. Note that it might be necessary to use external attenuators per channel after the demux if the transceivers have different overload limit.

Wanted output power can be found in Appendix A, for 1 channel, depending on channel configuration.

Calculate the SFP VOA setting based on the expected link loss. The link loss can be obtained by using the function OSC linkview. The following equation should be fulfilled:

SFP VOA setting (dB) = Wanted output power (dBm) - Link loss (dB) - Remote system target input power (dBm)

The link loss value in the above calculation includes: OSC link loss, Insertion loss through PPM modules that are not in OSC path, i.e. dispersion compensating modules, couplers etc. See Figure 23: Link Loss Defined.

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be removed.

Installation steps:

1. Install the booster as instructed in section 5.1.1 or 5.1.2 depending on hardware configuration that is used. It is important to set SFP VOA attenuation on the transmit side to the calculated value above in this section.
2. Set admin status up on EDFA and SFP VOA.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is needed.

5.1.5 DCP-R as booster

When using the DCP-R as a booster supporting 48 channels, the line power is set by using the target output power command in CLI in managedCLI automation mode. The unit will strictly keep this value and not adapt based on changes in link loss. See Figure 22:

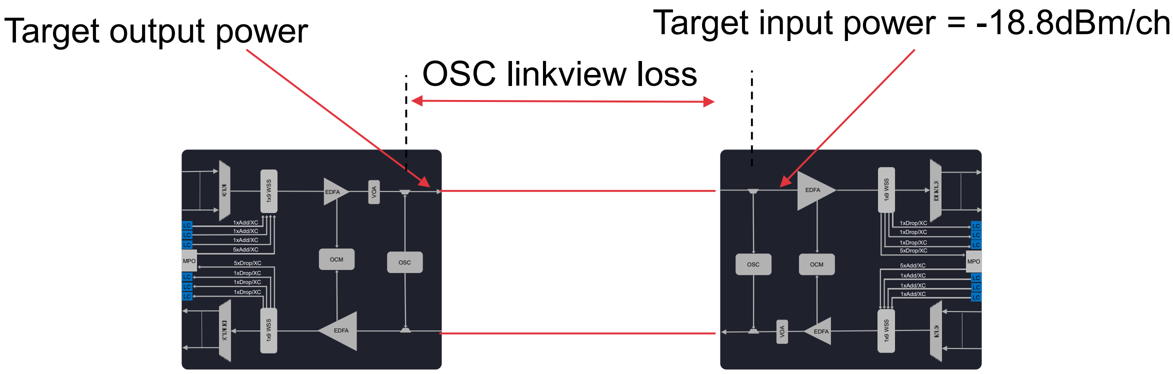


Figure 27: Definition explanation of Target output power and Remote system Target input power

The link loss can be obtained by using the function OSC linkview.

The target output power is determined by the following formula:

Target output power (dBm) = Remote system target input power (dBm) + Link loss (dB

For DCP products find the remote system target input power in below table:

Remote system Model PN	Remote system target input power (dBm/ch) 48ch
DCP-R-9D-CS	-18.8
DCP-R-34D-CS	Pin= 20.0-10*log(N)-Remote pre-amp gain N=Max number of channels Example: Gain=15dB, N=48ch Pin = 20 – 10*log(48) -15=-11.8
DCP-F-A22	-18.8
DCP-F-R22 (EDFA Rx)	-11.8
DCP-F-DE22 (EDFA Rx)	-11.8

DCP-F-DE22/A22 (EQ Rx)	-11.8
DCP-F-R22 (Express Rx)	-5.8

Table 3: Remote system target input power per system type

5.2 Line amplifier installation

5.2.1 DCP-F-A22 as line amplifier

The line amplifier is installed very similar to the booster.

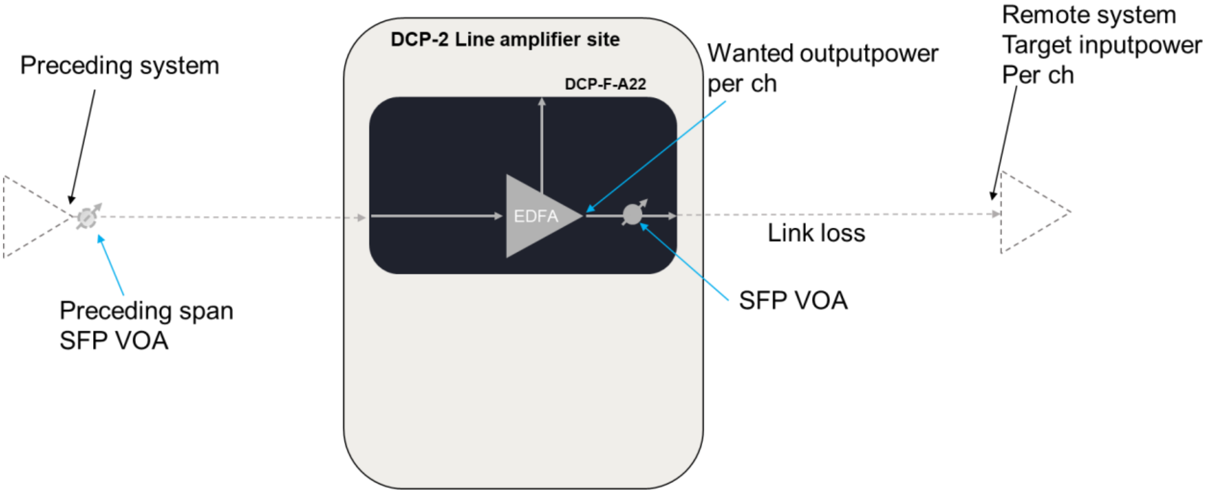


Figure 28: DCP-F-A22 as a line amplifier with definitions

First configure parameters for preceding span. Find out the wanted power level per channel on the system by looking in the table in Appendix A and the Tx power levels for 1 channel. Installation steps:

1. From preceding span connect all fibers as designed. See Figure 20 and Figure 21 for connections with and without OSC filter.

With OSC Filter**:** See Figure 20 for connections

a. Connect OSC transceiver to OSC filter.

b. Connect line fiber to Line on OSC filter.

c. Connect OSC filter EDFA Tx port to A22 EDFA Rx.

Without OSC Filter: See Figure 21 for connections

a. Connect line fiber directly to A22 EDFA Rx

2. Set admin status to EDFA up.

3. A spectrum analyzer should be used at OCM Tx to measure the EDFA Tx channel power. Add 20dB to the read channel power value on analyzer to get the actual EDFA Tx channel power. Compare to Tx power levels in Appendix A, for 1 channel.

4. Do different actions based on result:

a. If channel values are close Tx power levels (within +/1 dB) then proceed without action.

b. If channels values are too low configure preceding span SFP VOA. If the values are still to low increase the gain on line amplifier until average channel powers are within Tx power levels +/-1 dB.

c. If channel values are too high increase the SFP VOA setting on preceding span until average channel powers are within Tx power levels +/-1 dB.

Note! Using aggregate monitors in DCP-F-A22 for power levels will not be accurate when low channel counts are present. When channel amount >5 the Tx power levels in Appendix A can be used together with aggregate monitors such as power meters or EDFA Tx power reading in CLI.

Continue with transmitting path at section 5.2.3.

5.2.2 DCP-F-R22 or DCP-F-DE22 as line amplifier

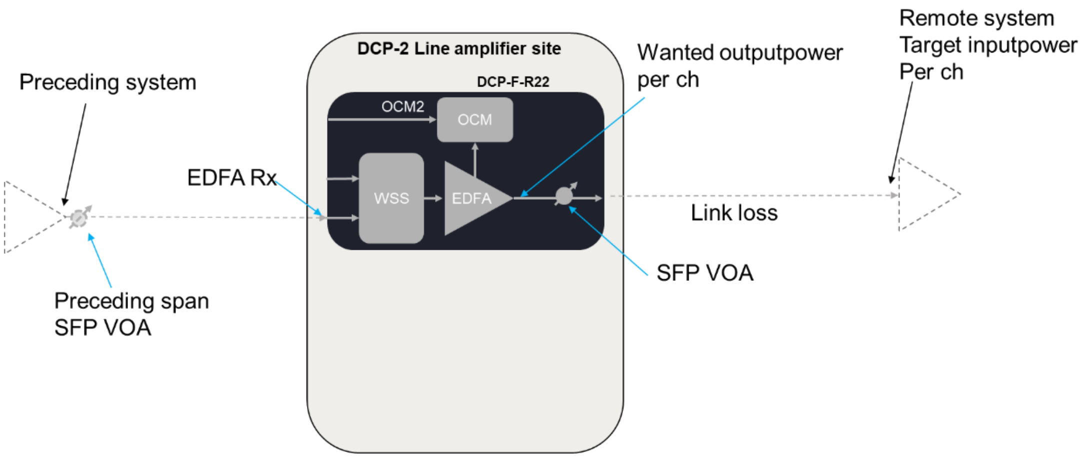


Figure 29: DCP-F-R22 as a line amplifier with definitions

First configure parameters for preceding span. Find out the number of channels the system is designed for.

5.2.2.1 DCP-F-R22 EDFA or DCP-F-DE22 EDFA port

Installation steps:

1. From preceding span connect all fibers as designed.

With OSC Filter**:** See Figure 20 for connections

a. Connect OSC transceiver to OSC filter.

b. Connect line fiber to Line on OSC filter.

c. Connect EDFA Tx port on OSC filter to R22/DE22 EDFA Rx .

Without OSC Filter: See Figure 21 for connections

a. Connect the line fiber directly to the R22/DE22 EDFA Rx.

2. On the EDFA interface set the maximum number of channels that the system is designed for. The default channel power will be automatically set.
3. Set all the channels that are added in the correct portmode. For DCP-F-R22 set portmode to edfa-rx. On DCP-F-DE22 set the added channels to portmode “on”.
4. Set admin status to EDFA up. Channels should be automatically regulated.
5. If any channel is not detected follow the steps below:
    a. Confirm that the laser is enabled on the source. If the input port is connected to a line confirm that light is coming into the port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.
    b. If the channel is still not detected lower the default WSS attenuation as explained in DCP-F user manual. It is possible to change individual channels default attenuation as well as groups.
    c. As a rule of thumb, lower the default WSS attenuation as much as needed for detection then reduce the setting another 3 dB for margin.
6. Check power levels at EDFA Tx that they are expected and compare Tx power levels in Appendix A.
    a. If the measured values are generally below the compared values increase the gain on EDFA with the appropriate amount.

Continue with transmitting path at section 5.2.3.

5.2.2.2 DCP-F-DE22 EQ combined with DCP-F-A22

For clarification on how to connect a DE22/A22 combo please see Figure 10, Figure 20 and Figure 21.

Installation steps:

1. From preceding span connect all fibers as designed.

With OSC Filter**:** See Figure 20 for connections

   a. Connect OSC transceiver to OSC filter.
   b. Connect line fiber to Line on OSC filter.
   c. Connect OSC filter EDFA Tx port to DE22 EQ Rx.
   d. Connect DE22 EQ Tx port to A22 EDFA Rx.
   e. Connect A22 OCM Tx to DE22 OCM Rx

. Without OSC Filter: See Figure 21 for connections

   a. Connect the line fiber directly to the DE22 EQ Rx
   b. Connect DE22 EQ Tx port to A22 EDFA Rx.
   c. Connect A22 OCM Tx to DE22 OCM Rx

2. Make sure the combinedMode on the DCP-F-DE22 is set to “enabled”.

3. On the EQ interface set the maximum number of channels that the system is designed for. The default channel power will be automatically set.
4. Make sure that all the channels that are added to the system has port mode “on”.
5. Set admin status to EDFA up on A22. Channels should be automatically regulated.
6. If any channel is not detected follow the steps below:
    a. Confirm that the laser is enabled on the source. If the input port is connected to a line confirm that light is coming into the port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.
    b. If the channel is still not detected lower the default WSS attenuation as explained in DCP-F user manual. It is possible to change individual channels default attenuation as well as groups.
    c. As a rule of thumb, lower the default WSS attenuation as much as needed for detection then reduce the setting another 3 dB for margin.
7. Check power levels at OCM Rx that they are expected and compare Tx power levels in Appendix A, 1 channel.
    a. If the measured values are generally below the compared values increase the gain at A22 EDFA with the appropriate amount.

Continue with transmitting path at section 5.2.3.

5.2.3 Transmit path

Continue installing settings on the transmit path.

Note the expected loss on the fiber in transmit direction. Observe that this link loss is including OSC filter loss. The link loss can be obtained by using the function OSC linkview. If exact loss is not known either connect OSC first and use CLI command osclinkview or calculate an approximate value by using 0.25 dB/km.

Use the applicable remote system target input power, see Appendix B. The different tables are for different channel amounts.

Wanted output power can be found in Appendix A, for 1 channel, depending on channel configuration.

Calculate the SFP VOA setting based on the expected link loss. The following equation should be fulfilled:

SFP VOA setting (dB) = Wanted output power (dBm) - Link loss (dB) - Remote system target input power (dBm)

The link loss value in the above calculation includes: OSC link loss, Insertion loss through PPM modules that are not in OSC path, i.e. dispersion compensating modules, couplers etc. See Figure 23: Link Loss Defined.

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be removed.

For installation steps see below:

1. Connect all fibers as designed towards next span.

With OSC Filter: See Figure 20 for connections

   a. Connect OSC transceiver to OSC filter.
   b. Connect EDFA Tx port to SFP-VOA Rx (if applicable).
   c. Connect EDFA Tx or SFP-VOA Tx (if applicable) to EDFA Rx on OSC filter..
   d. Connect EDFA Tx to OSC filter EDFA Rx.
   e. Connect Line fibers to OSC filter ”Line” .

Without OSC Filter: See Figure 21 for connections

   a. Connect EDFA Tx port to SFP-VOA Rx (if applicable).
   b. Connect EDFA Tx or SFP-VOA Tx (if applicable) to line fibers.

2. Set SFP VOA attenuation on the transmit side to the calculated value above.
3. Set admin status up on SFP VOA.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is needed.

5.3 Preamplifier installation

5.3.1 Preamplifier configuration

The preamplifier installation procedure is the same as for line amplifier configurations except that the Remote system target input power and link loss is different.

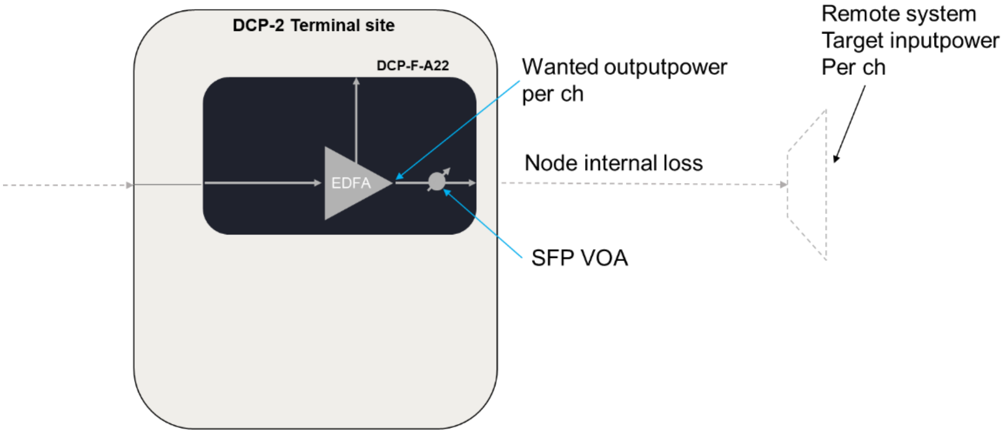


Figure 30: DCP-F-A22 as a preamp with definitions

In this case Remote system target input power will consist of the overload input power threshold of the transceivers used. If more than one type of transceivers are used the highest overload threshold should be used (the most power tolerant). Also the node internal loss value should include the drop insertion loss and any loss prior to that point, for instance PPM modules like DCM:s couplers etc. See Figure 23: Link Loss Defined.
Note that it might be necessary to use external attenuators per channel after the demux if the transceivers have different overload limit.

Wanted output power can be found in Appendix A, for 1 channel, depending on channel configuration.

Calculate the SFP VOA setting based on the expected link loss. The link loss can be obtained by using the function OSC linkview. The following equation should be fulfilled:

SFP VOA setting (dB) = Wanted output power (dBm) – Node internal loss (dB) - Remote system target input power (dBm)

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be removed.

Installation steps:

1. Install the preamplifier as instructed in section 5.1.1 or 5.1.2 depending on hardware configuration used. It is important to set SFP VOA attenuation on the transmit side to the calculated value above in this section.
2. Set admin status up on EDFA and SFP VOA.

Note that if SFP VOA is not used and attenuation is needed a fixed attenuator with the same attenuation amount is needed.

6 Use case specific installations

The cases discussed in this section will be the 2-degree ROADM case:

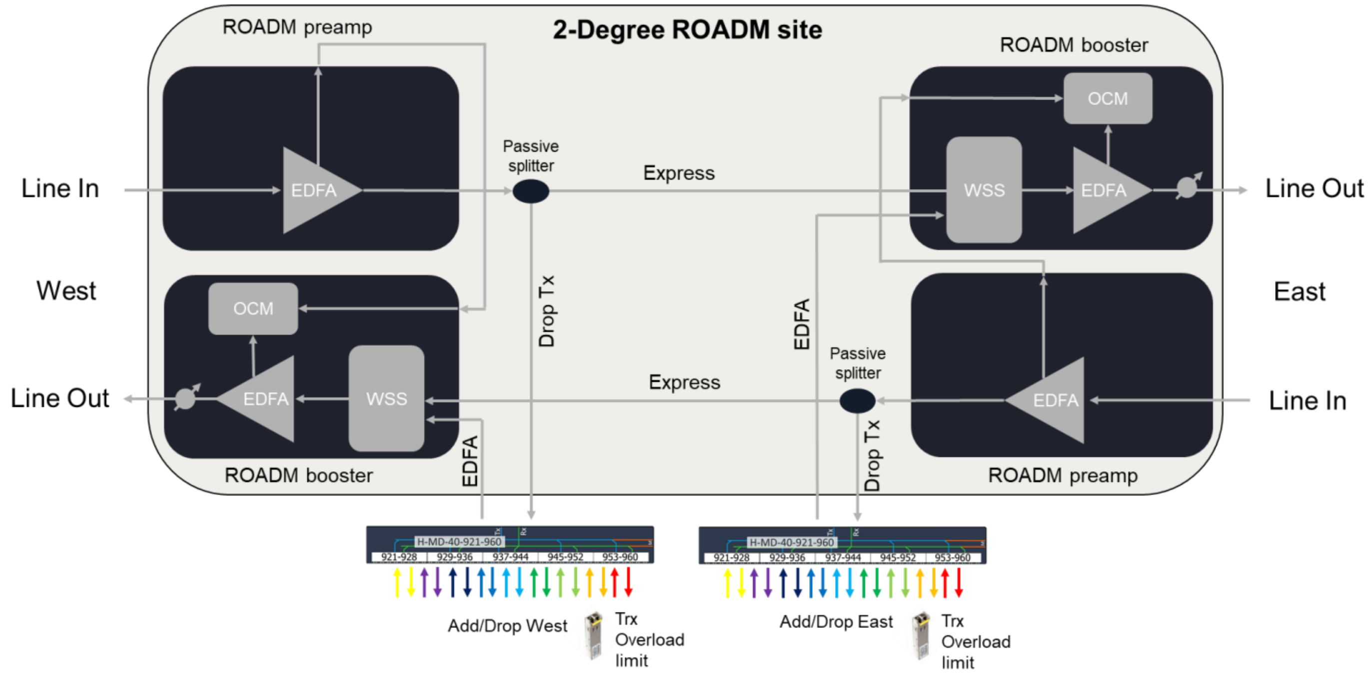


Figure 31: Figure of the 2-degree ROADM node

And the Active/passive use case:

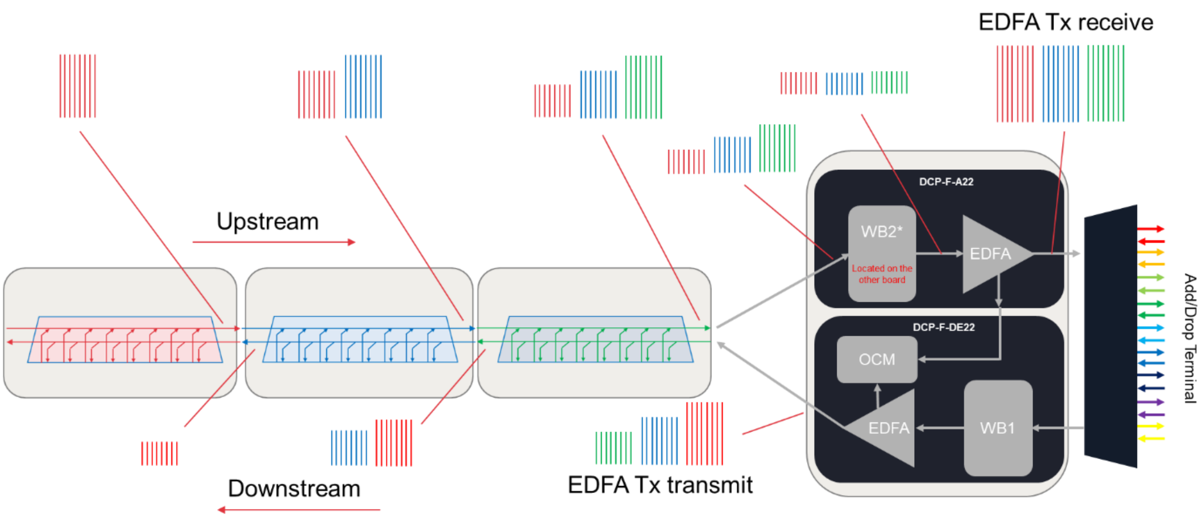


Figure 32: Active/passive use case without line amplifier

6.1 2-degree DCP-F ROADM

For a 2-degree ROADM node (see Figure 31) the ROADM preamp is installed as a line amplifier and the ROADM booster is installed as a booster amplifier (EDFA port). The following section details how to install the Drop Tx part and the Express port:

6.1.1 Drop Tx Installation

In this case the installation will make sure that the overload input power threshold of the transceivers used in Add/drop West and East are not violated. If more than one type of transceivers are used the highest overload threshold value should be used as installation parameter (the most power tolerant).

A fixed attenuator or SFP-VOA should be placed on the drop Tx path (after the drop coupler/passive splitter). It is important to place the attenuator after the drop coupler so that the attenuation only influences the drop Tx path.

After the installation of the ROADM preamp it is possible to read the average channel power out of preamp. This can be done by using a simple average calculation for the channels that are present in OCM Rx port on the ROADM preamp. The total ocm power value can be found in the cli under the ocm-rx port. Make sure the correct direction is used (East/West) for the calculation:

Average channel power (dBm) = sum (Total power OCM Rx) – 10 *log (number of channels)

Calculate the SFP VOA setting/fixed attenuator value based on the following equation:

SFP VOA setting/fixed attenuator (dB) = Average channel power (dBm) – coupler loss (Drop Tx path, dB) – demux loss (dB) – overload input power (dBm)

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be disregarded/removed.

Installation steps:

1. Install the calculated SFP VOA/fixed attenuator before the demux.
2. For each of the channels dropped measure the output power out from the demux so that it doesn’t violate the overload limit. If transceivers with different overload thresholds are used the most sensitive transceiver type will have to be individually attenuated per channel down to its overload threshold. If only one type of transceivers are used there should be no need for further attenuation.

6.1.2 Express port Installation

The express port on the DCP-F-R22 is installed in the following way.

Installation steps:

1. For each direction add the channels that are designed to go express on the R22 Express port.
2. For each optical channels (och) make sure the correct channel power is set and that portmode are set to express-rx.

3. Check that the admin status on the edfa interface port is set to up.

The channels will then be automatically regulated.

4. If any channel is not detected follow the steps below:
    a. Confirm that the laser is enabled on the source. If the input port is connected to a line confirm that the light is coming into the port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.
    b. If the channel is still not detected lower the default attenuation on the express port as explained in DCP-F user manual.
    c. As a rule of thumb, lower the default attenuation on the express port as much as needed for detection then reduce the setting another 3 dB for margin.

6.2 Active/passive wo line amplifier

The active/passive use case (see Figure 32) can also take the form of a ring but the installation is the same just done from two directions.

The recommendation is that the installation is done with a DCP-F-DE22/A22 combo, but it can also be achieved with 2 individual DE22 units. The key is that 2 control loops are needed, one in downstream direction and one in upstream direction.

6.2.1 Upstream, EDFA Tx Receive Installation

In order to install the receive direction the EDFA Tx receive (upstream) direction an attenuator should be placed after the EDFA in upstream direction. This attenuator will be ensure that maximum possible transmission conditions is achieved for all channels. If more than one type of transceivers are used the highest overload threshold value should be used as installation parameter (the most power tolerant).
Note that it might be necessary to use external attenuators per channel after the demux if the transceivers have different overload limit.

Calculate the SFP VOA setting/fixed attenuator value based on the following equation:

SFP VOA setting/fixed attenuator (dB) = Wanted power (dBm) – Excess loss (i.e. DCM, dB) – demux loss (dB) – overload input power (dBm)

If the SFP VOA attenuation value becomes negative the SFP VOA is not necessary in design and can be disregarded/removed.

Installation steps:

1. Ensure that all channels in design are set to portmode “on”. The channels will be automatically regulated as they are inserted.
2. If any channel is not detected follow the steps below:
    a. Confirm that the laser is enabled on the source and confirm that the light is coming into the input port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.

b. If the channel is still not detected lower the default attenuation as explained in DCP-F user manual. On DCP-F-DE22 it is possible to change per optical channel (individual channels default attenuation as well as groups).

c. As a rule of thumb, lower the default attenuation as much as needed for detection then reduce the setting another 3 dB for margin.

3. For each of the channels dropped measure the output power out from the demux so that it doesn't violate the overload limit. If transceivers with different overload thresholds are used the most sensitive transceiver type will have to be individually attenuated per channel down to its overload threshold. If only one type of transceivers is used there should be no need for further attenuation.

6.2.2 Downstream, EDFA Tx transmit Installation

In order to install the receive direction the EDFA Tx transmit (downstream) direction the wanted power on each channel should be modified/adapted. This is done in order to avoid to the highest possible degree using attenuators in the passive sites. The wanted power in the downstream direction involves an estimation of the loss downstream. This estimation can be done by adding the loss for the fiber to a specific site and also adding the express and drop losses for the filters to the same site.

Calculate the adapted wanted power value based on the following equation:

Adapted wanted power (dBm) = overload input power remote transceiver (dBm) – downstream loss (dB)

The adapted wanted power is limited to avoid unwanted behavior in amplifiers. The limits will differ depending on how many channels the system is designed for. As an example, in a 40 channel system the nominal output power for 1 channel is 4.0 dBm (Appendix A, 1 channel). From this value power can be increased by maximum 2 dB. It is also allowed to reduce the value down by 10 dB at most. It is however not allowed to set any channel power lower than -2 dBm. Hence the adapted power value for a 40 channel system should be between -2 dBm and + 6 dBm. The same calculation can be made for other channel amounts.

Installation steps:

1. For each channel to be added calculate the adapted wanted power value.
2. Set the wanted power on the channel to be added and set it to power mode.
3. If any channel is not detected follow the steps below:

    a. Confirm that the laser is enabled on the source and confirm that the light is coming into the input port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.

    b. If the channel is still not detected lower the default attenuation as explained in DCP-F user manual. On DCP-F-DE22 it is possible to change per optical channel (individual channels default attenuation as well as groups).

    c. As a rule of thumb, lower the default attenuation as much as needed for detection then reduce the setting another 3 dB for margin.

6.3 Active/passive with line amplifier

The active/passive use case can be extended by the use of another DCP-F-DE22/A22 combo as a line amplifier. Basically the installation is done in the same way as without line amplifier with the exception that the channels that will reach the line amplifier in the chain should have default power levels. Only the channels that are dropped before the line amplifier should have adapted power levels in the downstream direction (as described in above section). All the other control loops should be configured to default wanted power. See picture below for clarification.

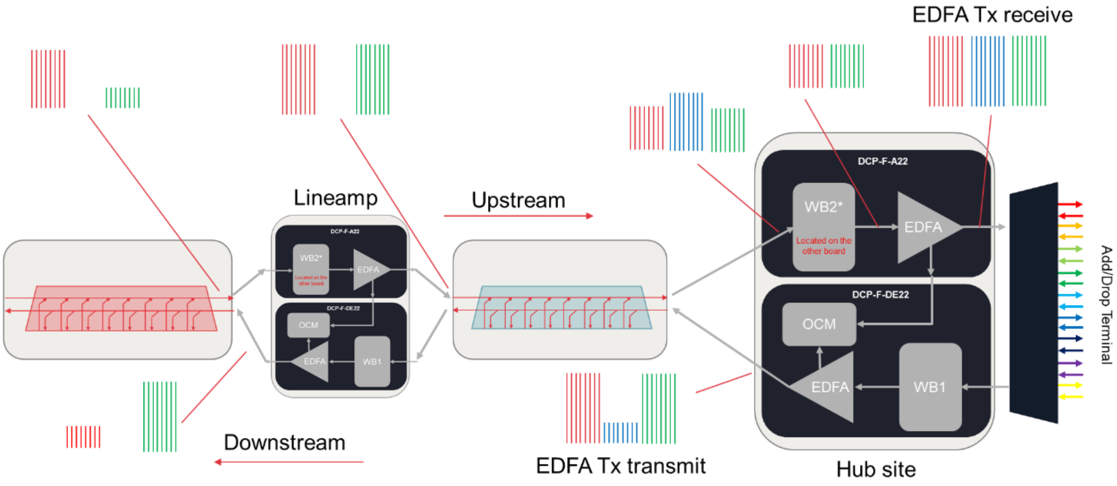


Figure 33: Explanation of power modes in active passive configuration with line amplifier

The Hub site to the right transmits all three bands; red, blue and green in the downstream direction. Only the blue is dropped before the lineamplifier therefore that wanted power is sent out lower (adapted). Red and green are sent out with nominal power level (+4 dBm for a 40 channel system). In the line amplifier downstream direction the red is sent out adapted (lower) because it is dropped after the lineamp. The green band is dropped outside of the picture and therefore is sent out strong but also adapted power. In the upstream direction for the lineamp it is sent out both red and green nominal output since both these bands will travel all the way to the Hub site (i.e. not dropped after the lineamplifier).

If wanted power is to be adapted the calculated wanted power in the downstream direction involves an estimation of the loss downstream. This estimation can be done by adding the loss for the fiber to a specific site and also adding the express and drop losses for the filters to the same site.

Calculate the adapted wanted power value based on the following equation:

Adapted wanted power (dBm) = overload input power remote transceiver (dBm) + downstream loss (dB)

The adapted wanted power is limited to avoid unwanted behavior in amplifiers. The limits will differ depending on how many channels the system is designed for. As an example, in a 40 channel system the nominal output power for 1 channel is 4.0 dBm (Appendix A, 1 channel). From this value power can be increased by maximum 2 dB. It is also allowed to reduce the value down by 10 dB at most. It is however not allowed to set any channel power lower than -2 dBm. Hence the adapted power value for a 40 channel system should be between -2 dBm and + 6 dBm. The same calculation can be made for other channel amounts.

Installation steps:

1. For each channel to be added calculate the adapted wanted power value.
2. Set the wanted power on the channel to be added and set it to power mode. Channels should be regulated automatically.
3. If any channel is not detected follow the steps below:
    a. Confirm that the laser is enabled on the source and confirm that the light is coming into the input port. This can be done by checking cabling and confirming by CLI that previous unit on the line is transmitting.
    b. If the channel is still not detected lower the default attenuation as explained in DCP-F user manual. On DCP-F-DE22 it is possible to change per optical channel (individual channels default attenuation as well as groups).
    c. As a rule of thumb, lower the default attenuation as much as needed for detection then reduce the setting another 3 dB for margin.

Appendix A Power levels DCP-F family

System design	8 channels		16 channels		24 channels	
No channels	Rx powerlevels	Tx power levels	Rx powerlevels	Tx power levels	Rx powerlevels	Tx power levels
1	-11,0	11,0	-14,0	8,0	-15,8	6,2
2	-8,0	14,0	-11,0	11,0	-12,8	9,2
3	-6,3	15,7	-9,3	12,7	-11,0	11,0
4	-5,0	17,0	-8,0	14,0	-9,8	12,2
5	-4,0	18,0	-7,1	14,9	-8,8	13,2
6	-3,2	18,8	-6,3	15,7	-8,0	14,0
7	-2,6	19,4	-5,6	16,4	-7,4	14,6
8	-2,0	20,0	-5,0	17,0	-6,8	15,2
9			-4,5	17,5	-6,3	15,7
10			-4,0	18,0	-5,8	16,2
11			-3,6	18,4	-5,4	16,6
12			-3,2	18,8	-5,0	17,0
13			-2,9	19,1	-4,7	17,3
14			-2,6	19,4	-4,3	17,7
15			-2,3	19,7	-4,0	18,0
16			-2,0	20,0	-3,8	18,2
17					-3,5	18,5
18					-3,2	18,8
19					-3,0	19,0
20					-2,8	19,2
21					-2,6	19,4
22					-2,4	19,6
23					-2,2	19,8
24					-2,0	20,0

System design	32 channels		40 channels		48 channels	
No channels	Rx powerlevels	Tx power levels	Rx powerlevels	Tx power levels	Rx powerlevels	Tx power levels
1	-17,1	4,9	-18,0	4,0	-18,8	3,2
2	-14,0	8,0	-15,0	7,0	-15,8	6,2
3	-12,3	9,7	-13,2	8,8	-14,0	8,0
4	-11,0	11,0	-12,0	10,0	-12,8	9,2
5	-10,1	11,9	-11,0	11,0	-11,8	10,2
6	-9,3	12,7	-10,2	11,8	-11,0	11,0
7	-8,6	13,4	-9,6	12,4	-10,4	11,6
8	-8,0	14,0	-9,0	13,0	-9,8	12,2
9	-7,5	14,5	-8,5	13,5	-9,3	12,7
10	-7,1	14,9	-8,0	14,0	-8,8	13,2
11	-6,6	15,4	-7,6	14,4	-8,4	13,6
12	-6,3	15,7	-7,2	14,8	-8,0	14,0
13	-5,9	16,1	-6,9	15,1	-7,7	14,3
14	-5,6	16,4	-6,6	15,4	-7,4	14,6
15	-5,3	16,7	-6,3	15,7	-7,1	14,9
16	-5,0	17,0	-6,0	16,0	-6,8	15,2
17	-4,7	17,3	-5,7	16,3	-6,5	15,5
18	-4,5	17,5	-5,5	16,5	-6,3	15,7
19	-4,3	17,7	-5,2	16,8	-6,0	16,0
20	-4,0	18,0	-5,0	17,0	-5,8	16,2
21	-3,8	18,2	-4,8	17,2	-5,6	16,4
22	-3,6	18,4	-4,6	17,4	-5,4	16,6
23	-3,4	18,6	-4,4	17,6	-5,2	16,8
24	-3,2	18,8	-4,2	17,8	-5,0	17,0
25	-3,1	18,9	-4,0	18,0	-4,8	17,2
26	-2,9	19,1	-3,9	18,1	-4,7	17,3
27	-2,7	19,3	-3,7	18,3	-4,5	17,5
28	-2,6	19,4	-3,5	18,5	-4,3	17,7
29	-2,4	19,6	-3,4	18,6	-4,2	17,8
30	-2,3	19,7	-3,2	18,8	-4,0	18,0
31	-2,1	19,9	-3,1	18,9	-3,9	18,1
32	-2,0	20,0	-3,0	19,0	-3,8	18,2
33			-2,8	19,2	-3,6	18,4
34			-2,7	19,3	-3,5	18,5
35			-2,6	19,4	-3,4	18,6
36			-2,5	19,5	-3,2	18,8
37			-2,3	19,7	-3,1	18,9
38			-2,2	19,8	-3,0	19,0
39			-2,1	19,9	-2,9	19,1
40			-2,0	20,0	-2,8	19,2
41					-2,7	19,3
42					-2,6	19,4
43					-2,5	19,5
44					-2,4	19,6
45					-2,3	19,7
46					-2,2	19,8
47					-2,1	19,9
48					-2,0	20,0

Appendix B Remote target input power levels DCP family

Remote system Model PN	Remote system target input power (dBm/ch) 48ch
DCP-R-9D-CS	-18.8
DCP-R-34D-CS	Pin= 20.0-10*log(N)-Remote pre-amp gain N=Max number of channels Example: Gain=15dB, N=48ch Pin = 20 – 10*log(48) -15=-11.8
DCP-F-A22	-18.8
DCP-F-R22 (EDFA Rx)	-11.8
DCP-F-DE22 (EDFA Rx)	-11.8
DCP-F-DE22/A22 (EQ Rx)	-11.8
DCP-F-R22 (Express Rx)	-5.8

Remote system Model PN	Remote system target input power (dBm/ch) 40 ch
DCP-M40	-18.5
DCP-F-A22	-18
DCP-F-R22 (EDFA Rx)	-11
DCP-F-DE22 (EDFA Rx)	-11
DCP-F-DE22/A22 (EQ Rx)	-11
DCP-F-R22 (Express Rx)	-5

Remote system Model PN	Remote system target input power (dBm/ch) 32 ch
DCP-F-A22	-17.1
DCP-F-R22 (EDFA Rx)	-10.1
DCP-F-DE22 (EDFA Rx)	-10.1
DCP-F-DE22/A22 (EQ Rx)	-10.1
DCP-F-R22 (Express Rx)	-4.1

Remote system Model PN	Remote system target input power (dBm/ch) 24 ch
DCP-F-A22	-15.8
DCP-F-R22 (EDFA Rx)	-8.8
DCP-F-DE22 (EDFA Rx)	-8.8
DCP-F-DE22/A22 (EQ Rx)	-8.8
DCP-F-R22 (Express Rx)	-2.8

Remote system Model PN	Remote system target input power (dBm/ch) 16 ch
DCP-F-A22	-14
DCP-F-R22 (EDFA Rx)	-7
DCP-F-DE22 (EDFA Rx)	-7
DCP-F-DE22/A22 (EQ Rx)	-7
DCP-F-R22 (Express Rx)	-1

Remote system Model PN	Remote system target input power (dBm/ch) 8 ch
DCP-F-A22	-11
DCP-F-R22 (EDFA Rx)	-4
DCP-F-DE22 (EDFA Rx)	-4
DCP-F-DE22/A22 (EQ Rx)	-4
DCP-F-R22 (Express Rx)	+2

Appendix C Link Scenarios “Point-to-Point”

DCP-F “Point to Point”

Model	**10G (ER)** Link budget	**400ZR** Link budget	**10G w FEC (ER)** Link budget	**QPSK 100G** Link budget	**Comments**
A22 preamp only “point to point”	20 dB	11 dB	29 dB	31 dB (25 dB)	QPSK in parentheses is low power Acacia.
R22 Booster only “point to point”	21 dB (ZR)	18 dB	23 dB (ZR)	19 dB (27 dB)	SFP+ APD ZR is used instead of ER
A22/A22 “point to point”	26 dB	26 dB	36 dB	37 dB	>33 dB link 1-4 channels LOS preamp will be active
R22/A22 “point to point”	28 dB	28 dB	38 dB	39 dB	>33 dB link 1-4 channels LOS preamp will be active

- All above link losses are without OSC filters.
    - 2x0,5 dB must be deducted if OSC is used.
- All above values are calculated for 40 channels. In general:
    - 96 channels -> -3,8 dB on all link losses (50 GHz spacing not supported in R6)
    - 80 channels -> -3 dB on all link losses (50 GHz spacing not supported in R6)
    - 48 channels -> -0,8 dB on all link losses
    - 32 channels -> +1 dB on all link losses
    - 16 channels -> +4 dB on all link losses
    - All above values assume a 5 dB IL AWG add/drop is used on both sides.
- The above only applies to solutions with a booster included, with preamp only channel amount does not influence link loss.
- 400ZR cannot be increased in link loss from 40ch because of its low transceiver output power (-10 dBm) when using R22.
    - With A22 400ZR links can be increased with maximum +4 dB.
- 10G is calculated with SFP+ ER optics (except for booster only case where ZR is used).

Appendix D Link Scenarios “2-degree DCP-F ROADM and Linear multi-links”

DCP-F “2-degree ROADM and Linear multi-links”

Model	**10G (ER)** Link budget	**400ZR** Link budget	**10G w FEC (ER)** Link budget	**QPSK 100G** Link budget
R22 booster A22 OLA & PA “Linear multi-links”	5x22 dB	5x22 dB	24x22 dB	24x22 dB
R22 booster only “2-degree ROADM”	4x7 dB	4x7 dB	17x7 dB	17x7 dB
R22 booster & PA “2-degree ROADM”	3x22 dB	3x22 dB	12x22 dB	12x22 dB

- All above link losses are without OSC filters.
  - 2x0,5 dB must be deducted if OSC is used.

- All above values are calculated for 40 channels. In general:
  - 96 channels -> -3,8 dB on all link losses (50 GHz spacing not supported in R6)
  - 80 channels -> -3 dB on all link losses (50 GHz spacing not supported in R6)
  - 48 channels -> -0,8 dB on all link losses
  - 32 channels -> +1 dB on all link losses
  - 16 channels -> +4 dB on all link losses

  - All above values assume a 5 dB IL AWG add/drop is used on both sides.

- The above only applies to solutions with a booster included, with preamp only channel amount does not influence link loss.

- 400ZR cannot be increased in link loss from 40ch because of its low transceiver output power (-10 dBm) when using R22.

  - With A22 400ZR links can be increased with maximum +4 dB.

- 10G is calculated with SFP+ ER optics (except for booster only case where ZR is used).