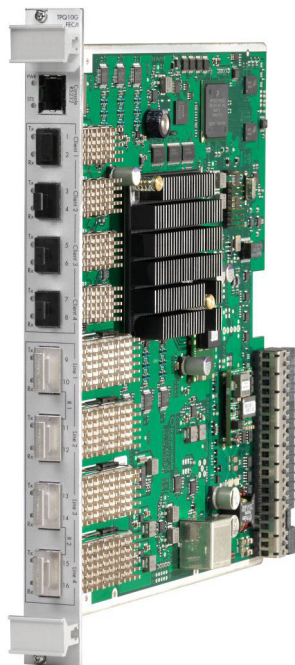


Single-slot Quad 10Gb/s FEC Transponder

Technical Description

Quad 10G FEC Transponder 1-slot (TPQ10GFEC/I)



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1 Introduction

This manual provides an overview of the Quad 10G FEC Transponder 1-slot (**TPQ10GFEC/I**).

Other related documents within the System Manual;

- Dimensioning Guidelines; for technical data on optical interfaces, restrictions, compatibility etc.
- Quad 10Gb/s FEC Transponder Installation Guide; for step-by-step instructions on how to install and commission the TPQ10GFEC/I unit.

2 Document Revision History

Table 1 Document Revision History

Revision	Date	Description of changes
A	2013-06-12	1st release.
B	2013-11-12	- Added chapter on 40GbE-LAN transport R22 updates; - Revertive switching - Added chapter on Signal Degrade
C	2013-02-24	Added information on client configuration "transpLAN10GbE" for 40GbE-LAN transport
D	2015-01-20	R24 updates: additions of loopback on regen image.
E	2015-06-01	R25 updates: Addition of support for SingleStrande TRX'es TRX100154 and TRX100155.
F	2016-06-01	Clarified port labels in 9 <i>Mechanical Layout</i> .
G	2017-03-21	Updates to reflect R-step of card. Introduction of new overlay and extraction handle

3 General

WDM is an analogue technique and requires a controlled environment for error-free transmission of the traffic. Transponders/Muxponders serve as buffers between the “client layer” and the “WDM domain”. They also add functional enhancements, like multiplexing to utilize the wavelengths more efficiently, performance management to supervise and monitor the status and embedded management channels to provide secure and easy management access to all NE’s. As a result, client equipment of different types (e.g. SDH/SONET, IP routers) and from different vendors can be connected to the XTM Series network without any impact on the transmission path through the network.

A Transponder/Muxponder also enables encapsulation of the client signal into a digital wrapper where extra bytes are added to the client signal at the client ingress point and removed at the client egress point. These OH-bytes can be used for a number of features, such as:

- Introduction of quality check of the WDM signal enabling Performance Management (PM) as well as Fault Management (FM) in the transmission domain.
- Insertion of management channels that are used to connect to other nodes in the network for management purposes. Also called “Embedded” or “In-band” management channels.
- Insertion of coding that detects and corrects bit errors; Forward Error Correction (FEC). This is typically needed for long-haul transport of 10Gb/s signals and higher.
- Insertion of path information that can be used to validate the connection.

4 Single-slot Quad 10Gb/s FEC Transponder

The Quad 10G FEC Transponder 1-slot (TPQ10GFEC/I) is a powerful and versatile product for transport of 10GbE-LAN, 10GbE-WAN and STM-64/OC-192 traffic. The unit also supports transport of Synchronous 10G Ethernet as defined in G.8262/Y.1362 option 1.

The unit contains four independent 10G Transponder functions having XFP transceivers on the line interfaces and SFP+ transceivers on the client interfaces. This combination provides usage of tunable DWDM transceivers on the line interface while lowest cost for client interface.

The client signals are mapped into a iWDM wrapper with FEC and extra OH-bytes for embedded management channels. The FEC coding gives the needed extra boost in transmission performance in amplified long-haul networks. The embedded management channels remove the need for a separate DCN connection for remote management access. The line rate is 11.10Gb/s.

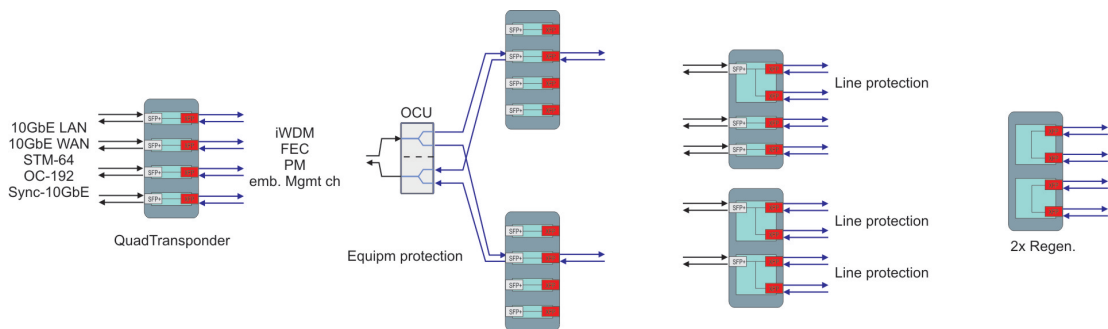


Fig. 1 Functional options for the TPQ10GFEC/I unit

The TPQ10GFEC/I is a Traffic unit based on reprogrammable HW (i.e. FPGA) that can be configured with different “Traffic images”. Two such images are provided:

- A Transponder image with four Transponder functions.
- A Regenerator image with two Regenerator functions.

The two first and two second Transponder functions can independently be collapsed into a single Transponder with 1+1 line protection.

Client/Equipment protection is also supported as an alternative resilience option.

The Regenerator image utilizes the four XFP interfaces to enable tunable DWDM transceivers on all line interfaces. Consequently the Traffic image contains two independent Regenerator functions.

The selection between Transponder function and Regenerator function is done when the unit is initiated. The board that is operating as a Transponder can be re-initialized into a Regenerator function, and vice versa.

When the client signal is 10GbE-LAN, a management-VLAN can be injected to provide management connectivity towards a Layer2 client. Layer2 signaling such as Link Fault messages are also generated upon failures.

The TPQ10GFEC/I can also be used to transport a 40GbE-LAN signal. The 40GbE-LAN support is based on parallel 4x10Gb/s transmission spread over 4 different wavelengths. Thus, the 40G interface from the client equipment must be a QSFP+ SR4 based interface interconnected to the four SFP+ interfaces of the TPQ10GFEC/I.

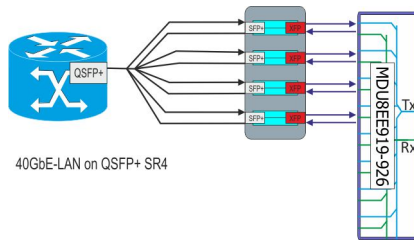


Fig. 2 40GbE-LAN over four parallel DWDM wavelengths on TPQ10GFEC/I

The functionality of the TPQ10GFEC/I unit in short:

- One board with two traffic images; 4x Transponder or 2x Regenerator (mixed mode not supported).
- Four separate, individual and transparent 10G Transponder functions for 10GBE LAN/WAN and STM-64/OC-192 signals with FEC and embedded management channels on line side.
- A transponder function for 40GbE-LAN transmission over four 10G lanes.
- Two Regenerator functions for signals from TPQ10GFEC/I, TPQ10GFEC, TPD10GBE-BU, MS-MXP/10G and GBE9/MXP10GFEC units.
- XFP transceivers on line interfaces enables configurations for colored CWDM or DWDM XFP's (fixed and tunable) with different distance options.
- SFP+ transceivers on client interfaces enabling uncolored and colored (CWDM and DWDM) connections towards client equipment.
- PM on client signal and line signal presented according to G.826.
- PM extraction (15min/24h) on client and line interfaces that can be exported to the network manager Infinera DNA-M for PM statistics.
- Sub 50ms 1+1 Line protection provided by collapsing two Transponder functions.
- Sub 50ms client/equipment protection between Transponder function on separate boards in same card cage and between boards in separate card cages when using the Protection Control Unit (PCU/2P).
- Combined client and line protection that provides a multi-path protection configuration e.g. 1+3 Line protection.
- Loopback (near-end and far-end) eases commissioning and trouble shooting.
- Layer-2 awareness: Ethernet utilization parameter for 10GbE-LAN clients.
- Layer-2 awareness: Injection of management VLAN on client interfaces for 10GbE-LAN clients.
- Layer-2 awareness: Generation of Link Fault messages as consequent action for 10GbE-LAN clients.

From Release R25.0 and onwards, the following additional SingleStrand XFP's are supported:

- TRX100154; SFP+,S-S,TX1270,RX1330,10GbE,40km
- TRX100155; SFP+,S-S,TX1330,RX1270,10GbE,40km

These TRX'es enables direct single-fiber configurations without need for a separate CWDM-filter and can be used on the client ports for 10GbE-LAN, 10GbE-WAN signals.

These operate on the CWDM channels 1270nm and 1330nm in up/down-link and must be placed at both ends of the connection.

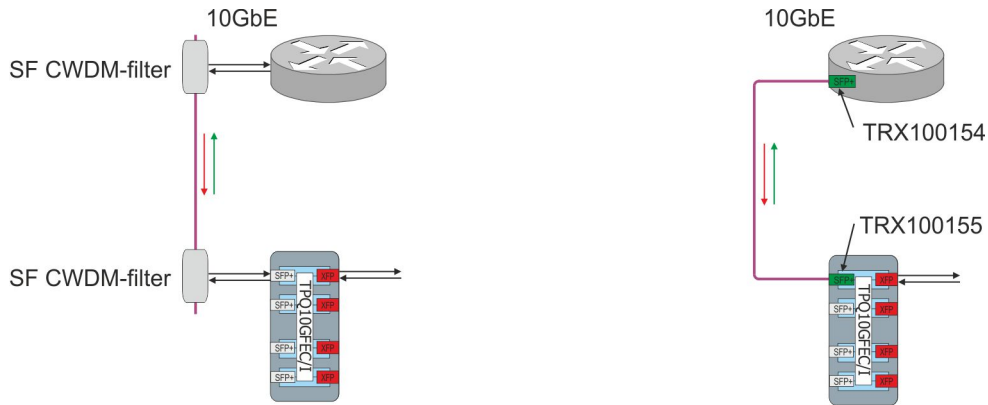


Fig. 3 Dual-fiber TRX with SF-filter vs SingleStrand SFP without filter

5 Application Examples

The TPQ10GFEC/I can be used in many applications, both in metro-access as well as regional networks.

5.1 CWDM Networks

Via the XFP's operating at CWDM wavelengths (TRX100071/bb and TRX100072/bb) it is possible to add 10G wavelengths on an existing CWDM network.

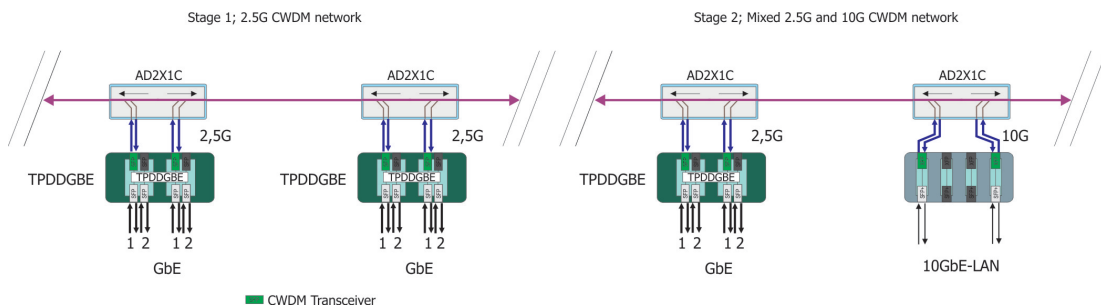


Fig. 4 2.5G and 10G wavelengths on same fiber

In the above example, a collector node is initially using the TPDDGBE Muxponder unit where 2xGbE signals are aggregated to a 2.5Gb/s line signal and transported on a CWDM wavelength via CWDM AD-filters. The TPDDGBE can be replaced with a TPQ10GFEC/I unit to enable direct transport of 10GbE-LAN signals without replacing the CWDM AD-filter. There is thus no need to change anything apart from the Transponder type. Other services carried on the same single-fiber will be unaffected.

5.2 Amplified DWDM Networks

The FEC function enables effective usage in amplified networks. Optical spans up to ~1500km can be bridged. Longer spans can be bridged by cascading 1500km optical segments.

The TPQ10GFEC/I can be used in both 32 (100GHz) and 40/80 channel (50GHz) configurations. See "Dimensioning Guidelines" within the System Manual for more details.

6 Basic Functionality

6.1 Optical Interfaces

The client interfaces are based on SFP+ transceivers enabling uncolored SM and MM as well as CWDM and DWDM interfaces towards client equipment.



A client interface equipped with DWDM SFP+ transceivers will not have the same OSNR tolerance as an XFP-based interface. This will impact on bridgeable distance if the client interface is to be connected to an amplified DWDM network.

The line interfaces are based on XFP transceivers enabling uncolored, CWDM, DWDM as well as tunable DWDM transceivers.

See section 10 *Technical Data* for a list of supported transceivers.

See also “Dimensioning Guidelines” within the System Manual for more details on optical parameters.

6.2 Loopback

Loopback can be set up as shown in the figure below.

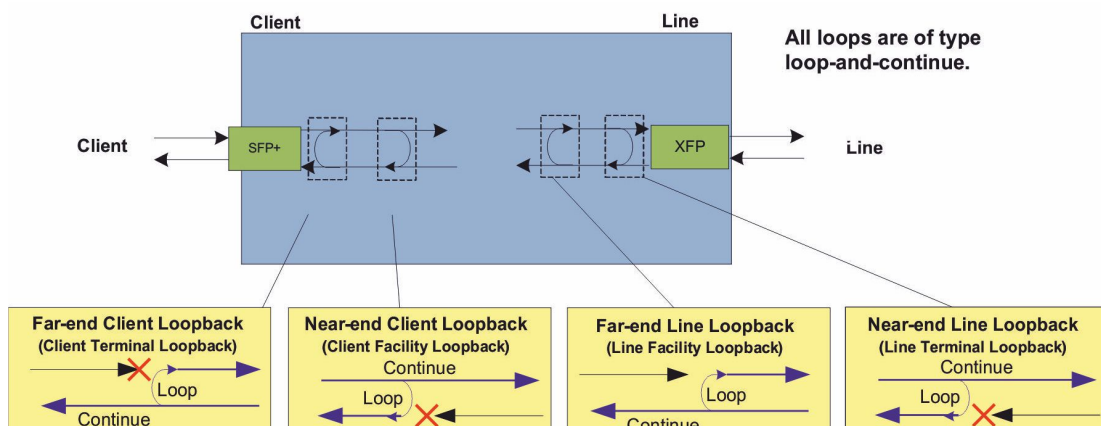


Fig. 5 Loopback options



A “Near-end Line loopback” (“Line Terminal Loopback”) will render in loss of remote management access via the embedded management channels. A time-out parameter is set enabling an automatic fall-back from loopback mode after the pre-set time.

Addition in release R24: Loopback is supported also on the regenerator image.

6.3 Resilience

The TPQ10GFEC/I support three different resilience configurations:

- Client/Equipment protection, non-revertive.
- 1+1 Line Protection. Non-revertive (default) or revertive (optional)
- 1+2 and 1+3 Line Protection, non-revertive.

The last option is a combination of Client/Line Protection and Line Protection and enables multiple stand-by paths for a connection. Each configuration is described further in below chapters.

The default protection mechanism is non-revertive and single-ended. An alarm will be raised if the stand-by path goes down.

See I&C manual for further details on configurations. See also Dimensioning Guidelines for further information on resilience options and characteristics.

6.3.1 Client/Equipment Protection

The TPQ10GFEC/I unit supports Client/Equipment Protection. A separate optical coupler is placed between the client equipment and the client interfaces of the TPQ10GFEC/I as shown in the figure below.

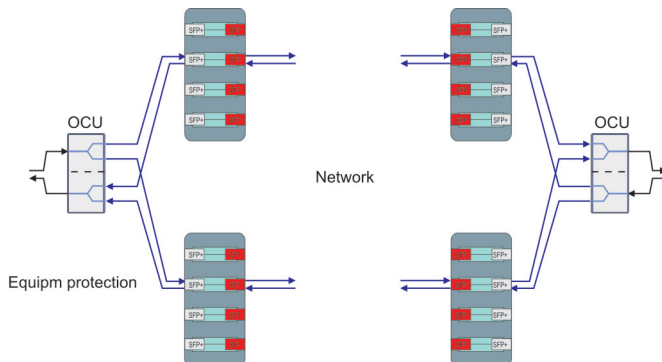


Fig. 6 Client/Equipment protection configuration

The incoming client signal is via the optical coupler (OCU2 or OCU4) connected to two Transponder functions and transported to the far-end node, which is configured in the same way. At the far end node, only one of the lasers facing the client equipment is active. Upon a failure that is detected at the far-end node, the stand-by laser is turned on and the active laser is turned off. The switching is non reverting. A switch will not be performed if the stand-by path is down.

The protection switch is based local decisions and on the following incidents:

- loss of frame, bit rate mismatch (on the line interface).
- loss of optical signal (on the line interface).
- Far-end Line errors, i.e. when a failure occurs at an intermediate regeneration site. This is signalled onwards to the termination node where a protection switch is performed.
- Far-end client errors. The received client signal at the far-end node is lost. The failure is signalled onwards to the termination node where a protection switch is performed.
- Missing Transceiver (on the line interface).

The client/equipment protection configuration can be set up between two Transponder functions located;

- on the same TPQ10GFEC/I unit, which makes this into a de-facto 1+1 Line Protection set-up i.e. not so relevant.
- on two separate TPQ10GFEC/I units located in same card cage.
- on two separate TPQ10GFEC/I units located in different chassis within same NE or in different NE. This requires usage of a Protection Switch Unit (PCU/2P) that provides the fast signalling between the two Transponder functions that is required to provide sub 50ms switching.

It is possible to set the line protection to the following modes:

- **down** – the protection group is inactive.
- **leftForced** – The left side is forced active.
- **rightForced** – The right side is forced active.
- **auto** – The application chooses which side should be active. This is the normal mode of operation.
- **toggle** – Switch the active side of the protection.

6.3.2 Line Protection

Line Protection is applied by using the line interface of the second transponder function. The line signal is electrically split to the two line interfaces. The received signal is taken via an internal switch function. The first and second Transponder pairs can independently be collapsed into a single Transponder with 1+1 Line protection.

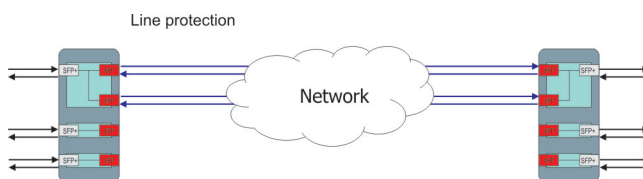


Fig. 7 Line Protection Example

A Line Protection switch is non-revertive and based on:

- Loss of frame, bit rate mismatch.
- Loss of optical signal.
- Far-end Line errors.
- Missing TRX.
- Signal Degraded (Optional, supported from R20)

Switching is performed within 50ms, except the Signal Degraded based switch which is performed within 2 seconds.

It is possible to set the line protection to the following modes:

- **down** – the protection group is inactive.
- **leftForced** – The left side is forced active.
- **rightForced** – The right side is forced active.
- **auto** – The application chooses which side should be active. This is the normal mode of operation.
- **toggle** – Switch the active side of the protection.

6.3.3 Multi-path protection

In some cases more than one stand-by protection path is required. This can be achieved by combining Client protection and Line protection on the same protection group and thus providing a 1+2 or 1+3 Line protection combination as shown in the figure below.

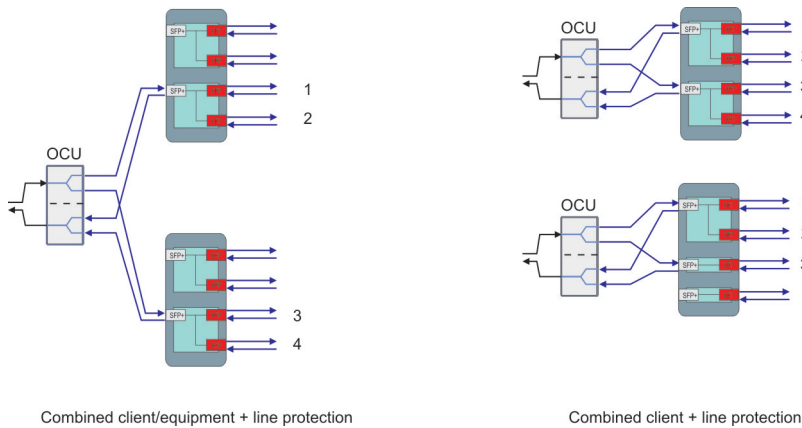


Fig. 8 Three example multi-path protection configurations

The figure shows that the multi-path protection can be applied on transponder functions within the same board, or located on two separate boards. The third example in the figure shows a 1+2 configuration. The un-used transponder functions can be used as is or in any other protection mode.

A PCU/2P unit can be used in the Client/Equipment protection group to further enhance the availability figures.

Upon a fiber cut, the protection switch will be done within the 1+1 Protection Group first and then perform a Client/Equipment Protection when the first 1+1 Line Protection Group has failed.

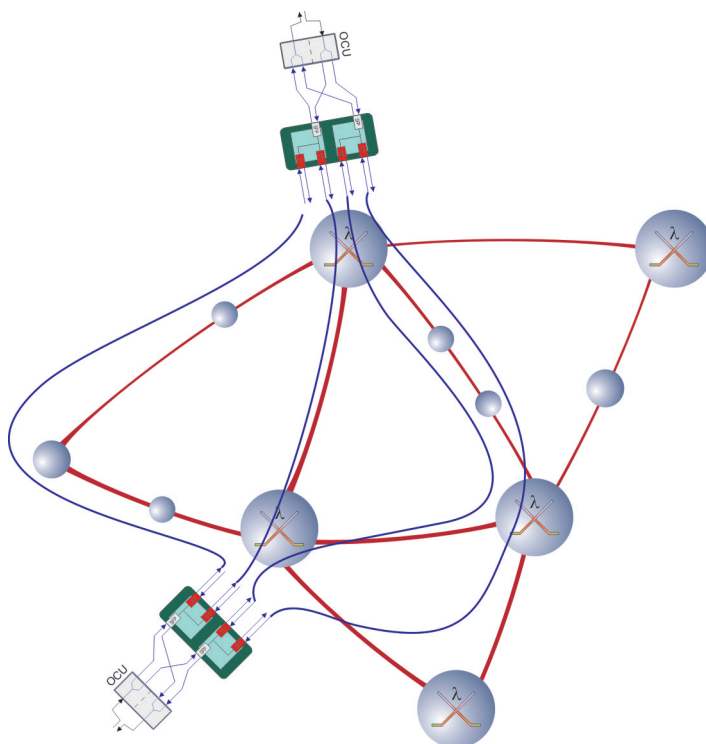


Fig. 9 Multi-path protection example

The figure above shows an example network where the two TPQ10GFEC/I Transponders have one active and three stand-by paths running over a ROAD network. The protection switching is still sub 50ms and requires no GMPLS/ASON software. Note that the protection switching is single-ended. This means that if a single-fiber is cut on an active path, only that direction will be switched. The up and downlink of an active connection will thus take two different routes. If both fibers are cut, then both directions are affected and re-gained via a protection switch to the same new path.

6.3.4 Revertive switching

Non-revertive vs revertive switching covers which actions that are taken when the original signal path is repaired and available again.

Revertive switching means that a switch-back is performed to the original signal path.

Non-revertive switching means that no switch-back is performed to the original signal path.

Revertive switching will render in two traffic hits, one upon the failure that renders in a protection switch and one when the switch-back is performed.

Non-revertive switching will render in one traffic hit, i.e. upon a failure that renders in a protection switch.

Normally the objective is to minimize the traffic effects since Service Levels Agreements (SLA's) are based on service availability. Consequently non-revertive switching is the preferred method in these situations.

Revertive switching is typically of interest when the SLA is based on latency. A switch-back to the low latency path is then of greater importance and the consequent traffic hit is regarded as acceptable.

Revertive switching requires that a primary and a secondary path must be defined. This is done in the node manager ENM. The switch back to the primary path will take place when the

primary path has been up and stable for a user defined time. The timer can be set from 1 minute to max 1440 minutes (24 hours). This timer value is configured in the node manager ENM. If the primary path is lost before the timer has reached zero, the timer will start at the user defined timer value when the primary path is up again.

6.3.5 Single-ended vs dual-ended switching

Single-ended protection switch means that the up-link and down-link are treated independently. Any protection switching is done based on local decisions and no signalling is done between the two end nodes. The example below shows the principle.

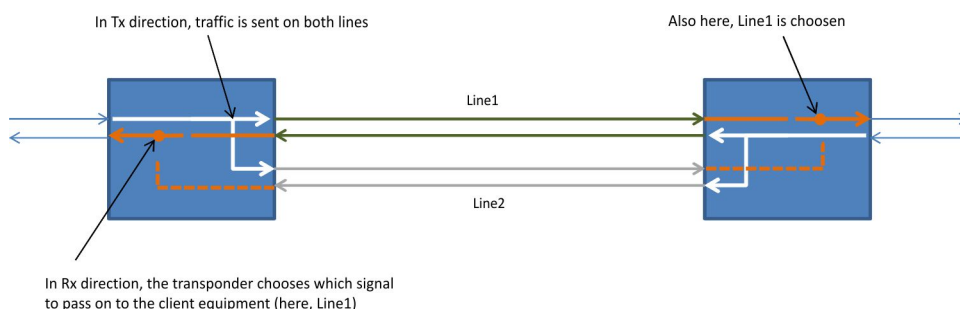


Fig. 10 Single-ended protection example

Fig. 11 shows a link with 1+1 line protection. At both ends “Line1” is selected as active path.

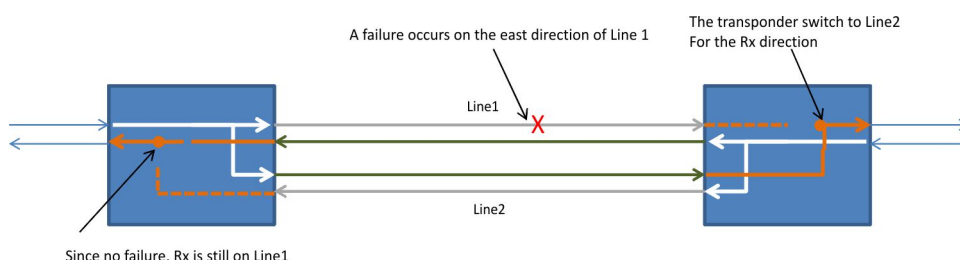


Fig. 11 Single-ended protection switch

In the case that a fault only affects one direction (in this example the input signal to the right Transponder is lost) the receiving Transponder will select the stand-by signal instead. This means that the two directions now will travel over two different signal paths.

Dual-ended protection switch means that a far-end error signal is send to the other (left) side so that this Transponder also will perform a protection switch. So both direction will thus always travel over the same signal path.

For this specific situation, dual-ended switching will render in two traffic hits, one upon the failure that renders in a protection switch and one when other side follows.

Single-ended switching will render on one traffic hit, that is, upon a failure that renders in a protection switch.

In the case that both directions are hit by a failure, there is no difference between single-ended and dual-ended protection.

6.3.6 Signal Degrade

The Signal Degrade (SD) function provides the ability to get an early warning that the FEC function is operating at its limit and that errors are slipping through to the egress client signal (s).

The SD function looks at the number of corrected errors and calculates a corresponding BER on the egress signal. The calculation of corrected errors is done in “real time” but the corresponding BER is an estimate since this is a measurement that has to be done over a longer time period.

A SD threshold can be selected at three different BER levels; 10E-12 (“rxBerLevel1”), 10E-13 (“rxBerLevel2”, default) and 10E-15 (“rxBerLevel3”).

When the FEC function collapses due to that the amount of bit errors exceeds the correcting capabilities, a FEC Failure alarm is raised. Further deterioration will render in Loss Of Frame (LOF) and Loss Of Signal (LOS).

6.4 Performance Monitoring

PM on client interface is provided and presented according to G.784/G.826.

PM on SDH/SONET and 10GbE-WAN is based on B1 byte calculations, LOF (Loss Of Frame) and SDH MS-AIS, SONET AIS-L. Detected AIS on ingress line signal will also affect PM on egress client signal.

PM on 10GbE-LAN is based on CRC bytes and PCS statistics (Hi BER, Local Fault, Remote Fault, Block Errors and Loss Of Sync).

PM on the line signal is based on uncorrected FEC errors and LOF (Loss Of Frame).

The PM is presented using “SES” and “UAS” parameters.

A number of history PM reports are logged in zipped XML format in the node:

- Up to 96, 15-minute reports.
- Up to 40, 24-hour reports.

These reports are located in the node and can be uploaded to Infinera DNA-M or other higher layer management systems.

Note that the FEC coding function corrects errors on the line. So even if errors occur between two TPQ10GFEC/I units, these errors will normally not be seen on the egress client signal since they have been corrected by the FEC function. When the number of bit errors exceeds the error correction capability of the FEC coding, these will be seen on the egress client signal. These uncorrected bit errors are used to provide PM on the egress client signal as well as ingress line signal.

A utilization parameter is presented for 10GbE-LAN signals. This is a percentage value showing to what extent the channel is utilized.

6.5 Management interconnect

There are multiple options to provide management interconnect. The typical approach in the Layer-1 domain is to use embedded management channels via OH-bytes in digital wrappers. This is typically used on Transponder or Muxponders where the client signal(s) are encapsulated into a digital frame having dedicated bytes for management interconnect. Another typical solution is to use a separate wavelength channel (OSC-channel). This is used primarily to provide management access to intermediate amplifier nodes or for cases where transparent Transponders are used that have no digital wrappers.

In the Layer-2 domain the solution is to use special packets that contain the management channels, i.e. VLAN channels.

Having a separate DCN network with access to all sites is another option to provide management access to nodes in a network.

In a mixed Layer-1 and Layer-2 network it is normally not possible to combine the respective solutions for management interconnect. Layer-1 devices can typically not communicate with a Layer-2 unit since it cannot distinguish between data packets and management packets. Adding a digital wrapper is not an option since the interface must be native Ethernet. Either a direct DCN access is required to provide management interconnect or by adding a separate OSC channel.

In the XTM Series platform some Layer-1 Transponders and Muxponders have been given a Layer-2 awareness functionality. This means that they can establish a management interconnection towards a Layer-2 device.

The figure below shows the options provided within the TM-platform.

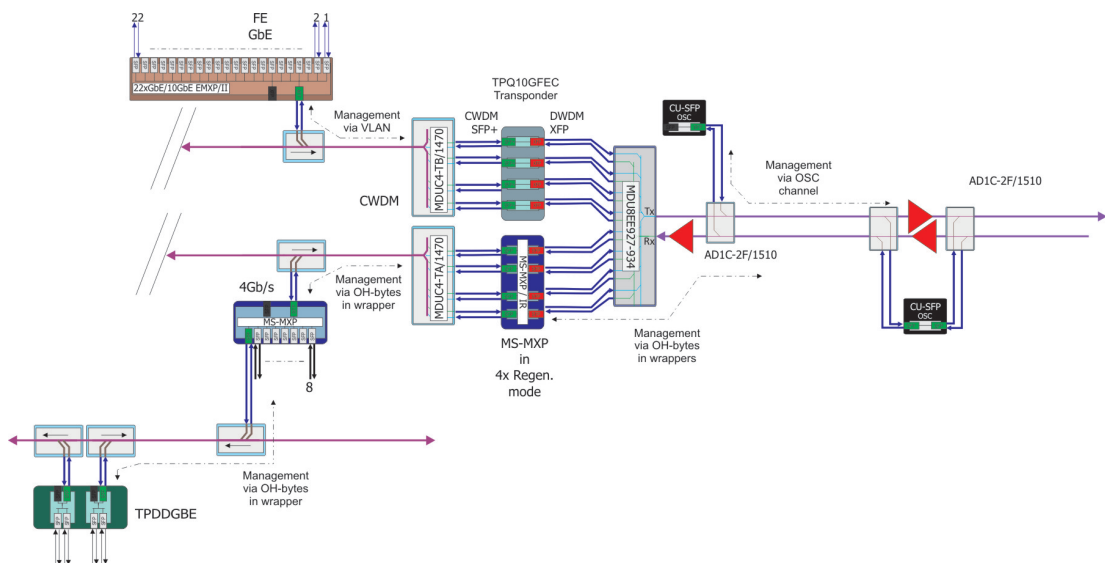


Fig. 12 Management interconnect options

6.5.1 Embedded Management Channels

The line interface of the TPQ10GFEC/I Transponders is a digital wrapper with FEC (Forward Error Correction) and with dedicated OH-bytes for management channels with a capacity of 1.369Mb/s. These channels are also used when downloading SW-upgrades from a central OSS site.

6.5.2 Management VLAN

For 10GbE-LAN clients it is possible to inject VLAN-packets for management interconnect. An example case is when an EMXP unit (Ethernet Muxponder) or EDU (Ethernet Demarcation Unit) is connected to the TPQ10GFEC/I unit from a remote location. Since the interconnect is done via native Ethernet it is not possible to use a digital wrapper with embedded management channels. By enabling injection of management VLAN packets, it is possible to establish a management interconnect to the Layer-2 units directly from the client interface of the Transponder. This VLAN interconnect is integrated with any other management interconnect solution within the TM-platform, i.e. OSC, embedded management channels in digital wrappers etc.

6.6 Synchronization

The outgoing line signal is synchronized via an internal oscillator. No client signal is thus required to create a line signal.

The outgoing client signal is synchronized via through-timing using a buffer solution with Phase-Locked-Loop (PLL).

The unit supports transport of 10GbE Sync-E signals (G.8262, Y.1362) according to Option 1.

6.7 Cascaded links

Up to 20 cascaded links (i.e. a total of 38 Transponders back-to-back) carrying 10GbE-LAN (also Sync-E) as well as STM-64/OC-192 and 10GbE-WAN signals is supported. Alternatively, if the regenerator image on TPQ10GFEC/I is used, up to 20 regen nodes are allowed between the TPQ10GFEC/I Transponders.

6.8 Path Trace Label

A path trace label can be inserted in the egress direction of the line signal and an expected value can be set for the ingress direction. This enables a validation of connectivity end-to-end. An alarm will be raised if a mismatch is detected.

6.9 Monitor Points

A number of analogue data can be retrieved from the unit:

- Board temperature: Given in Centigrade.
- Received optical power level.
- Laser Bias current.
- Laser output power.

All optical parameters are based on existing functionality within the SFP or XFP modules.

6.10 Board data

All boards/units within a XTM Series Network Element have unit related information stored in non-volatile memory banks. This information is stored at production and is required for administration and start-up of the boards.

The information is divided into three main groups:

- Environmental data - Contains data, which is read and used without knowledge of production data version.
- Generic board data - Contains administrative data, which is included on all boards, both active and passive.
- Specific board data - Data needed for proper board operation.

Some alarms are based on the presence of this information:

- “Vital Product Data Missing”: Information in the board data memory bank that is vital to manage the unit is missing. This alarm is classified as “critical” and may require board replacement.
- “Non-vital Product Data Missing”: Information in the board data memory bank that is not vital to manage the unit is missing. This alarm is classified as “minor”.

See *System Manual Volume C, Operation & Maintenance* for further details.

6.11 Alarms

Any generated alarms are collected by the Control Unit and accessible via the node manager ENM or network manager Infinera DNA-M. The status LED (STS-LED) on the board front indicates the severity of the active alarms. See 9 *Mechanical Layout*.

The STS-LED will also indicate status when performing Traffic Unit replacement. See *Spare part & Maintenance Guide* within the System Manual, Volume C for procedures and related LED indications.

The following alarms are generated from the TPQ10GFEC/I unit. See “Alarm Overview” within the System Manual, Volume C for more details on alarms, severity levels and corresponding LED indicators.

- Alarm Indication Signal
- BBE Threshold Exceeded
- Client-side Alarm Indication Signal Line
- Client-side MS Alarm Indication Signal
- ES Rx/Tx Threshold Exceeded
- Far End Client Failure
- Far End Loopback Enabled
- FEC Failure
- High Bit Error Rate
- High Received Optical Power
- Illegal Frequency
- Local Link Fault
- LoopFilter Unlocked
- Loss Of Frame
- Loss of Signal
- Loss of Sync
- Low Received Optical Power
- Near End Loopback Enabled
- No Frequency Set
- Non-qualified Transceiver
- Protection Communication Failure
- Protection Role Conflict
- Protection Service Degraded
- Protection Service Failed
- Protection Setup Failed
- Remote Link Fault
- SES Rx/Tx Threshold Exceeded
- Signal Degraded
- Trace Identifier Mismatch
- Transceiver Bit Rate Unavailable
- Transceiver is Missing
- Transmitter Failed
- TRX Media Mismatch
- UAS Rx/Tx Threshold exceeded
- Unexpected Frequency

From release R20, the Signal Degraded alarm can be triggered by selecting from three predefined estimated BER thresholds. As a default, the alarm threshold is 10^{-13} , the other two selectable thresholds are 10^{-12} and 10^{-15} . The Signal Degraded alarm can also be optionally enabled as a line protection switch criteria.

6.11.1 Auto Alarm Enable Function

To avoid a lot of unnecessary alarms during installation there is an 'auto alarm enable' function. This means that if a board or interface is set to administrative status up (in use) then no alarms will be raised from the board/interface until a transceiver/signal has been inserted for the first time.

E.g. Interfaces that never have had any transceiver will not raise a 'TRX missing alarm' until a transceiver is inserted and then removed again.

E.g. a interface has a transceiver but no signal. This will not raise a 'Loss of Signal' alarm until signal is inserted and then removed again.

To reset the 'auto alarm enable function' set the board/interface to administrative status 'service' and then back again to 'up'.

Protection alarms like 'Protection Service Degraded' and 'Protection Service Failed' will not be suppressed.

6.11.2 PM Alarms Suppression Function

PM threshold alarms will be suppressed when LOS and TRX Missing alarms are active.

When the LOS alarm is generated PM counters should be counting SES/UAS. No PM alarms are shown until the LOS or TRX missing alarm is cleared.

- Both 15m and 24h PM alarms are suppressed.
- LOS/TRXMISSING on the client suppresses all RX-PM alarms on the client and corresponding TX-PM alarms on the line.
- LOS/TRXMISSING on the line suppresses all RX-PM alarms on the line and all TX-PM alarms on the client.

If a 1+1 line protection is active, then LOS on the line will generate TX-PM alarms on the clients.

7 Traffic Images

The TPQ10GFEC/I has two Traffic Images:

- A 4x MultiService Transponder image (tpq10gfeci).
- A 2x Regenerator image (tpq10gfecregi).

The selection between Transponder function and Regenerator function is done when the unit is initiated. A board that is operating as a Transponder can be re-initialized into a Regenerator function and vice versa.

7.1 Transponder image

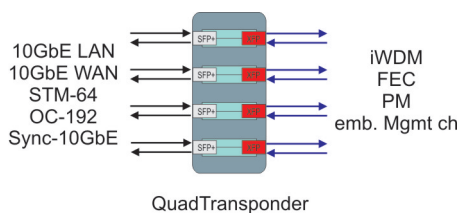


Fig. 13 Transponder image

The Transponder image (tpq10gfeci) has four independent Transponder functions, each supporting:

- STM-64
- OC-192
- 10GbE-LAN (default)
- 10GbE-WAN
- 40GbE-LAN (all four client interfaces used to transport 40G as four 10G lanes)

The transport between two Transponder functions is both data and sync transparent. The sync performance supports the Sync-E standards (G.8262, Y.1362) according to Option 1.

SFP+ transceivers are used to interface client equipment. Both uncolored, CWDM and DWDM versions are provided. A quality check is done on the ingress and egress client signal and the result is presented according to G.826 using ES, SES, UAS etc parameters. This is done for all client formats regardless on how the PM data is extracted. See chapter 6.4 for details.

The client signal is mapped into a digital wrapper with Forward Error Correction (FEC) and OH-bytes for embedded management channels and system-internal signalling, i.e. similar to G.709.

A path trace label can be inserted in the egress direction and an expected value can be set for the ingress direction. This enables a validation of connectivity end-to-end.

The two first and two second Transponder functions can be independently collapsed into a single Transponder with 1+1 Line Protection. See chapter 6.3.2 for details.

Each Transponder function can independently be configured to provide Client/Equipment protection. See chapter 6.3.1 for details. Client/Equipment and 1+1 Line protection can be mixed independently. See figure below.

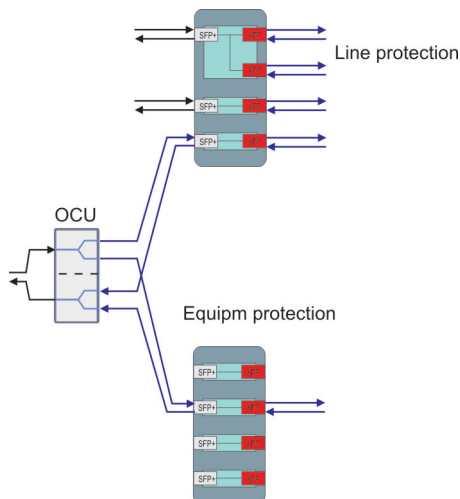


Fig. 14 Mixed Client/Equipment and 1+1 Line protection

A more advance resilience option can be created by combining Client/Equipment protection with 1+1 Line protection. This combination provides a 1+2 or 1+3 Line protection feature. See chapter 6.3.3 for details.

The default configuration is to use the TPQ10GFEC/I unit on all parts of the link. In some situations it could be required to connect a TPQ10GFEC/I Transponder with a Double 10Gb/s FEC Basic Unit (TPD10GBE-BU). This can be done if the line framing is manually changed.

The two line format modes are:

- FecLan10GbE_1A - iWDM 10G framing format type 1A (TPD10GBE-BU).
- FecLan10GbE_1B - iWDM 10G framing format type 1B (TPQ10GFEC/I and TPQ10GFEC). This is the default mode.

By manually setting the TPQ10GFEC/I unit in “framing format type 1A” the two units will interoperate. However, the PM extraction and calculation on the client signal is not equal.

The PM on TPD10GBE-BU is based on Loss of signal and Loss of Sync while the PM on the TPQ10GFEC/I is based on other parameters as described in chapters above.

7.1.1 40G Transport over 4x 10Gb/s lanes

The natural way of transporting a 40GbE-LAN signal is via the 40G Transponder unit (MS-TP/40G), using a single wavelength.

An alternative option is to transport a 40GbE-LAN signal via parallel 4x 10Gb/s transmission spread over 4 different wavelengths using the TPQ10GFEC/I or TPQ10GFEC Transponder units. The 40GbE-LAN interface from the client equipment must be a QSFP+ SR4 (TRX100256) interface interconnected to four MM SFP+ (TRX100103) interfaces on the TPQ10GFEC/I or TPQ10GFEC.

The Transponders shall be set to the format "transpLAN10GbE" to ensure full transparent transport of each 10G lane.

Due to the concept of transporting lanes, the PM data provided is "PM-Lite" i.e. simplified PM based on Loss of Optical Signal and Loss Of Sync.

The break-out patch cord PC-MPO12LCMM/2M has an MPO connector facing the 40G router and 12 LC connectors facing the TPQ10GFEC/I Transponders.

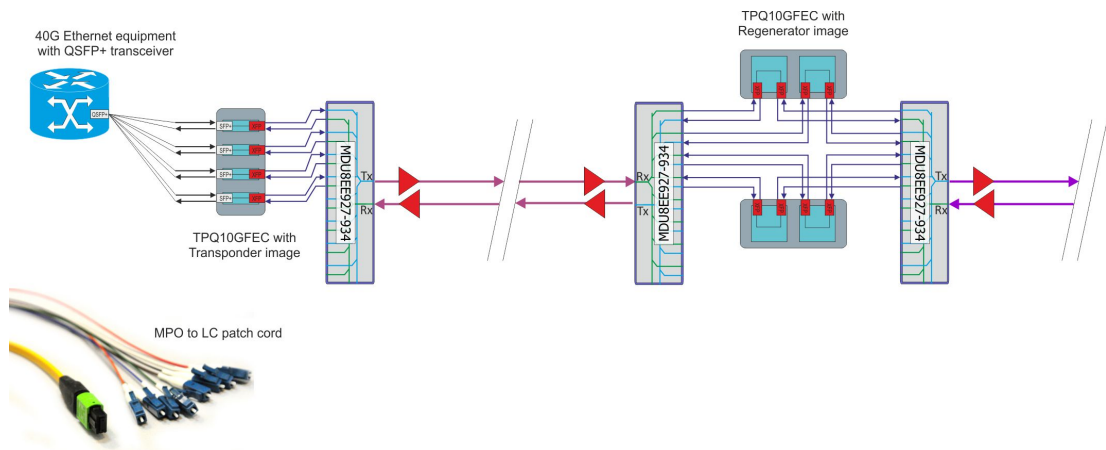


Fig. 15 40GbE-LAN over 4x 10G lanes

All four wavelengths must travel over the same route. The channels do not need to be consecutive.

The PC-MPO12LCMM/2M has a color coding on the LC connectors as shown in the table below.

Table 2 PC-MPO12LCMM/2M color coding

Fiber number	Tx/Rx direction	Channel	Color code
1	Rx	Ch 1	Blue
2	Rx	Ch 2	Orange
3	Rx	Ch 3	Green
4	Rx	Ch 4	Brown
5	-	-	Slate/Grey
6	-	-	White
7	-	-	Red
8	-	-	Black
9	Tx	Ch 4	Yellow
10	Tx	Ch 3	Purple/Violet
11	Tx	Ch 2	Rose
12	Tx	Ch 1	Aqua

7.2 Regenerator Image

The Regenerator image (tpq10gfecregi) provides two individual Regenerator functions having XFP-interfaces.

The Regenerator image can be used to generate line signals from the following units:

- Quad MultiService 10G FEC Transp (TPQ10GFEC)
- Quad 10G FEC Transponder 1-slot (TPQ10GFEC/I)
- MultiService MuxPonder 10G (MS-MXP/10G)
- Double 10Gb/s FEC Basic Unit (TPD10GBE-BU)
- 9xGbE/10G FEC MuxPonder (GBE9/MXP10GFEC)

The two last units have a slightly different framing format. The regenerator function of the TPQ10GFEC/I unit will automatically detect what frame format it is receiving so no manual intervention is required. There is also an option to manually force the interface to a specific framing format. This option is however only to be used if the automatic frame lock fails for some reason.

The interfaces used in regenerator mode is shown in chapter 9. Ports 9,10 and 11,12 are used for regen function 1 and ports 13,14 and 15,16 for regen function 2.



Note

Using a regenerator function on a TPD10GBE-BU to regenerate a signal from a TPQ10GFEC/I unit is not an allowed configuration.

8 Consequent Actions

- Loss of near-end ingress client signal renders in MS-AIS generation on remote egress client signal (default) or shut down via Forwards ALS.
- Loss of ingress line signal renders in MS-AIS generation on egress client signal (default) or shut down via Forwards ALS.

For 10GbE-LAN:

- Loss of near-end ingress client signal renders in Link Fault (LF) signalling on remote egress client signal (default). Optionally the egress client is shut down via Forward ALS.
- Loss of ingress line signal renders in Link Fault (LF) signalling on remote egress client signal (default). Optionally the egress client is shut down via Forward ALS.

Note! If the client interface has mgmt-VLAN configured, then there is an option to maintain injection of mgmt-VLAN instead of transmitting LF.

The figure below shows the default consequent actions:

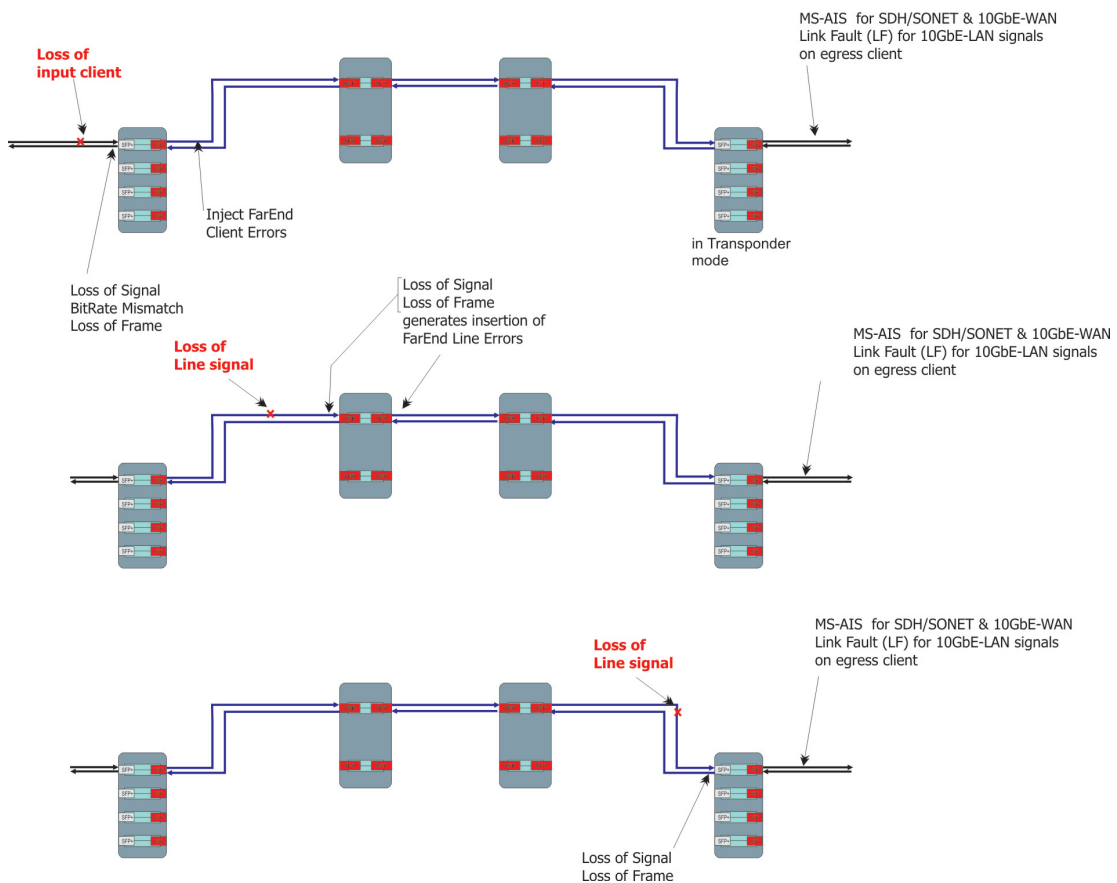


Fig. 16 Default consequent actions

If a Transponder is configured for 1+1 Line protection both lines must be down to render in the above consequent actions on the client egress signal.

9 Mechanical Layout

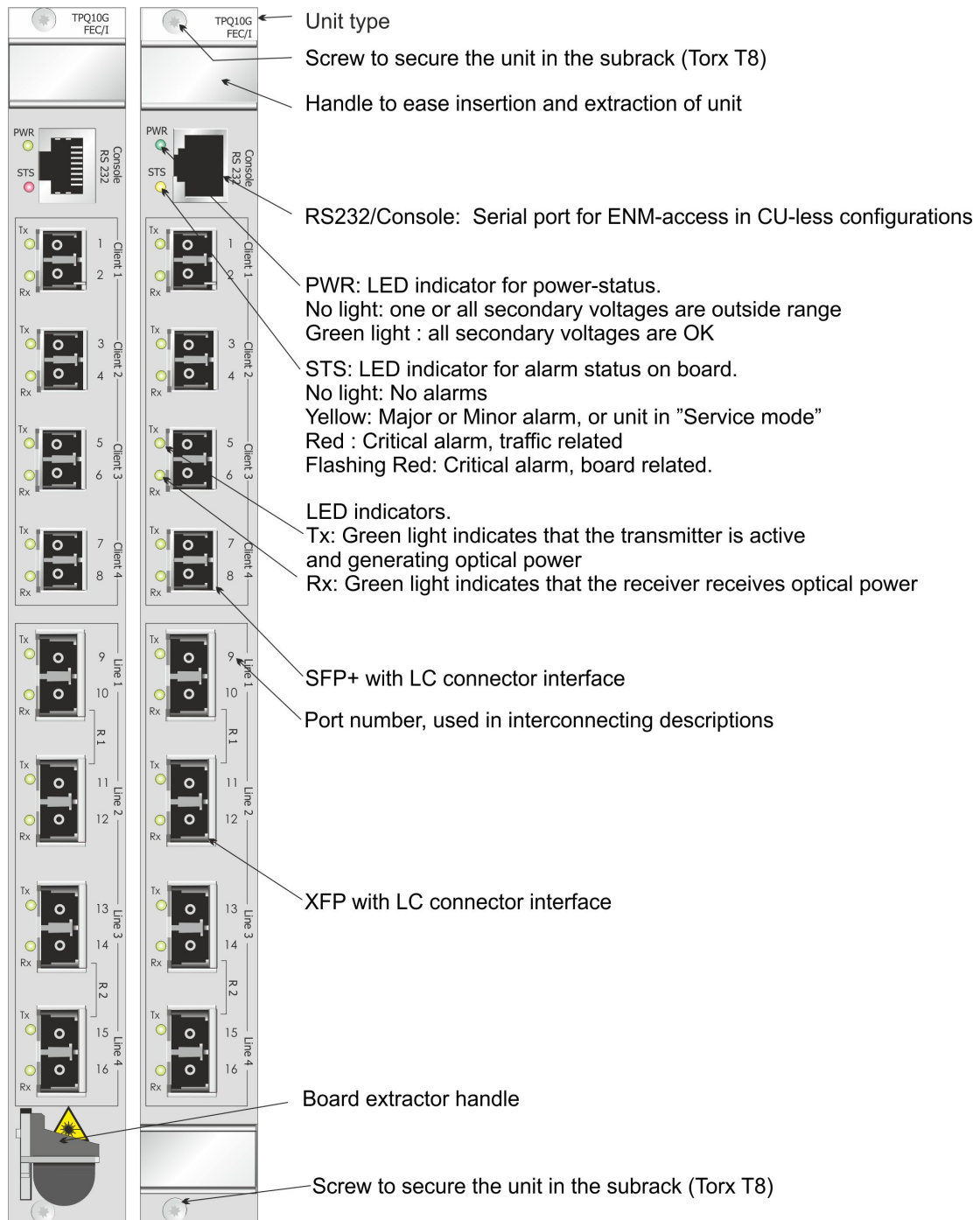


Fig. 17 Mechanical front. New and initial front mechanics. New front is introduced 2017.

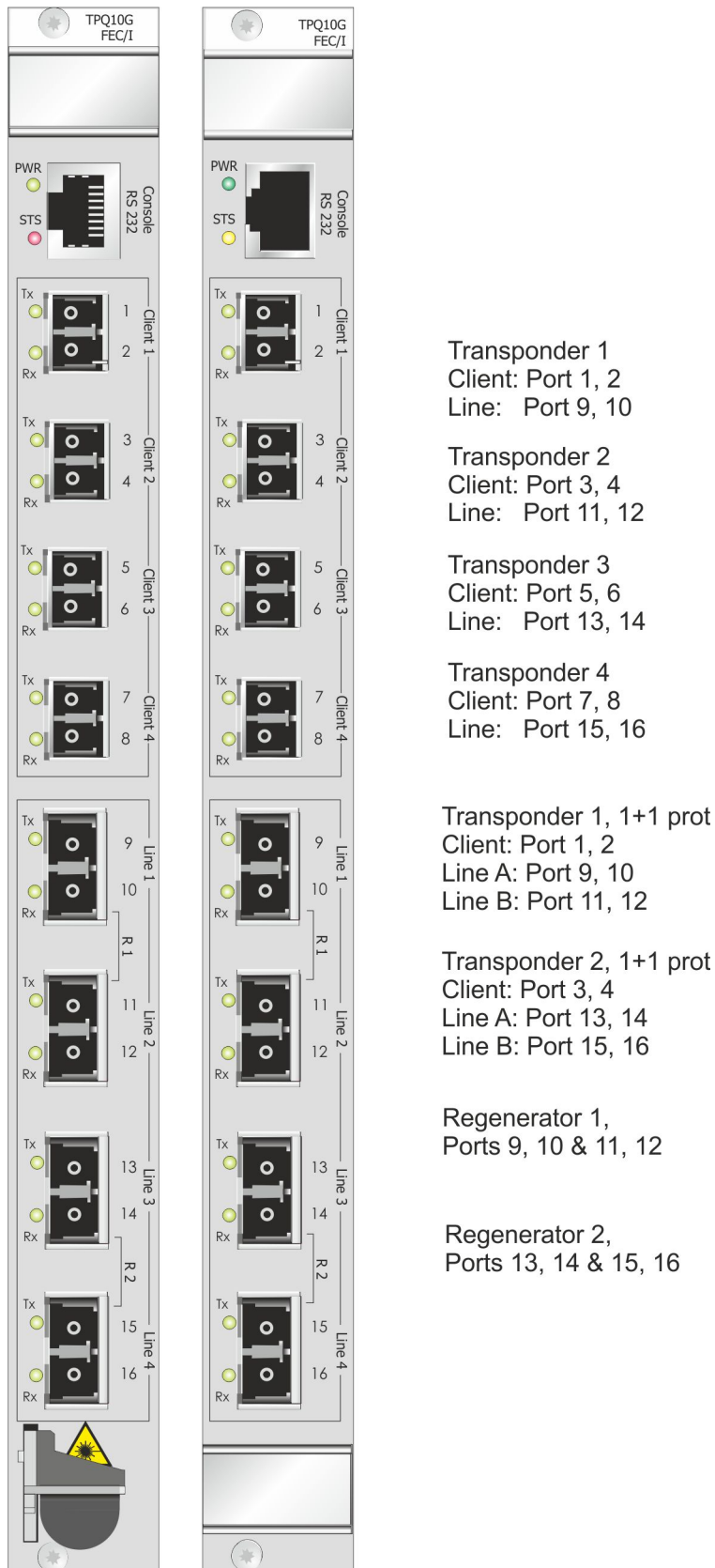


Fig. 18 Port usage. New and initial front mechanics. New front is introduced 2017.

10 Technical Data

This section lists the technical data for **TPQ10GFEC/I**.

Table 3 Electrical Data

Parameter	Value
Power consumption	~45W (Max value, fully equipped with TRX'es)
Weight	0.8 kg
Timing	Through-timing ingress to egress on client signals Internal oscillator on line signals Full 3R
Line rate	11.10Gb/s. Transparent.
Performance Monitoring	- PM on client and line interfaces presented according to G.826 (ES, SES, UAS) based on B1 byte calculations and LOF (SDH/SONET/ GbE-WAN), CRC bytes and PCS statistics (10GbE-LAN) - Optical parameters: Laser output power, Laser Temperature, Laser Bias, Received optical power (dependent on transceiver type)
Embedded management channels	On all line interfaces in Transponder mode Channel capacity 1.369Mb/s
Supported signal formats	10GbE-LAN (default) 10GbE-WAN STM-64 OC-192 40GbE-LAN via 4x 10G lanes ("transpLAN10GbE")
Latency	~6.8us
Misc	FEC RS(255,239) with same performance as G.709. Near/Far-end line loopback and Near/Far-end client loopback. Management VLAN for 10GbE-LAN clients
Resilience	Client/equipment protection; non-revertive 1+1 Line protection; non-revertive, revertive 1+3 Line protection; non-revertive

Table 4 Supported TRX'es

Item code	Item name	Interface
TRX100154	SFP+,S-S,TX1270,RX1330,10GbE,40km	C
TRX100155	SFP+,S-S,TX1330,RX1270,10GbE,40km	C
TRX100158	XFP, S-S,TX1270,RX1330,10GbE,40km	L
TRX100159	XFP, S-S,TX1330,RX1270,10GbE,40km	L
TRX100100	SFP+,1310nm,SM,10Gb/s,10km,E-Temp	C
TRX100103	SFP+,850nm,MM,10Gb/s,300m,E-Temp	C
TRX100114	SFP+, 1550nm, 10Gb/s, 40km, E-temp	C
TRX100115	SFP+, 1550nm, 10Gb/s, 80km	C
TRX100116	SFP+, 1310nm, 10Gb/s, 40km	C
TRX100071/bb	CWDM XFP 9,9-11,1Gb/s, 40km xxxnm	L
TRX100072/bb	CWDM XFP 9,9-11,1Gb/s, 70km xxxnm	L
TRX100106/bb	SFP+ YYYYnm, CWDM, SM, 10Gb/s, 40km	C
TRX100031/xxx (EOA-E)	XFP, DWDM, SM, 9,9-10,7Gb/s, 40km	L
TRX100032/xxx (EOA-A)	XFP, DWDM, SM, 9,9-10,7Gb/s, 80km	L
TRX100090/TC	Tune XFP, DWDM, 9,9-11,1Gb/s, 80km	L
TRX100091/TC	Tune XFP, DWDM, 9,9-11,1Gb/s, 40km	L
TRX100108/xxx	SFP+, ChYY, DWDM, 10Gb/s, 40km	C
TRX100109/xxx (EOA-E)	SFP+, ChYY, DWDM, 10Gb/s, 80km	C

"L" indicates that the TRX is used on line side. "C" indicates that the TRX is used on client side.

For technical data on supported transceivers, see *Dimensioning Guidelines* within the System Manual.

Note that the SingleStrand transceivers TRX100154 and TRX100155 requires SW of R25 or later.

Table 5 Product Revision Data

Product number	Rev	Introduced Release	Comment
TPQ10GFEC/I	R1A	R21.0 (June 2013)	1st released version.
	R1B	R28 (Feb 2017)	Introduction of card ejection lever and new overlay

Table 6 Product History

Release	Description
R21	1st introduction of board.
R23	Added support for TRX100116
R25	Added support for TRX100154 and TRX100155
R28	Introduction of card ejection lever and new overlay