DEDICATED HIGH CAPACITY SERVICE (DHCS)

Virgin media O2 Business

FLEXI FILTER SERVICE DESCRIPTION

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Document information

Title	Dedicated High Capacity Service Flexi Filer Service Description
Owner	Ian Bunning
Category Lead	James McGee
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Contributors

Name	Role	Nature of contribution
Andy Chomyn	Infinera	Technical content
Phil Corris	Solutions Architect	Technical content and review
Paul Brooks	Solution Architect	Technical content and review

Contents

1. Service Overview

1.1 What is Flexi Filter?

Flexi Filter is a solution offering the simplicity of a managed wavelength service combined with the flexibility to allow direct access to optical filter ports for those customers wishing to take advantage of their own DWDM infrastructure. The customer can opt for a single managed wavelength and grow capacity utilising the additional filter wavelengths or choose to add managed capacity on expansion ports built into the managed module.

The solution offers a modular approach to connectivity allowing the customer to choose from an array of managed service types, distance options, filter port density, connectivity speed and topology. The build as you grow capability also allows additional capacity to be added transparently in the future dependent on the base configuration chosen.

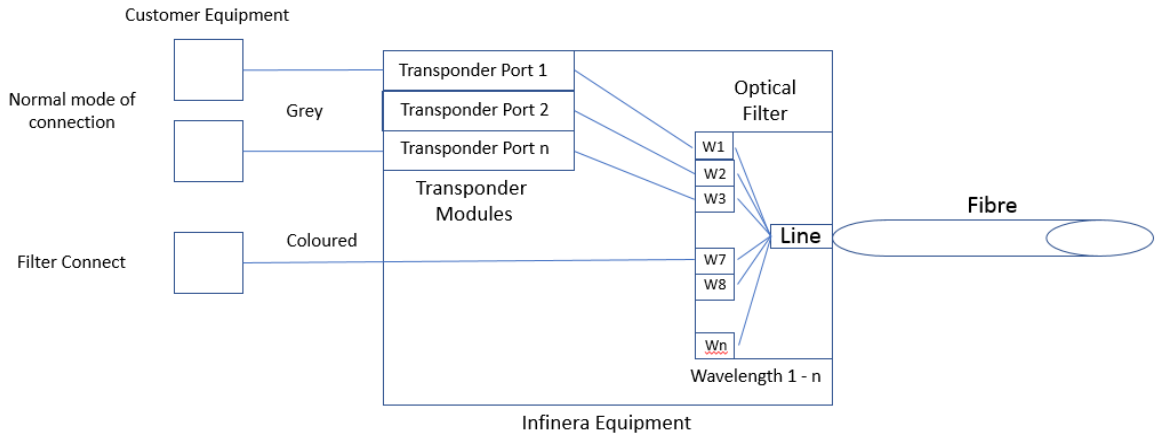
In addition, the solution allows for the initial managed service to be payload transparent (utilising optical pure optical transport) or active Ethernet facilitating active transportation of synchronous Ethernet and PTP 1588v2 (Transparent Clock).

1.2 Basic Solution Concept

Traffic is carried between sites over a pair of fibreoptic cables. To make better use of the bandwidth available over these fibres, the light travelling down the fibre is divided into specific wavelengths or colours, each specific colour carrying its own discrete data stream. This technique is called Wave Division Multiplexing (WDM) and in the case of this solution a specific type of WDM namely Dense WDM or DWDM. DWDM uses filters at each end of the fibre to allow for the connection of multiple coloured data streams, combining them over a single fibre. At the remote end another filter “de-multiplexes” this combined data stream and presents the discreet coloured signals.

To attach to these filters the data stream must be “coloured” to match the wavelength it is going to use. This is done using a transponder to transpond the “grey” light coming from the customers equipment into “coloured” light to transport over the filter.

In most cases a service provider will offer either pure fibre solution, meaning the customer is responsible for all aspects of equipment connectivity, or a managed service offering transponder ports for the customer to attach their “grey” optics to.



Flexi Filter is a hybrid solution offering the customer the option to attach their first service over a transponded port and then either utilise the remaining filter ports directly or take more transponded ports offered by Virgin Media.

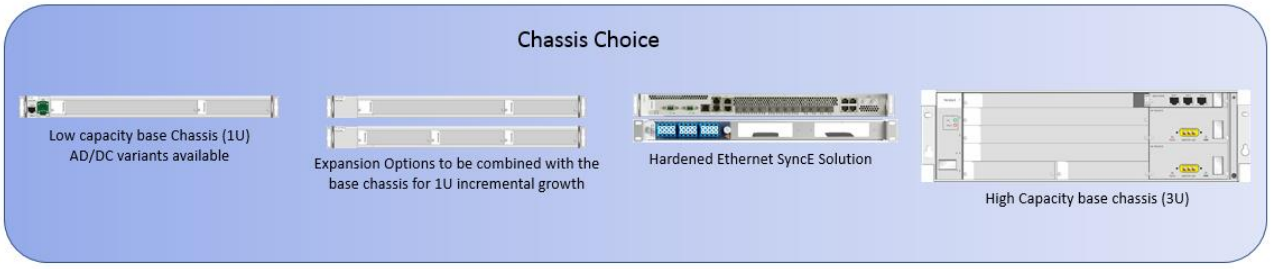
1.3 Solution Building Blocks

The Flexi Filter solution is highly configurable, and it is essential that you consider immediate and future plans when working with us to design your solution. Requirements to be taken into consideration are:

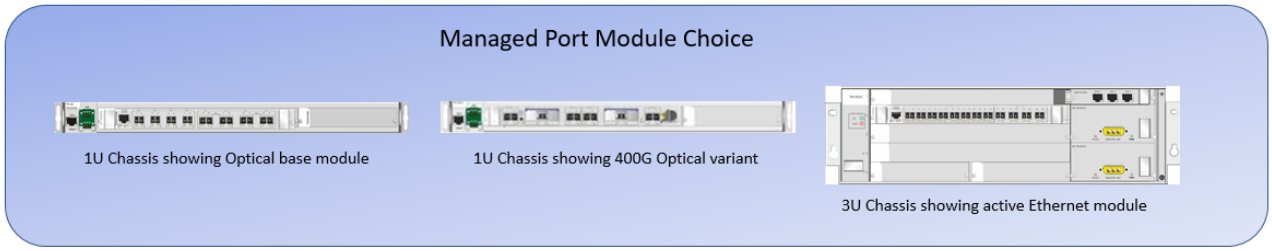
- Presentation of initial managed port
  - Active Ethernet, transparent 10G or 100G optical, client optic presentation
- Site location/environment
  - Requirements for hardened equipment, AC or DC presentation, space
- Distance between chosen sites
  - Requirements for signal amplification, Dispersion compensation
- Capacity requirements
  - Number of initial/final ports/wavelengths, current and future connectivity speeds
- Network Topology
  - Point-to-point, hub and spoke

To allow for maximum flexibility in solution design, Flexi Filter is built on a modular architecture utilising the Infinera range of Metro Packet-Optical products. This approach allows a solution tailored to the right combination of form-factor, capacity, distance and port presentation.

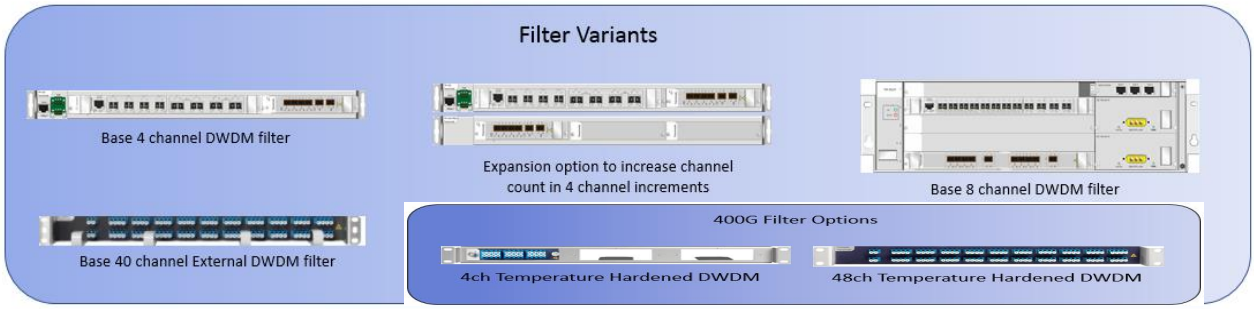
Technical specification of the modules, distance and filter combinations are covered later in this document, however the basic process for solution evaluation is as follows:



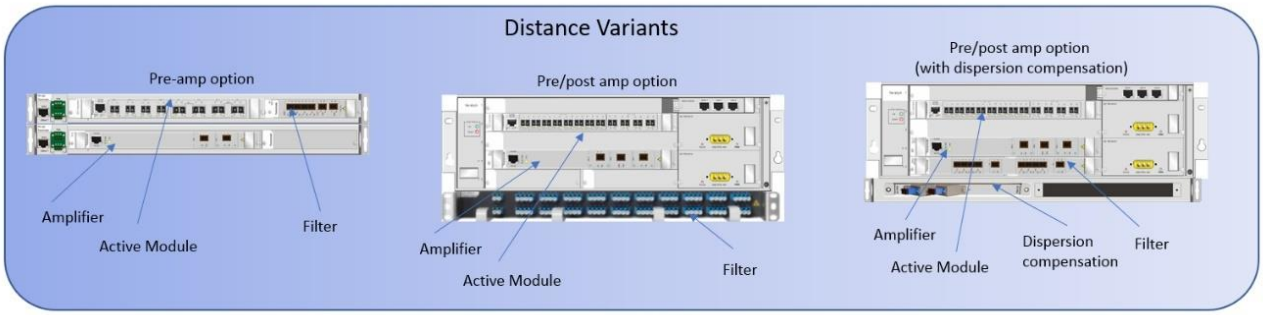
1. Chassis type: Dependent on capacity requirements (filter, amplification), two basic chassis options (sizes) are available as shown above.



2. Managed ports: The base chassis will house an Infinera line module which will support the first active (managed) customer port. This module may be active Ethernet supporting active Synchronous Ethernet and PTP 1588v2 or transparent optical supporting 10G or 100G. Modules are chassis independent.



3. Filter variant: Dependent on capacity requirements the appropriate DWDM filter will be added to the solution. Filters will be either housed within the chassis or, in the case of a 40 channel or hardened solution, will be externally mounted in a 1U standalone shelf. Although filters are also chassis independent, it is envisaged that 4 channel filters will be housed in the 1U solution and 8 channel in the 3U variant making better use of shelf capacity.



4. Amplification requirements: Amplification may be added dependent on distance and/or filter combination. The diagram above shows examples of module/filter/amplifier combinations but these are flexible dependent on requirements. Amplifiers will be housed within the chassis (or expansion chassis in the case of the 1U solution) with dispersion compensation module (if required) being housed in an external 1U shelf. Note that dispersion compensation will have a negative effect on the ability to mix 10G and 100G wavelengths. Care should be taken if this combination is required.

Topology variants will be covered later in this document, however, all solutions will comprise a combination of the above.

1.4 Geographical Coverage

The Flexi Filter solution will be available in all areas currently served by the Virgin Media Dedicated High Capacity Service (D-HCS).

1.5 Solution Management

All managed services will be connected to the Virgin Media Data Control Network (DCN) to manage the active service. Connectivity to the DCN will be via the Ethernet management port on the Infinera chassis, connected at one end with management traffic carried out-of-band to the remote site. Management traffic will be backhauled from the connected port either by a direct connection (if the service terminates at a Virgin Media site) or via a dedicated management fibre if not.

In the event of a service being exclusively supported by the Infinera XTM102 chassis, Virgin Media will utilise an Alcatel Omni Switch 6465T at one end to provide electrical to optical (Ethernet) conversion. These devices are available in both AC or DC versions – details are in Appendix A

Services connected directly to the filter are not actively managed/monitored and are the responsibility of the customer.

The managed service will be actively monitored via the Virgin Media Network Operations Center (NOC) where service disruption is automatically notified to the operator and a fault ticket raised.

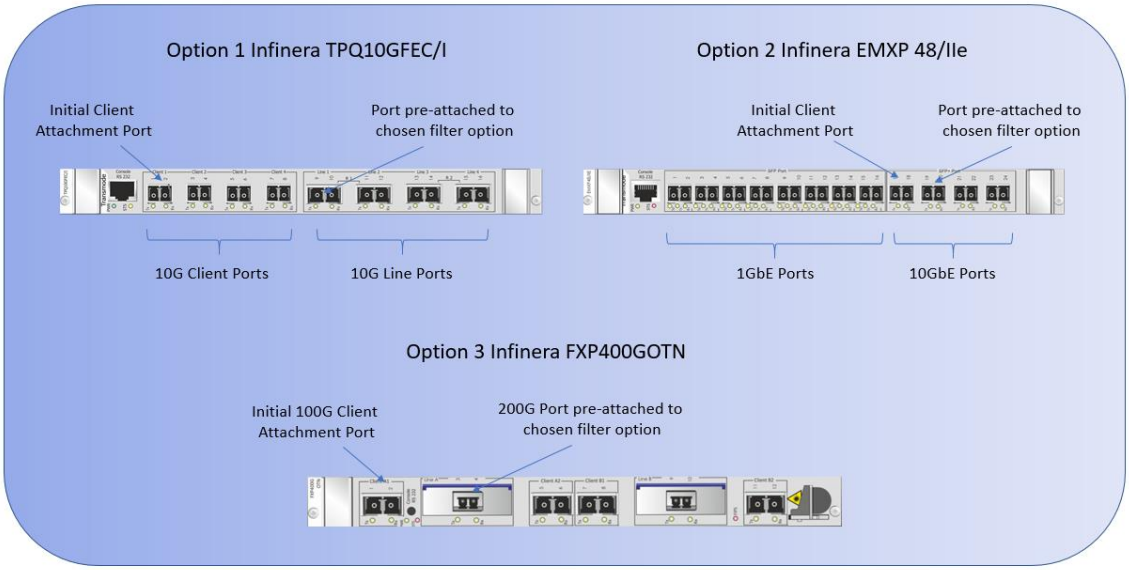
2. Service Presentation

2.1 Overview

Customer presentation i.e. Virgin Media demarcation and customer connection points for this service will be divided into two discreet service demarcation (customer) hand-offs. The first is the initial managed wavelength connected to the chosen active service module, the second is direct connectivity to an available filter port. The following describes the two connectivity requirements.

2.2 Managed port usage

The first port in the service will be a Virgin Media managed port using either of the three Infinera modules shown below. These modules are described in more detail in Appendix A at the end of this document.



Unless specifically ordered otherwise: client facing port will be populated with an SFP+, 1310nm, Single Mode, 10Gb/s, 10km, E-Temp optic for connection to the customers equipment (in the case of 10G) or a QSFP28,100G-LR4,1310nm,SM,10km (in the case of 100G client interconnect). This port will be the demarcation for the managed service and the customer will be responsible for cabling from this port to the client equipment. Clients will require single mode attachment (patch) fibres with LC or MU connectors (dependent on filter type).

Line side (i.e. connection to the filter) will utilise a coloured optic and will be pre-cabled to the first port of the chosen filter option. This connection is managed by and is the responsibility of Virgin Media. Examples showing final connectivity are given later in this document.

In addition to allowing direct filter attachment; options are also available to pre-connect additional managed user ports to enable additional managed services. As shown above, the managed Ethernet solution also offers the possibility to attach up to 8x1GbE clients which could be aggregated onto either of the line facing 10GbE ports.

2.3 Filter port usage

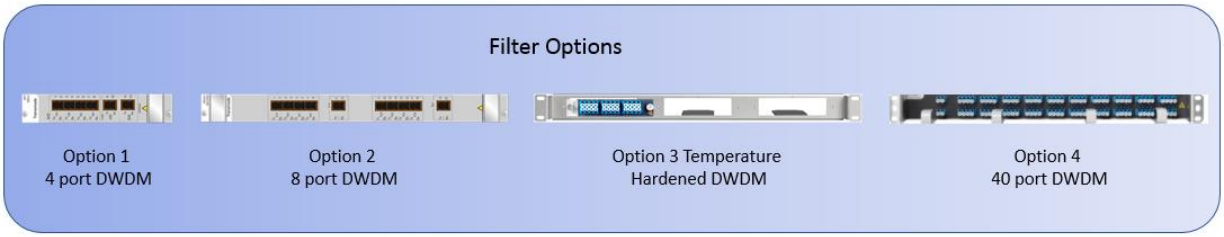
As an option; Virgin Media are offering direct connectivity to one or more of the remaining filter ports unused by the previous managed service (or services). This will allow direct connection to a specific wavelength on the managed filter. The customer is consequently responsible for the transponder function i.e. colouring the client interface to match the corresponding filter port frequency.

There is no limit to the number of free direct connect filter ports that can be used by the customer up to the total number of ports available in the solution chosen. This will be; **number of ports on the filter – 1**

(one port being used for the initial managed service). The bandwidth choosen to transmit over the available wavelengths is merely subject to physical limitations i.e. the condition, distance and amplification requirements of the fibre connecting your locations. These will be subject to survey during initial installation.

Set up and maintenance of the services over the filter ports are the customers responsibility. Virgin Media is responsible for the optical fibre, optical filters and the first (plus any additional) managed services.

Connectivity to the direct filter ports must be in line with standard safety and technical specification as outlined in appendix B to this document. This is to ensure both safe working practices and the integrity of the solution. Non-compliance with this working practice may result in failure of new and/or existing services and/or damage to transmission equipment. Virgin Media except no liability in this instance and such failure may result in additional cost for repair of equipment and restoration of service.



Virgin Media demarcation (customer connectivity point) in the case of direct filter connectivity will be at the filter port on the optical filter.

The diagram above shows four filter options, these are also covered in more technical detail in appendix A. In essence choice of filter is based on capacity requirements for the link, however, space availability may also affect filter choice. Filters are independent of chassis or managed module choice, however some filters lend themselves better to certain implementations (described below).

Technical specifications and descriptions of the filters are provided in Appendix A. It should be noted that in all cases, the first available channel i.e. channel 919 (frequency 191.9) will be reserved for the managed wavelength. Cascading of filters (to increase available capacity) is covered in Appendix B

- Option 1 – The 4 port filter is a half slot module compatible with any chassis type. This filter provides the flexibility to grow capacity in 4-wavelength increments and is ideally suited for use within the TM102 where, with the use of the TM102 passive expansion node, 4 filters (16 wavelengths of capacity) can be housed in only 2U of rack space.
- Option 2 – The 8 port filter is a single slot module also compatible with any chassis type. It would be recommended for use in the TM301 chassis option due to it's requirement for an entire slot. The 8 channel filter is completely compatible with other filters and offers the same frequency/channel range
- Option 3 – Both option 3 and option 4 are environmentally hardened for use outside normal environmentally controlled locations. Option 3 will be used where capacity is less than 40 channels and a temperature hardened solution is required. Functionality, connection and wavelength options are the same regardless of filter type

- Option 4 – For higher capacity requirements, Virgin Media will install the externally mounted 40 Channel filter. This filter is housed in a 1U shelf and is used to optimise space both in the rack and chassis. The 40 channel is also temperature hardened for -5 to +65 degrees centigrade
- Option 5 – Option 5 and 6 are for 75GHz channel filters allowing customers to connect 400G wavelengths, including the 400G ZR+ -10dbm Router Optic. The 4 port filter fits into the passive 1U TG holder which can house up to 3 filters.
- Option 6 – The 48 port 75GHz filter variant is a standalone 1U unit, similar to the standard 40 channel filter.

Connection to all filter types will be dual LC connector. Customers may choose single or connected (duplex) cables for this connectivity, however cables and connections are the responsibility of the customer.

Support for 400G services

Virgin Media are able to offer a bespoke compatible filter range to support 400G wavelength services utilising a wider than 50GHz bandwidth. This will permit either the initial managed service to be 400G* or 100G, followed by customers 3rd party coherent optics such as 400G ZR+, on the assumption the 3rd party optics will fit within a 75GHz spectrum centred around the standard ITU 100GHz grid.

As this is focused on higher bit-rates, there is no support intended for speeds below 100G coherent technology. No external dispersion compensation is required.

Topology options previously discussed in section 3.3 are supported.

Filter options are a 4channel cascade-able filter and a 48ch filter, enabling pay as you grow options.

Port options for the initial managed service are either 100G client using the previously mentioned FXP400GOTN card, or 400G client using the latest FXP400G-E. Either option enables customers to add their own 400G wavelengths subject to performance capabilities.

400G / 4x100G Optical Transport Option (FXP400G-E)

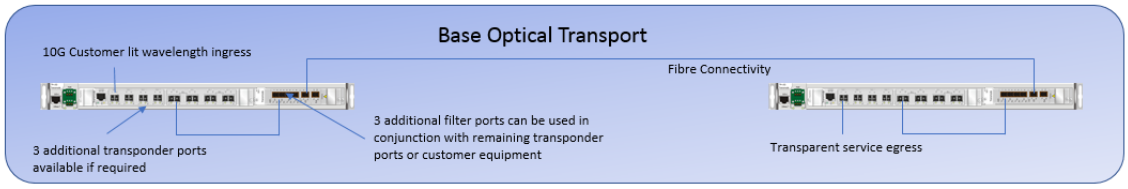
The 100G optical transport option will allow up to 400G Ethernet* or 4 x 100G client facing ports to be transported over a 400G wavelength. The 400G transport module is only available in the 3U multi slot chassis or a dedicated 1U chassis and only with the filters mentioned above in this sub-section.

The client side is based on pluggable QSFP28 ports. There are four client ports available for QSFP28 transceivers where one of the client ports is switchable to host a QSFP-DD transceiver as a dedicated 400G client. All 100G client ports are individually configurable to support either 100GbE-LAN or OTU4 client payload.

Distance / reach is a limiting factor for third party optics such as ZR+ with their low launch power and limited chromatic dispersion.

2.4 Example Connectivity

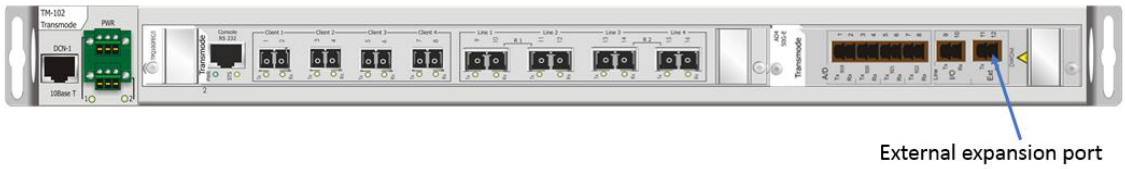
The diagram below provides an example base configuration utilising the 1U chassis solution housing the optical transport module (TPQ10GFEC/I) with a four-port filter.



The example shows customer managed connectivity to the first port of the optical transport module with the line port connected to the first port of the chosen filter. Customers may choose to continue with additional managed services using the available active ports or connect directly to the remaining ports on the filter for the Flexi Filter solution.

2.5 External Port Utilisation

An option exists for the customer to utilise the external port of the 4 or 8 channel filter for the connectivity of an external WDM or filter system.



This expansion port may be utilised by an external line system to access the additional wavelengths in the DWDM spectrum (i.e. those not being used by the filter itself). Potentially the customer could attach their own transmission (filter, ROADM) over this expansion port and access those wavelengths

This option would be made available for un-amplified versions only. Amplification and wavelength balancing will be the responsibility of the customer

If this option is required it must be specified at the time of the initial service order. The configuration above will be provided i.e. the optical TPQ10GFEC/I module plus the 4 channel filter housed in the 1U TM102 chassis. The first wavelength will be utilised by the first managed service, the next 3 wavelengths will be reserved by the filter i.e. Channels 919-922 inclusive (frequencies 191.9-192.2).

The remaining 36 channels/frequencies are technically available for use by the customer i.e. channels 923-957. Channel planning, testing, and amplification requirements are solely the responsibility of the customer. Virgin Media accepts no responsibility for 3rd party equipment attached to the filter port.

It is imperative that requirements for this option are discussed with the Virgin Media service representative in advance of service order to assess the viability of this option specific to the customer's use case.

3. Service Options

3.1 Port configuration variants

Active Ethernet (EMXP48/IIe)

The 10G ports on the EMXP/IIe are populated with SFP+ optics. The following variants are supported:

- Uncoloured optics - Uncoloured interfaces are supported for the SFP+ interfaces. Both single mode and multimode interfaces are supported. **Unless otherwise specifically ordered, customer termination will be on an uncoloured SM SFP+ as specified in this document.**
- CWDM - CWDM SFP+ and XFPs are available in 8 channels up to 70km.
- DWDM - DWDM SFP+ and XFPs are available in 40 channels up to 80km.
- Tuneable DWDM - The 80-channel tuneable DWDM 10G SFP+ modules up to 80km.

These SFP+ ports can be configured with 10G-LAN.

There are also 8x GbE SFP ports available.

Hardened Active Ethernet (TM-EMXP-1U)

Often paired with an EMXP48/IIe card, the TM-EMXP-1U is a hardened 1RU device that shares much the same feature set as the MXP48/IIe card and is ideal for ethernet aggregation.

The 10G ports on the TM-EMXP-1U are populated with SFP+ optics. The following variants are supported:

- Uncoloured optics - Uncoloured interfaces are supported for the SFP+ interfaces. Both single mode and multimode interfaces are supported. **Unless otherwise specifically ordered, customer termination will be on an uncoloured SM SFP+ as specified in this document.**
- CWDM - CWDM SFP+ and XFPs are available in 8 channels up to 70km.
- Tuneable DWDM - The 80-channel tuneable DWDM 10G SFP+ modules up to 80km.

Note: All SFP+ transceivers need to be I-temp class to support the extended temperate range of the TM-EMXP-1U.

These SFP+ ports can be configured with 10G-LAN.

The TM-EMXP-1U has 8x GbE SFP ports and 4x GbE electrical ports available.

If the device is being deployed in a mobile backhaul/fronthaul scenario, it is worth noting that the TM-EMXP-1U supports IEEE 1588v2 Transparent Clock for timing and synchronization.

Hardened 100G Active Ethernet (TM-EMXP-XH800/DC)

The XH800 provides a flexible solution for supporting a mix of GbE, 10G, 25G and 100G client interfaces up to total 200G line side capacity in a hardened 1RU device. Another feature supported in the XH800 is IEEE 1588v2 PTP Transparent Clock and PTP Boundary Clock, both highly relevant to 5G mobile applications.

The TM-EMXP-XH800/DC supports the following traffic interfaces:

- 12x10G SFP+
- 12x10G/25G/eCPRI SFP28
- 2x100G QSFP28
- 2x100G/200G Coherent DWDM CFP2

The following 10G optical transceivers are supported:

- Uncoloured optics - Uncoloured interfaces are supported for the SFP+ interfaces. Both single mode and multimode interfaces are supported. **Unless otherwise specifically ordered, customer termination will be on an uncoloured SM SFP+ as specified in this document.**
- CWDM - CWDM SFP+ are available in 8 channels up to 70km.
- Tuneable DWDM - The 80-channel tuneable DWDM 10G SFP+ modules up to 80km.

In 10G mode the SFP+ ports can be configured with 10G-LAN only.

The following 100G optical transceivers are supported:

- Uncoloured client optics – QSFP28 for both single mode and multimode
- Tuneable line side DWDM – CFP2 for 80-channel tuneable DWDM 2000km+

Optical Port (TPQ10GFEC/I)

The Transponder image of the module (used in this application) will be set to 10GbE-LAN. In the basic service offering, only a single port of the module will be used (for the initial managed service), however the remaining ports may be ordered for additional managed services.

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 uncoloured, CWDM and DWDM versions can be utilised, uncoloured will be provided by default. 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.

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.

100G Optical Transport Option (FXP400GOTN)

The 100G optical transport option will allow up to 4 x 100G client facing ports to be transported over 2 x 200G line side wavelengths. Both line side wavelengths will be connected to the chosen filter option for transport over the single managed fibre. The 100G transport module is available in all previously indicated form factors (chassis types) and with all filter options.

The client side is based on pluggable QSFP28 ports. There are 4 client QSFP28 ports available on the unit where two client ports are paired with one line port. All client ports are individually configurable to support either 100GbE-LAN or OTU4 client payload.

The line side is based on pluggable CFP2 ports. There are 2 line ports available on the unit. Depending on the choice of CFP2 each line port can individually be configured to support either 100Gbps or 200Gbps coherent line signals.

3.2 Amplification

Dependent on a combination of distance, fibre quality (OSNR) and the selection of filter options chosen, it may be necessary for the connection to include amplification. The table below gives an indication of the relative distances that can be achieved utilising different combinations of solution (chassis type), filters and amplification. This table should only be taken as a guide; verification of final solution requirements will be subject to survey.

Distance vs filter options

Chassis/Amp \ Filter	4 Channel	2 x 4 (8) Channel	8 Channel	3 x 4 (12) Channel	2 x 4+8 (16) Channel	4 x 4 (16) Channel	3 x 8 (24) Channel	40 Channel	Recommended Distance
Base XTM102	59Km	46Km	NA	33Km	40Km	20Km	31Km	24Km	40Km
XTM102 with Pre-amp	92Km	85Km	NA	72Km	NA	72Km	NA	76Km	74Km
Base XTM301	(Hub) 59Km	46Km	44Km	33Km	40Km	20Km	31Km	24Km	40Km
XTM301 with Pre-amp	(Hub) 92Km	NA	84Km	NA	74Km	NA	77Km	76Km	74Km
XTM301 with Pre and Post amp	(Hub) 110Km	NA	110Km	NA	110Km	NA	110Km	110Km	100Km

Note: All distance Subject to site/route specific survey

75GHz spaced filters for customer 400G wavelengths

Only 40ch if OA20LG Amp's used

Chassis \ Filter	4 channel	48 channel
Base XTM102/II(E)	14km	N/A
Preamp XTM102	44km	44km
Base XTM301	14km	N/A
Preamp XTM301	44km	44km
Pre and Boost XTM301	85km	85km

There are also several other parameters that must be considered when designing amplified networks. Some examples are:

- Bit rate: The network must be designed for the highest bit rate. As an example, a link with a mix of 10Gb/s and 100Gb/s wavelength channels will require a different configuration compared to a network with only 10Gb/s channels. The 100Gb/s channels will typically restrict the maximum distance.
- Line coding with or without Forward Error Correction (FEC): Some transponders have FEC that will give 3 to 5dB better power budget compared to transponders without FEC.
- Dispersion properties: Some Transponders have lasers with better dispersion tolerances.
- If Router 400G ZR+ optics are being used, are they -10dbm or 0dbm output to line? As this makes a big difference on Amplifier requirements and overall reach.
- Optical noise tolerance (OSNR)
- Number of channels: A network with max 16 channels will not have the same design solution as a network that needs to carry up to 80 channels.
- Distances requiring the use of dispersion compensation and consequent deployment of DCUs will affect the ability to simultaneously support concurrent 100G/200G wavelengths. Care should be

taken when designing initial network deployment to take future 100G requirements into consideration. It should also be noted that use of Bragg grating DCUs is required. Pure coherent implementations (not requiring dispersion compensation) are not affected.

Consequently, amplified networks require more technical skills to design compared to un-amplified networks. In un-amplified networks all wavelengths are independent, and it is mostly just a matter of making power budget and dispersion limit calculations on a per wavelength basis.

Designing amplified networks with line amplifiers requires that all wavelength channels must be taken into consideration. It is the “worst” wavelength channel that will define the complete network design.

It is therefore vital that, in the case of amplification being required, the proposed application for the service be discussed with the Virgin Media representative. Failure to take into consideration the above design restrictions in initial installation may restrict what may and may not be possible on the direct unmanaged filter connected ports.

Requirements are discussed further in Appendix B

3.3 Topology Options

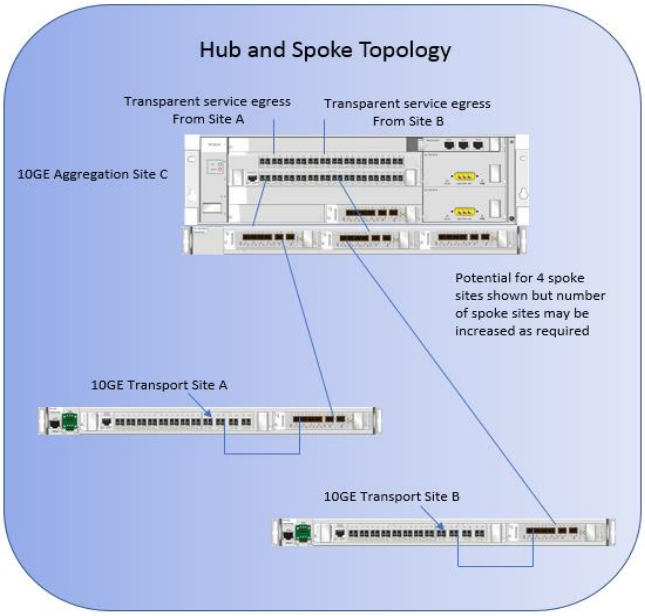
Point to point

The default configuration will be point-to-point (P2P) i.e. two sites connected together with a single fibre termination at each end. It is of course possible for P2P connections to form all or part of a mesh or ring network topology, however the switching between the discrete P2P links would be the responsibility of the customer and involve switching equipment external to the Virgin Media solution.

An example of a simple P2P architecture is shown in section 2.4

Hub and Spoke (Aggregation Model)

The flexibility of the Infinera Packet Optical architecture allows the delivery of multiple topology options. A Hub and Spoke solution can be offered where customers have a location that is required to terminate (or aggregate) several satellite or spoke locations.



The diagram above shows an aggregation solution providing a single hub site for up to 4 spoke locations. In this instance the solution is an active Ethernet option but could equally be pure optical using the TPQ10GFEC/I module or Fronthaul Flexponder solution. In the case where aggregation is being provided for an active Ethernet variant (as above), the termination (i.e. hub site) will utilise another member of the

Infinera EMXP family, namely the EMXP240/IIe. This module consists of 24 x 10GbE ports allowing aggregation of 12 remote spoke sites onto a single 2-slot unit. All technical specifications for this module are the same as with the EMXP48/IIe. Similarly, 2x remote XH800 units can be aggregated back into a single XH800 (i.e. hub site).

In essence the solution houses multiple point to point Flexi Filter connections in a single chassis at the hub location with standard P2P solutions at the spokes, reducing space, power and maintenance.

Hub and Spoke solutions will be tailored to specific customer requirements.

4. Further information

4.1 Protocol Transparency

Within the Flexi Filter solution there are five connection types (described above) and dependent on which the customer is connecting to, varying levels of transparency are provided, namely;

- Active Ethernet (Packet Optical – EMXP48/IIe and hardened TM-EMXP-1U)
  - Customer presentation is Ethernet framed traffic. Within the Ethernet flow, transportation of the protocol is transparent i.e. the service is transparent to customers VLAN, control frames and packet size.

- Hardened 100G Active Ethernet (TM-EMXP-XH800/DC)
  - Customer presentation is Ethernet framed traffic. Within the Ethernet flow, transportation of the protocol is transparent i.e. the service is transparent to customers VLAN, control frames and packet size.

- Optical Transport (TPQ10GFEC/I)
  - Although completely protocol transparent, the optical connection ports (i.e. attached to the TPQ10GFEC/I) must adhere to a signalling format that is either 10GbE WAN/LAN or STM-64/OC-192.

- 100G Optical Transport (FXP400GOTN)
  - The FXP400GOTN is a true G.709 OTN compliant unit from a mapping perspective, 100GbE-LAN client signal is thus mapped according to the standards in an ODU4 container using GMP mapping process.

- Direct Filter Connect
  - Although transportation across the filter solution is completely protocol and rate transparent it is important that the correct procedure for direct attachment to the filter port be adhered to. Please see Appendix B for details.

4.2 Test & Handover

Circuits are tested prior to handover to the customer to prove connectivity and performance. Virgin Media will ensure end-to-end fibre continuity (fibre performance) and service functionality of the first (managed) service. Virgin Media are not responsible for testing services using the direct attach filter ports.

4.3 Security Compliance

The Flexi Filter service is based up on our Dedicated high Capacity Services product which has been developed in line with industry best practice. The services have been externally audited by UKAS accredited auditors and are ISO 27001:2013 certified. In order to support the needs of our significant

Public sector install base, we have committed to maintaining our services to be compliant with appropriate CESG guidance, allowing us to provide customers with solutions that are capable of transmitting traffic up to UK HMG Government Security Classification of OFFICIAL.

Traffic may include more sensitive data caveated at OFFICIAL-SENSITIVE where approved by the system owner. The Government Security Classifications (GSC) policy states that OFFICIAL-SENSITIVE should 'still be managed within the "OFFICIAL" classification tier, but may attract additional measures (generally procedural or personnel)'. The GSC does not define these 'additional measures' but leaves it to the data or system owner to decide as the 'controls will be data and system dependent'. Therefore we are able to handle information marked at OFFICIAL-SENSITIVE in accordance with our existing information management policies and commercial good practice, which comply with GSC guidance for OFFICIAL classification.

This capability is achieved by having our network services are assured to CAS(T), which is a CESG approved assurance scheme that builds upon our ISO27001:2013 Certification by mandating specific physical, personnel, procedural and technical security controls relevant to a communications services provider. CAS(T) demonstrates compliance to CESG Security Procedures Telecommunications Systems and Services, which are designed to enable Communications Providers to provide assurance to customers that their telecommunications systems and services are adequately protected against risks to the confidentiality, integrity and availability of information classified as OFFICIAL. The customer should advise that a CAS(T) certified network is required so that VMB can ensure the premises housing the relevant network switches have been security hardened and any 3rd party providers used are also CAS(T) certified.

4.4 Reporting

No automated reporting is available for the service but may be made available upon request. This is for managed wavelengths only, any customer lit wavelengths are the responsibility of the customer.

5. Appendix A Equipment Specifications

5.1 Product summary

The solution described in this document will be provisioned using the Infinera Metro Ethernet product range, specifically those products listed below.

5.2 Infinera Chassis Specifications

The TM-Series includes a wide range of active and passive plug-in units optimised for cost-effective Layer 1 and Layer 2 transport. These plug-in units can be mounted in any of the TM-Series chassis – TM-3000/TM-3000/II, TM-301 and TM-102/TM-102/II. The selection of the specific chassis for a node is based upon the number of required slots and expected space for upgrades.

For the purpose of Flexi Filter, the proposed chassis types will be the TM102 and the TM301 as described below. This does not discount the possible use of the larger TM3000 should capacity requirements dictate.

In hardened environments, the layer 2 TM-EMXP-1U and TM-EMXP-XH800/DC chassis are available for up to 100G transport requirements. These do not have removable traffic cards.

5.2.1 TM102/II

The TM102 is a single RU chassis capable of housing a single slot, full hight, active traffic unit or amplifier and well as half hight passive line cards. The unit comes in 3 variants; the first, shown below, is a powered chassis comprising a single full size slot and a single half slot.

This unit is capable of accepting active modules in the full slot as well as passive units in the half slot. In addition, two further variants are totally passive units built to house passive modules only. These two units comprise a single full slot plus a half slot or three half slots.

The active unit can be supplied with DC or AC (via an AC power block) power.

The TM-102/II chassis has multiple and redundant fan units as well as dual primary power modules. All connections are made on the front of the chassis, so no rear access is required. Specifications are shown below

Specifications:

Dimensions	Height: 1U / 44 mm (1.7 in) Depth: 249 mm (9.8 in) excl mounting brackets. 295 mm (11.6 in) incl mounting brackets Width: 448 mm (17.6 in) excl mounting brackets
Primary Power	DC-inlets. Redundant
Cooling	Multiple, fixed fans
Mounting	ETSI, 19”
LAN/ Management Connections	RJ45
Primary Power Range, DC	48 VDC (40.8 – 57.6 VDC), 3 A Class III
Max Power at DC Powering	85 W

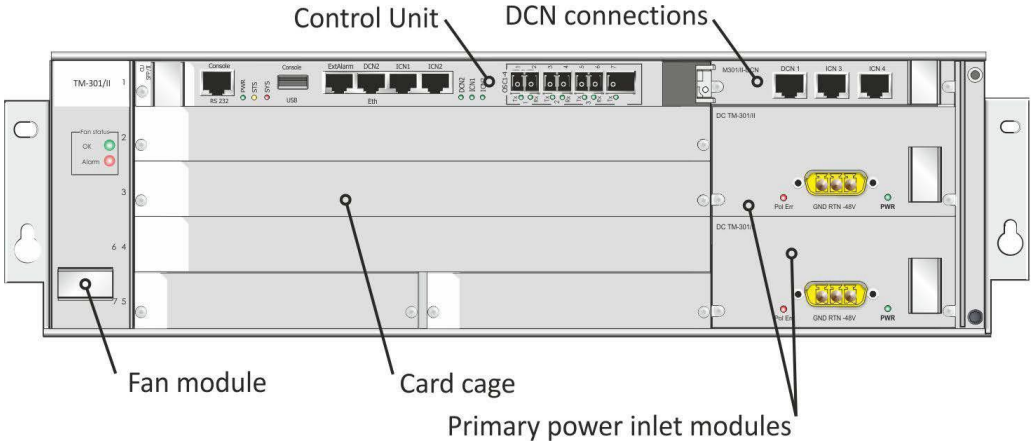
Max Inrush Current @ -48VDC	1.9 A / 30 ms
Primary Power Range AC	External AC/DC-converter 100–240 VAC, 50/60 Hz, 1.1A Class I
Max Power at AC Powering	90 W (via external AC/DC converter)
Max Power Consumption in Card Cage	75 W
Operating Conditions	ETSI EN 300 019-1-3 class T3.1

Specifications and Features Are Subject to Change

5.2.2 TM301/II

The TM-301/II chassis is a medium capacity enclosure, with up to four full-sized slots for Layer 0, Layer 1 or Layer 2 plug-in units and up to four half-sized slots typically used for Layer 0 plug-in units such as CWDM add/drop filters or other optical units. The TM-301/II chassis can be configured to any network element (NE) type or combination of NE types. The generic backplane imposes no restrictions on NE type or NE combination. This flexible approach is unique and eliminates the challenges associated with static NE types, such as terminal multiplexer only or add-drop multiplexer only NEs.

The TM-301/II chassis has redundant fan units and dual redundant primary power modules (A+B configuration). All connections are made from the front



The card cage has one dedicated slot for a Control Unit (CU). The following two slots are for full-sized plug-in units, such as Transponders, Muxponders, Optical Filters, Amplifiers, etc. The two following slots can mechanically be configured as half-sized or full-sized slots. Half-sized units are normally passive optical devices (e.g. add-drop filters). Specifications shown below

Specifications:

Dimensions	Height: 3U / 133 mm (5.2 in) Depth: 280 mm (11 in) Width: 445 mm (17.5 in) (excl. mounting brackets)

Primary Power	DC-inlets. Redundant, hot swap
Cooling	Redundant fan units. Hot swap
Mounting	ETSI, 19”, 23”
LAN/ Management Connections	RJ45
Primary Power Range, DC	48 VDC (40.5 – 57 VDC), 15A Class III
Max Power at DC Powering	567 W
Max Inrush Current @ -48 VDC	>25Apk, >1ms
Max Inrush Current @ AC	>50Apk, >100ms
Weight	11 kg (24 lb) mechanics + 2x fan unit + 2x DC inlet module + LAN module
Operating Conditions	ETSI EN 300 019-1-3 class T3.1 NEBS3

Specifications and Features Are Subject to Change.

5.2.3 TM-EMXP-1U

The TM-EMXP-1U is a 1RU pizza box design. It runs in a CU-less mode just in the same way as a single-slot XTM card in a TM102 chassis does. The Embedded Node manager (ENM) SW is thus running on the EMXP-based traffic unit that is housed in this chassis. There are in total 12 gigabit Ethernet interfaces on the TM-EMXP-1U. Eight of them are for pluggable optics in the SFP form factor. Four are on RJ45 interfaces that support 10/100/1000 BaseT. There are also Four 10G interfaces using SFP+ based pluggable optics. The TM-EMXP-1U has two redundant power inlets for –48V powering. For AC-powering a separate AC/DC converter can be used.

Specifications:

Environmental	40°C to 65°C (-40°F to 149°F) , 5% to 85% RH (for use inside a space protected from direct outside weather)
Dimensions	Height: 1RU / 44 mm (1.7 in) Depth: 198mm (excl mounting brackets)

	Width: 438 mm (including mounting brackets) Weight: 2.95kg (excl mounting brackets)
Primary Power	DC-inlets. Redundant. Fixed. 48VDC (24 – 60VDC) wide input, 3.8A Nominal Power Consumption: 49W Max Power Consumption: 89W
AC Power Options	Primary power range AC PS3A-10001/0n: 100-240VAC, 50/60Hz, 2.5A Class I See I&C manual for details on ACDC1RU285-1/0n
Cooling	Fixed fans. Multiple fan elements.
Mounting	ETSI, 19" type 1 and type 2, 23" (default is 19" mount)
LAN/ Management Connections	RJ45

Specifications and Features Are Subject to Change.

5.2.4 TM-EMXP-XH800/DC

The TM-EMXP-XH800/DC packet-optical transport switch is part of Infinera's XTM Series range of EMXP units, providing seamless integration of Layer 1 transport and Layer 2 metro Ethernet functionality in fiber deep packet-optical mobile transport applications. In addition to supporting demanding fiber deep Ethernet applications, the TM-EMXP-XH800/DC provides the high performance required for 4G and 5G, eCPRI and Ethernet switching in mobile X-haul networks. This includes 5G eCPRI fronthaul networks and high performance Carrier Ethernet applications. The TM-EMXP-XH800/DC has two redundant power inlets for –48V powering. For AC-powering a separate AC/DC converter can be used.

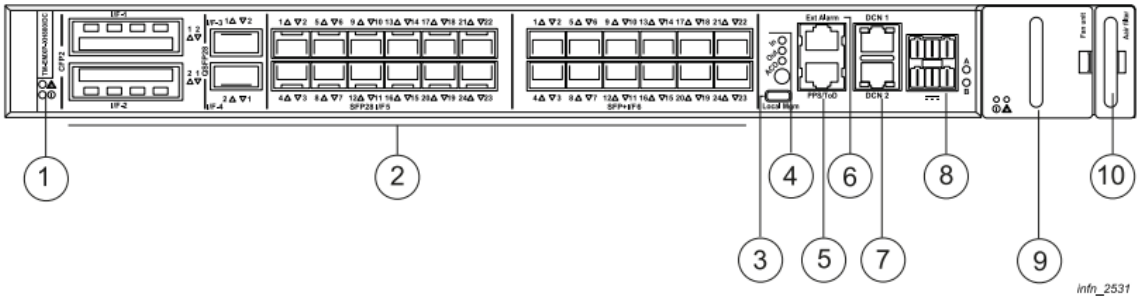


Table 2: Items on front

Pos.	Name
1	Power and status LED
2	Traffic Ports - CFP2, QSFP28, SFP28 and SFP+
3	Local management (USB-C) for CLI and serial communication.
4	ACO - external alarm cut off | In | Out
5	PPS/ToD - pulse per second/Time of Day
6	External Alarm
7	DCN 1 and DCN 2
8	Power connection (A and B)
9	Fan unit
10	Air filter

Specifications:

Dimensions	Height: 1U / 44.5mm (1.75 in) Depth: 255mm (10.1 in) without mounting brackets and 327mm (12.9 in) inc brackets Width: 444 mm (17.5 in)
Primary Power	DC-inlets. Redundant, Fixed.
Cooling	Fan unit replaceable in field
Mounting	ETSI, 19”, 23”
LAN/ Management Connections	RJ45 for DCN and USB-C for local management
Primary Power Range, DC	-40.5VDC to -57VDC
Max Power at DC Powering	15A
Weight	4.7KG (10.4lb)
Operating Conditions	Humidity 5% to 85% Rh, GR-3108 Class 2 Protected Equipment in Outside Environment (for use inside a space protected from direct outside weather)

	Normal operating temperature: -40°C to 65°C (-40°F to 149°F)

Specifications and Features Are Subject to Change.

5.3 Infinera Managed Line Modules

5.3.1 EMXP 48/IIe

The EMXP IIe packet-optical transport switch is part of the Infinera XTM Series, providing seamless integration of Layer 1 transport and Layer 2 metro Ethernet functionality in packet-optical applications.

The EMXP IIe units have a latency of two microseconds and virtually zero jitter for all packet sizes, regardless of traffic load. This makes them ideally suited to Ethernet applications in which latency and jitter are important, such as services for financial institutions, video distribution and LTE backhaul.

Synchronisation and Clocking

The implemented SyncE in the EMXP IIe supports clock selection logic and on-board holdover that exceeds synchronous digital hierarchy (SDH) requirements. Synchronisation signalling is used to provide traceability of the synchronisation source and to do automatic sync source selection, providing high reliability of the sync.

All EMXP IIe units support IEEE 1588 transparent clock for phase and time synchronisation. This function identifies PTP timing packets as close to the line interface as possible and adjusts the timestamps automatically for timing packets that are carried over native Ethernet or encapsulated in SVLANs or inside MPLS pseudowires. Adjusting these timestamps to compensate for the internal delay improves the accuracy of the PTP protocol and allows the protocol to have more switch hops between grandmaster and slave without the need for expensive external references (e.g. from GPS).

The table below shows an extract of the features of the EMXP edited to reflect the filter connect solution sub-set of Specifications relevant to this service.

Specification (valid for EMXP48 IIe)

Interfaces	EMXP48 IIe: 4x10 Gb/s + 8xGbE	GbE/FE interfaces (SFP): Uncoloured multi-mode and single mode CWDM up to 16 channels or DWDM up to 80 channels Single-strand fibre solution Electrical 10/100/1000BASE-T 10 Gb/s interfaces (SFP+): 10 Gb/s-LAN mode or OTU2e framing with GFEC, I.4 or I.7 FEC Uncoloured multi-mode and single mode CWDM up to 8 channels, DWDM up to 80 channels 100

Resilience Not included in this service	IEEE 802.3ad Link Aggregation with LACP. Normal LAG, N+1 and N+N protection LAG, Multi-chassis LAG MPLS over LAG including RFC6391 flow label ITU-T G.8032 Ethernet Ring Protection v1 and v2 Supports Ethernet ring over LAG and in-service adding/removing links MPLS-TP Linear Protection with Protection State Coordination (PSC) RFC6378
Ethernet Services EPL only in this service	E-Line (EPL and EVPL), E-LAN (EP-LAN and EVP-LAN), E-Tree (EP-Tree), E-Access CE 2.0 Compliant, MEF 9+14
Quality of Service Not included in this service	Policing using bandwidth profiles Flexible traffic classification, e.g. based on DSCP, CoS, port and inner/outer VLAN Eight strict priority queues / WRR queues, min and max shaping. WRED
Latency (using RFC1242 store and forward metric)	EMXP48 IIe: Ethernet 2.4 µs • OTU2e 6.2 µs (GFEC), 32 µs (I.4), 65 µs (I.7)
Performance Monitoring and OAM	IEEE 802.1ag Continuity Check and Loopback, Port Mirroring MPLS G-ACh channel for OAM RFC5586 BFD for MPLS Label Switched Paths (LSPs) RFC5884 Management VLAN for in-band management Port isolation using private VLAN technique Y.1731 Loss Measurements and Delay Measurements Link Layer Discovery Protocol (LLDP)
Synchronous Ethernet and Timing	ITU-T G.8262 Synchronous Ethernet Equipment Clocks (EEC) ITU-T G.8264 Ethernet Synchronisation Messaging Channel (ESMC) ITU-T G.781 Synchronisation Status Messages (SSM) IEEE 1588v2 Transparent Clock
Source-specific Multicast	RFC4607 Source-Specific Multicast for IP RFC4541 IGMP Snooping
L2 Switching	Selectable learning enabled per VLAN, 4,094 VLAN IDs, 128K MAC-addresses Storm control IEEE 802.1ad Q-in-Q SVLAN Flexible VLAN tag handling: push, pop, swap, pop-swap Super jumbo frames up to 10248 Bytes OpenFlow 1.3 control of switching resources (for EMXP IIe in “open” mode)
TDM over Ethernet	STM-1 and OC-3 via circuit emulation over Ethernet in iSFP-TDM155 STM-4 and OC-12 via circuit emulation over Ethernet in iSFP-TDM622 E1 via circuit emulation over Ethernet in iSFP-E1
Power Consumption (Including Optics)	EMXP48 IIe: Max 56 W

Specifications and Features Are Subject to Change.

5.3.2 TM-EMXP-XH800/DC

Please see section 5.2 for further information on the TM-EMXP-XH800/DC shelf.

Latency	Store-and-forward latencies • 10G to 100G less than 1 µS

Parameter	Value
Interfaces	
10G interfaces	12x SFP28, 12x SFP+
100G/200G interfaces	2x QSFP28 (100G), 2x CFP2 (100G/200G)
Ethernet Services	
Service VLANs	4094
MAC addresses	32K
Policies ingress/egress	256/128 (total max 348)
Jumbo frame size Byte	9216 Bytes
MEF Policers	256
Queues per port	8

Fronthaul ready synchronization

- Nanosecond-accurate timestamping capabilities for T-TC and T-BC
- 1PPS/ToD input/output
- Highly accurate G.8273.2 Option C compliance
- eEEC Synchronous Ethernet
- Optical Timing Channel (OTC) for single-fiber 1588 transport

5.3.3 TM-EMXP-1U

Please see section 5.2 for further information on the TM-EMXP-1U shelf. For further technical features please see section 5.3 EMXP 48/IIe.

5.3.4 TPQ10GFEC/I

The Quad 10G FEC Transponder (TPQ10GFEC/I) is part of the Infinera XTM Series , which is optimised for cost efficient transport in CWDM and DWDM networks.

This one-slot unit contains four individual transponder functions supporting transport of STM-64/OC-192, 10 GbE-WAN and 10 GbE- LAN signals. The client signal is mapped into a digital wrapper with forward error correction (FEC), which makes the transponders suitable for amplified long-haul networks.

The Quad 10G FEC transponder is a generic traffic unit in metro/ regional networks for backhaul of Ethernet and SDH/SONET traffic. For wholesale operators it is important to be able to transport both SDH/SONET and Ethernet signal data as well as synchronisation transparently. The latter is imperative for mobile backhauling of multiple synchronous Ethernet signal to support wholesale services to multiple operators over the same infrastructure.

Specifications

Supported Traffic Formats	STM-64/OC-192, 10 GbE-WAN, 10 GbE-LAN
Basic Configurations	4x transponder unit or 2x regenerator unit
Layer 1 Performance Monitoring	SDH/SONET: based on B1 calculations Ethernet: CRC bytes and PCS statistics Line signal: based on CRC Collected every 15 min/24 h and presented according to G.826 using ES, SES, etc.
Protection	1+1 line protection. Non-revertive/revertive switching typically <20 ms Equipment protection. Non-revertive/revertive switching typically <20 ms Combined equipment/line protection (1+3 line protection)
Power Consumption	Max 50 W worst case (with all client ports active and using DWDM SFPs)
Misc Line Interface Features	Embedded management channels on line signals Trail trace insertion to validate connection
Interfaces	Client interfaces: SFP+-based. Supporting MM, SM, 1310 nm/1550 nm, CWDM and DWDM. Including “SingleStrand” transceivers enabling direct operation on a single-fibre configuration without need for a DWDM filter Line interfaces: 40 ch DWDM via XFP with fixed wavelength, 80 ch via XFP with tunable laser, 8 ch CWDM
Layer 2 Features	Ethernet utilisation PM (in %) per 10 GbE-LAN port Inject and extract of mgmt-VLAN on 10 GbE-LAN clients
Synchronisation	Through-timing

	Supports SyncE transport (G.8262/Y.1362 option 1)

Specifications and Features Are Subject to Change

5.3.5 FXP400GOTN

The 400G Flexponder (FXP400GOTN) is part of the Infinera XTM Series. The 400G Flexponder enables mapping of up to four individual 100 gigabits per second (100G) client signals to a flexible choice of 100G or 200G coherent line signals. With its small footprint, occupying only a single slot in any of the TM-102/II (1 rack unit or 1RU), TM-301/II (3RU) or TM-3000/II (11RU) chassis, the 400G Flexponder is a market leader for high density, low power and cost-efficient transport in any part of the metro or regional network.

The 400G Flexponder utilizes state-of-the-art technology in the form of quad small form-factor pluggable (QSFP28) optical modules on the client side and small C form-factor pluggable (CFP2) optical modules on the line side. The pluggable CFP2 modules are used on the line side to provide a coherent signal on a single channel tunable over all channels in the 50 gigahertz (GHz) range of the C-band. The two individual CFP2 lines of the 400G Flexponder can be software-reconfigured to support various line speed modulation formats such as 100G quadrature phase-shift keying (QPSK) or 200G 16 quadrature amplitude modulation (16QAM).

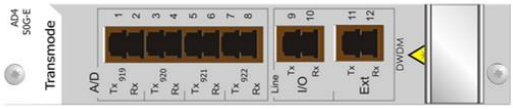
The 400G Flexponder supports standardized mapping of services according to ITU-T G.709 OTN. The pluggable client side can support various QSFP28 modules for 100 Gigabit Ethernet (GbE) and OTU4 services. This enables the 400G Flexponder to be deployed both in greenfield networks and existing OTN environments

Specifications	
Supported Traffic Formats	4x100 GbE 4xOTU4
Mapping	G.709 mapping to ODU4
Performance Monitoring (PM)	OTN: G.709 monitoring 100 GbE: based on CRC and RMON Collected every 15 min/24 h and presented according to G.826 End-to-end PM presentation
Line format	100G QPSK 200G 16QAM
Power Consumption	Maximum 77W, including optics
Misc. Line Interface Features	Management channels: GCC0, GCC1 and GCC2 Forward error correction: SD-FEC, Staircase FEC
Interfaces	Client interfaces: QSFP28-based. LR-4, SR-4, CLR-4, CWDM-4 Line interfaces: CFP2-based

Specifications and Features Are Subject to Change

5.4 Infinera Filter Solutions

5.4.1 4 Channel Filters – Infinera AD4/50G-E/xxx



The AD4/50G-E/xxx DWDM filters (shown above) are operating on the even 50GHz wavelengths which corresponds to the ITU-T 100GHz grid. In total ten 4ch AD-filters are provided to cover the complete 40ch configuration. Note that the pass-band is 100GHz.

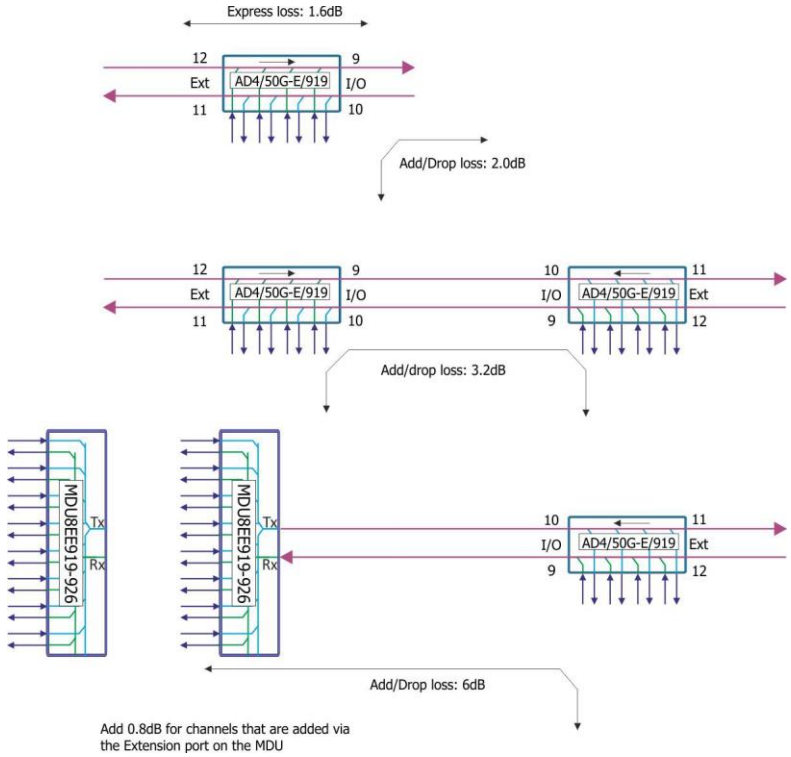
4ch AD-filter units are half-sized boards that can be mounted in the corresponding slot of any XTM chassis although for this application it is assumed the chassis to be used would be the TM102 (shown above).

The table below shows the available wavelengths/frequency on the filter. Note; the first channel i.e. 919 will be used to provide the managed service. The remaining channels are free for connection to customer equipment.

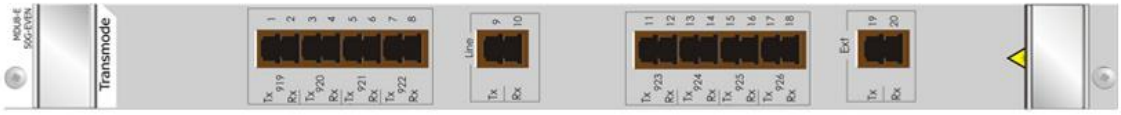
40ch MDU Even channels	Wavelength THz	Channel-number	4ch AD-filters Even channels
MDU40/50G-EVEN	191.9	919	AD4/50G-E/919
	192.0	920	
	192.1	921	
	192.2	922	
	192.3	923	AD4/50G-E/923
	192.4	924	
	192.5	925	
	192.6	926	
	192.7	927	AD4/50G-E/927
	192.8	928	
	192.9	929	
	193.0	930	
	193.1	931	AD4/50G-E/931
	193.2	932	
	193.3	933	
	193.4	934	

Electrical Parameters – Power consumption 0.1w

Loss values, including connectors shows max loss values for filters operating at the even 50GHz (i.e. 100GHz) grid. The same values apply on the filters operating on the odd 50GHz channels. The pass band is 100GHz for both AD-filters.



5.4.2 8 Channel Filters – Infinera MDU8-E/50G-EVEN/zzz-yyy



The MDU 8ch units are all-optical devices with both an 8ch Mux and an 8ch DeMux on the same board. All units have an extension port enabling the units to be cascaded.

One important feature is that the MDUs operate at 100GHz spacing which enables pluggable optics to be used on the MDU8EE units, i.e. SFPs and XFPs.

The MDU units are passive units, i.e. contains no microprocessors or other electrical components apart from a small memory circuit to provide remote inventory data.

All MDU8-versions are for fibre-pair configurations and can be combined with optical amplifiers to extend the transmission distances without electrical regeneration.

40ch MDU Even channels	Wavelength THz	Channel-number	4ch AD-filters Even channels	8ch MDU's Even channels	BSU1X5/ EVEN50G
MDU40/50G-EVEN	191.9	919	AD4/50G-E/919	MDU8EE919-926	Band 1
	192.0	920			
	192.1	921			
	192.2	922			
	192.3	923	AD4/50G-E/923		
	192.4	924			
	192.5	925			
	192.6	926			
	192.7	927	AD4/50G-E/927	MDU8EE927-934	Band 2
	192.8	928			
	192.9	929			
	193.0	930			
	193.1	931	AD4/50G-E/931		
	193.2	932			
	193.3	933			
	193.4	934			
	193.5	935	AD4/50G-E/935	MDU8EE935-942	Band 3
	193.6	936			
	193.7	937			
	193.8	938			
	193.9	939	AD4/50G-E/939		
	194.0	940			
	194.1	941			
	194.2	942			

The table above shows the available wavelengths/frequency on the filter. Note; the first channel i.e. 919 will be used to provide the managed service. The remaining channels are free for connection to customer equipment.

This section lists the technical data for the MDU 8 channel units.

Electrical Parameters – Power consumption 0.1w

Worst case loss values between MDU8EE & MDU8EO DWDM units

Add-Drop losses between DWDM units (incl. connectors)		
	MDU8EExxx-yyy	MDU8EOxxxx-yyyy
MDU8EExxx-yyy	max 7.0dB (typical 4dB)	-
MDU8EOxxxx-yyyy	-	max 7.0dB (typical 4dB)
Loss Extension Port	max 0.8dB (typical 0,5dB)	max 0.8dB (typical 0,5dB)
	Express losses	
OIU-C-50/100	1.9dB in Mux direction, 1.9dB in DeMux direction	

End-to-end loss between two MDU units of same sort is 7.0dB.

When Multiple MDU unit of same sort is connected, add 0.8dB per side for loss through extension ports.

When multiple MDU units are connected via OIU, add 1.9dB per side.

5.4.3 40 Channel Filters – Infinera CO-D40EV

The CO-D40EV is part of the Infinera XTG Series of passive optical filters. The CO-D40EV is a fully passive 40-channel dense wavelength division multiplexing (DWDM) mux/demux module (MDU) that fits into one rack unit (RU).

CO-D40EV works on dual fibre, allowing up to 40 bidirectional DWDM channels over one fibre pair.

CO-D40EV is compatible with any ITU-compliant DWDM transmission equipment. Each channel is 100 GHz spaced between 195.80 and191.90 THz.

Specifications

Max Insertion Loss	6 dB (Worst case for EOL and complete temperature range) 4 dB (BOL in room temperature)
Link Loss	12 dB (Worst case for EOL and complete temperature range) 8 dB (BOL in room temperature)
Dimensions	Height: 44.45 mm (1.75 in) Depth: 240 mm (9.5 in) Width: 435 mm (17.1 in)
Operating Temperature	-5 to 65 °C (23 to 149° F)
Connector Type	LC

Specifications and Features Are Subject to Change

Frequency/wavelength availability

DWDM (40 Channels)

Wavelengths	1562.23	1561.42	1560.61	1559.79	1558.98	1558.17	1557.36	1556.55	1555.75	1554.94
Frequency	191.9	192.0	192.1	192.2	192.3	192.4	192.5	192.6	192.7	192.8

Wavelengths	1554.13	1553.33	1552.52	1551.72	1550.92	1550.12	1549.32	1548.51	1547.72	1546.92
Frequency	192.9	193.0	193.1	193.2	193.3	193.4	193.5	193.6	193.7	193.8

Wavelengths	1546.12	1545.32	1544.53	1543.73	1542.94	1542.14	1541.35	1540.56	1539.77	1538.98
Frequency	193.9	194.0	194.1	194.2	194.3	194.4	194.5	194.6	194.7	194.8

Wavelengths	1538.19	1537.40	1536.61	1535.82	1535.04	1534.25	1533.47	1532.68	1531.90	[illegible]
Frequency	194.9	195.0	195.1	195.2	195.3	195.4	195.5	195.6	195.7	[illegible]

5.4.4 4 Channel 75GHz 400G Capable Filters – Infinera CO-D4/II

The CO-D4-xxx/II is a single sided, four channel, DWDM add/drop filter working on dual fibre. The product range comprises of 12 different part numbers in the DWDM channel plan below.

In comparison with CO-D4-xxx, the CO-D4-xxx/II has a wider wavelength band width to support 400Gb's transmission. CO-D4-xxx/II has a BW of 75GHz @ 3db.

CO-D4-xxx/II is designed to be used together with other DWDM products in the XTG Series such as the CO-D48EV/II.

Specifications

Max Insertion Loss	2.6 dB (Worst case for EOL and complete temperature range)
Link Loss	4.4 dB (Worst case for EOL and complete temperature range)
Dimensions	Height: 29 mm (1.1 in) Depth: 160 mm (6.3 in) Width: 130 mm (5.1 in)
Operating Temperature	-40 to 70 °C (-40 to 158° F)
Connector Type	LC

Product name	ADD and DROP (THz)			
	1	2	3	4
CO-D4-914/II	191,4	191,5	191,6	191,7
CO-D4-918/II	191,8	191,9	192,0	192,1
CO-D4-922/II	192,2	192,3	192,4	192,5
CO-D4-926/II	192,6	192,7	192,8	192,9
CO-D4-930/II	193,0	193,1	193,2	193,3
CO-D4-934/II	193,4	193,5	193,6	193,7
CO-D4-938/II	193,8	193,9	194,0	194,1
CO-D4-942/II	194,2	194,3	194,4	194,5
CO-D4-946/II	194,6	194,7	194,8	194,9
CO-D4-950/II	195,0	195,1	195,2	195,3
CO-D4-954/II	195,4	195,5	195,6	195,7
CO-D4-958/II	195,8	195,9	196,0	196,1

5.4.5 48 Channel 75GHz 400G Capable Filter – Infinera CO-D48EV/II

CO-D48EV/II is a 48ch dual fibre working DWDM Mux/Demux filter in a standalone 1RU rack-mountable chassis. CO-D48EV/II is compatible with any ITU compliant DWDM transmission equipment.

In comparison with CO-D48EV, the CO-D48EV/II has a wider wavelength band width to support 400Gb's transmission. CO-D48EV/II has a BW of 75GHz @ 3db.

The 48 channels cover from 191.4 THz to 196.1 THz are 100 GHz spaced.

When using the filter in 75GHz mode with OA20LG Amplifiers on 40 channels are available. To gain access to all 48 channels OA21VG Amplifiers are required.

Specifications

Max Insertion Loss	5.8 dB (Worst case for EOL and complete temperature range)
Link Loss	11.6 dB (Worst case for EOL and complete temperature range)
Dimensions	Height: 44.45 mm (1.75 in) Depth: 242 mm (9.6 in) Width: 445 mm (17.5 in)
Operating Temperature	-5 to 70 °C (23 to 158° F)
Connector Type	LC

Specifications and Features Are Subject to Change

Channel count	Channel number	Wavelength (nm)	Frequency (GHz)	Channel count	Channel number	Wavelength (nm)	Frequency (GHz)
1	914	1566.31	191400	**25**	938	1546.92	193800
2	915	1565.5	191500	**26**	939	1546.12	193900
3	916	1564.68	191600	**27**	940	1545.32	194000
4	917	1563.86	191700	**28**	941	1544.53	194100
5	918	1563.05	191800	**29**	942	1543.73	194200
6	919	1562.23	191900	**30**	943	1542.94	194300
7	920	1561.42	192000	**31**	944	1542.14	194400
8	921	1560.61	192100	**32**	945	1541.35	194500
9	922	1559.79	192200	**33**	946	1540.56	194600
10	923	1558.98	192300	**34**	947	1539.77	194700
11	924	1558.17	192400	**35**	948	1538.98	194800
12	925	1557.36	192500	**36**	949	1538.19	194900
13	926	1556.56	192600	**37**	950	1537.4	195000
14	927	1555.75	192700	**38**	951	1536.61	195100
15	928	1554.94	192800	**39**	952	1535.82	195200
16	929	1554.13	192900	**40**	953	1535.04	195300
17	930	1553.33	193000	**41**	954	1534.25	195400
18	931	1552.52	193100	**42**	955	1533.47	195500
19	932	1551.72	193200	**43**	956	1532.68	195600
20	933	1550.92	193300	**44**	957	1531.9	195700
21	934	1550.12	193400	**45**	958	1531.12	195800
22	935	1549.32	193500	**46**	959	1530.33	195900
23	936	1548.52	193600	**47**	960	1529.55	196000
24	937	1547.72	193700	**48**	961	1528.77	196100

5.5 Alcatel OmniSwitch 6465T for DCN Connectivity

5.5.1 Appearance

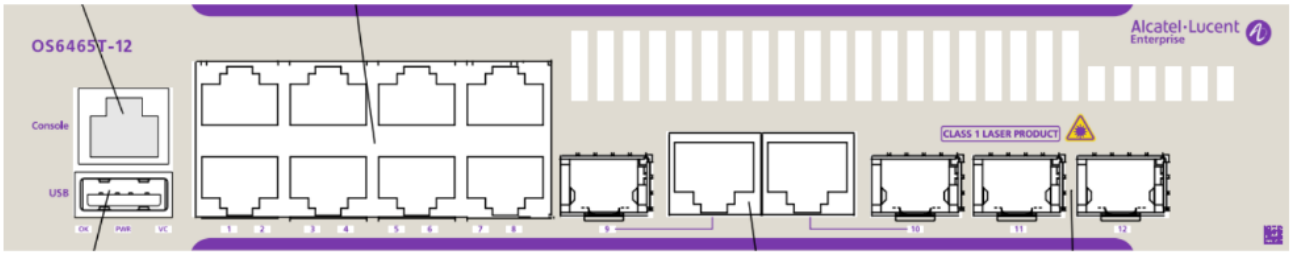


Figure 1- OS6465T front panel

On the front there are status LEDs, console, USB, 8 x 10/100/1000Base-T, 2 x combo RJ45 10/100/1000Base-T / SFP 100/1000Base-X and 2 x 1000Base-X ports.

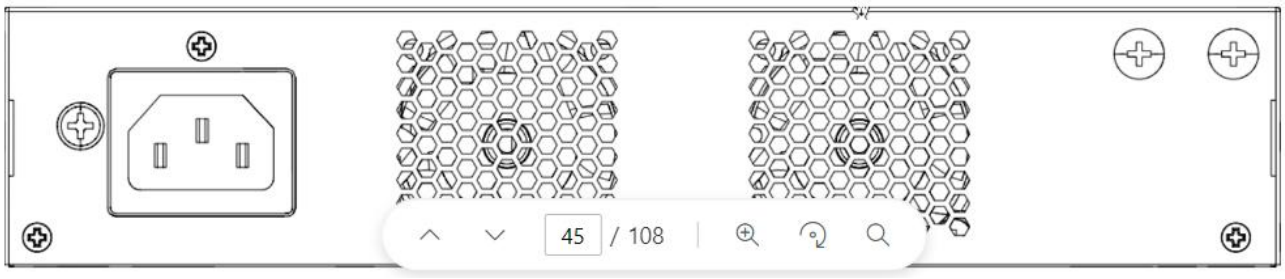


Figure 2 - OS6465T rear panel

On the rear there are earth connector and 240V IEC power socket.

5.5.2 Technical Specification

Component	Description
Total 10/100/1000Base-T ports	8 (1-8)
Total combo 10/100/1000Base-T / 100/1000Base-X ports	2 (9-10)
Total 1000Base-X ports	2 (11-12)
Flash memory size	1GB
RAM memory size	860MB SDRAM
Chassis Width	217.4mm
Chassis Height	44mm (1RU)
Chassis Depth	280.7mm
Chassis Weight	1.78kg
Power Consumption (idle)	16W
Operating Humidity	5% to 95% non-condensing
Storage Humidity	10% to 95% non-condensing
Operating Temperature	-10°C to +60°C
Internal Temperature Range	-15°C to +77°C
Storage Temperature	-40°C to +85°C
Default Upper Threshold Temperature	75°C
Danger Threshold Temperature	83°C

5.5.3 Power supply

As standard, the NTU's are provided with a single AC power supply.

Options for backup secondary power supply and DC supply are available upon request and must be specified at the time of ordering the service.

6. Appendix B Direct Filter Connectivity Requirements

The DWDM filters used in the Flexi Filter solution are passive devices. Customers will connect their own optical equipment to the filter ports using LC or MU (see filter specifications) filbers and whatever output is being produced by that equipment will be passed directly into the filter connection. There are no automated safety checks on power, frequency or format of the signal ingressing the system, therefore extreme care must be taken in assessing the source of the signal.

Incorrect wavelengths, over-powered source signal or questionable optics can, not only result in the failure of the new service (i.e. the service being connected to the filter), but the failure of existing services on the fibre (including the managed service) and, in extreme cases, failure and damage to the equipment itself.

It is recommended that only trained optical engineers have access to and responsibility for direct fibre connection to the filter system.

6.1 Fibre Safety

As stated above: The optical power level of the filters depends on the power levels of the attached systems. It is the responsibility of the customer to make sure that the combined system is classified, as an entity, according to IEC 60825-1&2 (latest edition) and to follow the necessary handling precautions.

Caution: It is the responsibility of the customer to obtain necessary optical classifications, when using the Flexi Filter service together with other optical equipment. The laser radiation from the filter system is invisible. Always use a power meter to verify the optical output power from a fibre connector or port in the system. Do not use any magnifying equipment to examine a fibre or optical connector. Use of optical equipment will increase the hazard level. Authorised personnel can use approved fibre inspection microscopes, when inspecting connectors, after it has been determined that no optical power is present at the connector.

6.2 Fibre cleanliness

All fibre cables and patch cords should be cleaned prior to connection to the filter port. Failure to maintain fibre integrity may result in poor connectivity or, in some cases, complete failure of the filter port.

6.3 Connecting to a filter port (unamplified)

Depending on the filter option chosen, the customer solution will have a number of available filter ports (from 3 to 39). The channel numbers are indicated in the filter modules or may be referenced in Appendix A. It is imperative that the correct input wavelength be attached to the correct corresponding filter port. If the customer is utilising a fixed coloured optic the correct optic must be used, if the customer is using a tuneable optic, it must be set to the correct wavelength.

As mentioned previously, in unamplified solutions each frequency/wavelength is largely independent. As long as the client line optics (i.e. the optic the customer uses for their own equipment) meet the channel/frequency and distance requirements of the link connectivity should be possible. Customers should check the specifications of the optics they are using to determine whether these requirements are met, whether power levels are sufficient or indeed need attenuation.

6.4 Connecting to a filter port (amplified)

Also see section 3.2 – Amplification. All constraints associated with unamplified solutions also apply in the case of an amplified connection, however additional elements must be taken in to consideration. As per section 3.2, in the case of amplified links, all wavelengths on the associated fibre are amplified. It is therefore important that, at the time of order, all potential requirements (both current and future) are taken into consideration. The link must be balanced for the worst possible scenario, therefore the speed of connection (whether 100G is being considered or only 10G), the configuration of the filters (are more filters likely to be added on this link) and topology are important.

DOCUMENT END