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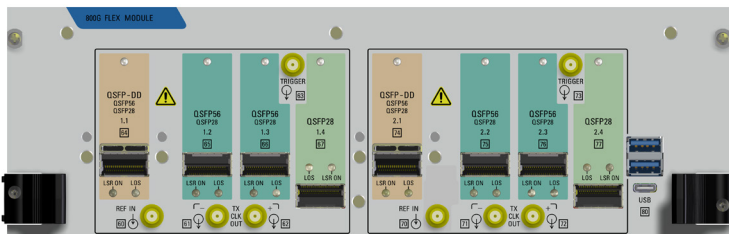
FlexE Testing

SW Options for ONT-800 CFP8, QFLEX and 800G FLEX Modules

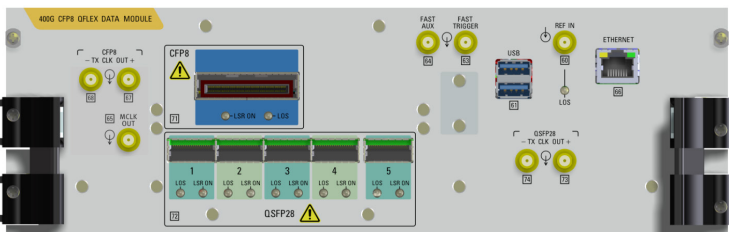
Launch FlexE products faster. ONT FlexE Software Options help to ensure ecosystem interoperability, deliver reliable performance, and accelerate product validation.

FlexE is a homogenous way for Network Managers to deliver flexible high-speed Ethernet services and enable software defined networks (SDN).

The ONT FlexE test application allows thorough design and verification testing of the FlexE Shim logic including FlexE Calendar, FlexE Management Channels, Overhead protocol functions and FlexE Clients configuration and performance.



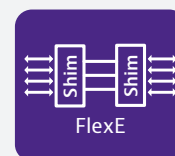
800G FLEX Module. Order Number 402-002.01



CFP8 QFLEX Data Module. Order Number 3076/92.65

Benefits and Features

- QSFP28 test interfaces
- 4 clients over 4 x 100GBASE-R PHY and 4 x 50GBASE-R PHY
- OIF IA FlexE 2.1
- Clients include N x 5G, 10G, 25G, 40G, 50G, 75G, 100G
- Application for 100G to 400G client testing with N x 5G client size
- Calendar configuration for FlexE Bonding, Sub-Rate and Channelization client setup
- FlexE Shim Alarm Error testing to check FlexE Overhead Frame and Overhead Multi-frame lock
- FlexE Management Channel Test with Transparency Check and Packet Capture
- FlexE Overhead Manipulation
- Port-to-port skew
- MAC client rate utilization and QoS



FlexE Test Introduction

FlexE is an Implementation Agreement defined by the Optical Networking Forum (OIF) to address the need for more flexible and scalable bandwidth serving high speed Ethernet rates. FlexE evolved out of earlier technologies such as Link Aggregation (LAG) and Multi-Link Gearbox (MLG). It provides functionality for Channelization, Bonding and Subrating applications to connect one or more Ethernet MACs using standard Ethernet PMDs between routers. Routers can be connected directly or through transport gear as illustrated in the three examples in Figure 1.

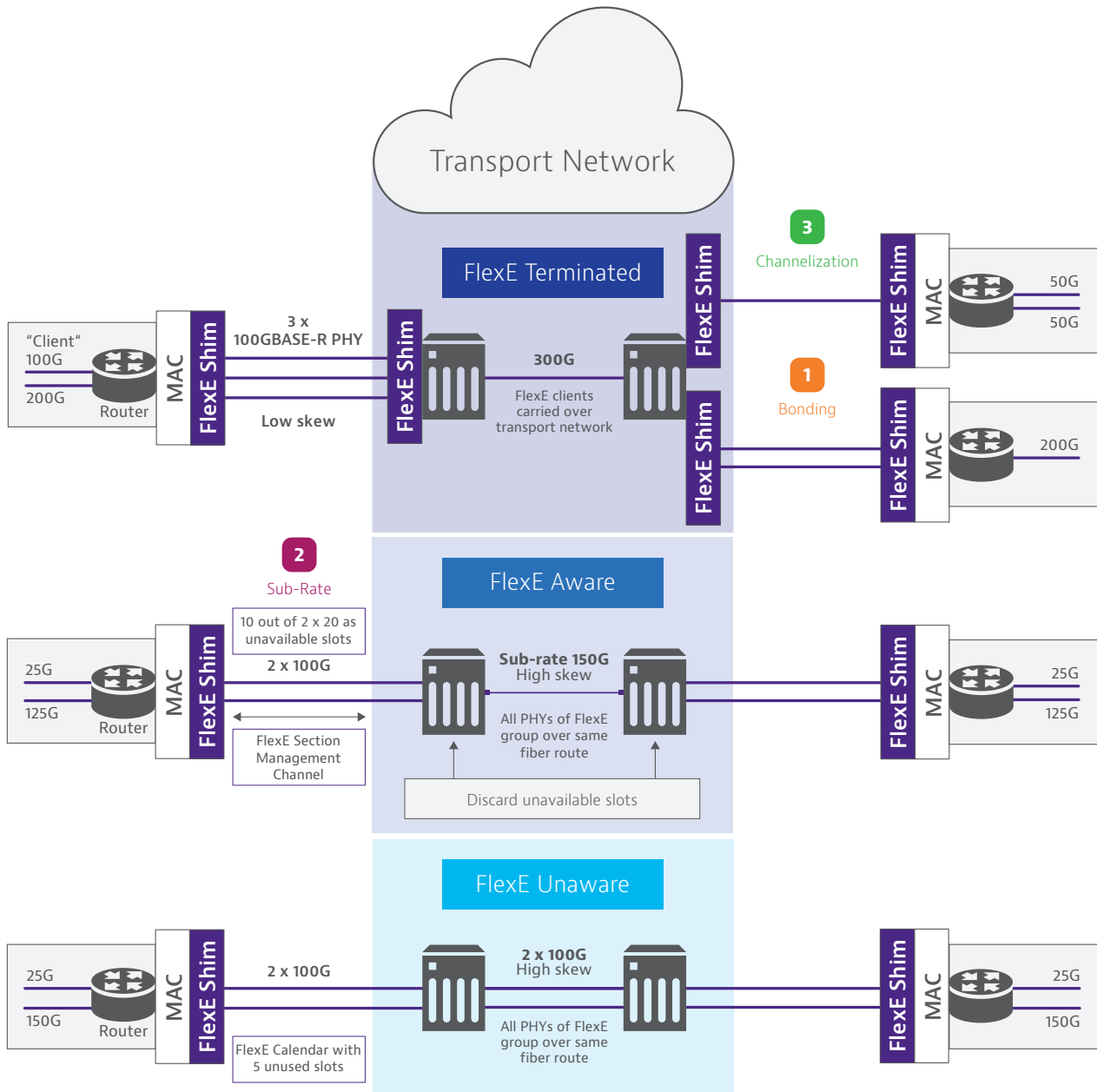


Figure 1. Examples for FlexE use cases with 100GBASE-R PHYs include Bonding, Channelization and Sub-Rating with Transport Network Equipment in FlexE Terminate, FlexE Aware and FlexE Unaware operation modes.

In essence, FlexE dissociates the Ethernet on the MAC client side from the actual physical interface as illustrated in Figure 2. The following illustration shows clients can be mapped across multiple PHYs through the 20 slots in sub-calendar per PHY.

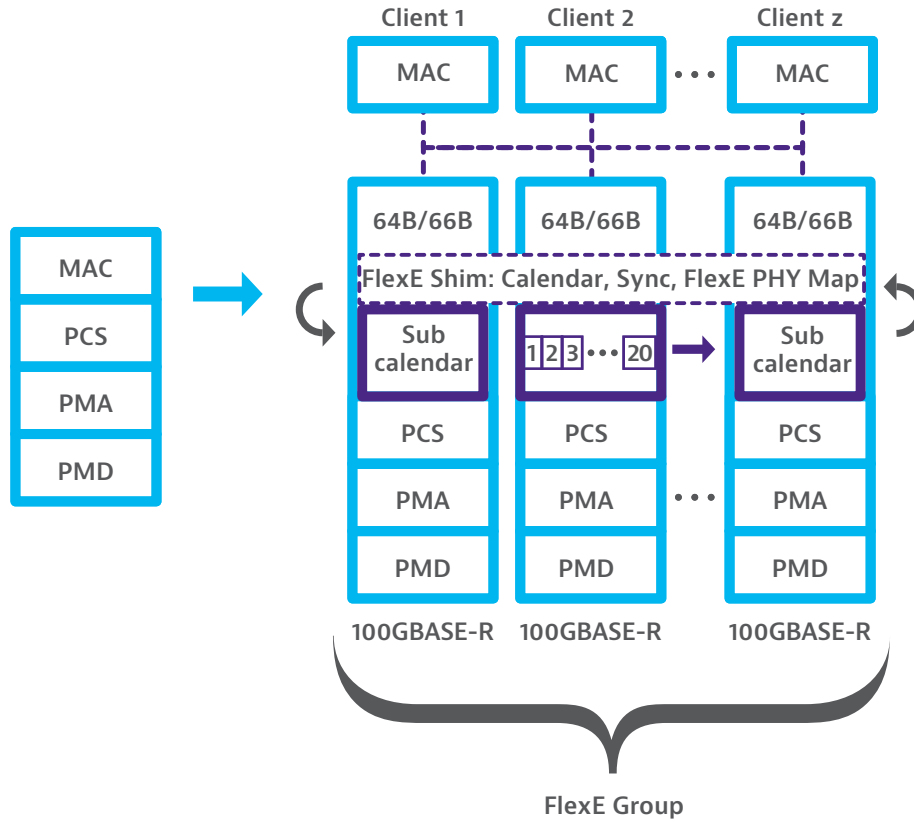


Figure 2. Enhanced Ethernet Layer model with FlexE Shim with example for 100GBASE-R PHY

The OIF FlexE 2.1 Implementation Agreement allows FlexE Groups composed of 50GBASE-R, 100GBASE-R, 200GBASE-R and 400GBASE-R PHYs. This is accomplished through the concept of a “100G FlexE Instance for 100GBASE-R, 200GBASE-R and 400GBASE-R PHYs.” The 200GBASE-R PHY is populated as two and the 400GBASE-R PHY as 4 x 100G FlexE Instances as illustrated in Figure 3, each with its own FlexE Overhead structure including Sub-Calendar. A 50G FlexE Instance carries 1x50GBASE-R PHY.

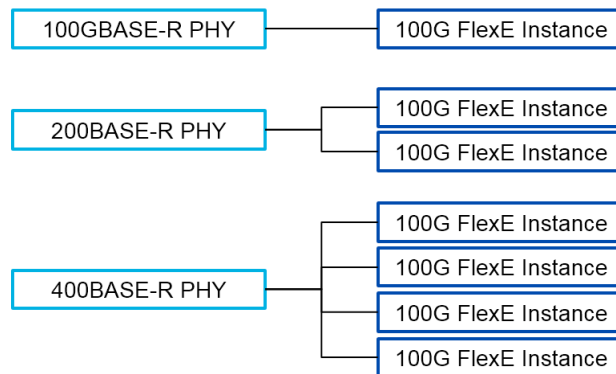


Figure 3. 100G FlexE Instance, in addition OIF IA FlexE 2.1 introduces the concept of a 50G FlexE Instance for 50GBASE-R PHYs

FlexE Use Cases

FlexE is an important building block for SDN networks as it allows network managers to adjust the network configuration by adding or removing clients from the service for typical use cases as shown in Table 1.

Segment	Use Case	Benefit
Operators	Flexible Ethernet Services	Enables SDN with lower cost per bit and new attractive Services and efficient restoration capabilities
Data Center Interconnect (DCI)	Carrier Ethernet Router to high-speed optical Transport networks	Full rate utilization of existing transport network
Intra-Data Center	Using high capacity circuits	Cost efficiency. Using available 100GE PMDs. Standardization independent
Mobile 5G	Network slicing in 5G Midhaul / Backhaul	Discrete channelization in Ethernet

Table 1. Typical FlexE use cases

FlexE Test Application

IC vendors, network equipment manufacturers and network operators need a test environment to validate and verify FlexE protocol mechanisms that span across multiple MAC clients and PHYs. Table 2 summarizes key ONT FlexE test functions.

FlexE Test Case	What needs to be tested?
Calendar Client Setup	Setup of multiple clients with different client sizes to support applications for bonding, channelization and sub-rating.
RX PHY and Calendar Map	PHY Map for entire FlexE Overhead Multi-frame and Sub-calendar map per time slot and associated client number.
FlexE Alarms and Errors	VIAVI ONT test set provides unique FlexE Shim Alarm and Error tests that help analyze FlexE Overhead logic and interoperability between network elements.
FlexE Overhead Manipulation	User manipulation of any bit in the FlexE Overhead and Overhead Multi-frame to provoke unusual configuration, device and network conditions.
FlexE Management Channel	FlexE Management Channel transparency and user defined bit loading in the Section-to-Section and Shim-to-Shim and optional Synchronization Messaging Channel.
Port Skew	Skew between PHYs because a PHY skew that is too high might prevent the payload from being reconstructable.
64B/66B Reconciliation	64B/66B Block analysis per FlexE client. Including Local and Remote Fault.
MAC / IP	FlexE MAC client rate, utilization, QoS, errors.

Table 2. ONT FlexE key test functions

FlexE Shim Alarms and Errors

The ONT FlexE test application introduces specific FlexE alarms and errors as listed in Table 3. Local Fault (LF) as defined in the OIF FlexE implementation agreement is presented on the ONT 64B/66B layer together with Remote Fault.

Test Metric	Type	Use Case
LOGA (Loss of Group Alignment)	Alarm	Indication that payload cannot be reconstructed.
Summary GNM (GIDM)	Alarm	Summary GNM alarm. Asserted if any instance has GNM. GIDM is in accordance with ITU-T G. 798 definition.
EPS (Excessive Port Skew)	Alarm	Skew between PHYs exceeding defined threshold
Group Numbers Inconsistent	Alarm	Accepted FlexE group numbers are not identical across the group.
Instance Numbers Inconsistent	Alarm	Accepted 100G FlexE Instance numbers do not match the accepted FlexE Map map on one or more 100G FlexE Instances.
FlexE Maps Inconsistent	Alarm	Accepted FlexE Maps are not identical across the group.
Calendar in Use Inconsistent	Alarm	Accepted "Calendar in use" does not match across the group.
LOF (Loss of FlexE Overhead frame)	Alarm	Loss of FlexE Overhead frame. Definition acc. ITU-T G. 798 (3 ms).
LOM (Loss of Multiframe)	Alarm	Loss of FlexE Overhead Multi-frame. Definition acc. ITU-T G. 798 (10 ms timer).
RPF (Remote PHY Fault) – OIF	Alarm	Inform far-end shim of locally detected failure of the PHY.
Unequipped Instance (PHY# for 100G)	Alarm	Enable/disable Unequipped Instance detection. Note, not supported for 100GBASE-R PHYs.
OOF (Out-of-frame)	Alarm	FlexE Overhead Frame mismatches on the sync header, control block typ or O code field for 5 occurrences.
OOM (Out-of-multiframe)	Alarm	Two consecutive FlexE Overhead Frames with failure to the expected OMF bit transition although good CRC.
GNM (Group Number Mismatch)	Configuration Alarm	Accepted group number does not match the Rx configured value.
Instance Number mismatch (INM)	Configuration Alarm	Accepted FlexE 100G Instance number does not match the RX configured value.
FlexE Map Mismatch (FMAPM)	Configuration Alarm	Accepted FlexE Map does not match the enabled PHYs.
CM (Calendar Mismatch)	Configuration Alarm	TX/RX calendar in use don't match.
CCM (Calendar configuration Mismatch)	Configuration Alarm	"Accepted calendar" of the "Accepted calendar in use" is different from the configured "RX calendar" of the "RX calendar in use".
Synchronization Configuration Mismatch	Configuration Alarm	Synchronization Configuration bit mismatch.
OH Block #1 Error	Error	Overhead anchor block error.
CRC-16 Error	Error	CRC-16 to protect FlexE overhead. FlexE Map values are only accepted from overhead frames with good CRC.
C-Bit Error	Error	3 x C-Bit in majority vote define the Calendar in Use.

Table 3. ONT FlexE Alarm and Errors

FlexE Management Channel Test

The IA OIF-FLEXE-02.1 supports two optional Management Channels and an optional Synchronization Messaging Channel. Use cases for Management Channels include (not exclusive):

- Management Channel – Enabling FlexE Aware use cases with sub-rating towards a FlexE Aware node
- Shim-to-Shim Management Channel – possible application is LLDP
- Synchronization Messaging Channel – can be used to carry PTP and/or SSM messages

The use of the different Management Channels is vendor specific. The only constraint is compliance of every 66B block as legal format according to IEEE 802.3 clause 82.

The ONT FlexE Management Channel Test Application includes a Transparency Check with Idle, User Data and Transparency Test pattern payload as per Table 4 and Alarm and Errors as defined by Table 5.

For additional troubleshooting of the Management Channels, the received 66B blocks according to the IEEE 802.3 clause 82.2.3 can be captured to a file.

Channel	Transparency Check Payload Pattern
Section Management Channel	PRBS31
Shim-to-shim Management Channel	PRBS31 inverted
Synchronization Message Channel	PRBS23

Table 4. ONT FlexE Management Channel Transparency Check payload pattern

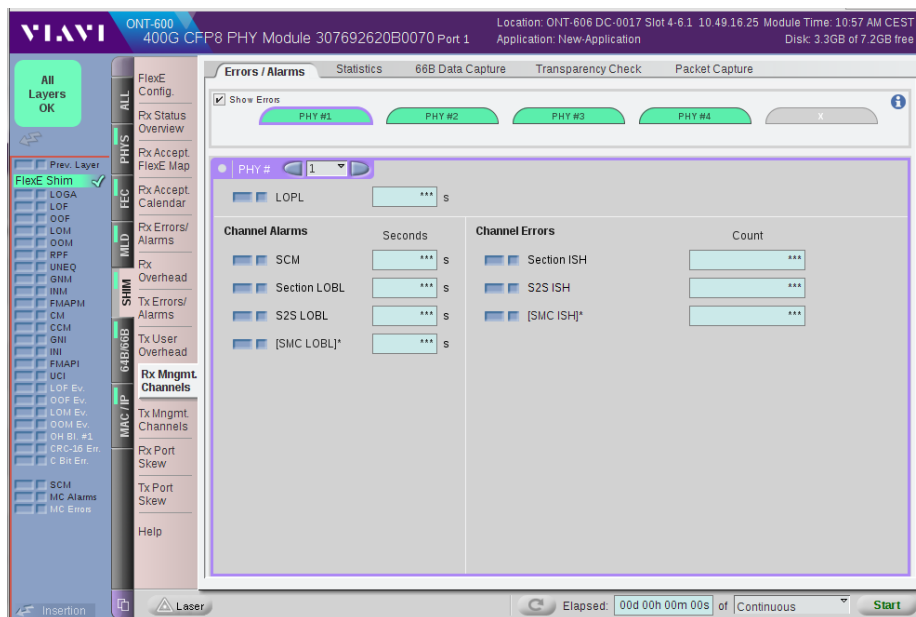


Figure 4. FlexE Management Channel Transparency Check with Bit Error per Management Channel

Test Metric	Type	Use Case
Section LOBL (Section Management Channel loss of block lock)	Alarm	Loss of Block Lock
S2S LOBL (Shim-to-Shim Management Channel loss of lock)	Alarm	Loss of Block Lock
SMC LOBL (Synchronization Message Channel loss of block lock)	Alarm	Loss of Block Lock
SCM (Synchronization Configuration mismatch)	Alarm	The SC bit RX value received does not match the expected RX configuration.
Section Management Channel invalid sync header	Error	Valid sync header values are 10 or 01
Shim-to-Shim Management Channel invalid sync header	Error	Valid sync header values are 10 or 01
Synchronization Message Channel invalid sync header	Error	Valid sync header values are 10 or 01
Section management channel pattern Loss	Error	Section Management Transparency Test
Synchronization message channel pattern Loss	Error	Synchronization Message Channel Transparency Test
Shim-to-shim management channel pattern Loss	Error	Shim-to-Shim Management Channel Transparency Test
Section management channel bit error	Error	Section Management Transparency Test – Bit Error Rate
Synchronization message channel bit error	Error	Synchronization Message Channel Transparency Test – Bit Error Rate
Shim-to-shim management channel bit error	Error	Shim-to-Shim Management Channel Transparency Test – Bit Error Rate

Table 5. ONT FlexE Management Channel Test Alarms & Errors

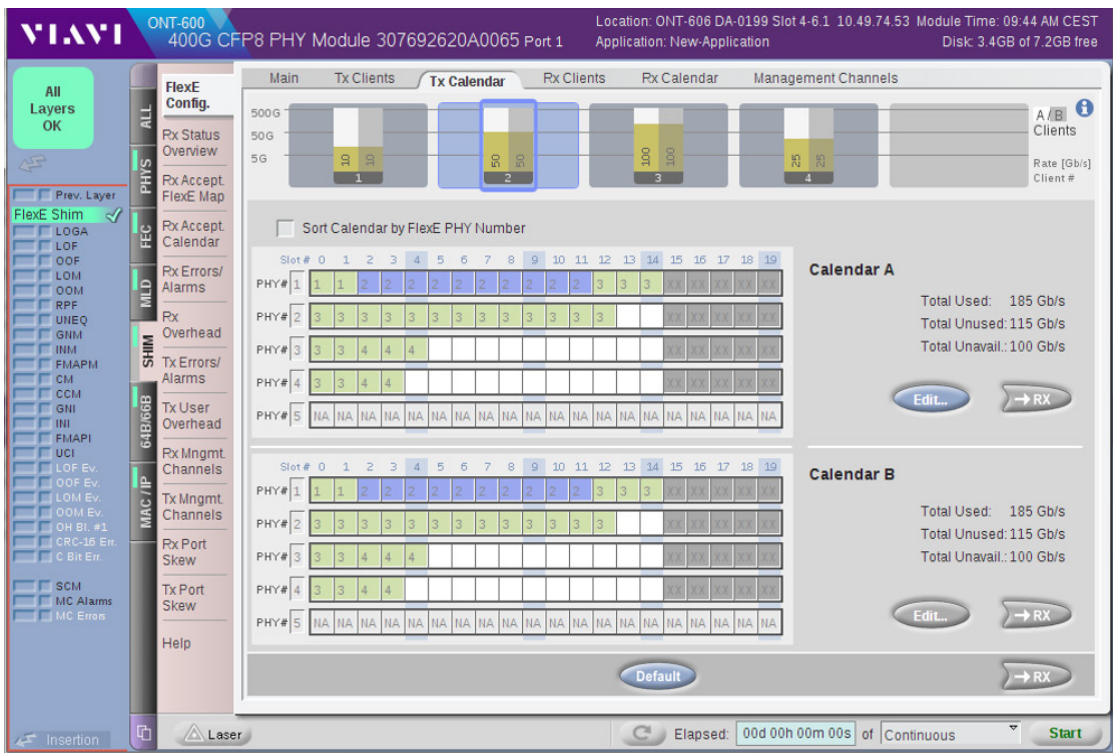


Figure 5. ONT FlexE applications with user configurable client setup into FlexE Calendar

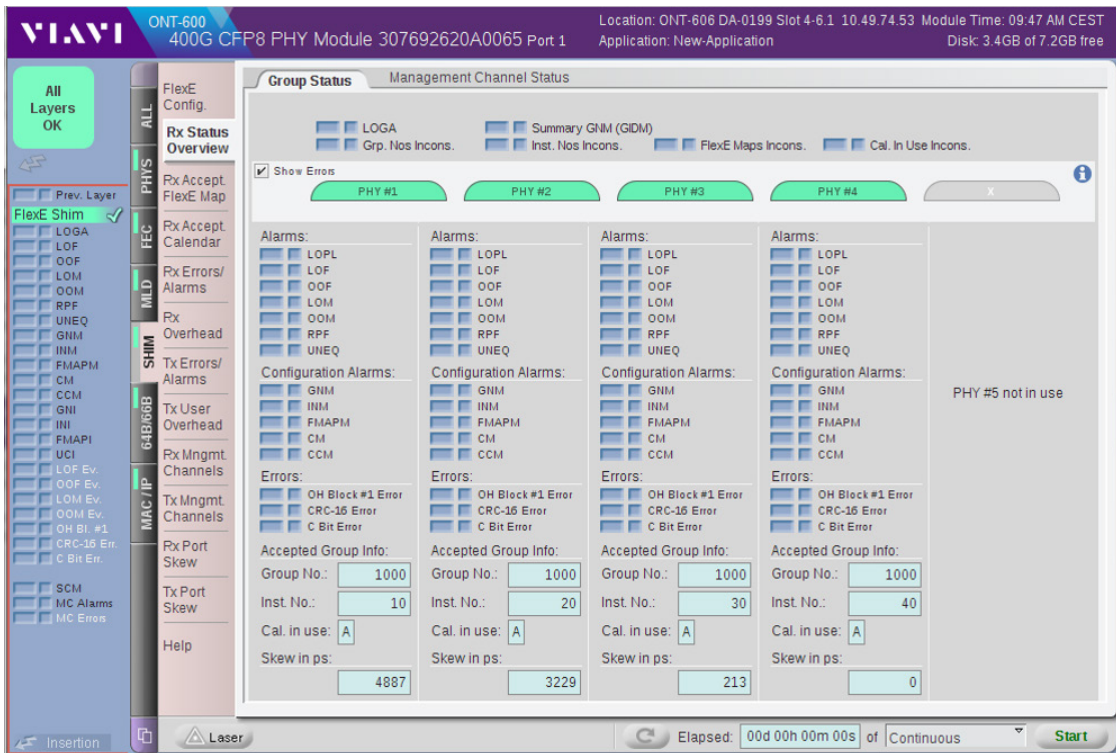


Figure 6. ONT FlexE RX Status Overview with key Alarms and Errors

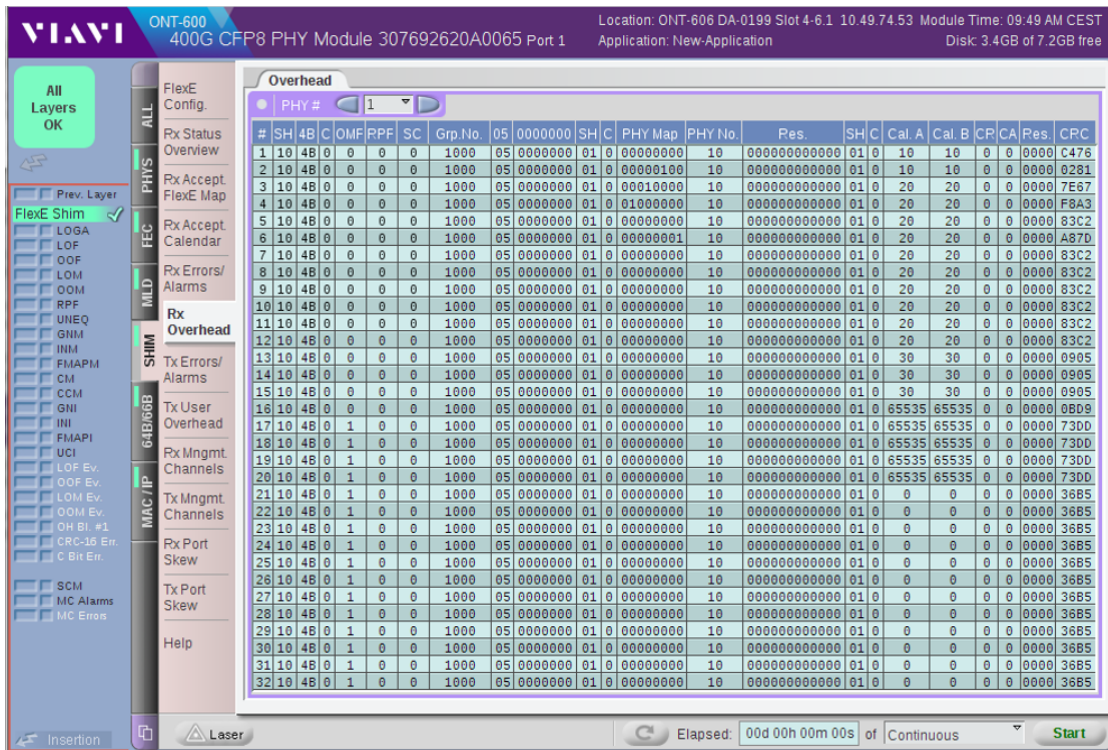


Figure 7. The ONT FlexE applications allows user defined overhead bit configuration

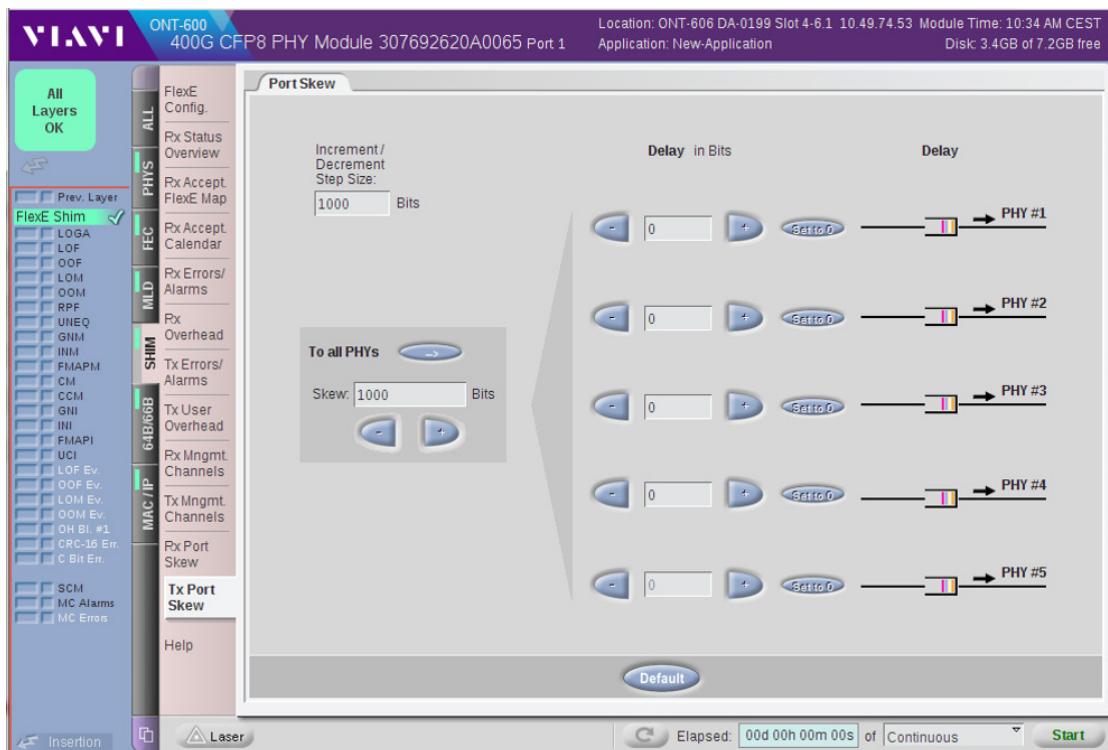


Figure 8. FlexE Port-to-Port Skew Test

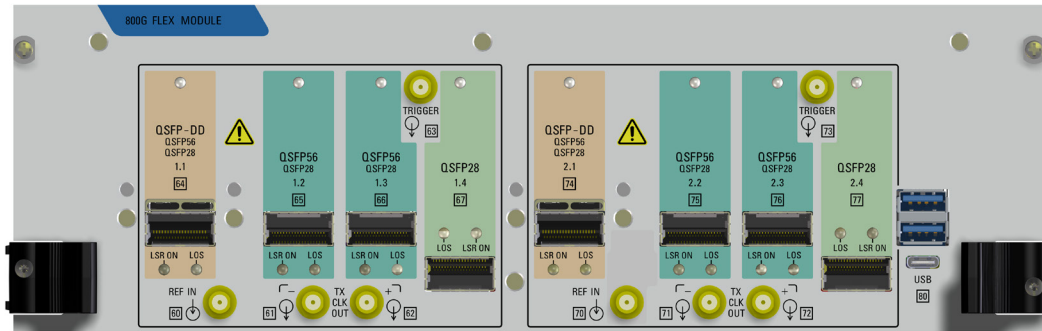


Figure 9. 800G FLEX Module includes 2 x QSFP-DD 400GE/PHY testing and optional FlexE using up to 4 x QSFP28 ports per portgroup.

Order number 402-002.01

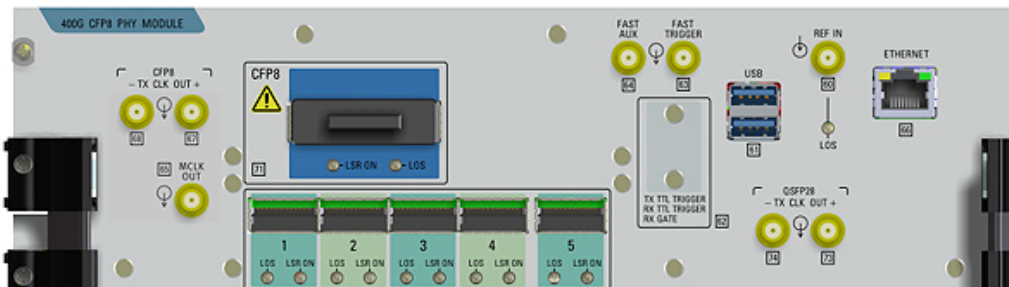


Figure 10. 400G CFP8 PHY Module includes 400GE/PHY testing and optional FlexE and/or FlexO testing using the QSFP28 ports.

Order number 3076/92.62

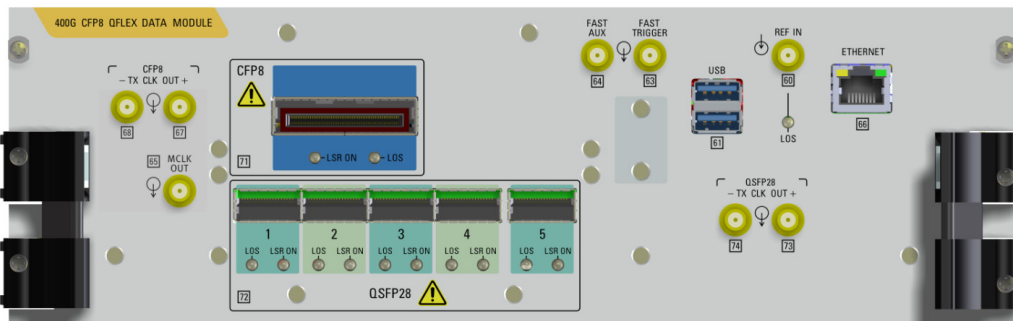


Figure 11. 400G CFP8 QFLEX DATA Module includes CFP8 slot and optional 400GE Test Application SW. QSFP28 Ports support optional FlexE or FlexO testing.

Order number 3076/92.65

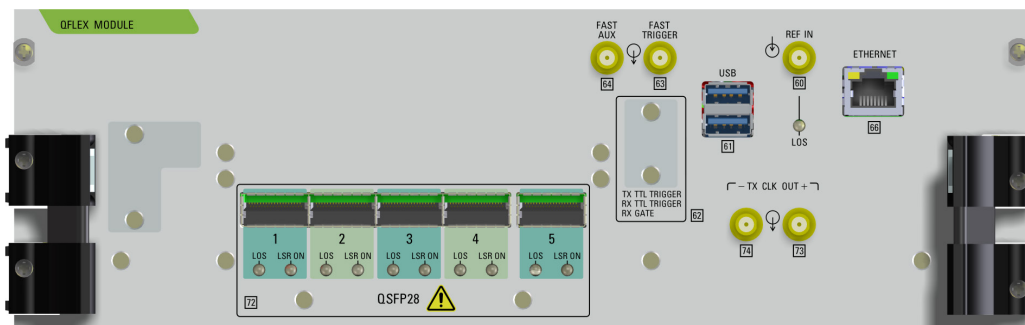


Figure 12. QFLEX Module with QSFP28 ports for optional FlexE and FlexO testing.

Order number 3076/92.63

Software Options for FlexE testing on CFP8/QFLEX Modules

All FlexE testing over up to 4 x QSFP28 test interface.

Part Number	Description
3076/97.50	FlexE 100GBASE-R PHY with clients up to 100GE
3076/97.51	FlexE FEC Validation
3076/97.52	FlexE Management Channel Test
3076/97.53	FlexE 100GBASE-R with client 100GE to 400GE
3076/97.54	Block code Based OAM

Software Options for FlexE testing on 800G FLEX Module

All FlexE testing over up to 4 x QSFP28 test interface.

Part Number	Description
402-620.61	FlexE 4x100GBASE-R PHY with client size up to 100G - Port Group 1
402-620.62	FlexE 4x100GBASE-R PHY with client size up to 100G - Port Group 2
402-864.60	FlexE 100G Ethernet FEC Validation - Module Option
402-868.60	FlexE Management Channel Test - Module Option

Ordering Guide

The following Test Modules support FlexE testing. They all occupy 3 slots within an ONT mainframe.

Part Number	Description	Comment	Test Interface
402-002.01	800G FLEX V2 Module	400G Module with 2xQSFP-DD slot, supports optional Physical Layer testing, full support of optional electrical interface, optional FlexE/O via QSFP28 interfaces.	2xQSFP-DD, 6xQSFP56, 8xQSFP28
3076/92.62	400G CFP8 PHY MODULE	400G Module with CFP8 slot, supports optional Physical Layer testing, full support of optional electrical interface, optional FlexE/O via QSFP28 interfaces. Already includes 400GE application SW.	CFP8, 4xQSFP28
3076/92.65	CFP8 QFLEX DATA MODULE	Module with CFP8 slot and QSFP28 slots. No application SW included	CFP8, 4xQSFP28
3076/92.63	QFLEX MODULE	FlexEthernet/Flex OTN Module with QSFP28 slots. No application SW included	4xQSFP28



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