# UX400-40/100GE Module
## 40G/100G Ethernet/OTU3/OTU4

**VeEX**

# VePAL UX400
## Universal Test Platform

**Next Generation Modular Platform for Transport, Carrier Ethernet, Mobile Backhaul, and Legacy Testing**

VeEX® UX400 is the industry's most flexible, compact, and future-proof test solution for OTN, SDH, SONET, PDH, T-Carrier, Carrier Ethernet, Mobile Backhaul, Core, and Storage Area Networks[1].

## 40G & 100G Multi-Protocol Test Module

The UX400 100G module, with its physical interfaces for OTU3, 40GE, OTU4, and 100G Ethernet testing, is a perfect complement to the UX400 Platform. The UX400 modular platform offers a full range of link and service testing capabilities for a complete DS1 to OTU4 and 10 Mbps to 100 GE, Transport and Carrier Ethernet testing in a single compact unit.

Installation, commissioning, monitoring and maintenance of OTN and Ethernet networks is simplified thanks to a combination of intuitive features and powerful test functions. Using an intuitive interface, fast troubleshooting and comprehensive analysis of transmission problems can be performed. Novice users benefit from the easy-to-use GUI, while experienced users will appreciate an array of advanced features such as OTL/PCS, CAUI/XLAUI Lane BERT, overhead monitor/control, Tandem Connection Monitoring, capture/decode, BERT, throughput test, and much more.

## Module Highlights

### General
- CFP port compliant to MSA standards
- Up to two 100G modules in one UX400 can be coupled for full bidirectional testing
- SCPI-based remote control and scripting commands

### OTN
- OTN testing for OTU3 and OTU4
- Complete multi-step Mapping/Multiplexing
- Ethernet over OTN, ODU0 and ODUflex
- Service Disruption measurements
- Tandem Connection Monitoring
- Overhead monitoring and byte decoding
- Payload and Line through monitor modes
- Per-lane optical power and frequency measurements
- External clock interface

### Ethernet
- 100G and 40G Ethernet testing
- Optical Lane BERT and CAUI/XLAUI Lane BERT
- PCS Layer Testing with Skew generation/monitoring
- Service Disruption Measurements
- RFC2544 testing
- Multi-stream testing up to 32 independent streams
- IPv4 and IPv6 traffic generation
- Q-in-Q (VLAN stacking) and multiple MPLS tag support
- BER testing at Layer 2 and Layer 3
- Smart Loop mode for Layer 2 and Layer 3
- Coupled operation (two modules)
- 1-way latency measurement
- Line rate packet capture with Wireshark™ decode

### SDH/SONET
- STM-256, OC-768, STL256.4
- Line Rate or as OTU3 payload

[1] Test interfaces, data rates, mappings, transmission protocols, and features depend on the availability of individual test modules

**Universal Expert**

# Test Interfaces

## Optical

Optical

CFP Modules
- 40GBase-FR
- 40GBase-LR4
- 100GBase-LR4
- 100GBase-LR10
- 100GBase-SR10

Rates
- OTU4          111.810 Gbps
- 100GE         103.125 Gbps
- OTU3          43.108 Gbps
- 40GE          41.25 Gbps
- STM-256       39.81 Gbit/s
- OC-768        39.81 Gbit/s

## Physical Layer

WDM (CFP dependent)
- 10x10G, 4x25G, 4x10G, 1x40G (NRZ)
- SMF or MMF

RX Optical Power Measurements
- Per-lane input power measurement
- ± 2 dB accuracy, 0.01 dB resolution
- Aggregated (total) power in dBm
- LOS and Saturation indication

TX Optical Power Monitoring
- Per-lane output power in dBm
- Aggregated (total) power in dBm

RX Frequency Measurements
- RX Frequency  (1 kHz resolution)
- Offset (ppm): Current, Minimum, Maximum

## CFP Module*

CFP Information
- Power Class, Vendor, P/N, Serial Number, MSA HW revision, MSA MIS revision, Control 1 Register (IEEE), Expected Ability (supported rates)

CFP Status (CFP dependent)
- Module status, Alarm status, Internal Temperature, Voltage
- CFP unplugged
- Host Lane Fault, Network Lane Fault, Module Fault
- Network Lane Alarm, Module Alarm, General Alarm

Automatic CFP initialization and laser safety reset (OFF) after hot swap

Operating temperature range: -10˚C to 70˚C

CFP transceivers conforming to Multi Source Agreement (MSA) specifications

Safety: Class 1 Laser Product. Comply with FDA/CDRH 21 CFR 1040.10 and 1040.11, EN (IEC) 60825 eye safety regulations

ROHS compliant and Lead Free per Directive 2002/95/EC

*CFP Module dependent*

## CAUI/XLAUI Control

Pre-emphasis and Equalization control for 100G CAUI and 40G XLAUI interfaces

Adjustments
- Independent (individual per-lane settings)
- Coupled Lanes (all the same)

TX Pre-emphasis
- Pre Tap, Post Tap 1, Post Tap 2 (0 to 15)
- Differential Voltage Offset (VOD): 200 to 1200 mV

RX Equalization
- Control: 1 to 16 dB
- DC Gain: 0 to 12 dB

## TX Clock Source**

Internal: Quartz, ± 3.5 ppm stability per ITU-T G.812

Tx Frequency Offset
- ±150 ppm
- Steps of 0.1 ppm

Recovered: from incoming RX signal

External Clock Input
- Connector: 75 Ohm BNC
- 2.048 MHz, 1.544 MHz, 5 MHz, 10 MHz
- 64 kbps, 1.544 Mbps, 2.048 Mbps (AMI, HDB3, B8ZS)
- 1 PPS

System's High-stability 1 PPS Clock
- GPS clock (UX400 platform option)
- Rubidium Atomic Clock (UX400 platform option)

Eye Diagram Clock Reference Output
- OTU4 and 100GE (4x25G only)
- Connector: 50 Ohm SMA
- OTU4 Frequency: 3.5 GHz
- 100GE Frequency: 3.22 GHz

*\*\*Rb clock can be disciplined by the GPS if both options are present. Check UX400 Platform datasheet for details.*

## Measurement Clock Reference**

Internal: Quartz, ± 3.5 ppm stability per ITU-T G.812

System's High-stability 1 PPS Clock
- GPS clock (UX400 platform option)
- Rubidium Atomic Clock (UX400 platform option)

# OTN Testing

The UX400-100G Module offers full range of OTN testing capabilities for OTU3 and OTU4 interfaces (CFP), including service-activation (Bringing-into-Service), performance verification, maintenance, and troubleshooting. It offers Multi-Layer testing from Physical layer (WDM), CFP, CAUI/XLAUI, OTL, OTU/ODUk, to bulk payloads, and Ethernet traffic generation up to 100% rate.

# OTN Functions

## Key Featuress

- OTU4 (111.81 Gbps)
- OTU3 (43.01 Gbps)
- Advanced Mapping/Multiplex Structures
- EoOTN testing with internally generated Ethernet payload mapped into OTU3 (up to 40 Gbps) or OTU4 (up to 100 Gbps)
- OTU, ODU, OPU overhead manipulation and monitoring
- OTU, ODU, OPU layer alarms/errors generation and analysis
- OTU, ODU, TCMi trace messages
- Forward error correction (FEC) testing
- Tandem Connection Monitoring
- Frequency offset generation

## Operating Modes

Normal (terminal)
- The instrument terminates the line, serving as source and sink for the generated traffic
- Offers full access to Overhead and Payload alarms and error generation and monitoring

Payload Through
- Instrument retransmits the received Payload and allows access to Overhead manipulation
- Offers full access to Overhead alarms and error generation as well as Payload monitoring

Line Through
- Instrument regenerates and retransmits the entire received signal
- Offers minimal interaction with the test signal
- Provides full access to Overhead and Payload alarms and error monitoring

## OTN Mappings

Standards: ITU-T G.709, ITU-T G.798, ITU-T G.872
Test rates: OTU4 (111.81 Gbps), OTU3 (43.01 Gbps)
Mapping Procedures
- AMP, BMP and GMP

## Direct OTN Mapping Options

Single-stage (direct) mapping options
- OTU4-ODU4(L)-OPU4-Bulk
- OTU4-ODU4-OPU4(L)-100GE
- OTU3-ODU3(L)-OPU3-Bulk
- OTU3-ODU3-OPU3(L)-40GE
- OTU3-ODU3-OPU3(L)-STM256/OC768

Payload Types
- FE: Bulk (Test Pattern) - Full Rate and Fixed Stuffing
- 07: Ethernet Traffic (Refer to Ethernet over OTN testing section for details)
- 02: Asynchronous CBR mapping (Refer to STM-256/OC-768)
- 03: Bit-synchronous CBR mapping (Refer to STM-256/OC-768)

## Single-Step OTN Mapping/Multiplex Options

OTU4 single-step mapping/multiplex structures
- OTU4-ODU4-ODU3 (31 TS)
- OTU4-ODU4-ODU2e (8 TS)
- OTU4-ODU4-ODU2 (8 TS)
- OTU4-ODU4-ODU1 (2 TS)
- OTU4-ODU4-ODU0 (1 TS)
- Flexible Tributary Slot (TS) selection

OTU3 single-step mapping/multiplex structures
- OTU3-ODU3-ODU2e (8 TS)
- OTU3-ODU3-ODU2 (8 TS)
- OTU3-ODU3-ODU1 (2 TS)
- OTU3-ODU3-ODU0 (1 TS)
- Flexible Tributary Slot (TS) selection

ODU0 Tributary Slots
- ODTU4.1: N=1 of 80 TS
- ODTU3.1: N=1 of 32 TS
- Flexible Tributary Slot (TS) selection

Payload Types
- FE: Bulk (Test Pattern)
- 21: ODU Mux structure

## Multi-step OTN Mapping/Multiplex Options

These 40/100G options offer the most complete and flexible combinations of payload mappings and multiplexing structures available for lab, manufacturing, advanced service-activation testing, maintenance, and troubleshooting environments, without increasing complexity or requiring additional training.
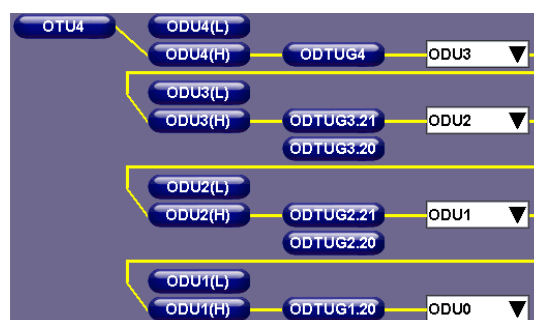


OTU4 multi-step mapping/multiplex structures
- OTU4-ODU4-ODU3-ODU2e
- OTU4-ODU4-ODU3-ODU2
- OTU4-ODU4-ODU3-ODU2-ODU1
- OTU4-ODU4-ODU3-ODU2-ODU1-ODU0
- OTU4-ODU4-ODU3-ODU2-ODU0
- OTU4-ODU4-ODU3-ODU1
- OTU4-ODU4-ODU3-ODU1-ODU0
- OTU4-ODU4-ODU3-ODU0
- OTU4-ODU4-ODU2-ODU1
- OTU4-ODU4-ODU2-ODU1-ODU0
- OTU4-ODU4-ODU2-ODU0
- OTU4-ODU4-ODU1-ODU0
- Flexible TS selection for each ODUk stage

OTU3 multi-step Mapping/Multiplex
- OTU3-ODU3-ODU2-ODU1
- OTU3-ODU3-ODU2-ODU1-ODU0
- OTU3-ODU3-ODU2-ODU0
- Flexible TS selection for each ODUk stage

ODU0 Tributary Slots
- ODTU3.1: N = 1 of 32 TS
- ODTU2.1: N = 1 of 2 TS
- ODTU0.1: N = 1 of 2 TS
- Flexible TS selection

Payload Types
- FE: Bulk (Test Pattern)
- 20: ODU Mux structure
- 21: 1.25G Slot Multiplexing

## Single-Step ODUflex Mapping/Multiplex Options

Adds ODUflex capabilities to the single-step OTN Mapping/ Multiplex options

OTU4 ODUflex Mapping/Multiplex Structures (Nx1.25 Gbps)
- OTU4-ODU4-ODUflex

OTU3 ODUflex Mapping/Multiplex Structures (Nx1.25 Gbps)
- OTU3-ODU3-ODUflex

ODUflex Tributary Slots
- ODTU4.ts: N=1 to 80 TS
- ODTU3.ts: N=1 to 32 TS
- Flexible TS selection

Payload Types
- FE: Bulk (Test Pattern)
- 21: 1.25G Slot Multiplexing

## Multi-step ODUflex Mapping/Multiplex Options

OTU4 ODUflex Mapping/Multiplex (Nx1.25 Gbps)
- OTU4-ODU4-ODU3-ODUflex
- OTU4-ODU4-ODU3-ODU2-ODUflex
- OTU4-ODU4-ODU2-ODUflex

OTU3 ODUflex Mapping/Multiplex (Nx1.25 Gbps)
- OTU3-ODU3-ODU2-ODUflex

ODUflex Tributary Slots
- ODTU3.ts: N = 1 to 32 TS
- ODTU2.ts: N = 1 to 8 TS
- Flexible TS selection for each ODU stage

Payload Types
- FE: Bulk (Test Pattern)
- 21: 1.25G Slot Multiplexing

## ODTUG Multiplexing

Payload Types supported
- FE – ODU4-PRBS, ODU3-PRBS
- 07 – OTU4-100GE, OTU3-40GE
- 20 – ODU Multiplex Structure
- 21 – 1.25G Slot Multiplexing

## Test Setup

Test configuration, menus, and results are presented in VeEX's intuitive GUI, requiring little or no training for new or existing VePAL™ users, maintaining a consistent user experience from the lab to the field.

Layer-based graphical configuration interface allow users to build the test signal in a logical layer by layer sequence
- CAUI/XLAUI
- OTL Lanes
- OTN Signal
- ODUk (Mapping and Multiplexing)
- Payload (Bulk or Ethernet)
- Test Pattern (CBR) or Traffic (Packets)

## OTL Layer

OTL4.10 (OTU4)

OTL3.4 (OTU3)

TX Lane Mapping and Skew Generation
- Lane ID, Lane #, and Channel assignments

Lane Mappings
- Default (1 to 1)
- Random assignment
- Lane ID Shift

Skew Settings
- Skew Range: 0 to 64000 bits
- Adjustable Increment/Decrement steps (0 to 200 bits)
- Increase and Decrease control buttons and direct keypad entry
- Alarm Threshold (1 to 4000 bits)
- Enable/Disable RX MFAS Deskew

Per-Lane Alarm and Error Monitoring
- Alarms: OTL-LOL, OTL-OOL, OTL-LOF, OTL-OOF, OTL-LOR, OTL-OOR, OTL-OOLLM, OTL-OOMFAS, High Skew
- Errors: OTL-LLM, OTL-MFAS, OTL-FAS
- Soft LED overview and individual event counters
- Per-lane Skew measurements in bits and picoseconds
- Independent OTL events log with time stamp

## OTU Layer

Alarm and Error Monitoring
- Alarms: LOM, OOM, SM-IAE, SM-BDI, SM-BIAE, SM-TIM
- Errors: MFAS, SM-BIP, SM-BEI, Correctable FEC, Uncorrectable FEC

## ODU Layer

Alarm and Error Monitoring
- Alarms: AIS, OCI, LCK, PM-BDI, PM-TIM
- Errors: PM-BIP, PM-BEI

## OPU Layer

Payload Type (PT): Generates and displays received PT value

Expected Payload label setting

Enable/Disable PLM monitoring

Alarm and Error Monitoring
- Alarms: PLM, LO-OMFI, OO-OMFI
- Errors: OMFI (ODTU4.M)

## GMP Stuffing

TX Settings
- Extended Offset support (Enable/Disable)
- Effective Cm Value

TX Values
- Nominal Cm Value, Nominal Bit Rate (kbps), Effective Bit Rate (kbps), Offset (ppm)

Alarm and Error Monitoring
- Alarms: GMP Loss of Sync, GMP Cm=0; in seconds
- Errors: CRC-5, CRC-8; count and ratio

RX Statistics
- Effective Cm Value, Minimum Cm Value, Maximum Cm Value
- Nominal Bit Rate (kbps), Effective Bit Rate (kbps), Offset (ppm)
- No Change, Single Increments, Double Increments, Single Decrements, Double Decrements, New Values

## AMP Stuffing

TX Settings
- Offset (ppm)
- Stuffing Method: +1/0/-1 (PJO2 not used), +2/0/-1 (PJO2 used)

RX Statistics
- Offset (ppm)
- Positive, Double Positive, Negative, Total

## BER Test

Alarm and Error Monitoring
- Alarms: LOP (Loss of Pattern)
- Errors: Bit (Test Sequence Error)

## Test Patterns

The following test sequences can be generated in Bulk mode
- PRBS: $2^{31}$-1 , $2^{23}$-1, $2^{15}$-1, $2^{9}$-1
- Normal or Inverted

## Service Disruption Measurements

Service disruption measurements are integrated to the regular OTN BER test, supporting simultaneous monitoring of multiple Physical, OTL, OTU, ODU alarm and error sensors. Each layer is monitored independently, including all the ODU layers in multi-stage mapping/multiplexing configurations.

Alarm Sensors
- Physical layer: LOS
- OTL layer: LOF, OOF, LOL, OOL
- OTN layers: OTU-LOM, OTU-OOM, SM-IAE, SM-BDI, SM-BIAE, ODU-LOF, ODU-OOF, ODU-LOM, ODU-OOM, ODU-LCK, ODU-OCI, ODU-AIS, PM-BDI

Error Sensors
- OTL layer: FAS, MFAS
- OTN layers: OTU-MFAS, SM-BIP, SM-BEI, ODU-FAS, ODU-MFAS,PM-BIP, PM-BEI, Bit Error/Pattern Loss

Event Separation: 0 to 10000 ms

Pass/Fail Limit: 1 to 1000 ms

Results Summary
- Total number of Service Disruptions
- Current Service Disruption (µs)
- Last Service Disruption (µs)
- Longest Service Disruption (µs)
- Shortest Service Disruption (µs)
- Time stamped with 1 µs resolution

Disruption Events Tables
- Track every Service Disruption event for each layer
- Time stamp with 1 µs resolution
- Duration with 1 µs resolution
- Pass/Fail Verdict
- Tracks individual sensor events that occurred during the disruption period with time stamp and duration (1 µs resolution)

## Error Insertion

OTL Layer
- FAS, MFAS, LLM
- Affected Lanes: Single or Multiple
- Modes: Single, Single Burst, Rate

OTU/ODU/OPU
- MFAS, SM-BIP, SM-BEI, Correctable FEC, Uncorrectable FEC, ODU-FAS, ODU-MFAS, PM-BIP, PM-BEI, TCMi-BIP, TCMi-BEI, GMP CRC-5, GMP CRC-8, OMFI (ODTU.M)
- Modes: Single, Single Burst, Rate

Payload
- Bit (Test Sequence Error)
- Modes: Single, Single Burst, Rate

## Alarm Generation

Physical Layer
- LOS
- Affected Optical Lanes: Single or Multiple
- Modes: Continuous (manual)

OTL Layer
- LOF, OOF, OOLLM, OOMFAS
- Affected Lanes: Single or Multiple
- Modes: Continuous (manual), Single Burst (# of ON frames), Continuous Burst (# of ON frames and # of OFF frames)

OTU/ODU/OPU
- OTU-LOM, OTU-OOM, SM-IAE, SM-BDI, SM-BIAE, SM-TIM, ODU-AIS, ODU-OCI, ODU-LCK, ODU-LOF, ODU-OOF, PM-BDI, PM-TIM, TCMi-AIS, TCMi-OCI, TCMi-LCK, TCMi-BDI, TCMi-TIM, TCMi-BIAE, TCMi-LTC, OPU-PLM, GMP LO-Sync, GMP Cm=0
- ODTU4.M: LO-OMFI, OO-OMFI
- Modes: Continuous (manual), Single Burst (# of ON frames), Continuous Burst (# of ON frames and # of OFF frames)

## OTN Overhead Analysis and Generation

Multi-stage support: Provides access to OTU and ODUk overheads for all the layers present in complex mapping/multiplex structures
- OTU4, ODU4, ODUk
- OTU3, ODU3, ODUk

Analysis – Decode and Display

Multiframe selection modes
- Display bytes can be locked to specific multi-fame (0 to 255)
- Free running

Byte Decoding
- On-screen Decode of all bytes and strings
- Byte Capture (raw data): 256 bytes (Hex)

ODUk bytes in hexadecimal, binary or ASCII formats
- SM-TTI (SAPI, DAPI, User), SM-BIP, SM-BEI (BEI/BIAE, BDI, IAE)
- PM-TTI (SAPI, DAPI, User), PM-BIP, PM-BEI (BEI/BIAE, BDI, IAE)
- TC, TCMi-TTI (SAPI, DAPI, User), TCMi-BIP, TCMi-BEI (BEI/BIAE, BDI, IAE)
- GCC0, CCC1, GCC2 bytes
- PCC/APS bytes
- Reserved bytes

OPUk bytes in hexadecimal and binary formats
- JC1, JC2, JC3, JC4, JC5, JC6, PSI, NJO/OMFI

Generation - Programmable Bytes and sequences

OTU and ODU Trace Generation
- SAPI (15 characters)
- DAPI (15 characters)
- User (31 characters)

TCMi Trace Generation
- SAPI (15 characters)
- DAPI (15 characters)
- User (31 characters)

Set TCMi Status
- No source TC, In use without IAE, In use with IAE, Reserved, ODUk-LCK, ODUk-OCI, ODUk-AIS
- Enable/Disable TC monitoring

OTU/ODU Trace Analysis and Generation
- Programmable Transmit and Expected OTU and ODUk Traces
- OTU and ODU SAPI, DAPI, and User
- Enable/Disable OTU/ODU TIM monitoring

## Tandem Connection Monitoring (TCM)

TCMi Monitoring (1 through 6)
- Alarms: AIS, OCI, LCK, BDI, BIAE, LTC, TIM
- Errors: BIP, BEI

Trace Identifier Monitoring and Generation
- Programmable Transmit and Expected SAPI, DAPI and User traces
- Copy trace from RX
- Enable/Disable TIM monitoring

## Ethernet over OTN Testing*

Internally generated Ethernet Payloads
- Layer 2
- Layer 3 (IPv4 and IPv6)
- VLAN: Up to 3 tags
- MPLS: Up to 3 tags

Ethernet Testing
- BERT
- Throughput

Traffic Flows
- Programmable test bandwidth up to 100%
- Constant Bandwidth
- Ramp (Start BW, Stop BW, BW steps, Ramp time, Repetitions)
- Burst (Two traffic levels - Burst 1 BW, Burst 2 BW, Burst 1 time, Bust 2 time)
- Single Burst (1 to 10000 frames)
- Unless otherwise specified, traffic (BW) values can be entered in % of line rate, # of IPG Bytes, Frames per Second, and Mbit/s

Test Patterns (payload)
- PRBS: $2^{31}-1$
- Normal or Inverted

Test Traffic RX Filter
- MAC Source, MAC Destination, Frame Type, DSCP, Protocol Type, IP Source, IP Destination

*Refer to the Ethernet Testing section for more details on Ethernet test results.

## Events Log

Date and time stamped record of all events occurred during a test, presented in tabular format
Includes event name, time, duration and count/severity
Individual event logs for OTL, OTN, BERT and Ethernet

## Soft LED Indicators

Fixed OTN indicators for Signal, Framing, Pattern and Errors/Alarms
Expanded, layer by layer, detailed status summary
Display historical events and conditions
History reset function
- Clears the LED reminder without affecting the measurement counters

# SDH/SONET Testing

STM-256 and OC-768 signals can be used as physical layer or as OTU3 payloads, and can even contain multiplexed clients, providing all the flexibility to address complex test scenarios.

## Key Features

- STM-256 (39.81 Gbps)
- OC-768 (39.81 Gbps)
- 40GBase-FR (single wavelength) and 40GBase-LR4 (WDM)
- Bulk VC/STS payloads
- Overhead manipulation and monitoring
- Alarms/errors generation and analysis
- Service Disruption and APS
- Round Trip Delay
- Tributary Scan
- Tandem Connection Monitoring
- Pointer Test Sequences

# STL Functions

## STL Sub-layer

STL256.4 (STM-256/OC-768)
TX Lane Mapping and Skew Generation
- Lane ID, TX Skew (bits), Lane #, and Channel assignments

Lane Mappings
- Default (1 to 1)
- Random assignment
- Lane ID Shift

Skew Settings
- Skew Range: 0 to 64000 bits
- Adjustable Increment/Decrement steps (0 to 200 bits)
- Increase and Decrease control buttons and direct keypad entry
- User-configurable High Skew Alarm Threshold (1 to 4000 bits)

Per-Lane Alarm and Error Monitoring
- Alarms: STL-LOL, STL-OOL, STL-LOF, STL-OOF, STL-LOR, STL-OOR, STL-AIS, High Skew
- Errors: STL-FAS, STL-LLM
- Soft LED overview and individual event counters
- Per-lane Skew measurements in bits and picoseconds
- Independent STL events log with time stamp

## STL Error Injection

FAS, LLM
- Affected Lanes: Single or Multiple
- Modes: Single, Single Burst, Rate
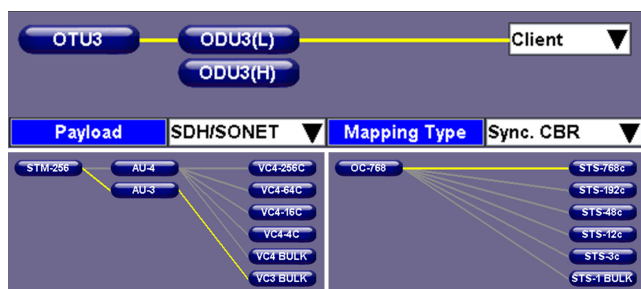
## STL Alarm Generation

LOS
- Affected Optical Lanes: Single or Multiple
- Modes: Continuous (manual)

LOF, OOF, AIS
- Affected Lanes: Single or Multiple
- Modes: Continuous (manual), Single Burst (# of ON frames), Continuous Burst (# of ON frames and # of OFF frames)

# SDH/SONET Functions

## Signal Structures



SDH/SONET over OTN
- OTU3-ODU3(L)-OPU3(L)-STM256-AU4/AU3-VCn
- OTU3-ODU3(L)-OPU3(L)-OC768-STSn
- Bit-Synchronous or Asynchronous CBR mappings

SDH/SONET
- STM256-AU4/AU3-VCn
- OC768-STSn

Mappings
- VCn: VC4-256c, VC4-64c, VC4-16c, VC4-4c, VC4, VC3
- STSn: STS-768c, STS-192c, STS-48c, STS-12c, STS-3c, STS-1

Payload
- Bulk (PRBS)

## SDH Overhead Analysis and Generation

Network Architectures supported
- Linear (per ITU-T G.783)
- Ring (per ITU-T G.841)

Analysis – Decode and Display
  SOH/POH bytes in hexadecimal, binary or ASCII formats
- S1 synchronization status
- C2 HP signal label
- TCM API Message
- J0 trace identifier (1, 16 or 64) in ASCII format
- J1 trace identifier (16 or 64 bytes) in ASCII format
- K1, K2 APS Control

Generation - Programmable Bytes
  RSOH
- J0 trace: 1 byte hexadecimal, 16 byte ASCII with CRC-7 and 64 byte with CR+LF
  MSOH
- K1, K2 APS bytes per ITU-T G.783 and G.841
- S1 synchronization status message
  HO-POH (VC-4, VC-3)
- J1 trace: 16-byte ASCII with CRC-7 or 64-byte ASCII sequences
- C2 signal label
- G1 (bit 5): End-to-end path status (RDI generation)
- K3 (bits 1-4) APS signaling
  LO-POH (VC-3)
- J1 trace: 16-byte ASCII with CRC-7 or 64-byte ASCII sequences
- C2 signal label
- TCM API Message (Enable/Disable)
- G1 (bit 5): End-to-end path status (RDI generation)
- K3 (bits 1-4) APS signaling

## SONET Overhead Analysis and Generation

Network Architectures supported
- Linear (per ITU-T G.783)
- Ring (per ITU-T G.841)

Analysis – Decode and Display
  SOH/POH bytes in hexadecimal, binary or ASCII formats
- S1 synchronization status
- C2 STS path signal label
- J0 trace identifier (1, 16 or 64) in ASCII format
- J1 trace identifier (16 or 64 bytes) in ASCII format
- J2 trace identifier (16 or 64 bytes) in ASCII format
- K1, K2 APS Control

Generation - Programmable Bytes
  Section Overhead
- J0 trace: 1 byte hexadecimal, 16 byte ASCII with CRC-7 and 64 byte with CR+LF
  Line Overhead
- K1, K2 APS bytes per ITU-T G.783 and G.841
- S1 synchronization status message
  STS-POH (STS-N SPE, STS-1 SPE)
- J1 trace: 16-byte ASCII with CRC-7 or 64-byte ASCII sequences
- C2 signal label
- G1 (bit 5): End-to-end path status (RDI generation)
- K3 (bits 1-4) APS signaling
  STS-POH (STS-1 SPE)
- J1 trace: 16 byte ASCII with CRC-7 or 64 byte ASCII sequence
- C2 signal label
- G1 (bit 5): End-to-end path status (RDI generation)
- K3 (bits 1-4) APS signaling

## SDH/SONET Alarms

Monitoring and Detection
- SDH: LOS, LOF, OOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-TIM, HP-RDI
- SONET: LOS, LOF, AIS-L, RDI-L, TIM-S, AIS-P, LOP-P, UNEQ-P, PLM-P, TIM-P, RDI-P

Generation
- SDH: LOS, LOF, MS-AIS, MS-RDI, RS-TIM, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, HP-RDI, HP-TIM
- SONET: LOS, LOF, AIS-L, RDI-L, TIM-S, TIM-P, LOP-P, AIS-P, UNEQ-P, PLM-P, RDI-P
- Modes: Continuous (manual), Single Burst (# of ON frames), Continuous Burst (# of ON frames and # of OFF frames)

## SDH/SONET Errors

Detection
- SDH: FAS, B1, B2, MS-REI, B3, HP-REI and bit errors
- SONET: FAS, S-BIP, L-BIP, REI-L, P-BIP, REI-P and bit errors

Insertion
- SDH: FAS, B1, B2, MS-REI, B3, HP-REI and bit errors
- SONET: FAS, BIP-S, BIP-L, REI-L, BIP-P, REI-P and bit
- Modes: Single, Single Burst, Rate

# Functions & Measurements

## Test Patterns

The following test sequences can be generated to fill the payload
- PRBS: $2^{31}-1$ , $2^{23}-1$, $2^{15}-1$, $2^{9}-1$
- Normal or Inverted

## Signal and Frequency Measurement

Signal level
- Optical power in dBm (TX and RX, per Optical Lane)

Frequency (Line)
- Resolution: 1 Kbit/s (Kbps)

Frequency Offset
- Resolution: 0.1 ppm
- Current, Minimum and Maximum
- Payload

## Service Disruption Measurements

Service disruption time (SDT) measurements are integrated to the regular BER tests, supporting multi-layer sensor monitoring for STM-256, OC-768 and SDH/SONET over OTN. Each layer is monitored independently, including OTL, OTN, ODU, STL and VC/STS layers in multi-stage mapping/multiplexing configurations.

Alarm Sensors
- Physical layer: LOS
- OTL layer: Refer to OTN Service Disruption
- OTN: Refer to OTN Service Disruption
- STL layer: LOF, OOF, LOL, OOL
- SDH Layer: LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-RDI
- SONET Layer: LOF, OOF, AIS-L, RDI-L, AIS-P, LOP-P, RDI-P

Error Sensors
- OTL layer: Refer to OTN Service Disruption
- OTN: Refer to OTN Service Disruption
- STL layer: FAS, MFAS
- SDH Layer: FAS, B1, B2, MS-REI, B3, HP-REI
- SONET Layer: FAS, BIP-S, BIP-L, REI-L, BIP-P, REI-P
- Payload: Bit Error/Pattern Loss

Event Separation: 0 to 10000 ms

Pass/Fail Limit: 1 to 1000 ms

Results Summary
- Total number of Service Disruptions
- Current Service Disruption (µs)
- Last Service Disruption (µs)
- Longest Service Disruption (µs)
- Shortest Service Disruption (µs)
- Time stamped with 1 µs resolution

Disruption Events Tables
- Track every Service Disruption event for each layer
- Time stamp with 1 µs resolution
- Duration with 1 µs resolution
- Pass/Fail Verdict
- Tracks individual sensor events that occurred during the disruption period with time stamp and duration (1 µs resolution)

## Pointer Analysis and G.783 Test Sequences

Pointer movements monitoring and generation for SDH and SONET
Monitor
- Current value, increments, decrements, sum, difference
- New Data Flags (NDF)
- Tributary frequency offset (ppm of AU or STS)

Generation
- Pointer sequences: ITU-T G.783, Telcordia GR-253
- Pointer Types: AU, STS
- Single pointer, increment, decrement, or increment/decrement
- Sequence: Basic, Single Alternating, Regular Additive, Regular Cancel, Double Alternating, Burst, Transient Burst, 87/3, 87/3 Additive, 87/3 Cancel, Periodic Additive, Periodic Cancel
- Programming of SS bits
- Adjustments: Increment, Decrement, New Value
- Parameters: N, T1, T2, T3, T4

## Tandem Connection Monitoring (TCM)

Generation and analysis of N1 and N2 bytes
Errors generated: TC-IEC, TC-REI, TC-OEI
Alarms generated: TC-LOF, TC-RDI, TC-UNEQ, TC-AIS, TC-ODI
Detection, display, analysis and storage of events
- TC-LOF, TC-IEC, TC-AIS, TC-REI, TC-RDI, TC-OEI, TC-UNEQ, TC-ODI
- Analysis and generation of APId (Access Point Identifier)

## Events Log

Date and time stamped record of all events occurred during a test, presented in tabular format
Includes event name, time, duration and count/severity

## Histograms and Bar Graphs

Histogram: Display of related Errors and Alarms versus time
Bar Graph: Error or Alarm severity versus time
Resolution: Seconds, minutes, hours and days

## Soft LED Indicators

Fixed indicators for Signal, Framing, Pattern and Errors/Alarms
Display historical events and conditions

# Ethernet Testing

## 40GE and 100GE Functions

Reliability, Scalability and Quality of Service are the attributes needed for Ethernet to turn into Carrier-grade Ethernet. With standard features including RFC2544 and Ethernet, MPLS and VLAN support, the UX400 has all the tools necessary to truly ensure end-to-end carrier-grade Ethernet services.

### Key Features

- 100G Ethernet (103.125 Gbps)
- 40G Ethernet (41.25 Gbps)
- Transmit frequency offset to stress the network up to ±150 ppm
- Optical Lane BERT
- CAUI/XLAUI Lane BERT
- PCS Layer Testing with Skew generation/monitoring
- Service Disruption Measurements
- Throughput, latency, jitter, frame loss, and back-to-back measurements per industry-standard RFC2544
- Multi-stream testing with up to 32 fully independent and configurable streams
- IPv4 and IPv6 traffic generation
- MAC Flooding
- VLAN Flooding
- Q-in-Q (VLAN stacking) and multiple MPLS tag support
- BER testing at Layer 2 and Layer 3 with or without VLAN and MPLS tags
- Smart Loop mode for Layer 2 and Layer 3 with all key measurements on received traffic provided on the loopback port
- Coupled operation (two modules)
- One-way latency measurements between two 40/100G modules installed on the same unit (no GPS synchronization required)
- One-way latency measurement between remote devices (with GPS synchronization) or two modules in the same unit
- Line rate packet capture with Wireshark™ decode

### Interfaces

100GE/40GE Compliant with IEEE 802.3ba
CFP transceiver interface compliant with CFP MSA (100G/40G Base R) and 10x10 standard
CFP Interface bit rates
- 40G Base-R: 41.25 Gbps
- 100G Base-R: 103.125 Gbps
Frequency offset: +/- 150ppm (0.1 ppm step)
External reference clock input: 2.048 Mbps, 2.048 MHz, 1.544 Mbps, 1.544 MHz, 10 MHz, Received signal

### Operating Modes

Terminate
Loopback

### 100G/40G PCS Layer Testing

PCS lane mapping: default, manually defined, random or shift
PCS Skew generation per lane pair (0 to 16000 bits)
Configurable Skew alarm threshold
RX Skew tolerance up to 4000 bits
RX PCS lane monitoring: skew measurement (bits and ps) and lane mapping
PCS Error/Alarm injection per lane or all lanes

PCS Error injection (single, burst or rate): Invalid Sync Header, Invalid Alignment Marker, BIP error
PCS Alarm injection (continuous): Loss of Alignment Marker Lock, Loss of Block Lock, High BER
PCS Lane Error counters (aggregate and per lane): Invalid Sync Header, Invalid Alignment Marker, BIP error
PCS Lane Alarm: Loss of Alignment, Loss of block label, High-BER

### Lane BERT

Per CAUI/XLAUI lane or optical lane unframed BERT
PRBS pattern: $2^{31}$-1, $2^{23}$-1, $2^{15}$-1, $2^{7}$-1
Error injection (single or burst) per lane or multiple lanes: Bit error
Alarm injection per optical lane or multiple optical lanes: Optical LOS
Per lane and aggregate Bit error count and rate and Pattern loss

### CAUI/XLAUI Signal Configuration

Per lane or all lanes TX pre-emphasis and RX equalization setup
TX configuration: VOD (mV), pre-emphasis (Pre Tap, Post Tap 1, Post Tap 2)
RX configuration: DC gain and Control

### Optical Power Measurement

Per wavelength TX and RX power measurements
CFP vendor's detailed register display: Vendor, part number, Serial number, standard compliance
Optical module status: Temperature, Voltage, Alarm status

### Framed Ethernet Traffic Generation

Layer 2 or Layer 3 traffic
Test Frame Header
- IEEE 802.3 and Ethernet II (DIX) frames
- Configurable Source and Destination MAC and Ethernet Type
- VLAN stacking up to 3 VLAN tags w/configurable priority & type
- Fully configurable IPv4 or IPv6 header
- MPLS up to 3 labels with configurable Label/S/CoS and TTL
Frame generation in fixed, random, increment, decrement modes
- Frame sizes from 64 to 1518 bytes and jumbo frames up to 10000 bytes
MAC flooding feature generates test frames with up to 4096 incremental Source and/or Destination MAC addresses
VLAN flooding feature generates test frames with up to 4096 incremental VLAN IDs
Traffic Pattern: Constant, Ramp, Multi Bursts, Single Burst
Ethernet Error Injection: Bit, CRC, Pause, IP Checksum, runt (60 bytes)
PCS Error Injection (per lane or multiple lanes): Invalid Sync Header, Invalid Alignment Marker, BIP error
Ethernet Alarm Injection: Local Fault, Remote Fault, Optical LOS
PCS Alarm Injection: Loss of Alignment Marker Lock, Loss of Block Lock, High BER

### Key Measurements

Error Measurements: Bit/BER (BERT and single stream Throughput Test), CRC, PCS Errored Blocks, IP checksum, jabber frames, runt frames, Frame loss (count and %), OSS
Alarm Detection: LOS, Service Disruption, Local and Remote Fault
PCS Alarms and Errors: Loss of Alignment, Loss of block label, High-BER, Invalid Sync Header, Invalid Alignment Marker, BIP error
Frame/Packet Statistics: Multicast, broadcast, unicast, pause frames, frame size distribution

Rates (min, max, average and current): frame rate, bandwidth utilization, frame rate, line rate, data rate

Delay (min, max, average and current): round trip delay, inter frame gap, jitter, local one-way delay (between 2 modules on the same unit) or one-way delay between remote devices with GPS synchronization

## Service Disruption Time (SDT)

Concurrent service disruption measurements are integrated to regular Ethernet tests, supporting simultaneous monitoring of multiple triggers at all layers

Layer 2 BERT triggers
- LOS, LOBL, LOAML, LOA, Local and Remote faults
- FCS error, Pattern loss

Layer 3 BERT triggers
- LOS, LOBL, LOAML, LOA, Local and Remote faults
- FCS error, IP check sum error, Pattern loss

Layer 2 Throughput triggers
- LOS, LOBL, LOAML, LOA, Local and Remote faults
- FCS error, Lost (Missing) frame, Out of sequence, Duplicate frames

Layer 3 Throughput triggers
- LOS, LOBL, LOAML, LOA, Local and Remote faults
- FCS error, IP check sum error, Lost (Missing) frame, Out of sequence, Duplicate frames

Measurements
- Disruption time: Current, Last, Minimum, Maximum, Total
- Number of occurrences
- Resolution: 1 µs

## Multiple Streams Throughput Testing

Up to 32 independent traffic streams generation and analysis, with configurable filters

Each stream can be set with independent frame size, bandwidth, traffic profile, and QoS levels

## RFC2544 Compliance Testing

Automated tests compliant with RFC2544 with configurable threshold values and maximum transmit bandwidth settings

Throughput, Latency, Jitter, Frame Loss, and Back-to-Back (burst) tests

Frame sizes: 64, 128, 256, 512, 1024, 1280, and 1518 bytes including 2 user configurable frames

## Loopback Mode

Layer 2: all incoming traffic is looped back with MAC source and destination addresses swapped

Layer 3: all incoming traffic is looped back with MAC and IP source and destination addresses swapped

Loopback traffic filters with all MAC/VLAN/IP parameters configurable

All key measurements on received traffic provided on the loopback port

## IP Test Suite

IP Configuration and validation (IPv4, IPv6, Static, DHCP, PPPoE)

MAC address (configurable or default)

Ping and trace-route tests (IP address or URL)

Network discovery/ARP wizard

## IPv6

IPv6 compliant test traffic generation and analysis for all test applications (Y.1564 V-SAM, RFC2544, BERT and Multi-stream Throughput)

IPv6 Loopback capability

IPv6 Static or Stateless Auto Configuration and Ping function

## Packet Capture and Decode

Packet capture at line rate

Configurable capture filters

Capture files export to PCAP format

Built-in Wireshark™ packet decode

# Additional Functions

## Test Results Management

Local and remote web-based interface provides easy access and manipulation to OTN and Ethernet Test Results

Save, View, Rename, Lock and Delete functions

Export results to USB
- PDF, CSV, TXT formats

File Organizer
- Filtering per test result type

File Sorting
- By Name, Port, Test Type, Date, Size, Locked/Unlocked

Screen capture: Screen shots in .bmp format

## Test Profile Management & Auto Scripting

Save and Recall test profiles to internal memory

Auto Script uses up to 10 saved test profiles to run batch tests

## Remote Access and Control

Compatible with VeEX SCPI Remote Client (optional)

Compatible with multi-platform VNC® clients

Web-based VNC® server (no PC client required)

ReVeal UX400 Data Management
- Test results management
- Advanced report generation with html, pdf, or csv formats, combine test results, add logos and comments
- Test profiles management: Online or offline test profile creation, upload and download

## General

Power Consumption

| | |
|---|---|
| Active | 58 watts (max) |
| Standby | <1 watt |

Environmental

| | |
|---|---|
| Operating temperature | 0 to 40°C (32 to 104°F) |
| Storage temperature | -20 to 70°C (-4 to 158°F) |
| Humidity | 5% to 90% non-condensing |

ROHS compliant and Lead Free per Directive 2002/95/EC