

RTU-600

100G Test Module



for RTU-300 Remote Test Unit

The RTU-600 hardware option for the RTU-300 standalone platform offers a full-featured centralized test solution for Ethernet, Mobile Backhaul, Storage Area Networks, OTN, SDH/SONET links and services testing — 40 Gbps and 100 Gbps. This factory-installed hardware option allow flexibility to fit any application. Available in QSFP28/QSFP+ version.



Module Highlights

The RTU-600 module, is a perfect complement to the RTU-300 platform, extending its testing range to 100 Gbps. Compatibility with the companion RTU-320 option offers a complete 64k to 100G test solution in a compact 1RU 19-inch rack package.

Installation, commissioning, monitoring and maintenance of Ethernet, OTN and SDH/SONET networks is simplified thanks to a combination of intuitive features and powerful test functions. Fast troubleshooting and comprehensive analysis of transmission problems can be performed using its common web or VNC-based graphical user interface. Novice users benefit from the easy-to-use GUI, while experienced users will appreciate an array of advanced features such as OTL/PCS, CAUI-4/XLAUI Lane BERT, Service Disruption, overhead monitor/control, Tandem Connection Monitoring, Protocol Capture/Decode, BERT, Throughput test, and much more.

General

- Available with QSFP28 for 100GE and OTU4 applications
- Supports IEEE 802.3bj Clause 91 RS-FEC as required for SR4 (QSFP28)
- QSFP+ for 40GE, OTU3
- External clock interface
- 150 ppm clock offset generation
- Soft LED indicators

Ethernet

- 40 Gbps and 100 Gbps Ethernet testing
- Supports IEEE 802.3bj Clause 91 RS-FEC
- Optical Lane BERT and CAUI-4/XLAUI Lane BERT
- PCS Layer Testing with Skew generation/monitoring
- Multi-stream testing up to 32 independent streams
- IEEE 802.3ah, ITU-T Y.1731, IEEE 802.1ag, MPLS-TP OAM support
- Q in Q (VLAN stacking), MPLS, MPLS-TP, PBB, EoE support
- MAC flooding
- RFC2544 and V-SAM (Y.1564) testing
- Service Disruption Measurements
- IPv4 and IPv6 traffic generation
- BERT and Throughput testing at Layer 2 and Layer 3
- Smart Loopback mode for Layer 2 and Layer 3
- Line rate packet capture with Wireshark™ decode
- Error and Alarm Injection

OTN Testing

- OTN testing for OTU3 and OTU4
- Complete multi-stage Mapping/Multiplexing
- Ethernet over OTN
- Service Disruption measurements
- Tandem Connection Monitoring
- Overhead monitoring and byte decoding
- Terminate, Payload Through and Line Through test modes
- Per-lane optical power and frequency measurements
- External clock reference interface
- Histogram Analysis

Module Highlights

QSFP28 Support

- Optical lane BERT
- PCS layer testing with skew generation/monitoring
- Transmit and receive optical power measurement
- Module status display

Packet Capture and Decode

Configurable capture filters

- MAC and IP
- UDP and/or TCP
- Multicast, Broadcast, IP Checksum error, UDP/TCP Checksum Error events

Integrated Wireshark™ packet decode

Packet captures can be saved and exported PCAP capture format, compatible with Wireshark

Auto Scripting

The Auto Scripting feature is the perfect tool for the lab environment where multiple short-term or long-term test configurations are required to stress the network equipment and/or network under test, in order to measure and qualify the performance capabilities. The feature is also important in field operations, not only to speed-up service turn-up times, but also to facilitate the entire workforce the same test profiles and test procedures for day-to-day operations.

The Auto Scripting application is an automated sequence of tests that can be carried out by selecting previously configured Throughput or BERT profiles. The profiles can be created with ReVeal and then loaded to the unit or created directly on the unit in the Throughput and BERT applications. Users can select up to ten profiles, each profile configured with its own duration. The duration can be in seconds, minutes, hours, or days. The test sequence will begin with the first profile configured with its corresponding duration, followed by each profile after that. At the end of each profile tested a results file will be stored automatically before the test sequence continues to the next profile. Users have the option to continue or stop the auto scripting test if errors or alarms are detected.



Application Examples

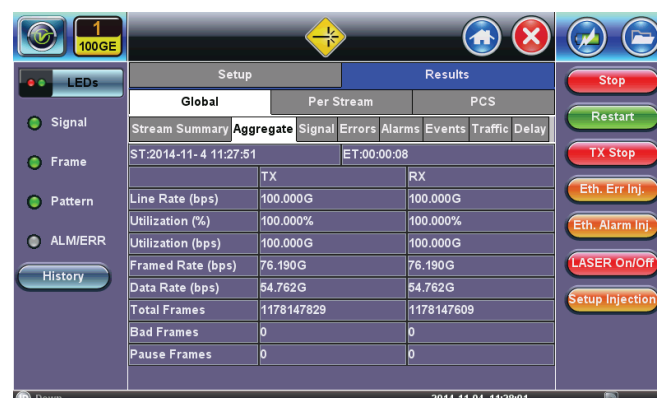
100GE Health - Module temperature, alarm and failure information display



100GE-LR4 Receive Optical Power per lane



Example of 100GE Layer 2 100% throughput test result display



100GE V-SAM test results with 8 services. RTU-600 is able to perform up to 32 services

Pass/Fail	IR(Mbps)	FLR(%)	FTD(ms)	FDV(ms)	AVAIL(%)
1 Pass	99.687	0.000000	0.00013	0.000008	100.000
2 Pass	99.687	0.000000	0.00014	0.000007	100.000
3 Pass	99.687	0.000000	0.00014	0.000008	100.000
4 Pass	99.687	0.000000	0.00014	0.000007	100.000
5 Pass	99.687	0.000000	0.00013	0.000008	100.000
6 Pass	99.687	0.000000	0.00013	0.000007	100.000
7 Pass	99.687	0.000000	0.00014	0.000008	100.000
8 Pass	99.687	0.000000	0.00013	0.000007	100.000

100GE-LR4 PCS analysis for alarms and errors

ST	CAUI ID	PCS ID	LOBL	ISH	LOAML	IAM	BIP	Hi Skew	VLIID	Hi-BER
0	0	1	2	3	4	5	6	7	8	9
10	10	11	12	13	14	15	16	17	18	19

100GE-LR4 PCS, CAUI-4, Virtual lane and skew control setup

VL ID	Tx Skew Bit	PCS#	CAUI#
0	0	1	0
1	0	2	0
2	0	3	0
3	0	4	0
4	0	5	0
5	0	6	0
6	0	7	0
7	0	8	0
8	0	9	0
9	0	10	0
10	0	11	0
11	0	12	0
12	0	13	0
13	0	14	0
14	0	15	0
15	0	16	0
16	0	17	0
17	0	18	0
18	0	19	0

*Dependent on module form factor and type.

Test Interfaces

Optical

QSFP28 Module

- 100GE
- OTU4

QSFP+ Module

- 40GE
- OTU3

Physical Layer

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

Optical Pluggable Modules*

Pluggable Module Information

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

Pluggable Module Status (QSFP28 dependent)

- Module status, Alarm status, Internal Temperature, Voltage
- QSFP28 unplugged
- Host Lane Fault, Network Lane Fault, Module Fault
- Network Lane Alarm, Module Alarm, General Alarm

Automatic QSFP28 initialization and laser safety reset (OFF) after hot swap

Operating temperature range: 0°C to 45°C

QSFP28 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

TX Clock Source

Internal: Quartz, ± 3.5 ppm

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, 10 MHz
- 1.544 Mbps, 2.048 Mbps (AMI, HDB3, B8ZS)
- 1 PPS

Measurement Clock Reference

Internal: Quartz, ± 3.5 ppm

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, VSAM, Throughput, MPLS and VLAN support, this test set has all the tools necessary to truly ensure end-to-end carrier-grade Ethernet services.

Key Features

- Transmit frequency offset to stress the network up to ± 150 ppm
- Optical Lane BERT
- CAUI-4/XLAUI Lane BERT
- FEC Layer Testing with Skew generation/monitoring
- 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
- 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
- Line rate packet capture with Wireshark™ decode

Interfaces

100GE/40GE compliant with IEEE 802.3ba

MSA compliant transceiver interfaces

QSFP28 Interface bit rates

- 100GBase-R 103.125 Gbps

QSFP+

- 40GBase-R 41.25 Gbps

Frequency offset: ± 150 ppm (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-4/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

Optical Power Measurement

Per wavelength TX and RX power measurements

QSFP28 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
- MPLS-TP label with configurable LSP, PW and CW fields
- Provider Backbone Bridge (PBB) support with configurable Backbone MAC Source and Destination, I-SID, PBB-VLAN ID and priority
- EoE (Ethernet over Ethernet) support with configurable EoE MAC Source and Destination, Ethernet Type, EoE VLAN ID and Priority, TTL and EID
- 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 16000 bytes

MAC flooding feature generates test frames with up to 4096 incremental Source and/or Destination MAC addresses

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

FEC Alarms and Errors: HiSER, LOA, LOAMPS, FEC Lane Swap, Uncorrected FEC, Corrected FEC errors, LOAMPS Event, LOA Event, Invalid Transcoded Block, and RX AM Sequence

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, 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 μ s

Multiple Streams Throughput Testing

Up to 32 independent traffic streams generation and analysis, with configurable filters on 40GE and 100GE interfaces

Up to 10 independent traffic streams generation and analysis, with configurable filters on 10GE interface

Up to 8 independent traffic streams generation and analysis, with configurable filters on 1GE interface

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

MAC flooding feature: generates test frames with up to 4096 incrementing Source and/or Destination MAC addresses

Test Patterns: PRBS: 2^{31-1} , 2^{23-1} , 2^{15-1} , 2^{11-1} , normal and inverted patterns, All 0s, All 1s and User Defined

Error Measurements: Bit/BER (Single Stream only), FCS/CRC, Jabber/Runt frames, IP Checksum, TCP/UDP Checksum, Frame Loss (count and %), Out of Sequence

Alarm Detection

- 10GE: LOS, LOSync, Service disruption (current, total, last, min/max, # of occurrences), Local Fault, Remote Fault, PCS-HI-BER, PCS-LOBL, WAN SONET Alarms: LOF, AIS-L and RDI-L WAN SDH Alarms: LOF, MS-AIS, MS-RDI
- 1GE: LOS, LOSync, Service disruption (current, total, last, min/max, # of occurrences)

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

- Frame arrival time (min, max, average and current), Frame Delay Variation

Service Disruption Time (SDT)

- Per stream inter-packet gap based measurement
- Configurable SDT measurement trigger and SDT violation threshold

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

OTN Testing

The RTU-600 Module offers full range of OTN testing capabilities for OTU3 and OTU4 interfaces, including service-activation (Bringing-into-Service), performance verification, maintenance, and troubleshooting. It offers Multi-Layer testing from Physical layer (WDM), or QSFP28, CAUI-4/XLAUI, OTL, OTU/ODUk, to bulk payloads, and Ethernet traffic generation up to 100% rate.

OTN Functions

Test Interfaces

MSA compliant transceiver interfaces

QSFP28 Interface bit rates

- OTU4 111.810 Gbps

QSFP+

- OTU3 43.108 Gbps

Key Features

- 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

Mapping Procedures: AMP, BMP and GMP

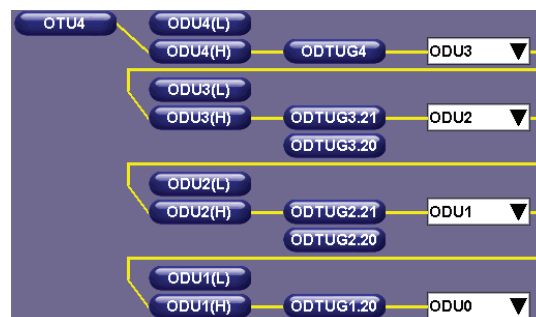
Direct OTN Mapping Options

Single-stage (direct) mapping options

- OTU4-ODU4-Bulk
- OTU4-ODU4-100GE
- OTU3-ODU3-Bulk
- OTU3-ODU3-40GE

Single & Multi-step 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 Single-step mapping/multiplex structures

- OTU4-ODU4-ODU3
- OTU4-ODU4-ODU2e
- OTU4-ODU4-ODU2
- OTU4-ODU4-ODU1
- OTU4-ODU4-ODU0

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 Single-step mapping/multiplex structures

- OTU3-ODU3-ODU2e
- OTU3-ODU3-ODU2
- OTU3-ODU3-ODU1
- OTU3-ODU3-ODU0

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

- ODTU4.1: N = 1 of 80 TS
- 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
- 07: Transparent Ethernet

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

- ODTU4.ts: N = 1 to 80 TS
- 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-4/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

**Check with factory for availability.*

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 (μ s)
- Last Service Disruption (μ s)
- Longest Service Disruption (μ s)
- Shortest Service Disruption (μ s)
- Time stamped with 1 μ s resolution

Disruption Events Tables

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

Common Functions & Measurements

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, Burst 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

Service Disruption

Service disruption time (SDT) measurements are integrated to the regular BER tests, supporting multi-layer sensor monitoring for OTN and SDH/SONET

OTN Sensors

- LOS, OTU-AIS
- OTU-LOF, OTU-LOM, OTU-IAE, OTU-BDI, SM-BIAE, ODU-AIS, ODU-LCK, ODU-OCI
- FAS, MFAS, OTU-BIP, OTU-BEI, ODU-BIP, ODU-BEI

Pass/Fail range: 15 to 200 ms

Gate Time: 20 to 4000 ms

SDT Results Summary

- Last Service Disruption Time
- Longest Service Disruption Time
- Shortest Service Disruption Time
- Time stamps
- Resolution: 10 μ s
- Total number of Service Disruptions events observed

Disruption Events Table

- Tracks every Service Disruption event for all layers
- Time stamp with 10 μ s resolution
- Duration with 10 μ s resolution
- Individual Pass/Fail Verdicts
- Tracks individual sensor events that occurred during the disruption period with time stamp and duration (10 μ s resolution)

Signal Level and Frequency Measurement

Available for Optical Interfaces

Signal level

- Optical power in dBm and Loss/Saturation graph

Frequency (Line and Payloads)

- Resolution: 1 bit/s (bps)

Frequency Offset

- Resolution: 0.1 ppm Current, Minimum and Maximum

Round Trip Delay

(Available for all interfaces & mappings)

Measurement Range: 1 μ s to 10 seconds Resolution: $\pm 0.1 \mu$ s

Event Logging

Date and time stamped records of all error and alarm events occurred during a test, presented in tabular format

Histograms

(Available for all interfaces)

Histogram: Simultaneous display of Errors and Alarms versus time for sequence of events correlation

Bar Graph: Individual Error or Alarm severity versus time

Resolution: Seconds, minutes, hours and days

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 RXTS 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

