ALBEDO Telecom

in Test we Trust

Zeus is a versatile tester for installation and maintenance of power utility communications. It supports legacy and modern interfaces: Ethernet/IP, PTP, SyncE, ToD, IRIG-B, T1/E1, C37.94, RS-232, G.703 and IEC 61850 protocols such as GOOSE, SV, and MMS.

Datasheet

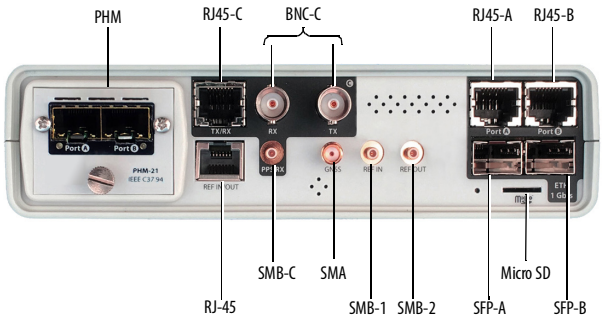
Updated on 13/10/25

Zeus — The Network Tester for Power Utilities

1. General

- Supports concurrent traffic generation and analysis up to 1 Gb/s (1.5 million frames/s with 64-byte frames) on Ports A and B, including multi-stream Ethernet/IP traffic, PHY/ETH/IP/UDP reflection, advanced QoS analysis, and lossless wire-speed forwarding in through mode.
- Two SFP compatible interfaces and two 1 Gigabit Ethernet RJ-45 connectors. Each SFP and RJ-45 pair forms one logical/physical port (Port A and Port B).
- Supports PRP endpoint emulation, enabling traffic generation/reception from DANs and SANs, with Capture and Event Logger extended to include PRP-specific fields, frames, and statistics.
- Supports automatic symmetric and asymmetric testing based on RFC 2544, ITU-T Y.1564, as well as synchronization testing for Synchronous Ethernet, IEEE 1588 (PTP), and NTP.
- GNSS input is provided via a dedicated SMA connector.
- Wirespeed (1 Gb/s) traffic capture and protocol analysis simultaneously on Ports A and B, in both endpoint and pass-through modes, with support for PTP, NTP, GOOSE, and SV.
- Performs latency analysis of IEC 61850 protocols, including GOOSE (Generic Object Oriented Substation Events) and SV (Sampled Values).

Front Panel



Back Panel

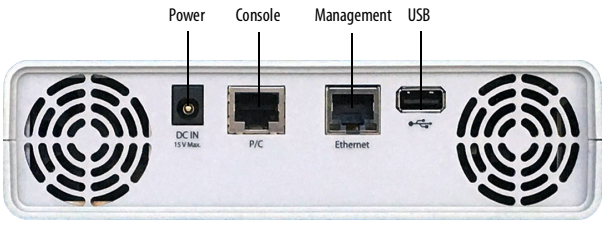


Figure 1. Ports and connectors

- Emulates and analyzes IEEE 1588 (PTP) and Synchronous Ethernet protocols, with advanced features including real-time TE, MTIE, and TDEV analysis, as well as timestamped protocol capture on interfaces up to 1 Gb/s.
- Supports ITU-T G.8272 testing for Primary Reference Time Clocks (PRTCs), including PRTC-A and PRTC-B.
- Performs ITU-T G.8273.2 testing for Telecom Boundary Clocks (T-BCs) and Telecom Time Slave Clocks (T-TSCs), covering Class A, B, C, and D devices.
- Covers ITU-T G.8273.3 and G.8273.4 testing for T-TCs, T-BC-Ps, and T-TSC-Ps.
- Hardware acceleration for time-critical protocols such as IEEE 1588 (PTP).
- E1/T1 generation and analysis with native support for balanced and unbalanced signals via primary (Port C) and optional secondary (Port D) ports.
- Performs advanced synchronization testing on E1/T1, and other clock interfaces, with support for GNSS, PPS, IRIG-B and other reference inputs.
- Supports IEEE C37.94, G.703 E0 interface (co-/contra-directional, centralized), data communication and voice frequency testing.
- Performs one-way and two-way latency measurements. One-way latency uses external timing, GNSS or other, to achieve high-accuracy results.

1.1 Operation Modes

		Operation modes							
		Eth	Eth L1	T1/E1	Analog	Data	Clock	E0	C37.94
Connection	End-point	YES	YES	YES	YES	YES		YES	YES
	Monitor	YES		YES		YES	YES	YES	YES
	Pass	YES		YES		YES			YES
	Loop	YES	YES	YES					YES
	Mux/Dmux			YES					

Table 1. Operation modes vs. Connection modes

- *L1 Endpoint operation:* Generation and analysis of PCS coding or framed/unframed patterns required for BER testing at Layer 1.
- *Ethernet Endpoint operation:* Generates and receives PCS coding and Ethernet frames (when enabled) on Ports A and B.
- *PRP Endpoint*: Simulates multi-stream traffic from SANs/DANs and measures performance (delay, frame loss, etc.) while providing dedicated PRP statistics. It also supports SV, GOOSE, and PTP testing over PRP; for PTP, both master and slave emulation are possible, with Time Error measured independently on LAN A and LAN B, including skew between the two ports
- *IP Endpoint operation:* Generates and receives IPv4/IPv6 datagrams on Ports A and B.
- *Through operation:* Operates transparently (no traffic is generated). Traffic received on Port A is forwarded to Port B, and vice versa.
- *E1/T1 Endpoint*: Emulates an E1/T1 network termination point with support for transmission, reception and loopback operation.

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- *E1/T1 Monitor*: Analysis of E1/T1 signals without generating test traffic.
- *E1/T1 Pass-through*: Transfers E1/T1 frames bidirectionally between ports and allows test signal manipulation, including symmetric/asymmetric delay and bit error injection.
- *E1/T1 MUX/DEMUX*: Supports simultaneous E1/T1 and data communication to test TDM multiplexers and demultiplexers.
- *Datacom Endpoint*: Emulates a DTE or DCE device for datacom testing.
- *Datacom Monitor*: Transparent monitoring of DTE–DCE communication.
- *C37.94 Endpoint*: Emulates an IEEE C37.94 termination point with support for transmission, reception, and loopback operation.
- *C37.94 Monitor*: Passive monitoring of IEEE C37.94 inputs without injecting test traffic.
- *C37.94 Pass-through*: Transfers IEEE C37.94 frames bidirectionally between ports and supports signal manipulation, including symmetric/asymmetric delay and bit error injection.
- *G.703 E0 Endpoint*: Supports generation and analysis on G.703 E0 interfaces (co-/contra-directional, centralized).
- *Voice Frequency:* Generation and analysis of analog signals in the telephone band (300–3400 Hz).
- *Clock Monitor*: Monitors clock signals, including IRIG-B time codes, for frequency and time accuracy and performs synchronization testing.

1.2 Test Interface and Clock Reference Summary

	Operation Modes			
	1GE	T1/E1	Clk Monitor	Cable
RJ45-A *(Rx/Tx)*	Ethernet, IP PTP, NTP, SyncE			Ethernet
	SyncE			SyncE
RJ45-B *(Rx/Tx)*	Ethernet, IP			Ethernet
	SyncE			SyncE
SFP-A *(Rx/Tx)*	Ethernet, IP PTP, NTP, SyncE			
	SyncE			
SFP-B *(Rx/Tx)*	Ethernet, IP			
	SyncE			
BNC-C *(Rx/Tx)*		E1	10 MHz 5 MHz 2048 kHz 1544 kHz	
RJ45 -C *(Rx/Tx)*		T1/E1	10 MHz 5 MHz 2048 kHz 1544 kHz 1PPS 1PP2S ToD	
SMB-C *(Rx)*			1PPS 1PP2S	
SMA	GNSS	GNSS	GNSS	GNSS
SMB-1 *(in)*	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B
SMB-2 *(out)*	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B	1PPS 1PP2S IRIG-B
RJ45 *(in/out)*	T1/E1 10 MHz 5 MHz 2048 kHz 1544 kHz 1PPS 1PP2S ToD IRIG-B	T1/E1 10 MHz 5 MHz 2048 kHz 1544 kHz 1PPS 1PP2S ToD IRIG-B	T1/E1 10 MHz 5 MHz 2048 kHz 1544 kHz 1PPS 1PP2S ToD IRIG-B	T1/E1 10 MHz 5 MHz 2048 kHz 1544 kHz 1PPS 1PP2S ToD IRIG-B

Table 2. Native Test Interfaces and Clock References
Clock references, Test signals

	Layout	Modes	Connectors
PHM-20		Datacom endpoint Datacom monitor Datacom loop	SS26 DCE SS26 DTE
PHM-21		IEEE C37.94 endpoint IEEE C37.94 through IEEE C37.94 monitor IEEE C37.94 loop	2 x SFP
PHM-22		G.703/E0 endpoint G.703/E0 monitor G.703/E0 loop	RJ-45
PHM-23		Analog	RJ-45 Headset
PHM-24		E1/T1 endpoint E1/T1 through E1/T1 monitor E1/T1 loop	RJ-45
PHM-25		Clk monitor (IRIG-B)	RJ-45 SMB

Table 3. Pluggable Hardware Module (PHM) Interfaces

2. Oscillator

- Default TCXO better than ±2 ppm
- Optional OCXO better than ±50 ppb
- Optional Rubidium better than ±5.0 e-11

2.1 Aging

	OCXO	Rubidium
Daily	$5.0e^{-10}$	$2.5e^{-11}$
Monthly	-	$5.0e^{-11}$
Yearly	$5.0e^{-8}$	$6.0e^{-10}$

Table 4. *Oscillator aging*

2.2 Locking time

	OCXO	Rubidium
Locking time	< 10 min	< 4 hours

Table 5. *Locking time*

2.3 Performance (Locked)

Reference	OCXO	Rubidium
GNSS (single-band)	± 20ns	± 15 ns
GNSS (multi-band)	± 10ns	±5 ns

Table 6. *RMS phase error*

2.4 Performance (Hold-over)

	OCXO	Rubidium
Phase within ±100 ns	30 minutes	10 hours
Phase within ±500 ns	2 hours	30 hours
Phase within ±1.0 µs	4 hours	60 hours
Phase within ±10.0 µs	24 hours	12 days

Table 7. *Holdover oscillator performance (±1 ºC)*

3. GNSS Synchronization Inputs

- Connector: SMA (50 Ω).
- Fixed position mode for GNSS references.
- Automatic setting of UTC-to-TAI offset (leap seconds) through GNSS.
- 4V - 5V DC output in GNSS port to feed an external antenna.
- Cable delay compensation.
- Automatic antenna detection.

3.1 Single-band Receiver

- 72-channel receiver.
- Sensitivity: -166 dBm (tracking), -148 dBm (cold start).
- Single or multiple constellation selection.
- Anti-jamming technology.
- Bands: (1) GPS L1, (2) GLONASS L10F, (3) Galileo E1B/C, (4) BeiDou B1.

3.2 Multi-band Receiver

- 184-channel receiver
- Sensitivity: -167 dBm (tracking), -148 dBm (cold start).
- Single or multiple constellation selection.
- Anti-jamming and anti-spoofing technology.
- Bands: (1) GPS L1C/A, L2C, L5, (2) GLONASS L10F, (3) Galileo E1B/C, E5b, E5a, (4) BeiDou B1I, B1C, B2a, (5) NavIC L5.

3.3 GNSS Compact Antenna

- SMA male connector
- Polarization: RHCP
- Frequency band: 1573 MHz - 1610 MHz
- Gain: 27 dB
- Noise figure: 1.5 dB
- Voltage: 2.7 V - 5.5 V
- Protection level: IP 67

4. Clock Reference Inputs

- 10 MHz, 5 MHz, 2048 kHz, 1544 kHz, E1, T1 (REF IN/OUT port).
- 1 PPS, 1PP2S balanced (REF IN/OUT) and unbalanced (REF IN port) compatible with standard ITU-T G.8271. ToD balanced (REF IN/OUT) compatible with ITU-T G.8271, China Mobile and NMEA formats.
- IRIG-B00X, B12X, B13X, B14X, B15X, B22X unbalanced (REF IN port) with IEEE C37.118 extensions. 50 Ω or high impedance modes. Up to 25 Vpp. AC or DC coupling.
- IRIG-B00X, B22X balanced (REF IN/OUT port) with IEEE C37.118 extensions. ITU-T V.11 electrical characteristics.
- Synchronous Ethernet on Ports A and B over any valid electrical or optical interface.
- Custom delay compensation for phase and time inputs.

5. Clock Reference Outputs

- 10 MHz, 5 MHz, 2048 kHz, 1544 kHz, E1, T1 (REF IN/OUT port).
- IRIG-B00X, B12X, B13X, B14X, B15X, B22X unbalanced (REF OUT port) with IEEE C37.118 extensions. 50 Ω or high impedance modes. 5 Vpp. AC or DC coupling.
- IRIG-B00X, B22X balanced (REF IN/OUT port) with IEEE C37.118 extensions. ITU-T V.11 electrical characteristics.
- 1 PPS, 1 PP2S, balanced (REF IN/OUT) and unbalanced (REF OUT port) compatible with standard ITU-T G.8271. ToD balanced (REF IN/OUT) compatible with ITU-T G.8271 and NMEA.
- Custom delay compensation for phase and time outputs.

6. Ethernet PHY

- The following Ethernet interfaces are supported by the SFP ports: 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX, 1000BASE-BX, 100BASE-FX.
- The following Ethernet interfaces are supported by the RJ-45 ports: 10BASE-T, 100BASE-TX, 1000BASE-T.
- Ability to enable or disable the light transmitter in optical interfaces.
- Electrical ports compliant with IEEE 802.3, with 1500 V (rms) isolation.
- SFP bay according with IEEE 802.3, not isolated, +3.3 V (maximum).

6.1 Auto-Negotiation

- Negotiation of bit rate. Allow 10 Mb/s, allow 100 Mb/s, allow 1000 Mb/s.
- Selection of clock master or slave roles in 1000BASE-T interface.
- Ability to disable auto-negotiation and force line settings in 10 Mb/s, 100 M/s electrical interfaces and 1000 Mb/s optical interfaces.

6.2 Synchronous Ethernet

- Interfaces: 100BASE-TX and 1000BASE-T (unidirectional) through the attached RJ-45 ports. Through external SFP: 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX, 1000BASE-BX, 100BASE-FX.
- Operation: Analysis of synchronous Ethernet signal in *Ethernet endpoint, IP Endpoint* and *IP Through modes*, generation of synchronous Ethernet signal in *Ethernet endpoint* and *IP Endpoint* modes. Transparent synchronous Ethernet pass-through in *IP Through* mode.
- Fixed frequency offset generation on transmitted signals with maximum value of ±120 ppm as per ITU-T O.174.
- Sinusoidal wander generation on Ethernet interfaces following ITU-T O.174.
- Generation, decoding and transparent forwarding (*IP Through mode*) of the ESMC carrying QL TLV, Extended QL TLV, and SSM code. Transmission and reception of "heart-beat" and event SSM messages is subject to ITU-T G.8264 clauses 11.3.2.1 and 11.3.2.2.
- SSM encoding supports QL transport according to Options I, II, or III as defined in ITU-T G.781.
- SSM messages are generated at port level. Source MAC address is set to the local profile MAC address.

6.3 Power over Ethernet

- PoE (IEEE 802.3af-2003) and PoE+ (IEEE 802.3at-2009) detection.
- PoE interfaces: 10BASE-T, 100BASE-T and 1000BASE-TX through attached RJ-45 Ports A and B.
- PoE pass-through when the equipment is configured in transparent (through) operation mode.
- PoE voltage between pairs 1-2 / 3-6 and 4-5 / 7-8 in endpoint test. Voltage and current in pairs 1-2/ 3-6 and 4-5 / 7-8 in through mode.

7. Ethernet MAC

- Ethernet MAC generation and analysis in *Ethernet* and *IP Endpoint* mode; analysis only in *Ethernet/IP Through* mode.
- Supported Ethernet frame formats: DIX, IEEE 802.1Q, IEEE 802.1ad.
- Support for Jumbo frames with MTU up to 10 kB.
- Configurable source and destination MAC addresses. The source MAC can be set to the factory default, a user-defined address, or a sequential range. The destination MAC can be configured as the opposite port's default address, a custom address, or a sequential range. When a range is selected, all addresses within it are used in the generated traffic.
- Configurable Type/Length field in Ethernet frames, unless restricted by a frame structure requiring a specific payload type.
- Supports VLAN and Q-in-Q modes. In VLAN mode, the Type/Length field is set to 0x8100; in Q-in-Q mode, it can be set to 0x88A8, 0x8100, 0x9100, 0x9200, or 0x9300.
- VLAN VID and User Priority configurable when VLAN is enabled.
- In Q-in-Q mode, supports configuration of S-VLAN VID, DEI, and PCP, as well as C-VLAN VID and User Priority.
- Configurable frame size.
- Supports FCS error insertion with selectable modes: single, burst, rate-based, and random.

8. MPLS

- MPLS generation and analysis in *IP Endpoint* mode; analysis only in *Ethernet/IP Through* mode.
- Supports single and double MPLS label stacks with labels formatted according to RFC 3032. For double label stacks, the bottom-of-stack (BoS) bit is set to 0 in the top (outermost) label and set to 1 in the bottom (innermost) label.
- Configurable TTL, EXP, and Label fields for Top and Bottom MPLS headers.
- When MPLS is enabled, the MAC Type field is set to 0x8847 for unicast or 0x8848 for multicast packets.

9. IPv4

- IPv4 generation and analysis in *IP Endpoint* mode; analysis only in *Ethernet/IP Through* mode.
- Enabling IPv4 generation forces the Ethernet Type field to 0x0800.
- Configurable source and destination IP addresses. The source address can be set via DHCP, static value, or defined as a sequential range. The destination address can be configured as the opposite port's current address, a custom address, or a defined range. When a range is specified, the generated traffic will cycle through all addresses within the range.
- Destination MAC address configurable manually or via ARP. The equipment replies to ARP requests using a single main IP address, set per port in the local profile menu. All other ARP requests are ignored.
- Configurable DSCP, CoS, TTL, and transport protocol. If UDP is selected, source and destination ports can also be configured.
- IP checksum error insertion in *IP Endpoint* mode, with single, burst, rate, and random modes. This operation does not affect lower-layer transmission and requires FCS field regeneration.

10. Generic / UDP Traffic Generator

- Supports traffic generation over 8 independent streams, each with configurable bandwidth profile and payload/pattern settings.
- Two independent traffic generators, one per test port (Port A and Port B).

10.1 Bandwidth Profiles

- Traffic generation supports four modes: *Continuous*, *Periodic burst*, *Ramp* and *Random*.
- *Continuous* traffic is defined by a single parameter entered either as a percentage of the channel capacity, a value in b/s or a value in frames/s.
- *Periodic* burst is specified by the following values: *High/Low traffic* (%, b/s, frames/s) and *High/Low duration* (frames, seconds).
- *Ramp* traffic is specified the following values: *High/Low traffic* (%, b/s, frames/s), *Steps* (integer number) and *Step duration* (seconds).
- *Random* traffic is based on *Poisson-distributed* average traffic, specified as a percentage, in b/s, or in frames/s.

10.2 Test Patterns and Payloads

- Layer 1 test patterns are available in *L1 endpoint* mode. All remaining patterns are available in IP endpoint and Ethernet endpoint modes.
- Layer 1 BER test patterns from IEEE 802.3-2008 Annex 36A: Long continuous random test pattern, Short continuous random test pattern.
- Layer 1 BER test patterns IEEE 802.3-2012: PRBS 2^{31}-1, A-seed, B-seed.
- Layer 2-4 BER test patterns: PRBS 2^{11}-1, PRBS 2^{15}-1, PRBS 2^{20}-1, PRBS 2^{23}-1, PRBS 2^{31}-1. These patters apply to stream 1 only.
- Test payload for SLA statistics based in the ITU-T Y.1731 vendor specific OAM payload (Layer 2 tests) or a proprietary ATSL format (Layer 3 tests). The SLA payload for Layer 2 tests configures the Ethertype field to the default value of 0x8902 (IEEE 802.1ag / ITU-T Y.1731 OAM).
- All zeros test pattern.
- TSE insertion supported in endpoint modes, with *single*, *rate* and *random* modes (only for bit patterns or payloads containing bit patterns).

11. Filter

- Supports up to 8 simultaneous traffic filters per port.
- Traffic processing is determined per frame using one or more filters. Each frame is handled by a single branch only. In case of conflict, the branch with the lowest index takes precedence.
- Frame selection is based on Ethernet header fields. If the frame carries IP, selection can also be performed using IP header fields and, when applicable, higher-layer protocol fields within the TCP/IP stack.
- Supports a generic filter with a user-defined offset and 16-bit mask for frame selection.

11.1 Ethernet Selection

- By source and destination MAC addresses, with support for address sets and masks.
- By Type/Length field, with selection mask.
- By C-VID and S-VID, with selection mask.
- By Service and Customer Priority Code Point (PCP), with selection mask.

11.2 MPLS Selection

- Separate filters for Top and Bottom MPLS labels.
- By label value, with support for label range selection.
- By EXP field value, with support for range-based selection.

11.3 IPv4 Selection

- By source and/or destination IPv4 address, with support for address sets using masks.
- By protocol value defined in the IPv4 header.
- By DSCP field, with support for filtering single values or value ranges.

11.4 IPv6 Selection

- By source and/or destination IPv6 address, with support for address sets using masks.
- By IPv6 flow label field.
- By next header field value.
- By DSCP field.

11.5 UDP / TCP Selection

- Selection by UDP and TCP port. Either single value filters or filtering of port ranges is available.

11.6 Protocol Selection

- By protocol type, including IEEE 1588-2008 over Ethernet and IPv4, NTP, and IEC 61850 GOOSE and SV.
- For IEEE 1588, filtering by Domain, Port Identity and Message Type (*Sync*, *Delay Request*, *Delay Response*, *Peer Delay Request*, *Peer Delay Response*, *Follow up*, *Peer Delay Follow up*, *Announce*, *Signaling*, *Management*).
- For NTP, selection by message type (*Symmetric active*, *Symmetric passive*, *Client*, *Server*, *Broadcast*, *Control*, *Other*).
- For IEC 61850: selection by APPID.

12. PTP / IEEE 1588

- PTP emulation and testing in *Ethernet*/*IP Endpoint* modes (Ports A and B).
- Hardware-assisted generation and decoding of Precision Time Protocol (PTP) as defined in IEEE 1588-2008.
- Supports both *Master* and *Slave* operation in Endpoint mode, with the ability to force either role.
- Encapsulations:
  PTP over UDP/IPv4 (*IP Endpoint*), per IEEE 1588-2008 Annex D,
  PTP over IEEE 802.3 (*Ethernet Endpoint*), per IEEE 1588-2008 Annex F.
- Compatible with unicast, multicast, and hybrid transmission modes (UDP and Ethernet payloads). Supports unicast negotiation.
- Supports *1-step* and *2-step* modes in both master and slave emulation.
- *Peer-to-peer* and *end-to-end* delay mechanisms supported.
- Configurable parameters: *Domain*, *Priority 1*, *Priority 2*, *Clock Class*, *forwardable/non-forwardable* multicast MAC address, *PTP Accuracy*, and *PTP Variance*.
- Configurable *Announce* capabilities: UTC offset, time and frequency traceability, timescale and time source.
- Message rate configuration for *Sync*, *Delay Request*, *Peer Delay Request*, and *Announce* messages, including *Announce timeout*.

12.1 PTP Test modes

- *Sync Analyzer*. Single PTP instance and four *Clock emulation* modes: *Test*, *Slave*, *Master* and *Auto*.
- *Dual Sync Analyzer*. One PTP *Test* instance per Ethernet port. Measures timing performance in each port and provides differential statistics between them.
- *BC/TC Test*. One PTP instance attached to each Ethernet port. One runs in *Master* mode, the other in *Test* mode. Enables accurate measurements of Boundary Clocks, Transparent Clocks, and other multi-port devices.
- *SC Test*. PTP *Master* emulation on one Ethernet port combined with a *clock analysis* instance. Designed for accurate measurement of PTP Slave Clock behavior.

13. NTP

- NTPv3/NTPv4 server and client emulation. Includes *Test* mode for evaluating NTPv3/NTPv4 server performance.
- Hardware-assisted time stamping for Network Time Protocol (NTP).
- In *Client* emulation and *Test* modes: configurable protocol version, server address (IP or domain name), and polling interval.
- In *Server* emulation mode: configurable protocol version, stratum level, and reference ID.

14. PHY Results

14.1 Cable Tests

- For inactive links: Detects open/short faults and estimates distance to fault (accuracy: 1 meter).
- For 10/100 Mb/s active links: Reports current local port MDI/MDI-X status.
- For 1 Gb/s active links: Reports current local port MDI/MDI-X status, pair polarity (normal/inverted), and pair skew (in nanoseconds).

14.2 SFP

- Detection of SFP presence, current interface, vendor, and part number.
- Optical power measurement (Tx and Rx) on compatible SFP transceivers.

14.3 Auto-Negotiation

- Auto-negotiation results with current bit rate and duplex mode.
- For 1000BASE-T, indicates clock Master/Slave role

14.4 Synchronous Ethernet

- Measures line frequency (MHz), frequency offset (ppm), and frequency drift (ppm/s) per ITU-T O.174.
- TIE, MTIE, and TDEV measurements on Ethernet interfaces with a sampling frequency of 50 Hz.
- Decoding of Synchronization Status Messages supporting both ITU-T G.781 SSM (QL in SSM for Options I, II, III) and ITU-T G.8264 ESMC (SSM in QL TLV and extended QL TLV).
- Displays Originator Clock Identity, flags, and number of cascaded EEC/eEECs from the nearest SSU/PRC when Extended QL TLV is received.

15. Frame Analysis

- Simultaneous per port statistics.

15.1 Ethernet Statistics

- Frame type counts: Ethernet, IEEE 802.1Q (VLAN), IEEE 802.1ad (Q-in-Q), control frames, and pause frames.
- Traffic type counts: unicast, multicast, and broadcast.
- Error analysis: FCS errors, undersized frames, oversized frames, fragments, and jabbers.
- Frame size distribution: ≤64, 65–127, 128–255, 256–511, 512–1023, 1024–1518, 1519–1522, 1523–1526, and 1527–MTU bytes.

15.2 MPLS Statistics

- MPLS stack length: minimum and maximum values.

15.3 IP Statistics

- Packet counts: IPv4, IPv6, unicast, multicast, and broadcast.
- Protocol counts: TCP, UDP, and ICMP packets.
- Checksum errors: IPv4, IPv6, UDP, and TCP.

15.4 Bandwidth Statistics

- Simultaneous per-port and per-stream traffic statistics.
- Current, maximum, and minimum Ethernet rates in bits/s, frames/s, and as a percentage of nominal channel capacity.
- Ethernet unicast, multicast, and broadcast traffic expressed as a percentage of nominal capacity.
- IPv4 and IPv6 traffic rates in bits/s, frames/s, and percentage of nominal capacity.
- UDP traffic rates in bits/s, frames/s, and percentage of nominal capacity.

15.5 SLA Statistics

- Simultaneous per-stream and per-port statistics.
- Frame Transfer Delay (FTD): Current, minimum, maximum, and average values, based on ITU-T Y.1563 definitions
- Delay Variation statistics:
  Standard deviation of FTD,
  Range of FTD: max FTD – min FTD,
  Current Frame Delay Variation (FDV), smoothed as defined in RFC 1889 / RFC 3393,
  Maximum and average FDV.
- Frame Reordering & Duplication statistics (RFC 5236):
  Out-of-order frame count and ratio
  Duplicated frame count and ratio.
- Frame Loss: Lost frame count and 2-way Ethernet Frame Loss Ratio (FLR).
- Availability Metrics: Severely Errored Seconds (SES), Percent Ethernet Unavailability (PEU), and Percent Ethernet Availability (PEA).

15.6 Service Disruption Time

- Simultaneous per-port analysis, performed statically over Flow 1.
- Service Disruption detection based on SLA pattern analysis within a synthetic traffic flow.
- 1 ms resolution.
- Reported metrics:
  Number of service disruption events,
  Total disruption time,
  Average, minimum, and maximum disruption duration.
  Duration of the most recent disruption event.

15.7 BER

- Simultaneous per-port analysis, performed statically over Flow 1.
- Metrics include:
  Bit error count, Seconds with errors, Bit Error Ratio (BER), Pattern loss count, Pattern loss seconds.

15.8 Network Exploration

- Simultaneous per-port results based on a single search field.
- Top Talkers: Displays the 16 most frequent source MAC addresses (*Ethernet Endpoint*) or source MAC/IPv4/IPv6 addresses (*IP Endpoint*).
- Top VID Statistics: Lists the 16 most common IEEE 802.1Q VID tags.
- Top S-VID Statistics: Lists the 16 most common IEEE 802.1ad S-VID tags.
- Automatic configuration of the eight available filter blocks to match entries in the Top Talkers list.

16. PTP/IEEE 1588 Statistics

- Protocol State Details: *Port state*, *BMCA state*, *master* and *grandmaster identities*, *grandmaster priorities*, *clock class*, *accuracy*, *variance*, *time source*, and *master* IP or MAC address.
- TX and RX PTP frame counter classified by type: *Sync*, *Delay Request, Delay Response, Peer Delay Request/Response, Follow Up, Announce, Signaling, and Management*.
- Error Detection:
  Domain mismatches (valid headers, mismatched PTP domain number),
  Sync sequence errors (unexpected sequence numbers)
- Sync Delay Statistics: Current, maximum, minimum, average, standard deviation, and range.
- Sync Delay Variation: Current, maximum, and average values.
- Sync Inter-arrival Time: Average and current values.
- Delay Request Delay Statistics: Current, minimum, maximum, average, standard deviation, and range.
- Round-trip Delay: Current and mean values using path delay mechanism.
- Correction Field Statistics: Current, maximum, and average values.
- Sync Floor Delay Metrics (ITU-T G.8260):
  Floor Packet Count (FPC), Floor Packet Rate (FPR),
  Floor Packet Percent (FPP) with configurable Pass/Fail threshold.
- Wander Metrics (ITU-T G.8260): *pktfilteredTIE*, *pktfilteredMTIE*, *pktfilteredTDEV* with configurable masks.
- Time Error (TE) Metrics: Two-way TE, max |TE|, and frequency-separated TE (low-frequency cTE, high-frequency dTE), all with user-defined Pass/Fail thresholds. Relative TE between slaves is also measured during dual slave emulation.
- Asymmetry Analysis: Path delay asymmetry between PTP master and client clocks.
- Frequency Offset Measurement.

17. NTP Statistics

- Protocol Status: *Port state, stratum, reference ID, polling interval, root delay, root dispersion, leap status,* and *current time.*
- Message Counters: TX/RX counts by type: *Symmetric Active*, *Symmetric Passive*, *Client*, *Server*, *Broadcast*, *Control*, and *Other*.
- Delay Metrics: Current value, mean, range and standard deviation for: *Offset (theta)*, *Delay (delta)*, *Forward path delay*, *Return path delay*, *Asymmetry* and *Jitter (psi)*.
- Two-Way Time Error (TE): Current, mean, min, max, and standard deviation.

18. IEC 61850 GOOSE

- Decodes and analyzes GOOSE frames per IEC 61850-7-2 and 61850-8-1.
- GOOSE Protocol scan with GoCBName, GoID, and DatSet identification.
- GOOSE Frame counters for the active flow and all flows.
- Latency metrics over the active flow: current, average, minimum, maximum, range, and standard deviation.

19. IEC 61850 Sampled Values (SV)

- Decodes and analyzes SV frames per IEC 61850-7-2 and 61850-9-2.
- SV Protocol scan with svID population and active flow selection.
- SV frame counters for active flow and all flows.
- Sample count and sampling rate measurement on active flow.
- Latency metrics (active flow): current, average, minimum, maximum, range, and standard deviation.

20. PRP Endpoint Emulation

- Emulates one or multiple PRP endpoints, supporting both Dually Attached Nodes (DANs) and Singly Attached Nodes (SANs).
- Generates and receives multi-stream traffic in PRP environments and measures performance metrics such as delay, frame loss, and throughput.
- Provides dedicated PRP statistics, including PRP node detection, redundancy checks, and detailed frame counters.
- Generation and analysis of delay skew between LAN A and LAN B traffic.
- Capture and Event Logger extended to decode and report PRP-specific fields and frames.
- Enables protocol testing over PRP, including IEC 61850 Sampled Values (SV), GOOSE, and IEEE 1588 (PTP).
- In PTP tests, supports both master and slave emulation, measuring Time Error (TE) independently on LAN A and LAN B, as well as skew between the two ports.

21. Automatic Tests

- Automatic test execution per IETF RFC 2544, and ITU-T Y.1564.
- Customizable pass/fail thresholds.
- User-selectable analysis port in symmetric tests.
- Fixed Port A operation in asymmetric tests.

21.1 IETF RFC 2544 Test

- Compatible with *Ethernet* and *IP Endpoint* modes.
- Supports throughput, frame loss, latency, back-to-back, and recovery time tests.

21.2 ITU-T Y.1564 Test

- Implements the Ethernet service activation methodology defined in ITU-T Y.1564 in *Ethernet* and *IP Endpoint* modes
- Supports up to 8 services in non–color-aware mode, or up to 4 services in color-aware mode, with *CIR* and *EIR* configurable per service.
- Allows per-service objectives for *Frame Transfer Delay* (FTD), *Frame Delay Variation* (FDV), *Frame Loss Ratio* (FLR), and *availability*.
- Phase 1 – Network Configuration Test:
  – Parameters: *Steps* (integer) and Step duration (seconds)
  – Bandwidth profile: Modified ramp using *CIR*, *EIR*, and *maximum throughput*
  Phase 2 – Ethernet Service Test:
  – Parameters: *Phase duration* and *bandwidth profile* (*deterministic*, *random*)
  – All services tested simultaneously at their CIR bit rate
- FTD, FDV (mean value) and FLR measured at each step in both phases.
- Pass/fail status computed per step. Phase 1 must pass all steps for Phase 2 to begin.

22. Port Loopback

- Layer 1-4 loopback.
- Option to loop all frames or only those matching active filter conditions.
- Loopback control for broadcast and ICMP traffic.

23. ICMP Processor (Ping / Traceroute)

- Generates on-demand ICMP Echo Request messages (RFC 792) with configurable destination IP, packet size and transmission interval.
- Analyzes ICMP Echo Reply messages with round-trip time and packet loss measurement.
- Processes ICMP *Time Exceeded* and *Port Unreachable* replies during traceroute testing.

24. Protocol Processor

- IPv4 ARP (RFC 826) for automatic MAC address resolution in *IP Endpoint* mode.
- DNS-based IPv4 destination resolution (*IP Endpoint* mode).
- DHCP client (RFC 2131) for dynamic or static IPv4 profile configuration.
- Traceroute over IPv4 using:
  – UDP packets with incremented TTL values
  – ICMP Echo Requests with incremented TTL values.

25. Protocol Analysis

- Simultaneous per-filter and per-port capture with filter tagging for later identification.
- Captures TX/RX streams in Endpoint mode (Ports A and B) and RX streams in Pass-through mode at all speeds.
- Simultaneous TX and RX frame capture.
- Capture buffer: 256 MB, with wrap-around for continuous operation.
- Export captured data in PCAP and PCAPNG formats.
- Hardware time-stamping of captured packets with 1 ns resolution.
- UTC time-stamping when synchronized to external reference (GNSS, ToD, or IRIG-B) or in holdover.
- Protocol decoding (Ethernet): *SLA payload* (ALBEDO proprietary), *ESMC* (QL TLV, Extended QL TLV), *ARP* and *Pause*.
- Protocol decoding (IP): *SLA payload* (ALBEDO proprietary), *NTP*, *IGMP*, *DHCP*, *DNS*, and *ICMP*.
- Decoding of:
  – PTP over Ethernet and over IP/UDP.
  – IEC 61850 *GOOSE* and *SV* protocols over Ethernet.
- Packet-by-packet latency measurement for: SLA payload (ALBEDO proprietary), IEEE 1588-2008, NTP, IEC 61850 GOOSE and SV.
- Triggered captures with configurable trigger position (first, last, intermediate frame) using single or multi-event filter-based triggers.

26. E1 Generation / Analysis

26.1 Connectors

- Unbalanced: BNC 75 Ω.
- Dual Balanced: RJ-48 120 Ω.

26.2 Line

- Configurable input impedance: nominal line, PMP 20/25/30 dB, or high impedance (>1000 Ω).
- Custom transmission clock: recovered or synthesized
- Output frequency offset: ±25,000 ppm adjustable around nominal.
- Line coding: HDB3, AMI.
- Input level range: 0 dB to –45 dBm.
- Pulse mask compliance: ITU-T G.703.
- Jitter compliance: ITU-T G.823.

26.3 Frame

- Supports 2 Mb/s unframed, ITU-T G.704, G.704 with CRC, G.704 with CAS, and G.704 with CRC + CAS.
- *Nx64* kb/s generation and analysis in contiguous and non-contiguous time slots.
- Custom NFAS spare bit generation in CRC-4 multiframe (G.704).
- CAS A/B/C/D bit generation for each voice channel.
- CAS multiframe spare bit generation (G.704 with CAS multiframe).
- Custom *Synchronization Status Message* (SSM) generation.

26.4 Line Analysis

- Line attenuation measurement (dB).
- Frequency (Hz) and frequency deviation (ppm).
- Customizable pass/fail thresholds

26.5 Frame and Pattern Analysis

- Defect Detection: LOS, LOF, AIS, RDI, CRC-LOM, CAS-LOM, MAIS, MRDI, LSS, All 0, All 1, Slip.
- Anomaly Detection: Code, FAS error, CRC error, REBE, MFAS error, TSE, TSBE.
- Performance Metrics:
  – ITU-T G.821: ES, SES, UAS, DM. with pass/fail evaluation.
  – ITU-T G.826: ES, SES, UAS, BBE (near/far end) with pass/fail evaluation.
  – ITU-T M.2100: ES, SES, UAS, BBE (near/ far end) with pass/fail evaluation.
- Channel Map and Time Slot Analysis:
  – Channel Map and Time Slot values in hex and binary.
  – Time Slot level and frequency per ITU-T G.711 A-law.
- FAS / NFAS word analysis.
- CAS A/B/C/D bit decoding.
- Synchronization Status Message (SSM) decoding and analysis.

26.6 Event Insertion

- Physical Layer: Code, AIS, LOS, bit error, delay.
- Frame Layer: FAS error, CRC error, MFAS error, REBE, LOF, MAIS, CAS-LOM, RDI, MRDI, CRC-LOM.
- Pattern-Level: TSE, Slip, LSS, All 0, All 1.
- Insertion modes:
  – Anomalies: Single, Rate.
  – Defects: Continuous, M-Single, MN-Repetitive.

27. T1 Generation / Analysis

27.1 Connectors

- Dual Balanced: RJ-48 120 Ω.

27.2 Line

- Configurable input impedance: nominal, PMP 20/25/30 dB, or high impedance (>1000 Ω).
- Cable delay equalization for up to 6 dB attenuation.
- Custom transmission clock: recovered or synthesized
- Output frequency offset: ±25,000 ppm adjustable around nominal.
- Line codes: B8ZS, AMI.
- Input level range: From 0 dB to -45 dB.
- Pulse mask compliance: ANSI T1.102-1999, ITU G.703.
- Jitter compliance: ANSI T1.102-1999, ITU-T G.823.

27.3 Frame

- Supports 1544 kb/s unframed, SF (D4), and ESF framing per ANSI T1.403-1999 and ITU-T G.704.
- *Nx64* and *Nx56* kb/s generation and analysis in contiguous and non-contiguous time slots with and without 'robbed bit' signaling.
- CAS A, B, C, D bit generation for each voice channel via 'robbed bit' mechanism.
- Generation of custom FDL word (ESF frame format).
- Custom *Synchronization Status Message* (SSM) generation.

27.4 Line Analysis

- Line attenuation measurement (dB).
- Frequency (Hz) and frequency deviation (ppm).
- Customizable pass/fail thresholds

27.5 Frame and Pattern Analysis

- Defect Detection: LOS, LOF, AIS, RDI, LSS, All 0, All 1, Slip.
- Anomaly Detection: Code, FAS error, CRC error, TSE.
- Performance Metrics:
  – ITU-T G.821: ES, SES, UAS, DM. with pass/fail evaluation.
  – ITU-T G.826: ES, SES, UAS, BBE (near/far end) with pass/fail evaluation.
  – ITU-T M.2100: ES, SES, UAS, BBE (near/ far end) with pass/fail evaluation.
- Channel Map and Time Slot Analysis:
  – Channel Map and Time Slot values in hex and binary.
  – Time Slot level and frequency per ITU-T G.711 μ-law
- CAS A/B/C/D bit decoding
- FDL decoding (ESF frame format).
- Synchronization Status Message (SSM) decoding and analysis.

27.6 Event Insertion

- Physical Layer: AIS, LOS, bit error, delay.
- Frame Layer: FAS error, CRC error, LOF, RDI.
- Pattern-Level: TSE, Slip, LSS, All 0, All 1.
- Insertion Modes:
  – Anomalies: Single, Rate
  – Defects: Continuous, Burst of M, M-out-of-N.

28. Data Communications

- Operating modes: DTE emulation, DCE emulation, and full-duplex monitor

28.1 Connectors

- Smart Serial universal connector for DTE and DCE operation (supports all interface types).

28.2 Interfaces
- V.24 / V.28: Asynchronous and Synchronous, 50 b/s to 128 kb/s.
- X.21 / V.11: Async (50 b/s to 128 kb/s), Sync (50 b/s to 10 Mb/s).
- V.35, V.36 (RS-449), EIA-530, EIA-530A: 50 b/s to 10 Mb/s.

28.3 Line
- Clock circuit selection (TC or TTC) in V.24 / V.28 synchronous, V.35, V.36, EIA-530 and EIA-530a interfaces.
- Output frequency offset configurable ±25,000 ppm from nominal.
- Data bits, stop bits, parity, and inter-word gap settings for V.24 and X.21/V.11 asynchronous interfaces.
- Input/output data-to-clock phase selectable at 0°, 90°, 180°, or 270°.

28.4 Line Analysis
- Frequency (Hz) and frequency deviation (ppm).
- Received character count (V.24 asynchronous).
- Measurement of phase offset between data and clock circuits.
- Logic analyzer for data/clock/control with user-defined control settings.

28.5 Clock and Pattern Analysis
- ITU-T G.821 performance: ES, SES, UAS, DM, with pass/fail indications.
- Defect insertion and analysis: LOC, AIS, LSS, All 0s, All 1s.
- Anomaly insertion and analysis: TSE, Slip.

29. IEEE C37.94

29.1 Connectors
- Dual-port operation over SMF or MMF using compatible SFP transceivers.

29.2 Line
- Transmission clock: recovered or internally synthesized.
- Laser enable/disable control.

29.3 Frame
- Unframed or framed operation (per IEEE C37.94, Section 4.1).
- Configurable bit rate from 64 kb/s to 768 kb/s in 64 kb/s increments.

29.4 Line Analysis
- Frequency (Hz) and frequency deviation (ppm).
- Transmitted and received optical power (dBm).
- Received data rate (kb/s).
- SFP information: transceiver type, vendor, model, and wavelength.

29.5 Frame and Pattern Analysis
- ITU-T G.821 performance: ES, SES, UAS, DM, with pass/fail indications.
- Event detection and insertion: LOS, AIS, FAS, RDI (yellow), LSS, All 0s, All 1s, Slip, TSE, Physical bit errors (EBIT) and Delay.

30. E0 Generation and analysis
- G.703 co-directional, contra-directional, and centralized interfaces operating at 48, 56, 64, 72, 128, 144, 192, and 256 kb/s.
- Custom transmission clock: recovered or synthesized.
- Output frequency offset configurable ±25,000 ppm from nominal.

30.1 Line Analysis
- Frequency (Hz) and frequency deviation (ppm).

30.2 Pattern Analysis
- ITU-T G.821 performance: ES, SES, UAS, DM, with pass/fail indications.
- Defect insertion and analysis: LOS, AIS, LSS, All 0s, All 1s.
- Anomaly insertion and analysis: TSE, Slip.

31. Patterns and Signals
- PRBS: 6, 7, 9 (ITU-T 0.150, 0.153); 11 (0.150, 0.152, 0.153); 15 (0.150, 0.151); 20 (0.150, 0.153); 23 (0.150, 0.151).
- Inverted PRBS: 6, 7, 9, 11, 15, 20, 23.
- Other patterns: QRSS, QRSS inverted, QBF / FOX, All 0s, All 1s.
- User-defined 32-bit word.
- Tone generation (E1 and T1 only): 10 Hz to 4000 Hz, from +6 to -60 dBm.

32. Voice Frequency Test
- Tone generation and analysis with configurable level from –60 dBm to +3 dBm (0.1 dB steps) and frequency from 2 Hz to 4000 Hz (1 Hz steps).
- Measurements*: Signal level (dBm), Noise level (dBm), Signal frequency (Hz)*
- Sensitivity: –60 dBm for signal, –80 dBm for noise.
- ITU-T G.711 analysis: maximum, minimum, and average code values.
- Frequency sweep: up to 8 user-defined frequencies with individual gain/loss thresholds.

33. Clock Monitor
- Frequency inputs:
  – Supported signals: 2048 kHz, 1544 kHz, 5 MHz, 10 MHz.
  – Connectors: RJ-48 (120 Ω) or BNC (75 Ω).
  – Input impedance: nominal line, PMP 20 dB, high-Z (>1000 Ω).
  – Coupling: Configurable AC or DC.
- Time Inputs:
  – Supported signals: 1 PPS and 1PP2S.
  – Connectors: RJ-48 (120 Ω) or SMB (50 Ω).
- Time of Day (ToD):
  – Protocols: ITU-T G.8271, China Mobile, NMEA.
  – Connectors: RJ-48 (120 Ω).

33.1 Line Analysis
- Frequency inputs:
  – Line attenuation (dB).
  – Frequency (Hz) and frequency deviation (ppm).
- IRIG-B:
  – Amplitude (Vpp).
- 1PPS and 1PP2S:
  – Duty cycle.

33.2 IRIG-B Inputs
- Supported formats: B00X, B12X, B13X, B14X, B15X, B22X.
- Connectors:
  – SMB (50 Ω) for all variants.
  – RJ-48 (120 Ω) for B00X and B22X.
- Input impedance: nominal line, PMP 20 dB, high-Z (>1000 Ω) (same as other frequency inputs).
- Modulation types supported: pulse width code, amplitude modulated, Manchester modulated
- Carrier frequencies (for amplitude modulated signals): 1 kHz, 10 kHz, 100 kHz, 1 MHz
- Capability to enable/disable CF, SBS, and BCD_{YEAR}
- CF bits formatted per IEEE C37.118
- Time setting for test outputs: manual or automatic
- Custom value configuration: LSP, LS, DSP, DST, Time Offset, Time Quality, Continuous Time Quality

33.3 IRIG-B Frame Analysis
- Decoding of BCD_{TOY} and BCD_{YEAR}.
- Consistency check with SBS.
- Recording of *LSP*, *LS*, *DSP*, *DST*, including duration of activation .
- Decoding of CF fields: *Time Offset*, *Time Quality* and *Continuous Time Quality*.
- Detection of a *Parity* anomaly.

34. Pulse Mask Analysis
- Interfaces: E1, T1.
- Operation modes: Eye diagram or continuous run.
- Display of positive, negative and positive / negative pulse.
- Measurement of pulse width, rise time, fall time, amplitude level, overshoot, and undershoot (for both polarities).
- Pass / fail indication per ANSI T1.101-1999 and ITU-T G.703 (1544 kb/s).

35. Jitter and Wander Generation
- Interfaces: E1/T1 (primary port), IEEE C37.94.
- Waveform: Sinusoidal modulation.

- Frequency range: 1 µHz to 100 kHz.
- Frequency resolution: 0.1 Hz (jitter), 1 µHz (wander).
- Amplitude range: 0 to 1000 UIpp (limited by modulation frequency per ITU-T O.171/O.172).
- Amplitude resolution: 1 mUIpp or $1/10^4$ of the configured value.
- Smooth amplitude variation across the jitter range (10 Hz ~ 100 kHz).
- Intrinsic jitter < 10 mUIpp.

36. Jitter Analysis

- Interfaces: E1/T1(primary port), 2048 kHz, 1544 kHz, IEEE C37.94.
- Measurement method: Closed-loop phase measurement.
- Modulation frequency range: 0.1 Hz to 100 kHz (locking time 10 s), 1 Hz to 100 kHz (locking time 1 s), 10 Hz to 100 kHz (locking time < 1 s).
- Modulation amplitude: 0 to 1000 UIpp (single range), frequency-dependent as per ITU-T O.171/O.172.
- Modulation amplitude resolution: 1 mUIpp.
- Measurement accuracy: Better than ITU-T O.172.
- Jitter results: Peak-to-peak jitter, RMS jitter, maximum jitter, HIT detection and count (user-defined threshold).
- Jitter observation periods: 1 s, 10 s, 60 s.
- E1 / 2048 kHz / IEEE C37.94 measurement filters (ITU-T G.703): LP (f < 100 kHz), LP+HP1 (20 Hz < f < 100 kHz), LP+HP2 (18 kHz < f < 100 kHz), LP+RMS (12 kHz < f < 100 kHz).
- T1 / 1544 kHz measurement filters (ANSI T1.102 T1): LP (f < 40 kHz), LP+HP1 (10 Hz < f < 40 kHz), LP+HP2 (8 kHz < f < 100 kHz).

37. Wander Analysis

- Interfaces: E1/T1 (primary port), 2048 kHz, 1544 kHz, 5 MHz, 10 MHz, 1 PPS, 1PP2S, ToD, IEEE C37.94, IRIG-B.
- Measurement method: Open-loop.
- Modulation frequency range: 1 µHz to 10 Hz.
- Wander sampling frequency: 50 Hz.
- Amplitude range: 0 to ±2 s (single range).
- Modulation amplitude accuracy: 2 ns.
- TIE analysis: Supported on E1, T1, 2048 kHz, 1544 kHz, 10 MHz, IEEE C37.94.
- TE analysis: Supported on 1 PPS, ToD, IRIG-B with min/max record tracking.
- Frequency offset and frequency drift with peak value records.
- Real-time metrics: Built-in TIE, MTIE, TDEV per ITU-T G.810.
- MTIE / TDEV resolution: 100 ps.
- Custom MTIE and TDEV pass/fail evaluation based on standard masks.

38. Latency

- Interfaces: E1/T1 (primary port), IEEE C37.94, Data Communications, G.703 Co-directional / Contra-directional / Centralized, Voice Frequency.
- Test modes: One-way and Two-way.
- Measurements: Round-trip delay, forward path delay, reverse path delay, asymmetry. All with min/max tracking.
- One-way testing features:
  – Remote end identification.
  – GNSS and ToD as reference clock sources.
  – Patch cord delay compensation.
- Customizable pass/fail criteria.

39. Port Loopback

- Interfaces: E1, T1, IEEE C37.94.
- Independent loopback control for each port.
- Latency emulation: User-defined, up to 50 ms.

40. Service Disruption Time

- Interfaces: E1, T1, IEEE C37.94, Data Communications, G.703 Co-directional / Contra-directional / Centralized.
- Resolution: 100 µs or lower, depending on detection/clearance rules.
- Statistics: Disruption event count; Total disruption time; Average, minimum, and maximum disruption duration; Duration of last disruption event.

40.1 In-service triggers

- LOS (Loss of Signal): Detection / Clearance per ITU-T G.775.
  E1: Clause 4.2, T1: Clause 4.3, IEEE C37.94-2017: Clause 5.1 (IEEE C37.94).
- AIS (Alarm Indication Signal): Detection / Clearance per ITU-T G.775.
  E1: Clause 5.2, T1: Clause 5.4.
- LOC (Loss of Clock): Detection / Clearance per ITU-T G.775
  Datacom synchronous: G.775 Clause 4.1 (applied to receiving clock circuit).
- RDI (Remote Defect Indication): Detection / Clearance per ITU-T G.775
  E1: Clause 6.2, IEEE C37.94: Clause 5.3.

41. Out of service triggers

- TSE (Test Sequence Error): Detection / Clearance per ITU-T O.150 Clause 4.2, with modified integration period: shortest of 64 bits or 100 µs.
- All 1s / All 0s: Detection / Clearance per ITU-T O.150 Clause 4.2, with modified integration period: shortest of 64 bits or 100 µs.

42. Platform

- Dimensions: 260 × 160 × 63 mm.
- Weight: 1.9 kg (with dual battery packs).
- Display: 8" TFT color screen, 800 × 480 pixels.
- Interfaces:
  – USB Type-A (USB 2.0, +5 V / 0.5 A max).
  – RS-232 / V.24 console port for maintenance.
  – Ethernet (10/100BASE-T) for management.
  – Wi-Fi (802.11a/b/g/n) via external dongle.

42.1 Power Specifications

- Battery operation time: 5~8 hours (LiPo).
- Battery recharge time: 4 hours (LiPo).
- DC input: 12 V nominal (max 15 V), 5 A max.
- AC adapter: 100–240 V~, 50/60 Hz, 1.5 A input ? 12 V DC, 5 A output.
- AC tolerance: Voltage fluctuations < ±10% of nominal.
- Safety rating: Overvoltage category II

42.2 User Interface

- Touch-screen, keyboard, and mouse control.
- Web-based report and configuration file management.
- Full remote control: SNMP or VNC.

42.3 Results

- PDF report generation.
- File export via SD card and USB port.
- Web and SNMP-based file management.
- Configuration and report file storage through USB.

42.4 Operational Ranges

- Operating temperature: −10°C to +45°C.
- Storage temperature: −20°C to +70°C
- Humidity: 5% to 95% (non-condensing).
- Altitude: Up to 3000 m.
- Environmental:
  – Pollution degree II.
  – Dust and rain protection: IEC 60529:2001, IP54.
- Vibration: IEC 60068-2-6 (10~500 Hz, 0.35 mm).
- Shock: IEC 60068-2-27 (150 m/s^2, 11 ms, half-sine pulse).

43. **Ordering Information**

Code	Description
ZEUS.HH	Battery operated, 1 Gb/s Ethernet / IEC 61805 tester with optional IEEE C37.94, E1/T1 and synchronization capabilities. Includes dual 10/100/1000 Mb/s electrical ports, dual SFP ports. GOOSE and SV delay, jitter and frequency analysis, Ethernet QoS statistics, RFC2544 performance test, L2-L4 BER test, continuous / burst / ramp / random traffic generation, traffic statistics, error analysis, connectivity test ('ping', 'traceroute'), analysis filters, event insertion, endpoint and pass-through operation modes, lossless wirespeed traffic capture in PCAP format, graphical display of events, report generation and export. Internal OCXO reference. External clock reference input: GNSS (GPS, GLONASS, Galileo BeiDou), IRIG-B, E1, T1, 2048 kHz, 1544 kHz, 5 MHz, 10 MHz, 1 PPS, 1PP2S and ToD. External clock reference output: IRIG-B, E1, T1, 2048 kHz, 1544 kHz, 5 MHz, 10 MHz, 1 PPS, 1PP2S and ToD.
ZEUS.ETHDUAL	Adds autonomous and simultaneous traffic generation capabilities to both Ethernet ports.
ZEUS.MSTR	Generation over eight independent traffic streams. Eight analysis filters for each test port.
ZEUS.1564	Set up of CIR, EIR and policing rate. Per stream quality objectives. Measurement of Information Rate (IR), Frame Transfer Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR) and Availability.
ZEUS.IPV6	Decoding and analysis of IPV6 datagrams. IPV6 traffic statistics and events. IPV6 packet filtering. TOP IPV6 source and destination addresses (with Network search option).
ZEUS.MPLS	Generation of single or double MPLS label according RFC 3032. Configuration of TTL, Traffic class, Label. Filter selection rules by Label and Traffic class fields. Analysis of MPLS. Top LSPs (with Network search option).
ZEUS.WIRE	Wiremap with open and short circuit detection. Measurement of distance to fault. Crossover / straight cable detection. Measurement of cable skew.
ZEUS.POE	PoE/PoE+ end point and pass through as per IEEE 802.3af and IEEE 802.3at with voltage and current measurement.
ZEUS.NS	Automatic detection of up to 16 most frequent streams listed by IPv4, VLAN and MAC.
ZEUS.ASYM	Enables separated measurement of upstream and downstream performance for RFC 2544 (measurement of throughput, latency, frame loss and back-to-back frames) and eSAM (measurement of the IR, FTD, FDV, FLR and Availability). Enables responder operation in asymmetric RFC 2544 and eSAM tests.
ZEUS.PRPT	Packet Redundancy Protocol (PRP) traffic generation with custom bandwidth profile and layer 2 settings. Single and multiple DAN-P / SAN-P emulation. In units with multistream generation and analysis capabilities generation of up to eight independent PRP traffic streams. In units with PTP testing capabilities, dually attached clock emulation and performance evaluation of PTP applications over PRP. PRP statistics and error detection. Nodes table with individual properties of each DAN-P / SAN-P attached to the network. Skew generation between LAN A and B. PRP event insertion. PRP traffic filtering, capture, decoding and export in PCAP / PCAPNG formats.

Table 8. *Ethernet testing*

Code	Description
ZEUS.E1	ITU-T G.703 2048 kb/s testing including BNC and RJ48 connectors, Single port E1 generation and analysis; ITU-T G.704 frame structure with or without CRC and with or without CAS; internal, recovered and external clock references; CAS ABCD bits generation and analysis; FAS / NFAS analysis; E1 frame occupation map; frequency and received power level measurements; G.821, G.826 and M.2100 performance analysis; round trip delay measurement; service disruption time test.
ZEUS.T1	ANSI T1.102 1544 kb/s testing over RJ-48 connector. Single port T1 generation and analysis; ANSI T1.403 SF (D4) and ESF frame structures with robbed bit generation and analysis; FDL signaling channel; internal, recovered and external clock references; T1 frame occupation map; frequency and received power level measurements; G.821, G.826 and M.2100 performance analysis; round trip delay measurement; service disruption time test.
ZEUS.DATA	DTE / DCE emulation and datacom monitor modes. V24 / V.28 (RS-232) asynchronous and synchronous interfaces, X.21 / V.11 (RS-422) asynchronous and synchronous, V.35, V.36 (RS-449), EIA-530 and EIA-530A.

Table 9. *TDM and Datacom testing*

Code	Description
ZEUS.C3794	Dual port IEEE C37.94 generation and analysis including IEEE C37.94 frame structure; internal, recovered and external clock references; frequency measurements; bit error ratio tests, G.821 performance analysis, anomaly and defect reports, round trip delay measurement, service disruption time test. Optical fibers and SFPs not included.
ZEUS.E0	Generation and analysis in ITU-T variable bit rate co-directional, contra-directional and centralized interfaces including internal, recovered and external clock references; frequency measurements; bit error ratio tests; G.821 performance analysis; round trip delay measurement; service disruption time.
ZEUS.VF	Generation and analysis of voice frequency tests, including frequency, level, noise, round trip delay and frequency sweep analysis.
ZEUS.PULSE	Displays the pulse shape and checks compliance with ITU-T G.703 mask. Includes eye diagram operation mode and analysis of pulse time and level metrics.
ZEUS.VFD	Enables latency tests in VF interfaces.
ZEUS.OWD	Measures end-to-end, one-way delay in ITU-T G.703 2048 kb/s, ANSI T1.102 1544 kb/s, IEEE C37.94, Datacom and VF interfaces. This test runs between two ports in the same unit (E1, T1 IEEE C37.94) or between two compatible test units to be installed in at the ends of the transmission path to be measured (all interfaces).
ZEUS.DUALTDM	Provides dual port traffic generation / analysis and bi-directional pass-through capabilities for ITU-T G.703 2048 kb/s or ANSI T1 102 1544 kb/s port. Plug-in module PHM24 included.

Table 9. *TDM and Datacom testing*

Code	Description
ZEUS.SET	Synchronization testing according to ITU-T G.8261, G.8262, G.8264. Ethernet line frequency (MHz), offset (ppm), drift (ppm/s). Analysis / Generation of ESMC messages. SyncE clock reference inputs.Synchronous Ethernet TIE / MTIE / TDEV measurement. Synchronous Ethernet wander generation.
ZEUS.PTPT	PTP master / slave emulation. PTP passive monitoring. PTP message classification and analysis. PDV analysis. PTP time interval error (TIE), maximum TIE (MTIE) and time deviation TDEV measurement. Floor delay population test. Time error (TE), max TE and path asymmetry test.
ZEUS.PTPT.ADV	Boundary Clock and Transparent clock test (simultaneous PTP master and slave emulation in one unit), Slave Clock test (simultaneous PTP master emulation and clock analysis in one unit), Dual Slave Emulation test with relative Time Error (TE) measurements between both test ports.
ZEUS.NTPT	Network Time Protocol test. NTPv3 / NTPv4 server and client emulation. NTP traffic filtering, classification and analysis. NTP delay, asymmetry and Time Error (TE) statistics.
ZEUS.JW	Peak-to-peak, RMS and max. jitter, jitter hits detection. Configuration of jitter filters. Frequency offset (ppm), frequency drift (ppm/s). Wander metrics (TIE, MTIE, TDEV). Sinusoidal jitter and wander generation.
ZEUS.CLK	1544 kHz, 2048 kHz, 5 MHz, 10 MHz, 1 PPS, 1PP2S and ToD clock monitoring. Clock TE / TIE / MTIE / TDEV analysis, frequency (Hz), frequency offset (ppm) and frequency drift (ppm/s) analysis, jitter / wander analysis.
ZEUS.IRIGB	IRIG-B00X, B12X, B13X, B14X, B15X, B22X monitoring. Balanced and unbalanced inputs. Includes IRIG-B frame analysis, TE / TIE / MTIE / TDEV analysis, frequency offset (ppm) and frequency drift (ppm/s) analysis.
ZEUS.RB	Rubidium time reference. Atomic (Rubidium) internal oscillator replacing standard time reference installed in the application board.
ZEUS.REF.ADV	Replaces the standard GNSS receiver by a multi-band GPS / GLONASS / Beidou / Galileo RF interface (SMA connector). Includes REF IN, REF OUT additional clock reference inputs (SMB connector), REF IN / OUT additional clock reference (RJ-48 connector) and PPS IN addtional test input (SMB connector). Provides absolute time reference required by one-way latency measurements and TDM, Synchronous Ethernet and IEEE 1588v2 synchronization tests. Provides hardware support for additional clock test signals.

Table 10. *Synchronization testing*

Code	Description
VNC.RC	Based on VNC for Windows and Linux. Ethernet / IP remote control that duplicates the tester graphical user interface in a remote computer.
AT.WIFI.RC	Provides WiFi interconnection to the management interface in accordance with IEEE 802.11g, IEEE 802.11b and IEEE 802.11n standards.
SNMP.RC	Allows user to control the tester remotely using SNMP queries.

Table 11. *General Purpose Options*