

## Specifications

1588 (PTP) (options 25x and 201, option PFV)	
<b>Master/Slave Emulation</b> (Option 25x)	Emulate up to two 1588 masters with full parametric control and Time Error/PDV/protocol anomaly impairment functions. Each master can have up to 8 attached slaves.  Emulate 1588 slave; calculate and display: PTP Time Error, 1 pps Time Error/ToD accuracy, TC CorrectionField accuracy, BC Time Error.
<b>Additional features for End-to-End</b> (Option 250/253)	Automatic configuration for e.g. ITU-T Phase Profile, 2-Way Time Error metrics, plus flexible user configuration.
<b>Additional features for Peer-to-Peer</b> (Option 252/253)	Automatic configuration for e.g. IEEE 802.1AS gPTP, Turnaround Time and Rate Ratio metrics.
<b>Header Capture and Alarms</b>	MessageType, TransportSpecific, VersionPTP, MessageLength, DomainNo, Flags, CorrectionField, SourcePortIdentity, SequenceID (errors highlighted), ControlField, LogMessageInterval, OriginTimestamp.
<b>Graphs Displayed</b> (Calnex Analysis Tool, CAT)	PTP Time Error (dTE, cTE, Max TE ), Transparent Clock accuracy, latency. Packet Delay Distribution. PacketMTIE/TDEV, MAFE, MATIE. Sync PDV ( <b>Master-to-Slave PDV</b> ), Delay_Req PDV ( <b>Slave-to-Master PDV</b> ), Slave Clock Wander (T3), Follow-up PDV, Delay_Resp PDV, PDelay_Req PDV, PDelay_Resp PDV, Delay Distribution Curve/Histogram.
<b>Standards Supported</b>	ITU-T G.826x/7x, MEF-18, IEEE/IEC 61850-9-3, IEEE C 37 238, IEEE 802.1AS
<b>PTP Field Verifier (PFV)</b>	Decode and display PTP Fields. Display Pass/Fail to standards-based or user-defined rules. Report Generation capability.
<b>PDV Editor Suite</b>	Edit any PDV file from the graphs. Profile Edits: Extract, Repeat, Copy, Paste (Replace or Insert); Modulate, Scale (%), Banding (Deplete or Concentrate); Adjust Delay Floor.
<b>Measurement Accuracy</b>	5 ns.
SyncE (options 213, 207, 208, 223)	
<b>Jitter/Wander Measurement</b>	To ITU-T G.8262 and O.174 – jitter/wander generation, wander transfer, jitter/wander tolerance, phase transient. Built-in frequency offset plus sinusoidal, MTIE and TDEV wander generation.
<b>MTIE/TDEV Analysis</b>	Built-in Calnex Analysis Tool (CAT) software with ITU-T and masks with Pass/Fail indication.
<b>SyncE Master</b>	Accuracy traceable to Reference source used (refer to Reference Clocks).
<b>Measurement Accuracy</b>	1 ns.
<b>ESMC (SSM) Features to G.8264, G.781, etc</b>	Decode ESMC messages to ITU-T G.8264 and plot Quality Level (QL) changes graphically (bi-directional). QLs: PRS, PRC, INV3, SSU-A/TNC, INV5, INV6, ST2, SSU-B, INV9, EEC2/ST3, EEC1/SEC, SMC, ST3E, PROV, STU/UKN, DNU/DUS.  Overwrite ESMC Message to change QL status.  Support for ESMC Decode and SyncE in 1588 mode (for concurrent SyncE and 1588 implementations).  Integrated display in Calnex Analysis Tool (CAT).
<b>ESMC Generation</b>	Generate ESMC (SSM) packets per ITU-T G.8264  QLs: PRS, PRC, INV3, SSU-A/TNC, INV5, INV6, ST2, SSU-B, INV9, EEC2/ST3, EEC1/SEC, SMC, ST3E, PROV, STU/UKN, DNU/DUS. Generate ESMC messages, change QL value and measure impact on wander.
Ethernet OAM (option 301)	
<b>Capture and Decode</b>	Packet Number, Arrival Time, Ethernet Destination Address, Ethernet Source Address, OAM Message Type, MEP ID, RDI, Period fps, TransID, TxFCf, RxFCf, TxFCb, Tx Timestamp(f), Rx Timestamp(f), Tx Timestamp(b), Rx Timestamp(b), Maintenance Domain Length, Maintenance Domain Name, Short MA Name Format, Short MA Name Length, Short MA Name, Time To Live, Origin MAC, Target MAC, Relay Action, OUI, TLV Offset, TLVs.
<b>Round-trip Delay</b>	Based on DMM/DMR messages. Displayed in table and graph. MEF and ITU-T delay methods supported.
<b>View Filtering</b>	MAC addresses and OAM Message types.
<b>Standards Supported</b>	ITU-T Y.1731, IEEE 802.1ag, IEEE 802.3ah, ITU-T G.8031, ITU-T G.8032
<b>Message Filters for Corruption and Delay</b>	CCM, LBM, LBR, LTM, LTR, AIS, LCK, TST, APS, MCC, LMM, LMR, 1DM, DMM, DMR, EXM, EXR, VSM, VSR. Any combination of above messages. CCM at 1 s and 3.33 ms both supported.
<b>Impairments and Delay</b>	Lost, Misordered, Repeated, Errored, AIS/LCK/RDI Generation, Fixed Delay, Variable Delay.
<b>Header Overwrite</b>	Ethernet Header or OAM Header – overwrite any bit (first 128 bytes) with hex or binary value or invert.
<b>Multi-MEG Mode</b>	Capture information for 1000s of MEGs including Eth Dest, Eth Src, SVID, CVID, MEL, MEP ID, OAM Message Count, AIS, RDI, CCM, CCM fps, etc.
NTP (option 404) and CES (option 202)	
	<div> <b>NTP</b>            Any packet rate.            Protocols            NTP (up to v4).            Header Capture and Alarms            Version, Mode, Stratum, Poll, Precision, Root Delay, Root Dispersion, ReferenceID, Reference Time, Origin, Receive, Transmit.            Graphs Displayed            Inter-Packet (Reserved_0, Sim_Active, Sim_Passive, Client, Server, Broadcast, Control, Reserved_7, all), Client PDV (<b>Client-to-Server PDV</b>), Server PDV (<b>Server-to-Client PDV</b>), RTD Variation. Delay Distribution Curve/Histogram.         </div> <div> <b>CES</b>            T1, E1, T3, E3 or Any.            SAToP, CESoPSN, TDMoIP.            L, R, M, FRG, Length and Sequence # (errors highlighted).            L, R, M Alarm Injection.            TIE vs Nominal, TIE vs Measured Average, Delay vs Packet #, Inter-packet Time (vs Time and vs Packet #), Delay Distribution Curve/Histogram.         </div>
<b>Standards Supported</b>	G.8261 (Test Cases 1 – 17), G.8273.2 and MEF-18.
<b>PDV Editor Suite</b>	Edit any PDV file from the graphs. Profile Edits: Extract, Repeat, Copy, Paste (Replace or Insert); ModulateScale (%), Banding (Deplete or Concentrate); Adjust Delay Floor.

Advanced Time of Day (option 230)	
<b>Time of Day (ToD) Emulation</b>	Generate ToD messages to CCSA, NMEA and ITU-T standards. <b>Control Fields/Values:</b> Event Message: TimeSource Type, TimeSource Status, TimeSource Alarms. Information Message: Leap Seconds, PPS Status, TAcc.
<b>Time of Day Measurement</b>	Decode and display ToD fields. Highlight errors e.g. CRC, Second jumps. Validate ToD alignment to 1 pps. Compare ToD and PTP message and status.
<b>Measurement Accuracy</b>	1 ns.
Wander Measurement on Other Frequencies (option 205)	
<b>Software Option 205</b>	For E1/T1/2 MHz Wander measurement including TIE/MTIE/TDEV and ITU-T Masks.
Phase and Time Measurement (option 206)	
<b>Software Option 206</b>	For 1 pps Time Error measurement (1 pps accuracy) in nanoseconds – measure 1 pps Time Error relative to 1 pps reference.
Network Emulation (options 708, 709, 710)	
<b>Selection of flow from multi-flow environment</b>	Automatic detection of flows and filter setup using Flow Wizard. Filters: any 1 to 64 bytes within the first 256 bytes of the frame. Integrated Wireshark decode.
<b>Impairment Profiles</b>	Select at time of purchase – 4, 8 or 16 Profiles (optional) <ul style="list-style-type: none"> <li>• 4 Profiles allows all impairments to be configured individually for up to 4 Flows (up to 2 bi-directional profiles).</li> <li>• 8 Profiles allows all impairments to be configured individually for up to 8 Flows (up to 4 bi-directional profiles).</li> <li>• 16 Profiles allows all impairments to be configured individually.</li> </ul>
<b>Packet Corruption</b>	Errored packets, Lost packets, Repeated packets (1 to 10000), Mis-ordered packets (1 to 32). Corruption modes: single, burst, rate (%), ratio (xE-y), constant.
<b>Latency/Delay and PDV/Jitter</b>	(a) Step waveform profile. (b) Gamma distribution of delays. (c) Gaussian distribution of delays. (d) Apply fixed delay to the filtered packets.
<b>Maximum Delay</b>	8 seconds at 1 G (100 M: 80 s, 10 G: 0.8 s)
<b>Bandwidth Control</b>	Control bandwidth throttle and buffer depth per profile. Preset and user-defined bandwidths. Basic mode and advanced policing and shaping mode.
General	
<b>Physical Interfaces</b>	<b>Ethernet</b> 100 M Electrical (RJ45), 100 M Optical – SGMII*. 1 G Electrical (RJ45), 1 G Optical – SFP. 10 G Optical (if option 111 fitted) – XFP or SFP+ (LAN-PHY). <div>*PTP PDV, NTP, CES, Services</div>
<b>Reference Clocks</b>	Lock internal timing reference to external reference. Reference Lock soft LED indication. External reference inputs: 64 kHz, 2.048 MHz, 10 MHz; T1 BITS clock; E1 MTS, SyncE. Internal reference Stratum-3, $\pm 4.6$ ppm.
<b>PC Control Interface</b>	Any standard PC or laptop running Windows 8 or 10. RJ45 LAN connection to instrument.
<b>TCP/IP Settings</b>	TCP Port, IP Address and Gateway settable.
<b>Automatic Flow-selection in Multi-flow Environment</b>	Automatic filter setting for 1588 in Master/Slave Emulation mode. Automatic detection of OAM (MEGs), 1588, CES and other flows and filter setup using FlowWizard. <b>Filter (1 to 64 bytes):</b> Setup messages for capture and replay. Select OAM type within a MEG flow. Select 1588 Message type(s) or groups. Integrated decode using industry-standard tool, Wireshark. Additional PTP analysis capability with PFV.
<b>Packet Capture Memory</b>	Capture complete packet and display contents. The filters can specify the packet types to be captured. Internal (2 Gb) or External (via USB).
<b>Graph Manipulation</b>	Zoom in (X and Y), Zoom out (X and Y), Marker 1, Marker 2, Min/Max display in nanoseconds.
<b>Impairments – Delay</b>	
<b>Fixed Delay</b>	6 $\mu$ s to 10 s.
<b>Variable Delays</b>	Gaussian, Gamma, User Defined – stored PDV profiles or captures from networks, G.8261 and MEF-18 Test Cases, Sawtooth – Systematic, Beating (F) and Beating (S), Step Function, Latency Ramp.
<b>1588 Delays applied to:</b>	Packet Sending Time, CorrectionField or Both.
<b>Impairments – Corruption</b>	Misordered, Lost, Repeated or Errored Packets.
<b>Control</b>	Single, Burst (1 to 10000), Duration (0.1 s to 10 s), Rate (0.00001% to 99.99999%), Ratio ( $1 \times 10^{-7}$ to $9 \times 10^{-1}$ ) or Constant.
<b>Overwrite Header</b>	Any bytes with any value in first 128 bytes.
<b>Switch Simulation</b>	Independently set: Latency, Buffer Depth (1 byte to 256 kbytes), Bandwidth (0% to 100%).
<b>Timing Measurements (Options 205, 206, 230)</b>	E1/T1 wander – TIE, MTIE, TDEV analysis with ITU-T masks - sample rate 0.1 Hz to 100 Hz. 1 pps accuracy – recovered slave clock 1 pps vs reference. ToD analysis.
<b>Simultaneous Measurements</b>	Chosen packet measurements can be performed simultaneously with all timing measurements (SyncE and Clock wander, 1pps Accuracy, ToD analysis).
<b>Remote Control</b>	Scripting via TCL, Perl and Python.
<b>Operation and Regulatory</b>	CE and EMC (incl. EN-61010, EN-61326, etc.) certified. Voltage 85 - 246 VAC, 100 - 240 VAC (Nominal) @ 50/60 Hz.
<b>GPS Antenna, Receiver and Rb Ref. (Option 132)</b>	PRS/Stratum 1 (GPS-locked): typical $1 \times 10^{-12}$ Outputs: 10 MHz, 1 pps.