VePAL TX130M+

DSn/PDH and Ethernet Test Set for Legacy and Synchronized Packet Networks

VeEX™ VePAL TX130M+ is a full-featured Mobile Backhaul test solution supporting legacy PDH/DSn, Carrier Ethernet technologies, and Synchronized Packet networks.

Platform Highlights

- Intuitive presentation of measurements with test graphics
- High resolution color touch-screen viewable in any lighting conditions fitted with protective cover
- Robust, handheld chassis packed with powerful and flexible features for demanding environments and test conditions
- Ethernet port and connection for back office applications, workforce management and triple play service verification
- User defined test profiles and thresholds enable fast, efficient and consistent turn-up of services
- USB memory stick support and FTP upload capability for test result storage and file transfer respectively
- Maintain instrument software, manage test configurations, process measurement results and generate customer test reports using included ReVeal™ PC software
- Extend field testing time using interchangeable Li-ion battery pack
- Perform remote testing and monitoring using the remote control option via standard Ethernet interface

Ethernet Features

- 10/100/1000Base-T Copper interface
- 1000Base-X & 100Base-FX Optical interfaces
- BERT, Throughput, Loopback, RFC2544, V-SAM (Y.1564)
- OAM (IEEE 802.3ah, IEEE 802.1ag, ITU-T Y.1731)
- Advanced IP Testing: Network discovery, HTTP/FTP test, VoIP, IPTV

SyncE/IEEE 1588v2

- Fully integrated solution for synchronized packet networks
- Supports IEEE 1588v2/PTP and SyncE/ITU-T G.8261 standards
- Master Clock and Slave clock emulation
- IEEE 1588v2/PTP protocol monitoring and decoding
- IEEE 1588v2/PTP PDV analysis
- Clock recovery from SyncE or PTP and output to E1 or DS1 port
- Wander measurement of SyncE or 1588v2/PTP recovered slave clock
- ESMC SSM generation, monitoring, and decoding
- Dual PDH/DSn & Ethernet testing with synchronized clocking

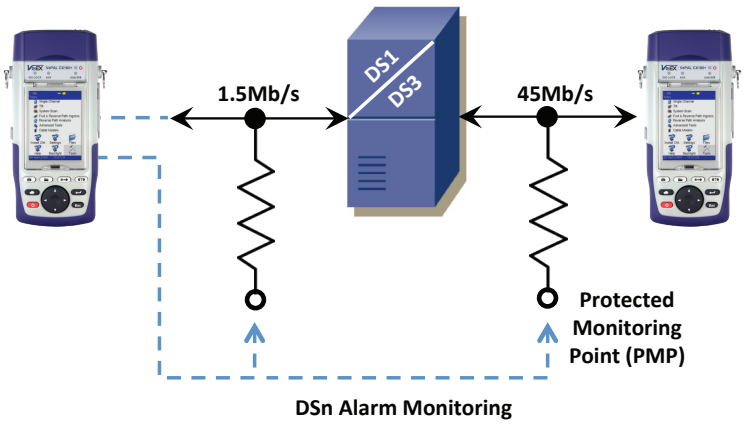
PDH/DSn Features

- Supports DS1, DS3, E1, E2, and E3 bit rates
- Dual Rx BERT on DS1, DS3 and E1 ports
- Full rate DS1, E1 and fractional Nx56 kbps or Nx64 kbps
- Non intrusive Pulse Mask Analysis
- Bit Error and Performance Analysis per ITU/Bellcore standards
- Histogram and Event Analysis for errors and alarms
- VF drop/insert via headset
- VF tone generation and measurement
- ISDN PRI (ANSI and ETSI) call set up and analysis
- Jitter Measurement
- Wander Measurement on E1
- Transmit Frequency Offset to stress clock recovery circuits

PDH/DSn

Transmission Testing

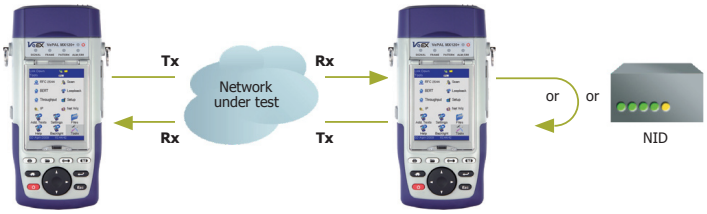
The TX130M+ is perfectly suited for both in-service and out-of-service measurements on PDH/DSn legacy TDM networks. Out-of-service testing usually applies to the installation, commissioning and the "bringing into service" measurements needed to qualify a digital transmission link using industry standard test patterns and methods. In-service testing is an important, ongoing maintenance task - field technicians can monitor PCM signals for errors, alarms, level, frequency and pulse shape to prevent service degradation. The transmitter and receiver can be configured independently to perform MUX tests and round trip delay measurements are possible at various points across the network using any of the test interfaces.



Ethernet

End-to-End Performance Testing

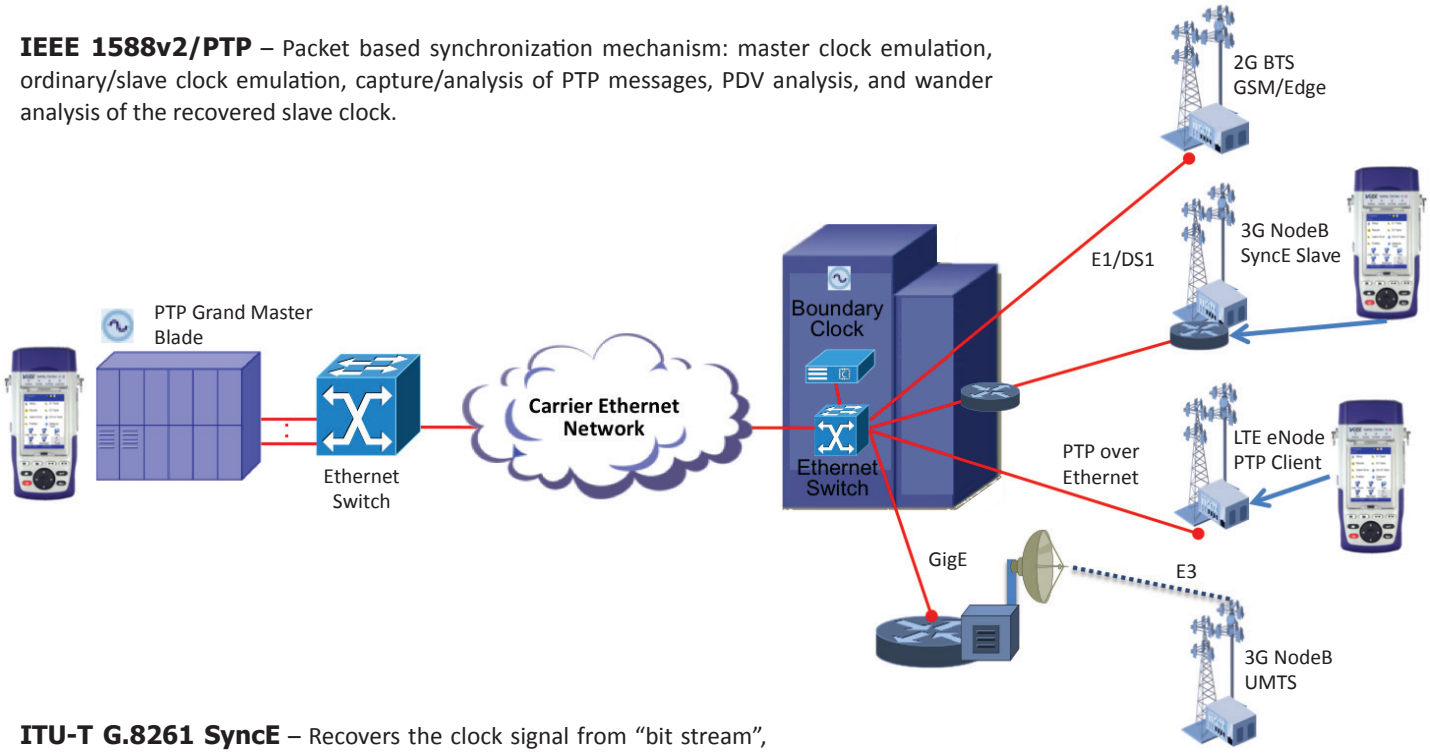
Irrespective of Ethernet service being installed, it is always necessary to verify that the network can carry out and cope with the allocated bandwidth required by the customer. Service Level Agreements (SLA) thus compel service providers to measure network throughput and other performance characteristics to ensure that bandwidth associated with different service types conform to customer expectations.



Synchronized Network

Synchronized Packet Network and Mobile Backhaul Testing – Mobile operators confronted with the explosive growth of data-centric services driven by 3G and LTE Smartphone applications, are urgently upgrading and migrating traditional TDM backhaul networks to Ethernet/IP packet-based technologies. The TX130M+ tester equipped with a variety of interfaces and applications is perfectly equipped to test both PDH/DSn and packet transport over copper and fiber backhaul connections across the Radio Access Network (RAN).

IEEE 1588v2/PTP – Packet based synchronization mechanism: master clock emulation, ordinary/slave clock emulation, capture/analysis of PTP messages, PDV analysis, and wander analysis of the recovered slave clock.



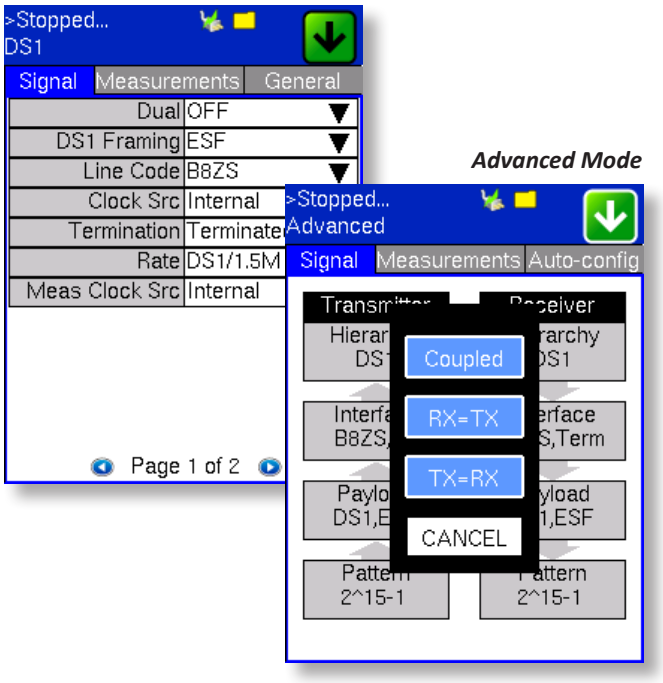
ITU-T G.8261 SyncE – Recovers the clock signal from "bit stream", similar to traditional SONET/SDH/PDH. Wander and frequency measurement of the recovered slave clock.

PDH/DSn Features

Quick and Easy Graphical Setup

Complex daily tasks are common in today's network environment, so technicians need a tester that is easy to configure and which doesn't require extensive product training beforehand.

The test interface, signal structure, and test pattern setups are structured logically ensuring quick and efficient configuration. An intuitive graphical menu and a list of shortcuts provides fast access to commonly used DSn or PDH test functions boosting productivity.

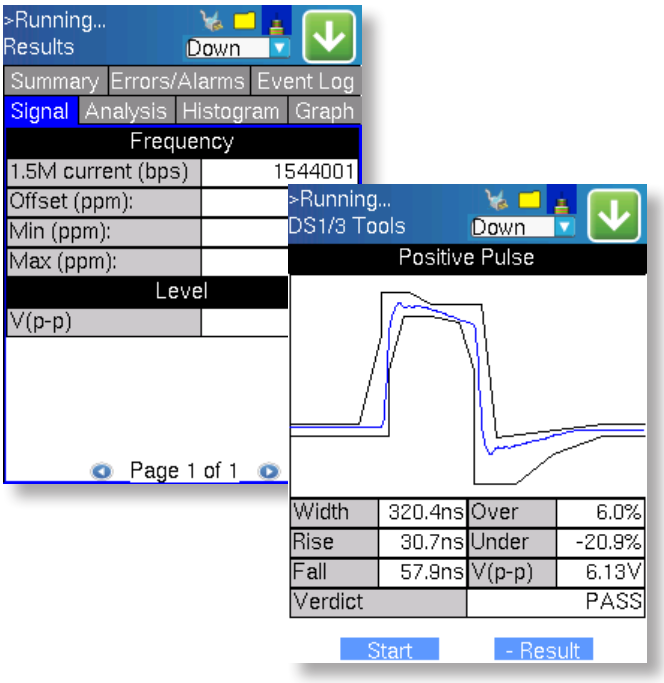


Physical Layer Testing

Prior to performing digital measurements, technicians should confirm analog parameters fall within prescribed limits.

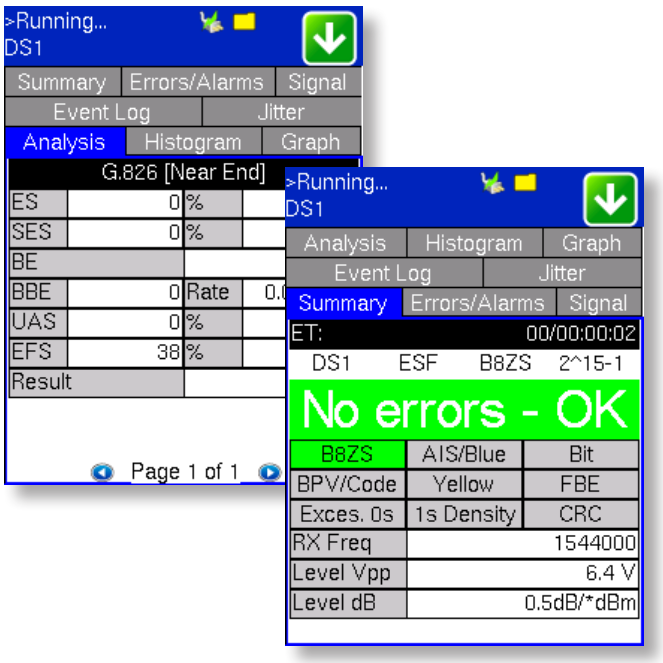
Clock tolerances for each signal hierarchy defined by ITU-T and ANSI recommendations can easily be verified.

Incorrect pulse shape is a result of excessive cable length, impedance mismatch, or poor transmitter design. The G.703 pulse mask option quickly identifies related problems.



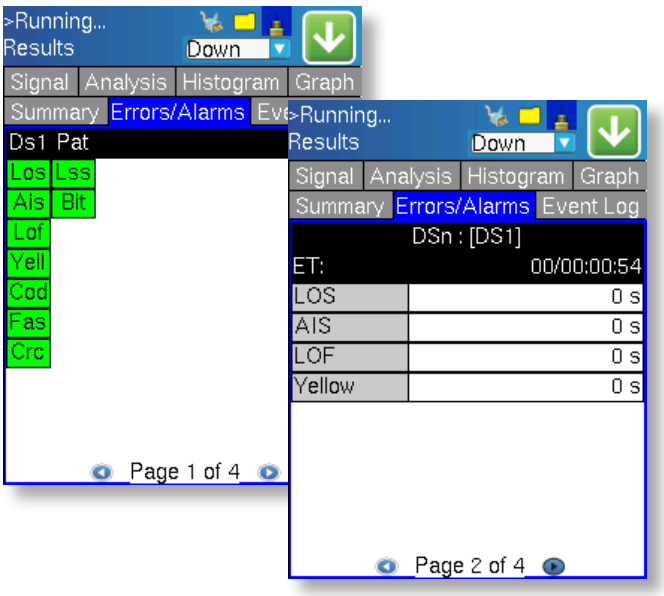
Performance Analysis Summary

The summary screen displays Pass/Fail criteria for each major parameter. A large color coded message informs or alerts the technician of the circuit's status. The Analysis tab reports test performance per ANSI, Bellcore or ITU-T recommendations.



Errors and Alarms

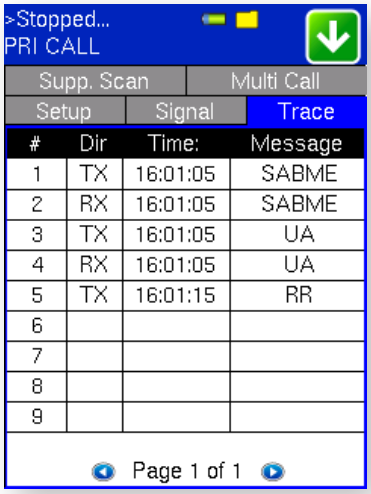
BER testing is commonly used to verify continuity across a digital link, to check for faults, and for performing acceptance tests. Equipped with an extensive range of test patterns including the ability to inject errors in the pattern, framing and alarm bits, the TX130M+ quickly evaluates circuits and examines error responses. Anomalies (errors) and defects (alarms) are clearly displayed and recorded for each network segment, and are logged for further analysis.



ISDN Testing

The ISDN option provides key functionality necessary for testing and troubleshooting DS1 or E1 Primary Rate connections. Operating in TE or NT modes, the unit is able to setup and receive ISDN calls with user-defined parameters including call control protocol, called number and related facilities.

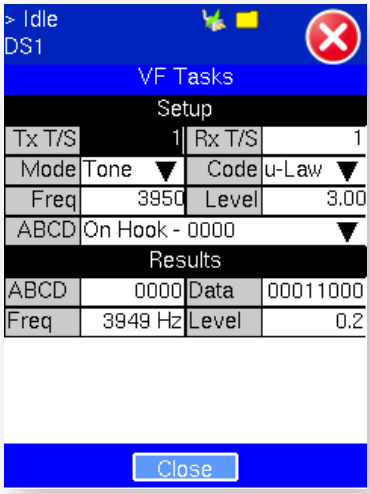
Protocol functions feature detailed signaling statistics, message monitoring and decode, and complete result presentation. With these capabilities, analysis of international and national ISDN, and other access protocols is possible.



VF Testing

The Voice Frequency (VF) option is a basic diagnostic tool to install, verify and troubleshoot voice circuits. Digital to analog conversion tests are performed by inserting/measuring tones with user defined frequency and level on selected sub-rate channels.

A microphone/headset adaptor enables Talk/listen capability on a selected timeslot while a powerful function allows VF decoding at all DSn/PDH rates.



Jitter Measurements

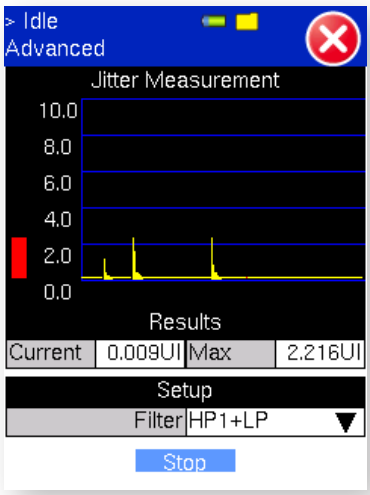
Data integrity in plesiochronous networks depends largely on the phase stability of clock and data signals, therefore excessive jitter can cause network outages. Because BER testing is the common method to diagnose network problems in the field, results often mislead the technician because only the effect of a problem and not the actual cause is reported. Ultimately, this makes fault identification more difficult, time consuming, and expensive.

The jitter software option of the TX130M+ uses advanced digital measurement techniques for measuring intrinsic jitter, allowing technicians to easily determine when jitter is the source of errors.

Jitter Metrics

Output jitter performance mandated by ITU-T and Telcordia standards is evaluated by measuring the recovered clock of the incoming signal (DS1, DS3, E1, E3) traversing the network.

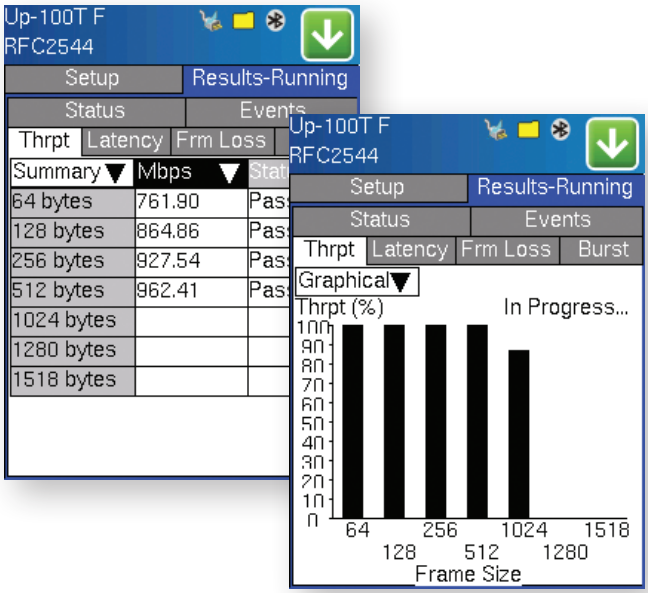
While the test duration is not defined in the mentioned standards, a measurement period time of 1 minute is recommended. Specified in unit intervals (UI), the maximum Peak-to-Peak Jitter is the most important parameter because Max values are indicative of performance, as these extremes generally cause errors. While jitter is defined as any phase variations above 10 Hz, the incoming signal must be filtered in order to measure jitter – the user is therefore able to select between Wide band and High band filters to adjust the measurement bandwidth as required. Visual Pass/Fail indication based on G.823 limits.



Ethernet Features

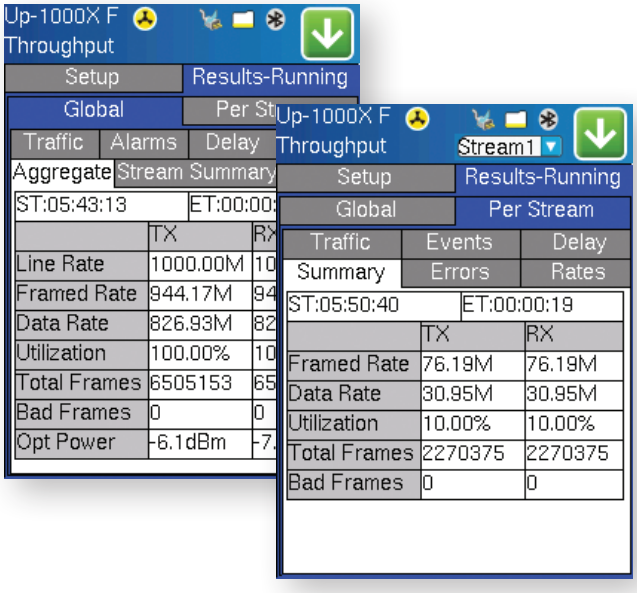
RFC2544 Compliance Testing

Performs the RFC2544 automated test suite at all recommended frame sizes including user configurable frame sizes and up to full line rate. The test suite can also be performed with the far end test partner in loopback mode or peer-to-peer mode - the latter allowing for symmetrical/asymmetrical testing. Thresholds may be configured for accurate SLA assurance and verification. The automated tests supported are throughput, latency, frame loss, and back-to-back frames.



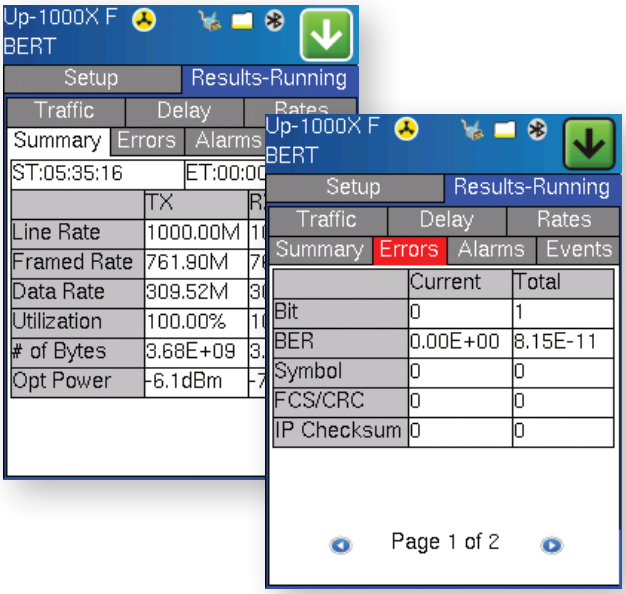
Multiple Streams Generation - Throughput Test

Up to eight traffic streams can be independently configured with CoS (VLAN priority) and QoS (TOS/DSCP) prioritization. This traffic feature, simulates multiple service conditions (e.g. Triple Play), and facilitates end-to-end QoS performance verification. The multiple stream throughput test may be performed with a second test unit at the far end in Smart Loop mode or Peer-to-Peer mode.



BERT

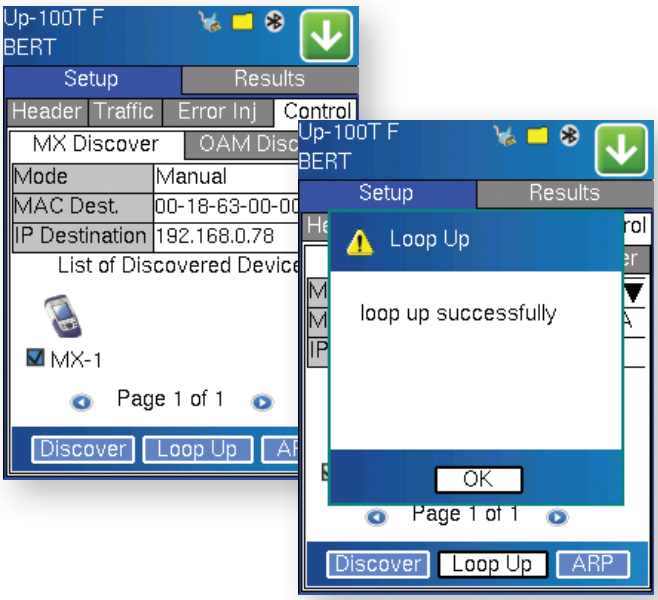
Unframed Layer 1, 2, 3, and Layer 4 BER testing is supported. The BER test can be configured to use regular PRBS test patterns, stress patterns or user defined test patterns to simulate various conditions. All patterns are encapsulated into an Ethernet frame to verify bit-per-bit performance of circuit under test.



One traffic stream is transmitted across the network under test and bit-per-bit error checking is then performed on the received traffic. Service disruption measurements as well as CRC error checking are also performed. The BER test can be performed with a physical loop (or plug) at the far end (for a layer 1 circuit), or a second test unit or intelligent loopback device in Smart Loop or in Peer-to-Peer mode.

Intelligent Network/Device Discovery

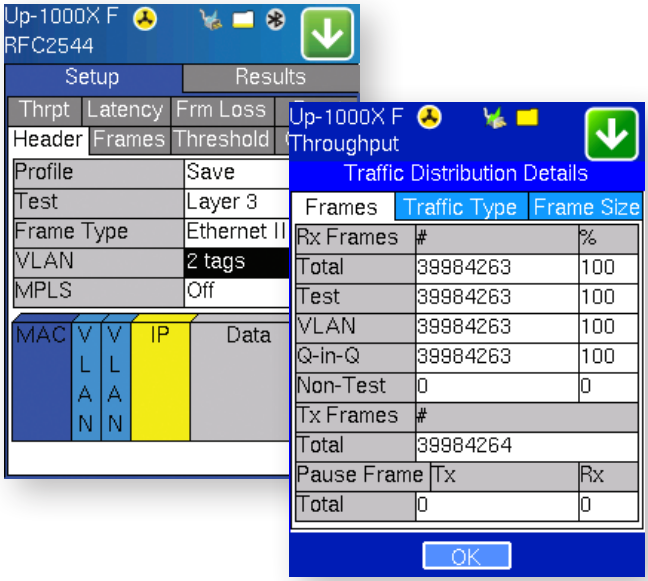
Easily discover and select another VeEX Ethernet tester or loopback device on the network under test for loopback testing applications. The local device will control the operation of the far end device, in either loopback or peer-to-peer mode (or symmetrical or asymmetrical traffic generation mode). This feature greatly simplifies field testing since there is no need for a second technician to be at the far end configuring the test partner device.



Ethernet Features *cont'd*

Q-in-Q (VLAN stacking)

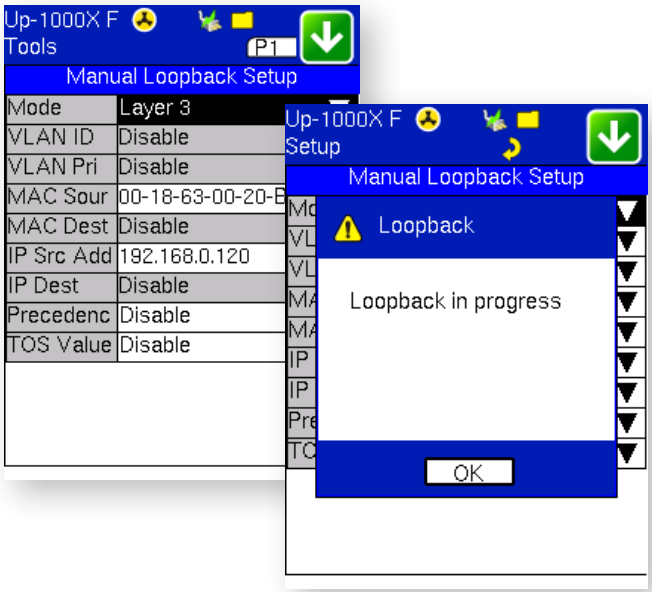
For Metro and Carrier Ethernet applications, VLAN stacking, also known as Q-in-Q, is supported. This feature makes a provision for carrier/service provider assigned VLANs, but also retains the VLAN of customer traffic.



Smart Loopbacks

Four modes are available for looping back test traffic. At Layer 1, all incoming traffic is looped back unaltered. For Layer 2, all incoming unicast traffic is looped back with the MAC source and destination addresses swapped. For Layer 3, all incoming unicast traffic is looped back with the MAC and IP source and destination addresses swapped, and for Layer 4, all incoming unicast traffic is looped back with the MAC, IP, and UDP/TCP ports swapped.

This feature also supports configurable traffic filter on all MAC, IP, and VLAN fields to allow full control over looped traffic.



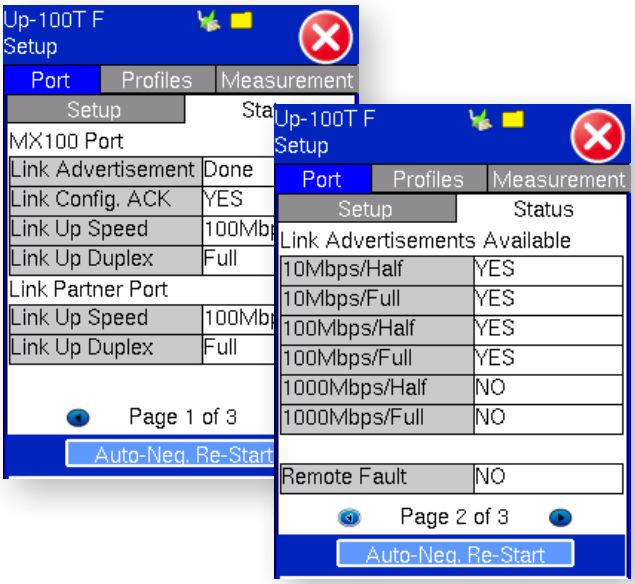
VLAN Scan and Traffic Monitor

Scan up to 4096 VLAN IDs for switch configuration verification. Verify which VLAN IDs are the top bandwidth users and monitor up to eight live traffic streams (in terminate mode).

Test Port Status

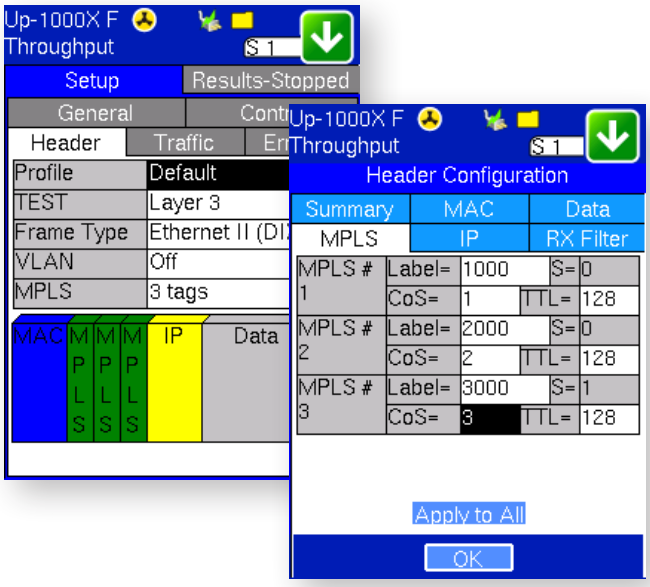
Auto-negotiation is a function that enables Fast Ethernet devices to automatically exchange information over a link about speed and duplex abilities. A common cause of performance issues on 10/100T Ethernet links occurs when one port on the link operates at half-duplex while the other port operates at full-duplex.

The port status feature of the TX130M+ reports the auto-negotiation and link advertisement parameters of both test set and link partner, which helps to reduce many link performance-related support calls.



MPLS Measurements

Multiple Protocol Label Switching (MPLS) is a technology that allows for a more efficient routing of Ethernet/IP packets via the use of MPLS routers in the network. MPLS labels reside between the MAC (Layer 2) and IP layers (Layer 3). Up to three MPLS tags can be configured in the traffic stream with user configurable Label, CoS, and TTL fields.



Ethernet Features *cont'd*

Auto Scripting

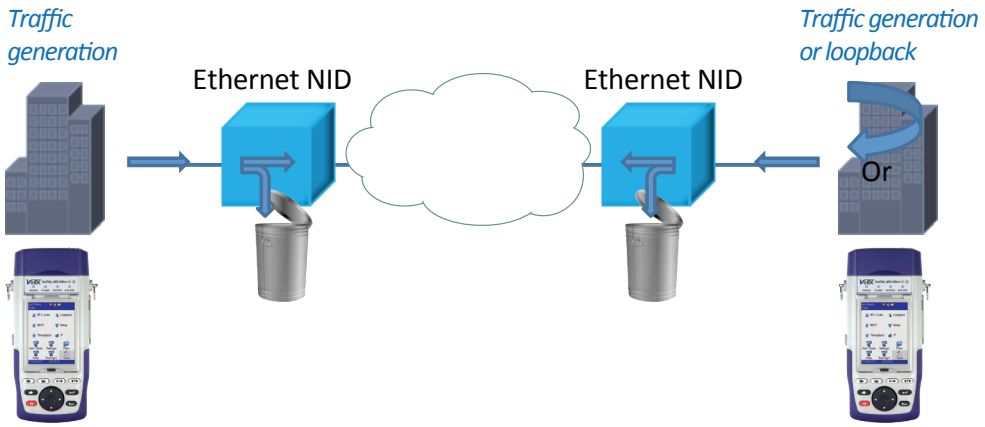
The Auto Scripting feature is the perfect tool for the lab environment where multiple short-term or long-term test configurations are required to stress the network equipment and/or network under test, in order to measure and qualify the performance capabilities. The feature is also important in field 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, the test sequence will begin with the first profile configured with its corresponding duration, followed by each profile after that. At the end of a test, each profile's test result is stored automatically before the test sequence continues to the next profile.

V-SAM Test

VeEX's V-SAM test suite is fully compliant with ITU-T Y.1564 and offers an efficient method to qualify and troubleshoot Ethernet Services. V-SAM addresses some of RFC2544 limitations by testing multiple services at once and providing simultaneous measurements of key SLA parameters.

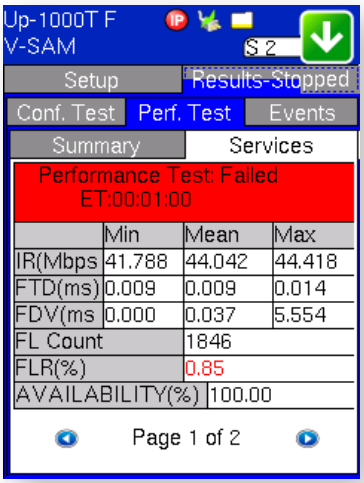
The purpose of the SAM test suite is to verify that the service is compliant to its Bandwidth Profile and Service Acceptance Criteria. The test is broken down into two phases:

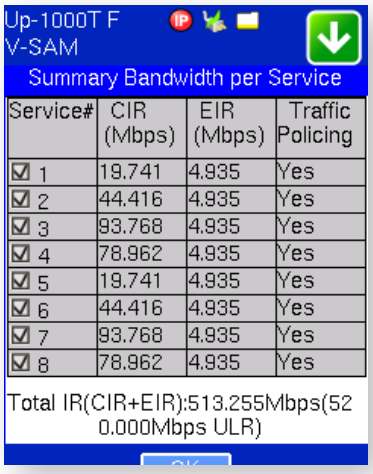
- Phase 1: Service Configuration test. The services running on the same line are tested one by one to verify the correct service profile provisioning.
- Phase 2: Service Performance test. The services running on the same line are tested simultaneously over an extended period of time, to verify network robustness.



This test suite was designed with the end user in mind and allows for quick provisioning, execution and analysis of the test results, even without prior detailed knowledge of the standard:

- Test profiles can be stored and recalled, and even created offline on a PC and loaded on the test set, to facilitate quick setup.
- A visual Pass/Fail banner and summary tables provides a quick overview of the status of all services.
- Color highlighting the failing parameters facilitates a quick understanding of the problem if troubleshooting is required.

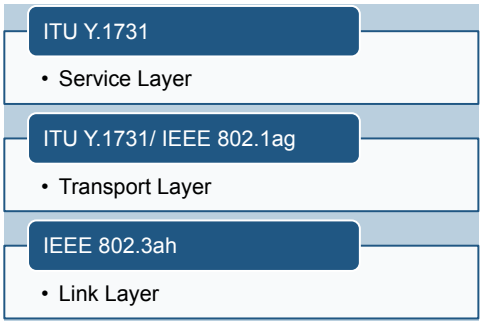




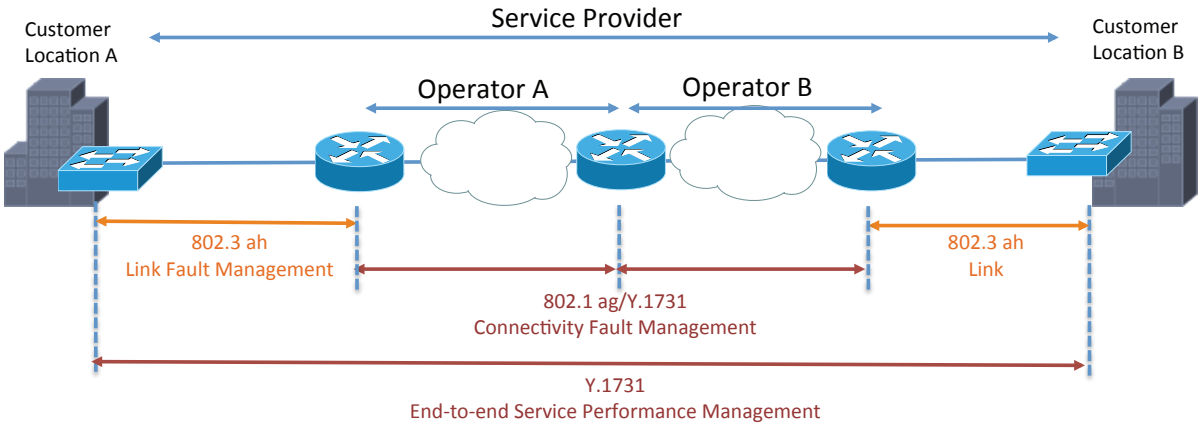
OAM

To achieve Carrier Class Ethernet, networks need to be managed and monitored by service providers in order to guarantee SLAs, and need to support automated defect detection and performance measurement. Standard bodies have developed protocols to achieve this.

- IEEE 802.3ah OAM for single segment “first mile” link fault management
- IEEE 802.1ag and ITU Y.1731 OAM for transport connectivity fault management
- ITU Y.1731 for end to end service level performance verification



The TX130M+ offers a complete tool set for Link Level (IEEE 802.3ah) and Service Level (IEEE 802.1ag/ ITU- Y.1731) OAM for monitoring and maintaining carrier grade Ethernet services.



Link Fault Management testing with 802.3ah OAM offers a full set of capabilities including:

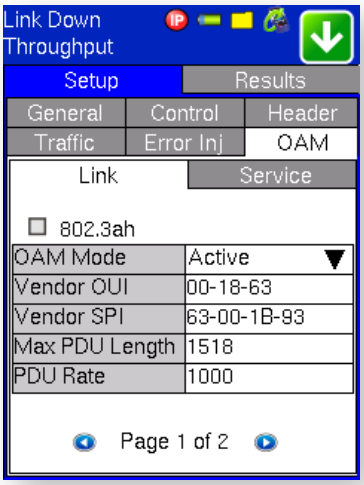
- Discovery mechanism to verify capabilities and provisioning of link partner
- Remote Loopback command for link performance testing
- Critical Link Event Notification

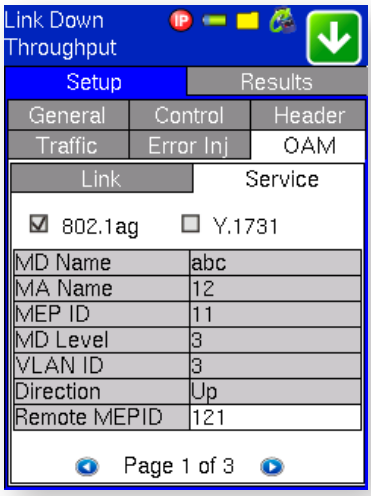
Connectivity Fault Management testing with 802.1ag and Y.1731, capabilities include:

- Linktrace message to perform path discovery
- Loopback message to test connectivity and isolate faults
- Continuity check messages to detect connectivity issues

Performance Management testing with Y.1731, capabilities include:

- Frame Loss Measurement (ETH-LM) function for service frame loss ratio measurement
- Delay Measurement (ETH-DM) function for frame delay and frame delay variation measurement



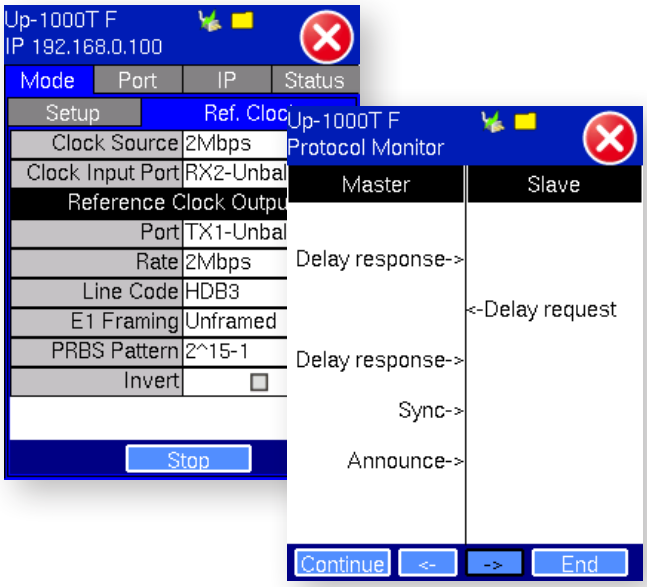


Synchronized Network Features

IEEE 1588v2/PTP Master Clock Emulation Mode

Master Clock emulation allows network synchronization properties to be verified prior to service delivery or during routine maintenance tasks. Using the internal precision clock or an external 1.544 Mbps, 2.048 Mbps, 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, or 1 PPS signal as the reference clock, the unit generates the PTP messages needed by a Slave device to synchronize.

The reference clock can further be applied to an outgoing 1.544 Mbps or 2.048 Mbps signal via balanced RJ45 or bantam interfaces or alternatively a 1.544 Mbps, 2.048 Mbps, 10 MHz, 25 MHz, 125 MHz, or 1 PPS signal can be generated on the unbalanced BNC port for other synchronization requirements. In this mode, the unit can be programmed to generate PTP messages at different rates to reduce or introduce network congestion.



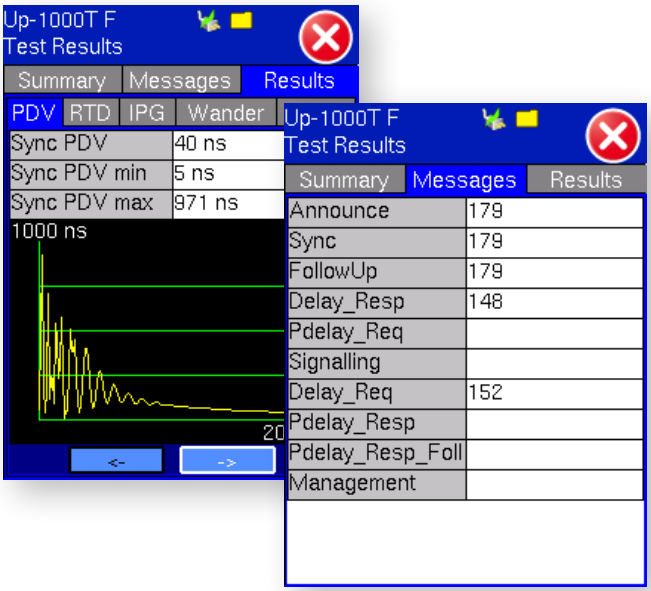
Ethernet Testing

Generate and analyze Ethernet test traffic in conjunction with 1588v2/PTP Master or Slave emulation.

IEEE 1588v2/PTP Slave Clock Emulation Mode

Emulates a Slave Clock device where synchronized clock is extracted using the PTP procedure. The extracted clock can be applied to an outgoing 1.544 Mbps or 2.048 Mbps signal on the DS1/E1 balanced test port or a 1.544 Mbps, 2.048 Mbps, 10 MHz, 25 MHz, 125 MHz, or 1 PPS reference signal can be made available on the unbalanced BNC port. After an IP layer connection is achieved, clock identities are exchanged between the test unit and the far end Master clock device. The PTP messages can be monitored and decoded.

In the Summary tab, an overview of the Total, CRC, lost, error, out of order and duplicated messages are displayed. The Message tab provides a concise record of all PTP message related items, while the Results tab provides detailed statistics and values for Packet Delay Variation (PDV), Round Trip Delay (RTD) and Inter-Packet Gap (IPG). Clock and Wander are measured against a reference clock (1.544 Mbps or 2.048 Mbps or 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, or 1 PPS).



ITU-T G.8261 SyncE Master Clock Emulation Mode

The reference clock can be based on the internal precision clock or from an external clock source at 1.544 Mbps, 2.048 Mbps, 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, or 1 PPS rate. The output reference clock can be synchronized to 1.544 Mbps or 2.048 Mbps and provided at the DS1/E1 port or a 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, and 1 PPS clock signal can be made available on the unbalanced BNC port.

ITU-T G.8261 SyncE Slave Clock Emulation Mode

Extracts clock information from the incoming Ethernet signal at the 10/100/1000Base-T, 100Base-FX or 1000Base-X interface. The recovered reference clock can be applied to a 1.544 Mbps or 2.048 Mbps signal at the DS1/E1 port or a 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, or 125 MHz, or 1 PPS clock signal can be made available on the unbalanced BNC port. Clock and Wander are measured against a reference clock (1.544 Mbps or 2.048 Mbps or 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, or 125 MHz, or 1 PPS).

ITU-T G.8261 SyncE/IEEE 1588v2/PTP "SYNC" Mode

This unique SYNC mode allows the clocks on both PDH/DSn and Ethernet interfaces to be synchronized, so that simultaneous BERT measurements can be performed. This integrated approach eliminates complex setups typical of using multiple testers and drastically reduces testing time of hybrid Synchronized Packet and legacy TDM services.

Synchronization Messages Capture

Message capture and decode for SyncE ESMC/SSM and IEEE 1588v2 messages.

ESMC SSM

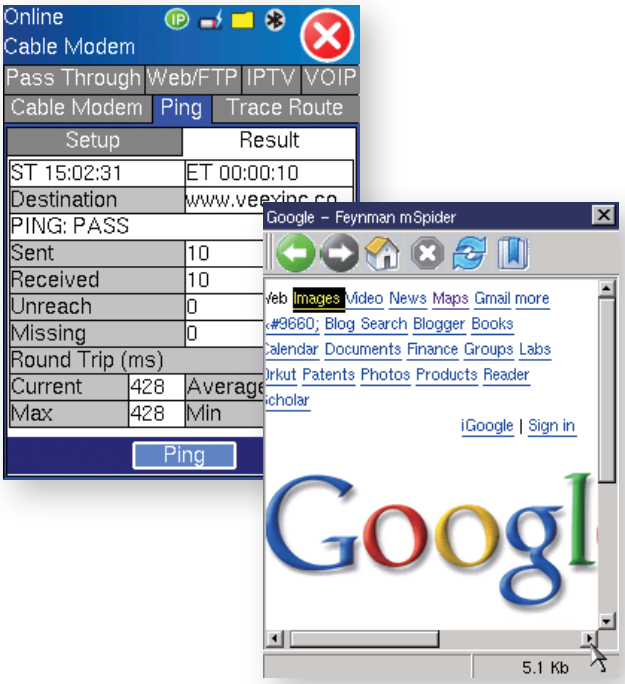
ESMC SSM messages generation with configurable type and rate. Includes ESMC SSM messages display and decode, with capture function in pcap format for external analysis.

Ethernet Testing

Generate and analyze Ethernet test traffic in conjunction with SyncE Master or Slave emulation.

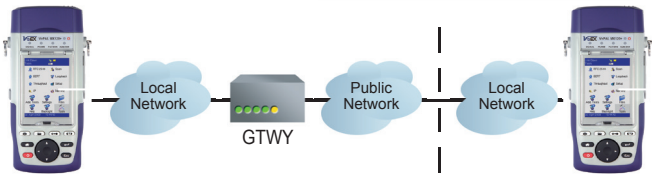
IP Testing

Internet connection services require that the IP connectivity be verified up to the public network. For a routed network, verifying end-to-end connectivity is also important prior to testing the throughput performance. Triple Play services are IP centric, so IP test functions are no longer considered a luxury. On a daily basis, technicians verify network connections during service installation and restoration, so Ping test, Trace Route, ARP, Web browser, FTP throughput, and VoIP Call emulation have become routine measurements. IP verification for IPv4 networks on the TX130M+ is possible over the 10/100/1000Base-T, 100Base-FX, 1000Base-X test ports, while a subset of these tools is available for IPv6 and the USB WiFi adaptor.



VeTest HTTP Throughput Test

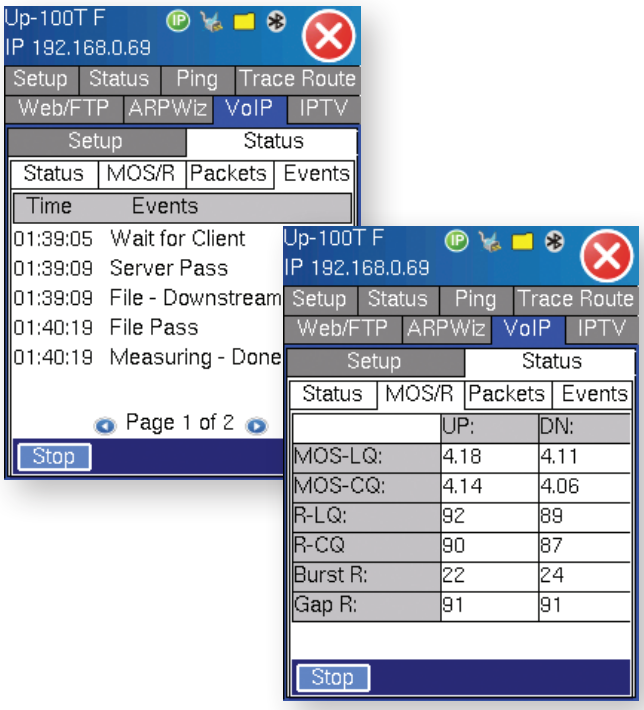
The VeTest feature qualifies network HTTP protocol performance by downloading and uploading files to a VeTest HTTP server. It can test up to the full line depending on the server specifications and limitations. Connection time to the server, data transfer time, line rate throughput rates, and protocol throughput rates key metrics are reported during the tests



VoIP Testing

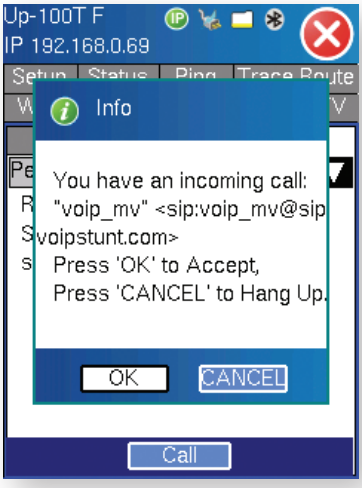
Take advantage of the three software options offering different test methods to verify and provision your VoIP network. Testing can be performed over any of the Ethernet test ports.

VoIP Check – Simulates a VoIP call to the nearest router and measures the round trip MOS score and related VoIP parameters.



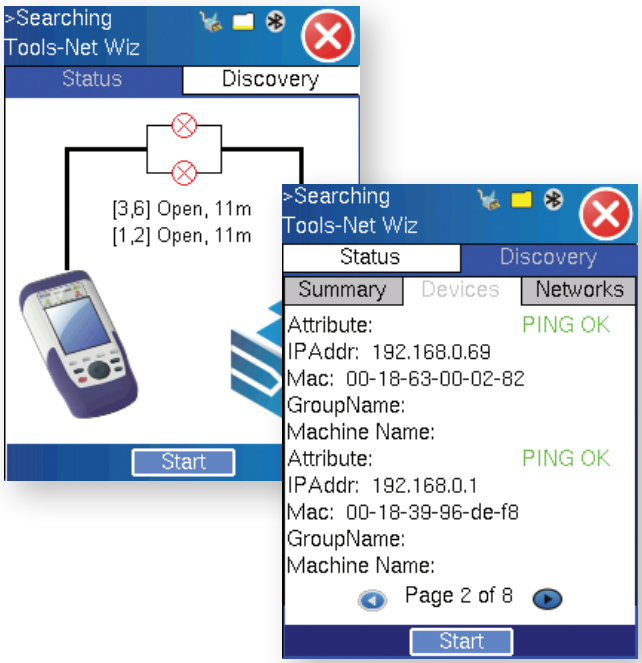
VoIP Expert – Generates industry standard wave files to verify MOS and R-Factor values of upstream and downstream paths and includes QoS measurements such as packet jitter, packet loss, and delay. Compatible with all VeEX testers including VX1000 VoIP server software.

VoIP Call Expert – Emulates an IP phone and can place and receive calls using SIP or H.323 protocols. Comprehensive Codec support and call destination options verify voice encoding and translation provisioning. Real-time evaluation of subjective voice quality is made possible using the Telchemy test method. Bulk call testing capability allows up to 24 simultaneous calls to be placed.



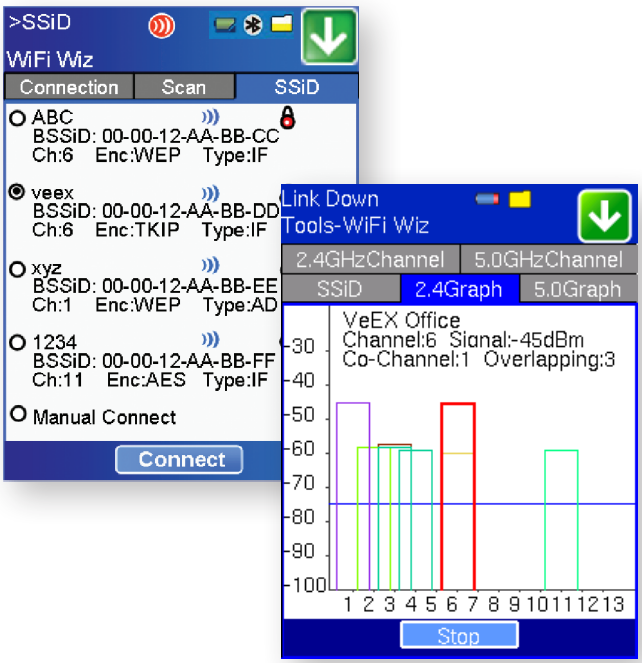
Net Wiz

Ethernet network installation is simplified using this basic, yet powerful feature. A built-in TDR identifies distance to short, distance to open, wire cross, and other anomalies associated with CAT-5 structured cabling. “Sniff” the network using the one-touch discovery feature. Identify routers, gateways, printers, PCs and other devices connected to the network within seconds.



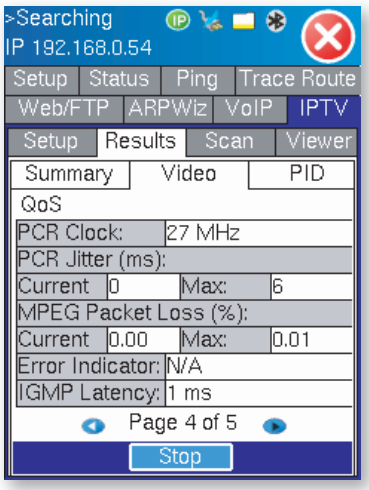
WiFi Wiz

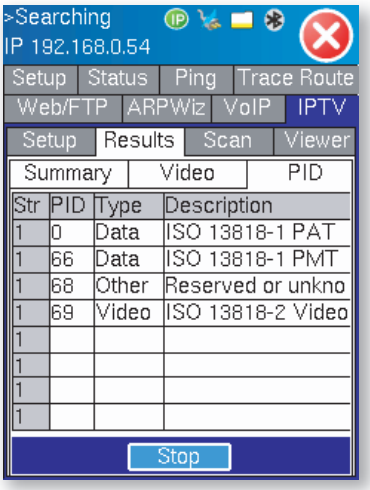
All VePAL products adopt a USB WiFi adaptor to make 802.11 a/b/g/n/ac wireless installations a simple task. Scan for available networks or perform signal strength and quality measurements to determine the best location for a new wireless access point. The IP Ping capability ensures the wireless network is properly installed and configured. A full suite of IP testing features is supported.

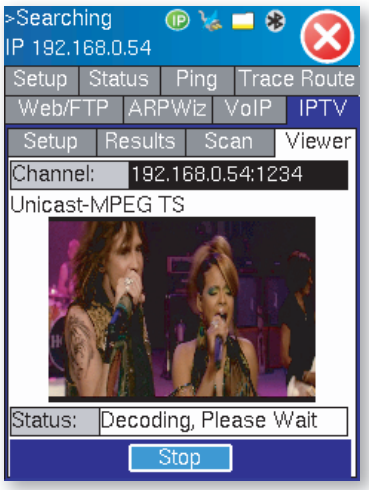


IPTV Service Verification

Take advantage of the two separate software options offering Designed and optimized for technicians turning up IP video service. Set-Top Box (STB) emulation includes registration, IGMP and RTSP signaling for Broadcast and Video on Demand (VOD) applications. Transport stream analysis encompasses data/video/audio bit rates and Program Identification (PID) mapping. Packet jitter and loss, IGMP latency (channel zapping), PCR statistics and Viewer function complete the Video Quality of Service (QoS) application suite.

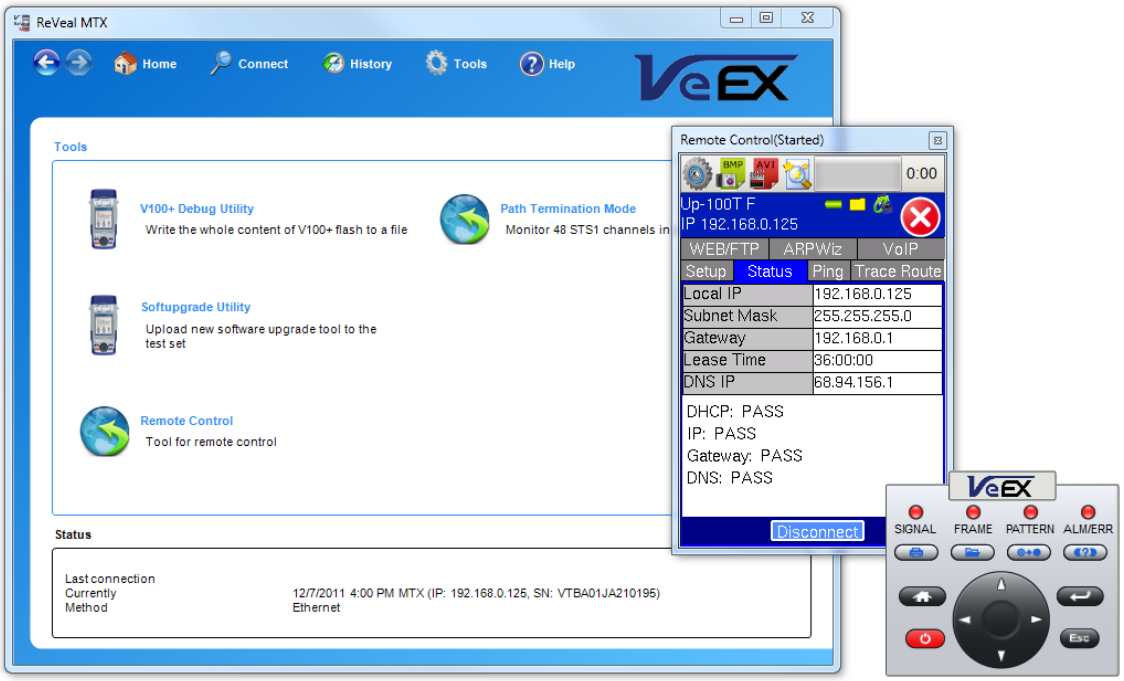






ReVeal MTX PC Tool

A software package shipped standard with each test set. Test and other installation profiles can be created and edited on a PC for upload to the test set via LAN connection. Test results can be downloaded and saved to a PC, where test data management and report generation can be performed. Users are able to check and upgrade their test sets without having to return the unit to the supplier, thus reducing downtime.



DSn/PDH

Electrical Interfaces

Dual Bantam (100Ω balanced) or dual RJ45 (100/120Ω balanced)

Rates and line code

- 1.544 Mbps AMI & B8ZS
- 2.048 Mbps HDB3 & AMI
- 64 kbps G.703 Codirectional (Optional)
- 3-pin 120Ω banana converter cable (F02-00-009G) is available for E1 and Codirectional

BNC (75Ω unbalanced) (2 Rx and 1 Tx)

Rates and line code

- 2.048 Mbps HDB3 & AMI
- 44.736 Mbps B3ZS
- 8.448 Mbps HDB3
- 34.368 Mbps HDB3

Compliant to ITU-T G.703, G.823, G.824, G.772 and ANSI T1.102 recommendations where applicable

Clock recovery (pulling range) per ITU-T G.703

Receiver Sensitivity

For 1.544 Mbps (DS1)

- Terminate: ≤ 6dB (cable loss)
- Monitor (PMP): ≤ 26dB (20dB resistive, 6dB cable loss)
- Bridge: ≤ 6dB (cable loss)

For 44.736 Mbps (DS3)

- Terminate: ≤ 12dB (cable loss)
- Monitor (PMP): ≤ 26dB (20dB resistive, 6dB cable loss)

For 2.048 Mbps (E1)

- Terminate: ≤ 6dB (cable loss)
- Monitor (PMP): ≤ 26dB (20dB resistive, 6dB cable loss)
- Bridge mode: ≤ 6dB (cable loss)

For 8.448 Mbps (E2)

- Terminate: ≤ 6dB (cable loss)
- Monitor (PMP): ≤ 26dB (20dB resistive, 6dB cable loss)

For 34.368 Mbps (E3)

- Terminate: ≤ 6dB (cable loss)
- Monitor (PMP): ≤ 26dB (20dB resistive, 6dB cable loss)

Clock Synchronization

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

Recovered from the incoming PDH or DSn signal

Recovered from SyncE or 1588v2

- Requires SyncE or 1588v2 options

External reference via RX2 balanced and unbalanced

- Signal: 1.544 Mbps, 2.048 Mbps

External reference via RX2 unbalanced

- Signal: 1.544 MHz, 2.048 MHz

Tx Frequency Offset

- Up to 50 ppm in steps of 0.1 ppm for DS1, E2, E3, and DS3
- Up to 25,000 ppm in steps of 0.1 ppm for E1 interface

Functions

Signal Structure

1.544 Mbps (DS1)

- Unframed or Framed SF (D4), ESF per ANSI and Telcordia standards where applicable
- Test signal in N x 64 kbps, N x 56 kbps where N=1 to 24

2.048 Mbps (E1)

- Unframed or Framed with/without CRC per ITU-T G.704 (PCM30, PCM30C, PCM31, PCM31C)
- Test signal in N/M x 64 kbps where N=1 to 30

8.448 Mbps (E2)

- Unframed or Framed according to ITU-T G.742

34.368 Mbps (E3)

- Unframed or Framed according to ITU-T G.751

44.736 Mbps (DS3)

- Unframed or Framed M13 and C-Bit Parity

Patterns

The following test patterns can be generated

- PRBS: 2^{11}-1, 2^{15}-1, 2^{20}-1, 2^{23}-1, 2^{31}-1: normal or inverted
- Fixed: 0000, 1111, 1010, 1000 and 1100
- 10 User programmable words up to 32 bits each

Errors

Insertion

- 1.544 Mbps (DS1): Code, FAS, Bit, Frame, CRC
- 2.048 Mbps (E1): Code, FAS, CRC, EBIT, Bit errors
- 8.448 Mbps (E2): Code, FAS
- 34.368 Mbps (E3): Code, FAS
- 44.736 Mbps (DS3): Code, FAS, MFAS, P/C-Parity, Bit errors
- Single or continuous rate (1 x 10^{-3} to 5 x 10^{-9})

Measurement

- 1.544 Mbps (DS1): Code, FAS, Bit, Frame, CRC
- 2.048 Mbps (E1): Code, FAS, CRC, EBIT and Bit errors
- 8.448 Mbps (E2): Code, FAS, Bit errors
- 34.368 Mbps (E3): Code, FAS, Bit errors
- 44.736 Mbps (DS3): Code, FAS, MFAS, P/C-Parity, Bit errors

Alarms

Generation

- 1.544 Mbps (DS1): AIS, yellow, idle, LOS, LOF
- 2.048 Mbps (E1): LOS, AIS, LOF, LOMF, RDI
- 8.448 Mbps (E2): LOS, AIS, LOF, RDI
- 34.368 Mbps (E3): LOS, AIS, LOF, RDI
- 44.736 Mbps (DS3): LOS, LOF, OOF, AIS, Parity
- Continuous or timed

Measurement

- 1.544 Mbps (DS1): LOS, AIS, LOF, AIS, yellow, idle and LSS
- 44.736 Mbps (DS3): LOS, AIS, LOF, Parity and LSS
- E1, E2, E3: LOS, AIS, LOF, OOF, RDI and LSS (where applicable)

SSM QL

- E1 Sa bits clock quality encoding and decoding
- Selectable Sa bits for SSM monitoring and generation

Measurement Functions

Test Results

Error count, ES, %ES, SES, %SES, UAS, %UAS, EFS, %EFS, AS, %AS, and rate for all events: errors and alarms

Performance Analysis

Measurements according to:

- ITU-T G.821: ES, EFS, SES and UAS with HRP 1% to 100%
- ITU-T G.826: EB, BBE, ES, EFS, SES, UAS; HRP of 1% to 100%
- In Service Measurement (ISM) using FAS, CRC or Code (DS1 or E1)
- Out of Service measurement (OOS) using bit errors (Test Sequence Error)
- ITU-T M.2100: ES, EFS, SES, UAS with HRP 1% to 100%
- User defined thresholds for Maintenance (MTCE) and Bringing into Service (BIS) objectives including In-service measurements on both near and far ends of path using TSE

Basic Wander Measurements (optional)

Test Signals: 1.544 and 2.048 Mbps
Reference Clocks: 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, 1.544 Mbps, 2.048 Mbps, 1 PPS
Reports current, minimum, and TIE in nanoseconds
MTIE report for the entire observation (test) time
Saves TIE data to USB for long-term and further MTIE and TDEV post-processing (requires MTIE and TDEV Wander Post-Analysis option and VeEX Wander Analysis PC software)

Jitter Measurement

Test rates: DS1, DS3, E1, E3
Range: Per ITU-T 0.171
PASS/FAIL Threshold: Per ITU-T G.823

Pulse Mask Analysis

DS3/DS1

- Bit rates: 1.544 Mbps (DS1) and 44.736 Mbps (DS3)
- Conformance Masks: ITU-T G.703, ANSI T1.102, T1.403, T1.404 where applicable

PDH

- Bit rates: 2.048 Mbps (E1) and 34.368 Mbps (E3)
- Conformance Mask: ITU-T G.703

Mode: Non-Intrusive
Display: Pulse shape with Conformance mask verification
Parameters: Width, Rise/Fall time, Overshoot/Undershoot

VF Measurement

VF drop/insert via Headset
ABCD bits monitor & transmit in selected timeslot channel
Programmable ABCD states for IDLE, SEIZE, USER for E1 and ON-Hook, OFF-Hook, WINK, USER for DS1
Tone generation: 1 Hz, 1 dB resolution

- Frequency (Hz): 50 to 3950 Hz
- Level (dBm): +3 to -60 dBmV

ISDN PRI Testing

NT and TE emulation
Bi-directional monitor and decode
Place/receive voice and data calls
Via Headset for B-channel talk/listen
Protocols

- DS1: National ISDN, AT&T Custom, and Northern Telecom DMS compatible
- E1: ETSI (Euro-ISDN)

D-channel monitor with full decode: Layer 2 (Q.921) and Layer 3 (Q.931)
Supports multirate N x 64k data call
Supplementary Services Test: Automatically tests the provisioning of the following: CLIP, CLIR, COLP, CFU, CFB, CFNR, SUB, MSN, DDI, HOLD, UUS, TP, AOC-S, AOCD, AOCE, MCID, CUG

Other Functions

Auto Configuration: Auto detection of line coding, framing, test pattern
Frequency Measurement (Unit/Resolution): Hz & ppm/1 Hz
Round Trip Delay (Range/Resolution): 1 µS to 10 seconds/ 1 µs or 1 U.I.
Event Logging: Date and time stamped events in tabular format
Histograms: Display of Errors and Alarms versus time
LED Indicators: Fixed LEDs for signal and error/alarm
E1 APS (Triggers): AIS, LOS, LOF

G.703 64k Codirectional Testing Option

Interfaces

- RJ48 (120Ω) , Bantam (100Ω)
- Available RJ48 to 3-pin Banana converter

Transmit Clock

- Internal, External, Received
- Frequency offset generation to ±150.00 ppm

Measurements

- Bit, Code, LOS, AIS, pattern loss (LSS) with Histogram and Bar Graph representation
- G.821 performance evaluation
- Signal level, data rate and offset
- Time-stamped Events Log
- Round-trip Delay

Error and Alarm Generation

- Bit, Code, LOS, AIS

DSn Functions (TX130M+ only)

Besides bantam DS1 interfaces, the North American version offers application-oriented DS1 and DS3 streamlined GUI that is shared among other TX-Series test set.

DS1 and DS3 Auto-Monitor

Quickly auto-configures to the received signal and runs a health check. Provides a summary screen with all alarm indications, frequency, signal level, BPV/code errors, FBE, clock slips Histogram and bar graph representation of errors and alarms Channelized DS3 support with selectable DS1 channel status

DS1 Loopback Commands

Enhanced DS1 Loopback command generation enable users to singlehandedly test DS1 links by activating automated loopbacks in the desired network elements.

In-band:

- CSU, NIU FAC1, NIU FC2 ESF Facility Data Link (FDL) Control
- Line and payload HDSL Abbreviated (short)
- From Network (CO) or CPE
- NLOC, NDU1, NDU2, NREM

HDSL Long (In-band)

- From Network (CO) or CPE
- 2-wire and 4-wire
- HTU-C, H4R1, H4R2, H4R3, HTU-R
- Arm, Query Loop, Time-out override, Loopback Query, Loop Up, Loops down, Disarm commands
- Detailed confirmation messages

User Defined codes

- Programmable codes up to 16 bits
- Programmable time out

DS1 Multi-BERT™

Bring into service and troubleshoot DS1 links quickly by automatically generating different test patters in a sequential BER test. Since certain test patterns can help identify and test for specific problems or behaviors, the test sequence can be customized with specific test patterns and timings to target specific test scenarios, like checking for proper line coding settings, framing, or clock recovery.

- Sequential BER testing with up to eight test patterns (any standard test pattern in any order)
- Single cycle and Continuous operations
- Individual pattern timing up to 3599 seconds (1 hour)
- Bit, Code, FBE, ES, and total test time report, per pattern and totals
- Monitors signal frequency, level (dB and dBm) and CRC error count

Ethernet

Ethernet Interfaces

Single 10/100/1000Base-T Port: RJ45 connector
Ethernet Classification: Per IEEE 802.3 compliant

Optical Interfaces

Single 1000Base-X/100Base-FX SFP Port: LC connector
ROHS compliant and Lead Free per Directive 2002/95/EC
Eye Safety: Class 1, per FDA/CDRH, EN (IEC) 60825

Ethernet Features

Auto Negotiation , Full and Half Duplex , Flow Control

Modes of Operation

Terminate, Monitor, Loopback

Multiple Streams Throughput Testing

Up to eight independent traffic streams generation and analysis, with configurable filters
Each stream can be set with independent frame size, bandwidth, traffic profile, and QoS levels

Key Measurements

Error Measurements: Bit (BERT and single stream Throughput Test), BER (BERT and single stream Throughput Test), CRC, symbol, IP checksum, TCP/UDP checksum, jabber frames, runt frames, Frame loss (count and %), OSS
Alarm Detection: LOS, pattern loss, service disruption 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
Service Disruption Time (SDT): per stream inter-packet gap based measurement, configurable SDT measurement trigger and violation threshold

Traffic Generation

Layer 1 Unframed and Framed, Layer 2, Layer 3, Layer 4
Test Frame Header:

- IEEE 802.3 and Ethernet II (DIX) frames
- Configurable Source and Destination MAC and Ethernet Type
- VLAN stacking up to 3 Q-in-Q tags w/configurable priority & type
- Fully configurable IPv4 or IPv6 header
- MPLS up to 3 labels with configurable Label/S/CoS and TTL fields (optional)
- UDP/TCP header with configurable Source & Destination ports

Frame size 64 to 1518 bytes and jumbo frame up to 10000 bytes
Traffic Pattern: Constant, Ramp, Multi Bursts, Single Burst
Error Injection: Bit, CRC, IP Checksum, TCP/UDP checksum, Pause, Symbol (Layer 1 Unframed)
MAC flooding feature generates test frames with up to 4096 incremental Source and/or Destination MAC addresses (optional single stream Throughput Test feature)
VLAN flooding feature generates test frames with up to 4096 incremental VLAN IDs (optional single stream Throughput Test)

ITU-T Y.1564 V-SAM Test

V-SAM test suite compliant with ITU-T Y.1564 standard
Support for Multi-stream traffic generation, Service Configuration and Service Performance tests
Independently configurable for each stream: Bandwidth profile parameters (CIR, EIR, CBS, EBS, Traffic Policing, Color Mode) and Service Acceptance criteria (FLR, FTD, IFDV, AVAIL)
Simple summary Pass/Fail results tables and drill down capability with detailed measurements (Frame Loss, Frame Transfer Delay, Frame Delay Variation, Availability) for each service

Link Level OAM - IEEE 802.3ah

Modes: Active and Passive, with configurable Vendor OUI, Vendor SPI, MAX PDU length, and PDU rate
Discovery capabilities: remote loopback, link events, MIB retrieval
Link Events Notifications: Link Fault, Critical Event, Dying Gasp

Service Level OAM - IEEE 802.1ag and ITU-T Y.1731

MEP emulation with configurable MD name, MA name, local MEP ID, MD level, VLAN ID
Continuity Check Message (CCM): with priority level & interval selection
Loopback Messages (LBM/LBR): loopback message generation and response to destination MEP or MAC address
Link Trace Messages (LTM/LTR): link trace message generation and response to destination MEP or MA address wit configurable TTL.
Loss Measurement Messages (LMM/LMR): loss measurement message generation and response to destination MEP or MAC with configurable rate and number of messages.
Delay Measurement Messages (DMM/DMR): delay measurement message generation and response to destination MEP or MAC with configurable rate and number of messages

RFC2544 Compliance Testing

Automated tests compliant with RFC2544 with configurable threshold values and maximum transmit bandwidth settings
Throughput, Latency, Frame Loss, and Back-to-Back (burst) tests
Frame sizes: 64, 128, 256, 512, 1024, 1280, and 1518 bytes including 2 user configurable frames
Test can be done to a remote loopback or to a remote test set with remote control of traffic generation and measurements at each end (requires asymmetric test option)

Bit Error Rate Testing

Single Stream test with test pattern: PRBS 2E31 -1, PRBS 2E23 -1, PRBS 2E15 -1, PRBS 2E11 -1, Normal and inverted patterns, All 0s, All 1s and User Defined
Layer 1 Framed: CRPAT, CSPAT, CRTPAT
Layer 1 Unframed: HFPAT, LFPAT, MFPAT, RDPAT, JTPAT, SNPAT

Traffic Filters

Up to eight traffic filters can be configured with MAC, VLAN, and IP fields for Monitor and Loopback modes

Smart Loopback Mode

Layer 1: loops back all incoming traffic
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
Layer 4: all incoming traffic is looped back with MAC, IP, and UDP/TCP ports swapped
Loopback traffic filters with all MAC/VLAN/IP/UDP parameters configurable

VLAN Scan and Monitor

Scans incoming traffic and discovers all VLAN flows including Q-in-Q tagging
Key statistics on traffic rates, alarms and errors are reported for monitored streams (up to 8)

Packet Capture

Line rate packet capture from test interfaces
Configurable capture filters (MAC and IP addresses)
Packet captures can be saved and exported in PCAP capture format compatible with Wireshark

IP Testing

Ping, Trace Route, ARP, FTP/Web tests, Web-browser. These tests are done via the chassis 10/100/1000Base-T, 100-FX, and 1000Base-X ports.

VoIP Testing

Codecs: G.711 μ-law, G.711 A-law, G.723.1 (optional), G.729 (optional)
Measurements: MOS (CQ and LQ) and ITU-T G.107 R-factor (CQ and LQ)
Packet Statistics: data throughput rate, packet loss, packet discard, OOS, duplicate, jitter
VoIP Check

- Simulates VoIP call to the nearest router by sending ICMP traffic with payload/rate mimicking VoIP traffic

VoIP Expert

- Client/Server mode provides bi-directional measurements
- Compatible with any VeEX field tester or centralized VeEX VX1000 Server software

VoIP Call Expert

- VoIP call setup: supports SIP and H.323 protocols
- Configurable jitter buffer (fixed or dynamic)
- Incoming call Auto Answer
- STUN support
- Talk/Listen with USB headset
- DTMF test (RFC4733)
- Signaling trace with protocol decode
- Up to 24 simultaneous calls

Net Wiz

Available on 10/100/1000Base-T test port
Detect distance to open/short, wire cross, impedance mismatch
Network device discovery; Auto Ping verification
TDR accuracy: ± 3 meters

WiFi Wiz

USB Wi-Fi adapter 802.11 a/b/g/n/ac
Access Points scan signal level and link quality measurement
WEP/WPA/WPA2 encryption
IP Connectivity test (Ping, trace route, Web/FTP test, Web browser, VoIP) (requires additional options)

VePAL Discovery Function and Remote Control

Discovery function to all VeEX VePAL devices within subnet or manual control of VeEX VePAL devices in routed network
Remote Control of Loopback capability
Remote Control of Asymmetric test capability for end to end RFC2544 test (optional)

VeTest HTTP Test

HTTP Throughput Full line rate HTTP client mode Connection time to server Total Data Transfer time HTTP Throughput rates Requires VeTest Server

IPTV

Provides STB emulation
Analyze up to 3 streams
Supports IGMP/RTSP signaling
Codecs MPEG2, MPEG4-part2, and MPEG4 part 10 (H.264)
IPTV image viewer for stream identification
PIDs count
Data Rates (Video, Audio, tables) and error counts
MDI score
Channel Zapping test

Packet Network Synchronization

TX130M+		Output Clock Signals						
		1.5 Mbit/s (Balanced)	2 Mbit/s (Balanced)	2 Mbit/s (Unbalanced)	10 MHz (Unbalanced)	25 MHz (Unbalanced)	125 MHz (Unbalanced)	1PPS (Unbalanced)
Input Reference Clock Types	2 Mbps (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	2 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	10 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	25 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	125 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	1 PPS (Unbalanced)	✓	✓	✓	✓	✓	✓	✓
	1588v2 Slave (Recovered)	✓	✓	✓	✓	✓	✓	✓
	SyncE Slave (Recovered)	✓	✓	✓	✓	✓	✓	✓

Modes of Operation

Master clock emulation: Offers recovered clock output (clock translation) for external analysis or to provide timing to other devices

Slave clock emulation: Offers recovered clock output (clock translation) for external analysis or to provide timing to other devices

Master clock sync: Uses the recovered clock to synchronize its PDH/DSn interfaces

Slave clock sync: Uses the recovered clock to synchronize its PDH/DSn interfaces

Wander Measurement

This optional feature for IEEE 1588v2 and SyncE slave modes provides full wander measurements on the recovered clock.

Test Signals: 1588v2 or SyncE recovered clocks

Reference Clocks: 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, 1.544 Mbps, 2.048 Mbps, 1 PPS

Reports current, minimum, and TIE in nanoseconds

MTIE report for the entire observation (test) time

Display Resolution: 7 ns

Saves TIE data to USB for long-term and further MTIE and TDEV post-processing (requires MTIE and TDEV Wander Post-Analysis option and VeEX Wander Analysis PC software)

ITU-T G.8261/SyncE

Master clock emulation

- ESMC SSM generation: configurable message type and rate

Slave clock emulation

- ESMC SSM generation: configurable message type and rate

Master or slave clock sync mode

- Perform simultaneous and synchronized tests on the PDH/DSn interface and SyncE Master and Slave

Measurements

- ESMC SSM messages counters
- ESMC SSM messages display and decode
- ESMC SSM messages capture in pcap format

Slave Clock measurements

- Slave clock offset measurements against reference clock (ppm)

IEEE 1588v2/PTP

Master clock emulation

- Unicast and multicast master emulation
- IPv4 and IPv6 support
- 2-step clock
- Configurable announce, Sync and Delay_req rates and domain number

Slave clock emulation

- Unicast or multicast slave emulation
- IPv4 and IPv6 support
- 1-step or 2-step clock
- Configurable announce, Sync and Delay_req rates and domain number

Master or slave clock sync mode

- Perform simultaneous and synchronized tests on the PDH/DSn interface and 1588/PTP Master and Slave

Measurements

- Message counters (Sync,Follow up, Delay Request/Response,Pdelay Request/Response, signaling, management) and statistics (Loss, CRC error, duplicate, out of order)
- PTP messages display and decode
- PTP messages capture in pcap format
- PDV measurements and graph display (Sync PDV, Delay_Req PDV)
- Round trip delay measurements and graph display
- IPG measurements and graph display

Slave Clock measurements

- Slave clock offset measurements against reference clock (ppm)

Reference Clock Analysis

Synchronized Clock Interfaces

Input

- Balanced: 1.544 Mbps or 2.048 Mbps
- Unbalanced (BNC, 75Ω): 1.544 Mbps, 2.048 Mbps, 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, 1 PPS

Output

- Balanced: 1.544 Mbps or 2.048 Mbps
- Unbalanced (BNC, 75Ω): 1.544 Mbps, 2.048 Mbps, 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, 1 PPS

Clock Wander Analysis (optional)

This advanced synchronization tool measures Wander (TIE) between any two Reference Clock types, including G.703, sinusoidal, and TTL signals. (Requires E3/DS3 hardware option)
Test Signals: 1.544 MHz, 2.048 MHz, 1.544 Mbps, 2.048 Mbps, 1 PPS
Reference Clocks: 1.544 MHz, 2.048 MHz, 10 MHz, 25 MHz, 125 MHz, 1.544 Mbps, 2.048 Mbps, 1 PPS
Reports current, minimum, and TIE in nanoseconds
MTIE report for the entire observation (test) time
Display Resolution: 7 ns for 1 PPS
Real-time Graph: TIE, last 200 s
Saves TIE data to USB for long-term and further MTIE and TDEV post-processing (requires MTIE and TDEV Wander Post Analysis option and VeEX Wander Analysis PC software)

Wander Post Analysis

MTIE and TDEV Wander Post Analysis (optional)

Available in PDH, DSn, SyncE, and IEEE 1588v2 test modes
Saves long-term real-time TIE measurements directly to a USB memory for further MTIE and TDEV post-processing, using VeEX's Wander Analysis PC software.
Sampling rates: 1/s, 5/s, 10/s, and 30/s
Includes VeEX Wander Analysis PC software
Requires Basic Wander Measurements options for each rate and protocol, or the Clock Wander Analysis option

VeEX Wander Analysis PC software

Provides fast post-processing of long-term clock stability data, such as MTIE and TDEV
Frequency offset calculation and removal
MTIE and TDEV Graphs
Standard and user-programmable masks
PASS / FAIL analysis
PDF report generation
Fully resizable window, to accommodate any screen size and detailed zoom levels
Compact stand-alone Windows® software

Reference Clock Types (Interfaces) \ Test Signal Types (Interfaces)	1.5 MHz (Balanced)	1.5 Mbit/s (Balanced)	2 MHz (Unbalanced)	2 MHz (Balanced)	2 Mbit/s (Unbalanced)	2 Mbit/s (Balanced)	1 PPS (Unbalanced)	1588v2 (recovered)	SyncE (recovered)
1.5 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓		✓	✓
1.5 MHz (Balanced)	✓	✓		✓		✓		✓	✓
1.5 Mbit/s (Balanced)	✓	✓		✓		✓		✓	✓
2 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓		✓	✓
2 MHz (Balanced)	✓	✓		✓		✓		✓	✓
2 Mbit/s (Unbalanced)			✓		✓			✓	✓
2 Mbit/s (Balanced)	✓	✓		✓		✓		✓	✓
1 PPS (Unbalanced)	✓	✓	✓	✓	✓	✓	✓	✓	
10 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓		✓	✓
25 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓		✓	✓
125 MHz (Unbalanced)	✓	✓	✓	✓	✓	✓		✓	✓

ReVeal MTX PC Software

Remote Control (optional)
Remote screen capture and movie capture
Remote Software management: software upgrade, software option management
Test results management
Advanced report generation with .pdf or .csv formats, combine test results, add logos and comments
Test profiles management online or offline test profile creation, upload and download
Wander files retrieval

Additional Test Features

Profiles: Save and recall test profiles
Screen capture: Screen shots in .bmp format via ReVeal MTX PC software
Remote control: via ReVeal MTX PC software
Results saving: 1000 results
Export test results via USB, FTP, or ReVeal MTX PC software

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

General Specifications

Size	210 x 100 x 55 mm (H x W x D) 8.25 x 3.75 x 2.25 in
Weight	Less than 1 kg (less than 2.2 lb)
Battery	LiIon smart battery, 2600 mAh 10.8VDC Battery operating time: 2-6 hours, application dependent
AC Adaptor	Input: 100-240 VAC, 50-60 Hz Output: 15VDC, 3.5A
Operating Temperature	-10˚C to 50˚C (14˚F to 122˚F)
Storage Temperature	-20˚C to 70˚C (-4˚F to 158˚F)
Humidity	5% to 95% non-condensing
Display	3.5” QVGA 320x240 color touch-screen
Ruggedness	Survives 1.5 m (5 ft) drop to concrete on all sides
Interfaces	USB 2.0, RJ45 10/100-T Ethernet
Languages	Multiple languages supported

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