Calnex Sentinel

4G and 5G OTA / 1pps / 100G / 25G / 10G / 1G / 100M

The Dedicated Synchronization Tester
Now featuring 25/100G, 5G OTA and battery operation for OTA measurements

Calnex Sentinel
Synchronization Tester

Key Features:

- Verify Phase, Time and Frequency synchronization
- Monitor performance and diagnose synchronization issues on 3G/4G/5G Mobile, Datacenter, Financial, Power and other Telecoms networks

Sentinel provides a comprehensive measurement suite including:

- Time Error (TE)
- Time Interval Error (TIE)
- MTIE
- TDEV
- ESMC Quality Levels
- 2wayTE
- Dynamic Time error
- High and low pass filtered 2wayTE
- Packet Selected 2WayTE
- SyncE wander
- Packet Delay Variation (PDV)
- Floor Packet Percentage (FPP)
- Frequency Error

Flexible network connection options:

- As a pseudo T-TSC to measure upstream network synchronization
- As a network monitor measuring live network PDV and TE

Clear Pass/Fail Metrics for easy analysis:

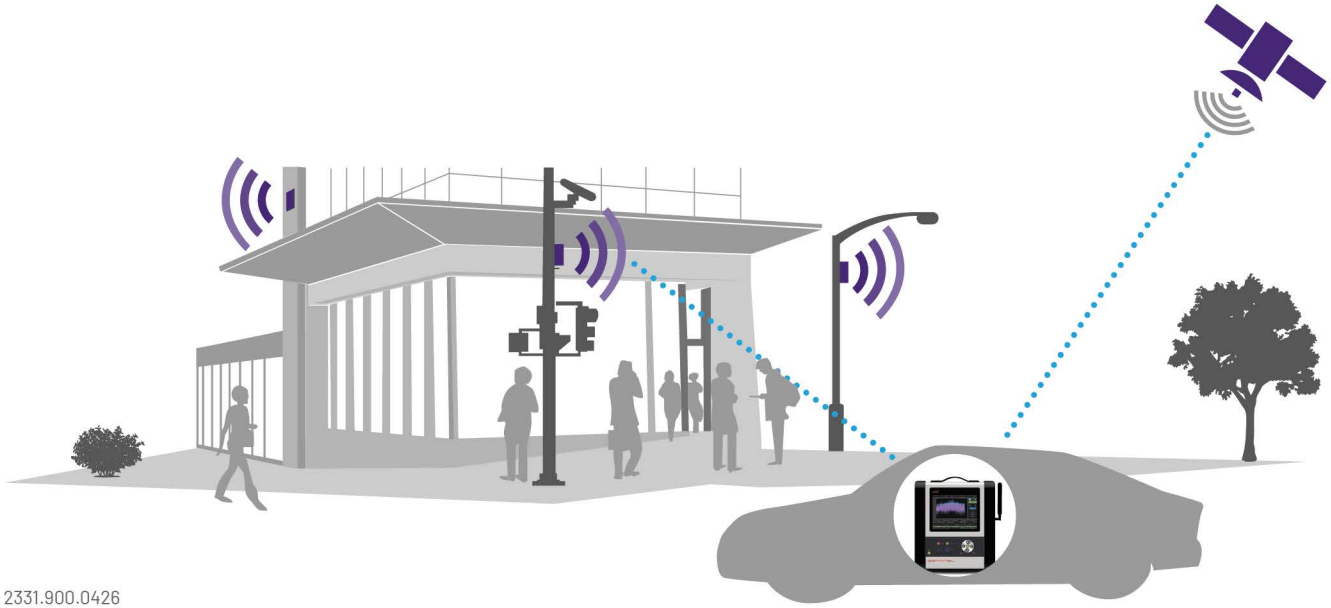
- ITU-T specified masks
- ITU-T, standards-based, vendor-specific limits
- Detailed measurement report in PDF format

Test Over-the-Air (OTA) synchronization in 4G and 5G mobile networks

How do you know if your Small Cells conform to 3GPP standards? With TDD and FDD systems implementing newer LTE features such as eICIC and CoMP, measuring the sync accuracy of a Small Cell/eNodeB is crucial. It's also quite a challenge, particularly when these network devices often lack a physical 1PPS output.

However, with Sentinel's non-invasive OTA test capability you can now measure, with precision, the Time Error between eNodeBs or gNodeBs and UTC to ensure they meet the 3GPP ≤3 µs phase alignment limit. Plus, with Sentinel's battery-powered option, you can make measurements in the field without requiring external power.

Figure 1. Evaluate OTA measurements using the Calnex Analysis Tool (CAT) for detailed insight into static and dynamic time and frequency synchronization.



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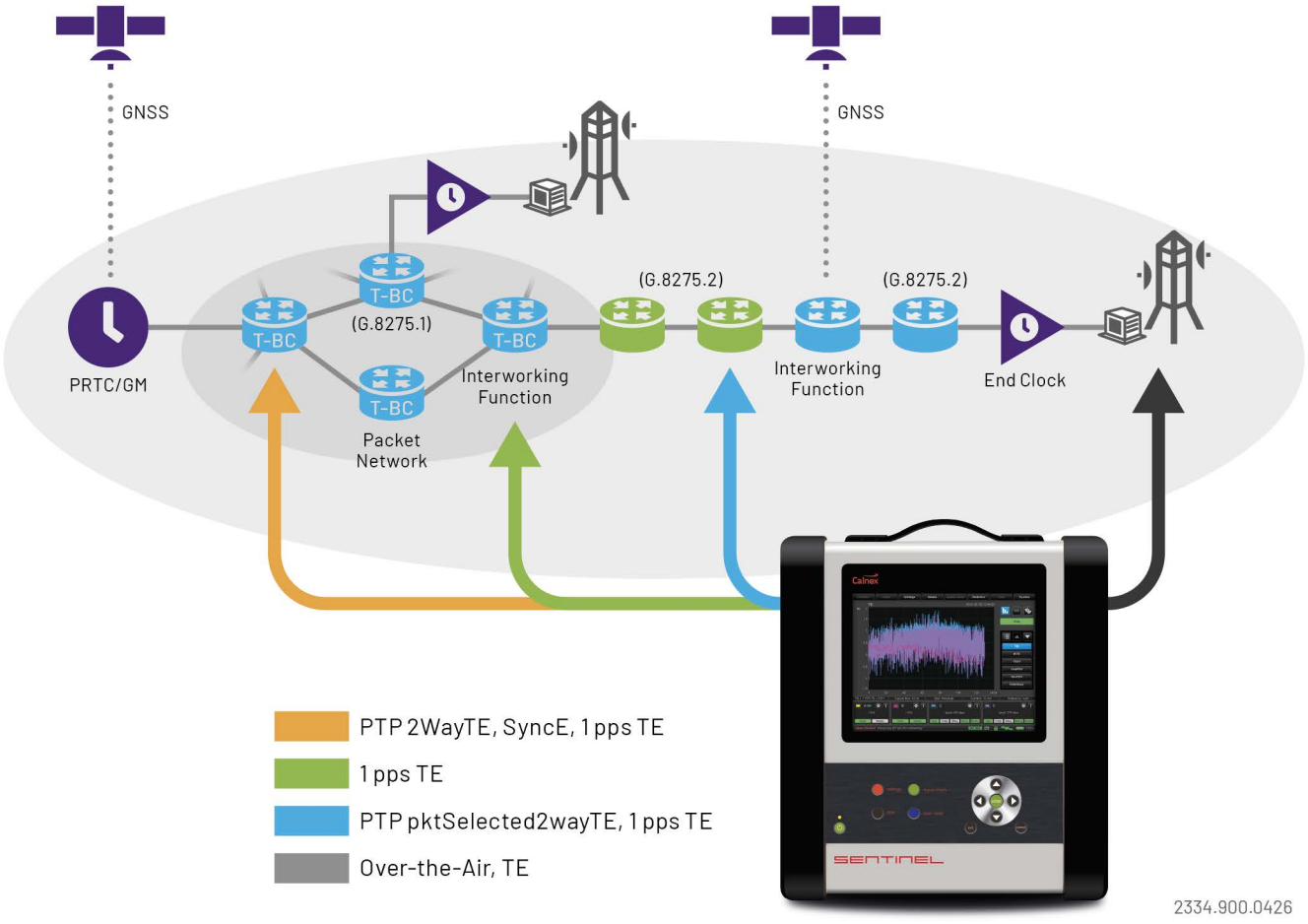
Deliver the fast, stable services your customers can rely on

Easily test the performance of your network's synchronization. Sentinel captures all data simultaneously enabling you to correlate timing performance at different points in the network, even between different timing architectures.

Test 3G/G/5G and Cell deployments at various points in the network, including near to the GrandMaster (GM), and validate network performance to ITU-T limits.

Use Sentinel to make long-duration, unattended measurements to identify slow variations in timing or sporadic transient behaviors.

Measurements are graphed in real time allowing you to easily check the status of an ongoing measurement, and gives you confidence of the measurement integrity before you commit to a long term test.



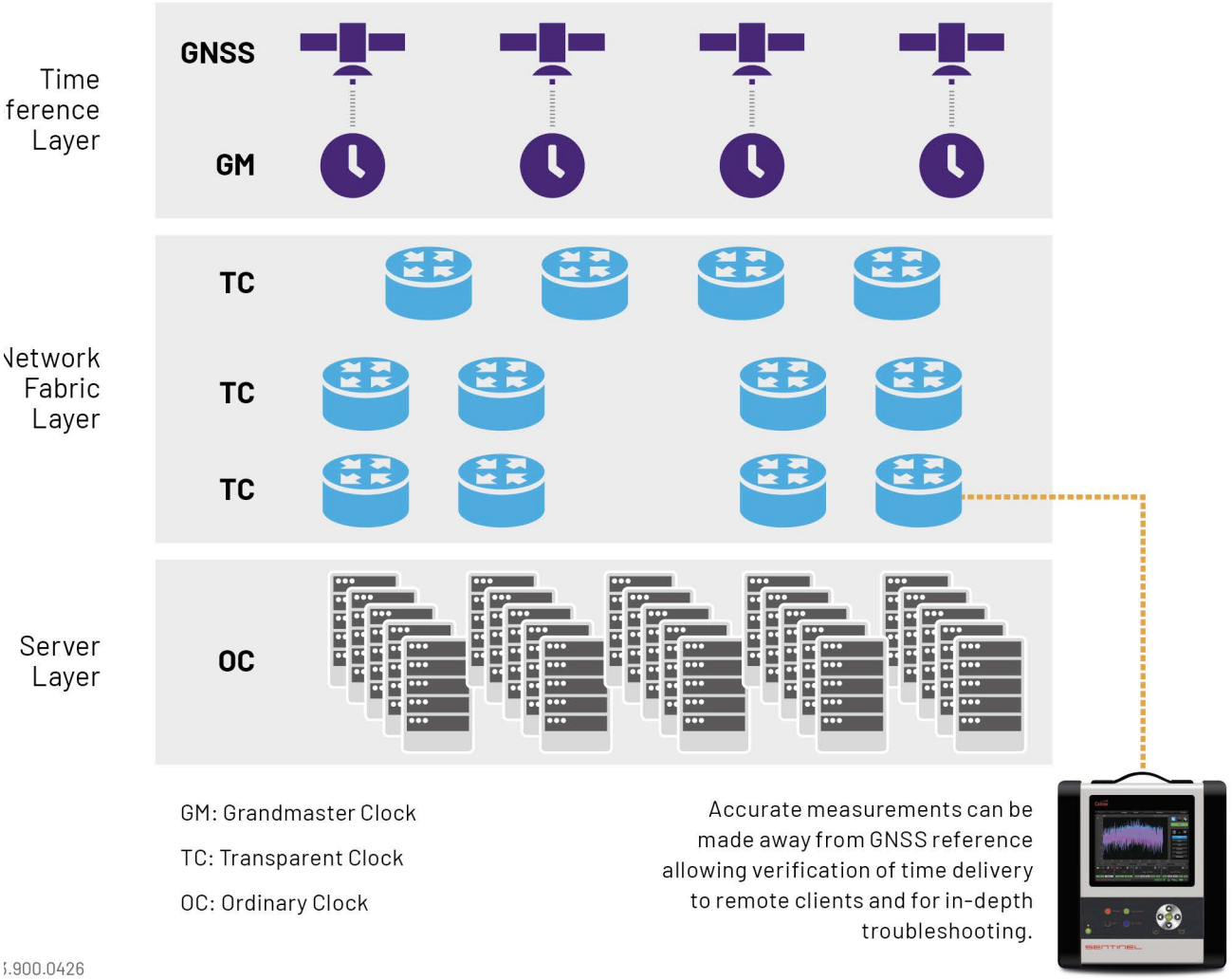
Test PTP and NTP synchronization in datacenters

Time synchronization is not new in datacenters but the required accuracy is increasing. This is being driven by higher throughput, the need for lower latency, the movement of storage and computation to the network edge, and regulatory and standards body requirements.

While NTP was traditionally sufficient to maintain millisecond level synchronization, the need for synchronization to 100s or 10s of microseconds, and sometimes even tighter, is now required.

Sentinel allows you to easily and thoroughly verify and monitor the synchronization within your datacenter, and prove time/phase accuracy with microsecond precision.

What's more, Sentinel's holdover performance and transport mode allows you to move around your facility and test synchronization without having to maintain a reference GNSS or 1 pps signal. This makes Sentinel an indispensable tester for deployment, troubleshooting and network maintenance



GM: Grandmaster Clock

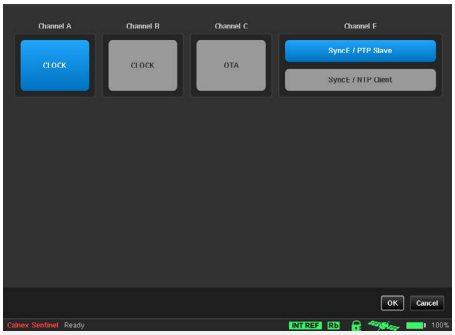
TC: Transparent Clock

OC: Ordinary Clock

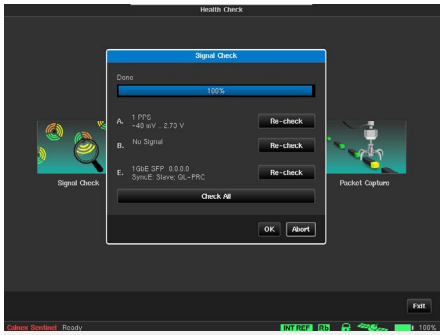
Accurate measurements can be made away from GNSS reference allowing verification of time delivery to remote clients and for in-depth troubleshooting.

Whatever your application, start testing in 3 easy steps

Advanced capabilities and intuitive operation means engineers at all skill levels can use Sentinel with total confidence.



1. Connect to the network



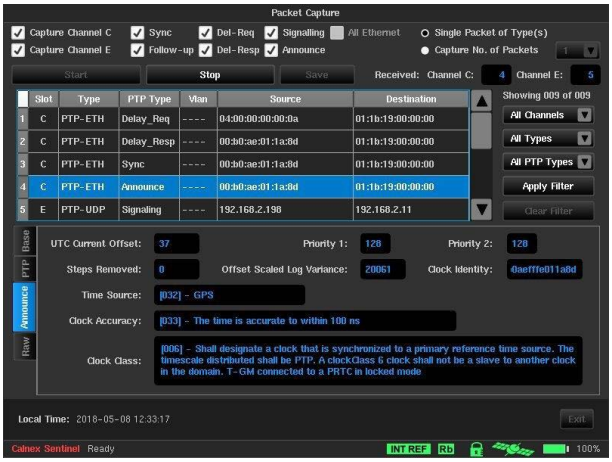
2. Run 'Health Check' to auto-discover connections and check PTP protocol compliance

3. Start all measurements at the same time

For detailed PTP Protocol Analysis, download data to Sentinel's on-boar. Packet Capture feature or by downloading data to the PTP Field Verifier (PFV) software.

Packet Capture and Decode

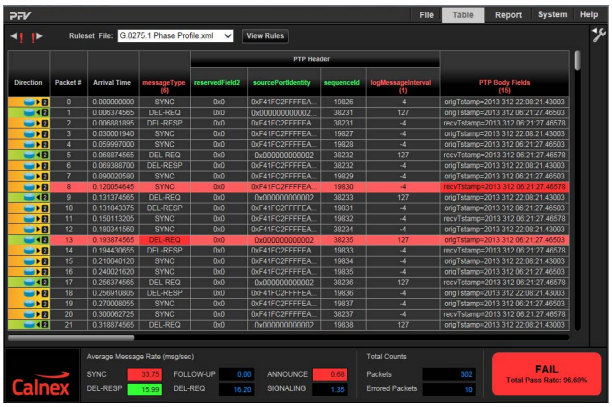
- Configuration issues – such as mismatch domain number configured for Master Clock and Subordinate Clock
- Protocol Implementation issues – such as the log interval of Del-Resp does not reflect the real packet rate as expected in multicast mode
- Protocol Signaling issues – such as signaling messages do not repeat after the negotiated contract period
- Capture and decode Announce messages – provides detailed information about the PTP GM which is fundamental to build up the Master-Subordinate clock hierarchy



PTP Field Verifier

Analyze PTP protocol for conformance to standards or user-defined profiles.

- Automatic Pass/Fail indication – check captured PTP messages against a pre-defined set of rules, with clear Pass/Fail alerts
- Check transmitted PTP messages for compliance with ITU-T, IEEE and user-defined standards and rules – areas of non-conformance immediately visible
- Flexible XML rules allow full customization of pass criteria
- Full report generation capability



Get greater measurement insight with the Calnex Analysis Tool (CAT)

The CAT provides powerful insight into network and device performance. All your measurement results are now in one place, and you can view multiple graphs simultaneously for easier correlation of your results.

Enhanced graphics makes it easy to evaluate ITU-T metrics such as Time Error (cTE, dTE), MTIE and TDEV against ITU-T masks.
While the customizable multi-graph window lets you rapidly select measurements and channels for detailed analysis.

CAT also provides one button generation of reports in PDF format including Pass/Fail statistics and details of failures. This allows you to share captures and results with vendors for fast, efficient and accurate troubleshooting.

Lab quality performance in an easy-to-use, portable package

No test port?

Use OTA measurements

Perform synchronization tests without physical connection to the network.

- 4G LTE-A
- 5G NR

No GNSS signal?

Use internal high-stability Rubidium (Rb) clock

Sentinel's built-in Rb clock is both highly stable and precise. Once disciplined, it has exceptional holdover performance allowing you to get to where you needto be and to make accurate measurements even when no reference 1 pps or satellite signal is available.

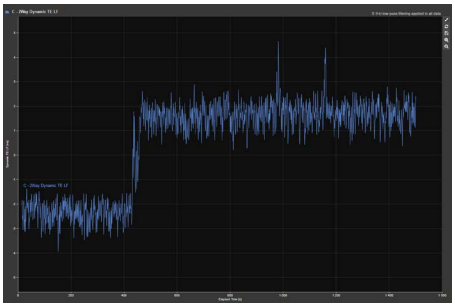
Problem in the network?

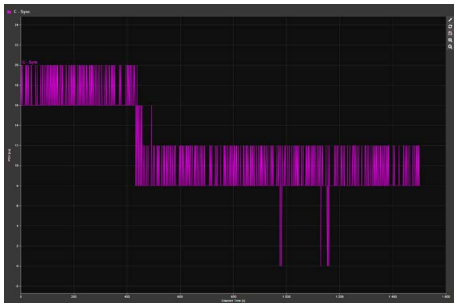
Use Capture and Replay

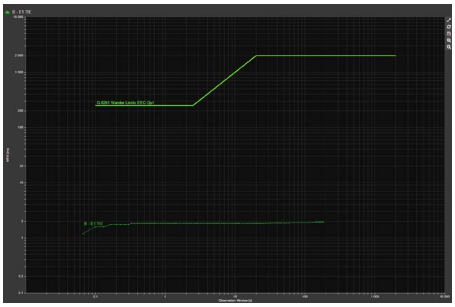
Measure the network and send measurements back to the lab/vendor to replay and fix issues. Data can be transferred from Sentinel via a memory stick or via ftp to a remote PC. Plus, you can ftp results from ongoing measurements.

Actual network performance can also be downloaded to the Calnex Paragon to test individual network components.

Use the CAT for a clearer picture







LTE-A/TDD LTE

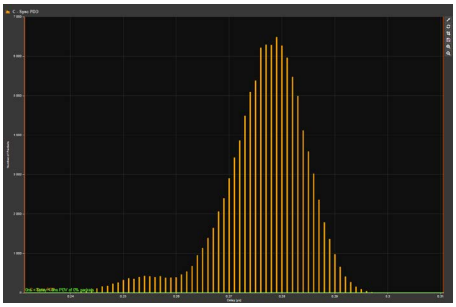
- PTP/1 pps MaxITEI
- PTP/1 pps dTE
- pktSelected2wayTE (APTS/PTS)

LTE-FDD/3G

- PDV FPP
- 16 ppb frequency wander
- MTIE/TDEV

TDM/Legacy

- E1/T1 wander
- MTIE/TDEV
- SSM



SyncE

- E1/T1 wander
- MTIE/TDEV
- ESMC

Financial/Power Networks

- NTP PDV distribution
- NTP 2wayTE

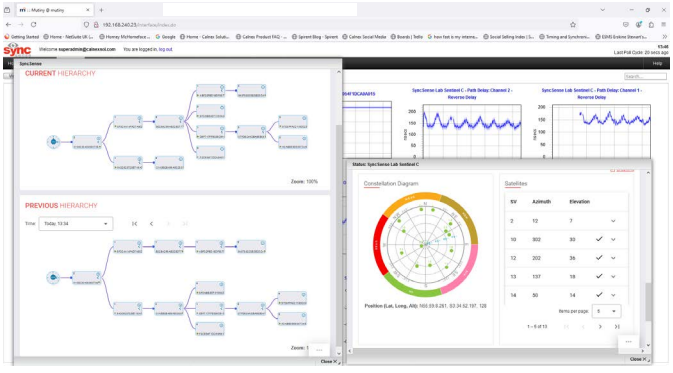
Enhanced monitoring and analysis with Calnex SyncSense

Calnex SyncSense is a sync-focused, highly scalable synchronization monitoring solution for both telecoms and data center networks. It is capable of continuously monitoring the sync performance of all the time-aware devices in your network to give you a clear view of your current network's sync state and any changes in the network that may cause timing errors.

Used in conjunction with Sentinel, it is also an effective way to manage long-term measurements to ensure your network's sync accuracy is maintained and for identifying and troubleshooting sync-related issues.

- Continuous monitoring of measurements being made by a remote Calnex Sentinel.
- Quick and easy way to check-in on the measurements.
- Easily manage the deployment of multiple Calnex Sentinels.
- Selectable alarm and notification thresholds.
- Multiple ways to contact you should there be an event.
- Ad hoc and automatic reporting.
- Automatic graphing and archiving of summarized measurement data.

By harvesting all available sync data (including ITU-T G.8275 Annex F) from multiple sources, SyncSense automatically creates a baseline so that you can benchmark and track changes, monitor trends, predict failures, and identify the cause of intermittent problems.



SyncSense can be ungraded to monitor additional time-aware devices in your network allowing total observability of your network's synchronization.

Related Products

Calnex Sentry

- Remotely monitor and diagnose sync issues on Ethernet and clock signals
- Remotely configure and download results via API
- Detect rogue time source in Datacenter or Telecom network

Calnex Paragon-X

- Test PTP (1588), SyncE, NTP, CES and OAM up to 10GbE
- Stress-test equipment with real network profiles from field tests to debug network issues
- Complete standards compliance testing to ITU-T G.826x/827x
- Test PTP Ordinary Clocks, Boundary Clocks and Transparent Clocks

Calnex Paragon-neo

- Industry-leading Time Error solution delivering sub-nanosecond accuracy – essential for validating new, high accuracy 5G network devices
- Addresses all 5G and ORAN Enhanced Time requirements at rates up to 400GbE
- Capture and decode PTP packets for analysis and Time Error testing
- Prove SyncE jitter and wander performance to ITU-T G.8262.1/G.8262
- Evaluate MTIE/TDEV pass/fail results to ITU-T G.8262.1/G.8262 masks
- Control ESMC (SSM) message generation for testing to ITU-T G.8264

Technical Specifications

Product Feature	Description
Metrics and Masks	
Test Modes	Masks or test limits can be applied to TE, 2wayTE, pktSelected 2wayTE, 2wayTEL, 2wayTEH, TIE, MTIE, and TDEV graphs. PRC/SSU/SEC: Masks for G.811/G.812/G.813-clocks (ETSI 300 462-3). Networks: According to G.823/G.824/G.8261/G.8261.1/G.8271.1/G.8271.2 SyncE: According to G.8261, G.8262 ANSI-standard: DS1 and OC-N masks
Graph Display	Display modes: TE, 2wayTE, pktSelected 2wayTE, TIE, MTIE, TDEV, Path Delay, PDV, 2wayTEL, 2wayTEH, Distribution of PDV, Selected PDV, Floor Packet Percentage, Maximum Average Frequency Error. Number of Graphs: Up to 6 graphs of the same type can be over-laid on screen. Color coded. Masks on Screen: Up to 6 MTIE and TDEV masks according to selected test mode. Pass/Fail result available for each mask
Clock Module Specifications	
Pre-defined Signal / Clock Types	• 1 pps (PTP Subordinate recovered clock). • 8 kHz (frame clock). • 64 kHz/64 kb/s (E0/DS0). • 1.544 MHz/1.544 Mb/s (T1/DS1 clock/data). • 2.048 MHz/2.048 Mb/s (E1 clock/data). • 5 MHz/10 MHz (frequency reference). • 25 MHz/125 MHz/156.25 MHz (SyncE clock rate). • 34 Mb/s (E3), 45 Mb/s (DS3). • 155.52 MHz/155 Mb/s (STM-1/STS-3 clock/data)
User-defined Clock Types	From 0.5 Hz to 200 MHz in 0.5 Hz steps. Note: symmetrical, unipolar clock signals

Technical Specifications continued

Product Feature	Description
Measurement Ports	Number of Ports: 2 per module. Connector: BNC. Impedance: 75 Ω, VSWR <2:1 or 1 MΩ. Voltage Range: ±5.00 V. Sensitivity: min input voltage 60 mVpp, Signal Check voltages are for indication only. Signal Type: Symmetrical pulse (clock signal); Unsymmetrical repetitive pulse (clock signal); HDB3-coded data (data signal); AMI B8ZS, B3ZS (data signal). 1 pps: Constant TE measurement accuracy with reference to GNSS ±75 ns
Relative Time Error	The accuracy with which Sentinel measures the phase difference between any two clock inputs ±5 ns
Ethernet Specifications	
Synchronous Ethernet	SyncE clock measurement. Conformance to G.8261 masks (MTIE/TDEV). Extract and graph ESMC message (SSM). Generate and change ESMC
PTP (1588) and NTP	Network 2-way TE, Forward (Sync) PDV, Reverse (DelReq) PDV and Network Delay. Raw PDV (vs time and distribution graphs). Selected Packet PDV (vs time and distribution graphs). Cluster/band packet selection. Pseudo-Subordinate Clock Mode or Monitor Mode. 1 ns resolution timestamp. Captured PDVs can be replayed on Calnex Paragon-X for troubleshooting. PTP (1588): Layer 2 Multicast and Layer 3 (UDP/IPv4, UDP/IPv6) Multicast/Unicast. NTP: Layer 3 (UDP/IPv4/IPv6) Unicast

Technical Specifications continued

Product Feature	Description
Measurement Ports	Number of Ports: Maximum of 2. Connectors: RJ45 for 100/1000 Base-T, SFP/SFP+ for 100M/1G/10G Optical, QSFP28 for 100G Optical, SFP28 for 25G Optical. (QSFP28 to SFP28 adapter supplied; optical transceivers not supplied)
Accuracy	PTP/NTP constant TE measurement accuracy with reference to GNSS ±75 ns
OTA Module Specifications	
Measurement Accuracy	±100 ns
Maximum input power	-20 dBm
Operating Frequencies	Up to 6 GHz
NR and LTE Bands	TDD and FDD
Platform Specifications	
Reference Clock	Built-in Rubidium reference or external reference input 1 MHz, 5 MHz or 10 MHz
Internal Data Storage	Up to 32G
External Data Storage	USB memory stick
Start/Stop	Via START/STOP key
Signal Check Parameters	Signal type (Clock, Data or Unknown); Frequency (for clock signals); Pulse width (for data signals)
Display	Color TFT, 8.4", 800 x 600 pixels, resistive touchscreen
Internal Rb Clock	
Stability	Output frequency accuracy (7 mins to warmup): 1×10^{-9} Ageing (1 day): $<1 \times 10^{-12}$ Ageing (1 year): $<5 \times 10^{-10}$
GNSS-disciplining	
Built-in GNSS Module	12 channels, TRAIM GNSS receiver, high sensitivity. GPS, GLONAS, Beidou, Galileo
Time Accuracy	±15 ns at 1σ after 24 hours lock
Frequency Accuracy	2×10^{-12} averaged over 24 hours

Technical Specifications continued

Product Feature	Description
GNSS Disciplining Modes	Always disciplining, always in holdover, disciplining only between measurements. Requires 6 hours discipling if disconnected from GNSS for <1 week; 12 hours if >1 week. Requires 1 hour disciplining if using Cs quality 1 pps (from any state)
External References	
Frequency Reference Input (std)	Input Frequency: 10 MHz, 5 MHz. Voltage Range: 0.1 Vrms to 5 Vrms. Impedance: Approx. 50 Ω
External 1 pps Timing Input	Voltage Range: 0 V to 0.8 V (Low), 2 V to 3.3 V (High) into 50 Ω. Required Accuracy: ±100 ns to UTC
GNSS Timing Reference	Antenna Input: N-type connector. DC-feed: +5 V on center pin to active GNSS antenna
Output References	
Reference Frequency Output	Reference Frequency: 10 MHz sine-wave. Output Levels: 1 Vrms in 50 Ω. Impedance: Approx. 50 Ω
1 pps Output	Source: Internal Rubidium oscillator. Output Logic Levels: TTL levels in 50 Ω
E1/T1 Output	Connector: Clock: BNC. Data: Isolated BNC. Frequency: 2.048/1.544 MHz, 2.048/1.544 Mb/s. Output Level: Accurate to G.703 ±1.2 V ±10% in 75 Ω
Interfaces	
USB Device Port	Connector: Std USB type B. USB Version: 2.0

Technical Specifications continued

Product Feature	Description
USB Host Port	Connector: Std USB type A. Maximum Supply Current: 400 mA. USB Version: 2.0
USB Charging Port	Input port only for charging Opt. 631 internal battery. Connector USB type C. Supports 20 V, 5 A profile
Ethernet	Communication Port: RJ45, 10/100 Base-T. Protocol: DHCP, FTP, VNC
Remote Operation	Remote operation via VNC. Event Log: On screen log of measurement start/stop, duration, alarms, loss of data, loss of communication link, etc. Log can be saved as text file. Report Generation: Printable, custom-designed measurement report in PDF format. Security: Password secured access.
Environmental Data	
Operating Temperature	0°C to 40°C. (30°C when charging Rb backup-battery.)
Storage	Temperature from 0 to 50°C and Humidity up to 90% non-condensing.
Safety	EN 61010-1: 2010.
EMC	EN 61326: 2013.
Power Supply	Line Voltage: 100 to 240 Vrms ±10%, 50 Hz to 60 Hz, <100 W.
Mechanical Data	
	Fold-out stand. Ruggedized casing.
Dimensions	(w x h x d) 320 x 388 x 126 mm (12.6" x 15.3" x 5")
Weight	Net <7 kg (15 lb); Shipping with transport case <16 kg (35 lb). Weights are approximations based on varying configurations

Ordering Information

Option	Description
Calnex Sentinel Sync Analyzer with built-in GNSS receiver. Needs minimum of one measurement option (module/port). Included with shipment: Calnex Analysis Tool (CAT), GNSS antenna, antenna cable (20 m), hard transport case, user manual on USB, line power cord, 1-year warranty and support.	
Configurable Options	
Option 610	Clock module 1 pps/E1/T1, any clock from 0.5 Hz up to 200 MHz with 0.5 Hz step. (maximum two per instrument)
Option 615	100M/1G packet port (PTP/NTP/SyncE). Can order maximum of 2 x Opt. 615. Includes SyncE/ESMC analysis for 100M/1G optical and electrical rates. (maximum two – Opt. 615 and/or Opt. 616 per instrument)
Option 616	100M/1G/10G packet port (PTP/NTP/SyncE). Can order maximum of 2 x Opt. 616. Includes SyncE/ESMC analysis for 100M/1G/10G optical and electrical rates. (maximum two – Opt. 615 and/or Opt. 616 per instrument)
Option 618	100G interface ordered at same time as Sentinel mainframe or software upgrade enabling second 100G port
Option 622	25G interface ordered at same time as Sentinel mainframe or software upgrade enabling second 25G port
Option 705	Over-the-Air (OTA) Time Error measurement module(maximum one per instrument)
Additional Options	
Option 620	PTP and NTP PDV measurement software (one license per instrument)
Option 623	Return to factory upgrade of Sentinel with serial no. beginning 400. This is required when upgrading Sentinel with 25G and/or 100G interfaces. Options 618 and/or 622 must be ordered at the same time
Option 631	Battery Powered Operation. Provides three battery-powered functions: • Transport Mode to maintain Rb accuracy in holdover mode during transportation. • Uninterruptible Power Supply maintains operation if external power is interrupted. • Measurements under battery power allows full operation of Sentinel without external supply
Option 812	One year extension of product warranty
Option 813	Two years extension of product warranty

Ordering Information continued

Option	Description
Optional Accessories	
Option 75	120 Ω balanced RJ45 to 75 Ω unbalanced BNC impedance converter (balun)
Option 133	External 1 pps/ToD/Frequency Converter accessory
Option 511	Carry-on bag

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