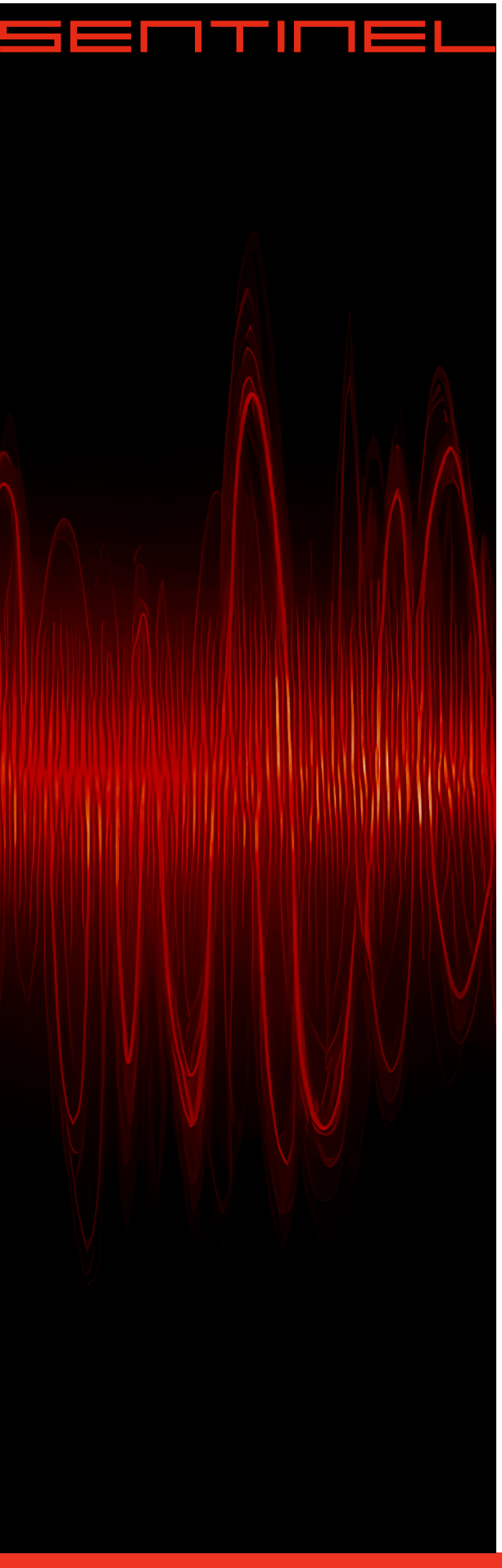


The dedicated synchronization tester

Now featuring 25/100G, 5G OTA and battery operation for OTA measurements

Verify phase, time and frequency synchronization

Monitor performance and diagnose synchronization issues on 3G/4G/5G mobile, data center, financial, power and other telecoms networks



Calnex Sentinel

Performance At-A-Glance

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

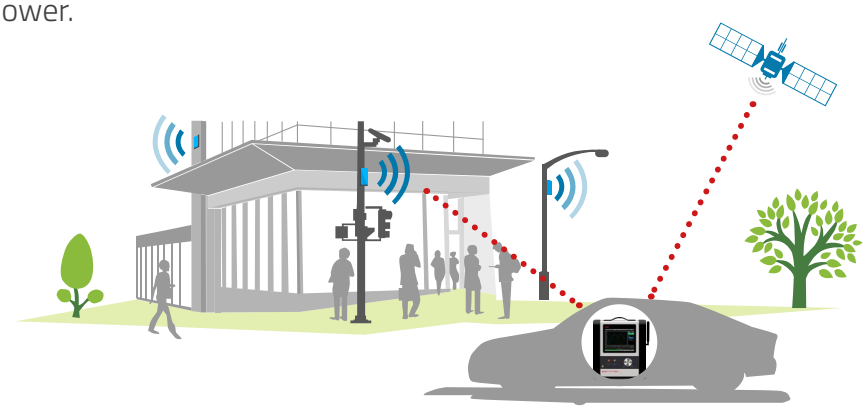
Clear Pass/Fail Metrics for easy analysis:

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

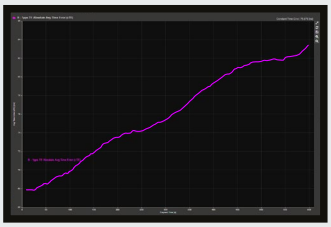
Test Over-the-Air (OTA) synchronization in 4G and 5G mobile networks

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 at the transmitter 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.



Over-the-Air (OTA) Synchronization Testing in the Field



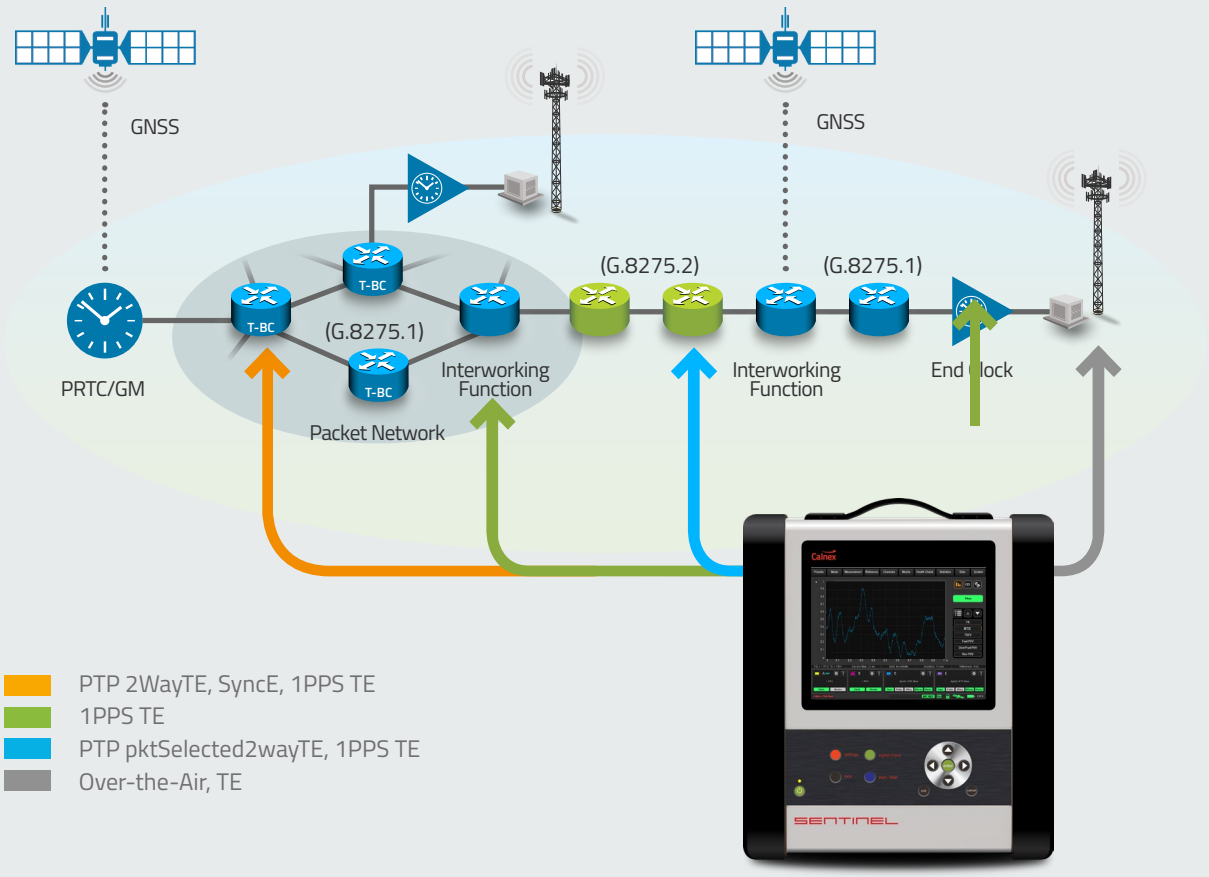
CAT

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

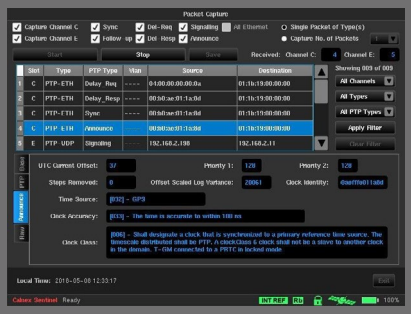
Deliver the fast, stable services your customers can rely on

- 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 3G/4G/5G and Small Cell deployments at various points in the network, including near to the GrandMaster (GM), and validate network performance to ITU-T limits.
- 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.

Measuring Synchronization Performance at Different Points Across the Network



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



Packet Capture and Decode

Capture and decode Signaling, Sync, Del-Req, Del-Resp and Announce messages to help identify:

- 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

Test sPTP and NTP synchronization in data centers

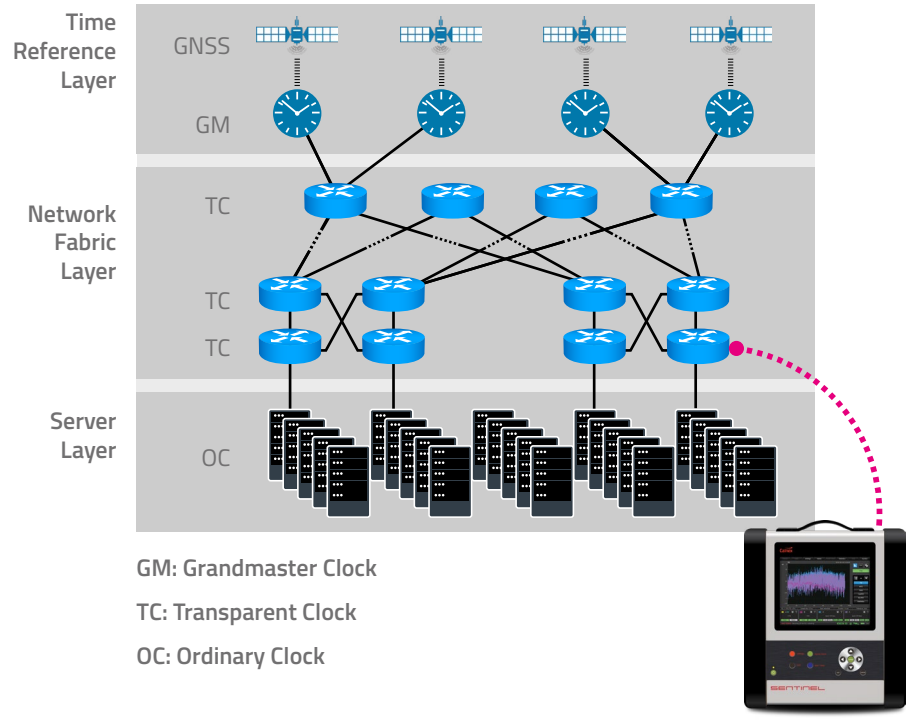
Time synchronization is not new in data centers but the required accuracy is increasing. This is being driven by higher throughput, the need for lower latency, the movement of storage and computation to the network edge, and regulatory and standards body requirements.

NTP was traditionally sufficient to maintain millisecond level synchronization. However, , 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 data center, and prove time/phase accuracy with nanosecond 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 1PPS signal. This makes Sentinel an indispensable tester for deployment, troubleshooting and network maintenance.

PTP Synchronization Monitoring Across Data Center Networks



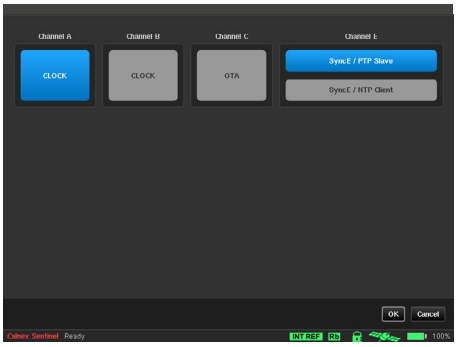
GM: Grandmaster Clock

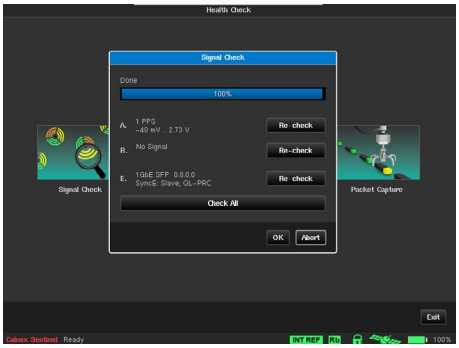
TC: Transparent Clock

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







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

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

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 need to be and to make accurate measurements even when no reference 1PPS 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.

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

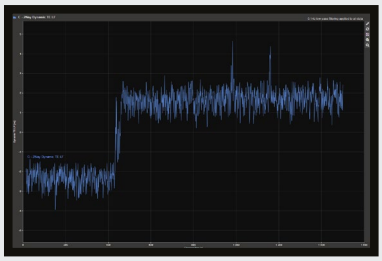


CAT provides powerful insight into network and device performance. All your measurement results are now in one place, and you can view multiple graphs simultaneously for easier correlation of your results.

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.

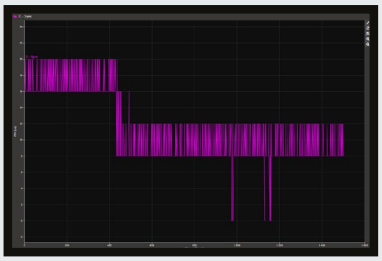
CAT also provides one button generation of reports in PDF format including Pass/Fail statistics and details of failures. This allows you to share captures and results with vendors for fast, efficient and accurate troubleshooting.

Use the CAT for a clearer picture



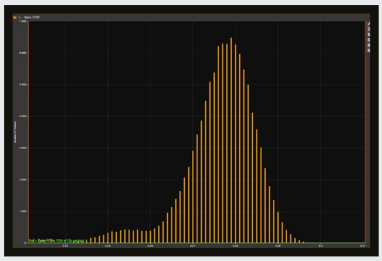
LTE-A/TDD LTE

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



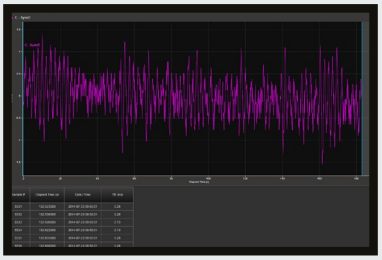
LTE-FDD/3G

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



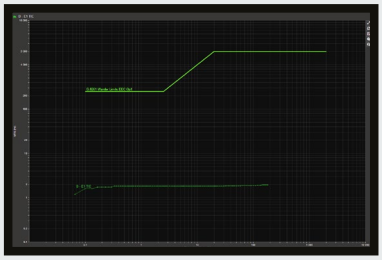
Financial/Power Networks

- NTP PDV distribution
- NTP 2wayTE



SyncE

- E1/T1 wander
- MTIE/TDEV
- ESMC



TDM/Legacy

- E1/T1 wander
- MTIE/TDEV
- SSM

Technical Specifications

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 Specification	
Pre-defined Signal/Clock	1PPS (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.
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). Frequency Measurement: TIE accuracy 1 ns. 1PPS: 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
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

* Except 100MbE (5 ns)

Platform Specifications (continued)

	Internal Rb Clock
Stability	Output frequency accuracy (7 mins to warmup): 1 x 10-9 Ageing (1 day): <1 x 10-12 Ageing (1 year): <5 x 10-10
	GNSS-disciplining
Built-in GNSS Module	12 channels, GPS L1, Galileo E1, GLONASS G1 and BeiDou B1 bands (not compatible with B1C)
Time Accuracy	±15 ns at 1 after 24 hours lock
Frequency Accuracy	2 x 10-12 averaged over 24 hours
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 1PPS (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 1PPS 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.
1PPS Output	Voltage Range: 0 V to 0.8 V (Low), 2 V to 3.3 V (High) into 50 Ω. Source: Internal Rubidium oscillator
E1/T1 Output	Output Logic Levels: TTL levels in 50 Ω. 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
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.
LAN/Management Port	Communication Port: RJ45, 10/100 Base-T. Protocol: DHCP, FTP, web-based GUI (http/https) with authentication if required, WebDav. Supports VLAN
Remote Operation	Remote operation via web-based GUI. 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
Dimensions (w x h x d)	Fold-out stand. Ruggedized casing. 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.

Specification is subject to change without notice.

Related Products

Calnex Sentry



Remotely monitor and diagnose sync issues on Ethernet and clock signals

Remotely configure and download results

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

Ordering Information

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 1PPS/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 Option 615. Includes SyncE/ESMC analysis for 100M/1G optical and electrical rates.
(maximum two – Option 615 and/or Option 616 per instrument)

Option 616: 100M/1G/10G packet port (PTP/NTP/SyncE). Can order maximum of 2 x Option 616.Includes SyncE/ESMC analysis for 100M/1G/10G optical and electrical rates.
(maximum two – Option 615 and/or Option 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:

1. Transport Mode to maintain Rb accuracy in holdover mode during transportation.

2. Uninterruptible Power Supply maintains operation if external power is interrupted.

3. 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.

Optional Accessories

Option 133: External 1PPS/ToD/Frequency Converter accessory.

Option 511: Carry-on bag.

Calnex Solutions plc designs, produces and markets test instrumentation solutions for network synchronization, monitoring and emulation.

For more information on Calnex's network emulation products, and how they enable network and application assurance, contact Calnex Solutions today:

tel: +44 (0) 1506 671 416
email: info@calnexsol.com



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