USER GUIDE

CX3001 v2.0

Calnex Sentinel

The Portable Synchronization Monitor

USER GUIDE R20

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Sentinel Sync Analyser

1.1 Introduction

Calnex Sentinel is a portable Synchronisation tester for testing both the legacy PDH/SDH networks and the newer SyncE, PTP (IEEE1588v2), NTP IP/Ethernet networks for mobile backhaul, data center, financial trading venues, power utility systems and, indeed, any network requiring Frequency, Phase or Time Synchronisation.

The Sentinel measures PTP or clock Time Error (TE) 5G NR or 4G LTE networks that use either ITU-T G.8275.1 Full on Path support, or ITU-T G.8275.2 Assisted Partial Timing Support (APTS)/Partial Timing Support (PTS), as well as TE measurements over the air (OTA) by examining the timing signals within the NR or LTE transmission.

The Sentinel is of modular design allowing flexible configuration and easy future upgrades. It contains three slots where measurement modules can be fitted. Newer revisions (serial number 400XXX) of the Sentinel come with two built-in licensable PTP measurement channels, leaving the other slots free for clock measurement and OTA modules.

The Sentinel is designed to simultaneously measure any combination of SyncE, PTP/NTP, E1/T1, 10MHz, 1 PPS, RF air interface phase and user defined clocks to multiple industry and standards masks.

The Sentinel supports real-time measurements and metric analysis of SyncE and clock TIE/MTIE/TDEV metrics and Packet PDV, FPP, Packet Distribution, 2WayTE and 1PPS TE. Additionally, it supports the measurement of Max |TE|, cTE and dTE to G.8271.1 and pktSelected 2WayTE for G.8271.2 APTS/PTS networks.

Its built-in high-quality Rubidium oscillator can be trained by GNSS (GPS, GLONASS, Galileo, Beidou and QZSS) or an external 1 PPS (Rb- or Cs-quality) atomic clock. The Rubidium oscillator is battery backed up allowing it to be held in holdover for up to three hours, so that Time can be maintained while travelling to the test site.

It is equipped with a large 8.4” color LCD touch screen, clearly showing graphs of Wander TIE/MTIE/TDEV and PTP/NTP PDV, Time Error, FPP, MAFE, Packet Distribution and other ITU-T metrics in real time during a measurement. The intuitive graphical user interface (GUI) accessible via the LCD touch screen is also accessible using a VNC client, permitting remote control if required.

There are different measurements module types available.

Clock Module

- For Recovered clock measurement.
- Provides two ports for Frequency, E1/T1 and 1 PPS measurement and analysis.

Packet Module

- Emulates one PTP time receiver on each packet module (maximum of two modules can be fitted).
- Transport protocol level for PTP measurement: UDP/IPv4, UDP/IPv6 or Ethernet.
- PTP Multicast and Unicast supported.
- PTP message rates up to 128 messages/sec.
- PTP packet by packet capture, measurement and analysis of PDV and TE.
- PTP TE and PDV measurements based on PTP event message timestamps.
- NTP packet by packet capture, measurement and analysis of PDV and TE.
- Emulated NTP Client on each module.
- Simultaneous measurement of SyncE and PTP/NTP for measuring Hybrid networks.
- Maximum of two Ethernet ports supporting 100M / 25GbE / 1GbE / 10GbE interface rates.

Over the Air (OTA) Module

- Determine absolute timing accuracy of 5G NR gNodeB or 4G LTE eNodeB RF interface.
- Frequency range from 350 MHz to 6 GHz.

1.2 Description

Front Panel

The Sentinel front panel has the elements summarized in Figure 1 and Table 1.

Figure 1 - Sentinel Front Panel Elements

1	**Color LCD Touch Screen** Interactive touch screen, which lets you navigate the Sentinel GUI.
2	**Health Check Button** Clicking this button opens the Health Check page (see TBD).
3	**Settings Button** Clicking this button opens the Settings page (see TBD)
4	**Power Button** Press to power on and to power off the Sentinel. In the Stand-by mode, power is maintained for the internal rubidium timebase, provided the mains cable is connected to the mains outlet.
5	**Lock Button** Pressing this button toggles between locking and unlocking the touch screen.
6	**Start/Stop Button** Pressing this button toggles between starting and stopping a measurement.
7	**Keypad** Buttons for navigation in the menus displayed on the touch screen. **[Enter]** Confirm or drill down within the GUI. **[Exit]** Exit from the menu, save the selection, and return to the previous page. **[Cancel]** Exit from the menu, cancel the selection, and return to the previous page.

Table 1 - Sentinel Front Panel Elements

Right Panel

The Sentinel right panel has the elements summarized in Figure 2 and Table 2.

Figure 2 - Sentinel Right Panel Elements (installed modules can vary)

1	**Unbalanced Clock Frequency Measurement Module**[1] This is for connection to BNC unbalanced clock frequency measurement channels. 2 channels per module. Frequency: 0.5 Hz (1 pulse per 2 seconds) to 200 MHz Impedance: 75 Ω or 1 MΩ selectable. Voltage Range: -5 V to +5 V Sensitivity: 60 mVpp Signal Type: Symmetrical pulse (Clock signal), Unsymmetrical repetitive pulse (Clock signal), HDB3-coded data (Data signal), AMI B8ZS, B3ZS (Data signal)
2	**Packet Module**[1] 1 channel per module, RJ45 or SFP connector.

1 Ethernet and clock modules are optional configurations for the Sentinel.

Table 2 – Sentinel Right Panel Elements

Left Panel

The Sentinel left panel has the elements summarized Figure 3 in and Table 3.

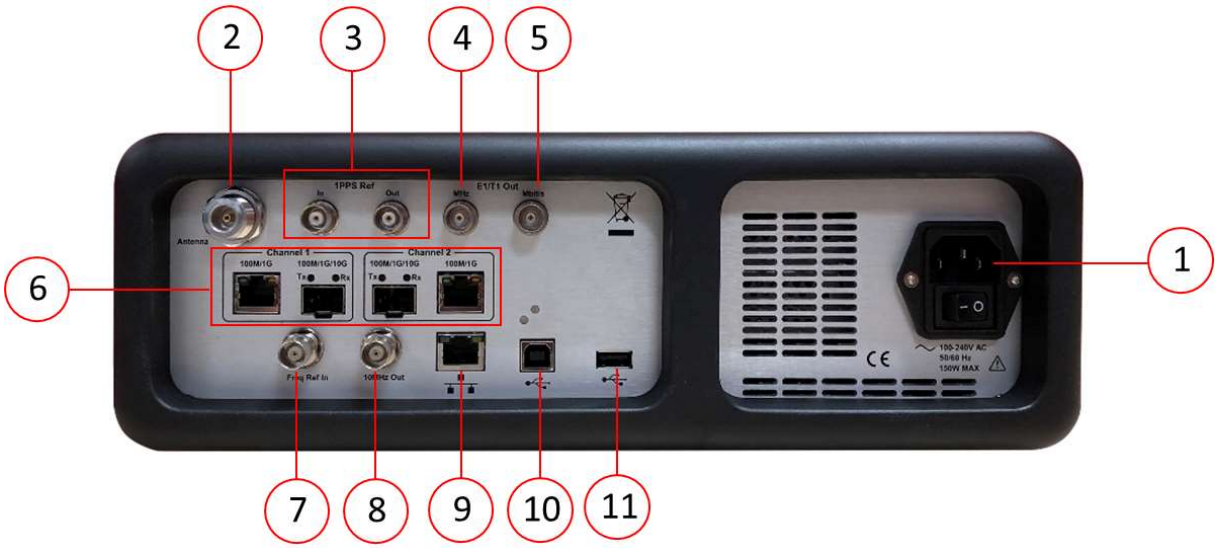


Figure 3 - Sentinel Front Panel Elements

1	**AC Power Input** For connection to the AC power use the supplied AC power cord.
2	**GNSS Antenna Input** N-Type connector for direct connection to an external GNSS Antenna.
3	**1PPS Reference In/Out** BNC connectors : Input for external 1PPS phase reference (TTL/50Ω) and output to use the Sentinel as a 1PPS phase reference (TTL/50Ω).
4	**E1/T1 clock output (MHz)** User settable E1 or T1 clock output, BNC 75 Ω. For more information, see E1/T1 Outputs on page 27.
5	**E1/T1 framed output (Mbit/s)** User settable E1 or T1 framed output, isolated BNC 75 Ω. For more information, see E1/T1 Outputs on page 27.
6	**100M/1G RJ45 Electrical Ethernet and 100M/1G/10G SFP(+) Optical Ethernet Measurement Ports**[1] These are for measurement Channel 1 and 2 connections to 100M/1G electrical interfaces (RJ45) or 100M/1G/10G (SFP(+)) optical interfaces on Ethernet devices, where licensed.
7	**Frequency Reference In** BNC connector: Input for precision external reference (1, 5, or 10 MHz clock).
8	**Frequency Reference Out** BNC connector: Output to use the Sentinel as a 10 MHz reference.
9	**LAN / Management Port** Standard RJ45 connector for connecting the Sentinel to a PC or LAN using the 10/100BASE-T protocol, enabling remote control over Ethernet.
10	**USB type B connector (for future use)** USB Device port
11	**USB Host Port** This is for storing measurement results, configuration presets and performing firmware upgrades via a USB memory stick. It can also be used to power a USB accessory. Connector: USB type A Max supply current: 400 mA USB version: 2.0

1 Ethernet and clock modules are optional configurations for the Sentinel.

Table 3 – Sentinel Left Panel Elements

Included Accessories

- AC power cord.
- GNSS Antenna and 20 m cable.
- User Guide
- CAT and PFV software on a USB memory stick.

1.3 Specifications

General Specifications

Power Supply

- Line Voltage: 100 – 240 V ±10%, 50 – 60 Hz, < 150 W.

Environmental Data

- For indoor or outdoor use, not in wet conditions.
- Temperature: Operating: 0°C to 40°C.
- Relative Humidity: Operating: ≤90 % non-condensing.
- Altitude: Operating: ≤2000 m.
- Overvoltage category: CAT II.
- Safety: EN 61010-1:2010, CAT II, Pollution degree 2, Measuring category I, CE.
- EMC: EN 61326-1: 2021; FCC 47 CFR: 2013 Part 15 Clauses 15.107 and 15.109: Class A.

Mechanical Data

- Fold-out stand; Shock resistant cabinet.
- Dimensions (w x h x d): 320 x 388 x 126 mm (12.6” x 15.3” x 5”).
- Weight: Net < 7kg (15 lb); Shipping with transport case < 16 kg (35 lb).

Platform Specifications

- Reference Clock: Built-in Rubidium reference or external reference input 1, 5 or 10 MHz.
- Display: Color TFT, 8.4", 800 x 600 pixels.
- Internal Memory: sufficient for > 3 days measurement.

Internal Time Base Stability (hold-over)

- Stability Versus Temperature: 20 to 26 °C: <1x10-11 (typ.), -20 to +65°C: <$1x10^{-10}$ baseplate.
- Ageing Rate per 24 h: <$5x10^{-11}$ per month); <$5x10^{-10}$ (yearly).
- Warm-up Stability: 12 min to <$1x10^{-9}$.
- Allan Variance: <$2x10^{-11}$ (1s); <$1x10^{-11}$ (10s); <$2x10^{-12}$ (100s).

GNSS disciplining

- Built-in GNSS module: 12 channels, TRAIM GNSS receiver, high sensitivity.
- Supported constellations: GPS, GLONASS, Galileo, Beidou and QZSS.
- Frequency accuracy: $2x10^{-12}$ averaged over 24 hours.

Input Modules

Clock module

- Number of channels: 2 per module.
- Connector: BNC, unbalanced.
- Frequency: 1 PPS/2s to 200 MHz.
- Impedance: 75 Ω or 1 MΩ selectable.
- Voltage Range: from -5 V to +5 V.
- Sensitivity: 60mVpp.
- Signal Type: Symmetrical pulse (Clock signal), Unsymmetrical repetitive pulse (Clock signal), HDB3-coded data (Data signal), AMI B8ZS, B3ZS (Data signal).

10GbE Packet module

- Connectors: RJ45 for 10/100/1000BASE-T, SFP(+) 100M/1GbE/10GbE.
- Number of channels: up to 2 per module.
- SyncE Wander measurement Accuracy: 1 ns.
- PDV measurement accuracy: 5 ns.
- Time Error Accuracy: +/-75 ns with reference to GNSS.

25/100GbE Packet module

- Connectors: QSFP28 100GbE.
- Number of channels: up to 2 per module.

- Time Error Accuracy: +/-75 ns with reference to GNSS.

OTA module

- Connectors: SMA connector for RF antenna.
- Number of channels: 1 per module.
- Time Error Accuracy: +/-100 ns with reference to GNSS.

Virtual Channels

- If Option 621 Multiple Measurement capability is enabled, 2WayTE can be measured on a total of 32 additional PTP or NTP streams (Virtual Channels). Virtual Channels must be Unicast and differentiated by IP address.

External References

Frequency Reference Input

- Input Frequency: 1 MHz, 5 MHz or 10 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: Type N connector.
- DC-feed: +5 V on centre pin to active antenna.

Output References

Frequency Reference Output

- Ref. Frequency: 10 MHz sinewave.
- Output Levels: 1 Vrms in 50 Ω..

1 PPS Output

- Source: Internal Rubidium oscillator.
- Output Level: TTL levels in 50 Ω..

E1/T1 Output

- Connector: Clock: BNC; Data: isolated BNC.
- Frequency: 1.544/2.048MHz, 1.544/2.048Mbit/s
- Output Level: Acc. to G703:10; ±1.2V ±10% in 75 Ω.

Interfaces

USB Device port

- Connector: USB type B.
- USB version: 2.0.

USB Host port

- Connector: USB type A .
- Max supply current: 400 mA.
- USB version: 2.0.

Management

- Communication port: RJ45, 10/100BASE-T.
- Protocol: DHCP and FTP server, VNC.

Safety Instructions

2.1 Introduction

Read this page carefully before you install and use the Sentinel.

The Sentinel is designed and tested according to safety Class1 requirements of standard IEC/EN 61010-1 and supplied in a safe condition. Before using the Sentinel, you must read this User Guide.

The Sentinel is designed to be used by trained personnel only. The cover of the Sentinel must only be removed for repair by Calnex personnel who are aware of the hazards involved. There are no user-serviceable parts inside the Sentinel.

If the surface of the Sentinel becomes dirty, remove the AC power and clean with a soft lint-free cloth. Never use flammable liquids to clean the Sentinel.

2.2 Safety Precautions

To ensure the correct and safe operation of the Sentinel, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Use of the Sentinel in a manner not specified by Calnex, may impair the protection provided by the Sentinel.

The Sentinel is portable and must be lifted and carried by only its handle. Never use the tilt bail to lift the Sentinel.

In normal operation the openings in the chassis must not be blocked, to allow for cooling of the internal components.

Always operate the Sentinel with unrestricted access to the AC power connector.

Caution and Warning statements

CAUTION:

Shows where incorrect procedures can cause damage to, or destruction of equipment or other property.

WARNING:

Shows a potential danger that requires correct procedures or practices to prevent personal injury.

Symbols

Indicates that the user should consult the manual.

Shows where the protective ground terminal is connected inside the instrument. Never remove or loosen this screw.

If in doubt about Safety

Whenever you suspect that it is unsafe to use the Sentinel, you must make it inoperative as follows:

- Disconnect the mains cable.
- Clearly mark the instrument to prevent its further operation.
- Contact Calnex customer service.

For example, the Sentinel is likely to be unsafe if it is visibly damaged.

2.3 Grounding

Whenever the Sentinel is connected to the mains voltage, any grounding fault will make it potentially dangerous. Before connecting the Sentinel to the mains supply, you must make sure that the protective ground functions correctly. Only then can the Sentinel be connected to the mains supply and only by using a three-wire mains cable. No other method of grounding is permitted. Extension cords must always have a protective ground conductor.

A power supply cord is supplied with the Sentinel. When obtaining a pluggable power cord for use with your local power connection the power cord must meet all local safety requirements, have an integrated safety ground wire, and be rated for the power requirements of the Sentinel.

WARNING:

If the Sentinel is moved from a cold to a warm environment, condensation may cause a shock hazard. Ensure that the grounding requirements are strictly met.

WARNING:

Never interrupt the grounding cable. Any interruption of the protective ground connection inside or outside the instrument or disconnection of the protective ground terminal is likely to make the Sentinel dangerous.

2.4 Power Switch

The Sentinel is equipped with a secondary power switch. It disconnects the main power-consuming circuits on the secondary side of the power supply. Mains voltage is always present on the primary side.

WARNING:

Always consider the Sentinel active as soon as it is connected to the primary AC power source with a mains cable. Disconnection of the mains cable completely cuts off the power supply to the Sentinel.

2.5 Disposal of Hazardous Material

The Sentinel uses a 3 V lithium cell to power a Real Time Clock. It is placed in a holder and can be changed by qualified personnel who are aware of the hazards involved.

WARNING:

Disposal of lithium cells requires special attention. Do not expose them to heat or to excessive pressure, which may cause the cells to explode. Make sure they are recycled according to local regulations.

2.6 GNSS Antenna Installation

The Sentinel is equipped with GNSS receiver, which requires GNSS antenna input. This input must be connected properly and safely to the external GNSS antenna.

WARNING:

For permanent installation, the GNSS antenna and associated cables require an EMP Protector to be fitted for safety reasons. The EMP Protector must be professionally fitted as per the manufacturer's instructions provided with the EMP Protector.

Observe all local regulations on the fitting, grounding and specification of lightning or surge arrestors on the antenna cable.

Disconnect or switch off in-line equipment when installing, checking, disconnecting and connecting EMP protectors. This includes also the exchange of gas discharge tubes (GDTs). Keep back from such activities during thunderstorms. Be aware that only a complete protection system according to IEC 62305-1 can protect your equipment and personnel against the impact of lightning.

This includes an external lightning protection system with air terminal, down conductor and grounding system and bonding of all incoming and outgoing lines (e.g. protectors for mains, data and telephone lines) - not RF lines only.

With GDT protectors take care that the GDT has been properly installed before putting the equipment into operation.

Using the Sentinel

3.1 General Operation

Set-Up

Connect the source(s) under test to the inputs on the Clock or Packet modules.

If using GNSS to discipline the internal Rubidium reference, connect the antenna cable to the **Antenna** connector of the left panel.

By default, the frequency reference to use is automatically selected. The internal Rubidium reference is used unless a valid external reference is connected to the external reference **Freq In** connector.

Connect the Sentinel to the mains supply. Ensure the power switch on the rear panel is in the on (**O**) position and press the power button on the front panel. The Sentinel powers-on automatically.

An identification screen appears like that in Figure 4, then the Sentinel main software starts up.

Figure 4 - Identification Screen

On completion of start-up, the initial startup screen appears (Figure 5). With the Sentinel is ready for use, the status at the bottom left is **Ready**. In case of a cold start the status is **Warming Up...** and the Rubidium icon towards the bottom right is yellow.

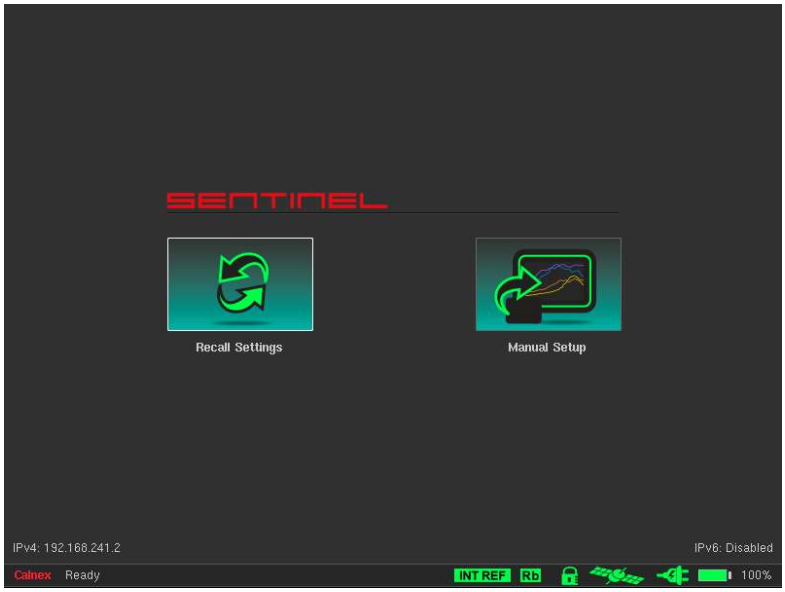


Figure 5 - Initial Startup Screen (when the Sentinel is ready for use)

The **Recall Settings** option allows previously saved configuration files to be re-loaded, automatically setting up Sentinel to the state defined in the preset file and then displaying the main operating screen (Figure 8 on page 15). Selecting the **Manual Setup** option moves directly to the main operating screen (Figure 8 on page 15).

Battery Operation

When fitted, Sentinel's battery can be used to provide power to the internal Rubidium oscillator, maintaining accuracy during transport to site. Depending on the option installed, the battery can also be used to provide a power source when no mains power is present, as well as acting as an uninterruptible power supply. Information about installed options is available in the **Installed Options** screen of the **System** screen (see Figure 73 on page 65).

Option 630 Transport Mode

If the **Transport Mode** option is present, Sentinel's battery can be used for providing power to the internal Rubidium oscillator during transport to site. The corresponding icon in the status bar will display battery charge percentage: 

.

Upon powering off the Sentinel, a dialog box appears (Figure 6) asking if **Transport Mode** should be enabled. In **Transport Mode**, the Sentinel will use the battery to keep the internal Rubidium oscillator powered for up to three hours when mains supply is not present.

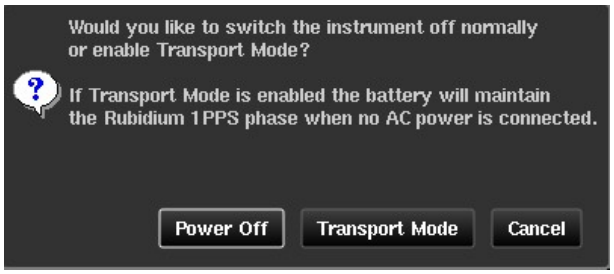


Figure 6 - Enable Transport Mode Dialog Box

Note: When in **Transport Mode**, the battery will not be charged. The battery is only charged when Sentinel is powered on and running.

Option 631 Battery Powered Operation

If the **Battery Powered Operation** option is present, **Transport Mode** can be enabled as described in the previous section. Additionally, when external power is removed from the Sentinel, it will automatically use the internal battery to allow the Sentinel to continue to operate with no interruption.

The external power status is indicated by the mains power icon in the status bar. A green icon () indicates mains power is present.

When mains power is removed, the mains power icon turns red (), and a dialog box (Figure 7) informs you that the Sentinel is now being powered by the internal battery.

Figure 7 - Mains Power Remove Dialog Box

In this state, you can continue to use the Sentinel as usual, including making measurements, until either the mains power is restored, or the internal battery is fully discharged. Battery charge is indicated by the corresponding icon in the status bar: 

.

When the Sentinel with option 631 is powered down, the power LED is red if the battery has charge. This is intentional and indicates that the Sentinel can be used without the need to charge the battery (i.e., a standby indicator).

Note: If the power LED is not illuminated, it is not possible to power the Sentinel from the internal battery and mains power must be applied as required. The battery must be fully charged before battery operation or transport mode is used.

Holding down the power button on a Sentinel with option 631 for up to 10 seconds causes the Sentinel to power off and back on again. This may be useful in scenarios where the GUI on the Color LCD Touch Screen is unresponsive.

Note: For the longest possible run time during a measurement, packet channels must be disabled through the Mode screen (see Mode on page 20).

Based on measurements made under ideal conditions, actual run time on the battery may vary. A fully charged battery provides the Sentinel with the following run times:

- Scenario 1: 90 minutes measurement
- Scenario 2: 60 minutes transport mode and 60 minutes measurement

Note: The run time scenarios quoted above are for OTA measurements only.

Powering Off

The Sentinel is powered off by pressing the power button on the front panel. When the indicator light goes red the Sentinel is powered off.

If the Sentinel is connected to the mains supply, the internal Rubidium oscillator is powered and retains its characteristics.

Disconnection of the mains cable completely cuts off the power supply to the Sentinel unless **Transport Mode** has been enabled, or the **Battery Powered Operation** option is installed (see previous section – Battery Operation).

3.2 Main Operating Screen Overview

The Sentinel's main operating screen has different elements as shown in Figure 8 and as summarized below.

Figure 8 - Main Operating Screen Elements

1. Configuration Bar

Each of the following tabs in the configuration bar lets you configure various aspects of the Sentinel.

- **Presets** – Automatically set the Sentinel's configuration to match a previously saved preset (**.preset**) file, save the current configuration as a preset (**.preset**) file, or set Sentinel back to the default configuration.
- **Mode** – Select the measurement inputs which will be active (e.g. clock, PTP, NTP and SyncE).
- **Settings** – Configure the measurement parameters (e.g. duration, sample time, references used), check GNSS status, and set the configuration of each of the active measurement channels (e.g. clock signal type, Ethernet rate and profile to be used).
- **Masks** – Set one or more limits on measurement metrics, based on pre-defined standards.

- **Health Check** – Automatically detect and configure the signal for clock inputs, check that the Sentinel's PTP protocol is working as expected for the PTP profile being used, and perform a debug packet capture on the Ethernet interface(s).
- **Data** – Recall data from a previous measurement or export the most recent measurement in .csv format.
- **System** – Set the Sentinel's date/time, change the LCD brightness, calibrate the screen, configure the LAN port, enable/disable remote access, manage the internal and/or external storage, view installed options, view event log, update the firmware, export problem report, reboot the Sentinel, or clear all data.

For more information about each of the tabs within the configuration bar, see Configuration Settings starting on page 17.

2. Measurement Graph Window

Displays the result of the selected metric for the current measurement, along with any applied masks. Graphs auto-scale to fit the current data or enabled masks.

3. Measurement Configuration Details

Provides information on the measurement parameters for the current measurement, as configured on the **Settings > Measurement** page.

4. Status Line

Provides information on the current measurement status of the Sentinel, including the time remaining when a measurement is running. The event messages that can appear here and within the log are summarized in Table 7 on page 98.

5. Viewing Mode Selector

Lets you select which information to display in the measurement graph window of the main operating screen:

 – full-size graph window

– measurement analysis (mean, last, max and min values)

 – masks table

When measurement analysis or masks table is selected, the graph window size is reduced to accommodate.

6. Start/Stop Measurement Button

When the Sentinel is idle, clicking on this button starts the measurement using the current configuration and prompts you to select a location to save the data.

Note: If the **Start** button is greyed out, the Sentinel is not ready for taking measurements (i.e. the timebase is not ready, or a Clock/Packet module is not ready).

When a measurement is running, clicking on this button stops the measurement, processes and saves the data, and provides a pass/fail indicator based on any applied masks. A short report is generated on measurement completion.

7. Graph/Metric Selector

Lets you select which graph or metric is displayed on the measurement graph window for the current measurement and lets you select which graphs and metrics are selectable from the main operating screen.

8. Channel Widget Panel

Each measurement channel is represented by a widget on the channel widget panel. Widgets show (where appropriate for the given input) signal type, line rate, IP address, whether the signal is present (clock), whether the appropriate messages are present (PTP/NTP), whether the measurement is within the applied mask(s), information on the physical properties of the input (signal voltage, SFP information, etc.) and quick access to the channel's **Settings** screen.

The color beside the channel name/number in the widget panel matches the measurement result color on the measurement graph window for easy identification.

9. Status Icon Indicator

Shows the current status of Sentinel's references, represented as colored icons. The icons shown in Figure 8 on page 15 are for the timebase reference, Rubidium, Rubidium disciplining, GNSS, and power.

Clicking on this area opens a **Status Icons** screen (Figure 102 on page 86) that gives a detailed description of each icon and its possible states.

Note: The status icons that appear may vary according to the hardware configuration and options available.

Configuration Settings

Manual configuration of Sentinel is simply a process of working through the tabs on the configuration bar (Figure 9) of the main operating screen as detailed below.

Figure 9 - Configuration Bar

4.1 Presets

When you click on the **Presets** tab in the configuration bar the **Presets** screen (Figure 10) appears.

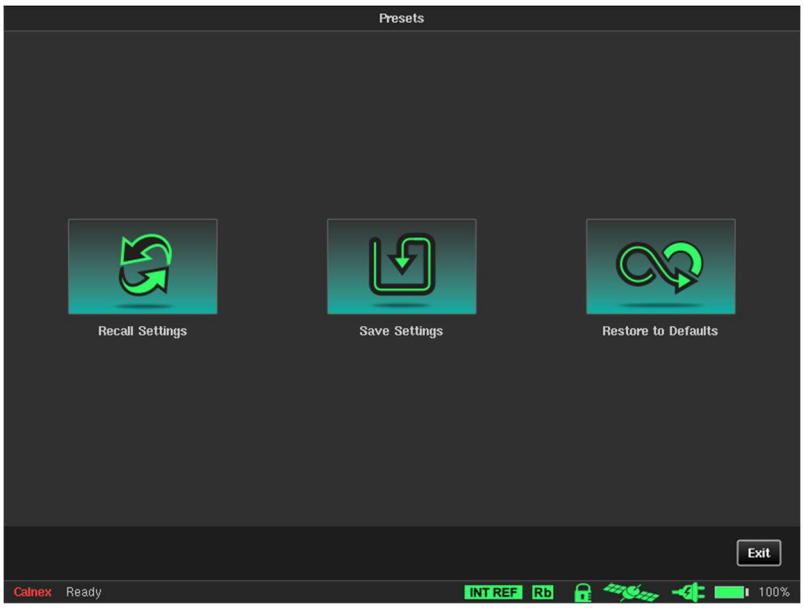


Figure 10 - Presets Screen

Clicking on the **Exit** button returns you to the main operating screen (Figure 8).

Recall Settings

Clicking the **Recall Settings** tile opens a **Load Measurement Settings Preset** screen. The **Load Measurement Settings Preset** screen lets you reload a previously saved **.preset** file, automatically setting up Sentinel to the state defined in the **.preset** file.

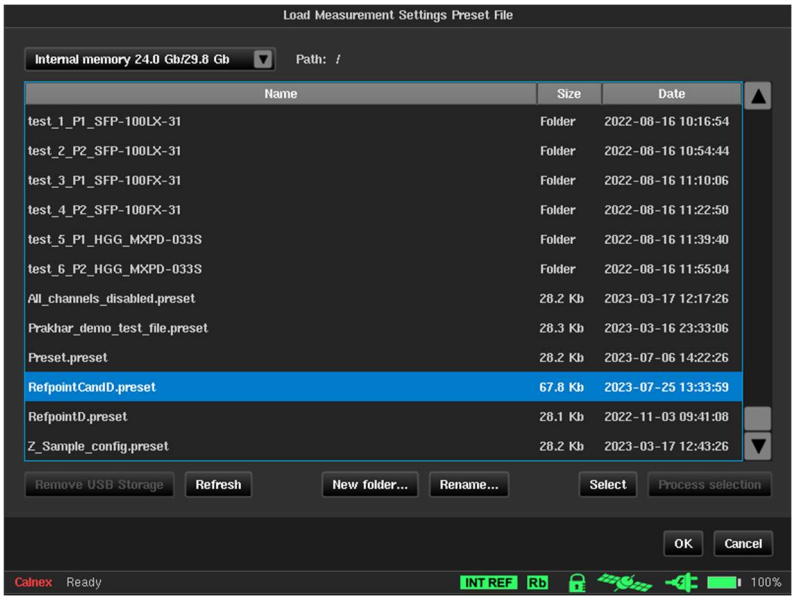


Figure 11 – Load Measurements Settings Preset File

To reload a **.preset** file, do the following:

1. Select either Internal memory or External memory (if a USB memory stick is connected).
2. Navigate to and select the appropriate **.preset** file.
3. Click **OK**.
   You are returned to the **Presets** screen, and a number of different messages appear, including **Please wait...** while the **.preset** file is loaded. Once the **.preset** file is loaded a **Settings successfully loaded from the file** dialog box appears.

4. In the **Settings successfully loaded from the file** dialog box, click **OK**.

Save Settings

Measurement settings can be saved and reloaded later. You can choose the filename and current settings will be saved in a **.preset** file. This function is especially useful for fast setup in the field. Clicking the **Save Settings** tile opens a **Save Settings** screen.

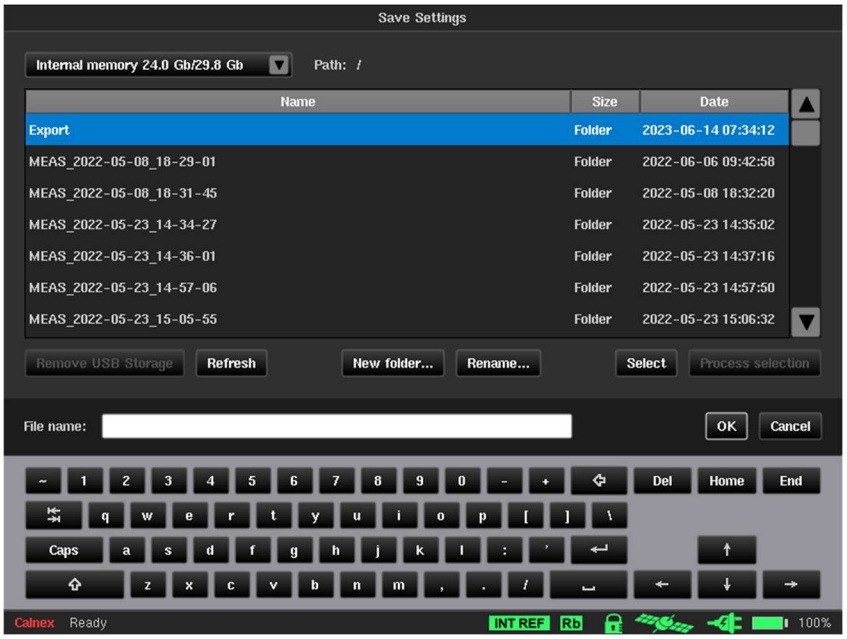
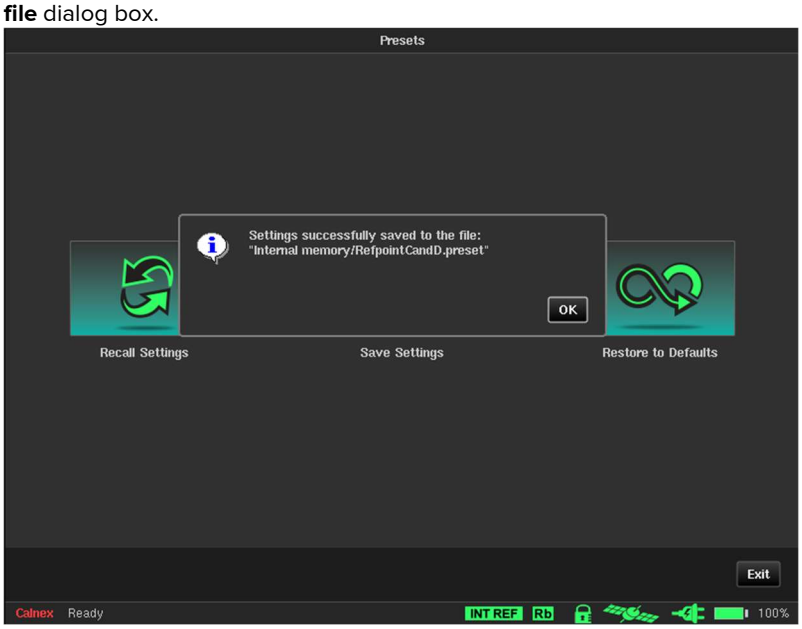


Figure 12 - Save Settings Screen

To save the current measurement settings, do the following:

1. Click in the **File name:** field.
2. Use the virtual keyboard to specify an appropriate filename without the **.preset** file extension (e.g. RefpointCandD).
3. Click **OK**.
   The **.preset** file is saved, and you are returned to the **Presets** screen with a **Settings successfully save to the**

file dialog box.



4. In the **Settings successfully save to the file** dialog box, click **OK**.

Restore to Defaults

To set the Sentinel back to its factory default settings, click the **Restore to Defaults** tile. From the **Restore default measurement settings?** dialog box (Figure 13) that appears, click **Yes** to confirm or **No** to cancel.

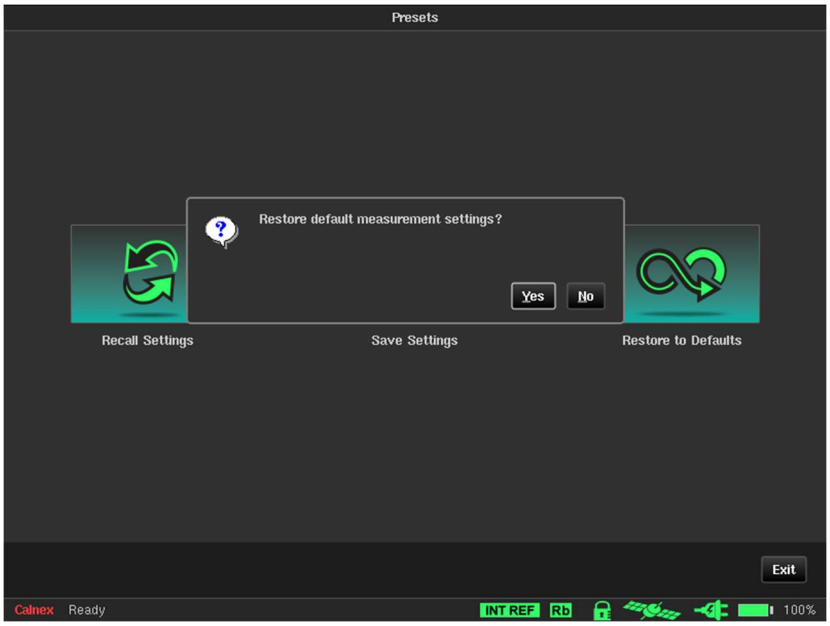


Figure 13 - Restore to Defaults Dialog Box

4.2 Mode

When you click on the **Mode** tab in the configuration bar the **Mode** screen (Figure 14) appears.

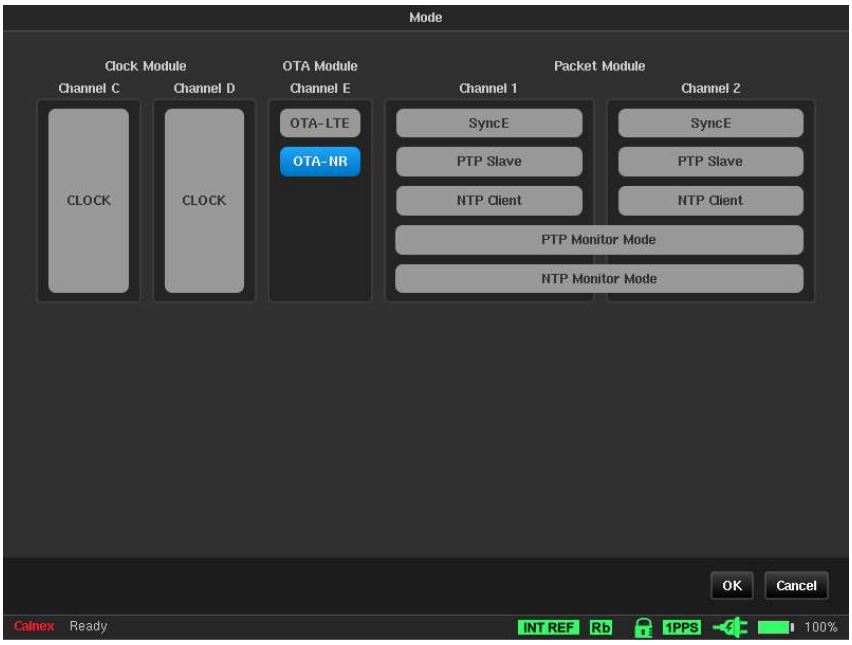


Figure 14 - Mode Screen

The **Mode** screen lets you configure the Sentinel measurement subsystem for the type of testing being performed. Sentinel expansion slot channels are labelled A – F and the packet modules are labelled 1 – 2.

The **Mode** screen displays the modules that are installed in Sentinel. The example in Figure 14 shows that two clock modules (Channel C and Channel D), two OTA modules are installed (OTA-LTE and OTA-NR), and two packet modules (Channel 1 and Channel 2) are installed.

You can enable/disable channels on the **Mode** screen according to your testing requirements.

Either the **PTP Monitor Mode** or **NTP Monitor Mode** can also be enabled through the **Mode** screen. For this to be possible, two packet modules must be installed and the **PDV option** must be enabled. Note that for the 4G/5G OTA module, only one OTA measurement type may be selected at a time. For the 4G OTA module, only **OTA-LTE** is present.

If a channel is disabled on the **Mode** screen, this is reflected in the corresponding widget within the channel widget panel on the main operating screen. The example in Figure 14 has one of the two clock modules (Channel C) enabled, and one of the two packet modules (Channel 1) enabled. In this case the corresponding channel widget panel on the main operating screen appears as shown in Figure 15.

Figure 15 - Example Widgets Panel (Channel D and Channel 2 Disabled)

Disabling unused channels simplifies configuration and results viewing by removing these channels from the configuration and results screen.

When either **PTP Monitor Mode** or **NTP Monitor Mode** is enabled, the channel widget on the main operating screen is combined for the two Packet Module channels as shown in Figure 16 (PTP example).

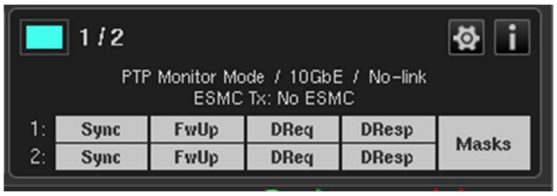


Figure 16 - Combined Channel Widgets for Packet Modules in PTP Monitor Mode

4.3 Settings

When you click on the **Settings** tab in the configuration bar the **Settings** screen appears with a page corresponding to the tab that was previously selected (Figure 17).

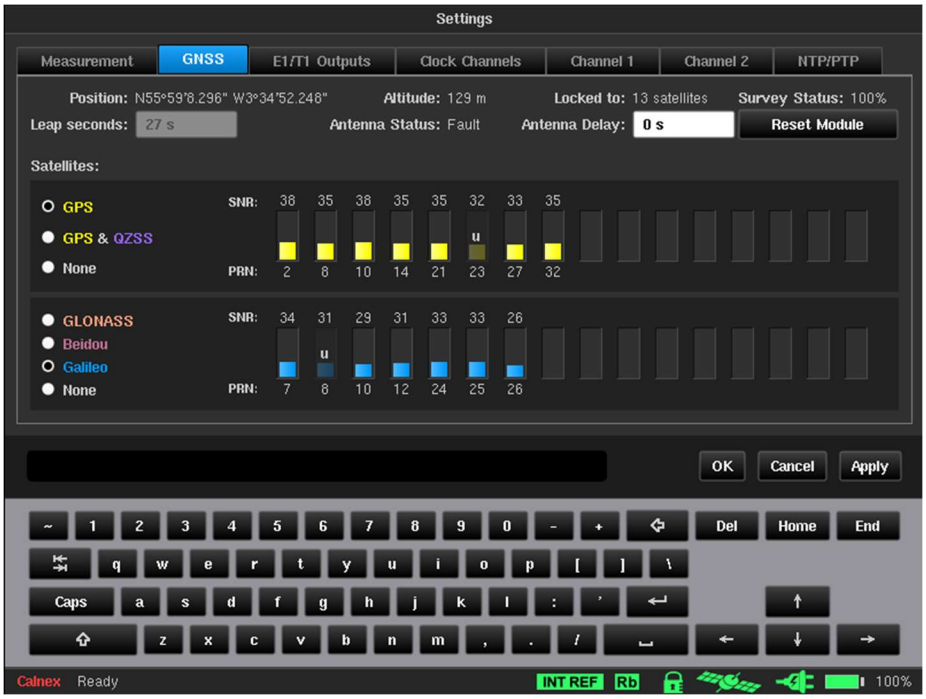


Figure 17 - Example Settings Screen - GNSS Tab Previously Selected

The **Settings** screen contains multiple tabs to configure all the relevant measurement subsystems selected through the **Mode** screen and some options that are common to all measurement types.

Any of the packet channels that were enabled in the **Mode** screen will have their corresponding tabs visible within the **Settings** screen. The example in Figure 17 shows a **Settings** screen where the packet channels **Channel 1** and **Channel 2** were enabled from within the **Mode** screen.

Note: If either **PTP Monitor Mode** or **NTP Monitor Mode** is enabled, the **Channel 1** and **Channel 2** tabs are not visible, and replaced by a **Monitored Channels** tab. For more information, see Monitor Mode on page 45.

A common set of buttons appear permanently on each of the **Settings** screens. The buttons always have the following functionality:

OK Apply all the settings changes that have been made whilst in the **Settings** screens. When applied return to the main operating screen.

Cancel Cancel all settings changes that have been made to date within the exception of any that have already been applied using the **Apply** button.

Apply Apply all settings changes that have been made and remain in the **Settings** screen.

The sections below describe each of the tabs available from within the **Settings** screen.

Measurement

The **Measurement** tab contains a **Common** page and **Timebase** page, which are accessible by clicking on their respective button.

Common

When you click on the **Common** button within the **Measurement** tab of the **Settings** screen, the **Common** page (Figure 18) appears.

Figure 18 - Common Page

The **Common** page defines the general characteristics of the measurement, and provides the following settings:

Start — Defines the **Start** mode (i.e. when the measurement starts) and allows the following options:

Immediate — Start the measurement as soon as the **Start** button is clicked.

Timer — Start the measurement at the specified time.

Start time — Defines start time when **Start** mode is *Timer*.

Note: In all cases (i.e. when the **Start** mode is either *immediate* or *timer*), even if a scheduled measurement is defined with the **Start** mode set to *timer*, the measurement is not made until the **Start** button is clicked.

Continuous Measurement — Defines whether the measurement when started should run on a continuous basis. This results in a series of 24 hours measurements being made. A new measurement is started each time 00:00 UTC is reached. The last 7 days of measurement data is retained in the folder named *continuous* within the internal storage. Each day of data is stored in a folder within the *continuous* folder with a name indicating the day the measurement started based on UTC time.

Whilst running in this mode it is not possible to measure any metrics e.g. TDEV, MTIE.

No masks will be checked whilst continuous mode is enabled.

Metrics — This disables metric calculation (e.g. TDEV, MTIE) and mask checking during the measurement.

If this option is selected and metrics are required after a measurement has been completed, this can be achieved using the Calnex Analysis Tool (CAT) which is supplied with Sentinel.

Duration — Duration of the measurement. The measurement duration is defined either by the time entered in the **Duration** field or by the stop time entered in the **Stop time** field. If a duration is entered, the **Stop time** is updated accordingly, and if a stop time and date are entered, the measurement duration is updated accordingly.

Stop time	Defines stop time when **Start** mode is *Timer*.
Estimated Data size	Displays estimated size of file for measurement data. Depending on the configuration, if the duration exceeds a certain length, the Sentinel enters **Long Term mode**. In **Long Term mode** only some of the available graphs are displayed and no metrics are calculated.
Sample time	Measurement interval. Signal measurements are made point by point at regular intervals defined by entry using the virtual keyboard. *33 ms* is the default setting to provide 30 TIE samples per second in accordance with the recommendations for wander measurement equipment in ITU-T O.172.
Auto-Restart	Defines whether the measurement restarts if there was a power interruption during the measurement.
TIE Mode	This setting allows the selection of the following measurement modes:
TIE	General TIE measurement for every enabled input channel.
TIE + 1 PPS TE	All connected 1 PPS signals will measure absolute differential TIE relative to the signal connected to the reference channel. All other signals measure normal TIE relative to the selected timebase.
TIE + 1PPS Alignment	This performs the same measurement as TIE + 1PPS TE but does not include time error caused by missed pulses, supressing steps of 1 second or more in the measurement.
TE	This performs the same measurement as *TIE*, but the initial phase offset of each signal is not compensated for.
Diff TIE	All connected signals (including SyncE) will measure differential TIE relative to the signal connected to the reference channel. See **Diff T(I)E reference** setting.
Diff TE	This performs the same measurement as *Diff TIE*, but the initial phase offset of each signal is not compensated for.
Diff T(I)E reference	Drop-down list for selection of the input channel or internal reference to be used as reference when **TIE Mode** is *Diff TIE, Diff TE* or *TIE + 1 PPS TE*.
G.8271.1 TE Mask Value	Sets the absolute value for the G.8271.1 Max|TE| mask. This is user defined and configures the Pass/Fail limit for TE measurements when that mask is selected.

Timebase

When you click on the **Timebase** button within the **Measurement** tab of the **Settings** screen, the **Timebase** page (Figure 19) appears.

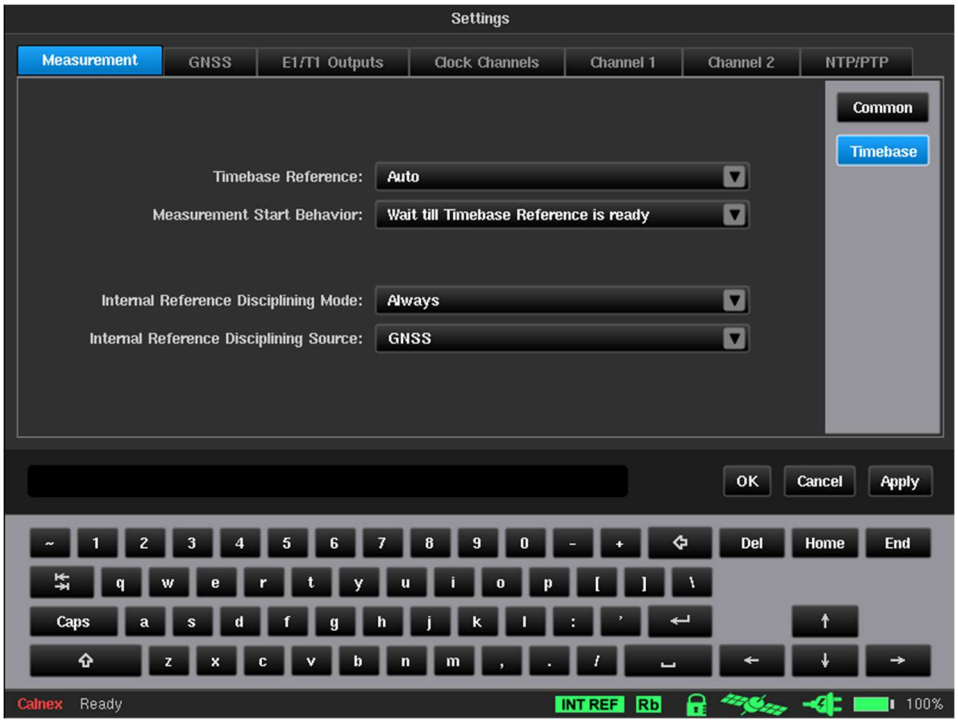


Figure 19 - Timebase Page

The **Timebase** page provides the following settings:

Timebase Reference

Internal	Use the internal Rubidium as the reference for measurements.
External	Use an external reference for measurements.
Auto	Use an external reference if connected to the **Freq In** connector. If no external reference is connected to the **Freq In** connector use the internal Rubidium reference.

Measurement Start Behavior

Start even if Timebase Reference is not ready	The measurements starts even if the internal Rubidium reference is not fully warmed up.
Wait till Timebase Reference is ready	The measurement will wait until the selected Timebase Reference is fully ready and warmed up.
Abort if Timebase Reference is not ready	The measurement will automatically stop if the reference is not ready to proceed.

Internal Reference Disciplining Mode

Never	Disable disciplining. The internal Rubidium reference will remain in free running mode and will never discipline to GNSS or an external reference even if available.
Not during measurement	Enable disciplining, but do not use it during measurement.
Always	Enable disciplining always, the internal Rubidium reference will not discipline if a suitable reference is not available.

Internal Reference Disciplining Source

GNSS	Use internal GNSS receiver. If the last disciplining was less than 1 week ago, the Sentinel must be disciplined for at least 6 hours, otherwise the Sentinel must be disciplined for at least 12 hours.
Ext 1 PPS (GPS/Rb Quality Source)	Use 1 PPS signal from an external GPS receiver or an external Rubidium quality atomic clock.
Ext 1 PPS (Cs Quality Source)	Use 1 PPS signal from an external Cesium quality atomic clock.

Note: The Sentinel will only discipline if the disciplining source selected is producing a valid disciplining output and so **Internal Reference Disciplining Mode** can be left to *Always* even if the source is not available. If the source is re-connected during a measurement, there may be a phase shift in the timebase reference.

GNSS

When you click on the **GNSS** tab of the **Settings** screen, the **GNSS** page (Figure 20) appears.

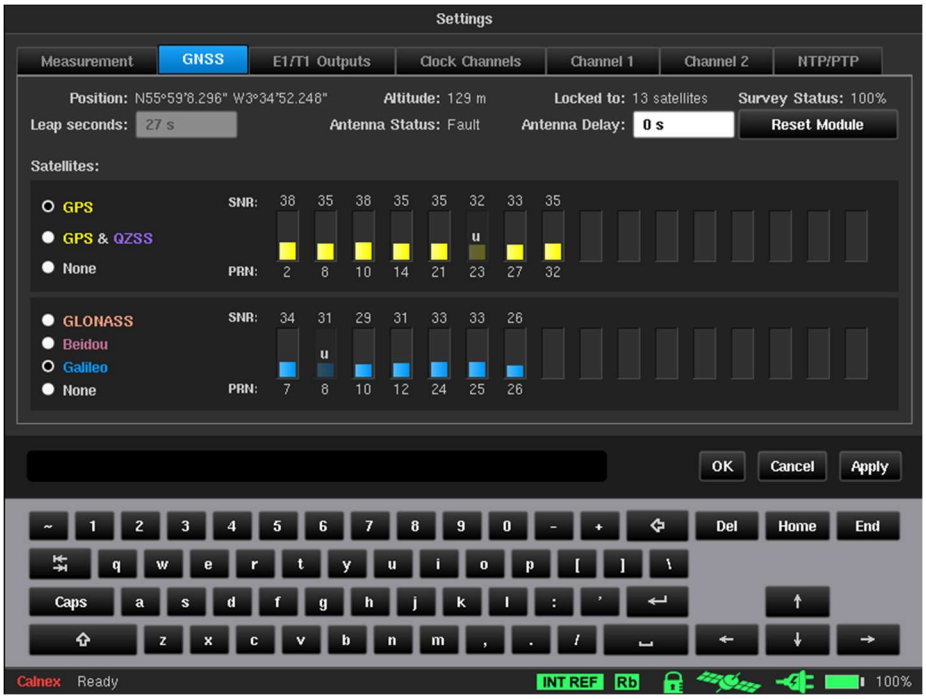


Figure 20 - GNSS Page

The **GNSS** page allows selection of GNSS constellation and displays general GNSS information received: position, altitude, number of satellites that receiver is locked to, antenna status and signal levels for all visible satellites. If the signal level of a satellite is not strong enough its signal bar is greyed out and contains the **u** character to indicate that the satellite is unused.

The top constellation selection determines whether GPS is used and if GPS is selected, whether QZSS is also used. If GPS is not selected, a constellation must be selected in the lower selection area. For multi-constellation operation, select GPS or GPS and QZSS and a secondary constellation. Table 4 shows valid GNSS configurations possible with the Sentinel.

GPS	GLONASS	Galileo	Beidou	QZSS
✓				
	✓			
		✓		
			✓	
✓	✓			
✓		✓		
✓			✓	
✓				✓
✓	✓			✓
✓		✓		✓
✓			✓	✓

Table 4 - Valid GNSS Configurations

Clicking **Apply** makes the GNSS module reset and begins a new site survey using the new constellation(s).

NOTE: Changing constellations causes the Rubidium timebase to unlock and it may experience a step input from the GNSS 1 PPS output. It is recommended that the Sentinel remains disciplining to GNSS for at least 6 hours after changing constellations. This period must be at least 12 hours if the Sentinel has not been disciplined for more than a week.

The satellite SNR status appears in the same colour as the text in the constellation name. The **Locked to** status displays the total number of locked satellites over all selected constellations.

GPS, Galileo and Beidou satellites transmit information that lets the Sentinel calculate the number of leap seconds that have occurred, and this is used to determine the offset between TAI and UTC. The **Leap seconds** value is updated automatically whenever this information is received.

GLONASS does not transmit leap second information and you must manually define the **Leap seconds** value if the current value is not correct. PTP uses TAI as the time base for its timestamps and if the **Leap seconds** value is incorrect it will show as whole seconds of offset in the FwdPDV, RevPDV and 2WayTE graphs.

Survey status shows progress of the GNSS receiver site survey.

Clicking **Reset Module** makes the GNSS receiver reset.

The **Antenna Delay** setting lets you compensate for antenna cable length, if required.

E1/T1 Outputs

When you click on the **E1/T1 Outputs** tab of the **Settings** screen, the **E1/T1 Outputs** page (Figure 21) appears.

Figure 21 - E1/T1 Outputs Page

The **E1/T1 Out** ports (**MHz** and **Mbit/s**) can be configured for either an E1 output signal or a T1 output signal.

The **E1/T1 Outputs** page contains the following settings, which define the signals generated by the **E1/T1 Out** ports (**MHz** and **Mbit/s**).

Mode

Drop-down list for selection of the type of output signal:

- *Disabled* – default setting. Disabled (i.e. no output signal generated).
- *E1* – E1 output signal generated (when selected, the **E1 Framing** setting is available).
- *T1* – T1 output signal generated (when selected, the **T1 Encoding** and **T1 Framing** settings are available).

E1 Framing

Drop-down list defining the E1 framing setting for when the E1 mode is selected:

- *HDB3 without CRC-4* – High-Density Bipolar Order 3 without Cyclic Redundancy Check 4 is used.
- *HDB3 with CRC-4* – High-Density Bipolar Order 3 with Cyclic Redundancy Check 4 is used.
- *HDB3 with AIS* – High-Density Bipolar Order 3 with Alarm Indication Signal testing is used.

T1 Encoding

Drop-down list defining the T1 encoding setting for then the T1 mode is selected:

- *B8ZS* – Binary Eight Zero Substitution encoding used.
- *AMI* – Alternate Mark Inversion encoding is used.

T1 Framing

Drop-down list defining the T1 framing setting for when the T1 mode is selected:

- *D4/Superframe* – Superframe is used.
- *Extended Superframe no CRC-6* – Extended Superframe without Cyclic Redundancy Check 6 is used.
- *Extended Superframe CRC-6* – Extended Superframe with Cyclic Redundancy Check 6 is used.
- *AIS* – Alarm Indication Signal testing is used.

Clock Channels

The **Clock Channels** tab contains a **Channels** page and **Signals** page, which are accessible by clicking on their respective button.

Channels

When you click on the **Channels** button within the **Clock Channels** tab of the **Settings** screen, the **Channels** page (Figure 22) appears.

Figure 22 - Channels Page (Channels C and D enabled)

The **Channels** page contains settings that define the characteristics of the input channels. The displayed values are those identified by the signal check, if the signal check has been run. For more information about running a signal check, see the Signal Check section on page 50.

Each installed channel (**A** to **F** depending on modules fitted) appears on a line with the following columns:

Signal type[1] — Drop-down list for selection of the type of input signal, including:

- Standard signal types predefined in the Sentinel.
- Signal types defined manually (see the Signals section on page 29).

Trigger level — Within the limit ± 5 V

Cable comp.[2] — Value up to 1000ns to compensate for delay introduced by the length of cable. (1 PPS signal only)

1 PPS converter[2] — Drop-down list to select if the Calnex converter box is being used to convert a balanced 1 PPS to single ended 1 PPS. When enabled, this automatically compensates for the delays introduced by that device.

Slope — Drop-down list defining the trigger slope: Positive or Negative.

Impedance — Drop-down list defining the channel impedance, 75 Ω or 1 M Ω.

Filter — Drop-down list (*ON/OFF*) for application of a predefined RC-type analogue LP filter with a cut-off frequency of approximately 10 kHz and signal rejection of 13 dB at 1 MHz. This filter is used to suppress noise on 1 PPS signal measurements.

---

[1] Signal types shown in Appendix A

[2] These items are greyed out if **Settings > Measurement > Common TIE Mode** is not set to *TIE + 1 PPS TE* or the signal type is not **1 PPS**.

Signals

When you click on the **Signals** button within the **Clock Channels** tab of the **Settings** screen, the **Signals** page (Figure 23) appears.

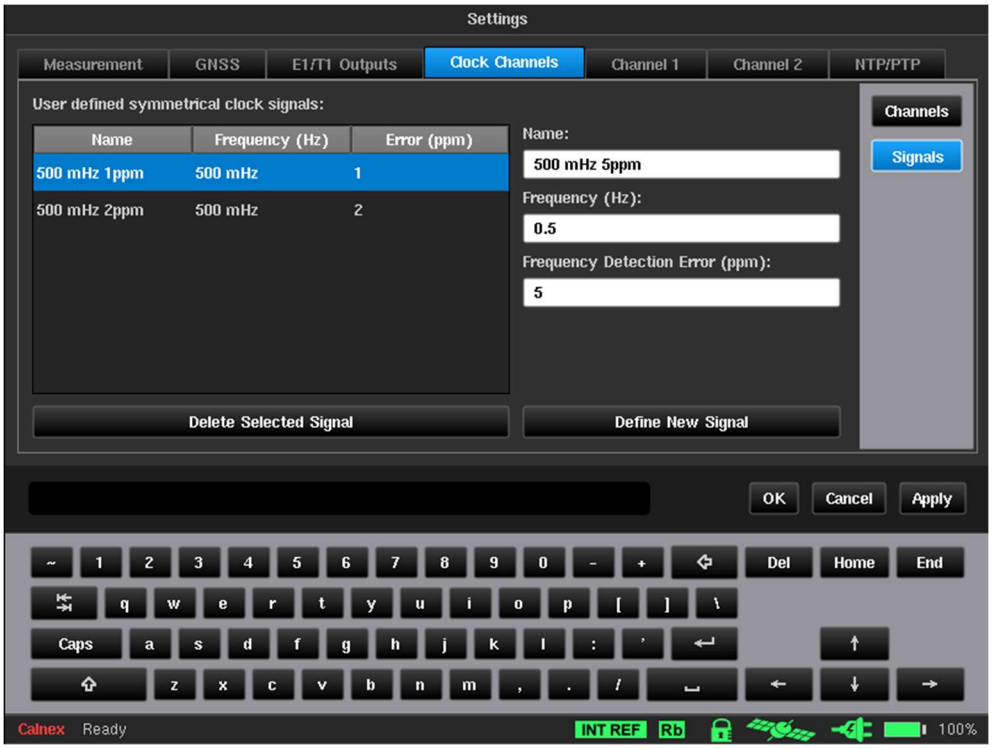


Figure 23 - Signals Page

The **Signals** page contains settings that define the input signals not included in the predefined **Signal type** list within the **Channels** page (Figure 22). Only clock type signals can be defined in the **Signals** screen.

The area on the left lists the user defined signals that have already been manually defined. To delete a user defined signal, select it so that it is highlighted in blue and click the **Delete Selected Signal** button.

You can use the fields on the right to define a new signal type, by entry using the virtual keyboard.

Name	Entry of the signal name. The name you specify appears in **Signal type** list within the **Channels** page.
Frequency (Hz)	The accepted values are those measurable by the Sentinel, i.e. 0.5 Hz (1PP2S) to 200 MHz.
Frequency Detection Error (ppm)	Tolerance in ppm on the frequency detected by the system during the signal check. If the measured signal is out of tolerance, a **signal unknown** message is displayed as result of the signal check.

To define a new signal type, specify an appropriate name, frequency and frequency detection error in the **Name**, **Frequency (Hz)**, and **Frequency Detection Error (ppm)** fields, respectively, and click the **Define New Signal** button.

Any user defined signals that you create are listed after the predefined signals in **Signal type** list within the **Channels** page (Figure 22).

Channel *X* (OTA-LTE)

If you select **OTA-LTE** in the **Mode** screen, a **Channel *X*** tab to be presented in the **Settings** screen with a **Cell Parameters** button and **Measurement** button (see Figure 24 and Figure 26).

Cell Parameters

When you click on the **Cell Parameters** button in the Channel X tab of an OTA-LTE module, the **Cell Parameters** page (Figure 24) appears.

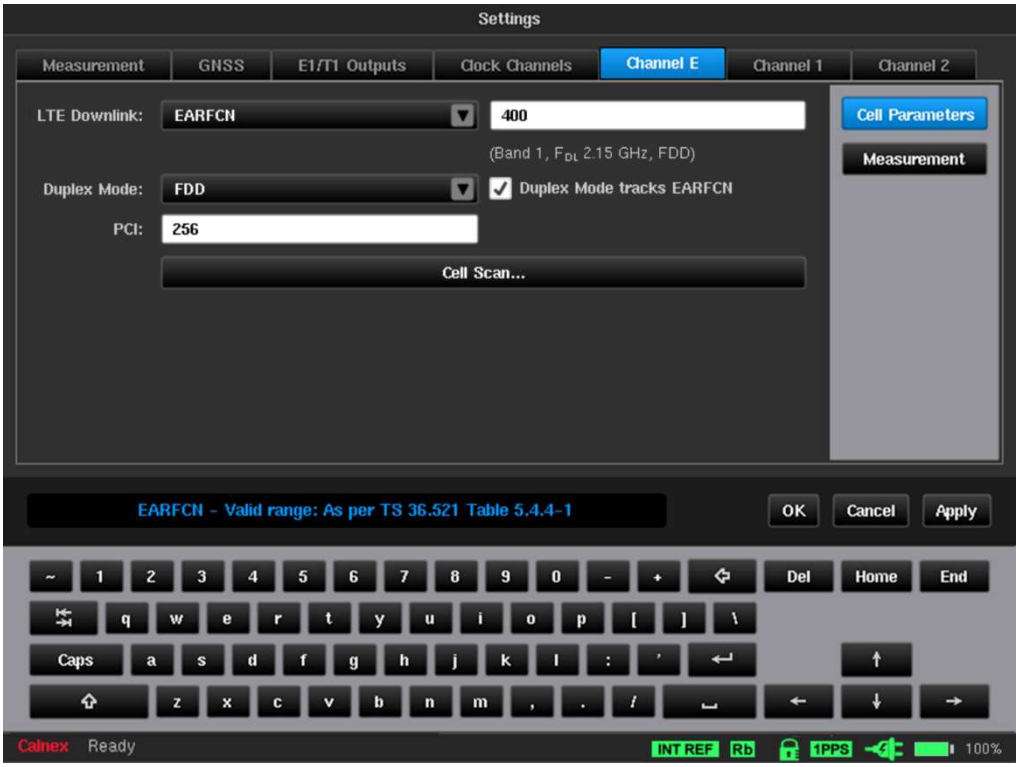


Figure 24 - Cell Parameters Page (OTA-LTE)

The following settings in the **Cell Parameters** page define all aspects of the OTA-LTE module cell parameter settings:

LTE Downlink	This allows the frequency of the LTE RF signal to be entered, either as the EARFCN or directly as an absolute frequency. The valid range is 350 MHz to 6 GHz or an EARFCN defined in TS 36.521 Table 5.4.4-1.
Duplex Mode	Selects whether LTE is Frequency Division Duplex (FDD) or Time Division Duplex (TDD).
Duplex Mode tracks EARFCN	Selects whether duplex mode (FDD or TDD) is automatically set based on the EARFCN chosen. This check box is only visible when EARFCN is selected for the LTE Downlink.
PCI	Identifies which Physical Cell ID (PCI) in the LTE frequency band is to be used as the source of the measurement.
Cell Scan	Clicking this button will cause each Physical Cell ID within the selected frequency band to be displayed along with a confidence level indicating the quality of the decoded result.

Cell Scan

The Cell Scan feature simplifies cell parameter configuration by giving you the option to select desired Physical Cell ID from a list. After clicking the **Cell Scan...** button, a scan of the selected frequency is performed, and the list of possible Cell IDs for OTA-LTE measuring appears.

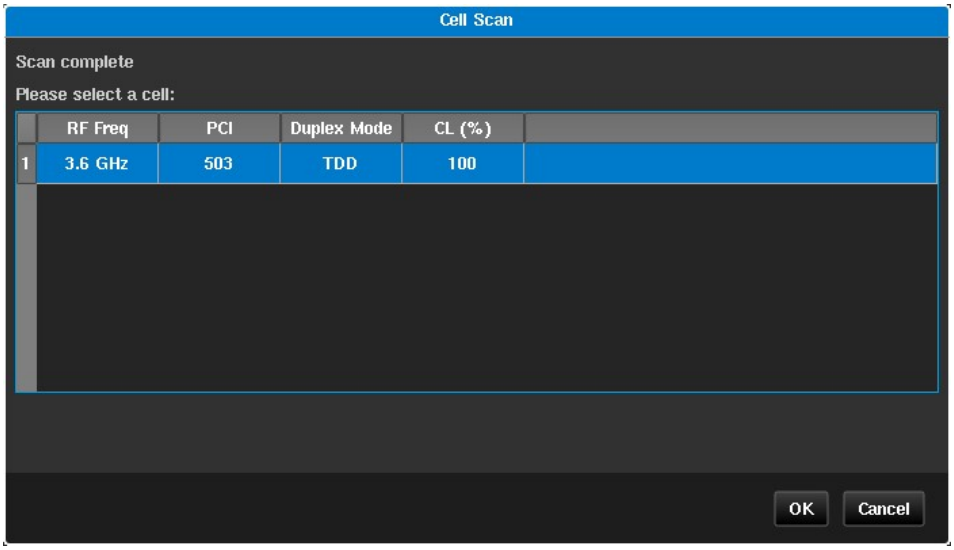


Figure 25 - Cell Scan Page (OTA-LTE)

After you select a row in the table and press the **OK** button, the corresponding fields in the cell parameters **Cell Parameters** page (Figure 24) are automatically completed.

Measurement

When you click on the **Measurement** button in the Channel X tab of an OTA-LTE module, the **Measurement** page (Figure 26) appears.

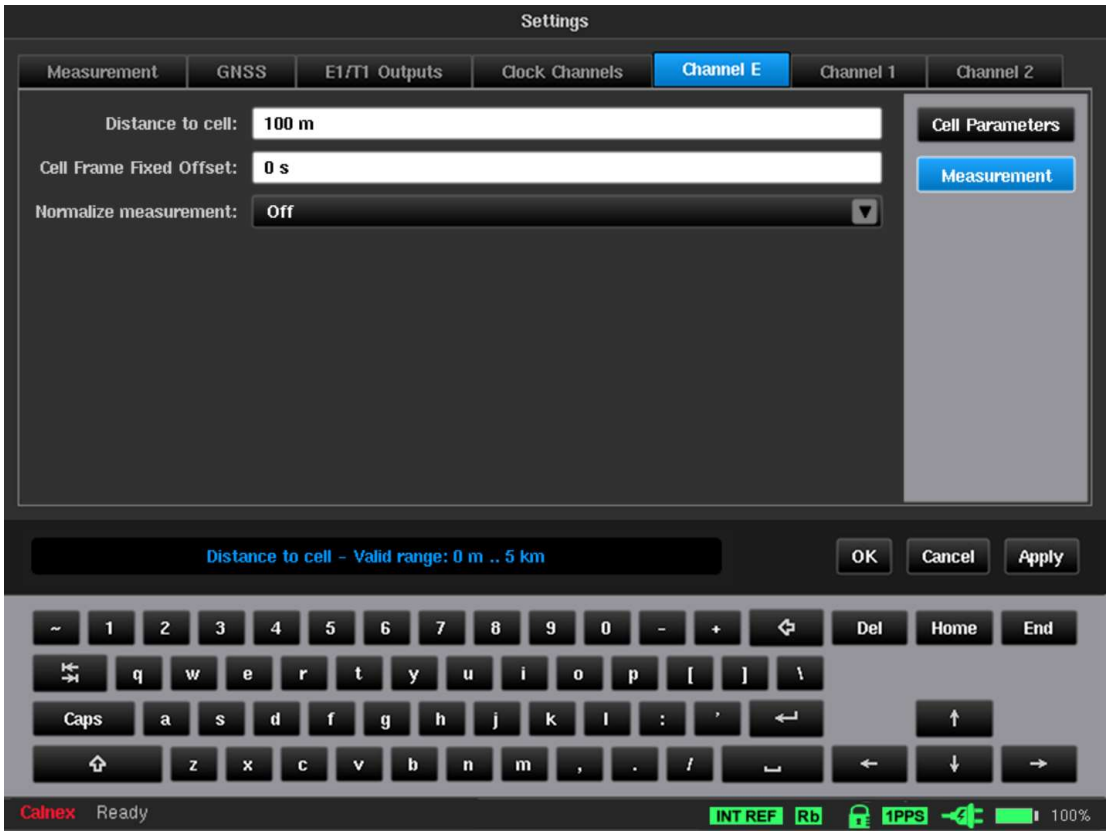


Figure 26 - Measurement Page (OTA-LTE)

The following settings in the **Measurement** page define all aspects of the OTA-LTE module measurement settings:

Distance to cell	Compensates for the time of flight of the RF signal to the test site.
Cell Frame Fixed Offset	Compensates for any known offset of timing pulses from start of cell.
Normalize measurement	When set to *On*, TE samples are normalised relative to the first sample i.e., the value of the first TE sample is zero. In this mode TE variation is displayed on the TIE graph. When set to *Off*, no TE normalization is applied i.e., the TE graph displays absolute delays (including propagation delay, time offset between Master and the Sentinel, and other time inaccuracies in the system).

Channel *X* (OTA-NR)

If you select **OTA-NR** in the **Mode** screen, a **Channel *X*** tab to be presented in the **Settings** screen with a **Cell Parameters** button and **Measurement** button (see Figure 27 and Figure 30).

Cell Parameters

When you click on the **Cell Parameters** button in the Channel X tab of an OTA-NR module, the **Cell Parameters – Cell Scan** page (Figure 27) appears (with the **Cell Scan** tab selected).

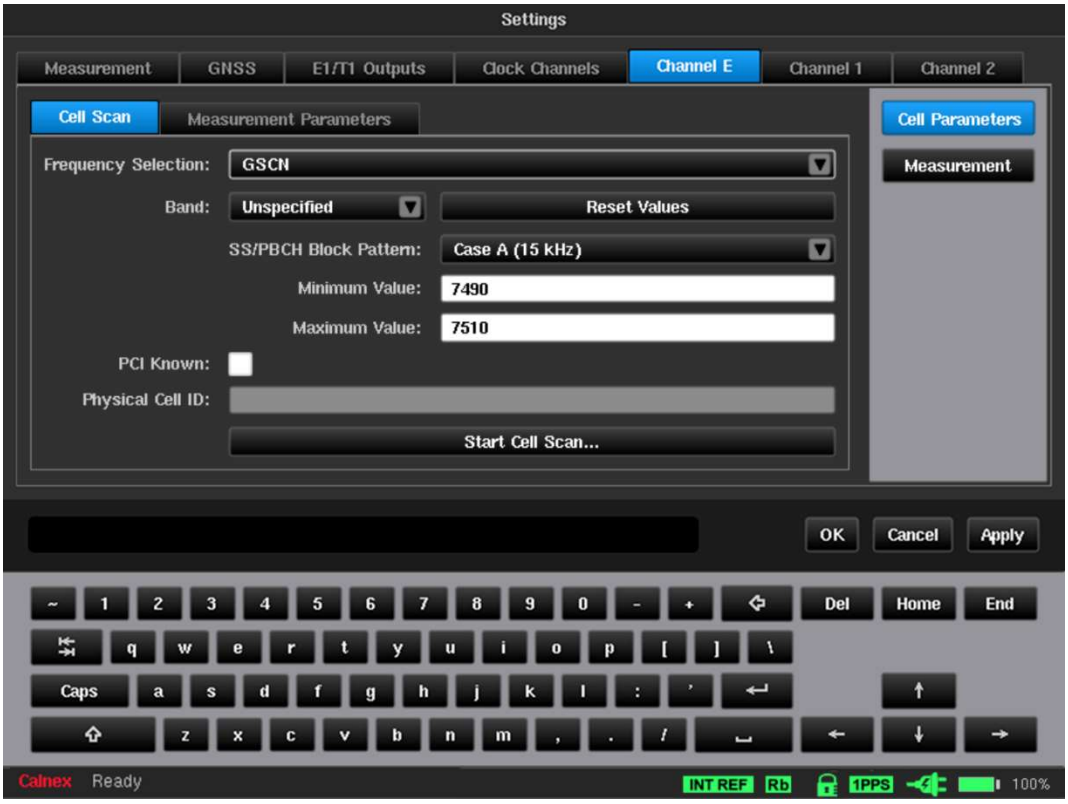


Figure 27 - Cell Parameters – Cell Scan Page (OTA-NR)

The following settings in the **Cell Parameters – Cell Scan** page tab define all aspects of the OTA-NR module cell parameter settings:

Frequency Selection	This allows the frequency of the NR RF signal to be entered, either as the GSCN or nrARFCN or directly as an absolute frequency (Hz). The valid range is 350 MHz to 6 GHz.
Band	Selects the NR frequency band if GSCN or nrARFCN Frequency Selection is used.

SS/PBCH Block Pattern	Selects which subcarrier spacing pattern is used by the signal to allow the Sentinel to detect and decode the Synchronisation Signal Block. If the Band has been specified this parameter is greyed out
PCI Known	Enables option to enter Physical Cell ID (PID), if known. If not known, cell scan returns a list of all detected PCIs.
Minimum Value	Defines the minimum value of the scan range if GSCN or nrARFCN Frequency Selection is used.
Maximum Value	Defines the maximum value of the scan range if GSCN or nrARFCN Frequency Selection is used.
Physical Cell ID	Identifies which physical cell in the configured NR frequency range is to be used as the source of the measurement. The valid range is 0 to 1007.
Start Cell Scan	See the Cell Scan section below for details.

Cell Scan

The Cell Scan feature simplifies cell parameter configuration by giving you the option to select desired Physical Cell ID from a list. After pressing the **Start Cell Scan...** button, a scan of the selected frequency is performed, and the list of possible Physical Cell IDs for OTA-NR measuring is displayed. If the PCI value is configured in the **Physical Cell ID** field of the **Cell Parameters – Cell Scan** page, only that PCI will appear within the cell scan results.

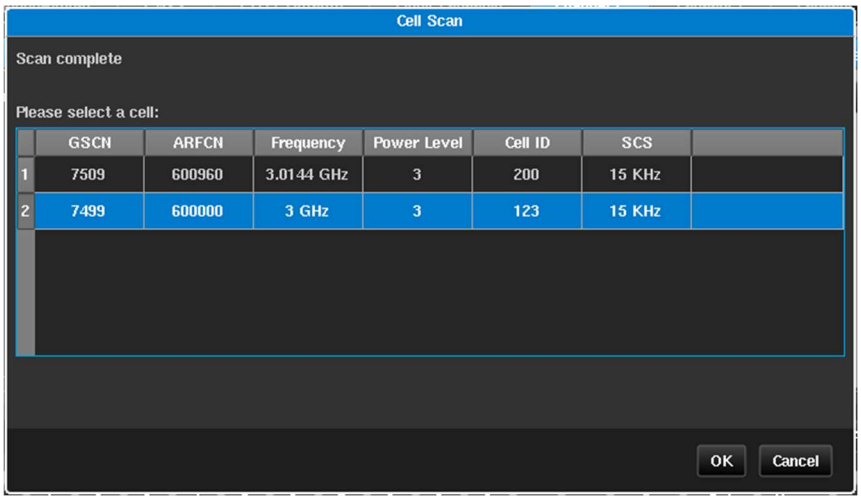


Figure 28 - Cell Scan Page (OTA-NR)

After you select a row in the table and press the **OK** button, the corresponding fields in the **Cell Parameters – Cell Scan** page (Figure 27) are automatically completed.

Measurement Parameters

When you click on the **Cell Parameters** button in the Channel X tab of an OTA-NR module, and click the **Measurement Parameters** tab, the **Cell Parameters – Measurement Parameters** page (Figure 29) appears.

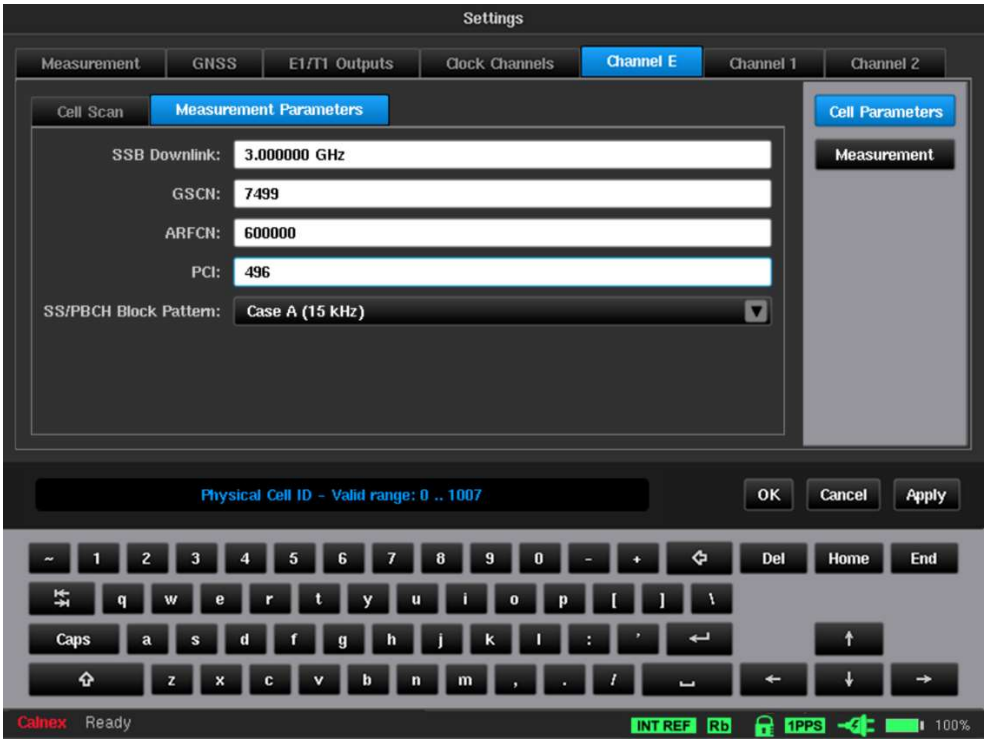


Figure 29 - Cell Parameters – Measurement Parameters Page (OTA-NR)

Signal parameters can be manually entered on this page, if known, without a cell scan being required. If manually entering parameters, only one of the three frequency parameters is required – **SSB Downlink**, **GSCN** or **ARFCN**. When one of these is entered, the other two automatically populate. Alongside one frequency parameter, **PCI** (Physical Cell ID) and **SS/PBCH Block Pattern** are required fields.

Measurement

When you click on the **Measurement** button in the Channel X tab of an OTA-NR module, the **Measurement** page (Figure 30) appears.

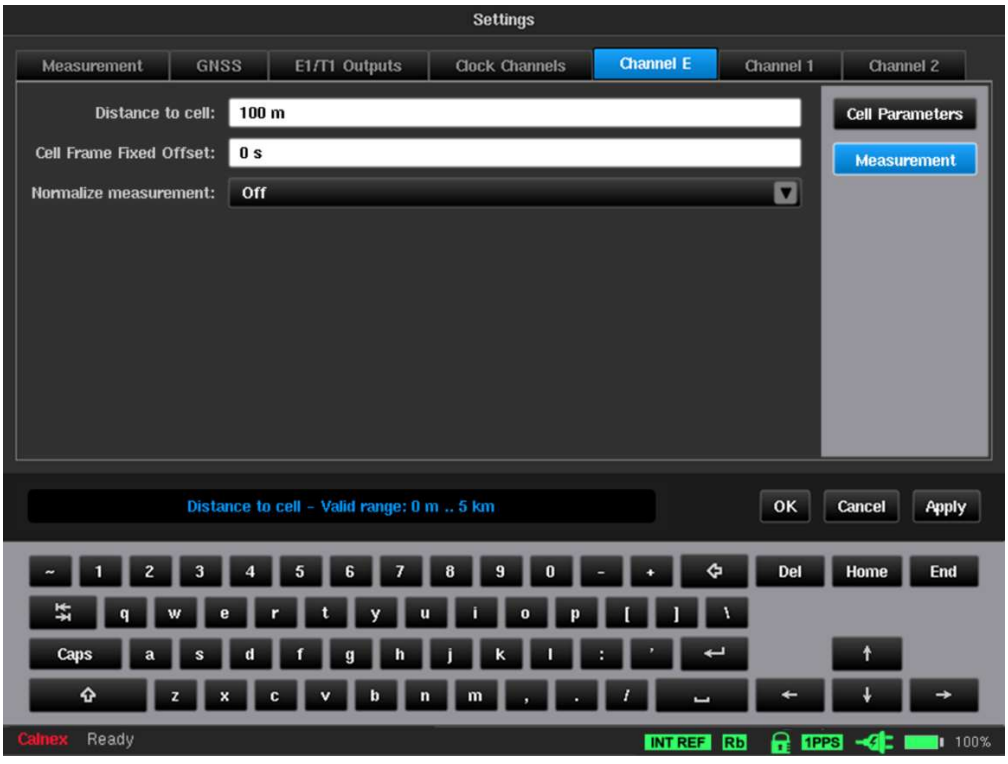


Figure 30 - Measurement Page (OTA-NR)

The following settings in the **Measurement** page define all aspects of the OTA-NR module measurement settings:

Distance to cell	Compensates for the time of flight of the RF signal to the test site.
Cell Frame Fixed Offset	Compensates for any known offset of timing pulses from start of cell.
Normalize measurement	When set to *On*, TE samples are normalised relative to the first sample i.e., the value of the first TE sample is zero. In this mode TE variation is displayed on the TIE graph. When set to *Off*, no TE normalization is applied i.e., the TE graph displays absolute delays (including propagation delay, time offset between Master and the Sentinel, and other time inaccuracies in the system).

Channel *X* (PTP / NTP)

Any of the Packet Modules that were enabled in the **Mode** screen will have their corresponding tabs visible within the **Settings** screen. The example in Figure 17 on page 21 shows a **Settings** screen where the Packet Modules **Channel 1** and **Channel 2** were enabled from within the **Mode** screen.

The channel used for the PTP or NTP connection is selected by the **Mode** screen, and a **Channel *X*** tab will be present for each PTP or NTP connection chosen.

Some of the menus such as **PTP** or **NTP** and **Selection** appear only when the **PDV Option** is enabled. This tab lets you change parameters related to Sync and PTP or NTP.

Interface

When you click on the **Interface** button within the **Channel X** tab of the **Settings** screen, the **Interface** page appears and contains the **Physical/Ethernet**, **IPv4** and **IPv6** tabs, whose settings are described below.

Physical Ethernet

When you click on the **Physical/Ethernet** tab in the Packet Module's **Interface** page, the **Physical Ethernet** page (Figure 31) appears.

Figure 31 - Physical Ethernet Page

Note: These settings are applied only for PDV measurements in **PTP time receiver / NTP Client** mode. When **Monitor mode** is enabled these settings are not applied and a **Monitored Channels** tab will be available.

The following settings in the **Physical Ethernet** page define all aspects of the Packet Module's physical ethernet settings:

Auto-Negotiation Sets auto-negotiation to either *Enabled* or *Disabled*.

When *Enabled*, the Sentinel auto-negotiates the line rate with the other device.

When *Disabled*, you must select the media type from the **Ethernet Media** drop down menu.

Ethernet Media Select media type for when Auto-negotiation is *Disabled*. Choose from *100BASE-T*, *1000BASE-T*, *100BASE-FX, 1000BASE-FX, 10G and 100G*.

Note: 100G is only available if the Sentinel has a 100G QSPF28 Ethernet Port Module installed as shown in Figure 2 on page 6.

VLAN 802.1Q Turn *On* /*Off* VLAN Ethernet packets tagging according to 802.1Q specification.

VLAN ID VLAN identifier.

VLAN Priority VLAN priority setting, range 0 to 7.

QSPC FEC Enable or Disable FEC (Forward Error Correction) mode, depending on the SFP in use.

MAC Address Read-only. Displays MAC Address of corresponding Packet module.

IPv4

When you click on the **IPv4** tab in the Packet Module's **Interface** page, the **IPv4** page (Figure 32) appears.

Figure 32 - IPv4 Page

The following settings in the **IPv4** page define all aspects of the Packet Module's IPv4 settings:

Address Assignment Drop-down list to select *Static*, *DHCP* or *Disabled*.

Static: Enter the IPv4 Address, Netmask and Gateway manually.

DHCP: To obtain IPv4 automatically from a DHCP server on the network.

Disable: No IPv4 Address is used for the measurement.

IPv4 Address	IP Address in IPv4 format.
IPv4 Netmask	Network mask in IPv4 format.
Gateway	Gateway IP Address in IPv4 format.
Ping	Clicking this button lets you run a network ping test to check the reachability to the configured gateway.

IPv6

When you click on the **IPv6** tab in the Packet Module's **Interface** page, the **IPv6** page (Figure 33) appears.

Figure 33 - IPv6 Page

The following settings in the **IPv6** page define all aspects of the Packet Module's IPv6 settings:

Address Assignment	Drop-down list to select *Static*, *DHCP* or *Disabled*. Static: Enter the IPv6 Address, Netmask and Gateway manually. DHCP: To obtain IPv6 automatically from a DHCP server on the network. Disable: No IPv6 Address is used for the measurement.
IPv6 Address	IP Address in IPv6 format.
IPv6 Network Prefix	Network mask in IPv6 format.
Gateway	Gateway IP Address in IPv6 format.
Ping	Clicking this button lets you run a network ping test to check the reachability to the configured gateway.

SyncE

When you click on the **SyncE** button within the **Channel X** tab of the **Settings** screen, the **SyncE** page (Figure 34) appears.

Figure 34 - SyncE Page

The **SyncE** page contains settings related to the Packet Module's Synchronous Ethernet.

Mode — The Packet Module can function in two modes – *Master* or *Slave*. In *Master* mode the Packet Module is a SyncE transmitter in the connected network segment. It is source of synchronization clock signal, and it can send ESMC messages over the network in accordance to specified scenario. In *Slave* mode the Packet Module can measure TIE of extracted synchronization signal and it can receive ESMC messages

ESMC Generation — Enables or disables ESMC messages generation scenario. Works only in *Master* mode.

ESMC Transition — Enables or disables periodic ESMC transition.

Initial SSM — Specifies initial SSM in scenario.

Alternate SSM — Specifies alternate SSM in scenario.

Transition Start — Defines the time from starting measurement when first transition occurs.

Transition Period — Defines the period between two adjacent ESMC transitions.

PTP

When you click on the **PTP** button within the **Channel X** tab of the **Settings** screen, the **PTP** page (Figure 35) appears.

Note: The **PTP** button and **PTP** page are only available if the **PDV Option** is enabled on the Sentinel and the **PTP Slave** has been enabled for the Packet Module in the **Mode** screen (see Figure 14 on page 20).

Figure 35 - PTP Page

The **PTP** page contains all the settings related to PTP stack behaviour in pseudo-slave mode.

The PTP transport protocol and relevant settings can be pre-set to values according to the ITU-T standard related to the test being performed via the **Profile** selection. The available standard profiles are as follows:

- *G.8265.1 Frequency Profile*
- *G.8275.1 Time/Phase Profile*
- *G.8275.2 Time/Phase Profile (PTS)*
- *G.8275.2 Time/Phase Profile (APTS)*
- *IEEE1588-2008 Default Profile*
- *Simple PTP (v2.1) [Meta Proposal]*

When a standard profile is chosen, only relevant fields are displayed and are populated with values from the ITU-T profile or the IEEE1588-2008 standard. Fields that are defined for this profile are highlighted in blue text. Clicking on a particular entry will detail what the IEEE1588 valid range is and what the range specified by the ITU-T profile is. For example, for ITU-T G.8275.1 testing the PTP Domain field has a specified range of 24 to 43, while for IEEE1588 the valid range is 0 to 255.

Any profile can be changed to any value. However, changing values in a standard profile that are outside the range for the profile cause it to change to a *Custom Profile*.

PTP mode	PTP protocol mode: *Unicast* or *Multicast*. This setting must be set accordingly to the PTP time transmitter configuration.
Transport protocol	Protocol level for PTP measurement: *UDP/IPv4*, *UDP/IPv6* or *Ethernet*.
Multicast MAC Addr	Select Multicast MAC Address – forwardable or non-forwardable; applies in *Ethernet* mode only.
IPv6 Multicast Scope	Applies in *UDP/IPv6 Multicast* mode only. Values are: *Interface – Local*, *Link – local*, *Realm – local*, *Admin – local*, *Site – local*, *Organisation – local* or *Global*.
DSCP	IP header DSCP setting, range 0 to 63; default 46.
Unicast Neg	Determines whether negotiation is enabled or disabled in Unicast mode.

Master address	Applies in *Unicast* mode only. Defines the IP address of PTP time transmitter. The **Ping** button lets you ping the time transmitter address.
Domain	PTP domain which PTP time transmitter is configured to work in.
Announce rate	Applies in *Unicast* mode only. Defines the number of announce messages to send per second.
Sync rate	Applies in *Unicast* mode only. Defines the requested number of sync messages to send per second (by the PTP time transmitter).
Delay req. rate	Defines the number of delay request messages to send per second.
Delay req. dithering	When *On*: Transmission times shall be selected such that the interval between successive Delay_req messages is taken from a random distribution. When *Off*: Delay_req transmission interval is constant.
Contract duration	Defines the requested PTP contract duration.
Include correction field	Defines whether the correction field is included in the PDV measurement; default enabled.
Normalize delays	When *On* - PDV samples are normalized relative to first delay sample so that first PDV sample has zero value. In this mode delay variations are displayed on PDV graphs. When *Off* - no PDV normalization is done, so PDV graphs display absolute delays (including propagation delay, time offset between time transmitter and the Sentinel, and other time inaccuracies in the system). PTP 2WayTE will be calculated when **Normalize delays** is *Off*.
Network Mask Limit	Sets the network mask limit value for the G.8271.1 Max|2WayTE| LPF (Channel X) mask. This is user defined and configures the Pass/Fail limit for 2WayTE LF measurements when that mask is selected.

When in Pseudo-slave mode, the Packet Module acts as a PTP time receiver, however the internal 1PPS is kept constant for the measurement and is not adjusted according to the PTP time transmitter. This allows measurement of PDV on time transmitter to Pseudo-slave network path.

NTP

When you click on the **NTP** button within the **Channel X** tab of the **Settings** screen, the **NTP** page (Figure 36) appears.

Note: The **NTP** button and **NTP** page are only available if the **PDV Option** is enabled on the Sentinel and the **NTP Client** has been enabled for the Packet Module in the **Mode** screen (see Figure 14 on page 20).

Figure 36 - NTP Page

This **NTP** page contains all settings related to NTP stack behaviour in pseudo-client mode.

NTP mode	Unicast (for information only – cannot be changed).
Transport protocol	Protocol level for NTP measurement: *UDP/IPv4*, *UDP/IPv6.*
Server address	IP address of NTP server. The **Ping** button lets you ping the server address.
Poll	Poll rate selection. The poll rate can be configured as 1 packet every 2^n seconds, where n=0 to 17. This gives a max poll rate of 1 packet per second and a minimum poll rate of 1 packet every 36.4 hours.
Version	NTP version. Sentinel supports versions 1 through 4.
Normalize delays	When *On* PDV samples are normalized relative to first delay sample so that first PDV sample has zero value. In this mode delay variations are displayed on PDV graphs. When *Off* – no PDV normalization is done, so PDV graphs display absolute delays (including propagation delay, time offset between Server and Sentinel, and other time inaccuracies in the system). NTP 2WayTE will be calculated when **Normalize delays** is *Off*
Network Mask Limit	This parameter is not applied for NTP.

Selection

When you click on the **Selection** button within the **Channel X** tab of the **Settings** screen, the **Selection** page (Figure 37) appears.

Note: The **Selection** button and **Selection** page are only available if the **PDV Option** is enabled on the Sentinel.

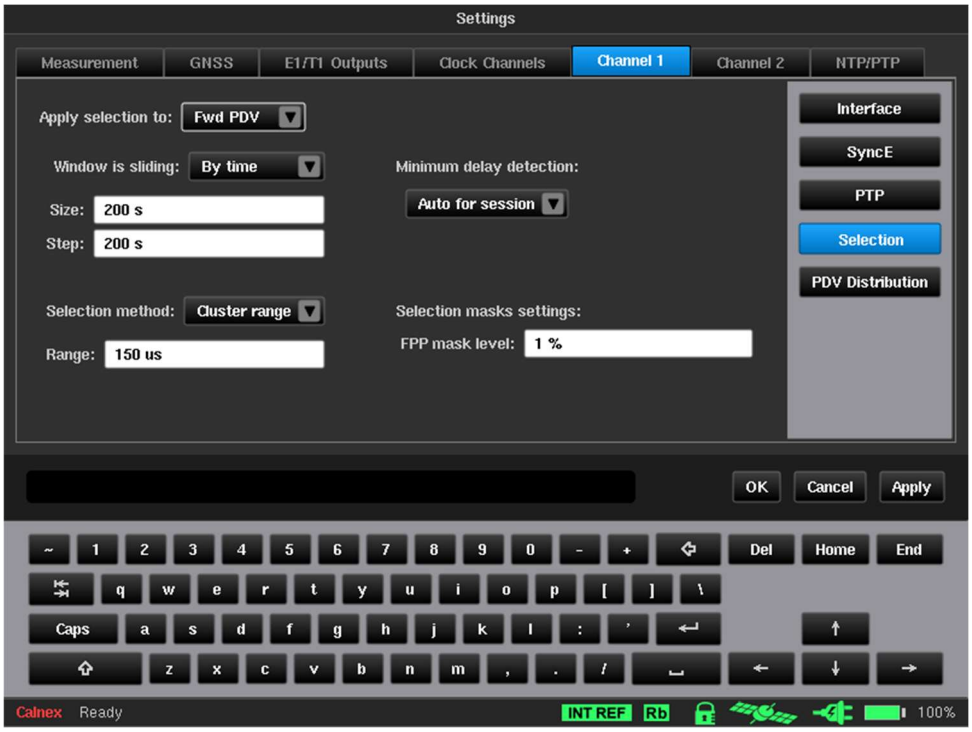


Figure 37 - Selection Page

For each installed Packet Module, a selection algorithm can be applied to only one of the following types of packet delays via the **Apply selection to** drop-down list:

- *Fwd PDV* – Forward Packet Delay Variation
- *Rev PDV* – Reverse Packet Delay Variation
- *Path Delay*
- *None*

Selection algorithm contains three components which can be set up independently as described in the sections Window parameters, Selection method, Minimum delay detection, and Selection masks settings.

By default, the settings are for ITU-T G.8261.1 FPP testing.

Window parameters

You can choose one type of window: **window is sliding** *by samples* or **window is sliding** *by time*.

When the **Window is sliding** *by samples*, it always consists of a constant number of samples but time interval between first and last sample in the window is varying. Window size and step are defined in terms of samples number.

When the **Window is sliding** *by time*, it contains set of samples in which time difference between last and first samples is not greater than given window size; Window step is also given in terms of time.

Window step to window size ratio determine overlapping rate. Normally, window step must not be greater than window size.

Figure 38 - Window is sliding settings

Selection method

Selection is a procedure of picking packets from a window which conforms to a given constraint. You can select one of two possible selection types to determine the constraints being used: *Band* selection and *Cluster range*.

Band selection is a selection of packets which are inside a range (defined by percentiles) of window packets sorted out by delay value. For example, range 0%-25% means selection of quarter of fastest packets (with lowest delay values).

Figure 39 - Band selection settings

Cluster range selection method is a selection of packets which are inside a range of current minimum delay parameter to current minimum delay + given range. The **Range** value you specify is constant during the measurement. Current minimum delay is determined depending on the settings of **Minimum delay detection** component.

Figure 40 - Cluster range settings

Minimum delay detection

Figure 41 - Minimum delay detection settings

The **Minimum delay detection** setting affects the lower edge of cluster range interval and can be one of the following:

Custom	The constant minimum delay you specify is used.
Auto for last	Minimum delay is automatically determined by packet delays received for last given amount of time.
Auto for session	Minimum delay is automatically determined as lowest delay packet ever received during measurement.

Selection masks settings (FPP mask level)

You can specify an FPP mask level in the **FPP mask level** field. The FPP mask marks minimum acceptable floor packets percentage for the G.8261.1 FPP Network Limit (Channel X) mask. This is user defined and configures the Pass/Fail limit for FPP measurements when that mask is selected. The FPP mask for a particular Packet module is considered failed if at least one of the FPP samples is below the FPP mask level. Otherwise, it is considered a pass.

PDV Distribution

Different PTP time receiver vendors have their own specification for PDV distributions for their PTP time receiver to work correctly. This PDV distribution function lets you set a vendor specific specification so that the Sentinel can be used to compare the measurement results against vendor specification for pass/fail test.

When you click on the **PDV Distribution** button within the **Channel X** tab of the **Settings** screen, the **PDV Distribution** page (Figure 42) appears.

Figure 42 - PDV Distribution Page

Mask Type — Different ways to define the PDV Distribution (Channel X) mask, either by range or by tolerance. When *Range* is selected, it is possible to set the required mask by min/max delay values. When *Tolerance* is selected, the mask can be set around a nominal value. When either *Range* or *Tolerence* is selected you can configure the Pass/Fail limits for Dist/FwdPDV, Dist/RevPDV and Dist/PathDelay measurements when the PDV Distribution (Channel X) mask is selected.

Min — Defines the minimum delay of the requested range. This setting is available when the **Mask Type** is set to *Range*.

Max — Defines the maximum delay of the requested range. This setting is available when the **Mask Type** is set to *Range*.

Nominal — Defines the requested nominal delay. This setting is available when the **Mask Type** is set to *Tolerance*.

Below — Deines the percentage below the nominal delay. This setting is available when the **Mask Type** is set to *Tolerance*.

Above — Defines the percentage above the nominal delay. This setting is available when the **Mask Type** is set to *Tolerance*.

Pass Criteria — Defines the percentage of packets which fall in the defined delay range. This setting is available when the **Mask Type** is set to *Range* or *Tolerance*.

Normalize by min delay

ON — The delay measurement references to the luckiest packet (packet with the minimum delay)

OFF — The delay measurement references to the first packet

Monitor Mode

When either **PTP Monitor Mode** or **NTP Monitor Mode** is enabled via the **Mode** screen (see Mode on page 20) a **Monitored Channels** tab is available in the **Settings** screen and the **Channel X** tabs (e.g. **Channel 1** and **Channel 2**) corresponding to the monitored Packet Modules and the **NTP/PTP** tab are not available.

When you click on the **Monitored Channels** tab of the **Settings** screen, the **Monitored Channels** page (Figure 43) appears.

Figure 43 - Monitored Channels Page - Monitor Mode

The **Monitored Channels** page contains the following buttons:

- **Monitor Mode** – clicking this opens the **Monitor Mode** page (see Figure 43).
- **Selection** – clicking this opens **Selection** page within the **Monitored Channels** tab. The selection settings are already discussed in Selection on page 42.
- **PDV Distribution** – clicking this opens the **PDV Distribution** page within the **Monitored Channels** tab. The selection settings are already discussed in PDV Distribution on page 44.
- **Interface** for each channel – clicking this opens an **Interface** page (Figure 44) within the **Monitored Channels** tab, which lets you configure the **Auto-Negotiation** and **Ethernet Media** settings of the monitored channel.

Figure 44 - Interface Page of a Monitored Channel

All settings on the **Monitor Mode** page correspond to PDV measurement performed in **Monitor Mode** (either **NTP Monitor Mode** or **PTP Monitor Mode**).

Protocol Level	Protocol level for PTP measurement: *UDP/IPv4*, *UDP/IPv6* or *Ethernet*. Protocol level for NTP measurement: *UDP/IPv4 or UDP/IPv6*.
Normalize delays	When set to *On*, PDV samples are relative to first delay sample so that the first PDV sample has zero value. When set to *Off*, true Fwd PDV / Rev PDV / Path Delay delays are shown.
Include correction field	Allows the correction field to be included in the PDV measurement; default *enabled*.
Network Mask Limit	Specifies the value of the TE mask
Discover...	Allows auto completion of the setting fields based on network traffic analysis and auto-detection of all possible nodes, which could be used for measuring PDV in monitor mode. For more information, see Discovery on page 46.
VLAN (802.1Q)	Specifies if VLAN packets are captured. Possible settings are *On* and *Off*.
VLAN ID	Specifies VLAN identifier when VLAN packets capturing is enabled. When **VLAN (802.1Q)** is set to *Off*, this setting is not available. See **VLAN (802.1Q)** setting.
Monitored domain	Specifies the PTP domain which is monitored. This setting is not available for NTP protocol.
Monitored mode	Specifies which type of traffic is monitored: *Unicast* or *Multicast*. This setting is not available for NTP protocol.
Monitored Master IP **Monitored Slave IP**	IP addresses of two PTP or NTP nodes which are monitored. This setting is not available for *Ethernet* protocol level.
Monitored Master MAC **Monitored Slave MAC**	MAC addresses of two PTP nodes which are monitored. This setting is not available for NTP protocol or *UDP/IP* protocol level.

Note: To measure PDV in Monitor Mode an external network Test Access Point (TAP) or optical splitter is required.

When operating in **Monitor Mode**, the Sentinel “sniffs” for PTP or NTP packets between two nodes. By monitoring the traffic between the two nodes available via the TAP, the Sentinel can measure PDV between channels.

Discovery

The Discovery feature simplifies defining the network node settings by giving you the possibility to select the desired node pairs from an auto discovered list. After clicking the **Discover...** button, network traffic analysis is performed and the list of possible nodes for PDV measuring appears in the **Data Flow Selection** page (Figure 45).

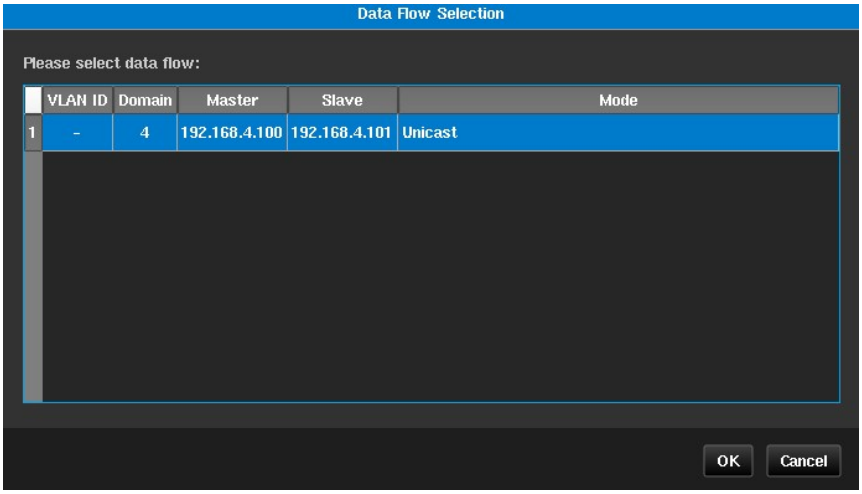


Figure 45 - Data Flow Selection Page

After you select a row in the table of the **Data Flow Selection** page and click **OK**, the **Data Flow Selection** page closes and the corresponding fields in the **Monitor Mode** page (Figure 43 on page 45) automatically update.

NTP/PTP (Virtual Channels)

The Sentinel provides a feature to define up to 32 virtual channels to measure up to 32 additional NTP/PTP streams on the physical channels. The IP Address of the virtual channel will be the IP Address of the selected physical interface.

If you enabled **Virtual Channels** for any of the **Packet Modules** in the **Mode** screen (see Figure 14 on page 20), the **NTP/PTP** tab is visible within the **Settings** screen.

When you click on the **NTP/PTP** tab of the **Settings** screen, the **NTP/PTP** page appears (like Figure 46 and Figure 47), allowing to define up to 32 virtual channels to measure up to 32 additional NTP/PTP streams on the physical channels.

The **NTP/PTP** page contains a **Mode** drop-down list to let you select either PTP or NTP mode. For more information, see PTP Virtual Channels below and NTP Virtual Channels on page 48.

PTP Virtual Channels

When you select **PTP** from the **Mode** drop-down list the **NTP/PTP** page appears like that in Figure 46.

Figure 46 - NTP/PTP - PTP Page

The **NTP/PTP** page for PTP Mode contains the following settings:

Packet Measurement Channel	1 – 32; disabled by default. Defines the virtual channel number.
Mode	Drop-down list to select **PTP**, NTP or to disable the virtual channel.
Physical Channel	Defines the physical channel on which the virtual channel configuration is applied.
Profile	Unicast profiles or custom profile with PTP unicast mode can only be used.

For the rest of the PTP settings and information regarding PTP configuration, see PTP on page 39.

Configure the virtual channels and click **OK** to apply the settings. You are returned to the main operating screen. Measurement only starts after clicking the **Start** button on the main operating screen. No measurement data/graph is shown on the main operating screen.

You can download the measured data over the API in CSV format for further analysis. The time error data for these Virtual Channels is also saved by Sentinel and can be downloaded for analysis by the Calnex Analysis Tool (CAT).

Refer to the *Calnex Sentinel/Sentry API User Guide* for detailed information on how to transfer the measurement data from Sentinel.

Note: Packet rate: 128 packets/s if only main two channels are used decreasing to 1 packet/s if two main and 32 Virtual Channels are active.

NTP Virtual Channels

When you select **NTP** from the **Mode** drop-down list the **NTP/PTP** page appears like that in Figure 47.

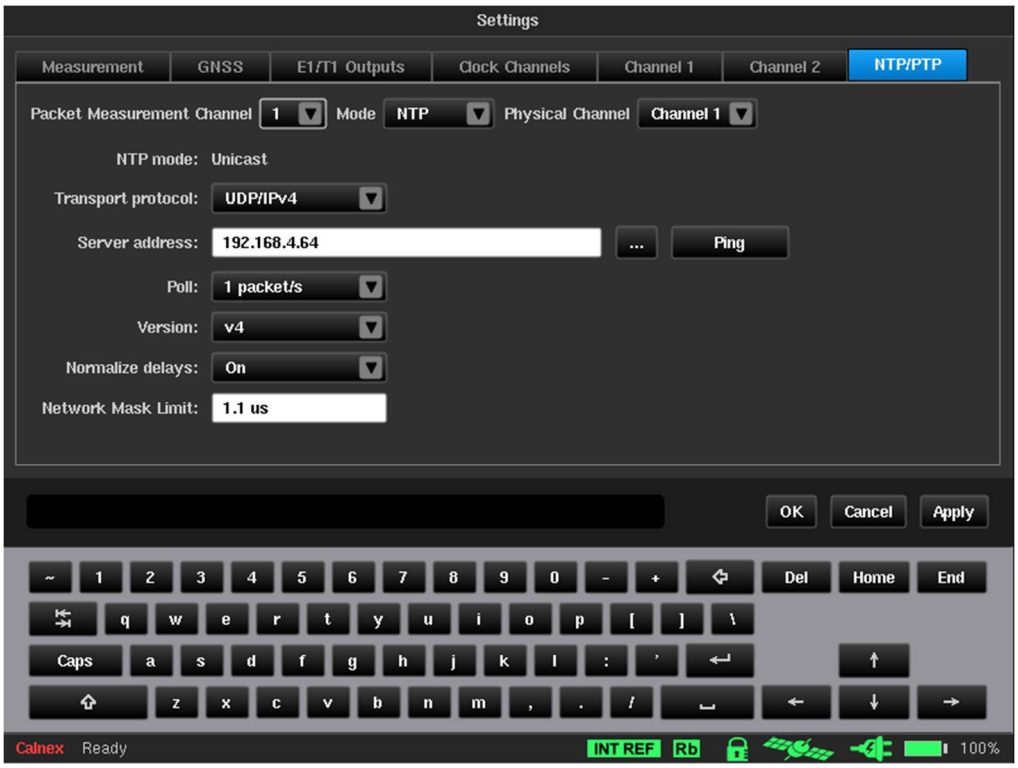


Figure 47 - NTP/PTP - NTP Page

The **NTP/PTP** page for NTP Mode contains the following settings:

Packet Measurement Channel 1 – 32; disabled by default. Defines the virtual channel number.

Mode Drop-down list to select PTP, **NTP** or to disable the virtual channel.

Physical Channel Defines the physical channel on which the virtual channel configuration is applied.

For the rest of the NTP settings and information regarding PTP configuration, see NTP on page 41.

Configure the virtual channels and click **OK** to apply the settings. You are returned to the main operating screen. Measurement only starts after clicking the **Start** button on the main operating screen. No measurement data/graph is shown on the main operating screen.

You can download the measured data over the API in CSV format for further analysis. The time error data for these Virtual Channels is also saved by Sentinel and can be downloaded for analysis by the Calnex Analysis Tool (CAT).

Refer to the *Calnex Sentinel/Sentry API User Guide* for detailed information on how to transfer the measurement data from Sentinel.

4.4 Masks

The Sentinel provides various predefined masks that can be applied to the graphs summarized in Table 5 on page 73 and Table 6 on page 73. You can select and display up to nine masks on the main operating screen at the same time and overlay the masks on the measurement curves.

When you click on the **Masks** tab in the configuration bar the **Masks** screen (Figure 48) appears.

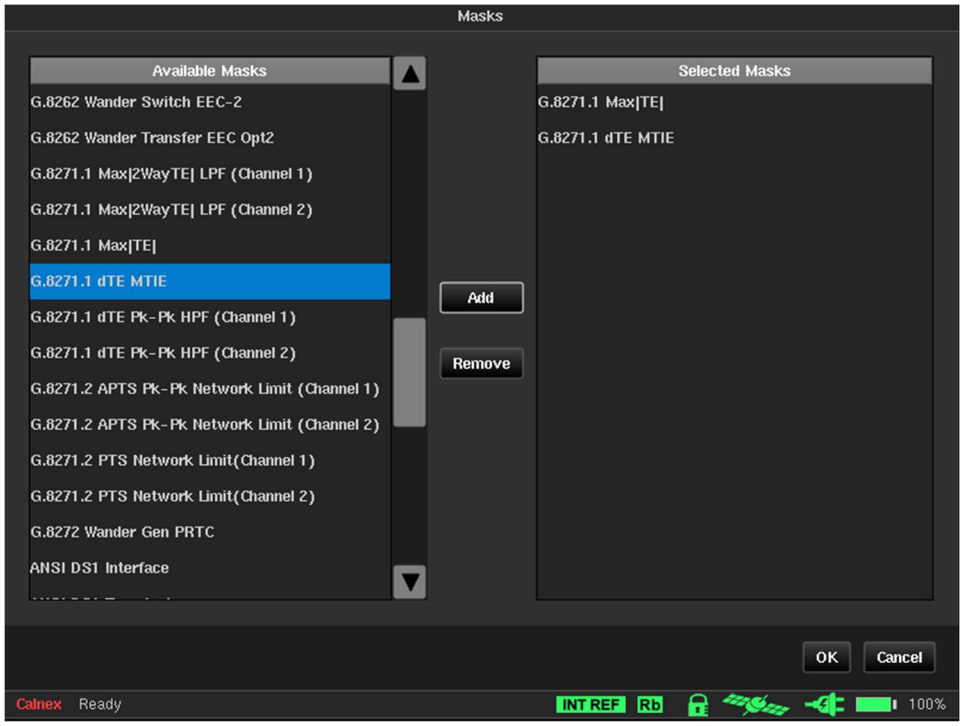


Figure 48 - Masks Screen

The **Masks** screen lets you select which masks are displayed on the main operating screen.

The **Available Masks** area on the left of the **Masks** screen lists the available masks within the Sentinel. For a full list of available masks see Appendix B.

The **Selected Masks** area on the right of the **Masks** screen lists the selected masks that will be displayed on the main operating screen.

Note: Before running a measurement, you must add the masks that you want to be applied to the measurement.

The **Add** button is used to add the mask currently selected in the **Available Masks** list to the **Selected Masks** list. The **Remove** button is used to remove the mask selected in the **Selected Masks** list, from the masks to be displayed.

To add one or masks so that they appear in the main operating screen, do the following:

1. Select a mask from the **Available Masks** list so that it appears highlighted in blue.
2. Click **Add**.
   The added mask appears in the **Selected Masks** list.
3. Repeat steps 1 and 2 for each of the masks that you want to appear in the main operating screen.
4. Click **OK**.

To remove one or masks so that they no longer appear in the main operating screen, do the following:

1. Select a mask from the **Selected Masks** list so that it appears highlighted in blue.
2. Click **Remove**.
   The removed mask no longer appears in the **Selected Masks** list.
3. Repeat steps 1 and 2 for each of the masks that you want to remove from the main operating screen.
4. Click **OK**.

4.5 Health Check

When you click on the **Health Check** tab in the configuration bar the **Health Check** screen (Figure 49) appears.

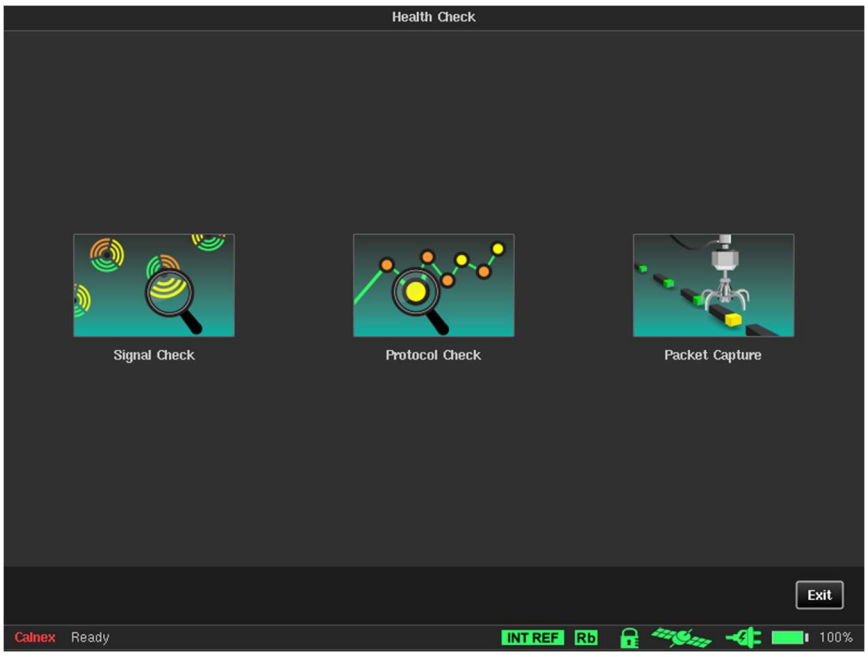


Figure 49 - Health Check Screen

The **Health Check** screen contains the following three utilities to automatically setup measurement inputs and to debug the setup of PTP measurements:

- Signal Check – for more information, see Signal Check below.
- Protocol Check – for more information, see Protocol Check on page 51.
- Packet Capture – for more information, see Packet Capture on page 52.

Signal Check

Running **Signal Check** detects all clocks that are connected to Sentinel and sets up the measurement subsystem. If a signal check is not performed then TIE measurements can display erroneous data.

When you click on the **Signal Check** tile in the **Health Check** screen, a **Signal Check** dialog box appears like that in Figure 50.

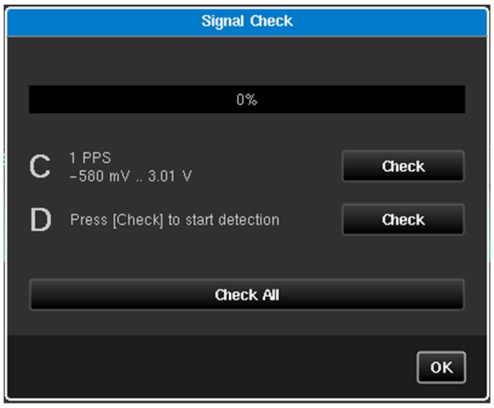


Figure 50 - Signal Check Dialog Box (before running a check – 0%)

If a signal check has previously been performed, the results appear next to the channel. The example in Figure 50 shows that a signal check had previously been performed on clock channel C, but never been performed on clock channel D.

Note: Even if an installed clock channel disabled on the **Mode** screen, it appears and can be checked within the **Signal Check** dialog box.

The **Signal Check** dialog box contains a **Check** button next to each of the installed clock channels. Clicking on the **Check** button launches the signal check for the corresponding clock channel. When a signal check is being performed the status bar shows the percentage status of the signal check.

The **Signal Check** dialog box also contains a **Check All** button. Clicking on the **Check All** button launches the signal check for each of the installed clock channels, in the order they are listed (e.g. Channel C then Channel D).

Once a signal check is complete, the results appear next to each clock channel and progress bar shows 100% like that in Figure 51.

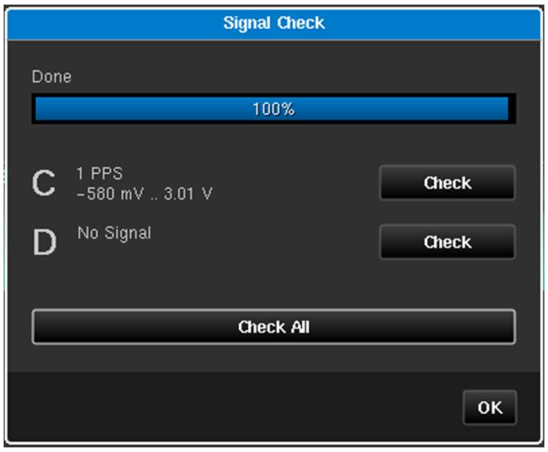


Figure 51 - Signal Check Dialog Box (after running a check - 100%)

Protocol Check

The **Protocol Check** is used to check that the PTP protocol is working as expected for the PTP profile being used by identifying and highlight any issues. When running a PTP measurement the validity of the Sentinel and GM settings can be checked using the protocol check procedure.

When you click on the **Protocol Check** tile in the **Health Check** screen, the **Protocol Check** dialog box (Figure 52) appears.

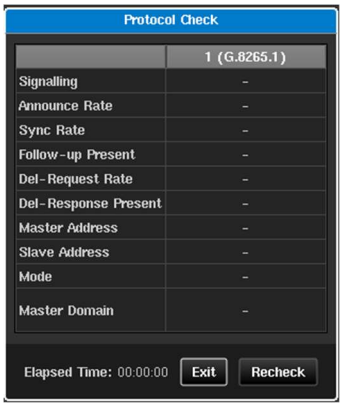


Figure 52 - Protocol Check Dialog Box (before a protocol check has been performed)

Clicking on the **Recheck** button makes the Sentinel start to look for PTP messages based on the PTP settings (see PTP on page 39) or Monitor Mode settings (see Monitor Mode on page 45).

Fields are populated as they are discovered by the protocol check. The message rates are checked against their advertised values.

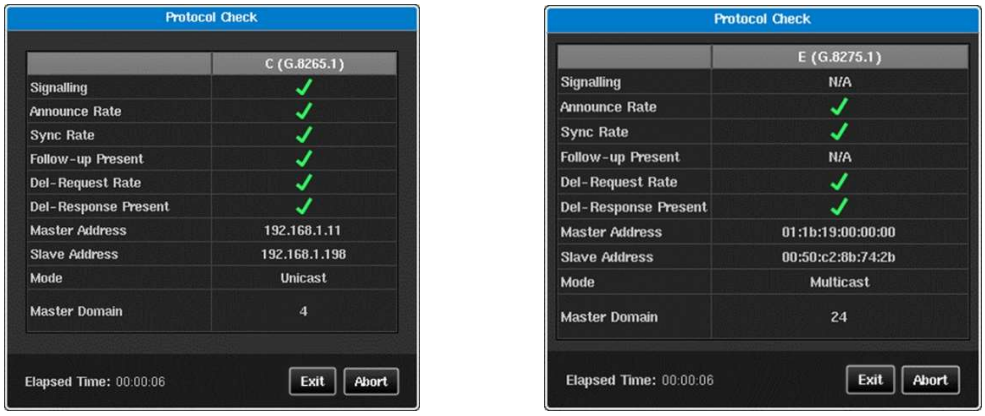


Figure 53 - Example Protocol Check Dialog Boxes

Fields that are not relevant to the operating mode are marked as N/A e.g. **Signalling** in Multicast mode or **Follow-up** messages in 1-step mode.

Master Address and Slave Address will be populated with the GM and T-TSC MAC addresses in *Ethernet* mode or IP addresses in *IPv4 / IPv6* mode. The Mode will be either *Multicast* or *Unicast* and the Master Domain will show the value used by the GM. If the Master Domain differs from the value configured by the Sentinel it will be highlighted in red text.

A clock displays the time since protocol check was started.

If a message type is present and passes its rate check a ✓ is displayed. If the message type is not present or the message rate is incorrect a ✗ is displayed and the message rate if appropriate.

The protocol check completes automatically if all PTP channels have successfully been analysed. If this does not occur, then you can terminate the check by clicking the **Abort** button.

Packet Capture

The packet capture utility captures the Ethernet flow on each PTP card to allow analysis of the packets to validate the exchange of PTP traffic between the GMC and the Sentinel.

When you click on the **Packet Capture** tile in the **Health Check** screen, a **Signal Check** screen (Figure 54) appears.

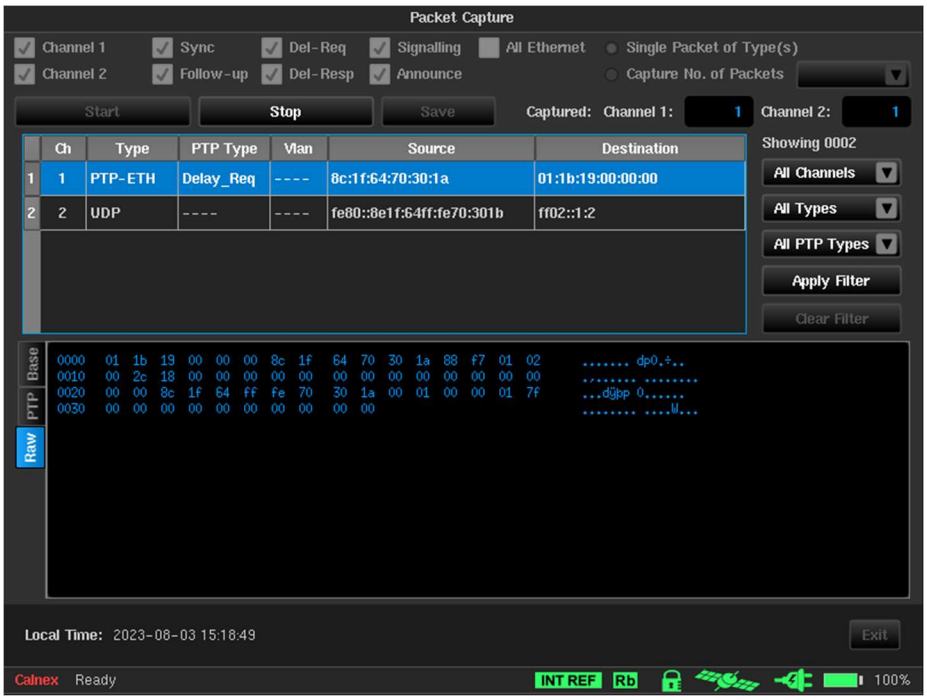


Figure 54 - Packet Capture Screen

The following check boxes configure which PTP ports are used, and which types of Ethernet packets are captured:

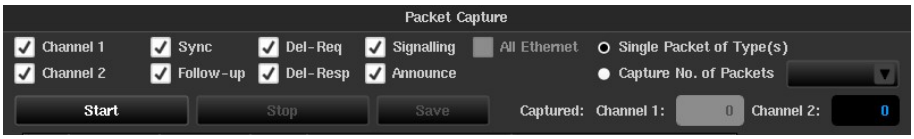


Figure 55 - Packet Capture Configuration Check Boxes

Channel *X* (*X* = 1 or 2)	Selects which PTP ports are used to capture packets.
Sync, **Follow-up**, **Del-Req**, **Del-Resp**, **Signalling** and **Announce**	Selects which type of PTP messages are captured.
All Ethernet	Captures all Ethernet packets.

Capture can be configured to capture a single packet of each PTP message type, selected by the check boxes, or to capture a specific number of packets.

To run the packet capture, click the **Start** button. The number of packets captured on each PTP card is displayed.

If **Single Packet of Type(s)** is selected, the capture ends when a single packet of each of the types selected has been captured. If **Capture Number of Packets** is selected, the capture ends when the specified number of packets of the specified types has been captured for each of the selected channels.

In either case you can stop packet capture by clicking the **Stop** button.

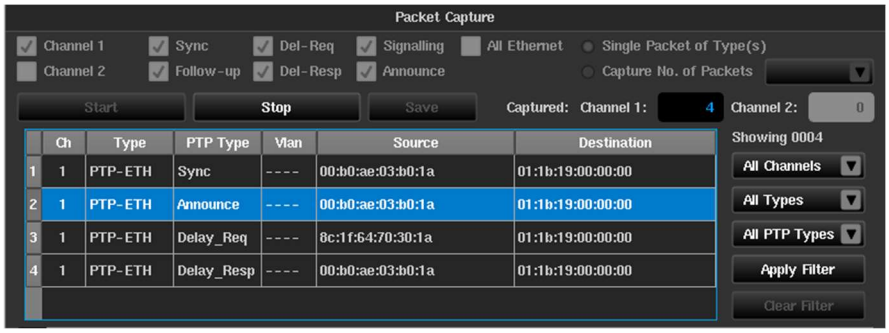


Figure 56 - Packet Capture Example – One Sync, Delay Request, Delay Response and Announce Message in Slot 1

The example in Figure 56 shows packet capture configured to capture one Sync, Delay Request, Delay Response and Announce message using the PTP card in slot 1. 4 packets are indicated as being captured on Channel 1 and Channel 2 is disabled so no packets have been captured.

You can filter the results by using the **Channel**, **Type** and **PTP Type** drop-down lists and clicking the **Apply Filter** button to the right of the results area.

Channel	*1 or 2* selects which PTP card is the source of the capture
Type	*PTP-UDP, PTP-ETH, ETH, IPv4, IPv6 or UDP* selects the type of packet to be displayed
PTP Type	*Sync*, *Delay_Req*, *Delay_Resp*, *Follow_Up*, *Announce*, *Signalling*, *Management*, *Pdelay_Req* or *Pdelay_Resp* selects the type of PTP message to be displayed

You can remove the filtering of results by clicking the **Clear Filter** button. There are also options to select all types or all channels for each of the filters.

Filtering can be a combination of one or more of the drop-down fields. The example Figure 57 shows filtering for Delay Request messages from slot 1.

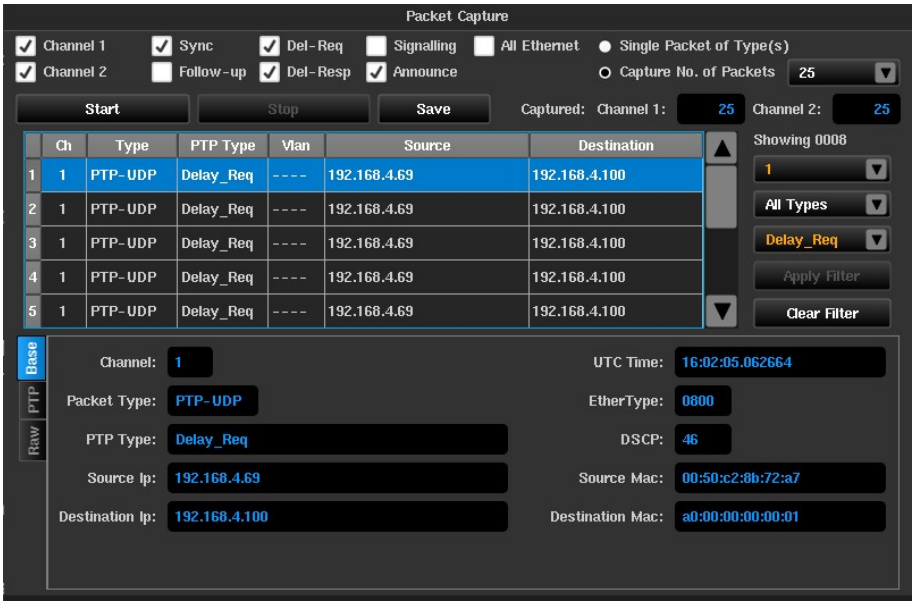


Figure 57 - Packet Capture Example – Delay Request Messages from Slot 1

The bottom portion of the **Packet Capture** screen shows context sensitive decode of the packet highlighted in the results area.

Various levels of decode take place depending on the types of packet captured. There are up to four tabs displayed for each message selected, as follows:

Base – Decode of packet transport header fields (MAC, VLAN, IP). All packets will have this tab.

Figure 58 - Packet Capture Base Tab

PTP – Decode of significant PTP header fields. Only packet types PTP-UDP and PTP-ETH packets have this tab.

Figure 59 - Packet Capture PTP Tab

Signal / Announce – Decode of the fields contained within a PTP Signalling or Announce message Only PTP-UDP and PTP-ETH Signalling / Announce packets have this tab.

Figure 60 - Packet Capture - Signal Tab

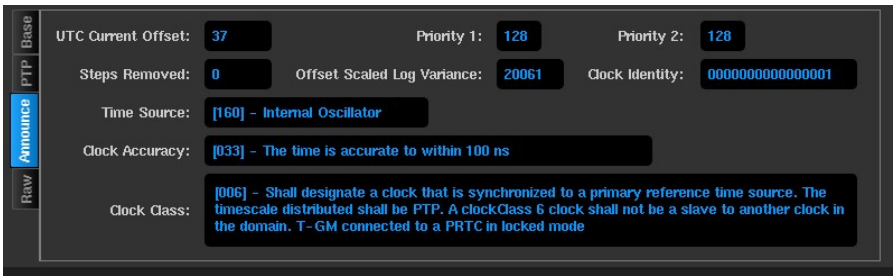


Figure 61 - Packet Capture Announce Tab

Raw – Hexadecimal and Ascii display of the captured packet. All packets have this tab.

Figure 62 - Packet Capture Raw Tab

Once you stop capturing packets (by clicking the **Stop** button), the captured packets can be saved by clicking the **Save** button. A **Save packet capture** screen appears, letting you save the packet capure file either on the internal memory of the Sentinel or to an externally connected USB memory stick. The saved files are in Next Generation PCAP format. The captured packets are saved together in a single **.pcapng** file. These file can be transferred from the Sentinel and analysed further using Calnex PTP Field Verifier (PFV) or other tools such as WireShark.

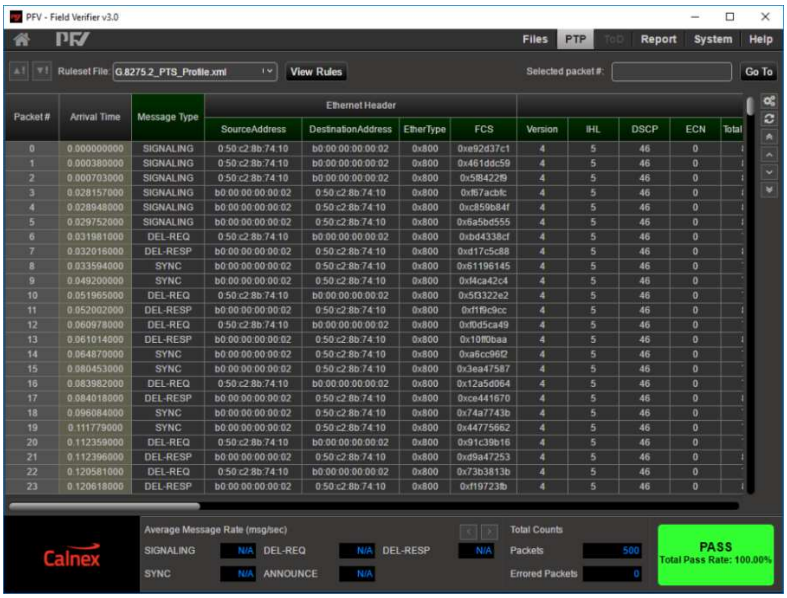


Figure 63 - Calnex PTP Field Verifier

4.6 Data

When you click on the **Data** tab in the configuration bar the **Data** screen (Figure 64) appears.

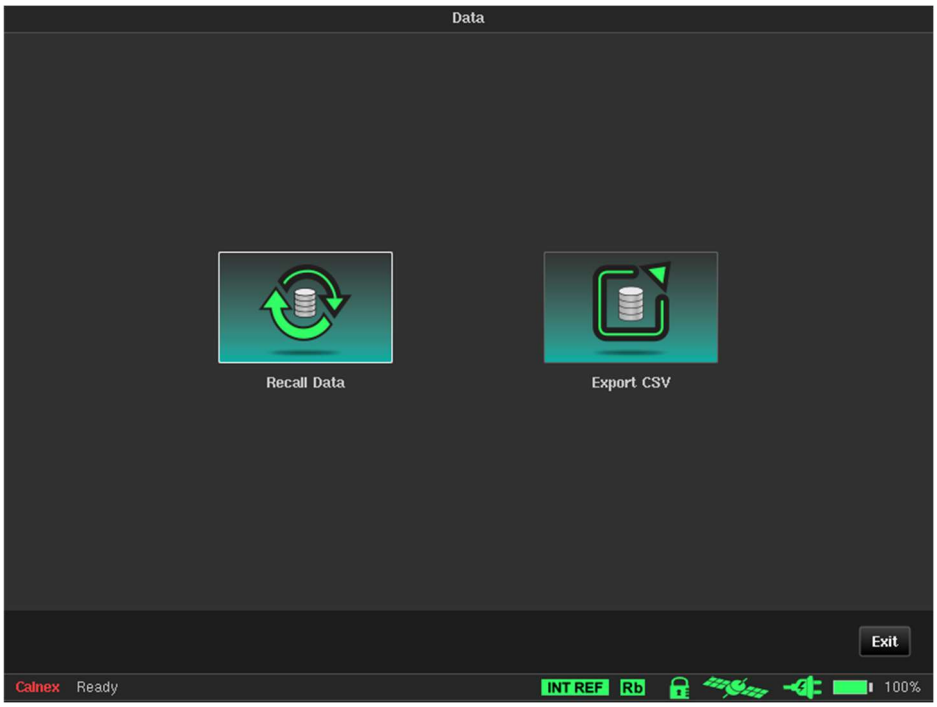


Figure 64 - Data Screen

The **Data** screen contains the following tiles associated with previous measurements:

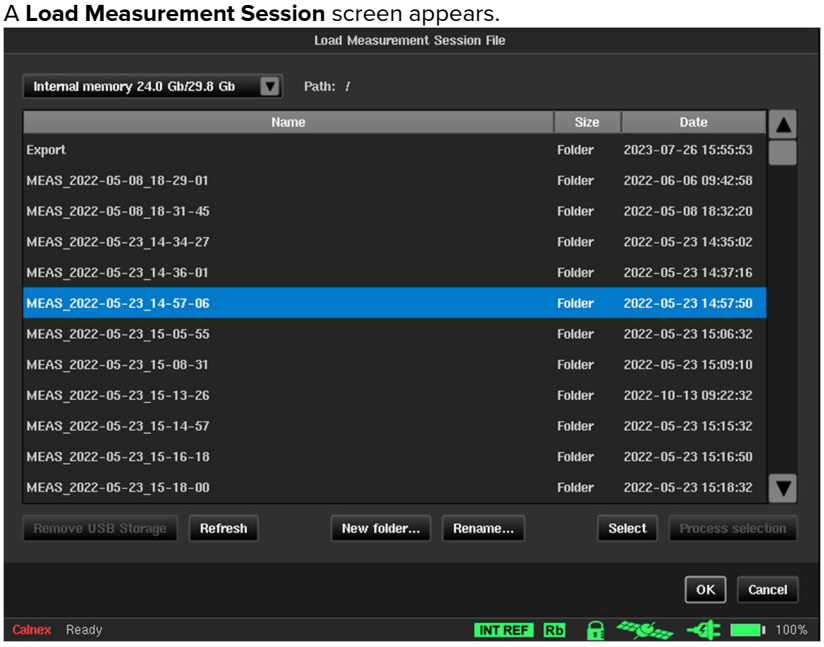
- **Recall Data** – lets you reload previous measurements. For more information, see Loading Previous Measurements below.
- **Export CSV** – lets you export the existing or previous measurements in CSV format. For more information, see Exporting Measurements on page 57.

Note: Sentinel measurement files can be directly read into the Calnex Analysis Tool (CAT) for in depth analysis and report generation. If the files are in Sentinel internal storage, then they can be copied either using an FTP client or by copying to a USB memory stick. For more information, see File Management on page 64.

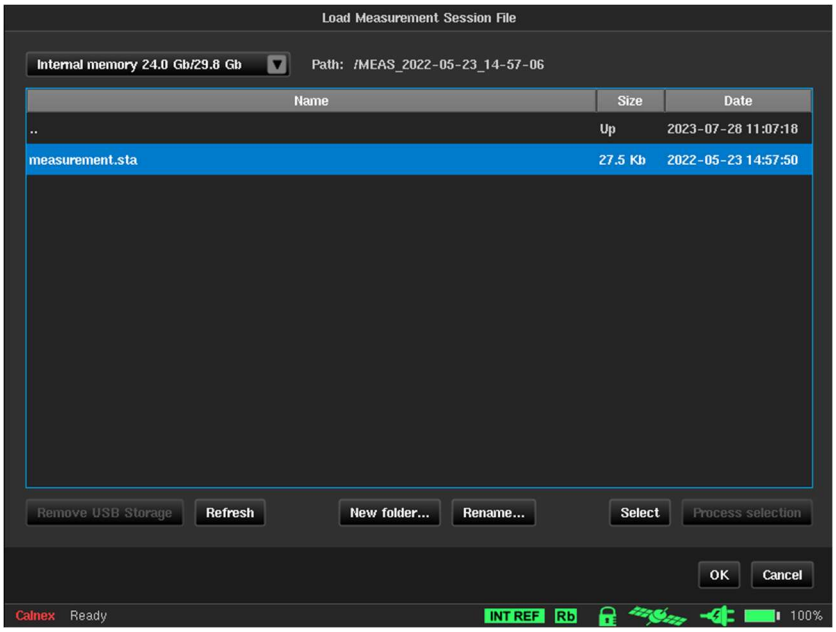
Loading Previous Measurements

To load a previous measurement on the Sentinel, do the following:

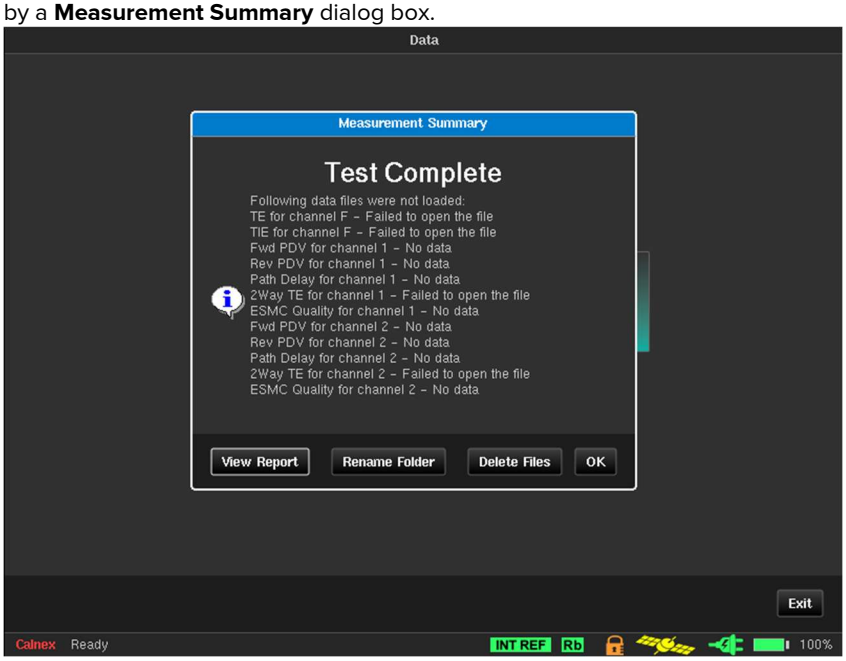
1. From the **Data** screen click the **Recall Data** tile.
   A **Load Measurement Session** screen appears.



2. From the **Load Measurement Session** screen that appears, drill down and navigate into the measurement folder of interest.
3. Select the **measurement.sta** file.



4. Click **OK**.
   A number of messages appear while the previous measurement state of the Sentinel are loaded, followed by a **Measurement Summary** dialog box.

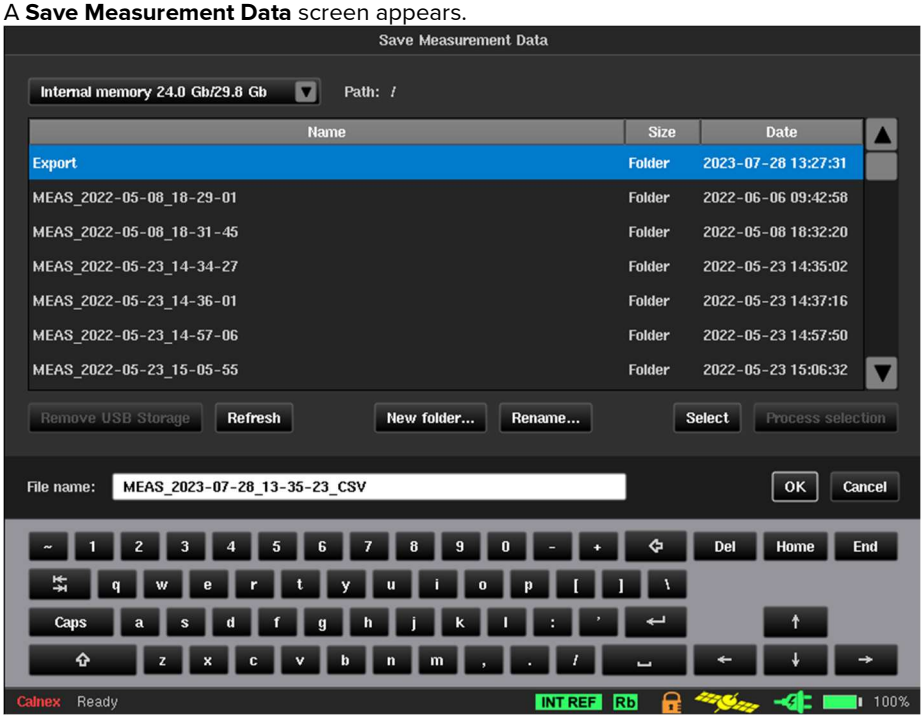


   Note: The time it takes to load an existing measurement varies depending on the duration of the original measurement. Measurements of long durations can take considerable time to load.
5. In the **Measurement Summary** dialog box, click **OK**.
6. In the **Data** screen, click **Exit**.

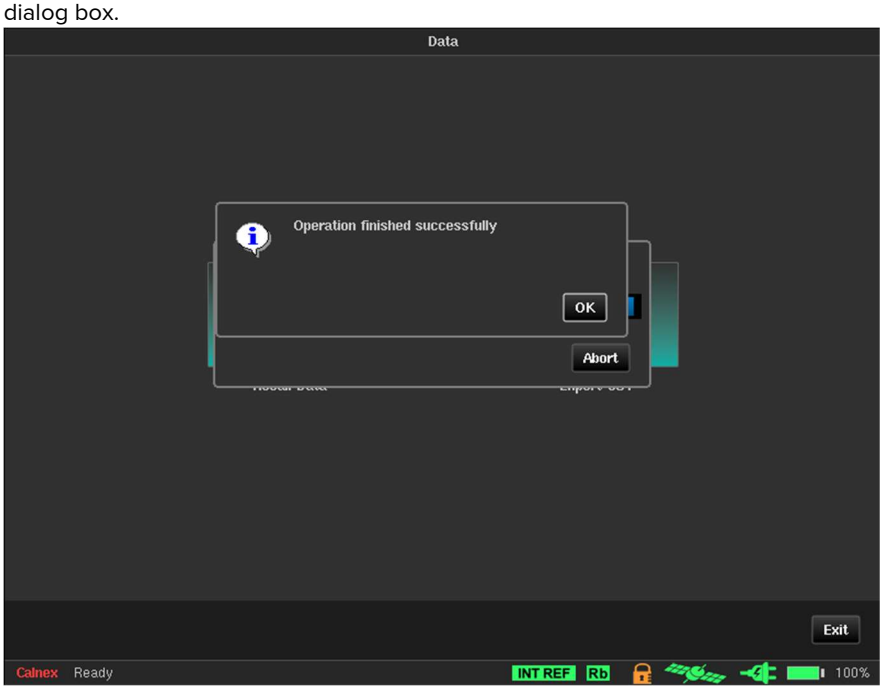
Exporting Measurements to CSV

To export a measurement to CSV, do the following:

1. From the **Data** screen click the **Export CSV** tile.
   A **Save Measurement Data** screen appears.



2. If necessary, drill down and navigate into a folder of interest where you want to save the exported CSV measurement.
3. The **File name** field automatically already has the filename completed with _CSV appended. If necessary, change the filename.
4. Click **OK**.
   A **Save file** dialog box appears while the file is being saved, followed by an **Operation finished successfully** dialog box.



5. In the **Operation finished successfully** dialog box, click **OK**.

4.7 System

When you click on the **System** tab in the configuration bar the **System** screen (Figure 65) appears.

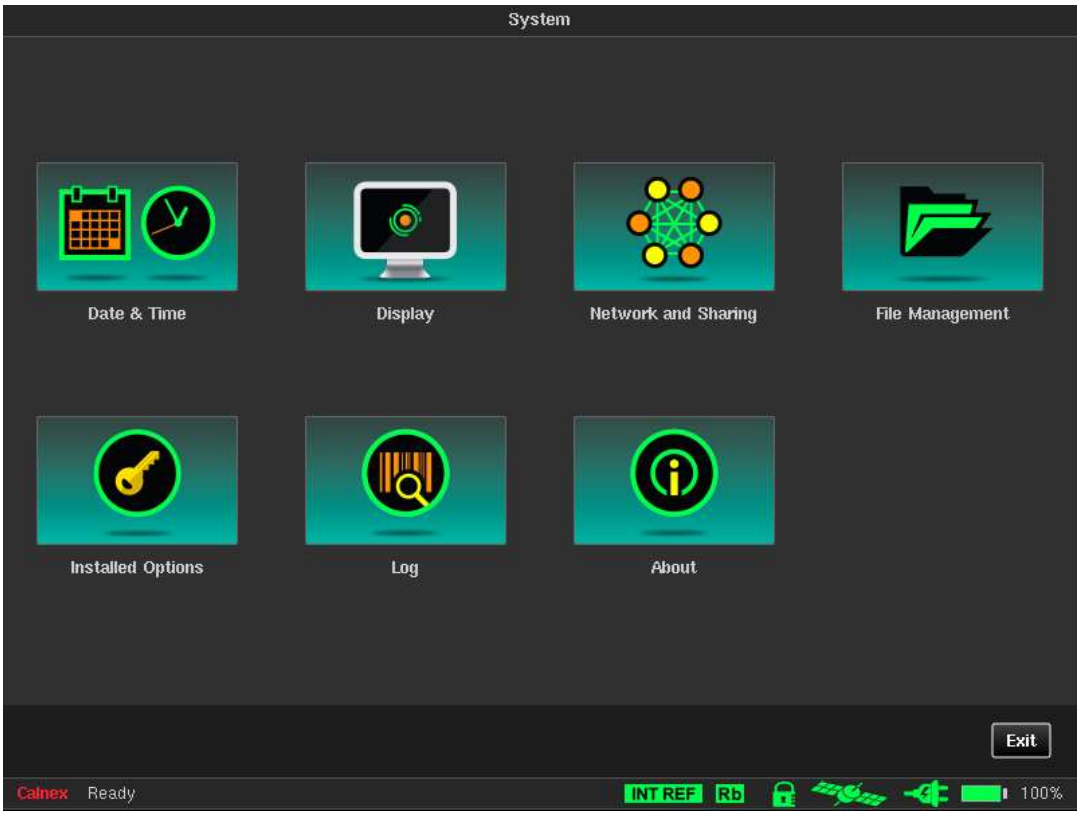


Figure 65 - System Screen

The **System** screen provides access to several other system related configuration screens by clicking on one of the tiles below:

- **Date & Time** – for more information, see Date & Time on page 60.
- **Display** – for more information, see Display on page 61.
- **Network and Sharing** – for more information, see Network and Sharing on page 62.
- **File Management** – for more information, see File Management on page 64.
- **Installed Options** – for more information, see Installed Options on page 65.
- **Log** – for more information, see Log on page 65.
- **About** – for more information, see About on page 67.

Date & Time

When you click on the **Date & Time** tile in the **System** screen, the **Date & Time** screen (Figure 66) appears.

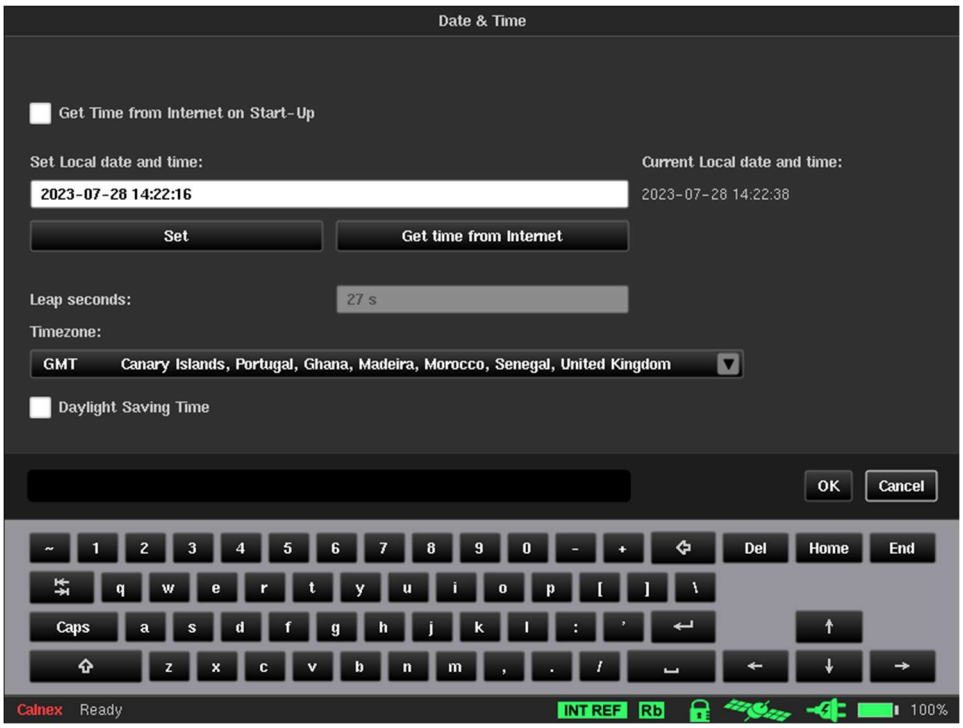


Figure 66 - Date & Time Screen

The date and the time can be entered manually in the **Set Local date and time** field and clicking on the **Set** button or can be synchronized with universal time by clicking on the **Get time from Internet** button if an external network connection is available. If GNSS is connected to the Sentinel, the date and time will automatically be synchronized to this, overriding the date and time set by the other methods.

If the **Get Time from Internet on Start-up** check box is ticked, the Sentinel automatically synchronizes the date and time from the Internet before the GNSS receiver starts up.

Ticking the **Daylight Saving Time** check box adjusts system time for daylight saving.

Display

When you click on the **Display** tile in the **System** screen, the **Display** screen (Figure 67) appears.

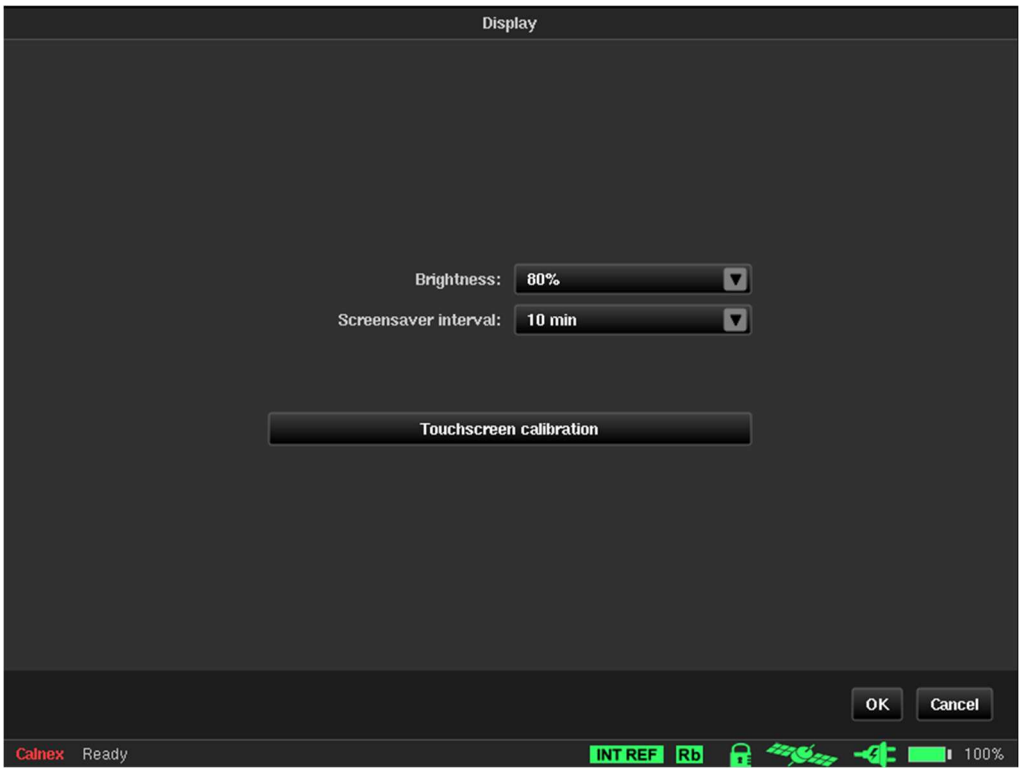


Figure 67 - Display Screen

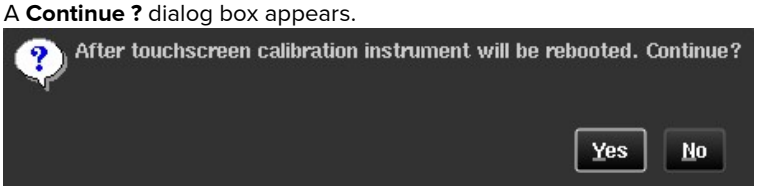
The default brightness of the LCD touch screen is 80% and screensaver interval is 10 minutes.

You can use the **Display** screen to modify these default settings, if desired:

Brightness Lets you choose LCD backlight intensity with 20% step (*20%, 40%*, *60%, 80%* or *100%*).

Screensaver interval Lets you define the time interval after which LCD backlight is switched off (*1 min*, *10 min*, *30 min*, *1 hour*).

The Sentinel touch screen is pre-calibrated. If you witness issues when navigating the GUI on the touch screen, you can re-calibrate the touch screen at any time by clicking on the **Touchscreen calibration** button. Touchscreen calibration is an automated operation performed by a special utility that asks you to touch several highlighted points on the touch screen. A reboot is required to finalise the calibration procedure. To re-calibrate the touch screen, perform the steps below:

1. Click the **Touchscreen calibration** button.
   A **Continue ?** dialog box appears.
   

2. From the **Continue?** dialog box that appears, click **OK**.
3. Follow the onscreen instructions to touch the points indicated on the touch screen.
4. Once completed, the Sentinel reboots.

Network and Sharing

When you click on the **Network and Sharing** tile in the **System** screen, the **Network and Sharing** screen appears.

The **Network and Sharing** screen has different pages as described in the sections below.

Ethernet

When you click on the **Ethernet** button in the **Network and Sharing** screen, the **Ethernet** page (Figure 68) appears.

The **Ethernet** page lets you define parameters of the Ethernet management connection. IP address, subnet mask and default gateway can be entered manually or set automatically using DHCP. If DHCP is used, the IP address allocated will be displayed in the **IP address** field. The **MAC address** field is read only and just for information.

It is possible to configure an IPv4 connection and IPv6 connection at the same time if required. The configuration for both IPv4 and IPv6 can be either *Disabled*, *DHCP* or *Manual* and do not need to be set to the same mode.

Figure 68 - Network and Sharing - Ethernet Page

Remote Access

When you click on the **Remote Access** button in the **Network and Sharing** screen, the **Remote Access** page (Figure 69) appears.

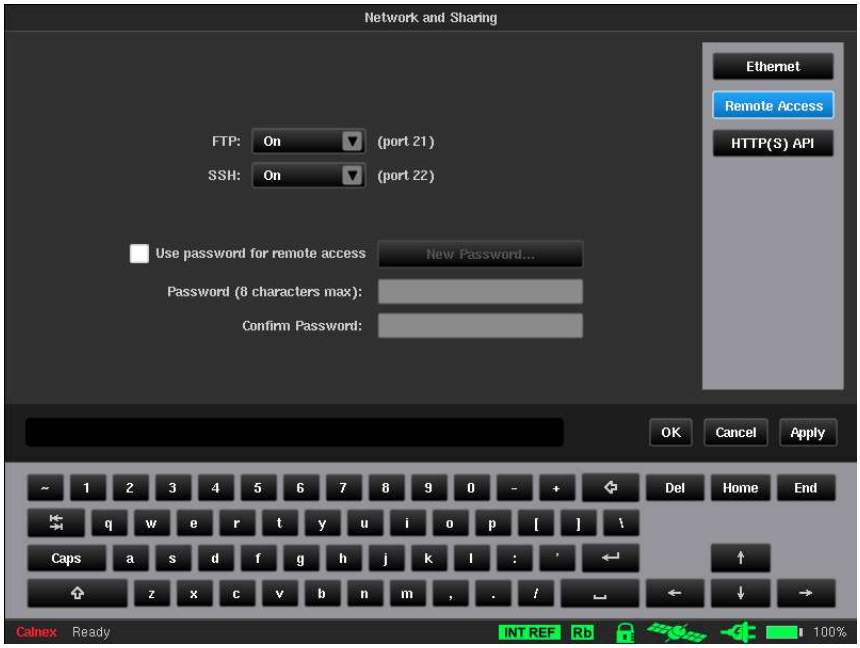


Figure 69 - Network and Sharing - Remote Access

The **Remote Access** page lets you configure the different ways to remotely access the Sentinel via Ethernet:

FTP File Transfer Protocol, allows access to Sentinel internal and external memory using an FTP client on a PC connected to the same network as the Sentinel.

SSH For Calnex customer support use only (service access using secure shell (SSH) protocol.

By default, no password is required for VNC and FTP connections.

To enable password protection, tick the **Use password for remote access** check box and type a password in **Password (8 characters max)** and **Confirm Password** fields.

To change an existing password, click **New Password...** button and type a new password in the **Password (8 characters max)** and **Confirm Password** fields.

The username for FTP connection is fixed – *remote*.

Note: Remote access settings changes are applied only after the Sentinel is rebooted.

HTTP(S) API

When you click on the **HTTP(S) API** button in the **Network and Sharing** screen, the **HTTP(S) API** page (Figure 70) appears.

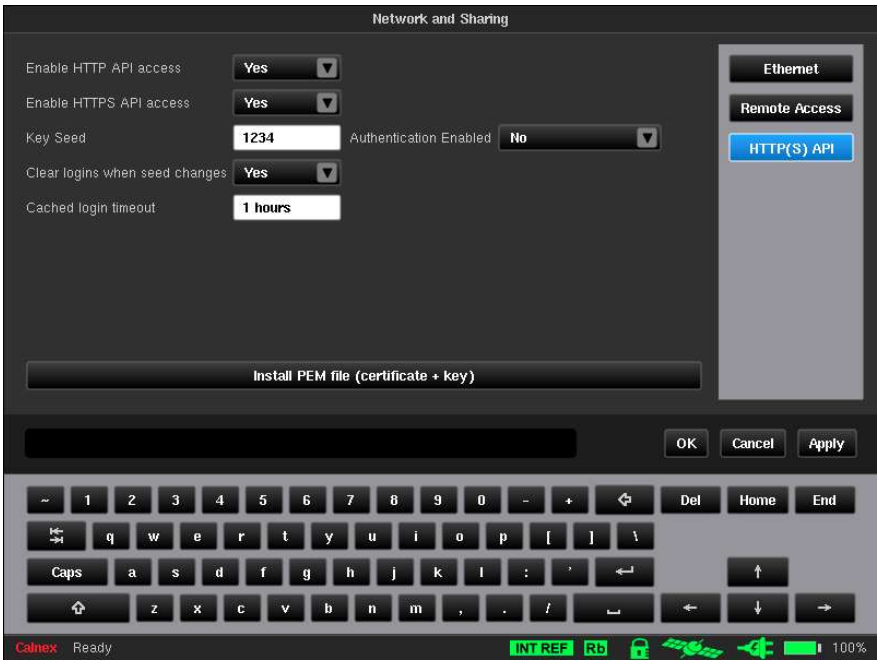


Figure 70 - Network and Sharing - HTTP(S) API Page

The Sentinel has an HTTP based API that can be used so that it can be remotely controlled. This API access is configured via the following settings available on **HTTP(S) API** page.

Enable HTTP API access This allows access to the API interface via the HTTP protocol. Where security is a concern for having open access to the Sentinel API it is recommended to disable this access method and turn on authentication for the API. To disable access to the Sentinel API fully both HTTP and HTTPS must be disabled.

Enable HTTPS API access Where security is a concern for access to the Sentinel API then it is recommended to use HTTPS and disable the HTTP interface. To disable access to the Sentinel API fully both HTTP and HTTPS must be disabled.

Key Seed This is the seed value that is used as part of the authentication handshake when authentication is enabled.

Authentication Enabled This setting enables authentication on the API interface.

Clear logins when seed changes When set, changing the value of the Key Seed will cause all sessions currently logged into the API interface to be logged out.

Cached login timeout This is the time that a login to the API interface will last before a new login is required. All logins are cleared when the Sentinel is rebooted.

Install PEM file (certificate + key) Clicking this button lets you select a **.pem** file, allowing you to install a certificate(s) and key(s) on the Sentinel. For more information, see Installing a certificate and key using a PEM file.

Installing a certificate and key using a PEM file

You can install a combined certificate and key on the Sentinel so that API access can be made securely via HTTPS using a secure connection. Once the combined certificate and key are installed on the Sentinel, any APIs called via HTTPS at the Sentinel's hostname with the curl command will not require the -k flag as the connection will be secure.

You must have a Privacy Enhanced Mail (PEM) (**.pem**) file containing the combined certificate and key associated with the hostname given to the Sentinel. Your IT department will have created the required PEM (**.pem**) file containing the necessary SSL certificate, private and public keys, intermediate certificate, and root certificate associated with the hostname of the Sentinel.

To install the PEM (**.pem**) file, do the following:

1. Copy the PEM (**.pem**) file provided by your IP department to the local file system on the Sentinel (via the USB memory stick or via an FTP client).
2. Click the **System** tab.
3. Click the **Network and Sharing** tile.
4. Click the **HTTP(S) API** button.
5. Click the **Install PEM file (certificate and key)** button.
6. From the **Select PEM file** screen that appears, navigate to, and select the **.pem** file so that it is highlighted in blue.
7. Click **OK**.
   The API service on the Sentinel restarts and the certificate(s) that were in the PEM (**.pem**) file are now applied and in use in the Sentinel.

File Management

When you click on the **File Management** tile in the **System** screen, the **File Management** screen (Figure 71) appears.

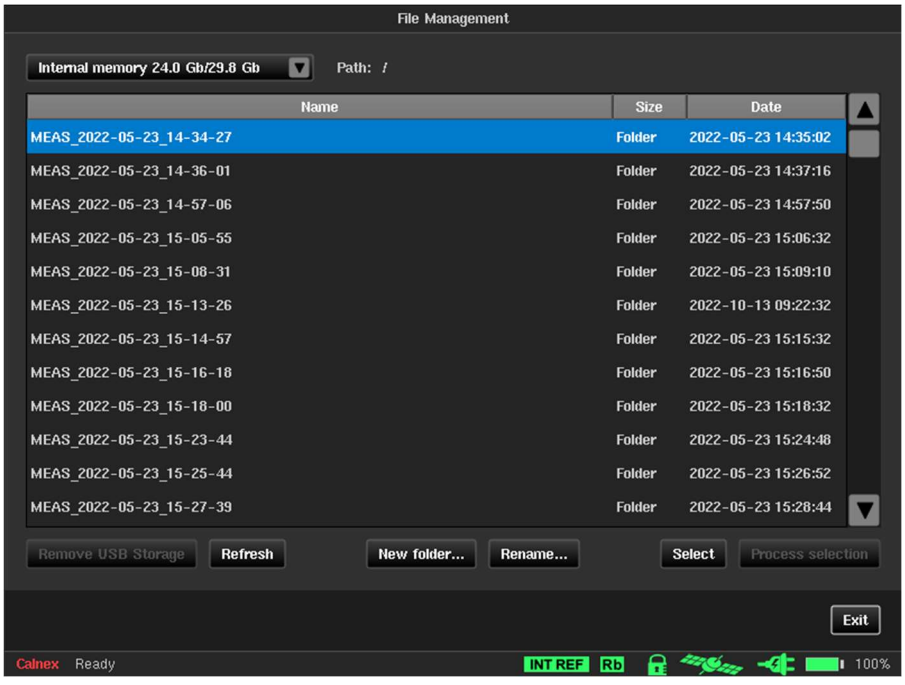


Figure 71 - File Management Screen

The **File Management** screen lets you manage the measurement files. A drop-down list provides information on available space on the internal memory of the Sentinel, or on the external USB memory stick if connected. The files can also be moved via the Ethernet network when they are saved on the intern memory.

If you want to remove an external USB memory stick, click the **Remove USB Storage** button before unplugging to ensure that data has been saved properly. If the **File Management** screen does not update after plugging / unplugging USB memory click the **Refresh** button to force an update.

Note: To aid remote control of the Sentinel the **Remove USB Storage** button changes to **Remount USB Storage** button when the external USB memory stick has been dismounted. The USB memory stick can be remounted by clicking this button which then returns to **Remove USB Storage**.

Various buttons are available at the bottom of the **File Management** screen. The **New folder...** button is used to create a new folder. The folder name is entered using the virtual keyboard. The **Rename...** button is used to rename a file or folder, in the same way. The **Select/Unselect** button is a toggle used to select/unselect files and folders in the list for further processing using **Process selection** button; the selected items are identified by highlighting and switching to italic characters.

Note: Files and/or folders remain selected even when you choose a folder different from which selected items belong to. This allows processing of files and/or folders from several different locations in memory.

The **Process selection** button is enabled when at least one file or folder is selected and will indicate the number of files currently selected. When you click the **Process selection** button, a dialog box (Figure 72) appears with the available operations, applicable to the internal memory and to any external memory: **Move here**, **Copy here**, **Remove**, **Unselect all**, **Cancel**.

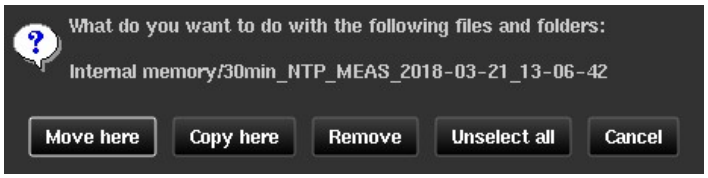


Figure 72 - Process Selection Dialog Box

Installed Options

When you click on the **Installed Options** tile in the **System** screen, the **Installed Options** screen (Figure 73) appears.

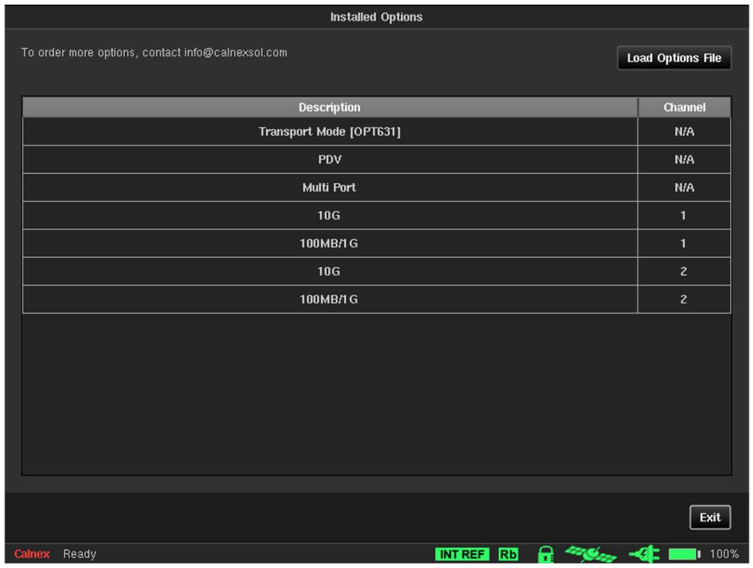


Figure 73 - Installed Options Screen

The **Installed Options** screen shows the list of licensed options that are installed on the Sentinel. If one or more Packet Modules are installed, then the **PDV** option is displayed. If a 10GbE Packet Module is installed, an entry appears for each licensed port and the relevant interface speeds available for that port.

Packet Module options can be upgraded in the field through a file supplied by Calnex. This file must be copied to either Sentinel internal or external memory and selected through the **Load Options File** button. Once the file has been loaded, Sentinel will reboot, and the new options are enabled.

Log

When you click on the **Log** tile in the **System** screen, the **Log** screen (Figure 74) appears.

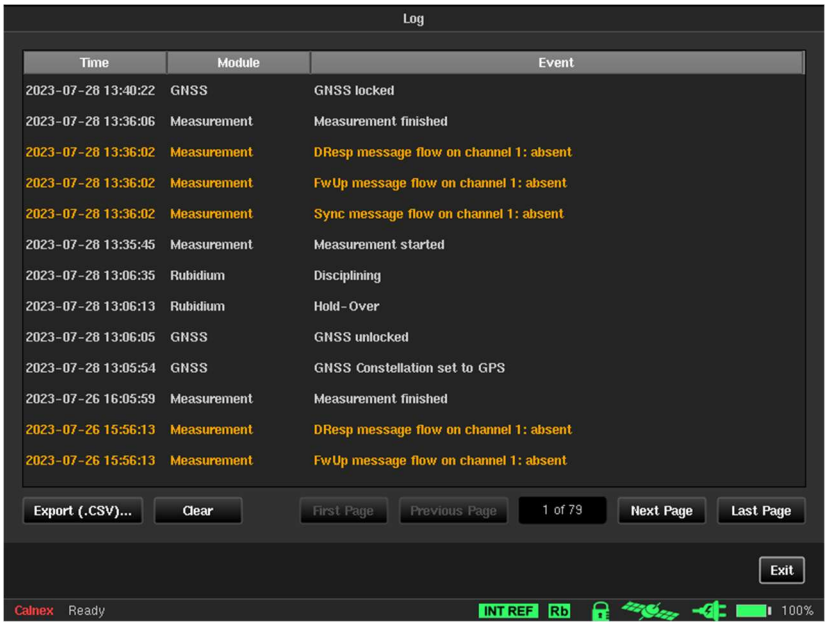


Figure 74 - Log Screen

The Sentinel keeps a log of different events (start up, power down, timebase warming, measurement start, loss of signal etc.) that can be seen in the **Log** screen. The Log can be exported to a CSV file that can be read by many spreadsheet editors and text viewers. For an explanation of the events in the log see Appendix C.

About

When you click on the **About** tile in the **System** screen, the **About** screen (Figure 75) appears.

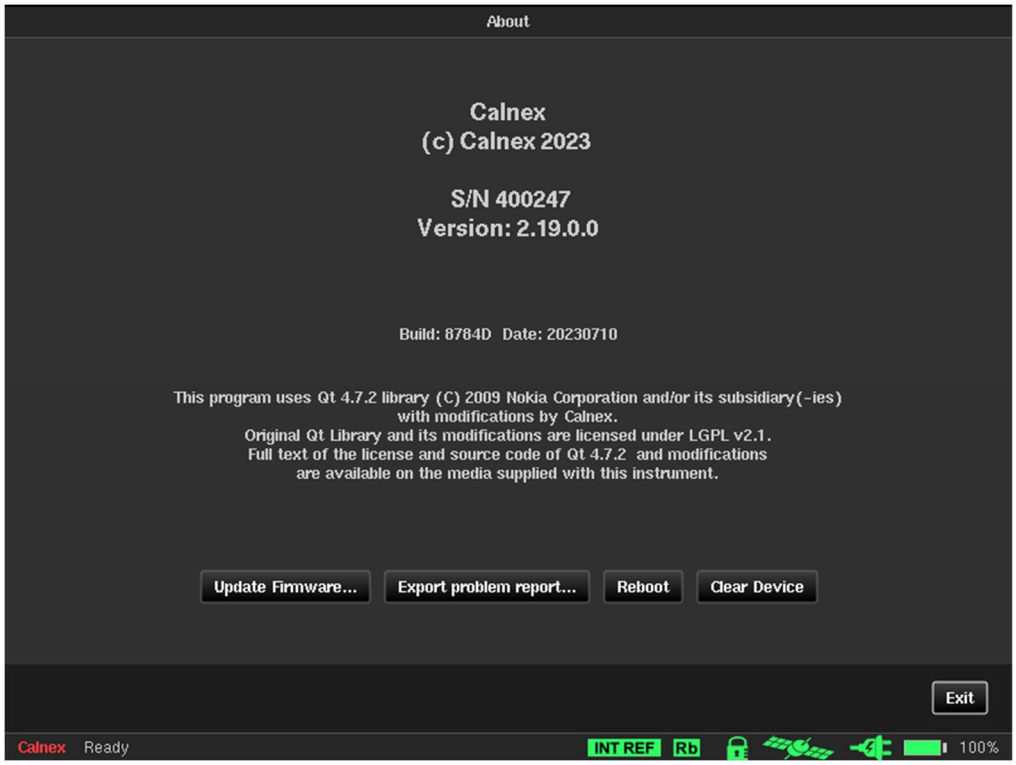


Figure 75 - About Screen

The **About** screen identifies the firmware installed on the Sentinel and the enabled options.

Update firmware... Used for updating the Sentinel from a firmware image located either in the internal memory or on an external USB memory stick. The Sentinel is rebooted to finalise the firmware update.

Export problem report... Lets you save internal system logs to a specified place in internal the internal memory or on an external USB memory stick. In the instance of a problem this information can be sent to Calnex customer support to help in investigation.

Reboot Lets the Sentinel be rebooted without removing power.

Clear Device Deletes all measurement and configuration data from the Sentinel. When selected, a warning message appears to confirm whether this action will be taken.

Operation

5.1 Measurements

Measurements are made by clicking the **Start/Stop** (toggle) button on the main operating screen.

Note: Before running a measurement, you must add the masks that you want to be applied to the measurement. For more information, see Masks on page 49.

Note: In all cases (i.e. when the **Start** mode is either *immediate* or *timer*), even if a scheduled measurement is defined with the **Start** mode set to *timer*, the measurement is not made until the **Start** button is clicked.

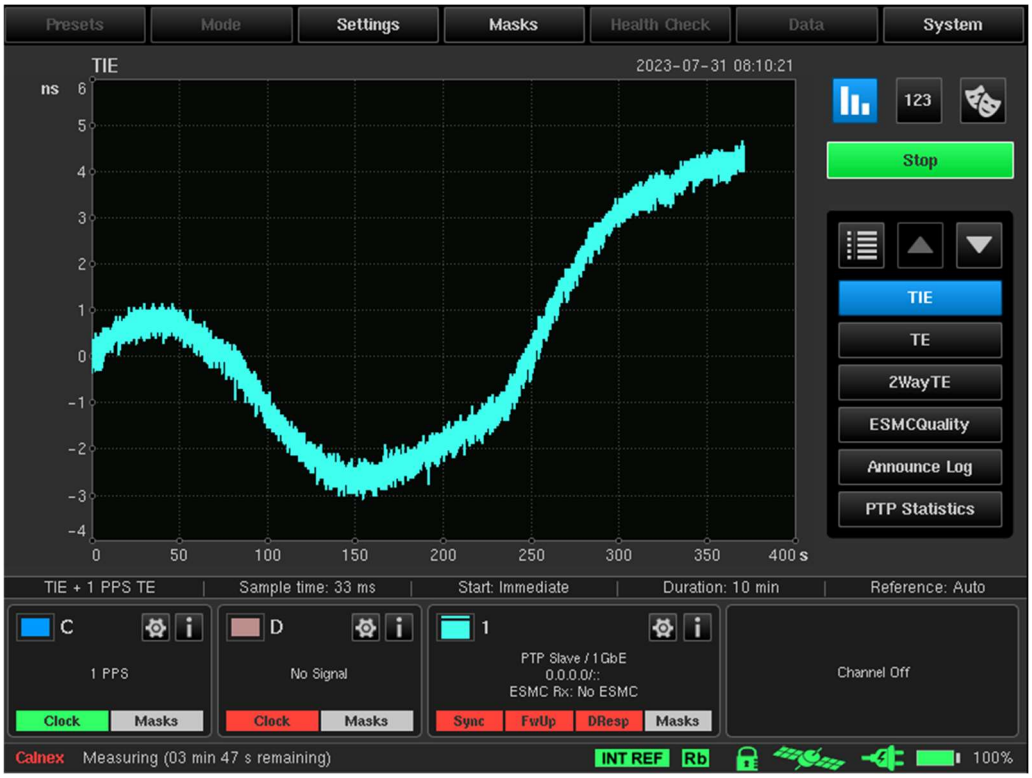


Figure 76 - Main Operating Screen - Measurement in Progress

By default, the measurement starts immediately, but a warm-up time may elapse first. You can program the measurement start and stop times via the **Settings** screen's **Common** page (see Common on page 22).

While a measurement is in progress, clicking the **Stop** button stops the measurement immediately. The measurement is saved for the completed duration before **Stop** was clicked.

A measurement with a defined measuring time stops automatically after the set time has elapsed. The default characteristics are as follows:

- Sample time: *33 ms*
- Duration: *10 min*
- Reference: *Auto* selection between internal oscillator and external reference

You can modify and save these characteristics in the **Settings** screen's **Common** page (see Common on page 22).

By default, you are prompted to select where to save the measurement.

Throughout the duration of the measurement, the TIE and/or Raw PDV are displayed, with plot scale adjustment as the time elapses. The calculated functions (MTIE and TDEV together with PDV Distributions, Selected PDV metrics: FPP, MAFE, and 2WayTE) and PTP Statistics can also be displayed during measurement acquisition.

The remaining measurement time appears on the status line at the bottom left of the main operating screen.

5.2 Saving Measurement Data

You can save measured TIE data, Raw PDV data (measured Fwd, Rev and Path Delay) and 2WayTE calculated data in the Sentinel's internal memory or on an externally connected USB memory stick. All calculated metrics are not saved. Measurement data is stored in binary format.

For each measurement, a separate folder is created with the default name in a form **MEAS_date_time**, where **date_time** corresponds to the date and time at the start of measurement. The folder contains a file named **measurement.sta** which records the measurement settings. A set of measurement files are also present with at least one for each input channel available. The measurement files are named in the form **channelX** for Raw TIE data, **channelX_[FWD_PDV | REV_PDV | PATH_DELAY]** for Raw PDV data, **channelX_2Way_TE** for 2WayTE data and **channelX_ESMC_QUALITY** for SyncE SSM message transitions. Channel files in binary format have **.dset** as their extension (i.e. dataset). A text file (**measurement.summary.txt**) is also saved in the folder, detailing a Pass/Fail summary for each channel along with the value of any user defined masks. PTP announce message arrival time and header fields are logged and stored in a CSV format file (**announce_message_updates.sentinel**).

Saved measurement data that has been exported via a USB memory stick or over the Ethernet connection can be loaded into the Calnex CAT analysis software package on a workstation or laptop for further analysis.

When you start a new measurement a **Save Measurement Data** screen (Figure 77) appears prompting you to save the measurement.

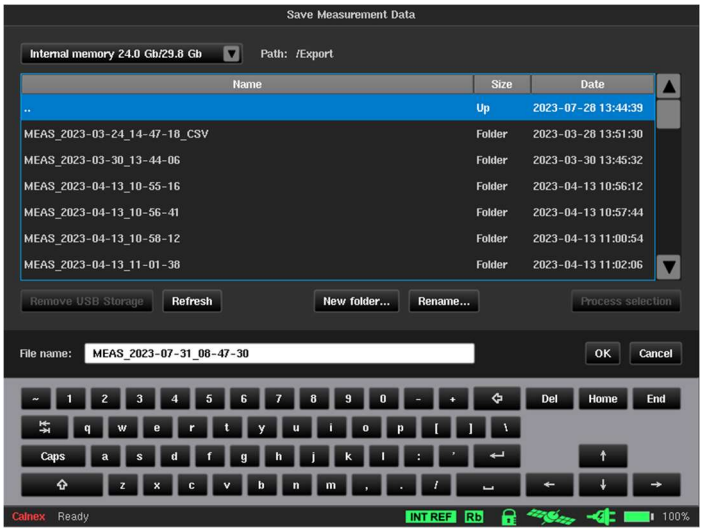


Figure 77 - Save Measurement Screen

The **Save Measurement Data** screen lets you select the save location for the measurement folder and define the name of the measurement folder. You can select and navigate within the Sentinel's internal memory or an externally connected USB memory stick. You can change the default folder name within the **File name** field.

Clicking on the **OK** button in the **Save Measurement Data** screen starts the measurement and returns you to the main operating screen.

Clicking on the **Cancel** button in the **Save Measurement Data** screen cancels starting the measurement and returns you to the main operating screen.

You can also rename, copy, move, or delete the measurement folder using the **File Management** screen (see File Management on page 64). You can copy or move the measurement folder using the USB interface or the Ethernet network via an FTP connection.

After a measurement has stopped the Sentinel needs some time to perform post-processing of measurement data (calculate metrics). During this stage a **Post-processing data** dialog box (Figure 78) appears on the main operating screen.

Figure 78 - Post-processing data dialog box

You can cancel the post-processing of measurement results with no loss of data by clicking the **Abort** button.

When the measurement has completed, if there are masks enabled (see Masks on page 49), the overall Pass/Fail status appears in a **Measurement Summary** dialog box (Figure 79) along with the location of the measurement results.

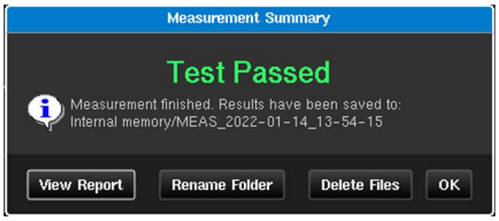


Figure 79 - Measurement Summary Dialog Box (when masks are enabled for the measurement)

Test Passed is displayed if no measured values fall out with the applied masks.

When the measurement has completed, if no are masks enabled, the **Test Compete** message appears in a **Measurement Summary** dialog box (Figure 80) along with the location of the measurement results.

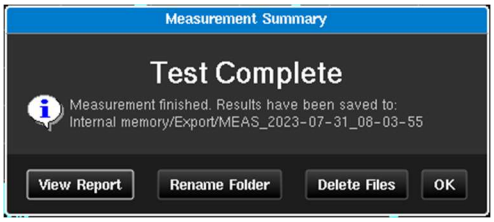


Figure 80 - Measurement Summary Dialog Box (when no masks are enabled for the measurement)

If required, you can view a summary of the test results by clicking the **View Report** button.

Measurement Result Graph

The Sentinel creates a graph for every measurement and its associated metrics. To configure the graphs that appear and the order that they appear in the navigation panel click on the **Graph Selection** button highlighted in Figure 81.

Figure 81 - Main Operating Screen - Graph Selection Button Highlighted

Upon clicking the **Graph Selection** button, the **Graph Selection** screen appears (Figure 82). The **Graph Selection** screen contains a show/hide check box and associated measurement description for each graph. To change the graph ordering by select the graph name (so it appears in blue) and click on the up/down **Order** arrow buttons as required.

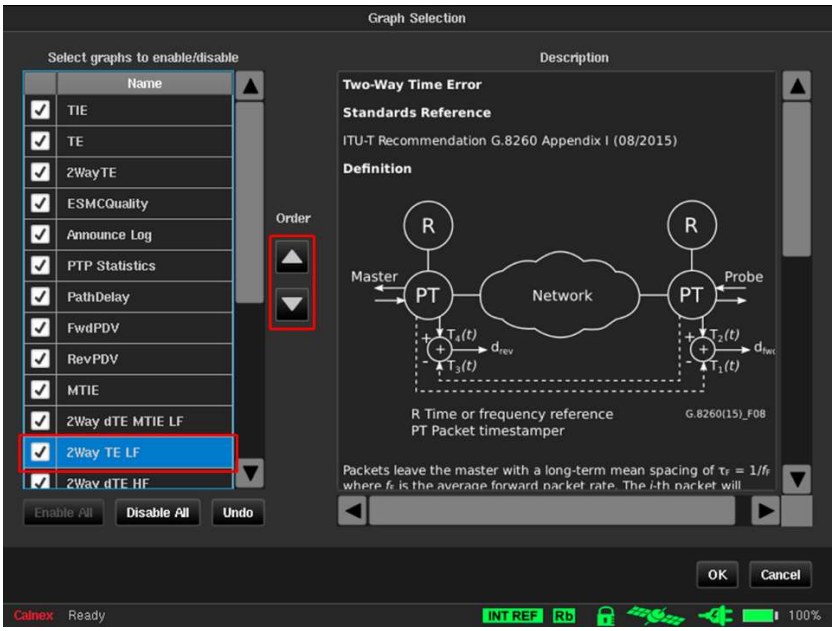


Figure 82 - Graph Selection Screen

The measurements made remain displayed on the main operating screen until a new measurement sequence is started by clicking the **Start/Stop** button.

The following metrics are calculated from the measurement results.

Metrics for TIE data

TIE	Time Interval Error
MTIE	Maximum Time Interval Error

TDEV	Time Deviation
Metrics for Raw PDV data (Fwd PDV, Rev PDV, Path Delay)	
Fwd/Rev/Path Delay distribution	FD/RD/PD Distribution
Metrics for Selected PDV data	
FPP	Floor Packets Percentage
MAFE	Maximum Average Frequency Error
SelPDV	Packet Delay Variation Selection
Metrics for Time Error data	
TE	Time Error
2WayTE	2Way Time Error
2Way dTE MTIE LF	2Way Dynamic Time Error MTIE Low-Pass Filtered
2Way TE LF	2Way Time Error Low-Pass Filtered
2Way dTE HF	2Way Dynamic Time Error High-Pass Filtered
pktSelected2WayTE	Packet-Selected 2Way Time Error for PTS/APTS networks

Masks are available to be overlaid on the graphs summarized in Table 5 and Table 6. The masks are selected in the **Masks** screen and are displayed by default once they have been selected as described in Masks on page 49.

The masks summarized in Table 5 cannot have their parameters modified and are visible in the measurement graphs as summarized in Table 5.

NON-CONFIGURABLE MASK(S)	VISIBLE IN GRAPH(S)
G.812 Type I Wander Gen G.812 Type II-III Wander Gen G.813 Wander Gen SEC Opt1 G.813 Wander Gen SEC Opt2 G.823 E1 PDH Sync Interface G.823 E1 PRC Interface G.823 E1 SEC Interface G.823 E1 SSU Interface G.824 T1 PDH Ref Interface G.8261 Enhanced SyncE Wander Limit (ePRTC) G.8261 Wander Limit EEC Opt1 G.8262 Wander Gen EEC Opt1 G.8262 Wander Gen EEC Opt2 G.8272 Wander Gen PRTC ANSI DS1 Interface ANSI OC-N Interface ETSI PDH Interface ETSI PRC Interface ETSI SEC Interface ETSI SSU Interface ETSI Wander Gen PRC ETSI Wander Gen SEC ETSI Wander Gen SSU	MTIE 2Way dTE MTIE LF TDEV
G.813 Holdover SEC opt2 G.813 Switch SEC opt2 G.823 E1 Traffic Interface 2048 G.824 T1 PRC Interface G.824 T1 Traffic Interface 1544 G.8261 Amd.2 Short Chain Network Limits (Fig 19) G.8261 E1 CES Case1 G.8261 E1 CES Case2 G.8261 T1 CES Case1 G.8261.1 Case 3 G.8262 Wander Switch EEC-2 ANSI DS1 Transient ANSI OC-N Transient	MTIE 2Way dTE MTIE LF

NON-CONFIGURABLE MASK(S)	VISIBLE IN GRAPH(S)
ANSI PRS Interface ANSI SMC Holdover	
G.813 Transfer SEC Opt2 G.824 T1 PDH Ref Interface SEC Opt2 G.8261 Wander Limit EEC Opt2 G.8262 Wander Switch EEC-2 Opt2	TDEV
G.8271.1 dTE MTIE	MTIE
G.8271.1 dTE Pk-Pk HPF (Channel X) *(see note)* **Note:** Because this mask is peak to peak and can be any absolute value, no limits are shown on the graph. The result (pass or fail) for the mask will only be shown.	2Way dTE HF
G.8271.2 PTS Network Limit (Channel X) G.8271.2 APTS Pk-Pk Network Limit (Channel X) *(see note)* **Note:** Because this mask is peak to peak and can be any absolute value, no limits are shown on the graph. The result (pass or fail) for the mask will only be shown.	pktSelected2WayTE
MAFE 16ppb MAFE NSN HRM 1 MAFE NSN HRM 2	MAFE/SelPDV

Table 5 - Non-Configurable Masks

The masks summarized in Table 6 can additionally have their parameters modified via their corresponding **Settings** page and are visible in the measurement graphs summarized in Table 6.

CONFIGURABLE MASK	VISBLE IN GRAPH(S)	SETTINGS PAGE - PARAMETER
G.8271.1 Max|TE|	TE	Settings > Measurement > Common – G.8271.1 TE Mask Value (see Common on page 22)
G.8271.1 Max|2WayTE| LPF (Channel X)	2way TE LF	Settings > Channel X > PTP – Network Mask Limit (see PTP on page 39)
G.8261.1 FPP Network Limit (Channel X)	FPP	Settings > Channel X > Selection – FPP mask level (see Selection masks settings (FPP mask level) on page 43).
PDV Distribution (Channel X)	Distr/FwdPDV Distr/RevPDV Distr/PathDelay	Settings > Channel X > PTP – Network Mask Limit (see PDV Distribution on page 44)

Table 6 – Configurable Masks

The various measurements made, and the masks applied are clearly identified (see Figure 83). A solid line indicates each of the measurements being made on each graph. Each channel uses a specific colour. The colour used is the same as that shown in the channel widget. A dashed line represents a mask.

This means that the quality of the measured signal can be interpreted immediately. For an FPP measurement to be compliant, its representative curve must be above the mask. For all other measurements to be compliant, the representative curve must be below the mask.

All active channels are automatically checked versus all relevant active masks in real-time. Mask pass / fail status is displayed inside each active channel widget, in relation with the selected masks (for MTIE and TDEV metrics).

Detailed information about check results are displayed in the masks table. For more information about viewing the masks table, see Masks Table on page 78.

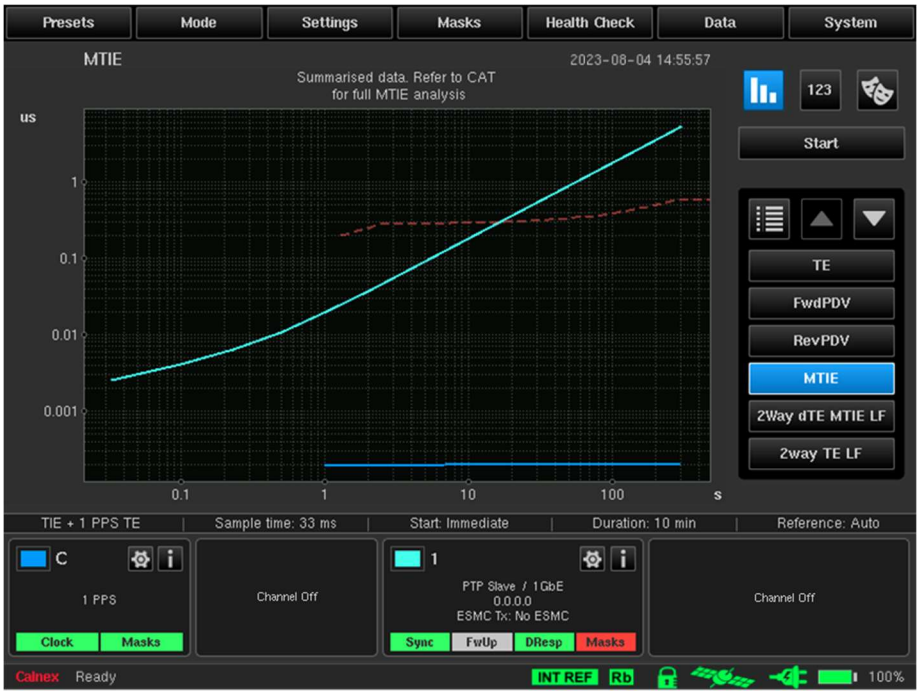


Figure 83 - Main Operating Screen with MTIE Graph Displayed

Metric for PTP Statistics

If a PDV measurement has taken place, then statistics of the PTP packets used in the measurement can be displayed by selecting to show the **PTP Statistics** metric on the **Graph Selection** screen (Figure 84).

Figure 84 - Graph Selection Screen (PTP Statistics Show Check Box Enabled)

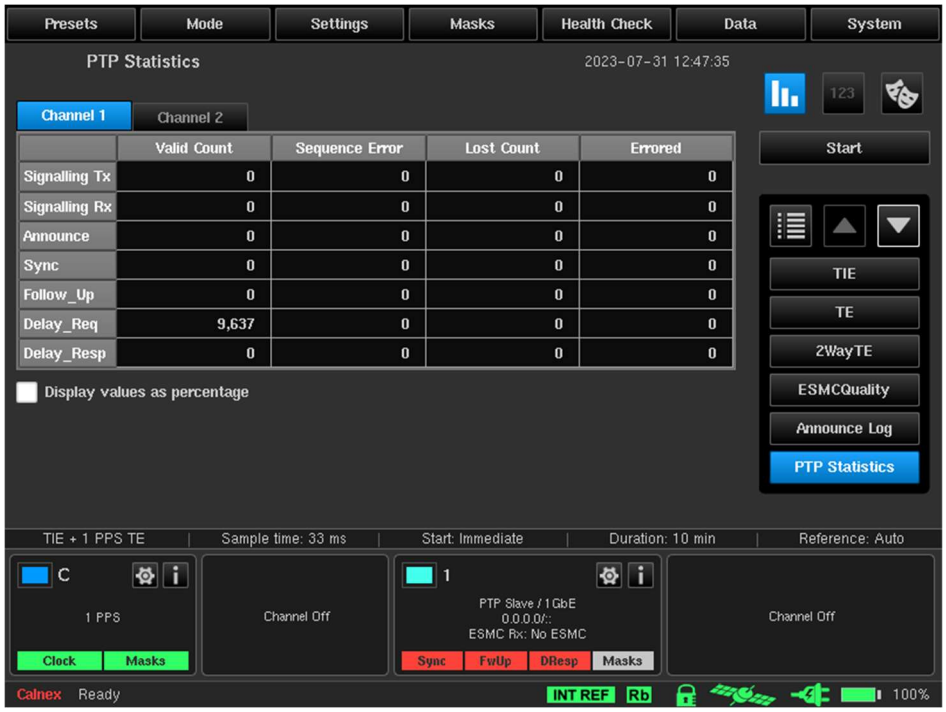


Figure 85 - Main Operating Screen with PTP Statistics Metric Selected

Statistics are held separately for each PTP card and are selected by the **Channel *X*** tabs at the top of the table (see Figure 85).

Columns indicate the number of PTP packets received that had a PTP sequence error, lost PTP packets or errored PTP packets.

You can also display statistics as a percentage rather than an absolute count by ticking the **Display values as percentage** check box.

The rows indicate the different types of PTP packets. Results are stored in .csv format to a file named ***ptp_measurement_statistics.sentinel*** in the folder specified when the measurement was started.

Note: In pseudo slave mode Signalling Tx and Delay_Req messages originate from the Sentinel and all others from the GM.

Note: In monitor mode all packets are received from the TAP or splitter and so the messages from the GM show up on one channel and the messages from the T-TSC on the other. All signalling appears in the **Signalling Rx** row. Signalling from the GM will be on the channel that has Sync messages and signalling from the T-TSC will be on the other channel.

Viewing Mode

The buttons in the viewing mode selector area on the main operating screen (**1** in Figure 86) let you select which information to display in the measurement graph window (**2** in Figure 86) of the main operating screen.

Figure 86 - Main Operating Screen - Viewing Mode Selector Buttons Area and Measurement Graph Window

The buttons in the viewing mode selector area have the following functions:

– displays a full-size graph window (for more information, see Full Size Graph Window on page 77).

– displays measurement analysis (mean, last, max and min values) (for more information, see Measurement Analysis on page 80).

– displays a masks table (for more information, see Masks Table on page 78).

When measurement analysis or masks table is selected, the graph window size is reduced to accommodate. The default view shows the full-size graph window.

7.1 Full Size Graph Window

You can display a full-size graph window by clicking on the **Full Size Graph Window** button in the viewing mode selector area on the main operating screen as highlighted in Figure 87.

Figure 87 - Main Operating Screen with the Full Size Graph Window Button Clicked

If no measurement is in progress or a previous measurement cleared (via **System > About > Reboot**), the full-size graph window is blank like that in Figure 87.

If a measurement is in progress, complete or a previous measurement has been loaded, the full-size graph window displays a graph like that in Figure 88.

Figure 88 - Main Operating Screen with Full Size Graph Window Showing Measurements

The type of graph that is displayed varies according to the graph metric button you clicked. The example in Figure 88 shows a TIE graph displayed. The graph metric buttons that are visible and their positional order can be configured in the **Graph Selection** screen (for more information, see Measurement Result Graph on page 71).

7.2 Masks Table

You can list of all currently selected masks and the status of each of these masks for relevant channels by clicking the **Mask** in the viewing mode selector area on the main operating screen as highlighted in Figure 89.

Figure 89 - Main Operating Screen with Masks Button Clicked

The masks table shows all enabled masks in rows and channels in columns. The button displays ✓ if all metrics are OK versus each mask. If at least one metric has failed, then ✕ is displayed. It is possible to click on these buttons and a metric results popup menu appears (Figure 90) detailing which metric the mask is applied to along with the status of mask check. Clicking on this metric results popup menu switches the screen to display the corresponding metric.

Figure 90 - Main Operating Screen with Tick Results Button Clicked

For example, in Figure 90 the **2Way dTE HF** metric is initially displayed. Clicking on the ✓ in the first row for the **G.8271.1 dTE MTIE** mask and clicking on the **2Way dTE MTIE LF passed** popup menu that appears results switching the displayed metric to **2Way dTE MTIE LF** as shown in Figure 91.

Figure 91 - Main Operating Screen After Clicking on the Metric Results Popup Menu

It is also possible to click on the mask name in the list of masks to enable/disable it within the mask table. For example, clicking on the enabled **G.8271.1 dTE Pk-Pk HPF** mask name results in disabling it and greying it out as shown in Figure 92.

Figure 92 - Main Operating Screen After Disabling a Mask from the Masks Table

7.3 Measurement Analysis

You can display the measurement analysis by clicking the **Measurement Analysis** button in the viewing mode selector area on the main operating screen as highlighted in Figure 93. This displays the Mean/cTE/Pk-Pk Max, Last Value, Min and Max values for the currently displayed graph metric.

Figure 93 - Main Operating Screen with Measurement Analysis Button Clicked

The example in Figure 93 is for a **TE** graph metric, and thus the mean value is displayed. If the **2Way dTE HF** was selected graph metric, the cTE is displayed instead of the mean value as shown in Figure 94.

Figure 94 - Main Operating Screen with cTE Column in Measurements Analysis

Either the **Mean**, **cTE**, or **Pk-Pk Max** column is displayed according to the selected metric, as follows:

- Mean column for the TIE, TE, Path Delay, FwdPDV, RevPDV, MTIE, 2WaydTE MTIE LF, TDEV, Distr/FwdPDF, Dist/RevPDV, Dist/PathDelay, SelPDV, FPP, and MAFE/SelPDV metrics.
- cTE column for the 2WayTE, 2Way TE LF, and 2Way dTE HF metrics.
- Pk-Pk Max column for the pktSelected2WayTE metric.

Widgets & Icons

The bottom of the main operating screen contains a channel widget panel (**1** in Figure 95) and status icons area (**2** in Figure 95).

Figure 95 - Main Operating Screen with Channel Widget Panel and Status Icons Highlighted

A widget is displayed in the channel widget panel for each of the input modules and corresponding channels. Each input module will feature one or more channel. The name of each widget corresponds to the symbol on the side panel of the Sentinel. For more information, see Measurement Channels.

When installed channels are disabled from within the **Mode** screen, they appear as **Channel Off**. The example in Figure 95 corresponds to having one Clock module (Channel C) enabled from the installed Clock modules C and D, and one Packet module (Channel 1) enabled from the installed Packet modules channels 1 and 2. The enabled and disabled modules within the **Mode** screen in this example would look like that in Figure 14 on page 20.

A set of status icons are available in the status icons area at the bottom of all screens indicating the state of various modules/features of the Sentinel. For more information, see Status Icons on page 85.

8.1 Measurement Channels

Each populated measurement channel has an associated widget to indicate the status and configuration of the channel, and to allow quick access to the channel settings.

Widgets show (where appropriate for the given input) signal type, line rate, IP address, whether the signal is present (clock), whether the appropriate messages are present (PTP/NTP), whether the measurement is within the applied mask(s), and information on the physical properties of the input (signal voltage, SFP information, etc.).

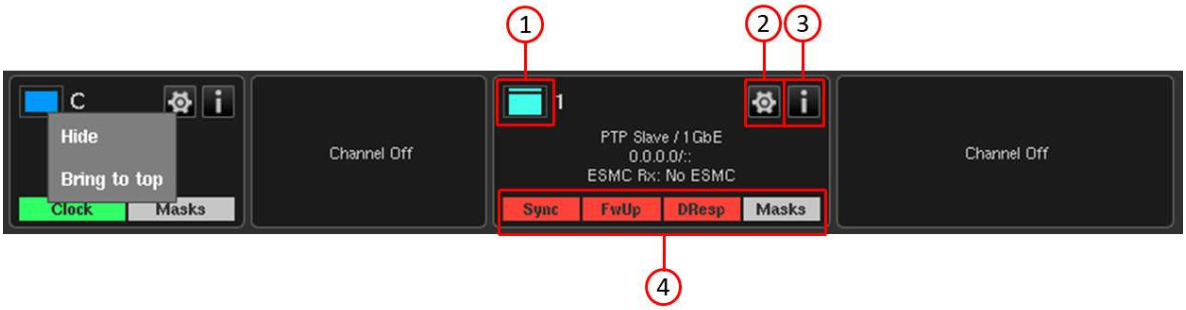


Figure 96 - Channel Widget Panel - Channel C and Channel 1 Enabled

In the top left of each widget for each channel has a button with a specific colour (**1** in Figure 96). The color of the button beside the channel name/number matches the measurement result color on the measurement graph window for easy identification. For example, in Figure 95, the dark blue color of channel C's measurement results appear in the MTIE graph, whereas the light blue color of channel 1's measurement results appear in the MTIE graph.

You can click on the colored button (**1** in Figure 96) in the top left of each widget for a channel to bring the channel to the foreground of the displayed measurements (**Bring to top**) or to hide it from the measurement screen and mask test (**Hide**). When hidden, the background of the input signal data is greyed out and you can click on the colored button to re-display the channel (**Show**).

Loss of signal LEDs and Mask pass / fail results (**4** in Figure 96) are displayed at the bottom of the widget.

- A green LED indicates that the associated clock signal, OTA lock or PTP/NTP message is present or that the mask has passed.
- A red LED indicates that the associated clock signal, OTA lock or PTP/NTP message is absent or that the mask has failed.
- A yellow LED indicates that the associated clock signal, OTA lock or PTP/NTP message has been absent but is now present again.
- A grey LED indicates that the associated PTP message is not relevant (e.g. Follow Up when running in 1-step mode) or the test has not run long enough to validate the mask.

Clicking on the **Settings** button (**2** in Figure 96) on a widget sends you directly to the **Settings** screen for that channel. If Channels 1 and 2 have been set up as PTP or NTP monitored channels in the **Mode** screen, clicking on the **Settings** button (**2** in Figure 96) on that widget takes you directly to the **Monitored Channels** page of the **Settings** screen for those channels.

Clicking on the **Info** button (**3** in Figure 96) opens a **Channel Information** screen with more detailed information on the selected channel.

- Information for clock channels appear like that described in PTP Clock Channel Information.
- Packet channels configured with PTP have more detailed information like that in PTP Channel Information on page 83.
- Packet channels configured with NTP have more detailed information like that in NTP Channel Information on page 83.

PTP Clock Channel Information

If you click on the **Info** button (**3** in Figure 96) of a clock channel in the channel widget panel, a **Channel Information** screen appears with the **Clock Channels** tab selected (Figure 97). The **Clock Channels** tab displays information for any of the clock channels that have been enabled from within the **Mode** screen.

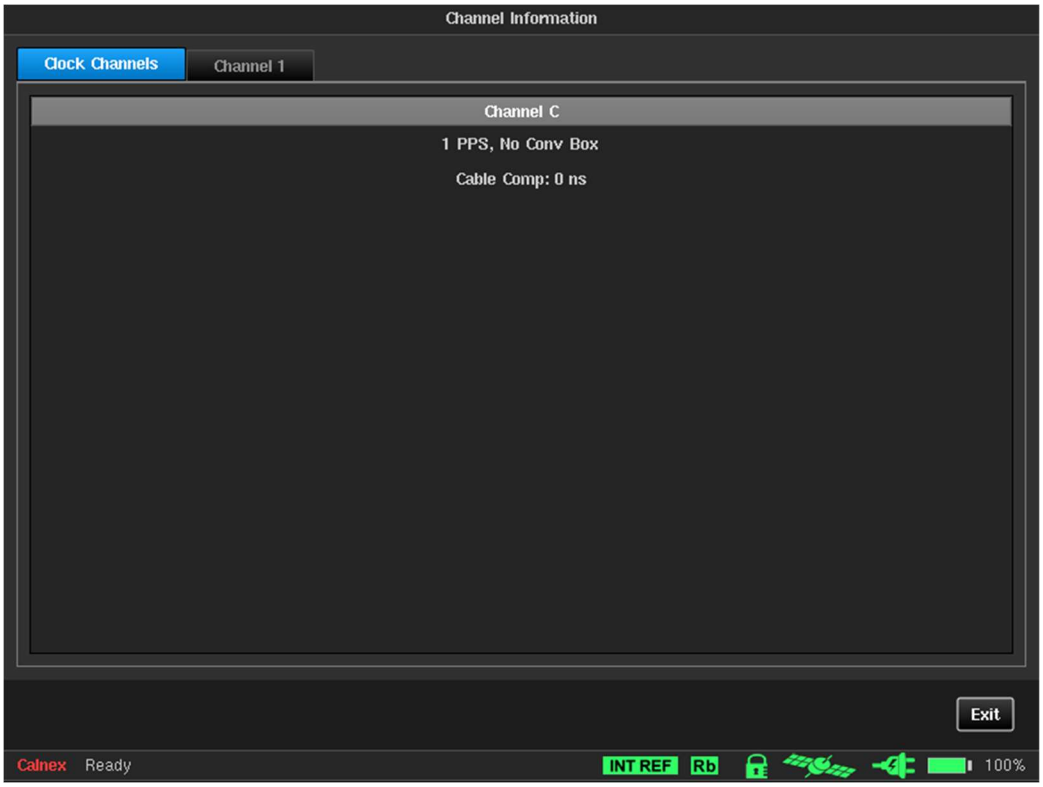


Figure 97 - Channel Information Screen - Clock Channels Tab Selected (Channel C Enabled in the Mode Screen)

Clicking on the **Exit** button returns you to the main operating screen.

PTP Channel Information

If you click on the **Info** button (**3** in Figure 96) of a packet channel that has been configured as a PTP slave in the channel widget panel, a **Channel Information** screen appears with the **Channel X** tab selected like that in Figure 98.

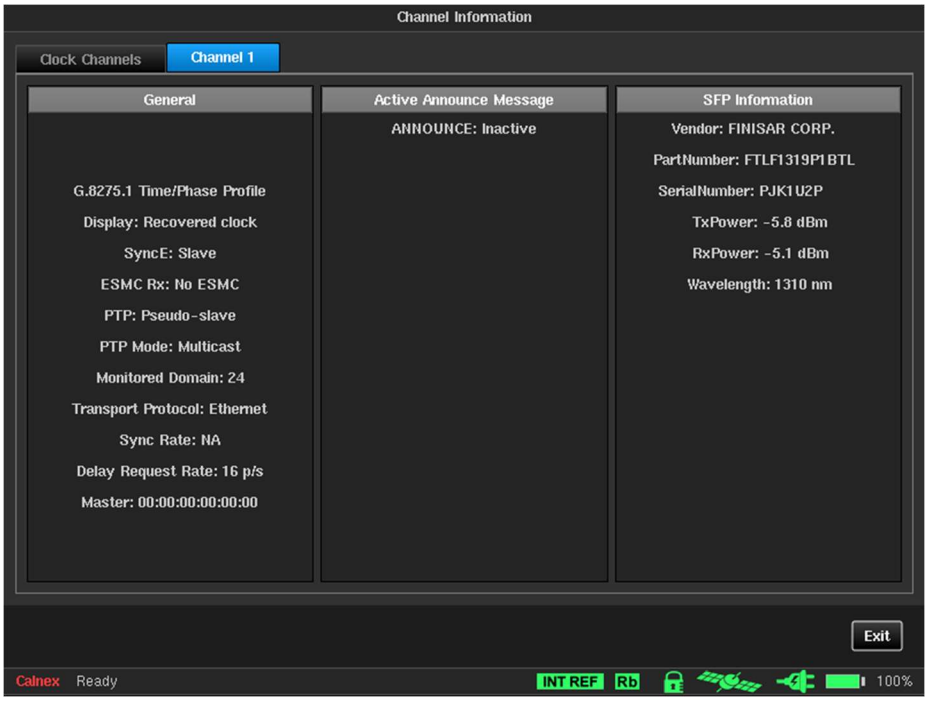


Figure 98 - Channel Information for a Packet Channel Configured as a PTP Slave

Clicking on the **Exit** button returns you to the main operating screen.

NTP Channel Information

If you click on the **Info** button (**3** in Figure 96) of a packet channel that has been configured as an NTP client in the channel widget panel, a **Channel Information** screen appears with the **Channel X** tab selected like that in Figure 99.

Figure 99 - Channel Information for a Packet Channel Configured as an NTP Client

Clicking on the **Exit** button returns you to the main operating screen.

OTA-LTE Channel Information

If you click on the **Info** button (**3** in Figure 96) of a packet channel that has been configured as OTA-LTE in the channel widget panel, a **Channel Information** screen appears with the **Channel X** tab selected like that in Figure 100.

Figure 100 - Channel Information for a Packet Channel Configured as OTA-LTE

Clicking on the **Exit** button returns you to the main operating screen.

OTA-NR Channel Information

If you click on the **Info** button (**3** in Figure 96) of a packet channel that has been configured as OTA-NR in the channel widget panel, a **Channel Information** screen appears with the **Channel X** tab selected like that in Figure 101.

Figure 101 - Channel Information for a Packet Channel Configured as OTA-NR

Clicking on the **Exit** button returns you to the main operating screen.

8.2 Status Icons

The status icons area contains different colored icons which show the current statuses of Sentinel's timebase reference, Rubidium, Rubidium disciplining, GNSS, power, and battery.

Clicking on the status icons area opens a **Status Icons** screen (Figure 102) that gives a detailed description of each icon and its possible states.

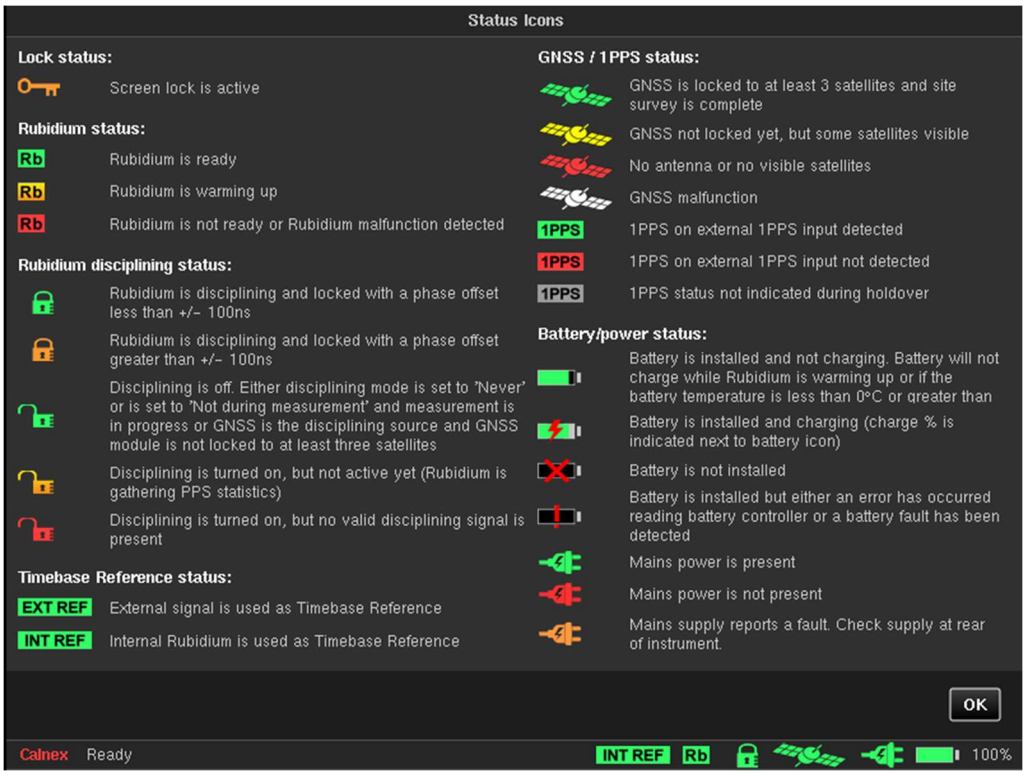


Figure 102 - Status Icons Screen

Clicking on the **OK** button returns you to the main operating screen.

8.3 Real Time Marker

When in any of the three viewing modes (i.e. full size graph window, measurement analysis, or masks table) a real time marker can be placed on any of the measurement graphs by clicking the desired point on the measurement graph. The real time marker can be removed by clicking on the date and time stamp of the real time marker.

Figure 103 - Real Time Marker on Full Size Graph Window Viewing Mode

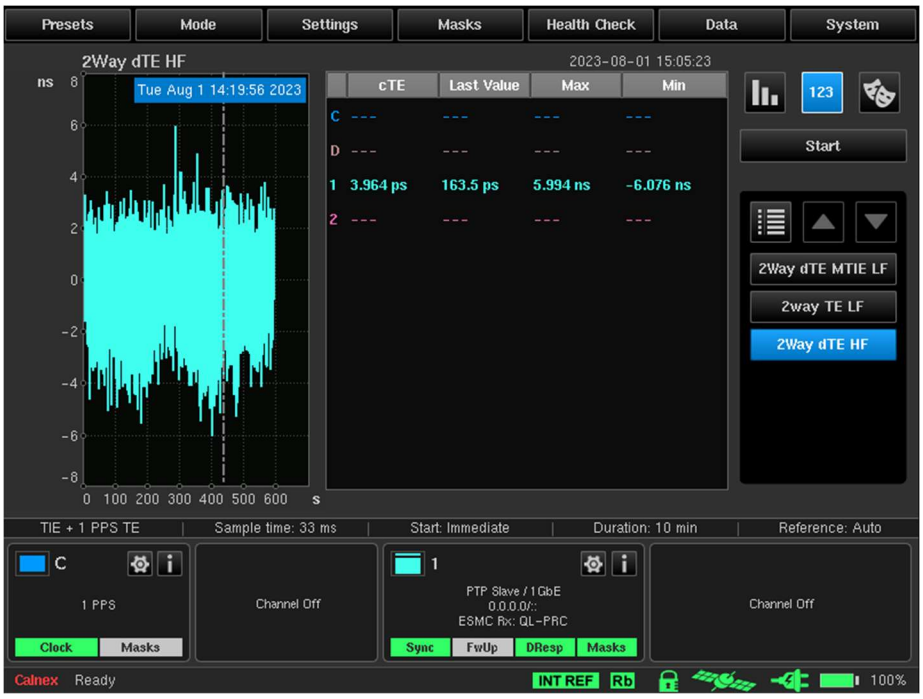


Figure 104 - Real Time Marker on Measurement Analysis Viewing Mode

Figure 105 - Real Time Marker on Masks Table Viewing Mode

Remote Control

The Sentinel can be remotely controlled via an HTTP(S) based API. A selection of features that are available via this service are as follows: measurements can be started and stopped; raw measurement data can be downloaded; device configuration can be viewed and modified. The API also allows new firmware to be downloaded to the Sentinel without needing local access.

The Sentinel can be accessed via HTTP and HTTPS. Where HTTPS is being used it is also possible to enable authentication to prevent un-authorised access to the Sentinel.

9.1 Authentication

The Sentinel remote-control interface can be protected. The authentication is implemented as a seed, key exchange. Authentication is enabled via the **Network and Sharing** screen's **HTTP(S) API** page (see Figure 70 on page 63). For information on the API authentication settings see HTTP(S) API on page 63.

Authentication where required is enabled via the **Authentication Enabled** drop-down list. A **Key Seed** must also be set at that point. The key seed is required each time a user wishes to start an authentication session with the remote-control API.

To start an authenticated session the *getkey* API call must be made passing the currently set key seed that has been configured within the **Network and Sharing** screen's **HTTP(S) API** page (see Figure 70 on page 63). On receiving the valid key seed, the Sentinel returns an access key that you can use for all services requiring authentication.

Example

An example handshake with the Sentinel using authentication would be as follows.

```
curl -k https://10.0.0.100/api/getkey?seed=1234
```

This will result in a response being received like the following:

```
34954a1a5ac07c8ed130d4444badb1e524f812d10e2180ced8cbb52f4344e17e
```

For the following commands, the key has been shortened for clarity, but the full key must be passed to the API call to pass authentication.

```
curl -k https://10.0.0.100/api/version?key=34954a1a5ac07c8ed130…
curl -k
"https://10.0.0.100/api/lockscreen?key=34954a1a5ac07c8ed130…&password=12345"
curl -k https://10.0.0.100/api/login?key=34954a1a5ac07c8ed130d444…
```

Note: When the ampersand (&) symbol is used within the URL using the curl command on Linux, the URL must be surrounded by inverted commas ("). Refer to the curl documentation for more information.

After the *login* API call has been made, it is no longer required to pass the key for each command as we have logged into the API using the required key and the *login* API call.

```
curl -k https://10.0.0.100/api/startmeasurement
curl -k https://10.0.0.100/api/logout
```

For the API calls *getkey* and *logout*, the key is not required. Following the logout call, the key is required on each subsequent API call.

```
curl -k https://10.0.0.100/api/stopmeasurement?key=34954a1a5ac07c8ed130…
```

The key obtained via *getkey* is valid until the next power cycle of the Sentinel or until the **Key Seed** is changed within the **Network and Sharing** screen's **HTTP(S) API** page (see Figure 70 on page 63).

Note: The -k flag with the curl command tells curl to allow insecure connections. The -k flag is required when accessing API calls via HTTPS when using the IP address or when using the hostname when no valid SSL certificate is installed. The -k flag is not required when accessing API calls via HTTP or when accessing API calls via HTTPS using the hostname when a valid SSL certificate is installed.

Login

The Sentinel considers authentication against a particular IP address. Once you have logged in to the remote interface, any access from the same source IP address is accepted without the need for the key being provided on each request. Where this is an issue, you must avoid using the login function and instead provide the key on each API request.

A login session remains valid until *logout* has been called or the timeout period as set via the **Cached login timeout** field in the **Network and Sharing** screen's **HTTP(S) API** page (see Figure 70 on page 63) has passed.

Refer to the *Sentinel/Sentry API User Guide* for detailed information on how to access and manage the Sentinel using the API.

Remote Access

10.1VNC Access

The Sentinel firmware includes a VNC server, so it be remotely accessed by a PC with a VNC client such as UltraVNC Viewer, TightVNC, TigerVNC, or VNC Viewer. Once the boot process is complete, in addition to using the touch screen, you can access the Sentinel's GUI using a PC connected on the same network as the Sentinel using your preferred VNC client.

To access the Sentinel using a VNC client, the Sentinel's IP address must be known and configured in the VNC client, along with the port number. The Sentinel's IPv4 and IPv6 IP addresses appears on the first and second line of the LCD Status Display, respectively.

The Sentry's IP address settings can be viewed and configured via the touch screen on the **Ethernet** page of the **Network and Sharing** screen of its GUI (see Ethernet on page 62).

The VNC sever on the Sentry uses a different port number for the IPv4 and IPv6 IP addresses.

- If you connect the VNC client with in IPv4 IP address, specify 5900 for the VNC port number.
- If you connect the VNC client with an IPv6 IP address, specify 5901 for the VNC port number.

Note: To define a VNC connection, some VNC clients use a separate field for the IP address and port number, while others use the same field for the IP address and port number. In the case when the same field is used for both the IP address and port number, you distinguish the IPv4 IP address from the port number with a colon (e.g. 192.168.207.21:5900) and you distinguish the IPv6 IP address from the port number using squared brackets (e.g. ::ffff:c0a8:cf15[5901]).

Note: By default, the Sentinel's VNC server does not require a password. Some VNC clients (e.g. UltraVNC Viewer) may ask you if you want to accept the connection to the server without authentication. In this case, accept the connection so that the VNC client can connect to the Sentinel's VNC server. If you decide to define a password for the Sentinel's VNC server later on (see Remote Access on page 62) you will need to specify this password in the VNC client.

Note: If you are using the Sentinel for the first time, and do not want to configure IPv4 and IPv6 addresses via the touch screen you can temporarily configure the network settings of a PC so that it is on the same network as the Sentinel (e.g. with an IPv4 address 192.168.0.10 subnet mask 255.255.255.0) and use a VNC client to connect to the Sentry's factory default IPv4 address of 192.168.0.100.

Calnex CAT PC Software

Calnex Analysis Tool (CAT) is a standalone PC software package that you can use for comprehensive analysis of TIE, PDV and TE measurements made by the Sentry and other network testing products from Calnex. It also has a comprehensive report generation capability and configurable mask functionality.

The metrics available to CAT are summarized below.

Clock Metrics

- MTIE/TDEV Analysis for Frequency
- ClkFFO

Packet metric Analysis for PTP and NTP

- PDV (PTP and NTP)
- FPP/FPC/FPR
- Packet TIE/MTIE/TDEV/FFO
- MAFE
- Packet Distribution (PDD)

Time Error Metrics

- PTP TE, cTE, dTE, Max |TE|
- PTP pktSelected2WayTE (ITU-T G.8271.2 APTS and PTS networks)

Preventative Maintenance

This section contains preventative maintenance procedures.

12.1 Update Firmware

Firmware update files can be obtained from the Calnex Customer Support. Firmware update files have the following format: **sentinel_fw_Rx.y.z.tar**

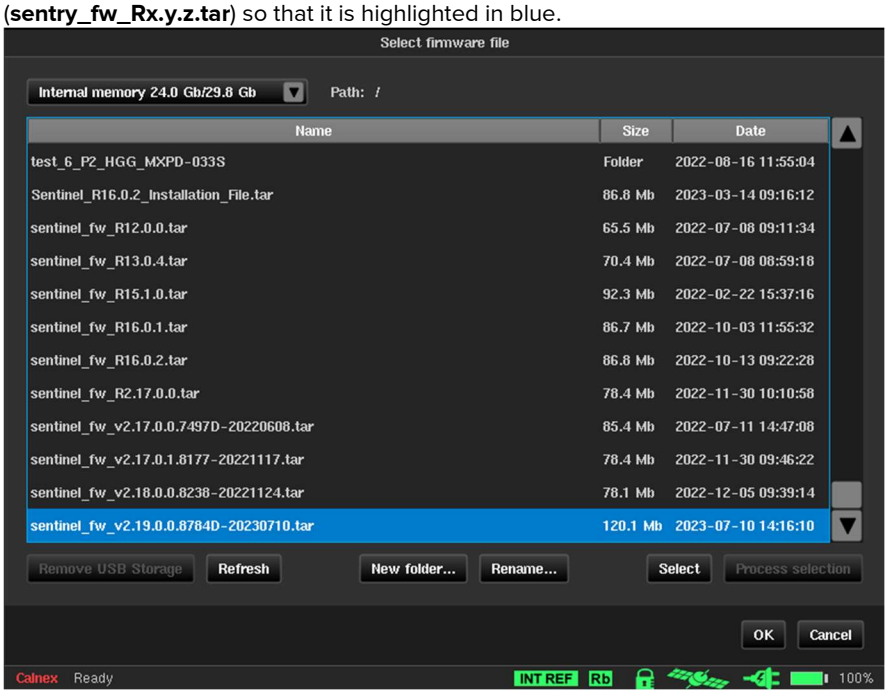
Note: The firmware update file is a **.tar** archive file. Its contents must not be extracted as the Sentinel is not able to install the firmware from the extracted files.

Note: The firmware update can also be performed using the Sentinel's API. For more information, refer to the *Calnex Sentinel/Sentry API User Guide*.

Firmware update files are installed via the Sentinel's USB Host Port using the **About** screen (see Figure 75 on page 67) that is accessible from within the **System** tab. The **About** page identifies the firmware installed in the Sentinel.

To update the Sentinel's firmware, do the following:

1. Insert the USB memory stick containing the firmware update file into USB Host Port of the Sentinel.
2. Select **System** > **File Management**.
3. From the **File Management** screen that appears, optionally copy the firmware update file (**sentinel_fw_Rx.y.z.tar**) to an appropriate location on the Sentinel's internal memory.
   Note: You can also use an FTP client to connect the Sentinel via FTP and upload the firmware update file to the Sentinel's internal memory.
4. Select **System** > **About**.
5. From the **About** screen that appears, click the **Update firmware**... button.
6. From the **Select firmware file** screen that appears navigate to and select the firmware update file (**sentry_fw_Rx.y.z.tar**) so that it is highlighted in blue.



7. Click **OK**. and run the update.

> **WARNING**:
>
> Never interrupt a firmware update operation.

The Sentinel reboots after firmware update is complete.

Appendix A: Signal Types

The following signal types are available, subject to firmware update:

1 PPS	25MHz (Ethernet)	1.544MHz (T1, Clock)	155.52MHz (STM-1)
125 MHz (Ethernet)	5 MHz	64 kbit/s (E0)	44.736 Mbit/s (T3)
155 MHz (STM-1)	64 kHz (E0, Clock)	2.048 Mbit/s (E1)	10 MHz
156.25 MHz	8 kHz (E0, Clock)	34.368 Mbit/s (E3)	51.840 Mbit/s (STM-0)
162.25 MHz	2.048 MHz (E1, Clock)	1.544 Mbit/s (T1)	155.52 Mbit/s (STM-1)
31.25 MHz	32.2265625 MHz		

Appendix B: Built-in Masks

The following masks are available, subject to Firmware update:

ANSI DS1 Interface
ANSI DS1 Transient
ANSI OC-N Interface
ANSI OC-N Transient
ANSI PRS Interface
ANSI SMC Holdover
ETSI PDH Interface
ETSI PRC Interface
ETSI SEC Interface
ETSI SSU Interface
ETSI Wander Gen PRC
ETSI Wander Gen SEC
ETSI Wander Gen SSU
G.812 Type II-III Wander Gen
G.812 Type I Wander Gen
G.813 Holdover SEC opt2
G.813 Switch SEC opt2
G.813 Transfer SEC Opt2
G.813 Wander Gen SEC Opt1
G.813 Wander Gen SEC Opt2
G.823 E1 PDH Sync Interface
G.823 E1 PRC Interface
G.823 E1 SEC Interface
G.823 E1 SSU Interface
G.823 E1 Traffic Interface 2048
G.824 T1 PDH Ref Interface
G.824 T1 PDH Ref Interface SEC Opt2
G.824 T1 PRC Interface
G.824 T1 Traffic Interface 1544
G.8261.1 Case 3
G.8261 E1 CES Case1
G.8261 E1 CES Case2
G.8261 Enhanced SyncE Wander Limit (ePRTC)
G.8261 T1 CES Case1
G.8261 Wander Limit EEC Opt1
G.8261 Wander Limit EEC Opt2
G.8261 Amd.2 Short Chain Network Limits (Fig 19)
G.8261.1 FPP Network Limit
G.8262 Wander Gen EEC Opt1
G.8262 Wander Gen EEC Opt2
G.8262 Wander Transfer EEC Opt2
G.8262 Wander Switch EEC-2
G.8271.1 Max|2wayTE| LPF
G.8271.1 Max|TE|
G.8271.1 dTE MTIE
G.8271.1 dTE Pk-Pk HPF
G.8271.2 APTS Pk-Pk Network Limit
G.8271.2 PTS Network Limit
G.8272 Wander Gen PRTC
MAFE 16ppb
MAFE NSN HRM 1
MAFE NSN HRM 2
PDV Distribution

Appendix C: List of Sentinel Log Messages

Table 7 details messages that appear on the **Log** screen (see Figure 74 on page 66) that is accessible from within the **System** tab, their meaning and whether any troubleshooting actions are required.

System Events		
Log Text	**Explanation**	**Action Required**
Started up	System start up.	None.
Powering system down	System power down.	None.
Configuration data was restored from backup as errors were detected	Configuration integrity check failed, data restored from last good settings.	Ensure that the Sentinel power down procedure is followed.
Last power down was unexpected	System shutdown procedure was not followed.	Ensure that the Sentinel power down procedure is followed.
Rubidium Events		
Log Text	**Explanation**	**Action Required**
Entering transport mode	Battery backed up transport mode was selected during shutdown.	None.
Warming Up	Initial Rubidium state when the Sentinel is powered on from cold. Takes approximately 10 minutes to warm up.	Error condition only if Rubidium remains in this state constantly. In this case export a problem report and power cycle the Sentinel.
Hold-Over	Rubidium will enter Hold-Over when the **Internal Reference Disciplining Source** is set to *Ext 1 PPS* in the **Settings > Measurement >Timebase** page and there is no External 1 PPS input present.	None.
Manual Hold-Over	Rubidium is placed in Manual Hold-Over by the software, when starting a measurement and *Not during measurement* is selected as the **Internal Reference Disciplining Mode** or *Never* is selected as the disciplining mode in the **Settings > Measurement >Timebase** page or when the **Internal Reference Disciplining source** is *GNSS* and GNSS is in the unlocked state.	None.
Disciplining	Rubidium is disciplining to a valid 1 PPS source (External 1 PPS or GNSS).	None.
Initialising Rubidium	Rubidium phase information was not maintained during last power down.	None.
No initialisation required	Rubidium phase information was maintained during last power down.	None. Either the AC cord was left connected or transport mode was successful.

Measurement Events		
Log Text	**Explanation**	**Action Required**
Signal absent on channel *x*	Clock module loss of Signal. Indicated on channel widget by the status LEDs.	Clock signal is not within expected range or not driven. Ensure a **Signal Check** was executed prior to starting measurement. Verify signal integrity on an oscilloscope or by connecting to a different measurement channel on the Sentinel.
Signal momentarily disappeared on channel X	Clock module has briefly had a loss of signal. Indicated by the status of the channel LED on widget.	None.
Link lost on channel Y	Ethernet link lost on channel.	Check network connection and **Channel X** > **Ethernet** settings on the Sentinel.
Link restored on channel Y	Ethernet link restored on channel.	None.
Sync message flow on channel Y: absent	PTP Sync messages are absent. Messages for follow-up, delay request and delay response can also be generated. Indicated on channel widget by change of LED state.	Check PTP master is generating messages and verify **Channel X** > **PTP** settings on the Sentinel match the PTP time transmitter settings.
FwUp message flow on channel Y: not tracked	No follow-up message in channel flow i.e. 1-step. Can also apply to sync, delay request and delay response messages in monitor mode as only one direction is monitored on each channel.	None.
Sync message flow on channel Y: momentarily disappeared	Sync message has momentarily disappeared. Messages for follow-up, delay request and delay response can also be generated. Indicated on channel widget by change of state for LED.	Check network and PTP time transmitter integrity.
In the above messages, X refers to a clock channel i.e. A or B if module is fitted in slot A-B, C or D if fitted in slot C-D or E or F if fitted in slot E-F. Y refers to a packet based channel i.e. 1 or 2 fitted in respective slot.		
Attempting measurement restart	Measurement start after power failure; only applicable if Auto-restart is ON.	None.
Measurement started	Measurement started.	None.
Measurement finished	Measurement finished.	None.
Measurement failed	Failed to start PDV measurement.	Export problem report and power cycle the Sentinel.
External Reference lost	External reference is selected as measurement time-base but no clock is detected.	Verify reference is connected to the **Freq in** connector on Sentinel and is generating 1, 5 or

		10 MHz. Check signal integrity on oscilloscope.
Internal Reference failure	*Internal* or *Auto* is selected as **Timebase Reference** in **Settings > Measurement > Timebase** page and Rubidium is not locked or is Warming Up.	Wait until Rubidium has warmed up and has stabilised. Setting **Measurement Start Behaviour** to *Wait till Timebase Reference is ready* in the **Settings > Measurement >Timebase** page will delay the measurement start until this occurs. If Rubidium status icon is red or does not leave the warming up state, export a problem report and power cycle the Sentinel.
GNSS Events		
Log Text	**Explanation**	**Action Required**
GNSS locked	Sentinel is locked to at least 3 satellites, the survey status is 100% and the antenna status is not shorted	None.
GNSS unlocked	Indicates that Sentinel was previously locked to GNSS and has now lost lock. This usually means that the Sentinel is no longer locked to 3 satellites.	If a GNSS antenna is connected, the number of visible satellites and their strength can be checked on the **Settings > GNSS** page.
Hardware Events		
Log Text	**Explanation**	**Action Required**
Communication with battery lost	Unable to read statistics from battery module.	Indicated by battery status icon. If problem does not clear, export a problem report and power cycle the Sentinel.
Communication with battery restored	Successful read from battery module after previous failure.	None. Battery communication error has cleared.
Failed to set up Battery for Standby	Cannot set battery to correct settings for entering transport mode.	Export a problem report and power cycle the Sentinel.
High battery temperature detected, charging paused	Battery charging is limited to a battery temperature 0°C ≤ T ≤ 45°C. This message shows that the battery temperature is outside this range.	None. If Sentinel is operating within its specified ambient range of 0°C ≤ T ≤ 40°C the battery temperature will return to within the charging range.
High battery temperature cleared	Battery temperature has returned to within the charging range (0°C ≤ T ≤ 45°C).	None.
Battery voltage low after charging, Battery Fault	Battery has failed to maintain its charge, indicating a battery fault.	Indicated by battery status icon. Export a problem report and power cycle the Sentinel. If problem does not clear, contact Calnex support.
Battery current low when charging, Battery Fault	Battery has failed to accept a charging current, indicating a battery fault.	Indicated by battery status icon. Export a problem report and power cycle the Sentinel. If

		problem does not clear, contact Calnex support.
Battery charge time excessive, Battery Fault	Battery has failed to charge within the specified time limit, indicating a battery fault.	Indicated by battery status icon. Export a problem report and shutdown the Sentinel. Contact Calnex support.
Battery charging enabled	Charging has commenced.	None.
Battery fully charged	Battery has reached full capacity, charging is disabled.	None.
Temperature sensors reading failed	Unable to read from processor board temperature sensors.	Check cooling fan on side of Sentinel is spinning. If fan is not spinning or the problem does not clear, export a problem report and power cycle the Sentinel.
Temperature sensor readings restored	Successful read from processor board temperature sensors after previous failure.	None. Sensor communication error has cleared.
Other Events		
Log Text	**Explanation**	**Action Required**
Enable calibration options	Calibration page enabled	None

Table 7 - Event Messages

A problem report can be generated by pressing the **Export problem report...** button on the **About** page of the **System** menu and saving to internal memory or an external USB drive. If after power cycling Sentinel, the problem does not clear then the problem report should be forwarded to Calnex along with a description of the fault and a block diagram of the test setup.

Appendix D: Reference Material

For additional information (test procedures) for Sentinel refer to the following:

- Field Test Plan for Frequency Synchronisation using PTP[2]
- Field Test Plan for Frequency Synchronisation using NTP[3]
- Synchronization Test Plan for TDD-LTE[4]
- Making OTA Sync Measurements with Calnex Sentinel[5]

[2] Calnex Document CX5018
[3] Calnex Document CX5017
[4] Calnex Document CX5019
[5] Calnex Document CX5027

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