User's Manual

xGenius

E1 / T1 / Datacom / IEEE C37.94 Testing Guide

UM-XGENIUS-TDM-09-05-19

ALBEDO Telecom

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Issue 2, 5/19

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Chapter 1
Introduction

The ALBEDO Telecom xGenius is hand-held tester for generation and analysis of ANSI T1.102 1544 kb/s (T1), ITU G.703 2048 kb/s (E1), ITU-T G.703 variable rate codirectional, contra-directional and centralized signals, IEEE C37.94 and data communications (V.11 / X.24, V.24, V.35, V.36, EIA-530, EIA-530A). The test unit has an external DC input but it also has internal batteries. This makes this tester suitable for field testing applications.

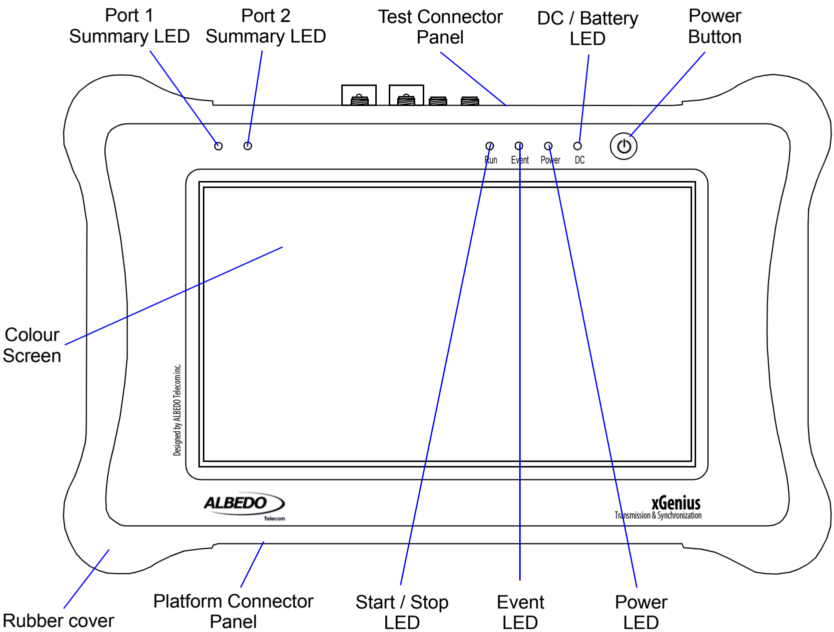

Figure 1.1: xGenius front view. The tester presents results by means a colour capacitive touch screen and the LEDs.

xGenius also offers Gigabit Ethernet generation and analysis up to 10 Gb/s. For more information about Gigabit Ethernet / IP testing check the xGenius *Gigabit Ethernet Testing Guide*.

Within your xGenius pack you will find the following items:

- One xGenius tester.
- One AC/DC adapter with a power cord specific for your country.
- One Carrying bag.
- One 75 Ω coaxial cables with BNC male connectors.
- One datacom cable set (if ordered).
- One audio headset (if ordered).
- One USB memory stick with user documentation.
- One printed copy of this user manual (if ordered).

Check with your distributor the availability of other optional items for your AT-2048 unit. Check the *Gigabit Ethernet Testing Guide* to know more about the items and options included in your Ether.Genius or Ether10.Genius pack.

1.1. Important Notice

Operation, manipulation and disposal warnings for your xGenius unit are listed below.

1.1.1. Warranty

The ALBEDO Telecom xGenius is supplied with a warranty that includes replacement of damaged or faulty components in the terms and period described in the ordering information. This Warranty does not apply to:

1. Product subjected to abnormal use or conditions, accident, mishandling, neglect, unauthorized alteration, misuse, improper installation or repair or improper storage.
2. Product whose mechanical serial number or electronic serial number has been removed, altered or defaced.
3. Damage from exposure to moisture, humidity, excessive temperatures or extreme environmental conditions.
4. Damage resulting from connection to, or use of any accessory or other product not approved or authorized by ALBEDO Telecom.
5. Product damaged from external causes such as fire, flooding, dirt, sand, weather conditions, battery leakage, blown fuse, theft or improper usage of any electrical source.

1.1.2. Safety

The ALBEDO Telecom xGenius test unit contains built-in batteries, improper use of which may result in explosion. Do not heat, open, puncture, mutilate, or dispose of the

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product in fire. Do not leave the device in direct sunlight for an extended period of time, which could cause melting or battery damage. Batteries must be replaced by ALBEDO Telecom authorized staff only. Use only the AC power adapter supplied by ALBEDO Telecom.

The equipment includes an active cooling mechanism. Do not block the air flow inputs and outputs during operation. Any use of this equipment other than the specified by the manufacturer may compromise the product electrical or mechanical safety.

The unit does not require any special maintenance. Use a soft cotton or microfibre cloth to keep your unit clean. A dry cloth for cleaning should be normally used. Using an aqueous product for cleaning is also allowable but it must be avoided putting liquid directly onto the equipment.

1.1.3. WEEE Notice

This product must not be disposed of or dumped with other waste. You are liable to dispose of all your electronic or electrical waste equipment by relocating over to the specified collection point for recycling of such hazardous waste. For more information about electronic and electrical waste equipment disposal, recovery, and collection points, please contact your local city centre, waste disposal service, or manufacturer of the equipment.

1.2. The Tester

Interaction with xGenius is based on a high resolution capacitive colour touch screen, and different kinds of status LEDs There are six LEDs (Run, Event, Power, DC, Port A summary, Port B summary). Their description is given below:

- *Run*: This is a LED that shows the current test status. The green colour is used to display a test running status. Off, means that there is no test running. Orange is displayed in the period of time between the action from the user to start / stop a test and the actual test start / stop.
- *Event*: A green Event LED is displayed when the equipment is generating some kind of impairment configured through the event insertion menu. The LED stays in off status when no event is being inserted
- *Power*: Displays the current tester on / off status. The green colour is displayed under normal operation conditions. Orange and red are shown to indicate a low battery load.
- *DC*: This led is lit when the DC input is connected. Orange indicates a *charging batteries* status and green means that the internal batteries are ready.
- *Port 1 / Port 2 Summary*: These LEDs provide a permanent indication of the current input signal (or signals) status. The LEDs summarize the Port A and Port B information given by the event LEDs. Or depending on the operation mode they may also summarize results from test Port C. If any event LEDs for a test port is in 'red' status, the port summary led will be set to 'red'. If any event LED is 'orange'

but there is no 'red' event, the summary led will be set to 'orange. The 'green' colour is used when no events are found in the input signal. Finally, the LED is switched off when the port is disabled.

The information supplied by the LEDs is also available in the screen so that there is not information loss when users access to the unit remotely (See section 11.5).

Users willing to use a mouse and keyboard are allowed to do so by connecting these devices to the USB port placed in the platform connector panel (See section 1.2.2).

There is a single button in xGenius that is used to switch the unit on and off. If the tester is in off status, push to switch it on. If the tester is on, use this key to switch it off (long push). The on / off button is also used for some other purposes like the test unit software upgrade (See section 1.5).

1.2.1. Test Connector Panel

xGenius is connected to the DUT / SUT through the test connector panel. Ports and elements included in this panel are described in the following list:

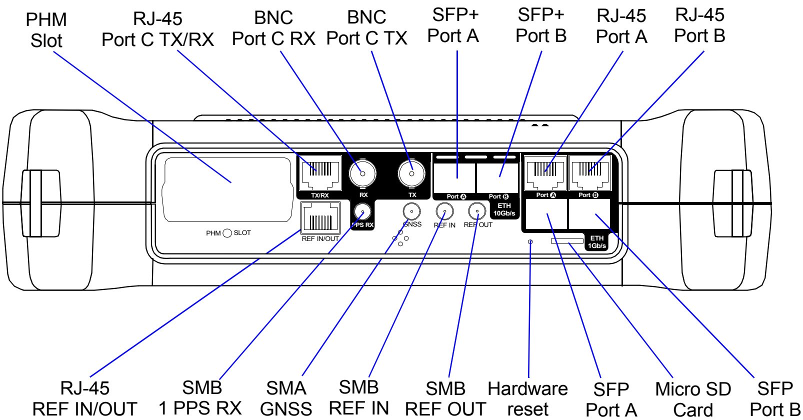

Figure 1.2: Test connector panel. Connection to the DUT / SUT is done in this panel.

- *RJ-45 Port A*. This is the primary 10/100/1000BASE-T port for Ethernet transmit and receive.
- *RJ-45 Port B*. This is the secondary 10/100/1000BASE-T port for Ethernet transmit and receive. This port is identical to the RJ-45 Port A in appearance but it provides only a subset of the features available for Port A. Port B supports monitor and loopback operation but it does not include traffic generation.
- *SFP Port A*: This port is used to connect the tester to the network through an optical interface with the help of an SFP module.
- *SFP / SFP+ Port B*: This port is used to connect the tester to the network through an optical interface with the help of an SFP module.

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- *SFP+ Port A*: This port can be used also with SFP+ modules compatible with 10 Gb/s transmission.
- *SFP+ Port B*: It can be used also with SFP+ modules compatible with 10 Gb/s transmission.
- *BNC Port C RX*: Unbalanced 75 Ω input. This input is used to analyse clock (1544 kHz, 2048 kHz, 10 MHz) and TDM (E1 and T1) signals. It is used as a clock reference input port as well.
- *BNC Port C TX*: Unbalanced 75 Ω output. This output is used to generate TDM signals (E1 and T1). It is used as a clock output as well.
- *RJ-45 Port C TX/RX*: Balanced 120 Ω input / output. This interface is used to analyse clock signals (1544 kHz, 2048 kHz, 5 MHz 10 MHz, 1 PPS, 1 PP2S) and generate and analyse TDM (E1 and T1) signals. This interface is used as a clock input / output as well.
- *SMA GNSS*: This is a SMA connector that can be used to attach a GNSS antenna. The purpose of the GNSS input is to provide a reliable and accurate synchronization source for the test unit (See section 2.9). This input is available only in units equipped with the built in GNSS receiver.
- *SMB Port C PPS RX*: 1 PPS 1 PP2S test input. This is the port to be used for analysis of unbalanced 50 Ω 1 PPS signals formatted as specified in ITU-T G.8271. This port is available only if the GNSS option is installed in the unit
- *SMB REF IN*: 1 PPS reference input. This port could be used as a 1 PPS clock reference input used in some latency and synchronization tests. This is an unbalanced 50 Ω interface that follows standard ITU-T G.8271. This port is available only if the GNSS option is installed in the unit
- *SMB REF OUT*: 1 PPS reference output. This port could be used as a 1 PPS clock reference output. The output is synchronized with the local oscillator. This is an unbalanced 50 Ω interface that follows standard ITU-T G.8271. This port is available only if the GNSS option is installed in the unit.
- *RJ 45 REF IN/OUT:* Reference input / output. It generates or accepts balanced 1544 kHz, 2048 kHz, E1, T1, 5 MHz, 10 MHz, 1PPS and 1PP2S clock references.
- *PHM Slot:* Enables connection of a *Pluggable Hardware Module* (PHM) to the test unit. The currently available PHMs include the datacom module (PHM-20), the dual port IEEE C37.94 module (PHM-21), the G.703 / E0 module (PHM-22) and the voice frequency module (PHM-23).
- *Micro SD Card*: Slot for micro SD Cards. These cards can be used as external storage devices.
- *Hardware reset*: Resets the hardware to recover the unit from most malfunctioning situations.

1.2.2. Platform Connector Panel

There is a connector panel specifically devoted to the platform ports. This panel includes capabilities like remote control and external device connection. A more detailed description is given below:

- *Power connector*: The input must be 12 V DC, 4 A. A suitable external AC / DC adapter for your country is provided with the tester.
- *RJ-45 printer or console*. Console connector. Currently there is no envisaged application for this interface in the test equipment
- *USB Master*: Use a USB cable with a Master type connector (Type A, *Host*) for this port. Currently this port is used for software upgrades and connection of external storage devices.
- *RJ-45 platform LAN connector*: This is a general purpose Fast Ethernet connector (10/100BASE-T). It is used for remote management of the test unit or to access to the configuration, report and trace files through a web interface.

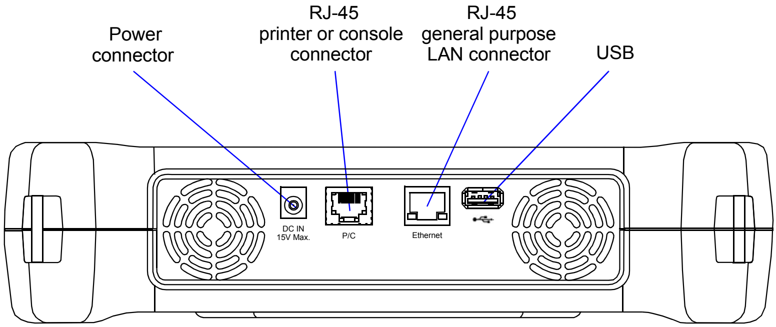

Figure 1.3: Platform connector panel. This panel includes connectivity to USB devices, Ethernet networks and power source.

1.3. The Graphical User Interface

The xGenius graphical user interface is based in a 800 x 480 colour touch screen that can be used to browse the different panels, configure the unit and start / stop tests.

1.3.1. The Home Panel

To display the Home panel, users must press the *Home* button (square icon on the top right corner of the screen). The *Home* panel contains two sub-panels with miscellaneous information. The main panel enables the user to configure a test, modify the port settings or check results from the current or a past test, the auxiliary panel

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contains miscellaneous information. There are three buttons in the main panel to enable the user to access to these resources:

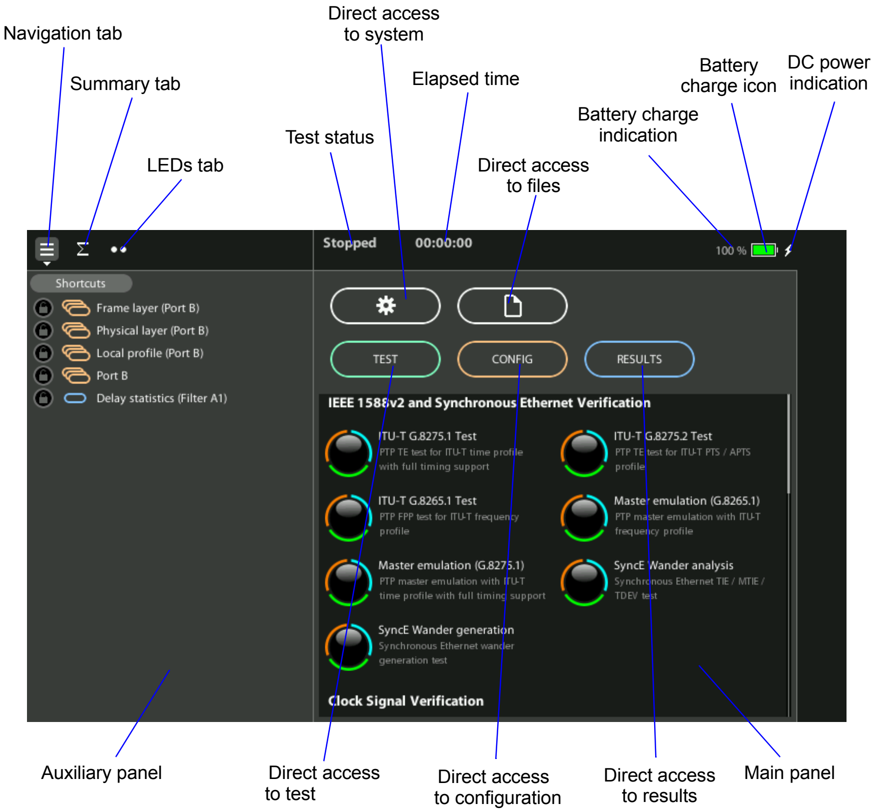

Figure 1.4: xGenius home panel.

- *TEST*: Contains configuration items related with general test configuration like test scheduling, test setup, performance objectives settings, event insertion, and event logging. Configuration of some special tests like the RFC 2544 or the eSAM or the Ping / Traceroute is also done from this menu. Finally, setting of some special operation modes like the PTP endpoint emulation is available in this menu as well (only in units with the correct PTP or Synchronous Ethernet licenses installed)
- *CONFIG*: Provides access to the global operation mode and configures test ports and other resources such as reference clock inputs and outputs, secondary interfaces, etc. The setup menu can be used to configure the test ports A and B.In units with the correct software options installed, it may also include menus to configure the E1 / T1 and other test interfaces.

- *RESULTS*: This item enables the user to browse test results. Most of them are not available if a measurement has not been previously started but there are some exceptions to this rule. The Results panel also contains access to the Event logger browser, that enables the user to display graphically miscellaneous events and performance metrics.

There are two additional buttons in the main panel not directly related with testing tasks but with test unit management. These are the *File* and *System* buttons and they have the following purpose:

- *File*: File management menus. Includes configuration, report and trace file management. Files can be deleted, copied, exported or imported.
- *System*: Provides platform management tools. For example language selection, screensaver configuration and others.

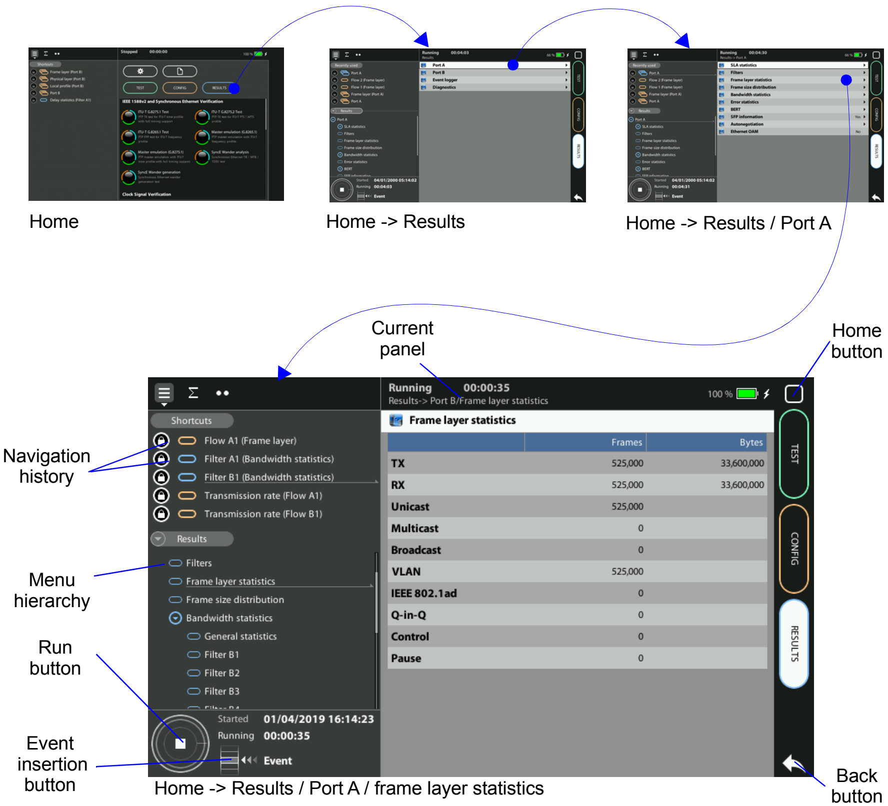

Figure 1.5: Access to a results table from the home panel in three different steps. In this case the test results are represented as a table, including a header (frames, bytes), a results list (TX, RX ,...) and different counters.

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The main panel may also contain shortcuts to predefined tests users are allowed to load depending on what they need to do. The number and type of these shortcuts depend on the license included in the test unit.

On the left side of the main panel there is an auxiliary area with three tabs:

- *Navigation tab*: Includes a *Recently Used* area to enable the customer to go to specific panels without the need to go through any intermediate panel and a menu tree to display the panel hierarchy corresponding to the *TEST*, *CONFIG* and *RESULTS* menus (or *File* and *System* menus).
- *Summary tab*: Has information about protocol stacks, traffic flows, filters, frame structures and some other details about the test unit configuration. It may also include relevant results in some configurations.
- *LEDs tab*: Displays visual information about status. Most LEDs are referred to test signal status but some others may be related clock references or other subsystems. The LEDs may display real time information but the can be also configured in *History* mode to store details about past events.

On the top side of the home panel there is a header zone which contains information about the current tester status (date, time, tests running, event insertion active) and an identifier for the currently displayed panel.

The *Navigation*, *Summary* and *LEDs* tabs, together with the header zone are replicated in all other *TEST*, *CONFIG* and *RESULTS* screens. The difference is that in screens other than the *Home* panel there is also a test control area to enable the user to start / stop tests or to add events to the outgoing signal.

1.3.2. The Menu Structure

Most of the graphical user interface panels are menus containing a variable number of items. Menus and sub-menus are organized in a tree. The tree root is the *Home* panel and the leaves are configuration or result panels. Results are usually presented in a list or a table. If all results cannot be simultaneously displayed, then the user is allowed to scroll up and down to browse the list. An scroll bar shows the current position in the menu if there is no room to display all items at the same time.

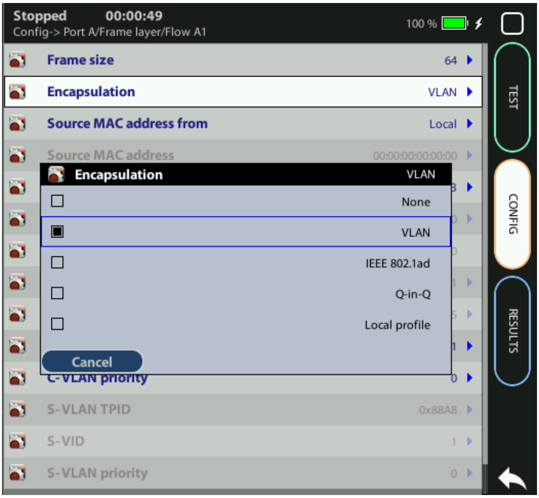

Figure 1.6: xGenius selection panel to enable users to choose between different Ethernet encapsulations

Configuration and result panels are conceptually different to menus even if both kinds of items could be displayed under the same higher level menu. For this reason they are displayed in a different way. While menus are described with black characters configuration and result panels are displayed in blue characters. The second difference is that only menus are displayed in the menu hierarchy (*Navigation* tab).

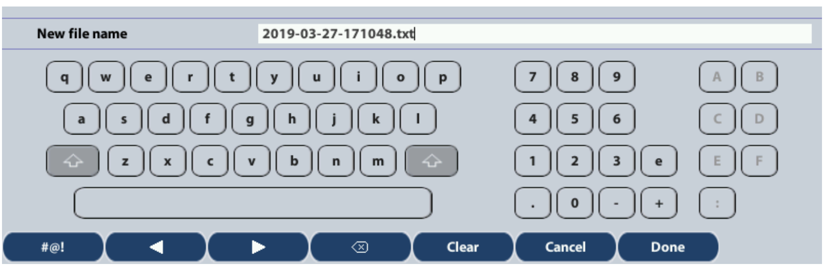

Figure 1.7: Data input keyboard. The keyboard is used to enter alphanumeric, numeric and hexadecimal characters.

Configuration panels are usually selection lists. Sometimes you can select only one simultaneous item in the list and sometimes selection of several items at the same time is possible. Keyboards are available if selection through lists is not possible. There is one keyboard for numeric settings and one for alphanumeric settings. These keyboards are also used to enter data types with a well defined formatting such as IP or MAC addresses.

1.3.3. The Summary and LEDs Tabs

The test signal status can be checked from the LEDs tab on the top left corner of the screen. The Softleds from the LEDs panel are always active, even when there is no test running. The LEDs may display real time information but they can be also configured in *History* mode to store details about past events. They are organized in rows and columns each row usually includes LEDs with a related meaning. Typically (but not always), events displayed in the same row correspond with the same protocol layer. For each row, there is a summary LED, which aggregates the result for all items in the same row. The results from the same summary column are also aggregated in a single hardware port summary LEDs.

(a) (b)

Figure 1.8: Special panels: (a) Summary panel, (b) LEDs panel.

The *Summary* tab provides some details about the current configuration and results. There is not a fixed structure for this tab, which has its own layout depending on the currently selected operation mode.Typically, this panel has graphical information about traffic flows, protocol stack, filters, signal processing blocks, etc.

1.3.4. Recently Used Panel and Menu Tree

The *Summary* tab has two differentiated areas. The *Recently Used* area provides quick access to important screens, the *Menu tree* contains the *TEST*, *CONFIG* or *RESULTS* menu trees with a general view of the choices available to users.

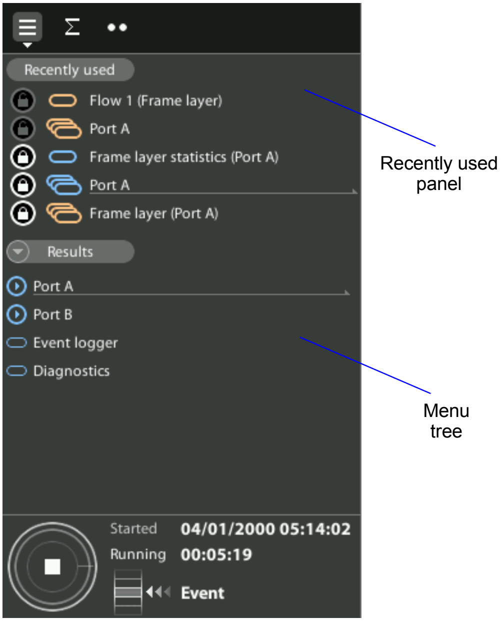

Figure 1.9: The Summary tab contains a Menu tree and the Recently Used panel.

- *Recently Used panel*: Each new screen visited by the user is listed in the *Recently Used* panel. New screens replace the older screens so that the oldest in the list is deleted when a newer one is visited. The *Recently Used* panel may contain up to five screens. To avoid any of the listed screens to be deleted from the list, users may lock them by pressing the *lock* button on the left of each screen. Locked screens can be unlocked by pressing the *lock* button a second time.
- *Menu Tree*: Contains the list of all sub-menus available in each of the *TEST*, *CONFIG* and *RESULTS* panel. Menus and sub-menus can be opened to display lower

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order sub-menus. Direct access to menus is possible by pressing the correct destination in the *Menu Tree*. Only menus are displayed in the tree. No configuration or result panels are shown in this area.

1.3.5. Predefined Tests

Predefined tests are special shortcuts located in the *Home* panel that enable xGenius users to access to common test scenarios without having to configure the unit step by step. The predefined test shortcuts configure most test parameters and provides quick access to the (usually few) parameters still to be configured. Specifically, the predefined test shortcuts do the following tasks:

- Displays an specific panel in the work-area that depends on the predefined test that has been loaded.
- A variable list of settings is configured in the unit such as operation modes, ports, interfaces and tests. The user interface, work area and all other complementary panels are upgraded in accordance with the new settings.
- Loads a list of shortcuts in the *bookmarks-list* that depends on each predefined test. The panel displayed on loading the predefined test is the first item in the bookmarks-list.

Predefined tests have been distributed in four categories: *IEEE 1588v2 and Synchronous Ethernet Verification*, *Clock Signal Verification*, *Ethernet / IP Verification*, *E1 / T1 Verification*. It follows a description of the tests included in each category:

- IEEE 1588v2 and Synchronous Ethernet Verification: *ITU-T G.8275.1 Test*, *ITU-T G.8275.2 Test*, *ITU-T G.8265.1 Test, Maser emulation, (G.8265.1)*, *Master emulation (G.8275.1)*, *SyncE Wander analysis*, *SyncE Wander generation*.
- Clock Signal Verification: *1PPS TE*, *1PPS to 1PPS TE*, *10 MHz TIE*.
- Ethernet / IP Verification: *RFC2544 (bridged, port A > B), RFC2544 (routed, port A > B)*, *eSAM (bridged, port A > B)*, *Traffic verification (bridged)*, *Traffic verification (routed)*, *Ping*, *Trace-route*. *TCP throughput (RFC 6349)*
- E1 / T1 Verification: *E1 / T1 Pulse Mask*, *E1 / T1 BER*, *G.821*, *G.826*, *E1 / T1 Jitter*, *E1 /T1 Wander*, *E1 / T1 RTD*, *E1/T1 OWD*,

1.4. Running Tests

Most of the results provided by the test unit are not available until you start a test. This section provides a high level description of the procedure to follow to configure your unit, start a test and review the results.

1. Configure the tester to send / receive signals in the right operation mode and through the right ports using the resources from the *CONFIG* menu. Connect it to the network.
2. Configure the specific parameters such as pass / fail objectives, test method or any other setting required for your test using the *TEST* menu.

3. Program the test start time and duration with the help of the *Autostart / stop* menu (within *Test*) or start the test immediately by pressing the *run* button in the test control area.
   Note: Most of the configuration is blocked when there is an ongoing test.
4. Wait for the test to finish or press *run* to finish immediately.
5. Check the test results in the *Results* menu.
   Note: Most test results are upgraded in real time as the test progresses. That means that is not really necessary to wait for the test to finish to check current results.

It must be stressed that this is only a high level description of test configuration and execution using xGenius. For a detailed description of the configuration procedures for specific tests visit the corresponding sections in the User Guide.

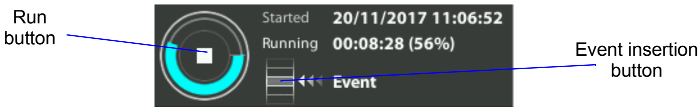

Figure 1.10: xGenius test control area with progress indication.

1.5. Upgrading the Unit

The test unit software can be upgraded with the help of a USB memory stick. Before proceeding with the upgrade, copy the ALBEDO software to the root directory in the memory stick. The file name of the upgrade package must not be modified. The USB must have a FAT32 file system.

Once the USB memory stick is ready. Follow this procedure to install the new software:

1. Switch the unit off.
2. Press the *Power* button and keep the button pressed until you see the *Power* LED to start blinking.
3. Release the *Power* button.
   You will hear a beep and the ALBEDO Software Installer will be loaded and executed. An informative panel will display the xGenius software version number found in the storage device.
4. Press *Continue* to continue with the installation process or *Cancel* to finish.
5. Select *Install* or *Upgrade. Install* regenerates all the software in the unit even if it is up to date. Upgrade regenerates only the software that has changed since the last upgrade. Use *Install* if you need to recover the unit after operation failure due to corrupted software. Use *Upgrade* otherwise.You can also cancel the process at this point by pressing *Cancel*.
6. Confirm your previous selection by pressing *Continue* or cancel with *Cancel*.

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7. Wait for the installation process to finish.
   Note: The full process may take a few minutes.
   Note: Do no disconnect the unit or remove the USB memory stick during installation.
8. Press *Continue* to close the Software Installer and finish the installation process. The unit will be automatically restarted. The new software will be loaded.

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Chapter 2
Connection to the Network

xGenius is equipped with one single full featured 1544 kb/s and 2048 kb/s port (Port C) but it may optionally include a second port (Port D) to be connected to the unit through an special adapter.

This chapter describes how to connect the tester to the DUT / SUT and how to configure it to receive and send signals. The basic procedure to do that is:

1. Set the right operation mode (*E1/T1 monitor*, *E1/T1 endpoint*, *E1/T1 MUX test, E1/T1 DEMUX test, Datacom Endpoint*, *Datacom Monitor*, *Through*, *G.703 / E0, Analog, C37.94 endpoint*, *C37.94 monitor*). The mode depends on the particular DUT / SUT to be verified and test to be done. Sometimes it will be necessary to configure the input impedance through the *Connection mode* menu.
2. Connect the test cables to the DUT / SUT. Again, this depends on the DUT / SUT and the test to be done.
3. Configure the Port C. You will not be able to see any information before you set the right line parameters within the test ports.

2.1. Setting the Operation Mode

As 2048 kb/s and 1544 kb/s interfaces, Port C and Port D (when installed) are independent but they share the same operation mode and hierarchy. That means that, for example, if you configure Port C to be a monitoring port, then Port D will become a monitoring port as well. In any other sense, Port C and Port D are allowed to have a different configuration.

To configure the operation mode follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The port configuration panel is displayed.
2. Select *Mode* to enter in the mode selection Menu
3. Choose between: *E1/T1 monitor*, E1/T1 *endpoint*, *E1/T1 through*, *E1/T1 MUX test, E1/T1 DEMUX test, Datacom endpoint, Datacom monitor, G.703 / E0, Analog, C37.94 endpoint*, *C37.94 monitor* or *C37.94 through*. Confirm.

Note: Some other operation modes may be available depending on the hardware / software options available in your test unit.

Table 2.1: E1/T1 Operation Modes

Setting	Description
E1/T1 monitor	When the tester is operating in *E1/T1 monitor* mode, the transmitter is switched off. This mode is suitable for analysis of life signals without disturbing the network. Applications requiring this mode are frequency or level monitoring, alarm monitoring or some kinds of in service performance monitoring. Often, the *E1/T1* monitor mode has to be combined with high impedance settings to avoid disturbing the line. For this reason, when you set this operation mode, high impedance operation is automatically enabled in the tester.
E1/T1 endpoint	If the tester is configured in *E1/T1 endpoint* mode, then it emulates an E1/T1 network terminating point. In this mode the generator sends a test signal to the DUT / SUT and the analyser receives a different signal (which may be the test signal once it has been transmitted through the DUT / SUT. This mode is used for transparency testing, BER testing and out of service performance monitoring.
E1/T1 MUX test	The *E1/T1 mux* operation mode is used when the DUT / SUT is an TDM multiplexer or something that is equivalent to a TDM multiplexer. The transmitter has the format of a tributary signal (either a G.703 64 kb/s signal or a datacom signal) and the receiver is configured for E1 or T1 signals. In this mode only a single time slot can be sent to the internal pattern analyser. The secondary output is not available.
E1/T1 DEMUX test	The *E1/T1 demux* mode is similar to the *E1/T1 mux* mode but in this case the DUT / SUT is equivalent to a demultiplexer. The transmitted test signal is a T1 or E1 signal and the received signal is a 64 kb/s G.703/E0 signal or a datacom 64 kb/s signal. In this mode, the internal test pattern can only be mapped to a single time slot. The secondary input is not available but the tone generator is still usable.

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Table 2.1: E1/T1 Operation Modes

Setting	Description
E1/T1 through	The *E1/T1 through* mode is suited for unidirectional or bidirectional intrusive monitoring. The signal from the E1 or T1 receiver is either dropped to an analysis block or is forwarded to the E1 / T1 transmitter of the opposite port. It is also possible to add signals from the generator blocks to the E1 / T1 multiplex. The event insertion can be used in E1 / T1 through mode to stress the DUT / SUT. This operation mode forwards traffic between two E1 / T1 ports and it therefore requires the PHM-24 module, which provides access to Port D, to be installed in the unit. It is also required to install the appropriate software license to unlock access to Port D.
Datacom endpoint	Use the *Datacom endpoint* mode to generate and analyse V.24 / V.28, X.21 / V.11, V.35, V.36 and EIA-530 datacom signals. For datacom modes, the Smart Serial connector (26-pin SS connector) is used. An specific connector for each DTE or DCE datacom interface is available through adaptor cable. When the test unit is configured in this mode, it replaces either the DTE or the DCE together with their data and control circuits. This operation mode requires access to the DTE and DCE datacom ports which is supplied though the PHM-20 module. It is also required the installation of the appropriate software license to unlock access to the DTE and DCE (datacom) ports.
Datacom monitor	The *Datacom monitor* mode analyses V.24 / V.28, X.21 / V.11, V.35, V.36 and EIA-530 datacom signals without disturbing communications between the DTE and DCE. If this mode is configured, the Smart Serial connector (26-pin SS connector) is used. The specific connector for the DTE and the DCE is available through two adaptor cables. This operation mode requires access to the DTE and DCE datacom ports which is supplied though the PHM-20 module. It is also required the installation of the appropriate software license to unlock access to the DTE and DCE (datacom) ports.

Table 2.1: E1/T1 Operation Modes

Setting	Description
G.703 / E0	This is the mode to be used to generate and analyse variable bit rate codirectional, contradirectional and centralized signals compliant with ITU-T G.703 through the G.703 / E0 port. *Note*: If the operation mode is set to *E1/T1 endpoint*, *E1/T1 monitor*, *E1/T1 MUX test* or *E1/T1 DEMUX test*, the G703 / E0 port still accepts a *Codirectional usage*. However, in this case it can only be used for adding/dropping E1 / T1 time slots. This operation mode requires access to the G.703 / E0 port which is supplied though the PHM-22 module. It is also required the installation of the appropriate software license to unlock access to the G.703 / E0 port.
Analog	This is the mode suitable for analogue voice frequency measurements. The equipment accepts an analogue telephone signal in its audio input and measures its frequency and level. It also generates a test audio signal in the analogue audio output. This operation mode requires access to the *Analog* port which is supplied though the PHM-23 module. It is also required the installation of the appropriate software license to unlock access to the voice frequency port.
C37.94 endpoint	Configures the equipment as a IEEE C37.94 termination point. IEEE C37.94 standard constitutes a communications interface for interconnection of power protection equipment (protection relays) and transmission equipment using two MMF or SMF optical fibres. This operation mode requires access to the Port A and B IEEE C37.94 SFP slots which is supplied though the PHM-21 module. It is also required the installation of the appropriate software license to unlock access to the Port A and B IEEE C37.94 ports.

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Table 2.1: E1/T1 Operation Modes

Setting	Description
C37.94 monitor	When the tester is operating in *C37.94 monitor* mode, the optical transmitters are switched off. This mode is suitable for analysis of life signals without disturbing the network. Applications requiring this mode are frequency or level monitoring and alarm monitoring. This operation mode requires access to the *Port A* and *Port B* IEEE C37.94 SFP slots which is supplied though the PHM-21 module. It is also required the installation of the appropriate software license to unlock access to the *Port A* and *Port B* IEEE C37.94 ports.
C37.94 through	The *C37.94 through* mode is suited for unidirectional or bidirectional intrusive monitoring.It forwards traffic received in *Port A* to *Port B* and traffic received in *Port B* is forwarded to *Port A*. This operation mode requires access to the *Port A* and *Port B* IEEE C37.94 SFP slots which is supplied though the PHM-21 module. It is also required the installation of the appropriate software license to unlock access to the *Port A* and *Port B* IEEE C37.94 ports.

2.2. Connecting the Tester to the DUT / SUT

If you have configured *E1/T1 endpoint* as the operation mode in the test unit, the Port C (and Port D, if installed) transmitter and receiver will be enabled. In this setup, usually you want to configure the interface input impedance to the link nominal impedance (75 Ω for the unbalanced interface and 120 Ω for the balanced one).

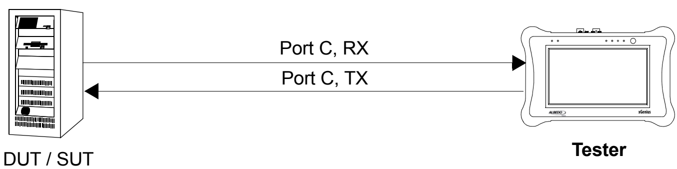

Figure 2.1: Common connection setup for the E1/T1 endpoint operation mode.

The endpoint connection is suitable for such tests where the equipment has to replace a network node or a complete network. Typical examples are transparency, and out-of-service BER / Performance tests. In all these measurements a test pattern is injected in the DUT / SUT. The test pattern is recovered at the receiver once it has been transmitted through the DUT / SUT. Any difference between the transmitted and received pattern is accounted.

The *G.703 / E0* mode is used in the same way than the *E1/T1 endpoint* mode. Testing capabilities over the G.703 / E0 interface are similar that for E1 / T1 signals but in this case over variable bit rate ITU-T G.703 / E0 signals.

The test unit includes several modes suitable for both intrusive and non-intrusive monitoring. The right mode for non-intrusive monitoring is the *E1/T1 monitor* mode. Usually, this mode requires configuration of the monitoring port input impedance to *-20 dB monitor*, *-25 dB monitor*, *-30 dB monitor*, or *High Impedance*. Configuring *High Impedance* is important in such cases where the monitoring point is not protected. Not setting *High Impedance* could cause service interruption in the line where the tester is connected.

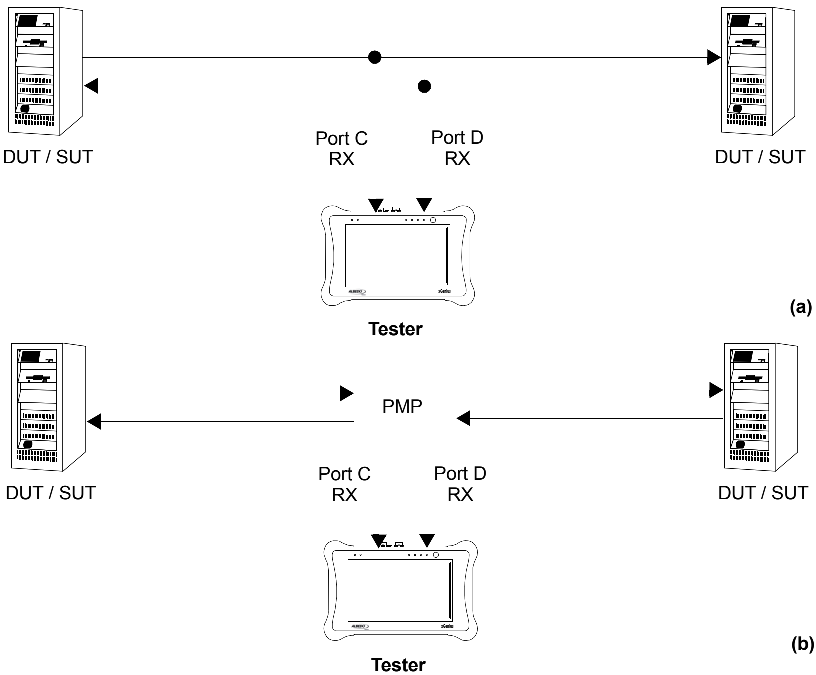

Figure 2.2: Non-intrusive E1/T1 line monitoring with xGenius: (a) High impedance monitoring. (b) Monitoring through a PMP.

Protected monitoring points isolate the network and the test equipment but they add a flat frequency attenuation. The tester amplifies the signal to compensate for the

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attenuation added by the protected monitoring point when either -20 dB monitor, -25 dB monitor or -30 dB monitor is configured.

When *E1/T1 monitor* is configured *Port C* and *Port D* (when installed) transmitters are disabled (they are not needed for passive monitoring). *Port C* and *Port D* can still be used at the same time. This feature enables bidirectional monitoring of E1/T1 signals.

Intrusive monitoring can be carried out with the *E1/T1 through* operation mode. When this mode is set, Port C receiver is connected to Port D transmitter and Port D receiver is connected to Port C transmitter. The signal could be bypassed from the receiver to the transmitter without any modification but dropping/adding time slots to the signal, inserting events or modifying the FAS / NFAS and CAS time slots is also possible.

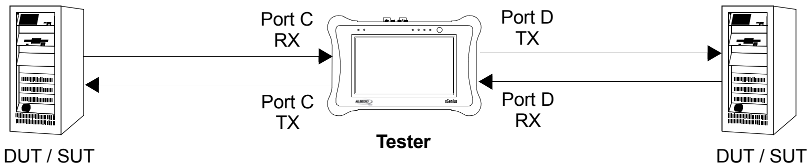

Figure 2.3: Bidirectional, intrusive monitoring using the xGenius *E1/T1 through* mode

Bidirectional intrusive monitoring is enabled through simultaneous connection of Port C and Port D to the network. Each port may have its own independent configuration. Please, note that bidirectional monitoring requires at least two test ports and therefore it is not available for xGenius unless you have the optional *Port D* installed in the unit (See section 2.6).

Also, there are two operation modes specifically devoted to E1/T1 MUX / DEMUX testing:

- *E1/T1 MUX test*: The receiver is the same that in the *E1/T1 endpoint* mode but the transmitter is low speed output (G.703 / E0 or datacom). Note that using a low speed output for transmission is different that using the same output to drop one time slot from an E1/T1 path with the tester configured in *E1/T1 endpoint* mode.
- *E1/T1 DEMUX test*: The transmitter is the same that in the *E1/T1 endpoint* mode but the transmitter is a low speed input (G.703 / E0 or datacom). Note that using a low speed input for receiving data is different that using the same input to add one time slot in an E1/T1 path with the tester configured in *E1/T1 endpoint* mode.

The test unit may also have two modes (*Datacom endpoint* and *Datacom monitor*) for data communications (interfaces V.24 / V.28, X.21 / V.11, V.35, V.36 and EIA-530). The *Datacom endpoint* and *Datacom monitor* modes are only available if the corresponding option is installed in the tester. Connection of the test unit under these modes is explained in the corresponding chapter.

Finally xGenius may also include three IEEE C37.94 modes, the *C37.94 endpoint*, *C37.94 monitor* and *C37.94 through*. These are used to verify low bit rate optical networks based on this interface. Enabling any of the IEEE C37.94 operation modes requires of the PHM-21 module. This module contains two SFP slots acting as extensions of the built in RJ-45 and optical *Port A* and *Port B*.

2.3. Configuring the E1 / T1 Test Port

Before receiving any valid signal or being able to perform any test, the 1544 / 2048 kb/s port line settings must be configured. The procedure to do that is the following:

Table 2.2: Port Setup Menu

Setting	Description
Port mode	Port specific operation mode that is complementary to the global operation mode. Both the global and the port specific operation modes are combined to determine which tests and which capabilities are available at any moment. These are the port modes currently supported by the test unit: • *TX/RX*: Both transmission and reception are enabled in the port. The transmitter is connected to the internal test traffic generator. • *Loopback*: The port receiver is connected to the transmitter. This port mode is used guarantee the continuity of the test pattern to in two-way tests. Users are allowed to modify the time slots individually in this mode by replacing them by custom test patters or signals added from a different interface (datacom, G.703/E0, VF).
Auto-configuration	Retrieves configuration data for *RX code*, *RX frame* and *RX pattern.* It configures the unit automatically with the information retrieved from the network.
Hierarchy	Selects between the ITU-T and ANSI hierarchies. These are the options: • *G.703/E1*: Enables the ITU-T G.703 hierarchy based on the 2048 Mb/s bit rate. • *T1/DS1*: Enables the ANSI T1.102 hierarchy based on the 1544 Mb/s bit rate.

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Table 2.2: Port Setup Menu

Setting	Description
Connector	Selects the input / output interface in the test connector panel. The available options are: • *Unbalanced*: BNC unbalanced connector, nominal impedance of 75 Ω (when not configured in high impedance mode). • *Balanced*: RJ-45 balanced connector, nominal impedance of 120 Ω (when not configured in high impedance mode). This setting is available only for Port C. Port D is only available trough a balanced RJ-45 connector.
Line	The *Line* item contains lower level menus used to configure the line signals transmitted and received through the test interfaces. The *Line* sub-menus enable configuration of the port input impedance, line code, transmission clock source and transmission frequency offset.
TX Frame	This control contains lower level menus that can be used to set the frame structure for the transmitter. It also controls how the test and live signals are distributed in the transmitted time slots.
RX Frame	This control contains lower level menus that can be used to set the frame structure for the receiver. It also controls how the test and live signals are processed by different analysis blocks.
Test pattern	This is a configuration item which contains lower lever menus to configure the transmitted and expected test patterns (PRBS or word).
External Interface	Enables configuration of the secondary input and output interfaces trough dedicated lower level menus.
Jitter generator	This control contains lower level menus to enable and configure the jitter generator. Jitter is a phase modulation added to the normal output signal. This control is available only if a jitter *Generation & analysis* test has been previously configured. The jitter generator is not available in Port D.
Jitter analyser	Configures the jitter analyser. This control is available only if a jitter *Generation & analysis* test has been configured. The jitter analyser is not available in Port D.

Table 2.2: Port Setup Menu

Setting	Description
Wander generator	This control contains lower level menus to enable and configure the wander generator. Wander is a phase modulation added to the normal output signal. This control is available only if a wander *Generation & analysis* test or *MTIE / TDEV* test has been previously configured. The wander generator is not available in Port D.

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select *Port C* (or port D, if installed) to enter in the port specific configuration menu.
3. Configure the *Connector* (Port C only), *Line* (See section 2.3.1) *TX Frame* and *RX Frame* (See section 6.3).
4. If you want to run an out-of-service test set the *Test Pattern* (See section 7.1) to either a pseudo-random bit sequence (PRBS) or a fixed bit word.
5. To add / drop external signals within one or several time slots configure the *External interface* (See section 7.1).
6. To add / drop a voice signal to the audio jack configure the *Audio Output Source* block (See section 2.4)
7. To add an harmonic tone to one or several time slots configure the *Tone Generator* (See section 2.5).

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2.3.1. Entering the Line Settings

Line settings include some of the most basic configuration parameters for 1544 / 2048 kb/s transmission and reception. Some of these include the line code, and the clock source. Follow these steps to configure the line parameters:

Table 2.3: Line Settings

Setting	Description
Connection mode	It configures the features of the network interface where the tester receiver is going to be connected. The available configurations for this field: • *Endpoint*: This connection represents a network termination point with the nominal impedance (75 Ω for the unbalanced port and 120 Ω for the balanced one). The expected attenuation is the theoretical cable attenuation with increases with the frequency square root. • *-20 dB monitor*: 20 dB protected monitoring point. This is a connection point that is isolated from the network and it is specially suited for monitoring purposes. A flat attenuation of 20 dB is expected for these points. • *-25 dB monitor*: 25 dB protected monitoring point. This is a connection point that is isolated from the network and it is specially suited for monitoring purposes. A flat attenuation of 25 dB is expected for these points. • *-30 dB monitor*: 30 dB protected monitoring point. This is a connection point that is isolated form the network and it is specially suited for monitoring purposes. A flat attenuation of 30 dB is expected for these points. • *High Z*: The port is configured with a very large input impedance. This *Connection mode* is suited for such applications where the tester has to monitor a link without disturbing the network operation and a protected monitoring point is not available.

Table 2.3: Line Settings

Setting	Description
TX code	Transmitted line code. The line code provides correct levels, pulse shapes and bit encoding rules for baseband transmission over an electrical interface. The possible configurations for this field are: • *HDB3*: High-density bipolar with three zeroes. Line code that alternates polarity when a binary ‘1’ is to be transmitted and replaces series of four bits that are equal to ‘0’ by reserved words that violate the alternating polarity rule but they keep the DC balanced. The replacement rule helps preserving the timing information. This line code is available in 2048 kb/s interfaces only. • *B8ZS*: Bipolar with eight-zero substitution line code. Line code that alternates polarity when a binary '1' is to be transmitted and replaces series of eight bits that are equal to '0' by reserved words that violate the alternating polarity rule but they keep the DC balanced. The replacement rule helps preserving the timing information. This line code is available in 1544 kb/s interfaces only. • *AMI*: Alternate mark inversion: Line code that alternates polarity when a binary ‘1’ is to be transmitted. It does not have a zero replacement rule. That means that this code has difficulties preserving timing information when long zero sequences are transmitted. • *Match RX*: Matches the code configured in the receiver this setting could be used to avoid configuring twice the same thing or to match the detected line code during the auto-negotiation process.
RX code	Received line code. The line code provides correct levels, pulse shapes and bit encoding rules for baseband transmission over an electrical interface. Configurations for the received line code are the same that for the transmitted code with the exception of the *Match RX* setting, which wouldn’t make sense for this field.

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Table 2.3: Line Settings

Setting	Description
TX clock source	Clock source for the transmitter. These are the options available for this setting: • *Synthesized*: It is used the clock signal configured in the *Reference clock* menu. Use this setting to check potential synchronization impairments in your network. • *Recovered*: The clock signal recovered from the receiver is used by the transmitter of the same port. Use this setting when you do not need to consider synchronization impairments in your test.
TX clock offset (ppm)	Frequency offset applied to the transmitter clock within the range of ±25,000 ppm. This feature is useful to stress the DUT / SUT.

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available)) to enter in the port specific configuration menu.
3. Configure the Connection mode. Use *-20 dB monitor*, *-25 dB monitor*, *-30 dB monitor* and *High Impedance* for monitoring. Use *Endpoint* in all other testing applications.
   Note: The Connection mode must be set to *High Impedance* in monitoring applications before connecting the tester to the DUT / SUT to avoid disturbing the line.
4. Set the *RX code* to *HDB3, B8ZS* or *AMI* and do the same (if necessary) with the *TX code*.
   The value to set in *TX code* and *RX code* depends on the line code used by the DUT / SUT in the network interface where the test unit is connected.
5. If you are using the transmitter in your measurement, configure the *TX clock source*. Normally, you will want to set *Recovered* here. However, you can use *Reference* to test specific synchronization issues in the network (See section 2.9).
6. Configure the *TX clock offset (ppm)* in such cases where you are using the transmitter and you want to stress the network with a frequency offset. Otherwise, make sure that the *TX Clock offset (ppm)* is set to 0 ppm.

2.4. Configuring the Audio Output Source

The test unit has a 2.5 mm audio jack that enables connection of an external headset with speakers and microphone. There is also a *600 Ω* port with RJ-48 connector that enables interconnection to an analog network interface. The tester is able to encode the audio signal from the microphone or the audio line input and add it to a 2048 kb/s frame or to drop a selected time slot to the speaker or the audio line out connected to the audio port.

The audio input is added to one or several time slots in the test port using the multiplexer menu (See section 6.3.1). The audio output accepts several signal sources as well:

- *Off*: The audio output is disconnected. No signal is sent to the analogue port.
- *Port C time slots*: The signal from a selected time slot in *Port C* is sent to the analogue output. The signal from the analogue input is sent to one or various time slots in the *Port C* if the port is configured to do so.
- *Port D time slots*: The signal from a selected time slot in *Port D* is sent to the analogue output. The signal from the analogue input is sent to one or various time slots in the *Port D* if the port is configured to do so. This configuration option is available only if *Port D* has been installed in xGenius.
- *Tone generator*: The signal from the tone generator is sent to the analog output

To configure the audio output follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select *Audio output source*
   The audio source selection menu.
3. Choose *Off*, *Port C timeslots*, *Port D timeslots* (if available) or *Tone Generator*.

2.5. Configuring the Tone Generator

The tone generator enables the unit to add harmonic tones with configurable amplitude and frequency to one or several time slots of a T1 or E1 signal.

Table 2.4: Tone Generator

Setting	Description
Tone level	Sets the test tone level in dBm for the tone generator block. The maximum power is +6 dBm, the minimum is -60 dBm. Resolution is 1 dB.
Tone frequency	Sets the tone frequency in Hz for the tone generator block. The maximum frequency is 4000 Hz, the minimum is 2 Hz. Resolution is 1 Hz.

Usually, it is required a previous setup of the test unit operation mode, line and frame parameters before configuring the tone generator. Specifically, the *Port C* or *Port D Multiplexer* block must have one or various time slots set to *Tone*. The steps to follow to configure the tone generator are the following:

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1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select *Tone generator*.
3. Enter the correct *Tone level (dBm)* and *Frequency (Hz)*.

2.6. Using Pluggable Hardware Modules (PHMs)

Pluggable Hardware Modules (PHMs) are a way to extend the default xGenius functionalities. There are currently four different PHMs. The PHM-20 can be used for datacom testing, PHM-21 is a dual-port IEEE C.37.94 module, the PHM-22 can be used for ITU-T G.703 co-directional, contra-directional and centralized tests and the PHM-23 is an analog (VF) test module. More PHMs can be designed in the future supporting more functions, interfaces and tests.

PHMs are hot pluggable:. Users are allowed plug or unplug modules at any time. If the correct software license is installed in the test unit, the menus requiring the PHM will be displayed in the regular menu structure but when the user enables any option related with the PHM a warning (yellow) indication will be displayed on the top of the screen to inform that the PHM is not attached. The warning message includes the PHM name. For example, if the *C37.94 endpoint* mode is enabled but the PHM-21 is not connected to the unit then a *PHM-21* warning message will be displayed.

2.7. Using the Auto-configuration

When some line, frame or pattern parameters are unknown, users can enable the auto-configuration capability and let the equipment look for the right configuration parameters. Auto-configuration works only when the analyser is configured in an E1 / T1 mode: *E1 / T1 endpoint*, *E1 / T1 monitor*, *E1 / T1 through, E1 / T1 MUX test.* The auto-configuration capability is not supported by the G.703 / E0, IEEE C37.94, analog and datacom receiving sections. Once the equipment is connected to the network, follow this procedure to use the auto-configuration capability:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select *Mode* to enter in the mode selection menu
3. Choose one of the operation modes with a G.703 / E1 or ANSI T1.102 / T1 receiving section: *E1 / T1 monitor*, *E1 / T1 endpoint*, *E1 / T1 through*, *E1 / T1 MUX test*.
4. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
5. Go to *Auto-configuration*.
6. Start the auto-configuration process by setting the *Enable* field to *Yes*.
   Auto-configuration starts
7. Wait for the auto-configuration to finish. Progress messages and result is displayed in the *Status* field.

Note: Test pattern auto-configuration requires the time slots configured in the *Demultiplexer* to *Pattern* to match the time slots transporting the test pattern in the received line signal.

2.8. The E1 / T1 Summary Panel

The *Summary* panel is available at any moment by going to the Summary tab in the auxiliary panel.

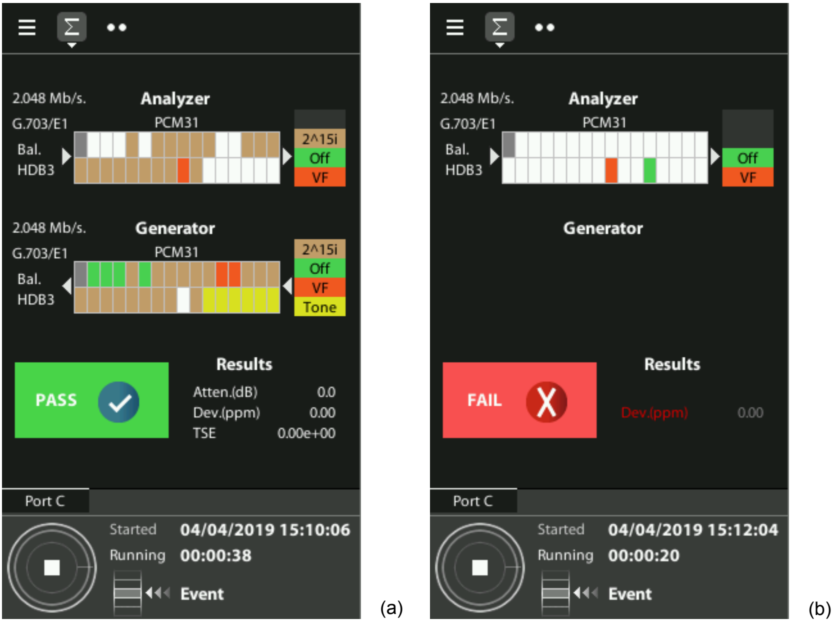

Figure 2.4: Summary panel for different operation modes: (a) E1/T1 Endpoint mode, (b) E1/T1 monitor mode.

The *Summary* panel contains a block diagram that indicates how the different tester blocks are connected and which is their current configuration. Connection between blocks depends on the current operation mode. Content of each block depends on the port specific configuration (Port C, Port D).

If the mode is set to *E1/T1 monitor*, the pattern generator is disconnected, there is no frame structure for the transmitter and the transmitter line signal is switched off. On the other hand, the receiver blocks are the same in *E1/T1 monitor* and in *E1/T1 endpoint* modes. If *E1/T1 through* is selected as the operation mode, then the *Demux* and *Mux* blocks are connected to allow the time slots content to go from the receiver to the transmitter.

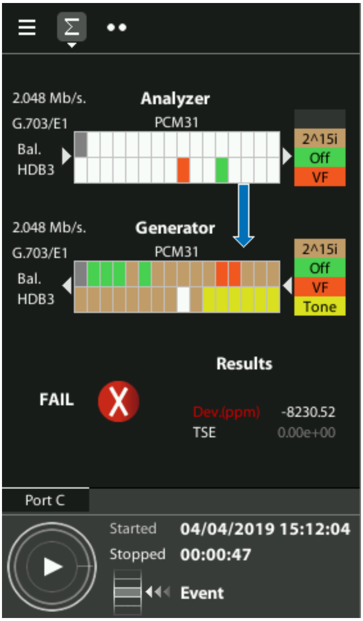

Figure 2.5: Summary panel for the E1/T1 through mode.

2.8.1. Global Pass / Fail indication

You can define objectives for many of the magnitudes measured by the test unit (line, BER, performance). Test results are compared with their objective during and after the test. The result of this comparison is aggregated and represented in the global Pass / Fail indication within the summary screen.

2.9. Testing with an External Clock Reference

Some tests performed by xGenius require a clock reference. Moreover, it is possible that the user is interested in setting the transmission timing source of Port A / Port B transmitters to something different to the default configuration. Clock reference configuration for tests that require an external timing source is carried out through the *Reference clock* menu. The source timing candidates are the following ones:

Table 2.5: Reference Clock Panel

Result	Description
Input clock	Enables the user to choose between different reference clock inputs, including the internal clock input. The specific clock input list depends on the hardware configuration and the current operation mode of your test unit
Output clock	Enables the user to choose between different clock reference clock outputs.These outputs could be used to synchronize an external equipment, including a second xGenius, with the test unit. The available outputs depend on your hardware configuration and the current operation mode.
Internal reference status	Displays information about the internal clock reference when it is free running, locked to an external reference or in holdover. • *Free run*: The clock reference input is internal and the oscillator is free running without any external discipline.The oscillator will exhibit a frequency offset that will depend on the oscillator type, aging, last calibration date and temperature. A free running oscillator may still be suitable to run some frequency tests but it will generally unsuitable to perform measurement related with time / phase. • *Do not use*: The oscillator has been configured to be disciplined to an external clock reference but the locking process is still starting. When the reference reports the “Do not use” status large variations in phase or frequency may happen and therefore the equipment is not yet ready for any test requiring accurate synchronization. • *Not sync*: The internal oscillator is in the process of acquiring the frequency and phase from the external clock reference. Large variations in the internal oscillator phase and frequency may happen during this period and the equipment is not ready for any test for this reason. • *Locking*: The internal oscillator is in the last phase of the locking process. No sudden phase changes are expected in this state. In this status, the unit becomes ready for all tests not requiring the maximum accuracy degree.

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Table 2.5: Reference Clock Panel

Result	Description
Internal reference status	• *Holdover:* The unit has been previously locked to an external time or phase reference but now the reference input is not being used. The unit keeps an accurate reference frequency and phase for a limited period of time. When the unit is operating in holdover mode it is still ready for testing even if no external clock reference is available. • *Error reference*: For some reason, the local oscillator is not able to finish with the locking sequence. This message should never be displayed under normal operation.
GNSS receiver	Enables access to the GNSS configuration menu and shows information about the GNSS receiver status, if this option is available. These are • *No data*: There is no connection between the test unit and the GPS / Glonass receiver or the receiver is not generating any data. • *Acquiring fix*: The GNSS receiver has not yet acquired position and time. Achieving this data may take a few seconds. The equipment may fail to achieve the fix if there are not enough satellites in sight. • *Waiting for PPS*: The GNSS receiver has acquired position and time and it is reporting this information but it is not yet generating the 1 PPS signal required for a correct assessment of the position / time. • *Synchronizing to PPS*: The GNSS receiver is now reporting position and time and generating a 1 PPS. The unit is acquiring this information. • *Synchronized to GNSS*: The test unit is tracking the GNSS signal. The time scale reported by the GNSS constellation is being used. For example the GPS time is 19 seconds behind TAI. • *Synchronized to UTC*: The test unit is tracking the GNSS signal. UTC time scale is used. Once the GNSS status is reported the unit cannot get the UTC time unless the TAI-UTC second count is known. This data is also reported by the satellite system and it takes some time before the information is acquired. The GNSS configuration menu is greyed out unless the GNSS clock reference input is configured in *Input clock*.

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Table 2.5: Reference Clock Panel

Result	Description
PPS / ToD input interfaces	Menu that configures and reports status of 1 PPS, 1 PP2S and ToD clock references outputs. Configuration of these interfaces is limited to a custom incoming cable delay compensation. The displayed status information corresponds with the ToD format (*ITU-T G.8271*, *NMEA*, *China Telecom*). This menu entry is enabled only if Input clock is configured to any of *1 PPS (REF IN)*, *1 PP2S (REF IN)*. *ToD (REF IN/ OUT)*.
PPS / ToD output interfaces	Menu that configures and reports status of 1 PPS, 1 PP2S and ToD clock reference outputs. Configuration of these interfaces is limited to a custom outgoing cable delay compensation and the ToD format (*ITU-T G.8271*, *NMEA*) to be configured at the output.
Oscillator	Opens the oscillator configuration menu.This menu enables users to get information about the oscillator status and force the holdover operation.

- *Internal*: The test unit clock reference is configured to use the timing from an internal oscillator. This oscillator is a temperature-controlled crystal oscillator (TCXO) which provides a frequency accuracy better than ±2.0 ppm. The user can optionally replace the TCXO by an oven-controlled crystal oscillator (OCXO) or a Rubidium oscillator which provide higher frequency accuracy than the TCXO.
- *Clock/PCM (Port Ref. In/Out)*: The clock reference is derived from an external PCM or clock signal. Options included in this set are 2048 kHz, E1,1544 kHz, T1, 5 MHz and 10 MHz. This signal is received through the REF IN/OUT RJ-45 port. For this reason, this option is available only if a clock reference output has not been previously configured over the same port.
- *ToD (Port Ref. In/Out)*: Clock reference input derived from an external 1 PPS / ToD interface received through the RJ-48 REF IN/OUT port. There are three ToD protocols supported: NMEA, China Telecom, ITU-T G.8271. These are automatically detected.
- *PPS (Port Ref In/Out)*: The clock reference is derived from an external 1PPS (1 pulse every second) or 1PP2S signal (1 pulse every two seconds) received through the RJ-48 REF IN/OUT port located in the test connector panel. PPS signal type is automatically detected and it doesn't require user intervention.
- *PPS (Ref. SMB)*: The clock reference is derived from an external 1PPS (1 pulse every second) or 1PP2S signal (1 pulse every two seconds) signal received through the PPS RX SMB port located in the test connector panel. PPS signal type is automatically detected and it doesn't require user intervention.

- *GNSS*: Actually, this is not a clock reference input but a RF input used by the optional built in GNSS receiver to internally generate a timing signal that improves the internal oscillator default performance when operating in free-running mode (See section 2.9.2).

Table 2.6: Oscillator Settings and Status

Result	Description
Oscillator status	For a proper operation of your xGenius test unit, the oscillator status should always be *Calibrated*. Not calibrated oscillators may not be able to track correctly an external reference and they could generate large frequency offsets when they operate in free running mode. Contact with the ALBEDO Telecom customer service or with the your ALBEDO Telecom local representative if your unit is showing something different to *Calibrated* in this field.
Oscillator type	Supported oscillator types are TCXO, OCXO and Rubidium. These are the basic properties and differences between all three possibilities: • *TCXO*: This oscillator has a frequency offset of the order of 1 ppm. It is well suited for all standard test applications not including one way latency measurements or synchronization testing involving GNSS, 1 PPS or PTP interfaces. It does not support operation in holdover mode. • *OCXO*: Standard oscillator for applications involving GNSS, 1 ppm or PTP interfaces. The frequency offset is of the order of 0.1 PPS. The long term stability of OCXOs are better than in TCXOs and for this reason they can be used in some holdover applications. • *Rubidium*: It offers better accuracy than OCXOs both in terms of phase and frequency stability. This oscillator is also better shielded against temperature variations than the OCXO. The main advantage of Rubidium oscillator is its excellent holdover performance. Rubidium units are best suited for synchronization tests requiring high accuracy degree both in locked or holdover states.

Table 2.6: Oscillator Settings and Status

Result	Description
Oscillator lock status	This field provides information about the disciplining status corresponding with the internal clock. It can be one of the following: • *Warm up*: Shows that the oscillator is still initializing. No accurate frequency or phase could be expected when the oscillator is still in this mode. The *Warm up* status could last for a few minutes. • *Locking*: The oscillator has finished the initialization sequence and it starts tracking the external reference frequency and phase. The objective of this state is to minimize the phase and frequency difference between the local oscillator and the reference. During the *Locking* period the oscillator frequency and phase may not be accurate or they may change quickly. For this reason no test should be run in *Locking* state. The *Locking* status lasts for around 20 minutes in Rubidium units and 5 minutes in OCXO units. • *Fine locking*: The unit is still trying to minimize the phase difference between the internal oscillator and the reference but no sudden phase changes are expected in this state. When the unit achieves the *Fine locking* status, it becomes ready for all tests not requiring the maximum accuracy degree. The Fine locking state lasts for a few seconds in OCXO units and about four hours in Rubidium units. • *Locked*: The unit cannot reduce the frequency and phase difference between the reference clock and the local oscillator any more and it just tracks the output to keep the differences to the minimum. In this situation, the test error is minimum and therefore the unit is ready for any measurement. • *Holdover:* The unit has been previously locked to an external time or phase reference but now the reference input is not being used. The unit keeps an accurate reference frequency and phase for a limited period of time. When the unit is operating in holdover mode it is still ready for testing even if no external clock reference is available. • *Holdover time out*: The unit has been working in holdover for longer than programmed in the *Holdover duration* field. The local oscillator frequency and phase are not reliable when working the holdover is timed out.

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Table 2.6: Oscillator Settings and Status

Result	Description
	• *Free running*: The local oscillator is not disciplined and it is operating on its natural oscillation frequency. How accurate this frequency is depends on which oscillator is being used (TCXO, OCXO or Rubidium) and how well the oscillator is calibrated. The phase and time supplied by a free running oscillator are not reliable. • *Reference error*: For some reason, the local oscillator is not able to finish with the locking sequence. This message should never be displayed under normal operation.
Force holdover	Puts the OCXO or Rubidium oscillator in holdover mode. When this mode is set, The user is allowed to physically unplug the external clock interface. The equipment, will try to generate accurate phase and frequency on its own based on previous data from the reference. The holdover mode is not available in TCXO units.
Holdover elapsed time	It accounts for the time from the beginning of the holdover period. This value should always be smaller than the *Holdover duration*. If the *Holdover elapsed time* becomes higher than the Holdover duration then the test unit goes to a holdover timed out state.
Holdover duration	This field could be used to configure the amount of time required to declare a holdover timed out. The default holdover duration period is 24 hours.

The procedure to configure the clock reference input in your xGenius unit is detailed in the following steps.

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Go to *Reference clock*.
3. Configure *Input clock* to one of *Internal*, *Clock/PCM (Port Ref. In/Out)*, *ToD (Port Ref. In/Out)*, *PPS (Port Ref. In/Out)*, *PPS (Ref SMB) or GNSS*.
4. If you have chosen *Clock/PCM (Port Ref. In/Out)* in the previous step, configure *Clock/PCM input, Connector and Termination* from the *Clock/PCM input interfaces* menu. If you have chosen *PPS (Port Ref. In/Out)*, *PPS (Ref. SMB) or ToD (Port Ref. In/Out)* configure the *Input reference delay* to compensate for the cable delay from the *PPS/ToD input interfaces menu* (See section 2.9.1). If you have configured GNSS in the previous step, configure *Antenna cable delay*, *Active GNSS* and other GNSS related parameters from the GNSS receiver menu (See section 2.9.2),

2.9.1. Using PPS / ToD and Frequency References

xGenius includes three different kinds of clock reference. Every class has different features and they are used for different applications. The parameters to be configured are also different depending on the clock reference class. Time an phase references require an adjustment to compensate for the latency in the patch cable from / to the DUT. The same setting applies both to phase and time references. On the other hand, frequency references require an impedance configuration. Setting a high impedance value enables monitoring applications without disturbing the line and the nominal impedance can be used to avoid reflections when the test unit is connected in endpoint mode.

Table 2.7: PPS/ToD Input Interfaces Options

Parameter	Description
Input reference delay	Compensates the delay added by the physical media propagation delay when the *Input clock* reference is set to *PPS (Port Ref. In/Out)*, *PPS (Ref. SMB) or ToD (Port Ref. In/Out)*.
Input ToD status	Displays information about the ToD protocol detected in the clock reference input. It could be *No ToD*, if the ToD format is not recognised or *G.8271*, *NMEA* or *China Telecom* when any of these ToD protocols is detected
Input PPS status	This field informs about the detected PPS signal type. It could be *1PPS* (1 pulse per second) or *1PP2S* (1 pulse every two seconds). It also displays a *No PPS* indication when no valid PPS signal is detected.

- *Frequency references*. This class includes the 2048 kHz, E1, 1544 kHz, T1, 5 MHz and 10 MHz. Locking the unit to any of these references is very fast. It takes only a few seconds even in Rubidium units. The disadvantage is that holdover from frequency references is not supported Frequency references are also unsuitable for time and latency tests but they are good for accurate frequency offset and drift tests and wander (TIE, MTIE, TDEV) tests.
- *Time references.* Includes the ToD reference. The ToD is made up of a 1 PPS that provides accurate phase timing and a protocol that distributes the time in an absolute time scale such as TAI or UTC. The ToD can be used to measure TE in any interface including, PTP, 1 PPS and frequency.
- *Phase references*. They are the 1 PPS and the 1 PP2S references. Phase references offer something that is in between time and frequency references. They can be used to measure TE in other phase references such as 1 PPS and 1 PP2S but they cannot do the measurement with time protocols such as IEEE 1588 / PTP.

GNSS has not been included in the previous description but from the point of view of the functionality it offers is equivalent to a ToD reference. There are some points specific about GNSS references: Timing is generated from one or various satellite constellations and information about geographical position and not only time is received. For these reasons GNSS references are configured separately (See section 2.9.2).

Table 2.8: Clock/PCM input interfaces Options

Parameter	Description
Clock/PCM input	Configures the Clock or PCM reference input interface: • *2048 kHz (Port Ref. In/Out)*: The clock reference is derived from an external ITU-T G.703 2048 kHz signal. This signal is received through the balanced RJ-48 Ref. In / Out port. • *E1 (Port Ref. In/Out)*: The clock reference is derived from an external ITU-T G.703 2048 kb/s signal. This signal is received through the balanced RJ-48 Ref. In / Out port. • *1544 kHz (Port Ref. In/Out)*: The clock reference is derived from an external 1544 kHz signal. This signal is received through the balanced RJ-48 Ref. In / Out port. • *T1 (Port Ref. In/Out)*: The clock reference is derived from an external ITU-T G.703 1544 kb/s signal. This signal is received through the balanced RJ-48 Ref. In / Out port. • *5 MHz (Port Ref. In/Out)*: This is a 5 MHz unipolar clock. Accepts square or sinusoidal signal received through the RJ-48 Ref. In / Out port. • *10 MHz (Port Ref. In/Out)*: This is a 10 MHz unipolar clock input. Accepts square or sinusoidal signal received through the RJ-48 Ref. In / Out port.
Connector	Configures the port connector in a Clock / PCM reference input. Since all references of this type are currently received through the balanced RJ-48 Ref. In / Out port, connector setting is not required.

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Table 2.8: Clock/PCM input interfaces Options

Parameter	Description
Termination	It configures the input / output impedance of the clock interface where the *Port C* is going to be connected. The available configurations for this field are: • *Endpoint*: This connection represents a network termination point with the nominal impedance (75 Ω for the unbalanced port and 120 Ω for the balanced one). The expected attenuation is the theoretical cable attenuation which increases with the frequency square root. • *-20 dB monitor*: 20 dB protected monitoring point. This is a connection point that is isolated from the network and it is specially suited for monitoring purposes. A flat attenuation of 20 dB is expected for these points.

2.9.2. Configuring the Built in GNSS Receiver

xGenius units may optionally be equipped with a built in GNSS receiver. These units have a SMA female connector suitable for connecting an external antenna. Units with the built in GNSS receiver are also supplied with a compact antenna with 5 m of coaxial cable plus a 10 m extension cable.Using a different antenna is possible as long as the specifications of the GNSS module are taken into account.

The GNSS interface can be used to synchronize the system time with a satellite constellation but in certain test units, some results may depend on the GNSS timing source. It this case, the test application may enable the GNSS reception on its own. In both cases, the GNSS state can be verified through the same *Clock reference* submenu. To display the GNSS status follow this procedure.

1. Attach the GNSS antenna to the unit. Make sure that the antenna sees as much of the sky as possible. The unit may fail to achieve synchronization if there are not enough satellites in sight. Some tests may loss accuracy if the number of satellites in sight is reduced.
1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Go to *Reference clock*.
3. Configure the clock reference input to *GNSS*.
4. Go to *GNSS receiver*.

5. Check the values of *GPS status*, *Satellites received*, *Satellites used*, *PDOP and TDOP*.

Table 2.9: GNSS Receiver Options

Parameter	Description
Antenna cable delay	Compensates the delay added by the physical media when the GNSS signal propagates from the antenna to the receiver.
Active GNSS	Configures the active GNSS constellations. Supported values are: • *GPS*: Enables the *Global Positioning System* in the equipment. This is the satellite constellation managed by the US government. • *Glonass*: Enables the *Global'naya Navigatsionnaya Sputnikovaya Sistema* (GLONASS) constellation, that constitutes the Russian alternative to GPS. • *BeiDou*: Enables BeiDou in the test unit. BeiDou is the Chinese positioning system alternative to the North-American GPS. • *Galileo*: Enables the European Galileo system in the test unit. Depending on the hardware configuration of your particular unit, some of these constellations may not be available for configuration. It is possible to enable two or more simultaneous constellations at the same time. In this case, the satellites for the selected constellations will be simultaneously used.
PPS timing reference	Configures which GNSS timing reference is used as a timing source for the local oscillator. It could be set to *GNSS*, *UTC* or automatic (*Auto*) The recommended value for this setting is *Auto*.

Table 2.9: GNSS Receiver Options

Parameter	Description
GNSS status	Displays the current status of the NMEA interface used for communication with the built in GPS / Glonass module or an external GPS receiver connected to the unit through a 1 PPS / ToD interface. The possible values of *GPS status* are listed below: • *No data*: There is no connection between the test unit and the GPS / Glonass receiver or the receiver is not generating any data. • *Acquiring fix*: The GPS / Glonass receiver is generating NMEA data but it is still not synchronized. Achieving synchronization may take some time. The equipment may fail to achieve synchronization if there are not enough satellites in sight. • *Waiting for PPS*: The GNSS receiver has acquired position and time and it is reporting this information but it is not yet generating the 1 PPS signal required for a correct assessment of the position / time. • *Synchronized To GNSS*: The GNSS receiver is reporting that it has achieved synchronization from the timing data received from the satellite constellations. This is a required condition before the system time becomes locked to the GNSS time.
Satellites received	This is a read only field that displays the number of satellites on sight. These satellites may correspond to any of the constellations currently enabled.
Satellites used	This field shows the number of satellites actually used by the test unit. One satellite may be on sight but it may not be used by the unit for different reasons. The *Satellites used* parameter is the only one relevant to rate the accuracy of the GNSS-derived timing reference
PDOP	Some tests may require a minimum number of satellites or an specific satellite geometry to achieve the required accuracy level. The Position Dilution of Precision (PDOP) gives information about how good is the current satellite geometry to achieve an accurate position estimate. The PDOP is a positive number. The smaller the number, the better is the accuracy. A minimum value of PDOP of 1.5 is recommended to get accurate results in critical tests.

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Table 2.9: GNSS Receiver Options

Parameter	Description
TDOP	Time Dilution of Precision (TDOP). This parameter gives information about how good is the current satellite geometry to achieve an accurate time estimate.
Fixed-position mode	This is the menu that enables the user to configure the fixed GNSS receiver fixed position mode. In this mode the equipment uses given spacial GNSS coordinates (longitude, latitude, altitude) in order to achieve maximum accuracy in the time estimate.
Leap seconds (TAI - UTC)	Reports the current time offset between TAI and UTC. This value is currently set (February 2019) to 37 seconds but this value changes from time to time as new leap seconds are added to the UTC time scale. The TAI to UTC offset is retrieved from the GNSS constellations without user intervention. This is, therefore a read only field.

You can also actively configure the xGenius GNSS receiver. Some settings are not mandatory but the increase in accuracy it could be obtained in this way is quite important. This is the required procedure:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Go to *Reference clock*.
3. Go to *GNSS receiver*.
4. Configure the Antenna cable delay to compensate for the distance between the receiver and the antenna.
5. Optionally, enable or disable any of the *GPS*, *GLONASS*, *BeiDou* or *Galileo* constellations through the *Active GNSS* setting.
6. Go to *Fixed-position mode*.
7. Optionally, adjust the *Position averaging time* and enable position averaging by configuring *Fixed-position mode* to *Auto-average*.
   The *Fixed-position status* field now displays *Averaging*
   Note: At least one hour of position averaging is required for a reasonable accuracy.
   Note: The position averaging procedure should be run only once as long as the test unit geographical location is not changed. The unit checks any change in position (longitude, latitude, altitude) every time it is connected to a GPS antenna. If a change in the coordinates is detected, then an error message is displayed in the status field and the mode is disabled.
8. Wait to the *Fixed position status* to become *Active*. The unit is now ready for testing.

Note: Theoretically, testing could start before the end of the position averaging process. The improved time estimation due to this function would be automatically applied starting from the end of the auto-averaging process.

2.9.3. Using the Holdover Mode

xGenius units carrying OCXO and Rubidium oscillators can operate in holdover mode. They can be disconnected from the clock reference input and they still keep accurate frequency and phase for a period of time that ranges from a few minutes for OCXO units or a few hours in Rubidium units. The holdover mode cannot be used in TCXO units.

The holdover mode is useful when, for some reason, there is not a suitable clock reference that could be used in the test site In this case, the equipment could be synchronized to a GNSS or any other clock source far from the test site and driven to holdover.The results are accurate within a period of time as long as the test unit is not restarted

To enable the holdover operation in xGenius, follow these steps:

1. Connect and configure the clock reference input in your test unit to *GNSS* or any of the 1 PPS, 1 PP2S or ToD interfaces (See section 2.9).
   Note: Holdover from a frequency reference is not supported.
2. For optimum performance, in Rubidium units, wait for at least two hours once the test unit is locked to the clock reference input. In OCXO units no additional waiting time is necessary once the equipment is locked.
   Note: Theoretically, the unit could the driven to holdover when it is still in a *Fine locking* state but the accuracy level will be lower if this is done.
3. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
4. Go to *Reference clock*.
5. Go to oscillator.
6. Optionally, configure *Holdover* duration to the time you want to keep the unit in holdover. The unit will go to a Holdover timeout once this time is reached and frequency / time traceability will be lost.
7. Configure *Force holdover* to *Yes*
   An small *H* is displayed in the screen to show that the unit has entered in holdover.
8. Optionally, unplug the clock reference input from the test unit.
   The REF LED now displays the red colour. The unit is ready for testing.

In Rubidium units, it is possible to recover from a holdover without restarting the oscillator control loop from the beginning. This is the right procedure to do that:

1. Plug a GNSS or 1 PPS clock reference to the right connector in your xGenius tester.
2. Make sure that the equipment is receiving the reference (green REF LED)

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3. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
4. Go to Reference clock.
5. Configure *Force holdover* to *No*
   Oscillator lock status will go to *Warm up* or *Fine locking*, depending on how far is the clock reference from the current local oscillator frequency and phase.

Holdover is important when accurate timing is required to run a test but the reference is not available in the location where the test is to be run. Typical examples are data centres in basements or in rooms without windows. These conditions make it difficult to use GNSS, which is the most universally available reference. The holdover mode has to be used carefully, however. Some oscillators can be set to “remember” frequency and phase for a period of time once they have been disconnected from the reference but sooner or later they will drift to their natural oscillation frequency and the holdover will resemble more and more to the free running operation. xGenius users must be aware of the performance level they could expect from the test unit to decide which tests are feasible and which are not.

For example, an xGenius with an internal Rubidium oscillator, is configured in holdover. The specification is that the phase error will be less than 1000 ns after 24 hours, which corresponds with an average frequency offset of1.2 x 10^{-11} for the 24 hour measurement period. If the holdover period is extended for longer, then the frequency will drift and the offset will increase to approach the oscillator natural frequency. This frequency depends on factors such as the aging.

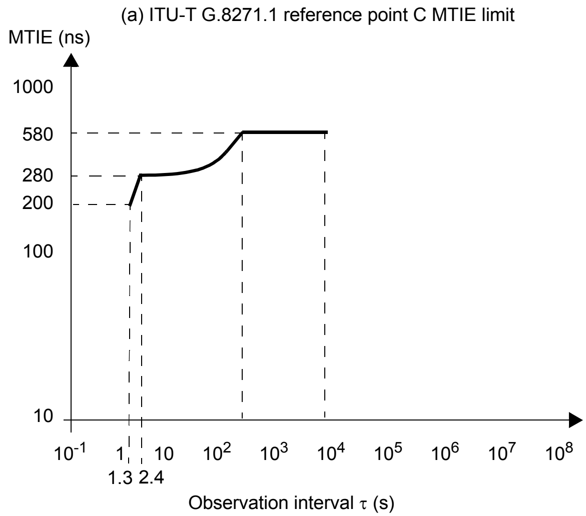

Figure 2.6: ITU-T G.8271.1 MTIE mask to be verified at the input of the T-TSC

The expected phase error (1000 ns) and frequency error (2 x 10^{-11}) must be compared with the expected test results: PRTCs (ITU-T G.8272 clocks) must supply an accuracy level in terms of TE better than 100 ns and the PRC (ITU-T G.811) accuracy in terms of frequency offset is 1 x 10^{-11} or better. It is clear that xGenius configured in holdover mode will not provide the accuracy level required to assess compliance with the G.7272 and G.811 frequency and phase requirements. On the other hand, ITU-T G.813 requires a frequency offset smaller or equal than 4.6 ppm for oscillators claiming compliance with this standard and ITU-T G.8271.1 specifies an MTIE of the order of hundreds of nanoseconds for a test period of 10000 seconds. For these test cases, holdover operation may be appropriate.

All previous examples are based in a comparison between the expected test error and the magnitude to be measured. Sometimes, the limiting factor could be not the magnitude to be measured but the test resolution or other error sources. An example of this is latency measurement in E1 and T1 interfaces. The expected accuracy level in these tests is two or three microseconds with perfect timing. For this reason, an error of hundreds of nanoseconds hardy matters.

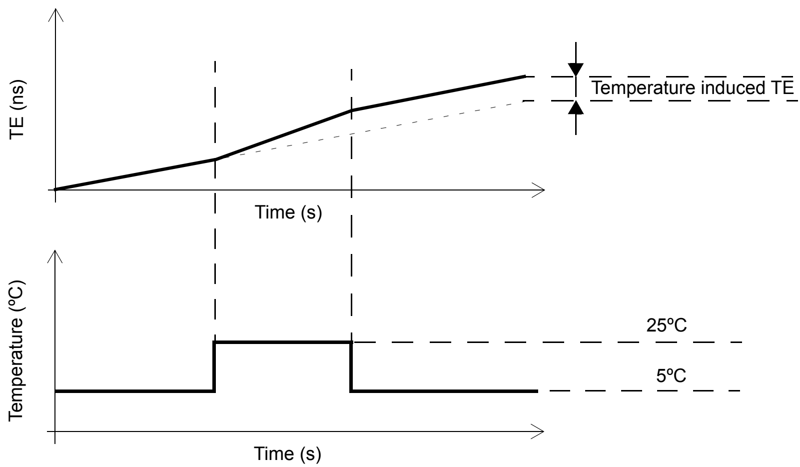

Figure 2.7: Temperature induced TE when the equipment is operating in holdover.

Aging is not the only factor that limits the accuracy of an oscillator. Magnetic fields, air flows, mechanical vibrations and among all them temperature have the capacity to modify the oscillator frequency.

For the example of the Rubidium xGenius, the holdover accuracy of 1000 ns in 24 hours applies only to operation with temperature changes within ±2ºC. If the temperature range changes in a range of ±10 ºC, then the error becomes closer to 3000 ns.

There are some interesting facts related with errors induced by temperature variations. We could try to describe two typical situations to illustrate these facts:

1. A test is to be done in a room where access to GNSS is not possible and there is no other signal that could be used as an alternative reference input. xGenius is synchronized in a different room at a different temperature and then moved to the test location. If the temperature difference in both rooms is larger than four degrees Celsius then the 1000 ns holdover performance could not be guaranteed. Not only phase and time measurements will be affected; the frequency in the test location will also be different to the room where the equipment was synchronized.
2. The test unit is synchronized in a laboratory and then transported to the test location. The temperature in the laboratory is similar to the test location but during transport the temperature is different. Now, frequencies in the laboratory and the testing site will be closer one each other because temperatures are the same in both locations. However, the phase and time error accumulates during transport. The longer the transport time and the temperature difference, the larger the error. The conclusion is that it is better to minimize the transport time when time and phase is to be tested because the accumulated error will be difficult to remove from the test result.

2.10.Using the Clock Reference Output

The xGenius clock reference output enables you to synchronize any external equipment with a clock signal generated by the tester or to connect the internal / recovered clock to an oscilloscope, spectrum analyser or other equipment. The reference clock output is therefore very useful for many tests related with network synchronization. These are the clock reference output ports and formats allowed by the test unit:

- *Clock/PCM (Port Ref. In/Out)*: The clock reference output is encoded as a frequency or PCM signal. Options included in this set are 2048 kHz, E1,1544 kHz, T1, 5 MHz and 10 MHz. This signal is transmitted through the REF IN/OUT RJ-45 port. For this reason, this option is available only if a clock reference input has not been previously configured over the same port.
- *ToD (Port Ref. In/Out)*: Clock reference output constituted by a 1 PPS / ToD interface transmitted through the RJ-48 REF IN/OUT port. There are two ToD protocols supported: NMEA, ITU-T G.8271. These are automatically detected. This option is available only if a clock reference input has not been previously configured over the same port.
- *1 PPS (Port Ref. In/Out):* Generates a 1 PPS output synchronized (phase and frequency) with the local oscillator through the RJ-48 REF IN/OUT port. For this reason, this option is available only if a clock reference input has not been previously configured over the same port.

- *1 PP2S (Port Ref. In/Out)*: The clock reference constituted by a 1 PP2S signal (1 pulse every two seconds) transmitted through the RJ-48 REF IN/OUT port. For this reason, this option is available only if a clock reference input has not been previously configured over the same port.
- *1 PPS (REF SMB):* Generates a 1 PPS output synchronized (phase and frequency) with the local oscillator through the SMB REF OUT port.
- *1 PP2S (REF SMB)*: The clock reference constituted by a 1 PP2S signal (1 pulse every two seconds) transmitted through the SMB REF OUT port.

Table 2.10: Clock/PCM output interfaces Options

Parameter	Description
Clock/PCM input	Configures the Clock or PCM reference input interface: • *2048 kHz (Port Ref. In/Out)*: The clock reference is encoded as an unipolar, square wave 2048 kHz signal. This signal is transmitted through the balanced RJ-48 Ref. In / Out port. • *E1 (Port Ref. In/Out)*: The clock reference is encoded as an ITU-T G.703 2048 kb/s signal with an all ones-payload. This signal is transmitted through the balanced RJ-48 Ref. In / Out port. • *1544 kHz (Port Ref. In/Out)*: The clock reference is encoded as an unipolar, square wave 2048 kHz signal. This signal is transmitted through the balanced RJ-48 Ref. In / Out port. • *T1 (Port Ref. In/Out)*: is encoded as an ITU-T G.703 1544 kb/s signal with an all ones-payload. This signal is transmitted through the balanced RJ-48 Ref. In / Out port. • *5 MHz (Port Ref. In/Out)*: This is a 5 MHz unipolar, square wave 5 MHz clock transmitted through the RJ-48 Ref. In / Out port. • *10 MHz (Port Ref. In/Out)*: This is a 10 MHz unipolar, square wave 10 MHz clock output transmitted through the RJ-48 Ref. In / Out port.
Connector	Configures the port connector in a Clock / PCM reference input. Since all references of this type are currently transmitted through the balanced RJ-48 Ref. In / Out port, connector setting is not required.

Table 2.10: Clock/PCM output interfaces Options

Parameter	Description
Frame structure	Sets the frame structure for E1 and T1 clock reference outputs. The available options are: • *PCM31*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. All other time slots carry an all ones pattern. This frame structure is available only for E1 references. • *PCM31C*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. The TS0 carries also a CRC-4 multiframe structure that enables error detection at the receiving end. All other time slots carry an all ones pattern. This frame structure is available only for E1 references. • *PCM30*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. The TS16 carries the CAS multiframe that provides signalling to the user time slots. Time slots different of TS0 and TS16 carry an all ones pattern. This frame structure is available only for E1 references. • *PCM30C*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. This frame includes at the same time the *CRC-4* and *CAS* multiframes. Time slots different of TS0 and TS16 carry an all ones pattern. This frame structure is available only for E1 references. • *SF*: 1544 kb/s TDM frame made up of 193 bits and 24 time slots (TS0, TS1,..., TS23) of 64 kb/s each. The first bit in the frame defines a multiframe and carries an alignment sequence. Time slots from TS0 to TS23 of carry an all ones pattern. This frame structure is available only for T1 references. • *ESF*: 1544 kb/s TDM frame made up of 193 bits and 24 time slots (TS0, TS1,..., TS23) 64 kb/s each. The first bit in the frame defines a multiframe and carries different kinds of information including the alignment sequence, a data communications channel and a CRC-6 frame check sequence. Time slots from TS0 to TS23 of carry an all ones pattern. This frame structure is available only for T1 references.

Table 2.10: Clock/PCM output interfaces Options

Parameter	Description
SSM signaling	Enables or disables the *Synchronization Status Message* (SSM) clock reference output. The SSM transports information about the current synchronization performance level transported in the E1 or T1 signal. The SSM information can be used by network clocks or other devices to know if the E1 or T1 signal is a reliable synchronization source. The SSM requires a frame structure with CRC in E1 interfaces (*PCM30C* or *PCM31C*). In T1 interfaces it requires FDL, which is only available with the ESF frame structure. The E1 NFAS also requires the user to configure which NFAS bit is used to transmit the message.

The configuration procedure to enable the reference clock output is detailed in the following steps:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Go to *Reference clock*.
3. Configure Output clock to *Clock/PCM (Port Ref. In/Out)*, *ToD (Port Ref. In/Out)*, *1PPS (Port Ref. In/Out)*, *1PP2S (Port Ref. In/Out)*, *1PPS (Ref SMB)* or *1PP2S (Ref SMB)*.
4. If you have chosen *Clock/PCM (Port Ref. In/Out)* in the previous step, configure *Clock/PCM Output, Connector, Frame structure and SSM signaling* from the *Clock/PCM output interfaces* menu.If you have chosen *ToD (Port Ref. In/Out)*, *1PPS (Port Ref. In/Out)*, *1PP2S (Port Ref. In/Out)*, *1PPS (Ref SMB)* or *1PP2S (Ref SMB)* configure the *Output reference delay* to compensate for the cable delay. If you have chosen *ToD (Port Ref. In/Out)*, configure the *Output ToD protocol* too.

Table 2.11: PPS/ToD output Interfaces Options

Parameter	Description
Output ToD Protocol	Configures the protocol in a ToD clock reference output. The supported protocols are ITU-T G.8271 and NMEA. You can also disable the ToD protocol. In that case, the interface is equivalent to a 1 PPS over a balanced interface.

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Table 2.11: PPS/ToD output Interfaces Options

Parameter	Description
Output Reference delay	Adds a delay compensation to 1 PPS / 1PP2S / ToD clock reference output. This setting could be useful to configure the correct phase alignment at the output when the input is not able to compensate a phase offset. It could also be used for verification purposes.

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Chapter 3
Testing Physical Properties

xGenius performs some basic testing that does not depend on the particular frame structure. These analogue tests include frequency, attenuation and latency.

Other family of related tests are performed not over the whole signal but on a specific time slot. This test requires an existing frame structure and a predefined encoding for the bit words stored within time slots. The test unit supports ITU-T G.711 encoding with A law and μ law. The most important time slot measurements are frequency and power level.

3.1. Frequency and Level Measurements

You don't need to start a measurement to get readings of attenuation, frequency, deviation and latency. However, results are not traced and logged. And they cannot be included in a report if a test is not started (*run* button).

Table 3.1: Line Settings

Setting	Description
Attenuation (dB)	Threshold value for the attenuation associated to the incoming signal expressed in dB. The reference level to compute de attenuation from the received signal follows ITU-T G.703. If the *Attenuation (dB)* value is out of range, the reading is displayed in red colour.
Frequency deviation (ppm)	Threshold value for the frequency offset for the incoming signal expressed in parts per million (ppm). If the *Frequency deviation* is out of range as specified in the *Frequency deviation (ppm)* line objective, the reading will be displayed in red colour.

You can configure a threshold for the analogue measurements. The received signal will be considered to be invalid if the line objectives are not met. To configure the line objectives, follow these steps:

1. From the *Home* panel, go to *Test*,
   The test configuration panel is displayed.
2. Go to the *Line objectives* menu (*Test* menu)
3. Enable the line objectives with the help of the *Enable* control
4. Enter the values for the *Attenuation (dB)* and *Frequency deviation (ppm)*.
   Note: *Port C* and *Port D* (when installed) share the same line objectives.

Line results can be checked at any time from a dedicated results panel. The procedure is the following:

1. From the *Home* panel, go to *Results*,
   The result verification panel is displayed.
2. Select either *Port C or Port D* (when available) to enter in the port specific results.
3. Select *Line*,
   The port specific line results are displayed in a list.

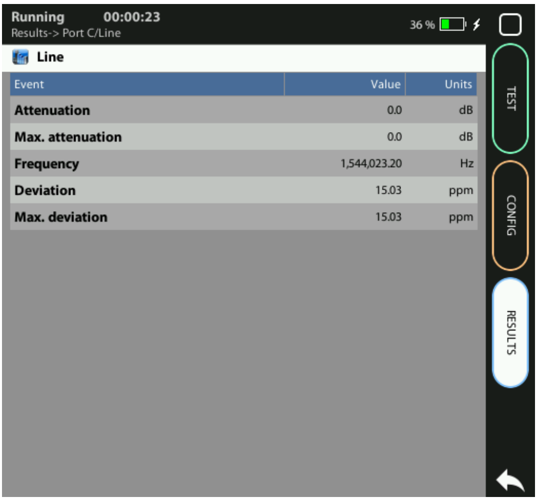

Figure 3.1: Attenuation, frequency, deviation and RTD results.

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Compliance status of the line results as per the configured line objectives is available in the summary screen. Line results are compared with their thresholds and aggregated to the global Pass / Fail indication.

Table 3.2: Line Results

Result	Description
Attenuation	Attenuation associated to the incoming signal expressed in dB. The reference level to compute de attenuation from the received signal follows ITU-T G.703. This result is available even if no test has been previously started with *run* (or the *Autostart / stop* settings).
Max. attenuation	Maximum value of the attenuation associated to the incoming signal expressed in dB. It corresponds with the maximum value recorded for the *Attenuation* result computed from the beginning of the test.
Frequency	Instantaneous value of the frequency computed for the incoming signal and expressed in Hertz (Hz). For E1 signals, the nominal value of the line frequency is 2048 kHz and for T1 is 1544 kHz This result is available even if no test has been previously started with *run* (or the *Autostart / stop* settings).
Deviation (ppm)	Instantaneous frequency offset value of the incoming signal expressed in parts per million (ppm). This result is available even if no test has been previously started with *run* (or the Autostart / stop settings).
Max. deviation	Maximum value of the frequency offset associated to the incoming signal expressed in parts per million (ppm). This result corresponds with the maximum value recorded for the Deviation result computed from the beginning of the test.

3.2. Measuring Delay

TDM signals experience delay as they propagate through the network. Delay is caused by the limited propagation speed of electric signals in the transmission medium. switches and multiplexers may add delay to signals too.

Circuit Emulation Services (CES) use a packet-switched network for TDM service delivery. End-to-end delay is more critical for packet-switched technologies than for circuit-switching. This is the reason because delay control becomes very important for CES. xGenius is prepared to verity that the delay is under acceptable limits in CES or legacy E1 / T1 services. Delay measurement is also available over data communications interfaces, the G.703 / E0 interface, IEEE C37.94 and even for VF (See section 3.4.3). Specifically, the operation modes that support the delay measurement are the *E1/T1 endpoint*, *E1/T1 through*, *Datacom endpoint*, *G.703 / E0, C37.94 endpoint* and *C37.94 through*.

xGEnius measures both round-trip delay and one-way delay. The one-way delay test has more requirements than the round-trip delay measurement. Two units are needed (one to be installed in the near measurement end and the second to the remote end). These units require an external accurate time synchronization source. This synchronization source is obtained from a GNSS or ToD interface.

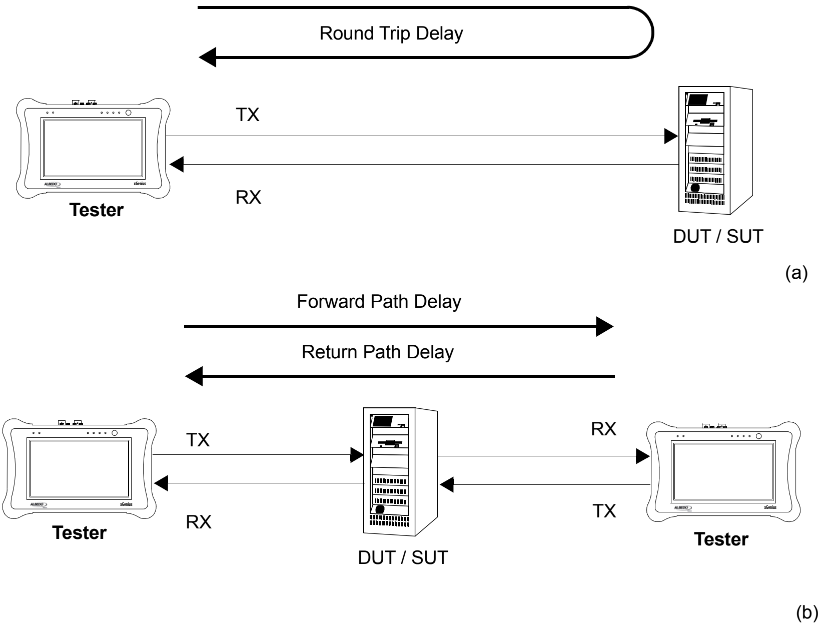

Figure 3.2: Latency test: (a) Round-trip delay measurement setup. This measurement requires a remote loopback element to provide a return path to the delay test pattern. (b) One-way delay, based on two cooperating units with external GPS synchronization.

It follows a description of the delay test configuration in an E1 / T1 interface. To know how to configure the latency test in datacom and IEEE C37.94 interfaces check the corresponding sections in this manual (See section 8.1.2, See section 9.5). Remember that if you are running a one-way delay test you must configure the near and far end units in the way described here. Configuration is identical in both units.

1. From the *Home* panel, go to *CONFIG*,
   The port configuration panel is displayed.

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2. Select *Mode* to enter in the mode selection menu and choose *E1 / T1 endpoint* or *E1 / T1 through.*
3. Configure the *Port C Hierarchy, Connector*, *Line*, *TX frame, RX frame* and *Test Pattern* (See section 2.3, See section 7.1).
   Note: At this point, the *Pattern* LED corresponding to *Port C* should be displaying the green colour to indicate test pattern continuity between the transmission ends. Specifically, you should be receiving no LSS defect.
4. If you are willing to run a one-way delay, configure the external synchronization input to either *ToD* or *GNSS* (See section 2.9).
   Note: At this point, the *Clock* LED should be displaying the green colour, and the *Locked* indication (*Internal reference status* field) in the *Clock setup* panel should be set to *Yes*.
5. Go to the *TEST* tab,
   The test configuration panel is displayed.
6. Go to *Delay test*.
   The latency test setup panel is displayed.
7. Start the delay test by configuring *Enable* to *Yes*.
8. Configure the *Measurement mode* to *Round trip* or *One-way*, depending on the test you want to do.
   Disconnect the unit from the network and connect the transmitter and the receiver corresponding to the test port through a short coaxial patch cable. If you are using a balanced interface, use a short RJ-48 loopback cable.
9. Configure Adjust zero offset to *Adjust* and wait for the value to change to *Ready*.
10. Set the *Zero offset (RTD), Zero offset (forward path)* and *Zero offset (return path)* fields if necessary.
11. Once you have calibrated the delay test, reconnect the unit to the network.
12. Optionally, enable the latency objectives with the help of the *Enable objectives* control.
13. If you have enabled the latency objectives in the previous step, configure *Threshold (RTD)*, *Threshold (forward path)* and *Threshold (return path)*.

Table 3.3: Delay settings

Setting	Description
Enable	Enables or disables the delay measurement. The delay measurement uses special test pattern bit marks that are detected as bit errors. If a measurement is started while the delay measurement is active, these errors will be recorded as normal bit errors. Delay pattern marks must not be confused with bit errors caused by network performance degradation.

Table 3.3: Delay settings

Setting	Description
Mode	It specifies the way the delay is measured. It is either *Round-trip* or *One-way*: • *Round-trip*: The equipment generates delay measurement marks and waits to receive its own marks after they have been transmitted through the network. • *One-way*: The test unit generates delay measurement marks but it waits for marks generated by the remote unit. These are used to calculate the return delay while the far end use the marks generated by the near end to compute the forward direction delay.
Adjust zero offset	This control calibrates the delay measurement result to zero. This is useful when the effect of cables or other elements has to be removed from the measurement.
Zero offset (RTD)	Removes a user configurable fixed offset to the round trip delay measurement. This setting is suitable when for any reason the automatic *Adjust zero offset* control cannot be used.
Zero offset (forward path)	Removes a user configurable fixed offset to the forward path delay measurement (*One-way* mode). This setting is suitable when for any reason the automatic *Adjust zero offset* control cannot be used.
Zero offset (return path)	Removes a user configurable fixed offset to the return path delay measurement (*One-way* mode). This setting is suitable when for any reason the automatic *Adjust zero offset* control cannot be used.
Enable objectives	Enables or disables Pass / Fail objectives for the latency test.
Threshold (RTD)	Configures the maximum allowed value for the round trip delay. Any RTD result larger than this threshold will generate a Fail verdict for the test.
Threshold (forward path)	Configures the maximum allowed value for the forward path delay in a one-way delay test. Any forward path latency result larger than this threshold will generate a Fail verdict for the test.
Threshold (return path	Configures the maximum allowed value for the return path delay in a one-way delay test. Any return path latency result larger than this threshold will generate a Fail verdict for the test.

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Once the equipment has been configured, it is ready to run the latency test. To do that follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The *Results* panel is displayed.
2. Go to Delay statistics
3. Check the *Current* value of the *Round-trip delay* (round trip delay tests) or the *Current* values of *Round-trip delay*, *Forward path delay*, *Return path delay* and *Asymmetry* (one way delay tests).
4. Program the test start time and duration with the help of the *Autostart/stop* menu (within *Test*) or start the test immediately by pressing *run*.
5. Wait for the test to finish or press *run* to finish immediately.
   Note: In fact, it is not necessary to wait until the test has finished. Partial results are presented in real time during test execution.
6. Check the *Maximum* and *Minimum* values of the *Round-trip delay* (round trip delay tests) or the *Maximum* and *Minimum* values of *Round-trip delay*, *Forward path delay*, *Return path delay* and *Asymmetry* (one way delay tests).
7. Check the Pass / Fail indication displayed on the top right corner in the *Delay* results panel.

Table 3.4: Delay results

Result	Description
Status	Displays the current testing status. is one of the following: • *Timeout*: No delay measurements detected within an acceptable time period. If this condition is declared the delay results are not valid. • *Acquiring*: Looking for valid delay measurement marks in the input interface. Delay results are not yet valid when this condition is declared. • *Local not sync*: No result can be computed because the local unit system clock is not properly synchronized. Check the ToD or GNSS synchronization in the near end unit. • *Remote not sync*: No result can be computed because the remote unit system clock is not properly synchronized. Check the ToD or GNSS synchronization in the far end unit. • *Unexpected loop*: The test unit is receiving its own test marks when measuring one-way delay but it shouldn't. Verify that the unit is receiving the marks from the remote unit.

Table 3.4: Delay results

Result	Description
Status	• *Correct*: Delay measurement marks detected on time. Delay results are now valid.
Round-trip delay	Displays the delay (round-trip delay) measured from the *Port C* output to the *Port C* input in *E1 / T1 endpoint* or *E1 / T1 through* modes. The same test is also available in the ITU-T G.703 / E0 and datacom, IEEE C37.94 and VF interfaces. Three different results related with the round trip delay are presented. The *Current* delay, the *Maximum* delay and the *Minimum* delay. The Current delay is an instant result that does not require a measurement to be started with the RUN button. The *Minimum* and *Maximum* delay store the minimum and maximum value displayed in the *Current delay* field along a measurement started with *run*. If there is no test running, then this field shows the minimum or maximum delay of the last test. Automatic and manual zero offset settings are considered when this result is presented.
Forward path delay	The *Forward path delay* is similar to the *Round-trip delay* but it is referred to the one-way delay computed between the local to the remote end.
Return path delay	The *Return path delay* is similar to the *Round-trip delay* but it is referred to the one-way delay computed between the remote to the local end.
Asymmetry	Displays the difference between the *Forward path delay* and *Return path delay* results in a one way delay test. It is a way to measure how different is the end-to-end delay in each transmission direction. Three different results related with the delay asymmetry are presented. The *Current* asymmetry, the *Maximum* asymmetry and the *Minimum* asymmetry. The *Current* asymmetry is an instant result that does not require a measurement to be started with the *run* button. The *Minimum* and *Maximum* asymmetry store the minimum and maximum value displayed in the *Current asymmetry* field along a measurement started with *run*. If there is no test running, then this field shows the minimum or maximum asymmetry of the last test.

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Table 3.4: Delay results

Result	Description
Remote host	If a one-way delay test is configured, it displays information about the far end, including the serial number of the unit installed there.

3.3.ITU-T G.711 Statistics

The test unit provides independent information about frequency and level for each time slot when it is configured for receiving framed 2048 kb/s signals. This test assumes that the information in the time slots is encoded as per ITU-T G.711 A law (E1 hierarchy) or G.711 µ law (T1 hierarchy).

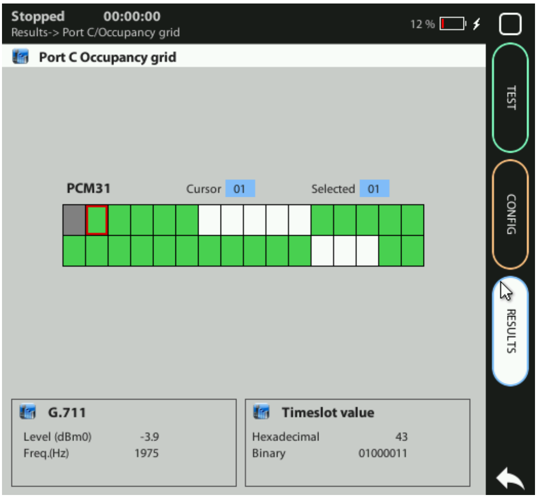

Figure 3.3: Occupancy Grid panel

The procedure to follow to read the G.711 results is the following:

1. From the *Home* panel, go to *Results*,
   The test configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific results.
3. Select *Occupancy* grid to display the G.711 results panel.
   Occupied time slots are represented in green colour, empty time slots are drawn in

white colour. The currently selected time slot has a red border.
Note: A time slot is considered to contain G.711 voice when the level is higher than -45 dBm and there are sign transitions. Otherwise, the time slot is considered to be empty from the point of view of this ITU-T standard.

4. Modify the currently selected time slot with the help of the cursors and press enter to confirm your selection.
G.711 results for the current time slot are displayed.
Note: To read the frame occupancy grid and the G.711 results you don't have to start a measurement first. These are permanent results.

Table 3.5: G.711 results

Setting	Description
Cursor	It represents the time slot that has the cursor in the graphical user interface. To mark a timeslot with the cursor just select it with the pointer.
Selected	Shows the time slot currently used for testing. All results in the *Occupancy Grid* panel are referred to the selected time slot. To select the timeslot with the cursor as the test timeslot, select it with the pointer.
Level (dBm0)	Power level for de current time slot measured in dBm0 as specified in ITU-T G.711.
Freq. (Hz)	Frequency for the current time slot measured in Hz. For a G.711 encoded signal with 8 kHz sampling frequency, the maximum allowed frequency is 4000 Hz.
Hexadecimal	Hexadecimal number that represents the last sampled value from the current time slot. The sampling frequency for time slot values is 1 Hz. This number is referred to the 8-bit PCM code that represents a G.711 A-law or G.711 μ-law compressed voice sample.
Binary	Binary 8-bit number that represents the last sampled value from the current time slot. The sampling frequency for time slot values is 1 Hz. This number is referred to the 8-bit PCM code that represents a G.711 A-law or G.711 μ-law compressed voice sample.

3.4. Voice Frequency Measurements

As voice telephone signals are transmitted through the network they may be subject to different processes such as amplification, filtering, encoding into digital formats and packetization. The network may also impair the signal by attenuating it, adding bit errors and by means linear and not linear distortion processes. The test unit measures these processes with the help of the *Analog* operation mode for voice frequency signals. When the equipment is configured in this mode, it accepts an analogue telephone signal in its audio input and measures its frequency, level and other parameters. It also generates harmonic tones in the analogue output that can be used as test signals.

Tests requiring tone generation and analysis over a VF interface require the installation in the unit of the PHM-23 module. This module provides the test interfaces required for interconnection to the DUT.

3.4.1. Measuring Frequency and Level

The procedure to set the *Analog* operation mode and run a simple frequency and level test in VF interfaces is as follows:

1. From the *Home* panel, go to *CONFIG.*
   The port configuration panel is displayed.
2. Set operation mode to *Analog.*
3. If necessary, configure the tone generator (See section 2.5).
4. Go to *RESULTS* tab.
   The *Results* panel is displayed.
5. Select *Analog*
   The voice frequency results panel is displayed.
6. Check the *Level (dBm0)*, *Freq. (Hz)* and the ITU-T G.711 signal code.
   Current, Minimum and Maximum value is displayed for each of these metrics. .

3.4.2. Frequency Sweep Test

The purpose of the frequency sweep test is to provide information about how analog signals is amplified or attenuated as it is transmitted through the network. With this objective, the test unit generates a sequence of harmonic tones with user configurable level and frequency and it records the power received for each of these tones. The transmitted and received levels are compared and a pass / fail result is generated based on this comparison.

The frequency sweep test is also capable of measuring the noise received from the transmission line. To do that it just records the received power when no signal is being transmitted.

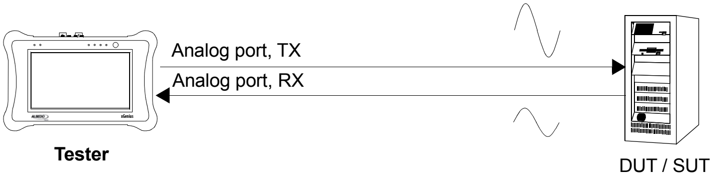

Figure 3.4: Frequency sweep test. The test unit generates a sequence of tones of varying frequency and measures the attenuation of these tones on reception.

Once the test unit has been connected to the network, follow this procedure to configure and run the frequency sweep test:

1. From the *Home* panel, go to *CONFIG.*
   The port configuration panel is displayed.
2. Set operation mode to *Analog.*
3. Go to *Analog*.
   The analog port settings are displayed
4. Configure *Signal* to *Tone*.
5. Go to the *TEST* tab.
   The *Test* configuration panel is displayed.
6. Go to *Analog*.
7. Configure *Analog test mode* to *Frequency response*.
8. Optionally, edit the analysis frequencies (*Freq. Hz*) and Pass / Fail thresholds (*Gain Thres.*) from the *Frequency configuration* menu.
9. Optionally, configure Trial duration (s.), to tell the unit how much time to devote to a single test iteration. There is one single iteration for each frequency to be measured.
10. Optionally, configure Level statistic.to either *Max* or *Min*.
    This parameter decides which statistic is displayed for each tone: minimum power (*Min*) or maximum power (*Max*). The test results, including the *Pass / Fail* verdict depend strongly on this setting.
11. Go to *RESULTS.*
    The *Results* panel is now displayed.
12. Go to *Frequency response*.
13. Press *run*.
    The test is started.

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14. Check the noise result on the top of the results panel. Check the *Gain* result for each configured frequency. If the *Gain* is larger than the threshold, the result will be displayed in red colour.

3.4.3. Delay Test

The test unit determines the one-way and two-way latency in a VF interface in the same way it is done in digital interfaces with the only difference that here a digital modulation has to be generated to distribute information about timing. This modulation is a simple 2-level digital amplitude modulation defined in standard ITU-T V.23. Other than that, test unit interconnection and configuration is quite similar to the E1 / T1 test case (See section 3.2). It follows an step by step description of the test procedure for VF:

1. From the *Home* panel, go to *CONFIG.*
   The port configuration panel is displayed.
2. Set operation mode to *Analog.*
3. Go to *Analog.*
   The analog port settings are displayed
4. Configure *Signal* to *V.23*.
5. If you are willing to run a one-way delay, configure the external synchronization input to either *ToD* or *GNSS* (See section 2.9).
   Note: At this point, the *Clock* LED should be displaying the green colour, and the *Locked* indication in the *Clock setup* panel should be set to *Yes*.
6. Go to the *TEST* tab.
   The *Test* configuration panel is displayed.
7. Go to *Delay test*.
   The latency test setup panel is displayed.
8. Start the delay test by configuring *Enable* to *Yes*.
9. Configure the *Measurement mode* to *Round trip* or *One-way*, depending on the test you want to do.
10. Disconnect the unit from the network and loop the TD and RD circuits to calibrate it.
    Note: In some situations, you may have to change the emulation mode (DTE or DCE) or the TD clock circuit (TC or TTC). These settings do not affect the result of the calibration but they must be configured again to the original values once the calibration process finishes.
11. Configure *Adjust zero offset* to *Adjust* and wait for the value to change to *Ready*.
12. Set the *Zero offset (RTD), Zero offset (forward path)* and *Zero offset (return path)* fields if necessary.
13. Once you have calibrated the delay test, reconnect the unit to the network.
14. Optionally, enable the latency objectives with the help of the *Enable objectives* control.
15. If you have enabled the latency objectives in the previous step, configure *Threshold (RTD)*, *Threshold (forward path)* and *Threshold (return path)*.

3.5. Verifying Pulse Mask Compliance

The test unit verifies that the pulse shape detected at the input of E1 or T1 ports is compliant with the pulse mask specified in ITU-T G.703. Pulse mask analysis is available for the Port C balanced and unbalanced inputs. The operation modes compatible with the G.703 pulse analysis are the *E1/T1 endpoint* and *E1/T1 through* modes. If you want to display the pulse shape and assess compliance with ITU-T G.703 you have to follow these steps:

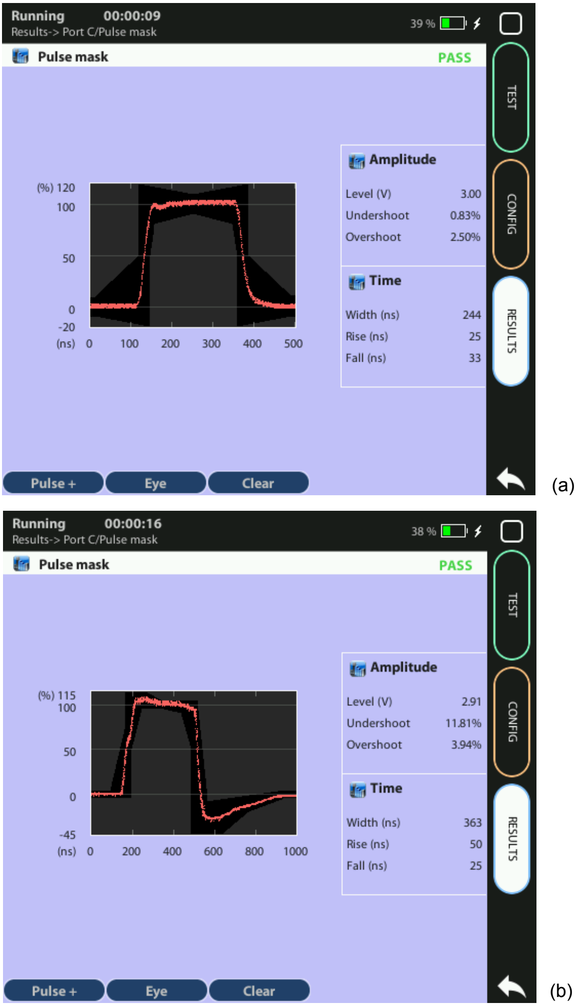

Figure 3.5: xGenius pulse shape analysis panel: (a) E1 pulse mask, (b) T1 pulse mask.

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1. From the *Home* panel, go to *TEST.*
   The *Test* configuration panel is displayed.
2. Enable *Pulse mask analysis*.
   Note: This is possible only in compatible modes (*E1/T1 endpoint* and *E1/T1 through*).
3. From the *Home* panel, go to *RESULTS.*
   The *Results* panel is displayed.
4. Select *Port C* to enter in the port specific results menu.
5. Select *Pulse mask*
   The pulse shape diagram and pulse metrics are displayed.
6. Set the pulse you want to display: *Pulse +*, to display the positive pulse, *Pulse -* for the negative pulse and *Pulse +/-* to display both at the same time.
7. Set the analysis mode to *Normal* (single pulse) or *Eye* (eye diagram).
   Note: In Eye mode, you can reset the displayed shape by pressing the *Clear* contextual button. If you leave the *Pulse* mask panel, the diagram will be reset as well.
8. If you want to run a test with pulse shape pass / fail indication, use the *run* key to start a measurement. The corresponding Pass / Fail indication is shown in the screen and, if report generation is enabled, it will be stored in the corresponding report.

Table 3.6: Pulse mask results

Setting	Description
Level (V)	This result is the pulse amplitude measured in Volt after a transition from 0 V and once this tension is considered to be stable. For *Pulse -*, the sign is changed from negative to positive. For *Pulse +/-*, this field shows the worst case amplitude between the positive and negative pulses.
Undershoot	This field is the peak minimum amplitude achieved after a transition to 0 V. The *Undershoot* is measured in percentage of the measured pulse level and the sign is not considered. For *Pulse +/-*, this field shows the worst case amplitude between the positive and negative pulses.
Overshoot	This field is the peak maximum amplitude achieved after a transition from 0 V. The *Undershoot* is measured in percentage of the measured pulse level and the sign is not considered. For *Pulse +/-*, this field shows the worst case amplitude between the positive and negative pulses.

Table 3.6: Pulse mask results

Setting	Description
Width (ns)	Time period between a transition from 0 V to the next transition to 0 V. The beginning and the end of this period is computed using the half (50% of the measured amplitude) pulse amplitude. For *Pulse +/-*, this field shows the worst case (largest) time computed for the positive and negative pulses.
Rise (ns)	In the pulse transition from 0 V, this is the time required to go from 10% to 90% of the measured amplitude. For *Pulse +/-*, this field shows the worst case (largest) time computed for the positive and negative pulses.
Fall (ns)	In the pulse transition to 0 V, this is the time required to go from 90% to 10% of the measured amplitude. For *Pulse +/-*, this field shows the worst case (largest) time computed for the positive and negative pulses.

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Chapter 4
Jitter Generation and Analysis

Jitter is defined as short-term variations of the significant instants of a digital signal from their reference positions in time. In other words, it is a phase oscillation with a frequency higher than 10 Hz. Jitter causes sampling errors and provokes slips in the *phase-locked loops* (PLL) buffers.

The test unit is able go generate and analyse jitter to make sure that the phase fluctuations in network equipment outputs remain under the limits specified by the standards.

4.1. Jitter Metrics and Measurement

The parameters that characterize the jitter of a digital signal are amplitude and frequency. The amplitude quantifies the extent to which a significant instant deviates from its nominal reference position. The frequency tells us how quickly this significant instant is moving relative to its ideal position in time.

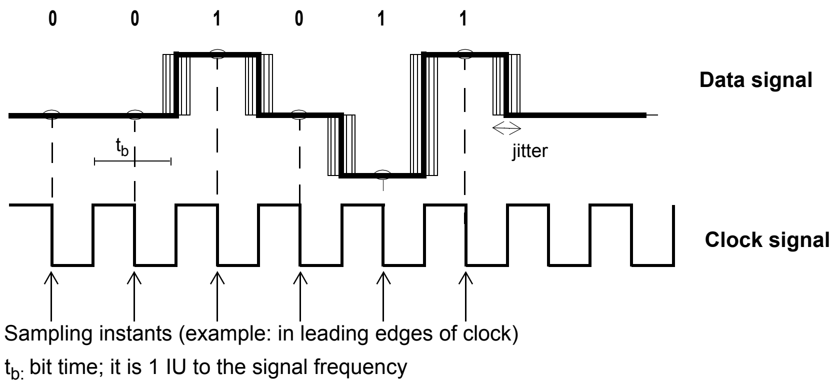

Figure 4.1: Definition of unitary interval.

If we look at the amplitude of phase fluctuation with time as a periodic signal, when its frequency is higher than 10 Hz, the fluctuation is said to be fast, and this is jitter. Phase fluctuation is not usually a periodic signal in real cases, and for this reason we analyse the presence of frequency components in its spectrum above or below 10 Hz, to determine if what we have is jitter or wander.

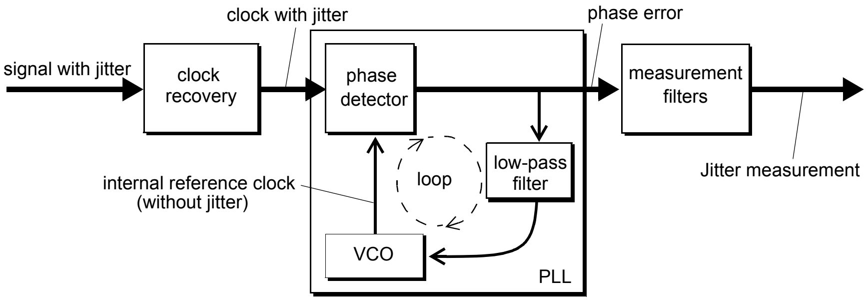

Figure 4.2: The jitter measurement does not need an external reference clock because it is recovered from the incoming signal to be tested.

4.1.1. Unitary interval

It is usual to measure jitter amplitude in terms of a relative unit. This unit is normalized in respect to the signal rate, and is called a unitary interval (UI). A unitary interval is defined as the time equivalent to the bit time for the work rate in question. Thus, a unitary interval for a 2048 kb/s signal corresponds to approximately 488 ns, whereas a UI for an SDH STM-1 signal (155.52 Mb/s) corresponds to 6.4 ns.

4.1.2. Jitter measurement filters

The simplest jitter measurements have the goal of obtaining peak-to-peak amplitude values in UI within a specific frequency band over a specific measurement interval. This means that any instrument capable of measuring these fluctuations must have a bank of weighting filters that limit the band of the signal measured. These filters (in terms of their frequency cut-offs and slopes) are defined by ITU-T Recommendations.

ITU-T G.823 establishes the levels of jitter that can be found in PDH interfaces, from 64 kb/s to 140 Mb/s. In the same way, Telcordia GR-499 deals with the jitter related to T-carrier 1.5 and 45 Mb/s interfaces. Two measurement filters are specified:

- *Wideband*: This filter measures jitter over the whole band of frequencies on which phase fluctuation is thought to exist, and the band depends on the specific hierarchical interface. This filter is specified between the frequencies HP1 and LP (high-pass filter and low-pass filter, respectively).
- *Highband*: This filter allows us to characterize the spectral distribution of the high frequency jitter, which is the jitter most likely to cause problems in clock recovery circuits. This filter is specified between the frequencies HP2 and LP.

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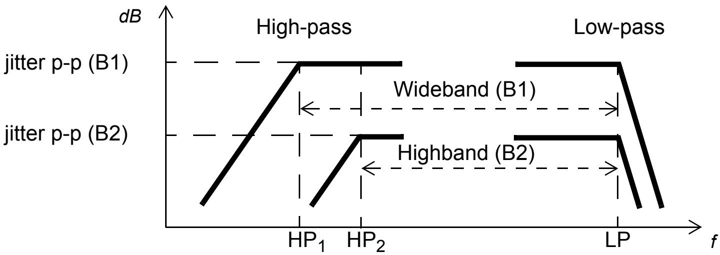
In short, weighting the measurement using filters serves to determine the spectral content of jitter in each frequency band (pass bands of the programmed filters). These weightings allow conclusions to be drawn when problems appear, or even enable us to predict them. For instance, a concentration of energy in a specific low frequency band may result in specific synchronization problems, or problems in operating the terminal equipment.



Rate	B_1	B_2
64 kb/s	0.25	0.05
2 Mb/s	1.5	0.2
8 Mb/s	1.5	0.2
34 Mb/s	1.5	0.15
140 Mb/s	1.5	0.075

Rate	HP_1	HP_2	LP
64 kb/s	20 Hz	3 kHz	20 kHz
2 Mb/s	20 Hz	18 kHz	100 kHz
8 Mb/s	20 Hz	3 kHz	400 kHz
34 Mb/s	100 Hz	10 kHz	800 kHz
140 Mb/s	200 Hz	10 kHz	3,500 kHz

Figure 4.3: Jitter measurement filters for PDH and maximum jitter values as per G.823.

4.1.3. Measurement interval

As mentioned before, a jitter amplitude measurement must be carried out over a given measurement interval. The usual measurement period is 60 seconds, although when measuring certain types of jitter, longer periods are required due to pointer adjustments (phase quantization), as these occur sporadically.

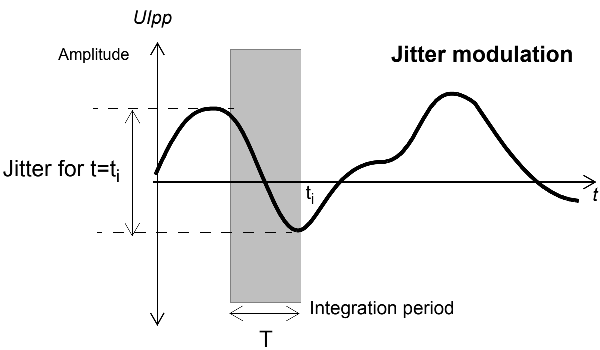


Figure 4.4: The integration period is the time interval measuring the jitter.

4.2. Jitter Analysis

This measurement attempts to obtain the jitter amplitude (expressed in UIs) present in the output port of a specific network equipment. The ITU-T specifies and limits the maximum amount of jitter allowed in a network. In particular, ITU-T G.825 (SDH) and G.823 (PDH), and Telcordia GR-253 (SONET) and GR-499 (T-carrier), limit the maximum amount of jitter in network equipment output ports. This output jitter may be generated by the equipment itself, or may result from the transfer of jitter from one of the inputs of the element, either the data input or the synchronization input. The result of the measurement is the jitter amplitude in a specific bandwidth, specified by the above-mentioned recommendations for each rate in the PDH and SDH hierarchies. Should we wish to measure the jitter generated by the NE, we need to connect an input signal free of jitter.

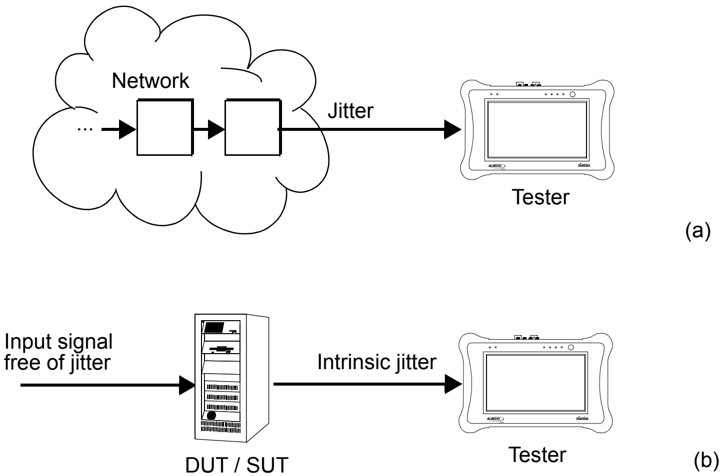


Figure 4.5: (a) Jitter in output port: General case. (b) Intrinsic jitter. DUT is the NE.

xGenius analyses jitter in *Port A* optical (IEEE C37.94 interfaces, PHM-21) and Port C (E1, T1 and frequency interfaces) but the following paragraphs deal only with the E1 / E1 test, which runs over *Port C*.

Some results provided by the jitter analyser are controlled by the *run* button and some others are available even if there is no ongoing test. All phase measurement LEDs (LVL, PLL and HIT) and real-time values of the rms and peak-to-peak jitter amplitudes are always available. Maximum peak-to-peak jitter and hit counts are controlled by the *run* button.

Basic information of the phase measurement function is available from de LED panel. The operation and meaning of the phase measurement LEDs is similar to any other

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xGenius LED. More complete results from the jitter analyser are available in an specific result panel but before obtaining valid results, the jitter analyser has to be configured form the *Port C* settings panel. The procedure for configuring the jitter analyser is as follows:

Table 4.1: Phase measurement LEDs

Event	Description
LVL	Indicates that there is enough signal power to carry out the phase impairment analysis. The signal level required for jitter tests is higher than for signal detection and decoding. That means that you can experience an LVL event without a LOS.
PLL	Event that shows that the jitter measurement PLL is unable to track the phase of the incoming signal. Depending on the jitter analysis settings, the measurement PLL may need a few seconds to stabilize before the phase readings are correct. During this time, the PLL event will be active and the colour displayed by the LED will be red. The information displayed by the PLL LED is equivalent to the value of the *PLL locked* field displayed in the *Jitter results* panel.
HIT	Hit event detected. A hit happens every time the jitter amplitude surpasses the user configurable hit threshold.

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Set operation mode to *E1/T1 endpoint*, *E1/T1 monitor*.
3. Go to *TEST* tab.
   The *Test* configuration panel is displayed.
4. In the *Jitter test* field, configure *Generation & analysis.*
5. Go to *CONFIG* tab again.
   The *CONFIG* configuration panel is displayed.
6. Select *Port C* to enter in the port specific configuration menu.
7. Go to the *Jitter analyser* menu.
8. Configure the integration period for your jitter measurement (1 s, 10 s or 60 s) with the help of the *Integration period* control.
9. Configure an extended jitter measurement band (> 0.1 Hz, >1 Hz) or the standard jitter band (10 Hz) in *Band range*.
10. If necessary, configure a jitter measurement filter with *Filter*.

11. If you want to detect hits, enter the *Hit threshold* in UIpp.

Table 4.2: Jitter analyzer settings

Event	Description
Integration period	This setting accounts for how much time is the jitter observed before displaying its value. The jitter measurement has a sliding window mechanism that is used to compute jitter peak-to-peak and rms values. The integration period is the length of the measurement sliding window.
Band range	Jitter is usually defined as a phase impairment with frequency above 10 Hz but the test unit can use extended measurement bands for jitter beyond the 10 Hz. This control sets the jitter measurement loop frequency response to select the standard or one of the extended bands for measuring jitter. The available options for this setting are the following: • *> 0.1 Hz*: Selects the 0.1 Hz extended jitter measurement band. This band accounts for phase impairments with periods of up to 10 s. • *> 1 Hz*: Selects the 1 Hz extended jitter measurement band. This band accounts for phase impairments with periods of up to 1 s. • *> 10 Hz*: Selects the 10 Hz standard jitter measurement band. This band accounts for phase impairments with periods of up to 0.1 s.
Filter	The jitter amplitude can be filtered by High-Pass (HP) and Low-pass (LP) filters before being represented to make sure that only the important frequency components are taken into account. The pass and stop bands of these filters is specified by ITU-T O.172. Unlike the measurement bandwidth set by the *Band range* control, the measurement Filter applied by this control are applied after the signal passes through the jitter measurement PLL. The tester supports the following filtering settings: • *None*: It applies no filters to the output of the jitter measurement PLL. The whole band is taken into account by the tester.

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Table 4.2: Jitter analyzer settings

Event	Description
	• *LP*: Applies the LP filter defined in ITU-T O.172 for jitter measurements. This filter has a cut-off frequency at 100 kHz (E1 interface) or 40 kHz (T1 interface). • *HP1 + LP*: Applies at the same time the HP1 and the LP filters as they are defined by ITU-T O.172. The result is that the jitter measurement pass band stands between 20 Hz and 100 kHz (E1 interface) or 10 Hz and 40 kHz (T1 interface). • *HP2 + LP*: Applies at the same time the HP2 and the LP filters as they are defined by ITU-T O.172. The result is that the jitter measurement pass band stands between 18 kHz and 100 kHz (E1 interface) or 8 kHz and 100 kHz (T1 interface). • *RMS + LP*: Applies at the same time a 12 kHz HP and the ITU-T O.172 LP filter for 2048 kb/s bit rate. The resulting measurement pass band stands between 12 kHz and 100 kHz.
LP filter cut-off	This is an informative field that can not be set by the user. It displays the cut-off frequency corresponding with the currently configured LP filter (if there is any).
HP filter cut-off	This is an informative field that can not be set by the user. It displays the cut-off frequency corresponding with the currently configured HP filter (if there is any).
Hit threshold (UIpp)	Configures the threshold used to account for phase hit events in UIpp.

Once the analyser has been configured, you can go to the jitter results panel to check test results:

1. From the *Home* panel, go to *RESULTS*,
   The results panel is displayed.
2. Select *Port C* to enter in the port specific results menu.
3. Go to *Jitter*.
4. Make sure that the PLL is tracking the phase of the incoming signal with the help of the *PLL locked* field.
5. Check the *Current (pp)* and *RMS* jitter amplitude values.
6. If you want to analyse the maximum jitter amplitude, the hit count and the hit seconds start a measurement with *run* or program a test.
   While the test is running, the maximum jitter and hit counts are upgraded in real time.

7. Wait for the test to finish (programmed tests only) or finish the test by pressing *run* a second time.
8. Check the final maximum jitter amplitude and hit counts.

Table 4.3: Jitter results

Event	Description
PLL locked	Displays information about the current jitter measurement PLL status. Jitter results are not valid until this field value is *YES*. Depending on the jitter analysis settings, the measurement PLL may need a few seconds to stabilize before the phase readings are correct. During this time, the PLL locked status will be NO. The information displayed by this field is equivalent to the value of the PLL LED displayed within the LEDs panel.
Current (pp)	Current peak-to-peak jitter expressed in UIpp and referred to the configured measurement band (LP, HP1, HP2 and RMS filters) and integration period. This result is available even if a test has not been started with the *run* button.
Maximum (pp)	Maximum jitter computed from the beginning of a test. This field stores the maximum value displayed in the *Current (pp)* field along a measurement started with RUN. If there is no test running, then this field shows the maximum jitter of the last test.
RMS	Current root mean squared (rms) jitter measured referred to the configured measurement band (LP, HP1, HP2 and RMS filters) and integration period. This result is available even if a test has not been started with the *run* button.
Hit count	Total number of hit events detected from the beginning of a test. A hit happens every time the jitter amplitude surpasses the user configurable hit threshold. The hit count measurement is controlled with the *run* button.
Hit seconds	Total number of seconds which contain at least one hit event detected from the beginning of a test. The hit seconds measurement is controlled with the *run* button.

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4.3. Jitter Generation

Jitter generation is required to verify the ability of a network element to attenuate or amplify phase impairments. To quantify the maximum jitter amplitude a network element is able to absorb without generating signal anomalies or defects it is also necessary to generate jitter in a controlled way.

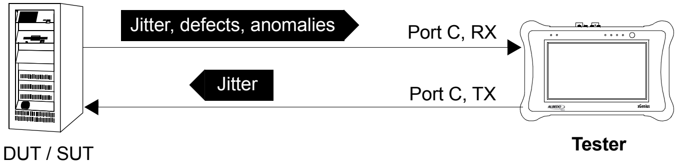

Figure 4.6: Jitter generator. The jitter generator is used to stress a network elements. Jitter may produce more jitter or errors in some output interfaces of this equipment that can be analysed by a tester. This tester may be the same jitter generator.

xGenius generates E1 and T1 jitter in the *Port C* only Moreover, jitter generation is not compatible with the *E1 monitor* and *E1 through* operation modes. To configure the jitter generator follow these steps.

1. From the *Home* panel, go to *CONFIG*.
   The test port configuration panel is displayed.
2. Set operation mode to *E1/T1 endpoint*.
3. Go to the TEST tab.
   The *Test* configuration panel is displayed.
4. In the *Jitter test* field, configure *Generation & analysis.*
5. Go to *CONFIG* tab.
   The *Setup* configuration panel is displayed.
6. Select *Port C* to enter in the port specific configuration menu.
7. Go to the *Jitter generator* menu.
8. Enable the jitter generator with the *Enable* control.
9. Set the *Modulation waveform* to *Sinusoidal*
   Note: Sinusoidal is the only waveform currently available for the jitter modulating signal.

10. Configure the frequency and amplitude of the jitter modulating signal.
    Note: Maximum amplitude depends on the frequency. Check the maximum amplitude allowed for the current frequency before setting the *Amplitude* field.

Table 4.4: Jitter generation settings

Event	Description
Enable	Enables or disables the jitter generator. If the generator is disabled, the Port C transmit signal will not contain any phase impairment other than the intrinsic jitter generated by the internal tester circuitry. If it is enabled, the phase will be modulated by the signal specified by the *Modulation waveform*, *Amplitude (UIpp)* and *Frequency* controls.
Modulation waveform	Modulating signal to be applied to the phase of the test signal generated by the tester. The only one possible configuration for the modulating waveform is currently *Sinusoidal,* that sets an harmonic modulating signal.
Amplitude (UIpp)	Sets the peak-to-peak amplitude of the modulating signal in UIpp. The maximum allowed value for this field depends on the *Frequency*. You can configure higher amplitude values if the frequency is smaller.
Max. amplitude (UIpp)	This is an informative field that can not be set by the user. It displays the maximum amplitude, expressed in UIpp, allowed for the *Amplitude (UIpp)* field. The maximum amplitude depends on the value of the *Frequency* field.
Frequency	Sets the frequency of the phase modulating signal in Hz or kHz.

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Chapter 5
Wander Generation and Analysis

When the phase fluctuation, presented by the signal received is fast enough, the circuits may not be able to track these fluctuations (absorb them). It is in such cases that the sampling instants of the clock obtained from the signal may not coincide with the correct instants, producing bit anomalies.

In the case of slow phase fluctuations, known as wander, the previously described effect does not occur. However, wander is propagated through the network and because it is never absorbed, it is accumulated causing jitter, slips and bit errors due to pointer adjustments and mapping / demapping processes.

5.1. The Metrics of Wander

Given that wander is a slow phase fluctuation (with spectral components below 10 Hz), wander measurements require long periods of time. It is also necessary to detect phase transients during these measurements, which calls for high temporal resolution, and, as a result, there is a considerable accumulation of data. With the aim of summarizing all this information, three parameters are defined below that are fundamental in measuring wander: TIE, MTIE, and TDEV.

5.1.1. TIE

The *time interval error* (TIE) is the slow phase fluctuation amplitude, which means that it indicates the phase variation of the clock to be measured, relative to the phase of an ideal reference clock during each instant of the measurement. Usually, TIE=0 is taken as a reference at the start of the measurement. The TIE is expressed in absolute time (ns, μs, ms).

5.1.2. MTIE

The *maximum time interval error* (MTIE) is the maximum value of peak-to-peak TIE in a certain observation time, τ. This means that in order to calculate the MTIE, a time window must be scrolled over the function TIE (t), recording the maximum peak-to-peak value of the TIE. This can be repeated for different values of τ, thus obtaining a graph of MTIE (τ).

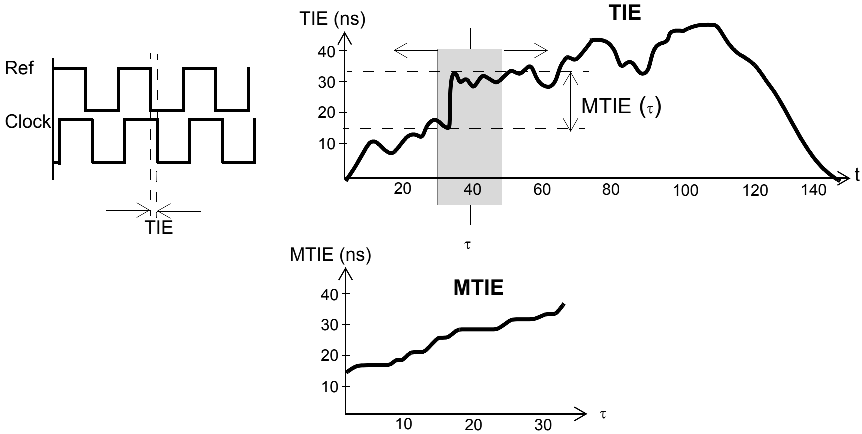

Figure 5.1: MTIE (τ): maximum peak-to-peak amplitude of the slow phase fluctuation or TIE in an observation window τ.

5.1.3. TDEV

Time deviation or TDEV is a measurement that characterizes the spectral content of a TIE (t) signal. This means that it measures the energy of wander frequency components. As is the case with MTIE, the TDEV is a function of the observation time τ.

The TDEV test can be understood by the operation performed by two processing blocks applied sequentially to the TIE (t) signal. The first block, H (f), is a filter with its pass-band 1/τ centered on the value 0.42/τ. The analysis is therefore limited to the pass-band mentioned before. The second block calculates the value of the root mean square (rms), which evaluates the energy of the components in the band being analysed. By varying the value of τ, we can then analyse the different frequency bands that are of interest to us. The above considerations have ITU-T G.810 and ANSI T1.101 as their source.

For a correct calculation of the TDEV, it is recommended that the length of the measurement be 12τ, although 3τ is usually enough; that is, we must have samples of TIE in at least the time interval (0, 3τ), with t=0 being the starting instant of the measurement. Given that the TDEV is an rms value, it is always positive, as a sum of squares.

The TDEV lets us evaluate the stability of the clock signal. We can characterize the transfer of wander in the network element used, in order to limit the build-up of this

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phase fluctuation (ITU and ETSI specifications on the transfer of wander between the ports of a synchronization source - clock - specify this transfer in terms of TDEV).

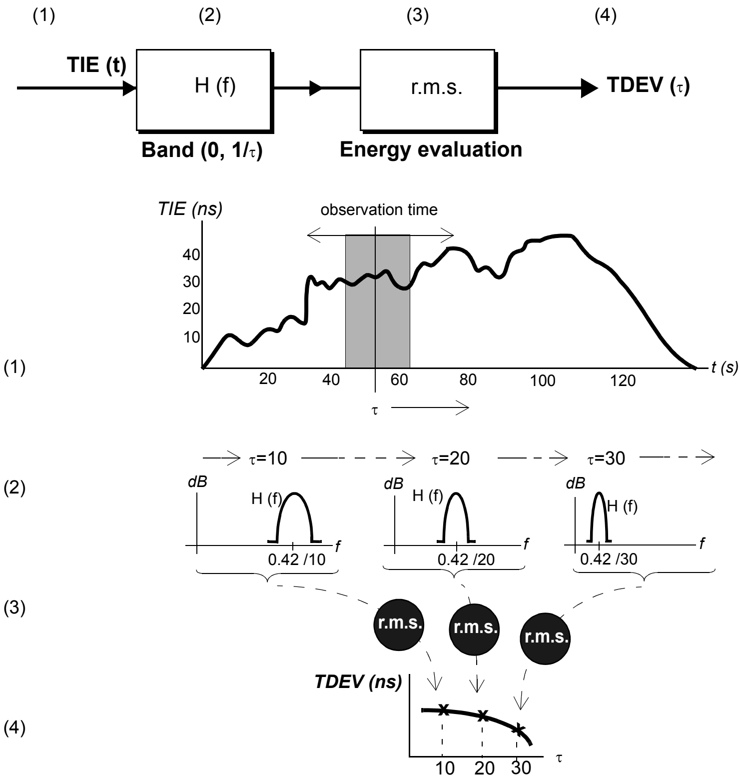

Figure 5.2: Calculation of the TDEV step by step. (1) for each window size swept; (2) low pass filter; (3) measurement of the rms value; and (4) new TDEV point.

Furthermore, the TDEV converges for all common types of phase noise, which makes it possible to identify the source and eventually correct the causes of degradation in transmission.

Table 5.1: TDEV slope for some types of phase noise.

Noise	Slope of the TDEV
White noise phase modulation (WPM)	-1/2
Flashing phase modulation (FPM)	0
White noise frequency modulation (WFM)	1/2
Random walk frequency modulation (RWFM)	3/2

5.2. Measuring Output Wander

xGenius computes the amount of wander present in *Port A* optical (IEEE C37.94 interfaces, PHM-21) and *Port C* (E1, T1 and clock interfaces) but the following paragraphs deal only with the E1 / E1 test, which runs over *Port C*.

Wander measurements can be configured in xGenius to run on internal clock or an external reference signal. Measurements with external reference require connecting the DUT / SUT to the test unit *Port C* and the reference to one of the available reference inputs (See section 2.9). The test unit must be configured in *E1/T1 endpoint, E1/T1 monitor* or *E1/T1 through* mode.

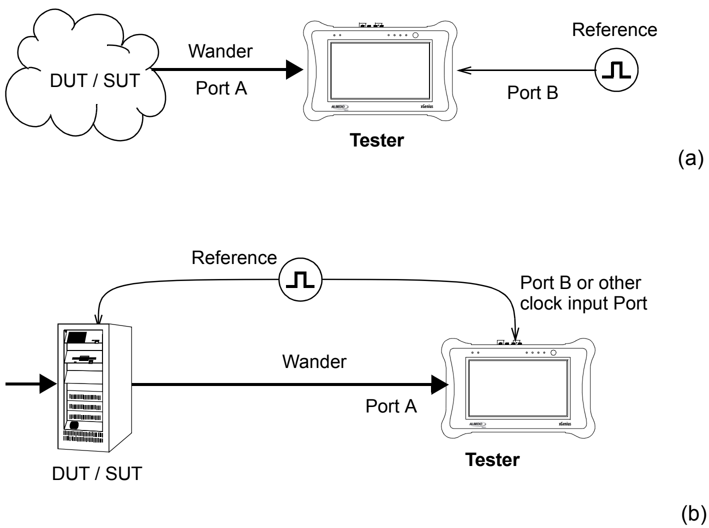

Figure 5.3: Measuring output wander: (a) in a network interface, the analyser is synchronized with a clock free of wander; and (b) in the interface of a device; the device and the analyser are synchronized using a common reference clock.

To configure the output wander test follow this procedure:

1. From the *Home* panel, go to *CONFIG*
   The port setup configuration panel is displayed.
2. Set operation mode to *E1/T1 endpoint,E1 /T1 monitor* or *E1/T1 through*.
3. Select *Port C* to enter in the port specific configuration menu.

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4. Configure the *Port C*, *Hierarchy*, *Connector*, *Line, TX frame, RX frame* and *Test pattern* to the right values (See section 2.3).
5. Go to the *TEST* tab.
   The test configuration panel is displayed.
6. In the *Wander test* field, configure *Generation & analysis*.
7. If you are using an external timing reference, enable it (See section 2.9).
   Note: If the reference is enabled and accepted the *REF* led should be green.

Table 5.2: Phase measurement LEDs

Event	Description
REF	This led indicates the presence or absence of a reference input signal. The REF led will not be lit if the Port B is not configured as a reference input.
LCK	It shows whether the local oscillator is locked to the external reference or not. The local oscillator must be locked before testing could start. In units with Rubidium oscillator, the LCK led displays green colour when the unit is still in *fine locking* status, which means that the unit is ready for most tests but it has not yet achieved its maximum accuracy.
LVL	Indicates that there is enough signal power to carry out the phase impairment analysis. The signal level required for wander tests is higher than for signal detection and decoding. That means that you can experience an LVL event without a LOS.
OVF	This led indicates a phase measurement overflow. Maximum TIE is ±2 s and the OVF alarm is enabled if the TIE is out of this range. Wander measurements may be wrong if the OVF event is has been enabled during the test.

Some wander results (*TIE*, *Offset*, *Drift*) can be read without the need to start a new measurement. The results that require to start a test with *run* (maximum offset, maximum drift) may be optionally stored and included in a report but this is not possible with the instant results. The procedure to display wander amplitude and related metrics is the following:

Table 5.3: Wander analysis results for E1 / T1 interfaces

Event	Description
Reset TIE	This control sets the value displayed in the TIE field to 0. *Note*: The TIE is restarted every time a new test runs. The *Reset TIE* control can used only if there is not an ongoing test.
TIE / TE	Displays the current *Time Interval Error* (TIE). The TIE is the cumulative phase error from the beginning of the test (or the last *Reset TIE* action) computed in time units. The allowed dynamic range for the TIE is ±2 s. Results out of this range will generate an overflow (*OVF*) event.
Min. TIE	Maximum TIE value registered from the beginning of the test, either negative or positive, computed in time units.
Max. TIE	Minimum TIE value registered from the beginning of the test, either negative or positive, computed in time units.
Offset	Difference between the frequency of the received signal and the reference signal frequency measured in parts per billion (ppb). Measurement of the frequency offset does not require to run a measurement. It is a permanent result that is available even if there is not an ongoing test.
Max. offset	Maximum frequency offset registered from the beginning of the test. The sign is not considered when the maximum offset is computed. For example, if the measured offset values are between -4 ppb and +3 ppb, the recorded maximum offset will be -4 ppb.
Drift	Change rate of the frequency offset expressed in parts per million per second (ppb/s).
Max Drift	Maximum frequency drift registered from the beginning of the test. The sign is not considered when the maximum offset is computed. For example, if the measured drift values are between -4 ppb/s and +3 ppb/s, the recorded maximum drift will be -4 ppb/s

1. From the *Home* panel, go to *RESULTS*,
   The Results panel is displayed.
2. Select *Port C* to enter in the port specific results menu.

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3. Go to *Wander*.
4. Select *Wander analysis*.
   The wander amplitude and related metrics are displayed.
5. Check the values of the instant results: *TIE*, *Offset*, *Drift.*
   Note: TIE value may be wrong if an overflow (*OVF*) event is registered. The *Reset TIE* contextual button sets the *TIE* value to zero at any time.
6. If you want to analyse the *Min. TIE*, *Max. TIE*, *Max. offset* and *Max. drift*, start a measurement with *run* or program a test.
   The *TIE* is set to zero even if the *Reset TIE* button is not pressed.
   While the test is running, *Min. TIE, Max. TIE, Max. offset* and *Max. drift* (and also *TIE*, *Offset* and *Drift*) results are upgraded in real time.
7. Wait for the test to finish (programmed tests only) or finish the test by pressing *run* a second time.
8. Check the final *Min. TIE, Max. TIE, Max. offset* and *Max. drift* results

5.3. Wander Generation

Wander generation can be used to stress network elements and see how phase modulation is accumulated as it is propagated. xGenius generates wander in *Port A* optical (IEEE C37.94 interfaces) and *Port C* (E1, T1 and clock interfaces) but the following paragraphs deal only with the E1 / E1 test, which runs over *Port C*. Moreover, wander generation is not compatible with the *E1/T1 monitor* and *E1/T1 through* operation modes. To configure the wander generator follow these steps.

1. From the *Home* panel, go to *CONFIG*.
   The test port configuration panel is displayed.
2. Set operation mode to *E1/T1 endpoint*.
3. Go to the *TEST* tab.
   The *Test* configuration panel is displayed.
4. In the *Wander test* field, configure *Generation & analysis*.
5. If you are using an external timing reference, enable it (See section 2.9).
   Note: If the reference is enabled and accepted the *REF* and *LCK* LEDS should become green.
6. Go back to the *CONFIG* tab.
   The test port configuration panel is displayed again.
7. Select *Port C* to enter in the port specific configuration menu.
8. Go to the *Wander generator* menu.
9. Enable the wander generator with the *Enable* control.
10. Set the *Modulation waveform* to *Sinusoidal*
    Note: *Sinusoidal* is the only waveform currently available for the wander modulating signal.

11. Configure the frequency and amplitude of the wander modulating signal.
    Note: Maximum amplitude depends on the frequency. Check the maximum amplitude allowed for the current frequency before setting the *Amplitude* field.

Table 5.4: Wander generation settings

Event	Description
Enable	Enables or disables the wander generator. If the generator is disabled, the Port A transmit signal will not contain any wander phase modulation. If it is enabled, the phase will be modulated by the signal specified by the *Modulation waveform*, *Amplitude (pp)* and *Frequency* controls.
Modulation waveform	Modulating signal to be applied to the phase of the test signal generated by the tester. The only one possible configuration for the modulating waveform is currently *Sinusoidal,* that sets an harmonic modulating signal.
Amplitude (pp)	Sets the peak-to-peak amplitude of the modulating signal in time units. The maximum allowed value for this field depends on the *Frequency*. You can configure higher amplitude values if the frequency is smaller.
Max. amplitude (pp)	This is an informative field that can not be set by the user. It displays the maximum peak-to-peak amplitude, expressed in time units, allowed for the *Amplitude (pp)* field. The maximum amplitude depends on the value of the *Frequency* field.
Frequency	Sets the frequency of the phase modulating signal in µHz, mHz or Hz.

5.4. Measuring MTIE/TDEV

The aim of this measurement is to quantify the amount of wander present in a network interface or a device. This quantification is usually made in terms of MTIE and TDEV.

Synchronization signals are distributed through SDH sections (STM-*n*) and PDH paths. The ETSI standard EN 300 462-3, ITU-T recommendations G.811, G.812, G.813 and others establish masks showing the limits of MTIE and TDEV, where applicable.

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The masks refer directly to each type of interface, that is, the TDEV and the MTIE are represented relative to the output wander of a PRC, an SSU, an SEC or a PDH output.

Table 5.5: MTIE / TDEV settings

Event	Description
Observation time	Maximum window length for MTIE and TDEV results. The measurement is automatically stopped when the observation time is reached. Currently allowed values for the *Observation time* are *100 s*, *1000 s*, *10000 s*, *100000 s* and *1000000 s*. *Note*: An MTIE / TDEV measurement may stop before reaching the maximum observation time if the autostop setting is configured to a value below the observation time.
Mask source	Configures the origin of the MTIE and TDEV masks to be used in the next measurement. The only currently allowed mask source is *Standard*, that configures the MTIE / TDEV mask from an ITU-T or an ETSI standard
Standard mask	Selects the MTIE and TDEV mask to be used in the next measurement when Mask source is set to *Standard*. Masks belong to one of four different groups: • Masks for TDM interfaces. This group contains the *PDH G.823 / EN 300 462-3-1*, *PDH G.8261 CES 2048 kb/s (1)*, *PDH G.8261 CES 1544 kb/s (1)* and *PDH G.8261 CES (2A)*. • Masks for *Primary Reference Clock* (PRC) outputs. These are the *PRC G.811, PRC G.823* and *PRC EN 300 462-3-1* masks. • Masks for *SDH Equipment Clock* (SEC) outputs, including the *SEC G.823 / EN 300 462-3-1*, *SEC G.813 / EEC G.8262 Constant Temperature (1)*, *SEC G.813 / EEC G.8262 Constant Temperature (2)*, *SEC G.813 Holdover (2)*, *SEC G.813 / EEC G.8262 Noise tolerance (1)*, *SEC G.813 / EEC G.8262 Noise tolerance (2)*, *SEC G.813 Noise transfer (2)*, *SEC G.813 Ref. sw. / EEC G.8262 Phase disc. (2), SEC G.813 / EEC G.8262 Variable temperature (1)*.

Table 5.5: MTIE / TDEV settings

Event	Description
Standard mask	• Masks for *Synchronization Supply Unit* (SSU) outputs. These are the *SSU G.823 / SSU EN 300 462-3-1*, *SSU G.812 Noise Generation (CT)*, *SSU G.812 Noise Generation (VT)*, *SSU G.812 Noise Tolerance* and *SSU G.812 Noise Transfer*. • Masks for *Ethernet Equipment Clock (EEC)* interfaces: *EEC G.8261 (1)*, *EEC G.8261 (2)*, *SEC G.813 / EEC G.8262 Constant Temperature (1)*, *SEC G.813 / EEC G.8262 Constant Temperature (2)*, *SEC G.813 / EEC G.8262 Noise tolerance (1)*, *SEC G.813 / EEC G.8262 Noise tolerance (2), SEC G.813 Ref. sw. / EEC G.8262 Phase disc. (2), SEC G.813 / EEC G.8262 Variable temperature (1).* • Masks for packet interfaces: *PEC G.8261.1*, *PEC G.8263 Constant temperature*, *PEC G.8263 Variable temperature*, *PTP G.8271.1 Reference point C*, *PRTC G.8272 Locked mode*, *BC G.8273.2 dTE Constant temperature*. • Masks for enhanced clocks: *ePRC G.811.1* and *ePRTC G.8272.1*. Pass / Fail results are computed by comparison of the test results and the configured mask value

The MTIE / TDEV test configuration procedure is described below:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Set operation mode to *E1/T1 endpoint* or.*E1/T1 monitor*
3. Select *Port C* to enter in the port specific configuration menu.
4. Configure the Port C, *Hierarchy, Connector*, *Line frame* and *Test pattern* to the right values (See section 2.3).
5. Go to the *TEST* tab.
   The *Test* configuration panel is displayed.
6. In the *Wander test* field, configure *MTIE / TDEV*.
7. Configure the *Observation time*, *Mask source* and *Standard mask* parameters for the next MTIE / TDEV measurement.
8. If you are using an external timing reference, enable it (See section 2.9).
   Note: If the reference is enabled and accepted the *REF* and *LCK* LEDs should become green.

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Once the MTIE / TDEV measurement has been configured, it can be started at any time. To carry out and get the result follow these steps:

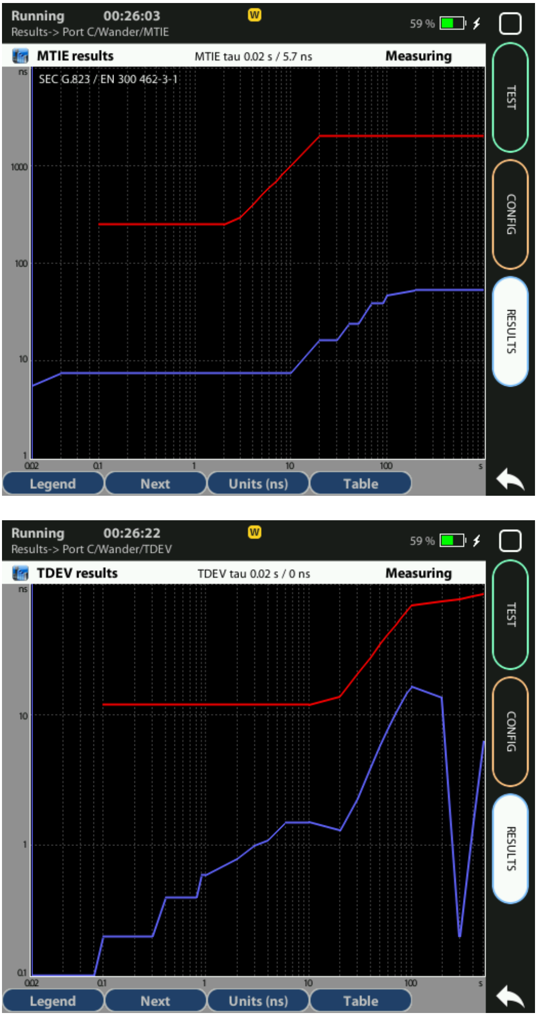
Table 5.6: MTIE / TDEV results

Event	Description
Time	Observation time expressed in time units. Both for the MTIE and TDEV, this field represents the length of a time window. The MTIE / TDEV tests ends when the *Time* reaches the value set in the *Observation time* field (*MTIE / TDEV settings* menu).
TIE	Displays the recorded TIE at the end of the test interval. The TIE is the phase difference between the test signal and the wander measurement reference expressed in time units.
MTIE	Maximum TIE (MTIE) measured at the end of the measurement interval expressed in time units. MTIE is computed and displayed in real time. That means that results for shorter time windows are available before the end of the test. The MTIE provides information about long term stability of a timing signal. If an MTIE value is compared with a mask and the result is fail, the result is displayed in red colour.
TDEV	Time Deviation (TDEV) corresponding to the associated observation time expressed in time units. TDEV is computed and displayed in real time. TDEV is related with the phase modulation power spectrum and it can be used to identify different types of phase noise. If a TDEV value is compared with a mask and the result is fail, the result will be displayed in red colour.
Mask	Mask value corresponding to the associated observation time. Masks are configured with the help of the *Mask source* and *Standard mask* controls. Pass / Fail result for MTIE / DTEV is decided comparing the mask with the numeric results.

1. From the *Home* panel, go to *RESULTS*,
   The test results panel is displayed.
2. Select *Port C* to enter in the port specific results menu.
3. Go to *Wander*.
4. Select *MTIE* to display MTIE results or *TDEV* to display TDEV results.
5. Press *run* or program a test start time.
   Note: Usually you will not need to program the test duration because MTIE /

TDEV test have their own timing. If you set an stop time, the measurement may stop before it has really finished.

6. Check the MTIE or TDEV results. These are upgraded in real time during the measurement time. Switch between the *MTIE* and *TDEV* panels if necessary. Press *Plot* (*F4* contextual key) at any time to display the graphical representation of the MTIE and / or TDEV.
7. Wait for the test to finish or abort by pressing *run* a second time.



(a)

(b)

Figure 5.4: E1 graphical wander results: (a) MTIE plot, (b) TDEV plot.

Chapter 6
Tests over E1 and T1 Signals

6.1. The E1 Frame

The E1 frame defines a cyclical set of 32 time slots of 8 bits. The time slot 0 is devoted to transmission management and time slot 16 for signalling; the rest were assigned originally for voice/data transport.

6.1.1. Frame Alignment

In an E1 channel, communication consists of sending consecutive frames from the transmitter to the receiver. The receiver must receive an indication showing when the first interval of each frame begins, so that, since it knows to which channel the information in each time slot corresponds, it can demultiplex correctly. This way, the bytes received in each slot are assigned to the correct channel.

The frame synchronization process is known as frame alignment. In order to implement the frame alignment mechanism so that the receiver of the frame can tell where it begins, there is what is called a frame alignment signal (FAS). In the 2048 kb/s frames, the FAS is a combination of seven fixed bits ("0011011") transmitted in the first time slot in the frame (*time slot zero* or TS0). For the alignment mechanism to be maintained, the FAS does not need to be transmitted in every frame. Instead, this signal can be sent in alternate frames (in the first, in the third, in the fifth, and so on). In this case, TS0 is used as the synchronization slot. The TS0 of the rest of the frames is therefore available for other functions, such as the transmission of the alarms.

6.1.2. NFAS

The bits of the TS0 that do not contain the FAS in positions 3 to 8 make up what is known as the *non-frame alignment signal* or NFAS. This signal is sent in alternate frames (frame 1, frame 3, frame 5, etc.). The first bit of the NFAS (bit 3 of the TS0) is used to indicate that an alarm has occurred at the far end of the communication. When operating normally, it is set to "0," while a value of "1" indicates an alarm.

The bits in positions 4 to 8 are spare bits, and they do not have one single application, but can be used in a number of ways, as decided by the telecommunications carrier. In accordance with the ITU-T Recommendation G.704, these bits can be used in specific point-to-point applications, or to establish a data link based on messages for operations management, maintenance or monitoring of the transmission quality, and so on. If these spare bits in the NFAS are not used, they must be set to “1” in international links.

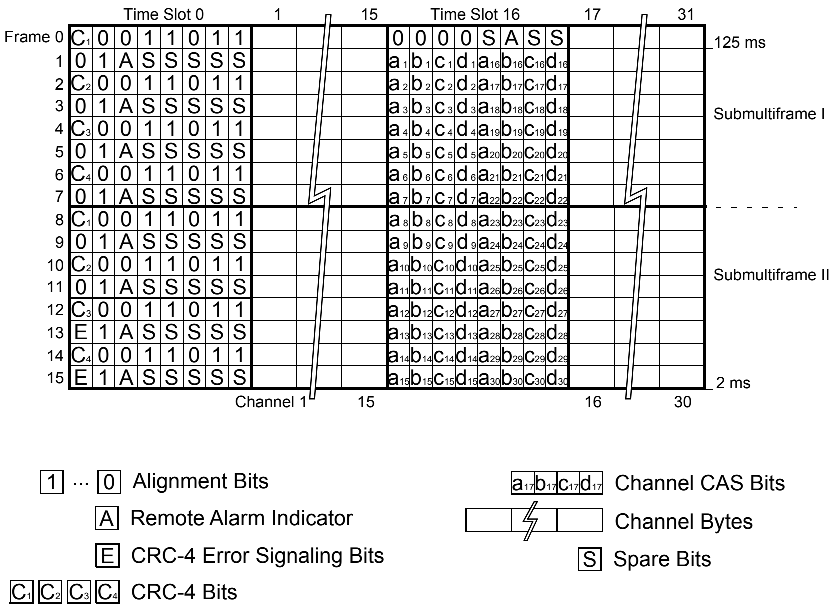


Figure 6.1: The E1 frame is the first hierarchy level, and all the channels are fully synchronous.

The *remote defect indication* (RDI) is sent in the NFAS of the return frames, with bit 3 being set to “1.” The transmitter then considers how serious the alarm is, and goes on generating a series of operations, depending on the type of alarm condition detected.

6.1.3. Multiframe CRC-4

In the TS0 of frames with FAS, the first bit is dedicated to carrying the *cyclic redundancy checksum* (CRC). It tells us whether there are one or more bit errors in a specific group of data received in the previous block of eight frames known as submultiframe.

The aim of this system is to avoid loss of synchronization due to the coincidental appearance of the sequence “0011011” in a time slot other than the TS0 of a frame with FAS. To implement the CRC code in the transmission of 2048 kb/s frames, a CRC-4 multiframe is built, made up of 16 frames. These are then grouped in two blocks of eight frames called submultiframes, over which a CRC checksum or word of four bits (CRC-

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4) is put in the positions C_i (bits #1, frames with FAS) of the next submultiframe. At the receiving end, the CRC of each submultiframe is calculated locally and compared to the CRC value received in the next submultiframe. If these do not coincide, one or more bit errors is determined to have been found in the block, and an alarm is sent back to the transmitter, indicating that the block received at the far end contains errors.

The receiving end has to know which is the first bit of the CRC-4 word (C1). For this reason, a CRC-4 multiframe alignment word is needed. Obviously, the receiver has to be told where the multiframe begins (synchronization). The CRC-4 multiframe alignment word is the set combination "001011," which is introduced in the first bits of the frames that do not contain the FAS signal.

The aim of monitoring errors is to continuously check transmission quality without disturbing the information traffic and, when this quality is not of the required standard, taking the necessary steps to improve it. Telephone traffic is two way, which means that information is transmitted in both directions between the ends of the communication. This in its turn means that two 2048 kb/s channels and two transmission directions must be considered.

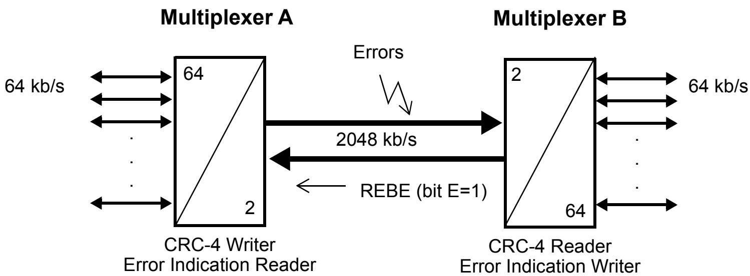

Figure 6.2: The A multiplexer calculates and writes the CRC code, and the multiplexer B reads and checks the code. When errors affect the 2-Mbit/s frame, the multiplexer B indicates the problem by means of the E-bit of the frame which travels toward the multiplexer A.

The CRC-4 multiframe alignment word only takes up six of the first eight bits of the TS0 without FAS. There are two bits in every second block or submultiframe, whose task is to indicate block errors in the far end of the communication. The mechanism is as follows: Both bits (called E-bits) have "1" as their default value. When the far end of the communication receives a 2048 kb/s frame and detects an erroneous block, it puts a "0" in the E-bit that corresponds to the block in the frame being sent along the return path to the transmitter. This way, the near end of the communication is informed that an erroneous block has been detected, and both ends have the same information: one from the CRC-4 procedure and the other from the E bits. If we number the frames in the multiframe is numbered from 0 to 15, the E-bit of frame 13 refers to the submultiframe I (block I) received at the far end, and the E-bit of frame 15 refers to the submultiframe II (block II).

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6.1.4. Signalling Channel

As well as transmitting information generated by the users of a telephone network, it is also necessary to transmit signalling information. Signalling refers to the protocols that must be established between exchanges so that the users can exchange information between them.

There are signals that indicate when a subscriber has picked up the telephone, when he or she can start to dial a number, and when another subscriber calls, and so on. The channel associated signalling (CAS) is defined in the ITU-T Recommendation G.704, which defines the structure of the E1 frame.

In CAS signalling, a dedicated signalling channel is associated with each information channel (there is no common signalling channel), meaning that the signalling circuits are personalized for each channel. CAS assigns to each 64 kb/s telephone channel a 2 kb/s for signalling. This signalling is formed by a word of 4 bits (generically known as A, B, C, and D) that is situated in the TS16 of all the frames sent. Each TS16 therefore carries the signalling for two telephone channels.

Given that there are only four signalling bits available for each channel, to transmit all the signalling words from the 30 PCM channels that make up a 2048 kb/s frame, it is necessary to wait until the TS16 of 15 consecutive frames have been received. The grouping of frames defines a CAS signalling multiframe, which consists of a set of the TS16 of 16 consecutive E1 frames.

In order to synchronize the CAS multiframe, that is to identify where it begins, a *multiframe alignment signal* (MFAS) is defined, made up of the sequence of bits “0000” located in the first four bits of the TS16 of the first frame of the CAS multiframe. The remaining four bits of the interval are divided between one alarm bit and three spare bits, making up the *non-multiframe alignment signal* (NMFAS). In short, the signalling information for the 30 channels is transmitted in 2 ms, which is fast enough if we consider that the shortest signalling pulse (the one that corresponds to dialling the number) lasts for 100 ms.

6.2. The T1 Frame

The T1 frame is made up of 24 byte-interleaved time slots, the 64-kb/s channels of eight bits, plus one framing bit that indicates the beginning of the T1 frame. The individual channels are synchronous with each other, and are then time division multiplexed in the T1 frame. Depending on the application, the T1 frames are grouped in *Superframe* (SF), 12 consecutive DS1 frames, and *Extended Superframe* (ESF), 24 consecutive frames. Depending on the application, the T1 signal is coded in AMI or in B8ZS.

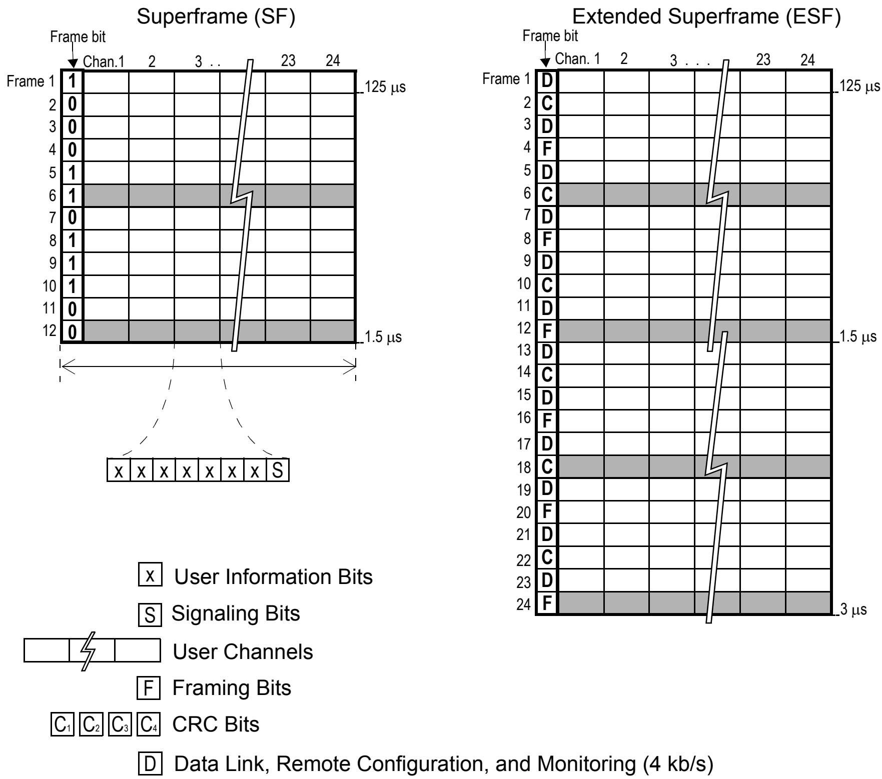

Figure 6.3: The T1 frame and superframe. Depending on the application, he frame bit has different interpretations

6.2.1. Frame bit

The F-bit delimits the beginning of the frame and has different meanings. Using ESF, the F-bit sequence has a pattern for synchronization, but if ESF is used, then there is a synchronization pattern, CRC control, and a data link control channel of 4 kb/s.

6.2.2. Signalling

When in-band signalling is used, the signalling goes in the least significant channel bit of every sixth T1 frame (SF and ESF framing), leaving the effective throughput of those channels at 56 kb/s, to keep distortion minimal. Although in-band is still in use, signalling (call setup, tear-down, routing, and status) is generally carried out of band over a separate network using a protocol called signalling system 7 (SS7).

6.3. Generation and Analysis of Framed Signals

The test unit generates and analyses different kinds of 1544 kb/s and 2048 kb/s signals and also unframed 1544 / 2048 kb/s signals. Frame structure and content can be configured in a flexible way. It follows a description of the frame configuration procedure. It is assumed that the equipment is already working with the correct operation mode and line settings.

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.

Table 6.1: RX Frame Settings

Setting	Description
RX structure	Sets the frame structure for Port C, Port D (if installed). The available options are the same that for the *TX structure* field.
Demultiplexer	Configures the content of the E1 or T1 time slots for the receiver. Signals and patterns are either analysed internally (pattern analyser) or forwarded to an external interface (E0, analogue or datacom). The *Demultiplexer* is not available if the *RX structure* is set to *Unframed*. In this case, the signal from the pattern generator is mapped to the unframed 2048 kb/s signal. The contents of the TS0 is not available when the *RX structure* is set to any of the available ITU-T G.704 frames because this time slot carries the FAS / NFAS word. For a similar reason TS16 is not available if any of the CAS frames is set in *RX structure*. Data sinks for the E1 time slots are graphically displayed. Each data source has its own colour: • :Empty time slot. This colour is used went the time slot content is configured to be a noise signal. • : Time slots are connected to the pattern analyser. • : It is used for not time slots not available for user configuration (FAS / NFAS, CAS). • : The selected time slot is connected to the external analogue output. An speaker can be connected to this interface to hear the signal. • : Time slots connected to an external low speed digital output (codirectional, datacom).

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Table 6.1: RX Frame Settings

Setting	Description
Timeslot bit rate	Configures the reception bit rate for T1 time slots. T1 time slots are allowed to operate at two different bit rates. The 64 kb/s rate devotes eight bits per frame per circuit but the 56 kb/s rate only seven. Some T1 implementations use one bit in each time slot to transfer signalling information. This way to share the 'robbed bit' between user data transmission and signalling may interfere with some applications. Specifically, 64 kb/s data channels are not compatible with the robbed bit mechanism. The solution is to use one bit only for signalling and seven bits (56 kb/s) only for user data transmission.
Enable robbed bits	Enables or disables the robbed bit mechanism in the interface. With this mechanism certain bits in the time slots are used for transmitting signalling information.
SSM signaling	Enables or disables the *Synchronization Status Message* (SSM) analysis in the unit. The SSM transports information about the current synchronization performance level transported in the E1 or T1 signal. The SSM information can be used by network clocks or other devices to know if the E1 or T1 signal is a reliable synchronization source. The SSM requires a frame structure with CRC in E1 interfaces (*PCM30C* or *PCM31C*). In T1 interfaces it requires FDL, which is only available with the ESF frame structure. The E1 NFAS also requires the user to configure which NFAS bit is used to transmit the message.

3. Configure the *Hierarchy* to either *G.703/E1* or *T1/DS1*.
4. Go to *RX_Frame*, to display the frame configuration menu.
5. Select *RX Structure* and configure the appropriate frame structure depending on whether you have selected the *G.703/E1* or the *T1/DS1* hierarchy: unframed or framed, with or without CRC-4 parity check, with or without CAS multiframe for *G.703/E1* or *unframed*, *SF* or *ESF* for *T1/DS1*.
6. Configure *the Demultiplexer* in accordance with the expected time slot content (See section 6.3.1).
   Note: The *Demultiplexer* is not available for unframed signals.
7. In T1/DS1 hierarchy, configure the transmitted *Timeslot* bit rate to *64 kb/s* or *56 kb/s*.
8. Configure *TX Frame* in the same way that *RX Frame.*
9. In T1/DS1 hierarchy, configure the received Timeslot bit rate to *64 kb/s* or *56 kb/s*.

10. Configure the *Multiplexer* block in the same way that *the Demultiplexer* but based on the test signals you are going to inject in the DUT / SUT (See section 6.3.1). *Note*: The *Multiplexer* block is not available for unframed signals.

Table 6.2: TX Frame Settings

Setting	Description
TX structure	Sets the frame structure for Port C and Port D (when available) transmitters. The available options are: • *PCM31*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. All other time slots carry user data. • *PCM31C*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. The TS0 carries also a CRC-4 multi-frame structure that enables error detection at the receiving end. All other time slots carry user data. • *PCM30*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. TS0 carries the FAS and NFAS words. The TS16 carries the CAS multiframe that provides signalling to the user time slots. Time slots different of TS0 and TS16 carry user data. • *PCM30C*: 2048 kb/s TDM frame made up of 32 time slots (TS0, TS1,..., TS31) of 64 kb/s each. This frame includes at the same time the *CRC-4* and *CAS* multiframes. Time slots different of TS0 and TS16 carry user data. • *SF*: 1544 kb/s TDM frame made up of 193 bits and 24 time slots (TS0, TS1,..., TS23) of 56 kb/s or 64 kb/s each. The first bit in the frame defines a multiframe and carries an alignment sequence. Some bits in certain time slots may carry signalling through the robbed bit mechanism. • *ESF*: 1544 kb/s TDM frame made up of 193 bits and 24 time slots (TS0, TS1,..., TS23) of 56 kb/s or 64 kb/s each. The first bit in the frame defines a multiframe and carries different kinds of information including the alignment sequence, a data communications channel and a CRC-6 frame check sequence. Some bits in certain time slots are allowed to carry signalling through the robbed bit. • *Unframed*: Unstructured data at 2048 kb/s or 1544 kb/s, depending on the current hierarchy settings. There is no FAS in the transmitted information and there is not a time slot structure.

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Table 6.2: TX Frame Settings

Setting	Description
TX structure	• *Match RX*: Matches the structure configured in the receiver. This setting could be used to avoid configuring twice the same thing or to match the detected frame structure during the auto-negotiation process.
Multiplexer	Configures the content of the E1 / T1 time slots for the transmitter. Signals and patterns are generated internally (pattern generator, tone generator) or externally (G.703/E0, analogue, datacom or E1 / T1 interface). The *Multiplexer* is not available if the *TX structure* is set to *Unframed*. In this case, the signal from the pattern generator is mapped to the unframed 2048 kb/s signal. The contents of the TS0 is not available when the *TX structure* is set to any of the available ITU-T G.704 frames because this time slot carries the FAS / NFAS word. For a similar reason TS16 is not available if any of the CAS frames is set in *TX structure*. Data sources for the E1 and T1 time slots are graphically displayed. Each data source has its own colour: • :Empty time slot. This colour is used went the time slot content is configured to be a noise signal. • : Time slots are connected to the pattern generator. • : This colour is used for time slots connected to the tone generator. If there are several time slots connected to the tone generator, all them will carry the same tone. That means that tone level, frequency and phase will be the same for all time slots. • : The selected time slots are connected to external analogue input. This input can be connected to a microphone. The signal from the microphone is converted to a G.711 format and sent in the E1 multiplex. • : It is used for not time slots not available for user configuration (FAS / NFAS, CAS). • : Time slots connected to an external digital low speed input (G.703 / E0, datacom).

Table 6.2: TX Frame Settings

Setting	Description
Multiplexer	: Time slots received the corresponding port input are bypassed to the port output without alterations. TS0 and TS16 can be set to the bypass option even not containing user information. This option is only available if *Mode* has been set to *E1/T1 through*.
CAS signalling	Configures the *Channel Association Signalling* (CAS) ABCD bits for each of the 30 time slots of the E1 frame. This menu is available only if one of the *PCM30C* or the *PCM30* frame is configured.
CAS spare bits	Configures the value of the CAS spare bits located in the first frame of the CAS multiframe. This setting does not make sense if the frame structure does not have a CAS multiframe (*TX structure* is configured to *PCM30* or *PCM30C*).
NFAS service bits	Sets the value for the NFAS service bits carried in E1 frames with CRC-4 multiframe. This setting does not make sense if the frame does not carry this kind of structure.
Timeslot bit rate	Sets the transmission bit rate for T1 time slots. T1 time slots are allowed to operate at two different bit rates. The 64 kb/s rate devotes eight bits per frame per circuit but the 56 kb/s rate only seven. Some T1 implementations use one bit in each time slot to transfer signalling information. This way to share the 'robbed bit' between user data transmission and signalling may interfere with some applications. Specifically, 64 kb/s data channels are not compatible with the robbed bit mechanism. The solution is to use one bit only for signalling and seven bits (56 kb/s) only for user data transmission.
Enable robbed bits	Enables or disables the robbed bit mechanism in the interface. With this mechanism certain bits in the time slots are used for transmitting signalling information.

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Table 6.2: TX Frame Settings

Setting	Description
Robbed bits	Configures the content of the T1 robbed bits. The content if the robbed bits is similar to the E1 CAS signalling bits. If the frame structure is SF and robbed bit generation is enabled, then the user could set two robbed bits A and B. In the ESF frame structure, four robbed bits per time slot are supported (A, B, C and D). The test unit always sets the same robbed bits for all T1 time slots.
FDL data link bits	Configures the *Facilities Data Link* (FDL) in ESF T1 frames. This is a 4 kb/s circuit used to transmit operations, administration and management information including alarms or Loopback management.
SSM signaling	Enables or disables the *Synchronization Status Message* (SSM) generation in the unit. The SSM transports information about the current synchronization performance level transported in the E1 or T1 signal. The SSM information can be used by network clocks or other devices to know if the E1 or T1 signal is a reliable synchronization source. The SSM requires a frame structure with CRC in E1 interfaces (*PCM30C* or *PCM31C*). In T1 interfaces it requires FDL, which is only available with the ESF frame structure. The E1 NFAS also requires the user to configure which NFAS bit is used to transmit the message.

6.3.1. Using the Multiplexer and the Demultiplexer

The *Multiplexer* and the *Demultiplexer* panels define the content of the transmitted signal and also provide information about the expected time slot content for the analyser. To use the *Multiplexer* and the *Demultiplexer* panels it is required a framed structure (the value configured in *TX Structure* or *RX Structure* must be one of the ITU-T G.704 or ANSI T1.403 frames). The *Multiplexer* and *Demultiplexer* panels are both used in a similar way.

1. From the *Multiplexer* or *Demultiplexer* panel, select one slot before configuring the contents you want for it. Use the cursors to do that.
2. Use the *Content-*, *Content+* to cycle the available contents for the current time slot and confirm your selection by touching the cursor.
   Note: If the E1 interface is configured, the TS0 and TS16 do not admit all test signals in all configurations.
   Note: Some content types are not allowed in more than one time slot simultaneously.

3. Go to step 1 and continue until all the time slots have the desired value.
   Note: To configure the same content in all time slots you can use the *Set all* contextual button. A quick shortcut to put the content *None* in all the available time slots is to use the *Clear all* contextual button.

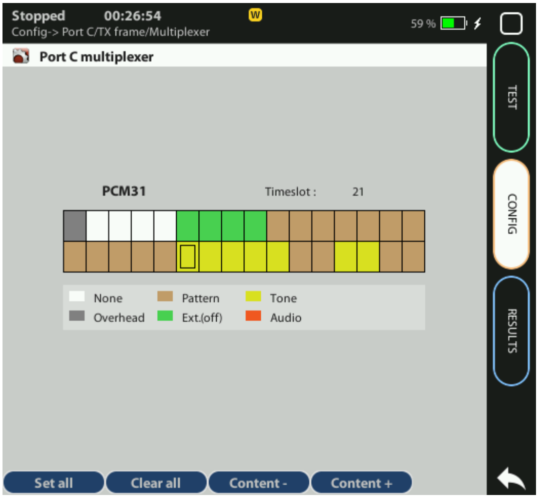

Figure 6.4: Multiplexer panel. This panel enables the user to send each individual time slot to different analysis blocks.

6.4.FAS / NFAS Generation and Analysis

The test unit monitors the FAS and NFAS word contents as it is transmitted within the ITU-T G.703 E1 frame. The equipment is also capable of setting the NFAS spare bits to any value decided by the user. The procedure for displaying the FAS and NFAS content is as follows:

1. From the *Home* panel, go to *RESULTS*,
   The *Results* panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific results menu.
3. Select *FAS/NFAS* to display the FAS / NFAS words for the whole CRC-4 multi-frame.
   Note: Displaying the FAS and NFAS requires a frame structure with CRC-4 multi-frame support (See section 6.3).For this reason, the FAS/NFAS menu entry remains disabled if *RX structure* is different of either *PCM31C* or *PCM31C*.

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To manipulate the NFAS spare bits, the procedure is:

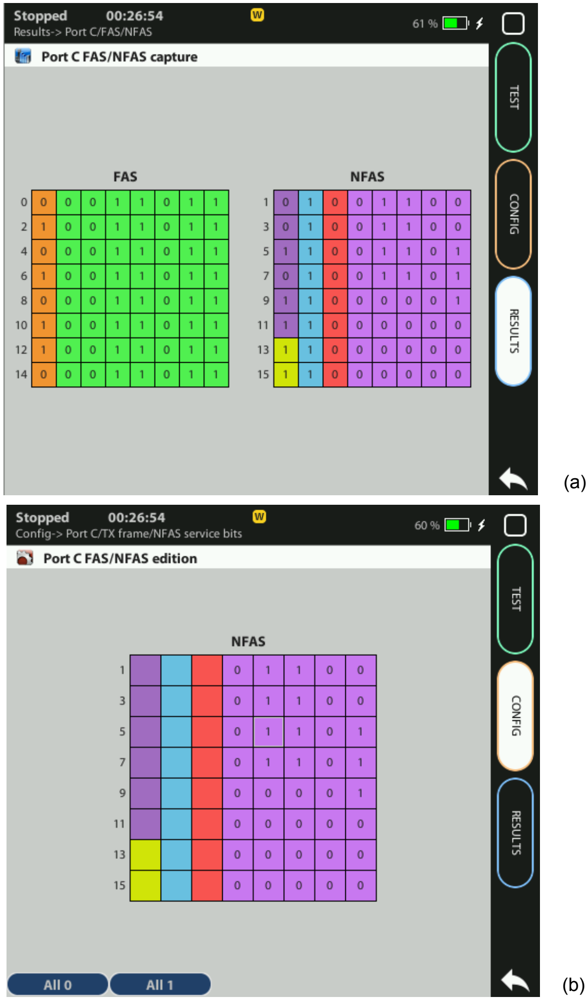

Figure 6.5: FAS / NFAS Generation and Analysis panels: (a) FAS / NFAS results panel. (b) NFAS configuration panel.

1. From the *Home* panel, go to *CONFIG*,
   The *test* port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
3. Go to *TX frame*, to display the frame configuration menu.

4. Configure *TX structure* to either *PCM30C* or *PCM31C*.
5. Go to *NFAS service bits*
   A diagram with the NFAS words transmitted in the CRC-4 multiframe is displayed.
6. Configure the NFAS spare bits at your will.

6.5. CAS Generation and Analysis

The tester is compatible with Channel Associated Signalling (CAS) transported within the E1 time slot 16. The equipment can both generate and analyse CAS signalling. CAS generation requires configuration of a frame structure with CAS (*PCM30* or *PCM30C*) in the transmitter. On the other hand, CAS analysis needs the previous configuration of a frame structure with CAS in the receiver. To display and set the CAS multiframe follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The *Setup* configuration panel is displayed.
2. Select either *Port C or Port D* (when available) to enter in the port specific configuration menu.
3. Select *TX frame* to display the port frame structure and content configuration menu.
4. Select *CAS signalling* to enter in the ABCD bits configuration panel.
5. Choose the numeric base for the ABCD edition by means the *Radix* contextual button: binary, decimal or hexadecimal.
6. Choose the time slot to be modified.
7. Select the ABCD value with the help of the *Value-* and *Value+* contextual buttons.
8. Touch again the time slot confirm the ABCD value configured in the previous step.
9. Repeat the steps 6, 7, 8 until all the time slots have the correct ABCD values.
   Node: The *Set all* contextual button can be used to configure the current ABCD value for all the time slots at the same time.
10. Leave the ABCD configuration panel.
11. Optionally, enter in the *CAS spare bits* (S bits) configuration panel and set the value for the Spare bit #1, 2 and 3.

CAS analysis is done as indicated below:

1. From the *Home* panel, go to *RESULTS*,
   The *Results* panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific results menu.
3. Select *CAS signalling* to display the received ABCD bits for each channel.
4. Choose the numeric base for the ABCD visualization by means the *Radix* contextual button: binary, decimal or hexadecimal.

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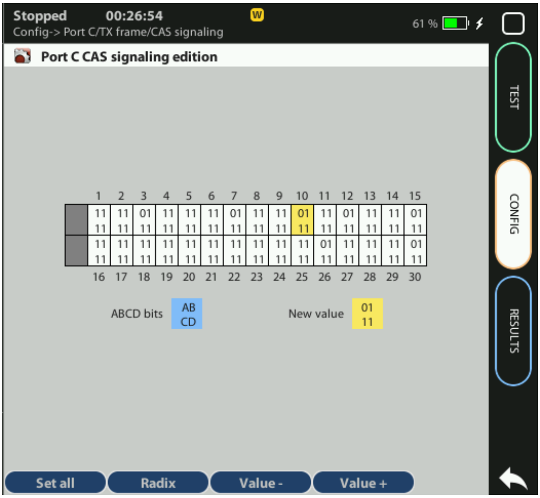
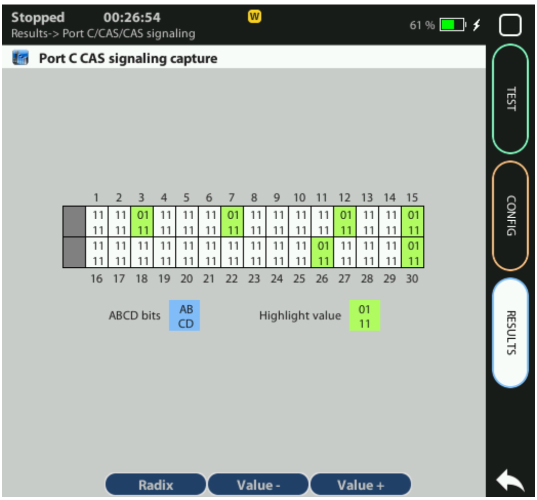
5. Select the highlighted ABCD value with the help of the *Value-* and *Value+* contextual buttons.
6. Leave de ABCD results screen.
7. Enter in the *CAS spare bits* (S bits) results panel and check the value for the Spare bit #1, 2 and 3.



(a)



(b)

Figure 6.6: CAS generation and analysis panels: (a) CAS generation, signalling words for each are displayed in binary format, (b) CAS analysis with the 1010 value highlighted.

6.6. SSM Generation and Analysis

The *Synchronization Status Message* (SSM) is used to report the synchronization *Quality Level* (QL). The synchronization QLs have a hierarchical structure to enable network elements to choose which reference input to use for timing purposes.

The SSM encoding is specified in standard ITU-T G.781. There are three options I, II and III. The most important ones are option I, used together with the E1 hierarchy in most countries of the world and option II, which is used with the T1 hierarchy in the US and Canada.

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Table 6.3: SSM Messages

ITU-T G.781 QL	Option I	Option II
0	-	QL-STU
1	-	QL-PRS
2	QL-PRC	-
3	-	-
4	QL-SSU-A	QL-TNC
5	-	-
6	.	.
7	-	QL-ST2
8	QL-SSU-B	-
9	-	-
10	-	QL-ST3 / QL-EEC2
11	QL-SEC / QL-EEC1	-
12	-	QL-SMC
13	-	QL-ST3E
14	-	QL-PROV
15	QL-DNU	QL-DUS

To enable SSM generation over E1 or T1 follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
3. Make sure that *Hierarchy* is configured to the required value: *T1/DS1* or *G.703/E1*.
4. Go to *TX frame*.
   The E1 / T1 transmitted frame configuration menu is displayed.

5. Configure *TX structure* to *PCM30C* or *PCM31C* (E1 hierarchy) or *ESF* (T1 hierarchy)
6. Go to *SSM signaling*.
7. Configure *Enable* to *Yes*
8. Enter the *ITU-G.781* option. You can choose between *Option I* or *Custom* for E1 and *Option II* or *Custom* for T1.
9. If you have chosen *Option I* or *Option II* in the previous step, choose the QL message to be generated. If you have chosen *Custom* in the previous step, configure a custom SSM in hexadecimal format with the help of *Custom message (hex)*.
10. If you are working with the *PCM30C* or *PCM31C* frame structures, configure *TS0 bit number (SAx)* to set the bit in the TS0 that carries the SSM message.
    The equipment is now generating the SSM that you have configured.

The previous procedure enables the generator but SSM analysis is independent of this. The correct steps to enable the analysis and display result are listed below:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
3. Make sure that *Hierarchy* is configured to the required value: *T1/DS1* or *G.703/E1*.
4. Go to *RX frame*.
   The E1 / T1 received frame configuration menu is displayed.
5. Configure *RX structure* to *PCM30C* or *PCM31C* (E1 hierarchy) or *ESF* (T1 hierarchy).
6. Go to *SSM signaling*.
7. Configure *Enable* to *Yes*
8. If you are working with the *PCM30C* or *PCM31C* frame structures, configure *TS0 bit number (SAx)* to set the bit in the TS0 that carries the SSM message.
9. Start a new test with the *run* button
10. Go to *RESULTS* tab,
    The *Results* panel is displayed.
11. Select either *Port C or Port D* to enter in the port specific configuration menu.
12. Go to *SSM signaling*
13. Check the *Sync. status message* and *Sync. status message (hex)* results

6.7. Robbed Bit Signalling Generation and Analysis

Call signalling in T1 systems may be based in different mechanisms. One of them is the Channel Associated Signalling (CAS). Conceptually, CAS works similarly in E1 and T1 interfaces. A signalling channel is associated with each information channel (there is no common signalling channel), meaning that the signalling circuits are personalized for each time slot. The main difference is that in T1 systems, the CAS signalling is

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implemented through the 'robbed bit' mechanism' that steals certain bits in some time slots to carry the signalling information. The procedure to enable robbed bit generation in the unit is as follows:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
3. Select *TX frame* to display the port frame structure and content configuration menu.
4. Configure *Enable robbed bits* to *Yes*.
   Note: You can only enable robbed bit generation if the transmitted frame structure is *SF* or *ESF*.
5. Select *Robbed bits* to enter in the *ABCD* bits configuration panel.
6. Insert the configured ABCD value with *ENTER* and the *F1* and *F2* contextual keys.
   Note: All channels carry the same ABCD value configured through this panel.

Robbed bit analysis is done as indicated below:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select either *Port C or Port D* (if available) to enter in the port specific configuration menu.
3. Select *RX frame* to display the port frame structure and content configuration menu.
4. Configure *Enable robbed bits* to *Yes*.
   Note: You can only enable robbed bit generation if the transmitted frame structure is *SF* or *ESF*.
5. Start a new test with the *run* button
6. Go to *RESULTS* tab,
   The *Results* panel is displayed.
7. Select either *Port C or Port D* (if available) to enter in the port specific results menu.
8. Select *Robbed bits* to display the received ABCD bits for each channel.
9. Choose the numeric base for the ABCD visualization by means the *Radix* contextual button: binary, decimal or hexadecimal.
10. Select the highlighted ABCD value with the help of the *Value*- and *Value*+ contextual buttons.

6.8. Event Insertion and Analysis

The most basic event you can measure in a 2048 kb/s or 1544 kb/s link is the bit error but is by no means the only measurable event. The tester accounts for different kinds of events affecting the structure or content of the TDM frame.

In Recommendation M.20, the ITU-T classifies events (*Failures*, using ITU-T terminology) in two different families:

- *Anomaly*: Discrepancy between the actual and desired characteristics of an item. Anomalies may or may not affect the ability of an item to perform a required function. Examples are a single bit error in the FAS, a CRC-4 error or single discrepancy between the expected and received test pattern.
- *Defect*: A defect is a limited interruption in the ability of an item to perform a required function. Successive anomalies causing a decrease in the ability of an item to perform a required function are considered as a defect. For example continuous bit errors in the FAS (FAS anomalies) lead to a LOF defect.

The test unit offers different ways of representing information about events. Two of them are discussed in this chapter: LEDs and counters.

6.8.1. The LEDs Panel

The LEDs provide permanent information about the received signals for the test ports. They are permanent indicators. That means that no test has to be started to get the information from the LEDs.

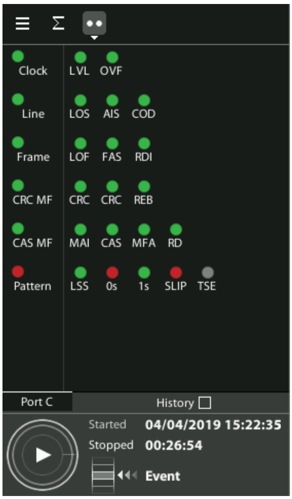

Figure 6.7: The xGenius LEDs panel.

There are two hardware global summary LEDs in the tester (one for Port C and one for Port D), six summary LEDs for each test port (*Clock*, *Line*, *Frame*, *CRC-4 MF*, *CAS MF* and *Pattern*). These LEDs summarize the information of the events shown in the LEDs panel. To display the LEDs panel just press the LEDs tab in the *auxiliary panel* (See section 1.3.3).

The LEDs have two operation modes:

- *Live*: Events are shown in real time. If something happens the corresponding LEDs change their colour to signal the event. LEDs return to their original status once the event disappears.
- *History*: The LEDs keep their original Anomaly / Defect status when the event disappears. This is useful when the tester is left a long time under operation and the user wants to receive quick feedback of past events.

The live or history modes can be configured from the LEDs panel by means the contextual keyboard. The *History* check box sets or unsets the history mode. If the history mode is enabled, then the *Reset* button resets the LEDs history.

Orange is used to signal anomalies and red indicates defects but there are more possible LED status:

- : OK, the event or events that correspond with the LED are not found in the incoming signal.
- : This is the colour displayed if anomalies are found in the signal. The particular event corresponds with the LED label.
- : This colour is displayed when a defect has been found in the signal. The particular event usually corresponds with the LED label. If the LED summarizes several events, then defects have precedence over anomalies and red is displayed rather than orange.
- : Disabled in the current configuration. For example, all events related with the 2048 kb/s CRC multiframe make no sense if the mentioned multiframe is disabled in the receiver configuration.
- : Disabled due to the presence of a more important event. For example bit errors cannot be detected when a LOS or AIS anomaly has been raised.

6.8.2. Defect and Anomaly Counters

The test unit detects and counts signal defects and anomalies. These events are permanently displayed my means the Softleds but they are not registered and stored unless you start a measurement. The procedure to use to register defects and anomalies is the following.

1. Configure the tester in accordance with the DUT and the measurement to be carried out: Choose the right operation mode, connect the tester to the DUT / SUT and configure the line, frame and pattern blocks for the test ports.
2. Program the test start time and duration with the help of the *Program* menu (within *Test*) or start the test immediately by pressing *run*.
Note: Most of the configuration is blocked when there is an ongoing test.

3. Wait for the test to finish or press *run* to finish immediately.
   Note: In fact, it is not necessary to wait until the test has finished; Partial results are presented in real time during test execution.

Table 6.4: Anomaly Counters

Event	Description
Code	A line code error detected. A code anomaly happens when for some reason the line code rules are not met in the receiving side.
FAS	FAS error. This anomaly indicates that one or more bits are incorrect in one Frame Alignment Sequence (FAS) The standard FAS is the seven-bit 0011011 word. This word is carried in alternate frames within the TS0.
CRC	CRC Error. The CRC-4 code is computed by the receiver on each received CRC-4 multiframe block (eight regular E1 frames). If the computed code does not match the received one, an CRC is accounted. CRC is an indicator of transmission errors. If the bit errors are uncommon enough to not overload the code, the CRC provides a good in-service BER estimation.
REBE	Remote End Block Error. This anomaly is raised if the first bit of the frames 14 or 16 of the 16-frame CRC-4 multiframe is set to 0. This anomaly indicates that an error has been found in a CRC-4 block in the opposite transmission direction by the remote end.In a few words, this error is an indicator of transmission errors in the opposite transmission direction.
MFAS	Multiframe FAS Error. CAS multiframe uses a fixed four bit sequence (0000) for multiframe delineation. An MFAS is registered for each error found in the expected MFAS word.
TSE	Test Sequence Error. One TSE is equivalent to a single bit difference between the transmitted and the received test pattern (PRBS or other).
TSBE	Test Sequence Block Error. One of the user-configurable data blocks of contains at least one TSE.

4. From the *Home* panel go to *RESULTS* to display to the sub-menu that provides access to all the results collected during the last test.
5. Select either *Port C or Port D* (if available) to enter in the port specific results.

6. Select *Defects* to display information about defects or *Anomalies* to display information about anomalies.

Table 6.5: Defect Counters

Event	Description
LOS	Loss of Signal alarm. This alarm is raised when no signal is detected in the receiver input.
AIS	Alarm Indication Signal. It is defined as an all-1 line signal. All bits in the AIS, even the ones in the TS0, are set to '1'. The AIS indicates a failure in the transmission source that does not allow transmission of user data towards the destination. For example, a regenerator that detects a LOS at its input may send an AIS downstream.
LOF	Loss of Frame. This defect is raised when for some reason the E1 analyser is unable to find the periodic FAS pattern in the incoming signal. LOF is an indication of framing problems in a network device due to a faulty line card or other reasons.
RDI	Remote Defect Indication: It is an alarm condition carried in the A-bits within the G.704 2048 kb/s frame. The RDI is raised when the A-bits are set to '1' by the transmitter. The RDI indicates that there is a failure in the transmission source that does not allow data transmission towards the origin. For example, a regenerator that detects a LOS at its input may send a RDI upstream.
CRC-LOM	CRC Loss of Multiframe. The 16-frame CRC multframe uses a fixed bit sequence (001011 binary) carried in frames 1, 3,5,7,9 and 11 for framing purposes. The CRC-LOM is declared when the CRC-4 framing sequence is not found in the incoming signal. This error usually indicates that the analysed frame lacks of CRC-4 multiframe structure. Note that the CRC alignment sequence should be carried within the frame even if the CRC-4 code generation is disabled.

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Table 6.5: Defect Counters

Event	Description
CAS-LOM	CAS Loss of Multiframe. The 16-frame CAS multiframe uses a fixed bit sequence (0000 binary) carried in the first four bites of frame 0 for frame alignment purposes. The CAS-LOM is declared when the CAS framing sequence is not found in the incoming signal. This error usually indicates that the analysed frame lacks of CAS multiframe structure.
MAIS	Multiframe AIS. This alarm is raised in case that an all-1 line signal is detected within the TS16 when a frame structure with CAS multiframe is configured. The MAIS indicates a failure in the transmission source that does not allow transmission of CAS information toward the destination.
MRDI	Multiframe Remote Defect Indication. It is an alarm condition carried in the A-bit within TS16 in the G.704 2048 kb/s frame. The RDI is raised when the A-bit are set to '1' by the transmitter. MRAI defect generation or detection is disabled when the configured frame structure does not carry the CAS multiframe in TS16. The MRDI indicates that there is a failure in the transmission source that does not allow transmission of the CAS multiframe towards the origin.
LSS	Loss of Sequence Synchronization. This event indicates that the expected test pattern does not match the actually received pattern.
All 0	This alarm occurs when all the user bit capacity is set to '0'. Note that in E1 frames TS0 and TS16 (if CAS is used) do not need to be all '0' to declare the *All 0* condition.
All 1	This alarm occurs when all the user bit capacity is set to '1'. Note that in E1 frames TS0 and TS16 (if CAS is used) do not need to be all '1' to declare the *All 1* condition.
Slip	Either one bit is missing or repeated in the received test pattern. This error is usually related with timing problems within the network.

6.8.3. Service Disruption Time

The *Service Disruption Time* (SDT) test enables xGenius to find short service interruptions over E1, T1, G.703/E0, Datacom and IEEE C37.94 interfaces. This section, focus in the E1 and T1 modes but much if the information is also true for the remaining test interfaces.

Dealing with service disruptions in TDM networks, it is observed that many problems are caused by events that can be accounted for in time scales of seconds but some others, like the ones related with protection switching happen in time scales of milliseconds. The objective of the STD is to detect and report these short interruptions that could potentially last for a few milliseconds only.

Table 6.6: Service Disruption Time Results

Field	Description
Disruptions	Accounts for the number of times the service has been interrupted since the beginning of the test.
Total	Total amount of time the service has not been available due to disruptions. It is computed as the accumulated disruption tome from the beginning of the test.
Average	Average disruption time. This metric is computed as the value of the *Total* field divided by *Disruptions*.
Minimum	Shortest disruption time computed from the beginning of the test.
Maximum	Longest disruption time computed from the beginning of the test.
Last	Disruption time corresponding to the last disruption event computed by the test unit.
Trigger	Event that is used to declare and record disruption events. It could be any of *LOS*, *AIS*, *RDI* or *TSE*. Multiple trigger selection is also allowed.

To configure the SDT in your test unit you have to follow these steps:

1. Make sure that your tester is connected to the network.
2. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
3. Set *Mode* to *E1/T1 endpoint*, *E1/T1 monitor*, E1/T1 MUX test or E1/T1 DEMUX test.
4. Configure the equipment so that the Line LEDs layer is green in all test ports to be used during the test. It is also recommended that the Frame, CRC MF, CAS MF and Pattern LEDs are also displaying the green color, but depending on the trig-

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gers chosen to run the test, this condition may not be mandatory (See section 2.2, See section 2.3, See section 6.3, See section 7.1).

1. From the *Home* panel, go to *TEST*,
   The *test* configuration panel is displayed.
2. Go to *Service disruption time test*.
3. Enable the SDT test through the *Enable* control.
4. Configure the trigger to LOS, AIS, RDI or TSE
5. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
6. Go to *Port C (or Port D, if available.*
7. Go to *Service disruption time*.
8. Start the test by pressing *run*.
9. Check the *Disruptions*, *Total*, *Average*, *Minimum*, *Maximum*, *Last* and *Trigger* results.

6.8.4. The Event Logger

Global counts, statistics and LEDs provide information about which events and how many of them have been registered but they do not say too much about how they are distributed in time. This information is supplied by the graphical representation tool or Event logger.

With the Help of the event logger function, you can select one or various events and trace them so that all changes along with the time and date these changes are registered are recorded with a 1 second resolution. The event logger provides different representations and different zoom levels to enable event analysis at different time scales.

6.8.5. Configuring the Event Logger

Traceable Events are categorized in different classes. Moreover, each test port has its own traceable events. These events may be different for each test port.

Table 6.7: Logging event categories

Event class	Description
Anomalies / defects	Accounts for E1,T1, datacom and other miscellaneous anomalies and defects. This category includes the following events: *LOS*, *AIS*, *CODE*, *LOF*, *FAS*, *RDI*, *CRCL*, *CRC*, *REBE*, *MAIS*, *CASL*, *MFAS*, *MRDI*, *DTE-LOC*, *DCE-LOC.*
BERT	Reports BER results by means the *LSS*, *TSE* and SLIP traceable events.
Line	Contains events related with physical transmission: *Attenuation*, *Frequency offset*.

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Table 6.7: Logging event categories

Event class	Description
Synchronization	This event category includes all events related with E1 synchronization testing, including jitter and wander analysis functions. This category includes the following events: *REF*, *LVL*, *PLL*, *HIT*, *OVF*, *TIE*, *Frequency offset*, *Frequency drift*.
Delay	This category accounts for latency analysis results. It includes the following items: *Round-trip delay*, *Forward delay*, *Return delay* and *Asymmetry*.

To enable the *Event logger* follow these steps.

1. From the *Home* panel, go to *TEST*,
   The *test* configuration panel is displayed.
2. Select *Event logger setup*.
   The event logger configuration menu is displayed.
3. Enable event logging with the help of the *Enable* control.
4. Optionally, clear the currently selected filters with the *Clear all filters* menu.
5. Select the *Port C* or *Port D* (if available).
6. Choose the event categories corresponding to the events you want to trace between: *Anomalies / defects*, *BERT*, *Line*, *Synchronization* or *Delay*.
7. Select the events to be monitored from the category you have selected in the previous step.

Once event logging is enabled and the monitored events have been selected, the equipment starts generating one trace file for each test started with *run* (or automatically through the Autostart/stop functionality).

6.8.6. Displaying Logs

You can either display trace files from finished tests or from the current test. You don't need to wait to the end of the test to display a trace file but logs are not upgraded in real time. You may need to re-open a trace file to display the results collected since the last time the file was opened. To display the trace files and browse the events they contain follow this procedure:

1. From the *Home* panel, go to *RESULTS*,
   The *Results* panel is displayed.
2. Select *Event logger* to enter in event tracer.
3. Press the "..." button.
   A list with all the available trace files is displayed. Files are identified by the measurement start date and time.
4. Select one trace file and display it with the help of the *Open* control.
   Note: A chronograph with the list of events included in the trace file is displayed

Use the navigation bar on the bottom of the screen to browse the events regis-

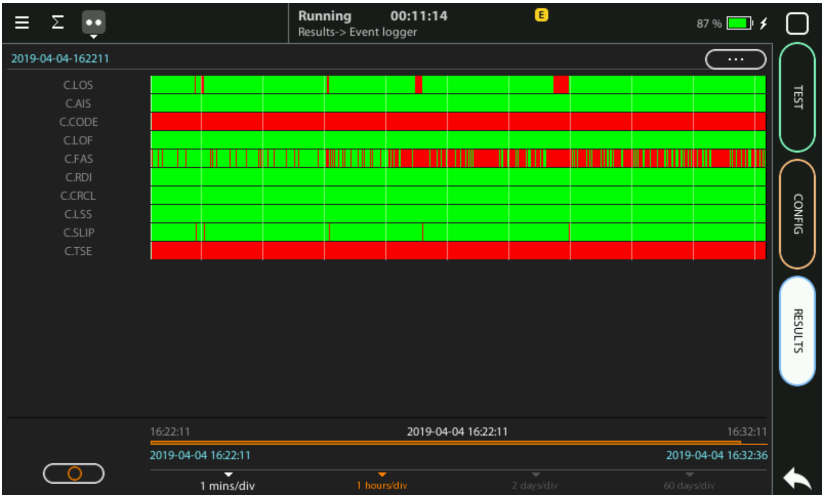

Figure 6.8: xGenius event logger panel. This panel traces all events previously selected from the event filter.

tered at different times. You can set the display scale to seven different zoom levels: *1 mins/div, 5 mins/div*, *20 mins/div*, *1 hours/div*, *5 hours/div*, *20 hours/div, 2 days/div.*

Figure 6.9: xGenius detailed view of events.

5. Select an event in the list to and an instant in the time bar to display the magnitude of the event at the chosen time. Optionally, press over the selected event to display detailed information about it, including a diagram of the amplitude for the current observation window.
6. Press the back arrow to go back to the chronograph view of the plot.

6.8.7. Exporting Logs

Users are allowed to export log files in CSV format. These files could be used as input for data processing software packages. A typical application is to use these graphics to generate high resolution plots from the data measured by xGenius. To export a file you can use the regular file exporting procedure for log files (See section 11.2.4). You can also export log files with the help of a web browser (See section 11.2.8).

Once the trace files have been exported to the external device they can be displayed, renamed or deleted form the file manager as any other output file generated by the test unit. (See section 11.2.2, See section 11.2.3). You can also copy and edit the log file to an external computer. Basically, a log file is a large table where each column corresponds with one event and each row is an instant of time. The table is filled with samples for the traced events collected at different instants of time.

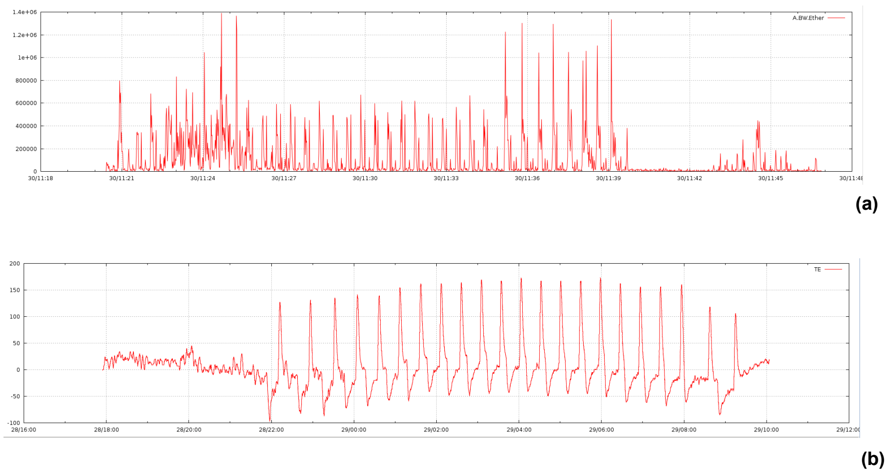

Figure 6.10: Plots generated from CSV files exported from xGenius.

6.8.8. Event Insertion

Sometimes it is necessary to insert events (defects or anomalies) in the generated signal to stress the DUT/SUT. The tester implements extended event insertion capabilities. The procedure to set event insertion is as follows:

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1. From the *Home* panel, go to *TEST*,
   The *Test* configuration panel is displayed.
2. Select *Insertion*
   The event insertion menu is displayed.
3. Select the event to be inserted with the help of the *Physical-level events*, *Frame-level events*, *Pattern-level events* menu items.
4. Select the insertion mode for the event selected in the previous step with the help of the *Mode* menu item. Available insertion modes for anomalies are: *Single*, *Rate*, *Burst* or *Continuous burst*. For defects, the insertion modes are: *Continuous*, *Burst of M*, *M out of N*.
5. Select the target port for the insertion with the Target port menu item (Port C or Port D).
6. Configure the insertion parameters with the help of the *Event rate*, *Burst length*, *M-Count* and *N-Count* menu items.
7. Start insertion by pressing the *event* button.
   Note: Depending on the insertion mode, event insertion will finish automatically or you will need to press *event* a second time to stop.

Table 6.8: Event Insertion Settings

Event	Description
Physical-level events	Contains a lower level menu with insertion events classified as physical level. These events are: *Code*, *AIS* and *LOS*. To disable insertion of physical-level events select *none* in this menu. Only one event can be inserted at the same time. Configuration of a frame-level or pattern-level event will disable insertion of any previous physical-level event.
Frame-level events	Contains a lower level menu with insertion events classified as frame level. These events are: *LOF*, *FAS*, *RDI*, *CRC-LOM*, *CRC*, *REBE*, *CAS-LOM*, *MAIS*, *MFAS*, *MRDI*. To disable insertion of frame-level events select *none* in this menu. Only one event can be inserted at the same time. Configuration of a physical-level or pattern-level event will disable insertion of any previous frame-level event.
Pattern-level events	Contains a lower level menu with insertion events classified as patter level. These events are: *TSE*, *Slips*, *LSS*, *ALL 0*, *A LL1*. To disable insertion of pattern-level events select *none* in this menu. Only one event can be inserted at the same time. Configuration of a physical-level or frame-level event will disable insertion of any previous pattern-level event.

Table 6.8: Event Insertion Settings

Event	Description
Mode	Configures the way events are inserted in the outgoing signal. Depending on whether the insertion event is an anomaly or a defect there are different insertion modes. For anomalies, the insertion modes are: • *Single*: A single event is inserted. Event insertion is triggered when the *event* key is pressed. • *Rate*: Events are inserted with a configurable rate. Insertion is deterministic (the time interval between consecutive events is a constant). Insertion starts if the *event* key is pressed. Insertions stops when the *event* key is pressed again. • *Burst*: A burst events a configurable number of events is inserted. Burst start is triggered with the *event* key. • *Continuous burst*: Inserts one event burst per second. The number of events per burst is configurable. Insertion starts / stops when *event* is pressed. For defects, the insertion modes are: • *Continuous*: Event is continuously inserted when the *event* is pressed. To stop insertion press Event again. • *Burst of M*: The event is inserted in M consecutive insertion opportunities. The exact definition of an insertion opportunity depends on the particular event to be inserted. Some alarms can be inserted once per frame, others are inserted once per CRC multiframe and some others once per CAS multiframe. Insertion is triggered with the *event* button. • *M out of N*: Event insertion is periodic. The event is inserted in M consecutive opportunities. The tester waits for N insertion opportunities before starting from the beginning. Insertion is started / stopped with the *event* button.
Target port	Sets the port where the event is going to be inserted. It is possible to insert events in the Port C or Port D .
Event rate	If the insertion mode has been set to *Rate*, this fields sets the rate at which events are inserted in the outgoing signal. The rate is entered in scientific notation: A x 10^{-B} In this notation B is a number between -3 and -9 (both included) and A is 0.9, 1.0 or 1.1. If you enter a number that is different of these, the closer one will be configured.

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Table 6.8: Event Insertion Settings

Event	Description
Burst length	If insertion mode has been set to *Burst* or *Continuous Burst*, this field sets the number of events that makes up the burst. For example a burst of 10 bit errors is made of ten consecutive TSE errors.
M-count	Number of consecutive times an event is inserted when *M-Single* or *M out of N* insertion modes are selected.
N-count	Number of consecutive insertion opportunities the tester waits between event bursts when *M out of N* insertion is selected.

6.9. Using the G.703 / E0 Port

When equipped with the PHM-22, xGenius accepts testing of variable bit rate G.703 codirectional, contradirectional and centralized signals. Unlike E1 and T1 frames, G.703 / E0 signals do not carry an specific frame structure. That means that configuration of *Multiplexer* or *Demultiplexer* blocks doesn't make sense for these signals. All defects and anomalies which require a frame structure are not available neither. The ITU-T G.703 generator / analyser can be used in different ways:

- *G.703/E0 endpoint emulation*. This is achieved with the *G.703 / E0* operation mode. In this mode G.703 codirectional, contradirectional and centralized signals are processed in the same way that E1 or T1 signals when the *E1/T1 endpoint* mode is configured.
- *G.703/E0 drop and insert*. The tester is configured to add / drop an E1 / T1 time slot to / from a codirectional interface. To do that, the tester has to be configured either in *E1/T1 endpoint* or *E1/T1 monitor* mode and *External interface* (*Port C* configuration menu) has to be set to G.703 / E0. *Codirectional*. The time slots to be added and dropped are configured with the help of the *Port A Multiplexer* and *Demultiplexer* blocks (See section 6.3.1). The ITU-T G.703 co-directional / contra-directional interface bit rate when it is configured for drop and insert is fixed to 64 kb/s.
- *G.703/E0 tributary in a MUX / DEMUX test*. In the E1 /T1 DEMUX test, Port C operate as the aggregated signal to be transmitted to a TDM demultiplexer. The G.703 co-directional, contra-directional or centralized interface plays the role of the tributary signal dropped from the demultiplexer. The E1/T1 MUX test is similar but it works in the opposite direction. The correct operation modes for the MUX and DEMUX tests are *E1 / T1 MUX test* and *E1 / T1 DEMUX test.* The correct setting for *Tributary interface* (*CONFIG* menu) to use codirectional, contradirectional and centralized G.703/E0 tributaries is G.703/E0.

Tests available for *G.703 / E0* drop / insert are the ones allowed in their operation modes (*E1 endpoint*, *E1 monitor*). Tests for *G.703 / E0* emulation are similar that for

E1/T1 endpoint emulation (line results, anomaly and defect counts, BER and performance tests). The occupancy grid results doesn't make sense for unframed signals and therefore these results are not available for codirectional endpoint emulation.

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Chapter 7
BER and Performance Tests

The bit error ratio (BER) is the most basic performance figure for TDM circuits. This chapter explains how to check the BER in the DUT / SUT.

Despite being useful, the BER is not the only performance metric for TDM links. The ITU-T has defined several standards to assess the performance of TDM links. Performance metrics defined in these standards are more sophisticated than the BER. The most basic of the ITU-T performance metric is the Errored Seconds Ratio (ESR) which is a parameter derived from the TSE and sometimes from ECRC, REBE and other events.

7.1. Setting up the Test Pattern and External Interface

The test unit is able to analyse different kinds of test patterns and signals. Individual time slots can also be inserted and dropped to a secondary low speed interface (Pot C only) for its analysis by an external equipment. Usually, it is required a previous setup of the tester operation mode, line and frame parameters. It follows the procedure for configuring the pattern and external interface blocks.

1. From the *Home* panel, go to *CONFIG*,
   The test configuration panel is displayed.
2. Select either *Port C* or *Port D* (if available) to enter in the port specific configuration menu.
3. Go to *Test Pattern* and select one of the available patterns in *RX Pattern* (*PRBS 6, PRBS7*, *PRBS 11*, *PRBS 15*, *PRBS 20*, *PRBS 23*, *QRSS, QBF/FOX, All ones* or their inverted versions) or a user defined pattern by selecting *Word* in the list.
   Note: If the received signal carries some ITU-T G.704 or ANSI T1.403 framing, the pattern will not be analysed until *Pattern* is set in at least one time slot within the *Demultiplexer* block.
   Note: If the received and the expected patterns do not match, an LSS defect will be raised. Isolated bit errors are displayed as TSE anomalies. Repeated or missing bits in the test patters are accounted as slips.

4. If you have selected *Word* in step 3, enter the user-defined 32-bit pattern in *RX Word* in hexadecimal format.
5. Configure the *TX Pattern* block (test pattern generator) in the same way that the *RX Pattern* block just configured.

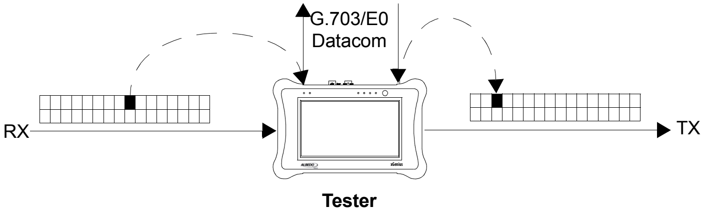

Figure 7.1: The Low speed external outputs can be used for add / drop time slots from / to external devices.

6. From the Port C port specific configuration, go to *External interface* and select G.703/E0 or Datacom interfaces.
   Note: If the received signal carries some G.704 or T1.403 framing, the signal will not be added / dropped to / from the frame until the external interface (color) is set in one or more slots in the *Multiplexer / Demultiplexer* block (See section 6.3.1).

Table 7.1: Test Patterns

Setting	Description
TX Pattern	Sets the transmitted test pattern. Patterns are either pseudo-random bit sequences (PRBSs) or fixed words. The test unit supports the following patterns: • *PRBS* 2^6*-1 /*2^6*-1 inverted:* Pseudo-random bit pattern built with a shift register with the following associated polynomial: X^6+X+1. This pattern is 63 bits long and it contains a maximum of 5 consecutive zeros. The 2^6*-1 inverted* pattern is a bitwise inverted version of the 2^6*-1.* • *PRBS* 2^7*-1 /*2^7*-1 inverted*: Pseudo-random bit pattern built with a shift register with the following associated polynomial: X^7+X^6+1. This pattern is 127 bits long and it contains a maximum of 6 consecutive zeros. The 2^7*-1 inverted* pattern is a bitwise inverted version of the 2^7*-1.*

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Table 7.1: Test Patterns

Setting	Description
	• *PRBS 2^{11}-1 /2^{11}-1 inverted*: This is a pseudo-random bit pattern specified in ITU-T O.153 for error performance measurements below the primary rate (2048 kb/s). The 2^{11}-1 inverted is a 2^{11}-1 bit wise inverted pattern. • *PRBS 2^{15}-1 /2^{15}-1 inverted*: This is a pseudo-random bit pattern specified in ITU-T O.151 for measurements at the primary rate or above. The 2^{15}-1 inverted is a 2^{15}-1 bit wise inverted pattern. • *PRBS 2^{20}-1 /2^{20}-1 inverted*: This is a pseudo-random bit pattern specified in ITU-T O.151 for error performance measurements at the primary bit rate or above. The 2^{20}-1 inverted is a 2^{20}-1 bit wise inverted pattern. • *PRBS 2^{23}-1 /2^{23}-1 inverted*: This is a pseudo-random bit pattern specified in ITU-T O.151 for error performance measurements at the primary bit rate or above. The 2^{23}-1 inverted is a 2^{23}-1 bit wise inverted pattern. • *QRSS / QRSS inverted*: Quasi-random signal source (QRSS) is a modified version of the PRBS 20. The length of this pattern is 1,048,575 bits. This pattern is generally used as a test signal to test T1 line. The *QRSS inverted* is a bitwise inverted version of the *QRSS* pattern. • *QBF/FOX*: Bit pattern that is built with the following ASCII encoded character sequence: *THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789*. This sequence is a variation of the pattern defined in ITU-T R.52 standard for telegraph communications. • *All zeroes / All ones*: Sets the transmitted pattern to all zeroes or all ones. • *User word*: Sets a 32-bit, user configurable word as the transmitted pattern. • *Match RX*: Matches the test pattern in the receiver. This setting could be used to avoid configuring twice the same thing or to match the detected pattern during the auto-negotiation process.
TX Word	Here it is configured the value of the user word that is used as the transmitted pattern when *Word* is configured in *TX Pattern*. If *Word* is not set in *TX Pattern*, then this field is not used.

Table 7.1: Test Patterns

Setting	Description
RX Pattern	Sets the expected test pattern. Patterns are either pseudo-random bit sequences (PRBSs) or fixed words. The supported transmitted and expected patters are the same.
RX Word	Here it is configured the value of the user word that is used as the expected pattern when *Word* is configured in *RX Pattern*. this field is not used if *Word* is not set in *RX Pattern*.

7.2. Computing the BER

The most useful results for computing or at least estimating the BER are the TSE (only out-of-service measurements) and the ECRC (Only E1 interfaces).

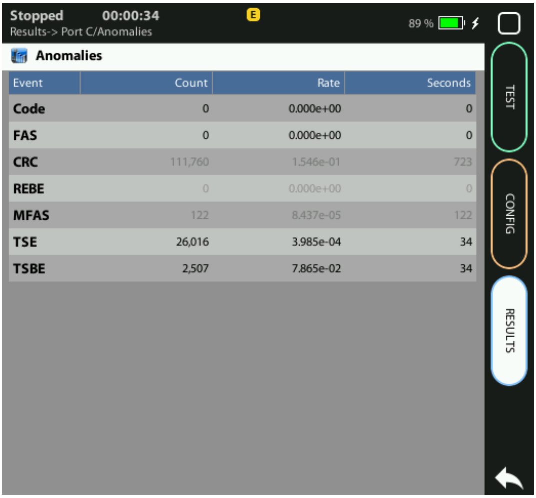

Figure 7.2: E1 anomaly statistics panel

- Test Sequence Error (TSE) is a single bit difference between the transmitted and the received pattern. It represents a single transmission bit error. It can be used to compute the BER even when the channel error probability is higher and when error events are bursty. The inconvenience is that it is an out-of-service metric. Is not available for permanent monitoring purposes.
- ECRC represents a CRC error in a 8-frame CRC-4 block. Unlike it happens with the TSE, the CRC-4 does not always represent a single bit error. When detected, the CRC-4 represents one or more bit errors. If bit errors are uncommon enough so that they do not happen more than once in a CRC-4 block (2048 bits, BER <

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10^{-4}) and error events are not bursty, then the CRC-4 errors are a good estimator of the bit error events.

It is possible to estimate the BER in de opposite transmission direction with the help of the REBE anomaly. REBE is derived from the ECRC and therefore is subject to the same limitations that the ECRC.

You can configure a BER objective for your tests based on the TSE event. This objective is compared with the test results and aggregated to the global Pass / Fail indication available in the summary screen (SUM key). Follow these steps to activate the BER objectives.

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Select the *Test pattern objectives* menu item.
3. Enable the line objectives with the help of the *Enable* control
4. Enter the value for the *TSE rate*.
   Note: Port C and Port D (when installed) share the same pattern objectives.

7.3. Testing Performance

The performance tests are useful to check how good is the performance of a TDM path in terms of bit errors and other defects and anomalies. The test unit supports three different performance tests, each with their own features. These tests are defined in three ITU-T Recommendations:

- ITU-T G.821: This standard was released for first time in 1980 to be used in digital links operating at rates below 2048 kb/s. At the time ITU-T G.821 was defined, an standard for links operating at 2048 kb/s and higher was not available. This is the reason because for some time, this ITU-T Recommendation was used in a very wide class of connections.
- ITU-T G.826: It was released in 1983 for performance assessment of links operating at 2048 kb/s and above. Performance metrics defined in this standard are based on the concept of block (a group of consecutive bits).
- ITU-T M2100: This ITU-T Recommendation provides performance limits for bringing-into-service and maintenance PDH paths and connections. While the G-series Recommendations define long-term performance objectives to be met, M.2100 and other M-series Recommendations are intended to assure that the long-term requirements of the G-series are met in every case. For this reason the requirements of the M-series are tougher than those on the G-series. An specific feature of M.2100 is that it allows shorter test intervals than ITU-T G.821 and G.826.

7.3.1. Setting the Performance Objectives

Before starting a ITU-T G.821, G.826 or M.2100 performance test, you have to set the correct performance objectives for the measurement:

1. From the *Home* panel, go to *TEST*,
   The *Test* configuration panel is displayed.
2. Select the *Performance Objectives* menu item to configure the performance standard and thresholds
3. Select the standard to be used (*G.821*, *G.826*, *M.2100*) in the Performance test with the help of the *Standard* menu item.
4. Configure the allocation parameter with the *Allocation (%)* menu item.
   Note: The meaning of the allocation parameter may not be the same in different performance standards. Check the ITU-T G.821, G.826 and M.2100 to get more information about the meaning of the allocation.
5. Configure the performance thresholds for the standard you have set in the previous step by means the *G.821*, *G.826* or *M.2100* menu items (ES, SES, DM and UAS for ITU-T G.821, ES, SES, BBE and UAS for G.826 / M.2100).

Table 7.2: ITU-T G.821, G.826 and M.2100 Objectives

Setting	Description
Standard	Selects the ITU-T performance standard for the next measurement. Available choices are *G.821*, *G.826* and *M.2100*. You can also choose *none* to disable any performance testing.
Allocation (%)	Represents the percentage of the reference objectives provided by the ITU-T performance standards which have to be met in the circuit under validation. ITU-T standards provide the methodology to compute the Allocation based on the circuit grade and the path length.
G.821	If the current performance standard is the G.821, this menu provides access to the objective settings for ES, SES, DM, UAS as defined in the corresponding ITU-T Recommendation.
G.826	If the current performance standard is the G.826, this menu provides access to the objective settings for ES, SES, BBE, UAS as defined in the corresponding ITU-T Recommendation.
M.2100	If the current performance standard is the M.2100, this menu provides access to the objective settings for ES, SES, BBE, UAS as defined in the corresponding ITU-T Recommendation.

If a performance test is configured and their objectives set, the result will be compared with these objectives and aggregated to the global Pass / Fail indication available in the summary screen.

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7.3.2. Running the Performance Test

1. Configure the tester in accordance with the DUT and the measurement to be carried out: Choose the right operation mode, connect the test unit to the DUT / SUT and configure the line, frame and pattern blocks for the test ports.
2. Configure the performance objectives (See section 7.3.1).
3. Program the test start time and duration with the help of the *Autostart/stop* menu (within *Test*) or start the test immediately by pressing RUN.
4. Wait for the test to finish or press RUN to finish immediately.
   Note: In fact, it is not necessary to wait until the test has finished. Partial results are presented in real time during test execution.
5. From the *Home* panel go to *Results* to display to the submenu that provides access to all the results collected during the last test.
6. Select either *Port A or Port B* (or *Port C* if you are using Ether.Genius or Ether10.Genius) to enter in the port specific results.
7. Select *G.821*, *G826* or *M.2100* to display the performance results for the last measurement.

Table 7.3: ITU-T G.821, G.826 and M.2100 Objectives

Setting	Description
ES	Errored Second. An ES is a second which contains at least one bit error (ITU-T G.821) or a second which contains one or more errored blocks or at least a defect (ITU-T G.826, M.2100). The ITU-T G.826 and M.2100 standards use out-of-service and in-service anomalies and defects to compute the ES. The ITU-T G.821 takes into account out-of-service events only. Performance recommendations provide the maximum allowed ESs by means the ESR (ES Ratio) defined as the ratio between the ES and the available seconds.

Table 7.3: ITU-T G.821, G.826 and M.2100 Objectives

Setting	Description
SES	Severely Errored Second. A SES is defined as a second with a BER worse than 10^{-3} (ITU-T G.821) or a second with 30% or more of errored blocks or at least a defect (ITU-T G.826, M.2100). The ITU-T G.826 and M.2100 standards use out-of-service and in-service anomalies and defects to compute the SES. The ITU-T G.821 takes into account out-of-service events only. Performance recommendations provide the maximum allowed SESs by means the SESR (ES Ratio) defined as the ratio between the SES and the available seconds.
UAS	Unavailable Second. Is a sequence that contains 10 or more consecutive SES. A sequence of US is not considered to finish before at least ten consecutive non-SES have occurred. This definition applies to G.821, G.826 and M.2100.
BBE	Background Block Error: Is a block which contains at least one error and it is not occurring as part of a SES. The BBE applies only to G.826 and M.2100 performance measurements.
DM	A Degraded Minute is one in which the estimated error rate exceeds 10^{-6} but does not exceed 10^{-3}. Degraded Minutes are determined by collecting all of the available seconds, removing any SES, grouping the result in 60-second long groups and counting a 60-second long group as degraded if the cumulative errors during the seconds present in the group exceed 10^{-6}. The DM applies only to G.821 and even for this recommendation DM has been suppressed in the more recent versions.

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Chapter 8
Data Communications Testing

xGenius has two data communications operation modes. The *Datacom endpoint* is used for DTE and DCE emulation. Some capabilities of the *Datacom endpoint* mode are BER / Performance tests over datacom interfaces and logic analysis of datacom signals. The *Datacom monitor* mode enables analysis of datacom signals between the DTE and DCE without disturbing them.

8.1. Emulating Datacom Endpoints

The test unit replaces a DTE or DCE when it is configured in *Datacom endpoint* mode. In this case the equipment assumes the same functionality that the DTE or DCE: It sends information through the circuits the DTE / DCE is expected to generate and it analyses data through the DTE / DCE circuits defined for each supported datacom standard.

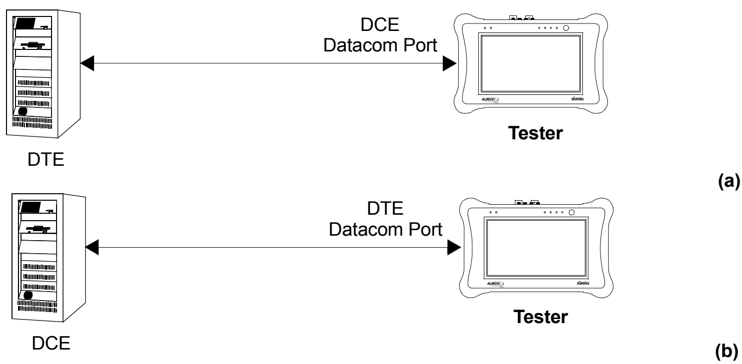

Figure 8.1: The tester configured in *Datacom Endpoint* mode replaces the DTE or the DCE. (a) DCE emulation, (b) DTE emulation.

Follow these steps to configure a datacom interface for DTE or DCE emulation:

1. From the *Home* panel, go to *CONFIG,*
   The test port configuration panel is displayed.
2. Select *Mode* and choose *Datacom endpoint* in the menu.

Table 8.1: Datacom Line Settings

Setting	Description
Interface	Current data communication standard. The interface selection configures the *Datacom DTE / Datacom DCE* interfaces for transmission and reception through the circuits defined in the standard. It is one of the following: • *X.21 / V.11 / RS-422*: Sets the X.21 / V.11 datacom interface. The X.21 / V.11 is an ITU-T specification of a data communications system for differential transmission. • *V.24* / RS-232: Sets the V.24 / V.28 datacom interface. It is essentially the same that RS-232C and EIA-232 standards. V.24 has an asynchronous operation mode for low speed, low reach applications and a synchronous operation mode that is typically used for transporting HDLC, X.25 or PPP applications. V.24 uses unbalanced transmission for all circuits. • *V.35*: Sets the V.35 datacom interface. The V.35 uses differential transmission for the clock and data signals while signals which normally incur a minimum state changes are unbalanced. • *V.36* / RS-449: Sets the V.36 interface. This interface is also referred as RS-449 This is a differential communications interface. It is used when either long reach or high speed is required. It also offers good noise immunity in environments with high levels of EMI. • *EIA-530* / RS-530: Sets the EIA-530 or RS-530 interface. Most EIA-530 signals conform with the RS-449 requirements as well. Applications are similar to the RS-449 applications. • *EIA-530A* / RS-530A: Sets the EIA-530A datacom interface. EIA-530A is similar but incompatible with EIA-530. EIA-530 circuits are balanced but some EIA-530A control circuits are unbalanced.*G.703 / E0*: Configures the ITU-T G.703 co-directional interface. This interface is available through an special adaptor for the DTE port. The G.703 / E0 datacom interface is available only for Ether.Genius and Ether10.Genius. Operation of the G.703 / E0 interface is different in the AT-2048 (See section 2.3).

Table 8.1: Datacom Line Settings

Setting	Description
Emulation	Chooses between DTE or DCE emulation. Available configuration values for this field are: • *DTE*: Sets Data Terminal Equipment (DTE) emulation. DTEs are end points in a data communications systems. • *DCE*: Sets Data Communications Equipment (DCE) emulation. DCEs are usually modems, routers or equipments with similar capabilities.
Operation	This setting configures synchronous or asynchronous operation in the V.24 and X.21 / V.11 datacom interface: • *Synchronous*: Timing information for the DTE and the DCE is sent over dedicated circuits. This circuit can be either the TC or the TTC for data from DTE and the RC for data from the DCE. • *Asynchronous*: There is not a timing circuit for the DTE and DCE. The information can be sent at any time.
TD clock circuit	Sets the timing circuit for the TD circuit. The TD is used to deliver information from the DTE to the DCE. There are two possible configurations for this setting: • *TC (DCE source)*. The TC circuit carries timing generated by the DCE. If TC is set in *TD clock circuit*, timing and information from the DTE will follow opposite path directions. • *TTC (DTE source)*: The TTC circuit carries timing generated by the DTE. If TTC is set in the *TD clock circuit*, timing and information from the DTE will follow the same direction. The TD clock circuit setting applies to the *V.35*, *V.36*, *EIA-530* and *EIA-530A* interfaces only.
TX clock source	Clock source for the transmitter. These are the options available for this setting. For datacom circuits, this setting is always *Synthesized*, which means that the transmitter is locked to the clock signal configured in the *Reference clock* menu. The *TX clock source* cannot be configured when the equipment is configured in DTE emulation mode and the transmitter is locked to the TC circuit generated from the DCE.

Table 8.1: Datacom Line Settings

Setting	Description
TX clock offset (ppm)	Frequency offset applied to the transmitter clock within the range of ±25,000 ppm. This feature is useful to stress the DUT / SUT. The frequency offset can be applied only if *TD clock circuit* is configured to *TC (DCE source)* with DCE emulation or *TTC (DTE source)* with DTE emulation.
Line rate	Configures the data rate for the currently selected datacom interface. The options available for this setting depend on the actual interface configured.
Nx64/56 factor	If you have set Nx64 or Nx56 as the *Bitrate*, this field configures the value of N. N must be a positive integer value. The maximum allowed value of N depends on the current interface.
User rate (b/s)	Data transmission rate in b/s. This setting is only available if the *Bitrate* field has been configured to *User*.
Data bits	Data bits per each V.24 asynchronous frame. It can be 5, 6, 7 8 bits. This setting applies only to V.24 and X.21 / V.11 operating in asynchronous mode
Stop bits	Stop bits for V.24 asynchronous frames. The available values are 1, 1.5 and 2 bits. This setting applies to V.24 and X.21 / V.11 interfaces operating in asynchronous mode only.
Parity	Presence and type of parity for V.24 asynchronous frames. The available values are *None*, *Even* or *Odd*. This setting applies to V.24 and X.21 / V.11 interfaces operating in asynchronous mode only.
Inter-word TX gap (half bits)	Configures the gap between consecutive words in the V.24 and X.21 / V.11 asynchronous interfaces in half bit units. For example, configuring this field to 2 leaves one idle bit between two consecutive words. This setting could be used to modify the effective transmission rate over the interface.

3. Select *Datacom* to enter in the datacom port specific configuration menu.
4. Press *Line* to configure the data communications line settings for your test.
5. Configure the datacom interface with the help of the *Interface* setting.
6. Select whether you want the test to replace a DTE or a DCE by means the *Emulation* setting.

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7. Configure the *Bitrate*. If you have set the *Bitrate* to *Nx64* or *Nx56* configure the *Nx64/56* factor as well. If you have set the *Bitrate* to *User* configure the *User rate*.
8. Configure the *TD clock circuit* (synchronous V.24 / RS-232, V.35, V.36 / RS-448, EIA-530 / RS-530, EIA-530A / RS-530A).
9. If *TD clock circuit* is *TTC (DTE source)* with *DTE emulation* or *TC (DCE source)* with *DCE emulation*, configure *TX clock offset (ppm)*.
10. Configure the synchronous / asynchronous *Operation* (V.24 / RS-232, X.21 / V11 / RS-422) and the *Data bits*, *Stop bits*, *Parity* and *Inter-word TX gap (half bits)* (V.24 / RS-232, X.21 / V11 / RS-422 asynchronous).

Some datacom tests like the datacom BER and the datacom ITU-T G.821 require a test pattern. Configuration of the test pattern for datacom is equivalent to the E1 test pattern. To configure it once the line settings are ready, follow these steps:

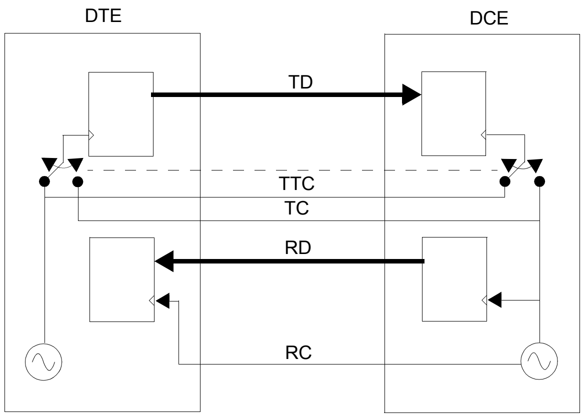

Figure 8.2: Transmission timing in V.24 / RS-232 synchronous, V.35, V.36 / RS-449, EIA-530 / RS-530 and EIA-530A / RS-530A interfaces.

1. From the *Home* panel, go to *CONFIG,*
   The test port configuration panel is displayed.
2. Select *Datacom* to enter in the datacom port specific configuration menu.
3. Go to *Test Pattern* and select one of the available patterns in *RX Pattern* (PRBS 6, PRBS 7, *PRBS 9, PRBS 11*, *PRBS 15*, *PRBS 20*, *PRBS 23*, QRSS, *All ones* or their inverted versions, QBF / FOX) or a user defined pattern by selecting *Word* in the list.
   Note: If the received and the expected patterns do not match, an LSS defect will be raised. Isolated bit errors are displayed as TSE anomalies. Repeated or missing bits in the test pattern are accounted as slips.
4. If you have selected *Word* in step 3, enter the user-defined 32-bit pattern in *RX Word* in hexadecimal format.

5. Configure the *TX Pattern* block (test pattern generator) in the same way that the *RX Pattern* block just configured.

Once the mode has been set to *Datacom endpoint*, the datacom interface has been configured and the test pattern is ready, the test can be started by pressing the *run* key.

Table 8.2: Datacom Anomalies

Event	Description
FRM	Frame anomaly. The-character does not have the correct structure of start bits, data bits, parity bit and stop bits. This event applies to V.24 / RS-232 and X.21 / V.11 / RS.449 interfaces operating in asynchronous mode only.
PRTY	Parity anomaly. The asynchronous interface does not have the correct even / odd parity. This event applies to V.24 / RS-232 and X.21 / V.11 / RS.449 asynchronous interfaces with even / odd parity only.
TSE	Test Sequence Error. One TSE is equivalent to a single bit difference between the transmitted and the received test pattern (PRBS or other).
TSBE	Test Sequence Block Error. One of the user-configurable data blocks of contains at least one TSE.

Tests for *Datacom endpoint* emulation are similar that for *E1/T1 endpoint* emulation (line results, delay (either one-way or two-way), anomaly and defect counts, BER and performance tests). The occupancy grid results doesn't make sense for unframed signals and therefore these results are not available for datacom endpoint emulation. Datacom *Line* results include the DTE / DCE frequency (Hz) and frequency offset (ppm). The most important practical difference between the *E1/T1 endpoint* results and the *Datacom endpoint* results is that the former are available in the *Port C* or *Port D* sub-menus (*Results* menu) and the latter are found inside the *Datacom* sub-menu (*Results* menu).

Table 8.3: Datacom Defects

Event	Description
LOC	Loss Of Clock. The clock for the RD circuit (RC circuit) or the clock TD circuit (TC or TTC circuits) are not available or do not have the right format. This defect does not apply to V.24 / RS-232 and X.21 / V.11 / RS.449 operating in asynchronous mode.

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Table 8.3: Datacom Defects

Event	Description
LSS	Loss of Sequence Synchronization. This event indicates that the expected test pattern does not match the actually received pattern.
All 0	This alarm occurs when all the user bit capacity is set to ‘0’.
All 1	This alarm occurs when all the user bit capacity is set to ‘1’.
Slips	Either one bit is missing or repeated in the received test pattern. This error is usually related with timing problems within the network.

8.1.1. Using the Circuit Map

It is sometimes useful to have full control over the datacom circuits as they are generated by the tester in the role of DTE or DCE. Even if the test equipment is just monitoring communications between the DTE and the DCE it could be interesting to get permanent information about the status of each datacom circuit. All this is possible thanks to the circuit map capability available in *Datacom endpoint* emulation and *Datacom monitor* modes. To display and use the datacom circuit map screen follow these steps:

Table 8.4: Datacom Defects

Column	Description
DTE <> DCE	Displays the direction of the information flow: from the DTE to the DCE or from the DCE to the DTE.
Circuit	Shows the circuit number assigned to the datacom circuit by the standards.
Signal	This is an alphanumeric identifier given to the circuit: It provides a short description of the circuit assigned functionality.
Activity	Reports circuit activity. Activity is measured in one second intervals. There are two activity status: • *Active*: At least one transition (1 to 0, 0 to 1, ON to OFF, OFF to on) has occurred the current one second period. • *Idle*: No transitions have occurred the current second period.

Table 8.4: Datacom Defects

Column	Description
State	Shows the current circuit status. Identifiers given to the states are different for data and control circuits. The test unit follows ITU-T V.11 and V.28 for designation of the circuit status. • *1*: Corresponds to a negative voltage polarity in the circuit. Applies to data circuits (TD, RD) only. • *0*: Corresponds to a positive voltage polarity in the circuit. Applies to data circuits (TD, RD) only. • *ON:* Corresponds to a positive voltage polarity in the circuit. Applies to control circuits only. • *OFF*: Corresponds to a negative voltage polarity in the circuit. Applies to control circuits only.

1. From the *Home* panel, go to *Results,*
   The *Results* configuration panel is displayed.
2. Select *Datacom* to enter in the datacom port specific results menu.

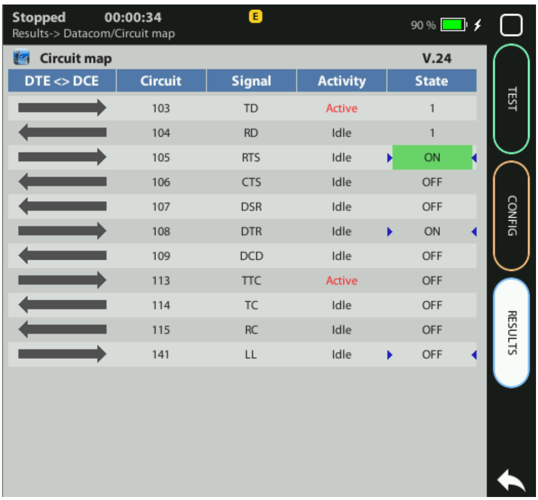

Figure 8.3: Circuit map analysis for the Datacom endpoint emulation and monitor modes.

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3. Select the *Circuit map* in the menu
   A table with all the available circuits for the currently configured datacom interface and some information about them is displayed.
4. Check the *Activity* and *State* columns.
5. Use the touch screen to select a circuit.
   Note: The circuits which are available for selection through the up and down keys depend on the current DTE / DCE emulation configuration. No selection is possible if the operation mode is *Datacom monitor.*
6. Click over the currently selected circuit to switch between the ON and OFF values.

8.1.2. Measuring Latency

Due to its special relevance, this section is devoted to the latency test in *Datacom endpoint* mode for xGenius. xGenius supports both round-trip and one-way delay configurations. The steps to follow to configure and run the latency test are as follows:

1. From the *Home* panel, go to *CONFIG*,
   The port configuration panel is displayed.
2. Select *Mode* to enter in the mode selection menu and choose *Datacom endpoint*.
3. Configure the datacom port interface, DTE / DCE emulation, bit rate and TD clock circuit (See section 8.1).
   Note: At this point, the *Pattern* LED corresponding to *Port C* should be displaying the green colour to indicate test pattern continuity between the transmission ends. Specifically, you should be receiving no LSS defect.
4. If you are willing to run a one-way delay, configure the external synchronization input to *GNSS* (See section 2.9).
   Note: At this point, the *Clock* LED should be displaying the green colour, and the *Locked* indication in the *Clock setup* panel should be set to *Yes*.

1. From the *Home* panel, go to *Test*,
   The *Test* configuration panel is displayed.
2. Go to *Delay test*.
   The latency test setup panel is displayed.
3. Start the delay test by configuring *Enable* to *Yes*.
4. Configure the *Measurement mode* to *Round trip* or *One-way*, depending on the test you want to do
5. Disconnect the unit from the network and loop the TD and RD circuits to calibrate it.
   Note: In some situations, you may have to change the emulation mode (DTE or DCE) or the TD clock circuit (TC or TTC). These settings do not affect the result of the calibration but they must be configured again to the original values once the calibration process finishes.
6. Configure *Adjust zero offset* to *Adjust* and wait for the value to change to *Ready*.

7. Set the *Zero offset (RTD), Zero offset (forward path)* and *Zero offset (return path)* fields if necessary.
8. Once you have calibrated the delay test, reconnect the unit to the network.
9. Optionally, enable the latency objectives with the help of the *Enable objectives* control.
10. If you have enabled the latency objectives in the previous step, configure *Threshold (RTD)*, *Threshold (forward path)* and *Threshold (return path)*.

Remember that if you are testing one-way delay you have to configure both the near end and far end units. Configuration is the same for both equipments. There is more information about the latency test settings and results in the section devoted to the E1 delay test (See section 3.2). The procedure to display results is as follows:

1. From the *Home* panel, go to *Results*,
   The *Results* panel is displayed.
2. Go to Delay
3. Check the *Current* value of the *Round-trip delay* (round trip delay tests) or the *Current* values of *Round-trip delay*, *Forward path delay*, *Return path delay* and *Asymmetry* (one way delay tests).
4. Program the test start time and duration with the help of the *Autostart/stop* menu (within *Test*) or start the test immediately by pressing *run*.
5. Wait for the test to finish or press *run* to finish immediately.
   Note: In fact, it is not necessary to wait until the test has finished. Partial results are presented in real time during test execution.
6. Check the *Maximum* and *Minimum* values of the *Round-trip delay* (round trip delay tests) or the *Maximum* and *Minimum* values of *Round-trip delay*, *Forward path delay*, *Return path delay* and *Asymmetry* (one way delay tests).

8.2. DTE and DCE Monitoring

The *Datacom monitor* mode can be used when it is wanted to monitor the datacom circuits between the DTE and DCE without disturbing them. To set the Datacom monitor mode in the test unit follow this procedure:

1. From the *Home* panel, go to *CONFIG,*
   The port configuration panel is displayed.
2. Select *Mode* and choose *Datacom monitor* in the menu.

When the *Datacom monitor* mode is set, you can configure the datacom interface in the same way that the *Datacom endpoint* mode (See section 8.1). Tests such as the datacom BER or performance require a test pattern. In monitor mode, the transmitter

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is disabled but the analysis test pattern still has to be configured. To do that, follow the same procedure that for the *Datacom endpoint* mode (See section 8.1).

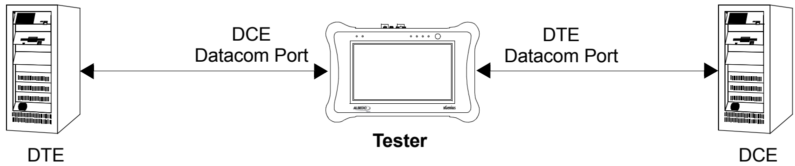

Figure 8.4: xGenius cconnection to monitor the DTE-DCE datacom path.

Once the mode has been set to *Datacom monitor*, the datacom interface has been configured and the test pattern is ready, the test can be started by pressing the *run* key. Tests results available for the *Datacom monitor* mode are the same that for the *Datacom endpoint* mode. However, when the test unit is configured in monitor mode, results for the DTE and the DCE are displayed simultaneously.

8.3. Add / Drop of E1 / T1 Tributaries to Datacom Interfaces

The xGenius Port C can be configured to add / drop an E1 or T1 time slot to / from a datacom interface. To do that, the tester has to be configured either in *E1/T1 endpoint* or *E1/T1 monitor* mode and the Port C external interface has to be set to *Datacom*. The time slots to be added and dropped are configured with the help of the *Port C Multiplexer* and *Demultiplexer* blocks (See section 6.3.1). Once the *E1/T1 endpoint* / *E1/T1 monitor* mode is set, the specific steps to follow for the add / drop test are the following:

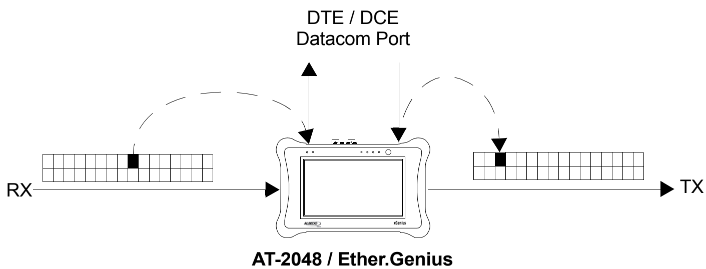

Figure 8.5: Add and Drop of E1 tributaries to Datacom interfaces.

1. From the Home panel, go to *CONFIG,*
   The test port configuration panel is displayed.
2. Select *Port C* to enter in the port specific configuration menu.
3. Set the E1 / T1 *Hierarchy, Connector*, *Line*, *TX frame, RX frame* and *Test Pattern* if necessary.
   Note: Within the *Multiplexer* and *Demultiplexer* blocks (*Frame* configuration) one or various time slots have to be configured for datacom add / drop. The time slots selected in the *Multiplexer* will be added from the datacom interface. The time slot selected in the *Demultiplexer* will be dropped to the current datacom interface.
   Note: Only one time slot can be configured for dropping to the datacom interface within the *Demultiplexer* menu. However, it is possible to configure several time slots under the *Multiplexer* menu. If the number of *Multiplexer* time slots is larger than one, the same datacom signal will be replicated in each of the selected time intervals.
4. Configure *Datacom* in *External Interface*
5. From the general *CONFIG* panel, select *Datacom* to configure de datacom port.
6. Press *Line* to configure the data communications line settings for your test.
7. Configure the datacom interface with the help of the *Interface* setting.
8. Select whether you want the test unit to replace a DTE or a DCE by means the *Emulation* setting.
9. Configure the *TD clock circuit* to *TC (DCE source)* or *TTC (DTE source)*.
   Note: Asynchronous operation for the V.24 interface is not available for add / drop tests.
   Note: The bit rate for add / drop tests is fixed to 64 kb/s.

Add / drop of the datacom signal starts immediately and does not require to start any test. When a test is started by pressing *run*, results for the *Port C* and *Datacom* port are simultaneously available.

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Chapter 9
IEEE C37.94 Testing

The IEEE C37.94 standard constitutes a communications interface for interconnection of power protection equipment (protection relays) and transmission equipment using two multimode optical fibers. This communications standard enables transmission of *N* x 64 kb/s (with *N* ranging between 1 and 12) to distances up to 2 km. The bit rate corresponding to *N*=1 is 64 kb/s. The bit rate corresponding to *N*=12 is 768 kb/s.

Optical transmission is used to guarantee reliable transmission within the substation environment where the IEEE C37.94 is designed to operate. This environment is characterized by a high level of electromagnetic perturbations caused by high voltages and currents in power lines. Specially during fault conditions the perturbation level can rise significantly and disturb communications channels based on copper wires.

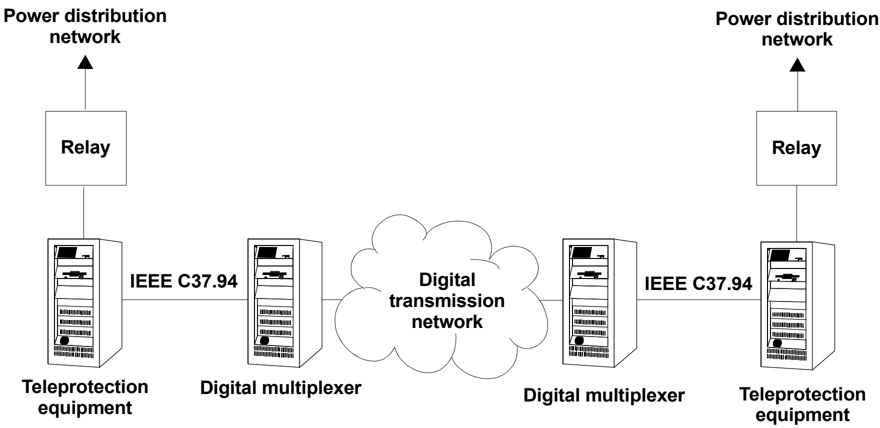

Figure 9.1: IEEE C37.94 reference model. The IEEE C37.94 interface, interconnects teleprotection and communication equipment inside a substation.

The IEEE C37.94 frame closely resembles the structure of an ITU-T G.703 2048 kb/s signal but it defines a framing structure prepared for conveying a single variable rate channel rather than various 64 kb/s multiplexed channels.

Emulation and testing of IEEE C37.94 interfaces is available in xGenius through the PHM-21 module.

9.1. Connection to the Network and Configuration

xGenius use the SFP ports attached to the PHM-21 module for IEEE C37.94 signal generation and analysis. These ports are labelled as Port A and Port B.

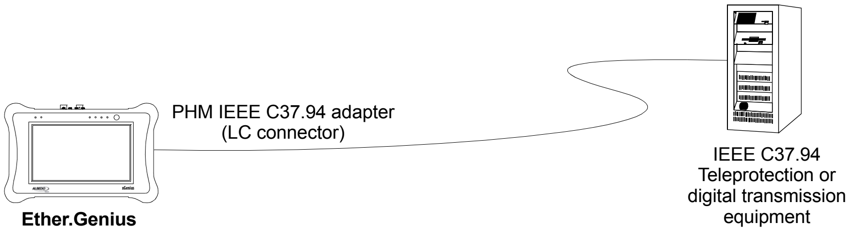

Figure 9.2: Using the AT-89 adaptor for connecting Ether.Genius to an IEEE C37.94 interface.

The IEEE C37.94 test interface configuration procedure of in xGenius is as follows.

1. Connect the IEEE C37.94 transceivers to your PHM-21 module and attach the PHM-21 to the xGenius PHM slot.
2. Connect the equipment to the device or network under test.
3. From the *Home* panel, go to *Setup*,
   The port configuration panel is displayed.
4. Select *Mode* to enter in the mode selection menu and choose *C37.94 endpoint*, *C37.94 monitor* or *C37.94 through*, depending on the test you wish to run.
5. Go to the *Port A* or *Port B* menu.
6. Enable optical transmission with the *Enable* control.
7. If you are operating in *C37.94 endpoint* mode, configure the *Port mode* to either *TX / RX* to generate and analyse traffic or *Loopback* to loop the traffic back to the origin.
8. Configure *TX clock source* to *Synthesized* or *Recovered*.
   Note: This parameter has the same meaning here than in G.703 tests (See section 2.3.1).
   Note: The *C37.94 monitor* and *C37.94 through* modes do not accept TX clock source configurations.
9. If you have configured a *Synthesized* clock source you can optionally configure a frequency offset to the transmitter through the *TX clock offset (ppm)* control.
10. Press *Frame* to configure the framing settings for your test.
11. Configure encapsulation to either *Unframed* or *C37.94.*

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12. If you have configured *C37.94* in the previous step, configure the data rate either through *TX timeslots* to any number between 1 and 12 or *TX data rate*.
    Note: This value is a multiplicative factor for the basic 64 kb/s IEEE C37.94 bit rate. *N*=1 corresponds to 64 kb/s and *N*=12 to 768 kb/s. This field has the same meaning here than in datacom interfaces (See section 8.1).
13. *Note*: The *C37.94 monitor* and *C37.94 through* modes do not require configuration of the *TX data rate* or *TX timeslots*.
14. Go to Test pattern
    Note: *Test pattern* configuration is not available for *C37.94 monitor* mode.
15. Configure *TX Pattern* and *RX Pattern* to suitable values.
    Note: *TX pattern* configuration is not available for *C37.94 through* mode.

This procedure constitutes the basic configuration mechanisms. For more details check the following sections about particular IEEE C37.94 tests.

9.2. Measuring Frequency, Bit Rate and Optical Power

The test unit measures the *Frequency* (Hz), frequency *Deviation* (ppm), digital *RX data rate*, and *RX optical power* associated to the IEEE C37.94 signal detected at its input. The unit also supplies information about the TX optical power injected to the network from the test port. Line results are permanent, there's no need to start a test with *run* to display the results.

The test procedure is similar to the one for ITU-T G.703 and datacom signals (See section 3.1, See section 8.1). The detailed steps to follow to display the IEEE C37.94 line results are as follows:

1. From the *Home* panel, go to *Results*,
   The result verification panel is displayed.
2. Select *Port A* or *Port B* (xGenius) to enter in the IEEE C37.94 port specific results.
3. Select *Line*,
4. Check the *Frequency*, *Deviation and RX data rate* results.
5. Leave the *Line* results with the *ESC* key.
6. Check the *TX optical power*, *RX optical power* results.

9.3. Running BER and Performance Tests

Some IEEE C37.94 tests like the datacom BER and the IEEE C37.94 ITU-T G.821 test require a test pattern. In this case, once finished the generic configuration procedure for IEEE C37.94 (See section 9.1), it is necessary to configure test pattern (See section 8.1).

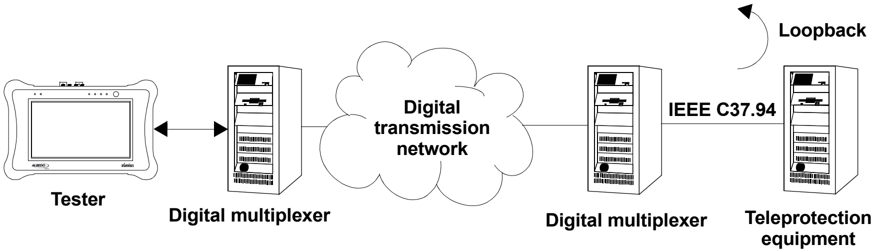

Figure 9.3: This illustration explains how to connect the test unit to carry out a BER test. Other connection setups are possible depending on the test requirements.

For the ITU-T G.821 test, there is one more setting to be configured. It follows a high level description about how to run and display the ITU-T G.821 test results.

1. Configure the ITU-T G.821 performance test and optionally enter custom objectives for your test (See section 7.3).
2. Go through the steps of the generic IEEE C37.94 test port configuration (See section 9.1).
3. Configure a test pattern (See section 9.1) and make sure you are not receiving the LSS defect.
4. Start the test with *run* or use the Autostart / stop settings to program an automatic test (See section 11.3).
5. From the *Home* panel go to *Results* to display to the sub-menu that provides access to all the results collected during the last test.
6. Select *Port A or Port B* (xGenius) to enter in the IEEE C37.94 port specific results.
7. Select *Performance* to access to the ITU-T G.821 performance results.
8. Check the *ES*, *SES*, *UAS*, *DM* test results (See section 7.3.2)

One general advise for BER and ITU-T G.821 performance tests is that they require test pattern continuity between the transmitter and the receiver. This condition is achieved by using a test port for transmitting the pattern and a second port for analysis or by means a loopback configured somewhere in the network to enable the transmitting port to receive back the test pattern.

9.4. Event Generation and Analysis

IEEE C37.94 Event insertion is carried out in the same way that for the E1 and datacom interfaces (See section 6.8.8). Events available for insertion in the IEEE C37.94 mode are: *Loss of signal* (LOS), *alarm indication signal* (AIS), frame alignment sequence error (FAS), remote alarm indication (RAI) or yellow alarm, loss of sequence

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synchronization (LSS), all zeroes (ALL0), all ones (ALL1), slips and test sequence errors (TSE).

Again, event analysis is similar to datacom event analysis. Event information is available through software LEDs (See section 6.8.1) or result tables (See section 6.8.2). There is also the possibility to display events in graphic charts (See section 6.8.4).

9.5. Measuring Latency

Latency measurements in a IEEE C37.94 interface follows the same principles than in G.703 or datacom interfaces (See section 3.2, See section 8.1.2). This is a high level description of the test procedure:

1. Configure the IEEE C37.94 generation and analysis normally (See section 9.1).
2. To run a one-way latency test enable and configure the GNSS clock input (See section 2.9).
3. Enable and configure the latency test in the same way than in a regular E1 / T1 / datacom latency test (See section 8.1.2)
4. Calibrate the unit following the standard procedure both in one-way and round trip delay tests (See section 8.1.2).
5. Run the test and check the results as in any regular E1 / T1 / datacom latency test (See section 8.1.2).

9.6. Jitter and Wander Generation and Analysis

Measuring jitter and wander over C37.94 is pretty much the same that the E1 and T1 tests. The main difference to be taken into account is that jitter and wander generation and analysis is available for Port A only. Users are referred to the chapters in the current document for more information about how to configure and run these tests.

Chapter 10
Clock Interface Monitoring

TE and MTIE / TDEV test results are available either from the Ethernet / IP output (PTP and Synchronous _Ethernet tests) or in a frequency / time output from the PTP slave. The xGenius Ethernet Testing Guide focuses in Ethernet and IP synchronization tests. This document is devoted to clock interface tests, including phase / time interfaces such as 1 PPS.

In xGenius, monitored signals include both frequency (2048 kHz, 1544 kHz, 5 MHz, 10 MHz) and time (1 PPS, 1 PP2S, ToD). The performance metrics in these interfaces are similar to that in Ethernet / IP ports. Traditional MTIE and TDEV are used rather than their versions for packet interfaces (See chapter 5 for more information about MTIE and TDEV tests). The TE is used as the key performance metric for 1 PPS and 1 PP2S interfaces and TIE is used in frequency interfaces.

There is also a jitter analysis test available for 2048 kHz and 1544 kHz (See chapter 4 for more information about jitter tests).

10.1.Connecting the Unit

Connect the DUT to the *Port C* and follow these steps to enable the clock analysis in the port. Note that the *Port C* connector to be used is depends on the interface to be tested. 1 PPS tests may run over the *Port C* SMA or RJ-48 connectors. Frequency tests may run over the *Port C* BNC or RJ-48 connectors:

1. From the *Home* panel, go to *CONFIG*,
   The port configuration panel is displayed.
2. Select *Mode* to enter in the mode selection menu
3. Choose *Clock monitor*.

10.2.Configuring the Clock Reference

The main purpose of the xGenius *Clock monitoring* mode is to measure wander over the supported frequency / phase.interfaces. The requirements for this kind of tests are the same that in any other interface. Specifically, they require the test unit to be locked to an external synchronization source or at least to be working in holdover (See section 2.9).

The requirements for 1 PPS tests are slightly different than for frequency interfaces (1544 kHz, 2048 kHz, 10 MHz). For 1 PPS tests the only valid references are GNSS, ToD or 1 PPS. For ToD test, acceptable references are either GNSS or ToD. 1 PPS / ToD testing in holdover mode is also supported.

Configuring an external clock reference is not required for the 2048 kHz and 1544 kHz jitter analysis tests.

10.3.Configuring the Port

Once the reference has been connected and configured, it is time to configure the test signal. To do that follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The test port configuration panel is displayed.
2. Select *Port C* to enter in the port specific configuration menu.
3. Configure *Clock frequency* to *1544 kHz*, *2048 kHz*, 5 MHz, *10 MHz*, *1PPS*, *1PP2S (Port C)* or *ToD (Port C)*.
4. Configure the Connector to *Balanced* or *Unbalanced* to use the Port C RJ-48 or BNC connectors respectively.
   Note: In 1PP2S / 1PP2S tests, the unbalanced connector is referred as Unbalanced (PPS RX) and it corresponds with the Port C SMB connector.

10.4.Configuring the Jitter Test

Once the clock interface is configured, may still configure the test to be run. To enable the wander test, the correct procedure is as follows:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Configure *Jitter test.*to *Generation & analysis*.
   Note: This option is available only for 2048 kHz and 1544 kHz test interfaces.

1. From the *Home* panel, go to *CONFIG*,
   The *Setup* configuration panel is displayed.
2. Select *Port C* to enter in the port specific configuration menu.
3. Go to *Jitter analyser.*
4. Configure *Integration period*, *Band range*, *Filter* and *Hit threshold* (See section 4.2.)

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10.5.Running the Jitter Test

Once the analyser has been configured, you can go to the jitter results panel to check test results. This procedure is closely related to the jitter results verification for E1 and T1 interfaces (See section 4.2):

1. From the *Home* panel, go to *RESULTS*,
   The results panel is displayed.
2. Select *Port C* to enter in the port specific results menu.
3. Go to *Jitter*.
4. Make sure that the PLL is tracking the phase of the incoming signal with the help of the *PLL locked* field.
5. Check the *Current (pp)* and *RMS* jitter amplitude values.
6. If you want to analyse the maximum jitter amplitude, the hit count and the hit seconds start a measurement with *run* or program a test.
   While the test is running, the maximum jitter and hit counts are upgraded in real time.
7. Wait for the test to finish (programmed tests only) or finish the test by pressing *run* a second time.
8. Check the final maximum jitter amplitude and hit counts.

10.6.Configuring the Wander Test

Once the clock interface is configured, may still configure the test to be run. To enable the wander test, the correct procedure is as follows:

1. From the *Home* panel, go to *Test*,
   The test configuration panel is displayed.
2. Go to *Wander test.*
   Note: The *Wander test* is not compatible with the *Jitter test*
3. Enable the MTIE / TDEV test by setting the *Enable* control to *On*.
4. Configure the *Standard mask* to any of the listed MTIE and TDEV masks.

10.7.Running the Wander Test

Te test is now ready to start. Press *Run* in the test unit to do that. The results are computed by the test unit in real time and they can be checked at any moment in the following way:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port C* to enter in the port specific results.

3. Go to *Line* and check the *Attenuation*, *Max. attenuation*, *Frequency*, *Deviation* and *Max. deviation* results.
   Note: There are no Line results for 1 PPS tests.
4. Leave the *Line* test results.
5. If you have configured a jitter test go to *Jitter* and check the *PLL locked*, *Current (pp)*, *Maximum (pp)*, *RMS*, *Hit count* and *Hit seconds* results
6. If you have configured a wander test go to *Wander test*.
7. Go to *Wander analysis* and check the *TIE*, *Min. TIE, Max. TIE*, *Offset*, *Max. Offset*, *Drift* and *Max. drift*.
   Note: In 1 PPS, 1 PP2S and ToD tests the *TE*, *Max. TE* and *Min TE* replace the *TIE* and *Max. TIE* statistics.
   Note: The wander analysis metrics have the same meaning that the same metrics for the E1 / T1 test (See section 5.2)
8. Leave the previous panel.
9. Choose between *MTIE* or *TDEV*
10. Check the *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).
    Note: The MTIE and TDEV metrics have the same meaning that the same metrics for the Synchronous Ethernet test (See section 5.4)

To stop the test press *RUN* a second time at any moment.

Table 10.1: Wander analysis results for clock interfaces

Event	Description
Reset TIE	This control sets the value displayed in the TIE field to 0. *Note*: The TIE is restarted every time a new test runs. The *Reset TIE* control can used only if there is not an ongoing test.
TIE / TE	Displays the current *Time Interval Error* (TIE) in frequency interfaces (*1544 kHz*, *2048 kHz*, *5 MHz*, *10 MHz*) or *Time Error* (TE) in phase and time interfaces (*1 PPS*, *1PP2S*, *ToD*). The *TIE* is the cumulative phase error from the beginning of the test (or the last *Reset TIE* action) computed in time units. The *TE* is the absolute time difference between clock provided by the signal under test and the selected reference (1 PPS, 1PP2S, ToD, GNSS) also expressed in time units. Both the TIE and the TE are defined by the standard ITU-T G.810.
Min. TIE / Min. TE	Minimum TIE or TE value, depending on the interface type, registered from the beginning of the test and expressed in time units.

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Table 10.1: Wander analysis results for clock interfaces

Event	Description
Max. TIE / Max. TE	Maximum TIE or TE value, depending on the interface type, registered from the beginning of the test and expressed in time units.
Offset	Difference between the frequency of the received signal and the reference signal frequency measured in parts per billion (ppb). Measurement of the frequency offset does not require to run a measurement. It is a permanent result that is available even if there is not an ongoing test.
Max. offset	Maximum frequency offset registered from the beginning of the test. The sign is not considered when the maximum offset is computed. For example, if the measured offset values are between -4 ppb and +3 ppb, the recorded maximum offset will be -4 ppb.
Drift	Change rate of the frequency offset expressed in parts per million per second (ppb/s).
Max Drift	Maximum frequency drift registered from the beginning of the test. The sign is not considered when the maximum offset is computed. For example, if the measured drift values are between -4 ppb/s and +3 ppb/s, the recorded maximum drift will be -4 ppb/s.
Rx ToD timestamp	Displays the timestamp received from the ToD interface.with the DD/MM/YYYY HH:mm:SS.
Rx ToD protocol	Current ToD protocol detected by the test unit. It is any of the supported input ToD Protocols: *NMEA*, *China Telecom* or *ITU G.8271*.

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Chapter 11
Test Management

This chapter describes all those features available in your test unit that are not directly related with configuring your tester or reading measurement results but they are important for proper test management. Specifically, configuration and result management, report generation and test platform settings are covered in the following sections.

11.1.Generating Reports

Users may want to generate reports based on their measurements. Reports are important to save results for later reference. Reports can be used to share a test result or to include results in documents.

Depending on the purpose of the report, users have different ways to generate and store them. The test unit offers maximum flexibility and at the same time simplicity when configuring reports. Follow these steps to configure and generate a report:

1. From the *Home* panel, go to *File* ( ),
   The tester file manager base menu is displayed.
2. Select *Report files* to go to the report file settings
3. Enable report generation by means the *Generate reports* control.
4. Set the *Report format*, *Report named after* and *Report header* fields.
5. If you have set *Report named after* to *User ref.+sequence*, configure the *User reference* field to the desired sequence.
6. Optionally, if you have configured *Report named after* to *User ref.+sequence* or *Serial no.+sequence*, enter the *Next sequence number* to be applied to the next report.
7. Set the correct action to be carried out when the internal storage is full.

If report generation is enabled, a new report is generated each time a test finishes either by pressing the run button or automatically. Reports are available as standard text or PDF files from the USB slave connector and they can be exported through the USB master port, the SD card reader or the web interface.

Table 11.1: Report Files Panel

Setting	Description
Internal memory	Displays report files stored in the internal tester memory. The test unit stores up to 50 report files.
External devices	Displays report files stored in external devices (micro SD memory card, USB memories or drives) connected to the tester. The amount of files stored in an external device is only limited by the device capacity.
Generate reports	Enables / Disables report generation.
Report format	Selects the report format for future reports. • *PDF*: Reports are generated using the portable document format (PDF). Use this configuration if you want to make difficult for anyone to modify the report. • *Plain text*: Reports are text documents which can be edited with any text editor. Use this configuration if you want to modify the report or include it in a wider document.
Report named after	This control enables the user to choose between different templates for the report name. There are three different templates to choose: • *Start time*: The report is identified by a time stamp that contains both data and time with the following format: yyyy-MM-dd-hhmmss. • *User ref. + sequence*: The report name is set to a user configurable string plus a sequence number that is incremented for each new test. • *Serial no. + sequence*: The report name is set to the tester serial number plus a sequence number that is incremented for each new test.
User reference	This could be any alphanumeric string containing upper case letters, lower case letters and numeric digits. This field makes sense only if the report name format is *User ref. + sequence*.
Next sequence	Displays and configures the sequence number that will be assigned to the next report to be generated. This field makes sense only if the report name format is *User ref. + sequence* or *Serial no. + sequence*.

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Table 11.1: Report Files Panel

Setting	Description
Report header	This menu item enables you to configure report data that will be stored with the test result. These data identify the report, customer, and also includes some other relevant information. • *Customer*: Field that can be used to set the company where the test report applies. • *Department*: This field can be used to identify the department where the user that has carried out the tester. belongs. • *Company*: This is the field that identifies the company that carries out the test. • *Location*: This describes where the test results from the network were recorded. • *Operator*: This field may contain the name of the operator that owns the network infrastructure where the test was run.

11.2.File Management

xGenius stores configurations, event logs and reports in files. These files can be deleted, renamed or exported to an external USB memory or micro SD card. Configurations can be shared between different test units by means compatible storage devices. Report files can be included to documents, sent by e-mail or printed. Event logger files can be processed by external software packages to generate sophisticated plots or other kinds of data representations.

11.2.1.Saving Configurations

To store the current configuration follow these steps:

1. From the *Home* panel, go to *File* ( ),
   The tester file manager base menu is displayed.
2. Select *Configuration files* to go to the configuration file settings.
3. Select the location to save the configuration: *Internal memory*, or *External devices*.
   Note: If you select E*xternal devices*, you will be asked to choose the specific storage device (USB device or micro SD card).
   Note: If there is no external device connected to the unit, a *No devices present* popup panel is displayed.
4. Press the *Save* contextual button.
5. Enter a file name for the configuration file that is going to be saved and confirm with the *Done* contextual button.

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11.2.2.Renaming Files

Configurations, event logger files and report files can be renamed after they are created. To rename files follow these sequence:

1. From the *Home* panel, go to *File* (🗋),
   The tester file manager base menu is displayed.
2. Select *Configuration files*, *Event logger files* or *Report files*.
3. For *Configuration files* and *Report files*, select the location of the file you want to rename: *Internal memory*, or *External devices*.
   Note: If you select E*xternal devices*, you will be asked to choose the specific storage device (USB device or micro SD card).
   Note: If there is no external device connected to the unit, a *No devices present* popup panel is displayed.
4. Select the file you want to rename.
   Note: You can select several files in the list, but renaming of many files at the same time is not allowed.
5. Press the *Rename* contextual button.
6. Enter the new file name for the selected configuration or report file with the alphanumeric keyboard. Confirm with the *Done* contextual button.

11.2.3.Deleting Files

With the file manager you can delete files that are not needed anymore. To do that follow these steps:

1. From the *Home* panel, go to *File* (🗋),
   The tester file manager base menu is displayed.
2. Select *Configuration files, Event logger files,* or *Report files*.
3. For *Configuration files* and *Report files*, select the location of the file you want to delete: *Internal memory*, or *External devices*.
   Note: If you select E*xternal devices*, you will be asked to choose the specific storage device (USB device or micro SD card).
   Note: If there is no external device connected to the unit, a *No devices present* popup panel is displayed.
4. Select the file you want to delete.
   Note: You can select several files in the list at the same time.
5. Press the *Delete* contextual button.
6. Enter the new file name for the selected configuration or report file with the alphanumeric keyboard. Confirm with the *Done* contextual button.

11.2.4.Exporting Files to External Devices

Configurations, report files and event log files can be exported to external devices like USB memories or micro SD cards. The procedure is as follows:

1. From the *Home* panel, go to *File* (🗋),
   The tester file manager base menu is displayed.
2. Select *Configuration files* or *Report files*.
3. Select *Internal memory*, to list the files currently stored in the unit.
4. Select the files you want to export.
5. Press the *Export* contextual button.
   A popup menu to select the external device where the files will be exported is opened.
   Note: If there is no external device connected to the unit, a *No devices present* popup panel is displayed.
6. Select an external device, confirm, and wait for the files to be copied.
7. Remove the USB storage device or micro SD card from the unit.

11.2.5.Importing Configurations

If you have a configuration file from a compatible tester you can import and load this file in your unit to reproduce similar measurements. This is the procedure you have to follow:

1. From the *Home* panel, go to *File* (🗋),
   The tester file manager base menu is displayed.
2. Select *Configuration files* to go to the configuration file settings.
3. Select *External devices* to list the files currently stored in the external device.
   A popup menu to select the source external device is opened.
   Note: If there is no external device connected to the unit, a *No devices present* popup panel is displayed.
4. Select the configuration files you want to import.
5. Press the *Import* contextual button, confirm, and wait for the files to be copied from the internal memory.
6. Remove the USB storage device or micro SD card from the unit.

11.2.6.Verifying the Current Disk Usage

Configurations, *Reports* and *Event logs* share the same storage space in the disk. Users are allowed to check which is the disk occupation status and depending on the result they can decide to delete files of a certain type. The procedure to do that is as follows:

1. From the *Home* panel, go to *File* (🗋),
   The tester file manager base menu is displayed.
2. Select *Disk usage*.
   The disk usage is displayed graphically and the storage space used for each file type is shown in KB or MB.

3. Optionally, select *Configuration files*, *Report files* or *Event logger files* and delete all files of these type with the appropriate contextual key.

11.2.7.Configuring What to Do When the Disk is Full

Users decide what to do when the disk storage capacity is exhausted. The available options are:

- *Block measurements*: No new measurements can be run when the internal memory is full.
- *Stop file generation*: New measurements are run even if the internal memory is full but no reports are generated for them.
- *Delete oldest files*: When the maximum available capacity is reached, new files replace the older ones. Use this action with care. No warning is displayed when old reports are deleted.

To configure this action, the correct procedure is:

1. From the *Home* panel, go to *File* ( ),
   The tester file manager base menu is displayed.
2. Configure *Action when disk full* to *Block measurements*, *Stop file generation*, *Delete oldest files*.

11.2.8.Using the Embedded Web Server

As an alternative of using a USB external storage device or a micro SD card for file management, the tester has a web interface that can be used for the same purpose.

The web interface can be used for downloading configurations, reports and event log files from a remote computer without using any accessory other than an standard network connection. Currently, the web interface does not support file uploading but for this purpose, the USB and micro SD interfaces are still available.

To use the web interface you need to connect the platform network connector to the management network and configure the management Ethernet interface (See section 11.4.1). Once you have done this, follow this procedure:

1. Open a browser in a computer with network connection.
2. Type the IP address you have assigned to the tester in the browser destination URL.
   The web interface home panel is displayed in the Internet browser.
3. Choose the files you want to display (*Configuration flies*, *Report files, Event logger files* or any other if available) and the location of these files (*Internal memory*, *USB*, *SD-CARD*) and press to the correct hyper link.
   A list with the available files for the selected category is displayed in the web browser.

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4. Select the file you want to download it to the local computer.
   The web browser displays a dialogue that requests your configuration to download the selected file. If you accept, the file will be downloaded.

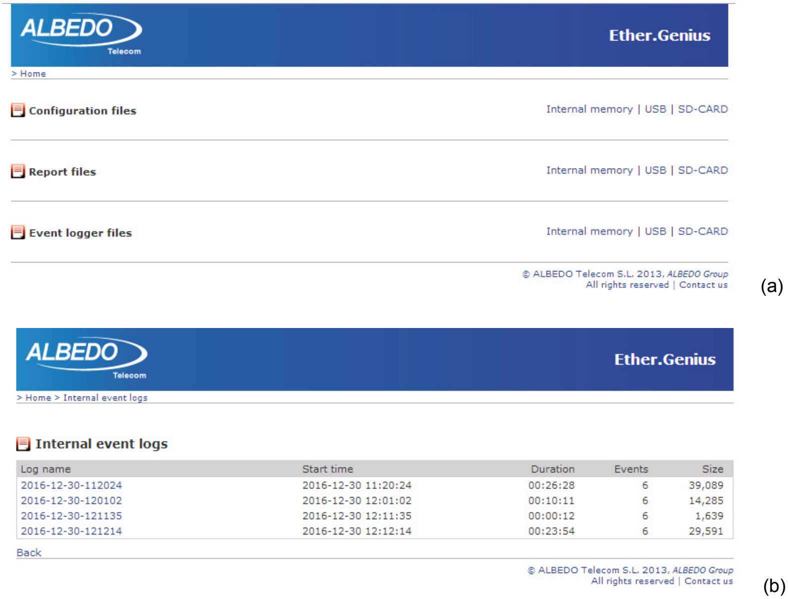

Figure 11.1: xGenius web interface: (a) Home panel (b) Event logger file management panel.

11.3.Programming Tests

xGenius is able to start and finish tests without direct user intervention. All automatic testing features are included within the *Autostart/stop* menu.

Follow these steps to program an automatic measurement in the test unit.

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Select *Autostart/stop* to enter in the automatic test programming menu.
3. If you want the automatic test to start at a specific date and time set *Start mode* to *Auto* and enter the start date and time in *Start time.*
   Note: Manual start has precedence over auto-start. That means that if a tester is started by pressing *Run* but there is an automatic test programmed the manual test will start anyway.

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4. If you want the automatic test to stop at a specific time after it has started set *Stop mode* to *Auto* and enter test duration with the help of the *Duration* and *User duration* controls.
   Note: Manual stop has precedence over autostop. That means that if a tester is stopped by pressing *Run* but there is an automatic test programmed the manual test will stop anyway.

Table 11.2: Autostart / stop Panel

Setting	Description
Start mode	Configures the start test mode. There are two different choices here: • *Manual*: The test starts when there is not an ongoing test and *Run* is pressed. • *Auto*: The test starts at a configured date and time without the need of pressing any key.
Start time	Enter the start date and time for the next automatic measurement with the following format: *dd/MM/yyyy hh:mm:ss*. To configure Start time, you have to set *Start* mode to *Auto* before.
Stop mode	Configures the stop test mode. There are two possibilities: • *Manual*: The test finishes when there is an ongoing test and *Run* is pressed. • *Auto*: The test finishes when a configurable test duration is reached. This mode does not require user intervention once the duration has been set and the measurement has started.
Duration	Sets the duration of the next measurement. The available test durations are: 15 minutes, 1 hour, 1 day, 7 days, 30 days or user configurable duration. Setting up *Duration* requires previous configuration of *Stop Mode* to *Auto*.
User duration	Sets the duration of the next measurement when *Stop mode* has been configured to *Auto* and *Duration* to *User*. The duration has to be entered in a *hh:mm:ss* format.
Last started on	Displays the date and time when the last measurement was started.
Last stopped on	Displays the date and time when the last measurement was stopped. If there is an ongoing test, the value of this field is empty.

Table 11.2: Autostart / stop Panel

Setting	Description
Last power down on	Displays the date and time when the tester was powered down for last time.

11.4.Using the System Menu

The System menu includes platform wide settings organized in four different sub-menus:

- *General settings*: This menu includes controls to manage the way the user interface behaves and how the information is presented.
- *Network configuration*: Includes the IP configuration corresponding with the platform NIC.
- *System information*: This menu has the test unit model name and serial number and software, firmware and hardware versions.
- *Licensing*: This is a menu that displays the software versions installed in the tester and enables their management.

Table 11.3: General Settings Panel

Setting	Description
Brightness (%)	Sets the screen brightness from 10% to 100%. Within the *Brightness* panel, the left and right cursors are used to set the correct value and a contextual key (*Done*) is used to confirm selection.
Keyclick	Enables or disables the keyclick. The keyclick is a sound that is played each time a key is pressed.
Language	Selects the user interface language. Menus, selection lists and results are presented in the language selected here. The languages currently available are English and Spanish.
Clock setup	Configures the system time and date. You can either type the correct date and time manually or let the equipment to retrieve the correct values from a *Network Time Protocol* (NTP) server.

Table 11.3: General Settings Panel

Setting	Description
Time display	Select the way the time is displayed in the graphical user interface. One of the following has to be selected: • *Elapsed*: Time from the beginning of the test is displayed with the following format *hh:mm:ss*. If there is not an ongoing test, then the duration of the last test is shown • *Absolute*: The current date and time is displayed with the following format: *dd/MM/yyyy hh:mm:ss*.
Screensaver	Sets or unsets the screen saver. The screen saver reduces power consumption and increases operation time under battery operation.
Screensaver delay	Configures the delay to switch the screensaver on. The backlight brightness is set to a low value once the time configured here has finished. The display backlight is switched off after twice the screensaver delay. The available configuration values for this item are: 10s, 30s, 1min, 2min, 5min, 10min, 20min.
Remote control	This is a menu that contains the controls necessary to enable and configure the VNC remote control. The items contained in this menu are: • *Enable*: Enables or disables the Ethernet / IP remote control. The remote control is an optional feature that enables remote users to use the tester from a computer running VNC. • *Remote control password*: Configures a password for the remote control. Any alphanumeric string should be accepted. Use the same password in the remote VNC client to access to the tester user interface.

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Table 11.3: General Settings Panel

Setting	Description
SNMP	This menu contains the controls necessary to enable and configure SNMP in units compatible with this protocol. The items contained in this menu are: • *Enable*: Enables or disables the SNMP server in the unit. If this setting is configured to *On*, the SNMP server is enabled and it responds to SNMP requests. If *Enable* is configured to *Off*, then the unit ignores SNMP requests. • *Read community*: Community name used for read operations. Write operations based on the read community name will fail. The default read community is *public*. • *Write community*: Community name used for write operations. The write community can be used for read operations as well. The default write community is *private*.

There is also a *Reset to factory defaults* control in the system menu that enables to recover de default configuration in the test unit. Please, note that the settings from the System menu, including network settings, clock settings and others, are not restored with this control.

This section supplies a description of the *General settings* menu and *System information* menu. To learn how to configure and use the network interface or how to install licenses for new software options go to the sections specifically dedicated to these topics.

Table 11.4: System information panel

Setting	Description
Model Name	Shows the test unit model name: xGenius.
Serial number	Displays the test unit serial number. It is a 8 character alphanumeric string
Software version	Displays the current software release.
Hardware version	Displays the current hardware release.
PM release	Displays the current power management release.
Firmware versions	Displays the current firmware release.

11.4.1.Using the Network

The platform network interfaces are currently user for three different purposes:

- *IP remote control*. This feature enables any user to access to the equipment from a remote location, configure a test, run it and display the results.
- The *Web interface*: This is used to retrieve reports configurations or any other file available in the tester internal memory or attached storage device.
- *Maintenance and factory configuration*: The ALBEDO Telecom staff use the platform network interfaces to configure or verify the equipment in the factory. This feature is not available to ordinary users.

Table 11.5: Network Configuration Panel

Setting	Description
Ethernet interface	Configuration menu for the platform network interface. This menu can be used to configure the interface IP address and mask either automatically (DHCP) or statically.
Wireless interface	Configuration menu for the platform wireless network interface. This menu is used to set the radio parameters for the interface such as the SSID and the network parameters like the IP address and mask. The wireless interface requires a compatible WiFi adapter for the USB port. This adapter is supplied by ALBEDO as an optional accessory.

Before you can use the network interface you need to enable the interface and configure an IP profile either automatically through DHCP or by hand. If you are using a wireless interface you also need to enter the radio interface and encryption settings.

Table 11.6: Network Interface Configuration

Setting	Description
Enable interface	Enables or disables the network interface. Note that the link led placed in the Ethernet platform connector is lit even if the interface is not enabled.
Wireless network	This is a menu that configures the WiFi in wireless interfaces. It contains settings such as the ESSID or the wireless encryption protocol. This menu is not available in Ethernet interfaces.

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Table 11.6: Network Interface Configuration

Setting	Description
Use DHCP	Configures the mechanism used to set the interface IP address and mask (and also other system-wide settings like the gateway address and the DNS server). If *Use DHCP* is enabled, the IP profile is configured automatically using a DHCP server installed in the network. Otherwise, the user has to enter the IP address, mask, default gateway and DNS address by hand.
Static IP address	Static IP address assigned to the interface in a decimal four dotted format. This setting makes sense only if *Use DHCP* is not enabled.
Static network mask	Static network mask in a decimal four dotted format. This setting makes sense only if *Use DHCP* is not enabled.
Fixed gateway address	IP address corresponding to the network device used to send IP packets to external networks. The gateway address is configured in decimal, four-dotted format.
Fixed DNS address	IP address corresponding to the host used for domain name resolution. A DNS server allows the user to identify destinations by alphanumeric domain names rather than numeric IP addresses. The DNS address has to be entered in decimal, four-dotted format.
Leased IP address	Current DHCP-assigned IP address in a decimal four dotted format. This is a read-only field that cannot be directly configured by users This setting makes sense only if *Use DHCP* is enabled.
Leased network mask	Current DHCP-assigned network mask in a decimal four dotted format. This is a read-only field that cannot be directly configured by users. This setting makes sense only if *Use DHCP* is enabled.
Leased gateway address	Current DHCP-assigned default gateway in a decimal four dotted format. This is a read-only field that cannot be directly configured by users This setting makes sense only if *Use DHCP* is enabled.
Leased DNS address	Current DHCP-assigned DNS server in a decimal four dotted format. This is a read-only field that cannot be directly configured by users This setting makes sense only if *Use DHCP* is enabled.

Table 11.6: Network Interface Configuration

Setting	Description
Ethernet address	48-bit physical address of the NIC attached to the test unit. In Ethernet interfaces, this address is assigned to the NIC when it is manufactured and it cannot be changed later. In wireless interfaces, the Ethernet address corresponds with the MAC address assigned to the external WiFi adapter by the manufacturer. Replacing the adapter modifies the MAC address.

To configure and use the platform network interfaces follow these steps:

1. If you are using an Ethernet interface, connect the platform Ethernet connector (platform panel, RJ-45 connector with the *Ethernet* label) to the management network. If you are using a wireless interface, attach a compatible USB dongle to the platform USB connector (USB master connector in the platform connector panel).
2. From the *Home* panel, go to *System*,
   The general system menu is displayed in the screen.
3. Select *Network configuration* to display the network configuration and management menu.
4. Go to the *Ethernet interface* or *Wireless interface*, depending on the physical medium you want to use to control de unit.
   Note: The wireless interface configuration is not available if you do not attach a compatible wireless USB dongle to the test unit USB port.
5. Enable the platform network interface with the *Enable interface* control.
6. Enable DHCP with the *Use DHCP* control if you want to let DHCP to configure your IP settings automatically or disable it to configure an static IP profile.
7. If you are not using DHCP, enter correct values for the *Static IP address*, *Static network mask*, *Fixed gateway address* and *Fixed DNS address*.
8. If you are configuring a wireless interface, go to *Wireless network* and configure the *Association mode*, *ESSID network*, *Encryption* and *Type of key*. Depending on the *Type of key* configure the *Hexadecimal key*, *ASCII key* and *Key number*.
9. Optionally, check from a remote computer that the equipment is responding to ping requests.

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If you are configuring a wireless interfaces there is an specific configuration to be done before you can set the IP layer. These configuration includes the setting of the wireless network

Table 11.7: Wireless interface settings

Setting	Description
Association mode	Configures the way the test unit has to access to communicate to other devices through the wireless interface: There are two different possibilities: • *Infrastructure*: The unit is connected to a central point known as wireless access point. The access point bridges traffic to the wired network or to other wireless devices but there is never a direct communication between two wireless end points. • *Ad-Hoc*: There is a direct association between two wireless end points without the mediation of any access point.
ESSID network	Extended Service Set Identification. In a infrastructure wireless network it identifies the access point where the endpoints are connected. In ad-hoc connections there is no access point but the ESSID still operates as a network identifier. The ESSID has to be the same in ad-hoc communicating peers.
Encryption	Enables or disables encryption over the wireless interface, The encryption protocol configured in this field must match the configuration in the remote device or in the access point. The encryption schemes currently supported are WEP-64 and WEP-128. These are the details: • *Off*: Disables all encryption over • *WEP-64*: First version of the Wired Equivalent Privacy (WEP) protocol based on a 40-bit key plus a 24-bit initialization vector. • *WEP-128*; Enhanced version of the Wired Equivalent Privacy (WEP) protocol based on a 104-bit key followed by a 24-bit initialization vector

Table 11.7: Wireless interface settings

Setting	Description
Type of key	Configures the way the key for the WEP encryption is going to be entered. There are the possible configurations for this setting: • *HEX*: Configures the WEP key in hexadecimal format. For WEP-64 you have to enter exactly 10 hexadecimal digits (from 0 to 9 or *A*, *B*, *C*, *D*, *E* and *F* letters). If you are using WEP-128 you need to enter 26 hexadecimal digits. • *Passphrase*: Generates the WEP key from an alphanumeric pattern made up of upper and lower case letters, decimal digits and spaces. Specifically, the passphrase procedure could be used to generate four different WEP-64 keys or one WEP-128 key. • *ASCII*: Configures the WEP key in ASCII format. For WEP-64 you have to enter 5 ASCII characters. If you are using WEP-128 you have to enter a 13 character key.
Hexadecimal key	Configures the WEP key in hexadecimal format (valid if *Type of key* has been configured to *HEX*). If *Encryption* is *WEP-64* the hexadecimal key is made up of 10 hexadecimal digits. If *Encryption* has been set to *WEP-128*, then you are required to enter 26 hexadecimal digits.
ASCII key	If *Type of key* has been configured to ASCII, it configures the WEP key in ASCII format. If the encryption protocol is WEP-64, the ASCII key is made up of exactly 5 characters (upper and lower case letters, decimal numbers). If you are using WEP-128 you have to enter a 13 character key. If T*ype of key* is *Passphrase*, it configures the WEP key through a variable length alphanumeric sentence which can be made of several words separated by spaces.
Key number	If you are configuring the WEP-64 protocol key through a passphrase you will be asked to supply the key number. The reason is that the passphrase procedure generates four different keys. The user has to choose the key to be used for authentication. If you are using WEP-128 then the passphrase generates only a single key and there no need to do any selection.

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Table 11.7: Wireless interface settings

Setting	Description
Current key (Hex)	Displays the current key in hexadecimal format. If you have configured an hexadecimal key, the *Current key (Hex)* and the *Hexadecimal key* fields should be displaying the same but if you are using an ASCII key or a passphrase the key will not match the value you have entered.
Associated	Could be either *Yes* or *No*, depending whether the unit is associated with an access point or not. The association status does not guarantee by itself that the test unit is allowed to exchange information with the access point. Specifically, the association is still established even if the encryption standard or the key are incorrect. Associations between endpoints and access points make sense only if the *Association mode* is *Infrastructure*.

11.4.2.Installing Software Options

New software for xGenius can be licensed after the unit as been purchased when new testing needs arise. To install new software options for your unit follow this procedure.

Table 11.8: Licensing

Setting	Description
Licensed options	Shows a list with all the software options currently available in your test unit.
License key	Hexadecimal number provided by ALBEDO Telecom that enables secure management of the software options installed in your test unit. Enter the license key in this field before adding the new software options to your test unit.
Action	Set this field to Activate to add new software options to your tester. You have to enter the *License key* before adding new options.
Status	Displays the result of the software option activation operation performed by enabling the *Activate* field.

1. Contact with your local sales representative to purchase software options for your test units.
   You will receive one variable length license key for each tester you want to upgrade.

2. From the *Home* panel, go to *System (*)*,
   The system configuration panel is displayed.
3. Select *Licensing* to enter in the software upgrade menu.
4. Enter the key supplied by your ALBEDO Telecom representative in *License key*.
5. Enable the new software options with the *Action* control.
6. Check that the upgrade has been successful with the help of the *Status* control.

11.4.3.Upgrading the Power Management

The *Power Management* monitors and controls the battery charge and discharge processes. This component does not change when the software and firmware are upgraded and usually remains without modification for the whole test unit live cycle. However, the Power Management runs a algorithm that users can upgrade if necessary. The procedure to do that is described below:

1. From the Home panel, go to *System* (*).
2. Open the Licensing menu.
3. Enter the maintenance password for your unit in *Service password*.
   Note: This password is different for each unit and it is supplied by ALBEDO Telecom on demand.
4. Press the back key to display the *System* panel again.
5. Go to *Service*.
6. Open *PM firmware update*.
7. Press the green *Update* button
   The following text is displayed: *PRESS and HOLD the reset button on the rear panel and then press the CONTINUE button at the same time*.
8. Now press the *Hardware reset* button (See section 1.2.1) and then, without releasing, press *CONTINUE*. You can also cancel the operation with *CANCEL*.
9. If you have pressed *CONTINUE* in the previous step, the power management version will be upgraded in the unit. The process takes 2 or 3 seconds.
   Once finished, the following message is displayed in the screen: *The unit will be powered off*.
10. Press CONTINUE.
    The unit is powered off.
11. Power the unit on.
12. From the *Home* panel, go to *System (*)*.
13. Open the *System information* menu.
14. Make sure that the power management button is now up to date.
15. Leave the *System information* menu with the help of the back key.
16. Go to the *Licensing* menu.
17. Delete the service password you have entered previously.

11.4.4.Using NTP and GPS/NMEA for System Clock Synchronization

The system clock controls the date and time assigned to configuration and report files and controls the auto-start / stop function. xGenius users can manually set the system time and date by entering the correct values but they can also synchronize the clock with an external NTP server or GNSS. The NTP server must be available through the management Ethernet port. The GNSS timing is received through the 1 PPS / ToD clock input or through the built in.GNSS module, if available (See section 2.9).

Table 11.9: Time Source Configuration Options

Setting	Description
Date	This is used to configure the current date. The date is used for the *Autostart/stop* features and other purposes. The date has to be entered with the following format: *dd/MM/yyyy*. You can only modify the date if the current time source has been set to *Manual*.
Time	This is used to configure the current time. The time is used for the *Autostart/stop* features and other purposes. The time has to be entered with the following format: *hh:mm:ss*. You can only modify the time if the current time source has been set to *Manual*.
Time source	It is either *Manua*l, *NTP* or *GPS / NMEA.* The meaning of each configuration option is as follows: • *Manual*: The user configures the *Date* and *Time* fields manually. System date and time is controlled by the internal clock. • *NTP*: An external *Network Time Protocol* (NTP) server controls the value of the *Date* and *Time* fields. The system is synchronized with the server each time the equipment is restarted or when a new capture is run. • *Time reference*: The unit is configured to get the system time and date from the GNSS satellite systems tor ToD. This setting is available only if the unit has been properly configured to receive a a time reference based on any of these interfaces (See section 2.9).
UTC offset (hours)	This is the time difference in hours between your local time zone and the *Universal Time Coordinated* (UTC) time zone This setting makes sense only if *Time Source* has been configured to *NTP* or *Time reference*.

Table 11.9: Time Source Configuration Options

Setting	Description
UTC offset (min)	This is the value to be configured when the time offset between your local time zone and the UTC zone is not an integer value of hours. This setting makes sense only if *Time Source* has been configured to *NTP* or *Time reference*.
Locked	This is a read-only field that is set to *Yes* when the system clock is synchronized with the time announced in a NMEA interface.The value of *Locked* is *No* otherwise. Some tests requiring GPS / Glonass synchronization may require the system clock to be locked to the satellite system. This sense makes sense only if *Time Source* has been configured to *Time reference*.
NTP server	IP address or domain name corresponding to the NTP server you want to use to synchronize your unit. If you want to use a domain name for the server you need to make sure you have configured a DNS server in your network settings (See section 11.4.1). This setting makes sense only if *Time Source* has been configured to *NTP*.
NTP status	Displays the current status of the NTP server configured in the *NTP server* field. It is one of the following: • *Server not available*: The server configured in NTP server is not available. Make sure that your network interface is properly configured and that the server is accessible. • *Waiting*: The test unit is still waiting for a reply from the remote server. • *Synchronized*: The equipment is correctly synchronized with the external server configured in *NTP server*. This is a not editable field. It is only active if *Time Source* has been configured to *NTP*.

To configure the system time and date in your test unit follow these steps:

1. From the *Home* panel, go to *System (*)*,
   The general system menu is displayed in the screen.
2. Select *General settings* to display the platform-wide configuration.
3. Go to *Clock setup*

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4. Configure *Manual*, *NTP* or *Time reference* time and date with the help of the *Time source* field.
   Note: The *Time reference* setting requires that an appropriate clock input is enabled as a reference interface before configuring the system clock *Time source* (See section 2.9).
5. If you have configured *Time source* to *Manual* in the previous step, configure the *Date* and *Time* field to your local time and date. If *Time source* has been configured to *Time reference*, enter the *UTC offset (hours)*, *UTC offset (min).* If the configuration is to *NTP* then enter also the *NTP server* and wait for the equipment to establish synchronization with the server.

11.5.Using the Remote Control

The remote control application constitutes a remote graphical user interface that reproduces pixel by pixel the tester screen in virtually any remote device supporting the VNC protocol. This includes not only computers but also smartphones or tablets. The only requirements for the controlling devices are:

- IP connectivity with the tester. Any IP connection including Ethernet and WiFi should work.
- They must have a VNC client installed. Currently, there are VNC clients for most OS in the market. Some of them are free.

The remote control is an optional feature for xGenius that is supplied by ALBEDO Telecom with an special license.

Before using the remote control you need to configure the platform Ethernet interface and connect the equipment to the management network (See section 11.4.1). Once this is done, follow this procedure to use the remote control:

1. From the *Home* panel, go to *System*,
   The system configuration panel is displayed.
2. Select *General settings* to display miscellaneous system-wide settings, including the ones referred to the remote control.
3. Enable the remote control with the help of *Remote control*.
4. Optionally, supply a password with *Remote control password*. The password you configure here will be requested in all incoming VNC connections.
5. In the controlling device, run the VNC client and enter the password you have configured in *Remote control password* if you are requested to do so.

6. Use the keyboard or the mouse to browse the instrument panels, start measurements, insert events or any other action.

Table 11.10: Remote Control Keys

Key	Description
Home	It is equivalent to the HOME key. It displays the *Home* panel.
Esc	It is equivalent to the Esc key. It leaves the current panel and displays the previous one in the panel hierarchy.
Enter	It is equivalent to the ENTER key. It confirms settings.
Ctrl+L	It is equivalent to LEDS. It displays the *Leds* panel.
Ctrl+S	It is equivalent to SUM. it displays the *Summary* screen
Ctrl+R	It is equivalent to RUN. It starts / stops a measurement
Ctrl+E	It is equivalent to EVENT. It starts / stops event insertion

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Appendix A
Technical Specification

A.1. General

1. Generation and analysis over a single port (Port C) which accepts both E1 and T1 signals.
2. Runs advanced synchronization tests in E1, T1 and miscellaneous clock interfaces and accepts 1 PPS and GNSS references.
3. Includes support for IEEE C37.94, data communications, G.703 co-directional and voice frequency generation and analysis
4. Runs one-way and two-way latency tests. One-way latency uses GNSS and ToD information to get accurate results.

A.2. Operation modes

1. *E1 / T1 Endpoint*: Emulation of a E1 / T1 network termination point including both transmission and reception.
2. *E1 / T1 Monitor*: Analysis of E1 / T1 inputs without generating any test signal.
3. E1 / T1 MUX / DEMUX: Enables E1 / T1 and data communications at the same time to test TDM multiplexers and demultiplexers.
4. *Datacom Endpoint*: Emulation of a data communications DTE or DCE.
5. *Datacom Monitor*: Transparent, passive monitoring of a DTE to DCE connection.
6. *C37.94 Endpoint*: Emulation of a IEEE C37.94 network termination point including both transmission and reception.
7. *C37.94 Monitor*: Analysis of IEEE C37.94 inputs without generating any test signal.
8. *C37.94 Pass-through*: Transfers frames between ports in both transmission directions and enables test signal alteration.
9. *G.703 E0 Endpoint*: Generation and analysis over G.703 co-directional, contra-directional and centralized interfaces.

10. *Voice Frequency:* Generation and analysis of analog signals in the telephone band (300 ~ 3400 Hz).
11. *Clock Monitor*: Monitors frequency and time clock signals and runs synchronization tests on them.

A.3. Clock

1. Internal time reference better than ±2.0 ppm.
2. Optional OCXO internal reference better than ±0.1 ppm. Optional Rubidium internal reference.
3. Holdover operation in units equipped with OCXO and Rubidium references.

A.3.1. Rubidium Reference

1. Free running output freq. accuracy (7.5 minutes warm up): ±1e-9
2. Free running output freq. accuracy on shipment (24 h. warm up): ±5e-11
3. Aging (1 day, 24 hours warm up): ±.5e-11
4. Aging (1 year): ±1e-9
5. Time / Phase accuracy to UTC (locked to GNSS): ±20 ns at 1**σ** after 24 hours lock
6. Holdover output time accuracy (after 24 h. locked): ±100 ns / 2h, ±1.0µs / 1 day

A.3.2. Built in GNSS

1. Compatibility with GPS, GLONASS, BeiDou and Galileo with single or multiple constellation selection.
2. Fixed position mode for GNSS references.
3. Automatic setting of UTC-to-TAI offset (leap second count) through GNSS.
4. 4V - 5V DC output in GNSS port to feed an external antenna.
5. Cable delay compensation.

A.3.3. GNSS Compact Antenna

- SMA male connector
- Polarization: RHCP
- Frequency band: 1573 MHz - 1610 MHz
- Gain: 27 dB
- Noise figure: 1.5 dB
- Voltage: 2.7 V - 5.5 V
- Protection level: IP 67

A.3.4. Clock Reference Inputs

1. 10 MHz, 5 MHz, 2048 kb/s, 2048 kHz, 1544 kb/s, 1544 kHz (REF IN/OUT port).

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2. 1 PPS, 1PP2S balanced (REF IN/OUT) and unbalanced (REF IN port) compatible with standard ITU-T G.8271. ToD balanced (REF IN/OUT) compatible with ITU-T G.8271, China Mobile and NMEA formats.
3. Ethernet through Port A and Port B (over any valid electrical / optical synchronous Ethernet interface).
4. Custom delay compensation for phase and time inputs.

A.3.5. Clock Reference Outputs

1. *2048 kHz* and *10 MHz* unbalanced (port C).
2. 1 PPS, 1 PP2S, balanced (REF IN/OUT) and unbalanced (REF OUT port) compatible with standard ITU-T G.8271. ToD balanced (REF IN/OUT) compatible with ITU-T G.8271 and NMEA.
3. Custom delay compensation for phase and time outputs.

A.4. E1 Generation / Analysis

A.4.1. Connectors

1. Unbalanced (BNC) 75 Ω.
2. Balanced (RJ-48) 120 Ω.

A.4.2. Line

1. Configurable input impedance: nominal line impedance, PMP 20 dB, PMP 25 dB, PMP 30 dB, high impedance (> 1000 Ω).
2. Custom transmission clock: recovered or synthesized
3. Configurable output frequency offset within ±25,000 ppm around the nominal frequency.
4. Line codes: HDB3, AMI.
5. Input Level: From 0 dB to -45 dBm.
6. Pulse mask compliance: ITU-T G.703.
7. Jitter compliance: ITU-T G.823.

A.4.3. Frame

1. 2 Mb/s unframed, ITU-T G.704, ITU-T G.704 CRC, ITU-T G.704 CAS, ITU-T G.704 CRC + CAS.
2. *Nx64* kb/s generation and analysis in contiguous and non-contiguous time slots.
3. Generation of custom NFAS spare bits (ITU-T G.704 frame with CRC-4 multi-frame).
4. CAS A, B, C, D bit generation for each voice channel. Generation of CAS multi-frame spare bits (ITU-T G.704 frame with CAS multi-frame).
5. Custom *Synchronization Status Message* (SSM) generation.

A.4.4. Line Analysis

1. Line attenuation (dB).
2. Frequency (Hz), frequency deviation (ppm).
3. Custom pass / fail indications

A.4.5. Frame and Pattern Analysis

1. Defects: LOS, LOF, AIS, RDI, CRC-LOM, CAS-LOM, MAIS, MRDI, LSS, All 0, All 1, Slip.
2. Anomalies: Code, FAS error, CRC error, REBE, MFAS error, TSE, TSBE.
3. ITU-T G.821 performance: ES, SES, UAS, DM. ITU-T G.821 results include pass / fail indications.
4. ITU-T G.826 performance: ES, SES, UAS, BBE (near and far end statistics). ITU-T G.826 results include pass / fail indications.
5. ITU-T M.2100 performance: ES, SES, UAS, BBE (near and far end statistics). ITU-T M.2100 results include pass / fail indications.
6. Channel map and time slot analysis: time slot value in hexadecimal and binary formats, time slot level and frequency computed following the ITU-T G.711 A law.
7. FAS / NFAS word analysis.
8. CAS A, B, C, D bit analysis.
9. Synchronization Status Message (SSM) decoding and analysis.

A.4.6. Event Insertion

1. Physical: Code, AIS, LOS.
2. Frame: FAS error, CRC error, MFAS error, REBE, LOF, MAIS, CAS-LOM, RDI, MRDI, CRC-LOM.
3. Pattern: TSE, Slip, LSS, All 0, All 1.
4. Insertion modes: Single (anomalies), rate (anomalies), continuous (defects), M-single (defects), MN-repetitive (defects).

A.5. T1 Generation / Analysis

A.5.1. Connectors

1. Balanced (RJ-48) 120 Ω.

A.5.2. Line

1. Configurable input impedance: nominal line impedance, PMP 20 dB, PMP 25 dB, PMP 30 dB, high impedance (> 1000 Ω). Cable delay equalization up to a 6 dB attenuation.
2. Custom transmission clock: recovered or synthesized

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3. Configurable output frequency offset within ±25,000 ppm around the nominal frequency.
4. Line codes: B8ZS, AMI.
5. Input Level: From 0 dB to -45 dB.
6. Pulse mask compliance: ANSI T1.102-1999, ITU G.703.
7. Jitter compliance: ANSI T1.102-1999, ITU-T G.823.

A.5.3. Frame

1. 1544 kb/s unframed, SF (D4) and ESF in accordance with ANSI T1.403-1999 and ITU-T G.704.
2. *Nx64* and *Nx56* kb/s generation and analysis in contiguous and non-contiguous time slots with and without 'robbed bit' signaling.
3. CAS A, B, C, D bit generation for each voice channel through the 'robbed bit' mechanism.
4. Generation of custom FDL word (ESF frame format).
5. Custom *Synchronization Status Message* (SSM) generation.

A.5.4. Line Analysis

1. Line attenuation (dB).
2. Frequency (Hz), frequency deviation (ppm).
3. Custom pass / fail indications

A.5.5. Frame and Pattern Analysis

1. Defects: LOS, LOF, AIS, RDI, LSS, All 0, All 1, Slip.
2. Anomalies: Code, FAS error, CRC error, TSE.
3. ITU-T G.821 performance: ES, SES, UAS, DM with pass / fail indications.
4. ITU-T G.826 performance: ES, SES, UAS, BBE (near and far end statistics) with pass / fail indications.
5. ITU-T M.2100 performance: ES, SES, UAS, BBE (near and far end statistics). with pass / fail indications.
6. Channel map and time slot analysis: time slot value in hexadecimal and binary formats, time slot level and frequency computed following the ITU-T G.711 μ law.
7. CAS A, B, C, D bit analysis.
8. FDL analysis (ESF frame format).
9. Synchronization Status Message (SSM) decoding and analysis.

A.5.6. Event Insertion

1. Physical: AIS, LOS.
2. Frame: FAS error, CRC error, LOF, RDI.
3. Pattern: TSE, Slip, LSS, All 0, All 1.

4. Insertion modes: Single (anomalies), rate (anomalies), continuous (defects), burst of M (defects), M out of N (defects).

A.6. Data Communications

1. Operation: DTE emulation, DCE emulation and full duplex monitor.

A.6.1. Connectors

2. Smart Serial universal data communications connector for the DTE and DCE (all interfaces).

A.6.2. Interfaces

1. V.24 / V.28 asynchronous from 50 b/s to 128 kb/s.
2. V.24 / V.28 synchronous from 50 b/s to 128 kb/s.
3. X.21 / V.11 asynchronous from 50 b/s to 128 kb/s.
4. X.21 / V.11 synchronous from 50 b/s to 2048 kb/s.
5. V.35 from 50 b/s to 2048 kb/s.
6. V.36 (RS-449) from 50 b/s to 2048 kb/s.
7. EIA-530 from 50 b/s to 2048 kb/s.
8. EIA-530A from 50 b/s to 2048 kb/s.

A.6.3. Line

1. Clock circuit selection (TC or TTC) in V.24 / V.28 synchronous, V.35, V.36, EIA-530 and EIA-530a interfaces.
2. Configurable output frequency offset within ±25,000 ppm around the nominal frequency.
3. Data bits, stop bits, parity and inter-word gap configuration in V.24 and X.21 / V.11 asynchronous interfaces

A.6.4. Line Analysis

1. Frequency (Hz), frequency deviation (ppm).
2. Received character count (V.24 asynchronous)
3. Logic analyser capability for data, clock and control circuits with custom setting of control circuits.

A.6.5. Clock and Pattern Analysis

1. ITU-T G.821 performance: ES, SES, UAS, DM. ITU-T G.821 results include pass / fail indications.
2. Defect insertion and analysis: LOC, AIS, LSS, All 0, All 1.
3. Anomaly insertion and analysis: TSE, Slip.

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A.7. IEEE C37.94

A.7.1. Connectors

1. Dual port operation over SMF or MMF with suitable SFP.

A.7.2. Line

1. Transmission clock: Recovered or internally synthesized.
2. Laser on and off control.

A.7.3. Frame

1. Unframed or framed operation.
2. Frame structure follows IEEE C37.94 section 4.1.
3. Configurable bit-rate between 64 kb/s and 768 kb/s in steps of 64 kb/s.

A.7.4. Line Analysis

1. Frequency (Hz), frequency deviation (ppm).
2. Transmitted optical power (dBm), received optical power (dBm).
3. Received data rate (kb/s).
4. SFP information: transceiver, vendor, model and wavelength.

A.7.5. Frame and Pattern Analysis

1. ITU-T G.821 performance: ES, SES, UAS, DM. ITU-T G.821 results include pass / fail indications.
2. Event detection and insertion: LOS, AIS, FAS, RDI (yellow), LSS, ALL0, ALL1, Slip, TSE.

A.8. E0 Generation and analysis

1. G.703 co-directional, contra-directional and centralized interface operating 48 kb/s, 56 kb/s, 64 kb/s, 72 kb/s, 128 kb/s, 144 kb/s, 192 kb/s, 256 kb/s.
2. Custom transmission clock: recovered or synthesized.
3. Configurable output frequency offset within ±25,000 ppm around the nominal frequency.

A.8.1. Line Analysis

1. Frequency (Hz), frequency deviation (ppm).

A.8.2. Pattern Analysis

1. ITU-T G.821 performance: ES, SES, UAS, DM. ITU-T G.821 results include pass / fail indications.
2. Defect insertion and analysis: LOS, AIS, LSS, 0s, 1s.

3. Anomaly insertion and analysis: TSE, Slip.

A.9. Patterns and Signals

1. *PRBS 6*, *PRBS 7*, *PRBS 9* (ITU-T O.150, O.153), *PRBS 11* (ITU-T O.150, O.152, O.153), *PRBS 15* (ITU-T O.150, O.151), *PRBS 20* (ITU-T O.150, O.153), *PRBS 23* (ITU-T O.150, O.151), *PRBS 6 inverted*, *PRBS 7 inverted*, *PRBS 9 inverted*, *PRBS 11 inverted*, *PRBS 15 inverted*, *PRBS 20 inverted*, *PRBS 23 inverted*, *QRSS*, *QRSS inverted*, *QBF / FOX*, *all 0*, *all 1*.
2. User configurable 32 bit word.
3. Tone (from 10 Hz to 4000 Hz, from +6 dBm to -60 dBm) (E1 and T1 interfaces only).

A.10.Voice Frequency Test

1. Tone generation and analysis function. Configurable level between -60 dBm and +3 dBm in steps of 0.1 dB. Configurable frequency between 2 Hz and 4000 Hz in steps of 1 Hz.
2. Measurement of *Signal level (dBm)*, *Noise level (dBm)*, *Signal Frequency (Hz)*
3. Sensitivity: -60 dBm (signal measurements), -80 dBm (noise measurements).
4. ITU-T G.711 analysis: maximum code, minimum code, average code.
5. Frequency sweep test with up to 8 user configurable frequencies with custom gain / loss threshold for each of them.

A.11.Clock Monitor

1. Frequency inputs: 2048 kHz, 1544 kHz, 5 MHz, 10 MHz in RJ-48 (120 Ω) or BNC (75 Ω) connectors.
2. Time inputs: 1 PPS and 1PP2S over SMA (50 Ω) or RJ-48 (120 Ω), ToD (ITU-T G.8271, China Mobile, NMEA) over RJ-48 (120 Ω).
3. Configurable input impedance: nominal line impedance, PMP 20 dB, high impedance (> 1000 Ω).

A.11.1. Line Analysis

1. Interfaces 2048 kHz, 1544 kHz, 10 MHz
2. Line attenuation (dB).
3. Frequency (Hz), frequency deviation (ppm).

A.12.Pulse Mask Analysis

1. Interfaces: E1, T1

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2. Operation modes: Eye diagram or continuous run.
3. Display of positive, negative and positive / negative pulse.
4. Measurement of pulse width, rise time, fall time, level, overshoot and undershoot (positive and negative pulses).
5. Pass / fail indication for compliance with ANSI T1.101-1999 and ITU-T G.703 1544 kb/s mask.

A.13.Jitter and Wander Generation

1. Interfaces: E1, T1, IEEE C37.94.
1. Modulation waveform: sinusoidal.
1. Modulation frequency range: 1 μHz to 100 kHz.
1. Modulation frequency resolution: 0.1 Hz (jitter), 1 μHz (wander).
1. Modulation amplitude: 0 ~ 1000 UIpp. Maximum depends on modulation frequency as specified in ITU-T O.171 and O.172.
1. Modulation amplitude resolution: 1 mUIpp or $1/10^4$ of the configured value.
1. Smooth amplitude changes in jitter range (10 Hz ~ 100 kHz).
1. Intrinsic jitter < 10 mUIpp.

A.14.Jitter Analysis

1. Interfaces: E1, T1, 2048 kHz, 1544 kHz, IEEE C37.94.
2. Closed loop phase measurement method.
3. Modulation frequency range: 0.1 Hz to 100 kHz (locking time 10 s), 1 Hz to 100 kHz (locking time 1 s), 10 Hz to 100 kHz (locking time < 1 s).
4. Modulation amplitude: 0 to 1000 UIpp (single range). Maximum amplitude depends on modulation frequency as specified in ITU-T O.171 and O.172.
5. Modulation amplitude resolution: 1 mUIpp.
6. Measurement accuracy: better than ITU-T O.172.
7. Jitter measurement results: peak to peak jitter, RMS jitter, maximum jitter, hits detection and count (user selectable threshold).
8. Jitter measurement observation time: 1 s, 10 s, 60 s.
9. E1 / 2048 kHz / IEEE C37.94 measurement filters (ITU-T G.703): LP (f < 100 kHz), LP+HP1 (20 Hz < f < 100 kHz), LP+HP2 (18 kHz < f < 100 kHz), LP+RMS (12 kHz < f < 100 kHz).
10. T1 / 1544 kHz measurement filters (ANSI T1.102 T1): LP (f < 40 kHz), LP+HP1 (10 Hz < f < 40 kHz), LP+HP2 (8 kHz < f < 100 kHz).

A.15.Wander Analysis

1. Interfaces: E1, T1, 2048 kHz, 1544 kHz, 5 MHz, 10 MHz, 1 PPS, 1PP2S, IEEE C37.94.
2. Open loop measurement method.
3. Modulation frequency range: 1 μHz to 10 Hz.
4. Wander sampling frequency: 50 Hz.
5. Modulation amplitude: 0 to ±2 s (single range).
6. Modulation amplitude accuracy: 2 ns.
7. Statistics range: 10^2, 10^3, 10^4, 10^5, 10^6 s.
8. TIE analysis in E1, T1, 2048 kHz, 1544 kHz, 10 kHz and IEEE C37.94. TE analysis (module 1 second) in 1 PPS interface with minimum and maximum records.
9. Frequency offset, frequency drift with maximum records.
10. Built in real time TIE, MTIE, TDEV (ITU-T G.810)
11. MTIE and TDEV resolution: 100 ps.
12. Custom MTIE and TDEV pass / fail indication based on standard masks.

A.16.Latency

1. Interfaces: E1, T1, IEEE C37.94, data communications, G.703 co-directional, G.703 contra-directional, G.703 centralized, voice frequency.
2. One way and two way modes.
3. Results: round trip delay, forward path delay, reverse path delay, asymmetry with minimum and maximum records.
4. Remote end identification in one way tests.
5. Clock sources for one way tests: GNSS and ToD
6. Patch cord delay compensation.
7. Custom pass / fail indications.

A.17.Port Loopback

1. Interfaces: E1, T1, IEEE C37.94, data communications, G.703 co-directional, G.703 contra-directional, G.703 centralized.
2. Independent loopback control for each port.
3. Custom latency generation up to 50 ms at 2048 kHz.

A.18.Service Disruption Time

1. Interfaces: E1, T1, IEEE C37.94, data communications, G.703 co-directional, G.703 contra-directional, G.703 centralized.

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2. Resolution is 100 µs or the smaller resolution allowed by the detection / clearance rules.
3. Statistics are service disruption events count. Total disrupted time. Average, minimum and maximum time in a service disruption event. Time in the last disruption event.

A.18.1. In-service triggers

1. LOS with detection / clearance following ITU-T G.775 clause 4.2 (E1), ITU-T G.775 clause 4.3 (T1) and IEEE C37.94-2017 clause 5.1 (IEEE C37.94).
2. AIS with detection / clearance following ITU-T G.775 clause 5.2 (E1), ITU-T G.775 clause 5.4 (T1).
3. LOC with detection / clearance following ITU-T G.775 clause 4.1 applied to the receiving clock circuit (datacom synchronous).
4. RDI with detection / clearance following ITU-T G.775 clause 6.2 (E1) and IEEE C37.94 clause 5.3 (IEEE C37.94).

A.18.2. Out of service triggers

1. TSE with detection / clearance following ITU-T O.150 clause 4.2 modifying the integration period to the shortest of 64 bits or 100 µs.
2. 1s and 0s with detection / clearance following ITU-T O.150 clause 4.2 modifying the integration period to the shortest of 64 bits or 100 µs.

A.19. Platform

- Size: 260 x 160 x 63 mm.
- Weight: 1.9 kg (two battery packs).
- Screen: 8 inch, TFT color (800 x 480 pixels).
- USB type A port, according USB standard 2.0, DC output: +5 V / 0.5 A (max).
- RS-232 / V.24 console port for maintenance tasks.

A.19.1. Power Specifications

- Operation time with batteries (LiPO): 5 ~ 8 hours.
- Battery recharge time (LiPO): 4 hours.
- DC input, 12 V (nominal), 15 V (maximum) / 5 A (maximum).
- External AC power adapter 100 - 240 V ~50 / 60 Hz, 1.5 A. Output 12 V DC, 5 A.
- AC power grid fluctuations < ±10% of the nominal voltage
- Over-voltage category II

A.19.2. User Interface

- Graphical user interface controlled by touch-screen, keyboard or mouse.
- Web based report and configuration file management.

- Full remote control: SNMP or VNC.

A.19.3. Results

- Storage in TXT and PDF file formats.
- File transfer to SD card and USB port.
- File management through web interface and SNMP.
- Configuration and report storage and export through attached USB port.

A.19.4. Operational Ranges

- Operational range: -10ºC to +45ºC.
- Storage range: -20ºC to +70ºC.
- Operation humidity: 5% - 95%.
- Height: Up to 3000 m above the sea level.
- Pollution degree II

Appendix B
Accessory Specification

B.1. PHM-20 Datacom Pluggable Hardware module

The PHM-20 provides access to the datacom modes in xGenius. Specifically, it enables users to configure the *Datacom endpoint* and *Datacom monitor* operation modes. If the unit is operating in *E1 / T1 endpoint*, *E1 / T1 through* or *E1 monitor* modes, it enables the datacom add & drop options. In *E1 / T1 MUX test* and *E1 / T1 DEMUX* test, it allows users to configure datacom tributaries. Access to these operation modes and functions also requires an special software license.

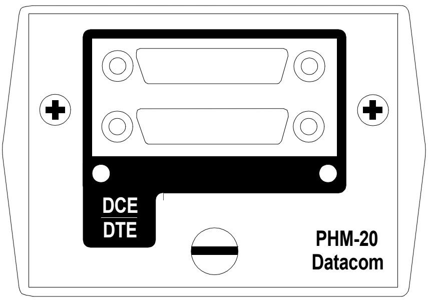

Figure B.1: The PHM-20 enables the datacom modes in xGenius.

Supported data communication interfaces are X21 / V11 / RS-422, V.24 / RS-232, V35, V.36 / RS-449, EIA-530 / RS-530 and EIA-530A / RS-530A. Interconnection between an xGenius equipped with the PHM-20 module and the DUT requires one of the datacom cables designed for each different interface. Datacom cables are also different it the unit is going to run a test in DCE emulation mode (female port) or DTE emulation (male port).

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B.2. PHM-21 IEEE C37.94 Pluggable Hardware module

The PHM-21 provides access to the IEEE C37.94 modes in xGenius. Specifically it enables the *IEEE C37.94 endpoint*, *IEEE C37.94 monitor* and *IEEE C37.94 through* modes. An special software license is required to access to these operation modes.

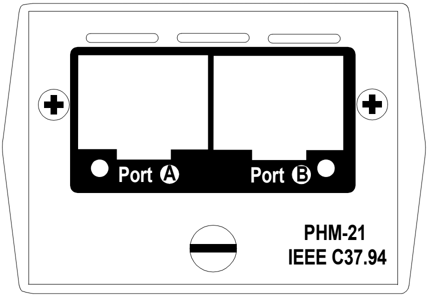


Figure B.2: The PHM-21 enables the IEEE C37.94 modes in xGenius

The PHM-21 operates as an extension of the Ethernet SFP ports A and B and it therefore keeps the same naming convention.Interconnection with the DUT requires special SFPs compatible with the C37.94 interface. These SFPs are supplied by ALBEDO Telecom. The test unit is compatible both with 850 nm SFPs compatible with transmission over MMF and 1310 nm SFPs for transmission over SMF.

B.3. PHM-22 G.703 / E0 Pluggable Hardware module

The PHM-22 provides access to the G.703 codirectional, contradirectional and centralized interfaces operating at bit rates under the primary rate.An special software license is required to access use the PHM-22 module

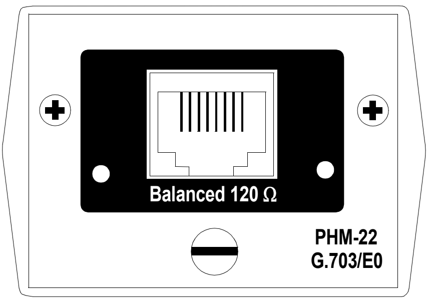


Figure B.3: The PHM-22 enables the G.703 codirectional, contradirectional and centralized interfaces in xGenius

This mode also allows configuration of add & drop over 64 kb/s codirectional interfaces when the unit is operating in *E1 / T1 endpoint*, *E1 / T1 through* or *E1 monitor* modes. Finally, if the equipment is configured in *E1 / T1 MUX test* and *E1 / T1 DEMUX* test, it allows users to configure 64 kb/s codirectional tributaries.

B.4. PHM-23 VF Pluggable Hardware module

The PHM-23 module provides access to the analog operation mode. This mode enables tone generation and analysis and latency testing in VF networks.

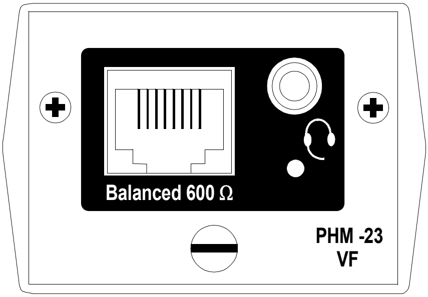
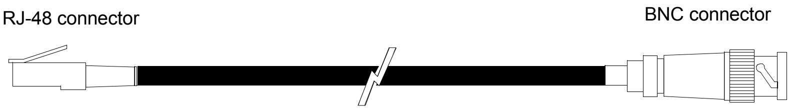
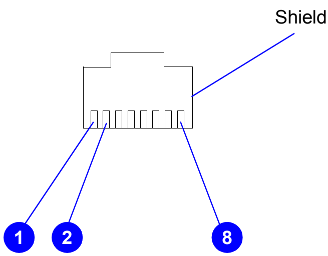


Figure B.4: The PHM-23 enables the voice frequency (Analog) mode in xGenius.

The PHM-23 requires an special software license before it can be used.

B.5. AT-76 Balanced RJ-48 to Unbalanced BNC E1 Balun





Pin	Signal
1	Balun pin 1
2	Balun pin 2
3	-
4	-
5	-
6	-
7	-
8	-
Shield	Balun metal shield

Figure B.5: AT-76 E1 Balun for xGenius.

The AT-76 is an E1 balun, it operates in a similar way than the AT-84 adapter but it only connects the RJ-48 input to a balanced interface. It is well suited to applications where no signal output is required. The most typical example is 1544 kHz / 1544 kb/s / 2048 kHz / 2048 kb/s / 10 MHz clock reference input. Please, note that this cable cannot be used with 1 PPS interfaces.

B.6. AT-40 and AT-41 1 PPS Input and Output Cables

These cables connect the AT-91 unbalanced 1 PPS input and output pins to a BNC interface. This connector is much more common for 1 PPS interfaces that the native AT-91 RJ-48 connector. These cables are not designed to operate as standalone devices. They should be used with the AT-91 adapter only.

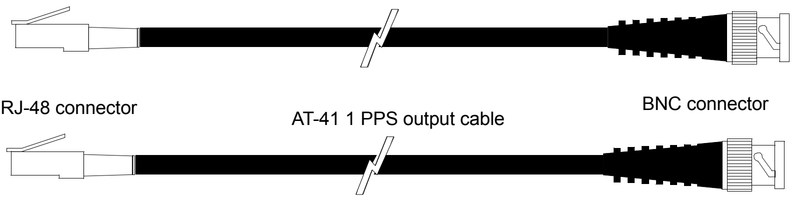


Figure B.6: AT-40 and AT-41 1 PPS input and output cables

B.7. AT-84 Balanced RJ-48 to Unbalanced BNC E1 Balun

Accessory for AT-2048 that converts the RJ-48 balanced output to a balanced BNC interface.

- AT-2048 connector: RJ-48 (RX: pins 1,2; TX: pins 4,5).
- E1 connectors: BNC.
- Bandwidth: DC - 5 MHz
- Input and output impedance: 75 Ω.
- Cable length: 100 cm.

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B.8. AT-85 Balanced RJ-48 to Balanced CF (Siemens) Adapter

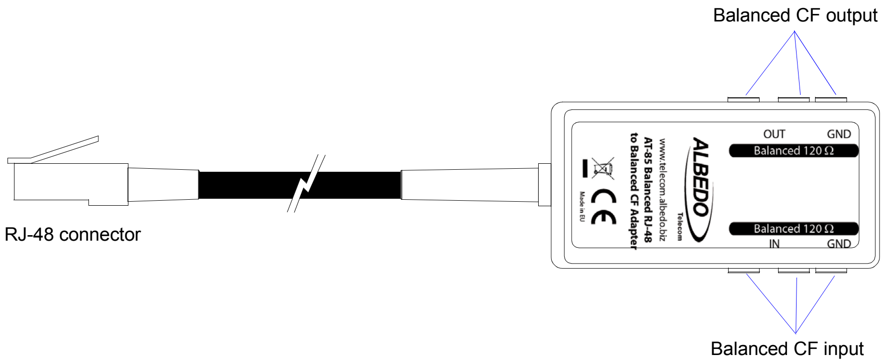


Figure B.7: AT-85 balanced RJ-48 to balanced Siemens adapter for xGenius.

This adapter is suitable for conversion of the AT-2048 Port B or Ether.Genius / Ether10.Genius Port C RJ-48 connector to 4 mm banana connectors compatible with Siemens connector. This adapter does not perform any impedance or balanced / unbalanced conversion. It is just a connector adapter.

B.9. AT-86 Stereo Audio Adapter

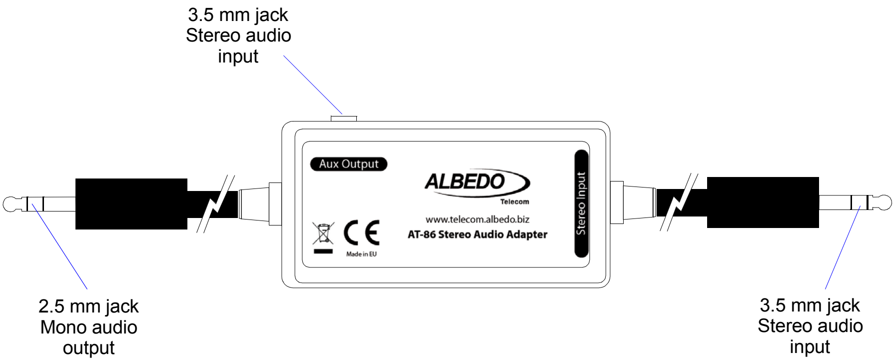


Figure B.8: AT-86 Stereo audio adapter for xGenius.

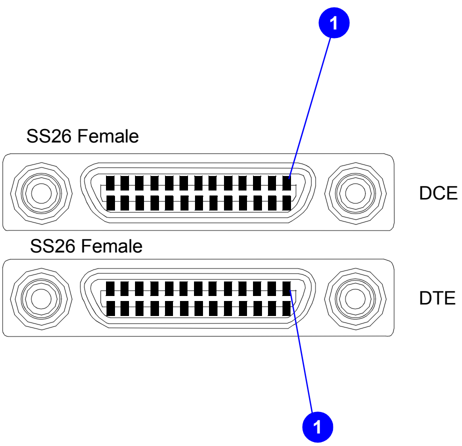
The AT-86 adapter enables connection of any stereo, like for example an smartphone output or an mp3 player output input to the AT-2084 / Ether.Genius /Ethert10.Genius.

no signal output is required. For example, it can be used for bidirectional monitoring or for connection of an unbalanced clock input.

Appendix C
Connector Pin-outs

This appendix provides the AT-2048 connector pin-outs.

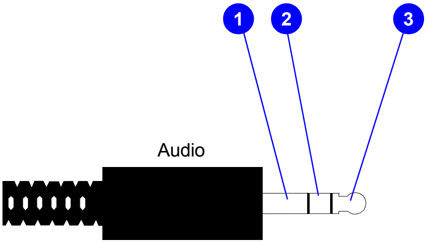
C.1. Smart Serial DTE / DCE Connectors (PHM-20)



Pin	Signal (DTE)	Signal (DCE)
1	LI	LI
2	DSR+	DTR+
3	CTS+	RTS+
4	CTS-	RTS-
5	RTS-	CTS-
6	RTS+	CTS+
7	DTR+	DSR+
8	DCD+	DCD+
9	RD+	TD+
10	RC+	TTC+
11	TC+	TC+
12	TTC+	RC+
13	TD+	RD+
14	TD-	RD-
15	TTC-	TC-
16	TC-	TC-
17	RC-	TTC-
18	RD-	TD-
19	DCD-	DCD-
20	DTR-	DSR-
21	RI	RI
22	GND	GND
23	TM	TM
24	SI	SI
25	DSR-	DTR-
26	GND	GND

Figure C.1: Smart Serial DTE / DCE connectors

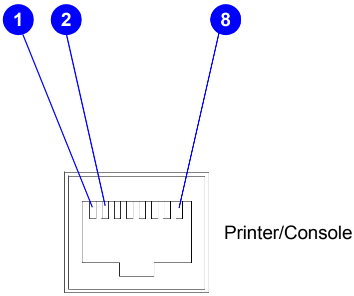
C.2. Audio Connector (2.5 mm Jack)



Pin	Signal
1	GND
2	Speaker
3	Microphone

Figure C.2: Audio connector (2.5 mm jack).

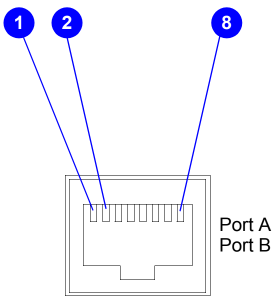
C.3. Printer / Console Connector (RJ-48)



Pin	Signal
1	CTS
2	-
3	RX
4	-
5	-
6	TX
7	-
8	RTS

Figure C.3: Printer / Console connector (RJ-45)

C.4. Balanced TX / RX Ports (RJ-48)



Port C / Port D

Pin	Signal
1	E1 in +
2	E1 in -
3	-
4	E1 out +
5	E1 out -
6	-
7	-
8	-

G.703 / E0

Pin	Signal
1	E1 in / E0 in +
2	E1 in / E0 in -
3	E0 clock in +
4	E1 out / E0 out +
5	E1 out / E0 out-
6	E0 clock in -
7	E0 clock out +
8	E0 clock out -

Figure C.4: Balanced TX / RX ports (RJ-45)

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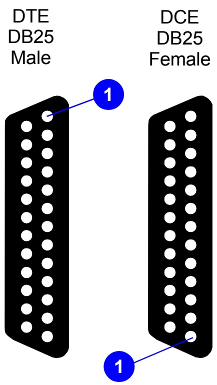
Appendix D
Datacom Cable Pin-outs

This appendix provides cable pin-outs of datacom cables compatible with xGenius. These cables can be supplied by ALBEDO Telecom, by an external supplier or manufactured by the customer.

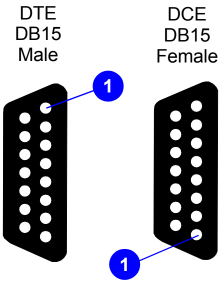
D.1. V.24 / V.28 Adaptor Cables



Circuit	Signal	Description	DB25
	GND		1
103	TD	Data transmit (DTE to DCE)	2
104	RD	Data reception (DCE to DTE)	3
105	RTS	Request to send	4
106	CTS	Ready for sending	5
107	DSR	Data set ready	6
108	DTR	Data terminal ready	20
109	DCD	Data within limits	8
113	TTC	Timing for receiving in 103	24
114	TC	Timing for sending in 103	15
115	RC	Timing for receiving in 104	17
141	LL	Loop 3 test condition in DCE	18

Figure D.1: V.24 / V.28 Adaptor Cables

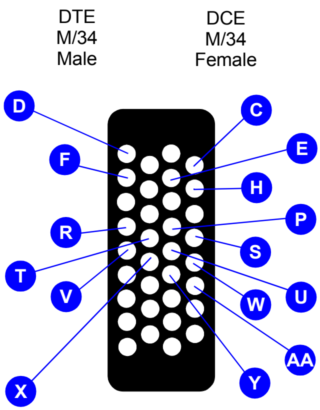
D.2. X.21 / V.11 Adaptor Cables



Circuit	Signal	Description	DB15
103	T+	Data transmit (DTE to DCE)	2
	T-		3
104	R+	Data reception (DCE to DTE)	4
	R-		5
105	C+	Control	6
	C-		20
106	I+	Indication	8
	I-		24
115	S+	Clock	15
	S-		17

Figure D.2: X.21 / V.11 Adaptor Cables

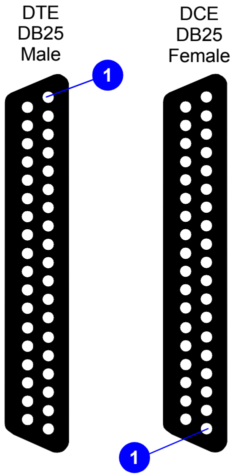
D.3. V.35 Adaptor Cables



Circuit	Signal	Description	M/34
103	TD+	Data transmit (DTE to DCE)	P
	TD-		S
104	RD+	Data reception (DCE to DTE)	R
	RD-		T
105	RTS	Request to send	C
106	CTS	Ready for sending	D
107	DSR	Data set ready	E
108	DTR	Data terminal ready	H
109	DCD	Data within limits	F
113	TTC+	Timing for receiving in 103	U
	TTC-		W
114	TC+	Timing for sending in 103	Y
	TC-		AA
115	RC+	Timing for receiving in 104	V
	RC-		X

Figure D.3: V.35 Adaptor Cables

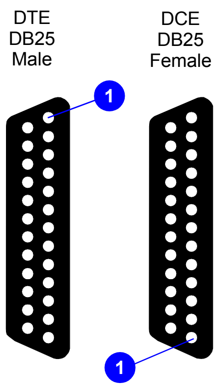
D.4. V.36 Adaptor Cables



Circuit	Signal	Description	DB37
103	TD+	Data transmit (DTE to DCE)	4
	TD-		22
104	RD+	Data reception (DCE to DTE)	6
	RD-		24
105	RTS+	Request to send	7
	RTS-		25
106	CTS+	Ready for sending	9
	CTS-		27
107	DSR	Data set ready	11
108	DTR	Data terminal ready	12
109	DCD	Data within limits	13
113	TTC+	Timing for receiving in 103	17
	TTC-		35
114	TC+	Timing for sending in 103	5
	TC-		23
115	RC+	Timing for receiving in 104	8
	RC-		26
141	LL	Loop 3 test condition in DCE	10

Figure D.4: V.36 Adaptor Cables

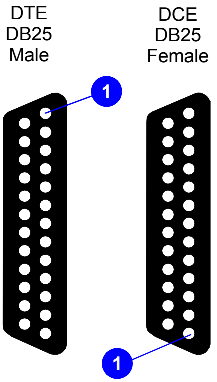
D.5. EIA-530 Adaptor Cables



Circuit	Signal	Description	DB25
103	TD+	Data transmit (DTE to DCE)	4
	TD-		22
104	RD+	Data reception (DCE to DTE)	6
	RD-		24
105	RTS+	Request to send	7
	RTS-		25
106	CTS+	Ready for sending	9
	CTS-		27
107	DSR+	Data set ready	11
	DSR-		12
108	DTR+	Data terminal ready	13
	DTR-		17
109	DCD+	Data within limits	35
	DCD-		5
113	TTC+	Timing for receiving in 103	23
	TTC-		8
114	TC+	Timing for sending in 103	26
	TC-		10
115	TTC+	Timing for receiving in 104	23
	TTC-		8
141	LL	Loop 3 test condition in DCE	26

Figure D.5: EIA-530 Adaptor Cables

D.6. EIA-530A Adaptor Cables



Circuit	Signal	Description	DB25
103	TD+	Data transmit (DTE to DCE)	4
	TD-		22
104	RD+	Data reception (DCE to DTE)	6
	RD-		24
105	RTS+	Request to send	7
	RTS-		25
106	CTS+	Ready for sending	9
	CTS-		27
107	DSR	Data set ready	11
108	DTR	Data terminal ready	13
109	DCD+	Data within limits	35
	DCD-		5
113	TTC+	Timing for receiving in 103	23
	TTC-		8
114	TC+	Timing for sending in 103	26
	TC-		10
115	TTC+	Timing for receiving in 104	23
	TTC-		8
141	LL	Loop 3 test condition in DCE	26

Figure D.6: EIA-530A Adaptor Cables

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