User's Manual

xGenius

Ethernet & IP Testing Guide

UM-XGENIUS-ETH-07-12-17

Run
Event
Power
DC
ALBEDO
xGenius
Transmission & Synchronization

ALBEDO
Telecom

Copyright

The information contained in this document is the property of ALBEDO Telecom S.L. and is supplied without liability for errors and omissions.

No part of this document may be reproduced or used except as authorised by contract or other written permission from ALBEDO Telecom S.L. The copyright and all restrictions on reproduction and use apply to all media in which this information may be placed.

ALBEDO Telecom S.L. pursues a policy of continual product improvement and reserves the right to alter without notice the specification, design, price or conditions of supply of any product or service.

© ALBEDO Telecom S.L. 2017
All rights reserved

Issue 1, 12/17

For any query or requirement regarding the *Gigabit Ethernet Generator & Analyser* product line, contact with ALBEDO Telecom using the following contact details:

ALBEDO Telecom S.L.
C/ Joan d'Àustria 112
08018 Barcelona - Spain

E-mail: *support.telecom@albedo.biz*
Telephone: *+34 93 221 28 73*

Table Of Contents

Chapter 1: Introduction 1

Important Notice 2

Warranty 2

Battery Safety 3

WEEE Notice 3

The Tester 3

Test Connector Panel 4

Platform Connector Panel 5

The Graphical User Interface 6

The Home Panel 6

The Menu Structure 9

The Summary and LEDs Tabs 11

Recently Used Panel and Menu Tree 12

Running Tests 13

Upgrading the Unit 13

Chapter 2: Connection to the Network 15

Setting the Operation Mode 15

Connecting the Tester to the Network 18

Configuring the Connector 19

Using the SFP / SFP+ Ports 20

Configuring Port A and Port B Auto-negotiation Parameters 22

Entering the Port Local Settings 25

Choosing between One-way, Two-way or Asymmetric Testing 28

Using the RFC 2544 / ITU-T Y.1564 Responder Function 32

Using the Traffic Reflector 33

Testing with an External Clock Reference 34

Using the Built in GNSS Receiver 39

Using the Clock Reference Output 40

Using the Holdover Mode 41

Chapter 3: Cable Tests 43

Electrical Test..43
Basic Principles of Ethernet Cable Wiring 43
Connecting the Tester 45
Running the Test 46

Measuring Optical Power 50

Measuring PoE / PoE+ Electrical Parameters 50

Chapter 4: Traffic Generation...55

Generation of Ethernet Traffic 55
Physical Layer Settings 56
Frame Settings 56
Configuring the Bandwith Profile 63
Choosing the Test Payload for Ethernet...66

Generation of IPv4 Traffic 69
Configuring the Physical and MAC Layers 71
Configuring MPLS 71
Configuring the Port Local Network Profile..75
Configuring the IPv4 Datagram 75
Setting the Bandwidth Profile 80
Choosing the Test Payload for IPv4 80

Event Insertion 80

Chapter 5: Basic Frame Analysis 85

Global Counts and Statistics 86
Frame Counts...86
Error Counts 88
Network Counts 89
Bandwidth Statistics 91
Frame Size Distribution 93
MPLS Statistics 93

Using the Network Search Capability 94

The LEDs Panel..95

The Event Logger...99
Configuring the Event Logger...100
Displaying Logs 101
Exporting Logs...104

BER Testing...105

Framed BER Tests 105
Physical Layer BER Tests 107

Service Disruption Time 112

Chapter 6: Multi-Stream Analysis 115

Enabling and Disabling Filters 115

Configuring Filters 117
MAC Selection 118
C-VLAN and S-VLAN Selection 119
MPLS Selection 121
IPv4 Selection 123
IPv6 Selection 125
UDP Selection 128
Fixed Offset Selection 129

Per-Stream Counts and Statistics 130
Bandwidth Statistics 131
SLA Statistics 132

Chapter 7: Automatic Performance Tests 137

Performance Assessment with the RFC 2544 Test 137
Throughput 139
Latency 141
Frame Loss 142
Back-to-Back Frames 142
System Recovery 143
Configuration Pass / Fail Thresholds 144
Getting Test Results 145
Generation of RFC 2544 Result Reports 150

Performance Assessment with the eSAM Test 152
Bandwidth Profiles for Ethernet Services 155
Test Configuration 159
CIR Configuration Test 165
EIR Configuration Test 166
Policing Configuration Test 166
Performance Test 168
Generation of eSAM Result Reports 169

Chapter 8: Ping and Traceroute Tools 173

Ping 173

Internet Control Message Protocol 173
Test Configuration 174
Result verification 176

Traceroute 178
Test Configuration 178
Result verification 180

Chapter 9: IEEE 1588 Analysis 183

Ethernet Synchronization with IEEE 1588 183
Precedents: IP Synchronization with NTP 184
PTP Protocol Details 184
The Synchronization Mechanism 185
Protocol Encapsulation 186
Unicast Addressing Mode 187

IEEE 1588 Grandmaster and Slave Emulation 187
Configuration of the IEEE 1588 Master and Slave 189
Protocol State 201
Message Statistics 206
Delay Statistics 208
Clock Status 213
Unicast Negotiation Results 215

The Pseudo-slave Emulation Mode 216
TE Test 217
Wander (MTIE / TDEV) Test 218
Floor Delay Population Test 224

Passive Monitoring 227

Clock Interface Monitoring 229
Connecting the Unit 230
Configuring the Clock Reference 230
Configuring the Port 230
Configuring the Jitter Test 231
Configuring the Wander Test 232
Running the Test 233

Chapter 10: Synchronous Ethernet Analysis 235

Introduction to Synchronous Ethernet 235
Ethernet Synchronization Messaging Channel 237
Synchronous Ethernet for the 1000BASE-T Interface 237

Frequency Measurement 240

MTIE / TDEV Analysis 240
Frequency Offset Generation 242
Wander Generation 243
Operation in IP Through Mode 244
ESMC Generation and Analysis 245

Chapter 11: Test Management 249
Generating Reports 249
File Management 251
  Saving Configurations 252
  Renaming Files 252
  Deleting Files 252
  Exporting Files to External Devices 253
  Importing Configurations 253
  Using the Embedded Web Server 254
Programming Tests 255
Using the System Menu 257
  Using the Network 259
  Installing Software Options 264
  Using NTP and GPS/NMEA for System Clock Synchronization 265
  Configuring the GNSS Receiver 267
Using the Remote Control 270

Appendix A: Technical Specification 273
General 273
Operation Modes 273
Ethernet PHY 273
  Auto-Negotiation 273
  Power over Ethernet 274
Synchronous Ethernet 274
  Operation 274
  Wander Generation Function 274
  Analysis 274
Clock References 275
  Rubidium Reference 275
GNSS Input 275
  GNSS Compact Antenna 276

Ethernet MAC **276**

MPLS **276**

IPv4 .... **276**

Traffic Generator **277**
    Bandwidth Profiles 277
    Test Patterns and Payloads 277

Event Insertion **277**

Filter **277**
    Ethernet Selection 277
    MPLS Selection 277
    IPv4 Selection 278
    IPv6 Selection 278
    UDP Selection 278

PHY Results **278**
    Cable Tests 278
    Auto-Negotiation 278
    SFP 278
    Power over Ethernet 278

Frame Analysis **279**
    Ethernet Statistics 279
    MPLS Statistics 279
    IP Statistics 279
    Bandwidth Statistics 279
    SLA Statistics 279
    Service Disruption Time 280
    BER 280
    Network Exploration 280

Automatic Tests **280**
    IETF RFC 2544 Test 280
    eSAM Test 280

Port Loopback **280**

Ping and Trace-route **281**

PTP (IEEE 1588) **281**
    Operation 281
    Protocol State Results 281
    Results 281
    Time Error Test 282
    MTIE and TDEV Test 282
    Floor Delay Population Test 282

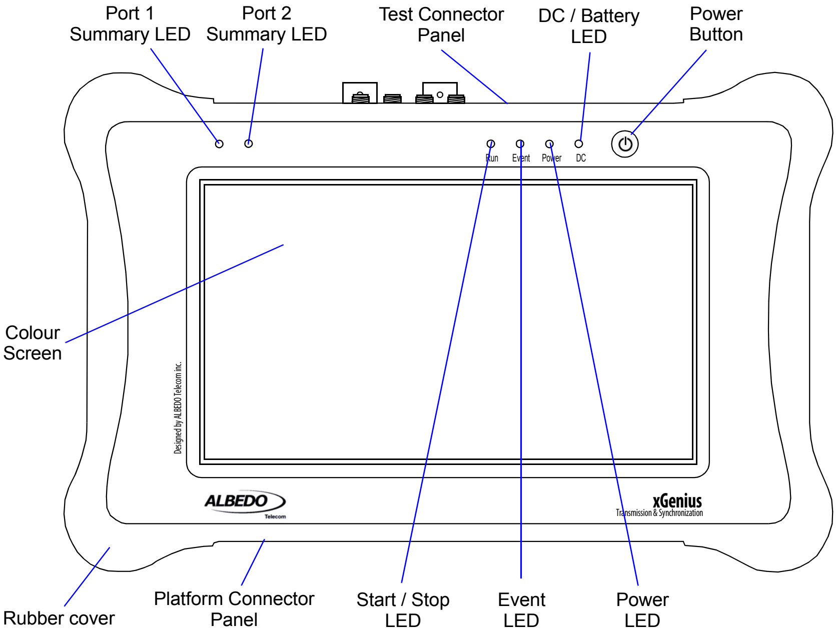
Clock Monitor Mode **282**

Protocols **282**
User Interface **282**
Platform **283**
    User Interface 283
    Results 283
    Operational Ranges 283

Appendix B: Common Issues and Solutions **285**

Chapter 1
Introduction

The ALBEDO Telecom xGenius is a dual port hand-held Ethernet traffic generator and analyser conceived to rate conformance and performance of native Ethernet networks or Ethernet services like Ethernet Private Lines (EPLs) or Ethernet Private LANs (EPLANs).



Port 1
Summary LED
Port 2
Summary LED
Test Connector
Panel
DC / Battery
LED
Power
Button
Run
Event
Power
DC
Colour
Screen
Designed by ALBEDO Telecom inc.
ALBEDO
Telecom
xGenius
Transmission & Synchronization
Rubber cover
Platform Connector
Panel
Start / Stop
LED
Event
LED
Power
LED

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

xGenius operates at bit rates up to 10 Gb/s. It comes with optional synchronization testing capabilities and TDM analysis and generation features. For this reason, xGenius is suitable for testing in environments where packet switching has not totally replaced legacy circuit switching technology, like in some cellular networks or electrical substations.

The test unit has an external DC input but it also has internal batteries. This makes this tester suitable both for laboratory applications and field applications which require versatile and reliable operation.

Within your xGenius test kit you will find the following items:

- One xGenius test unit.
- One AC/DC adapter with a power cord specific for your country.
- One Carrying bag.
- One Cat. 5e cable with RJ-45 connectors certified for operation at 1 Gb/s rates.
- Two SFP / SFP+ for connection to optical interfaces (if ordered).
- Two MMF or SMF cables to be used with the SFPs (if ordered).
- One coaxial cable with BNC male connectors.
- 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 xGenius unit.

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. Battery 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 product in fire. Do not leave the device in direct sunlight for an extended period of time, which could cause melting or battery damage.

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:

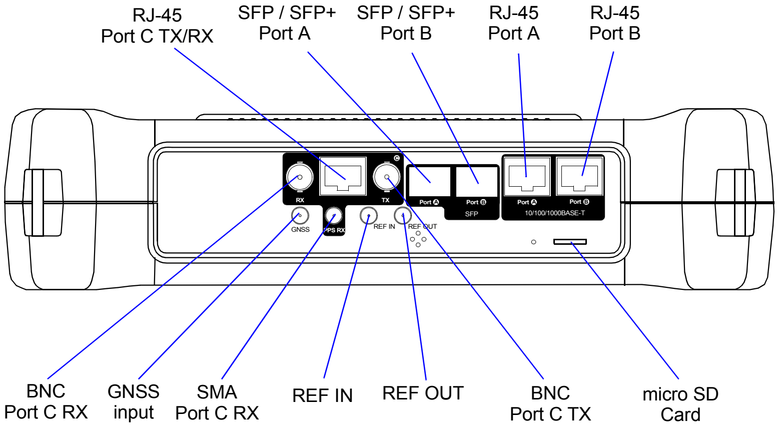

RJ-45
Port C TX/RX
SFP / SFP+
Port A
SFP / SFP+
Port B
RJ-45
Port A
RJ-45
Port B
RX
TX
C
Port A
Port B
SFP
Port A
Port B
10/100/1000BASE-T
GNSS
PPS RX
REF IN
REF OUT
BNC
Port C RX
GNSS
input
SMA
Port C RX
REF IN
REF OUT
BNC
Port C TX
micro SD
Card

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 / 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.This port can be used also with SFP+ modules compatible with 10 Gb/s transmission.
- *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. 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. It can be used also with SFP+ modules compatible with 10 Gb/s transmission.

- *micro SD Card*: Slot for micro SD Cards. These cards can be used as external storage devices.
- *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, 10 MHz, 1 PPS) and generate and analyse TDM (E1 and T1) signals. This interface is used as a clock input / output as well.
- *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 2.8). This input is available only in units equipped with the built in GNSS receiver.
- *SMA Port C RX*: 1 PPS 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
- *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
- *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.

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.

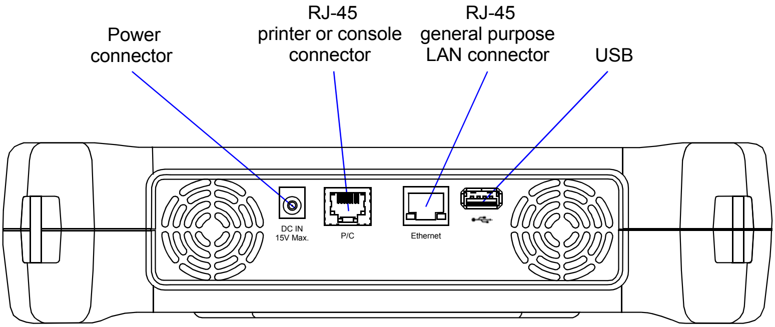

Power connector
RJ-45 printer or console connector
RJ-45 general purpose LAN connector
USB
DC IN 15V Max.
P/C
Ethernet

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

- *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)
- *SETUP*: 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 test ports C and D and the wander generator.

- *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.

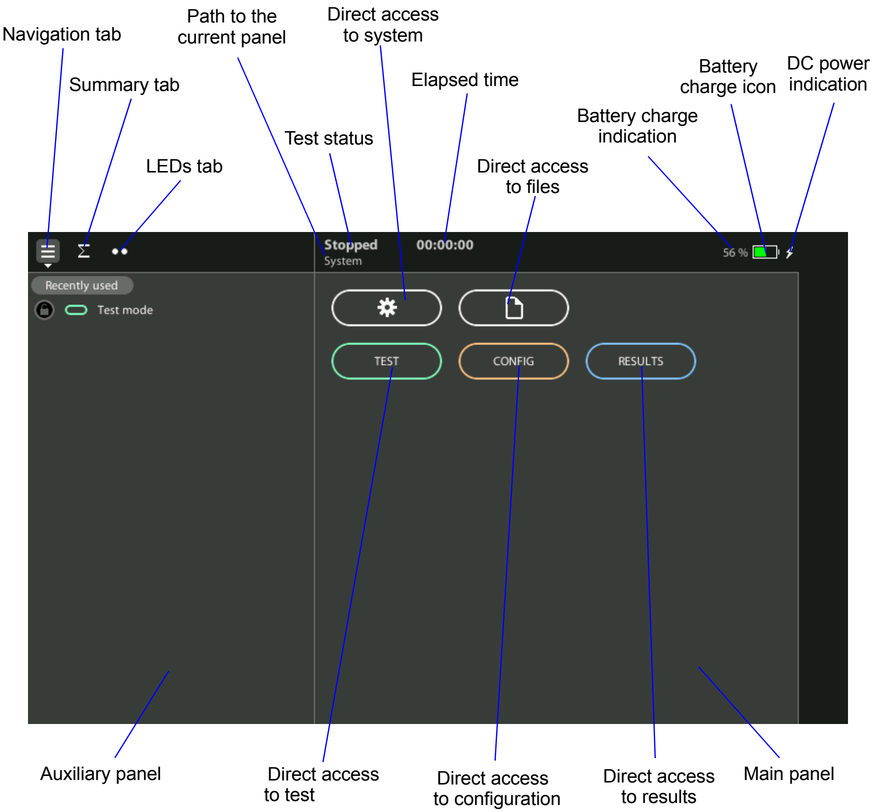

Navigation tab
Path to the current panel
Direct access to system
Summary tab
Elapsed time
Battery charge icon
DC power indication
Battery charge indication
Test status
LEDs tab
Direct access to files
Stopped
System
00:00:00
56 %
Recently used
Test mode
TEST
CONFIG
RESULTS
Auxiliary panel
Direct access to test
Direct access to configuration
Direct access to results
Main panel

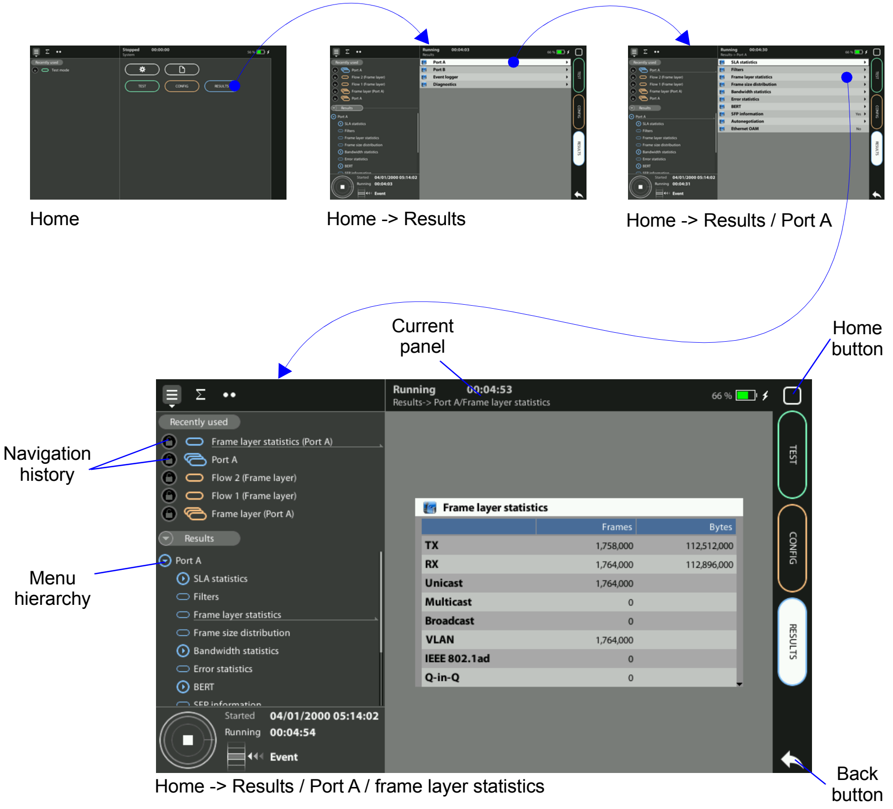
Figure 1.4: xGenius home panel.

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. Units with a GNSS input include a menu that enables the user to synchronize the system time with the GPS, GLONASS, BeiDou and Galileo time.

On the left side of the Home 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*, *SETUP* 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.



Home

Home -> Results

Home -> Results / Port A

Home -> Results / Port A / frame layer statistics

Current panel
Home button
Navigation history
Menu hierarchy
Back button
Running 00:04:53
Results-> Port A/Frame layer statistics
66 %
Recently used
Frame layer statistics (Port A)
Port A
Flow 2 (Frame layer)
Flow 1 (Frame layer)
Frame layer (Port A)
Results
Port A
SLA statistics
Filters
Frame layer statistics
Frame size distribution
Bandwidth statistics
Error statistics
BERT
SFP information
Started 04/01/2000 05:14:02
Running 00:04:54
Event
TEST
CONFIG
RESULTS

Frame layer statistics

	Frames	Bytes
TX	1,758,000	112,512,000
RX	1,764,000	112,896,000
Unicast	1,764,000	
Multicast	0	
Broadcast	0	
VLAN	1,764,000	
IEEE 802.1ad	0	
Q-in-Q	0	

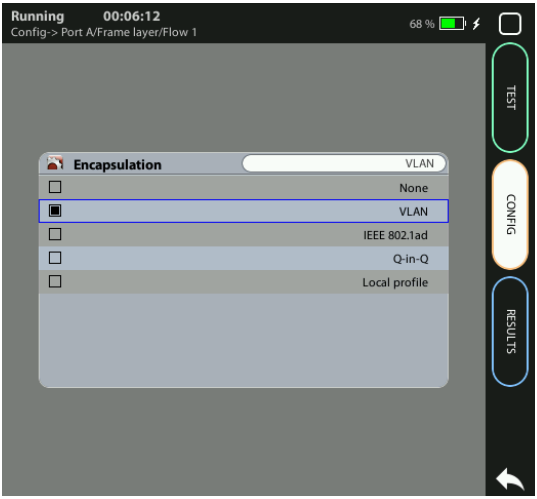
Figure 1.5: Access to a results table from the home panel in three different steps. In this case the test results are represented as a table, including a header (frames, bytes), a results list (TX, RX ,...) and different counters.

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.

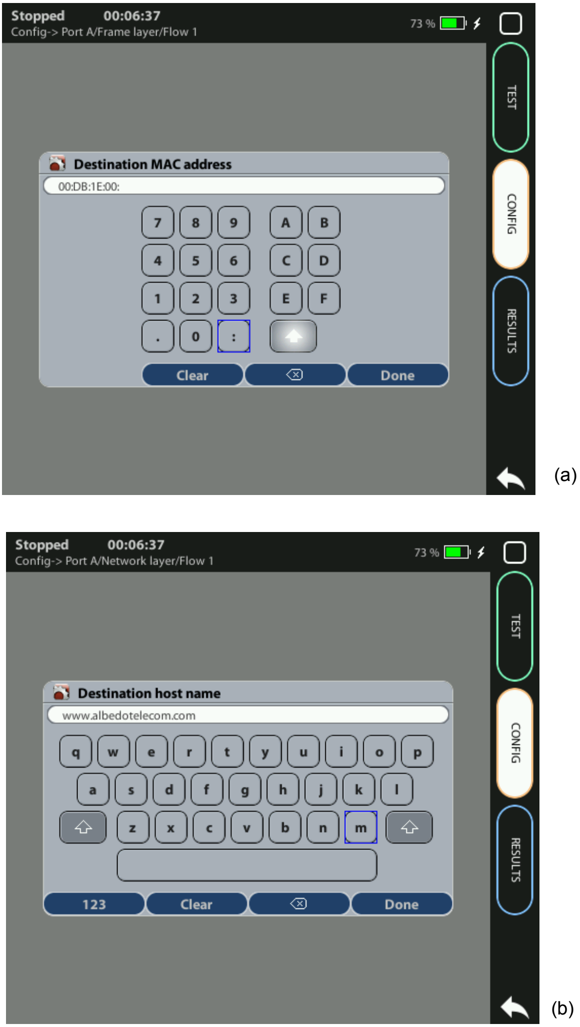


Encapsulation VLAN

☐ None
☒ VLAN
☐ IEEE 802.1ad
☐ Q-in-Q
☐ Local profile

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).


(a)

Stopped 00:06:37
Config-> Port A/Frame layer/Flow 1

Destination MAC address: 00:DB:1E:00:

(b)

Stopped 00:06:37
Config-> Port A/Network layer/Flow 1

Destination host name: www.albedotelecom.com

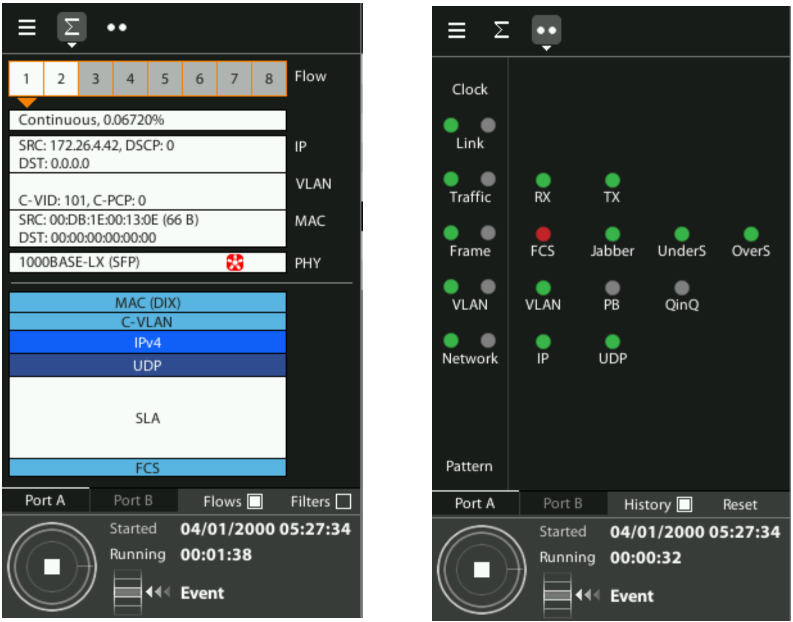
73 %
TEST
CONFIG
RESULTS
7
8
9
A
B
4
5
6
C
D
1
2
3
E
F
.
0
:
Clear
Done
q w e r t y u i o p
a s d f g h j k l
z x c v b n m
123
Clear
Done

Figure 1.7: Different kinds of data input keyboards: (a) Alphanumeric keyboard, (b) Numeric keyboard.

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.


1
2
3
4
5
6
7
8
Flow
IP
VLAN
MAC
PHY
MAC (DIX)
C-VLAN
IPv4
UDP
SLA
FCS
Port A
Port B
Flows
Filters
Event
Clock
Link
Traffic
RX
TX
Frame
FCS
Jabber
UnderS
OverS
VLAN
VLAN
PB
QinQ
Network
IP
UDP
Pattern
Port A
Port B
History
Reset
Event

Continuous, 0.06720%

SRC: 172.26.4.42, DSCP: 0
DST: 0.0.0.0

C-VID: 101, C-PCP: 0

SRC: 00:DB:1E:00:13:0E (66 B)
DST: 00:00:00:00:00:00

1000BASE-LX (SFP)

Started 04/01/2000 05:27:34
Running 00:01:38

(a)

Started 04/01/2000 05:27:34
Running 00:00:32

(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.

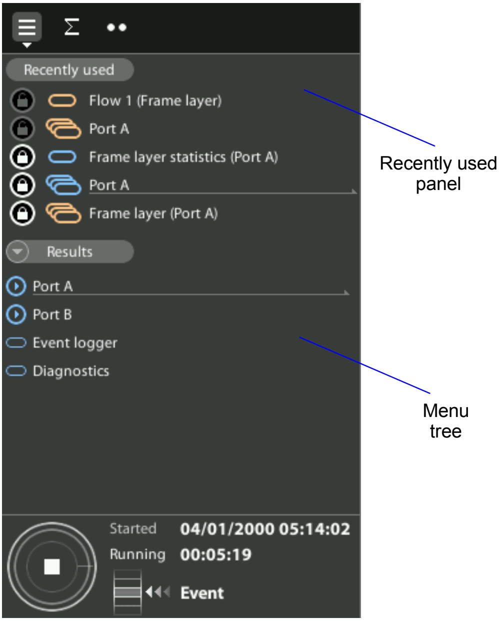

Recently used
Flow 1 (Frame layer)
Port A
Frame layer statistics (Port A)
Port A
Frame layer (Port A)
Results
Port A
Port B
Event logger
Diagnostics
Started 04/01/2000 05:14:02
Running 00:05:19
Event
Recently used panel
Menu tree

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 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.

1.4. 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,

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*.
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.

Chapter 2
Connection to the Network

The test unit is equipped with two identical 1 Gb/s RJ-45 ports and two 1 Gb/s SFP ports (or two 10 Gb/s SFP+). The RJ-45 ports are used for connection to Ethernet electrical interfaces. The SFP / SFP+ ports are normally used for optical connections. Each RJ-45 / SFP / SFP+ interface constitutes a single logical port. These ports are labelled as Port A and Port B.xGenius includes a third port (Port C) for TDM and clock signal generation and analysis

Port A and Port B do not share the same generation and analysis capabilities. Port A is a full featured Ethernet port but Port B is conceived as a secondary testing port only. For this reason, Port B does not include advanced traffic generation. Port B can loop frames / packets toward their origin if configured to do so. It also responds to pings (ICMP echo request message) and other basic protocols like ARP. Analysis capabilities of Port A and Port B are similar with some exceptions like the cable test, the PoE / PoE+ analysis or most synchronization tests.

This chapter describes how to connect the tester to the network and how to configure it to receive and send signals. The general, high level procedure to do that is:

1. Configure the Port A / Port B, including global and port specific operation modes and generation / analysis properties.
2. Connect the test cables to the network. Use the electrical or optical ports depending on the particular network properties.
3. Traffic generation does not start until you start a test with RUN. Most of the results are not available neither.

2.1. Setting the Operation Mode

As Ethernet interfaces, Port A and Port B are independent but they share the same global operation mode. That means that, for example, if you configure Port A to be an IP endpoint port, then Port B will become an IP endpoint port as well. In any other sense, Port A and Port B are allowed to have a different configuration.

To configure the xGenius global 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: *Ethernet endpoint*, *IP endpoint*, *IP Through*, *Ethernet cable test* or *L1 endpoint*.
   Note: Some other operation modes may be available depending on the hardware / software options available in your test unit.

Table 2.1: Global Ethernet Operation Modes

Mode	**Description**
Ethernet endpoint	If the tester is configured in *Ethernet endpoint* mode, then it emulates an Ethernet network terminating point. In this mode the generator sends a test signal made up of Ethernet frames to the DUT / SUT and the analyser receives new Ethernet frames from the DUT / SUT. The received signal may be the same test signal once it has been transmitted through the DUT / SUT. This mode is used for continuity / transparency testing, BER testing and performance (SLA, eSAM, RFC 2544) measurements in Ethernet interfaces. You can use this operation mode if you have IP over Ethernet but you don't care about the network protocol used in the network.
IP endpoint	If the tester is configured in *IP endpoint* mode, then it emulates an IP network terminating point. In this mode the generator sends a test signal made up of IPv4 frames to the DUT / SUT and the analyser receives new IPv4 / IPv6 frames from the DUT / SUT. The Received signal may be the same test signal once it has been transmitted through the DUT / SUT. This mode is used for continuity / transparency testing, BER testing and performance (SLA, eSAM, RFC 2544) measurements in IP / Ethernet interfaces.
IP through	The *IP Through* mode is suited for bidirectional intrusive monitoring. The signal from the Port A receiver is forwarded to the Port B transmitter. An equivalent operation is performed on the signal received on Port B. As it passes through the test unit, the test signal is analysed and statistics about it are collected and recorded.

Table 2.1: Global Ethernet Operation Modes

Mode	Description
Ethernet cable test	This is the correct mode to check the UTP / FTP / STP cable transmission parameters like the wire map, skew and MDI / MDIX port status. It there is any cable fault like an open or a short circuit, it is detected and an estimated distance to the fault is displayed. If this mode is enabled, port B is forced to a *Link* status and port A is set to an special *Cable test* status that is specifically used for cable tests.
L1 endpoint	This is a mode specifically conceived for physical layer BER tests. When the equipment is configured in this mode is unable to generate user-configurable frames but it can still generate and analyse the PCS codes required for BER testing at L1.

There is a 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.

Table 2.2: Port Modes

Mode	Description
TX / RX	Both transmission and reception are enabled in the port. The transmitter is connected to the internal test traffic generator. This is the port mode to be used most of the times for testing in endpoint mode. The *TX / RX* mode is available for Ethernet Port A only.
Monitor	The port is configured in promiscuous monitoring mode and the port transmitter is disabled. All kinds of traffic generation are disabled in *Monitor* mode but the equipment can still reply to some ARP and ICMP requests for technical reasons. Use this mode if you want to get statistics about the network traffic, including traffic from remote test unit but you don’t want to disturb the network with any test traffic internally generated by the unit.
Loopback	The port receiver is connected to the transmitter so that part or all the received frames are sent towards the origin. This port mode is used guarantee the continuity of the test payload or pattern to in two-way tests.

Table 2.2: Port Modes

Mode	Description
Cable test	This is a mode specifically used for cable tests. It is used if the global operation mode is set to *Ethernet cable test*. The *Cable test* port mode disables transmission of Ethernet frames or IP packets. It also stops any layer 2 or layer 3 analysis. The *Cable test* port mode is available for port A only.
Link	This is a mode specifically used for cable tests. It is used if the global operation mode is set to *Ethernet cable test*. The *Link* test mode disables transmission of Ethernet frames or IP packets. It also stops any layer 2 or layer 3 analysis. The only function of the *Link* port mode is to supply link to enable *Port A* to measure the all cable parameters. The *Link* port mode is available for port B only.
Disabled	Both the port transmitter and receiver are disabled. Use this mode if you are not going to use the corresponding port and you want to extend the operation time with batteries to the maximum.

To configure the test unit port specific operation mode follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration menu.
3. Select *Port mode* to enter in the mode selection Menu
4. Choose between: *TX / RX*, *Monitor*, *Loopback, Cable test, Link* or *Disabled*.
   Note: Some other operation modes may be available depending on the global operation mode and the actual port you are configuring.

2.2. Connecting the Tester to the Network

The way you connect your tester to the network depends on the global operation mode. For example, if you set the tester to operate in *IP through* mode, you will be required to connect the equipment in “transparent” mode, with the traffic going through the unit from Port A to Port B and Port B to Port A.

The operation mode also depends largely of the type of DUT / SUT. If you are connecting the equipment to an IP router, probably it does not make sense to configure the equipment in *Ethernet endpoint* mode because the router will be unable to recognise and forward traffic without an IP payload. Note that the opposite is not true. You may want to send IP traffic trough an Ethernet network and for this reason, the *IP* *endpoint* mode is compatible with Ethernet network testing. Many users (carriers and service providers) are offering Ethernet services like Ethernet Private Lines (EPLs) or Ethernet Private LANs (EPLANs) and they prefer to avoid making any decision concerning IP addressing. They also prefer to avoid generation of any IP stack protocol (ICMP, ARP, DHCP, PPP) within their administrative domains. For these users, the *Ethernet Endpoint* mode is the most appropriate.

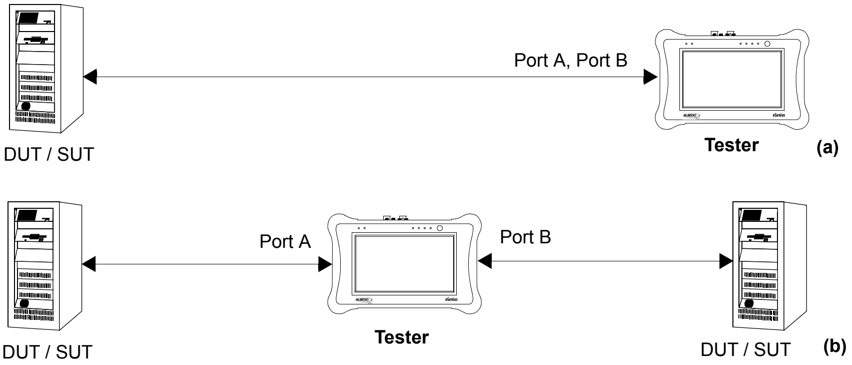


Figure 2.1: Basic connection setup for xGenius testers: (a) Ethernet and IP endpoint operation modes. (b) Ethernet / IP through mode.

2.2.1. Configuring the Connector

Both Port A and Port B have one Electrical (RJ-45) and SFP / SFP+ connector each. Which one is enabled at any moment is a user decision. Normally, the SFP / SFP+ is used to connect the equipment to an optical interface but nothing stops the user to attach a compatible electrical SFP module to Port A or Port B and carry out an electrical test with an SFP.

The procedure for configuring the connector (RJ-45 or SFP / SFP+) is the following

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration.
3. Go to *Physical* to enter in the physical settings configuration panel.
4. Select *Connector* to display the available options for the port connector.
5. Choose the right connector.
   Note that Port A and Port B do not need to be both optical or electrical at the same time. The test unit is compatible with operation requiring conversion between optical and electrical transmission if all other operation conditions are met.

2.2.2. Using the SFP / SFP+ Ports

The SFP ports are the only choice available for optical tests. They can also be used for electrical tests if compatible SFP / SFP+ are connected but this is usually not necessary due to the attached RJ-45 ports which require no adapters.

Table 2.3: Ethernet SFP Results

Result	Description
SFP present	Shows information about presence of an SFP in the current port.
Transceiver	Displays the current Ethernet interface. Supported interfaces are listed below: • 10BASE-T: Used for transmission at 10 Mb/s over two pairs of Cat. 3 UTP cable with range of 100 m. • 100BASE-TX: Used for transmission at 100 Mb/s over two pairs of Cat. 5 UTP cable with range of 100 m. • 100BASE-FX: Used for transmission at 100 Mb/s over two MMF in the 1310 optical window. This interface requires an special SGMII compliant SFP supplied by ALBEDO Telecom. • 1000BASE-T: Used for transmission at 1000 Mb/s over four pairs of Cat. 5e UTP cable with range of 100 m. • 1000BASE-SX: Used for transmission at 1000 Mb/s over two MMF operating in the 850 nm optical window. Ranges are usually a few hundred metres. This interface is supported by means an external SFP only. • 1000BASE-LX: Used for transmission at 1000 Mb/s over two MMF or SMF in the 1310 nm optical window. Ranges use to be a few kilometres. This interface is supported by means an external SFP only. • 10GBASE-SR: Used for transmission at 10 Gb/s over two MMF operating in the 850 nm optical window. Ranges up to 300 m depending on the actual optical fibre used as the transmission medium. This interface is supported by Ether10.Genius only and it requires an external SFP+. • 10GBASE-LR: Used for transmission at 10 Gb/s over two SMF operating in the 1310 nm. optical window. Standard range is up to 10 km but commercial SFP may offer longer ranges. This interface is supported by Ether10.Genius only and it requires and external SFP+.

Table 2.3: Ethernet SFP Results

Result	Description
Vendor	If there is an SFP connected to the port, this field shows information about the vendor. This information is recorded within a memory in the SFP when it is manufactured.
Model	If there is an SFP connected to the port, this field shows information about the vendor. This information is recorded within a memory in the SFP when it is manufactured.
TX optical power	In compatible optical SFPs, this field displays the currently transmitted optical power expressed in dBm. Resolution for this result is 0.1 dBm but real result accuracy depends on the specific SFP module.
RX optical power	In compatible optical SFPs, this field displays the currently received optical power expressed in dBm. Resolution for this result is 0.1 dBm but real result accuracy depends on the specific SFP module.
Wavelength	In optical SFPs, this field displays the nominal wavelength used by the light source.

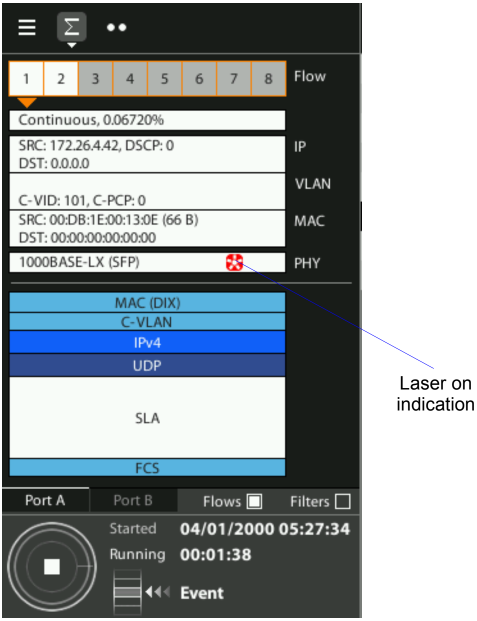
To display the SFP / SFP+ interface information follow these step sequence:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *SFP information* and check the *SFP present*, *Transceiver*, *Vendor*, *Model*, *TX optical power*, *RX optical power* and *Wavelength*.

For security reasons, the optical transmitter is not automatically enabled when the equipment boots up. To switch the optical transmitter on, follow this procedure:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration.
3. Go to *Physical* to enter in the physical settings configuration panel.
4. Set *Laser* to *On* to enable the optical transmitter in the current port.
   Note: It is recommended to switch the optical transmitter once the testing has finished.

Current on / off status of the optical transmitter is always available from the *Summary* tab.



Continuous, 0.06720%

SRC: 172.26.4.42, DSCP: 0
DST: 0.0.0.0

C-VID: 101, C-PCP: 0

SRC: 00:DB:1E:00:13:0E (66 B)
DST: 00:00:00:00:00:00

1000BASE-LX (SFP)

Started 04/01/2000 05:27:34
Running 00:01:38

Laser on indication

Figure 2.2: *Laser on* indication in the xGenius Summary panel.

2.2.3. Configuring Port A and Port B Auto-negotiation Parameters

Many Ethernet ports use auto-negotiation to negotiate speed, duplex operation and other parameters with the peer interface. Ethernet auto-negotiation can be enabled or not in the test unit. If auto-negotiation is enabled, the user decides whether to restrict the available bit-rates. If the user decides to disable auto-negotiation, then the bit rate is forced to a user configurable value.

It should be noticed that Ethernet international standards (and specifically the IEEE 802.3) either does not define any auto-negotiation mechanism for some interfaces or it explicitly forbids not auto-negotiated operation in some interfaces. For example, There is no auto-negotiation for 10 Gb/s interfaces. SFP+ are always configured to a forced 10 Gb/s bit rate in full duplex mode. On the other hand, auto-negotiation is mandatory in 1000 Mb/s electrical interfaces. Auto-negotiation should not be disabled if this interface is being used.

Table 2.4: Ethernet Auto-negotiation Setup

Setting	Description
Enable	Enables or disables the standard Ethernet auto-negotiation procedure during the connection setup. Auto-negotiation sets the link bit rate, duplex mode, flow control mode without user intervention. Disable Auto-negotiation only if you know that the remote end does not support this procedure or if you want to check link operation without auto-negotiating.
1000-FD	Allows / disallows the interface to negotiate the 1000 Mb/s transmission rate. This is the only choice available if an optical SFP transceiver for 1000BASE-X is attached to the port.
100-FD	Allows / disallows the interface to negotiate the fast Ethernet speed (100 Mb/s) if you are using the RJ-45 port or a compatible electrical SFP for data transmission.
10-FD	Allows / disallows the interface to negotiate the 10 Mb/s transmission rate if you are using the RJ-45 port or a compatible electrical SFP for data transmission.
Clock role	Sets the master / slave clock role in 1000BASE-T interfaces. The available settings for this field are listed below: • *Auto*: The master / slave role designation is automatic and in principle random. • *Master*: The synchronization master role is forced for the interface. This is the right configuration for frequency offset generation or sinusoidal phase modulation generation in xGenius. • *Slave*: The synchronization slave role is forced for the interface. This is the right configuration value for frequency and phase measurements over the interface, including MTIE and TDEV, in the units with the.ability to measure these metrics. The clock role setting makes sense only if the equipment is allowed to negotiate the 1000BASE-T interface over a native RJ-45 port.

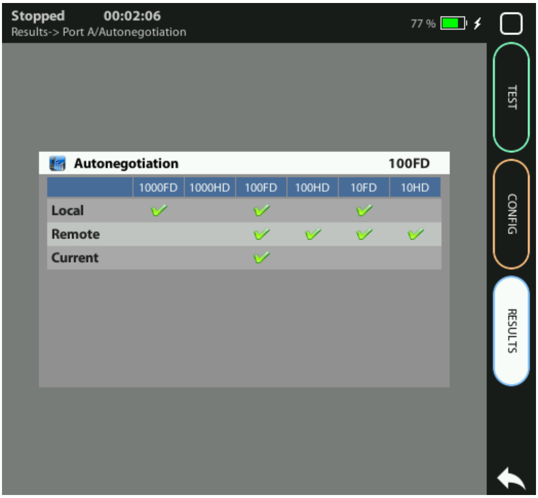
Under normal circumstances, the preferred link speed is the highest available. Use *1000-FD*, *100-FD* and *10-FD* settings if you want to analyse the link operation under sub-optimal circumstances. For e example use it to operate at 10 or 100 Mb/s in a link supporting 1000 Mb/s. The general procedure to configure the auto-negotiation in your test unit is as follows:

Table 2.5: Ethernet Auto-negotiation Results

Result	Description
Local	Displays the bit rate and duplex mode supported by the equipment Port A or Port B. If the current connector is the RJ-45, the supported bit rates are 10 Mb/s, 100 Mb/s and 1000 Mb/s (1000FD, 100FD and 10FD). If the connector is set to SFP the supported bit rate is 1000 Mb/s (1000FD).
Remote	Displays the bit rate and duplex mode supported by the remote device connected to Port A or Port B. It is one or several of 1000FD, 1000HD, 100FD, 100HD, 10FD, 10HD.
Current	Bit rate and duplex operation agreed during the auto-negotiation process. It is one (and only one) of the 1000FD, 100FD and 10FD set. If there is more than one compatible interface, the one with higher bit rate is preferred.

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration.
3. Go to *Physical layer* to enter in the physical settings configuration panel.
4. Go to *Autonegotiation*.
5. Set *Enable* to *Yes* to configure the link speed using auto-negotiation or to *No* to disable auto-negotiation and force the link speed to a fixed value.
6. If you have enabled auto-negotiation in the previous step configure the allowed bit rates through the *1000-FD*, *100-FD* and *10-FD* menus. If auto-negotiation is disabled, set the *Forced bit-rate* to *10* or *100* from the *Physical layer* menu.
   Note: The 1000 Mb/s rate in electrical interfaces cannot be forced and it is only available through auto-negotiation due to IEEE 802.3 restrictions.The 10 Gb/s cannot be auto-negotiated due to restrictions in the same standard. This bit rate is always forced.

Once the tester has been connected to the network and the right connector type as been configured, follow these steps to check auto-negotiation results:



Autonegotiation 100FD

	1000FD	1000HD	100FD	100HD	10FD	10HD
Local	✓		✓		✓	
Remote			✓	✓	✓	✓
Current			✓			

Figure 2.3: Albedo xGenius auto-negotiation results panel.

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A or Port B* to enter in the port specific results.
3. Press *Auto-negotiation*
   The auto-negotiation status table for the current port is displayed.
4. Verify which bit rate / duplex modes combinations are supported by the local interface and the remote peer in the *Local* and *Remote* rows. Check the current speed and duplex mode in the *Current* row.

2.3.Entering the Port Local Settings

Ethernet devices do not normally require any configuration to work other than their factory-set MAC address but when the equipment is configured in *IP Endpoint* mode it behaves like any other IP host in the network. That means that the test unit should be able to receive traffic directed to it or transmit test and signalling traffic to other devices. To do that, users should assign an IP profile to each test port. Port A is full featured and it needs and IP address, network mask, gateway address and DNS address to operate.

Port B does not need to generate traffic, it only receives traffic from other interfaces or responds to some requests. For this reason, Port B does not need a full IP profile.

Table 2.6: Local Ethernet / IP Profile

Result	Description
Ethernet address	This is a read-only field that displays the factory MAC address assigned to the port. The traffic generator supports emulation of MAC traffic from sources other than the factory MAC, but the address displayed here is the real, unique MAC address used in default configuration.
Frame	This menu configures the Ethernet frame properties including encapsulation, VLAN properties. Specifically, the *Frame* has the following settings: • *Encapsulation*: Selects between untagged Ethernet frames (*None*) or IEEE 802.1Q VLAN-tagged frames (*VLAN)*. • *C-VID*: Configures the VLAN identifier when Encapsulation has been configured to *VLAN*. Any value within 0 to 4096 is allowed for this field. • *C-VLAN priority*: Configures the VLAN priority bits assigned to the frame. Any value between 0 and 7 is allowed for this field. The *Frame* settings apply to all traffic generated by the unit unless it is specified otherwise by the corresponding settings. The *Frame* settings also apply to the traffic received in the test port.
Use DHCP	Defines the procedure used to set the IP profile to the current port. The port IP profile is made up of an IPv4 address, a network mask, an optional gateway address and an optional DNS address. If *Use DHCP* is enabled, then the *Dynamic Host Configuration Protocol* (DHCP) defined in standard RFC 1531 will be used to set the IP profile in the current port.
Static IPv4 address	Is the 32 bit IPv4 address assigned to the local port in decimal, four-dotted format. Addressing scheme used here follows standards RFC 790 and RFC 791. The static addressing is used only if no dynamic address configuration like DHCP is used for the port.

Table 2.6: Local Ethernet / IP Profile

Result	Description
Static IPv4 network mask	Subnet mask used to identify the network address bits and host address bits in the *Static IPv4 address*. The use of the subnet mask is defined in RFC 1219. The subnet mask is entered in decimal, four-dotted format and it must belong to the same network (same network bits) than the current port. The static addressing is used only if no dynamic address configuration like DHCP is used for the port.
Static IPv4 gateway	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. The gateway address is used only by the port transmitter (not by the receiver). For this reason, this setting is available only in port A.
Static IPv4 DNS server	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. The DNS address is useful only by transmitting IP packets. For this reason, this setting is available only in port A.
Leased IPv4 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 IPv4 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 IPv4 DNS server	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. The DNS server is used only by the port transmitter (not by the receiver). For this reason, this setting is available only in port A.

Table 2.6: Local Ethernet / IP Profile

Result	Description
Leased IPv4 gateway	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. The gateway address is used only by the port transmitter (not by the receiver). For this reason, this setting is available only in port A.

In order to configure the IP profile in your test unit follow these steps:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration.
3. Enter in *Local profile*.
4. Configure the encapsulation to *None* or *VLAN* depending on where the equipment is to be connected. If the encapsulation is set to *VLAN*, configure the *C-VID* and *C-VLAN* priority to the correct values for your network.
5. Decide whether you want to configure the local IP profile with the help of the DHCP protocol or you want to statically set these profiles by means the *Use DHCP* control.
   If you have enabled DHCP wait for the tester to get an IP profile from a DHCP server. If DHCP is not enabled, enter a valid *Static IPv4 address*, *Static IPv4 network mask*, *Static IPv4 gateway* and *Static IPv4 DNS address*.
   Note: For Port B, you only need to enter a valid IPv4 address and network mask.

2.4. Choosing between One-way, Two-way or Asymmetric Testing

Two-way tests measure network performance using a closed transmission path. There is usually a traffic reflector like Ether.Loop / Ether.DuaLoop / Ether10.DuaLoop that returns the traffic towards the origin. The return path is not always the same that the forward path but the test traffic always finishes in the same port where it was originated. ALBEDO Telecom test units support two-way tests in their Port A. Port B can be used as a local traffic reflector but installing an external reflector in a remote network location is also possible.

One-way tests are done in open paths in the network. Traffic is generated in a test interface, transmitted through the network and analysed by a second test interface. One-way tests provide a more accurate description of network performance than two-way tests but they require more difficult set-ups and have more requirements than two-way tests. Specifically, delay measurements require the generator and the analyser to use a common timing source. Delay variation measurements does not require the transmitter and the receiver to be synchronized but short term variations on the frequency offset between the transmitter and the analyser may also degrade the result accuracy.

Currently,xGenius supports one way measurements between Port A and Port B in the same unit. In this way, it is guaranteed that the generator and the analyser are using the same timing source. Moreover, the test unit supports one way measurements between units placed in remote locations when they are configured to use GNSS synchronization.

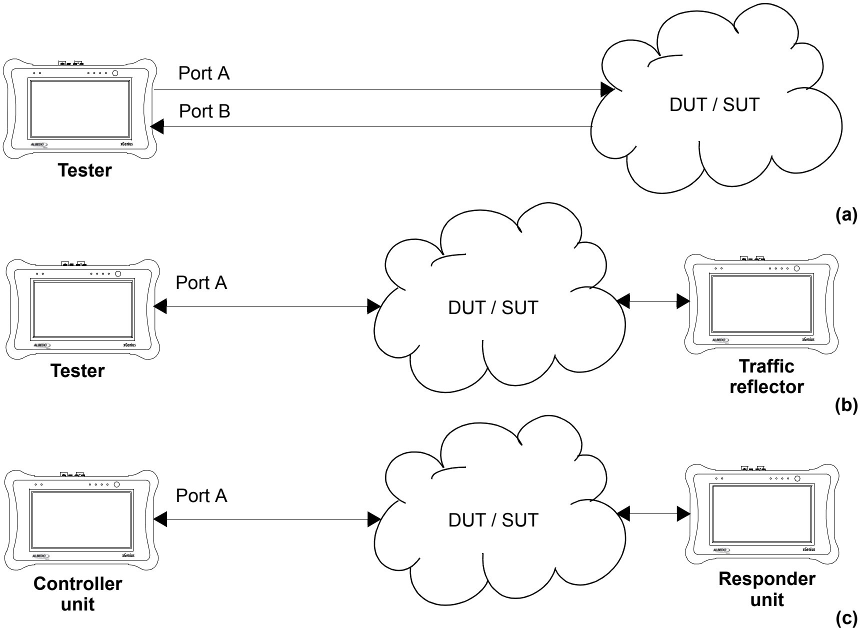


Figure 2.4: Connection setup for one-way and two-way tests: (a) One-way test, the test pattern leaves the tester in port A and it is received in port B. (b) Two-way test, the test pattern leaves in port A and it is received in the same port A (c) Asymmetric test, the controller and responder units run a collaborative test. Typically, the controller generates commands for the responder. the responder executes these commands and it reports status and results.

The asymmetric test is similar in some respects to the one-way test but it is more powerful because it allows the user to perform most of the configuration from a single end. Once finished, the results are read from the same end where the test has been configured. The asymmetric test is based on collaborative operation of the controlling test unit and a remote responder unit (See section 2.5). The limitations are the same that in the one-way tests. In latency measurements, the near and far ends are required to be synchronized. Asymmetric testing has to be supported by the particular test to be executed. Particularly, the asymmetric test is available in RFC 2544 and eSAM tests only (See chapter 7).

Table 2.7: Test Mode Configuration

Setting	Description
Test method	Configures the way the currently configured test is to be executed. It is one of the following: • *One-way (A>B)*: Port A is configured for traffic generation. Port B becomes an analyser. This mode is suitable for measurements in open paths in the network. • *Two-way (A>A)*: Port A is configured both for traffic generation and traffic analysis. This mode is suitable for measurements in closed paths in the network. • *Upstream*: Configures the unit as a controller in an asymmetric test. The controller becomes a traffic generator and the responder an analyser. This test method is therefore suitable for the analysis of the path that goes from the controller to the responder. This test method is available only if one of the RFC 2544 or eSAM performance tests has been previously enabled. • *Downstream*: Configured the unit as a controller in an asymmetric test. The controller becomes a traffic analyser and the responder generates test traffic.This test method is therefore suitable for the analysis of the path that goes from the responder to the controller. This test method is available only if one of the RFC 2544 or eSAM performance tests has been previously enabled. • *Remotely managed*: Configures the unit in responder mode. This is the mode suitable to be used in the far end in an asymmetric RFC 2544 or eSAM test. When the unit is operating in responder mode most settings are disabled.
Remote management UDP port	UDP port to be used for in-band signalling in asymmetric tests configured to run in IP endpoint mode. The in-band signalling generated in IP endpoint mode is made up of UDP packets. These packets are directed to the 55230 port. This port may be modified when required like in the case when the default port is blocked by a firewall. The in-band signalling in Ethernet endpoint is not encapsulated in UDP and port configuration is therefore not required.

Table 2.7: Test Mode Configuration

Setting	Description
Remote unit IP	Configures the responder IP address when the global operation mode is *IP endpoint* and *Test method* has been configured to either *Upstream* or *Downstream*. The responder global operation mode has to be configured to *IP endpoint* as well and the *Test mode* must be *Remotely managed*.
Remote unit MAC	Configures the responder MAC address when the global operation mode is *Ethernet endpoint* and *Test method* has been configured to either *Upstream* or *Downstream*. The responder global operation mode has to be configured to *Ethernet endpoint* as well and the Test mode must be *Remotely managed*.
Remote test protocol status	This is a read only field that displays information about the responder from the controlling unit. The different possibilities are listed below: • *Idle*: The controller is not connected to the remote unit. This is the case when the test has not been started. • *Connected*: The controller is connected to the remote unit and running a test. This status is achieved once the user starts the test with the help of the *RUN* key or any other procedure. • *Agent unreachable*: The controller cannot connect to the remote unit. This situation arises either if there is a communication problem between the controller and the responder or when the controller / responder units are not correctly configured.
Connected unit IP	This is a read only field that displays the IP address of any controller connected to a responder.This field makes sense only when the *Test method* is configured to *Remotely managed* and the global operation mode is *IP endpoint*.
Connected unit MAC	This is a read only field that displays the MAC address of any controller connected to a responder.This field makes sense only when the *Test method* is configured to *Remotely managed* and the global operation mode is *Ethernet endpoint*.

To switch between one-way, two-way or asymmetric operation follow these steps:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *Test mode*

3. Configure *Test method* to *One-way (A > B)*, *Two-way (A > A)*, *Upstream* or *Downstream*.
   Note: The asymmetric test modes (*Upstream*, *Downstream*) are available only if an eSAM or RFC 2544 test has been previously enabled (See chapter 7).
4. If you have configured either the *Upstream* or *Downstream* test modes, configure *Remote unit MAC* (in *Ethernet endpoint* mode) or *Remote unit IP* (in I*P endpoint* mode).
   Note: A unit configured in *Remotely managed* mode has to be installed and configured in the remote end before any asymmetric test can be run (See section 2.5).

2.5. Using the RFC 2544 / ITU-T Y.1564 Responder Function

xGenius can be remotely managed by a compatible test unit in order to run an RFC 2544 or ITU-T Y.1564 asymmetric test. The asymmetric tests are far more powerful than the symmetric RFC 2544 and ITU-T Y.1564 because they enable separated measurement of the upstream and the downstream. This is important in asymmetric paths, where each transmission direction has a different bandwidth, latency, etc.

When configured in responder mode, the unit becomes basically a passive device. All the instructions about how to run the test are generated by the remote unit and delivered to the test unit through an in band signalling channel. When a downstream test is configured in the remote unit, the responder acts as a traffic generator and the analysis is carried out in the far end. In the upstream test it happens the opposite: The responder analyses the traffic from the remote end and reports the result to the controller through the signalling channel. The correct procedure to configure xGenius as a passive responder is as follows:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select *Mode* to enter in the mode selection menu
3. Choose between: *Ethernet endpoint* or *IP endpoint*
   Note: This is an important decision. Controllers can connect only to responders configured to the same global operation mode.
4. From the *Home* panel, go to *TEST*,
   The test setup panel is displayed.
5. Go to *Test mode*
6. Configure Test method to *Remotely managed*.
   Note: Most functionality is disabled in *Remotely managed* mode. The way to recover the unit whole compatibility is to disable this mode.
7. Wait for remote connections in Port A. These are signalled in the *Connected unit MAC* (Ethernet endpoint mode) or *Connected unit IP* (IP endpoint mode).

2.6. Using the Traffic Reflector

You can configure the test unit ports in loopback mode so that the traffic they receive is forwarded toward their originator. This is very useful in many test and measurement applications where the traffic generator is waiting to receive the test traffic so that it can correlate the frames with the original ones.

Table 2.8: Local Ethernet / IP Profile

Result	Description
Loop mode	The loop mode determines which fields within the Ethernet frame or the IP datagram are swapped before forwarding. Is one of the following ones: • *Physical loop*: Loops frames without other alteration than pulse shape regeneration. This mode may cause problems if it is used in a bridged network. • *MAC loop*: Swaps source and destination MAC addresses before forwarding the frame. This is the correct mode to be used in bridged networks. • *IP loop*: It operates in the same way that the *MAC loop* mode but is swaps source and destination IP addresses as well. This is the correct mode to be used in routed networks. The *IP loop* mode is not available in *Ethernet endpoint mode*. • *UDP loop*: It works in the same way that the *IP loop* mode but it swaps source and destination UDP ports as well. This mode can be used if there are network devices working at the transport layer like for example firewalls or NAT routers. The *UDP loop* mode is not available in *Ethernet endpoint* mode.
Traffic to loop	Configures which frames are looped in the current test port. The available configurations are: • *All frames*: Loops all frames received in the test port. • *Filtered frames*: Loops frames matching any of the eight receiving filters available for configuration. All non-matching frames are discarded. Use this option if you need a tight control on the looped frames.
Loop broadcast frames	Chooses whether to loop Ethernet broadcast frames. If broadcast loop is disabled, all frames with destination MAC address set to *FF:FF:FF:FF:FF:FF* are discarded. Use this setting if you want to avoid Ethernet broadcast frames to proliferate and potentially flood the network.

Table 2.8: Local Ethernet / IP Profile

Result	Description
Loop ICMP packets	Chooses whether to loop ICMP packets. If ICMP loop is disabled, all ICMP frames (IP protocol number 1) will be discarded. Use this setting to avoid ICMP packet proliferation in the network.

It must be remembered that while a port is operating in loopback mode (or even in monitor mode) it still replies to some basic network protocols like ARP or ICMP echo request (ping) messages. Of course, ARP and ICMP echo requests are also looped if the port is configured to do so.

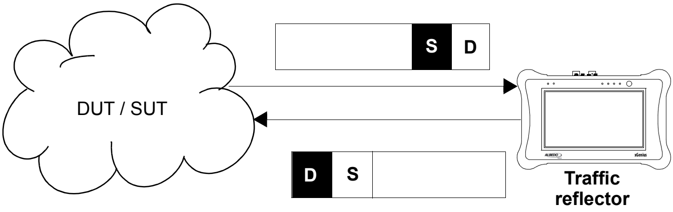


Figure 2.5: This figure illustrates the loop-back operation (*MAC loop*). Source and destination addresses are swapped so that they can be processed in the normal way by intermediate switches.

2.7. 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:

- *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.

- *2048 kHz (Port C)*: The clock reference is derived from an external ITU-T G.703 2048 kHz signal. This signal is received through the Port C. For this reason, this option is available only in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test)*.
- *E1 (Port C)*: The clock reference is derived from an external ITU-T G.703 2048 kb/s signal. This signal is received through the Port C. For this reason, this option is available only in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test)*.
- *1544 kHz (Port C)*: The clock reference is derived from an external 1544 kHz signal. This signal is received through the Port C. For this reason, this option is available only in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test)*.
- *T1 (Port C)*: The clock reference is derived from an external ITU-T G.703 1544 kb/s signal. This signal is received through the Port C. For this reason, this option is available only in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test)*.
- *10 MHz (Port C)*: This is a 10 MHz unipolar clock, square or senoidal signal received through Port C. This input is not available for the xGenius E1 / T1 operation modes.
- *Ethernet (Port A) / Ethernet (Port B)*: A Synchronous Ethernet signal recovered from Port A (or Port B) is used as the external clock reference. The equipment may fail to synchronize to a conventional (asynchronous) Ethernet input depending on the specific frequency offset of the input compared with the free running frequency of the internal clock. For the particular case of a 1000BASE-T input, the interface must be forced to an slave role before the input can be used as a synchronization reference (See section 2.2.3).
- *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 2.8).
- *PPS (REF IN SMA)*: The clock reference is derived from an external 1 PPS signal received through the PPS RX SMA port located in the test connector panel. The 1 PPS input can be used both for Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test*) and E1 / T1 tests (*E1 / T1 endpoint*, *E1 / T1 monitor*, *E1 / T1 through*).

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

Table 2.9: External Clock Reference 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.
Port C connector	Selects the Port C connector to be used as the clock input / output. 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).
Port C 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.
Input reference delay	Compensates the delay added by the physical media propagation delay when the *Input clock* reference is set to *PPS (REF IN SMA)*.

Table 2.9: External Clock Reference Panel

Result	Description
Output reference delay	Adds a delay compensation to 1 PPS 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.
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 2.9: External Clock Reference Panel

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.

Table 2.9: External Clock Reference Panel

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.

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*, *2048 kHz (Port C)*, *E1 (Port C)*, *1544 kHz (Port C)*, *T1 (Port C)*, *10 MHz (Port C)*, *Ethernet (Port A)*, *Ethernet (Port B) or GNSS*, *PPS (REF IN SMA)*.
4. If you have chosen one of *2048 kHz (Port C)*, *E1 (Port C)*, *1544 kHz (Port C)*, *T1 (Port C)* or *10 MHz (Port C)* in the previous step, configure *Port C connector* and *Port C termination*. If you have chosen *PPS (REF IN SMA)* configure the *Input reference delay* to compensate for the cable delay.

2.8. Using the Built in GNSS Receiver

xGenius units may be equipped with a built in GNSS receiver. These units have a SMA female connector suitable for connecting an 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. To use the built in GNSS module follow these steps:

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.
2. Configure the clock reference input to GNSS (See section 2.7).
3. Set the value of *Input reference delay*. to compensate for the antenna cable delay.
4. Optionally, configure the GNSS receiver (See section 11.4.3).

2.9. 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:

- *2048 kHz (Port C)*: The clock reference output is encoded as a ITU-T G.703 2048 kHz signal. This signal is transmitted through the Port C. For this reason, this option is available only in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test)*.
- *10 MHz (Port C)*: The clock reference output is configured as an square 10 MHz signal. As this signal is transmitted through the Port C unbalanced (BNC) interface, it is only available in Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test).*
- *PPS (REF OUT SMA):* Generates a 1 PPS output synchronized (phase and frequency) with the local oscillator through the SMA REF OUT connector located in the test connector panel. The 1 PPS output can be used both for Ethernet / IP operation modes (*Ethernet endpoint*, *IP endpoint*, *IP through*, *Ethernet cable test*) and *E1 / T1* tests (*E1 / T1 endpoint*, *E1 / T1 monitor*, *E1 / T1 through*).

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 2048 kHz (Port C), 10 MHz (Port C) or PPS (REF OUT SMA).

4. If you have chosen 2048 kHz (Port C) in the previous step, configure Port C connector and Port C termination.
5. Optionally, if you have chosen PPS (REF OUT SMA), configure the *Output reference delay* to compensate for the cable delay.

2.10.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 goes for 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 interfaces (See section 2.7).
   Note: Holdover from a frequency reference is not supported.
2. 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 low if this is done.
3. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
4. Go to Reference clock.
5. Configure *Force holdover* to *Yes*
   An small *H* is displayed in the screen to show that the unit has entered in holdover.
6. 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)
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.

Chapter 3
Cable Tests

xGenius has the ability to check wiring and performance of Ethernet cables or optical fibres to make sure they will operate as expected when connected to the network.

Cable testing can be used to estimate the cable length, recognise cabling types or detect wiring faults. Performance of optical fibers is measured in terms of the received optical power.

3.1. Electrical Test

Electrical cable test requires an special operation mode which prevents the unit sending any frame (See section 2.1). When the unit is configured in *Ethernet cable test*, mode, the port mode becomes *Cable test* (port A) and *Link* (port B) and there is no way to change the port mode unless the general operation mode is set to something different of *Ethernet cable test*.

In this operation mode the test unit could have a network link in the remote end of the device under test (the cable) or not. Depending on how the cable is connected, it would be possible to compute different results.

3.1.1. Basic Principles of Ethernet Cable Wiring

Twisted pair cables for Ethernet LAN applications generally come in groups of four pairs (8 wires). Only two of the four pairs carry information at 10 and 100 Mb/s but all four pairs are simultaneously used in 1 Gb/s links. There are many possible pair interconnections that would work, but only two of them are standard. These are known as T-568A and T-568B wire maps. Usually, all four pairs are always connected, but for 10 and 100 Mb/s operation only pairs 2 and 3 are used. 1 Gb/s port and cable wirings are designed to be backwards compatible with slower 10 Mb/s and 100 Mb/s interfaces so that the same Gigabit cable can be used for all bit rates. Some cables designed to operate at 10 Mb/s and 100 Mb/s may have only connections necessary for transmission at these speeds. These cables are not compatible with the 1 Gb/s bit rate. Ethernet cables may have poor performance or may not work at all if wires are not properly connected.

All the different test results are provided for each *Media Dependent Interface* (MDI). An MDI corresponds with a single Ethernet pair transceiver. There are four of them in 1000BASE-T (MDI-0, MDI-1, MDI-2 and MDI-3) and two in 100BASE-TX / 10BASE-T (MDI-0 and MDI-1). Using the MDIs to supply information about wiring is the most logical choice: Pin assignment in a connector may change but MDIs are always the same and, at logical level, communication between MDIs is very simple: MDI-0 is connected to MDI-0, MDI-1 is connected with MDI-1, etc.

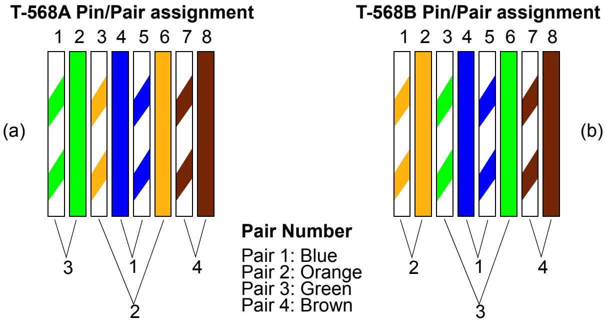


Figure 3.1: T-568A and T-568B wiring standards. Pair numbering (1, 2, 3, 4) is a way to identify pairs in the cable and is not to be confused with MDI numbering (MDI-0, MDI-1, MDI-2, MDI-3).

Old Ethernet stations had a fixed pin-out for MDI-0, MDI-1, MDI-2 and MDI-3. This fixed assignment for stations corresponds to the *MDI* status. These older stations were connected to Ethernet hubs and switches through a straight cable and to a second station through a crossover cable. For this reason, MDI pair assignment in hubs and switches was required to be complementary to the wiring of stations. This second pair assignment corresponds to the *MDIX* status:

Table 3.1: Pair assignment for MDI and MDIX port modes

	MDI-0	MDI-1	MDI-2	MDI-3
MDI	1-2	3-6	4-5	7-8
MDIX	3-6	1-2	7-8	4-5

In old devices with static MDI pair assignment, the description of the interface could be based either on MDI-0 to MDI-3 or pair 1 to pair 8 but with most of the current Ethernet devices the situation is different. Modern Ethernet stations and switches can switch their ports between *MDI* and *MDIX* status before link establishment to make sure that an MDI port is connected with a remote MDIX port through an straight cable and that an MDI (or MDIX) port is connected to a second MDI (or MDIX) port through a crossover cable.

The advantage of this procedure is that there is no need to think about which cable (crossover or straight) is required for interconnection of network equipment and stations. However, if you need to know the way the cable is wired, then it is mandatory to know the MDI / MDIX status of the near and far ends.

Table 3.2: Crossover status (*MDI / MDIX*) and cable Wiring

Near end	Far end	Cable
MDI	MDI	Crossover
MDI	MDIX	Straight
MDIX	MDI	Straight
MDIX	MDIX	Crossover

3.1.2. Connecting the Tester

Cable testing with the *Ethernet cable test* mode is different to the other modes because in this case the test equipment does not generate any digital framed or unframed signal. It relies on the remote end to supply some information about the wiring and other metrics related with the physical transmission medium. The amount of information to be supplied depends on the communications interface. It is not the same for Gigabit Ethernet than for Fast Ethernet interfaces. If there is no link from the remote end, the equipment attempts to find out the reason (short circuit, open circuit...).

The test cable is available for Port A only. The Port B could be used as an auxiliary port to determine whether a cable is straight or crossover. Cable tests can only be run from the native RJ-45 interfaces, they are not available through electric SFP modules.

The best way to run the cable test is to connect the cable under test between port A and port B. You can use other test configurations like a connection between Port A and a switch but in this case you will be unable to get all the information from the cable. Here you have some details about the available connection modes for the cable test and the results obtained from each of them:

- Port A - Port B closed loop: *Fault*, *Crosstalk*, *Distance (m.)*, *Crossover*, *Polarity*, *Skew (ns)*, *Wiring*.
- Port A connection with remote link: *Fault*, *Crosstalk*, *Distance (m.)*, *Crossover*, *Polarity*, *Skew (ns)*.
- Port A connection without link: *Fault*, *Crosstalk*, *Distance (m.)*.

In case a fault is found in some pair (*Open*, *Short*), some results may not be available for the corresponding MDI. If no fault is found then the *Distance (m)* field is empty. The *Skew (ns.)* test result is displayed only in 1000BASE-T interfaces.

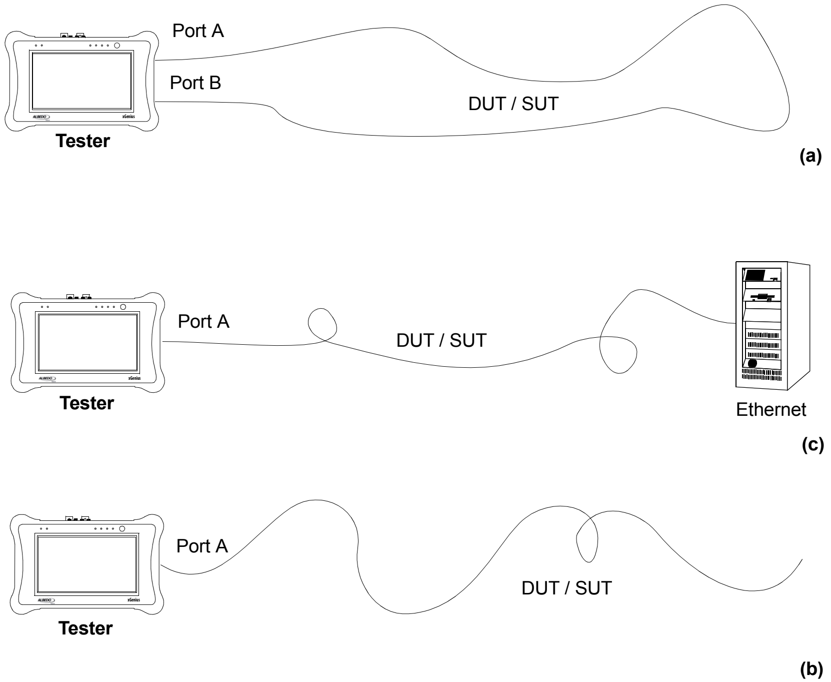


Figure 3.2: Basic connection setup for xGenius tester: (a) Port A - Port B closed loop, (b) Port A connection with remote link, (c) Port A connection without link.

3.1.3. Running the Test

Once the tester has been connected to the network in any of the supported test configurations. It is required to configure and run the cable test by means the tester user interface. It is assumed that the *Connector* setting is configured to *Electrical* in the test ports (See section 2.2.1). The test procedure is as follows:

1. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
2. Select *Mode* to enter in the mode selection menu

3. Choose *Ethernet cable test*. Confirm by pressing ENTER.
4. From the *Home* panel, go to *Results*,
   The port setup panel is displayed.
5. Select *Port A* to enter in the test Port A specific results panel.

Table 3.3: Common cable wiring problems

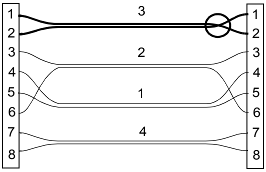
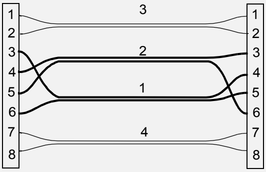
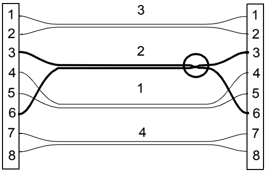
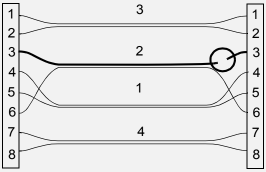
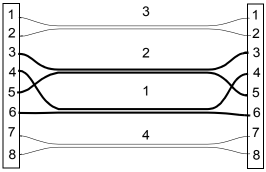
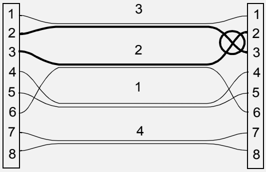
Description	Diagram	Diagnostic
Inverted cable. Polarity is inverted in both ends of the same pair	 1 2 3 4 5 6 7 8 3 2 1 4 1 2 3 4 5 6 7 8	The *Polarity* result for de corresponding MDI (MDI-0, MDI-1, MDI-2 or MDI-3) is *Negative* rather than *Positive.*
Pairs 1 and 2 are wired to the wrong pins in the connector	 1 2 3 4 5 6 7 8 3 2 1 4 1 2 3 4 5 6 7 8	The *Fault* result for MDIs corresponding to pairs 1 and 2 is *Open*. *Distance (m)* displays the distance to the far end. The *Crosstalk* shows that pairs 1 and 2 are coupled.
There is a short circuit between the conductors in pair 2	 1 2 3 4 5 6 7 8 3 2 1 4 1 2 3 4 5 6 7 8	The *Fault* result for the MDI corresponding to pair 2 displays *Short*. *Distance (m)* displays the distance to the short circuit.
One of the cables of port A is broken and it contains an open circuit	 1 2 3 4 5 6 7 8 3 2 1 4 1 2 3 4 5 6 7 8	The *Fault* result for the MDI corresponding to pair 2 displays *Open*. *Distance (m)* displays the distance to the open circuit.

Table 3.3: Common cable wiring problems

Description	Diagram	Diagnostic
Swapped pair, connections are OK but wires of the same connection are twisted in different pairs.		No fault is detected in any pair (*Fault* displays *OK* for all MDIs) but if the cable is long enough it will result in significative crosstalk between coupled pairs.
Miswired cable		The diagnostic of the cable shows crosstalk between the MDIs corresponding to pairs 2 and 3.

6. Go to Cable
   The Ethernet cable test result panel is displayed
7. Run the test by pressing the *RUN* test and wait a few seconds to the end of the measurement.
8. Check the *Fault*, *Crosstalk*, *Distance (m.)*, *Crossover*, *Polarity*, *Skew (ns.)* and *Wiring* test results for each MDI-*n*.

Table 3.4: Cable test results

Result	Description
Fault	Displays information about faults found in the corresponding MDI. In case a fault is found the *Fault* indication could be either *Open* or *Short*. • *Open* means that it has been found an open circuit in the remote end. An open circuit is declared when the impedance in the remote end is very large (the reflection coefficient is close to 1). • *Short* means that it has been found a short circuit in the remote end. The short circuit is declared if the impedance in the remote end is zero or close to zero (the reflection coefficient is close to -1).

Table 3.4: Cable test results

Result	Description
Crosstalk	Crosstalk is detected when there is electromagnetic coupling between pairs. Coupling could be inductive / capacitive if there is a twisting defect in the pair or it can be resistive if there is a problem with the dielectric medium between conductors. Some wiring faults between the cable and the connector may cause crosstalk too. The crosstalk is indicated in the equipment as a collection of numbers separated by ‘-’ for each MDI. For example if MDI-0 and MDI-3 are coupled, then the crosstalk result for MDI-0 and MDI-3 will be 0-3.
Distance (m.)	The *Distance (m.)* result displays the distance to an open circuit / short circuit fault in with an accuracy of ±1 m. If you there is no fault, no distance is displayed. The maximum range of the distance test is 100 m. To measure the cable length, just leave the far end disconnected and run the test. xGenius will detect an open circuit in all MDIs and the *Distance (m.)* results displays the cable length.
Crossover	Displays whether the local *MDI-n* is in straight (MDI) or crossover (MDIX) status. Note that *Crossover* is not really a cable result, it is the local port MDI/MDIX status. This status may be random and depends on the cable and the remote port. Therefore this result may be modified if the cable is disconnected and reconnected again.
Polarity	Polarity could be positive or negative for each *MDI-n.* A negative polarity indicates that the pair connects pins of inverted polarity in the local and remote end. Positive polarity means that local and remote pins have the same assigned polarity.
Skew (ns.)	Relative propagation delay, expressed in nanoseconds, experienced by the pair associated to the MDI and compared to the MDI that has minimum propagation delay. That means that the Skew (ns.) is always zero for at least one MDI. The skew result is not measured for 10 Mb/s and 100 Mb/s interfaces.

Table 3.4: Cable test results

Result	Description
Wiring	A cable could be designed to cross at the remote end the pairs used for transmitting and receiving (crossover cable) or not (straight cable). The wiring result checks whether a cable is straight or crossover. This test result depends on the local and remote MDI / MDIX status and it can only be determined if the cable is connected through test port A and B.

3.2. Measuring Optical Power

The test unit reports the transmitted and received optical power if it is equipped with SFP / SFP+ supporting this measurement (See section 2.2.2). The following description assumes that the *Connector* setting is configured to *Optical* in the test ports (See section 2.2.1). The test procedure is 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
3. Choose *Ethernet endpoint, IP endpoint or IP through*.
4. From the *Home* panel, go to *RESULTS*,
   The port setup panel is displayed.
5. Select either *Port A or Port B* to enter in the port specific results menu.
6. Go to *SFP information*.
7. Check the results of *TX optical power* and *RX optical power*.

3.3. Measuring PoE / PoE+ Electrical Parameters

Power over Ethernet (PoE) is a technology that enables remote powering of devices such as VoIP telephones or cameras through the electrical Ethernet interface, commonly based in CAT 5 or CAT 6 UTP cable, so that these devices do not need any other external power source.

PoE was defined in standard IEEE 8023af in 2003 and was improved in 2009 in the standard IEEE 802.3at, known as PoE+. The first version of the standard was designed to provide powers up to 15.4 W but IEEE 802.3at supports up to 25 W. Some current commercial PoE+ devices can deliver much higher powers, however.

The PoE / PoE+ standard defines two devices, the Power Source Equipment (PSE) and the Powered Device (PD). The PSE generates the power required to feed the PD and it can be an *Endspan* or a *Midspan*. Endspans are usually Ethernet switches or routers with PoE / PoE+ functionality. On the other hand, Midspans are devices connected between a switch or a router without PoE / PoE+ and the PD. These Midspans inject the current required to feed the PD.

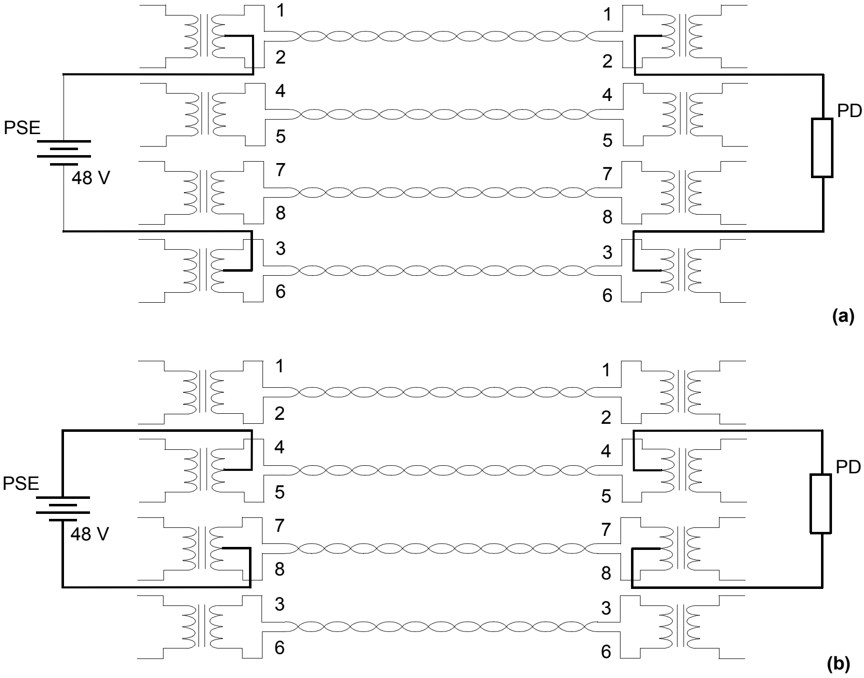


Figure 3.3: PoE / PoE+ powering alternatives: (a) Alternative A, power is injected between wires 1/2 and 3/6. (b) Alternative B, power is injected between wires 4/5 and 7/8.

To deliver power to the PD, the PoE / PoE+ standards define to different options. The alternative A injects power between wires 1/2 and 3/6 while the Alternative B uses pairs 4/5 and 7/8 to deliver power. The PoE / PoE+ implements a simple protocol to avoid injecting power in non-PoE devices. Before injecting a large amount of current in the line, the PSE senses the PD to see how much current it consumes. Once the PD identification has finished the PSE increases the voltage and classifies the PD depending on the consumed current in five categories numbered from 0 to 4. Finally the PSE stabilizes the voltage to around 48 V DC and the normal powering operation starts.

Table 3.5: Cable test results

Result	Description
Status	Displays the current PoE / PoE+ measurement status. The *Status* could be any of the following items: • *Measuring*: The system has detected PoE or PoE+ and it is measuring normally. • *No PoE*: No PoE / PoE+ detected. No test result is displayed. • *Error*: Unspecified error condition. It should never appear in normal circumstances.
Voltage	Displays the voltage measured between wires 1/2 and 3/6 (Alternative A). This result is available both in endpoint and pass-through modes.
Polarity alternative A	If the current powering alternative is Alternative A, it displays which of the 1/2 or 7/8 wires has positive and negative polarity. If the power alternative is Alternative B, it displays no result.
Current	If the powering alternative is Alternative A, it displays the current injected in the PD.If the power alternative is Alternative B, it displays no result. This result is available only in the equipment is connected between the PD and PSE in pass-through mode.
Power	If the powering alternative is Alternative A, it displays the power injected in the PD. If the power alternative is Alternative B, it displays no result. This result is available only in the equipment is connected between the PD and PSE in pass-through mode.
Polarity alternative B	Displays the voltage measured between wires 4/5 and 7/8 (Alternative B). This result is available both in endpoint and pass-through modes.
Current	Displays the Alternative B current in the same conditions that the Alternative A
Power	Displays the Alternative B power in the same conditions that the Alternative A current

xGenius may optionally include support for PoE and PoE+ measurement. The unit is compatible both endpoint and pass-through measurements. If the tester is connected in endpoint mode, it replaces the PD and it is capable of measuring the PoE / PoE+ voltage as generated by the PSE. In pass-through mode, the measurement includes voltage, current and power. The correct test procedure is as follows:

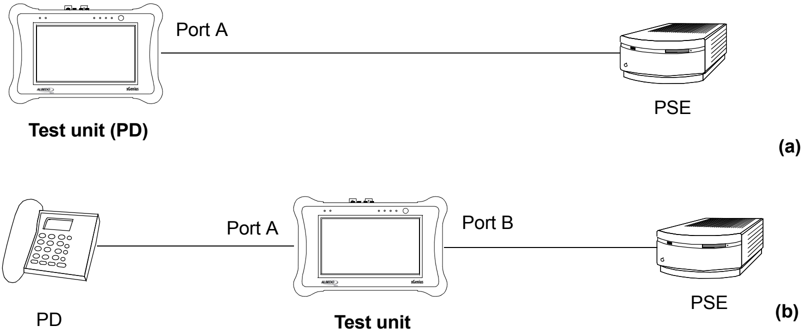


Figure 3.4: Connection ofxGenius to measure PoE / PoE+: (1) The test unit replaces the PD. The unit measures only voltage, (2) The test unit is connected between the PD and the PSE, In this case it measures voltage, current and power.

1. Connect the equipment either in endpoint or pass-through mode (See section 2.2).
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 *Ethernet endpoint, IP endpoint or IP through*.
4. Go to *Port A.*
   The port specific settings for Port A are now displayed.
5. Go to *Physical layer* to enter in the physical settings configuration panel.
6. Configure the *PoE* setting to *On*.

Once configured, you can check the test results by following these steps:

1. From the *Home* panel, go to *CONFIG*,
   The port configuration panel is displayed.
2. Go to *Port A.*
   The port specific settings for Port A are now displayed.
3. Select the PoE results menu and make sure that the status is *Measuring*.
4. Check the Voltage result in endpoint mode or *Voltage* and *Polarity*, *Current* and *Power* for your PoE / PoE+ alternative in pass-through mode.

Chapter 4
Traffic Generation

One of the key features of ALBEDO Telecom family of Ethernet Generators & Analysers is the ability to generate traffic with deterministic and random bandwidth profiles. The traffic generation feature can be used to stress the network, simulate user traffic and, if a suitable payload is configured, to measure critical network performance parameters like bit errors, packet loss or latency.

xGenius has eight independent full featured traffic generators attached to the main test port (Port A). Each traffic flow may be configured with specific encapsulation and addressing parameters thus providing great versatility in all applications requiring Ethernet and IP traffic generation.

4.1. Generation of Ethernet Traffic

In the test unit, generation of custom Ethernet frames is available for Port A in *Ethernet endpoint* mode through the *Frame*, *Bandwidth profile* and *Payload* settings for each of the eight available traffic flows. This is a short description of the Ethernet traffic generation menus:

- *Frame*: Configures the encapsulation and MAC addresses. If the Ethernet frames have any VLAN tag, this menu configures the VID and priority for these tags.
- *Bandwidth profile*: Sets the traffic generation statistics. There are four different generation profiles to choose: *Constant*, *Periodic burst*, *Ramp* and *Random*.
- *Payload*: This menu is used to set the payload to be inserted in the generated Ethernet frames. The SLA payload enables the user to measure delay, jitter and packet loss. The BERT payload (flow 1 only) is used for BER testing in framed interfaces.

Frame generation capability is controlled by the RUN button. That means that no test traffic is generated if you don't press RUN. However, the tester may generate signalling traffic or reply to certain messages like ARP or ICMP echo requests even if there is not an ongoing test. Some automatic tests like the RFC 2544 or the eSAM have their own internal traffic generation dynamics but they are controlled by the RUN button as well.

4.1.1. Physical Layer Settings

Before starting any frame generation test, the equipment must be connected to the network and the electrical and optical physical layer must be correctly configured. Ethernet technology has been designed to keep physical layer configuration to the minimum. But there are at least two settings you may need to check before you get a link from the DUT / SUT. These settings are the *Connector* (See section 2.2.1) and the *Auto-negotiation* (See section 2.2.3). You will know that Port A is prepared for traffic generation and analysis when the *10G, 1000, 100* or *10* LED (See section 5.3) is displayed in green colour.

4.1.2. Frame Settings

Most of the Ethernet frame fields are available for configuration in the test unit. Before configuring these fields it is necessary to tell to the tester which frame structure is going to be used for traffic generation. The *Frame type* is a port-wide setting. Once you choose an specific framing for your traffic, all streams you define for the port carry the same framing structure. The only currently available *Frame type* is *DIX*, The *DEC, Intel, Xerox* (DIX) frame, structure also known as Ethernet II framing. DIX / Ethernet II framing encode the payload type in the *Type* frame field. This is the most common framing format found in real networks: For example, RFC 894 mandates a DIX / Ethernet II frame structure with the *Type* field set to 0x0800 for IPv4 encapsulation.

Table 4.1: Ethernet Frame Settings

Setting	Description
Encapsulation	This field configures the way the data is encapsulated in Ethernet frames for transmission in the current stream. The allowed encapsulations are the following ones: • *None*: A DIX or IEEE 802.3 frame carries the test data, depending on the current value of the *Frame type* setting. • *VLAN*: Transmitted frames are labelled with an IEEE 802.1Q frame tag. Settings related with configuration of the VLAN tag are enabled when this option is selected. • *Q-in-Q*: Transmitted frames carry two VLAN tags, one service provider tag (S-VLAN) and a customer tag (C-VLAN). The C-VLAN is identified by the normal IEEE 802.1Q Ethertype and the S-VLAN carries one of the not-standard Ethertypes. • *IEEE 802.1ad*: Transmitted frames carry two VLAN tags. It is similar to the Q-in-Q encapsulation but this option follows strictly the standard IEEE 802.1ad encapsulation for Provider Bridges (PB). Specifically, the IEEE 802.1ad carries the special 0x88a8 Ethertype within the S-VLAN.

Table 4.1: Ethernet Frame Settings

Setting	Description
Encapsulation	• *Local Profile*: Sets the encapsulation (and eventually the C-VID and C-VLAN priority) to the same value configured in the local profile (See section 2.3). This is the default configuration. It is useful when the user wants to control the encapsulation in various streams through a single setting.
Source MAC address from	Establishes the origin of the source MAC address for the current stream. There are two possible settings: • *Local*: The source address is set to the factory MAC address assigned to the port. Use this setting if there is no other requirement. • *Manual*: The source address is set to the value configured in *Source MAC address*. Use manual MAC addresses if you want to simulate traffic generated by an equipment different to the tester or, in multi-stream operation, to simulate traffic transmitted from different stations. Most of the times you will want to avoid duplicated addresses in your network. For this reason, make sure that no other equipment is using the manually configured MAC address. • *Remote*: This option is available only in RFC 2544 or eSAM downstream asymmetric tests (See section 2.5). It configures the source MAC address to be the far end address. It must be taken into account that in downstream asymmetric tests, the far end is configured for traffic generation this setting corresponds with traffic to be generated not in the local unit but in a different one.
Source MAC address	Source MAC address carried by the frames generated in the current stream if *Source MAC address type* is set to *Manual*. Anything from 00:00:00:00:00:00 to ff:ff:ff:ff:ff:ff is allowed.

Table 4.1: Ethernet Frame Settings

Setting	Description
Des. MAC address from	Establishes the origin of the destination MAC address for the current stream. There are three different settings available for configuration: • *ARP*: Uses the Address Resolution Protocol (IETF RFC 826) to configure the destination MAC address without user intervention. The ARP requires the IPv4 destination address to be previously configured to work. For this reason, ARP is available only in *IP endpoint* mode. • *Manual*: The destination address is set to the value configured in *Destination MAC address*. • *Range*: Test data in the current stream is transmitted to a group of MAC addresses configured with *Destination MAC address* and *Address number within range*. Use this option if you want to deliver the test data sequentially to many different destinations. • *Remote*: This option is available only in RFC 2544 or eSAM upstream asymmetric tests (See section 2.5). It configures the destination MAC address to be the far end address.
Destination MAC address	Destination MAC address carried by the frames generated in the current stream if *Des. MAC address type* is set to *Manual*. If *Des. MAC address type* is set to *Range*, this field contains the first destination MAC address within the range. Anything from 00:00:00:00:00:00 to ff:ff:ff:ff:ff is allowed for this field.
Address range size	Configures the number of MAC addresses within an address range. This control is valid only if *Des. MAC address type* is set to *Range*. In this case, the Ethernet frames transmitted in the current stream will contain as many destination addresses as previously configured in this field. The destination MAC address is increased by one unit for each transmitted frame starting with the value configured in *Destination MAC address*. If there are no more addresses left in the range, transmission returns to the initial address and starts the process from the beginning.

Table 4.1: Ethernet Frame Settings

Setting	Description
Ethertype	Ethertype value carried by the frames generated in the current stream. This value is found within the Ethernet *Type* header field in DIX / Ethernet II frames or within the LLC / SNAP header in IEEE 802.3 frames. Depending on the configuration, the *Ethertype* value is fixed and cannot be set by the user. If the operation mode is *IP endpoint*, the Ethertype is automatically configured to 0x0800 (Internet Protocol, version 4). If the payload type is configured to *SLA* in *Ethernet endpoint* mode, the Ethertype is set to 0x8902 (IEEE 802.1ag / ITU-T Y.1731 OAM) to account for the special structure of the Ethernet SLA measurement payload.
C-VID	VLAN identifier assigned to tagged frames (IEEE 802.1Q) or C-VLAN identifier for double tagged frames (IEEE 802.1ad, Q-in-Q). In frames with two VLAN tags, the C-VID usually accounts for the VLAN structure corresponding to the customer network. Any value within 0 to 4095 is allowed for this field.
C-VLAN priority	3-bit class of service (CoS) field defined to set frame groups with different priorities or to provide specific treatments to special frames within a network or an administrative domain. This field is carried by the Q-tag of Ethernet frames with a single tag or by the C-tag of Ethernet frames with two tags. Any value from 0 to 7 is allowed for this field. Specific actions to be carried out on frames with different CoS labels depend on the network and the service provider.
S-VLAN TPID	Ethertype to be associated to the S-VLAN tag in Q-in-Q frames. Four different values are possible: 0x8100, 0x9100, 0x9200 and 0x9300. It the encapsulation is set to IEEE 802.1ad, the S-VLAN Ethertype is automatically set to 0x88a8 and this field is not available for configuration.
S-VID	VLAN identifier assigned to the S-tag in double tagged frames (IEEE 802.1ad, Q-in-Q). In frames with two VLAN tags, the S-VID usually accounts for the VLAN structure corresponding to the service provider network. Any value within 0 to 4095 is allowed for this field.

Table 4.1: Ethernet Frame Settings

Setting	Description
S-VLAN priority	3-bit class of service (CoS) field defined to set frame groups with different priorities or to provide specific treatments to special frames within a network or an administrative domain. This field is carried by the S-tag (service provider tag) of Ethernet frames with two tags. Any value from 0 to 7 is allowed for this field. Specific actions to be carried out on frames with different CoS labels depend on the network and the service provider.
Drop-eligible indicator	This is a single bit field that is used to mark drop eligible frames. These frames are usually dropped first when congestion is detected in a network node. The Drop eligible operator is carried within the S-tag of IEEE 802.1ad frames.
Frame size	Ethernet MAC frame size including the destination MAC address, source MAC address, type / length field, payload, FCS and any VLAN tag carried by the frame. Anything between 64 B and 10000 B is allowed but frames longer than 1518 B (without VLAN tags and MPLS labels) are out of the IEEE 802.3 standard. It is possible to generate frames longer than the port Maximum Transmission Unit (MTU) but these frames are considered oversized frames when they are analysed by the tester. To avoid an *OverS* anomaly in this case, increase the value of the port MTU.

The second port-wide setting to be configured is the Maximum Transmission Unit (MTU). This setting is relevant for the analyser only and it configures the largest frame size accepted without declaring the *OverS* defect. Standard IEEE 802.3 specifies an MTU of 1518 bytes for ordinary Ethernet frames but 1522 is admitted for VLAN frames and 1526 is valid for frames carrying two VLAN tags (IEEE 802.3ad, Q-in-Q). Some switches provide support for much larger frames known as jumbo frames. These frames are more efficient because the ratio of header bytes to payload bytes is smaller for larger frames but they are currently not accepted by any international standard.

The following steps illustrate the frame configuration procedure in xGenius. Both the port-wide and flow-specific configuration is included.

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).

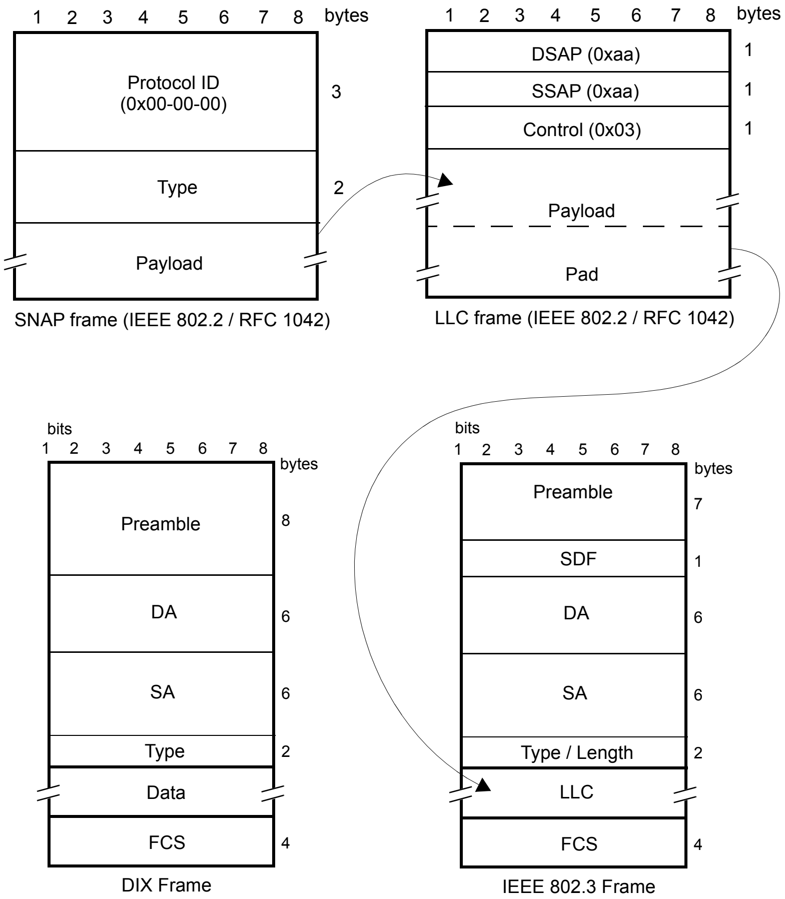

1 2 3 4 5 6 7 8 bytes
Protocol ID
(0x00-00-00)
3
Type
2
Payload
SNAP frame (IEEE 802.2 / RFC 1042)
1 2 3 4 5 6 7 8 bytes
DSAP (0xaa)
1
SSAP (0xaa)
1
Control (0x03)
1
Payload
Pad
LLC frame (IEEE 802.2 / RFC 1042)
bits
1 2 3 4 5 6 7 8
bytes
Preamble
8
DA
6
SA
6
Type
2
Data
FCS
4
DIX Frame
bits
1 2 3 4 5 6 7 8
bytes
Preamble
7
SDF
1
DA
6
SA
6
Type / Length
2
LLC
FCS
4
IEEE 802.3 Frame

Figure 4.1: MAC frame structure: IEEE 802.3 and DIX

2. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
3. Select either Port A or Port B to enter in the port specific configuration.
   Note: Most of the frame configuration settings are not available from Port B because traffic generation is not available from this port.
4. Enter in the *Frame* menu.
   All settings related with frame configuration are displayed.
5. Configure the correct MTU with the help of the *MTU* menu. You may want to set the MTU to 1518 bytes for traffic analysis in line with IEEE 802.3 or to other value to allow jumbo frames. The maximum allowed MTU is 10,000 bytes.

6. Select one of the traffic flows between *Flow #1* and *Flow #8* to enter in the flow specific configuration.
7. Configure the encapsulation you are going to use in the generated frames. Basically, the *Encapsulation* menu sets the number of VLAN tags to be included in the generated frames.

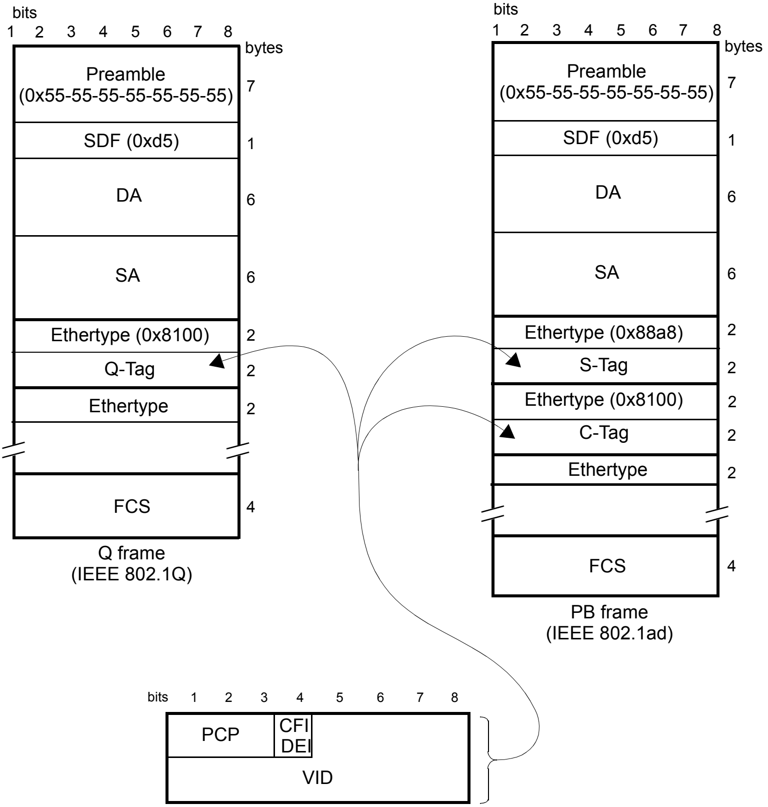

bits
1 2 3 4 5 6 7 8
bytes
Preamble (0x55-55-55-55-55-55-55)
7
SDF (0xd5)
1
DA
6
SA
6
Ethertype (0x8100)
2
Q-Tag
2
Ethertype
2
FCS
4
Q frame (IEEE 802.1Q)
Ethertype (0x88a8)
S-Tag
Ethertype (0x8100)
C-Tag
PB frame (IEEE 802.1ad)
PCP
CFI
DEI
VID

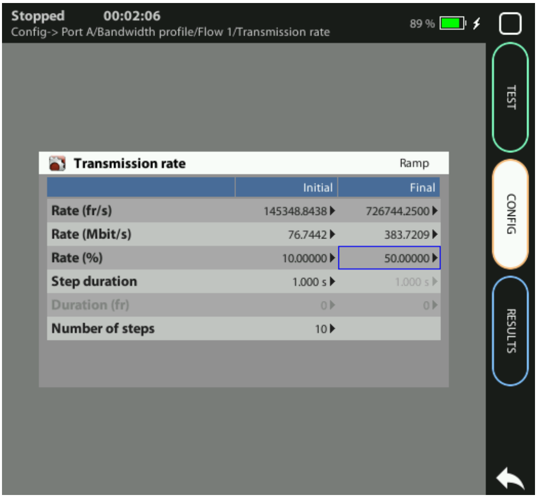
Figure 4.2: IEEE 802.1Q y IEEE 820.1ad frame structures.

8. Enter the source MAC address with the help of the *Source MAC address from* and *Source MAC address* controls. You can configure the factory MAC address as the source address for the generated frames or enter a custom address.
9. Enter the destination MAC address or addresses by using the *Destination MAC address from*, *Destination MAC address* and *Address range size*. If you choose to generate a destination address range you will be requested to enter the number of addresses that made up the range.

10. Configure the *Ethertype* value.
    Note: Some frame structures require an specific value of the Ethertype. This field cannot be configured in this case.
11. If you are using frames carrying one (IEEE 802.1Q) or two (IEEE 802.1ad, Q-in-Q) VLAN tags, enter the *C-VID* and *C-VLAN priority*.
12. If you are using frames carrying two VLAN tags (IEEE 802.1ad, Q-in-Q), enter the *S-VID*, *S-VLAN priority* and *Drop-Eligible Indicator*.
13. If you are generating not-standard Q-in-Q frames, set the *S-VLAN TPID* to one of the allowed values.
14. Configure the frame length to the correct value with the help of *Frame size*.
15. If necessary, repeat the specific flow configuration for one or more traffic flows (*Flow #1* to *Flow #8*) from the *Frame* menu.

4.1.3. Configuring the Bandwith Profile

In the same way that the *Frame* menu configures the frame format for each of the available traffic flows, the Bandwidth profile sets how many frames are transmitted and how transmission events are distributed in time. The simplest is to generate frames with a constant bit rate specified in frames per second, bits per second or as a percentage of the total transmission channel capacity. However, the test unit provides other alternatives to the constant transmission like the periodic burst and ramp transmission or random transmission with Poisson statistics.



Transmission rate Ramp

	Initial	Final
Rate (fr/s)	145348.8438 ▸	726744.2500 ▸
Rate (Mbit/s)	76.7442 ▸	383.7209 ▸
Rate (%)	10.00000 ▸	50.00000 ▸
Step duration	1.000 s ▸	1.000 s ▸
Duration (fr)	0 ▸	0 ▸
Number of steps	10 ▸	

Figure 4.3: Albedo xGenius bandwidth profile configuration panel.

The bandwidth profile settings are available only in port Port A because the traffic generator is not available in Port B. The procedure to configure the bandwidth profile in a traffic flow is as follows:

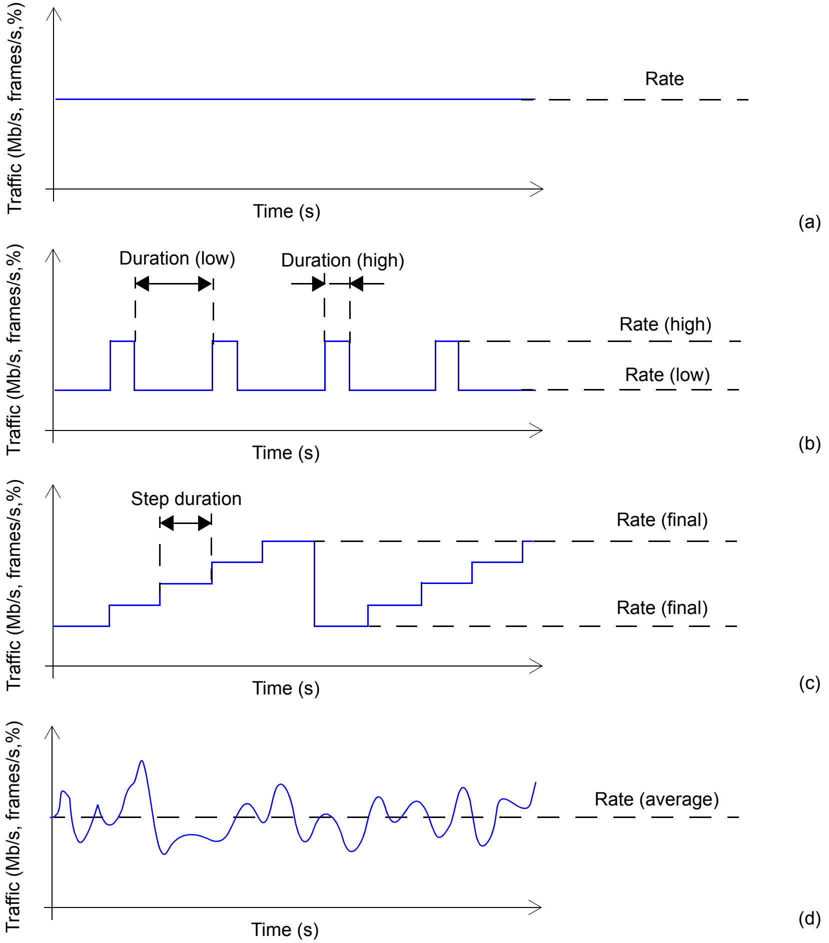


Figure 4.4: Bandwidth profiles for Albedo xGenius: (a) Continuous traffic generation, (b) Periodic burst generation, (c) Ramp generation, (d) Random traffic generation with Poisson probability distribution.

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.

3. Select Port A to enter in the port specific configuration.
   Note: There is no bandwidth profile configuration for Port B because Port B is unable to generate synthetic traffic.
4. Enter in the *Bandwidth profile* menu.
5. Select one of the traffic flows between *Flow #1* and *Flow #8* to enter in the flow specific configuration.
   All configuration items related with the bandwidth profile are displayed.
6. Configure the transmission mode to one of the available profiles with the help of the *Mode* control.

Table 4.2: Ethernet Payload Settings

Setting	Description
Mode	Configures the traffic shape to be used by the traffic generator in the current stream. There are five possible generation modes for this for the bandwidth profile • *Off*: No frames are transmitted in the current stream. Use this setting if you want to disable traffic generation in the current stream but you don't want to globally disable generation in the test port. • *Continuous*: Frames is transmitted at a constant speed to match a value configured in bits per second, frames per second or a percentage of the line capacity. • *Periodic burst*: Traffic generation is distributed in periodic bursts of fixed length. Between traffic bursts the user may choose to generate background traffic or disable traffic generation. • *Ramp*: Generates traffic that increases its bit rate with time in steps. The number of steps and step duration are configured by the user. Minimum and maximum traffic generated in the ramp are user configurable as well. Ramp generation is periodic. Traffic generator is restarted when it finishes with the last step of an specific ramp. • *Random*: The number of frames generated per time unit is a Poisson random variable. This is equivalent to say that the distance between two consecutively generated frames is an exponential random variable. Use the Random generation profile to generate traffic that resembles network traffic as much as possible.

Table 4.2: Ethernet Payload Settings

Setting	Description
Transmission rate	This control displays an editable table that enables the user to enter the parameters associated with the traffic to be generated by the current stream. Parameters to be configured depend on the current bandwidth profile generation mode: • *Continuous* traffic: The relevant bandwidth parameter is the transmission *Rate* configured in *fr/s*, *Mb/s* or *percentage*. • *Periodic burst*: Values to be entered are the high and low transmission rates (in *fr/s*, *Mb/s* or *percentage*) and the high and low durations expressed in seconds or frames. • *Ramp*: Relevant configuration parameters are the initial and final transmission rates (in *fr/s*, *Mb/s* or *percentage*), the *Step duration* configured in seconds and the *Number of steps*. • *Random*: The bandwidth parameter to be configured is the average transmission rate in *fr/s*, *Mb/s* or *percentage*.

7. Configure the transmission rate parameters with *Transmission Rate*.
   Note: Depending on the current transmission mode you will be requested to enter different traffic parameters in the *Transmission Rate* panel.
   Note: Changing some transmission parameter may affect the value of other parameters previously configured in the same panel. For example, setting the transmission rate in frames per second modifies the rate in bits per second and the percentage value of the transmission rate.
   Note: If the channel capacity varies, the transmission rates configured as percentages of the overall channel capacity are kept to the same value but the bits per second and frames per second are recomputed for the new channel capacity.
8. If necessary, repeat the bandwidth profile configuration process for one or more traffic flows (*Flow #1* to *Flow #8*) available from the *Bandwidth profile* menu.

Test traffic generation does not start immediately after setting the bandwidth profile parameters. Traffic generation requires a test to be started with by pressing *run*.

4.1.4. Choosing the Test Payload for Ethernet

The traffic generated by xGenius is synthetic. It does not contain any real user data. In fact, the user payload of the internally generated frames is replaced by a test payload. Many times, test payloads are much more than dummy bit sequences designed to replace the user traffic. Test payloads may contain time stamps or sequence numbers that determine which test metrics are available from the result panels or which tests will be run. For this reason, configuration of the right test payload is important to get the required results.

Selection of the test pattern is relevant both for the generator and the analyser. When you generate a test payload or pattern in Port A, the same port is automatically configured so that it is waiting for frames carrying the same pattern in the receiver. Settings related with test payload / pattern selection are available both in Port A and Port B. The procedure to select the test payload in the tester is as follows:

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
3. Select either *Port A* or *Port B* to enter in the port specific configuration.
4. Enter in the *Payload* menu.

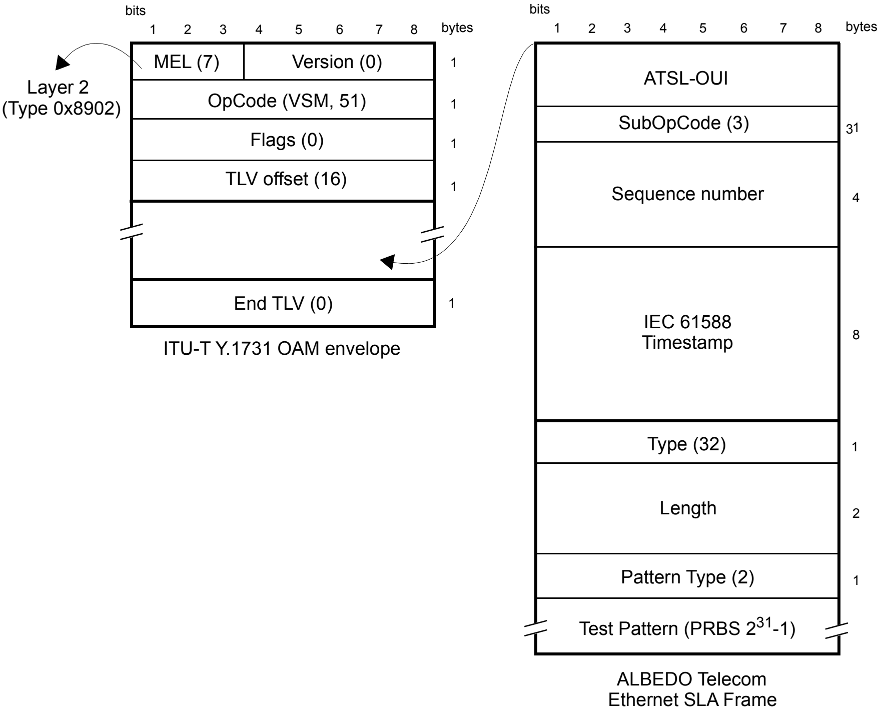

bits
1 2 3 4 5 6 7 8
bytes
Layer 2
(Type 0x8902)
MEL (7)
Version (0)
1
OpCode (VSM, 51)
1
Flags (0)
1
TLV offset (16)
1
End TLV (0)
1
ITU-T Y.1731 OAM envelope
bits
1 2 3 4 5 6 7 8
bytes
ATSL-OUI
SubOpCode (3)
31
Sequence number
4
IEC 61588
Timestamp
8
Type (32)
1
Length
2
Pattern Type (2)
1
Test Pattern (PRBS 2^{31}-1)
ALBEDO Telecom
Ethernet SLA Frame

Figure 4.5: Albedo payload for SLA tests (Ethernet Endpoint mode).

5. Select one of the traffic flows between *Flow 1* and *Flow 8* to enter in the flow specific configuration.
   All settings related with payload configuration in the current flow are displayed.

6. Choose one of *BERT*, *SLA* or *All zeroes* in *Payload type*.
   Note: BER is available only for flow 1.
7. If you have configured *Payload type* to BER, choose the bit pattern you are going to use for generation (Port A) and analysis (Port A and Port B) with the help of the *BERT patterns* control.
8. If you have configured *BERT patterns* to *User*, enter a 32-bit test pattern in *User payload* in hexadecimal format.
9. If necessary, repeat the payload configuration process for one or more traffic flows (*Flow #1* to *Flow #8*) available from the *Payload* menu.

Table 4.3: Ethernet Frame Settings

Setting	Description
Payload Type	• *BERT:* The payload content is set to a bit pattern suitable for measuring the Bit Error Ratio (BER). The tester includes support for two different kinds of BERT pattern: Pseudo-Random Bit Sequences (PRBSs) or 32-bit user configurable patterns. BERT generation and analysis over framed interfaces is supported by flow 1 only. • *SLA:* This is the payload to be used to measure latency, packet loss and all the SLA metrics derived from them. If the current operation mode is set to *Ethernet endpoint*, the SLA payload constitutes a proprietary extension of the Operation, Administration and Maintenance (OAM) protocol for Ethernet defined in ITU-T Y.1531. The SLA payload in *IP Endpoint mode* is a proprietary ALBEDO Telecom format. • *All zeroes*: Sets the transmitted pattern to all zeroes.

Table 4.3: Ethernet Frame Settings

Setting	Description
BERT Patterns	Sets the transmitted and expected test pattern (port A) or the expected test pattern (port B). Supported patterns are: • *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. • *User*: Sets a 32-bit, user configurable word as the transmitted pattern.
User payload	Here it is configured the value of the user payload that is used as the transmitted pattern when *BERT Pattern* is set to *User*.

Some test payloads are byte patterns (*BERT* pattern, *all-Zeroes* pattern) but some others have a more complex structure like the *SLA* test payload. Specifically, the SLA test payload used by test unit is a proprietary extension of the Operations, Administration and Maintenance (OAM) payload defined by standard ITU-T Y.1731.

4.2. Generation of IPv4 Traffic

Without a Network layer, all the Ethernet traffic generated by test unit would be unable lo leave the local network and reach remote networks. The Network Layer, or Layer 3, provides end-to-end connectivity between stations that can use heterogeneous underlying technologies and they are not necessarily attached to the same network. Routers are devices that are designed to manage Layer 3 protocols and data forwarding based on routing tables.

The *Internet Protocol* (IP) is the most popular Layer 3 protocol. It was conceived by the U.S. *Department of Defence* (DoD) during the cold war to facilitate communication between dissimilar computer systems in a reliable way. IP interconnects public or private autonomous systems providing a connectionless service.

There are two IP protocol versions (IPv4 and IPv6). IPv4 addresses can be defined as a subset of the IPv6 addressing space but IPv4 and IPv6 can be regarded as different and incompatible network protocols in any other sense. Currently, xGenius traffic generation functionality is compatible with version four of the IP protocol (IPv4). Traffic analysis include both versions of the IP protocol, IPv4 and IPv6.

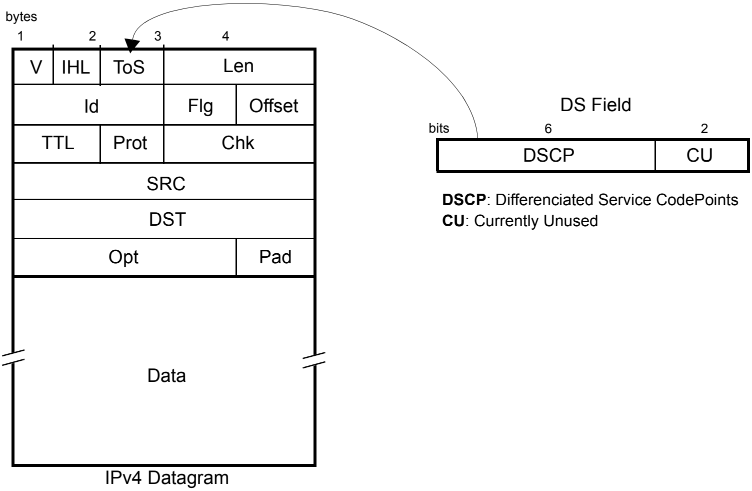


Figure 4.6: IPv4 datagram structure.

The correct operation mode for IPv4 packet generation is the *IP Endpoint* mode. Basically, the traffic generator in *IP Endpoint* mode is configured in the same way than in *Ethernet Endpoint* mode. However, there are some differences to be taken into account:

- In *IP Endpoint* mode, the test equipment becomes a host in an IP network and it has similar properties than any other network equipment. For this reason it is necessary to assign a valid IP profile to the tester either automatically (DHCP) or by hand.
- The test equipment is now ready to use some helper protocols to make the configuration process easier. Specifically, the *Address Resolution Protocol* (ARP), configures destination MAC address without user intervention. The *Domain Name Service* (DNS) replaces the configuration of the destination IP addresses by the much simpler domain name configuration.

- Ethernet frames carry IPv4 packets with an specific structure and content. It is necessary to configure the IPv4 packet before it is prepared to generate IP datagrams.
- Optionally IPv4 packets carry one or more MPLS labels. The transmission parameters of MPLS labels have to be configured when they are enabled.

4.2.1. Configuring the Physical and MAC Layers

Physical (layer 1) and MAC (layer 2) configuration is similar in *IP Endpoint* and *Ethernet Endpoint* modes (See section 4.1.1, See section 4.1.2). The only difference is that users now have at their disposal the ARP mechanism to configure the destination MAC address automatically. ARP gets the destination MAC address from the network using the destination IPv4 address by means a broadcast protocol.

To use ARP to set the destination MAC address without user intervention, you have to configure the *Destination MAC address from* to ARP (See section 4.1.2). Once ARP has been configured the test unit generates one or several broadcast ARP requests to compute the destination MAC address. Generation of ARP control traffic is automatic and it is not controlled with the RUN button like it happens with the test traffic.

4.2.2. Configuring MPLS

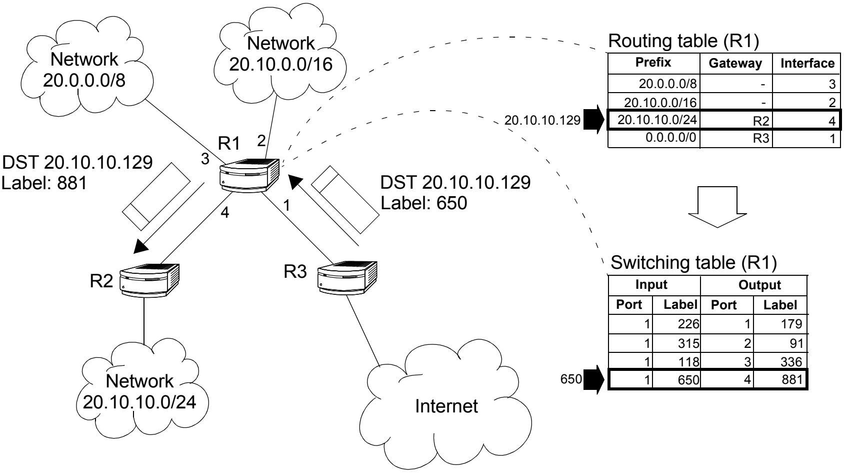
Multi-Protocol Label Switching (MPLS) is a technology designed to speed up IP packet switching in routers by separating the functions of route selection and packet forwarding into two planes:

- *Control Plane*: This plane manages route learning and selection with the help of traditional routing protocols such as *Open Shortest Path First* (OSPF) or *Intermediate System - Intermediate System* (IS-IS).
- *Forwarding Plane*: This plane switches IP packets, taking as a basis short labels prepended to them. To do this, the forwarding plane needs to maintain a switching table that associates each incoming labelled packet with an output port and a new label.

The traditional IP routers switch packets according to their routing table. This mechanism involves complex operations that slow down switching. Specifically, traditional routers must find the longest network address prefix in the routing table that matches the destination of every IP datagram entering the router.

On the other hand, MPLS routers, also known as *Label-Switched Routers (LSR)*, use simple, fixed-length label forwarding instead of a variable-length IP network prefix for fast forwarding of packetized data.

MPLS enables the establishment of a special type of virtual circuits called *Label-Switched Paths* (LSP) in IP networks. Thanks to this feature, it is possible to implement resource management mechanisms for providing hard QoS on a per-LSP basis, or to deploy advanced traffic engineering tools that provide the operator with tight control over the path that follows every packet within the network. Both QoS provision and advanced traffic engineering are difficult, if not impossible to solve in traditional IP networks.


Network
20.0.0.0/8
Network
20.10.0.0/16
R1
2
3
4
1
DST 20.10.10.129
Label: 881
DST 20.10.10.129
Label: 650
R2
R3
Network
20.10.10.0/24
Internet
20.10.10.129
650
Routing table (R1)
Switching table (R1)

Routing table (R1)

Prefix	Gateway	Interface
20.0.0.0/8	-	3
20.10.0.0/16	-	2
20.10.10.0/24	R2	4
0.0.0.0/0	R3	1

Switching table (R1)

Input		Output	
Port	Label	Port	Label
1	226	1	179
1	315	2	91
1	118	3	336
1	650	4	881

Figure 4.3 Traditional routers have to perform complex operations to resolve the output interface of incoming packets. LSRs resolve the output interface with the help of a simple switching table.

To sum up, the separation of two planes allows MPLS to combine the best of two worlds: the flexibility of the IP network to manage big and dynamic topologies automatically, and the efficiency of connection-oriented networks by using pre-established paths to route the traffic in order to reduce packet process on each node.

The test unit can be configured to generate and analyse MPLS packets carrying one or two labels. The configuration procedure is as follows:

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
3. Select either Port A or Port B to enter in the port specific configuration.
   Note: MPLS configuration settings are not available from Port B because traffic generation is not available from this port.
4. Enter in the *MPLS* menu.
   All settings related with MPLS packet generation configuration are displayed.

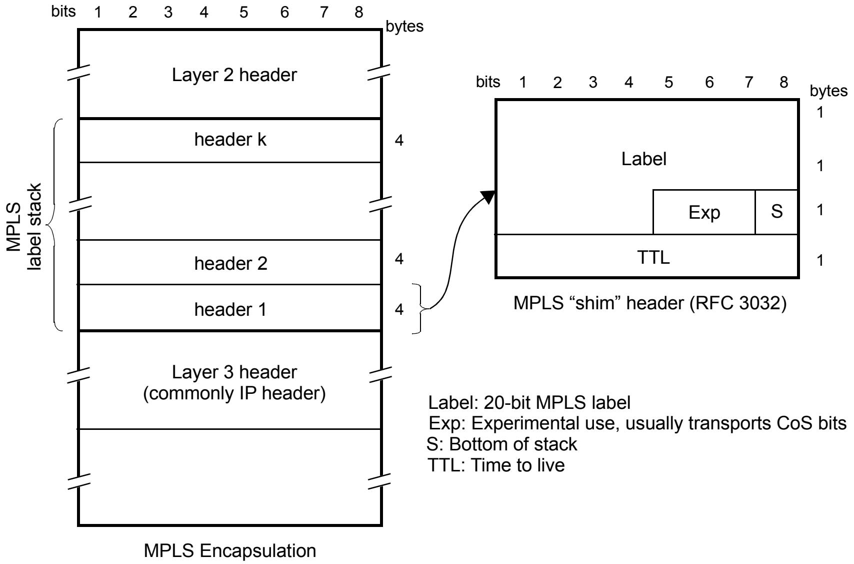

bits 1 2 3 4 5 6 7 8
bytes
Layer 2 header
header k
4
header 2
4
header 1
4
Layer 3 header
(commonly IP header)
MPLS
label stack
MPLS Encapsulation
bits 1 2 3 4 5 6 7 8
bytes
1
1
1
1
Label
Exp
S
TTL
MPLS "shim" header (RFC 3032)
Label: 20-bit MPLS label
Exp: Experimental use, usually transports CoS bits
S: Bottom of stack
TTL: Time to live

Figure 4.4 MPLS "shim" header format. The label is usually inserted between layer-2 and layer-3 headers.

5. Select one of the traffic flows between *Flow #1* and *Flow #8* to enter in the flow specific configuration.

Table 4.4: MPLS Settings

Setting	**Description**
Stack configuration	Configures the size of the MPLS label stack for the current flow. Both single and double stack configurations are supported. • *Off*: Disables MPLS generation in the current flow. • *Single MPLS label*: Enables single MPLS label generation in the current flow. The user is expected to configure the bottom label, traffic class and TTL for the MPLS header. • *Double MPLS label*: Enables double MPLS label generation in the current flow. The user is expected to configure both the top and bottom label, traffic class and TTL for the MPLS headers.

Table 4.4: MPLS Settings

Setting	Description
Bottom label	MPLS label used for switching traffic in the bottom MPLS header. This field is enabled when the user has selected *Single MPLS label* or *Double MPLS label* in *Stack configuration*.
Bottom traffic class	Contains the traffic class identifier for the bottom MPLS header. It was first thought that this field could carry the 3 Type-of-Service (ToS) bits defined for Class of Service (CoS) definition in the IP version 4, but currently, the ToS field is being replaced by 6-bit *Differentiated Services Code Points* (DSCP). This means that only a partial mapping of all the possible DSCPs into this field is possible. This field is enabled when the user has selected *Single MPLS label* or *Double MPLS label* in *Stack configuration*.
Bottom TTL	This field contains a *Time To Live* value for the bottom MPLS header. The value of this field is decremented by one unit every time the packet traverses an LSR. The packet is discarded if the value reaches 0. This field is enabled when the user has selected *Single MPLS label* or *Double MPLS label* in *Stack configuration*.
Top label	This field contains the MPLS label used for switching traffic in the top MPLS header. This field is enabled only if the user has selected *Double MPLS label* in *Stack configuration*.
Top traffic class	This field contains the traffic class identifier for the top MPLS header. It was first thought that this field could carry the 3 Type-of-Service (ToS) bits defined for Class of Service (CoS) definition in the IP version 4, but currently, the ToS field is being replaced by 6-bit *Differentiated Services Code Points* (DSCP). This means that only a partial mapping of all the possible DSCPs into this field is possible. This field is enabled only if the user has selected *Double MPLS label* in *Stack configuration*.
Top TTL	This field contains a *Time To Live* value for the top MPLS header. The value of this field is decremented by one unit every time the packet traverses an LSR. The packet is discarded if the value reaches 0. This field is enabled only if the user has selected *Double MPLS label* in *Stack configuration*.

6. Configure *Stack configuration* to *Off* to disable MPLS generation over the current flow. Set *Single MPLS label* or *Double MPLS label* to generate IP packets carrying one or two MPLS labels.
7. If you have configured *Single MPLS label* in the previous step, type the correct values for *Bottom label, Bottom traffic* class and *Bottom TTL*. If you have configured *Double MPLS label,* enter the values for *Bottom label*, *Bottom traffic class*, *Bottom TTL*, *Top label*, *Top traffic class* and *Top TTL*.

4.4.3. Configuring the Port Local Network Profile

The test equipment requires a local IP profile when it is operating in *IP Endpoint* mode. Even if the traffic generator has been configured to work with a custom IP address (different to the local IP address), the equipment still requires an internal address for some tests like the IP Ping or the Traceroute. Furthermore, some control and signalling protocols may work with the information stored in the local IP profile only. Specifically, it must be noticed that the test unit only responds to ARP and ICMP echo requests from the IP address and VID configured in the local profile. This fact must be taken into account when the source IP address is configured to something different to *Local* (*Network layer* settings) and *Encapsulation* is set to something different to *Local profile* (*Frame layer* settings).

Configuration of the local IP profile is available form the port specific settings within the Setup menu (See section 2.3).

4.4.4. Configuring the IPv4 Datagram

The IPv4 packet content is set much in the same way that the MAC frame content. However, in this case, MAC addresses are replaced by IPv4 addresses. Of course, IPv4 datagrams have their own structure and they contain some fields not present in Ethernet frames.

Table 4.5: IPv4 Packet Settings

Setting	Description
Source IPv4 address from	Establishes the origin of the source IPv4 address for the current stream. There are two possible settings: • *Local*: The source address is set to the IPv4 address configured in the port local profile. The local address may be either configured by means the DHCP protocol or in may be static. • *Manual*: The source address is set to the value configured in *Source IPv4 address*. Use manual IPv4 addresses if you want to simulate traffic generated by an equipment different to the tester or, in multi-stream operation, to simulate traffic transmitted from different hosts. Probably, you will want to avoid duplicated IP addresses in your network. For this reason, make sure that no other equipment is using the manually configured IPv4 address. • *Remote*: This option is available only in RFC 2544 or eSAM downstream asymmetric tests (See section 2.5). It configures the source IPv4 address to be the far end address. It must be taken into account that in downstream asymmetric tests, the far end is configured for traffic generation. This setting corresponds with traffic to be generated not in the local unit but in a different one.
Source IPv4 address	Source IPv4 address carried by the packets generated in the current stream if *Source IPv4 address from* is set to *Manual*. The address is entered in decimal, four-dotted format. Any address between 0.0.0.0 and 255.255.255.255 is admitted as a source IPv4 address.
Destination IPv4 address from	Establishes the origin of the destination IPv4 address for the current stream. There are three different settings available for configuration: • *Manual*: The destination address is set to the value configured in *Destination IPv4 address*. • *Range*: Test data in the current stream is transmitted to a group of IPv4 addresses configured with *Destination IPv4 address* and *Address range size*. Use this option if you want to deliver the test data sequentially to many different destinations.

Table 4.5: IPv4 Packet Settings

Setting	Description
Destination IPv4 address from	• *Host name*: Uses the Domain Name Service (DNS) to set the destination IP address by using descriptive alphanumeric strings. The DNS mechanism requires intervention of at least one DNS server. The DNS server IP address has to be configured in the local port profile either statically or by means DHCP. • *Remote*: This option is available only in RFC 2544 or eSAM upstream asymmetric tests (See section 2.5). It configures the destination IP address to be the far end address.
Destination IPv4 address	Destination IPv4 address carried by the packets generated in the current stream if *Destination IPv4 address from* is set to *Manual*. The address is entered in decimal, four-dotted format. Any address between 0.0.0.0 and 255.255.255.255 is admitted as a destination IPv4 address.
Destination IPv4 address (DNS)	Destination IPv4 address carried by the packets generated in the current stream if *Destination IPv4 address from* is set to *Host name*. This is a read only field that it cannot be edited directly. It displays the result of the DNS name resolution carried out with the host name configured in *Destination host name.*
Address range size	Configures the number of IPv4 addresses within an address range. This control is valid only if *Destination type* is set to *Range*. In this case, the IP datagrams transmitted in the current stream will contain as many destination addresses as previously configured in this field. The destination IP address is increased by one unit for each transmitted frame starting with the value configured in *Destination IPv4 address*. If there are no more addresses left in the range, transmission returns to the initial address and starts the process from the beginning. Transmission of destination IPv4 address ranges is compatible with transmission of destination MAC address ranges but the address number of the MAC address range is always fixed to the same number that the IP range. It is not possible to transmit a destination MAC address range with a single IPv4 address.

Table 4.5: IPv4 Packet Settings

Setting	Description
Destination host name	Domain name to be used as a destination if *Destination type* is set to *Domain name*. Unlike IP addresses, domain names are easy-to-remember alphanumeric strings but they have to be translated to IP addresses before any packet can be sent to the destination. The translation process requires the intervention of at least one DNS server. The DNS server IP address has to be configured in the local port profile either statically or by means DHCP.
DSCP	Differentiated Services Code Point. It is 6-bit class of service (CoS) field defined to set packet groups with different priorities or to provide specific treatments to special packets within a network or an administrative domain. Any value from 0 to 63 is allowed for this field. Specific actions to be carried out on frames with different DSCPs depend on the network and the service provider.
TTL	Initial Time To Live value configured in the packets transmitted in the current stream. The TTL is decreased by one unit each time it lefts a network node. If the value reaches zero, then the packet is discarded. The TTL is then a measure of the number of nodes the packet is allowed to transverse before reaching its destination.
UDP	Enables or disables transmission of the User Datagram Protocol (UDP) in the current stream. The UDP is defined in RFC 768 and it is a lightweight transport protocol for unreliable data transmission. RFC 768 defines an eight-byte fixed length header for UDP that is generated when UDP generation is enabled in the stream. If UDP generation is on, the *Transport protocol* field is set to 17. This value cannot be edited by the user.

Table 4.5: IPv4 Packet Settings

Setting	Description
Transport protocol	This setting contains an 8-bit word that constitutes the protocol identifier to be transmitted by the traffic generator. TCP uses 6 as the protocol number, UDP uses 17 for the same purpose and ICMP uses number 1. However, the payload structure does not match the structure corresponding to these protocols even if the correct protocol number is configured. To enable UDP header and payload generation, enable UDP in the current stream.
Source port	Source transport layer port transmitted in the UDP header in the current stream. Ports are service identifiers used to multiplex data from different applications generated by IP hosts. The tester supports source port generation for UDP streams only.
Destination port	Destination transport layer port transmitted in the UDP header in the current stream. Ports are service identifiers used to multiplex data from different applications generated by IP hosts. The tester supports destination port generation for UDP streams only.

All the IPv4 datagram configuration lays within the *Network* menu. The network menu is not enabled unless the port is configured in TX / RX mode. For this reason, there is no Network configuration menu in Port B (Port B does not support TX / RX mode). The procedure to follow to configure the IP datagram is described below:

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1). Check that your tester is operating in *IP Endpoint* mode (See section 2.1) and that the port is in *TX / RX*.
2. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
3. Select Port A to enter in the port specific configuration.
   Note: There is no network configuration for Port B.
4. Enter in the *Network layer* menu.
5. Select one of the traffic flows between *Flow 1* and *Flow 8* to enter in the flow specific configuration.
   All settings related with network configuration in the current flow are displayed.
6. Enter the source IP address with the help of the *Source IPv4 address from* and *Source IPv4 address* controls. You can configure the IP address from the local IP profile as the source address or enter a custom address.

7. Enter the destination IPv4 address or addresses by using the *Destination IPv4 address from*, *Destination IPv4 address*, *Address range size* and *Destination host name*. If you choose to generate a destination address range you will be requested to enter the number of addresses that made up the range. If you choose to enter the destination as a host name rather than an IPv4 address, you will be requested to enter a valid domain name.
8. Configure the DSCP and TTL if necessary.
9. Enable or disable UDP generation and analysis with the help of the *UDP* control.
10. If you have enabled UDP, enter the *Source Port* and *Destination Port* to be used in the generated UDP packets.
11. If you have not enabled UDP, configure the *Transport Protocol* code.
12. If necessary, repeat the IPv4 configuration process for one or more traffic flows (*Flow #1* to *Flow #8*) available from the *Network layer* menu.

4.4.5. Setting the Bandwidth Profile

Setting the bandwidth profile in IP Endpoint mode is the same that in Ethernet Endpoint mode (See section 4.1.3)

4.4.6. Choosing the Test Payload for IPv4

The test unit includes special packet payloads and patterns required for all usual applications, including BER tests and SLA tests. Payloads and patterns available in *IP Endpoint* mode are similar than in *Ethernet Endpoint* mode (See section 4.1.4). However, there is a difference concerning the SLA payload. While in Ethernet Endpoint the SLA payload is defined as an extension of the ITU-T Y.1731 structure, in *IP Endpoint*, this payload is ALBEDO Telecom proprietary. In practical terms, the structure of the SLA payload should not make any difference when testing.

4.5. Event Insertion

Sometimes it is necessary to insert events in the generated signal to stress the DUT/SUT. The test unit implements extended event insertion capabilities. The procedure to set event insertion with the test unit is as follows:

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 *Event to be inserted* menu item.
4. Select the insertion mode for the event selected in the previous step with the help of the *Mode* menu item. Available insertion modes are: *Single*, *Rate*, *Burst* or *Random*.

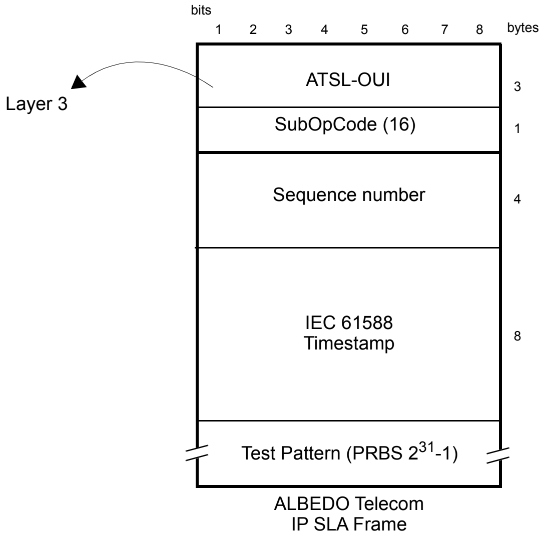

bits
1
2
3
4
5
6
7
8
bytes
Layer 3
ATSL-OUI
3
SubOpCode (16)
1
Sequence number
4
IEC 61588
Timestamp
8
Test Pattern (PRBS 2^31-1)
ALBEDO Telecom
IP SLA Frame

Figure 4.7: Albedo payload for SLA tests (IP Endpoint mode).

5. Configure the insertion parameters with the help of the *Event rate*, *Number of frames*, *Probability (%)* and *Frame size (bytes)* menu items.

6. 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 4.6: Event Insertion Settings

Setting	Description
Event to be inserted	Contains a selection list with events the user can choose for insertion in the transmitted data stream.The events available are: • *None*: Disables event insertion in the target port and flow. No event will be generated in case the user presses EVENT. • *FCS*: Generates *Frame Check Sequence* errors. A frame with a FCS error is a frame with a legal size which contains an invalid FCS field. In normal circumstances, FCS errors are caused by transmission errors. An optical Ethernet link with a poor power budget may experience FCS errors • *IPv4 checksum*: Generates frames with an invalid IPv4 header checksum. In normal circumstances, in Ethernet networks, IP checksum errors are related with corrupted traffic generation. IPv4 checksum error insertion is available only in *IP endpoint* mode. • *Undersized frames*: This event is used to generate frames shorter than the minimum legal size (64 bytes). The frame size of an undersized frame is configured through the *Frame size (bytes)* field. • *TSE*: Generates *Test Sequence Errors*, One TSE is equivalent to a single bit difference between the transmitted and the received test pattern (PRBS or other). TSE event insertion is not available if the target port transmitter is not configured for transmission of a BER test pattern.

Table 4.6: Event Insertion Settings

Setting	**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. • *Burst*: A burst events a configurable number of events is inserted. Burst start is triggered with the EVENT key. • *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. • *Random*: The number of events generated is random.For each insertion opportunity, the transmitter decides if the event is inserted or not depending on a user configurable insertion probability.
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 a real positive number smaller than 10.
Number of frames	If insertion mode has been set to *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.
Probability (%)	If the insertion mode is set to *Random,* this is the probability of a single event occurrence expressed as a percentage.
Frame size (bytes)	If *Event to be inserted* has been configured to *Undersized frames*, this field configures the frame length corresponding to these undersized frames expressed in bytes. It is a number between 32 and 63.
Target flow	Sets the traffic flow where the event is going to be inserted. Currently it is only supported insertion in flow 1.

Chapter 5
Basic Frame Analysis

ALBEDO xGenius can be used to get advanced traffic counts and statistics about Ethernet and IP networks operating at rates up to 10 Gb/s. These statistics include frame and error counts, bandwidth statistics, quality of service statistics, frame size statistics and other results.

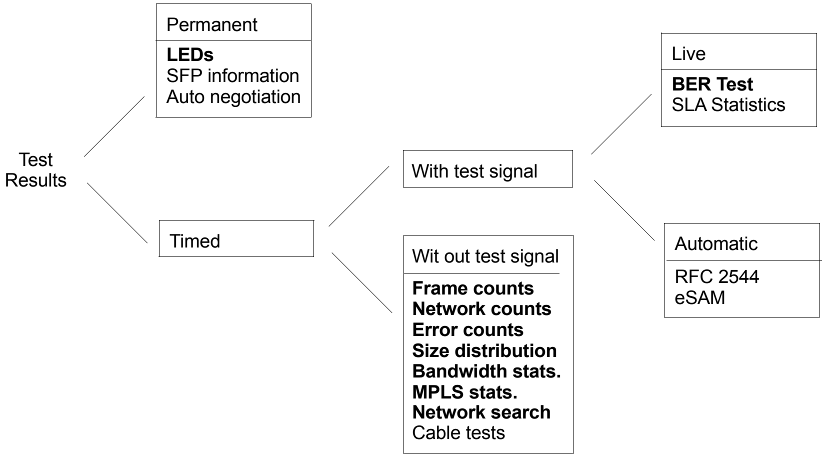

Test Results
Permanent
LEDs
SFP information
Auto negotiation
Timed
With test signal
Wit out test signal
Frame counts
Network counts
Error counts
Size distribution
Bandwidth stats.
MPLS stats.
Network search
Cable tests
Live
BER Test
SLA Statistics
Automatic
RFC 2544
eSAM

Figure 5.1: Statistics and counts available in xGenius.

Test results supplied by the test unit can be classified in many different ways. One of them is to think in test results that require a previous test start action with the RUN button (*timed* results) or results which are always available when the equipment is on (*permanent* results). A second approach is to classify test results in those which depend on an special test signal transmitted from an special traffic generator and results available in any case, even if there is no test signal available for analysis.

This chapter deals mainly with timed results which does not require test signals and the closely related LED results even if these are permanent results. At the end of the chapter BER test results are also addressed, but these are different in nature to all other measurements because they require a BERT payload / pattern received in the test interface. These test may be generated by the same test unit or a remote tester.

5.1. Global Counts and Statistics

Global frame counts and statistics are those not associated to any particular stream. Some global statistics have a per-stream statistic counterpart. Examples of this are the bandwidth statistics and some frame counts.

Global counts and statistics for Port A and Port B are identical. Global frame statistics are controlled by the RUN button. That means that results are not collected if a test is not started before. Once the test is running results are upgraded in real time.

Counts and statistics described in this section are available both in endpoint (*Ethernet Endpoint*, *IP Endpoint*) and through mode.

5.1.1. Frame Counts

Frame counts provide information about how many frames have been received in the test interface from the beginning of the test. These counts are also useful to classify the frames received in different families.

To display the transmitter statistics follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *Frame layer statistics*.
4. Check the *TX frames*, *RX frames*, *Unicast frames*, *Multicast frames*, *Broadcast frames*, *VLAN*, *IEEE 802.1ad*, *Q-in-Q*, *Control frames*, *Pause frames* and *BPDU* counters.

Table 5.1: Global Frame Statistics

Metric	**Description**
TX frames	Total number of frames transmitted by one tester port since the test started.
RX frames	Total number of frames received by one tester port since the test started.

Table 5.1: Global Frame Statistics

Metric	Description
Unicast frames	Total number of Ethernet unicast frames received from the beginning of the test. Unicast frames are recognised because they contain a unicast destination MAC address. Unicast MAC frames have their multicast bit set to ‘0’. The multicast bit of a MAC address is the least significant bit of the more significant address byte.
Multicast frames	Received Ethernet multicast frames from the beginning of the test. Ethernet multicast frames have their multicast bit in their destination MAC address set to ‘1’. The multicast bit of a MAC address is the least significant bit of the more significant address byte.
Broadcast frames	Total number of Ethernet broadcast frames received from the beginning of the test. Broadcast frames carry the broadcast Ethernet address (*ff:ff:ff:ff:ff:ff*) in the destination field.
VLAN	Total number of Ethernet VLAN frames transmitted from the beginning of the test. IEEE 802.1Q VLAN frames contain an special Ethertype (Type / Length field) value (*0x8100*).
IEEE 802.1ad	Total number of *Provider Bridge* (PB) frames received from the beginning of the test. PB frames are defined by standard IEEE 802.1ad. PB frames contain two VLAN tags referred as C-VLAN and S-VLAN. The C-VLAN carries Type *0x8100*. The S-VLAN has the special Type *0x88a8*.
Q-in-Q	Total number of double-tagged VLAN frames received from the beginning of the test. Q-in-Q frames contain an S-VLAN and a C-VLAN but they are not compliant with the IEEE 802.1ad standard. This standard requires the Type field for the S-VLAN to be *0x88a8* but not-standard Q-in-Q frames use different values like *0x8100*, *0x9100*, *0x9200* or *0x9300*.
Control frames	Total number of Ethernet MAC control and supervision frames received from the beginning of the test. Ethernet control frames are recognised due to an special Ethertype (Type / Length field) value (*0x8808*).

Table 5.1: Global Frame Statistics

Metric	Description
Pause frames	Total number of Ethernet *Pause* frames received from the beginning of the test. Pause frames are an special type of control frames and therefore their Ethertype is 0x8808. The specific features of *Pause* frames is that their *Opcode* field is 0x0001 and their destination MAC address is *01:80:c2:00:00:01* (a multicast MAC address).

5.1.2. Error Counts

xGenius is prepared to get any defect or fault in the received data stream. These faults include invalid checksum, alignment or size and frame structure defects. If configured in pass-through mode, the test unit, automatically drops frames with errors but these are still counted and presented in the error statistics panels. To access to the error statistics:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *Error statistics*.
4. Check the *FCS*, *Undersized*, *Oversized*, *Jabbers*, *IPv4 / IPv6 errors* and *UDP errors* counters.

Table 5.2: Global Error Counts

Metric	Description
FCS	Count of all the FCS errors detected from the beginning of the test. A frame with a FCS error is a frame with a legal size which contains an invalid FCS field. FCS errors are caused by transmission errors. An optical Ethernet link with a poor power budget may experience FCS errors
Undersized	Total number of received frames which are smaller than 64 bytes.
Oversized	Total number of received frames which are larger than the configured MTU.
Jabbers	Jabber count from the beginning of the test. A Jabber is defined as a frame greater than 1518 bytes with a bad CRC.

Table 5.2: Global Error Counts

Metric	Description
IPv4 / IPv6 errors	Displays information about the total number of errored IPv4 and IPv6 packets. An IPv4 or IPv6 packet is declared an errored packet if it is improperly built: Datagram header has an unexpected structure, field values are different to the expected ones or it has an unexpected length. An IPv4 datagram is also considered to be invalid if it contains checksum errors.
UDP errors	Displays information about the total number of errored UDP packets. UDP packets are considered to contain errors if either their structure or their content is invalid. For UDP, this means that the packet has an unexpected length or it contains checksum errors.

5.1.3. Network Counts

The Network layer statistics panel has similar purpose than the Frame layer statistics but in this case it displays counters related with the IP layer rather than with Ethernet. Network statistics are not available in *Ethernet Endpoint* mode because the IP structure is neither generated nor decoded in this operation mode.

Table 5.3: Global Network Statistics

Metric	Description
IPv4 / IPv6 TX	Aggregated number of transmitted IPv4 and IPv6 packets since the last test start. IPv4 packets are encapsulated in Ethernet frames (with or without an LLC / SNAP header) carrying the 0x0800 Type. IPv6 packets are encapsulated (with or without the LLC / SNAP header) with the Ethertype field set to 0x86dd.
IPv4 RX	Total number of received IPv4 packets since the last test start. IPv4 packets are encapsulated in Ethernet frames (with or without an LLC / SNAP header) carrying the 0x0800 Type.
IPv6 RX	Total number of received IPv6 packets since the beginning of the test with RUN. IPv6 packets are encapsulated in Ethernet frames (with or without an LLC / SNAP header) carrying the 0x86dd Type.

Table 5.3: Global Network Statistics

Metric	Description
Unicast pkts.	Aggregated count of unicast IPv4 and IPv6 packets received from the beginning of the test. An IPv4 unicast packet is a packet directed to a unicast IPv4 address. An IPv4 unicast address is any valid, not-broadcast Class A (1.0.0.1 - 126.255.255.254), Class B (128.1.0.1 - 191.255.255.254) or Class C (192.0.0.1 - 192.255.254.254) address. An IPv6 unicast packet is a packet directed to a unicast IPv6 address. All non-multicast IPv6 (prefix ff00::/8) packets are considered to be unicast.
Multicast pkts.	Aggregated count of unicast IPv4 and IPv6 packets received from the beginning of the test. An IPv4 multicast packet is a packet directed to a multicast IPv4 address. An IPv4 multicast address is any valid Class D (224.0.0.0 - 239.255.255.255) address. An IPv6 multicast packet is a packet directed to a multicast IPv6 address. IPv6 multicast addresses is an address starting with the ff00::/8 prefix.
Broadcast pkts.	Total count of broadcast IP packets received from the beginning of the test. An IPv4 broadcast packet is a packet directed to the currently configured network broadcast address or the global broadcast address (255.255.255.255). The network broadcast address is the IPv4 address that has all the host bits set to 1. There is no definition for IPv6 multicast addresses. For this reason IPv6 statistics are not included in this result field.
UDP packets	UDP packets or segments are IP packets carrying the User Datagram Protocol (UDP) defined in RFC 768. The protocol number assigned to UDP is 17.
ICMP / ICMPv6	Aggregated count of ICMP and ICMPv6 messages received from the beginning of the test. ICMP packets carry Internet Control Message Protocol (ICMP) messages defined in RFC 792. ICMPv6 messages carry the version 6 of Internet Control Message Protocol defined in RFC 4443. The protocol number assigned to ICMP is 1. For ICMPv6 the protocol number is 58.

To display the network statistics corresponding to the last (or current) test, follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *Network layer statistics*.
4. Check the *IPv4 TX*, *IPv4 RX*, *Unicast pkts.*, *Multicast pkts.*, *Broadcast pkts.*, *UDP* and *ICMP* counters.

5.1.4. Bandwidth Statistics

Bandwidth statistics inform about how many frames and bits are you receiving per time unit and how much of the available bandwidth is being used by the traffic. Traffic statistics are supplied at many different transmission layers, including Ethernet, IP and UDP. IP and UDP is closer to the amount of usable data and Ethernet statistics are more related with the bandwidth available for transmission. For this reason, the Ethernet bandwidth is expressed as a percentage of the nominal transmission bandwidth but this is not the case with IP and UDP bandwidth statistics.

Bandwidth statistics are timed measurements, you need to run a test to start collecting results. In order to access to these results follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *Bandwidth statistics*.
4. Select *General statistics*.
5. Check the *Eth. (current)*, *Eth. (min.)*, *Eth (max.)*, *Eth. unicast*, *Eth. multicast*, *Eth. broadcast*, *IPv4 (current)*, *UDP (current)* results.

Table 5.4: Bandwidth Statistics

Metric	Description
Eth. (current)	Total amount of Ethernet traffic received during the last second computed in bits per second, frames per second and as a percentage of the total channel capacity. The frame bits considered in Ethernet traffic statistics are between the first bit of the destination address field to the last bit of the FCS field. The current Ethernet traffic counter requires previous initialization of a test with the RUN button.

Table 5.4: Bandwidth Statistics

Metric	Description
Eth. (max)	Peak value of Ethernet traffic registered from the beginning of the test. The *Ethernet (max)* value displays the maximum value found in the *Ethernet (current)* field since the test started. The *Ethernet (max)* is displayed in three different units: bits per second, frames per second and percentage of the overall channel capacity.
Eth. (min)	Minimum value of Ethernet traffic registered from the beginning of the test. The *Ethernet (min)* value displays the minimum value found in the *Ethernet (current)* field since the test started. The *Ethernet (max)* is displayed in three different units: bits per second, frames per second and percentage of the overall channel capacity.
Eth. unicast	Total amount of unicast Ethernet traffic received during the last second computed in frames per second. Unicast frames are recognised because they contain a unicast destination MAC address. Unicast MAC frames have their multicast bit set to '0'. The multicast bit of a MAC address is the least significant bit of the more significant address byte.
Eth. multicast	Total amount of multicast Ethernet traffic received during the last second computed in frames per second. Ethernet multicast frames have their multicast bit in their destination MAC address set to '1'. The multicast bit of a MAC address is the least significant bit of the more significant address byte.
Eth. broadcast	Total amount of broadcast Ethernet traffic received during the last second computed in frames per second. Broadcast Ethernet frames carry the broadcast Ethernet address (*ff:ff:ff:ff:ff:ff*) in the destination field.
IPv4 (current)	Total amount of IPv4 traffic received during the last second computed in bits per second, frames per second and as a percentage of the overall channel capacity. The current IPv4 traffic counter requires previous initialization of a test with the RUN button.

Table 5.4: Bandwidth Statistics

Metric	Description
IPv6 (current)	Total amount of IPv6 traffic received during the last second computed in bits per second, frames per second and as a percentage of the overall channel capacity. The current IPv6 traffic counter requires previous initialization of a test with the RUN button.
UDP (current)	Total amount of traffic associated to the Ethernet / IP / UDP payloads computed in bits per second, frames per second and as a percentage of the overall channel capacity. The current *User traffic* counter requires previous initialization of a test with the RUN button.

5.1.5. Frame Size Distribution

Frame size is important because it tells how a network is used. Some applications, like VoIP use short frames while most data applications based on a client / server architecture use short frame lengths for the client requests and long frames for the server replies. The ALBEDO Telecom xGenius provides frame size results as described in standard RFC 2819. The procedure for displaying the received frame size distribution is as follows:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *Frame size histogram*.
4. Check the frame size intervals: *64 or less*, *65 - 127*, *128-255*, *256 - 511*, *512-1023*, *1024 - 1518, 1519 - 1522*, *1523-1526*, *1527 - MTU*.

5.1.6. MPLS Statistics

Network statistics and all other results are not affected when the received traffic contains MPLS labels. For example, IPv4 datagrams are still IPv4 packets when they have one or more MPLS labels and they are still recognised as unicast, multicast or broadcast packets when this happens.MPLS test results are limited to an indication of the presence of MPLS in the received traffic and some statistics about the MPLS stack size. To display the MPLS statistics follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *MPLS statistics*.

4. Check the *MPLS labels per packet (min.)* and *MPLS labels per packet (max.)* counters.

Table 5.5: MPLS statistics

Metric	Description
MPLS labels per packet (min.)	Minimum number of MPLS labels per packet found in the received traffic from the beginning of the test. If it has been received at least one frame without MPLS labels, this result will be set to 0.
MPLS labels per packet (max.)	Maximum number of MPLS labels per packet found in the received traffic from the beginning of the test.

5.2. Using the Network Search Capability

Network Search is an optional monitoring tool for the test unit that reports the top MAC, IPv4 and IPv6 addresses found in the network. Also, if you are connected to a tagged interface, the network search can be configured to collect the most viewed VLANs. Network search can be used to look for an specific traffic flow in your network or maybe as a preliminary analysis tool before filtering the interesting traffic flows and getting detailed statistics about them. In fact, the Network Search capability is prepared to be used as a preliminary analysis tool: Once the traffic search has finished the user can choose which filters to configure following the results of the network search. All this is done by a simple key press. Network Search is used in the following way:

1. From the *Home* panel, go to *SETUP*,
   The test port settings panel is displayed.
2. Select either *Port A* or *Port B* to enter in the port specific configuration.
3. Go to *Search network by* and define your search field: *Source MAC address*, *Destination MAC address*, *VLAN, Source IPv4 address*, *Destination IPv4 address, Source IPv6 address, Destination IPv6 address*.
   Note: *Source IPv4 / IPv6 addresses* and *Destination IPv4 / IPv6 addresses* are available only if you are working in an IP mode (*IP endpoint* or *IP through*). You can configure *VLAN* even if you are not connected to a tagged interface but you will not collect any VLAN information when you start the measurement. In order to disable the network search in the current port set *Search network* by to *Off*.
   Note: You can run one Network search in Port A and one in Port B. To do that, simply configure a search field for each port.
4. Leave the previous panel to *Home* and go to *RESULTS*.
   The test port results panel is displayed.
5. Select either *Port A or Port B* to enter in the port specific results.
6. Go to *Network Search*.

7. Start a test by pressing *Run*.
   The network search panel is filled with popular addresses or VLANs found in your network. There is a percentage that indicates how many times each address or VLAN has been found to the time.
8. Finish the search by pressing *Run* a second time.
9. Choose which addresses or VLANs will be used to configure the filters on the receiver.
10. Press the *Configure* contextual button to configure the filters with the previously collected data. To get extended information about these filters you will need to run a second measurement once they have been configured with this action (See chapter 6).

5.3. The LEDs Panel

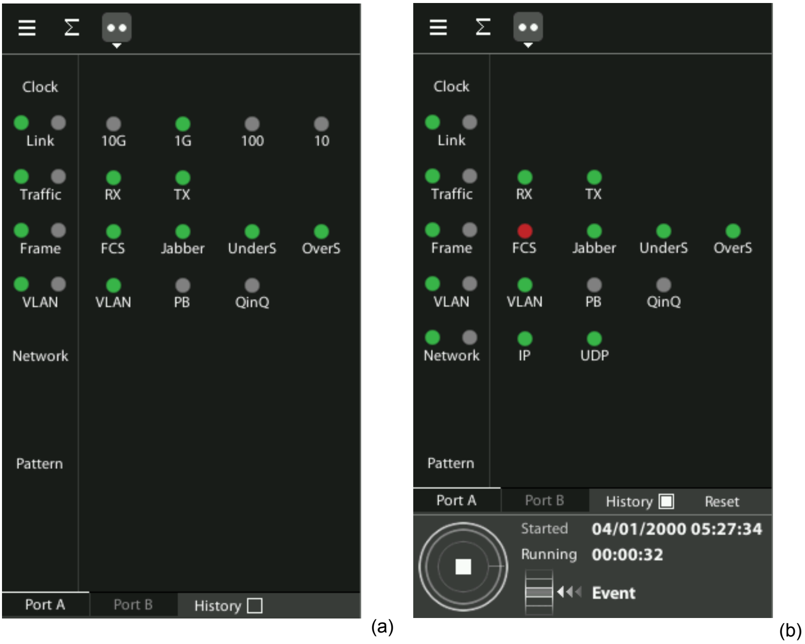
The LEDs panel offers a quick view of the current xGenius connection and operation status. They are permanent indicators. That means that no test has to be started to get the information from the LEDs.

There are two hardware global summary LEDs in the equipment (one for Port A and one for Port B), six summary LEDs for each test port (*Link*, *Traffic*, *Frame*, *VLAN, Network* and *Pattern*). These summary LEDs summarize the information of the events shown in the LEDs panel. To display the LEDs panel use the LEDS key or the corresponding active area in the screen. If the LEDs panel is already visible press again to return to the previous screen.

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* (F3) contextual button sets or unsets the history mode. If the history mode is enabled, then the Reset (F4) button resets the LEDs history.


Clock
Link
10G
1G
100
10
Traffic
RX
TX
Frame
FCS
Jabber
UnderS
OverS
VLAN
VLAN
PB
QinQ
Network
IP
UDP
Pattern
Port A
Port B
History ☐
Reset
Event
(a)
(b)

Started 04/01/2000 05:27:34
Running 00:00:32

Figure 5.2: Albedo xGenius LEDs panel.

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.
- 🟧 and 🟥: This is the colour displayed if faulty conditions are found in the signal. Conditions marked with 🟥 tend to be more important than the ones marked with 🟧.
- ▨: Shows that no operation condition can be established due to the lack of matching traffic for the corresponding event. For example, the FCS led is ▨ if no traffic is received because there are no frames where to check the FCS. It can

also indicate that the LED has been disabled due to the presence of a more important event.

Table 5.6: LED Indications

Metric	Description
REF	External clock input status LED. Displays green colour if a valid reference signal is found in the corresponding clock input port. Otherwise, the displayed LED colour is red.
LOCK	This LED is green when synchronization with the current clock has succeed. If external synchronization fails for some reason, the LED colour changes to red. Sometimes, it may take a few seconds to achieve synchronization with the external clock input. The LED colour during this transient period is yellow. The *LOCK* LED is enabled only when the clock reference is detected in the corresponding reference input clock interface.
10G	The port is operating at 10 Gb/s from the optical port. Auto-negotiation is not defined in 10 Gb/s links and therefore this LED does not depend on any automatic process. It is enabled when a proper signal is detected in the SFP+ port input.
1000	The port is operating at 1000 Mb/s either from the optical or the electrical port. Port speed is decided immediately after connecting the port to the DUT / SUT using Ethernet auto-negotiation or it is forced by the user.
100	The port is operating at 100 Mb/s from the electrical port. Port speed is decided immediately after connecting the port to the DUT / SUT using Ethernet auto-negotiation or it is forced by the user.
10	The port is operating at 10 Mb/s from the electrical port. Port speed is decided immediately after connecting the port to the DUT / SUT using Ethernet auto-negotiation or it is forced by the user.
RX	At least one frame was received during the current second in the current interface.
TX	At least one frame was transmitted during the current second in the current interface.

Table 5.6: LED Indications

Metric	Description
FCS	At least one frame with FCS errors has been found during the current second. A frame with a FCS error is a frame with a legal size which contains an invalid FCS field. FCS errors are caused by transmission errors. An optical Ethernet link with a poor power budget may experience FCS errors
Jabber	At least one jabber was received during the current second. Jabbers are defined as frames greater than 1518 bytes with a bad CRC.
UnderS	At least one undersized frame was received during the current second. An undersized frame is a frame which has a size smaller than 64 bytes.
OverS	At least one oversized frame was received during the current second. An oversized frame is a frame which has a size larger than the configured MTU.
VLAN	At least one frame with an VLAN tag was received during the current second in the current interface.
PB	At least one PB frame containing the IEEE 802.1ad Ethertype value (*0x88a8*) has been detected during the current second in the current interface. PB frames carry two VLAN tags known as S-VLAN and C-VLAN.
Q-in-Q	At least one frame carrying two VLAN tags but not the IEEE 802.1ad Ethertype (*0x88a8*) has been detected during the current second in the current interface. Q-in-Q frames carry two VLAN tags known as S-VLAN and C-VLAN but they are not compliant with any international standard like the IEEE 802.1ad.

Table 5.6: LED Indications

Metric	Description
IPv4/v6	If this led is green, at least one correct IPv4 or IPv6 datagram was received during the current second. If red, this led indicates that one incorrect datagram has been received during the current second. One IPv4 / IPv6 datagram is incorrect if its header has an unexpected structure, field values are different to the expected ones, it has an unexpected length or it contains checksum errors.
UDP	If this led is green, at least one correct UDP packet was received during the current second. If red, this led indicates that one incorrect datagram has been received during the current second. One UDP packet is incorrect if it has an unexpected length or it contains checksum errors.
LSS	Loss of Sequence Synchronization. This event indicates that the expected test pattern does not match the actually received test pattern. This event does not apply if the tester is configured to receive an SLA payload and, for framed analysis, it is referred to the stream 1 (the only stream with pattern analysis capabilities).
TSE	Test Sequence Error. One TSE is equivalent to a single bit difference between the transmitted and the received test pattern (PRBS or other). This event does not apply if the tester is configured to receive an SLA payload and, for framed analysis, it is referred to the stream 1 (the only stream with pattern analysis capabilities).

5.4. 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. These information is supplied by the xGenius 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.

5.4.1. 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 5.7: Logging event categories

Event class	Description
Anomalies / defects	Accounts for Ethernet /IPv4 /IPv6 anomalies and defects. This category includes the following events: *Link*, *FCS*, *Undersized*, *Oversized*, *Jabbers*, *IPv4 / IPv6 errors*, *UDP errors.*
Bandwidth statistics	Reports bit rates in *bit/s* for different protocol layers, including: *Ethernet bit rate*, *IPv4 bit rate*, *IPv6 bit rate*, *UDP bit rate*. The *Bandwidth statistics* category includes one set of traceable events for each filter (*Filter 1*, *Filter 2*,...) and one additional global statistics subclass.
Frame layer statistics	Event category that includes transmission statistics related with different frame structures: *RX frames*, *TX frames*, *Unicast*, *Multicast*, *Broadcast*, *VLAN*, *IEEE 802.1ad*, *Q-in-Q*, *Control*, *Pause*.
SLA statistics	Provides information about, delay, delay variation, frame loss and other QoS parameters. Includes the following events*: RX frames*, *RX bytes*, *FTD*, *FDV*, *Lost frames*, *Duplicated frames*, *SES*. This category has one subclass for each filter (*Filter 1*, *Filter 2,...*) so that metrics from different frame flows can be simultaneously traced and compared.
BERT	Reports BER results by means the *LSS*, *TSE* traceable events.
PTP	Includes events related with PTP performance in terms of latency, path asymmetry, PDV, time / frequency offset and wander. Traceable PTP events are: *Sync PTD (current)*, *Sync PDV (current)*, *Delay req. PTD (current)*, *Two-way PTD (current)*, *Sync IAD (current)*, *PTP slave frequency offset*, *PTP slave phase offset*, *TE (Total)*, *TE (Constant)*, *TE (Dynamic)*, *Sync correction (current)*.
Synchronization	This event category includes all events related with Synchronous Ethernet. Both message statistics, and time / frequency metrics are available. The traceable event list is: REF, OVF, TIE, Frequency offset, Frequency drift.

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 A* or *Port B* (or *Port C* depending on the current operation mode)
6. Choose the event categories corresponding to the events you want to trace between: *Anomalies / defects*, *Bandwidth statistics*, *Frame layer statistics*, *SLA statistics*, *BERT*, *PTP*, *Synchronization*.
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).

5.4.2. 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:

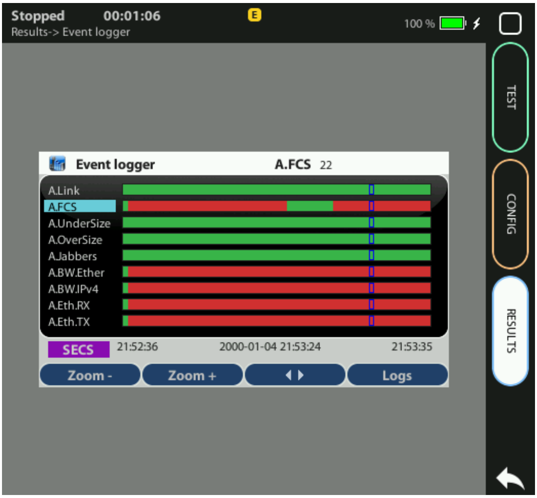

Stopped
00:01:06
Results-> Event logger
E
100 %
TEST
CONFIG
RESULTS
Event logger
A.FCS 22
A.Link
A.FCS
A.UnderSize
A.OverSize
A.Jabbers
A.BW.Ether
A.BW.IPv4
A.Eth.RX
A.Eth.TX
SECS
21:52:36
2000-01-04 21:53:24
21:53:35
Zoom -
Zoom +
◀ ▶
Logs

Figure 5.3: xGenius event logger panel. This panel traces all events previously selected from the event filter.

1. From the *Home* panel, go to *RESULTS*,
The *Results* panel is displayed.
2. Select *Event logger* to enter in event tracer.
3. Press *Logs*.
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.
5. Use the cursors to browse the events registered at different times. You can set the display scale to seconds (SECS), minutes (MINS), hours (HOURS) and days (DAYS) with the help of the *Zoom+* and *Zoom-*. . Toggle between quick and slow event browsing if necessary.

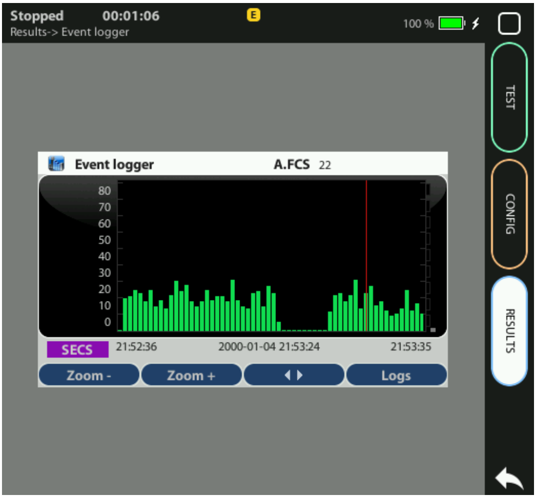

Stopped
00:01:06
E
Results-> Event logger
100 %
TEST
CONFIG
RESULTS
Event logger
A.FCS 22
80
70
60
50
40
30
20
10
0
SECS
21:52:36
2000-01-04 21:53:24
21:53:35
Zoom -
Zoom +
Logs

Figure 5.4: xGenius detailed view of events.

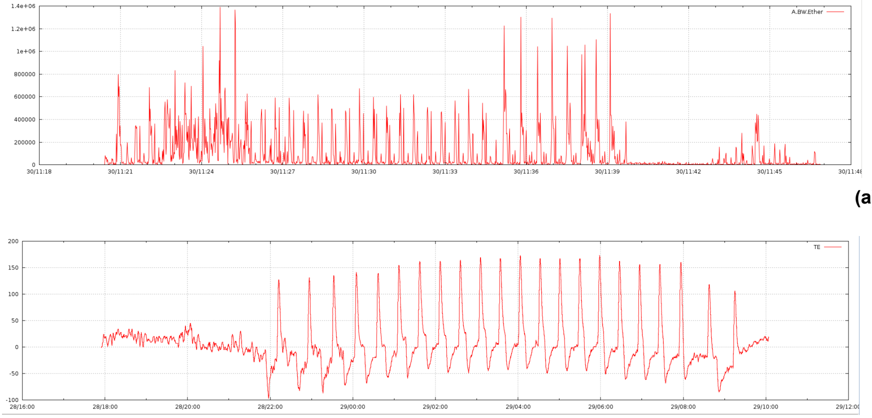
5.4.3. Exporting Logs

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 log file follow these steps:

1. Insert a compatible SD / HCSD card or a USB memory stick in the correct test unit ports.
2. From the *Home* panel, go to *RESULTS*,
The *Results* panel is displayed.

3. Select *Event logger* to enter in event tracer.
4. Press *Logs*.
   A list with all the available trace files is displayed. Files are identified by the measurement start date and time.
5. Select one or several trace files and export them with the help of the *Export* control.
   A progress bar is displayed
6. Wait to the end of the file export process. The whole process may take a few seconds



(a)

(b)

Figure 5.5: Plots generated from CSV files exported from xGenius.

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). There is an alternative path to export files directly to an external computer when the test unit management interface is connected to a network by using the xGenius web interface (See section 11.2.6)

5.5. BER Testing

xGenius testers support Bit Error Rate (BER) testing over framed and unframed interfaces. The former computes the BER over Ethernet or IP interfaces, the later doesn't take into account the frame structure associated to the Ethernet interface and accounts for bit errors directly in the physical layer.

5.5.1. Framed BER Tests

Framed BER tests are compatible with Ethernet and IP interfaces. It is even possible to carry out a BER test between specific source and destination UDP ports.

Table 5.8: BERT Results

Metric	Description
TSE	Test Sequence Error. One TSE is equivalent to a single bit difference between the transmitted and the received test pattern (PRBS or other). This field is a cumulative counter of all the TSE events found from the beginning of the test. In framed Ethernet interfaces transmission errors may cause the test patterns to be altered and produce bit errors. However, the Ethernet FCS field contains a CRC-32 code designed for error detection. For this reason, the receiver (or any intermediate network element) may detect and discard the frame before any TSE is detected by the pattern analyser. The only way to account for TSE errors would be to recompute the FCS field after any transmission error.
BER	The Bit Error Ratio (BER) this is the ratio of the received TSE to the total amount of transmitted bits. The BER is one of the most fundamental quality parameters of TDM digital circuits. However, due to other degradation sources specific of statistically multiplexed networks (frame loss, variable frame delay), the performance description based on the BER may be incomplete in Ethernet / IP networks.
ES	This is the amount of Errored Second (ES) outcomes from the beginning of the test. An ES is defined as a second which contains at least one TSE or a higher order defect like an LSS.
LSS	Loss of Sequence Synchronization. This event indicates that the expected test pattern does not match the actually received pattern. Frame loss events may cause temporary LSS.

Framed BER test is not as useful in Ethernet as it is in TDM networks but it can be used to trace connectivity with remote equipments and detect any temporary availability fault. The tester considers that a frame contains bit errors when the test pattern carried by the frame does not match the expected pattern but the checksum fields are still correct. For this reason, xGenius Test Sequence Error (TSE) events are closer to corrupted frame events than to real transmission errors. In framed interfaces, transmission errors are likely to cause checksum errors and they are discarded before they can reach the test pattern analyser. In other words, for the tester, checksum errors (FCS errors, IPv4 errors, UDP errors) have higher precedence than bit errors. For this reason, transmission errors are usually accounted as a simultaneous checksum error and a lost frame event rather than a TSE event.

xGenius testers include one single test pattern generator (Port A) and two pattern analysers (one for Port A and one for Port B). Pattern generator is bound with Flow 1 while traffic analysers are attached to Filter 1.

Before running a framed BER test, first you need to make sure that your equipment is configured in *Ethernet endpoint* or *IP endpoint modes* (See section 2.1). The traffic generator must be configured in the same way than any other traffic test, including the physical layer settings, frame settings, the network settings and the bandwidth profile (See chapter 4). The procedure to configure the test is as follows:

1. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
2. Select either *Port A* or *Port B* to enter in the port specific configuration.
3. Enter in the *Payload* menu.
4. Select *Flow 1* to enter in the flow 1 specific configuration.
   All settings related with payload configuration in the current flow are displayed.
5. Choose one of *BERT* in *Payload type* (See section 4.1.4).
6. Choose the bit pattern you are going to use for generation (Port A) and analysis (Port A and Port B) with the help of the *BERT patterns* control.
7. If you have configured *BERT patterns* to *User*, enter a 32-bit test pattern in *User payload* in hexadecimal format.

Once the test has been configured it can be started at any time with the help of the RUN button. BER results for the last (or current) test are available at any time:

1. From the *Home* panel, go to *Results*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Go to BERT
4. Select *Filter 1* to enter in the flow 1 specific results.
5. Check the *TSE BER*, *ES*, and *LSS* results.

5.5.2. Physical Layer BER Tests

The Physical Layer BER or L1 BER test measures the same parameters than the framed BER test but it is based on much simpler test patterns. Unlike the framed patterns, L1 patterns are fixed and not editable by the user. Some of them carry a minimum envelope like a preamble, an FCS or an IFG that enable some network elements to process the data stream in the same way than a framed flow. The advantage of L1 test patterns is that they are processed as a byte stream by the analyser (as opposed to a frame sequence). The result is a more accurate description of the transmission performance in terms of bit errors. On the other hand, L1 test patterns do not contain source and destination addresses or CoS labels to force the stream to follow an specific path in the network. Moreover, there is not a “bandwidth profile” you can use with L1 patterns, they are just byte sequences. At best, when they are carried within an Ethernet envelope, they use the whole capacity in the transmission interface.

The test unit supports three types of L1 test patterns referred as L1-unframed, L1-PCS-synchronized patterns and L2-compliant patterns. These are the properties of each type:

- *L1-unframed patterns:* They are constituted by a basic bit stream operating at the nominal speed defined for the interface. These patterns do not pass through network elements expecting an Ethernet stream but they are still useful to test the optical signal or data paths through L1 circuits not involving any Ethernet processing, even at the most basic level.
- *L1-PCS-synchronized patterns*: These patterns are defined by a sequence of *Physical Coding Sublayer* (PCS) symbols. For 1 Gb/s interfaces, L1-PCS-synchronized patterns are defined in terms of 8B/10B symbols. The pattern is not created as an 8-bit (8B) symbol and then converted to the correct 10-bit (10B) code. The result is that L1-PCS-synchronized patterns can be analysed at the bit level. L1-PCS-synchronized traffic passes through any circuit that has not any subsystem requiring valid MAC addressing or valid FCS codes.
- *L2-compliant patterns*: These test patterns are designed to resemble an Ethernet frame. The pattern is similar to a basic frame through de data link layer, including a preamble with a valid *Start of Frame Delimiter* (SFD), a FCS code and the correct encoding if the inter-frame gap. The pattern, however, overwrites all other parts of the frame, including MAC and IP addresses. L2-compliant patterns pass through any element looking for a valid Ethernet frame with FCS.

In xGenius, L1-PCS-synchronized patterns are supported only by the optical interfaces. L2-compliant patterns are available from all physical interface configurations.

Table 5.9: Test Patterns for Unframed Operation

Setting	**Description**
RPAT	*Random Data Pattern*. This is a L1-PCS-synchronized test pattern defined in the NCITS TR-25-1999. This pattern is designed to provide energy across the entire frequency spectrum, and they provide a good basic BER test. The RPAT consists on the continuous repetition of the following sequence expressed in hexadecimal format: 0x3e-b0-5c-67-85-d3-17-2c-a8-56-d8-4b-b6-a6-65. The RPAT is available for optical L1 BER tests only.
JPAT	*Jitter Tolerance Pattern*. This is a L1-PCS-synchronized test pattern defined in the NCITS TR-25-1999. This test is designed for receiver jitter tolerance testing. The JPAT consists on the cyclic transmission of the following 8B/10B symbol sequence: D30.3 (repeated 192 times) and D21.5 (repeated 64 times)
SPAT	*Supply Noise test pattern*: This is a L1-PCS-synchronized test pattern defined in the NCITS TR-25-1999. It represents the worst-case power supply noise introduced by a transceiver. The SPAT consists on the cyclic transmission of the following hexadecimal pattern: 0xac-d4-ca-cd-4c (512 times). The SPAT is available for optical L1 BER tests only
HFPAT	*High Frequency test pattern*. This is a L1-PCS-synchronized test pattern defined in Annex 36A of the IEEE 802.3 standard. The purpose of the pattern is to test random jitter at a BER of 10^{-12}, and also to test the asymmetry of transition times. The HFPAT consists in the continuous repetition of the D21.5 code-group and it corresponds with the following bit sequence: 1010101010101010... The RPAT is available for optical L1 BER tests only.

Table 5.9: Test Patterns for Unframed Operation

Setting	Description
LFPAT	*Low Frequency test pattern*. This is a L1-PCS-synchronized test pattern defined in Annex 36A of the IEEE 802.3 standard. The purpose of this pattern is to test low-frequency random jitter and also to test PLL tracking error. The LFPAT consists on the continuous repetition of the K28.7 code-group and it corresponds with the following bit sequence: 11111000001111100000... The RPAT is available for optical L1 BER tests only.
MFPAT	*Mixed Frequency test pattern*.This is a L1-PCS-synchronized test pattern defined in Annex 36A of the IEEE 802.3 standard. The purpose of this pattern is to test the combination of random and deterministic jitter. The MFPAT consists on the continuous repetition of the K.28.5 code-group and it corresponds with the following bit sequence: 11111010110000010100111110101 1... The RPAT is available for optical L1 BER tests only.
LCRPAT	*Long Continuous Random test pattern*. This a L2-compliant test pattern defined in Annex 36A of the IEEE 802.3 standard. This pattern is designed to provide a broad spectral content and minimal peaking, allowing for the measurement of jitter at either the component or system level. The structure of the LCRPAT is based on cyclic transmission of a valid preamble, SDF sequence, the modified RPAT sequence repeated 126 times, a valid FCS and a 12-byte IFG The modified RPAT consists on the following sequence before the 8B/10B encoding: 0xbe-d7-23-47-6b-8f-b3-14-5e-fb-35-59.
SCRPAT	Sort Continuous Random test pattern. This is a L2-compliant test pattern defined in Annex 36A of the IEEE 802.3 standard. This pattern is designed to provide a broad spectral content and minimal peaking, allowing for the measurement of jitter at either the component or system level. The SCRPAT pattern structure is identical to the LCRPAT but the modified RPAT is repeated only 29 times resulting in shorter MAC frames.

Table 5.9: Test Patterns for Unframed Operation

Setting	Description
A / B-Seed	This code is a L1-PCS-synchronized test pattern generated by loading predefined seeds *An*, *Bn*, *Ai*, *Bi* in an scrambler with polynomial $G(X) = 1 + X^{39} + X^{58}$ and predefined sequences at the scrambler input. The scrambler and the input is reset every 128 blocks (each block corresponds with a 64 bit code). As there are four seeds and four inputs, the pattern repeats every 512 blocks. The four seeds are defined as follows: • An: 0x3c-8b-44-dc-ab-68-04-f • Bn: 0x34-90-6b-b8-5a-38-88-4 • Ai: Results from bit wise inversion of An • Bi: Results from bit wise inversion of Bn The inputs are 0x00-00-00-00-00-00-00-00 (64-zeros), 0x55-00-00-01-00-00-00-01 (Local fault ordered set) and their inverted versions. The A/B-Seed pattern is available for 10 Gb/s interfaces only.
PRBS $2^{31}-1$	This code is a L1-unframed pattern corresponding with the output generated by a displacement register with polynomial $G(X) = 1 + X^{28} + X^{31}$.

The testers include one L1 test pattern generator (Port A) and two pattern analysers (one for Port A and one for Port B). For a L1 BER test it is required one test pattern generator and at least one analyser. Generators and analysers can be physically located in one or various units. Configuration of L1 BER tests is slightly different than the L2-L4 framed BER test. The procedure is as follows:

1. Make sure that your tester is connected to the network.
   Note: Depending on your test setup you may need to connect various equipments, including traffic reflectors in the network.
   Note: Testing with L1-PCS-synchronized patterns (optical tests) does not require link establishment. Pattern generation is started as soon as testing starts without waiting for link auto-negotiation or other link establishment mechanism to finish.
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 *L1 Endpoint*. Confirm by pressing ENTER.
4. Select either *Port A* or *Port B* to enter in the port specific configuration.

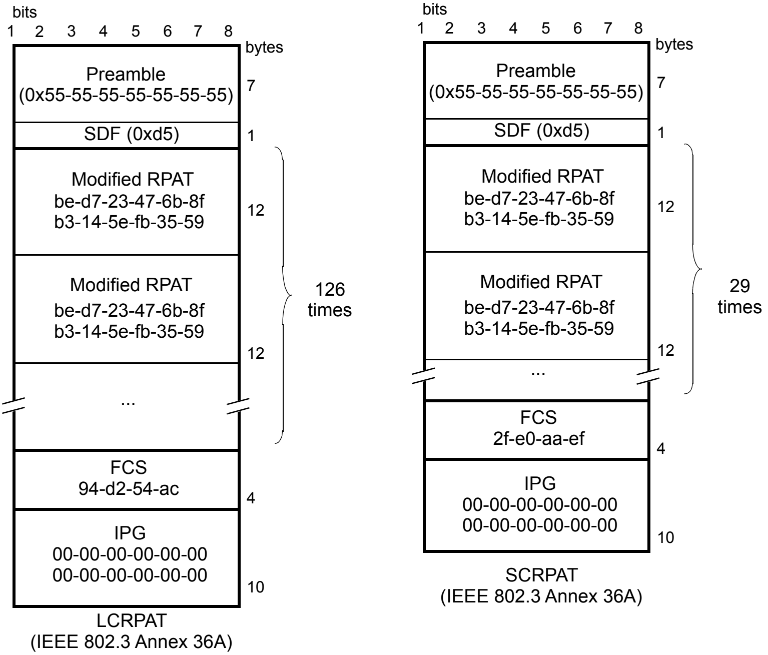

bits
1 2 3 4 5 6 7 8
bytes
Preamble
(0x55-55-55-55-55-55-55)
7
SDF (0xd5)
1
Modified RPAT
be-d7-23-47-6b-8f
b3-14-5e-fb-35-59
12
Modified RPAT
be-d7-23-47-6b-8f
b3-14-5e-fb-35-59
12
...
126
times
FCS
94-d2-54-ac
4
IPG
00-00-00-00-00-00
00-00-00-00-00-00
10
LCRPAT
(IEEE 802.3 Annex 36A)
bits
1 2 3 4 5 6 7 8
bytes
Preamble
(0x55-55-55-55-55-55-55)
7
SDF (0xd5)
1
Modified RPAT
be-d7-23-47-6b-8f
b3-14-5e-fb-35-59
12
Modified RPAT
be-d7-23-47-6b-8f
b3-14-5e-fb-35-59
12
...
29
times
FCS
2f-e0-aa-ef
4
IPG
00-00-00-00-00-00
00-00-00-00-00-00
10
SCRPAT
(IEEE 802.3 Annex 36A)

Figure 5.6: L2 compliant patterns supported by the ALBEDO Telecom family of Ethernet Generators / Analysers.

5. Go to *L1 BERT pattern* and select one or *RPAT*, *JPAT*, *SPAT*, *HFPAT*, *LFPAT*, *MFPAT*, *LCRPAT*, *SCRPAT*, *A/B-Seed* or *PRBS* 2^{31}*-1*.

   Note: *RPAT*, *JPAT*, *SPAT*, *HFPAT*, *LFPAT,MFPAT, A/B-Seed and PRBS* 2^{31}*-1* patterns are not available in BER tests through electrical interfaces.
   Note: Depending on your particular test setup you may need to repeat this operation both Port A and Port B.

Once the test has been configured it can be started at any time with the help of the RUN button. BER results for the last (or current) test are available at any time:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Go to *BERT*
4. Select *Physical layer BERT* to enter in the L1 BER test results.
5. Check the *TSE, BER*, *ES*, and *LSS* results.

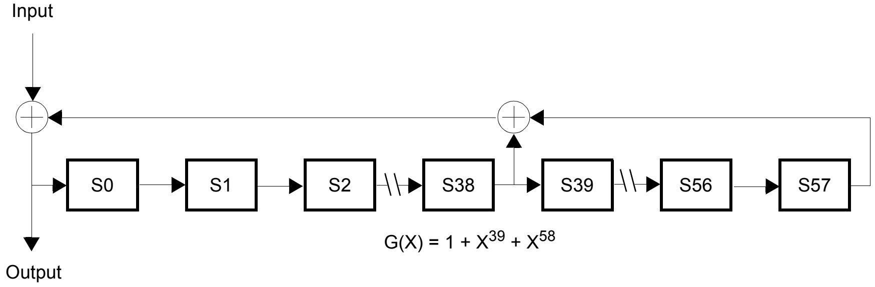


Figure 5.7: This diagram represents the scrambler required to generate the A-Seed and B-Seed patterns for 10 Gb/s LAN interfaces.

5.6. Service Disruption Time

The *Service Disruption Time* (SDT) test enables xGenius to find short Ethernet service interruptions.Some service disruptions are caused by problems 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 5.10: 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.

The SDT testing methodology requires the test unit to receive a constant bit rate of test frames. A warning message is displayed if the message rate is not large enough to achieve an accuracy level of 1 ms.The SDT is compatible both with *Ethernet endpoint* and *IP Endpoint* operation modes. 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. The physical layer must be up and working (See section 4.1.1) in all test ports to be used during the test.
2. Configure the test unit to generate al least 1000- frames/s (See section 4.1, See section 4.2)
3. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
4. Configure *Test mode* to *One-way (A > B)* if you want to run the SDT in port B or to *Two-way (A > A)* if you want to run the test in port A.
5. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
6. Go to *Port B* if you have configured *One-way (A > B)* or to *Port A* if you have configured *Two-way (A > A).*
7. Go to *Service disruption time*.
8. Start the test by pressing *RUN*.
9. Check the *Disruptions*, *Total*, *Average*, *Minimum*, *Maximum* and *Last* results.
   Note: The accuracy in these results may not be the optimum if the test frame rate is below 1000 frames/s. In this case a *Measuring (low rate)* message is displayed in the results screen.

Chapter 6

Multi-Stream Analysis

xGenius is capable of processing and computing statistics over fractions of the Ethernet / IP traffic meeting specific conditions. The process of selecting a fraction of traffic is called filtering. The result of the filtering process is one or several traffic streams.

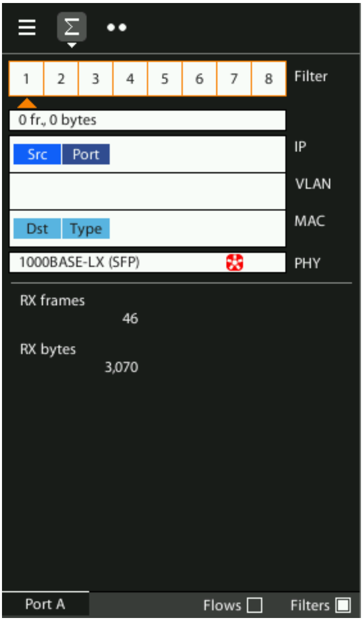
This chapter describes how to configure the tester for packet filtering and how to get statistics and results from each stream. These results can be classified in different categories:

- How many frames made up the traffic stream to be analysed. For example, filters can tell you how many frames have been received from an specific flow from the beginning of the test.
- The filter analysis tells what kind of data contains the traffic stream under analysis. For example, it the stream has at least some frames with the test payload required to measure SLA statistics you will be informed with an special indication.
- Filters are useful to get information about how much of the available bandwidth is being used by a traffic stream. If, for example, you choose to filter all broadcast IP packets (destination IPv4 address set to 255.255.255.255) you will measure how much traffic is consumed by broadcast traffic in your network like for example in ARP requests.
- Finally, the test unit provides per-filter information about critical SLA parameters like delay, delay variation or packet loss. It depends of the filtering criteria you are using that the SLA results you get are meaningful for your purposes or not.

6.1. Enabling and Disabling Filters

Traffic selection or filtering is configured by first enabling one or several filtering blocks and after that setting the filtering criteria. xGenius supports Ethernet, VLAN, IPv4 and TCP / UDP filters.

The test unit is equipped with 8 filters. Each filter has a priority number. If one frame is selected by an specific filter it will not be processed by any lower priority filters. In other words, traffic is processed by at most one matching filter, the one with the highest precedence.



RX frames
46

RX bytes
3,070

Figure 6.1: Filter summary panel. Filter status can be checked from this panel.

A filter admits three different configurations:

- *Block*: The filter blocks all the incoming traffic. No frame can match the filter. It can be considered that the filter remains disabled if it is configured to the block status.
- *Custom*: The filter accepts user defined matching rules like matching an specific VLAN, a group of source IP addresses and many others.
- *Match TX*: Matches the traffic configured in the corresponding flow from the traffic generator (*Filter 1* matches *Flow 1*, *Filter 2* matches *Flow 2*, etc.). Port B does not have traffic generation capabilities and therefore it attempts to match traffic transmitted at port A. The way traffic is matched in Port A and Port B filters is different. Port A expects that MAC addresses, IP addresses and UDP ports will be reversed when compared with the generator settings. For example, Port A filters look for the IP address configured as a source in the IP destination address field of incoming traffic. This address reversal rule does not apply to Port B.

Current filtering configuration is always available from the summary screen. In this screen use the F1 / F2 contextual buttons to choose between Port A or Port B filters and the F4 contextual button to display filtering configuration. The right / left cursors can be used to increase or decrease the filter index (*Filter 1*, *Filter 2*,...)

6.2. Configuring Filters

To allow the filter to accept and process frames, a correct filtering criteria must be configured before being used.

To configure the correct filtering criteria two decisions must be taken. First, it is necessary to know which frame fields are going to be matched and after that, which are the value or values to be matched. The first decision involves choosing whether the filtering is going to be done at MAC, IP or transport layer and which specific frame field or fields are going to be used for filtering (MAC addresses, IP addresses, Ethertype field, protocol or any other). The second is carried out by configuring the field value and sometimes a mask. The mask selects which field bits are taken into account when a frame is matched. Matching masks are not related to IP subnet masks even if they can be applied to IP addresses. Specifically, the binary representation of a matching mask does not need to be a sequence of '1' followed by a sequence of '0' like IP network masks are.

The generic procedure to configure one or several matching criteria in the test unit is the following:

1. From the *Home* panel, go to *CONFIG*,
   The test port settings panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific configuration.
3. Enter in *Filters*
4. Select one of the filtering menus labelled as *Filter 1*, *Filter 2*, etc.
   All configuration items related with the filter configuration are displayed.
5. Configure Filter mode to one of *Block*, *Custom* or *Match TX* values
   Block and *Match TX* have fixed filtering rules but if you choose custom, different types of filtering rules are enabled for that filter: *Fixed offset*, *MAC*, C-*VLAN, S-VLAN, IPv4*, *IPv6, UDP*.
6. If you have configured *Custom* filtering, select the matching rule.
7. For custom filters, choose a matching field and configure the matching mode for this field. Most of the matching fields have at least two matching modes. The *Equal* mode selects frames matching the configured value or values for the field and *Ignore* does not match any frame by the current field. Other matching modes may be available in specific fields.
8. Configure the field value to be matched by the filter.
9. If the matching field has this capability, enter the mask value. To select a single value, set of the mask bit values to all ones.
10. Optionally, configure more matching rules for the current filter by repeating steps 3, 4, 5, 6 and 7 as many times as necessary.

6.2.1. MAC Selection

MAC frames are envelopes in which the Ethernet frames are sent and received. MAC frame format is currently specified by the standard IEEE 802.3. This format is shared by all existing Ethernet interfaces thus making Ethernet the most scalable transmission technology currently available.

xGenius provides frame selection based on the MAC address source and destination and Ethertype value. It is possible to configure a matching mask for all three fields to select a value set rather than a single value.

Table 6.1: MAC Selection

Field	Description
Source MAC address match	Enables selection by source MAC address in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The source MAC address is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Equal to*: All frames matching a user configurable pattern are allowed to pass through the filter. The matching pattern is configured with the help of the *Source MAC address* and *Source MAC address mask* fields.
Source MAC address	This is a 48-bit MAC address in the standard hexadecimal-digit format *XX:XX:XX:XX:XX:XX*. Source addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching frames to this filter are configured in the *Source MAC address mask*.
Source MAC address mask	This is the mask for the source MAC address filter selection rule. Before comparing the *Source MAC address* field with the frame addresses, bit wise AND operations are carried out between the value configured here and the *Source MAC address* field so that only the values surviving the AND are taken into account for matching the filter.
Destination MAC address match	Enables selection by destination MAC address in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source MAC address selection* setting.

Table 6.1: MAC Selection

Field	Description
Destination MAC address	This is a 48-bit MAC address in the standard hexadecimal-digit format *XX:XX:XX:XX:XX:XX*. Destination addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching frames to this filter are configured in the *Destination MAC address mask*.
Destination MAC address mask	This is the mask for the destination MAC address filter selection rule. Before comparing the *Destination address* field with the frame addresses, bit wise AND operations are carried out between the value configured here and the *Destination address* field so that only the values surviving the AND are taken into account for matching the filter.
Ethertype match	Enables selection by Ethertype value in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source address selection* and *Destination address selection* settings.
Ethertype	This setting contains a 2-byte field that constitutes the Ethertype value to be matched in the incoming traffic. Ethertypes matching some or all bytes of the value configured here will be allowed to pass through the filter. Bits used for matching frames to this filter are configured by means the *Ethertype mask*.
Ethertype mask	This is the mask for the Ethertype filter selection rule. Before comparing the *Ethertype* field with the frame Ethertype, bit wise AND operations are carried out between the value configured here and the *Ethertype* field so that only the values surviving the AND are taken into account for matching the filter.

6.2.2. C-VLAN and S-VLAN Selection

Within enterprise networks, VLANs are important because they enable network segmentation on an organisational basis, by functions, project teams or applications, rather than on a physical or a geographical basis. The network can be reconfigured through software, instead of physically unplugging and moving devices or wires.

VLANs are an important contribution to scalable Ethernet networks, because they limit broadcast traffic inherent to the bridging mechanism. Large amounts of broadcast traffic may damage performance and even collapse network equipment, which is why it must be controlled.

Standard IEEE 802.1Q specifies the most popular VLAN frame format. VLAN frames carry a 16-bit header which specifies the VLAN Identifier (VID) and the frame priority within the VLAN. Many carrier Ethernet networks use the VID for segmentation just like enterprises. The VID in carrier Ethernet networks is used by service providers as general purpose identifier. They can be associated to an specific service, customer, node or several of them at the same time. Sometimes, service providers use a two-level VLAN structure. Levels are designated as customer VLAN (C-VLAN) and service VLAN (S-VLAN). This two-structure is know as Q-in-Q. The standardised version of the Q-in-Q frame is defined in IEEE 802.1ad. The test unit supports both single-level Q-frame and the two-level Q-in-Q-frame.

Table 6.2: C-VLAN and S-VLAN Selection

Field	Description
VID match	Enables selection by VID in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The VID is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Equal to*: All frames matching a user configurable pattern are allowed to pass through the filter. The matching pattern is configured with the help of the *VID* field.
VID	This setting contains a 10-bit identifier that constitutes the VID value to be matched in the incoming traffic. It is possible to match the S-VID or the C-VID through separated entries in the filtering menu. For single-tagged frames it is assumed that the frame does not contain S-VID field and therefore configuration is done through the C-VLAN menu.
Priority codepoint match	Enables selection by IEEE 802.1Q/p priority bits in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *VID match* field.

Table 6.2: C-VLAN and S-VLAN Selection

Field	Description
Priority codepoint	This setting contains a 3-bit identifier that constitutes the priority value to be matched in the incoming traffic. It is possible to match the S-VLAN or the C-VLAN priority codepoints through separated entries in the filtering menu. For single-tagged frames it is assumed that the frame does not contain S-VLAN priority codepoint field and therefore configuration is done through the C-VLAN menu.
Drop-eligible indicator match	Enables selection by the S-VLAN drop-eligible indicator in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and with ones are blocked. The available configuration values for this field are the same that for the *VID match* field.
Drop-eligible indicator	This is a single bit field that is used to signal which frames have precedence when the node has to drop some information due to congestion or other causes. The Drop-eligible indicator is defined only for the S-VLAN tag of double-tagged frames.For this reason is only available for S-VLAN matching rules.

6.2.3. MPLS Selection

MPLS traffic carry one or various 4-byte headers. Each of these headers is made up of a 20-bit MPLS label, a 3-bit traffic class identifier and other fields (See section 4.2.2). The filtering capabilities of the test unit can be used to match MPLS header field of IP packets carrying up to two different labels.

Table 6.3: MPLS Selection

Field	Description
Bottom label match	Enables selection based on the bottom MPLS label in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The bottom MPLS label is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Equal to*: All frames matching a user configurable MPLS label are allowed to pass through the filter. This label is configured with the help of the *Bottom label* field.

Table 6.3: MPLS Selection

Field	Description
Bottom label	Bottom of the stack MPLS label. It is 20-bit MPLS label in decimal format. Labels are used for switching packets in MPLS networks. Labels have local meaning only. That means that a single LSP could have different MPLS labels in different links between different routers
Bottom traffic class match	Enables selection based on the class of service bits included in the top MPLS label in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The bottom class of service field is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Equal to*: All frames matching a user configurable class of service field are allowed to pass through the filter. The class of service field is configured with the help of the *Bottom traffic class* field.
Bottom traffic class	Bottom 3-bit MPLS CoS identifier. It was first thought that this field could carry the 3 IPv4 Type-of-Service (ToS) bits, but currently, the ToS field is being replaced by 6-bit *Differentiated Services Code Points* (DSCP). This means that only a partial mapping of all the possible DSCPs into this field is possible.
Top label match	Enables selection based on the top MPLS label in the current filter. Top label matching makes sense only if the received packets carry two MPLS labels. In this case the top label is the one placed closer to the layer two header. The available configuration values for this field are the same that for the *Bottom label match* setting.
Top label	Top of the stack MPLS label. It is 20-bit MPLS label in decimal format. Labels are used for switching packets in MPLS networks. Labels have local meaning only. That means that a single LSP could have different MPLS labels in different links between different routers
Top traffic class match	Enables selection based on the class of service bits included in the top MPLS label in the current filter. The available configuration values for this field are the same that for the *Top label match* setting.

Table 6.3: MPLS Selection

Field	Description
Top traffic class	Top 3-bit MPLS CoS identifier. It was first thought that this field could carry the 3 IPv4 Type-of-Service (ToS) bits, but currently, the ToS field is being replaced by 6-bit *Differentiated Services Code Points* (DSCP). This means that only a partial mapping of all the possible DSCPs into this field is possible.

6.2.4. IPv4 Selection

The test unit filtering capabilities can be programmed to match fields within the IPv4 datagram. It is currently supported IP datagram matching based on source IP address, destination IP address, protocol and DSCP. Source and destination IP addresses can be matched by means selection masks.

Table 6.4: IPv4 Selection

Field	Description
Source IPv4 address match	Enables selection by source IPv4 address in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The source IP address is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Equal to*: All frames matching a user configurable pattern are allowed to pass through the filter. The matching pattern is configured with the help of the *Source IPv4 address* and *Source IPv4 address mask* fields.
Source IPv4 address	This is a 32-bit IPv4 address in the standard four-dotted decimal format *A.B.C.D*. Source addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching frames to this filter are configured in the *Source address mask*.
Source IPv4 address mask	This is the mask for the source IPv4 address filter selection rule. Before comparing the *Source address* field with the frame addresses, bit wise AND operations are carried out between the value configured here and the *Source address* field so that only the values surviving the AND are taken into account for matching the filter.

Table 6.4: IPv4 Selection

Field	Description
Destination IPv4 address match	Enables selection by destination IPv4 address in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv4 address match* setting.
Destination IPv4 address	This is a 32-bit IPv4 address in the standard four-dotted decimal format *A.B.C.D*. Destination addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching frames to this filter are configured in the *Destination address mask*.
Destination IPv4 address mask	This is the mask for the source IPv4 address filter selection criteria. Before comparing the *Source address* field with the frame addresses, bit wise AND operations are carried out between the value configured here and the *Source address* field so that only the values surviving the AND are taken into account for matching the filter.
IP protocol match	Enables selection by the 1-byte IPv4 protocol field in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv4 address match* setting.
IP protocol	Configures the protocol to be filtered when protocol selection is enabled. The available configuration values are the following: • *Numeric*: Use this control if the traffic to be matched is different of UDP, TCP and ICMP and it has an specific protocol identifier assigned by the IANA. • *UDP*: Matches traffic with a *User Datagram Protocol (UDP)* envelope. Traffic commonly transported over UDP includes IP voice, IP video and DNS. • *TCP*: Matches traffic carried over the Transfer Control Protocol (TCP). Most data applications (web, file transfer, e-mail...) ere normally based on TCP transport. • *ICMP*: Matches *Internet Control Message Protocol* packets. IP operation and maintenance traffic like ping use ICMP.

Table 6.4: IPv4 Selection

Field	Description
IP protocol number	This setting contains an 8-bit word that constitutes the protocol identifier to be matched in the incoming traffic. Configuring this field to 17 is equivalent of setting the *Standard protocol selection* to UDP. TCP uses 6 as the protocol number and ICMP uses number 1. This control is enabled only if Standard protocol selection has been previously set to *Numeric*.
DSCP match	Enables selection by the 6-bit DSCP field in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv4 address match* field.
DSCP	This setting contains a 6-bit word in decimal format that constitutes the DSCP to be matched in the incoming traffic.

6.2.5. IPv6 Selection

Version 6 of the IP protocol is increasingly important in current network deployments. For this reason, the test unit supports filtering based on various IPv6 packet fields including addresses, CoS marks, flow labels and higher layer protocol identifiers.

Table 6.5: IPv6 Selection

Field	Description
Source IPv6 address match	Enables selection by source IPv6 address in the current filter. The value configured here is used to determine which packets are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The source IP address is ignored and not taken into account for the purpose of the filter. All packets are allowed to pass through the filter when *Ignore* is configured if they are not blocked by other selection rule. • *Equal to*: All packets matching a user configurable pattern are allowed to pass through the filter. The matching pattern is configured with the help of the *Source IPv6 address* and *Source IPv6 address mask* objects.

Table 6.5: IPv6 Selection

Field	**Description**
Source IPv6 address	This is a 128-bit IPv6 address in the *A:B:C:D:E:F:G:H* format, where *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H* are hexadecimal numbers between *0000* and *ffff*. Source addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching packets to this filter are configured by means the *Source IPv6 address mask* field.
Source IPv6 address mask	This is the mask for the source IPv6 address filter selection rule. Before comparing the *Source IPv6 Address Match* field with the actual IPv6 addresses, bit wise *AND* operations are carried out between the value configured here and the source address so that only the values surviving the *AND* are taken into account for matching addresses.
Destination IPv6 address match	Enables selection by destination IPv6 address in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv6 address match* setting.
Destination IPv6 address	This is a 128-bit IPv6 address in the *A:B:C:D:E:F:G:H* format, where *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H* are hexadecimal numbers between *0000* and *ffff*. Destination addresses matching some or all bits of the address configured here will be allowed to pass through the filter. Bits used for matching packets to this filter are configured by means the *Destination IPv6 address mask* field.
Destination IPv6 address mask	This is the mask for the destination IPv6 address filter selection rule. Before comparing the *Destination IPv6 Address Match* field with the actual IPv6 addresses, bit wise *AND* operations are carried out between the value configured here and the source address so that only the values surviving the *AND* are taken into account for matching addresses.
Next Header match	Enables selection by the 8-bit IPv6 next header field in the current filter. The value configured here is used to determine which packets are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv6 address match* setting.

Table 6.5: IPv6 Selection

Field	Description
Next Header	Configures the protocol identifier to be filtered when *Next Header matching* is enabled. The available configuration values are the following: • *Numeric*: Use this control if the traffic to be matched is different of UDP, TCP and ICMP and it has an specific protocol identifier assigned by the IANA. • *UDP*: Matches traffic with a *User Datagram Protocol (UDP)* envelope. Traffic commonly transported over UDP includes IP voice, IP video and DNS. • *TCP*: Matches traffic carried over the Transfer Control Protocol (TCP). Most data applications (web, file transfer, e-mail...) ere normally based on TCP transport. • *ICMP*: Matches *Internet Control Message Protocol* packets. IP operation and maintenance traffic like ping use ICMP.
Next Header number	This object contains an 8-bit word that constitutes the next header identifier to be matched in the incoming traffic. For example, configuring this object to 17 matches UDP traffic, TCP uses 6 as the protocol number and ICMPv6 uses number 58. The *Next Header number* configuration field is enabled only if *Next Header* is configured to *Numeric*.
Flow Label match	Enables selection by the 20-bit IPv6 flow label field in the current filter. The value configured here is used to determine which packets are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv6 address match* setting.
Flow label	The *Flow Label* IPv6 field contains a 20-bit word that identifies an unidirectional data flow. These labels remain at disposal of intermediate routers for stateful and stateless processing at flow level. For example, the flow label could be used to prevent load balancing on a particular traffic flow.
DSCP match	Enables selection by the 6-bit differentiated services code point (DSCP) field in the current filter. The value configured here is used to determine which packets are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source IPv6 address match* field.

Table 6.5: IPv6 Selection

Field	Description
DSCP	This object contains a 6-bit word in decimal format that constitutes the DSCP to be matched in the incoming traffic.

6.2.6. UDP Selection

Some applications do not require reliable transmission at the transport layer either because they implement their own error control mechanisms or because the mechanisms used by TCP are too slow for them. These applications can use the light weight User Datagram Protocol (UDP). Like TCP, UDP provides communications through ports to applications but it doesn't have any error recovery capability.

Table 6.6: UDP Selection

Field	Description
Source port match	Enables selection by source UCP port in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: The source port is ignored and not taken into account for the purpose of the filter. No frame is selected by the filter when *Ignore* has been configured. • *Range*: All frames with a destination port in an specified range are allowed to pass through the filter. The port range is specified with the help of the *Minimum source port* and *Maximum source port* fields.
Minimum source port	This is the minimum 16-bit UDP source port allowed to pass through the *Source port match* filter. The port is configured and displayed in decimal format.
Maximum source port	This is the maximum 16-bit UDP source port allowed to pass through the *Source port match* filter. The port is configured and displayed in decimal format.
Destination port match	Enables selection by the 2-byte UDP protocol field in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are the same that for the *Source address match* field.
Minimum destination port	This is the minimum 16-bit UDP destination port allowed to pass through the Destination port selection filter. The port is configured and displayed in decimal format.

Table 6.6: UDP Selection

Field	Description
Maximum destination port	This is the maximum 16-bit UDP destination port allowed to pass through the Destination port selection filter. The port is configured and displayed in decimal format.

6.2.7. Fixed Offset Selection

Generic selection is the matching mode to be used when the Ethernet frames carry uncommon protocols or if inspection beyond the UDP and TCP transport protocols is required. This selection mode defines an offset and a mask. Frames matching the specified mask in the configured offset are selected.

Table 6.7: Generic Selection

Field	Description
Filter match	Enables fixed offset selection in the current filter. The value configured here is used to determine which frames are allowed to pass through the filter and which ones are blocked. The available configuration values for this field are: • *Ignore*: Generic matching is ignored and not taken into account for the purpose of the filter. All frames are allowed to pass through the filter when *Ignore* is configured if they are not blocked by other selection criteria. • *Equal to*: All frames matching a user configurable pattern are allowed to pass through the filter. The matching pattern is configured with the help of the *Payload selection*, *Offset (bytes)*, *Match code* and *Mask* fields.
Payload selection	Defines the payload type and the reference point within the frame to start counting the filter offset. The reference can be the beginning of the MAC, IPv4, IPv6 or UDP payload depending on the chosen value. It is also possible to set the reference to the beginning of the Ethernet frame (first byte immediately after the SDF) by configuring *Whole frame* in this field. The *Payload selection* field is shared by all the port A or port B filters. If the *Frame start* field is modified for one specific filter, the remaining filters of the same port will be automatically configured to the same value.

Table 6.7: Generic Selection

Field	Description
Offset (bytes)	This field defines the offset expressed in bytes from the reference point defined with the *Payload selection* control. The value 0 corresponds with the first byte of the MAC, IPv4 or UDP payload (or the first frame byte, if *Payload selection* is set to *Whole frame*). If due to the limited frame size, some or all the byte positions defined by the *Offset (bytes)* field, do not exist in the corresponding payload, the equipment will consider that the frame does not match the filtering criteria. The offset field is shared by all the port A or port B filters. If the *Offset (bytes)* field is modified for one specific filter, the remaining filters of the same port will be set to the same value.
Match code	16-bit code expressed with four hexadecimal digits used to match frames.in the current filter.
Mask	This is a mask for the generic filter match code. Before comparing the *Match code* with the selected bytes in the Ethernet frame, bit wise AND operations are carried out between the value configured here and the *Match code* field so that only the values surviving the AND are taken into account for matching the filter.

6.3. Per-Stream Counts and Statistics

Once the filter has been configured, it is usually desirable to know how many matching frames have been found for each filter and what are the matching traffic properties. xGenius offers a complete set of statistics for each of the eight filtered streams, including bandwidth and SLA metrics. To get general statistics about filtered frames follow this procedure:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Go to *Filters*
   A table with dedicated information for each filter is displayed.

4. Check the *Frames*, *Bytes* and *Traffic* results.

Table 6.8: General Filter statistics

Field	Description
Frames	Count of all frames matching the selection rule for the current filter.
Bytes	Byte count corresponding to the traffic stream associated with the current filter. Note that only with the *Frames* and *Bytes* results it is possible to compute new statistics like the average frame size of the matching traffic.
Traffic	Displays information about the traffic type detected during the last second. There are three possible results: • *None*: No traffic has been detected matching the filtering rules for the current filter during the last second. Either there is no traffic received in the port or the filter rules are too restricting to match any frame. • *Other*: At least one frame of network traffic matching the filter rules has been found during the last second. Traffic may come from anywhere in the network. • *SLA*: At least one frame carrying the ALBEDO Telecom SLA payload and matching the filter rules has been found during the last second. The SLA payload is ALBEDO proprietary and therefore it has probably been transmitted by an ALBEDO Telecom equipment. SLA statistics for the current filter cannot be calculated if no SLA traffic matching the filtering rules is received.

6.3.1. Bandwidth Statistics

Filter specific bandwidth statistics have the same meaning that the port-wide bandwidth statistics (See section 5.1.4) but in this case they are restricted to the traffic matching the filtering rules rather than the whole traffic received in the test port. Let’s suppose that you want to know how much bandwidth is using an IPTV stream in your network. If you know some information about the stream like for example the destination UDP port used by the stream packets or the destination multicast IP address you can use them as a filtering rules and the bandwidth statistics for the filtered traffic will provide the result in the Ethernet, IP and UDP layers.

The procedure to display the bandwidth statistics for each of the configured filters is as follows:

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

3. Go to *Bandwidth statistics.*
4. Select one of the filter menus labelled as *Filter 1*, *Filter 2*, etc.
   All the result menus related with the current filter are displayed.
5. Check the *Eth. (current)*, *Eth. (min.)*, *Eth (max.)*, *IPv4 (current)*, *UDP (current)* results.

6.3.2. SLA Statistics

SLA statistics are more similar to BER results than bandwidth statistics or error counts: Like it happens with BER results, SLA statistics require an special frame / packet payload. In this case, the payload to be used is the SLA payload (See section 4.1.4, See section 4.4.6). That means that the tester you are using as a traffic generator must be configured to use this payload to obtain any valid result.

Table 6.9: SLA Availability Statistics

Field	Description
Lost frames	Total amount of lost frames from the beginning of the test. One frame is considered to be lost if it is never received or if it is received with a delay larger than 10 seconds.
FLR	Ratio of the total amount of lost frames to the total transmitted frames from the beginning of the test. Definition of the FLR parameter follows ITU-T Y.1563.
SES	This is the amount of Severely Errored Second (SES) outcomes from the beginning of the test. The SES is computed as specified in ITU-T Y.1563. The frame loss threshold used to declare a SES is 50% of the frames that made up the transmitted block.
PEU (%)	Percent Ethernet service Unavailability defined as per ITU-T Y.1563 and recorded from the beginning of the test. The PEU constitutes a availability performance figure that informs about the percentage of time that the DUT / SUT has been not available for transmit / receive data.
Out-of-sequence frames	Total amount of packets received with an unexpected sequence number. Duplicated sequence numbers are not taken into account for computing the Out-of-sequence frame statistic. This metric is based on the definitions given in RFC 5236.

Table 6.9: SLA Availability Statistics

Field	Description
Duplicated frames	Total amount of frames received with a duplicated sequence number. A triplicated frame event is accounted as two duplicated frame events. The same reasoning is applied for frames repeated more than three times. The duplicated frames metric is based on the definitions given in RFC 5236.

It is possible to use the same test port for SLA traffic generation and analysis (Port A) or use Port A for traffic generation and Port B for analysis. Using Port A for generation and analysis requires a loop-back device somewhere in the network to redirect the traffic towards the origin (See section 2.2.3). It is also possible to generate traffic with one tester and use a remote equipment to analyse this traffic but delay statistics will be probably wrong or at least will have a poor accuracy due to the lack of a common timing source for the generator and the analyser.

The test unit supports SLA tests both in bridged environments (*Ethernet endpoint* test mode) and routed environments (*IP endpoint* test mode). Traffic generation in pass through mode is not supported, for this reason, there are no SLA results in *IP Through* mode.

The testers measure and represent up to eight sets of SLA statistics for each of the eight filter blocks. An important advise is that strictly, SLA results are meaningful only for frames carrying the SLA payload. Other traffic accounted in the same filter may be subject to different delay conditions. However, if one filter is receiving mixed (SLA and not SLA) traffic, it is possible to guarantee the representativeness of the SLA results if the correct filtering conditions are applied for the traffic. For example if it is know that the DUT / SUT is applying different forwarding policies depending only on the DSCP field, filters should be configured to use the DSCP as a filtering rule.

SLA results are timed, you need to start a test with run to enable the equipment to collect results. If you are using the equipment also as a test traffic generator you will also need to start a test to enable traffic generation. Once the test is configured and running you can access to the results. To configure and run an SLA test follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
   Note: To enable Port B SLA statistics the correct Test mode is One-way (A > B) and to compute the SLA statistics in Port A, Test mode has to be configured to Two-way (A > A).
3. Go to *SLA statistics*.

4. Select one of the filtering menus labelled as *Filter 1*, *Filter 2*, etc.
   All the result menus related with the current filter are displayed.
5. Go to either *Availability statistics* or *Delay statistics*.
6. If you have chosen *Availability statistics* in the previous step then check the *Lost frames*, *FLR*, *SES*, *PEU (%)*, *Out-of-sequence frames* and *Duplicated frames* results.If you have chosen *Delay statistics* in the previous step then check the *Current, Maximum*, *Minimum Average, Standard dev.iation* and *Range* values of the *FTD* and the *Current, Average* and *Maximum* values of the *FDV*.

Table 6.10: SLA Delay Statistics

Field	**Description**
FTD (current)	Current value of the point-to-point Ethernet Frame Delay computed as specified in ITU-T Y.1563 and expressed in ms. To display the current FTD it is required a previous initialization of a test with *Run*.
FTD (maximum)	Peak value of FTD registered from the beginning of the test. The *FTD (max)* value is a packet by packet computed statistic. All relevant SLA packets are considered for calculation of this statistics.
FTD (minimum)	Minimum value of FTD registered from the beginning of the test. The *FTD (min)* value is a packet by packet computed statistic. All relevant SLA packets are considered for calculation of this statistics.
FTD (average)	Average of all registered FTD values from the beginning of the test. All relevant SLA packets are considered for calculation of this statistics (no sampling process is involved in the calculation of this statistic).
FTD (standard deviation)	Standard deviation (positive square root of the variance) corresponding with all the registered FTD values from the beginning of the test. The standard deviation quantifies the delay dispersion or delay variation found in the DUT / SUT.
FTD (range)	This performance metric is the result of subtracting *FTD (min)* from *FTD (max).* The range is an alternative way to the standard deviation to quantify the delay dispersion found in the DUT / SUT.

Table 6.10: SLA Delay Statistics

Field	Description
FDV (current)	Current value of the jitter computed as per RFC 3393 and RFC 1889. Delay variation is computed over consecutively transmitted packets. The jitter value is smoothed with the function defined in RFC 1889 before being displayed. The current FDV constitutes still another metric to quantify the delay variation in the DUT / SUT. To display the current jitter it is required a previous initialization of a test with *Run*.
FDV (maximum)	Smoothed jitter maximum computed from the beginning of the test. The *FDV (max)* is a packet-by-packet statistic that does not involve any sampling process.
FDV (average)	Average of all individual delay variation values computed from the beginning of the test. Each individual delay variation is evaluated as the absolute value of the FTD associated to a given frame minus the FTD associated to the frame transmitted next. All possible consecutive frame transmission events are taken into account for the calculation of this performance metric. The only exception to this rule is if one or both frames are lost.

Chapter 7
Automatic Performance Tests

Automatic tests are different to the measurements explained in previous chapters in that they are usually easier to configure and run. Specifically, the user does not need to worry about which bandwidth profile to use or which test payload to configure. However, users are still required to enter the correct MAC and IP addresses, CoS marks, and other frame and network configuration through the menu system (See section 4.1.2 and See section 4.4.4). Due to the way automatic tests use the bandwidth profile settings, the equipment may need to generate large amounts of traffic. This traffic may cause congestion in some unprepared networks and damage performance of any service already deployed. For this reason, users are advised to use automatic measurements with care.

The second relevant property of automatic tests is that they provide a clear pass or fail result that is easier to understand than a numeric latency figure or a bandwidth statistic. Thresholds for the pass / fail results can be tuned through specific menus.

ALBEDO xGenius currently supports two different automatic measurements: The IETF RFC 2544 tests and the Ethernet service activation test methodology (eSAM) based on the ITU-T Y.1564 standard. The former has been used for many years and its a very well established network benchmarking mechanism. The latter has been introduced more recently but it has several advantages over the RFC 2544 tests like faster execution, support for multi-service environments and support for colored traffic.

7.1. Performance Assessment with the RFC 2544 Test

The RFC 2544 is an IETF standard that describes benchmarking tests for network devices. Vendors can use these tests to measure and outline the performance characteristics of their Ethernet and IP switching equipment. As these tests follow standard procedures, they also make it easier for customers to make sense of the glitzy marketing-speak employed by most vendors.

The tests described in the document aim to evaluate how a device would act in a real situation. The RFC 2544 describes out-of-service tests, which means that real traffic must be stopped and the tester will generate specific frames to evaluate throughput, latency, frame loss rate, burst tolerance, overload conditions and recovery.

To configure an RFC 2544 follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
3. Choose between *Ethernet endpoint* or *IP endpoint* with the *Mode* setting.
4. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
5. Go to *Performance test* and configure *RFC 2544*.
6. Go to *RFC 2544 configuration*.
   The panel with specific configuration of the RFC 2544 throughput, latency, frame loss, back-to-back frames and system recovery time tests is displayed.
7. Configure the test frame sizes with the help of the *Frame sizes* multiple selection list. The available frame sizes are: *64*, *128*, *256*, *512*, *1024*, *1280*, *1518* and *User-defined*.
8. If *User-defined* is enabled in the previous step, configure the user frame size to something between 64 and 10000 bytes through the *User frame size* control.
9. Configure the *Throughput test* (See section 7.1.1), *Latency test* (See section 7.1.2), *Frame Loss test* (See section 7.1.3), *Back-to-back test* (See section 7.1.4) and *System recovery test* (See section 7.1.5).
10. Leave *RFC 2544 configuration* and enter in *RFC 2544 objectives*.
11. Set the pass / fail thresholds for the throughput, latency, frame loss, back-to-back frames and system recovery tests from the *Performance objectives* menu (See section 7.1.6).
12. Leave the *RFC 2544 objectives* and *Performance test* panels.
13. Go to *Test mode*
14. Depending on your test setup (See section 2.2.3), configure *Test method* to *One-way (A > B)*, *Two-way (A > A)*, *Upstream* or *Downstream*.
15. If you have configured either the *Upstream* or *Downstream* test modes, configure *Remote unit MAC* (in *Ethernet endpoint* mode) or *Remote unit IP* (in I*P endpoint* mode).
    Note: A unit configured in *Remotely managed* mode has to be installed and configured in the remote end before any asymmetric test can be run (See section 2.5).
16. From the *Home* panel, go to *CONFIG*,
    The port setup panel is displayed.
17. Configure the *Frame layer* (See section 4.1.2) in Port A for Flow 1. Parameters to be configured are source and destination MAC addresses, VLANs, etc.
    Note: All flows different to *Flow 1* are disabled in RFC 2544 tests. This test is only

compatible with a single flow transmission.
Note: If you are running an *Upstream* asymmetric test in *Ethernet endpoint* mode, you are allowed to configure the *Destination MAC address from* field to *Remote*. In this way, you are setting the destination MAC address to be the responder address.
Note: If you are running a *Downstream* asymmetric test, you need to think in the port settings you configure as the configuration for the responder device (who is going to be the traffic generator). For this reason you are allowed to configure the *Source MAC address from* field to *Remote*. This setting configures the source address in the traffic generator (the responder device, in this mode) to be the own responder address.

18. If you are working in *IP endpoint* mode, configure the *Local profile* (See section 2.3) and the *Network layer* (See section 4.4.4). Parameters to be configured are IP addresses, DSCPs, etc.
    Note: If you are running an *Upstream* asymmetric test in *IP endpoint* mode, you are allowed to configure the *Destination IP address from* field to *Remote*. In this way, you are setting the destination IP address to be the responder address.
    Note: In the same way than in Downstream Ethernet end point tests, you need to think in the port settings you configure as the configuration for the responder device. For this reason you are allowed to configure the *Source IP address from* field to *Remote*. This setting configures the source address in the traffic generator to be the own responder IP address.

You can optionally attach a GNSS receiver to the test units (controller and responder) to measure one way delay in the RFC 2544 test (See section 2.8). To do that follow these 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 GNSS

7.1.1. Throughput

The aim of a *throughput test* is to determine the maximum number of frames per second that the device can process and forward without dropping or losing any. Put in simple terms, the procedure used to compute the throughput is as follows:

1. Send a certain number of frames at a specific rate through the DUT / SUT and count the frames transmitted by the DUT / SUT.
2. If the count of transmitted frames is equal to the count of received frames, increase the transmission rate and re-run the test. Otherwise, reduce the transmission rate to be used in the next trial.
3. Re-run the test until fewer frames are transmitted than received by the DUT / SUT. The throughput is the fastest rate at which the count of test frames transmitted by

the DUT is equal to the number of test frames sent to it by the measurement equipment.

Table 7.1: RFC 2544 Throughput Test Settings

Setting	Description
Enable	Enables or disables the RFC 2544 throughput test. The throughput test will not run with the remaining RFC 2544 tests if they are not previously enabled. The *Latency* and *System recovery* tests depend on the throughput results and they are disabled if the throughput test is also disabled.
Maximum rate (%)	It is the maximum bit rate the DUT / SUT supports due policing or other bandwidth limiting mechanisms. The *Maximum rate (%)* constitutes the upper level of the throughput result. The *Maximum rate (%)* is configured as a percentage of the nominal transmission rate configured through link auto-negotiation or fixed by the network administrators. If the DUT / SUT is not using bandwidth limiting mechanisms or the maximum rate is unknown, configure this field to 100 %. Test results should not change but it will take more time to get the same results with the same accuracy level.
Resolution (%)	Minimum throughput, expressed as a percentage of the nominal channel capacity, that can be distinguished by the RFC 2544 throughput algorithm. This algorithm finishes when the distance between the real throughput and the value estimated by the algorithm is smaller than the resolution. Configuring an smaller value of the resolution increases measurement accuracy but also increases the time needed to finish the throughput test.
Trial duration (s.)	This value corresponds with the duration of a single throughput trial test expressed in seconds. Each algorithm test cycle contains one trial. The equipment transmits test traffic during the time specified by this setting before deciding by means the analysis of the number of lost frames whether to continue or not. Some equipments may need some time before they start dropping frames. If the trial duration is too short this may cause the estimated throughput to be larger than it will in stationary transmission conditions.

Table 7.1: RFC 2544 Throughput Test Settings

Setting	Description
Max. frame loss (%)	The equipment decides whether it is operating above or below the actual DUT / SUT throughput by comparing the number of transmitted and received frames. It decides that the current transmission rate is higher than the real throughput if the frame loss ratio is larger than the *Max.frame loss* (%) configured here. In the same way, the tester decides that the current test rate is smaller than the actual throughput if the computed frame loss ratio is smaller than the *Max. frame loss (%)*.

7.1.2. Latency

This test determines the latency inherent in the DUT / SUT. The initial data rate is based on the results of the throughput test. Typically, packets are timestamped using the SLA payload (See section 4.1.4, See section 4.4.6), and the time they take to travel through the DUT / SUT is measured.

In order to determine the latency usually you first measure the throughput for the DUT / SUT at each of the defined frame sizes, and send a stream of frames through the DUT / SUT at the determined throughput rate to a specific destination. If you don't measure throughput the latency will be measured at the nominal capacity for the transmission medium.

The time at which this frame is completely transmitted is recorded, and this will be timestamp A. The receiver of the test equipment must recognize the tag information in the frame stream and record the reception time of the tagged frame. This will be timestamp B. The latency is the difference between timestamp B and timestamp A, according to the definition found in RFC 1242.

Table 7.2: RFC 2544 Latency Test Settings

Setting	Description
Enable	Enables or disables the RFC 2544 latency test. The latency test will not be executed if is not previously enabled by this control.
Trial duration (s.)	This value corresponds with the duration of a single latency trial test expressed in seconds. For each frame size, the RFC 2544 algorithm measures the latency several times. This parameter configures the duration of each latency measurement
Iterations	This parameter corresponds with the number of times the latency is measured for every frame size.

7.1.3. Frame Loss

The aim of this test is to determine the frame loss ratio through the entire range of input data rates and frame sizes. The procedure is the following:

1. Send a certain number of frames at a specific rate through the DUT / SUT, counting the frames transmitted and received and computing the frame loss ratio. The first trial should be run for the frame rate that is 100% of the maximum rate supported by the interface.
2. Repeat the procedure for the speed that corresponds to the next test bit rate.
3. Continue this sequence (reducing the bit rate in every step) until there are two consecutive trials where no frames are lost.

Table 7.3: RFC 2544 Frame Loss Test Settings

Setting	Description
Enable	Enables or disables the RFC 2544 frame loss test. The frame loss test will not be executed if is not previously enabled by this control.
Resolution (%)	Measures the decrease in terms of bit rate the tester uses to measure frame loss expressed as a percentage of the nominal transmission capacity. For example if throughput result is 100% for one specific frame size and this field is set to 10%, then frame loss will be evaluated for 100%, 90%, 80%... of the transmission medium capacity. If frame loss is configured to 1%, the bit rates used in consecutive trials will be 100%, 99%, 98%... Setting an smaller *Resolution (%)* increases frame loss test accuracy but the tame it takes to finish the test is also increased.
Trial duration (s.)	This value corresponds with the duration of a single frame loss trial test expressed in seconds. For each configured frame size and load, the equipment sends and analyses traffic for a time period specified by this field. Longer trial duration periods tend to give more accurate frame loss results but they make measurements longer.

7.1.4. Back-to-Back Frames

A back-to-back frames test determines the *node buffer capacity* by sending bursts of traffic at the highest theoretical rate, and then measuring the longest burst where no packets are dropped. The test procedure is as follows:

1. Send a burst of frames with minimum inter-frame gaps to the DUT / SUT, and count the number of frames forwarded.

2. If the count of transmitted frames is equal to the number of frames forwarded, increase the length of the burst and re-run the test. If the number of forwarded frames is less than the number transmitted, reduce the length of the burst and re-run the test.
3. Continue until the back-to-back frames results has been computed with acceptable accuracy.

The back-to-back value is the number of frames in the longest burst that the DUT / SUT can handle without losing any frame. It is recommended to run the test for at least 2 seconds, and it should be repeated at least 50 times with the average of the recorded values being reported.

Table 7.4: RFC 2544 Back-to-back Test Settings

Setting	Description
Enable	Enables or disables the RFC 2544 back-to-back frames test. The back-to-back frames test will not be executed if is not previously enabled by this control.
Maximum burst length (fr.)	This is the maximum frame burst to be used in an back-to-back frames test trial. The DUT / SUT should drop some frames when it receives a burst with the length configured in this field. If the actual back-to-back frames result is larger than the *Maximum burst length (fr.)*, the equipment will be unable to find it.
Resolution (fr.)	It is the minimum back-to-back frames result the equipment distinguishes as different results. When a test cycle finishes, the measurement algorithm compares the burst length with the result of the previous cycle. If the difference between them is smaller than the resolution, then the algorithm terminates. The final back-to-back result is the one computed in the last cycle.
Iterations	Configures the number of bursts sent per test cycle. Increasing *Iterations* makes the back-to-back test result more reliable but it also increases the overall testing time.

7.1.5. System Recovery

This test determines the node speed at which the DUT / SUT recovers from an overload condition. The procedure is as follows:

1. Measure the throughput for the DUT / SUT at each of the listed frame sizes.
2. Send a stream of frames at a rate that is 110% of the recorded throughput rate or the maximum rate for the media, whichever is lower, for at least 60 seconds.

3. At Timestamp A, reduce the frame rate to 50% of the above rate and record the time of the last frame lost (Timestamp B). The system recovery time is calculated by subtracting Timestamp B from Timestamp A. The test must be repeated a number of times, and the average of the recorded values is reported.

The system recovery results should be reported as a table, with a row for each of the tested frame sizes. There should be columns for the frame size, the frame rate used as the throughput rate for each type of data stream tested, and for the measured recovery time for each type of data stream tested.

Table 7.5: RFC 2544 System Recovery Test Settings

Setting	Description
Enable	Enables or disables the RFC 2544 system recovery test. The system recovery test will not be executed if is not previously enabled by this control.
Trial duration (s.)	Time, computed in seconds, the DUT / SUT is overloaded by frame transmission above the recorded throughput value.
Iterations	Number of times the recovery time is measured in one test cycle. The final value of the recovery time will be the averaged value computed for each iterations. The more iterations per test cycle the more reliable the test results are. However, increasing the iterations increases the total testing time as well.

7.1.6. Configuration Pass / Fail Thresholds

One of the advantages of the RFC 2544 tests is the ability to supply a clear pass / fail results based on certain thresholds configured before the test start. To configure the pass / fail thresholds follow these steps:

Table 7.6: RFC 2544 Performance Objectives

Setting	Description
Throughput	Sets a performance objective for the RFC 2544 throughput test. The test will be considered to fail if the measured throughput is smaller that the threshold and it will be passed otherwise.
Latency	Sets a performance objective for the RFC 2544 latency test. The test is considered to fail if the result is larger than the threshold and it is considered to pass otherwise.

Table 7.6: RFC 2544 Performance Objectives

Setting	Description
Frame loss	Configures an performance objective for the RFC 2544 frame loss test. The test is considered to fail if there is at least one result within the frame length and bit rate ranges which produces a frame loss figure larger than the threshold. The test is considered to pass otherwise.
Back-to-back frames	Sets a performance objective for the RFC 2544 back-to-back frames test. The test is considered to fail if the back-to-back frames result is smaller than the configured threshold and it is considered to pass otherwise.
System recovery	Sets the performance objective for the RFC 2544 system recovery time test. The test fails if the system recovery time result is longer than the threshold and passes otherwise.

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *Performance objectives*,
3. Select *RFC 2544*.
   Note: You must enable the RFC 2544 test before you are allowed to enter in this menu.
4. Enter the thresholds for *Minimun throughput (%)*, *Maximum latency*, *Maximum frame loss (%)*, *Minimum frame burst (fr)*, *Maximum recovery time*.
   Note: Each specific test has to be individually enabled before you can set the performance objective for it.

7.1.7. Getting Test Results

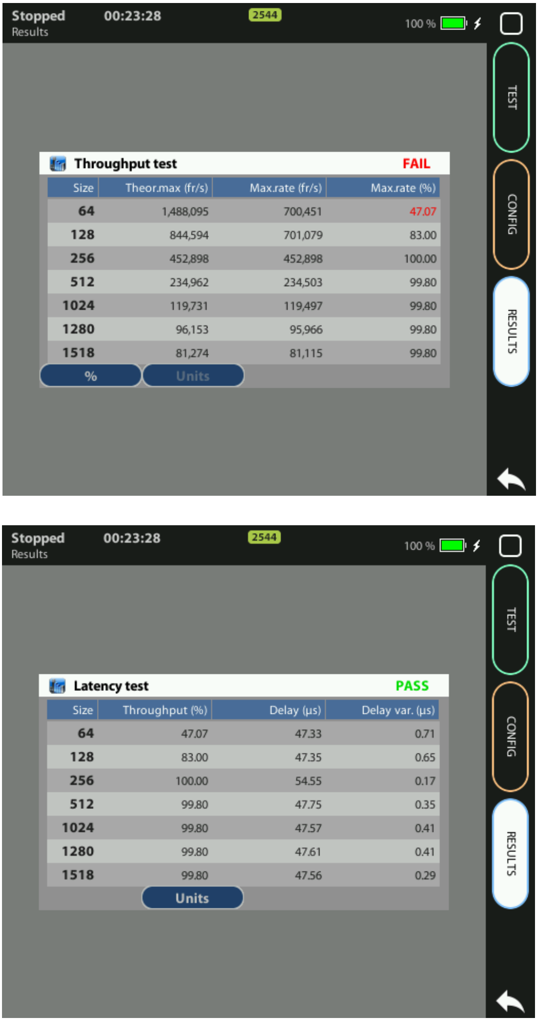
The RFC 2544 provides a description of the way test results must be presented to the user. Normally, these results are displayed as tables. Each row represents the test frame length or bit rate and columns are usually test results like throughput, latency or others.

The RFC 2544 results can be evaluated as pass or fail. Failed results are represented with red color. One test is considered to fail it at least one test result fails. The whole RFC 2544 fails if one particular test result fails. The global Pass / Fail can be checked at any moment, even before the end of the test from the *Summary* panel (SUM key).

Once the test has been configured, it can be started at any time with the help of the RUN button. You can wait to the test to finish but it is also possible to check partial test results at any moment. To do that follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.

2. Select either *Port A or Port B* to enter in the port specific results. *Note*: If you have configured *Test method* to *One-way (A > B),* the RFC 2544 results are available in *Port B*. On the other hand, if you have configured *Two-way (A > A)*, the RFC 2544 results are available in *Port A*.



Throughput test FAIL

Size	Theor.max (fr/s)	Max.rate (fr/s)	Max.rate (%)
64	1,488,095	700,451	47.07
128	844,594	701,079	83.00
256	452,898	452,898	100.00
512	234,962	234,503	99.80
1024	119,731	119,497	99.80
1280	96,153	95,966	99.80
1518	81,274	81,115	99.80

(a)

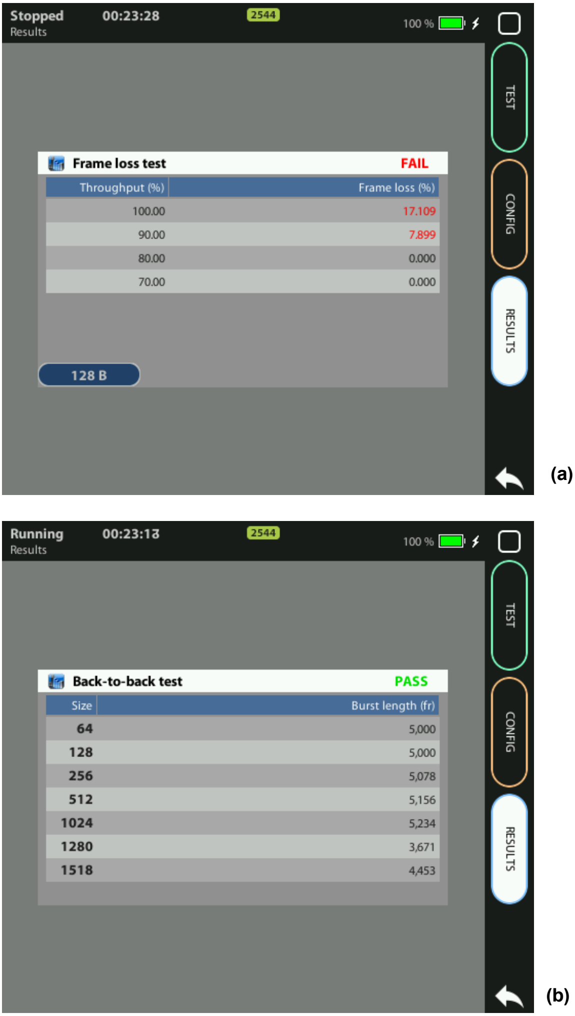
Latency test PASS

Size	Throughput (%)	Delay (µs)	Delay var. (µs)
64	47.07	47.33	0.71
128	83.00	47.35	0.65
256	100.00	54.55	0.17
512	99.80	47.75	0.35
1024	99.80	47.57	0.41
1280	99.80	47.61	0.41
1518	99.80	47.56	0.29

(b)

Figure 7.1: RFC 2544 test results: (a) Throughput results table, (b) Latency results table.

3. Select *RFC 2544*.
4. Check the *Status* field to know the pass / fail test result. If the test has not yet finished, this field will display a *In progress* message. If the equipment detects an error during text execution it will display an error message.


Stopped
Results
00:23:28
2544
100 %
TEST
CONFIG
RESULTS
128 B
(a)
Running
Results
00:23:13
2544
100 %
TEST
CONFIG
RESULTS
(b)

Frame loss test FAIL

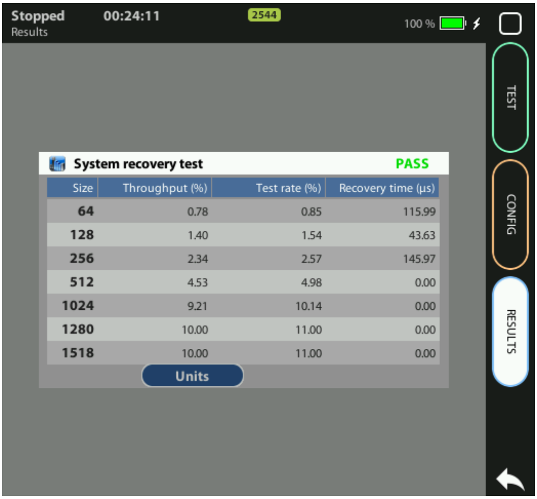
Throughput (%)	Frame loss (%)
100.00	17.109
90.00	7.899
80.00	0.000
70.00	0.000

Back-to-back test PASS

Size	Burst length (fr)
64	5,000
128	5,000
256	5,078
512	5,156
1024	5,234
1280	3,671
1518	4,453

Figure 7.2: RFC 2544 test results: (a) Frame loss result table, (b) Back-to-back frames result table.

5. Check the *Current stage* and *In progress* fields to know what is doing the tester in the current moment and which is the current test progress.
6. Go to the *Throughput test*, *Latency test*, *Frame lost test*, *Back-to-back test* and *System recovery test* and check the detail led results for each of them.
   Note: Test results depend on the frame length and some of them also on the throughput. For this reason, RFC 2544 result tables depend on both magnitudes: *Size* and *Throughput (%)*. *Throughput (%)* represents the bit rate used for testing latency and frame loss. It can be the previously measured maximum rate attainable bit rate expressed as a percentage of the nominal interface rate (10 Mb/s, 100 Mb/s, 1000 Mb/s, 10 Gb/s) or a different value depending on the particular test settings.



System recovery test PASS

Size	Throughput (%)	Test rate (%)	Recovery time (µs)
64	0.78	0.85	115.99
128	1.40	1.54	43.63
256	2.34	2.57	145.97
512	4.53	4.98	0.00
1024	9.21	10.14	0.00
1280	10.00	11.00	0.00
1518	10.00	11.00	0.00

Figure 7.3: RFC 2544 System recovery time results table.

Note: The system recovery time tests sends traffic above the throughput value in order to overload the DUT / SUT, the test traffic in this case is indicated in the results table by means the *Test rate (%)* column.

Table 7.7: RFC 2544 Test Results

Setting	Description
Theoret. max rate (fr/s)	Theoretical maximum rate attainable in the transmission medium expressed in frames per second. In an Ethernet link, this rate is calculated as nominal transmission capacity in bits per second (10 Mb/s, 100 Mb/s, 1000 Mb/s, 10 Gb/s) divided by the frame bits (including the 64-bit preamble and the 96-bit interframe gap). The theoretical maximum rate result is available in the *Throughput test* result table.
Measured max rate (fr/s)	Measured maximum rate attainable in the transmission medium expressed in frames per second. This result is always smaller or equal than the theoretical maximum rate result. The measured maximum rate result is available in the *Throughput test* result table
Delay (μs)	Latency result measured in microseconds. The delay result has to be understood as the one-way delay if the test is configured as a *One-way (A > B)* test or as the round-trip delay if the test is configured as *Two-way (A > A)*. In many setups the round-trip delay is roughly twice that the one-way delay but in asymmetric setups this is not true anymore.
Delay var (μs)	Delay variation measured in microseconds. The delay variation is computed as specified in IETF RFC 3393 and it is to be understood as a one-way delay metric if the test is configured as a *One-way (A > B)* test or as a two-way metric if the test method is *Two-way (A > A)*. In asymmetric tests this metric is also one-way and corresponds to the upstream or downstream path depending on the configure test method.
Frame loss (%)	Frame loss result expressed as a percentage of the total amount of frames transmitted in the trial for an specific frame length and throughput.
Burst length (fr)	Longest burst accepted by the DUT / SUT which produces no packet loss.
Recovery time (μs)	Time invested to recover from an overload condition expressed in microseconds.

7.1.8. Generation of RFC 2544 Result Reports

An essential part of standardized network testing is report generation. Reports summarize test results in a document that can be edited or shared with the customer. RFC 2544 reports include a text header with basic information about the test like start time, duration and configuration. Test results are presented in tables. There is one table for each test: throughput, latency, frame loss, back-to-back frames and system recovery time. All results include a Pass / Fail indication. The report also includes a global Pass / Fail indication which summarizes all test results: It follows an example of a typical RFC 2544 report as is generated by the test unit:

```
RFC 2544 Test Report

Report name              2012-11-22-185949
Customer
Department
Company
Location
Operator
Start Time               Thu Nov 22 18:59:49 2012
Elapsed Time             11:16:44
Test Unit                Ether.Giga Gigabit Ethernet Tester
Serial number            MEM0009P
Software version         1.13.35


Global results

Status                             FAIL
Completed                          100%


Test Unit Configuration

Mode                               IP endpoint
Test method                        Two-way (A > A)

                                                Port A              Port B
Port mode                                        TX/RX            Loopback
Connector                                   Electrical          Electrical
Encapsulation                                     None
Source MAC address                   00:DB:1E:00:01:10
Destination MAC address              00:DB:1E:00:01:11
Address range size                                ----
C-VID                                             ----
C-VLAN priority                                   ----
S-VID                                             ----
S-VLAN priority                                   ----
DEI                                               ----

Source IPv4 address                        172.26.3.23
Destination IPv4 address                   172.26.4.24
Destination host name                             ----
Address range size                                ----
DSCP                                                 0

Performance objectives
```

```
Minimum throughput (%)                     50.000
Maximum latency                         10.000 ms
Maximum frame loss (%)                      1.000
Minimum frame burst (fr)                     1000
Maximum recovery time                   10.000 ms


Throughput test

  Frame sizes  Theor.max (fr/s)  Max.rate (fr/s)     Max.rate (%)     Sta-
tus
           64           148,809           40,399           27.140     FAIL
          128            84,459           39,755           47.070     FAIL
          256            45,289           39,009           86.130     PASS
          512            23,496           23,496          100.000     PASS
         1024            11,973           11,973          100.000     PASS
         1280             9,615            9,615          100.000     PASS
         1518             8,127            8,127          100.000     PASS


Latency test

  Frame sizes       Throughput (%)         Delay     Delay var.      Status
           64               27.140     778.03 us       14.62 us        PASS
          128               47.070      84.47 us       14.23 us        PASS
          256               86.130     228.79 us        5.04 us        PASS
          512              100.000     172.88 us        3.65 us        PASS
         1024              100.000     140.27 us        4.99 us        PASS
         1280              100.000     162.50 us        3.80 us        PASS
         1518              100.000     185.06 us        3.56 us        PASS


Frame loss test

  Throughput (%)       64     128     256     512    1024    1280    1518
          100.00   73.126  52.885  13.869   0.000   0.000   0.000   0.000
           90.00   70.086  47.603   4.368   0.000   0.000   0.000   0.000
           80.00   66.364  40.995   0.000     ---     ---     ---     ---
           70.00   61.527  32.571   0.000     ---     ---     ---     ---
           60.00   55.078  21.274     ---     ---     ---     ---     ---
           50.00   46.084   5.506     ---     ---     ---     ---     ---
           40.00   32.623   0.000     ---     ---     ---     ---     ---
           30.00   10.208   0.000     ---     ---     ---     ---     ---
           20.00    0.000     ---     ---     ---     ---     ---     ---
           10.00    0.000     ---     ---     ---     ---     ---     ---
                     FAIL    FAIL    FAIL    PASS    PASS    PASS    PASS


Back-to-back test

  Frame sizes           Burst length (fr)                        Status
           64                      46,875                          PASS
          128                      46,875                          PASS
          256                      46,875                          PASS
          512                   3,000,000                          PASS
         1024                   3,000,000                          PASS
         1280                   3,000,000                          PASS
         1518                   3,000,000                          PASS


System recovery test
```

```
Frame sizes      Throughput (%)      Recovery time                   Status
         64               27.14         620.400 us                     PASS
        128               47.07         906.000 us                     PASS
        256               86.13         335.000 us                     PASS
        512              100.00           0.000 us                     PASS
       1024              100.00           0.000 us                     PASS
       1280              100.00           0.000 us                     PASS
       1518              100.00           0.000 us                     PASS

                                     (c) 2012 ALBEDO Telecom
```

7.2. Performance Assessment with the eSAM Test

Ethernet service activation though eSAM defined in ITU-T 1564 has arisen as an alternative to RFC 2544 verification. Unlike the RFC 2544, eSAM is designed for

Ethernet service activation from the beginning. The advantages of eSAM in front of RFC 2544 are summarized in the following points:

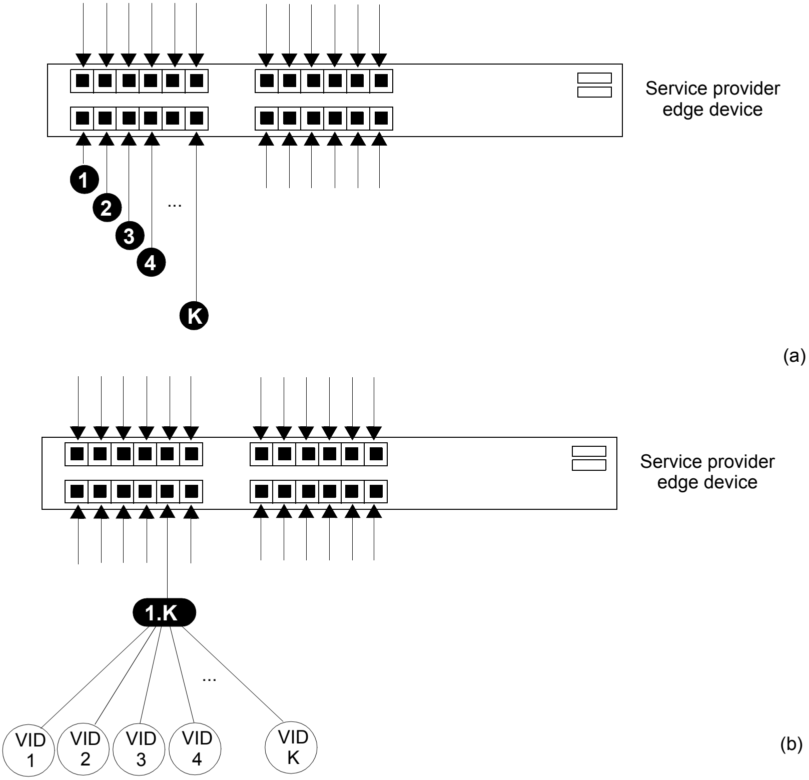

Service provider edge device
1
2
3
4
...
K
(a)
Service provider edge device
1.K
...
VID 1
VID 2
VID 3
VID 4
VID K
(b)

Figure 7.4: (a) Port based Ethernet service, one service per port. (b) Ethernet service multiplexing based on service delimiting markers like the VLAN tag.

1. *Faster execution*: An standard eSAM test is made up of a short configuration test and a longer performance test. If the configuration test fails there is no need to execute the long performance test. The result is that network administrators have time to correct any configuration issue before having to wait for the complete test execution.
2. *FDV results*. Frame Delay Variation (FDV) is a key metric to evaluate network performance. FDV is very sensitive to congestion and other degradations that affect

end-to-end network performance and it is therefore an essential parameter to measure.

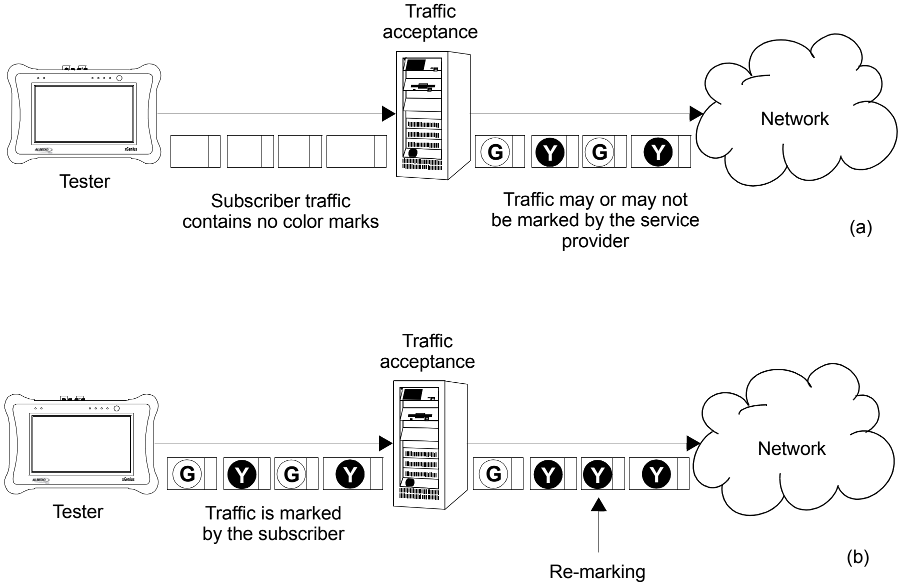

Traffic acceptance
Tester
Subscriber traffic contains no color marks
G
Y
G
Y
Network
Traffic may or may not be marked by the service provider
(a)
Traffic acceptance
Tester
G
Y
G
Y
Traffic is marked by the subscriber
G
Y
Y
Y
Network
Re-marking
(b)

Figure 7.5: (a) Non-color-aware service. It the service provider is wiling to implement different transmission priorities for this service, marking will have to be carried out by the access network by means some traffic classification algorithm. (b) In a color-aware service subscribers mark their own traffic from the beginning. The service provider may remark some traffic depending on the traffic acceptance algorithm.

3. *Compatible with multi-service environments*: Modern Ethernet services may be port based but service multiplexing in the same port by means some service delimiting tag is also very popular. The eSAM test has been designed to operate in environments using service multiplexing. In this case, all services are simultaneously tested and independent results are given for each of them.
4. *Supports color-aware traffic*: The eSAM test is compatible with color markers used by some service providers to enable the different performance levels in their applications. Color markers classify the network traffic in three sets: *green* traffic is transmitted within the delay and frame loss ratio limits guaranteed by the SLA agreement, *yellow* traffic is transmitted but the SLA agreement performance limits do not apply for it, and finally *red* traffic is discarded and not transmitted (red traffic is therefore never seen in the network). Common color markers used in practical

applications are the DSCP (Layer 3) and the VLAN priority bits (Layer 2). The latter requires the subscriber frames to be encapsulated in VLAN tagged frames.

7.2.1. Bandwidth Profiles for Ethernet Services

To see how eSAM works it is essential to understand how Ethernet services are defined. Network operators have at their disposal the tools that enable them to define their services with great flexibility. The information rate associated with Ethernet service is not limited to the nominal speed of the access network interface. For example, certain operator way want to define a 2 Mbit/s service over an optical Gigabit Ethernet interface.

Performance in terms of delay, packet loss and other metrics is applied to traffic flows defined by their generation statistics or bandwidth profile. The mechanism used by service providers to make sure the ingress traffic has the correct bandwidth profile is admission control. Once the Ethernet access has been set up, the service provider performs admission control over the customer traffic at the user-network interface. Admission control for Ethernet services uses bandwidth profiles based on four parameters initially defined by the Metro Ethernet Forum (MEF):

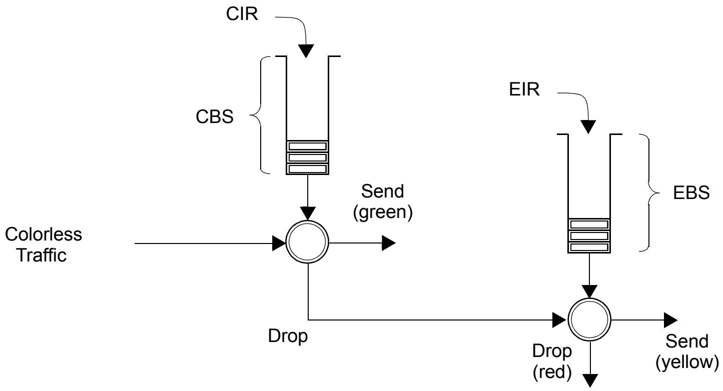


Figure 7.6: Two-rate Three color marker (trTCM). policing algorithm.

- *Committed Information Rate (CIR)*: Rate up to which service frames are delivered as per the service performance objectives.
- *Committed Burst Size (CBS)*: Maximum number of bytes up to which service frames may be sent as per the service performance objectives without considering the CIR.
- *Excess Information Rate (EIR)*: Rate up to which service frames are still delivered but they are not subject to any performance objective.
- *Excess Burst Size (EBS)*: The number of bytes up to which service frames are sent (without performance objectives), even if they are out of the EIR threshold.

The MEF specifies the RFC 2698 *Two-rate Three-Color Marker* (trTCM) as the admission control mechanism for carrier Ethernet services. The trTCM is obtained by chaining two simple token bucket policers. Tokens fill the main bucket until they reach the capacity given by the CBS parameter, at a rate given by the CIR parameter. The secondary bucket is filled with tokens with the EIR rate until they reach the capacity given by the EBS parameter.

The traffic that passes through the first bucket (green traffic) is delivered with the QoS agreed with the service provider, but any traffic that passes through the secondary bucket (yellow traffic) is re-classified and delivered as best-effort traffic, or it is given a low priority. Non-conforming traffic (red traffic) is dropped.

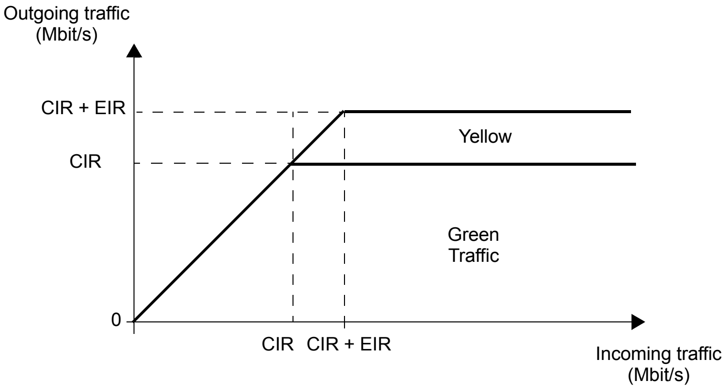
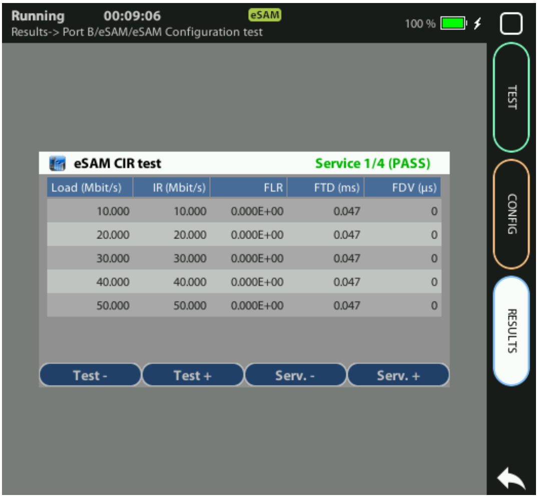


Figure 7.7: The amount of traffic that crosses an admission control filter. Graphics represent steady states, traffic is usually allowed to be greater than the CIR and EIR for short periods of time. Traffic delivery is guaranteed if the rate is smaller than the CIR. Excess traffic (EIR traffic) is delivered as well, but it is marked as low priority and usually discarded first if congestion occurs.

Note than the best effort classical service can be obtained simply by setting the CIR parameter to zero. Moreover, service providers may allow their subscribers to add their color marks to the traffic they generate before the traffic admission algorithm is applied. This kind of pre-marking transfers more control on the application performance to the end user. However, admission control is necessary even in this case and frame remarking is done on non-conforming traffic anyway.



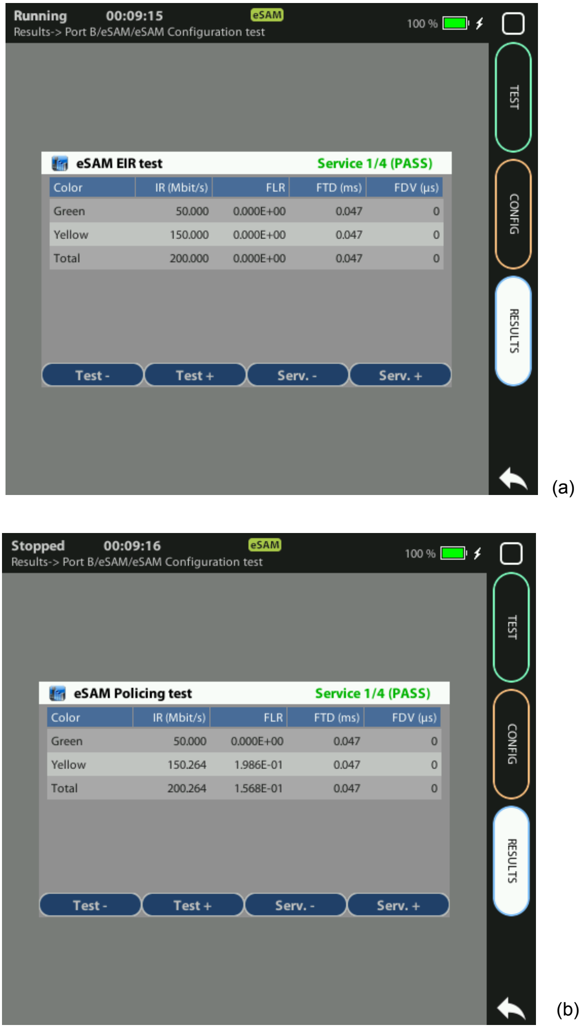
Results-> Port B/eSAM/eSAM Configuration test

eSAM CIR test — Service 1/4 (PASS)

Load (Mbit/s)	IR (Mbit/s)	FLR	FTD (ms)	FDV (µs)
10.000	10.000	0.000E+00	0.047	0
20.000	20.000	0.000E+00	0.047	0
30.000	30.000	0.000E+00	0.047	0
40.000	40.000	0.000E+00	0.047	0
50.000	50.000	0.000E+00	0.047	0

Figure 7.8: CIR test results as presented by xGenius.

The basic purpose of eSAM is to check that green and yellow frames are transported with the required performance in terms of Frame Total Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR) and availability. The existence of a policing algorithm like the trTCM means that testing the ability of the network to discard non-conforming traffic is another important requirement for eSAM. Transmission of green traffic is verified by the CIR test and the performance test, transmission of the yellow traffic is checked with the EIR test and red (discarded) traffic is measured by the policing test. Finally, the Information Rate (IR) is measured in all CIR, EIR and policing tests for all traffic classes to make sure that the information is preserved by the network when required to do so. More details about these specific tests are provided in the following sections.



Running 00:09:15 eSAM
Results-> Port B/eSAM/eSAM Configuration test

eSAM EIR test Service 1/4 (PASS)

Color	IR (Mbit/s)	FLR	FTD (ms)	FDV (µs)
Green	50.000	0.000E+00	0.047	0
Yellow	150.000	0.000E+00	0.047	0
Total	200.000	0.000E+00	0.047	0

100 %
TEST
CONFIG
RESULTS
Test -
Test +
Serv. -
Serv. +

(a)

Stopped 00:09:16 eSAM
Results-> Port B/eSAM/eSAM Configuration test

eSAM Policing test Service 1/4 (PASS)

Color	IR (Mbit/s)	FLR	FTD (ms)	FDV (µs)
Green	50.000	0.000E+00	0.047	0
Yellow	150.264	1.986E-01	0.047	0
Total	200.264	1.568E-01	0.047	0

100 %
TEST
CONFIG
RESULTS
Test -
Test +
Serv. -
Serv. +

(b)

Figure 7.9: EIR and policing test results as presented by xGenius.

7.2.2. Test Configuration

The way the equipment is configured depends on the particular network and service to be tested. Before running the test, there are several questions the user must answer:

- What kind of network is going to be tested? Configuration is different for IP networks and Ethernet networks. Note than a network may carry IP over Ethernet frames but it may still be more interesting to run an Ethernet test than an IP test.
- How is the test equipment going to be connected to the network? Configuration is not the same if there is a traffic reflector used to loop frames back to the analyzer (two-way test) or if Port B is going to be used for analysis (one-way test).
- How many services are required to be measured in the same test? Is there any color marker used to classify the traffic? Which are the CIR / EIR values for each service? Is there any policing mechanism for the Ethernet services configured in the network?
- What is the required performance for each service in terms of FTD, FDV, FLR and availability?
- In IP tests, what are the correct IP profiles to be used? IP addresses, network masks, gateways and DNS servers (if used) must be known before the test can be configured. Usually DHCP protocol makes easier configuration of IP profiles but DHCP may not be available in some networks.

Table 7.8: eSAM Configuration

Setting	Description
Color mode	Set this field to *On* if the traffic contains color labels. Color labels enable the network to supply differentiated services to selected traffic. These services consist in low delay paths, high priority frame scheduling or low packet loss probability. Set the *Color mode* to *Off* if you want to leave the service provider network to decide the priority of user traffic based on the result of a traffic acceptance algorithm (policer, shaper).

Table 7.8: eSAM Configuration

Setting	Description
Color method	The color method configures which field in the test traffic implements the color mechanism. There are the following potential choices: • *DSCP*: Differentiated Services Code Point. It is 6-bit class of service label that accepts values between 0 and 63. DSCP makes sense as a color marker in routed networks and for this reason it is not available in *Ethernet endpoint mode*. • *C-VLAN priority*: 3-bit class of service field carried by the VLAN tag in IEEE 802.1Q frames or in the C-VLAN tag in IEEE 802.1ad and Q-in-Q frames. Using this field requires frames containing at least one VLAN tag. Color markers based on the C-VLAN priority field make sense only in switched networks for this reason it is not available in *IP Endpoint*. • *C-VID*: VLAN identifier assigned to tagged frames (IEEE 802.1Q) or C-VLAN identifier for double tagged frames (IEEE 802.1ad, Q-in-Q). The VID is commonly used in carrier Ethernet networks as a service discriminator. The test unit accounts for the possibility to use this field as a color marker as well. It requires the tester to be configured in *Ethernet Endpoint* mode and an encapsulation with at least one VLAN tag. • *S-VLAN priority*: 3-bit class of service field carried by the S-VLAN tag in IEEE 802.1ad and Q-in-Q frames. Color markers based on the C-VLAN priority field make sense only in switched networks for this reason it is not available in *IP Endpoint* mode. • *S-VID*: VLAN identifier assigned S-VLAN tag in double tagged frames (IEEE 802.1ad, Q-in-Q). The VID is commonly used in carrier Ethernet networks as a service discriminator. The test unit accounts for the possibility to use this field as a color marker as well. It requires the tester to be configured in *Ethernet Endpoint* mode and an IEEE 802.1ad / Q-in-Q encapsulation
Number of services	Defines the number of services to be simultaneously tested. The maximum number of services to be tested is eight (non-color-aware mode) or four (color-aware mode).

Table 7.8: eSAM Configuration

Setting	Description
Number of steps	Number of different bit rates to be tested in the configuration CIR test. The test bit rates are equally distributed between 0 and CIR bit rates.
Step duration (s)	Duration of each iteration of the CIR test. If Number of steps is configured to 1, it is the duration of the CIR test. Any value between 1 and 60 seconds is accepted.
Policing test	Enable to execute the policing test as a part of the eSAM test suite or disable if you don't want to run the policing test. You may want to disable the policing test if you know that the network under test is not using any traffic admission algorithm and you don't want the configuration test to fail for this reason.
Performance test duration	Duration of the eSAM performance test. The performance test is executed once the configuration test has finished. For the performance test you can choose between one of the three duration presets (*15 min.*, *2 hours*, *24 hours*) or you can set your own test duration with a resolution of one second by setting this field to *User duration*. It is possible to use this field to disable the performance test. This is interesting if you want to check the network configuration but you don't need to know the performance.
User duration	Use this field to configure the eSAM performance test duration if you have set *Performance test duration* to *User duration*.
Service configuration	Displays a panel that enables the user to enter the CIR and EIR for each service to be tested. The service configuration panel also displays information about traffic flows assigned to each eSAM service. Two flows are required to test one color-aware service and one flow is necessary for each non-color-aware service.

Once all the details about test equipment connection and network / service configuration have been clarified is time to configure the test. To do that follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.

3. Choose between *Ethernet endpoint* or *IP endpoint* with the *Mode* setting.
4. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
5. Go to *Performance test* and configure *eSAM*.
6. Enter in the *eSAM* menu to configure the global ITU-T Y.1564 settings.
7. Configure the *Color mode* to *On* if the service provider allows pre-marking of Ethernet frames / IP datagrams or set it to *Off* otherwise.
8. If you have configured *Color mode* to *On*, set the *Color method* to *DSCP* (IP Endpoint mode), *C-VLAN priority*, *C-VID*, *S-VLAN priority* or *S-VID* (Ethernet Endpoint mode).
   Note: C-VLAN priority and C-VID color markers require VLAN, Q-in-Q or IEEE 802.1ad encapsulation. S-VLAN priority and S-VID color markers require Q-in-Q or IEEE 802.1ad encapsulation.
9. Set the number of services you want to test within the same test with the help of the *Number of services* control.
   Note: The maximum number of services is 4 if *Color mode* is *On* or 8 if *Color mode* has been configured to *Off*.
10. Configure the *CIR* and *EIR* parameters for each service to be tested from the *Service configuration* panel.
11. Enter the number of steps and duration of each step for the CIR test with the help of the *Number of steps* and *Step duration (s)* controls.

Table 7.9: eSAM Performance Metrics

Result	**Description**
Load (Mbit/s)	Amount of test traffic offered to the network expressed in Mbit/s. This traffic is always larger or equal than the measured Information Rate (IR). Currently this parameter is displayed as a result only for the CIR configuration test. Traffic load for EIR and performance tests can be checked in the service configuration panel for eSAM tests. For policing tests, the load is always higher than the CIR + EIR in an amount than is computed automatically as specified in ITU-T Y.1564.
IR (Mbit/s)	Average Information Rate (IR) computed for the traffic currently being tested (green, yellow, aggregated, etc.) within the configured test period. Only test traffic is taken into account to measure the IR. The definition and application of the IR metric follows ITU-T Y.1564.

Table 7.9: eSAM Performance Metrics

Result	Description
FLR	Ratio of the total amount of lost frames to the total transmitted frames from the beginning of the test. Definition of the FLR parameter follows ITU-T Y.1563.
FTD (ms)	Is the worst case (maximum) Frame Total Delay (FTD) found from the beginning of the eSAM configuration or performance test and expressed in milliseconds. The definition of *FTD (ms)* follows ITU-T Y.1563 and it is computed in the same way that the *FTD (maximum)* metric supplied by the xGenius *SLA statistics*.
FDV (ms)	Is the worst case (maximum) Frame Delay Variation (FDV) found from the beginning of the eSAM configuration or performance test and expressed in millisecond. The definition of *FDV (ms)* follows RFC 3393 and RFC 1889 and it is computed in the same way that the *FDV (maximum)* metric supplied by the xGenius *SLA statistics*.
Avail (%)	The Avail (%) constitutes an availability performance figure that informs about the percentage of time that the DUT / SUT has been not available for transmit / receive data during the eSAM performance test. This performance metric is computed as *100% - PEU(%)*. Where the PEU(%) is the Percent Ethernet service Unavailability defined in ITU-T Y.1563 and supplied by the xGenius *SLA statistics*. This metric is computed for eSAM performance tests only. Configuration tests are considered too short to make any accurate availability result significant enough.

12. Enable the Policing test with *Policing test* if your network is using a traffic admission mechanism that limits the amount of accepted ingress traffic.
13. Configure the duration of the eSAM performance test with the help of the *Performance test duration* and *User duration* controls.
14. Leave the *eSAM* configuration panel and from the *Test* menu select Performance objectives.
15. Select *eSAM* and enter the performance objectives in terms of the *FLR*, *FTD*, *FDV* and *Avail.* fields for each service you want to test.
16. Leave the *eSAM objectives* and *Performance test* panels.
17. Go to *Test mode.*

18. Depending on your test setup (See section 2.2.3), configure *Test method* to *One-way (A > B)*, *Two-way (A > A)*, *Upstream* or *Downstream*.
19. If you have configured either the *Upstream* or *Downstream* test modes, configure *Remote unit MAC* (in *Ethernet endpoint* mode) or *Remote unit IP* (in I*P endpoint* mode).
    Note: A unit configured in *Remotely managed* mode has to be installed and configured in the remote end before any asymmetric test can be run (See section 2.5).
20. From the *Home* panel, go to *CONFIG*,
    The port setup panel is displayed.
21. Configure the *Frame layer* (See section 4.1.2) in Port A for all your services. Parameters to be configured are source and destination MAC addresses, VLANs, frame size, etc.
    Note: To know the correspondence between flows and eSAM services, check the *Service configuration* panel you have used to configure the CIR and EIR values for the test.
    Note: Test traffic corresponding to different services should not have exact configurations. Otherwise, the analyser (and the network) will fail to classify the traffic. A service delimiting field could be used for this purpose. It is common to use the VID but anything that makes traffic from different services different in some way is accepted by the tester.
    Note: If you are configuring coloured traffic, the color makers (C-VLAN priority, C-VID, S-VLAN priority, S-VID) must have a different value for green and yellow traffic corresponding to the same service. The test will fail to start if this requirement is not met.
    Note: If you are running an *Upstream* asymmetric test in *Ethernet endpoint* mode, you are allowed to configure the *Destination MAC address from* field to *Remote*. In this way, you are setting the destination MAC address to be the responder address.
    Note: If you are running a *Downstream* asymmetric test, you need to think in the port settings you configure as the configuration for the responder device (who is going to be the traffic generator). For this reason you are allowed to configure the *Source MAC address from* field to *Remote*. This setting configures the source address in the traffic generator (the responder device, in this mode) to be the own responder address.
22. If you are working in *IP endpoint* mode, configure the *Local profile* (See section 2.3) and the *Network layer* (See section 4.4.4) for all your services. Parameters to be configured are IP addresses, DSCPs, etc.
    Note: Previous notes about flows / services, service delimiting tags and color markers are valid in *IP endpoint* as well but in this case the color marker to be used is the DSCP rather than VLAN priorities or VIDs.
    Note: If you are running an *Upstream* asymmetric test in *IP endpoint* mode, you are allowed to configure the *Destination IP address from* field to *Remote*. In this way, you are setting the destination IP address to be the responder address.

Note: In the same way than in Downstream Ethernet end point tests, you need to think in the port settings you configure as the configuration for the responder device. For this reason you are allowed to configure the *Source IP address from* field to *Remote*. This setting configures the source address in the traffic generator to be the own responder IP address.

23. Run the eSAM test with the help of the *RUN* button.

You can optionally attach a GNSS receiver to the test units (controller and responder) to measure one way delay in the eSAM test (See section 2.8). To do that follow these 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 GNSS.

7.2.3. CIR Configuration Test

The CIR Configuration test is the most basic eSAM test. Its purpose is to check the ability of the network to deliver frames at CIR rate within acceptable performance limits. This test consist in loading the service with the maximum bit rate it supports without any degradation that is the CIR by definition. Optionally, the user is allowed to configure other test rates smaller than the CIR. For colored services, the only traffic color to be generated in the CIR test is green.

CIR test results are made up of the IR, FTD, FDV and FLR for all the test loads. The test is considered to pass if the computed performance metrics (FTD, FDV and FLR) are better than the corresponding performance thresholds. Test results, including the final Pass / Fail are essentially the same for color aware and non-color aware CIR tests.

It is possible to execute several (up to four color-aware or eight non-color-aware) CIR tests. In this case, CIR tests are executed sequentially for each configured service. To check the CIR test results follow this procedure:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
   Note: If you have configured *Test method* to *One-way (A > B),* the eSAM results are available in *Port B*. On the other hand, if you have configured *Two-way (A > A)*, the RFC 2544 results are available in *Port A*.
3. Select *eSAM*.
4. Check the *Status* field to know the pass / fail test result. If the test has not yet finished, this field will display a *In progress* message. If the equipment detects an error during text execution it will display an error message.
5. Check the *Test remaining time* to get an estimation about how much time is left to finish the current test.

6. Go to *eSAM Configuration test*.
   A table with eSAM configuration test results is displayed.
7. Use the *Test-* and *Test+* contextual keys to select the eSAM CIR test results. Use the *Serv-* and *Serv+* contextual keys to select the table corresponding to the service you want to check.

7.2.4. EIR Configuration Test

The purpose of the EIR Configuration test is to measure network performance when it is loaded with an information rate that matches the CIR + EIR. Unlike it happens with the CIR configuration test, the way the results are computed is very different for color-aware and non-color-aware services. The reason is that there is no performance limit in non-color-aware services when the transmission rate is above the CIR but for color-aware services it is still possible to guarantee the quality of service of green frames. The EIR test is executed and evaluated as follows:

- *Non-color-aware services*: The network is loaded with a CIR + EIR bit rate and the IR, FTD, FDV and FLR are measured. The test is considered to pass if CIR * (1 - FLR) < IR < CIR + EIR.
- *Color-aware services*: The network is loaded with CIR green traffic and EIR yellow traffic. The IR, FTD, FDV and FLR is measured for both traffic classes. The test is passed if the FTD, FDV and FLR for green traffic are within acceptable limits.

It must be noticed that performance metrics are always measured but they are relevant for the pass / fail results only for guaranteed (green) traffic.

It is possible to execute several (up to four color-aware or eight non-color-aware) EIR tests. In this case, EIR tests are executed sequentially for each configured service. Users may not want to run the EIR test. To do that, they have simply to configure the EIR to 0 for services where the test is not going to be executed.

The procedure to follow to display the EIR test results is similar than for the CIR results but in this case it is necessary to use he *Test-* and *Test+* contextual keys to select the eSAM EIR test results rather than the CIR ones

7.2.5. Policing Configuration Test

The Policing test is useful to make sure that the network drops non-conforming (red) traffic. The policing test loads the network with a policing rate computed automatically as specified in ITU-T Y.1564. The policing test is always higher than the sum of the CIR and the EIR. Again, test execution and result presentation is different in color-aware and non-color aware services. Details are as follows:

- *Non color-aware services*: The network is loaded with a CIR + EIR + policing bit rate and the IR, FTD, FDV and FLR are measured. The test is considered to pass if CIR * (1 - FLR) < IR < CIR + EIR + 1%. The extra 1% is used to account for the burstability of policing filters due to an EBS parameter different to zero.
- *Color-aware services*: The network is loaded with CIR green traffic and EIR + policing yellow traffic. The IR, FTD, FDV and FLR is measured for both traffic

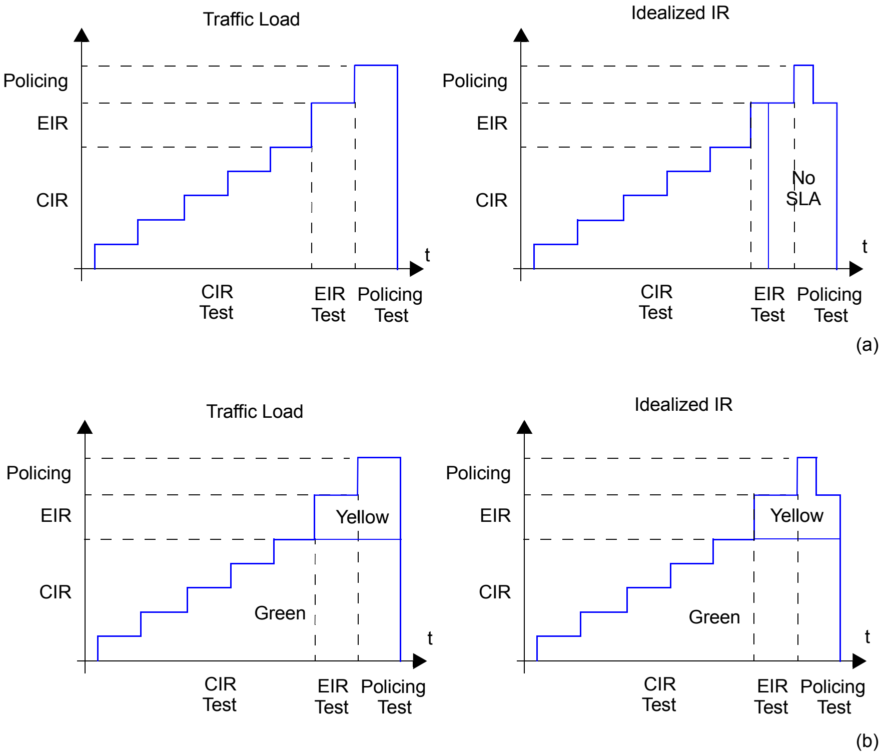

Traffic Load
Idealized IR
Policing
EIR
CIR
t
No
SLA
CIR Test
EIR Test
Policing Test
(a)
Traffic Load
Idealized IR
Policing
EIR
CIR
Yellow
Green
t
CIR Test
EIR Test
Policing Test
(b)

Figure 7.10: Typical CIR, EIR and Policing tests in colour-aware and non colour aware services: (a) No colours are defined in the interface. Some traffic may be degraded if CIR < IR < EIR because quality of service is not guaranteed for excess traffic. If IR > EIR some traffic will be lost due to the action of the policing filter. (b) Coloured interface: Yellow traffic does not have quality of service guarantees but SLA is meet for Green traffic as long as the IR remains smaller than the CIR.

classes. The test is passed if the FTD, FDV and FLR for green traffic are within acceptable limits and if the aggregated IR (green + yellow) meets the following double inequality: CIR * (1 - FLR) < IR < CIR + EIR + 1%.

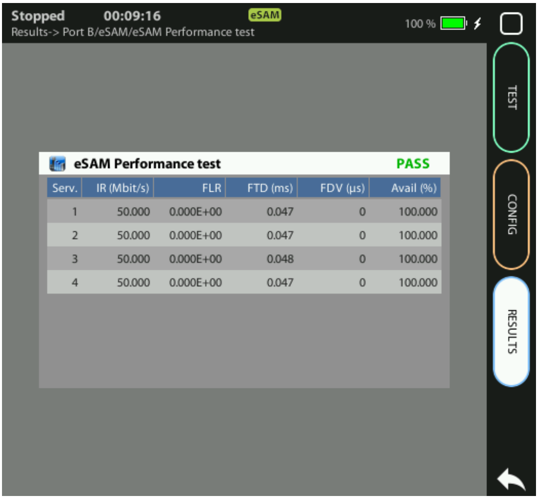
Like it happens with the CIR and EIR tests, it is possible to execute several (up to four color-aware or eight non-color-aware) policing tests. In this case, policing tests are executed sequentially for each configured service.

Users may choose to disable the policing test if the network is not using any admission control mechanism based on policing filters. The policing test fails if it is executed in networks not supporting policing.

The procedure to follow to display the policing test results is similar than for the CIR results but in this case it is necessary to use he *Test-* and *Test+* contextual keys to select the eSAM policing test results rather than the CIR ones

7.2.6. Performance Test

The eSAM performance test is executed only if the configuration CIR, EIR and policing tests are passed. While configuration tests take a few minutes to finish, a performance test may take hours or even days depending on the test requirements.



Stopped 00:09:16
Results-> Port B/eSAM/eSAM Performance test

eSAM Performance test PASS

Serv.	IR (Mbit/s)	FLR	FTD (ms)	FDV (µs)	Avail (%)
1	50.000	0.000E+00	0.047	0	100.000
2	50.000	0.000E+00	0.047	0	100.000
3	50.000	0.000E+00	0.048	0	100.000
4	50.000	0.000E+00	0.047	0	100.000

Figure 7.11: Performance results as presented by xGenius.

In some ways, the performance test is similar to the CIR test because in the network is loaded with the CIR bit rates of all configured service but in this case all services are tested simultaneously and therefore the total load is the sum of all CIR rates for all Ethernet services under test. This is important because a network may be able to support all services if they are not all them loaded at the same time but it may fail to support all services operating at maximum speed. The second difference between CIR and performance tests is that performance test uses to be long enough to compute a significant availability figure.

The performance test computes the IR, FTD, FDV, FLR and availability for all the services being tested. The test is passed if all performance metrics are found to be within acceptable limits.

The procedure to follow to display the performance test results is similar than for the CIR results but in this case it is necessary to go the *eSAM Performance test* result panel rather than to the *eSAM Configuration test* panel.

7.2.7. Generation of eSAM Result Reports

Report generation for eSAM works in a similar way that for RFC 2544. There's no need to make any special configuration in order to get the eSAM test report. It is only necessary to enable report generation (See section 11.1).

Report organization is similar than in other tests, The report contains a header, containing details about which equipment has been used to run the test, when the tester has been executed, and other information, a global PASS / FAIL indication, followed by test-specific PASS / FAIL indications, a summary of the test setup and finally detailed descriptions of the eSAM configuration and performance tests.

```
eSAM test report

Report name                 2013-04-11-173048
Custom
Department
Company
Location
Operator
Start Time                  Thu Apr 11 17:30:48 2013
Elapsed Time                00:03:08
Test Unit                   Ether.Giga Gigabit Ethernet Tester
Serial number               MEM0009P
Software version            1.13.35


Global results (Port A)

                                   Service         Status

Global status                          ---           PASS

eSAM Configuration test                  1           PASS
eSAM Configuration test                  2           PASS
eSAM Configuration test                  3           PASS
eSAM Configuration test                  4           PASS
eSAM Performance test                  ---           PASS


Test Unit Configuration

Mode                                    IP endpoint
Test method                             Two-way (A > A)

                                        Port A              Port B
Port mode                               TX/RX               Loopback
Connector                               Electrical          Optical

eSAM test configuration

Color mode                                                On
Color method                                            DSCP
```

```
Number of services                                    4
Number of steps                                       1
Step duration (s)                                     3
Policing test                                  Disabled
Performance test duration                 User duration
User duration                                  00:01:00


Service configuration

Service               CIR           EIR
   1           2.000 Mb/s    2.000 Mb/s
   2           2.000 Mb/s    2.000 Mb/s
   3           2.500 Mb/s    2.500 Mb/s
   4           2.500 Mb/s    2.500 Mb/s


eSAM objectives

Service               FLR           FTD             FDV          Avail.
   1            1.000E-03    100.000 ms       50.000 ms       99.000 %
   2            1.000E-03    100.000 ms       50.000 ms       99.000 %
   3            1.000E-03    100.000 ms       50.000 ms       99.000 %
   4            1.000E-03    100.000 ms       50.000 ms       99.000 %

eSAM CIR test

Service 1

Load (Mbit/s)    IR (Mbit/s)   FLR         FTD (ms)   FDV (ms)    Status
2.000            2.000        0.000E+00    0.145      0.014       PASS

Service 2

Load (Mbit/s)    IR (Mbit/s)   FLR         FTD (ms)   FDV (ms)    Status
2.000            2.000         0.000E+00   0.158      0.015       PASS

Service 3

Load (Mbit/s)    IR (Mbit/s)   FLR         FTD (ms)   FDV (ms)    Status
2.500            2.500         0.000E+00   0.149      0.022       PASS

Service 4

Load (Mbit/s)    IR (Mbit/s)   FLR         FTD (ms)  FDV (ms)     Status
2.500            2.500         0.000E+00   0.148     0.019        PASS

eSAM EIR test

Service 1

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green          2.000    0.000E+00          0.395          0.115      PASS
Yellow         2.000    0.000E+00          0.388          0.116      PASS
Total          4.000    0.000E+00          0.395          0.116      PASS

Service 2

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green          2.000    0.000E+00          0.141          0.012      PASS
Yellow         2.000    0.000E+00          0.144          0.012      PASS
Total          4.000    0.000E+00          0.144          0.012      PASS
```

```
Service 3

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green          2.500    0.000E+00          0.498          0.184      PASS
Yellow         2.500    0.000E+00          0.495          0.181      PASS
Total          5.000    0.000E+00          0.498          0.184      PASS

Service 4

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green          2.500    0.000E+00          0.196          0.020      PASS
Yellow         2.500    0.000E+00          0.219          0.021      PASS
Total          5.000    0.000E+00          0.219          0.021      PASS


eSAM Policing test

Service 1

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green           ----          ---           ----           ----      ----
Yellow          ----          ---           ----           ----      ----
Total           ----          ---           ----           ----      ----

Service 2

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green           ----          ---           ----           ----      ----
Yellow          ----          ---           ----           ----      ----
Total           ----          ---           ----           ----      ----

Service 3

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green           ----          ---           ----           ----      ----
Yellow          ----          ---           ----           ----      ----
Total           ----          ---           ----           ----      ----

Service 4

Color    IR (Mbit/s)          FLR       FTD (ms)       FDV (ms)    Status
Green           ----          ---           ----           ----      ----
Yellow          ----          ---           ----           ----      ----
Total           ----          ---           ----           ----      ----

eSAM Performance test

Service  IR (Mbit/s)   FLR        FTD (ms)   FDV (ms)   Avail.     Status
1        2.000         0.000E+00    0.501    0.071     100.000 %    PASS
2        2.000         0.000E+00    0.540    0.061     100.000 %    PASS
3        2.500         0.000E+00    0.484    0.063     100.000 %    PASS
4        2.500         0.000E+00    0.532    0.075     100.000 %    PASS

                                        (c) 2013 ALBEDO Telecom
```

Chapter 8
Ping and Traceroute Tools

Ping and Traceroute are two basic IP network verification tools. Both Ping and Traceroute can be considered as an integrating part of the Operations, Administration and Maintenance (OAM) suite for the IP protocol family. Due to the high availability of this tools, Ping and Traceroute can be used for testing in almost any network.

8.1. Ping

Ping checks "distance" to any host in the network in terms of delay and packet loss. Results may not be as accurate as the SLA statistics supplied by other xGenius tests but Ping tests are fast, virtually supported by any IP network element and they are at least a good way to check end-to-end network connectivity before running a more sophisticated test.

8.1.1. Internet Control Message Protocol

Ping is an application of the Internet Control Message Protocol (ICMP) Echo request and Echo reply messages. The IP protocol alone is unable to monitor whether the packets arrive to final destination. Moreover, it does not provide any error reporting when routing and forwarding anomalies occur. This task is left to the ICMP protocol.

ICMP is a network layer Internet protocol that provides mechanisms to report errors and other information regarding IP packet processing back to the source. It is used for error reporting and analysis, transferring messages from routers and stations, and for reporting network configuration and performance problems.

ICMP generates several kinds of useful messages, including *Destination Unreachable*, *Echo Request* and *Echo Reply*, *Redirect*, *Time Exceeded*, and *Router Advertisement* and *Router Solicitation*. The ICMP functionality includes: Report network errors, Congestion indication, Troubleshooting assistance, Announce packet time-outs when TTL field is set to zero.

8.1.2. Test Configuration

The setup of a Ping test is much more simple than other tests. It does not require any special remote device like a traffic reflector to work and it works in virtually any network. The steps to follow to configure the IP ping are:

1. Make sure that the Port A of your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
3. Configure *Ping/Traceroute* to *Ping*.
4. From the *Home* panel, go to *CONFIG*
   The test port settings panel is displayed.
5. Configure *IP endpoint* with the help of the *Mode* setting.
6. Select *Port A* to enter in the port A specific configuration.
7. Configure the *Local profile* (See section 2.3) either by means the DHCP protocol or by hand.
8. Go to *Ping/Traceroute*
9. Enter the destination IPv4 address by using the *Destination IPv4 address from*, *Destination IPv4 address* and *Destination host name*.
10. Configure the *Timeout*, *Interval*, *ICMP packet size* and *TTL* parameters for the test.
11. Run the Ping test with the help of *Run*.

Table 8.1: IP Ping Settings

Setting	Description
Destination IPv4 address from	Establishes the origin of the destination IPv4 address for the current stream. There are two different settings available for configuration: • *Manual*: The destination address is set to the value configured in *Destination IPv4 address*. • *Host name*: Uses the Domain Name Service (DNS) to set the destination IP address by using descriptive alphanumeric strings. The DNS mechanism requires intervention of at least one DNS server. The DNS server IP address has to be configured in the local port profile either statically or by means DHCP.

Table 8.1: IP Ping Settings

Setting	Description
Destination IPv4 address	Destination IPv4 address carried by the packets generated in the current stream if *Destination IPv4 address from* is set to *Manual*. The address is entered in decimal, four-dotted format. Any address between 0.0.0.0 and 255.255.255.255 is admitted as a destination IPv4 address.
Destination IPv4 address (DNS)	Destination IPv4 address carried by the packets generated in the current stream if *Destination IPv4 address from* is set to *Host name*. This is a read only field that it cannot be edited directly. It displays the result of the DNS name resolution carried out with the host name configured in *Destination host name.*
Destination host name	Domain name to be used as a destination if *Destination type* is set to *Domain name*. Unlike IP addresses, domain names are easy-to-remember alphanumeric strings but they have to be translated to IP addresses before any packet can be sent to the destination. The translation process requires the intervention of at least one DNS server. The DNS server IP address has to be configured in the local port profile either statically or by means DHCP.
Timeout	Time the receiver waits for an ICMP Echo replay for each ICMP Echo request it generates. No new Echo request is issued until either the previous reply is received or the timeout period finishes without any Echo reply reception. The default value for *Timeout* is 5.0 seconds.
Interval	Separation between two consecutive ICMP transmissions. The effective separation may be longer than the value configured in this field if the time it takes to receive the corresponding ICMP Echo reply is longer than the *Interval*. The default value for *Interval* is 1.0 seconds
ICMP packet size	Packet size used in transmitted ICMP Echo requests. In order to obtain the total frame size it is necessary to add the ICMP header length (8 bytes), IPv4 datagram header length (20 bytes) and the Ethernet (DIX) frame header and trailer (18 bytes). The default value is 56 bytes that is equivalent to a frame size of 102 bytes (56 bytes + 8 bytes + 20 bytes + 18 bytes).

Table 8.1: IP Ping Settings

Setting	Description
TTL	Initial Time To Live value configured in the packets transmitted in the current stream. The TTL is decreased by one unit each time it lefts a network node. If the value reaches zero, then the packet is discarded. The TTL is then a measure of the number of nodes the packet is allowed to transverse before reaching its destination.

8.1.3. Result verification

Ping results are presented in real time within a dedicated panel in the test unit. To display the Ping results follow these steps:

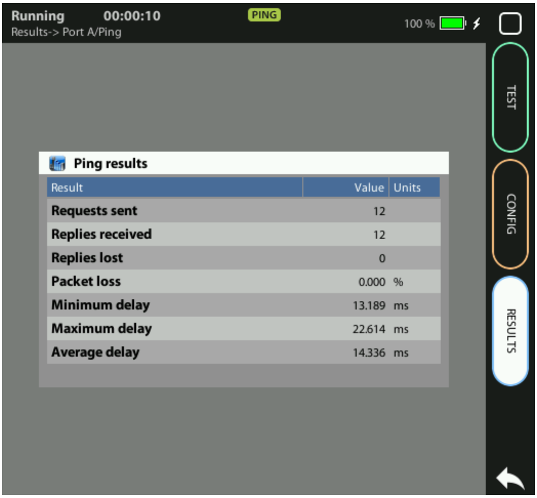
Table 8.2: IP Ping Results

Metric	Description
Requests sent	Number of ICMP Echo request messages sent from the beginning of the test.
Replies received	Number of ICMP Echo reply messages received from the destination. If the number of replies received is smaller than the request send, then it can be concluded than the network has dropped some packets. On the other hand, if the replies number is higher than the request count, then the network is probably duplicating packets somewhere.
Replies lost	Is the count of ICMP Echo reply messages lost from the beginning of the Ping test.
Packet loss	This metric is the ratio between the ICMP Echo request messages sent and the ICMP Echo reply messages lost.
Minimum delay	Minimum delay between the Echo request message transmission and the corresponding Echo reply reception event , computed over all the available Echo request / reply pairs. The Ping minimum delay can be considered an estimate of the minimum round trip delay between source and destination but the Ping delay may include ICMP protocol processing delays in intermediate router and in the destination.

Table 8.2: IP Ping Results

Metric	Description
Maximum delay	Maximum delay between the Echo request message transmission and the corresponding Echo reply reception event computed over all the available Echo request / reply pairs,. The maximum delay figure is subject to the same non-zero processing delay uncertainties than the *Minimum delay*.
Average delay	Mean delay between Echo request transmission and Echo reply reception events computed over all the available Echo request / reply pairs. The mean ping delay is subject to the same processing delay uncertainties than the *Minimum delay*.

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Select *Ping*.
4. Check the *Requests sent*, *Replies received*, *Replies lost*, *Packet loss*, *Minimum delay*, *Maximum delay* and *Average delay* statistics.



Ping results

Result	Value	Units
Requests sent	12	
Replies received	12	
Replies lost	0	
Packet loss	0.000	%
Minimum delay	13.189	ms
Maximum delay	22.614	ms
Average delay	14.336	ms

Figure 8.1: xGenius Ping results panel.

8.2. Traceroute

Traceroute can be defined as an extended Ping test that traces intermediate network elements between the source and destination. These elements are identified by their IP addresses. For this reason, Traceroute is often used to check the path the packets follow when they are transmitted to the network.The test unit support two different implementations of the Traceroute application based on different probe packets:

- *ICMP Traceroute*: The test equipment uses ICMP Echo request messages with increasing TTL values to identify the nodes in the test path. Each node decreases the TTL value in one unit before forwarding the test packet. If the TTL reaches the value of 0, then the hop replies with an ICMP Time to live exceeded message to the transmission source.
- *UDP Traceroute*: It works in a similar way than the UDP Traceroute but in this case the probe packet is a regular UDP packet directed to an arbitrary port rather than an ICMP Echo request message.

It is important to notice that some network elements located in the Traceroute test part will never be detected by this test as in is required that these elements implement the IP protocol stack reply to be able to reply to the probe packets. Ethernet switches, broadband modes operating in bridged mode and media converters fall in this category.

8.2.1. Test Configuration

Connection setup is the same for Traceroute and Ping tests. Traceroute also shares the simple and quick setup procedure with the Ping test. To configure Traceroute follow these steps:

1. Make sure that the Port A of your tester is connected to the network. The physical layer must be up and working (See section 4.1.1).
2. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
3. Configure *Ping/Traceroute* to *Traceroute*
4. From the *Home* panel, go to *SETUP*,
   The test port settings panel is displayed.
5. Configure *IP endpoint* with the help of the *Mode* setting.
6. Select either Port A to enter in the port specific configuration.
7. Configure the *Local profile* (See section 2.3) either by means the DHCP protocol or by hand.
8. Go to *Ping/Traceroute*
9. Enter the destination IPv4 address by using the *Destination IPv4 address from*, *Destination IPv4 address* and *Destination host name*.
10. Configure the *Timeout*, *Interval*, *Max. number of hops*, *Number of packets/hop*, *Traceroute protocol* and *UDP port* (UDP Traceroute only) parameters for the test.

11. Run the Traceroute test with the help of *Run*.

Table 8.3: Traceroute Settings

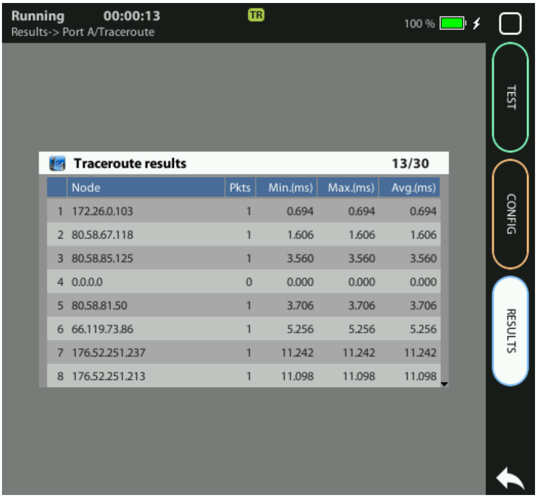
Setting	Description
Destination IPv4 address from	This field has the same meaning than the *Destination IPv4 address* from setting used by the Ping test (See section 8.1.2).
Destination IPv4 address	This field has the same meaning than the *Destination IPv4 address* setting used by the Ping test (See section 8.1.2).
Destination IPv4 address (DNS)	This field has the same meaning than the *Destination IPv4 address (DNS)* setting used by the Ping test (See section 8.1.2).
Destination host name	This field has the same meaning than the *Destination host name* setting used by the Ping test (See section 8.1.2).
Timeout	Time the receiver waits for an ICMP Time-to-live exceeded reply for each UDP request (UDP Traceroute) or ICMP Echo request (ICMP Traceroute). No new UDP / ICMP Echo request is issued until either the previous reply is received or the timeout period finishes without any Echo reply reception. The default value for *Timeout* is 5.0 seconds.
Interval	Separation between two consecutive ICMP / UDP transmissions. The effective separation may be longer than the value configured in this field if the time it takes to receive the corresponding ICMP Port unreachable / Time-to-live exceeded is longer than the *Interval*. The default value for *Interval* is 1.0 seconds
Max. Number of hops	Maximum length of the path to be analysed with Traceroute expressed in the number of hops (routers, hosts) it contains. The test fails to reach the end point if the path to be tested contains more hops than the number configured in this field. The default number of hops is 30.
Number of packets/ hop	Number of test packets directed to each hop in the test path. The default is 1 hop but this value could be increased to reduce the variability of delay statistics or to get more accurate packet loss statistics.

Table 8.3: Traceroute Settings

Setting	Description
Traceroute protocol	It is one of ICMP or UDP. These protocols define totally different Traceroute probe packets • ICMP: Uses ICMP Echo request messages with increasing TTL values as probe packets. • UDP: Uses UDP requests with increasing TTL values directed to a user configurable port as probe packets.
UDP port	Configures the destination UDP port used in UDP Traceroute tests. This setting is not required for ICMP Traceroute tests.

8.2.2. Result verification

Traceroute results are presented in real time within a dedicated panel in the test unit. To display the Traceroute results follow these steps:



Running 00:00:13

Results-> Port A/Traceroute

Traceroute results 13/30

	Node	Pkts	Min.(ms)	Max.(ms)	Avg.(ms)
1	172.26.0.103	1	0.694	0.694	0.694
2	80.58.67.118	1	1.606	1.606	1.606
3	80.58.85.125	1	3.560	3.560	3.560
4	0.0.0.0	0	0.000	0.000	0.000
5	80.58.81.50	1	3.706	3.706	3.706
6	66.119.73.86	1	5.256	5.256	5.256
7	176.52.251.237	1	11.242	11.242	11.242
8	176.52.251.213	1	11.098	11.098	11.098

Figure 8.2: xGenius Traceroute results panel.

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

4. Check the *Node* list and the *Pkts*, *Min.(ms)*, *Max.(ms)* and *Avg.(ms)* statistics for each node in the list.

Table 8.4: Traceroute Results

Result	Description
Node	IP address corresponding to a network node detected by the Traceroute test. The are displayed in a list following the same order than they have been detected by the probe packets.
Pkts	Number of ICMP Time to live exceeded messages received from a particular node in the path.
Min. (ms)	Minimum delay between the probe packet transmission and the corresponding ICMP reply reception event computed over all request / reply pairs for a particular node The Traceroute minimum delay can be considered an estimate of the minimum round trip delay between the source and the node but the Traceroute delay may include protocol processing delays in intermediate network elements.
Max. (ms)	Maximum delay between the probe packet transmission and the corresponding ICMP reply reception event computed over all request / reply pairs for a particular node. The maximum delay figure is subject to the same non-zero processing delay uncertainties than the *Min. (ms)* delay
Avg. (ms)	Maximum delay between the probe packet transmission and the corresponding ICMP reply reception event computed over all request / reply pairs for a particular node. The mean ping delay is subject to the same processing delay uncertainties than the *Min. (ms)* delay*.*

Chapter 9
IEEE 1588 Analysis

xGenius may optionally supply IEEE 1588 version 2, also known as *Packet Time Protocol (PTP)*, emulation and analysis features.

Some of the potential applications for the IEEE 1588 emulation and testing capabilities included in xGenius are:

- PTP grandmaster emulation synchronized with an external clock source based on GNSS, 2048 kb/s, 2048 kHz, 1 pps, Synchronous Ethernet and other interfaces.
- PTP slave emulation with extended performance measurements from the associated grandmaster and network, including master identity and status, PDV analysis and frequency / phase offsets.
- PTP pseudo-slave operation. In this mode the test unit behaves in the same way than any standard PTP slave but indeed does not get synchronization from any IEEE 1588v2 grandmaster but from a clock reference chosen by the user. This test enables evaluation of metrics to quantify slow phase perturbations in the PTP timing such as TE, MTIE and TDEV. The Floor delay population test is also to be run in this operation mode.
- Passive monitoring testing of the communication between PTP master and slave. Connection of the passive monitor could be done in end-point or pass-through modes. Supported monitoring tests are related with master identity and status, PDV analysis and frequency offset.

9.1. Ethernet Synchronization with IEEE 1588

The Precision Time Protocol (PTP), included in IEEE standard 1588 was originally designed to provide timing for critical industrial automation. With the 2008 version of this standard (IEEE 1588v2), PTP overcomes effects of latency and jitter through chains of Ethernet switches, providing accuracy in the nanosecond range.

9.1.1. Precedents: IP Synchronization with NTP

The Network Time Protocol (NTP), is one of the oldest protocols still in use and it is available in two flavours: the full version and Simple NTP (SNTP), a subset of NTP.

The latest version of NTP, version 4 (NTPv4) can usually maintain time to within 1-20 ms using traditional software-interrupt based solutions over the public Internet and can achieve accuracies of microseconds or better in LANs under ideal conditions. NTP has been the most common and arguably the most popular synchronization solution, because it performs well over LANs and WANs and at the same time it is inexpensive, requiring very little hardware.

NTP should be able to deliver accuracy of 1-2 ms on a LAN and 1-20 ms on a WAN. However, protocol performance is far from guaranteed largely because of variable delays added by switches and routers.

9.1.2. PTP Protocol Details

PTP requires a central grandmaster clock and low-cost PTP slave clock sites. Master and slave network devices are kept synchronized by the transmission of timestamps transmitted within the PTP messages.

Depending on how many ports has a network clock, it is referred by the IEEE 1588 standard as an *Ordinary Clock* (single port device) or a *Boundary Clock* (multi port device). The version 2 standard also defines the concept of *Transparent Clocks* that improve timing accuracy when the protocol is run in network paths which contain intermediate switches.

Table 9.1: IEEE 1588v2 Device Description

Device	Description
Ordinary Clock	A single port device that can be a master or slave clock.
Boundary Clock	A multi port device that can be a master or slave clock.
End-to-end Transparent Clock	A multi port device that is not a master or slave clock but a bridge between the two. Forwards and corrects all PTP messages.
Peer-to-peer Transparent Clock	A multi port device that is not a master or slave clock but a bridge between the two. Forwards and corrects Sync and Follow-up messages only.
Management Node	A device that configures and monitors clocks.

The normal execution of the PTP has two phases:

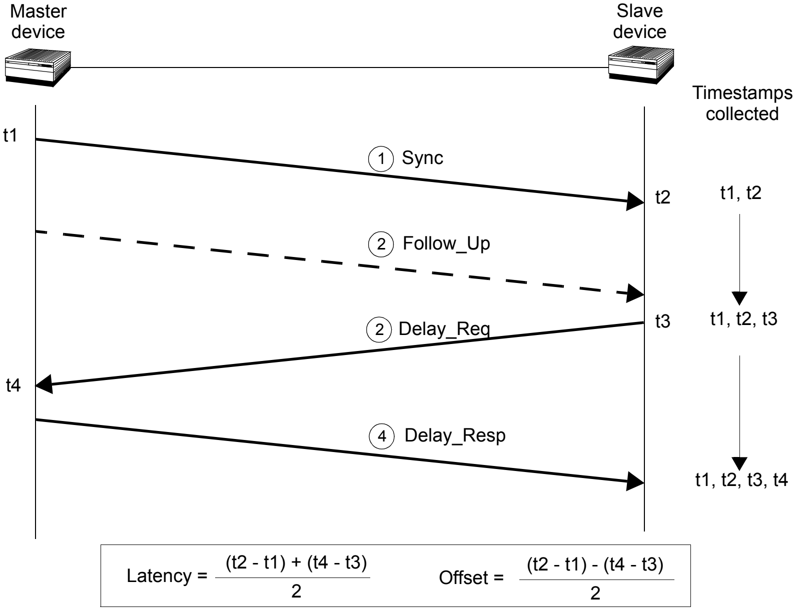
1. *Master-Slave hierarchy establishment*. Ordinary and boundary clocks decide which port has the master or slave role in each link with the help of the Best Master Clock (BMC) algorithm. The information required for operation of the BMC is sup-

plied by special *Announce* messages generated periodically by Ordinary and Boundary Clocks.

2. *Clock synchronization*. Slave clocks may have a positive or negative offsets when compared with their masters and latency from masters to slaves is also unknown. PTP devices start a procedure to compute latencies and offsets. These parameters will be used to adjust timing in slave devices.

9.1.3. The Synchronization Mechanism

Once the master and slave hierarchies have been established, by observing the clock property information contained in *Announce* messages sent by PTP devices, the synchronization process starts.



$$\text{Latency} = \frac{(t2 - t1) + (t4 - t3)}{2} \qquad \text{Offset} = \frac{(t2 - t1) - (t4 - t3)}{2}$$

Figure 9.1: Sync and Delay request-response mechanisms used by the PTP. The basic parameters of Latency and Offset are computed from the t1, t2, t3 and t4 timestamps.

Before synchronization between the master and the slave clock has been achieved, it may exist a frequency offset between both clocks. This offset is computed with the help of the *Sync* message. *Sync* messages are sent periodically by the master to upgrade offset information in the slave. *Sync* messages may carry an accurate times-tamp indicating the departure time of the own message but this requires timestamping hardware which may not always be available. To avoid dedicated hardware *Follow_Up* messages can be used. *Follow_Up* messages carry timestamps for a previous *Sync* message allowing a more relaxed timestamping procedure and simpler hardware.

The *Sync* mechanism, however, does not take into account propagation time of *Sync* messages through the network. For this reason, the slave may request a latency measurement with a *Delay Req* message. Masters reply to a *Delay Req* with *Delay_Resp* message. The timestamps the slave gets from the Delay Request-Response mechanism are used to achieve accurate time synchronization in the slave clock.

The most difficult challenge of PTP is operation through chains of Ethernet switches. Most switches store packets in local memory while the MAC address table is searched and the cyclic redundancy check field of the packet is verified before it is sent out on the appropriate port/s. This process introduces variations in the time latency of packet forwarding and damages accuracy of the PTP protocol. Version 1 of the PTP protocol deal with this problem by implementing Boundary Clocks within the switches. Version 2 uses the more advanced concept of Transparent Clock to deal with the same problem.

Transparent clocks do not participate in the master-slave hierarchy but they process PTP messages by adding special correction fields within the message based on their own estimations of packet residence times in the device. There are two different kinds of Transparent Clocks depending on whether they use the Peer-delay mechanism or the Delay request-response mechanism to compute the propagation delay between master and slave. The Peer-delay mechanism is more sophisticated and it has more pre-requisites than the Delay-request response mechanism but the Peer-delay mechanism is more scalable. End-to-end Transparent clocks add residence time compensations to all the PTP event messages but Peer-to-peer Transparent Clocks are only required to compensate *Sync* and *Follow-up* messages because they do not use the *Delay_Req* and *Delay_Resp* (Delay request-response mechanism) and they do not need to forward the *Pdelay_Req* and *Pdelay_resp* messages (Peer delay mechanism).

9.1.4. Protocol Encapsulation

PTP messages can be carried over a large family of protocols including IPv4, IPv6, IEEE 802.3 Ethernet, DeviceNET, ControlNET and IEC 61158 Type 10. The most important encapsulations are the IP and Ethernet variations (see Figure 9.2:).

IEEE 1588 messages encapsulated in Ethernet frames use the special 0x88f7 Ethertype, specifically reserved for this purpose. Messages associated with the peer-delay mechanism carry the 01:1B:19:00:00:00 multicast destination address while the remaining messages carry the 01:80:C2:00:00:0E multicast address. On the other hand, messages encapsulated in IPv4 datagrams, use the UDP protocol for transport and the destination port is 319 (event messages) or 320 (all other messages). Multicast addresses to be used when the encapsulation is set to IPv4 are the 224.0.0.107 (peer delay mechanism messages) and the 224.0.1.129 (all other messages).

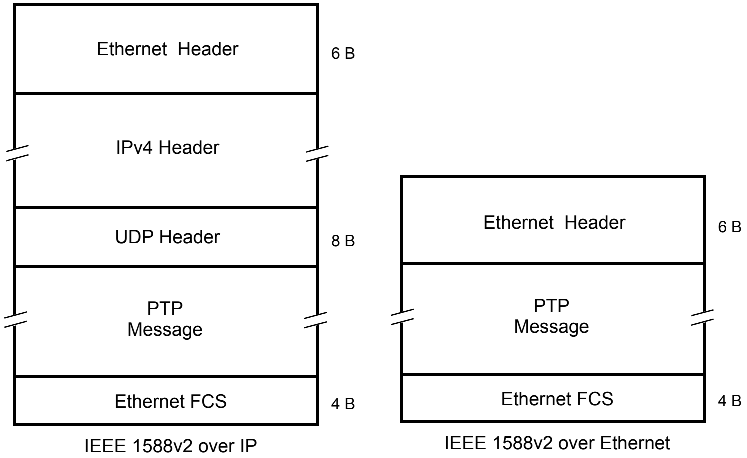


Figure 9.2: IP and Ethernet encapsulations for PTP messages.

9.1.5. Unicast Addressing Mode

The IEEE 1588v2 standard also allows for a unicast communication architecture different to the multicast operation. Unicast is to be used in networks with no support of multicast mechanisms such as most of the current implementation of the Internet. In fact, unicast addressing has been adopted by ITU-T G.8265.1 that defines a PTP profile for frequency synchronization through IP networks. The ITU-T G.8265.1 profile applies to the UDP encapsulation only. It adopts the Signalling message format defined in IEEE 1588v2 to exchange information between PTP endpoints. The ITU-T G.8265.1 also defines some complementary mechanisms to ensure the interoperability of entities implementing this PTP profile.

Without an special configuration, unicast endpoints are unable to exchange any PTP message because they don't know the identity of the remaining endpoints. Operation in unicast mode therefore requires the configuration of suitable remote PTP entities (by means their IP address) in at least some devices. This is usually done in the devices willing to become slaves. These devices then initiate a dialogue with the grandmaster to negotiate the exchange of different PTP message types including *Announce*, *Sync* and *Delay reply*. Only when the delivery of these messages is granted by the grandmaster the synchronization process starts.

9.2. IEEE 1588 Grandmaster and Slave Emulation

xGenius can be configured to behave as different kinds of PTP entities, including PTP master and slave clocks. Theoretically, there is no difference between any standard PTP clock and these equipments but the testers supply measurement results that are useful to qualify the stability of a PTP timing source, the network performance when delivering different IEEE 1588v2 messages and the ability of PTP slaves to recover an accurate timing from the messages they receive from their masters:

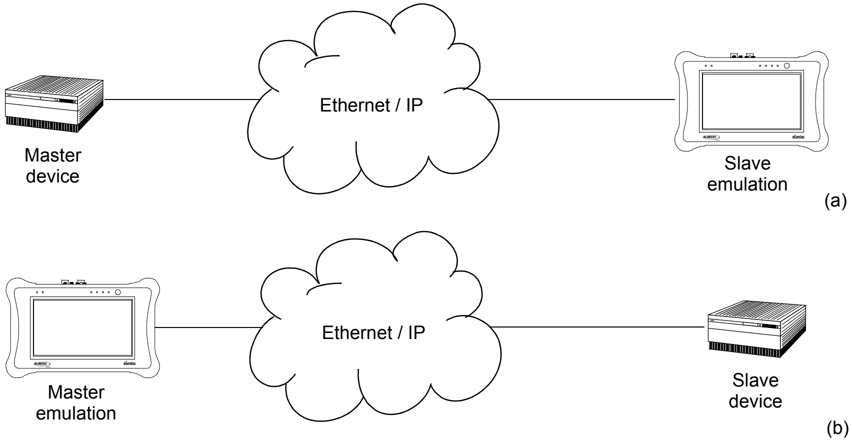


Figure 9.3: IEEE 1588 master and slave emulation modes: (a) Connection diagram corresponding to the PTP slave emulation mode, (b) connection corresponding to the master emulation mode.

The IEEE 1588 test results provided by xGenius when they are configured in *Clock emulation* mode can be classified in four different families:

- *Protocol state*: Not specifically test results. The protocol state contains details received from the master or the grandmaster clock (or the own test equipment when configured in master emulation mode).
- *Message statistics*: Includes message counts classified by their type (*Sync*, *Delay Request*, *Follow up*,...).
- *Delay statistics*: The *Packet Delay Variation* (PDV) and the *Packet Total Delay* (PTD) are some of the test results included in this family. Among different things, the delay statistics are useful to measure fast variations in the network transmission conditions affecting the timing accuracy of PTP slave devices.
- *Slave clock status*. When the test unit is configured in slave emulation mode, it tracks the frequency and phase of a PTP master. Due to phase / frequency instability in the master clock, or impairments caused by transmission through the packet switched network, the slave clock has to continuously adjust its frequency and phase. This test result quantifies the difference between the local (slave) clock and the estimated frequency / phase received from the master.

The exact test results available in any case depend on the current operation mode and on the test port. Port B contains a reduced set of PTP test results (*message statistics*) and it is unable to generate any message on its own. For this reason, for a full PTP analysis in master or slave emulation mode, it is recommended to connect the equipment to the network through the port A. Details about which results are available in each mode are provided in the following sections.

9.2.1. Configuration of the IEEE 1588 Master and Slave

When configuring the test unit in master or slave emulation modes, it has to be taken into account that only the test Port A contains a full implementation of the protocol. Port B can be used to collect message statistics but transmission and decoding of PTP messages required to supply synchronization to remote entities (master emulation mode) or to synchronize the own clock with a remote entity (slave mode) are available for Port A only.

The IEEE 1588 slave and master clock emulation is compatible with the *Ethernet endpoint* and *IP endpoint* operation modes (See section 2.1). Configuration is slightly different in each case. If you are operating in *IP endpoint* mode you need to configure your local profile before you can run a PTP test. To do that, the required steps are:

1. From the *Home* panel, go to *CONFIG*
   The test port settings panel is displayed.
2. Select *Port A* to enter in the port specific configuration.
3. Configure the *Local profile* (See section 2.3) either by means the DHCP protocol or by hand.

The previous steps are not required if the equipment is operating in *Ethernet endpoint* mode. To run a PTP test (either in *Ethernet endpoint* mode or *IP endpoint* modes) follow these steps:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *PTP (IEEE 1588)*.
3. Configure the equipment to become an active IEEE 1588 entity by configuring *PTP test* to *Emulation*.
   A label with the text PTP is displayed in the top notification area.
4. Configure *Clock emulation*, to *Master*, *Slave* or *Auto*, depending on your preferences.
5. Set the transport protocol to either *Ethernet* or *UDP*.
   Note: If you are operating in *Ethernet endpoint* mode, the *UDP* transport protocol is not allowed.
6. Configure the *Addressing mode* to *Unicast* or *Multicast*, depending on the system where the test unit is to be connected.
7. Depending on the PTP profile implemented in your system, configure *Path delay mechanism* to either *End-to-end* or *Peer-to-peer*.
8. Configure the *Domain* to the right value for your network.

9. Configure the *Priority 1*and *Priority 2* fields to the right values. These values determine the PTP role (master or slave) to be played by the test unit when *Clock emulation* parameter is set to *Auto*.
10. If you have configured *Clock emulation* to *Master* or *Auto* configure the *Master* clock type to *One-step* or *Two step* and set the *Clock class* and *Custom clock class* attributes.
11. If you have configured *Addressing mode* to *Unicast*, then you can configure one or more PTP entities to communicate with from the *Unicast master table* menu *Note*: Remote PTP entities are configured through their IP or MAC address, depending on the *Transport protocol.*
12. Configure the timing of the different messages associated to PTP from the *Message timing* menu
13. Optionally, configure the *Time properties* to custom values by setting the Mode field within this menu to Manual.

It must be taken into account that when the equipment is configured in slave emulation mode the timing is derived from the PTP messages it receives from the test interface. Any external reference such as GNSS or 1 PPS is ignored and could be disabled. When the unit is configured to run in master emulation mode the time to be distributed is obtained from the external reference if the time is available (GNSS). With phase references (1 PPS) the PTP phase is still aligned with the reference but only the local system time could be distributed. With frequency references (2048 kHz, 2048 kb/s, 1544 kHz, 1544 kb/s, 10 MHz) both the phase alignment and the time are internally generated from the system clock but the PTP signal is still syntonized with the reference frequency.

Table 9.2: IEEE 1588 Settings

Setting	Description
PTP mode	Configures the IEEE 1588 test to be executed. These are the options currently available for this setting: • *None*: Disables all PTP generation and analysis. • *Emulation*: Choose this mode if you want the test unit to behave as a PTP slave or master clock. The unit becomes a new PTP entity in your network it will generate and receive IEEE 1588 messages in the same way than any other master / slave clock installed in your network once it is properly configured. • *Test*: Configures the unit as a PTP pseudo-slave that behaves in the same way than any standard PTP slave but doesn't get synchronization from the IEEE 1588v2 grandmaster but from a clock reference chosen by the user. This is the correct operation mode to run a PTP *TE / MTIE / TDEV* test or a *Floor Delay Population* test. • *Passive monitor*: This is the right mode to verify PTP communications between a PTP master and slave without disturbing the transmission channel and the PTP entities.
Clock emulation	This setting enables the user to configure the role of the test unit within the PTP network. It is one of the following: • *Master*: The equipment is forced to assume the role of a PTP master clock within the network. • *Slave*: The equipment is forced to assume the role of a PTP slave clock within the network. • *Auto*: The equipment behaves as a PTP ordinary clock. It becomes a master or slave depending on the result of the BMC algorithm.

Table 9.2: IEEE 1588 Settings

Setting	Description
Transport Protocol	Configures the encapsulation protocol for the PTP messages. It is one of the following: • *Ethernet*: PTP messages are transmitted and received through an IEEE 802.3 / Ethernet encapsulation as specified in IEEE 1588-2008 Annex F. This transport protocol is used by the PTP Power profile (IEEE C37.238-2011) and the ITU-T G.8275.1 Telecom phase and time profile. • *UDP*: PTP messages are encapsulated in UDP over IPv4 frames as specified by IEEE 1588-2008 Annex D. This frame structure is used by the PTP Telecom profile for frequency synchronization (ITU-T G.8265.1) and the PTP Telecom profile for phase and time applications with partial timing support from the network (ITU-T G.8275.2).
Addressing mode	Defines the addressing procedure used by PTP endpoints to reach remote devices. It could be based in either multicast or unicast addressing: • *Unicast*: Enables unicast transmission of all PTP messages. For unicast addressing to work it is required knowledge from the endpoints about the remote end unicast address. Grandmasters know to which address to send messages thanks to a slave initiated handshake procedure based on time-limited leases but, if unicast operation is enabled, at least one grandmaster unicast MAC or IP address has to be configured in the slave. In the test unit grandmaster addresses are configured in the *Unicast master table*. Unicast addressing is used by the PTP Telecom profile for frequency synchronization (ITU-T G.8265.1) and the PTP Telecom profile for phase and time applications with partial timing support from the network (ITU-T G.8275.2). • *Multicast*: Configures multicast transmission in the PTP interface. It means that destination addresses of PTP messages transmitted by the interface will be multicast. If the current payload setting is UDP, then the correct destination addresses are 224.0.1.129 and 224.0.0.107. In Ethernet payloads the multicast addresses are 01:80:C2:00:00:0E and 01:1B:19:00:00:00. Multicast addressing is required by the PTP Power profile (IEEE C.37.238-2011) and the ITU-T G.8275.1 Telecom phase and time profile.

Table 9.2: IEEE 1588 Settings

Setting	Description
Path delay mechanism	Decides whether to use the end-to-end or the peer-to-peer delay mechanism to compensate the latency between PTP endpoints. The available configurations are: • *End-to-end*: Delay is computed by exchanging delay request and reply messages between endpoints. This operation mode is used by the PTP Telecom profile for frequency synchronization (ITU-T G.8265.1),the ITU-T Telecom phase and time profile with full timing support from the network (ITU-T G.8275.1) and partial timing support from the network (ITU-T G.8275.2). • *Peer-to-peer:* Delay is computed by exchanging peer-delay request and reply messages between PTP peers. A PTP peer is not necessarily an endpoint. Intermediate devices such as transparent clocks may also participate in the peer delay mechanism. The PTP Power profile (IEEE C37.238-2011) is based in the peer-to-peer delay mechanism.
Master clock type	Configures generation of follow up packets for *Sync* and other PTP messages. This setting could have two different values: • *One-step:* Means that no follow up messages are generated. The time stamps are carried by *Sync* and *Peer Delay Response* messages themselves. • *Two-step*: In this case a follow up message is generated for each Sync and Peer Delay Response message. The Sync and Peer Delay Response messages provide information about meaningful transmission instants and the follow-ups are the time-stamps for these instants. No one of the methods is more accurate than the other but one-step clocks are more efficient because they generate less messages to send the same information. PTP slave clocks are required to be compatible with the one-step and two-step mechanisms. End-to-end slave clocks are required to accept follow up messages when received but they do not generate these messages themselves. Peer-to-peer messages on the other hand have to reply to peer delay requests from other PTP entities and therefore the clock type has to be configured in these clocks even if they do not operate as PTP masters.

Table 9.2: IEEE 1588 Settings

Setting	Description
Message timing	This menu contains menu items necessary to configure the timing associated to the transmission of several message types when the equipment is configured in clock emulation or test modes. With the help of the *Message timing* menu you can configure the following parameters: *Sync TX interval*, *Delay Request TX interval*, *Peer Delay Request TX interval*, *Announce TX interval*, *Announce RX timeout (#msgs)*, *Unicast Sync interval, Unicast Delay Request interval*, *Unicast Peer Delay Req. interval.*
Domain	Configures the PTP domain for the test unit. The PTP domain is identified by a number between 0 and 255. The equipment is allowed to exchange PTP information only with clocks within the same domain. The unit ignores all messages received from other domains (these messages are classified as *Domain mismatches*). All PTP equipments from other domains will probably ignore all messages from the tester.
Priority 1	This is a numeric parameter used by the BMC to establish the master / slave hierarchy with the help of the BMC algorithm. The range of accepted values of *Priority 1* is between 0 and 255. It is more likely that the test unit becomes a PTP master during the BMC if *Priority 1* is configured to an small value.
Priority 2	This is a numeric parameter used by the BMC to establish the master / slave hierarchy with the help of the BMC algorithm. The range of accepted values of *Priority 2* is between 0 and 255. It is more likely that the test unit becomes a PTP master during the BMC if *Priority 2* is configured to an small value.

Table 9.2: IEEE 1588 Settings

Setting	Description
Unicast master table	Contains a table where the user can configure one or several PTP peer addresses. By default, unicast entities do not receive any announcement message from other PTP devices deployed in the network. Before unicast clocks can exchange any piece of information with other PTP entity they need to establish an association with this entity. This is usually done with a slave initiated dialogue. In order to be able to start this dialogue, the unicast endpoint must know the IP addresses (UDP payload) or MAC addresses (Ethernet payload) corresponding with the peers. These are the addresses to be configured in this table. This configuration is required only when the equipment is expected when the unit is expected to operate as an slave. Multicast communications do not require setting of this table neither.
Unicast peer IPv4 address	The Unicast peer IPv4 address is the peer address configured when *Transport protocol* is to *UDP*, *Addressing mode* is *Unicast* and the *Path Delay Mechanism* is configured to *Peer-to-peer*. When the peer-to-peer delay mechanism is configured in *Path delay mechanism*, message delivery happens between contiguous devices and it is not necessarily end-to-end. It is therefore required to configure the peer address which it is normally different to the remote end address.
Unicast peer MAC address	The Unicast peer IPv4 address is the peer address configured when *Transport protocol* is to *Ethernet*, *Addressing mode* is *Unicast* and the *Path Delay Mechanism* is configured to *Peer-to-peer*. When the peer-to-peer delay mechanism is configured in *Path delay mechanism*, message delivery happens between contiguous devices and it is not necessarily end-to-end. It is therefore required to configure the peer address which is normally different to the remote end address.

Table 9.2: IEEE 1588 Settings

Setting	Description
Master identity	Menu that contains the menu items necessary to set the master identity either as a MAC address, IPv4 address or host name. You can also leave the equipment to choose the master identity for you if you set the *Source of identity* sub-field to *Auto*. Configuring the master identity makes sense only you have configured the equipment as a *Passive monitor*.
Clock class	Sets the clock class as defined in IEEE 1588-2008 or the clock-source quality-level defined in ITU-T G.781. The Clock class defines traceability of the time or frequency distributed by the master clock and it is one of the parameters used to establish the master / slave hierarchy with the help of the BMC. This field is available for configuration only if *Clock emulation* has been set to *Auto* or *Master*.
Custom clock class	The *Custom clock class* sets a custom clock class in numeric format when *Clock class* has been configured to *Custom*. Any *Custom clock class* between 0 and 255 is allowed here.
Time Properties	Configures the values of certain flags related with traceability of the time and / or frequency signal generated by the test equipment when it is configured in PTP master emulation mode.
Clock id.	Read only field that reports the Clock Id. assigned to the PTP engine running in the port. The Clock Id. is built from the port A MAC address following IEEE 1588v2.
Port	Port number. In a multi-port PTP device with it identifies each port. xGenius have all one single PTP port and therefore the port number is always 1.

When the test unit is configured in endpoint mode and PTP entity emulation is enabled, the equipment can still be configured as a multistream traffic generator (See section

4.1, See section 4.2). This feature is useful to verify the performance of the PTP protocol with different traffic loads.

Table 9.3: IEEE 1588v2 Time Properties Settings

Setting	Description
Mode	It is one of *Manual* or *Auto* • *Manual*: The user decides the value of the time properties fields and flags. This setting is required if detailed debug of the PTP master-to-slave association is required. For example some slaves may refuse get locked to the master when the time or frequency is not traceable. • *Auto*: Let the test unit decide which settings to use for the time properties. The equipment always tries to use the best time source available. For example, it uses TAI time scale if possible and it sets the correct current UTC offset if this information is available. Specifically, when either a phase or a frequency reference is used the automatic time scale is always *Arbitrary*.When a time reference (GNSS) is used the time scale is TAI but a transient Arbitrary time scale could be transmitted for a few minutes before the GNSS receiver has got from the satellite system all the information required to generate an accurate TAI time. Using *Manual* time properties does not make sense if the unit is not operating in PTP master emulation mode. For this reason, this control is configured statically to *Auto* in slave emulation mode.
UTC Offset	This field reports the difference between the TAI and UTC time scales. Due to the leap seconds mechanism this offset is always an integer number of seconds. Currently (November 2017), the TAI time is 37 seconds ahead of UTC. The UTC offset is required only if the slave has to translate the time into the UTC time scale. All xGenius time measurements in test mode are done in the TAI time scale and therefore they are not affected by the value of this flag
UTS Offset valid	The value of this flag is true if the value configured in the UTC offset is usable by slave (or boundary) clocks.

Table 9.3: IEEE 1588v2 Time Properties Settings

Setting	Description
Timescale	The time scale is an standard for the duration of the time unit (usually the atomic second) together with an epoch, which constitutes an origin for the seconds count. It is one of *Arbitrary* or *TAI.* • *Arbitrary:* It means that a custom time scale is being distributed. Basically, any non-TAI time scale, included UTC, is considered arbitrary. In an arbitrary time scale there is no control on the second length or in the epoch time. There is also the possibility of unexpected gaps in seconds count. • *TAI*: International Atomic Time. Weighted average of the time kept by about 200 atomic clocks in over 50 national laboratories worldwide. It is a continuous time scale (it contains no leap seconds), it uses the atomic second as a time unit. The epoch for the TAI time scale is 00:00:00 01/01/1970.
Time traceable	This flag is set to true when the time provided by a network clock is traceable to a primary time source. For example, the GPS satellite constellation is time traceable.
Frequency traceable	This flag is set to true when the time provided by a network clock is traceable to a primary frequency source. For example, the GPS satellite constellation is frequency traceable.
Time source	Sets the time source used by the grandmaster clock in a certain PTP domain. It could be one of: *Atomic clock*, *GPS*, *Terrestrial radio*, *PTP*, *NTP*, *Hand-set*, *Internal oscillator*, *Others.*

In any PTP endpoint emulation test it is important to pay attention to the PTP message timing. There is a menu specifically devoted to configure the timing for the different PTP messages (*Message Timing* menu). As an example, configuring the correct *Announce TX interval* and *Announce TX timeout (#msgs)* is essential even if the unit is going to play the slave role. This is because the test unit may wrongly understand that one or several messages are lost and trigger the actions corresponding to this event.

Table 9.4: IEEE 1588v2 Message Timing Configuration

Setting	Description
Sync TX interval	Sync message rate transmitted by the test unit when the *Addressing Mode* is configured to *Multicast*. Allowed values are 128 pkt/s, 64 pkt/s, 32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 s/pkt and 8 s/pkt. Sync messages are not transmitted by PTP slaves and therefore this setting is enabled only if *Clock emulation* is set to *Auto* or *Master*.
Delay Request TX interval	Delay Request message rate transmitted by the test unit when the *Addressing Mode* is configured to *Multicast*. Allowed values are 128 pkt/s, 64 pkt/s, 32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 s/pkt and 8 s/pkt. Delay Request messages are not transmitted by PTP grandmasters and therefore this setting is enabled only if *Clock emulation* is set to *Auto* or *Slave*. If the *Path delay mechanism* is configured to *Peer-to-peer* then Peer Delay Request rather than Delay Request messages are transmitted and therefore this field is greyed out.
Peer Delay Request TX interval	Peer Delay Request message rate transmitted by the test unit when the *Addressing Mode* is configured to *Multicast*. Allowed values are 128 pkt/s, 64 pkt/s, 32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 s/pkt and 8 s/pkt. Peer Delay Request messages are not transmitted by PTP grandmasters and therefore this setting is enabled only if *Clock emulation* is set to *Auto* or *Slave*. The *Path delay mechanism* must be also configured to *Peer-to-peer* to enable these messages to be transmitted.
Announce TX interval	Configures the Announce message rate. It is important that this parameter is homogeneous in all PTP entities in the domain. Allowed values for the Announce TX interval are 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 s/pkt, 8 s/pkt, 16 s/pkt, 32 s/pkt, 64 s/pkt, 128 s/pkt and 256 s/pkt.

Table 9.4: IEEE 1588v2 Message Timing Configuration

Setting	Description
Announce RX time-outs (#msgs)	Sets the number of missing Announce packets before a PTP slave declares the timing source to be lost. Any value between 2 and 10 messages is allowed. Only PTP slaves are expected to keep track of received Announce messages and therefore, this option is greyed out if *Clock emulation* is configured to *Master*.
Unicast Sync interval	Sync message rate negotiated by unicast PTP entities. If the entity finally becomes a grandmaster it will deliver packets at the negotiated rate. Both grandmasters and slaves participate in the unicast Sync interval negotiation and therefore, unlike it happens in the multicast addressing mode, this setting makes sense in all clock emulation modes. Allowed values for the *Unicast Sync interval* are 128 pkt/s, 64 pkt/s, 32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s and 2 s/pkt.
Unicast Delay Request interval	Delay request message rate negotiated by unicast PTP entities. If the entity finally becomes an slave it will deliver packets at the negotiated rate. Both grandmasters and slaves participate in the unicast Delay Request interval negotiation and therefore, unlike it happens in the multicast addressing mode, this setting makes sense in all clock emulation modes. If the *Path delay mechanism* is configured to *Peer-to-peer* then Peer Delay Request rather than Delay Request messages are transmitted and therefore this field is greyed out. Allowed values for the *Unicast Delay Request interval* are 128 pkt/s, 64 pkt/s,32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 pkt/s, 8 pkt/s, 16 pkt/s, 32 pkt/s, 64 pkt/s.

Table 9.4: IEEE 1588v2 Message Timing Configuration

Setting	Description
Unicast Peer Delay Req. interval	Peer Delay Request message rate negotiated by unicast PTP entities. If the entity finally becomes an slave it will deliver packets at the negotiated rate. Both grandmasters and slaves participate in the unicast Peer Delay Request interval negotiation and therefore, unlike it happens in the multicast addressing mode, this setting makes sense in all clock emulation modes. The *Path delay mechanism* must also configured to *Peer-to-peer* to enable these messages to be transmitted. Otherwise, Delay Request rather than Peer Delay Request messages will be transmitted. Allowed values for the *Unicast Peer Delay Request interval* are 128 pkt/s, 64 pkt/s, 32 pkt/s, 16 pkt/s, 8 pkt/s, 4 pkt/s, 2 pkt/s, 1 pkt/s, 2 s/pkt, 4 pkt/s, 8 pkt/s, 16 pkt/s, 32 pkt/s, 64 pkt/s.

9.2.2. Protocol State

The basic PTP results are available in the *Protocol State* panel. All the information contained in this panel is collected from *Announce* messages received from remote PTP entities or is an indication of the state of the internal PTP synchronization machine.

The *Protocol State* results are permanent, it is not required to start a test (*RUN* button) to display the information from this panel. The information is updated in real-time as new changes in the protocol state are registered by the test unit. To display the protocol state panel follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.

2. Select either *Port A* to enter in the port A specific results.

Table 9.5: Protocol State Results

Result	Description
Port state	Displays one of the port states defined for the BMC algorithm in standard IEEE 1588-2008. These states determine which is the current role of the network equipment within the synchronization network (master or slave) or inform about special conditions or problems within the BMC algorithm. The Port State is set to one of the following values: • *Initializing*: While a port is in the *Initializing* state, the port initializes its data sets, hardware, and communication facilities. The port does not place any PTP messages on its communication path. • *Faulty*: The fault state of the protocol. A port in this state does not place any PTP messages. • *Disabled*: The port does not place any messages on its communication path. All PTP received messages are ignored except for statistic compilation. • *Listening*: The port is waiting for an announce receipt timeout to expire or to receive an *Announce* message from a master. The purpose of this state is to allow orderly addition of clocks to a domain. • *Pre-master*: The port behaves in all respects as though it were in the *Master* state except that it does not place any messages on its communication path except for *Peer Delay Request*, *Peer Delay Response* or *Peer Delay Follow up*. • *Master*: The port is behaving as a master clock. • *Passive*: The port does not place any messages on its communication path except for *Peer Delay Request*, *Peer Delay Response* or *Peer Delay Follow up*. • *Uncalibrated*: One or more master ports have been detected in the domain. The appropriate master port has been selected, and the local port is preparing to synchronize to the selected master port. This is a transient state to allow initialization of synchronization servos, updating of data sets when a new master port has been selected. • *Slave*: The port is synchronizing to the selected master port.

Table 9.5: Protocol State Results

Result	Description
Master IP address	This is a 32-bit IPv4 address in the standard four-dotted decimal format *A.B.C.D* that describes the master. This result is displayed only if the PTP *Transport Protocol* is - *UDP*. If the test equipment is operating in master emulation mode or if there is no master, the IP address corresponding to the active PTP port in the unit is shown instead.
Master Ethernet address	48-bit MAC address in the standard hexadecimal-digit format *XX:XX:XX:XX:XX:XX* corresponding to the PTP master where the test unit is currently connected. This result is displayed only if the PTP *Transport Protocol* is - *Ethernet*. If the test equipment is operating in master emulation mode or if there is no master, the MAC address corresponding to the active PTP port in the unit is shown instead.
Master identity	EUI-64 code associated to the master clock. The EUI-64, computed as explained in standard IEEE 1588-2008, constitutes a globally unique identifier.
Master port number	Number of ports reported by the master. Devices with one port are referred as Ordinary Clocks by IEEE 1588v2. Devices with more than one port are termed as Boundary Clocks.
Tiimescale	The time scale is an standard for the duration of the time unit (usually the atomic second) together with an epoch, which constitutes an origin for the seconds count. It is one of *Arbitrary* or *TAI.* • *Arbitrary:* It means that a custom time scale is being distributed. Basically, any non-TAI time scale, included UTC, is considered arbitrary. In an arbitrary time scale there is no control on the second length or in the epoch time. There is also the possibility of unexpected gaps in seconds count. • *TAI*: International Atomic Time. Weighted average of the time kept by about 200 atomic clocks in over 50 national laboratories worldwide. It is a continuous time scale (it contains no leap seconds), it uses the atomic second as a time unit. The epoch for the TAI time scale is 00:00:00 01/01/1970.

Table 9.5: Protocol State Results

Result	Description
Grandmaster identity	EUI-64 code associated to the grandmaster clock. The EUI-64, computed as explained in standard IEEE 1588-2008, constitutes a globally unique identifier. The Grandmaster identity is different to the master identity only when the synchronization is transmitted through a chain involving several PTP master / slave relations.
Grandmaster priority 1	Priority 1 parameter configured in the grandmaster. The *priority 1* is a numeric parameter used by the BMC algorithm to establish the master / slave hierarchy. The smaller this value is, the higher priority is assigned to the clock to become master.
Grandmaster priority 2	Priority 2 parameter configured in the grandmaster. The *priority 2* is a numeric parameter used by the BMC algorithm to establish the master / slave hierarchy. The smaller this value is, the higher priority is assigned to the clock to become master.
Grandmaster clock class	Clock class associated to the grandmaster clock in decimal format. The Clock class defines traceability of the time or frequency distributed by the master clock and it is one of the parameters used to establish the master / slave hierarchy with the help of the BMC.
Grandmaster clock class desc.	Clock class associated to the grandmaster clock described with alphanumeric characters. Examples of possible clock class descriptors are: *Custom*, *Synchronized to PRC*, *Holdover*, *Default,* etc.
Grandmaster clock accuracy	The grandmaster clock accuracy indicates the expected accuracy of a clock when it is the grandmaster, or in the event it becomes the grandmaster. This is a field that characterized a clock for the purpose of determining the master / slave hierarchy.
Grandmaster clock variance	Grandmaster clock statistic variance estimated as specified in IEEE 1588-2008. This field is used by the grandmaster clock to report the variability of its own internal oscillator.

Table 9.5: Protocol State Results

Result	Description
Grandmaster time source	Indicates the time source used by the grandmaster clock. The value is not used in the selection of the grandmaster clock. It is one of the following • *Atomic clock*: Any device that is based on atomic resonance for frequency and that has been calibrated against international standards for frequency and time. • *GPS*: Any device synchronize to a satellite system that distribute time and frequency tied to international standards. • *Terrestrial radio*: Any device synchronized via any of the radio distribution systems that distribute time and frequency tied to international standards • *PTP*: Any device synchronized to a PTP-based source of time external to the domain • *NTP*: Any device synchronized via the Network Time Protocol (NTP) or the Simple Network Time Protocol (SNTP) to servers that distribute time and frequency tied to international standards. • *Hand set*: Used for any device whose time has been set by means of a human interface based on observation of an international standards source of time to within the claimed clock accuracy. • *Other*: Other source of time and / or frequency not covered by other values. • *Internal oscillator*: Any device whose frequency is not based on atomic resonance nor calibrated against international standards for frequency, and whose time is based on a free running oscillator with epoch determined in an arbitrary or unknown manner.

3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Protocol state* and check *Port state*, *Master IP address / Master Ethernet address*, *Master identity*, *Master port number*, *Timescale, Grandmaster identity*, *Grandmaster priority 1*, *Grandmaster priority 2*, *Grandmaster clock class*, *Grandmaster clock class desc.*,*Grandmaster clock accuracy*, *Grandmaster clock variance*, *Grandmaster time source*.

9.2.3. Message Statistics

The *Message statistics* panel include counts of each PTP message type defined in IEEE 1588-2008. This result panel includes statistics both about received and transmitted (internally generated) packets.

There is one Message statistics panel for each test port. In case, that protocol emulation or delay / jitter tests are not required, Port B can be used for message statistics compilation. The procedure to display the message statistics is as follows:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Message statistics*.
5. Press *Run* to start a new test and check the transmitted (TX) and received (RX) values of *Sync*, *Delay Request*, *Delay Response*, *Peer Delay Request*, *Peer Delay Response*, *Follow-up*, *Peer Delay*, *Follow-up*, *Announce*, *Signaling*, *Management* and *Domain mismatch*,

Table 9.6: IEEE 1588 Message Statistics

Result	Description
Sync	Accounts for the number of received (RX) and transmitted (TX) *Sync* messages. *Sync* messages are generated by PTP master clocks and carry information about their clock frequency and phase. To achieve accurate synchronization the PTP slave needs to complement the information obtained from the Sync messages either with the Delay request-response or the Peer delay mechanisms.
Delay Request	Number of received (RX) and transmitted (TX) *Delay Request* messages. The *Delay Request* message is part of the *Delay request-response* mechanism used to measure the two-way latency between master and slave. The *Delay Request* message is always generated by the PTP slave.
Delay Response	Number of received (RX) and transmitted (TX) *Delay Response* messages. The *Delay Response* message is part of the *Delay request-response* mechanism used to measure the two-way latency between master and slave. The *Delay Response* message is always generated by the PTP master as a reply to a *Delay request* received from a slave.

Table 9.6: IEEE 1588 Message Statistics

Result	Description
Peer Delay Request	Computed number of received (RX) and transmitted (TX) *Peer Delay Request* messages. The *Peer Delay Request* message is part of the *Peer Delay* mechanism used to measure the two-way latency between master and slave.
Peer Delay Response	Number of received (RX) and transmitted (TX) *Peer Delay Response* messages. The *Peer Delay Response* message is part of the *Peer Delay request-response* mechanism used to measure the two-way latency between master and slave. The *Peer Delay Response* message is always generated by the PTP entity as a reply to a *Peer Delay Request* received from the peer entity.
Follow-up	Number of received (RX) and transmitted (TX) *Follow-up* messages. *Follow up* packets are generated by some PTP masters when for some reason *Sync* messages cannot carry accurate timestamps. In this case the a *Follow up* message carrying the accurate timestamps is transmitted immediately after every *Sync* packet.
Peer Delay Follow-up	Number of received (RX) and transmitted (TX) *Peer Delay Follow-up* messages. *Peer Delay Follow-up* packets are generated by some PTP devices using the *Peer delay* mechanism masters when for some reason *Sync* messages cannot carry accurate timestamps. In this case the a *Follow up* message carrying the accurate timestamps is transmitted immediately after every *Sync* packet.
Announce	Number of received (RX) and transmitted (TX) *Announce* messages. Announce messages are generated by PTP ordinary and boundary clocks in order to establish or modify a master / slave hierarchy by means the *Best Master Clock* (BMC) algorithm.
Signaling	Number of received (RX) and transmitted (TX) *Signalling* messages. *Signaling* messages are generated by PTP entities to negotiate some optional features like unicast transmission.

Table 9.6: IEEE 1588 Message Statistics

Result	Description
Management	Number of received (RX) and transmitted (TX) *Management* messages. Management messages are used to connect the PTP entities to the management system and enable operation and maintenance of the synchronization network.
Domain mismatch	Total count of received IEEE 1588 messages no corresponding to the currently configured PTP domain.
Sync seq. anomaly	This is a counter increased in one unit for each out-of-order received Sync message. An out-of-order message contains a sequence number different to the expected value.

9.2.4. Delay Statistics

The *Delay statistics* panel is probably one of the most important PTP results panel available in *PTP clock emulation* mode as it contains valuable quantitative information to assess the performance of the transmission network. Like it happens with most of the PTP results, the *Delay statistics* are available only for Port A.

Delay statistics do not depend on the operation mode (*IP endpoint* or *Ethernet endpoint*) but they do on the clock role. For example, in master emulation mode, *Sync* messages are ignored and therefore all metrics related with this message are not available. The PTP delay statistics are compensated with the help of the correction field included in PTP event messages. The objective of the delay compensation is to evaluate the transmission performance achieved with switches behaving as transparent clocks. It is important to note that if the equipment is configured in slave emulation mode, some delay statistics may not be accurate. The reason is that in this mode the time reference is generated based on received PTP messages, which are at the same time the objects to be evaluated. One of the most visible effects is that any steady state long term estimation of the path asymmetry is zero. An alternative to improve the accuracy of the delay statistics is to use an external time reference (GNSS) and configure *PTP mode* to *Test* (pseudo-slave).

The procedure to display the delay statistics associated to PTP messages is as follows:

Table 9.7: IEEE 1588 Delay Statistics

Result	Description
Sync PTD (current)	Last calculated value of the Packet Total Delay (PTD) experienced by IEEE 1588 *Sync* messages when they travel from the master to the test unit (with *end-to-end* delay mechanism) or from the peer entity to the slave (with *peer-to-peer* delay mechanism). The result is expressed in microseconds. The Sync *PTD (current)* metric is compensated in delay which means that corrections carried out by intermediate IEEE 1588 transparent clocks are taken into account to compute the end result. This result is available only if the equipment is operating in *Slave emulation* mode or in *Test* mode.
Sync PTD (minimum)	Minimum value of *Sync PTD (current)* registered from the beginning of the test. This result is available if the equipment is operating in slave emulation mode or in test mode.
Sync PTD (maximum)	Maximum value of *Sync PTD (current)* registered from the beginning of the test. This result is available if the equipment is operating in slave emulation mode or in test mode.
Sync PTD (average)	Mean value of the PTD computed over all *Sync* messages received from the beginning of the test and expressed in microseconds. This result is available if the equipment is operating in slave emulation mode or in test mode.
Sync PTD (std. dev.)	Standard deviation of the PTD computed over all Sync messages received from the beginning of the test. Note that even if it is an statistic corresponding to the PTD, the standard deviation is a quantity related with how the PTD varies over the collected samples. In fact, the *Sync PTD (std. dev.)* does not depend on the absolute delay from the master and it is computed in slave emulation, pseudo-slave emulation (*Test mode*) and passive monitoring modes.

Table 9.7: IEEE 1588 Delay Statistics

Result	Description
Sync PTD (range)	Difference between the *Sync PTD (maximum)* and *Sync PTD (minimum)*. This is an Sync PTD statistic but like it happens with the *Sync PTD (std. dev.)* it is more related with delay variation than with absolute delay. It could be that the *Sync PTD (range)* is known even if *Sync PTD (maximum)* and *Sync PTD (minimum)* are not. For this reason, the *Sync PTD (range)* statistic is computed in slave emulation, pseudo-slave emulation (*Test mode*) and passive monitoring modes.
Sync PDV (current)	Current value of t the Packet Delay Variation (PDV) computed as per RFC 3393 and RFC 1889. Delay variation is computed over consecutively transmitted packets. The instantaneous value is smoothed with the function defined in RFC 1889 before being displayed. The *Sync PDV (current)* is computed in slave emulation, pseudo-slave emulation (*Test mode*) and passive monitoring modes.
Sync PDV (maximum)	Maximum value of *Sync PDV (current)* registered from the beginning of the test. The *Sync PDV (maximum)* is computed in slave emulation, pseudo-slave emulation (*Test mode*) and passive monitoring modes.
Sync PDV (average)	Mean value of all the Sync PDV values computed from the beginning of the test. Each individual delay variation is evaluated as the absolute value of the PTD associated to a given frame minus the PTD associated to the frame transmitted next. All possible consecutive frame transmission events are taken into account for the calculation of this performance metric. The only exception to this rule is if one or both frames are lost. The *Sync PDV (average)* is computed in slave emulation, pseudo-slave emulation (*Test mode*) and passive monitoring modes.
Delay req. PTD (current)	Last calculated value of the PTD experienced by IEEE 1588 *Delay req.* messages (or *Peer delay req.* messages) when they travel from the test unit to the master (with *end-to-end* delay mechanism) or from the test unit to the peer entity (with *peer-to-peer* delay mechanism).

Table 9.7: IEEE 1588 Delay Statistics

Result	Description
Delay req. PTD (minimum)	Minimum value of *Delay req. PTD (current)* registered from the beginning of the test. The *Delay req. PDV (minimum)* is computed both in slave emulation and test modes.
Delay req. PTD (average)	Mean value of the PTD computed over all *Delay req.* messages transmitted from the beginning of the test.
Delay req. PTD (std. dev.)	Standard deviation of the PTD computed over all Delay request messages received from the beginning of the test. This metric is computed when the equipment is operating in IEEE 1588 slave clock emulation or in test mode.
Delay req. PTD (range)	Difference between *Delay req. PTD (maximum)* and *Delay req. PTD (minimum)*. This metric is computed only in slave emulation and test modes.
Two-way PTD (current)	This result is computed as the sum of the *Sync PTD (current)* and *Delay req. PTD (current).* It is an estimation of the time invested by a two-way IEEE 1588 packet transmission between the master and the slave. This metric is computed in slave emulation mode and in test mode
Two-way PTD (minimum)	This result is computed as the sum of the *Sync PTD (minimum)* and *Delay req. PTD (minimum).* It is an estimation of the minimum time invested by a two-way IEEE 1588 packet transmission between the master and the slave. This metric is computed in slave emulation mode and in test mode.
Two-way PTD (average)	Metric calculated as the sum of the *Sync PTD (average)* and *Delay req. PTD (average)*. It is an estimation of the average time invested by a two-way IEEE 1588 packet transmission based on the packets collected from the beginning of the test. The *Two-way PTD (average)* is computed in slave emulation mode and in test mode.

Table 9.7: IEEE 1588 Delay Statistics

Result	Description
Asymmetry (current)	This result is computed as the difference of the *Sync PTD (current)* and *Delay req. PTD (current)*. Delay asymmetry may cause a wrong time estimates in PTP slave clocks and for this reason this parameter has to be carefully controlled in PTP roll-outs for phase and time applications. This metric is computed both in slave emulation mode and in test mode.
Asymmetry (minimum)	This result is computed as the difference of the *Sync PTD (minimum)* and *Delay req. PTD (minimum).* This metric is computed both in slave emulation mode and in test mode.
Asymmetry (maximum)	This result is computed as the difference of the *Sync PTD (maximum)* and *Delay req. PTD (maximum).* This metric is computed both in slave emulation mode and in test mode.
Asymmetry (average)	This result is computed as the difference of the *Sync PTD (average)* and *Delay req. PTD (average).* This metric is computed both in slave emulation mode and in test mode.
Sync IAD (current)	Current Inter Arrival Delay (IAD) computed over the *Sync* packets received from a remote IEEE 1588 master clock. The Sync IAD is defined as the delay between two consecutively received IEEE 1588 Sync packets. The *Sync IAD (current)* metric is computed in slave emulation, pseudo-slave emulation (*test mode*) and passive monitor modes.
Sync IAD (average)	Mean value of the Sync IAD computed over all *Sync* messages received from the beginning of the test and expressed in microseconds. The *Sync IAD (average)* metric is computed in slave emulation, pseudo-slave emulation (*test mode*) and passive monitor modes.

Table 9.7: **IEEE 1588 Delay Statistics**

Result	Description
Sync correction (current)	Current value of the correction field found in received Sync messages. This value corresponds with correction field found in the last decoded Sync message. The *Sync correction (current)* metric is computed in slave emulation, pseudo-slave emulation (*test mode*) and passive monitor modes.
Sync correction (maximum)	Maximum value of the correction field found in a *Sync* registered from the beginning of the test. The *Sync correction (maximum)* metric is computed in slave emulation, pseudo-slave emulation (*test mode*) and passive monitor modes.
Sync correction (average)	Mean value of all the Sync correction field computed over all received Sync messages from the beginning of the test. The *Sync correction (average)* metric is computed in slave emulation, pseudo-slave emulation (*test mode*) and passive monitor modes.

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Delay statistics*.
5. Press *Run* to start a new test and check the values of *Sync PTD (current)*, *Sync PTD (minimum)*, *Sync PTD (maximum)*, *Sync PTD (average)*, *Sync PTD (std. dev.)*, *Sync PTD (range)*, *Sync PDV (current)*, *Sync PDV (maximum)*, *Sync PDV (average)*, *Delay req. PTD (current)*, *Delay req. PTD (minimum)*, *Delay req. PTD (maximum)*, *Delay req. PTD (average)*, *Delay req. PTD (average)*, *Delay req. PTD (std. dev.)*, *Delay req. PTD (range)*, *Two-way PTD (current)*, *Two-way PTD (minimum)*, *Two-way PTD (average)*, *Asymmetry (current)*, *Asymmetry (minimum)*, *Asymmetry (maximum)*, *Asymmetry (average)*, *Sync IAD (current)*, *Sync IAD (average), Sync correction (current), Sync correction (maximum), Sync correction (average)*.

9.2.5. Clock Status

When the test unit is operating in slave emulation mode it is required to track the frequency and phase of a signal generated by a PTP master and encoded in different types of messages. Not ideal conditions in the master, the transmission network and the slave cause transient or permanent phase and frequency errors in the clock recovered by the slave equipment. These errors can be estimated on the basis of fluctuations no the received phase. The phase and frequency error are displayed in the *Slave clock status* panel. To display the phase and frequency errors, follow these steps:

Table 9.8: Slave Clock Status Metrics

Result	Description
PTP time	If the unit is operating as a PTP grandmaster, this field shows the system time, which is the time the unit distributes to the remote PTP slaves. In PTP slave emulation mode, this field displays the time and date recovered from the grandmaster in the correct time scale as long as there is enough information to do that. The PTP time is not available if the unit is operating as a pseudo-slave (*Test* mode) or as a PTP monitor (*Monitor* mode)
Timescale	The *Timescale* defines how time is accounted by the device. The PTP protocol supports two different time scales: • *PTP*: This time scale is continuous and based on the SI second in the same way that the *International Atomic Clock* (TAI) time. The epoch (time origin) is defined to be 01/01/1970 00:00:00 TAI. • *Arbitrary*: Constitutes a continuous time scale with an epoch defined by an administrative procedure external to the PTP protocol. If the unit is configured in master emulation mode this field displays the current time scale being distributed by the test unit. In slave emulation mode this field shows the time scale inherited from the grandmaster.
UTC Offset	If the time scale is *PTP*, this field displays the offset between the UTC and the PTP (TAI) time. In January 2017 the UTC offset is 37 seconds.
Frequency offset	Displays the frequency offset between currently selected IEEE 1588 grandmaster and the test unit. If the equipment is working in slave emulation or passive monitoring modes, it slowly tracks the frequency recovered from the master. In this case, under ideal transmission conditions, the *Frequency offset* should converge to an small value. If the equipment is operating in pseudo-slave emulation (*Test* mode). This result corresponds with the offset between the frequency recovered from the grandmaster and the clock reference frequency.

Table 9.8: Slave Clock Status Metrics

Result	Description
Phase offset	Phase offset between the currently selected IEEE 1588 master and xGenius. If the equipment is working in slave emulation mode, it tracks the phase recovered from the master (and compensates for transmission latency using either the *Delay request-response* or the *Peer delay* mechanisms). The phase offset should be close to zero under ideal or nearly ideal transmission conditions. In pseudo-slave emulation mode (*Test* mode*),* the phase offset shows the phase difference between the reference and the PTP signal. If the reference does not contain time information, the phase information is greyed out.

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Clock status*.
5. Press *Run* to start a new test and check the values of *PTP Time*, *Timescale*, *UTC offset* and *Frequency offset* and *Phase offset*.

9.2.6. Unicast Negotiation Results

If the equipment has been configured to use the unicast addressing model (See section 9.2.1), users are allowed to see the active signalling leases that enables the endpoint to transmit and receive miscellaneous PTP messages. To verify the unicast PTP leases follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Unicast negotiation.*
5. Select either *Outgoing leases* to see the message exchange leases initiated by the device or *Incoming leases* to see the leases initiated by the peer.
6. Check the *Clock id*. *Port*, *Address* and *Status fields* corresponding each PTP peer.
7. Scroll up or down to one of the table rows and select to display details about a particular unicast peer.
8. Check the *Message type*, *Interval* and *Status* for each row in the table

9.3. The Pseudo-slave Emulation Mode

The pseudo-slave emulation is similar to the slave emulation mode but the test unit now keeps an independent synchronization source. Typically, a GNSS reference is used but the test equipment could use any other reference such as 1 PPS, frequency inputs or even the internal oscillator in holdover / free running states. From the outside, the pseudo-slave and slave emulation modes are indistinguishable but internally they are different. Now the reference and test signals can be compared and the measurement bandwidth could be extended to very low frequencies involving phase variations of hours or days typical of wander tests. If a time reference such as GNSS is used the *Time Error* (TE) could be computed as well. Finally, the pseudo-slave operation mode is also compatible with background traffic generation. This feature could be used to check any change in the TE, MTIE and TDEV depending on the traffic load. Additionally, some special test metrics such as the Floor delay population test require previous configuration of this PTP operation mode.

The pseudo-slave test mode is compatible both with the *IP endpoint* and the *Ethernet endpoint* operation modes. If the test is to be run in *IP endpoint* mode, the user is required to configure a valid IP profile (See section 9.2.1). Once the local profile has been configured the steps to follow to enable the pseudo-slave mode are described below:

1. Configure the clock reference input (See section 2.7).
2. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
3. Go to *PTP (IEEE 1588)*.
4. Configure the equipment to become a PTP pseudo-slave entity by configuring *PTP test* to *Test*.
   A label with the text PTP is displayed in the top notification area.
5. Set the transport protocol to either *Ethernet* or *UDP*.
   Note: If you are operating in *Ethernet endpoint* mode, the *UDP* transport protocol is not allowed.
6. Configure the *Addressing mode* to *Unicast* or *Multicast*, depending on the system where the test unit is to be connected.
7. Depending on the PTP profile implemented in your system, configure *Path delay mechanism* to either *End-to-end* or *Peer-to-peer*.
8. Configure the *Domain* to the right value for your network.
9. If you have configured *Addressing mode* to *Unicast*, then you can configure one or more PTP entities to communicate with from the *Unicast master table* menu
   Note: Remote PTP entities are configured through their IP or MAC address, depending on the *Transport protocol.*
10. Configure the timing of the different messages associated to PTP from the *Message timing* menu

9.3.1. TE Test

The basic performance parameter for phase and time deployments is TE. Basically, TE tells how much time a certain clock is ahead or behind some reference time. TE is generated in PTP-aware and non-PTP-aware network entities. Moreover, the transmission medium could also contribute to the TE. There are two mechanisms that could potentially generate TE:

- *Due to limited PRTC performance*, the time distributed through the network may not be accurate. If the PRTC is in holdover status an additional phase offset is expected to happen. This offset will be propagated to all the equipments locked to the PRTC.
- *Due to path delay asymmetry* the master-to-slave and the slave-to-master propagation delays may not be the same. It is not difficult to see that the TE generated by path asymmetry is one half of the value of the asymmetry. For example if the master-to-slave latency is 1 ms different compared with the slave-to-master latency, then the induced TE in the PTP slave will be 500 ns.

To measure the TE you have to configure the PTP pseudo-slave (*Test*) mode in your test unit. The only clock reference input that is compatible with the TE test is *GNS*S Once the equipment is configured in pseudo-slave mode, follow these steps:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to Time error statistics
5. Start a test with the help of *Run*.
6. Check the *Current*, *Maximum* and *Minimum* values corresponding with the *Total, Constant* and *Dynamic* TE.

Table 9.9: TE Statistics

Result	Description
Total	*Total TE*. This result accounts for the difference in time units between the time carried by the signal under test minus the reference. Computing the *Total* TE requires a time reference. The only reference that is currently available for this purpose is GNSS. *Current, Minimum* and *Maximum* figures are computed for the total TE. The minimum and maximum values are referred to the whole test duration.

Table 9.9: TE Statistics

Result	Description
Constant	*Constant Time Error* (cTE). This result expresses TE components that are immune to filtering. Such TE components are the result of, for example, asymmetry in the transmission medium between network elements or asymmetries within network elements. The cTE spans the frequency band between 0 and 0.1 Hz. Constant (0 Hz) cTE could theoretically be compensated through a static setting in the slave equipment, but slowly varying TE with periods of hours or days is both difficult to compensate or filter and it therefore should be avoided as much as possible. *Current, Minimum* and *Maximum* figures are computed for the cTE. The minimum and maximum values are referred to the whole test duration.
Dynamic	*Dynamic Time error* (dTE*)*. High frequency component of the TE. It is related to random noise accumulation due to packet-delay variation experienced by the timing signal packets or due to any other phase noise source. The power spectrum of the dynamic TE is spread out over the frequencies larger than 0.1 Hz and the power can be reduced, to some extent, through low-pass filtering. *Current, Minimum* and *Maximum* figures are computed for the dTE. The minimum and maximum values are referred to the whole test duration.

9.3.2. Wander (MTIE / TDEV) Test

Wander in a digital signal is defined as a slow phase fluctuation that degrades the quality of the clock embedded in the signal. The upper limit to the wander frequency band is usually defined to be 10 Hz but wander could have periods of hours or even days. Wander is propagated through the network and because it is not absorbed or filtered, it is accumulated impairing the timing signal. This concept of phase fluctuation could be translated without relevant modifications to synchronization protocols for packet switched networks such as PTP / IEEE 1588v2.

Measuring wander to assess the long term stability of a timing signal involves the use of an accurate clock reference due to the inability to filter out wander components from the signal under test. The phase of the reference clock is then compared with the phase corresponding to the signal under test. Performance metrics are then derived from the phase error. There are many performance figures defined to assess the quality of a timing signal but the most important of them are:

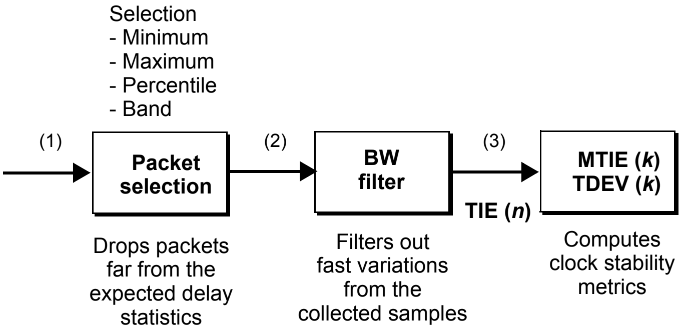

Selection
- Minimum
- Maximum
- Percentile
- Band
(1)
Packet selection
(2)
BW filter
(3)
TIE (n)
MTIE (k)
TDEV (k)
Drops packets far from the expected delay statistics
Filters out fast variations from the collected samples
Computes clock stability metrics

Figure 9.4: Wander measurement mechanism. The timing information has to be filtered before being delivered to the MTIE and TDEV block.

- The *time interval error* (TIE) is the 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 measurement instant. The time origin, TIE=0 is taken as a reference at the start of the measurement. The TIE is expressed in absolute time units (ns, μs, ms).
- The *maximum time interval error* (MTIE) is the maximum value of peak-to-peak TIE in a certain observation time. This means that in order to calculate the MTIE, a time window of predefined length, *k*, must be scrolled over the function TIE (*n*), recording the maximum peak-to-peak value of the TIE. This can be repeated for different values of *k*, thus obtaining a graph of MTIE (*k*).
- *Time deviation* or TDEV is a measurement that characterizes the spectral content of a TIE (*n*) signal. This means that it measures the power of wander frequency components. 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. As it is the case with MTIE, the TDEV is a function of the observation time *k*.

In digital circuits (PDH, SDH, SONET) the wander is always measured over the recovered clock. As the wander cannot be filtered out by the clock recovery circuit, the results are not affected by this test mechanism but on the other hand the unwanted fast phase fluctuations are removed or greatly attenuated. When dealing with PTP, wander can be evaluated directly from the packet interface but with this procedure the results are unrealistically pessimistic. The reason is that a real PTP slave clocks implement several packet selection and filtering mechanisms to improve the synchronization performance. ITU-T G.8260 defines several filtering mechanisms to be applied to the test equipment that makes it possible for these equipments to emulate the way commercial devices process and filter the PTP messages.

xGenius measures the *pktFilteredTIE*, *pktFilteredMTIE* and *pktFilteredTDEV* in the terms defined in ITU-T G.8260. The IEEE 1588 MTIE / TDEV is compatible with the *Ethernet endpoint* and *IP endpoint* operation modes (See section 2.1).

Table 9.10: Wander Test Configuration Parameters

Setting	Description
Enable	Enables or disables the PTP wander test. Wander tests can be executed only if PTP test has been configured to *Wander test*.
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. A critical error such a loss of clock reference or a loss of signal also stops the test.
Metric	Configures the performance metrics to be used in the next PTP wander test. The only option available in the current release is *pktFilteredTDEV / MTIE*. This option corresponds with the *pktFilteredMTIE* and pktFilteredTDEV as they are defined in ITU-T G.8260. The pktFilteredMTIE and pktFilteredTDEV are similar to their counterparts for TDM networks, the MTIE and TDEV, but these are computed directly in a packet interface.

Table 9.10: Wander Test Configuration Parameters

Setting	Description
Selection method	Configures one of the packet selection method to be used to filter PTP samples to compute wander performance metrics. The selection method configured in this field constitutes a not linear filter applied to the timing input before it is transferred to the wander metric calculation block. This filtering is used to discard samples and avoid unrealistic wander results. For example the filter could be used to discard packets with potentially more delay variation. The selection methods supported by the test units are defined in ITU-T G.8260 and they are listed below: • *Minimum:* Selects the packet with smaller end-to-end delay within the filtering window. • *Maximum:* Selects the packet with larger end-to-end delay within the filtering window. • *Percentile*: Uses a percentile value expressed in % to configure the packets to be processed by the MTIE / TDEV block (*Max. percentile*). Packets with an end-to-end delay larger than the configured percentile are not taken into account. • *Band*: Uses two percentile values expressed in % to configure the packets to be processed by the MTIE / TDEV block (*Max. percentile*, *Min. percentile*). Samples with a delay smaller than *Min. percentile* or larger than *Max. percentile* are ignored by the MTIE / TDEV block.
Selection window length	Configures the length of the not linear sample selection filter in seconds. Longer selection filters may potentially generate more accurate results but they involve an increase in the test period or at least in the amount of time required to get the first results
Min. percentile	Minimum allowed percentile in *Band* selection modes.
Max. percentile	Maximum allowed percentile in *Percentile* and *Band selection* modes.

Table 9.10: Wander Test Configuration Parameters

Setting	Description
BW filter window	Window length expressed in seconds for the linear filtering processing block placed before the MTIE and TDEV block. Unlike the selection filter, the linear filtering operates by averaging sample values before they are used to compute the MTIE and TDEV values. With this operation, it is pretended to simulate the behaviour of a real timing synchronization circuit that always tends to average the samples on its input. The BW filter window length is subject to the same kind of trade off that than the selection window. The longer the window the more accurate results but longer windows involve longer test periods as well.
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	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 9.10: Wander Test Configuration Parameters

Setting	Description
Standard	• 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*. Pass / Fail results are computed by comparison of the test results and the configured mask value

To measure the TE you have to configure the PTP pseudo-slave (*Test*) mode in your test unit. Any clock reference input, including time, phase and frequency references are compatible with the MTIE / TDEV test. Once the test unit is configured in pseudo-slave mode, follow these steps:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *PTP wander test.*
3. Enable the MTIE / TDEV test by setting the *Enable* control to *On*.
4. Configure the *Observation time*, to one of the allowed values. The test finishes automatically when the *Observation time* is reached.
5. Optionally, configure the packet selection filter through the *Selection method*, *Selection window length*, *Min. percentile* and *Max. percentile* settings.
6. Optionally, configure the low pass filter by means the *BW filter window* control.
7. Configure the *Mask source* and *Standard mask* parameters for the next MTIE / TDEV measurement.

The unit is now ready to run the test and read the results. To do that, this is the correct procedure:

1. From the *Home* panel, go to *RESULTS,*
   The test port results panel is displayed.

2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *PTP wander test*.
5. Choose between MTIE or TDEV
6. Start the test by pressing *Run*.
7. Check the *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).
   Note: The TIE, MTIE and TDEV values must be understood as pktFilteredTIE, pktFilteredMTIE, and pktFilteredTDEV respectively.
   Note: The amount of time to wait before the first results are displayed depends of the filter settings.

9.3.3. Floor Delay Population Test

PTP slave clocks may increase their accuracy and stability by implementing packet selection mechanisms. In simple terms, this means that it is an advantage for PTP slave clocks to just discard packets with a potentially large amount of phase error rather than trying to use them in any way.

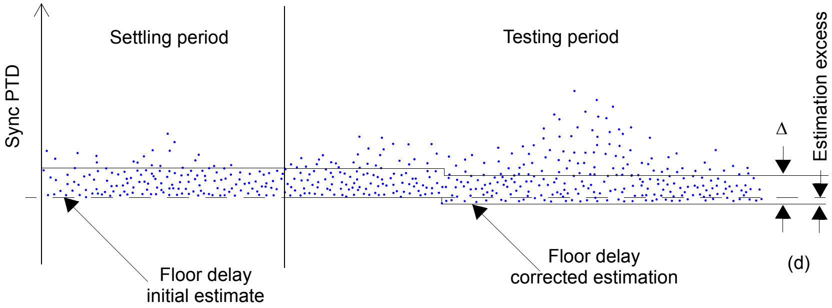


Figure 9.5: Illustration of the floor delay population test. Samples are classified as conforming or not conforming depending on the latency they experience from the grandmaster.

The floor delay population test attempts to implement a mechanism to measure the number of samples suitable for slave synchronization. With this objective in mind, the test defines an acceptable end-to-end delay range. The lowest delay is defined to be the floor delay for the path under test. In other words, the smallest time recorded for a packet as it is transmitted through the path. The highest delay is obtained by adding a fixed time to the floor delay. Samples are rated as conforming if they are found between the minimum and the maximum delay. Not conforming packets exhibit an end-to-end delay larger than the maximum. By definition, there are no packets with end-to-end delay below the floor delay.

xGenius implement the floor delay population with the equipment configured in pseudo-slave mode. The procedure to configure the equipment in this mode is the same that for the MTIE / TDEV test (See section 9.3.2). If the equipment is configured in *IP endpoint* mode, configuration of a IP profile is also necessary. This configuration is also identical to the MTIE / TDEV test (See section 9.3.2). Once the IP profile, the external reference and the pseudo-slave mode are all configured, these are the steps to follow to run the floor delay population test:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *Floor delay population test (FPP).*
3. Configure *Enable* to *On* to activate the test
4. Enter the value of the *Min. delay settling time* if you want to modify the floor delay calculation period.
5. Configure the *FPC window length* if you want to modify the time window to compute the FPC, FPR and FPP metrics.
6. Modify the values of *FPC delta* and *FPP threshold* to change the default pass / fail threshold for the FPP.

Table 9.11: Floor Delay Population Test Configuration Parameters

Setting	Description
Enable	Enables or disables the PTP floor delay population test. Wander tests can be executed only if PTP test has been configured to *Wander test.*
Obs. floor delay method	It determines the procedure to measure the floor delay. The only floor delay measurement method available today is *Progressive*. The *Progressive* mechanism evaluates the floor delay along the whole testing period but there is an initial period of configurable length that is used to do a first estimate of this parameter. In order to get the maximum accuracy in the test results, the observed floor delay during the settling period has to be as exact as possible. Variations of the floor delay after the settling period are computed as an estimation excess. Results are therefore less accurate as the estimation excess becomes larger.
Min. delay settling time	Amount of time devoted to compute the floor delay. Longer values for this setting contribute to a more accurate estimation of the floor delay and therefore higher quality in the test results.
Overall min. floor delay	This configuration field is not used in the current implementation of the floor delay population test.

Table 9.11: Floor Delay Population Test Configuration Parameters

Setting	Description
FPC window length	The floor delay population method is based on a sliding window mechanism. The relevant metrics are referred to a time window that changes its position in time. The FPC window length configures the floor delay population test sliding window length. ITU-T G.8261.1 uses a window length of 200 s to specify the network operation limits.
FPC delta	Configured the delay excess from the floor delay used to determine the conformity of a received sample. ITU-T G.8261 uses a delta of 150 µs to specify the operation network limit
FPP threshold	This parameter is the ratio of conforming samples to the total amount of received samples. ITU-T G.8261.1 state that at least 1% of the received samples should be within a 150 µs range accounted from the floor delay computed for the path.

Table 9.12: Floor Delay Population Results

Result	Description
FPC (pkts)	*Floor Packet Count* (FPC). This is the amount of conforming packets received within the current window. This count is updated once per second as new samples are received and the test window moves through the time axis. ITU-T Recommendations do not currently supply any network operation limit based on the FPC metric.
FPR (pkts/s)	The *Floor Packet Rate* (FPR) corresponds with the amount of conforming samples received per unit time. ITU-T Recommendations do not currently supply any network operation limit based on the FPR metric.
FPP (%)	The *Floor Packet Percentage* (FPP) is the ratio of conforming samples to received packets expressed as a percentage. ITU-T G.8261 specifies an FPP of 1% or smaller for a delta of 150 µs and a test window of 200 s.
Estimated floor delay	This result field is not used in the current implementation of the floor delay population test.
Observed floor delay	This result field is not used in the current implementation of the floor delay population test.

Table 9.12: Floor Delay Population Results

Result	Description
Estimation excess	The *Estimation excess* is the difference between the floor delay computed in the initial settling period and the smallest observed delay during the test period. Ideally, the *Estimation excess* should be 0. A value different to 0 implies that the initial floor delay estimation was not accurate. A large estimation excess may involve a partial accuracy loss in the test results.
Floor delay estimation	This field reports a possible loss of accuracy due to a wrong estimation of the floor delay.
Sync packet rate	The *Sync packet rate* field reports modifications on the Sync message packet rate during the current test. Message rate modifications affect the test results and must be avoided during the testing period.

Once the test has been configured, follow these steps to run the measurement and read the results:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Floor delay population test (FPP)*.
5. Press *Run* to start a new test
   Note: On the top right corner a *Settling* indication is displayed at the beginning of the test. Once the settling period expires the indication changes to Testing but no result is displayed before the measurement window is filled with data.
6. Check the values of *FPC (pkts)*, *FPR (pkts/s)* and *FPP (%)*.
7. Verify that the *Estimation excess*, the *Floor delay estimation* and *Sync packet rate* are acceptable.

9.4. Passive Monitoring

Sometimes, the ability to qualify the operation of an existing PTP slave already connected to the network is more important than a full emulation of a PTP slave. A typical example happens when an slave device exhibits poor performance for unknown reasons. A quick PDV measurement with xGenius could be useful to determine whether the problem is caused by the network (congestion, inappropriate switches) or the device (high sensitivity to PDV, configuration problem).

The passive monitoring operation mode is defined so that it doesn't affect the network in any way. No PTP traffic is generated in this mode. Interaction is limited to analysis of the different types of messages received from other PTP master and slave clocks. Connection in Ethernet or IP endpoint is allowed when the monitoring mode is configured but the *IP through* mode is allowed as well. By connecting the equipment in pass-through mode at the output of the DUT (usually a PTP slave) it is possible to analyse the messages the DUT is receiving without any intermediate device that could be masking the real synchronization performance.

When the test unit is operating in *PTP monitor* mode it cannot track the phase generated by the master because it does not estimate the path delay (Delay request-response mechanism, Peer-delay mechanism) but it can still syntonize the master frequency. The result is that all metrics related with absolute phase or delay are not available in PTP *Passive monitor* mode.

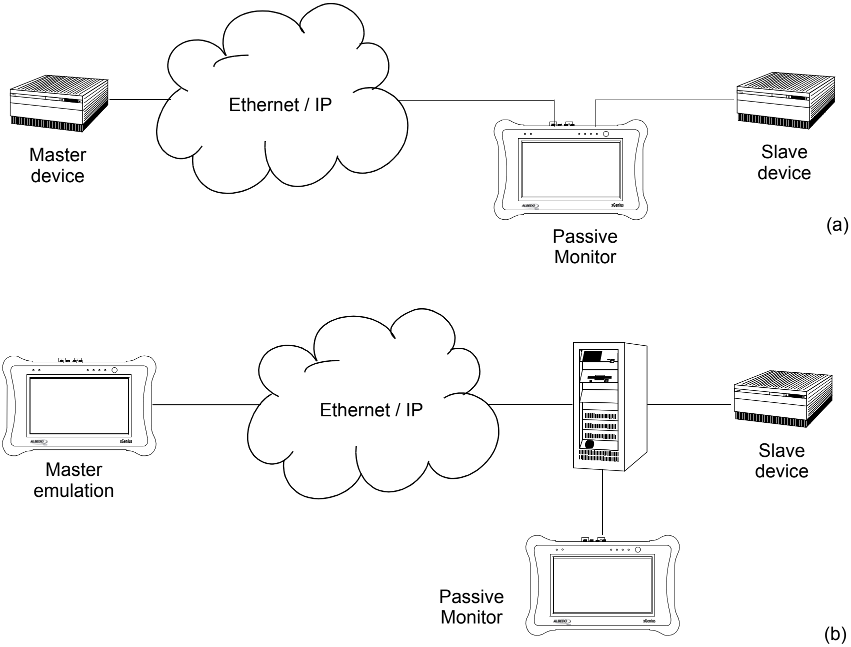


Figure 9.6: Connection of xGenius to the network in PTP *Passive monitor* mode: (a) Connection in pass-through mode (IP through operation mode). (b) Connection in endpoint mode (*Ethernet endpoint* or *IP endpoint* operation modes).

If you want to run the PTP monitor in *IP endpoint* or *IP through* modes, you will need to set your local profiles with correct IP addresses, network masks and gateways. For the specific case of the *IP through* mode, you will have to configure the local profile of both *Port A* and *Port B*. The details are as follow:

1. From the *Home* panel, go to *CONFIG*
   The test port settings panel is displayed.
2. Select *Port A* to enter in the port specific configuration.
3. Configure the *local profile* (See section 2.3) either by means the DHCP protocol or by hand.

If your operation mode is *IP endpoint*, the local profile configuration finishes here. If you are working in *IP through* mode, repeat the previous steps for *Port B*. The configuration specific for the PTP protocol is detailed in the following steps:

1. From the *Home* panel, go to *TEST*,
   The test configuration panel is displayed.
2. Go to *PTP (IEEE 1588)*.
3. Configure the equipment to become an passive IEEE 1588 monitor by configuring *PTP test* to *Monitor*.
   A label with the text PTP is displayed in the top notification area.
4. Set the transport protocol to either *Ethernet* or *UDP*.
   Note: If you are operating in Ethernet endpoint mode, the *UDP* transport protocol is not allowed.
5. Configure the *Domain* to the right value for your network. The default value in most networks is 0.
6. Go to *Master identity* to select a remote PTP master clock.
7. Configure Source of identity to one of the allowed values: *Auto*, *IPv4 address*, and *Host name* (UDP transport protocol) or *Auto* and *MAC address* (*Ethernet transport* protocol).
8. If you have configured *Source of identity* to *IPv4 address*, *Host name* or *MAC address*, fill the correct master identify field with the data from your master.
9. Optionally, configure the timing of the different messages associated to PTP from the Message timing menu.

Once configured, you can use the same measurement procedures described for the PTP master and slave clock emulation (See section 9.2) to get statistics and counts in your test environment. The only difference in the results is that in the *Passive monitor* mode only a subset of the statistics available for the endpoint emulation are available.

9.5. Clock Interface Monitoring

TE and MTIE / TDEV test results are available either from the Ethernet / IP output (PTP test) or in a frequency / time output from the PTP slave.

In xGenius, monitored signals include both frequency (2048 kHz, 1544 kHz, 10 MHz) and time (1 PPS). 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. The TE is used as the key performance metric for 1 PPS interface and TIE is used in frequency interfaces.

There is also a jitter analysis test available for 2048 kHz and 1544 kHz

9.5.1. Connecting the Unit

Connect the DUT to the Port C and follow these steps to enable the 1 PPS 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*.

9.5.2. 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 2.7, See section 2.8, See section 2.10).

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 or 1 PPS. 1 PPS testing in holdover mode are also supported.

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

9.5.3. 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 *Setup* configuration panel is displayed.
2. Select *Port C* to enter in the port specific configuration menu.
3. Configure *Clock frequency* to *1544 kHz (Port C)*, *2048 kHz (Port C)*, *10 kHz (Port C)* or *PPS (Port C)*.
4. Configure the Connector to *Balanced* or *Unbalanced* to use the Port C RJ-48 or BNC connectors respectively.
   Note: In 1 PPS tests, the unbalanced connector is referred as Unbalanced (PPS RX) and it corresponds with the Port C SMA connector. This connector is available in units with the GNSS hardware option.

9.5.4. 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:

Table 9.13: 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.

Table 9.13: 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 (2048 kHz) or 10 Hz and 40 kHz (1544 kHz). • *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 (2048 kHz) or 8 kHz and 100 kHz (1544 kHz). • *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.

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*.

9.5.5. 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.

9.5.6. Running the 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 tests the *TE* and *Max. TE* replace the *TIE* and *Max. TIE* statistics.
   Note: The wander analysis metrics have the same meaning that the same metrics for the Synchronous Ethernet test (See section 10.4)
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 10.4)

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

Table 9.14: Jitter results

Metric	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.

Chapter 10
Synchronous Ethernet Analysis

xGenius may optionally support the ITU-T defined Synchronous Ethernet standard which enables these equipments qualify Synchronous Ethernet network equipment or to generate Ethernet signals synchronized to various timing sources, including GPS and TDM.

10.1.Introduction to Synchronous Ethernet

Synchronous Ethernet is an ITU-T standard that provides mechanisms to transfer frequency over the Ethernet physical layer, which can then be made traceable to an external source such as a network clock. As such, the Ethernet link may be used and considered part of the synchronization network.

The proposal to specify the transport of a reference clock over Ethernet links was brought by operators to ITU-T Study Group 15 in September 2004. The aim of Synchronous Ethernet is to avoid changes to the existing IEEE Ethernet, but to extend it working within its protocol definitions.

Despite being an IEEE standard, Ethernet architecture has been described in ITU-T G.8010 as a network made up of an ETH layer and a ETY layer. Put in simple terms, the ETY layer corresponds the physical layer as defined in IEEE 802.3, while the ETH layer represents the pure packet layer. Ethernet MAC frames at the ETH layer are carried as a client of the ETY layer. In OSI terminology, ETY is layer 1, ETH layer 2. Synchronous Ethernet is based on the ITU-T G.8010 description of the Ethernet architecture.

A key topic in Synchronous Ethernet is the definition of the mechanisms necessary to achieve interworking between SDH / SONET and Synchronous Ethernet equipment. These mechanisms and procedures are found fundamentally in three different recommendations: ITU-T G.8261, G.8262 and G.8264. The aspects covered there include the following:

- Extension of the synchronization network to include Ethernet as a building block (ITU-T G.8261). This enables Synchronous Ethernet network equipment to be connected to the same synchronization network that SDH / SONET. Synchronization for SDH /SONET can be transported over Ethernet and the opposite is also true.

- The ITU-T G.8262 defines Synchronous Ethernet clocks compatible with SDH / SONET clocks. Synchronous Ethernet clocks are based on ITU-T G.813 clocks and they are defined in terms of accuracy, noise transfer, holdover performance, noise tolerance, and noise generation. These clocks are referred as Ethernet Equipment Slave clocks. While the IEEE 802.3 standard specifies Ethernet clocks to be within ±100 ppm. EECs accuracy is within ±4.6 ppm. Additionally, by timing the Ethernet clock, PRC traceability of the interface is achievable.
- ITU-T G.8264 extends the usability of the ITU-T G.707 Synchronization Status Message (SSM) by Synchronous Ethernet equipment. The SSM contain an indication of the quality level of the clock that is driving the synchronization chain. The *Ethernet Synchronization Message Channel* (ESMC) is used for propagation of the SSM through the Synchronous Ethernet network.

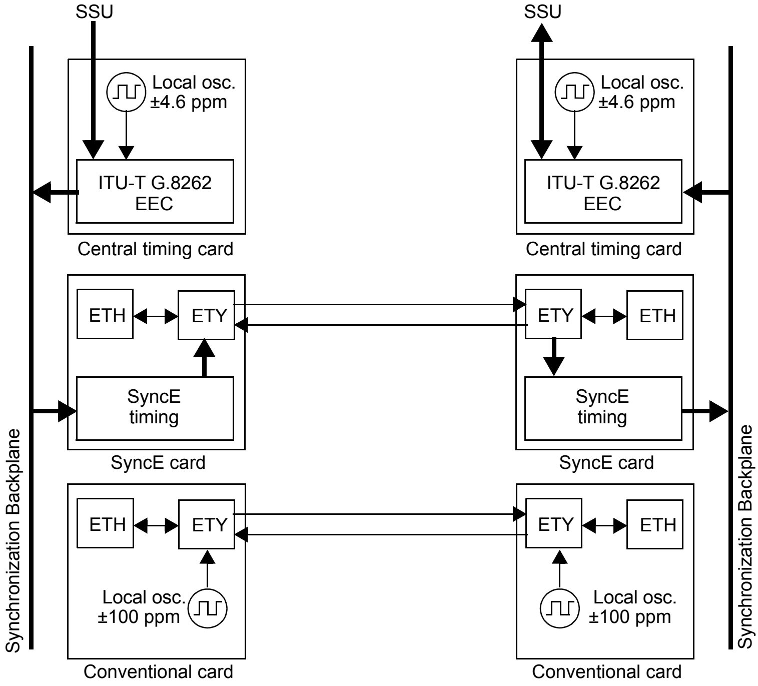

SSU
SSU
Local osc.
±4.6 ppm
ITU-T G.8262
EEC
Central timing card
Local osc.
±4.6 ppm
ITU-T G.8262
EEC
Central timing card
ETH
ETY
SyncE
timing
SyncE card
ETY
ETH
SyncE
timing
SyncE card
ETH
ETY
Local osc.
±100 ppm
Conventional card
ETY
ETH
Local osc.
±100 ppm
Conventional card
Synchronization Backplane
Synchronization Backplane

Figure 10.1: Synchronous Ethernet Architecture and comparison with conventional Ethernet

The basic difference between a conventional Ethernet and a Synchronous Ethernet network interface card is that the Synchronous Ethernet card is prepared to accept external timing or to supply timing to other subsystems. On the other hand, the conventional card is relegated to operate with its own ±100 ppm internal clock. Note that the conventional card is still able to use the clock from an external subsystem (for example the CPU) for data transmission but data reception is not coupled to the transmitter clock and it is also uncoupled to other transmitters in the network. This last feature is the one that defines IEEE 802.3 Ethernet as an asynchronous technology.

Synchronous Ethernet ability to accept or give timing signal makes this technology suitable for hierarchical synchronization. Here, the key element is the EEC which enables Ethernet nodes to accept or supply synchronisation to other Ethernet or TDM equipments. Thanks to this property, Synchronous Ethernet becomes a new building block of the synchronization network.

10.1.1.Ethernet Synchronization Messaging Channel

In SDH / SONET, the SSM provides traceability of synchronization signals and it is therefore required to extend the SSM functionality to Synchronous Ethernet to achieve full inter operability with SDH equipment.

In SDH, the SSM message is carried in fixed locations within the SDH frame. However, in Ethernet there is no equivalent of a fixed frame. The mechanisms needed to transport the SSM over Synchronous Ethernet are defined by the ITU-T in G.8264 in cooperation with IEEE. More specifically, the ESMC, defined by the ITU-T is based on the Organization Specific Slow Protocol (OSSP), currently specified in IEEE 802.3ay.

The ITU-T G.8264 defines a background or *heart-beat* message to provide a continuous indication of the clock quality level. However, event type messages with a new SSM quality level are generated immediately.

The ESMC protocol is composed of the standard Ethernet header for a slow protocol, an ITU-T specific header, a flag field, and a type length value (TLV) structure. The SSM encoded within the TLV is a four-bit field whose meaning is described in ITU-T G.781.

10.1.2.Synchronous Ethernet for the 1000BASE-T Interface

Historically, the 1000BASE-T is the first Ethernet interface that makes use of advanced modulation and encoding technology to enable simultaneous full duplex transmission over four twisted pairs in Cat. 5 cables.

Another property that makes different the 1000BASE-T interface to other Ethernet interfaces such as 1000BASE-X or 100BASE-TX is synchronization. The 1000BASE-T modulation is not compatible with asynchronous operation. During the auto-negotiation process, 1000BASE-T peers decide which transmission end becomes the master and which is the slave. This basic synchronization mechanism is suitable to achieve synchronization in the 1000BASE-T link but is not a mechanism it can be used for global synchronization of the Ethernet network. In fact, the 1000BASE-T synchronization mechanism constitutes a limitation to the operation of Synchronous Ethernet. One link that is operating as a 1000BASE-T slave is unable to accept a timing signal from the EEC and thus is unable to accept an arbitrary timing source.

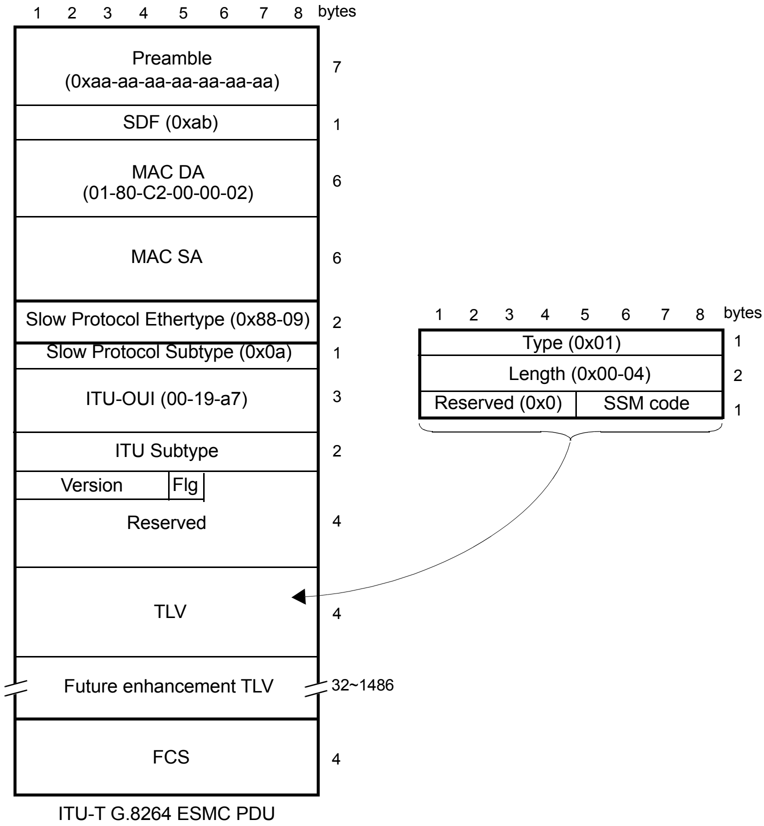

1 2 3 4 5 6 7 8 bytes
Preamble (0xaa-aa-aa-aa-aa-aa-aa)
7
SDF (0xab)
1
MAC DA (01-80-C2-00-00-02)
6
MAC SA
6
Slow Protocol Ethertype (0x88-09)
2
Slow Protocol Subtype (0x0a)
1
ITU-OUI (00-19-a7)
3
ITU Subtype
2
Version
Flg
Reserved
4
TLV
4
Future enhancement TLV
32~1486
FCS
4
ITU-T G.8264 ESMC PDU
1 2 3 4 5 6 7 8 bytes
Type (0x01)
1
Length (0x00-04)
2
Reserved (0x0)
SSM code
1

Figure 10.2: Ethernet Synchronization Message Channel (ESMC) protocol data unit.

This condition is different to other Ethernet interfaces where the transmission is synchronized to timing sources other than the reception clock and are therefore suitable to be added to a hierarchical synchronization network through the EEC without any special constrain.

Ethernet 1000BASE-T interfaces can still use Synchronous Ethernet but the EEC is always required to be connected to the master while the slave is constrained to operate with the timing signal recovered from the master. The result is that synchronization of 1000BASE-T is always unidirectional and propagating from the master to the slave while in 1000BASE-X or 100BASE-T you can theoretically have one synchronization signal propagating in each transmission direction.

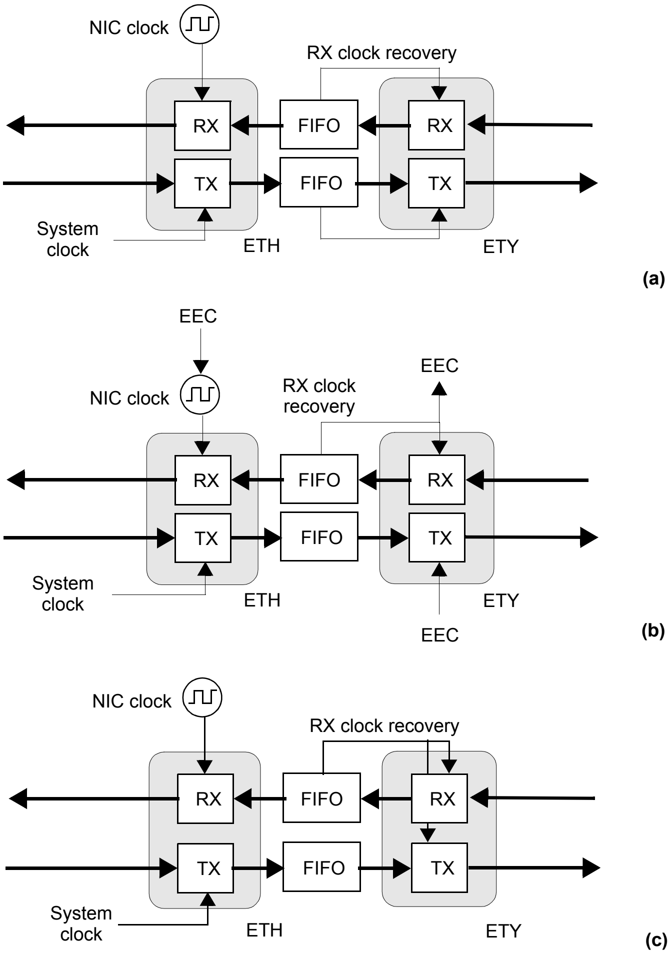

NIC clock
RX clock recovery
RX
FIFO
RX
TX
FIFO
TX
System clock
ETH
ETY
(a)
EEC
NIC clock
RX clock recovery
EEC
RX
FIFO
RX
TX
FIFO
TX
System clock
ETH
ETY
EEC
(b)
NIC clock
RX clock recovery
RX
FIFO
RX
TX
FIFO
TX
System clock
ETH
ETY
(c)

Figure 10.3: Ethernet synchronization models: (a) Conventional Ethernet. There are at least two clock domains. The transmitter and the receiver are in different clock domains (b) Synchronous Ethernet. All clocks are slaves of the EEC. The RX recovered clock could be used as an input for the EEC. (c) 1000BASE-T slave. The TX clock is always an slave of the RX clock.

10.2.Frequency Measurement

In conventional Ethernet, the received frequency is not a critical parameter as long as it is within the ±100 ppm range specified by the IEEE 802.3 standard. However, Synchronous Ethernet frequency is important because this frequency is used by external elements as a synchronization source. xGenius includes a frequency measurement that can be used to verify that the frequency offset of the received signal lies within acceptable limits. To enable the frequency measurement in the test unit, follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
   Note: if you are measuring frequency over the 1000BASE-T interface, force the slave role in the test port by disabling *100-FD* and *10-FD* and configuring *Clock role* to *Slave* (See section 2.2.3).
2. From the *Home* panel, go to *Results*,
   The port setup panel is displayed.
3. Select either *Port A or Port B* to enter in the port specific results menu.
4. Go to Frequency.
5. Check the *Frequency* and *Frequency deviation* results.

If you need increased accuracy for your frequency test, you can use an external clock for measuring. Different kinds of clock inputs are accepted by the test unit, including TDM, frequency and GNSS sources (See section 2.9)

10.3.MTIE / TDEV Analysis

The Synchronous Ethernet wander test is in many aspects similar to the PTP / IEEE 1588v2 analysis (See section 9.3) and analogous to the E1 / T1 analysis (See the *E1 / T1 / Datacom Testing Guide*). The main difference with the PTP / IEEE 1588v2 test is that in Synchronous Ethernet there no need to explicit configuration of any packet selection mechanism or linear filter and therefore the pktFilteredTIE, pktFilteredMTIE and pktFilteredTDEV could be replaced by the TIE, MTIE and TDEV. The difference with the E1 / T1 analysis is basically the operation frequency which is 1544 kHz / 2048 kHz for E1 / T1 wander tests and the Ethernet line frequency for Synchronous Ethernet. To configure and run an MTIE / TDEV test in a Synchronous Ethernet interface follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
2. Connect and configure a clock reference in your test unit (See section 2.7).
3. From the *Home* panel, go to *CONFIG*
   The Port configuration panel is displayed.
4. Set operation mode to *Ethernet endpoint*, *IP endpoint* or *IP through*.

5. From the *Home* panel, go to *TEST*
   The test configuration panel is displayed.
6. In the *SyncE wander test* field, configure *MTIE / TDEV*.
7. Configure the *Observation time* to one of the allowed values. The test finishes automatically when the *Observation time* is reached.
8. Configure the *Mask source* and *Standard mask* parameters for the next MTIE / TDEV measurement.

The unit is now ready to run the test and read the results. To do that, this is the correct procedure:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *SyncE wander* to display the Synchronous Ethernet synchronization results.
4. Go to *Wander analysis.*
5. Run the test by pressing the *RUN* key.
6. Check the *Overflow*, *TIE*, *Offset*, *Max. offset*, *Drift* and *Max. drift* results
7. Leave the current panel and choose between MTIE or TDEV
8. Check the *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).
   Note: MTIE and TDEV test results could be displayed either through a table or in graphical format with the help of the *F4* contextual button.

Table 10.1: Wander analysis results

Result	Description
Overflow	This is an indication about TIE measurement overflow. TIE dynamic range is ±2 s. If the phase excursion is higher than this value, the displayed TIE will not be correct. To indicate this condition, the *Overflow* field displays *Yes*.
TIE	Displays the current Time Interval Error (TIE). The TIE is the cumulative phase error from the beginning of the test. The allowed dynamic range for the TIE is ±2 s. Results out of this range will generate an overflow event.
Offset	Difference between the frequency of the received signal and the reference signal frequency measured in parts per million (ppm). 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.

Table 10.1: Wander analysis results

Result	Description
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 ppm and +3 ppm, the recorded maximum offset will be -4 ppm.
Drift	Change rate of the frequency offset expressed in parts per million per second (ppm/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 ppm/s and +3 ppm/s, the recorded maximum drift will be -4 ppm/s

10.4.Frequency Offset Generation

xGenius can be used to impair the frequency of the test signal generated in test ports A and B with a frequency offset in the range of -125 ppm and +125 ppm. This test can be used to check how tolerant to frequency variations is a network element. Also, if you have a chain with various equipments transmitting a synchronization reference, you can replace the reference by the xGenius test signal and test the ability of the chain to transmit frequency variations to the last element of the chain. The configuration procedure for frequency offset generation over Ethernet interfaces is as follows:

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
   Note: if you are generating frequency offset over the 1000BASE-T interface, force the master role in the test port by disabling *100-FD* and *10-FD* and configuring *Clock role* to *Master* (See section 2.2.3).
1. From the *Home* panel, go to *SETUP*,
   The port setup panel is displayed.
2. Go to *Wander generator*.
3. Configure the *Frequency deviation (ppm)* with the frequency offset you want to generate between -125 and 125 ppm.
   Note: The frequency offset is generated in all ports operating in master mode at

the same time. Make sure that you are not generating any unwanted perturbation in a network interface.

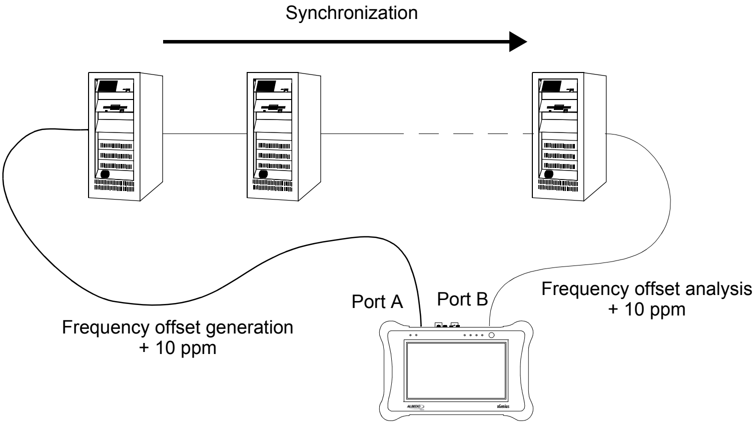


Figure 10.4: If Synchronous Ethernet is used for transmission of timing signals, network elements in the chain should be transparent to offset generation at its input and therefore any frequency offset should be recovered at the output of the chain.

10.5.Wander Generation

Wander generation can be used to stress network elements and see how phase modulation is accumulated as it is propagated through the network. To configure the wander generator follow these steps.

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
2. If you are using an external timing reference, enable it (See section 2.4).
3. From the *Home* panel, go to *CONFIG*,
   The *Setup* configuration panel is displayed.
4. Set operation mode to *Ethernet endpoint*, *IP endpoint* or *IP through*.
5. From the *Home* panel, go to *Test*
   The *Test* configuration panel is displayed.
6. Configure *SyncE wander test* to *Generation*.
7. From the *Home* panel, go back to *Setup*,
8. Go to the *Wander generator* menu.

9. Enable the wander generator by configuring *Wander generator* to *On*.
   An small *W* is displayed on the top of the screen to show that the wander generator has started working.
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 10.2: Wander generation settings

Setting	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.

10.6.Operation in IP Through Mode

You can use the test unit to forward and impair the Ethernet frequency in pass-through mode. Specifically, xGenius is capable of forwarding synchronization and traffic between port A and B and adding frequency offset to the signal forwarded to port A. The procedure to do that is as follows:

1. Make sure that your tester is connected to the network in pass-through mode. The physical layer must be up and working in ports A and B (See section 4.1.1).
   Note: if you are working with the 1000BASE-T interface, force the master role in

the test A and slave role in test port B. Also, you have to disable the *100-FD* and *10-FD* auto-negotiation options for both ports (See section 2.2.3).

2. From the *Home* panel, go to *CONFIG*,
   The port setup panel is displayed.
3. Configure *Mode* to *IP Through*.
4. Go to *Reference clock*.
5. Configure *Input clock* to *Ethernet (Port B)*.
6. From the port setup panel, now go to *Wander generator*.
7. Configure the *Frequency deviation (ppm)* with the frequency offset you want to generate between -125 and 125 ppm.
   The unit adds an offset to the frequency detected in Port B. This offset is transmitted to test port A.

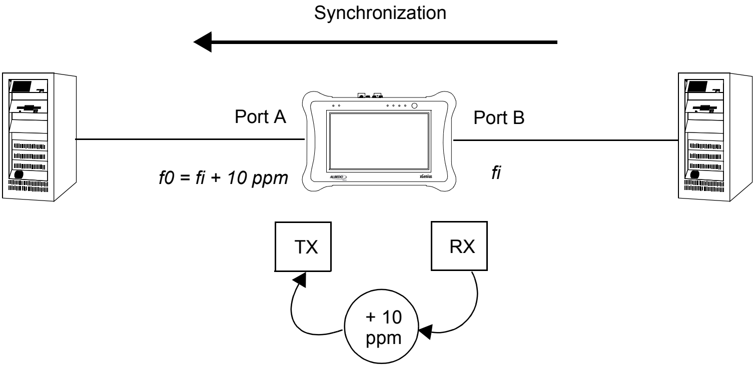


Figure 10.5: With the help of xGenius it is possible to generate frequency offset in pass-through mode to stress the network.

10.7.ESMC Generation and Analysis

The test unit can be configured to generate and analyse the ESMC in a Synchronous Ethernet interface. Specifically, Port A is allowed both to generate and monitor the ESMC and Port B can only monitor the ESMC. The correct ESMC generation procedure is as follows:

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The *Setup* configuration panel is displayed.
3. Select *Port A* to enter in the port specific configuration.

4. Make sure that Port mode is configured to TX / RX
   Note: Depending on the unit global operation mode the TX / RX port mode may not be available. Specifically, you cannot configure *TX / RX* in *IP through* mode.
5. Enable the ESMC generation by configuring *Enable* to *Generation &* slightly. ESMC generation starts from this moment
6. Configure the *ITU-T G.781* option (*Option I*, *Option II*, *Option III*) to assign labels to the SSM in accordance with your network. You can also set *ITU-T G.871* to *Custom* to configure the SSM in numeric format.
   Note: The *ITU-T G.871* setting is applied also to the decoding of the SSM received from the remote end.
7. Enter the correct SSM from the *Sync. status message (SSM)* control if you are configured *Option I*, *Option II* or *Option III* in ITU-T G.781 or through *Custom SSM* if you have configured *Custom* in *ITU-T G.781*.

The ESMC analysis procedure is slightly different. In order to configure it, follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working in the correct test interface (See section 4.1.1).
2. From the *Home* panel, go to *CONFIG*,
   The *Setup* configuration panel is displayed.
3. Select *Port A* or *Port B* to enter in the port specific configuration.
4. Make sure that Port mode is configured to *TX / RX* or *Monitor*.
5. Enable the ESMC analysis by configuring *Enable* to *Analysis* or *Generation & Analysis*.
   Note: *Generation & Analysis* also enables *ESMC* generation.
6. Configure the *ITU-T G.781* option (*Option I*, *Option II*, *Option III*) to decode the SSM in accordance with your network. You can also set *ITU-T G.781* to *Custom* to display the SSM in numeric format only.

Finally, if you have configured ESMC Generation & Analysis or ESM Analysis you can read the current SSM and other parameters from the test unit. This is the correct sequence to do that:

1. From the *Home* panel, go to *RESULTS*,
   The test port results panel is displayed.
2. Select *Port A* or *Port B* to enter in the port specific results.
3. Go to ESMC.
4. Start a test.using *Run*.

5. Check the *Current QL*, *Current QL (hex)*, *Message count* and *Event count* parameters.

Table 10.3: ESMC analysis results

Event	**Description**
Current QL	Displays the ITU-T G.781 mnemonic corresponding to the current quality level received in SSM messages This result is referred to the last SSM message decoded by the test unit. The identifier displayed in this field depends on the *ITU-T G.781* settings. Labels are different for ITU-G G.781 Option I, Option II and Option III.
Current QL (hex)	Displays the hexadecimal code corresponding to the current quality level received in SSM messages. This result is subject to the same conditions that *Current QL* but it does not depend on the synchronization option (Option I, Option II or Option 3).
Message count	Shows the number of SSM packets received from the beginning of the test
Event count	Displays the number of SSM packets with the *Event* flag enabled received from the beginning of the test. The *Event* flag indicates a change in the QL and therefore this result could be used to account for the transitions occurred from the beginning of the test.

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*.

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.
Maximum reports	Displays the maximum number of reports that can be stored within the tester internal memory. Currently this number is limited to 50 files.
Action when disk full	Action to be carried out when the maximum reports limit is reached. There are three possible choices here: • *Block measurements*: No new measurements can be run when the internal memory is full • *Stop report generation*: New measurements are run even if the internal memory is full but no reports are generated for them. • *Delete oldest reports*: 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.

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.

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

Configuration and report files can be exported to external devices like USB memories or 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.

Even log files have their own file export procedure different to the one described in this section (See section 5.4.3).

11.2.5.Importing Configurations

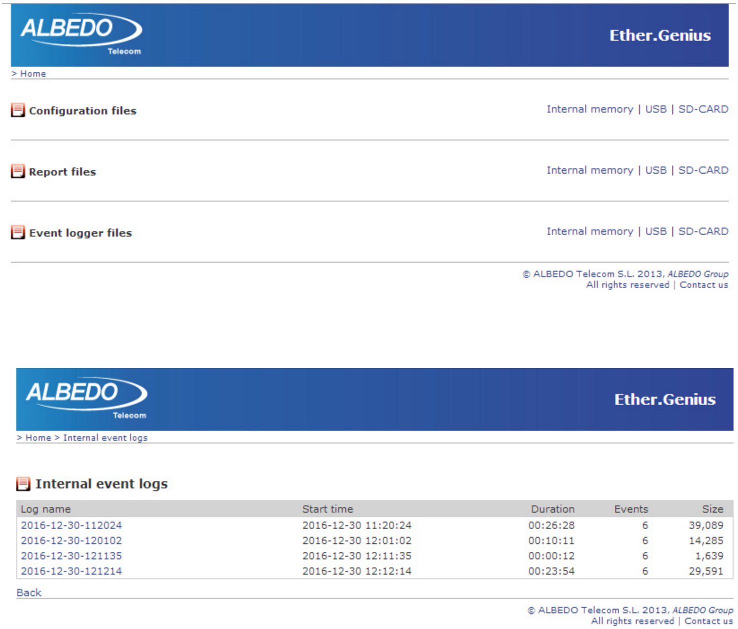
If you have a configuration file from a compatible tester you can import and load this file in your unit to reproduce similar measurements. This is the procedure you have to follow:

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.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.



> Home

Configuration files Internal memory | USB | SD-CARD

Report files Internal memory | USB | SD-CARD

Event logger files Internal memory | USB | SD-CARD

© ALBEDO Telecom S.L. 2013, *ALBEDO Group*
All rights reserved | Contact us

(a)

> Home > Internal event logs

Internal event logs

Log name	Start time	Duration	Events	Size
2016-12-30-112024	2016-12-30 11:20:24	00:26:28	6	39,089
2016-12-30-120102	2016-12-30 12:01:02	00:10:11	6	14,285
2016-12-30-121135	2016-12-30 12:11:35	00:00:12	6	1,639
2016-12-30-121214	2016-12-30 12:12:14	00:23:54	6	29,591

Back

© ALBEDO Telecom S.L. 2013, *ALBEDO Group*
All rights reserved | Contact us

(b)

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

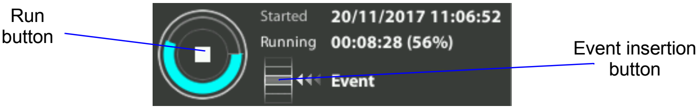
The web interface can be used for downloading configurations, reports and event log files from a remote computer without using any accessory other than an standard network connection. Currently, the web interface does not support file uploading but for this purpose, the USB and micro SD interfaces are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

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.



Started 20/11/2017 11:06:52

Running 00:08:28 (56%)

Figure 11.2: xGenius test control area with progress indication.

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.
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.
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.
GNSS	Configures the GNSS receiver in units carrying the GNSS hardware (See section 11.4.4).
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.

Table 11.3: General Settings Panel

Setting	Description
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.
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 alpha-numeric string
Software release	Displays the current software release.
Hardware release	Displays the current hardware release.
Firmware release	Displays the current firmware release.
PM release	Displays the current power management 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.
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.

Table 11.6: Network Interface Configuration

Setting	Description
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.
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.

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.

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 number	8-digit hexadecimal number provided by ALBEDO Telecom that identifies the software options to be added to your unit. Enter your license number in this field before adding the new software options to your test unit.
License key	8-digit 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.
Activate	Set this field to Yes to add new software options to your tester. You have to enter the *License number* and 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 license number and one 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 number and key supplied by your ALBEDO Telecom representative in *License number* and *License key*.
5. Enable the new software options with the *Activate* control.
6. Check that the upgrade has been successful with the help of the *Status* control.

11.4.3.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 2.5).

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*.

Table 11.9: Time Source Configuration Options

Setting	Description
Time source	It is either *Manual*, *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. • *GPS / NMEA*: The unit is configured to get the system time and date from the GNSS satellite systems through a NMEA interface. This setting is available only if the unit has been properly configured to receive a GPS / Glonass signal (See section 2.5).
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 *GPS / NMEA*.
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 *GPS / NMEA*.
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 *GPS / NMEA*.
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*.

Table 11.9: Time Source Configuration Options

Setting	Description
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*
4. Configure *Manual*, *NTP* or *GPS / NMEA* time and date with the help of the *Time source* field.
   Note: *GPS / NMEA* is only available in units xGenius with a GNSS receiver.
   Note: The *GPS / NMEA* setting requires that GNSS is enabled as a reference interface before configuring the system clock *Time source* (See section 2.8).
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 *GPS / NMEA*, 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.

11.4.4.Configuring the GNSS Receiver

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 System sub-menu. To display the GNSS status follow this procedure.

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

Table 11.10: Time Source Configuration Options

Parameter	Description
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.

Table 11.10: Time Source Configuration 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. • *Waiting*: 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. • *Synchronized*: The GPS / Glonass 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 GPS / Glonass 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.
TDOP	Time Dilution of Precision (TDOP). This parameter gives information about how good is the current satellite geometry to achieve an accurate time estimate.

Table 11.10: Time Source Configuration Options

Parameter	Description
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.

You can also actively configure the xGenius GNSS receiver. Despite being not mandatory, 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 *System*,
   The system configuration panel is displayed.
2. Go to *General settings*.
3. Go to GNSS.
4. Optionally, enable or disable any of the *GPS*, *GLONASS*, *Beidou* or *Galileo* constellations through the Active GNSS setting.
5. Go to *Fixed-position mode*.
6. 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.
7. 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.

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, WiFi and 3G 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 11.11: Remote Control Keys

Key	Description
Up, Down, Left, Right	These keys are equivalent to the cursor keys in the tester local interface. They move the focus through the different fields available in the current panel and they also help with the navigation through different panels.
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
F1, F2, F3, F4	They are equivalent to the F1, F2, F3, F4 contextual keys. The purpose of these keys depend on the current screen.

Appendix A
Technical Specification

A.1. General

- Operation over two Gigabit Ethernet physical interfaces based either on SFP, SFP+ or RJ45 connectors.
- Traffic generation and analysis features up to 10 Gb/s, equivalent to 15 millions of frames, if frame size is set to 64 bytes or 1 Gb/s, equivalent to 1.5 millions of frames.

A.2. Operation Modes

- *L1 Endpoint operation: The equipment generates PCS codes and L1 BER measurement patterns.*
- *Ethernet Endpoint operation*: The equipment generates and receives Ethernet PCS codes and Ethernet frames.
- *IP Endpoint operation*: The equipment generates and receives IPv4 datagrams.
- *Through operation*: Traffic is forwarded between port A and B.
- *Clock monitor*: Disables signal generation and accepts a frequency or time clock input in the auxiliary unit Port C.

A.3. Ethernet PHY

- Supported interfaces (SFP+): *10GBASE-SR, 10GBASE-LR, 10GBASE-ER*
- Supported interfaces (SFP): *10BASE-T*, *100BASE-TX*, *100BASE-FX*, *1000BASE-T*, *1000BASE-SX*, *1000BASE-LX*, *1000BASE-ZX*.
- Supported interfaces (RJ-45 ports): *10BASE-T*, *100BASE-TX*, *1000BASE-T*.
- On/off laser control for optical interfaces.

A.3.1. Auto-Negotiation

- Negotiation of bit rate. Allow 10 Mb/s, allow 100 Mb/s, allow 1000 Mb/s.

- Negotiation of *Master* and *Slave* roles in the 1000BASE-T interface.
- Ability to disable auto-negotiation and force line settings.

A.3.2. Power over Ethernet

- PoE (IEEE 802.3af-2003) and PoE+ (IEEE 802.3at-2009) detection.
- PoE interfaces: 10BASE-T, 100BASE-T and 1000BASE-TX through attached RJ-45 ports A and B.
- PoE pass-through when the equipment is configured in transparent (through) operation mode.

A.4. Synchronous Ethernet

- Supported interfaces: 100BASE-TX and 1000BASE-T through the attached RJ-45 ports. 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX and 1000BASE-BX through SFP, 10GBASE-SR, 10GBASE-LR and 10GBASE-ER through SFP+.

A.4.1. Operation

- Analysis of synchronous Ethernet signal in *Ethernet endpoint*, *IP Endpoint* and *Through modes*, generation of synchronous Ethernet signal in Ethernet endpoint and IP Endpoint modes. Transparent synchronous Ethernet pass-through in *Through mode*.
- Configuration of internal, external or recovered clock in Ethernet interfaces.
- Fixed freq. offset generation on transmitted signals with maximum value of ±125 ppm (resolution 0.001 ppm) as per ITU-T O.174 (11/2009) 8.2.1.
- ESMC analysis, ESMC generation with custom ITU-T G.781 SSM.

A.4.2. Wander Generation Function

- Sinusoidal modulation waveform.
- Modulation frequency range: 1 μHz to 10 Hz.
- Modulation frequency resolution: 1 μHz
- Maximum modulation amplitude as specified in ITU-T O.174.
- Phase amplitude error and intrinsic jitter / wander as specified in ITU-T O.174

A.4.3. Analysis

- Measurement of the line frequency (MHz), frequency offset (ppm) and frequency drift (ppm/s) as specified in ITU-T O.174 (11/2009) clause 10.
- TIE / MTIE / TDEV measurement on Ethernet interfaces following ITU-T O.172 clause 10.

A.5. Clock References

- Internal time reference better than ±2.0 ppm. Optional internal reference better than ±0.1 ppm. optional Rubidium internal reference.
- Ethernet input through Port A or Port B over any valid electrical / optical Synchronous Ethernet interface.
- Frequency reference inputs: 10 MHz, 2048 Mb/s, 2048 MHz, 1544 Mb/s, 1544 MHz through Port C (balanced 120 Ω or unbalanced 75 Ω).
- Phase reference inputs:1 pps 50 Ω unbalanced through SMA connector. Interface specification matches ITU-T G.8271.
- Reference outputs: 1 pps unbalanced 50 Ω SMA. 2048 kHz and 10 MHz unbalanced RJ-48. Interface specification matches ITU-T G.8271 specifications.

Table 1: Frequency reference input levels

Type	Pulse	Mode	Level (Max)	Level (Min)	Duty cycle
1544, 2048 kHz	Unipolar, square, senoidal	Endpoint	5 Vpp	500 mVpp	40 - 60%
		Monitor	0.5 Vpp	100 mVpp	40 - 60%
1544, 2048 kb/s	AMI, HDB3	Endpoint	Nom. G.703	-12 dB (line)	40 - 60%
		Monitor	Monitor -20 dB		40 - 60%
10 MHz	Unipolar, square, senoidal	Endpoint	5 Vpp	1 Vpp	45 - 55%
		Monitor	1 Vpp	100 mVpp	45 - 55%

A.5.1. Rubidium Reference

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

A.6. GNSS Input

- SMA female connector.
- 4 to 5 V DC output for remote antenna powering.
- Cable delay compensation
- Compatible with GPS, GLONASS, Beidou and Galileo

- Fixed position mode to increase time estimation accuracy when the position doesn’t change with time

A.6.1. 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.7. Ethernet MAC

- Frame formats: *DIX*, *IEEE 802.1Q*, *IEEE 802.1ad*.
- Support for Jumbo frames with MTU up to 10 kB.
- Setting of *source* and *destination MAC addresses*. Destination addresses can be configured as a single value or as a range.
- Setting of the *Type / Length* value.
- Configuration of the *VID* and *priority codepoint* in VLAN modes.
- In Q-in-Q / IEEE 802.1ad modes, configuration of the S-VLAN *VID*, *DEI* and *priority codepoint*. Configuration of the C-VLAN *VID* and priority *codepoint*.
- Configuration of the *frame size*.

A.8. MPLS

- MPLS generation and analysis in *IP Endpoint* mode. MPLS analysis in *IP through* mode.
- Support of a single and double label stack (*Top* and *Bottom* labels). Label formatting follows RFC 3032.
- Configuration of the TTL, traffic class and label value for *Top* and *Bottom* MPLS headers.

A.9. IPv4

- Configuration of *source* and *destination IPv4 addresses*. Destination addresses can be configured as a single value or as a range.
- Configuration of *DSCP* CoS labels, *TTL* and *transport protocol*.
- If transport protocol is UDP, support of UDP frame with *source* and *destination port* configuration.

A.10.Traffic Generator

- Generation over 8 independent streams. Each stream has its own specific bandwidth profile and payload / pattern configuration.

A.10.1. Bandwidth Profiles

- Generation modes: *Continuous*, *Periodic burst*, *Ramp* and *Random*.

A.10.2. Test Patterns and Payloads

- Layer 2-4 BER test patterns: *PRBS* 2^{11}*-1*, *PRBS* 2^{15}*-1*, *PRBS* 2^{20}*-1*, *PRBS* 2^{23}*-1*, *PRBS* 2^{31}*-1* along with their inverted versions and user (32 bits). These patters apply to stream 1 only.
- Test payload for SLA tests.
- *All zeros* test pattern.
- NCITS TR-25-1999 *RPAT*, *JPAT* and *RPAT* for L1 BER tests (1 Gb/s interface).
- IEEE 802.3, Annex 36A *HFPAT*, *LFPAT*, *MFPAT*, *LCRPAT*, *SCRPAT* for L1 BER tests (1 Gb/s interface).
- IEEE 802.3 *PRBS* 2^{31}*-1*, *A-seed*, *B-seed* (10 Gb/s interface).

A.11.Event Insertion

- Insertion of TSE, FCS errors, Undersized frames and IPv4 checksum errors.
- Insertion modes: Single, burst, rate and random.

A.12.Filter

- Up to 8 simultaneous filters can be applied to the traffic.
- The equipment supports a generic filter which can select frames by using a *16 bit mask* and an arbitrary *offset* defined by the user.

A.12.1. Ethernet Selection

- By *source* and *destination MAC addresses*. Selection of MAC address sets with masks.
- By *Type / Length* value with selection mask.
- By *C-VID* and *S-VID* with selection mask.
- By *service* and *customer priority codepoint* value with selection mask.

A.12.2. MPLS Selection

- Separated filters to account for the top and bottom MPLS headers.
- Filtering by label value.

- Filtering by traffic class.

A.12.3. IPv4 Selection

- Selection by I*Pv4 source* or *destination* address. It is possible to select address sets by using masks.
- Selection by *protocol*.
- Selection by *DSCP value*.

A.12.4. IPv6 Selection

- Selection by IPv6 source or destination address (or both at the same time). It is possible to select address sets by using masks.
- Selection by IPv6 flow label.
- Selection based on the next header field value.
- Selection by DSCP value.

A.12.5. UDP Selection

- Selection by *UDP port*. Either as a single value or a ranges.

A.13. PHY Results

A.13.1. Cable Tests

- *Optical power* measurement (transmitted and received power) over compatible SFP transceivers.
- Inactive links: *Open/short fault indication* and *distance to fault* in meters (accuracy: 1 m, range 100 m).
- Active links: current local port *MDI / MDIX* status, cable wiring (straight, crossed), polarity (positive, negative) pair skew (1000BASE-T only), crosstalk.

A.13.2. Auto-Negotiation

- *Bit rate* and *duplex mode*.

A.13.3. SFP

- *SFP presence*, current *interface*, *vendor*, and *part number*.

A.13.4. Power over Ethernet

- Type of PoE: PoE (IEEE 802.3af), PoE+ (IEEE 802.3at), none.
- PoE voltage between pairs 1-2 / 3-6 and 4-5 / 7-8 in endpoint test. Voltage and current in pairs 1-2 / 3-6 and 4-5 / 7-8 in through mode.

A.14.Frame Analysis

- Support of *local one-way* (port A-port B) and *two-way* (port A-port A) test modes.
- Separate traffic statistics for Port A and B.

A.14.1.Ethernet Statistics

- Frame counts: *Ethernet*, *VLAN*, *IEEE 802.1ad frames*, *Q-in-Q frames*, *control frames*, *pause frames*.
- Frame counts: *unicast*, *multicast* and *broadcast*.
- Basic error analysis: *FCS errors*, *undersized frames*, *oversized frames*, *jabbers*.
- Frame size counts: *64 or less*, *65-127*, *128-255*, *256-511*, *512-1023*, *1024-1518*, *1519-1522*, *1523-1526* and *1527-MTU* bytes.

A.14.2.MPLS Statistics

- MPLS stack length: minimum, maximum.

A.14.3.IP Statistics

- Packet counts: *IPv4 packets, IPv6 packets*.
- Packet counts: *unicast*, *multicast* and *broadcast*.
- *UDP packets*, *ICMP packets*.
- *IPv4 errors*, *IPv6 errors.*
- *UDP* errors.

A.14.4.Bandwidth Statistics

- Ethernet traffic statistics expressed in bits per second, frames per second and a percentage of the nominal channel capacity.
- *Unicast*, *multicast* and *broadcast* traffic figures expressed in frames per second units.
- IPv4 and IPv6 statistics (frames per second, bits per second and percentage).
- UDP traffic (frames per second, bits per second and percentage).

A.14.5.SLA Statistics

- Multistream SLA analysis.
- Delay statistics: ITU-T Y.1563 *FTD* (current, minimum, maximum, and mean values).
- Delay variation statistics: ITU-T Y.1563 *FTD* (standard deviation), ITU-T Y.1563 *FDV* (peak), RFC1889 / RFC 3393 *jitter* (current, maximum and mean values).
- Frame loss: ITU-T Y.1563 *FLR*.
- Duplicated packets, out -of -order packets (RFC 5236).
- Availability statistics: SES and ITU-T Y.1563 *PEU*.

A.14.6. Service Disruption Time

- Measures short service interruptions in a test packet stream
- Resolution: 1 ms
- Statistics: *disruptions count*, *total disrupted time*, *last disruption time*, *average disruption time*, *minimum disruption time*, *maximum disruption time*.

A.14.7. BER

- *Bit error count*, *seconds with errors*, *bit error ratio* (BER).
- *Pattern losses*, *pattern loss seconds*.

A.14.8. Network Exploration

- *Top talkers* statistics: Displays the 16 most common source MAC / IPv4 / IPv6 addresses.
- *Top VID* (IEEE 802.1Q) or *C-VID* (IEEE 802.1ad): Displays the 16 most common VID / C-VID tags.

A.15. Automatic Tests

- The equipment supports automatic normalized tests defined in IETF RFC 2544 and ITU-T Y.1564 (eSAM).
- Support of *local one-way* (port A - port B) and *two-way* (port A - port A) tests.
- Support of upstream and downstream asymmetric tests.
- Support of Ethernet and IP test modes.

A.15.1. IETF RFC 2544 Test

- Support of RFC-2544 *throughput*, *frame-loss*, *latency*, *back-to-back* and *recovery time* tests.

A.15.2. eSAM Test

- Testing of up to eight services (non-color aware mode) or up to four services (color aware mode).
- Configuration of the CIR and *EIR* for each service.
- Configuration tests (CIR, EIR and policing) with *FTD*, *FDV*, *FLR* results for each service.
- Performance test with *FTD*, *FDV*, *FLR* and *availability* results for all services.

A.16. Port Loopback

- Layer 1-4 loopback.
- Loop frames matching current filtering conditions or loop all frames in layer 2-4 loopbacks.

- Loop controls for broadcast and ICMP frames.

A.17.Ping and Trace-route

- Generation of on demand *ICMP echo request* (RFC 792) messages with custom destination IP address, packet length and packet generation interval.
- Analysis of *ICMP echo reply* (RFC 792) messages with measurement of round trip time and lost packets.
- Analysis of *ICMP Time-To-Live Exceeded* and *ICMP Port unreachable* replies received in the trace-route test.

A.18.PTP (IEEE 1588)

A.18.1.Operation

- Generation / Decoding of PTP - IEEE 1588-2008.
- Master / Slave operations, ability to force master or slave roles.
- Generation / Analysis of up to128 Sync PTP messages/sec.
- 1-step and 2-step mechanism synchronization.
- PTP pass-through monitoring.
- Encapsulations: PTP over UDP / IPv4, PTP over Ethernet.
- Unicast / Multicast profiles.

A.18.2.Protocol State Results

- Port state, master identity, grandmaster identity, BMC priorities, clock class, accuracy, clock variance, time source.

A.18.3.Results

- TX and RX PTP frame counts classified by frame type: *Sync*, *Delay request*, *Delay response*, *Peer delay request*, *Peer delay response*, *Follow up*, *Peer delay response follow up*, *Announce*, *Signaling*, *Management*.
- *Sync message packet delay* statistics: Maximum, minimum, average, standard deviation and range of the delay. Current, maximum and average *Sync* packed delay variation.
- *Sync Inter Arrival time* analysis: Maximum, minimum and average.
- Delay request message delay statistics: *current*, *minimum*, *maximum*, *average*, *standard deviation* and *range*.
- *Round trip delay* computed with the path delay mechanism: *Current* and *mean* values.
- *Correction field statistics*: *current*, *maximum* and *average*.

A.18.4. Time Error Test

- TE and max |TE| measurement on PTP
- Constant TE (cTE) and dynamic TE (dTE) components
- Path Delay Asymmetry Between PTP master and client clocks
- Frequency offset

A.18.5. MTIE and TDEV Test

- *Metrics*: TIE (ITU-T G.8260 *pktFilteredTIE*), MTIE (ITU-T G.8260 *pktFilteredMTIE*) and TDEV (ITU-T G.8260 *pktFilteredTDEV*).
- Packet selection methods: maximum, minimum, percentile, band.
- User customizable low pass filter
- Custom pass / fail results based on standard masks.

A.18.6. Floor Delay Population Test

- Metrics: FPC (ITU-T G.8260 *Floor Packet Count*), FPR (ITU-T G.8260 *Floor Packet Rate*), FPP (ITU-T G.8260 *Floor Packet Percent*).
- Automatic floor delay calculation with detection of floor delay estimation excess.
- Custom pass / fail results.

A.19. Clock Monitor Mode

- Frequency inputs: 2048 kHz, 1544 kHz, 10 kHz in RJ-48 (120 Ω) or BNC (75 Ω) connectors.
- Time inputs: 1 pps over SMA (75 Ω) or RJ-48 (120 Ω).
- *TIE* / *MTIE TDEV* on 1544 kHz, 2048 kHz, 10 MHz and 1 pps interfaces.
- *TE* and *max* |*TE*| measurement (module 1 second) in 1 pps interface.

A.20. Protocols

- *ARP* (IETF RFC 826).
- *DNS* (IETF RFC 1034, RFC 1035).
- *DHCP* (client side) (IETF RFC 2131).
- *Trace-route* application using UDP.
- *NTP* (client side) (IETF RFC 5905) for system time synchronization with an external time server.

A.21. User Interface

- Direct configuration and management in graphical mode using the keyboard and display of the instrument.

- Remote access for configuration and management in graphical mode from remote IP site thought the Ethernet interface of the control panel.
- File management and download through web interface.

A.22.Platform

- Size: 260 x 160 x 63 mm.
- Weight: 1.6 kg (with rubber boot, one battery pack).
- Screen: 8 inch, TFT color (800 x 480 pixels).
- Operation time with batteries (LiPO): 5 ~ 8 hours.
- Battery recharge time (LiPO): 4 hours.

A.22.1. 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.22.2. 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.22.3. Operational Ranges

- Operational range: -10ºC to +50ºC
- Storage range: -20ºC to +70ºC
- Operation humidity: 5% - 95%

Appendix B
Common Issues and Solutions

The following table summarizes some common configuration issues related with everyday use of xGenius. Some of them are applicable only to a very specific situations but some others are valid as a general use advises. For example it is always better to use the local IP address as the source address for test traffic than an spoofed (manual) address whenever is possible.

Table B.1:

Issue	Solution
DHCP does not work	• Make sure that the network supports DHCP configuration and that your equipment is authorized to get a DHCP lease from the server. • In some situations xGenius DHCP address configuration may be slow. The user can force immediate address negotiation by disabling DHCP for one moment and enabling it again.
Ping / Traceroute tests not available	• These are IP tests they are available only if the unit operation mode is set to IP endpoint mode.
eSAM, RFC 2544 or SLA test results are not available.	• eSAM, RFC 2544 or SLA analysis is active either in Port A results or in Port B results but never in both ports at the same time. Make sure that your test method settings (one-way or two way) are correct.
BER test results are not available	• BER testing require an special test payload. Configure the BERT payload in the *Payload* sub-menu within the port specific setup menu. Depending on your test setup you may need to configure the Port A and Port B payload to BERT.

Table B.1:

Issue	Solution
The unit is unable to establish link	• The test interface is configured in optical mode but you are using an electrical connector or the equipment is configured in electrical mode but you are using an electrical connector: Configure the right connector for your test by means the *Physical layer* settings in the port specific configuration menu. • You are using the optical interface but the light source is off. Please, remember that for security reasons the optical source is never enabled when the equipment is restarted. Make sure that the optical source is enabled in your optical tests. • The test interface does not support auto-negotiation but the equipment is configured to operate with auto-negotiation. The solution in this case is to disable auto-negotiation and force the bit rate to 10 or 100 Mb/s.
ARP does not resolve any destination MAC address.	• Your local proflie contains wrong settings. Your xGenius unit decides where to send ARP requests using your local IP address, subnet mask and default gateway configuration. If there is an error with these settings your requests will be lost in the network or the destination will be unable to send the reply back to the origin. Make sure that your local profile contains the correct configuration. • ARP requests are encapsulated in a wrong frame structure. For example, the network may be unable to process standard Ethernet frames if it is waiting for VLAN tagged frames. Make sure that you are using the correct encapsulation. • ARP requests are delivered to unsupported VLANs. Make sure that you configure the correct VIDs in your frames.

Table B.1:

Issue	Solution
Test traffic is not transmitted through a switch	• Configuration for testing through a switch is more simple than for a router but you still need to check that you have configured the right destination MAC address, encapsulation and correct VLAN tags in the *Frame layer* menu. If you have configured a two-way test and in the remote end you have a traffic reflector, you have to configure the remote device MAC address as the destination address for your streams. If you use Port B as the traffic analyser in a one-way test, you have to configure the Port B MAC address as the destination address for your traffic streams.
Test traffic is not transmitted through a router	• You are using an incorrect MAC destination address. When you transmit data through a router the destination MAC address has to be configured to the router MAC address corresponding to the interface you are connected with. The easiest is to configure ARP in *Frame layer* settings and leave the tester auto-configure the right destination MAC address. • You are using a wrong frame encapsulation in your *Frame layer* settings. Make sure that you are using the correct encapsulation (VLAN, Q-in-Q, IEEE 802.1ad). • You are using incorrect IP settings in *Local profile* and *Network settings*. Your local profile should contain a unique IPv4 address. The default gateway must be placed in your local network (the network prefix should match the network prefix of your IP address). The remote address should be routable from the tester. For example you can not send traffic to a private address behind a NAT filter from the Internet. • The remote host should be able to reply to ARP requests. Note that xGenius is unable to respond to ARP requests from addresses different to the local one. In case you need to receive test traffic in addresses different from the local one, you will need to configure static ARP entries in the router.

Table B.1:

Issue	Solution
No traffic detected in Filters panel.	• The traffic is being lost somewhere in the network. Use the global result statistics to know if this is the case. Make sure that the remote loopback device (if used) is properly configured. Check the *Network layer* (destination IP address), the *Frame layer* (destination MAC address, encapsulation, VLAN tags) and *Local profile* (IPv4 address, network mask, gateway and DNS server). The network will fail to send the test data to the destination if destination addresses and VID values are not configured to the right values. • You are receiving test traffic but filtering is not working properly. Use the *Match TX* setting in your filter configuration if you know that the network is not modifying the traffic in some way (CoS re-labelling, port modification in NAT filters or others). If the network is modifying the traffic, use a *Custom* filter instead.
All SLA test results are zero	• You may have a problem with the filter configuration. See how to solve problem with the filters (*No traffic detected in Filters*) • SLA results are computed only if you configure an special SLA payload in the generator and the analyser. for all your streams . You can set the SLA payload with the help of the *Payload* menu within the Port A setup. If you are using Port B as a traffic analyser, you will need to configure SLA payload in this port as well.
eSAM test fails to start	• If you are running a color-aware test the eSAM requires the green and yellow markers to have a different value for each service. For example, if you are using the VLAN priority bits as the color marker and you configure the green traffic priority bits to “1” in service number 1, then you have to configure the same field to something different to “1” for yellow traffic in the same service. Note that you can still configure the yellow traffic priority bits to “1” in services 2, 3 and 4.

Table B.1:

Issue	**Solution**
eSAM Policing test always fails.	• You are running a policing test but there is not a traffic admission mechanism configured in the network. The eSAM policing test is designed to test this mechanism and it fails if not conforming traffic is not dropped. If you want to avoid the eSAM test to fail for this reason you have to disable the policing test using the *Policing test* control in the *eSAM* menu.
eSAM or RFC 2544 test returns a *No traffic* message.	• If you are testing through a switched network, you may be using incorrect *Frame layer* settings. Check the solution on how to proceed when *Test traffic is not transmitted through a switch.* • If you are testing through a routed network, you may be using incorrect *Local profile* or *Network layer* settings. Check the solution about how to proceed when *Test traffic is not transmitted through a router.* • The network may be re-labelling traffic or modifying the test traffic in some way. Check the solution about how to proceed when *No traffic detected in Filters panel.*