User Guide

ETS-1000G

10 Gigabit Ethernet Analyzer

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Telecom Test and Measurement

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Units of Measurement

Units of measurement in this publication conform to SI standards and practices.

January 25, 2013

Version number: 1.0.0

Contents

Certification Information

North America Regulatory Statement on Product Safety

This unit was certified by an agency approved in both Canada and the United States of America. It has been evaluated according to applicable North American approved standards for product safety for use in Canada and the United States.

Electronic test and measurement equipment is exempt from FCC part 15, subpart B compliance in the United States of America and from ICES-003 compliance in Canada. However, EXFO Inc. makes reasonable efforts to ensure compliance to the applicable standards.

The limits set by these standards are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

European Union (CE) Information

Electronic test and measurement equipment is subject to the EMC Directive in the European Union. The EN61326 standard prescribes both emission and immunity requirements for laboratory, measurement, and control equipment. This unit has been tested and found to comply with the limits for a Class A digital device. Please refer to the *CE Declaration of Conformity* on page ix.

Note: *If the equipment described herein bears the CE symbol, the said equipment complies with the applicable European Union Directive and Standards mentioned in the Declaration of Conformity.*

Laser

Your instrument is a Class 1 laser product in compliance with standards IEC 60825-1 and 21 CFR 1040.10. Laser radiation may be encountered at the output port.

CE Declaration of Conformity

DECLARATION OF CONFORMITY

Application of Council Directive(s):
1999/5/EC – The R&TTE Directive
2011/65/UE – Restriction of the use of certain hazardous substances (RoHS)
And their amendments

Manufacturer's Name and Address:

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Equipment Type/Environment: Test & Measurement / Basic
Trade Name/Model No.: Ethernet Loopback Device / ETS-1000G

Standard(s) to which Conformity is declared:

EN 55022: 2006	**Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement**
EN 55024 :1998 + A1: 2001 + A2: 2003	**Information Technology Equipment - Immunity Characteristics - Limits and Methods of Measurements**
EN 61010-1:2001 Edition 2.0	**Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements**
EN 60825-1:2007 Edition 2.0	**Safety of laser products – Part 1: Equipment classification and requirements**

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive and Standards.

Manufacturer:

Stephen Bull, E. Eng
Vice-President Research and Development

400 Godin Avenue,
Quebec City, Quebec
G1M 2K2 CANADA
January 21, 2013

CE EXFO

1 Introducing the ETS-1000G

The analyzer ETS-1000G (hereinafter referred to as the device, the tester) is designed for analyzing and performing diagnostic tests of equipment in the Ethernet networks. It supports all data transfer rates from 10 Mbps to 10 Gbps.

Scope of use

- Certification of channels and fault diagnostics in the networks that use the Ethernet technology with rates 10/100/1000 Mbps and 10 Gbps.
- Checking the quality of provided services for conformance to the Service Level Agreement (SLA) (for Voice-over-IP (VoIP) and Video-over-IP services).

Key Features and Benefits

➤ Interfaces:

10G Ethernet: SFP+;
1G Ethernet: SFP (1000BaseX) / RJ-45 (10/100/1000BaseT);
LAN 10/100 BASE-T;
USB 1.1/2.0.

- Testing in compliance with RFC 2544:

  throughput,
  latency,
  frame loss rate,
  limit load.

- Measurement of the bit error rate (BERT) on the physical layer, the data link layer, the network layer and the transport layer using standard and user-defined sequences.
- Support for Q-in-Q (VLAN Stacking): double encapsulation with an option to insert up to 3 VLAN tags. An option to set a VLAN priority, a VLAN ID.
- Support for multi-protocol label switching: an option to insert up to 3 MPLS labels.
- Setting up a loopback on the physical, data link, network and transport layers.
- Intelligent device search mode: detecting other ETS-1000G devices in the network and subsequently enabling the Loopback mode on them for the data link, network or transport layer using the OAM protocol.
- Generating and analyzing several data streams to check the operability and the Quality of Service (QoS) of different services.
- Managing the device over TELNET.
- Displaying test results through the WWW interface.
- Packet jitter measurement.
- Gathering and displaying statistics of the traffic being received and transmitted on the physical, data link and network layers in compliance with RFC 2819[4].

Conventions

Before using the product described in this guide, you should understand the following conventions:

WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in *death or serious injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in *minor or moderate injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in *component damage*. Do not proceed unless you understand and meet the required conditions.

IMPORTANT

Refers to information about this product you should not overlook.

Supply Kit

The supply kit consists of the following:

Name	Quantity
10 Gigabit Ethernet Analyzer ETS-1000G	1
Pulsed power supply unit with connecting cable	1
PC connecting cable	2

2 Safety Information

Before working with analyzer ETS-1000G carefully read this operations manual, the purpose of the keyboard, external connectors and parts tester.

Laser Safety Warnings

WARNING

When the LASER LED is on or flashing, the ETS-1000G is transmitting an optical signal.

WARNING

Do not install or terminate fibres while a laser source is active. Never look directly into a live fibre, and ensure that your eyes are protected at all times.

WARNING

This product may employ a Class 1M SFP or SFP+. Check pluggable transceiver label for laser classification.

WARNING

Use of optical instruments with this product will increase eye hazard.

Installation Instruction Warnings

CAUTION

This unit is designed for indoor use only.

CAUTION

No user serviceable parts are contained inside. Contact the manufacturer regarding service of this equipment.

CAUTION

All electrical interfaces are SELV (Safety Extra Low Voltage) circuitry intended for intra-building use only.

IMPORTANT

All wiring and installation must be in accordance with local building and electrical codes acceptable to the authorities in the countries where the equipment is installed and used.

CAUTION

Electrostatic Discharge (ESD) Sensitive Equipment:

Plug-in modules can be damaged by static electrical discharge. To minimize the risk of damage, dissipate static electricity by touching a grounded unpainted metal object

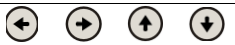
- **before removing, inserting, or handling the module.**
- **before connecting or disconnecting cables to/from the module.**
- **before inserting or removing SFP/SFP+ to/from the module.**

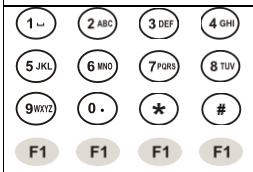
3 Device Description

The parts of the device are explained in the sections that follow.

Front Panel

Keyboard

Icon	Description
	**On/Off** To switch the device on or off, press and hold the key for 2-3 s.
	**Main menu** The key for returning to the main menu from any submenu.
	**Enter** When a menu item is selected, pressing the key opens the respective menu. When a menu item that provides for inputting parameter values is selected, pressing the key enables the data input mode. To confirm input data and exit the data input mode, press the key repeatedly.
	**Cancel/Escape** The key is used for returning to the previous menu or canceling data input in the data input mode.
	**Laser** After pressing the key, the prompt to switch the laser on appears on the screen (if the laser is disabled). If a user presses  (Yes), the laser will be enabled and the Laser LED will be lit red (refer to *LEDs* on page 11). To disable the laser, press  again. Depending on the 10G or 1G mode SFP+ or SFP laser is turned on.
	Function keys
	Cursor keys

Icon	Description
	Numeric, character and symbol keys. Digits, letters and characters that can be input using the numeric keyboard.

LEDs

LED	Color	State	Description
10G, 1st LED	Green	LED is constantly on.	A connection to the 10G equipment being tested is established.
	Red	LED is constantly on.	No connection.
	—	LED is off.	Interface is disabled.
10G, 2nd LED	Green	LED is flashing or constantly on.	Packet traffic is being transmitted over 10G interface.
	—	LED is off.	Packet traffic is not being transmitted.
10G, 3rd LED	Green	LED is flashing or constantly on.	Packet traffic is being received on 10G interface.
	—	LED is off.	Packet traffic is not being received.

LED	Color	State	Description
1G, 1st LED	Green	LED is constantly on.	A connection to the 1G equipment being tested is established.
	Red	LED is constantly on.	No connection.
	—	LED is off.	Interface is disabled.
1G, 2nd LED	Green	LED is flashing or constantly on.	Packet traffic is being transmitted over 1G interface.
	—	LED is off.	Packet traffic is not being transmitted.
1G, 3rd LED	Green	LED is flashing or constantly on.	Packet traffic is being received on 1G interface.
	—	LED is off.	Packet traffic is not being received.
Test	Green	LED is constantly on.	A test is being performed.
	Green	LED is flashing.	The Loopback mode is enabled.
	—	LED is off.	The Loopback mode is disabled; testing is not performed.
Laser	Red	LED is constantly on.	Laser is enabled (SFP/SFP+).

The LED which is located at the bottom of the device's clipboard is lit when the external power supply is connected:

- Green - batteries are charged,
- Green (flashing) - batteries are being charged,
- Green (blinking) - the device's SW versions are being updated.

Status Bar

The status bar contains data about the following parameters (from left to right):

- Battery charge level,
- Data rate ("- - -" indicates that a connection to the equipment being tested is not established),
- SFP/SFP+ module type,
- Test being conducted ("—" indicates that testing is not being performed at the moment),
- Rx signal power level (10G, SFP+),
- Current time.

The tests being performed are indicated in the status bar using abbreviations:

Abbreviation	Expansion
THR (throughput)	Throughput analysis.
LAT (latency)	Latency analysis.
FRL (frame loss)	Frame loss analysis.
BTB (back-to-back)	Back to back analysis.
LB1 (loopback layer 1)	Loopback on the physical (first) layer.
LB2 (loopback layer 2)	Loopback on the data link (second) layer.

Abbreviation	Expansion
LB3 (loopback layer 3)	Loopback on the network (third) layer.
LB4 (loopback layer 4)	Loopback on the transport (fourth) layer.
BER (bit error rate test)	Determining the bit error rate.
PJ (packet jitter)	Determining the packet jitter.
GEN (generate)	Generating test traffic.
J+G (jitter + generate)	The functions of determining the packet jitter and generating test traffic are started on the same port.
CTR (complex traffic)	Generating/receiving complex traffic.

External Connectors

The layout of external connectors on the top and side panels of the device is shown in following figures

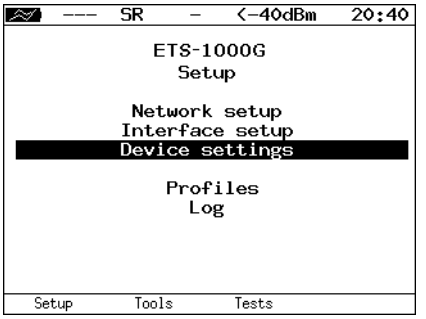
The digit 1 in the above figure specifies the reset button.

Marking	Description
10G	Connecting the SFP+ module
1G	RJ-45 connectors to connect to the tested network or equipment (supported rates 10/100/1000 Mbps) Port of the device contains 2 connectors — RJ-45 and SFP. During the test only one connector of the port is used.
	SFP-module connectors
LAN	Remote control of the tester
USB	Connecting to a PC via the USB interface
DC IN	External power unit connector

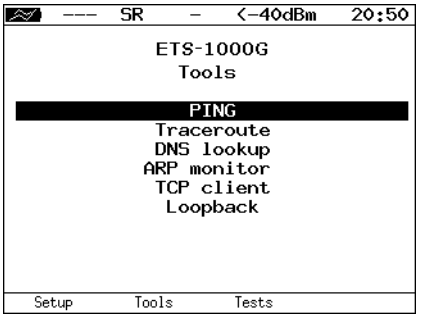
Control Menu Structure

The main menu of the ETS-1000G device consists of three submenus (hereinafter referred to as menus). To switch between them, use the following keys: F1 (ETS-1000G Setup), F2 (ETS-1000G Tools), F3 (ETS-1000G Tests).

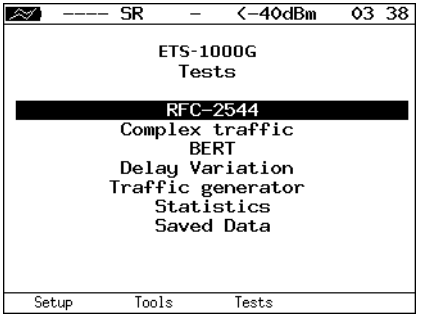
1. ETS-1000G Setup.


--- SR - <-40dBm 20:40
ETS-1000G
Setup
Network setup
Interface setup
Device settings
Profiles
Log
Setup
Tools
Tests

2. ETS-1000G Tools.



3. ETS-1000G Tests.



4 RFC 2544

RFC 2544 methodology define a set of tests which are used for evaluating key features of network devices and checking conformance of the services being rendered to the specifications stipulated in SLA between telecommunications operators and clients.

Owing to an opportunity of making an analysis of throughput, latency, frame loss rate and limit load, these methods are currently are a de facto standard for evaluating the performance of Ethernet-based networks.

ETS-1000G allows performing four standard tests in compliance with RFC 2544.

Throughput Analysis

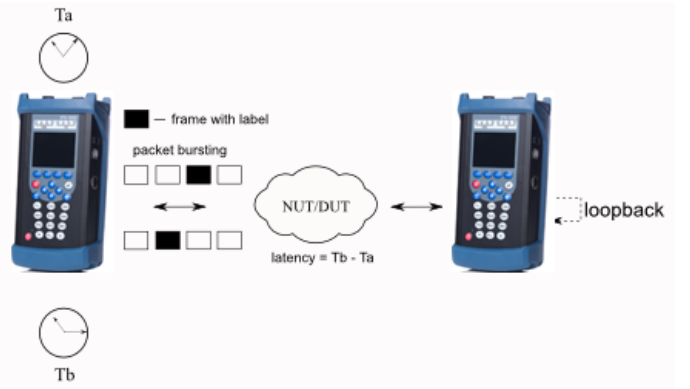
Note: *An analysis of throughput is performed for determining the maximum possible switching speed for network elements in transport Ethernet-based networks.*

Throughput is the maximum data rate at which the quantity of frames[1] that have been transferred via DUT is equal to the quantity of frames that have been sent to it from the test equipment. During an analysis of throughput, a number of packets are sent to the DUT input with the minimum interframe gap[2]. Then the quantity of packets that have been received from the output port of DUT is calculated. If it is less than the quantity of transmitted packets, the interframe gap will be increased and the test will be repeated. The binary search method is used for determining throughput.

[1] The terms a frame and a packet are used in descriptions as synonyms.

[2] Hereinafter it is assumed that the tester automatically executes all the operations under consideration.

Latency Analysis

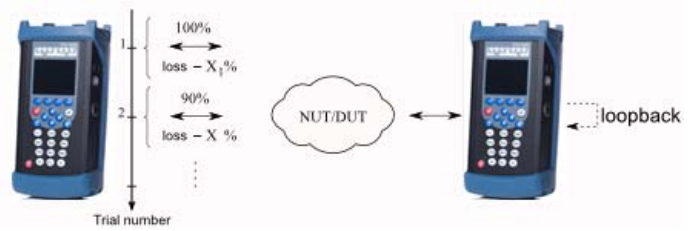


Note: *An analysis of latency is used for evaluating the time it takes a frame to be transferred from the source to the destination and back to the source element. A variable latency value may cause problems in the operation of real-time services.*

During an analysis of latency, the throughput of DUT is determined first. Then a frame ow is sent to the destination for each packet size determined by RFC 2544 at the flow data rate corresponding to it. After a while a label of the specific format is inserted into one packet. A Ta value (the time by which the labeled packet has been completely transmitted) is recorded on the transmitting side. On the receiving side the label is identified and a Tb value (the time when the labeled packet was received) is recorded.

A latency is a difference (Tb - Ta). The analysis results are used for calculating an average latency.

Frame Loss Rate Analysis



Note: *An analysis of frame loss rate is necessary for checking the network's capability to support real-time applications (which do not provide for retransmission), as a high frame loss rate causes the deterioration of QoS.*

An analysis of frame loss rate allows calculating the percentage of frames that a network element has failed to transmit in case of steady load due to the shortage of hardware resources.

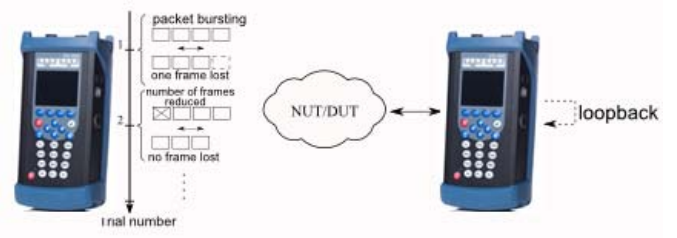
During an analysis of frame loss rate, a number of frames are sent to the input of DUT at a certain rate (input count) and the quantity of packets which have been received from the output port of DUT (output count) is calculated.

Frame loss rate is calculated according to the following formula:

$$\frac{100 \text{ x (inputcount — outputcount)}}{\text{(inputcount)}}$$

The first attempt should be made at the maximum data rate for this connection. The next attempt should be made at the rate which equals 90.

Back to Back Analysis

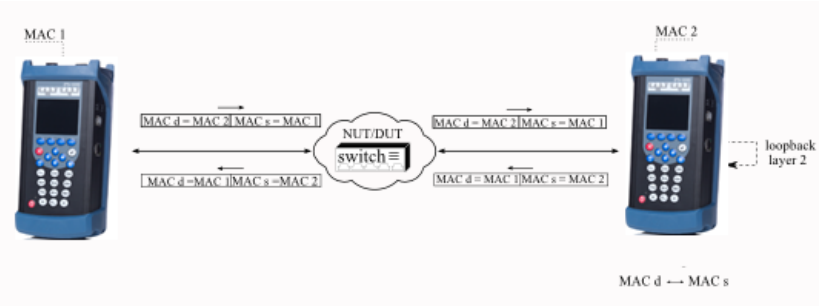


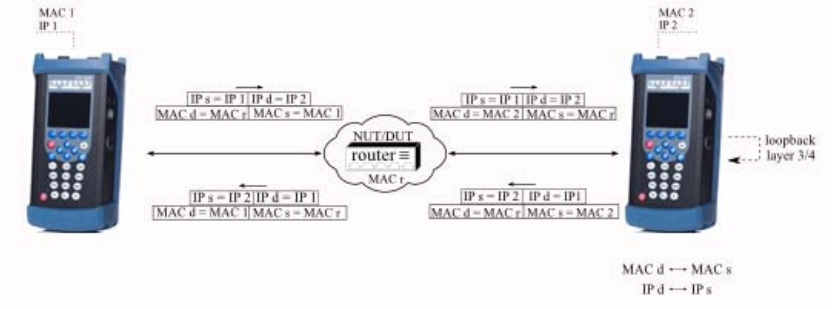
Note: *An analysis of limit load allows evaluating the time it takes the device to process the limit load.*

During an analysis of data transmission unevenness, a number of frames are sent to the input of DUT with the minimum interframe gap and the quantity of packets which have been received from the output of DUT is calculated. If it turns out to be equal to the quantity of sent frames, the test will be finished. If the quantity of packets on the output of DUT is less than the quantity of transmitted packets, the time will be reduced and the test will be repeated.

5 Preparing RFC 2544 for Analysis

To make an analysis in compliance with RFC 2544, it is necessary to connect the device to the device/network under test according to one of the diagrams shown below.





The following notation conventions are used in the diagrams:

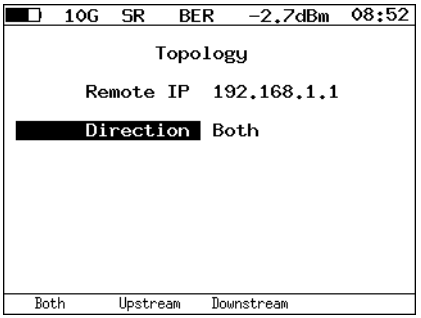
Notation	Description
MAC s	A sender's MAC address.
MAC d	A destination MAC address.
IP s	A sender's IP address.
IP d	A destination IP address.
MAC r	A router's MAC address.
MAC 1	A MAC address of ETS-1000G.

Notation	Description
IP 1	An IP address of ETS-1000G.
MAC 2	A MAC address of the remote device which implements traffic redirection (loopback).
IP 2	An IP address of the remote device which implements traffic redirection (loopback).
switch	A network switch.
router	A router.

To test the networks which include the devices operating on the data link layer of the OSI model, for example, a switch, ETS-1000G should be connected according to the diagram. In this case the traffic being generated by the device should be redirected back via setting up a loopback. The source and destination MAC addresses in incoming packets are swapped and the traffic is sent back to the source port.

To test the networks which include the devices operating on the network layer of the OSI model, for example, a router, ETS-1000G should be connected according to the similar diagram as shown on the previous page. Unlike the previous case, both the source and destination MAC and IP addresses in incoming packets are swapped and the traffic is sent back to the source port.

Topology

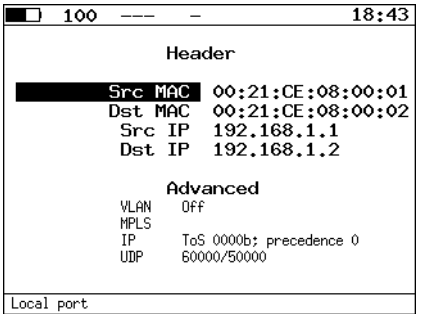


Remote IP	Remote device IP address (see *Asymmetric Test* on page 45)
Direction	Testing direction: ➤ both — select if you want to perform measurement of both direction (from local device to remote and from remote device to local); ➤ upstream — select if you want to perform asymmetric test in the direction from local device to remote (see *Asymmetric Test* on page 45); ➤ downstream — select if you want to perform asymmetric test in the direction from remote device to local (see *Asymmetric Test* on page 45).

Main header parameters

Header parameters can be set using the menu

RFC 2544 > Setup > Header.



Src MAC	A sender's MAC address.
Dst MAC	A destination MAC address.
Src IP	A sender's IP address.
Dst IP	A destination IP address.

When setting MAC addresses, account must be taken of the following aspects:

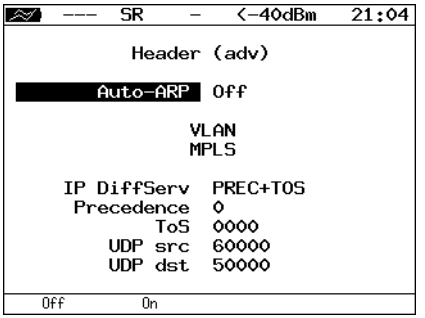
- The source interface MAC address should be used for specifying the sender's MAC address.
- If there is a direct connection between the source and the destination without any intermediate routers, the destination interface MAC address should be used for specifying the destination MAC address.
- If there is at least one router between the source and the destination, the MAC address of the router which is nearest to the source should be specified as the destination MAC address.

There is an option to automatically substitute MAC addresses and IP addresses:

- Press F1 (when Src. MAC or Dst. MAC is selected) to substitute the MAC address of test port which has been specified using the Interface Parameters menu for the current MAC address.
- Press F1 (when Src. IP or Dst. IP is selected) to substitute the IP address of test port which has been specified using the Network Parameters menu for the current IP address.
- Press F3 (when Dst. MAC is selected) to submit an ARP request. As a result of this request the MAC address corresponding to the destination IP address will be substituted for the current destination MAC address.

Besides, the parameter values specified using the Header (Advanced) menu are displayed on the screen.

Additional header parameters



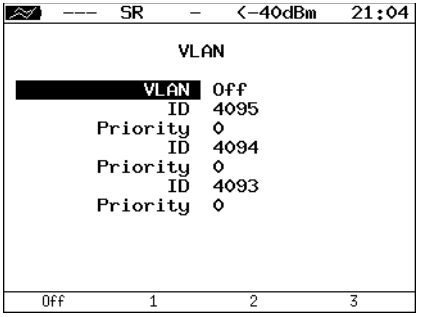
Auto-ARP	If On is selected, then an ARP request will be submitted automatically when tests are started. As a result of this request the MAC address corresponding to the destination IP address specified using the Header menu will be substituted for the current destination MAC address.

VLAN	Opening the VLAN menu which allows setting up to three VLAN tags.
MPLS	Opening the Label Stack menu.
IP DiffServ	Allows selecting the Precedence and ToS fields (PREC+TOS) or the DSCP field (DSCP) to set the Class of Service for the traffic received from various applications. The description of these fields is given below.
Precedence	This field specifies a frame priority. Eight frame priority values are supported. A sender can set any value from the table (see *Reference Tables* on page 143) in this field.
ToS	This field defines the Type of Service of an IP packet. A sender can set any value listed in the table. Besides, it is possible to set any other combination of 4 bits according to the router's settings.
DSCP	The DSCP field consists of 8 bits. It allows setting more Classes of Service for traffic than the Precedence and ToS fields do. The description of six highorder bits is given in *Reference Tables* on page 143. Two low-order bits are used by TCP for transmitting congestion information. They are described in *Reference Tables* on page 143.
UDP src	A sender's UDP port number.
UDP dst	A destination UDP port number.

Press F1 (when VLAN is selected) to automatically substitute the settings of test port which have been specified using the menu Interface Parameters > VLAN for the VLAN settings.

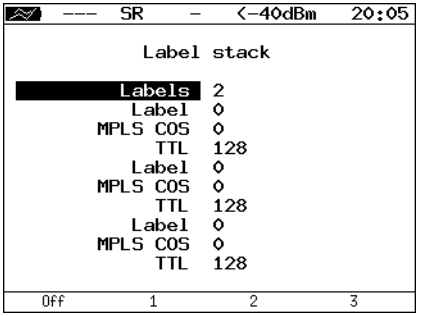
Press F1 (when MPLS is selected) to automatically substitute the settings of test port which have been specified using the menu Interface Parameters > MPLS for the MPLS settings.

VLAN setting



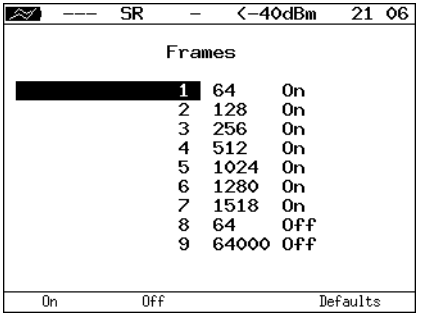
VLAN	Selecting the number of labels (1 - 3, Off).
ID	A 12-bit VLAN identifier. It is a number in the range from 0 to 4095. It uniquely defines the VLAN which a frame belongs to. The zero value of VLAN ID indicates that this frame carries no information about VLAN and contains priority information only. If the value of VLAN ID is set to 1, when the frame passes through the switch's port, the value of VLAN ID of this frame will be set to the port's VLAN ID.
Priority	This field defines a traffic priority. Eight traffic priority values are supported. A correspondence between traffic priorities and traffic types is described in *Reference Tables* on page 143.

MPLS setting



Number of Labels	Select the number of labels (1 - 3, Off).
Label	The label value.
MPLS COS	The Class of Service of a packet.
TTL	The time-to-live of a labeled packet.

Select the Frame Size



There are two ways to set the size of the frames to be transmitted:

1. To select standard sizes in compliance with RFC 2544 (using F4 (By default)): 64, 128, 256, 512, 1024, 1280 and 1518 bytes. In this case it is possible to additionally set one frame of a random size.
2. To input the sizes of frames manually.

Note: *The frame sizes should not be less than 64 bytes and should not exceed 64000 bytes.*

Setting Test Parameters

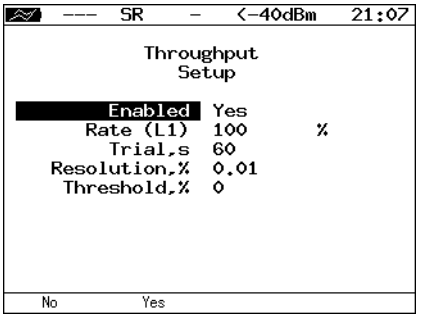
There are two ways to set values of test parameters for making an analysis:

1. Select standard settings in compliance with RFC 2544. To do so, select RFC-2544 > Setup and press F4 (By default).
2. Set parameters manually according to the directions given in the subsequent sections.

To optimize the speed and to increase the efficiency of making an analysis, ETS-1000G provides an option to change the standard values of test parameters (defined by RFC 2544).

Test results are represented in the tabular and graphical forms according to RFC 2544 recommendation.

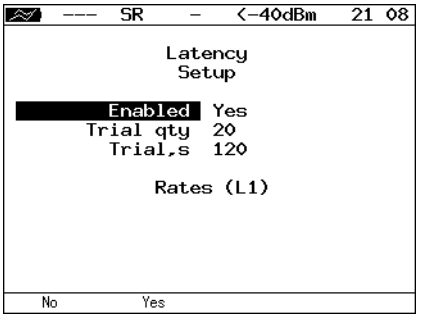
Parameters of the Throughput Test



Enabled	Enabling/disabling the throughput analysis.
Rate (L1)	A raw data rate value (L1) that is specified in percentage terms (F1), Kbps (F2) or Mbps (F3).

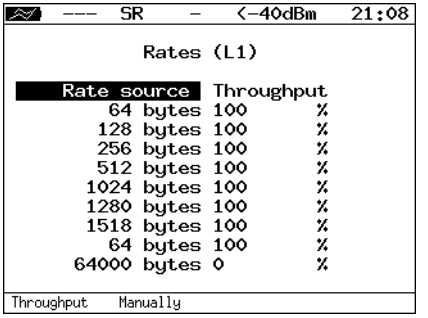
Trial, s	The period of time during which the test should be performed for each frame size specified in the settings (*1-3600 s*).
Resolution, %	Resolution at which the throughput search should be performed. Possible values: 10, 1, 0.1, 0.01, 0.001, 0.0001. The minimum resolution value corresponds to the highest accuracy of channel throughput measurement and the longest test duration.
Threshold, %	Threshold of available loss (0-10%). If the quantity of received packets is less than the quantity of transmitted packets by the value of allowed loss threshold, the test will be considered as completed.

Parameters of the Latency Test



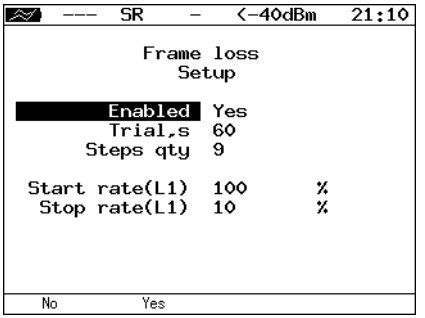
Enabled	Enabling/disabling the data deference analysis.
Trial qty	The number of test reiterations for each defined frame size.

Trial, s	The period of time during which the test should be performed for each frame size specified in the settings (*1-3600 s*).
Rates (L1)	Open the Rates (L1) menu.



Rate source	If the Throughput value is selected (F1), the Latency test will be performed using the load value obtained as a result of the Throughput test. If the Manually value is selected (F2), then user-defined values will be used for performing the test.

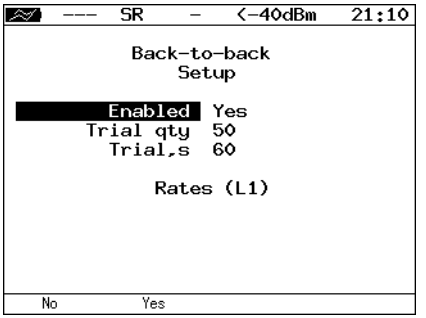
Parameters of the Frame Loss Rate Test



Enabled	Enabling/disabling the deviation loss rate analysis.
Trial, s	The period of time during which the test should be performed for each frame size specified in the settings (*1-3600 s*).
Steps qty	The number of load adjustment steps.

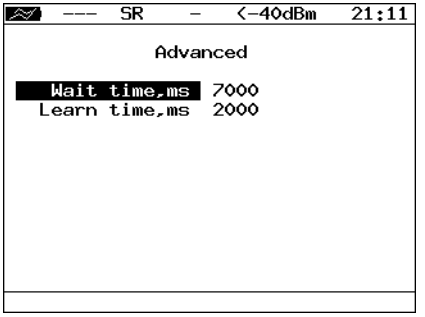
The Start rate (L1) and Stop rate (L1) fields allow setting the range of load values to be used for performing the loss rate analysis. Raw data rate values (L1) can be specified in percentage terms (F1), Kbps (F2) or Mbps (F3).

Parameters of the Back-to-Back Test



Enabled	Enabling/disabling the limit load analysis.
Trial qty	The number of test reiterations for each frame size configured in the settings.
Trial, s	The period of time during which the test should be performed for each frame size specified in the settings (*2-3600 s*).
Rates (L1)	Open the Rates (L1) menu.

Advanced Settings



Wait time, ms	The time between completing a test iteration and sending a learning frame.
Learn time, ms	The interval between sending a learning frame and starting the test.

According to RFC 2544, the interval is 7000 ms (2000 ms are allocated for receiving residual frames, 5000 ms are allocated for stabilization of the device under test), and the duration of learning is 2000 ms.

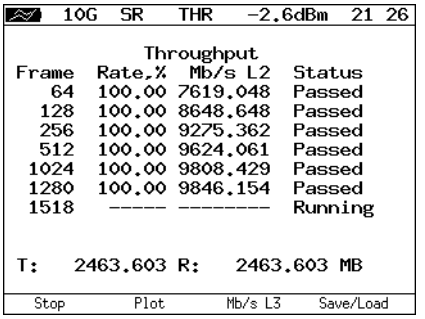
A user may set arbitrary values of the interval within the range from 100 to 10,000 ms. The duration of learning should not be shorter than 100 ms and longer than 10,000 ms.

6 Analyzing RFC 2544

To start tests that are based on RFC 2544, open the RFC-2544 menu and press F1 (Start). All the selected tests will be conducted.

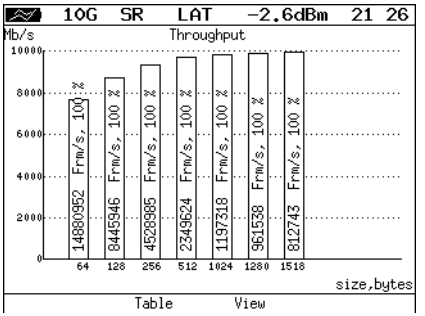
To conduct tests selectively, open the menu of the specific test and press F1 (Start).

Throughput Test Results



Test results are displayed in the tabular form: the frame size (in bytes), a throughput value (in %), which has been obtained as a result of the analysis. (To select the unit of measurement, including Mbps L2, Mbps L3, Mbps L4 or fps, press F3).

To switch to the graphical representation of test results, press F2 (Plot).



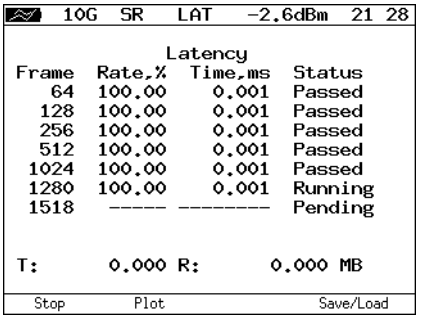
It is possible to switch between two options of the graphical representation of test results using F3 (View):

1. The maximum value on the Y-axis indicates the maximum data rate. Empty columns indicate the maximum theoretical throughput value.
2. The maximum value on the Y-axis indicates the maximum measured throughput value.

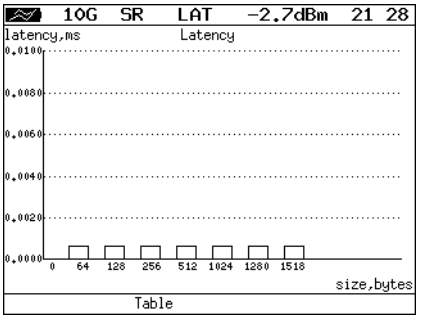
In both cases values on the X-axis indicate frame size values.

Filled columns in the diagram are used for displaying the throughput value obtained as a result of testing which is expressed in fps and in percentage terms relative to the stated load.

Latency Test Results

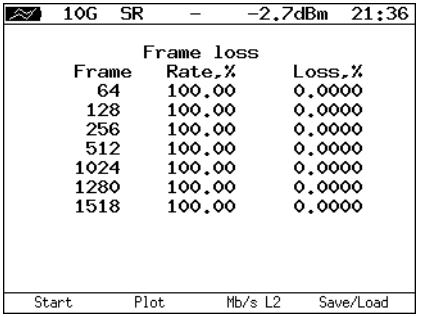


The table displays an average latency value (in ms) for each data frame size specified in the settings and the respective throughput value (in %), which has been obtained as a result of the Throughput test.

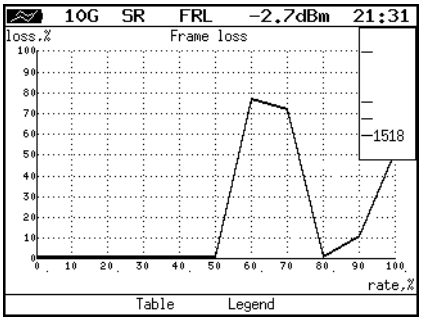


The diagram shows a column for each frame size whose height corresponds to an average latency value (in ms).

Frame Loss Rate Test Results

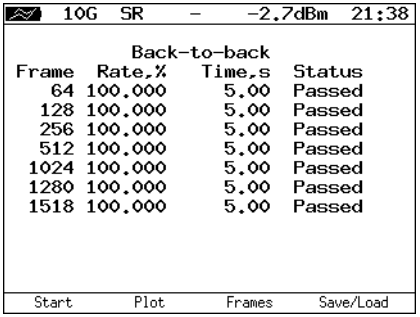


The table lists frame loss rate values for each packet size (in bytes) and the respective channel occupancy (in %). To select the unit of measurement, including Mbps L2, Mbps L3, Mbps L4 or %, press F3.



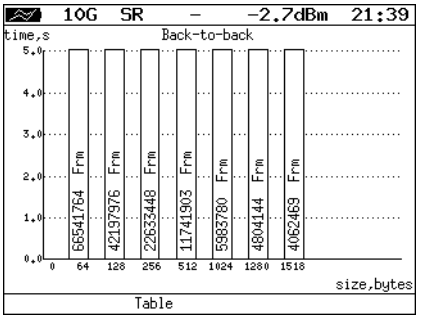
The diagram shows dependence of the frame loss rate (in %) on the load (in %) for each frame size specified in the settings.

Back to Back Test Results



The table lists the load defined in the test settings and the time it takes the device to process the limit load for each packet size. If the time during which the device endures the maximum load cannot be determined, the test status column will display Error and the Time, s column will be filled with dashes.

It is possible to display the Frames column containing the number of frames which have been transmitted during the test instead of the Time, s column. To do so, press F3 (Frames).



The diagram shows a column for each configured frame size whose height corresponds to the time during which the device endured the limit load.

The number of packets transmitted during the test is indicated on the columns in the diagram.

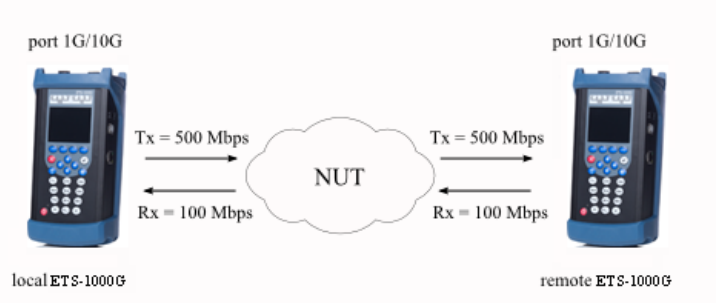
Saving Test Results

In the mode of testing based on RFC 2544, press F4 (Save/Load) to open the menu which allows displaying information about saved measurements (F1), saving test results and parameters (F2), loading (F3) and deleting (F4) saved measurement results and parameters.

7 Asymmetric Test

Asymmetric test function is used to check operability of communication link that has different data transmitting and receiving parameters (throughput etc) — asymmetric channels.

Note: *The option is not included in the basic configuration; should be purchased additionally.*



Measurements of the asymmetric channels parameters should be performed independently for each direction. Therefore, the test traffic transmission is produced in one selected by the user direction.

By testing two ETS-1000G should be used: local and remote. On the local device the test parameters are set. The remote device is on the other end of asymmetric channel.

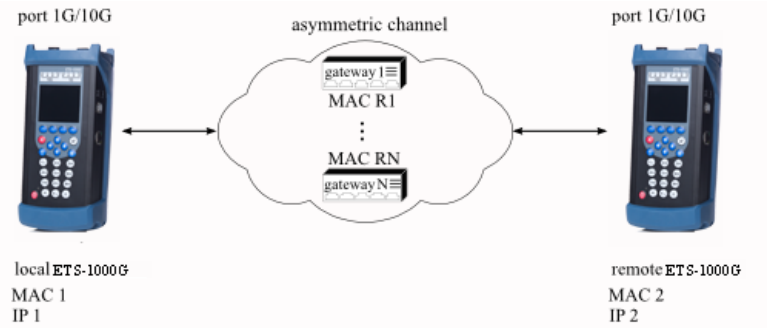
Testing results are displayed on the screen of the local device.

Note: *Tests for which the function is available are BERT and RFC 2544: throughput, frame loss, back-to-back. RFC 2544 latency test is not available.*

Testing Example

The following description is an example of an asymmetric testing for the BERT (for RFC 2544 procedure is similar).

Connection scheme is shown in the following image.



The following notation conventions are used in the diagrams:

MAC 1 – local device MAC address;

IP 1 – local device IP address;

MAC R1 – MAC-address of the gateway that is nearest to the local device;

MAC RN – MAC-address of the gateway that is nearest to the remote device;

MAC 2 – remote device MAC address;

IP 2 – remote device IP address.

To perform measurement in the direction from local device to remote, do the following:

1. Make sure that the local and remote device support asymmetric test function: in the ETS-1000G. Setup > Device settings > Options menu list of options should contain XAT option.

2. Connect the local and remote device according to the scheme shown in the scheme image on this page.

3. On the local and remote device switch to the ETS-1000G. Setup > Network Setup menu and set:

Interface – Test

One of the following methods specify the IP address of local device (IP 1) and remote device (IP 2):

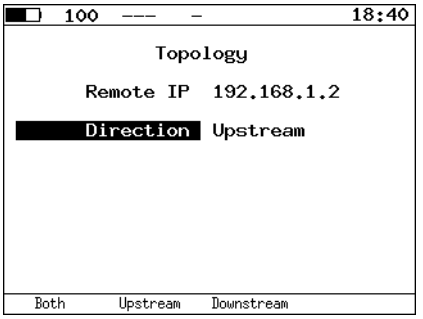
- ➤ set IP address manually;
- ➤ receive IP address via DHCP.

4. On the local device switch to the BERT > Setup > Topology menu.

Set:

Remote IP – IP 2

Direction – Upstream



5. On the local device switch to the BERT > Setup > Header menu.

Set:

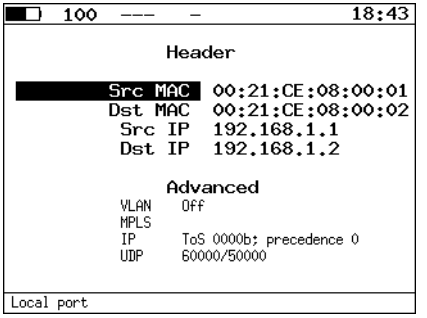
Src MAC - MAC 1

Dst MAC - MAC R1

Src IP - IP 1

Dst IP - IP 2

Note: *To get gateway MAC address it is necessary to submit an ARP request: switch to the Dst MAC menu item and press* F3 *button.*



According to the section *BERT* on page 77 on the local device it is necessary to perform BER test settings. Then switch to the BERT menu and press F1 (Start) button.

Note: *After pressing the Start button the following messages can be displayed on the screen of the local device:*

- Connecting to remote port... — occurs immediately after the test start.
- No route to host — occurs if the local device is unable to connect to the remote device.
- Connection is lost — occurs if the remote device is not responding after the connection is established.

- Remote unit is busy — occurs when the remote device is already under test.
- Asymm. BERT at L1 is not supported — occurs when you try to perform BERT on the first level.

Note: *The Unit is used for remote testing message is displayed on the screen of the remote device during the test.*

To perform measurement in the direction from remote device to local, do the following:

1. Make sure that the local and remote device support asymmetric test function: in the ETS-1000G. Setup > Device settings > Options menu list of options should contain XAT option.
2. Connect the local and remote device according to the scheme shown in the image.
3. On the local and remote device switch to the ETS-1000G. Setup > Network Setup menu and set:

   Interface - Test

   One of the following methods specify the IP address of local device (IP 1) and remote device (IP 2):

   - set IP address manually;
   - receive IP address via DHCP.
4. On the local device switch to the BERT > Setup > Topology menu.

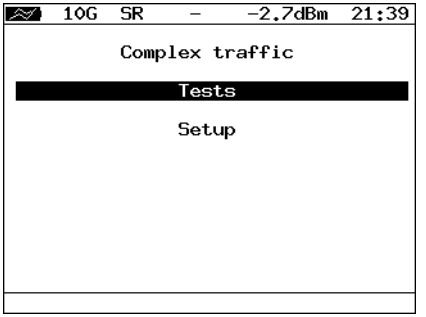
   Set:
   Remote IP - IP 2
   Direction - Downstream
5. On the local device switch to the BERT > Setup > Header menu.

   Set:
   Src MAC - MAC 2
   Dst MAC - MAC RN
   Src IP - IP 2
   Dst IP - IP 1
6. According to the section *BERT* on page 77, on the local device it is necessary to perform BER test settings. Then switch to the BERT menu and press F1 (Start) button.

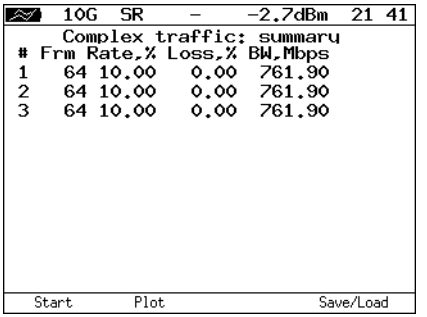
Note: *After pressing the Start button a messages similar to the listed on page 48 can be displayed on the screen of the local and remote device.*

8 Complex Traffic

The complex test traffic generation function1 allows creating up to 10 data streams with various parameters. It can be used for checking whether the priority assignment function is properly implemented in the device being tested and for simulating various workload profiles.



Tests	Opening the Complex Traffic: Report screen (for starting a test, displaying measurement results).
Setup	Opening the Settings menu.

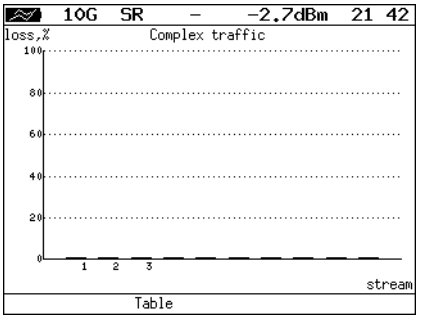


To start a test, adjust the test parameters using the Settings menu and press F1 (Start).

After the test has been completed, the following data will be displayed for each stream:

- the specified frame size,
- the specified data rate (L2),
- the frame loss value obtained as a result of testing,
- the bandwidth calculated according to the results of testing.

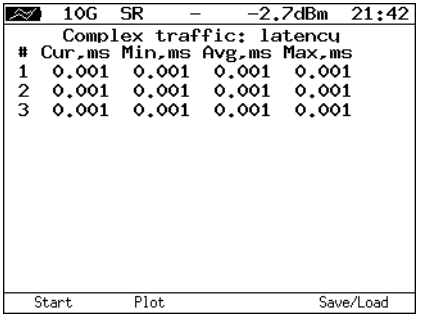
Press F2 (Diagram) to open the screen which contains the graphical representation of test results.



The diagram shows a column for each stream whose height corresponds to the respective frame loss value.

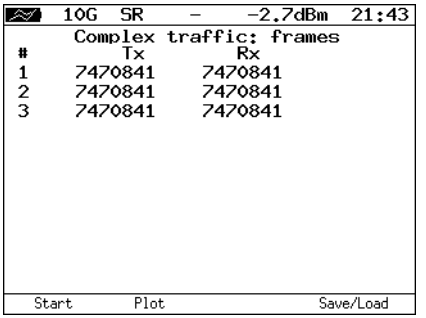
Press F4 (Save/Load) to open the Results menu.

Press ➔ to open the Complex Traffic: latency screen.

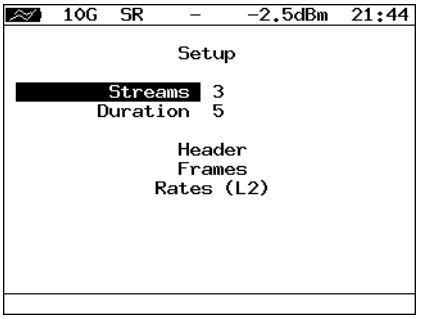


Cur	Current data deference.
Min	Minimum data deference.
Avg	Average data deference.
Max	Maximum data deference.

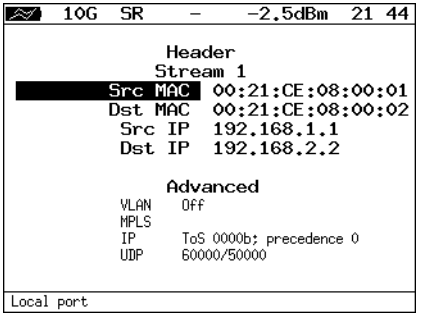
Press ⊕ again to open the Complex Traffic: Frames screen.



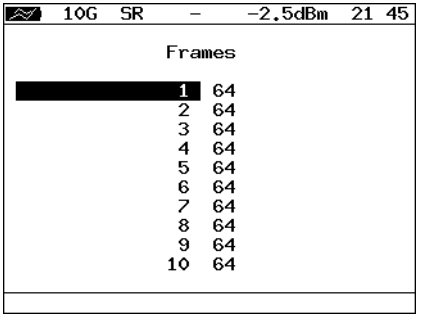
The screen displays the number of transmitted packets (Tx) and the number of received packets (Rx) for each stream.



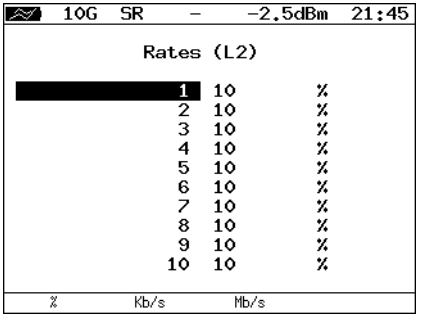
Streams	Quantity of data streams (1-10).
Duration	Duration of generating the specified quantity of streams (1-2886 s).
Header	Opening the Header menu.
Frames	Opening the Frames menu.
Rates (L2)	Opening the Rates (L2) menu.



To select the number of the stream to be adjusted, use the keys ← and →.



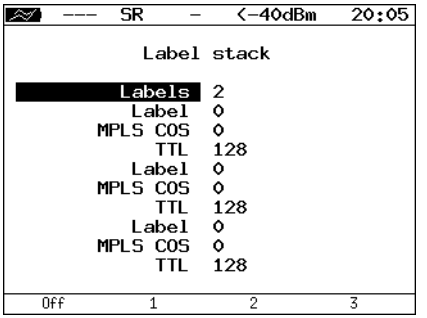
Frame sizes should be set manually within the range from 64 to 9600 bytes for each stream.



A data rate value (L2) should be specified in percentage terms (F1), Kbps (F2) or Mbps (F3).

Complex Traffic MPLS Setting

The label stack to be used for testing is set using the Label Stack menu: ETS-1000G. Measurements > Complex Traffic > Setup > Header > Advanced > MPLS.



Labels	Select the number of labels (from 1 to 3) to be added to an outgoing packet.
Label	The label value.
MPLS COS	The Class of Service of a packet.
TTL	The time-to-live of a labeled packet.

9 Loopback

The loopback feature is used for testing networks in compliance with RFC 2544, measuring BER and solving some other tasks. It allows looping back the traffic coming to the device on the four OSI layers.

On the physical layer (L1) all incoming traffic is left unchanged and redirected back. Besides, statistics of received traffic is collected.

On the data link layer (L2) all incoming frames are redirected back, the source and destination MAC addresses may be swapped. Statistics of received and transmitted traffic is collected.

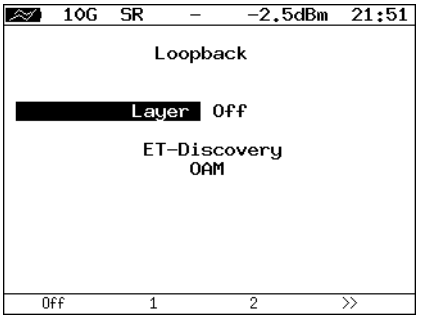
On the network layer (L3) all incoming packets are redirected back, the source and destination MAC and IP addresses are swapped. Statistics of received and transmitted traffic is collected.

On the transport layer (L4) all incoming traffic is redirected back. In addition to swapping the source and destination MAC and IP addresses, the source and destination TCP/UDP port numbers are swapped too.

Note: *Defective packets are not redirected in case of setting up a loopback on the data link (L2), network (L3) and transport (L4) layers.*

Note: *Packets with identical MAC Dst and MAC Src, M Protocol Data Units (OAMPDU) and ARP requests which are contained in the incoming traffic are not redirected in case of setting up a loopback on the data link (L2), network (L3) and transport (L4) layers.*

Note: *If an incoming packet contains an MPLS label, it will be redirected without changing the label value.*



Layer	Select the OSI layer on which test traffic should be redirected: ➤ Off – disable the loopback feature, ➤ 1 – the physical layer, ➤ 2 – the data link layer (MAC), ➤ 3 – the network layer (IP), ➤ 4 – the transport layer (TCP/UDP).
ET-Discovery	Open the ET-Discovery menu.
OAM	Open the OAM menu.

10 OAM

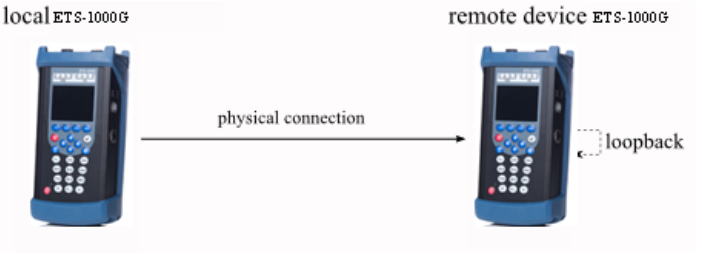
An important task of telecommunications service providers is to ensure a high grade of administration and maintenance of Ethernet-based networks. The IEEE 802.3ah standard was developed for that purpose [7] (also known as Ethernet in the First Mile (EFM) OAM).

OAM (Operations, Administration, and Maintenance) is a link state monitoring protocol that is implemented on the data link layer of the OSI model. The transmission of information between Ethernet devices is implemented using protocol data units (OAMPDU).

An important feature of the OAM protocol consists in providing an opportunity of enabling the Loopback mode on a remote device.

To establish a connection between the ETS-1000G device and a remote device over the OAM protocol and to enable the Loopback mode, it is necessary to execute the following procedure:

1. Establish a direct connection between the local ETS-1000G device and the remote device according to the diagram shown below.



2. Enable the operation of the OAM protocol in the active or passive mode on the remote device.

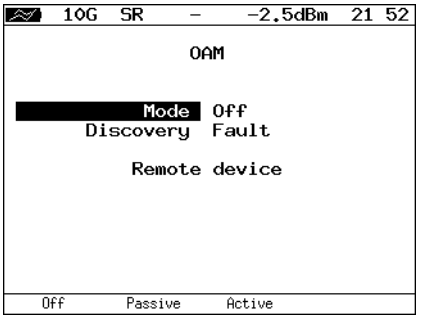
   On the local device:

3. Open the OAM menu.
4. Select the active operating mode for the OAM protocol in the Mode menu item.
5. The remote device detection status should be set to Send any in the Discovery menu item.

6. Open the Remote Device menu. Information about the remote device should be displayed in the screen.

7. Press F1 (LB up). The Loopback mode will be enabled for the data link layer (L2) on the remote device (traffic will be redirected without the swapping of MAC addresses).

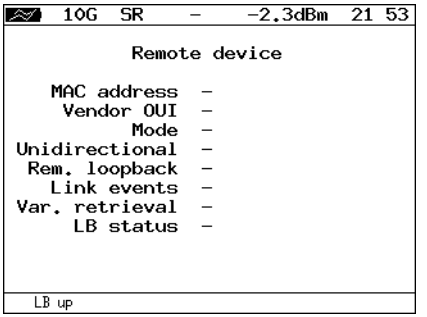
To disable the Loopback mode, press F1 (LB down).



Mode	The possible OAM states are: ➤ **Active** – the active mode. In this mode the port can send the commands to detect devices and to enable the Loopback feature on the remote device, and also respond to the Ethernet OAM commands received from the remote device. ➤ **Passive** – the passive mode. In this mode the port cannot initiate enabling the Loopback feature, it can only respond to the Ethernet OAM commands received from the remote device. ➤ **Off** – OAM is disabled.

Discovery	A remote network device detection status. The possible statuses are: ➤ Fault — the initial state. A connection to the remote device is not established. ➤ Send local — send OAMPDU with information about supported operating modes. ➤ Passive wait — wait for OAMPDU with information about supported operating modes from the remote device which has been configured in the active mode. ➤ Send loc/rem — send OAMPDU with information about the operating modes supported for the local and remote devices, and with the label indicating the possibility to establish a connection. ➤ Send loc/rem ok — receive OAMPDU with information that operating modes of the local and remote devices are compatible. ➤ Send any — a connection has been established.
Remote device	Open the menu that contains information about the remote device.

Note: *A connection can be established successfully only if the remote device supports the Remote loopback feature. If this feature is unavailable, the remote device detection status will be set to Send loc/rem ok.*

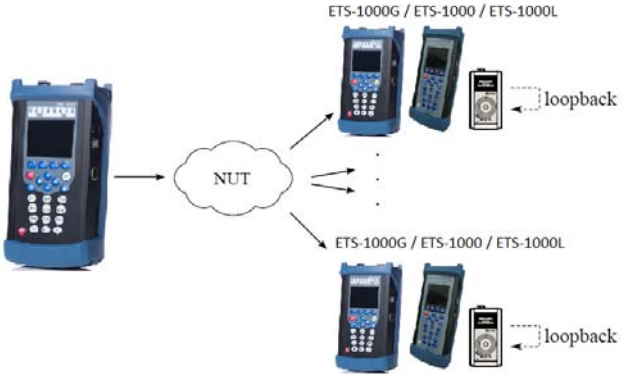


MAC address	The MAC address of the remote device.
Vendor OUI	The unique organization identifier which is used for generating the MAC address.
Mode	The remote client's OAM state.
Unidirectional	Support for unidirectional interconnection.
Rem. loopback	Support for the remote loopback mode.
Link events	Support for the notification of connection errors.
Var. retrieval	Support for reading the variables used for the evaluation of link quality.
LB status	A status of the Loopback mode on the remote device.

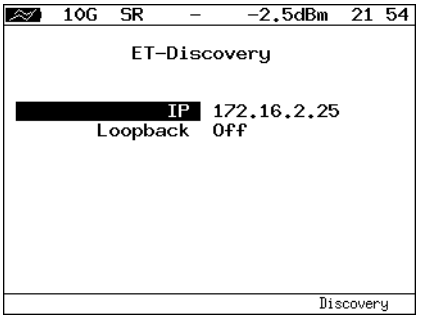
Note: *ETS-1000G doesn't support the unidirectional, link events and var. retrieval features.*

11 ET–Discovery

The ET–discovery function allows enabling the Loopback mode for the data link layer (L2), the network layer (L3) or the transport layer (L4) on the remote analyzer (ETS-1000G) or the remote loopback device.



According to the test diagram, it is possible to enable the Loop-back mode successively on several devices ETS-1000G, which can belong both to different subnets or to the same subnet.



IP	An IP address of the remote device.
Loopback	Select the loopback layer: ➤ F1 - Disable the Loopback mode. ➤ F2 - Enable the data link layer loopback. ➤ F3 - Enable the network layer loopback. ➤ F4 - Enable the transport layer loopback.

To obtain data on the remote device and ensure that the Loopback mode can be enabled, follow the procedure below:

1. Connect ETS-1000G to the network according to the diagram shown in the previous page.
2. Open the Network Parameters menu, specify the port's IP address or make sure that the device has received the correct IP address via DHCP.
3. Open the ET Discovery menu.
4. Specify the IP address of the remote device in the IP address field.
5. Press (Detect). If the function has been executed successfully, the IP address, the name and the MAC address of the remote device will be displayed on the screen. The Loopback menu item will become available for editing.
6. 6. Select the loopback layer using F2 , F3 , F4 .

Note: *The data are transmitted over UDP. Destination port: 32 792. Source port: 32 793.*

12 TCP/IP Tests

The tests which are described in this section are used for diagnostics in the networks containing the devices which ensure the switching and routing of the data being transmitted. The TCP/IP tests which are implemented in the device allow detecting the problems relating to the network configuration, checking the network connectivity, determining data transmission routes, checking the operability of data links and estimating their occupancy.

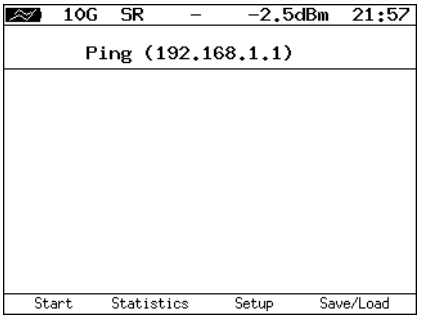
Ping

The Ping tool allows checking the operability of data links and intermediate network devices. When the test is being performed, the system sends requests to the specified node and records the responses being received from it. Analysis results are used for generating a statistical report.

To perform the test, follow the procedure below:

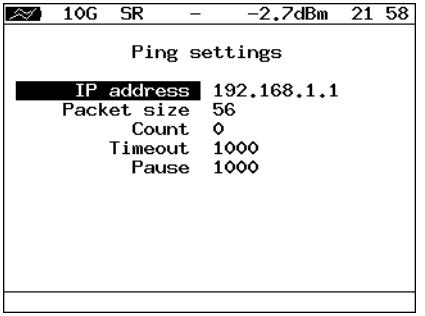
1. Connect the device to the network under test according to the diagram shown below.

2. Set up a network connection (refer *Network Parameters* on page 103).
3. Open the Ping menu.



F1 (Start)	Start the test.
F2 (Statistics)	Open the Statistics screen.
F3 (Setup)	Open the Ping Setup menu.
F4 (Save/Load)	Open the menu for saving test results.

4. Set up the test parameters in the Ping Setup menu.



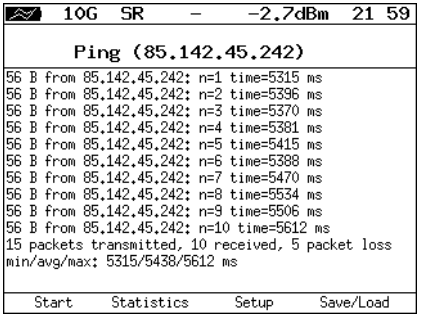
IP address	The IP address of the node whose accessibility is to be checked.

Packet Size	The size of an ICMP packet (in bytes).
Count	The quantity of packets to be sent (from 0 to 9999). If the zero value is selected, the packets will be sent until a user presses (Stop).
Timeout	The timeout for receiving a response to a ping request (in ms).
Pause	The time interval between two consecutive attempts to send a request (in ms).

5. Open the Ping menu and press F1 (Start). The test will be started. As it is being performed, the lines containing the following data (from left to right) are displayed in the screen:

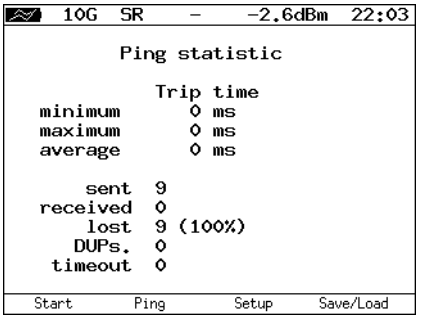
- the size of an ICMP packet,
- the IP address of the network node which has responded to the ping request,
- the packet serial number,
- the time period between sending a request and receiving a reply.

An example of test results is shown in the following figure.



The test results are used for generating a statistical report.

Statistics contains information about the minimum and maximum time between sending a request and receiving a response, and about the number of transmitted, sent, lost and repeated packets (with the same serial number). The value in the timeout line indicates the number of packets for which the timeout for receiving a response to a ping request has expired.

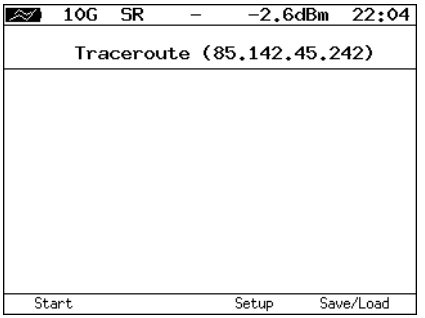


Traceroute

The Traceroute tool is used for determining data routes and allows diagnosing the availability of intermediate network devices. During the test a sequence of frames is sent to the specified node and the system displays information about all the intermediate routers through which the data have been relayed on the way to the end node.

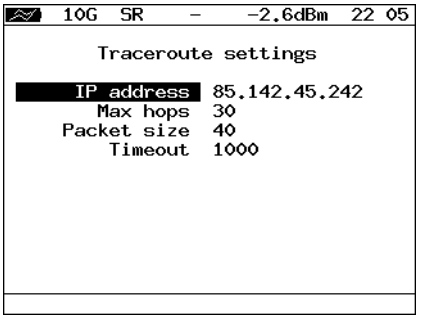
To perform the test, follow the procedure below:

1. Connect the device to the network under test according to the diagram shown on this page.
2. Set up a network connection (refer *Network Parameters* on page 103).
3. Open the Traceroute menu.



F1 (Start)	Start the test.
F3 (Setup)	Open the Traceroute Setup menu.
F4 (Save/Load)	Open the menu for saving test results.

4. Set up the test parameters in the Traceroute Setup menu.

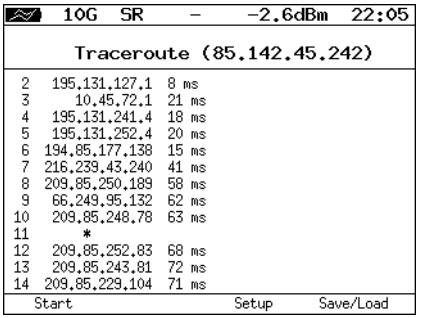


IP address	An IP address of the end node.
Max. hops	The maximum number of routers through which packets can be transmitted.
Packet Size	The size of a frame (in bytes).
Timeout	The timeout for sending the next request (if the response to the previous one has not been received).

5. Press F1 (Start). The test will be started. As it is being performed, the lines containing the following data (from left to right) are displayed in the screen:

- the number of an intermediate node,
- the IP address of an intermediate node,
- the response time.

If the timeout for receiving a response from an intermediate node has expired, the asterisk character (*) will be displayed in the line containing results. An example of test results is shown in the following image.

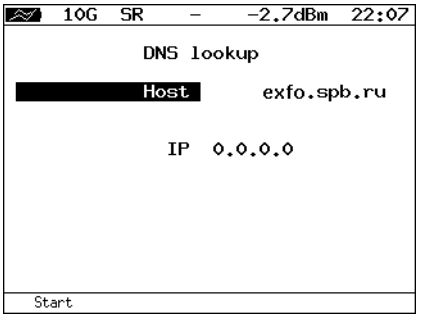


DNS Lookup

The DNS lookup tool allows detecting faults in the operation of NS servers. The Domain Name System (DNS) is a distributed database that provides a node's IP address according to the request containing its domain name.

To perform the test, follow the procedure below:

1. Connect the device to the network under test according to the diagram shown in this chapter.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Open the DNS menu.



Host	The name of the node whose IP address should be determined.
IP	The IP address of the node whose name was specified above which has been received as a result of performing the test.

4. Select the Host menu item and specify the domain name of the node.
5. Press F1 (Start). The IP address of the node will be displayed in the IP menu item.

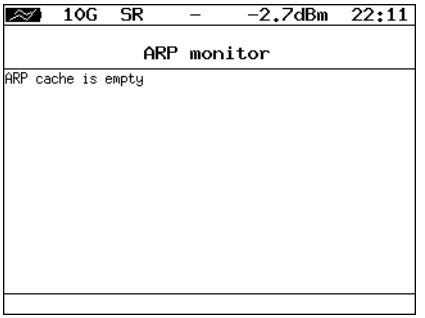
   If the IP address fails to be determined, the zero IP address (0.0.0.0) will be displayed in the IP menu item.

ARP Request Monitor

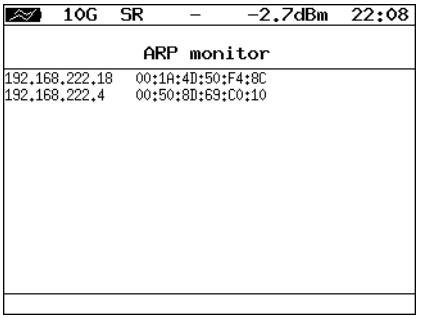
The ARP monitor tool allows monitoring the ARP responses being transmitted in the network and intercept the device IP and MAC addresses which are contained in them.

To perform the test, follow the procedure below:

1. Connect the device to the network under test according to the diagram shown in this chapter.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Open the ARP Monitor menu.



4. After a while the message ARP table is empty disappears and network devices' IP and MAC addresses are displayed on the screen.



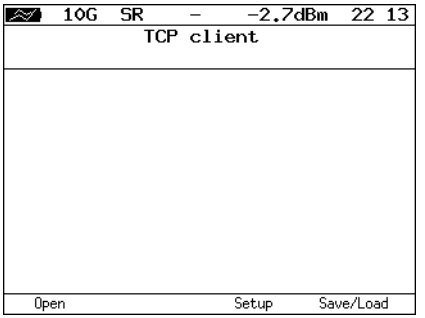
If an entry hasn't been updated within a minute, it will be deleted from the list.

TCP Client

The TCP client tool allows establishing a TCP connection to a remote network node to receive data from it and transmit data to it. This feature can also be used for the management of a remote node over TELNET.

To establish a connection, follow the procedure below:

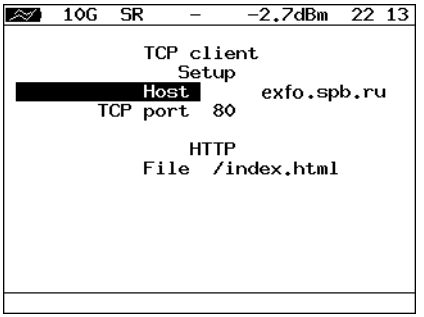
1. Connect the device to the network according to the diagram shown in this chapter.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Open the TCP Client menu.



F1 (Open)	Establish a TCP connection.
F3 (Setup)	Open the TCP Client. Setup menu.
F4 (Save/Load)	Open the menu for saving test results.

4. Open the TCP Client. Setup menu and adjust the connection parameters:

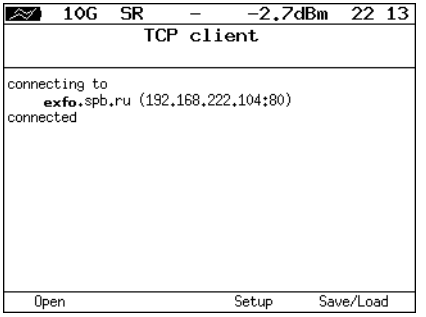
- ➤ Enter the domain name or the IP address of the node.
- ➤ Specify the port number (the most frequently used port numbers are listed in *Reference Tables* on page 143).



Host	The domain name or the IP address of the node.
TCP Port	The destination port number.
File	The name of the le whose content should be displayed in the result window if an HTTP GET request has been handled successfully.

5. Open the TCP Client menu and press (Establish) to establish a TCP connection.

If a connection has been established successfully, a user may submit commands of the respective protocol to request web pages from the server. If problems occur during the connection establishment, an error message will be displayed. Some error messages are listed in *Reference Tables* on page 143.



Web pages are transmitted over HTTP. This protocol defines an HTTP GET request. It can be used for checking whether a server responds to HTTP requests and obtaining content of the specified resource.

13 BERT

BERT (Bit Error Rate Test) is a test that allows determining the main bit index of link quality, the bit error rate, i.e. the number of bit errors divided by the total number of transferred bits.

A binary sequence that is known at the far end and the near end is inserted into an Ethernet frame which is transmitted to the physical media.

At the far end the sequence is compared with the original one and the bit error rate is calculated. To enable the connection to a TDM network, an interface converter is used. It converts the packet network traffic (Ethernet) into the traffic being transmitted across TDM networks.

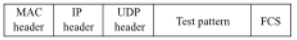
The test can be implemented on four OSI layers.

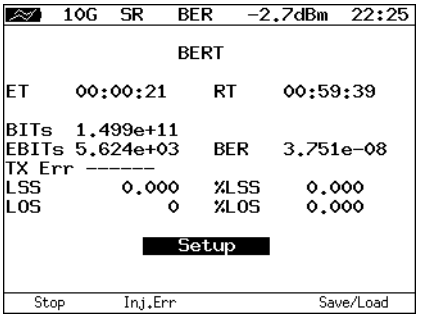
On the physical layer data is sent in portions at a certain interframe gap (IFG). In this case the transmitting fiber optic pair is looped to the receiving one or the Loopback function is used to conduct the test.

On the data link layer an Ethernet header is added to data, which allows transmitting test packets across the network that contains the devices operating on the second layer of the OSI model (for example, a switch). The methods for connecting the device to the network being tested are shown in the figures in this chapter.

On the network layer data is inserted into an IP packet, and then it is inserted into an Ethernet frame. It allows transmitting test packets across the network which contains the devices operating on the data link layer and the network layer (for example, a switch, a router). The methods for connecting the device to the network being tested are shown in the figures.

An Ethernet frame that is generated on the transport layer contains an IP header and a UDP header, which allows transmitting a test sequence using transport protocols. The methods for connecting the device to the network being tested are shown in the images in this chapter.





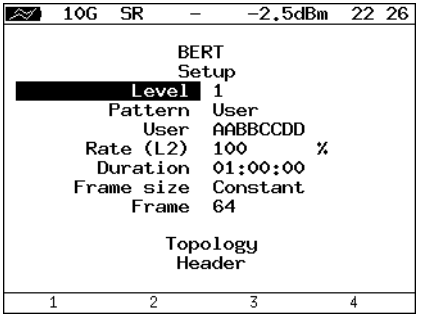
ET	The time that has elapsed since the beginning of the test.
RT	The time that is left until the end of the test.
BITs	The number of received bits.
EBITs	The number of bit errors.
BER	The number of bit errors divided by the total number of received bits.
TX Err	Number of manually injected errors.
LSS	The time during which the loss of test sequence synchronization was observed.
%LSS	The ratio of the time during which there was the loss of test sequence synchronization to the time that has elapsed since the beginning of the test (in percentage terms).
LOS	The time during which there was no signal.
%LOS	The ratio of the time during which there was no signal to the time that has elapsed since the beginning of the test (in percentage terms).
Setup	Open the BERT Setup menu.

Note: *LSS is a state when there is no synchronization with the data being received and it is impossible to evaluate the BER parameter. The possible causes of the loss of synchronization are:*

- Inconsistency of test sequences (for example, PRBS 2e15 is set at the receiving end, but PRBS 2e23 is being transmitted through the channel).
- The BER value of the channel being used for transmitting the sequence is too high (the threshold value is 0.01).

You can manually inject single-bit errors into the outgoing test pattern simply by clicking the F2 button.

Press F4 (Save/Load) to enter the menu which allows displaying information about saved measurements (F1), saving test results and parameters (F2), loading (F3) and deleting (F4) saved measurement results and parameters.

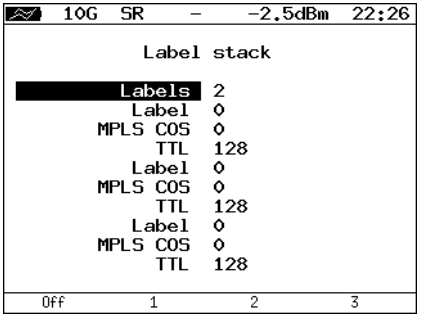


Level	Selecting an OSI layer on which the test is to be conducted: ➤ 1 - the physical layer ➤ 2 - the data link layer (MAC) ➤ 3 - the network layer (IP) ➤ 4 - the transport layer (TCP/UDP)

Pattern	Selecting a standard test sequence or a user-defined test sequence.
User	Enter a user-defined test sequence.
Rate (L2)	Data rate value (L2) in percentage terms (F1), in Kbps (F2) or in Mbps (F3).
Duration	Set the measurement duration.
Frame size	If Random is selected, then the frame size will vary according to the uniform law within the set limits (Min. frame, Max. frame menu items). If Constant is selected, then the frames whose size is set using the Frame menu item will be used for testing.
Frame	Set the data frame size.
Topology	Switch to the Topology menu.
Header	Open the Header menu.

BERT MPLS Setting

The label stack to be used for testing is set in the MPLS menu.



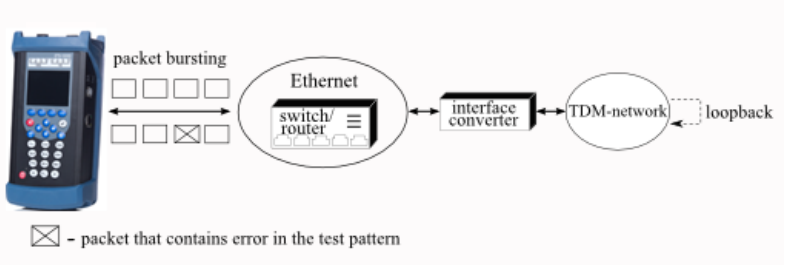
Labels	Select the number of labels (from 1 to 3) to be added to an outgoing packet.
Label	The label value.
MPLS COS	The Class of Service of a packet.
TTL	The time-to-live of a labeled packet.

Connection Options

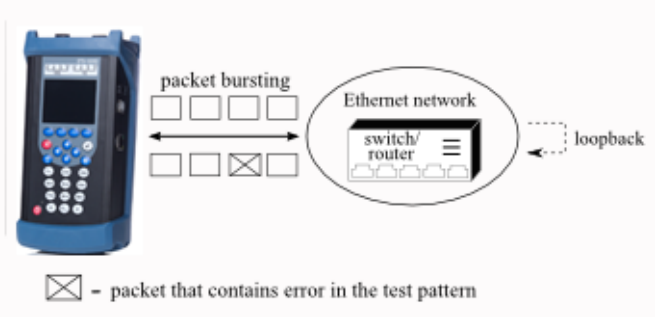
Testing on the physical layer (option 1)

Testing on the physical layer (option 2)

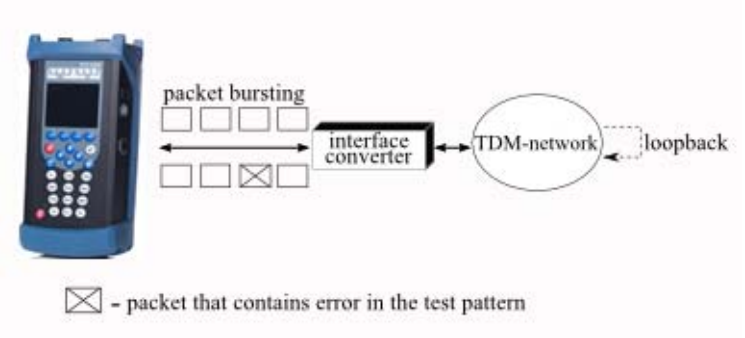
Testing on the data link/network layer (option 1)



Testing on the data link/network layer (option 2)

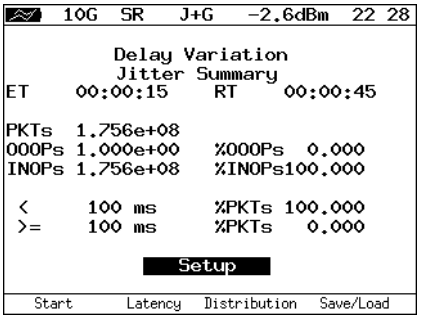


Testing on the data link/network layer (option 3)



14 Delay Variation

During an analysis of Ethernet-based networks, an important task is to determine the packet jitter and latency. According to RFC 4689[5], the packet jitter is the absolute difference of propagation of two successively received packets which belong to the same data stream. This parameter is used for evaluating the network's capability to transmit the deference-sensitive traffic, such as video or voice. Using Delay Variation option you can measure packet jitter and latency distribution.



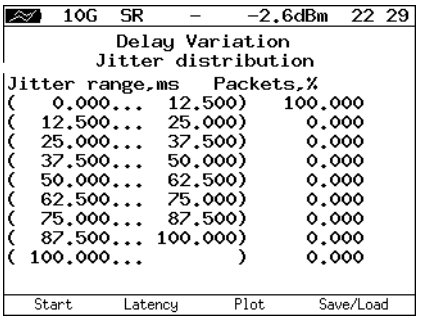
ET	The time that has elapsed since the beginning of the test.
RT	The time that is left until the end of the test.
PKTs	The total number of received packets.
OOOPs	The number of packets which have been received in the order that is different from the order in which they were sent.
%OOOPs	The number of packets which have been received not in the order in which they were sent; specified as the percentage of the total number of received packets.
INOPs	The number of packets which have been received in the order in which they were sent.
%INOPs	The number of packets which have been received in the order in which they were sent; specified as the percentage of the total number of received packets.

< ms %PKTs	The number of packets (as the percentage of number of received packets) for which the jitter was below the specified threshold. ***Note:*** *When the test is performed according to the Static Traffic Generation Configuration 2 shown on page 91, this value for latency is not available (n/a).*
>= ms %PKTs	The number of packets (as the percentage of number of received packets) for which the jitter was above or equal to the specified threshold. ***Note:*** *When the test is performed according to the Static Traffic Generation Configuration 2 shown on page 91, this value for latency is not available (n/a).*
Setup	Open the Delay Variation Setup menu.

To start determining the packet jitter and latency for the packets being received to 10G/1G port, press F1 (Start).

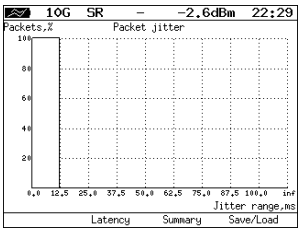
To select Jitter or Latency measurement results press F2.

To open the screen which contains information about the jitter/latency distribution, press F3 (Distribution).

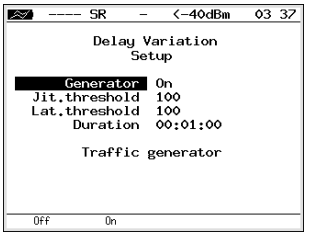


The screen displays two columns. The first one contains the limits of subintervals, the second one contains the number of packets (in percentage terms) for which the jitter/latency belongs to the specified subinterval. The upper interval limit can be set in the Delay Variation > Setup menu. It is specified as Jitter/Latency Threshold, ms. The interval from zero to the set threshold is divided into a certain number of subintervals. According to the results of the test, the percentage of packets for which the jitter/latency lies within these limits is displayed for each subinterval in the right column.

To open the screen which contains the graphical representation of the packet jitter/latency, press F3 (Plot).



Press F4 (Save/Load) to open the menu which allows displaying information about saved measurements (F1), saving test results and parameters (F2), loading (F3) and deleting (F4) saved measurement results and parameters (refer *Saving test results and statistics* on page 101).



Generator	Enable/disable the test traffic generator. If On is selected, the generator will be enabled at the start of the Delay Variation test.
Jit. threshold, ms	The threshold jitter value.
Lat. threshold, ms	The threshold latency value.
Duration	The Delay Variation measurement duration.
Traffic generator	Open the Traffic Generator menu.

15 Traffic Generator

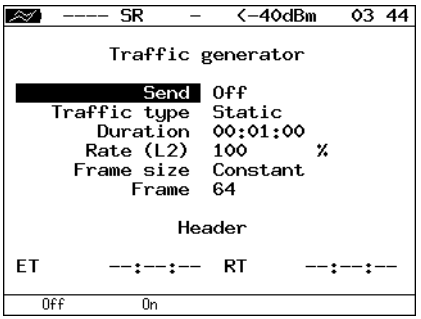
The test traffic generation option allows to produce different types of test traffic: static, MAC flood, VLAN flood, IP flood.

MAC, IP and VLAN flood modes allow to consume the limited addressable memory of the DUT and to check if it has any protection against this kind of attacks.

When you select MAC flood last 3 bytes of source MAC address will be changed randomly.

When VLAN flood is selected, all VLAN ID and VLAN Priority bits will be changed randomly.

When you select IP flood last byte of destination IP address will be changed randomly.



Send	Enable/disable the test traffic generation.
Traffic type	Type of traffic that will be generated: static, MAC flood, VLAN flood, IP flood.
Duration	The time during which test traffic should be generated.
Rate (L2)	Data rate value (L2) in percentage terms (F1), in Kbps (F2) or in Mbps (F3).

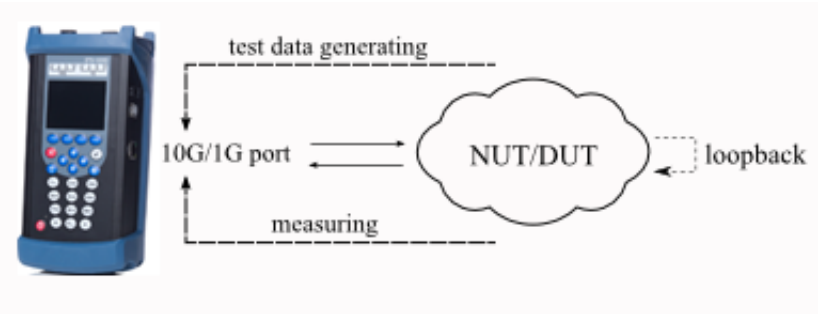
Frame Size	If Random is selected, then the frame size will vary according to the uniform law within the set limits (Min.frame, Max. frame menu items). If Constant is selected, then the frames whose size is set using the Frame menu item will be used for testing.
Frame	Frame size (any value within the range from 64 to 9600 bytes).
Header	Open the Header menu.
ET	The time that has elapsed since the beginning of the traffic generation.
RT	The time that is left until the end of the traffic generation.

Static Traffic

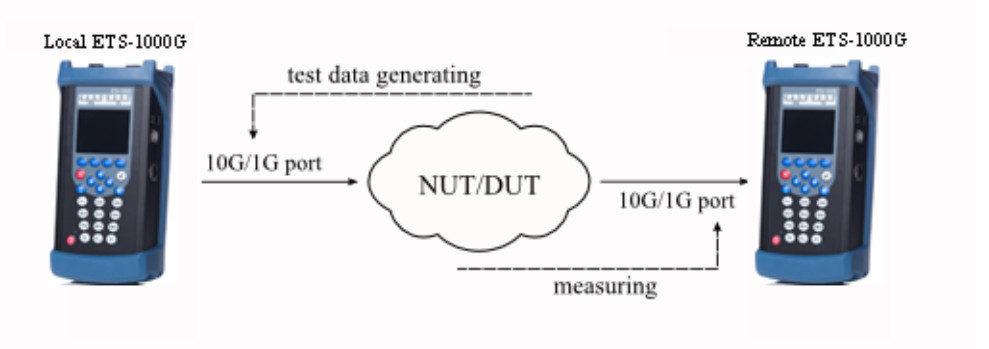
The static test traffic generation feature can be used during the jacket jitter or latency distribution measurement.

It is possible to generate test traffic and measure the packet jitter and latency distribution on port 10G/1G of the device, and also to generate test traffic on the local device's port (ETS-1000G) and perform measurement on the remote device's port (ETS-1000G).

Static Traffic Generation Configuration 1



Static Traffic Generation Configuration 2



If ETS-1000G is connected to the network to conduct, for example, the Packet jitter test, do the following:

1. Open the Network setup menu, specify the IP address of 10G/1G port or make sure that the device has received the correct IP address via DHCP.
2. Open the Delay Variation > Setup menu:
   - ➤ Enable the test traffic generator.
   - ➤ Specify the required threshold value.
   - ➤ Specify measurement duration.
3. Open the Traffic generator menu:
   - ➤ Set the generation parameters.
   - ➤ Set the header parameters according to the information provided in *Main header parameters* on page 26 and *Additional header parameters* on page 27 section.
   - ➤ If the generator is disabled in the Delay Variation > Setup menu, enable the test traffic generation feature.
4. Open the Delay Variation > Summary menu and press F1 (Start).

If the local and remote devices are connected to the network, to conduct the test, do the following:

1. Open the Network Setup menu on the local and remote devices, specify the IP address of test port or make sure that the device has received the correct IP address via DHCP.
2. Open the Traffic generator menu on the local device:
   - ➤ Set the generation parameters.
   - ➤ Set the header parameters according to the information provided in *Main header parameters* on page 26 and *Additional header parameters* on page 27 section.
3. Open the Delay Variation > Setup menu on the remote device:

- ➤ Disable the test traffic generator.
- ➤ Specify the required threshold value.
- ➤ Specify measurement duration.

4. Open the Traffic generator menu on the local device and enable the test traffic generation feature.
5. Open the Delay Variation > Summary menu on the remote device and press F1 (Start).

If the local and remote devices are connected to the network according to the diagram to conduct the test, do the following:

1. Open the Network Setup menu on the local and remote devices, specify the IP address of test port or make sure that the device has received the correct IP address via DHCP.
2. Open the Traffic generator menu on the local device:
   - ➤ Set the generation parameters.
   - ➤ Set the header parameters according to the information provided in *Main header parameters* on page 26 and *Additional header parameters* on page 27 section.
3. Open the Delay Variation > Setup menu on the remote device:
   - ➤ Disable the test traffic generator.
   - ➤ Specify the required threshold value.
   - ➤ Specify measurement duration.
4. Open the Traffic generator menu on the local device and enable the test traffic generation feature.
5. Open the Delay Variation > Summary menu on the remote device and press F1 (Start).

MAC/IP and VLAN flood

MAC, IP and VLAN flood modes allow to consume the limited addressable memory of the DUT and to check if it has any protection against this kind of attacks.

Note: *Flood traffic is not included in the basic configuration. It is available as an option upon special request.*

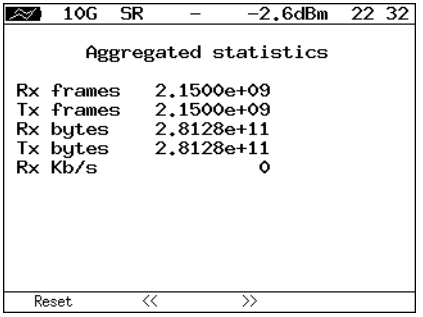
To perform the test you need to:

1. Connect 10G/1G port of the ETS-1000G to the NUT/DUT.
2. Open the Network Setup menu on the local and remote devices, specify the IP address of test port or make sure that the device has received the correct IP address via DHCP.
3. Open the Traffic generator menu on the local device:
   - ➤ Set the generation parameters.
   - ➤ Set the header parameters according to the information provided in *Main header parameters* on page 26 and *Additional header parameters* on page 27 section.
   - ➤ Select On (F2) in the Send field. Test traffic generation will begin from the 10G/1G port to NUT/DUT. Each packet will contain random source MAC/IP address or VLAN Priority/ID value.

16 Statistics

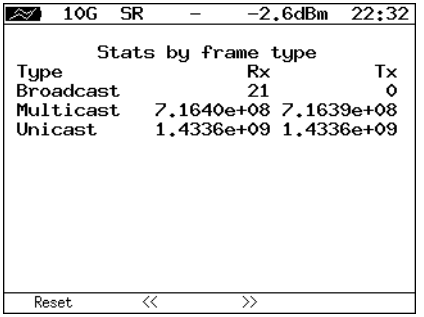
ETS-1000G enables gathering and displaying statistics of the traffic being received and transmitted on the physical, data link and network layers in compliance with RFC 2819. Statistical data are displayed on several screens. To switch between the screens, use ◄ / ► or F2 / F3 . To reset statistics, press F1 (Reset).

Summary statistics



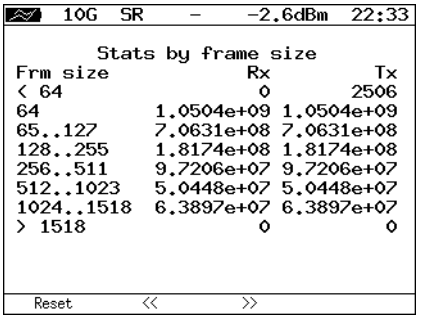
Rx frames	The number of received frames.
Tx frames	The number of transmitted frames.
Rx bytes	The number of received bytes.
Tx bytes	The number of transmitted bytes.
Rx Kbps	Information on the current load on the receiving part of the port.

Statistics of Frame Types



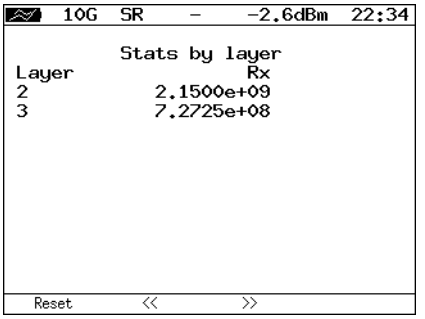
Broadcast	Broadcast frames.
Multicast	Multicast frames.
Unicast	Unicast frames.
Rx	The number of received frames.
Tx	The number of transmitted frames.

Statistics of Frame Sizes



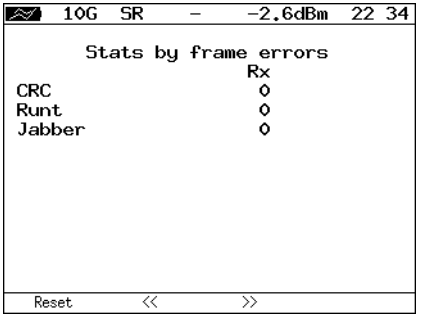
Size	The size of a frame (in bytes).
Rx	The number of received frames.
Tx	The number of transmitted frames.

Statistics for Layers



Layer 2	The number of received (Rx) frames on the data link layer.
Layer 3	The number of received (Rx) frames on the network layer.

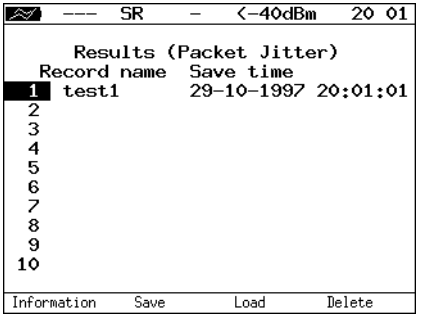
Statistics of Frame Errors



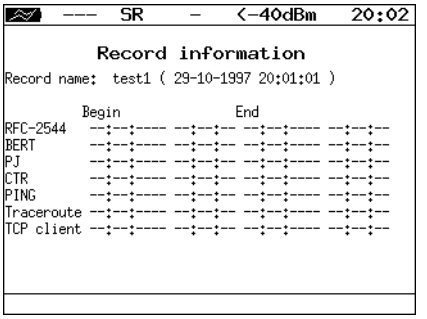
CRC	The number of received frames which have an invalid checksum.
Runt	The number of received packets which do not exceed 64 bytes with a correct checksum.
Jabber	The number of received packets which exceed 1518 bytes in size and have an invalid checksum.

17 Saving test results and statistics

The Results menu is used for viewing information about saved measurements (F1), saving test results (including statistics) and parameters (F2), loading (F3) and deleting (F4) saved measurement results and parameters.



To view detailed information about an entry, press F1 .



To save data:

- ➤ Select the number to be used for saving measurement data.
- ➤ Press ✓.
- ➤ Specify the entry name.
- ➤ Press ✓.
- ➤ Press F2 (Save).

To load saved measurement results and test parameters:

➤ Select the entry number.

➤ Press F3 (Load).

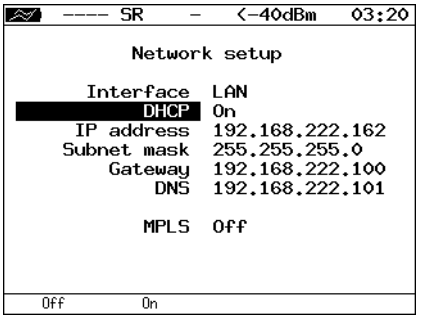
To delete saved measurement results:

➤ Select the number of the entry to be deleted.

➤ Press F4 (Delete).

➤ Press F3 (Yes).

18 Network Parameters



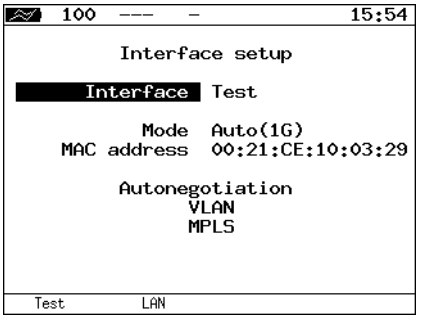
Interface	Select the interface (Test or LAN) to be configured.
DHCP	If this feature is enabled, the DHCP server will automatically send the port's IP address, the subnet mask, the gateway's IP address and the IP address of a node where the DNS database resides to the tester.
IP address	The IP address of the port (Test or LAN) being configured. There are two ways to set the IP address: ➤ to input the IP address manually (in this case the DHCP option should be set to Off); ➤ to obtain the IP address over DHCP via selecting the DHCP option and pressing (On). The obtained IP address will be valid, if it is displayed in the IP address menu within 1-2 seconds.
Subnet mask	It defines a part of the IP address specified in the previous menu item that refers to the network address and a part that refers to the address of a node in the network.
Gateway	The gateway's IP address.
DNS	The IP address of the network node where the DNS database resides.

MPLS	Enable/disable an option to send the packets containing labels for the 10G/1G port or the LAN port. If Off is selected, the MPLS menu item (the Interface Parameters menu) will become unavailable for editing.

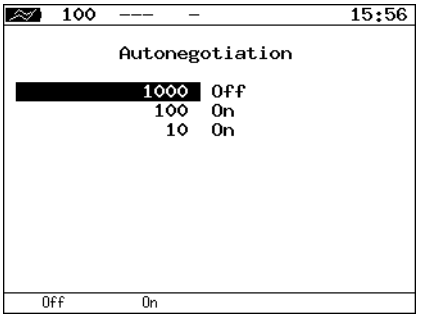
Note: *The gateway's IP address and the IP address of the network node where the DNS database resides are set independently for each port.*

Note: *MPLS is not included in the basic configuration. It is available as an option upon special request.*

19 Interface Parameters

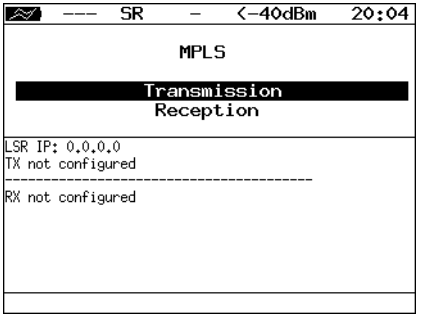


Interface	Select the interface (Test or LAN) to be configured.
Mode	Select the interface mode: 10G (10 Gbps rate for 10G port with SFP+ module); 10G(WAN) (WAN-mode | 10G Ethernet, adapted to work in OC-192 networks); Auto(1G) (autonegotiation mode for 1G port); 1 000/100/10 (set fixed rate 1000 Mbps, 100 Mbps or 10 Mbps port 1G). If you select Auto(1G), the Autonegotiation menu item is enabled.
MAC address	The MAC address of the port (Test or LAN) being configured. Press F1 (Default) to use the port's MAC address specified in the Information menu as the current MAC address.
Autonegotiation	Switch to the Autonegotiation setup screen.
VLAN	Open the VLAN menu.
MPLS	Open the MPLS menu.



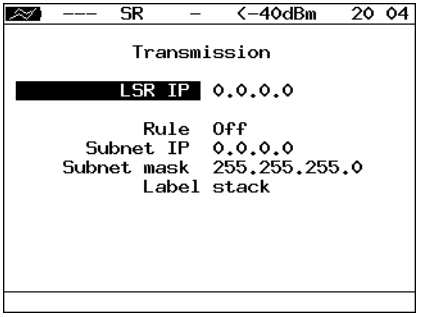
To establish a connection in the autonegotiation mode you need to select the preferable connection rates by pressing F1 (Off) or F2 (On) buttons.

The connection will be established only if the auto-negotiation mode is enabled also on remote end, and if the remote device supports at least one the same connection rates. The connection will be established at the maximum preferable rate for both device.

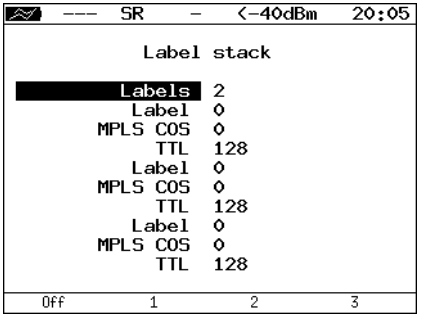


Transmis-sion	Open the Transmission menu.
Reception	Open the Reception Rules menu.

Besides, the MPLS parameters specified using the Reception and Transmission menus are displayed on the screen.



LSR address	The IP address of the label-switching router's interface to which the device is connected.
Rule	Enable/disable the rule for sending packets to the subnet whose parameters are configured below.
Subnet IP	The subnet IP address.
Subnet mask	The subnet mask.
Label Stack	Open the Label Stack menu.

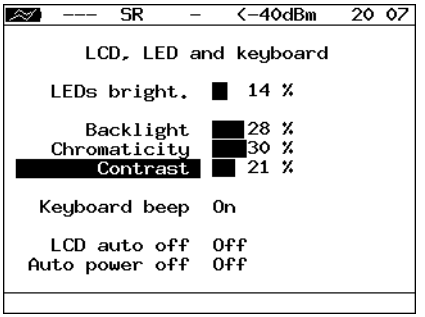


Labels	Select the number of labels (from 1 to 3) to be added to the packet to be transmitted.
Label	The label value.
MPLS COS	The Class of Service of a packet.
TTL	The time-to-live of a labeled packet.

Labels	Select the number of in incoming packets.
Label 1, Label 2, Label 3	The label value.

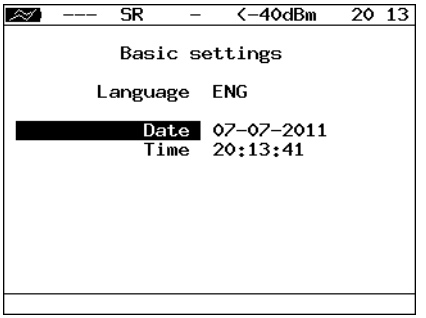
20 Device Settings

Display Settings



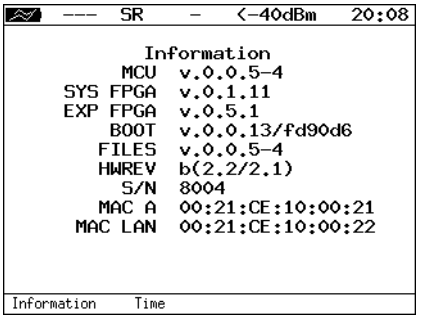
LEDs bright.	Adjust the intensity level of LEDs on the clipboard of the device.
Backlight	Adjust the display illumination brightness.
Chromaticity	Adjust the image color.
Contrast	Adjust the image contrast.
Keyboard beep	Enable/disable keypad tones.
LCD auto off	This field can be used for setting the following values of the automatic display illumination switch-off time: Off, 20 s, 40 s, 60 s. To increase the battery life, select the minimum value.
Auto power off	This field can be used for setting the following values of the automatic device switch-off time: Off, 1, 5, and 10 minutes.

General Settings



Language	Change the interface language.
Date	Set the date.
Time	Set the time.

Information

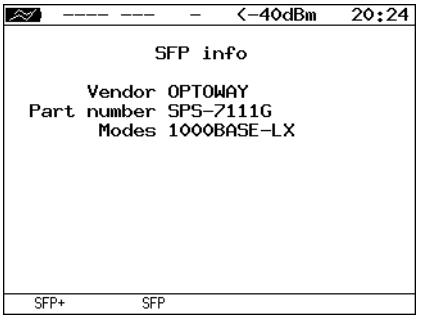


MCU	The MCU program version.
SYS FPGA	The system FPGA microcode version.
EXP FPGA	The expansion FPGA microcode version.
BOOT	The loader version.
FILES	The file system version.
HWREV	The mainboard and expansion card version.
S/N	The serial number.
MAC TEST	The MAC address of test port.
MAC LAN	The MAC address of the LAN port.

Pressing F2 (Time) opens the Operation Time screen.

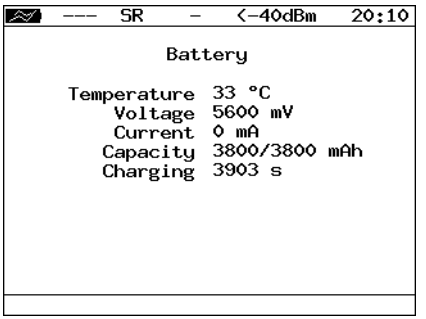
Current	The operation time of the device since the last time it was switched on until now.
Previous	The operation time of the device since the previous activation until the previous deactivation.

SFP/SFP+ Information



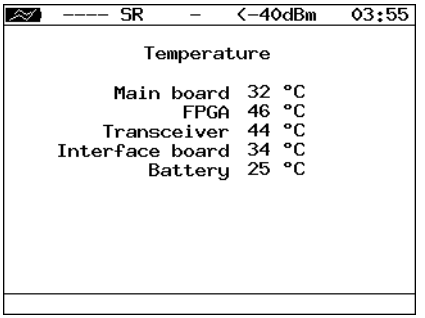
The screen displays information about the vendor, the part number and the supported data transfer modes of the SFP/SFP+ module.

Storage Battery



The screen displays information about the storage battery state, including the temperature (C), the voltage (mV), the current (mA), the current/maximum capacity (mAh), the charge time — the time that has passed since the storage battery charging started (s).

Temperature



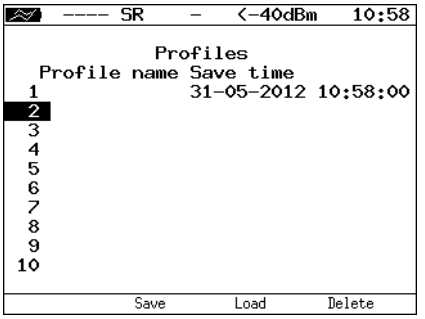
The screen displays the current temperature of different device components.

Option Control

Options are features of ETS-1000G which are available upon special request. To activate options, it is necessary to enter the key which has been generated for the specified serial number of the device in the Options menu directly on the device or using the remote control command *ats* (refer to Annex B).

21 Profiles

ETS-1000G provides for an opportunity of creating profile of settings, which enables a user to adjust main tests and network interfaces promptly when performing tests.



Each setting profile includes:

- Setting of topologies, headers and frame sizes for such tests as RFC 2544, BERT, packet jitter, complex traffic, test traffic, and also individual setting for each of these tests,
- Network interface settings,
- Setting of IP utilities: Ping, Traceroute, TCP Client.

To create a settings profile, adjust parameters as necessary, open the Profile menu, set the profile name and press F2 (Save).

To load a saved profile, use F3 (Load).

The remote control commands used for working with settings profiles are described in *Remote Control Commands* on page 151.

22 Event Logging

The event logging system outputs messages about occurred events in the Log menu, and also to the console terminal in case of establishing a connection to the device through the USB interface or the remote control over TELNET.

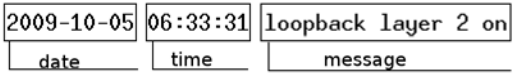
The events to be logged include:

- Starting/stopping a test,
- Enabling/disabling the Loopback mode,
- A change in the connection state,
- Using the device for remote testing,
- Switching the device on/off,
- A low battery charge level.

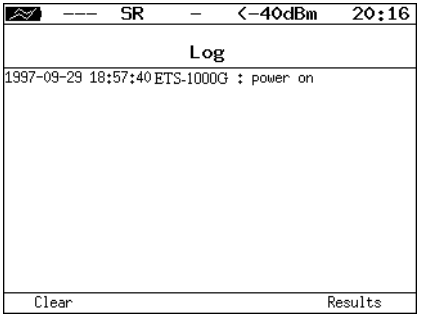
If any of the aforementioned event occur, a message of the following format will be displayed on the console terminal/in the Log menu:

<date> <time> <message>

For example, when the Loopback mode is enabled for Layer 2, the following message will be displayed on the console terminal:



By default the output of messages via the USB interface and TELNET is disabled. The output of messages can be enabled/disabled using the remote control command *log on/off*.



To empty the buffer, use F1 (Clean). F4 (Results) is used for opening the Results menu for saving messages about occurred events. Besides, the messages are also saved when saving results and settings of any tests.

23 Remote Control

ETS-1000G provides an opportunity of communicating with a personal computer through the USB 1.1/2.0 interface or the LAN port. Thus a user can control the device in the terminal mode over TELNET, through the WWW interface, and conduct tests, adjust analysis parameters, obtain measurement results and update software versions.

Updating SW versions on the device

Note: *Inappropriate actions during the SW update operations may cause partial inoperability of the device. In this case the recovery can only be implemented at the service center.*

The most recent SW versions for ETS-1000G are available in the Internet (http://www.myexfo.com). The current software version numbers can be viewed in the Information menu (Device Settings > Information).

To update the device's software, follow the procedure below:

1. Download the file system image file and save it on the PC.
2. Connect the device to the external power supply.
3. Establish a connection to the PC via USB (refer *Connecting to a PC via the USB Interface* on page 122).
4. Check the connection using the AT command. The device should respond OK.
5. Open the loader menu. To do so, press and hold the power-on/power-off button, and simultaneously press the reset button, which is located on the side panel of the device.
6. The following message should be displayed in the program's window:

   ETS-10G+ bootloader 0.0.15

   Update via XMODEM:

   CCCC...
7. In the Transfer > Send File menu of HyperTerminal specify the path to file system image file in the Filename window.

8. Select the Xmodem in the Protocol window. Click Send.

9. The process of updating SW versions will be started in a second. After that there is no need to hold the power-on/power-off button any longer.

10. If the image on the screen of the device has been restored, the update process has been completed successfully.

Connecting to a PC via the USB Interface

To enable connecting the device to a PC via the USB interface, it is necessary to install the Virtual COM Port driver as a preliminary. The driver les for different operating systems and the instructions for installing them can be found on the web site of FTDI Chip:
http://www.ftdichip.com/Drivers/VCP.htm.

It is possible to interact with the device using HyperTerminal, an application that is included in the standard delivery set of OS Windows, as well as third-party terminal programs. To enable updating SW versions, the terminal program should support le transfer over the X-modem protocol.

If you use HyperTerminal, take the following actions to establish a connection to the device via the USB interface.

1. Turn on ETS-1000G.

2. Connect the device to the USB port of the PC using the cable included in the delivery set.

3. Run HyperTerminal (Start > Programs > Accessories > Communications > HyperTerminal).

4. Set the connection name.

5. Select the serial port (COM port) to which the device is connected using the standard device manager application (My Computer > Properties > Hardware > Device Manager.

6. Set the following serial port parameters:

➤ Bits per second: 57600

- Data bits: 8
- Parity: No
- Stop bits: 1
- Flow control: No

7. Click OK and HyperTerminal will attempt to establish a connection to the device. Check the connection using the AT command.The device should respond OK.

Remote Control Over TELNET

TELNET (Telecommunication Network) is a protocol for accessing a remote network device. This protocol enables a PC user to communicate with the device which is located on the far end of the connection to configure test parameters, to view existing settings and to conduct tests.

It is possible to interact with the device using HyperTerminal, an application that is included in the standard delivery set of OS Windows, as well as third-party terminal programs that enable file transfer over TELNET.

To control ETS-1000G over TELNET, take the following actions.

1. Connect the device to a PC through test or the LAN port.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Enter the following command in the terminal application:

   telnet port IP address
4. The username and the password (by default) are admin.
5. The interaction with the device is implemented using the commands listed in *Remote Control Commands* on page 151.

Remote Control Through the WWW Interface

The remote control feature allows viewing results and settings of main tests and save them on a PC using a web browser.

To view test results and settings, it is necessary to:

1. Connect the device to a PC through test port or the LAN port.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Specify the IP address of the corresponding port in the address bar of the web browser.

To save test results, it is necessary to:

1. Connect the device to a PC through test port or the LAN port.
2. Set up a network connection (refer to *Network Parameters* on page 103).
3. Specify the IP address of the corresponding port in the address bar of the web browser.
4. Select the delimiter:
   - ➤ comma
   - ➤ semicolon
5. Click the Download report link. The data will be saved to a .csv file.

Taking Screenshots

To take a screenshot of the device's screen, it is necessary to:

1. Connect the device to a PC through test port or the LAN port.
2. Set up a network connection (refer to *Network Parameters* on page 103).

3. Specify the following address in the address bar of the web browser:

   http://port IP address/sshot.

4. In a few seconds the screenshot will be displayed in the web browser window on the PC.

24 Service and Maintenance

To help ensure long, trouble-free operation:

- Always inspect fiber-optic connectors before using them and clean them if necessary.
- Keep the unit free of dust.
- Clean the unit casing and front panel with a cloth slightly dampened with water.
- Store unit at room temperature in a clean and dry area. Keep the unit out of direct sunlight.
- Avoid high humidity or significant temperature fluctuations.
- Avoid unnecessary shocks and vibrations.
- If any liquids are spilled on or into the unit, turn off the power immediately, disconnect from any external power source, remove the batteries and let the unit dry completely.

WARNING

Use of controls, adjustments, and procedures for operation and maintenance other than those specified herein may result in hazardous radiation exposure.

Recalibrating the Unit

Manufacturing and service center calibrations are based on the ISO/IEC 17025 Standard, which states that calibration documents must not contain a recommended calibration interval, unless this has been previously agreed upon with the customer.

Validity of specifications depends on operating conditions. For example, the calibration validity period can be longer or shorter depending on the intensity of use, environmental conditions and unit maintenance. You should determine the adequate calibration interval for your unit according to your accuracy requirements.

Under normal use, EXFO recommends calibrating your unit every two years.

Battery Charging Procedure

To charge the battery it is necessary to execute the following actions:

1. Connect the external power unit.
2. Make sure that the charge has begun: LED indicator located at the bottom of the front panel ashes green.
3. If the LED is lit green — charge is finished or battery temperature is greater than 65 ^{o}C, and the charge stopped until the cooling battery. After cooling, battery charge is automatically renewed.
4. To control the battery charging it is necessary to switch on the device, turn off the power supply and after 2 minutes to check the voltage value in the menu “Device settings” > “Battery”. If the voltage exceeds 9.8V — battery is charged, If the voltage is less than 9.8V — charge has been stopped until the cooling battery.

The time required to charge the battery is about 5 hours. Recommended indoor temperature during charging is from 15 ^{o}C to 25 ^{o}C. If the temperature is higher more time to charge may be required.

In the future you need to charge the battery when:

- the battery is partial discharged;
- the battery is full discharged;
- if the tester is not used more than 1 month.

Note: *Before the first use, switch on the device.*

Note: *Battery replacement is made only by the manufacturer.*

Recycling and Disposal (Applies to European Union Only)

For complete recycling/disposal information as per European Directive WEEE 2002/96/EC, visit the EXFO Web site at www.exfo.com/recycle.

25 Troubleshooting

Typical fault indications	Possible cause	Fault elimination method
Invalid system time	Set the system time.	The device cannot be turned on.
The reset button has been pressed.	The storage battery is discharged.	Turn the external power supply on, charge the storage battery.
	Software failure	Press the reset button through the opening on the side panel of he device using a thin blunt-pointed rod.
The storage battery cannot be charged from the external power supply unit.	The power supply unit is faulty; there is a break in the plug; the storage battery is damaged.	Check and replace the power supply unit or the storage battery if necessary.

Contacting the Technical Support Group

To obtain after-sales service or technical support for this product, contact EXFO at one of the following numbers. The Technical Support Group is available to take your calls from Monday to Friday, 8:00 a.m. to 7:00 p.m. (Eastern Time in North America).

For detailed information about technical support, visit the EXFO Web site at www.exfo.com.

Technical Support Group
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

26 Warranty

General Information

EXFO Inc. (EXFO) warrants this equipment against defects in material and workmanship for a period of one year from the date of original shipment. EXFO also warrants that this equipment will meet applicable specifications under normal use.

During the warranty period, EXFO will, at its discretion, repair, replace, or issue credit for any defective product, as well as verify and adjust the product free of charge should the equipment need to be repaired or if the original calibration is erroneous. If the equipment is sent back for verification of calibration during the warranty period and found to meet all published specifications, EXFO will charge standard calibration fees.

IMPORTANT

The warranty can become null and void if:

- **unit has been tampered with, repaired, or worked upon by unauthorized individuals or non-EXFO personnel.**
- **warranty sticker has been removed.**
- **case screws, other than those specified in this guide, have been removed.**
- **case has been opened, other than as explained in this guide.**
- **unit serial number has been altered, erased, or removed.**
- **unit has been misused, neglected, or damaged by accident.**

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL EXFO BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Liability

EXFO shall not be liable for damages resulting from the use of the product, nor shall be responsible for any failure in the performance of other items to which the product is connected or the operation of any system of which the product may be a part.

EXFO shall not be liable for damages resulting from improper usage or unauthorized modification of the product, its accompanying accessories and software.

Exclusions

EXFO reserves the right to make changes in the design or construction of any of its products at any time without incurring obligation to make any changes whatsoever on units purchased. Accessories, including but not limited to fuses, pilot lamps, batteries and universal interfaces (EUI) used with EXFO products are not covered by this warranty.

This warranty excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the product or other factors beyond the control of EXFO.

IMPORTANT

EXFO will charge a fee for replacing optical connectors that were damaged due to misuse or bad cleaning.

Certification

EXFO certifies that this equipment met its published specifications at the time of shipment from the factory.

Service and Repairs

EXFO commits to providing product service and repair for five years following the date of purchase.

To send any equipment for service or repair:

1. Call one of EXFO's authorized service centers (see *EXFO Service Centers Worldwide* on page 137). Support personnel will determine if the equipment requires service, repair, or calibration.
2. If equipment must be returned to EXFO or an authorized service center, support personnel will issue a Return Merchandise Authorization (RMA) number and provide an address for return.
3. If possible, back up your data before sending the unit for repair.
4. Pack the equipment in its original shipping material. Be sure to include a statement or report fully detailing the defect and the conditions under which it was observed.
5. Return the equipment, prepaid, to the address given to you by support personnel. Be sure to write the RMA number on the shipping slip. *EXFO will refuse and return any package that does not bear an RMA number.*

Note: *A test setup fee will apply to any returned unit that, after test, is found to meet the applicable specifications.*

After repair, the equipment will be returned with a repair report. If the equipment is not under warranty, you will be invoiced for the cost appearing on this report. EXFO will pay return-to-customer shipping costs for equipment under warranty. Shipping insurance is at your expense.

Routine recalibration is not included in any of the warranty plans. Since calibrations/verifications are not covered by the basic or extended warranties, you may elect to purchase FlexCare Calibration/Verification Packages for a definite period of time. Contact an authorized service center (see *EXFO Service Centers Worldwide* on page 137).

EXFO Service Centers Worldwide

If your product requires servicing, contact your nearest authorized service center.

EXFO Headquarters Service Center
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

EXFO Europe Service Center
Omega Enterprise Park, Electron Way
Chandlers Ford, Hampshire S053 4SE
ENGLAND

Tel.: +44 2380 246810
Fax: +44 2380 246801
support.europe@exfo.com

EXFO Telecom Equipment (Shenzhen) Ltd.
3rd Floor, Building 10,
Yu Sheng Industrial Park (Gu Shu Crossing), No. 467,
National Highway 107,
Xixiang, Bao An District,
Shenzhen, China, 518126

Tel: +86 (755) 2955 3100
Fax: +86 (755) 2955 3101
support.asia@exfo.com

A Specifications

Interfaces

10G SFP+	10GBASE-SR/SW, 10GBASE-LR/LW, 10GBASE-ER/EW
1G SFP	1000BASE-SX, 1000BASE-LX, 1000BASE-EX, 1000 BASE-T
RJ-45	10/100/1000 BASE-T
USB type B	Control interface
LAN 10/100 Ethernet	Control interface

Testing

Transmission rates	10 Mbps, 100 Mbps, 1Gbps, 10 Gbps
Supported frame formats	Ethernet II, IPv4, UDP, TCP
Setting of frame parameters	Source/destination MAC address, VLAN ID, VLAN priority, source/destination IP address, ToS field, Precedence field, DSCP field, source/destination UDP port, frame sizes from 64 to 64000 bytes
MPLS	Up to 3 MPLS labels to be received and sent
VLAN	Up to 3 VLAN labels
RFC 2544	Throughput, latency, frame loss, limit load
BERT	Testing on the physical, data link, network and transport layers. Ability of manually inject single-bit errors into the outgoing traffic. Test results: BITs, EBITs, BER, LSS, %LSS, LOS, %LOS. Support for the modes of random and fixed frame sizes. Test sequences: CRTP, 2e11-1, 2e15-1,2e20-1, 2e23-1, 2e29-1, 2e31-1, a user-defined test sequence (4 bytes)

Delay Variation	Test results: PKTs, OOOPs, INOPs, %OOOPs, %INOPs,number of packets, for which the jitter/latency was below (above) the specified threshold. Support for the modes of random and fixed frame sizes.
Complex traffic	Up to 10 data streams with individual load and frame headers. Frame loss for each data stream; the bandwidth calculated according to the results of testing. The current, minimum, average and maximum data deference values. The number of sent and received packets for each data stream.
Statistics (RFC 2819)	Statistics of frame types, frame sizes, layers, error frames. The number of received and transmitted packets, displaying the port load in the real time. Frame types: broadcast, multicast, unicast. Runt packets, jabber packets. The number of frames transmitted on the data link and network layers. CRC, checking for runt, jabber.
DNS	Determining an IP address of a network device according to the known domain name.
Route	Determining data transmission routes in the TCP/IP networks.
Ping	The minimum, average, maximum time periods between sending a request and receiving a reply. The number of sent, received, lost and repeated packets. The number of packets for which the response time has been exceeded.
ARP request monitor	The possibility to monitor the ARP responses being transmitted in the network and intercept the device IP and MAC addresses which are contained in them.
TCP client	Establishing a TCP connection to a remote network device, controlling over TELNET, sending a HTTP GET request.
Loopback	Layers: the physical layer, the data link layer with support for VLAN, the network layer, the transport layer.
ET discovery	Enabling the Loopback mode on a remote analyzer (ETS-1000G) or a remote loopback device.

OAM	Enabling the Loopback mode for the data link layer on a remote device using the OAM protocol in compliance with IEEE 802.3ah standard.
Remote control	Controlling the device in the terminal mode over TELNET, through the WWW interface. Conducting tests, setting parameters, obtaining measurement results.

General Features

Physical specifications	
Overall dimensions of the measuring unit (HxWxD)	200x101x59 mm
Weight of the measuring unit	0.940 kg
Operation conditions	
Operating temperature range	0-35 °C
Transport and storage temperature range	-10...+45 °C
Relative humidity	40-90%, without condensate
Power supply	
External power supply unit	Pulsed (19 V, 2.1 A)
External power supply voltage	19 V
Current	~1.5 A
Storage battery	7 NiMH 8.4 V, 4500 mA x h
Power protection elements	Thyristor surge protection
	Internal fuse, 7 A
Battery life (in the normal mode)	1 – 2 hours (depending on the type of SFP+/SFP module used)
Charging time of storage batteries	10 hours

Service life of storage batteries s	500 “charge-discharge” cycle
Other	
Display	Color graphic display, 320x240 pixels
Keyboard	25 keys
Languages	English

Delivery options

XMPLS	MPLS diagnostics
	Up to 3 MPLS labels to be received and sent.
XAT	Asymmetric test (see *Asymmetric Test* on page 45)
	Asymmetric test function is used to check operability of communication link that has different transmitting and receiving rates.
XADV	Switch stability control (see *Traffic Generator* on page 89)
	Traffic generation with random source MAC addresses or VLAN labels (MAC/VLAN flooding).
	Router stability control (see *Traffic Generator* on page 89)
	Traffic generation with random destination IP addresses (IP flooding).

B Reference Tables

Traffic Types and Priorities

Value	Description
1	Background
0 (Default)	Best Effort
2	Excellent Effort
3	Critical Application
4	Video
5	Voice
6	Internetwork Control
7	Network Control

The Network Control and Internetwork Control traffic types are reserved for network control messages. Priorities 4 and 5 can be used for deference-sensitive traffic, such as video or voice. Traffic priorities from 3 to 1 are used for different tasks: from streaming applications to FTP traffic that is able to handle possible losses. Class 0 is reserved for the <<best-efforts>> delivery and it is assigned when no other class is specified.

Precedence Values

Value	Description	Comments
0	Routine	Normal priority
1	Priority	Preferred priority
2	Immediate	Immediate priority
3	Flash	Expedited priority
4	Flash Override	Emergency priority
5	CRITIC/ECP	Critical priority
6	Internetwork Control	Internetwork control
7	Network Control	Network control

ToS Values

Value	Description	Comment
1000	Minimize delay	To minimize the delay. It is used when he time of packet delivery from the source network device to the destination (latency period) is most critical and has to be minimal.
0100	Maximize throughput	Maximize throughput. It indicates that a packet should be transferred through the channel with the maximum throughput.
0010	Maximize reliability	Maximize reliability. It is used when it is important to make sure that data will reach the destination without retransmission.
0001	Minimize monetary cost	To minimize the cost. It is used when it is necessary to minimize the data transmission cost.
0000	All normal	Normal service. In this case a packet is routed according to a provider's decision.

Class of Service and DSCP Values

Traffic Class	Values of the DSCP field
Default	000 000
AF11	001 010
AF12	001 100
AF13	001 110
AF21	010 010
AF22	010 100
AF23	010 110
AF31	011 010
AF32	011 100
AF33	011 110
AF41	100 010
AF42	100 100
AF43	100 110
EF	101 110

Each Class of Service is associated with the specific value of the DSCP field. The table lists the values recommended in compliance with RFC 2597 [10] and RFC 2598[11].

Default — Non-guaranteed delivery. The network resources which remain idle during the transmission of traffic of other classes are allocated for the traffic of this Class of Service.

AF — Assured Forwarding. It is used for delivering traffic of the most TCP applications using four independent AF classes. Within each class IP packets can be assigned one of three data packet discard disciplines.

EF— Expedited Forwarding. It is used for processing the deference-sensitive traffic that requires the minimum jitter, such as video or voice (VoIP; Voice over IP).

ECN Values

Value	Description
00	Not-ECT (Not-ECN-Capable Transport) — traffic that does not support ECN.
01	ECT (1) (ECN-Capable Transport) — traffic that supports ECN.
10	ECT (0) (ECN-Capable Transport) — traffic that supports ECN. Routers treat it similarly to ECT (1).
11	CE (Congestion Experienced) — confirmed congestion.

ECN (Explicit Congestion Notification) — an explicit notification of congestion. Setting bits in this field allows routers to detect congestion on the data transmission path to the specified network node without discarding a packet.

TCP/IP Port Numbers

Port number (protocol)	Description
21 (FTP)	File Transfer Protocol
22 (SSH)	A secure protocol for remote control and file transfer
23 (TELNET)	A protocol for accessing a remote network device
25 (SMTP)	An e-mail transfer protocol
80 (HTTP(WWW))	A protocol that is used by web browsers and web services for file transfer
161 (SNMP)	A protocol for controlling network devices

Connection Errors

Message	Description
protocol not supported	The protocol is not supported.
can't assign requested address	The requested address cannot be assigned.
network is down	The network is inaccessible.
network is unreachable	The network does not work.
network dropped connection on reset	A connection to the network has been lost.
software caused connection abort	Software has released a connection
connection reset by peer	The node has released a connection.
connection timed out	The connection timeout has expired.
connection refused	An attempt to establish a connection has been refused.
host is down	The node does not respond.
no route to host	A route to the node is unavailable.

Test Sequences

Sequence type	Method of application (recommended)
2e9-1	To detect errors (in case of transmitting data over a communication link at the rate of up to 14.4 Kbps).
2e11-1	To detect errors and jitter (in case of transmitting data over a communication link at the rate of 64 Kbps and 64NKbps, where N is an integer).
2e15-1	To detect errors and jitter (in case of transmitting data over a communication link at the rate of 1544, 2048, 6312, 8448, 32,064 and 44,736 Kbps).
2e20-1	To detect errors (in case of transmission over a communication link at the rate of up to 71 Kbps).
2e23-1	To detect errors and jitter (in case of transmitting data over a communication link at the rate of 34,368 and 139,264 Kbps).
2e29-1, 2e31-1	To detect errors (in case of transmitting data at high data rates (over 139,264 Kbps)).

Digits, Letters, and Characters

Key	Digits	Letters	Characters
1 ␣	1	—	␣ @ / -
2 ABC	2	a b c	—
3 DEF	3	d e f	—
4 GHI	4	g h i	—
5 JKL	5	j k l	—
6 MNO	6	m n o	—
7 PQRS	7	p q r s	—
8 TUV	8	t u v	—

Key	Digits	Letters	Characters
9WXYZ	9	w x y z	—
0 .	0	—	. , : ;
*	—	—	*

C Remote Control Commands

Remote control commands (a console terminal)

Command	Description
AT	An empty command which is used for checking a connection.
ATR	Restart the device.
ATM	Display the current measurement results.
ATMN	Display the saved measurement results which were assigned serial number N (N = 1...10)
ATMA	Display all saved measurement results.
ATMI	Display information about saved measurement results.
ATI	Display information about the device.
ATH	Display help information about commands.
ATS	Input the key (a number in the decimal format) to activate options. The key should be specified right after ats (without a space).
ATC	Switch to the mode which allows setting and starting tests (optionally).

Remote control commands (TELNET)

Command	Information to be output to the console
RFC 2544	
show rfc2544 header src udp	The source UDP port number.
show rfc2544 header src mac	The source MAC address.
show rfc2544 header src ip	The source IP address.
show rfc2544 header dst udp	The destination UDP port number.

Command	Information to be output to the console
show rfc2544 header dst mac	The destination MAC address.
show rfc2544 header dst ip	The destination IP address.
show rfc2544 header vlan count	The number of VLAN tags.
show rfc2544 header vlan [1-3] id	The VLAN identifier value.
show rfc2544 header vlan [1-3] priority	The traffic priority value.
show rfc2544 header mpls count	Select the number of labels.
show rfc2544 header mpls [1-3] label	The label value.
show rfc2544 header mpls [1-3] cos	The Class of Service of a labeled packet.
show rfc2544 header mpls [1-3] ttl	The time-to-live of a labeled packet.
show rfc2544 header autoarp	Display whether the feature of submitting an ARP request automatically is enabled or disabled.
show rfc2544 header diffserv	Display whether the IP Precedence field and the Type of Service field or the DSCP field are selected.
show rfc2544 header dscp	The value of the DSCP field.
show rfc2544 header precedence	The frame priority value.
show rfc2544 header tos	The Type of Service of a packet.
show rfc2544 throughput duration	The test duration for the throughput analysis, s.
show rfc2544 throughput enabled	Display whether the throughput determination test is to be performed.
show rfc2544 throughput maxrate	The load rate for the throughput analysis.
show rfc2544 throughput resolution	The resolution value for the throughput analysis.
show rfc2544 throughput threshold	The loss threshold value for the throughput analysis.

Command	Information to be output to the console
show rfc2544 frames [1-9] size	The frame size defined by a user (or a standard value that complies with RFC 2544).
show rfc2544 frames [1-9] enable	Display whether the frame size is to be used for performing the test.
show rfc2544 latency enabled	Display whether the frame propagation delay analysis is to be made.
show rfc2544 latency count	The number of test iterations for the latency analysis.
show rfc2544 latency duration	The test duration for the frame propagation delay analysis, s.
show rfc2544 latency rates src	The source of load values for the latency analysis.
show rfc2544 latency rates [1-9]	The load values to be used for the latency analysis.
show rfc2544 frameloss enabled	Display whether the frame loss rate analysis is to be made.
show rfc2544 frameloss duration	The test duration for the frame loss rate analysis, s.
show rfc2544 frameloss steps	The number of load adjustment steps for the frame loss rate analysis.
show rfc2544 frameloss rates start	The initial load value for the frame loss rate analysis, specified in %
show rfc2544 frameloss rates stop	The final load value for the frame loss rate analysis, specified in %
show rfc2544 back2back enabled	Display whether the limit load analysis is to be made.
show rfc2544 back2back count	The number of test iterations for the limit load analysis.
show rfc2544 back2back duration	The test duration for the limit load analysis, s

Command	Information to be output to the console
show rfc2544 back2back rates src	The source of load values for the limit load analysis.
show rfc2544 back2back rates [1-9]	The load values to be used for the limit load analysis.
show rfc2544 advanced wait	The Interval parameter value.
show rfc2544 advanced learn	The Learning parameter value.
rfc2544 start	Start the tests to be conducted in compliance with RFC 2544.
rfc2544 stop	Stop the tests being conducted in compliance with RFC 2544.
rfc2544 results	Results of the tests conducted in compliance with RFC 2544.
Complex traffic	
show ctraf nstreams	The number of data streams.
show ctraf stream	The number of the stream to be adjusted.
show ctraf duration	The duration of generating the specified quantity of streams.
show ctraf header src mac	The source MAC address.
show ctraf header src ip	The source IP address.
show ctraf header src udp	The source UDP port number.
show ctraf header dst mac	The destination MAC address.
show ctraf header dst ip	The destination IP address.
show ctraf header dst udp	The destination UDP port number.
show ctraf header vlan count	The number of VLAN tags.
show ctraf header vlan [1-3] id	The VLAN identifier value.
show ctraf header vlan [1-3] priority	The traffic priority value.

Command	Information to be output to the console
show ctraf header mpls count	Select the number of labels.
show ctraf header mpls [1-3] label s	The label value.
how ctraf header mpls [1-3] cos	The Class of Service of a labeled packet.
show ctraf header mpls [1-3] ttl	The time-to-live of a labeled packet.
show ctraf header autoarp	Display whether the feature of submitting an ARP request automatically is enabled or disabled.
show ctraf header diffserv	Display whether the IP Precedence field and the Type of Service field or the DSCP field are selected.
show ctraf header dscp	The value of the DSCP field.
show ctraf header precedence	The frame priority value.
show ctraf header tos	The Type of Service of a packet.
show ctraf rate	The data rate value.
show ctraf frame	The frame size.
ctraf start	Start the generation of complex traffic.
ctraf stop	Stop the generation of complex traffic.
ctraf results	Results of generating complex traffic.
BERT	
show bert header src mac	The source MAC address.
show bert header src ip	The source IP address.
show bert header src udp	The source UDP port number.
show bert header dst mac	The destination MAC address.
show bert header dst ip	The destination IP address.
show bert header dst udp	The destination UDP port number.
show bert header vlan count	The number of VLAN tags.

Command	Information to be output to the console
show bert header vlan [1-3] id	The VLAN identifier value.
show bert header vlan [1-3] priority	The traffic priority value.
show bert header mpls tx count	Select the number of labels to be transmitted.
show bert header mpls tx [1-3] label	The label value.
show bert header mpls tx [1-3] cos	The Class of Service of a labeled packet.
show bert header mpls tx [1-3] ttl	The time-to-live of a labeled packet.
show bert header autoarp	Display whether the feature of submitting an ARP request automatically is enabled or disabled.
show bert header diffserv	Display whether the IP Precedence field and the Type of Service field or the DSCP field are selected.
show bert header dscp	The value of the DSCP field.
show bert header precedence	The frame priority value.
show bert header tos	The Type of Service of a packet.
show bert frame random min	The minimum frame size value for the uniform distribution law.
show bert frame random max	The maximum frame size value for the uniform distribution law.
show bert frame constant	The frame sizes to be used for testing.
show bert frame type	Display whether a random frame size or a fixed frame size is set.
show bert level	The OSI layer on which the test is to be conducted.
show bert pattern	A standard test sequence.
show bert user-pattern	A user-defined test sequence.

Command	Information to be output to the console
show bert rate	The stated load, Kbps
show bert duration	The measurement duration.
bert start	Start the BERT test.
bert stop	Stop the BERT test.
bert results	Results of the BERT test.
Packet jitter	
jitter start	Display whether the test traffic generator is enabled or disabled.
show jitter txgen	The threshold jitter value, ms.
show jitter threshold	The jitter measurement duration.
show jitter duration	Start the Packet Jitter test.
jitter stop	Stop the Packet Jitter test.
jitter results	Results of the Packet Jitter test.
Test traffic	
show txgen header src mac	The source MAC address.
show txgen header src ip	The source IP address.
show txgen header src udp	The source UDP port number.
show txgen header dst mac	The destination MAC address.
show txgen header dst ip	The destination IP address.
show txgen header dst udp	The destination UDP port number.

Command	Information to be output to the console
show txgen header vlan count	The number of VLAN tags.
show txgen header vlan [1-3] id	The VLAN identifier value.
show txgen header vlan [1-3] priority	The traffic priority value.
show txgen header mpls count	Select the number of labels.
show txgen header mpls [1-3] label	The label value.
show txgen header mpls [1-3] cos	The Class of Service of a labeled packet.
show txgen header mpls [1-3 ttl	The time-to-live of a labeled packet.
show txgen header autoarp	Display whether the feature of submitting an ARP request automatically is enabled or disabled.
show txgen header diffserv	Display whether the IP Precedence field and the Type of Service field or the DSCP field are selected.
show txgen header dscp	The value of the DSCP field.
show txgen header precedence	The frame priority value.
show txgen header tos	The Type of Service of a packet.
show txgen port	The port on which test traffic is to be generated.
show txgen frame random min	The minimum frame size value for the uniform distribution law.
show txgen frame random max	The maximum frame size value for the uniform distribution law.
show txgen frame constant	The frame sizes to be used for testing.
show txgen frame type	Display whether a random frame size or a fixed frame size is set.
show txgen duration	The duration of test traffic generation.
show txgen rate	The stated load, Kbps or %

Command	Information to be output to the console
txgen start	Start the generation of test traffic.
txgen stop	Stop the generation of test traffic.
txgen results	Results of generating test traffic.
Loopback	
show loopback layer	The loopback layer.
Network parameters	
show network dhcp	Display whether the DHCP feature is enabled or disabled for port Test.
show network ip	The IP address of port Test.
show network subnet	The subnet mask for port Test.
show network gateway	The gateway's IP address for port Test.
show network dns	The IP address of the network node where the DNS database resides for port Test.
show lan dhcp	Display whether the DHCP feature is enabled or disabled for the LAN port.
show lan ip	The IP address of the LAN port.
show lan subnet	The subnet mask for the LAN port.
show lan gateway	The gateway's IP address for the LAN port.
show ifce mac	The connection status.
Interface parameters. Port Test	
show link	The MAC address of port Test.
show ifce vlan count	The number of VLAN tags.
show ifce vlan [1-3] id	The VLAN identifier value.
show ifce vlan [1-3] priority	The traffic priority value.
show ifce mpls tx lsr	The IP address of the label-switching router's interface.

Command	Information to be output to the console
show ifce mpls tx rule	Display whether the rule for sending packets to the subnet is enabled or disabled.
show ifce mpls tx subnet	The subnet IP address.
show ifce mpls tx mask	The subnet mask.
show ifce mpls tx stack count	The number of labels to be added to the packet to be transmitted.
show ifce mpls tx stack [1-3] label	The label value.
show ifce mpls tx stack [1-3] cos	The Class of Service of a labeled packet.
show ifce mpls tx stack [1-3] ttl	The time-to-live of a labeled packet.
show ifce mpls rx count	The number of labels in incoming packets.
show ifce mpls rx [1-3] label	The label value.
Interface parameters. LAN port	
show lan mac	The MAC address of the LAN port.
show lan vlan count	The number of VLAN tags.
show lan vlan [1-3] id	The VLAN identifier value.
show lan vlan [1-3] priority	The traffic priority value.
TCP/IP tests	
ping	Start the Ping test.
Saving/loading results	
results save N	Save measurement results and assign them serial number N (N = 1...10).
results load N	Load the saved measurement results which were assigned serial number N.
results show	Display the current measurement results.
results show N	Display the saved measurement results which were assigned serial number N.

Command	Information to be output to the console
results show all	Display all saved measurement results.
results info	Display information about saved measurement results.
Log	
log off/on	Disable/enable the event logging system.
log show	Display messages about occurred events.
Statistics	
statistics	Display statistical data.
General commands	
show version	SW version numbers.
exit	Exit the command mode.
reboot	Restart the device.
help	List available commands.
configure	Switch to the configuration mode.
username	Change the username.
password	Change the password.
show options	View available options.
show time	View the current time.
show date	View the current date.

Remote control commands (TELNET). Configuration mode

Command	Action
RFC 2544	
rfc2544 header src udp int	Set the source UDP port number.
rfc2544 header src mac XX:XX:XX:XX:XX:XX	Set the source MAC address.
rfc2544 header src ip i.i.i.i	Set the source IP address.
rfc2544 header dst udp int	Set the destination UDP port number.
rfc2544 header dst mac XX:XX:XX:XX:XX:XX	Set the destination MAC address.
rfc2544 header dst ip i.i.i.i	Set the destination IP address.
rfc2544 header vlan count off/1/2/3	Select the number of VLAN tags.
rfc2544 header vlan [1-3] id int	Set the VLAN identifier value.
rfc2544 header vlan [1-3] priority int	Set the traffic priority value.
rfc2544 header mpls count o/1/2/3	Select the number of labels.
rfc2544 header mpls [1-3] label long	Set the label value.
rfc2544 header mpls [1-3] cos int	Set the Class of Service of a packet.
rfc2544 header mpls [1-3] ttl int	Set the time-to-live of a labeled packet.
rfc2544 header autoarp off/on	Disable/enable the feature of submitting an ARP request automatically.
rfc2544 header diffserv prec+tos / dscp	Select the IP Precedence field and the Type of Service field or the DSCP field for inserting.
rfc2544 header dscp text	Set the value of the DSCP field, 8 bits.
rfc2544 header precedence int	Set the frame priority value.

Command	Action
rfc2544 header tos text	Set the Type of Service of a packet.
rfc2544 throughput duration int	Set the test duration for the throughput analysis.
rfc2544 throughput enabled no / yes	Disable/enable the throughput analysis.
rfc2544 throughput maxrate	Set the load rate for the throughput analysis.
rfc2544 throughput threshold int	Set the loss threshold value for the throughput analysis.
rfc2544 throughput resolution 10 / 1 / 0.1 / 0.01 / 0.001 / 0.0001	Set the resolution value for the throughput analysis.
rfc2544 frames [1-9] enable off / on	Disable/enable the use for an analysis of the respective frame size.
rfc2544 frames [1-9] size int	Set the frame size.
rfc2544 latency enabled no / yes	Disable/enable the propagation delay analysis.
rfc2544 latency count int	Set the number of test iterations for the propagation delay analysis.
rfc2544 latency duration int	Set the test duration for the propagation delay analysis.
rfc2544 latency rates src throughput / manually	Set the source of load values (throughput, manually).
rfc2544 latency rates [1-9]	Set the load values for each frame size in %
rfc2544 frameloss enabled no / yes	Disable/enable the frame loss rate analysis.
rfc2544 frameloss duration int	Set the test duration for the frame loss rate analysis.
rfc2544 frameloss steps int	Set the number of steps for the frame loss rate analysis.
rfc2544 frameloss rates start	Set the initial load for the frame loss rate analysis, specified in %.

Command	Action
rfc2544 frameloss rates stop	Set the final load for the frame loss rate analysis, specified in %.
rfc2544 back2back enabled no / yes	Disable/enable the limit load analysis.
rfc2544 back2back count int	Set the number of test iterations for the limit load analysis.
rfc2544 back2back duration int	Set the test duration for the limit load analysis
rfc2544 back2back rates src throughput / manually	Set the source of load values (throughput, manually).
rfc2544 back2back rates [1-9]	Set the load values for each frame size.
rfc2544 advanced wait int	Set the Interval parameter value.
rfc2544 advanced learn int	Set the Learning parameter value.
Complex traffic	
ctraf header mpls count o / 1 / 2 / 3	Select the number of labels.
ctraf header mpls [1-3] label long	Set the label value.
ctraf header mpls [1-3] cos int	Set the Class of Service of a packet.
ctraf header mpls [1-3] ttl int	Set the time-to-live of a labeled packet.
ctraf header autoarp off / on	Disable/enable the feature of submitting an ARP request automatically.
ctraf header diffserv prec+tos / dscp	Select the IP Precedence field and the Type of Service field or the DSCP field for inserting.
ctraf header dscp text	Set the value of the DSCP field, 8 bits.
ctraf nstreams int	Specify the number of data streams.
ctraf stream int	Specify the number of the stream to be adjusted.
ctraf duration int	Set the duration of generating the specified quantity of streams.

Command	Action
ctraf header src mac XX:XX:XX:XX:XX:XX	Set the source MAC address.
ctraf header src ip i.i.i.i	Set the source IP address.
ctraf header src udp int	Set the source UDP port number.
ctraf header dst mac XX:XX:XX:XX:XX:XX	Set the destination MAC address.
ctraf header dst ip i.i.i.i	Set the destination IP address.
ctraf header dst udp int	Set the destination UDP port number.
ctraf header vlan count off / 1 / 2 / 3	Select the number of VLAN tags.
ctraf header vlan [1-3] id int	Set the VLAN identifier value.
ctraf header vlan [1-3] priority int	Set the traffic priority value.
ctraf header precedence int	Set the frame priority value.
ctraf header tos text	Set the Type of Service of a packet.
ctraf rate int	Set the data rate value (in percentage terms by default).
ctraf rate int unit	Specify the data rate value, including the unit (Kbps, Mbps or %).
ctraf frame int	Specify the frame size.
	BERT
bert header mpls tx count off / 1 / 2 / 3	Select the number of labels to be transmitted.
bert header mpls tx [1-3] label long	Set the label value.
bert header mpls tx [1-3] cos int	Set the Class of Service of a packet.
bert header mpls tx [1-3] ttl int	Set the time-to-live of a labeled packet.
bert header autoarp off / on	Disable/enable the feature of submitting an ARP request automatically.

Command	Action
bert header diffserv prec+tos / dscp	Select the IP Precedence field and the Type of Service field or the DSCP field for inserting.
bert header dscp text	Set the value of the DSCP field, 8 bits.
bert header src mac XX:XX:XX:XX:XX:XX	Set the source MAC address.
bert header src ip i.i.i.i	Set the source IP address.
bert header src udp int	Set the source UDP port number.
bert header dst mac XX:XX:XX:XX:XX:XX	Set the destination MAC address.
bert header dst ip i.i.i.i	Set the destination IP address.
bert header dst udp int	Set the destination UDP port number.
bert header vlan count off / 1 / 2 / 3	The number of VLAN tags.
bert header vlan [1-3] id int	Set the VLAN identifier value.
bert header vlan [1-3] priority int	Set the traffic priority value.
bert header precedence int	Set the frame priority value.
bert header tos text	Set the Type of Service of a packet.
bert frame random min int	Set the minimum frame size value for the uniform distribution law.
bert frame random max int	Set the maximum frame size value for the uniform distribution law.
bert frame constant int	Set the frame sizes to be used for testing.
bert frame type constant / random	Select the frame size variation law.
bert level 1 / 2 / 3 / 4	Select the OSI layer on which the test is to be conducted.
bert pattern user / crtp / 2e11-1 / 2e15-1 / 2e20-1 / 2e23-1 / 2e29-1 / 2e31-1	Select a standard test sequence or a user-de fined test sequence.
bert user-pattern hex	Specify the user-defined sequence.

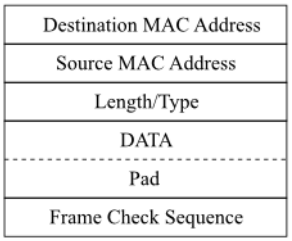
Command	Action
bert rate	Specify the required load.
bert duration hh.mm.ss	Set the measurement duration.
Packet jitter	
jitter txgen off / on	Disable/enable the test traffic generator.
jitter threshold int	Set the threshold jitter value.
jitter duration hh.mm.ss	Set the jitter measurement duration.
Test traffic	
txgen header mpls count off / 1 / 2 / 3	Select the number of labels.
txgen header mpls [1-3] label long	Set the label value.
txgen header mpls [1-3] cos int	Set the Class of Service of a packet.
txgen header mpls [1-3] ttl int	Set the time-to-live of a labeled packet.
txgen header autoarp off / on	Disable/enable the feature of submitting an ARP request automatically.
txgen header diffserv prec+tos / dscp	Select the IP Precedence field and the Type of Service field or the DSCP field for inserting.
txgen header dscp text	Set the value of the DSCP field, 8 bits.
txgen header src mac XX:XX:XX:XX:XX:XX	Set the source MAC address.
txgen header src ip i.i.i.i	Set the source IP address.
txgen header src udp int	Set the source UDP port number.
txgen header dst mac XX:XX:XX:XX:XX:XX	Set the destination MAC address.
txgen header dst ip i.i.i.i	Set the destination IP address.
txgen header dst udp int	Set the destination UDP port number.
txgen header vlan count off / 1 / 2 / 3	Set the number of VLAN tags.
txgen header vlan [1-3] id int	Set the VLAN identifier value.

Command	Action
txgen header vlan [1-3] priority int	Set the traffic priority value.
txgen header precedence int	Set the frame priority value.
txgen header tos text	Set the Type of Service of a packet.
txgen port a / b	Select the port on which test traffic is to be generated.
txgen frame random min int	Set the minimum frame size value for the uniform distribution law.
txgen frame random max int	Set the maximum frame size value for the uniform distribution law.
txgen frame constant int	Set the frame sizes to be used for testing.
txgen frame type constant / random	Select the frame size variation law.
txgen duration hh.mm.ss	Set the measurement duration.
txgen rate	Specify the required load.
Loopback ***Note:*** *Commands from the Loopback section take effect only after executing the command "settings apply" or restarting the device using the command "reboot".*	
loopback layer off / 1 / 2 / 3 / 4	Select the layer on which test traffic should be redirected.
Network parameters *Commands from the Network parameters and Interface parameters sections take effect only after executing the command "settings apply" or restarting the device using the command "reboot".*	
network dhcp off / on	Disable/enable the DHCP feature for port Test.
network ip i.i.i.i	Set the IP address of port Test.
network subnet i.i.i.i	Set the subnet mask for port Test.
network gateway i.i.i.i	Set the gateway's IP address for port Test.

Command	Action
network dns i.i.i.i	Set the IP address of the network node where the DNS database resides for port Test.
lan dhcp off / on	Disable/enable the DHCP feature for the LAN port.
lan ip i.i.i.i	Set the IP address of the LAN port.
lan subnet i.i.i.i	Set the subnet mask for the LAN port.
lan gateway i.i.i.i	Set the gateway's IP address for the LAN port.
Interface parameters. Port Test	
ifce vlan count off / 1 / 2 / 3	Set the number of VLAN tags.
ifce vlan [1-3] id int	Set the VLAN identifier value.
ifce vlan [1-3] priority int	Set the traffic priority value.
ifce mpls tx lsr i.i.i.i	Set the IP address of the label-switching router's interface.
ifce mpls tx rule off / on	Disable/enable the rule for sending packets to the subnet.
ifce mpls tx subnet i.i.i.i	Set the subnet IP address.
ifce mpls tx mask i.i.i.i	Set the subnet mask.
ifce mpls tx stack count off / 1 / 2 / 3	Set the number of labels to be added to the packet to be transmitted.
ifce mpls tx stack [1-3] label long	Set the label value.
ifce mpls tx stack [1-3] cos int	Set the Class of Service of a labeled packet.
ifce mpls tx stack [1-3] ttl int	The time-to-live of a labeled packet.
ifce mpls rx count off / 1 / 2 / 3	Set the number of labels in incoming packets.
ifce mpls rx [1-3] label long	Set the label value.
Interface parameters. LAN port	
lan mac XX:XX:XX:XX:XX:XX	Set the MAC address of the LAN port.

Command	Action
lan vlan count off / 1 / 2 / 3	Set the number of VLAN tags.
lan vlan [1-3] id int	Set the value of the 12-bit VLAN identifier.
lan vlan [1-3] priority int	Set the traffic priority value.
Profiles	
profile rename [n] [name]	Set the profile name.
profile save [n]	Save the current settings to cell n.
profile lock [n]	Enable write protection for cell n.
profile unlock [n]	Disable write protection for cell n.
profile load [n]	Load the settings profile from cell n.
profile delete [n]	Remove the settings profile from cell n.
profile list	Display a list of saved profiles in the following format: “index, name, data, status”, where index is the number of the cell where the profile is stored, name is the profile name, data is the date of saving, and status is the cell's status (write-protected or not).
profile show [n]	Display the content of profile n.
General commands	
exit	Exit the configuration mode.
help	List available commands.
time HH:MM:SS	Set the time.
date DD-MM-YYYY	Set the date.

D Ethernet Frame Structure



Destination MAC Address — A destination MAC address. A 6-byte field that contains an IP address of the network node to which the frame is addressed.

Source MAC Address — A source MAC address. A 6-byte field that contains an address of the frame sender.

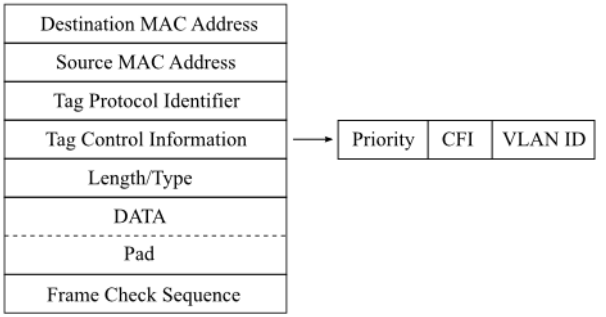
Length/Type — Length/Type. This field contains a 16-bit integer and can take on one of two values:

- If the number specified in this field is less than or equal to 1500, then the field will take on the Length value and it will define a data field's length.
- If the number specified in this field is greater than or equal to 1536, then the field will take on the Type value and it will indicate the type of the protocol being used.

Data — A data field that may contain from 46 or 42 (if the frame contains a VLAN tag) to 1500 bytes.

Pad — A padding field. If a data field's length is less than 46 bytes, then the frame will be padded with a padding field to the minimum possible value (64 bytes).

Frame Check Sequence — a checksum. A 4-byte field that contains a checksum.



Tag Protocol Identifier — the "Protocol Identifier**"** tag. 16 bits that determine whether a frame belongs to 802.1Q standard [9].

Tag Control Information — Information for tag management.

TCI contains three fields.

- **Priority —** User (VLAN) Priority. Three bits which carry information about a frame's priority (eight frame priority values are supported).
- **CFI —** Canonical Format Indicator. A one-bit flag that is always equal to zero for Ethernet frames.
- **VLAN ID —** VLAN Identifier (VID). A 12-bit VLAN identifier that is defined in 802.1Q standard [9]. It uniquely identifies the VLAN a frame belongs to.

E Glossary

Port

A physical interface with the medium being tested.

10Base-T

The standard for data transmission at the rate of 10 Mbps over the Ethernet network using a twisted pair cable.

100BASE-T (100BASE-TX)

The standard for data transmission at the rate of 100 Mbps over the Ethernet network using a twisted pair cable.

10GBASE-T

The standard for data transmission at the rate of 10 Gbps over the Gigabit Ethernet network using a <<twisted pair>> cable.

Back-to-back

A test that determines the time it takes the device to process the limit load.

AF

Assured Forwarding. It is used for delivering traffic of the most TCP applications using four independent AF classes. Within each class an IP packet can be assigned one of three data packet discard priorities.

ARP

Address Resolution Protocol. A network protocol that is used for the resolution of IP addresses (network layer addresses) into MAC addresses (data link layer addresses) in the TCP/IP networks.

DHCP

Dynamic Host Configuration Protocol. A protocol that a network node uses for obtaining an IP address and other parameters required for the operation in the TCP/IP networks automatically.

DNS

Domain Name System. A distributed system (a database) that is used for translating a network device name into an IP address. DNS operates in the TCP/IP networks.

DSCP

Differentiated Services Code Point. A field in the IP packet header that consists of 8 bits. It allows classifying more traffic types than the Precedence and ToS fields.

DUT

Device Under Test. The device being tested.

ECN

Explicit Congestion Notification. Setting bits in this field allows routers to detect the congestion on the data transmission path to the specified network node without discarding a packet.

EF

Expedited Forwarding. It is used for processing the deference-sensitive traffic that requires the minimum jitter, such as video or voice (VoIP; Voice over IP).

Ethernet

Local networking technology. It is defined in the IEEE standards, group 802.3.

Frame loss rate

A test that determines the percentage of frames that a network element has failed to transmit in case of steady load due to the shortage of hardware resources.

FTP

File Transfer Protocol. A protocol that supports le transmission in computer networks.

Gateway

A network device that allows connecting two or more different-type network systems and transforms the data streams being transmitted between them.

ICMP

Internet Control Message Protocol. A network protocol that is a part of the TCP/IP protocol stack. It is mainly used for the transmission of error messages and messages about other exceptions that occur during data communication.

IEEE 802.1Q

A standard that defines changes in the Ethernet frame structure which allow transmitting VLAN information over the network.

IP

Internet Protocol. One of main protocols of the TCP/IP protocol family that enables the non-guaranteed packet delivery which doesn't require establishing a connection to the recipient.

IP address

Internet Protocol address. A unique identifier (address) of the device connected to the unified network based on the TCP/IP protocol family. It is represented in the form of a 32-bit binary number.

Jabber frame

A data packet that exceeds 1518 bytes in size and has an invalid checksum.

LAN

Local Area Network. A network that covers a relatively small territory (for example, Ethernet). It features a high data rate (from 10 Mbps to several Gbps) and a low error rate.

MAC address

Media Access Control address. A unique identifier that is used for addressing network devices on the physical layer. A 48-bit MAC address is used in Ethernet.

MPLS

Multi-Protocol Label Switching. An IP datagram transfer technology that is used in high-speed switching devices.

NUT

Network Under Test. The network being tested.

OAM

Operations, Administration, and Maintenance. A link state monitoring protocol.

OSI

Open Systems Interconnection Reference Model. The seven-layer hierarchical model for network communications and network protocol interaction that was developed by the International Organization for Standardization (ISO). The model's layers are placed vertically above each other. Each layer interacts with the neighboring ones and implements certain functions.

RJ

Registered Jack. A standardized physical interface that is used for interconnecting telecommunications equipment.

RJ-45

A connector that complies with the Registered Jack standard and is used for connecting twisted pairs in Ethernet networks.

Runt frame

A data packet that doesn't exceed 64 bytes with a correct frame-check sequence.

SLA

Service Level Agreement. The main document that regulates mutual relations between a service provider and a customer.

TCP

Transmission Control Protocol. A standard transport layer protocol that belongs to the TCP/IP protocol family and enables the reliable duplex streaming.

Throughput

A test that determines the maximum data rate at which the quantity of test frames that have been transferred via DUT is equal to the quantity of frames that have been sent to it from the test equipment.

ToS

Type of Service. A set of four-bit flags in the IP packet header. They enable an application that sends data to notify the network of the required type of network service.

Traceroute

An ICMP-based program that is used for determining data routes in TCP/IP networks.

UDP

User Datagram Protocol. It is a transport protocol that supports data transmission in IP networks and ensures reliable message delivery without establishing a connection to the recipient.

VLAN

Virtual Local Area Network. It is a group of network devices which function as if they were connected to the same network segment.

VLAN ID

VLAN Identifier (VID). A 12-bit VLAN identifier that is defined in 802.1Q [9]. It uniquely identifies the VLAN a frame belongs to.

VLAN Priority

Three bits which carry information about a frame's priority. There are eight possible priority values.

Data link layer

It enables the interaction between networks on the physical layer and the monitoring of errors that may occur. The data link layer can interact with one or several physical layers, control them and manage this interaction.

Learning frame

A frame that has the source MAC address identical with the destination MAC address. When a switch receives this frame, it filters it as the output interface is identical with the input one. At the same time, the switch reads the source MAC address and stores the interface from which it was received.

Network switch

A device that is used for interconnecting several nodes in a computer network. It transmits data directly to the recipient. The switch operates on the data link layer of the OSI model.

Network hub

A device that is used for joining several nodes in a computer network. All the devices connected to the hub ports receive the same information.

Network layer

It enables determining a data transmission route. It is responsible for translating logic addresses and names into physical ones, determining the shortest routes, switching and routing, tracing faults in the network.

Transport layer

It ensures the reliable packet transport between two network end points. Despite the fact that lower layer protocols check whether each data transmission operation is being executed correctly, this layer ensures that the data being transmitted are additionally checked for correctness.

Physical layer

Its peculiar task is to transmit data stream. It transmits electric and optic signals to the cable, receives them and converts them into data bits according to the digital signal coding methods.

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NOTICE
通告

CHINESE REGULATION ON RESTRICTION OF HAZARDOUS SUBSTANCES
中国关于危害物质限制的规定

NAMES AND CONTENTS OF THE TOXIC OR HAZARDOUS SUBSTANCES OR ELEMENTS CONTAINED IN THIS EXFO PRODUCT

包含在本 **EXFO** 产品中的有毒有害物质或元素的名称和含量

O	Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006 表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T11363-2006 标准规定的限量要求以下。
X	Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T11363-2006 标准规定的限量要求。

Part Name 部件名称	Toxic or hazardous Substances and Elements 有毒有害物质和元素					
	Lead 铅 (Pb)	Mercury 汞 (Hg)	Cadmium 隔 (Cd)	Hexavalent Chromium 六价铬 (Cr VI)	Polybrominated biphenyls 多溴联苯 (PBB)	Polybrominated diphenyl ethers 多溴二苯醚 (PBDE)
Enclosure 外壳	O	O	O	O	O	O
Electronic and electrical sub-assembly 电子和电子组件	X	O	X	O	X	X
Optical sub-assembly[a] 光学组件 [a]	X	O	O	O	O	O
Mechanical sub-assembly[a] 机械组件 [a]	O	O	O	O	O	O

a. If applicable.
如果适用。

MARKING REQUIREMENTS
标注要求

Product 产品	Environmental protection use period (years) 环境保护使用期限 (年)	Logo 标志
This Exfo product 本 EXFO 产品	10	
Battery[a] 电池 [a]	5	

a. If applicable.
如果适用。

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