USER MANUAL

40/100G Test Module

for the VePAL UX400

Please direct all questions to your local VeEX Sales Office, Representative, or Distributor. Or, contact VeEX technical support at www.veexinc.com.

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1.0 About This User Manual

The purpose of this manual is to help users successfully use the features of VePAL UX400 test platform.

This manual is intended for novice, intermediate, and experienced users. It is assumed that users have basic computer experience and skills, and are familiar with basic telecommunication concepts, terminology, and safety. For more technical resources, visit VeEX Inc. website at www.veexinc.com.

Every effort was made to ensure that the information contained in this manual is accurate. However, information is subject to change without notice. We accept no responsibility for any errors or omissions. In case of discrepancy, the web version takes precedence over any printed literature.

This device uses software either developed by VeEX Inc or licensed by VeEX Inc from third parties. The software is confidential and proprietary of VeEX Inc. The software is protected by copyright and contains trade secrets of VeEX Inc or VeEX's licensors. The purchaser of this device agrees that it has received a license solely to use the software as embedded in the device, and the purchaser is prohibited from copying, reverse engineering, decompiling, or disassembling the software.

If any assistance is needed or there are any questions related to the use of this product, call or e-mail our Customer Care department for customer support. Before contacting our Customer Care department, have the serial number ready. Please refer to the Basic Operations section of this manual for details on locating the unit serial number.

Customer Care:

Phone: +1 510 651 0500

E-mail: customercare@veexinc.com

Website: www.veexinc.com

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2.0 Introduction to 40G/100G Modules

40G and 100G test interfaces are available on the UX400 40G/100G, TX300s-100G, and RXT6000/e/+ test sets. Testing on each platform share a common user interface and similar feature set to ease the transitioning from one product or platform to another.

40G/100G Features

Refer to the latest specification sheet for a breakdown of available test modes for each platform and module. Available test modes vary depending on the test platform and module, but may include the following:

General

- CFP, CFP2, CFP4, QSFP28, QSFP+ ports compliant to MSA standards

OTN

- OTN testing for OTU3 and OTU4
- Complete multi-step Mapping/Multiplexing with Ethernet, SDH, SONET, PDH, DSn payloads
- Ethernet over OTN, ODU0 and ODUflex
- Service Disruption measurements
- Tandem Connection Monitoring
- Overhead monitoring and capture byte decoding
- Payload and Line through monitor modes
- Per-lane optical power and frequency measurements

Ethernet

- 100G and 40G Ethernet testing
- Optical Lane BERT and CAUI/XLAUI Lane BERT
- PCS Layer Testing with Skew generation/monitoring
- Service Disruption Measurements
- RFC2544 testing
- Multi-stream testing up to 32 independent streams
- IPv4 and IPv6 traffic generation
- Q-in-Q (VLAN stacking) and multiple MPLS tag support
- BER testing at Layer 2 and Layer 3
- Smart Loop mode for Layer 2 and Layer 3
- Coupled operation (two modules)
- 1-way latency measurement
- Line rate packet capture with Wireshark™ decode

SDH/SONET

- STM-256, OC-768, STL256.4 with bulk, PDH and DSn payloads
- Line Rate or as OTU3 payload

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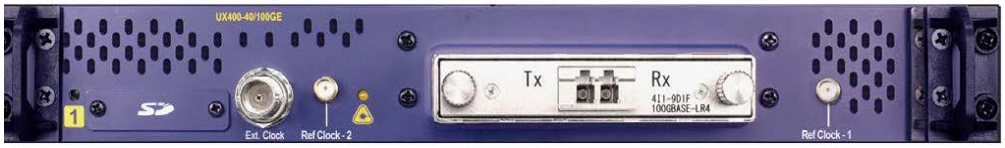
2.1 Connector Panels and Test Ports

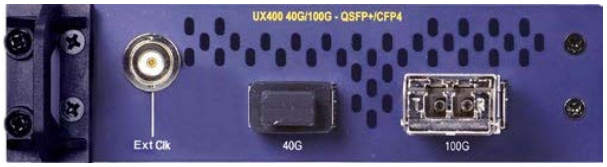
Left to right: CFP, CFP2, CFP4, QSFP28 pluggable optical modules

Pluggable optical module versions for each test platform are listed below:

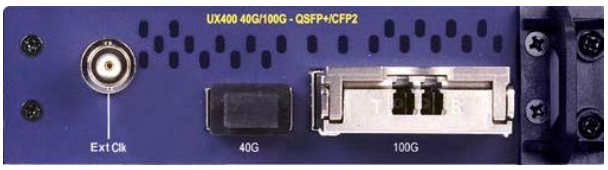
UX400-100G



UX400-100G CFP connector panel



UX400-100G QSFP+ and CFP4 connector panel



UX400-100G QSFP+ and CFP2 connector panel

- UX400-100G: CFP
- UX400-100G: CFP2 (CFP4*), QSFP+
- UX400-100G: CFP4, QSFP+
- UX400-100G: QSFP28, QSFP+

TX300s-100G

- TX300s-100G: CFP4, QSFP+
- TX300s-100G: QSFP28, QSFP+

RXT-6000

- RXT-6000 100G: CFP2, QSFP+, SFP+, RJ45
- RXT-6000+ 100G: CFP2 (CFP4*), QSFP28, QSFP+, SFP+, RJ45
- RXT-6000e 100G: CFP2 (CFP4*), QSFP28/QSFP+, 2x SFP28, 2x RJ45 (optional PDH/DSn)
- RXT-6200 100G: CFP4, 2x QSFP28/QSFP+, 2x SFP28, 2x RJ45 (optional PDH/DSn)

** Using CFP2-to-CFP4 or CFP2-to-QSFP28 adapter*

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3.0 Safety Information

Safety precautions should be observed during all phases of operation of this instrument. The instrument has been designed to ensure safe operation however please observe all safety markings and instructions. Do not operate the instrument in the presence of flammable gases or fumes or any other combustible environment. VeEX Inc. assumes no liability for the customer's failure to comply with safety precautions and requirements.

Optical Connectors

The test sets display a laser warning icon when the laser source is active to alert the user about a potentially dangerous situation. It is recommended to:

1. Deactivate the laser before connecting or disconnecting optical cables or patchcords.
2. Never look directly into an optical patchcord or an optical connector interface (SFP+) while the laser is enabled. Even though optical transceivers are typically fitted with Class 1 lasers, which are considered eye safe, optical radiation for an extended period can cause irreparable damage to the eyes.
3. Never use a fiber microscope to check the optical connectors when the laser source is active.

Safe Module Handling

While replacing test modules, all work on the open panel must be performed only by suitably qualified personnel who is familiar with the dangers both to people and to the instrument itself.

- Modules are not hot swappable. The platform must be turned off and unplugged from VAC mains when removing or inserting test modules.
- For safety and EMC (Electromagnetic Compatibility), empty module slots must be properly covered with blank panel covers.
- Prevent foreign objects from entering the unit, before, during and after module exchange or re-configuration process. They could create short circuits or damage internal fans.
- Always store test modules by themselves in individual ESD protected packaging (with no loose elements, like screws or tools).

Lithium-ion Battery Precautions

Lithium-ion (Li-ion) battery packs are compact and offer high capacity and autonomy, which make them ideal for demanding applications, like providing long lasting power to portable test equipment. For safety reasons, due to their high energy concentration, these batteries packs and products containing them must be used, charged, handled, and stored properly, according to the manufacturer’s recommendations.

Li-ion battery packs contain individual Li-ion cells as well as battery monitoring and protection circuitry, sealed in its plastic container that shall not be disassembled or serviced.

The test set unit's battery pack is also fitted with a safety connector to prevent accidental short circuits and reverse polarity.

- Always charge the unit's battery pack inside the test platform battery bay using the AC/DC adapter supplied by VeEX.
- Do not charge or use the battery pack if any mechanical damage is suspected (shock, impact, puncture, crack, etc).
- Do not continue charging the battery if it does not recharge within the expected charging time
- Storage: For long term storage, the battery pack should be stored at 20°C/68°F (room temperature), charged to about 30 to 50% of its capacity. Spare battery packs should be charged and used at least once a year to prevent over-discharge (rotate them regularly).
- It is recommended to charge and use battery packs at least every three months. Battery packs shall not go without recharging (reconditioning) for more than six months.

After extended storage, battery packs may reach a deep discharge state or enter into sleep mode. For safety reasons, Li-ion batteries in deep discharge state may limit the initial charging current (pre-recharge) before starting their regular fast charging cycle. The pre-charging state may take several hours.

- Air transportation of Li-ion batteries is regulated by United Nations' International Air Transportation Association (IATA) Dangerous Goods Regulations and by country-specific regulations. Please check local regulations and with common carriers before shipping Li-ion battery packs or products containing relatively large Li-ion battery packs.

Electrical Connectors

Telephone lines may carry dangerous voltages. Always connect the electrical test ports to known test interfaces which carry low level signals.

ESD: Electrostatic Discharge Sensitive Equipment

Test modules could be affected by electrostatic discharge. To minimize the risk of damage when replacing or handling test modules, make sure to follow proper ESD procedures and dissipate any electrostatic charge from your body and tools and the use proper grounding gear.

- Perform all work at a workplace that is protected against electrostatic build-up and discharging.
- Never touch any exposed contacts, printed circuit boards or electronic components.
- Always store test modules in ESD protected packaging.
- Wear ESD protection and grounding gear when:
    - Inserting, extracting, or handling test modules.
    - Inserting or removing SFPs, XFPs, QSFPs, or CFPs from the platform.
    - Connecting or disconnecting cables from modules or platform.

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4.0 Basic Operations

Refer to the TX300S, UX400, and RXT-1200, platform manuals for information about Basic Operations, Home menu, Launching Test Applications etc.

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5.0 Utilities

Refer to the TX300S, UX400, and RXT-1200, platform manuals for information about all Utilities and Tools available.

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6.0 100G Ethernet Test Application

Refer to the RXT-1200, TX300, or UX400 platform manuals for information on launching test applications and assigning test modules (UX400 only).

When the dual port interfaces and software options are enabled, the test module can operate a combination of two ports at the same time.

Port selection buttons are available on the left side panel below the History tab.

Note: *The configuration parameters (header, bandwidth, etc. for each application (on each of the ports) are completely independent from one another. All test feature combinations are allowed and completely independent (Loopback, BERT, Throughput, RFC2544, VSAM) in dual port operation. However, some advanced tools, such as IPTV, VLAN scan, Packet Capture, etc. are available in single port testing mode only. The user interface will provide an error message when a feature is not available in dual port operation.*

When first starting the test application, the soft LEDs might be red. Soft LEDs that are steady green indicate that the module is ready to perform different tests. This may require turning the **LASER On** button for optical interfaces or tapping the **History** tab to clear blinking LED reminders of past Errors and Alarms (test results are not affected).

Note: *Available test configurations will vary based on the test platform and installed module.*

Ethernet Home Menu

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6.1 Setup

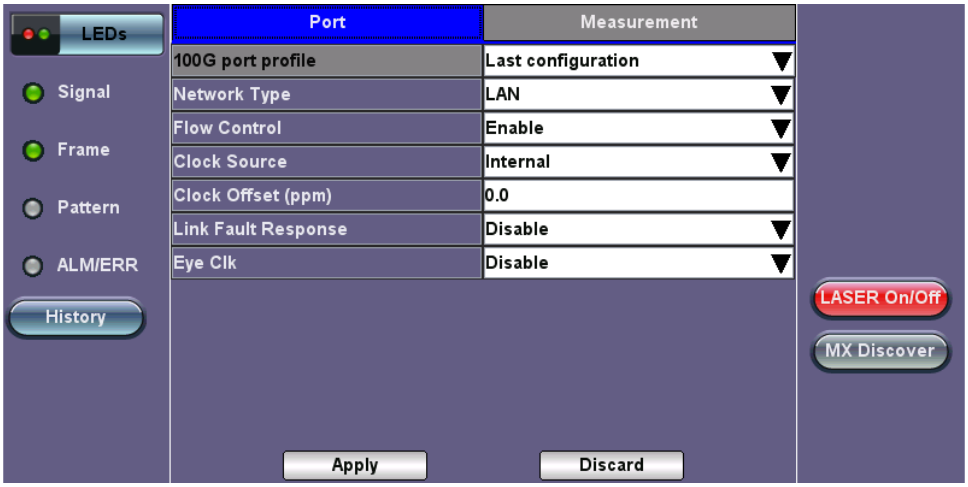
6.1.1 Port Setup

Port setup configuration is accessed from the **Setup** menu located on the Ethernet home menu. The available configuration settings depend on the interface selected in the Test Mode selection.

Select the operation mode and the interfaces that will be used to carry out tests. Once the operating mode and interfaces are selected, independently configure the auto-negotiation, speed, duplex, and flow control settings for each port (where applicable).

After configuring settings, tap **Apply** to save changes. Tap **Discard** to revert to previous selections.

UX400 100G Ethernet Test App Setup



40G and 100G Port, RXT-6000:

- **100G port profile**: Lock, Delete, Save, Save as..., Default, Last configuration
- **Network Type**: LAN
- **Flow Control**: Enable/Disable
- **Clock Source**: Internal, External (various rates), RxCLK, GPS 1 PPS, Atomic 1PPS
- **Clock Offset (ppm)**: Can be configured; range is +/- 150ppm
- **Link Fault Response:** Disable or Enable (also enables Local link and failure, remote, failure)
- **Eye Clk** (100G only)

Status

The **Status** tab lists current port settings. Please note that the Status tab is only available if a fiber port option is selected from the **Test Port Selection** menu.

Note: *Test units shipped before January 2012 support up to +/- 50 ppm offset only. Units shipped from 2012 onwards, support up to +/- 150 ppm offset. This applies to both 10GE WAN and 10GE LAN modes.*

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6.1.2 Measurement Setup

The measurement and event log settings are configured on this screen.

- **Profile**: Delete, Save, Save as..., Default.
- **Mode**: Manual, Timed
  - Manual mode: Starts and stops the measurements manually.
  - Timed mode: Defines the duration of the test; after the test is started, the test will run for the configured duration and stop automatically.
- **TX Start**: Separated and Coupled. Configure how the measurements are started when in BERT and Multiple Streams test modes.
  - Separated: Independent control (Start/Stop) of the transmitter is enabled. At the start of the test only the receiver is turned on -- the user must start the transmitter manually.
  - Coupled: Transmitter and receiver are turned on at the same time, and the Tx and Rx measurements start at the same time at the start of the test.
- **Clock (ToD) Synchronization Device:** Disable, GPS, 1PPS, Local, Atomic 1PPS. Select the device to be used to synchronize the clock to perform the One Way Delay measurement.

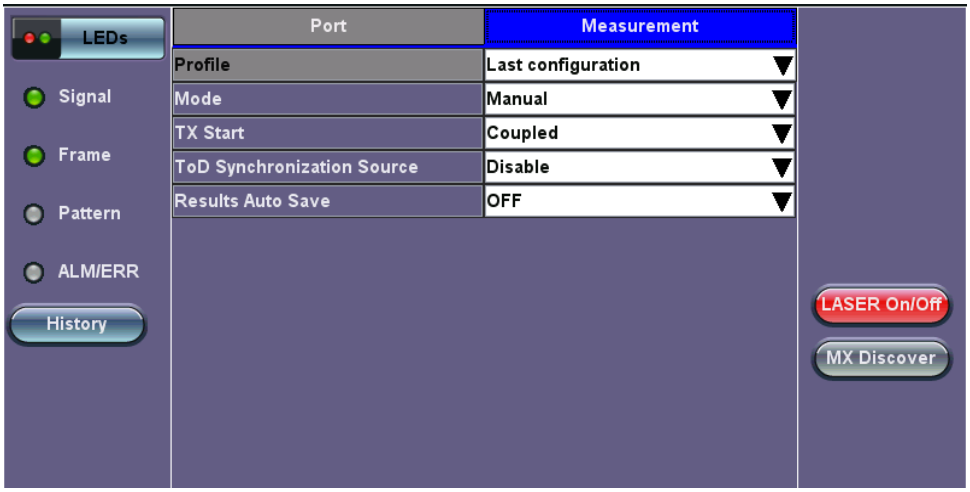
When a device is selected the following fields can be seen on the screen:

  - **External Clock Input:** 1pps (SMA Port). The SMA Port must be used for the 1pps signal.
  - **UTC ToD:** Displays the Coordinated Universal Time (UTC) Time of Day once it is acquired.
  - **Clock Sync Time:** Time field to configure the UTC ToD that both test sets, carrying out a one-way delay test between each other, will be synchronizing their internal time stamping at.
    Note: *Both test sets must be configured to the same Clock Sync Time.*

Note: *Clock Synchronization is not supported on all the test set models. Check with customer care for availability.*

- **Gratuitous ARP**: ON or OFF. If set to ON, a gratuitous ARP is performed. When the test port has an IP connection, an ARP request will be transmitted at regular intervals to keep the router/gateway ARP table aware of the test set's IP address. This setting is useful for long-term L3 routed testing.
- **Results Auto Save**: ON or OFF. If set to ON, results will be saved automatically

Measurement Setup



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6.1.3 MX Discover and Control

Before proceeding with MX Discover or Control, be sure to assign an IP address to each test port. To assign an IP address, proceed to the home menu and select the IP icon.

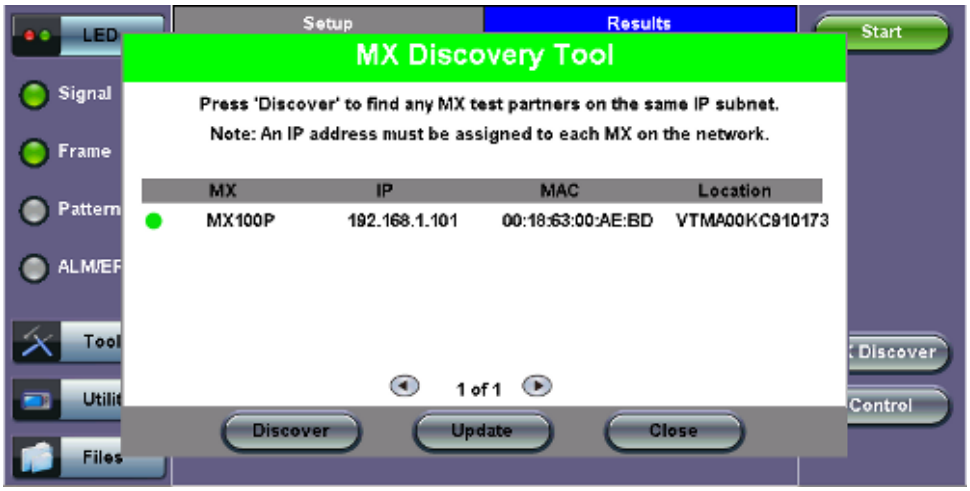
Note: *If using OAM Discover, it is unnecessary to assign an IP address to the local or remote unit.*

Using MX Discover

MX Discover enables the test set to discover other VeEX VePal test sets and devices with an assigned IP address on the same subnet. To discover other devices using **MX Discover**:

1. Tap on the **MX Discover** button and then press **Discover**.
2. A list of discovered devices on the same IP subnet will appear. Select a unit to connect to from the list of devices.
3. Tap on **Close** to exit the window.

MX Discovery Tool



Loop Control

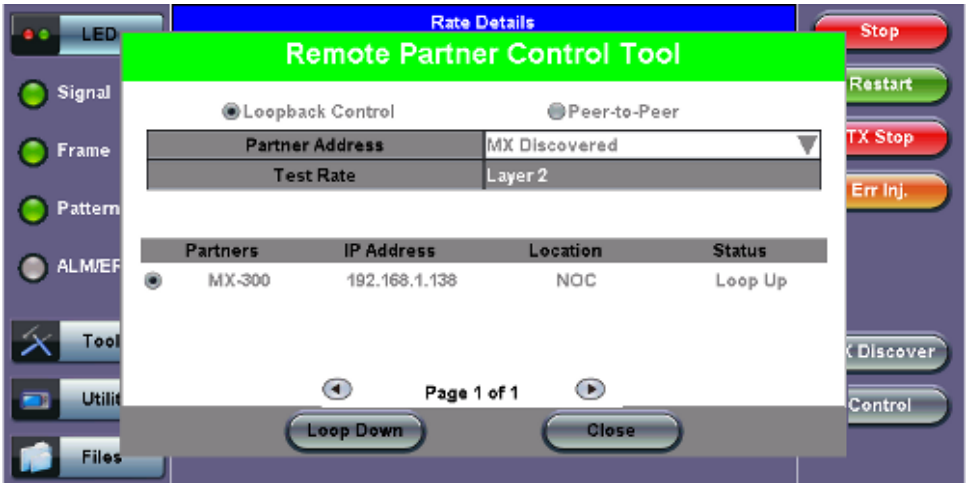
The **Loop Control** button becomes available on the right side menu when any Ethernet application (V-SAM, RFC 2544, Throughput, BERT) is selected. Press the **Loop Control** button to configure loop up and loop down commands necessary to control a far-end unit. The loop up command contains information about the test layer. Looping back test traffic is possible as follows:

- **Layer 1:** All incoming traffic is looped back unchanged
- **Layer 2:** All incoming unicast traffic is looped back with the MAC source and destination addresses swapped
- **Layers 3 & 4:** All incoming unicast traffic is looped back with MAC/IP source and destination addresses swapped

To configure loopback control on the unit, select from the following options under **Partner Address**:

- **MX Discovered:** Lists MX discovered devices. Select from the list of discovered devices to loop up/down
- **User Defined:** Input the destination IP address of the far-end device
- **OAM Discover**: Lists OAM discovered devices. Select from the list of discovered devices to loop up/down
- **X-Loop:** Loops non-VeEX networking equipment.
- **VL2-Loop**: Input the Mac address or VLAN ID and Pri of the far-end device

Remote Partner Control



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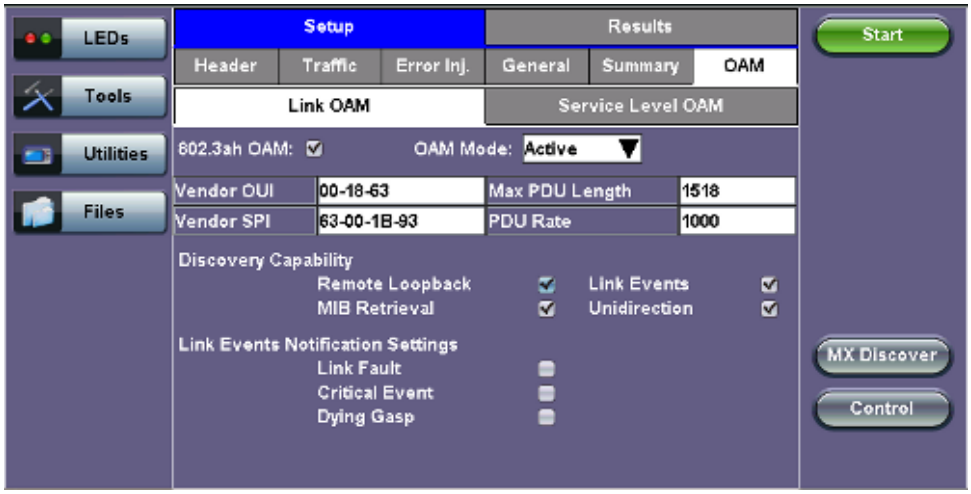
OAM Discover

Like MX Discover, OAM Discover can also be used to discover far-end test units without manually configuring the local or remote unit's destination address. If OAM is enabled on the test set, any link partner that supports the IEEE 802.3ah protocol will be discovered automatically and displayed under the **OAM Discover** tab. To access OAM Discover:

1. Go to **Throughput** > **OAM** > **Link OAM** and tap on the 802.3ah check box to activate Link OAM. Select Active from the **OAM Mode** drop-down menu (only Active mode can send loop commands).
2. Tap **OAM Loopback Loop Control** button and select the **OAM Discover** tab to see a list of discovered OAM devices. You can also see a list of OAM devices by tapping the **Loop Control** button and selecting **OAM Discover** tab. Select an OAM device and press **Loop Up** to send a loop up command to the selected remote unit.

For detailed descriptions of Discovery Capabilities, Link Events, and Notification Settings, refer to Ethernet OAM Testing.

Activating 802.3ah Link OAM



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6.1.4 ViPAG/V-Route Test

ViPAG/V-Route can be accessed from the Test Mode menu. Refer to the TX300S, UX400, or RXT-1200 platform manual for information on launching test applications from the Test Mode menu.

The following selections are available on the unit:

- **SILO/Router Wrap Test:** "On local unit" testing on a single unit

SILO/Router Wrap Test is the default selection for 40/100G test sets.

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ViPAG/V-Route Setup

Quick Test Setup Welcome Page

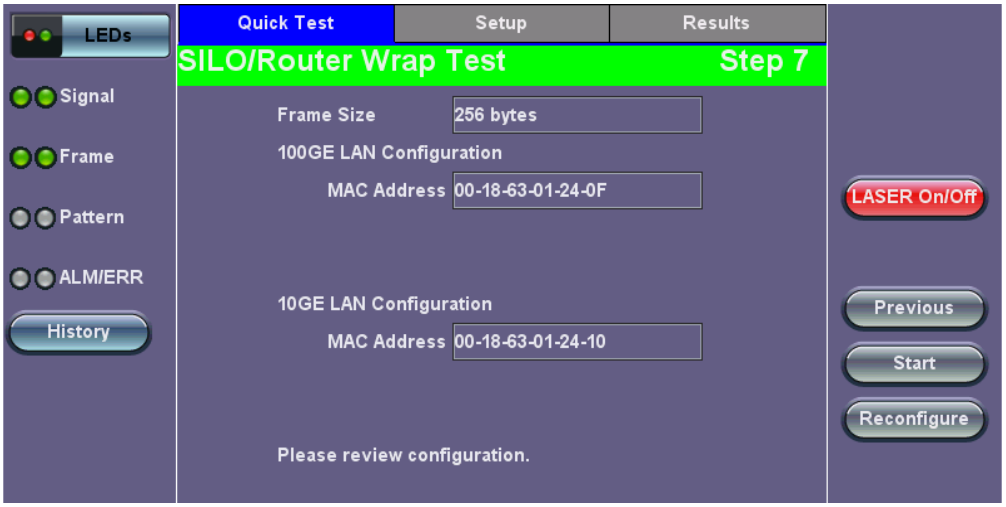
***Note**: Quick Test menu options may vary depending on the unit you are using.*

Quick Test Setup

Fill out each screen and press **NEXT** to proceed to the next page or **Previous** to go back to the previous screen.

- **Select the test type**: SILO/Router Wrap Test
- **Step 1:** Select the router test interface. "Local unit" denotes a router wrap test while "end-to-end" conducts an end-to-end test. For End-to-End testing, select whether this unit will be a ***Controller*** or ***Responder***. For **End to Loopback** testing, select whether this unit will be Generating Traffic or in Loopback Mode. The frame size for each option listed below is 256 bytes. 100G to 10G is the default test option.
- **Step 2 (SILO/Router Wrap only):** Layer 2 is selected by default.
- **Step 3:** Configure port settings for port 1. Refer to Port Setup for detailed instructions.
- **Step 4:** Configure port settings for port 2.
- **Step 5:** Enable up to 3 VLAN tags. Configure ID, Priority, Type, and Drop Eligible.
- **Step 6:** Enter the frame size. The default frame size for each option is 256 bytes.
- **Step 7:** Review the settings for both ports. Press **Start** to begin testing. Pressing **Reconfigure** will restart the Quick Test Setup and return the screen to Step 1.

SILO/Router Wrap Test Configuration Summary

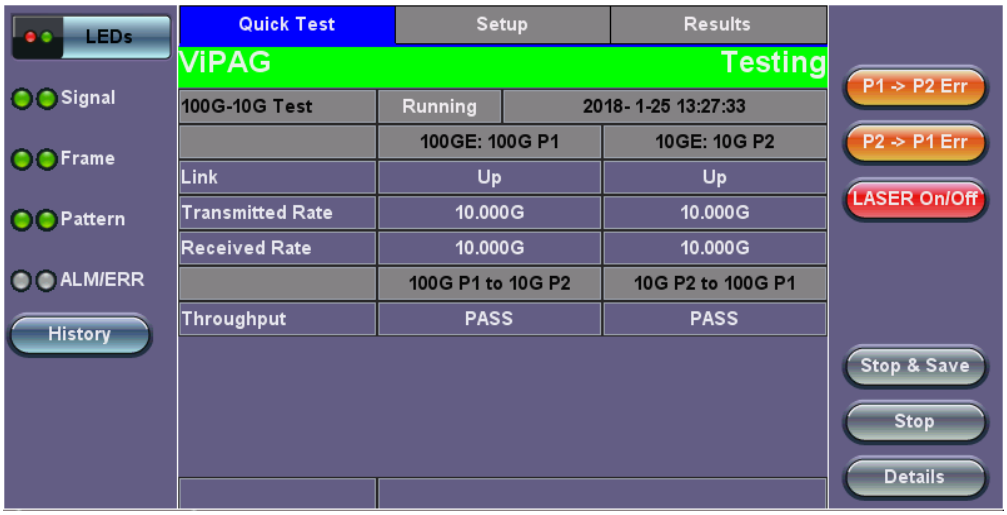


Quick Test View

After starting the test, the Error Injection button for each port (P1->P2 Error and P2->P1 Error) becomes available and the screen displays Quick Test view and the following results for both ports:

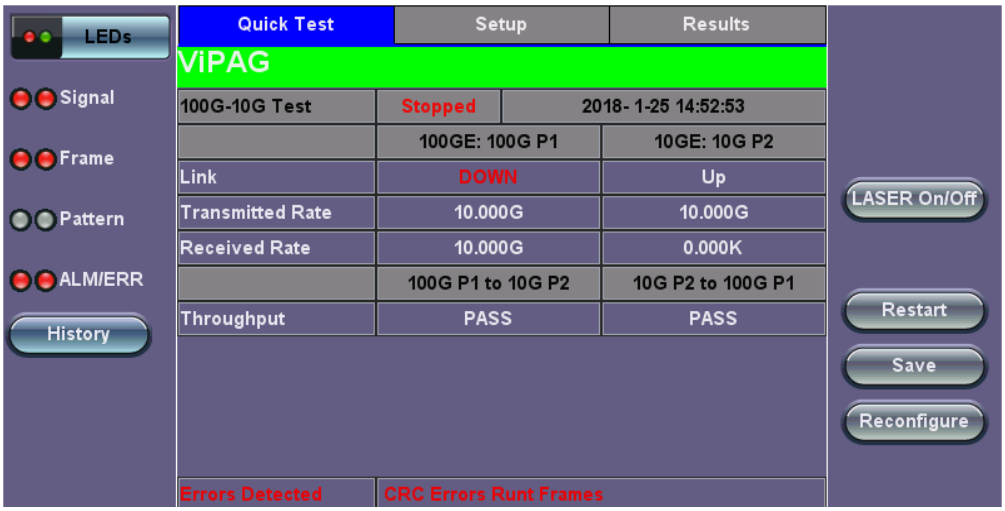
- Link Up/Down status
- Transmitted Rate
- Received Rate
- Throughput - Pass/Fail status

Quick Test Results Summary



Stop & Save stops the test and enables naming of saved test results. **Details** brings up the **Results** screen.
In case of link or IP related test failure, ViPAG will indicate the possible failure in red text and give instructions on what to check for.

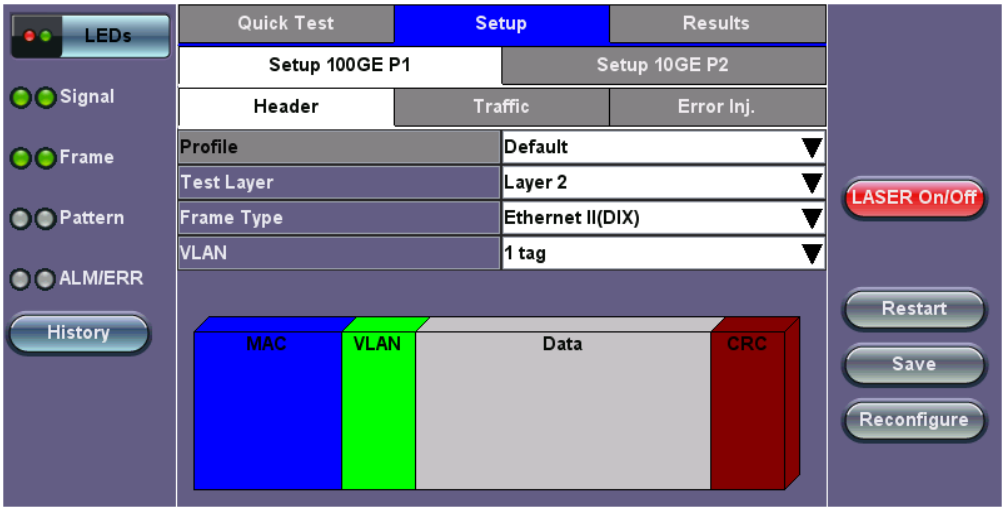
Test Failure



Setup

Test sets come preconfigured. To customize settings for both ports, go to the **Setup** tab. For configuration instructions, please refer to BERT.

Setup



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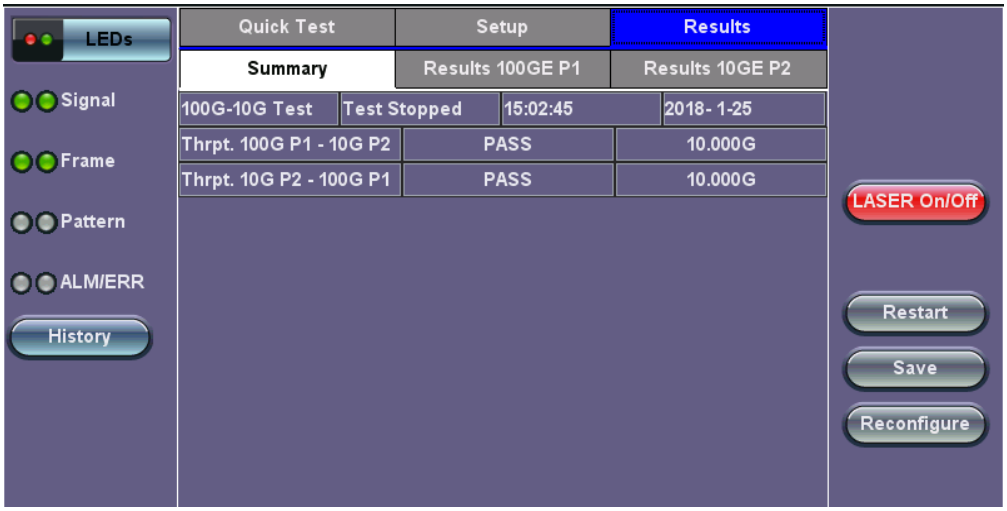
Results

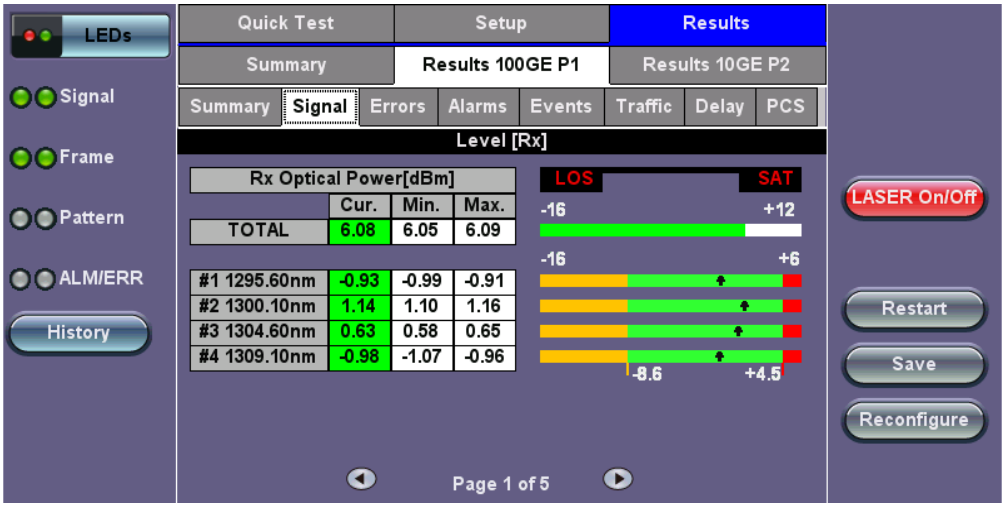
Results - Summary



The **Summary** tab lists the Pass/Fail status of the Throughput test for each port along with test measurements.

The **Results** tabs for each port lists statistical results similar to those featured in the BERT Results section. Please see BERT Results for more information.

Port Results - Signal



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6.2 IP

6.2.1 IP Connection

Port setup and IP connection are required prior to performing the following Ethernet applications: Ping, Trace Route, Web/FTP, ARP Wiz, VoIP, IPTV testing, and 688v2 (except Layer 2).

Tap on **IP** from the Ethernet home menu to access Port and IP settings.

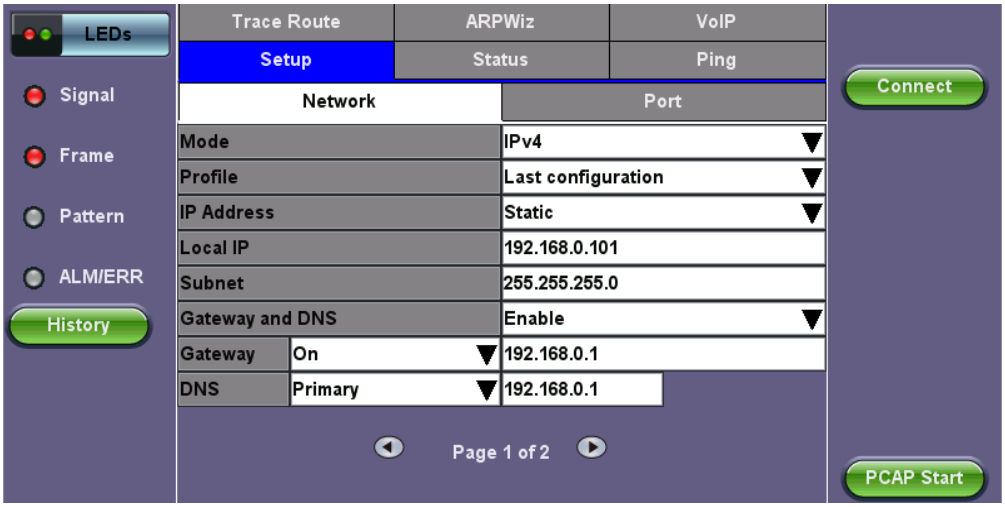
6.2.1.1 Setup

Select PPoE, IPv4, or IPv6 from the Mode menu.

Point-to-Point Protocol over Ethernet (PPoE)

- **Authentication:** PAP, CHAP, or CHAP & PAP.
- **VLAN:** Off or 1 Tag.
- **ID:** VLAN ID. Enter value 0 to 4095.
- **Pri:** VLAN priority 0 to 7.
- **DNS:** Selecting Manual DNS opens another menu. Select from Off, Primary, or Primary & Secondary. Enter the Primary and/or Secondary DNS if required.

IP Setup - IPv4



IPv4 or IPV6

- **IP Type:** IPv4 or IPv6
- **IP Address:** Static, DHCP (IPv4 only) or AUTO (IPv6 only)
- **Static:** The user is required to enter a Local IP, Gateway address, and Subnet. All Static fields can be filled by tapping on the section to access an alphanumeric keyboard
    - **Local IP:** IPv4/IPv6 address of the test set
    - **Gateway:** IPv4/IPv6 address of the network gateway
    - **CIDR** (IPv6 only)**:** The user can enter a Classless Inter -domain Routing Network
    - **Subnet** (IPv4 only)**:** The user can enter a subnet mask
- **DNS:** Off, Manual, or Auto. If Manual is selected, a DNS IP is required in order to use the URL as a destination. Enter the IP address of the Domain Name System (DNS) Server providing domain name translation to IP addresses.
- **VLAN:** Off, 1 Tag, 2 Tags. For each VLAN tag, enter the following:
    - **ID:** VLAN ID. Enter value 0 to 4095.
    - **Pri:** VLAN priority 0 to 7.

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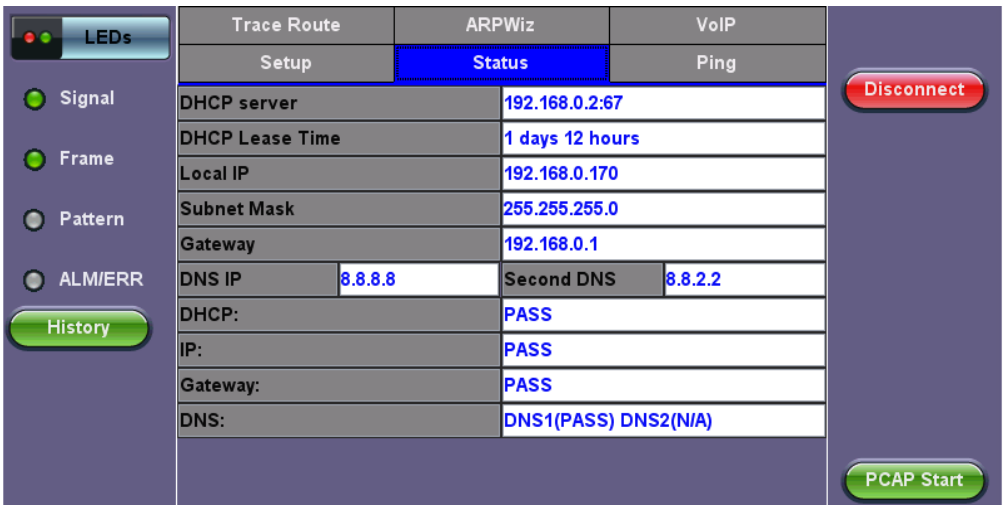
6.2.1.2 Status

Ensure the Status is PASS before continuing with any IP tests. If the connection fails, go back to the setup screen to verify that the parameters are entered correctly. Verify that the Ethernet cable is properly connected on the management port on the left hand side of the unit.

PASS Status



- **DHCP:** PASS indicates that an IP address has successfully been assigned.
- **IP:** PASS indicates that the IP address assigned has been verified to be unique in the network.
- **Gateway:** PASS indicates that the gateway IP address is valid.
- **DNS:** PASS indicates that the DNS IP address is valid.

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6.2.2 Trace Route

Trace Route is a common method used to find the route to the destination IP address or URL.
Refer to **Trace Route** in the **TX300S, MTTplus, RXT-1200, or UX400 platform manuals** for more information on this feature including setup and results.

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6.2.3 ARP Wiz

ARP Wiz uses the Address Resolution Protocol (ARP) to verify the status of each IP address in a user-selectable IP range. It is the standard method for finding a host's hardware address when only its network layer address is known.
Refer to **ARP Wiz** in the **TX300S, MTTplus, RXT-1200, or UX400 platform manuals** for more information on this feature including setup and results.

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6.2.4 Ping

Ping is a popular computer network tool used to test whether a particular host is reachable across an IP network. A ping is performed by sending an echo request or ICMP (Internet Control Message Protocol) to the echo response replies.
Refer to **Ping** in the**TX300S, MTTplus, RXT-1200, or UX400 platform manuals** for more information on this feature including setup and results.

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6.3 PCS

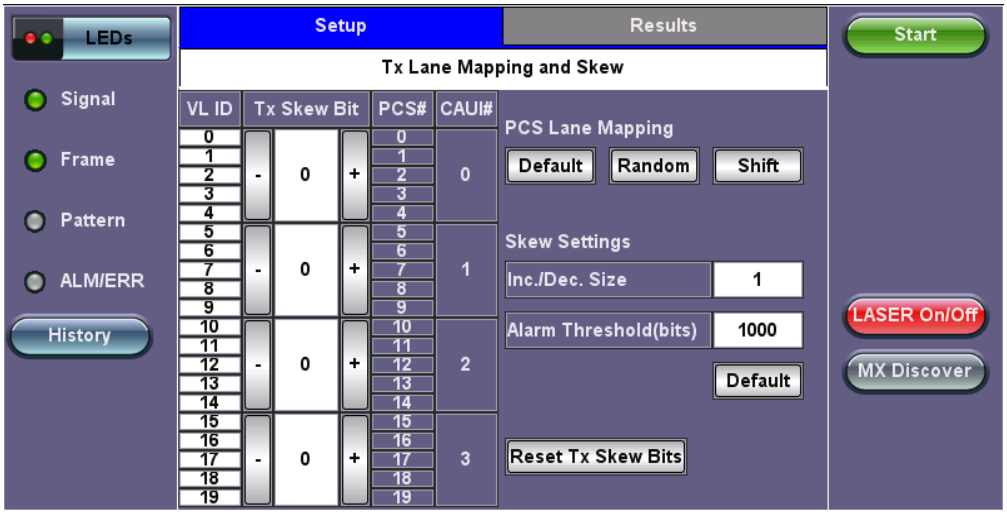
PCS layer testing helps validate and test all aspects of the PCS layer, which plays a significant role in 100G traffic generation/reception. Lane mapping and skew generation allows for the realignment of the virtual lanes and the injection of skew bits into each physical lane in order to stress and validate the PCS receiver.

6.3.1 Setup

6.3.1.1 Tx Lane Mapping and Skew

- **PCS to CAUI lanes configurable mapping:**
  - The **Default**, **Random**, and **Shift** buttons define the alignment markers ID that will be assigned to each lane
  - Receivers must be able to reorder and reassemble any mapping of PCS lanes into single stream
- **Skew Settings (up to 16000 bits time)**
  - Enter relative delay that will be introduced for the PCS lane pair (CAUI lane)
  - Default Alarm Threshold is 1000 bits
  - Stresses the de-skew function on the receiver side
- **Skew alarm threshold value:** User configurable threshold for Skew alarm

PCS Setup - Tx Lane Mapping and Skew



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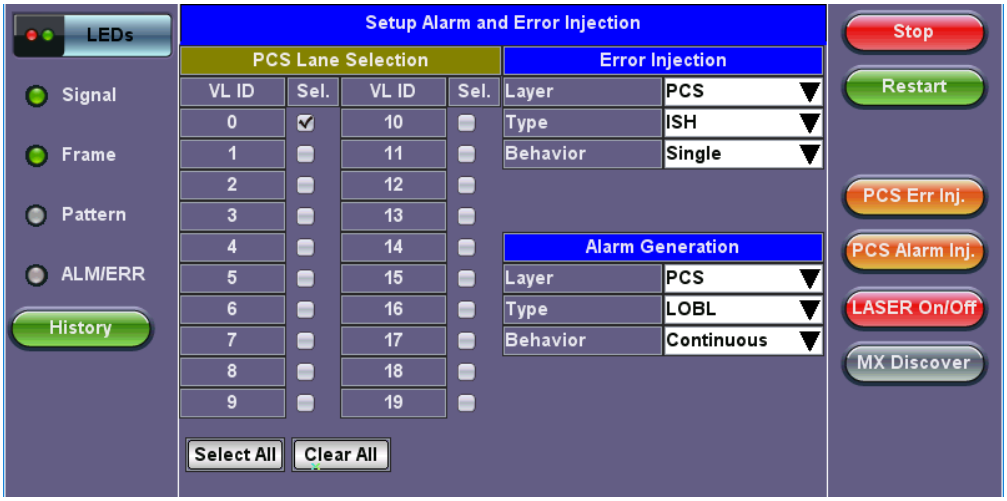
6.3.1.2 TX Alarm/Error Injection

To setup errors and alarms tap on the **Setup Injection** button, which appears after the test has started. Errors and alarms are assigned to the **PCS Err. Inj.** and **PCS Alarm Inj.** buttons and can be injected during testing.

- **Error Injection per PCS lane:**
  - **Invalid Sync header (ISH):** first 2 bits of the 64/66 block header
  - **Invalid alignment marker (IAM):** inserted every 16383 block on each virtual lane it contains the Virtual lane identifier
  - **BIP:** generates bit interleave parity error
  - **Behavior:** Single, Single Burst, or a user-defined Rate of error injection

- **Alarm Generation:**
  - **LOBL:** Loss of block lock
  - **LOA:** Loss of Alignment marker
  - **HI-BER:** high bit error rate of sync header
  - **Behavior:** Continuous error injection is chosen by default

PCS Setup - Alarm/ Error Injection



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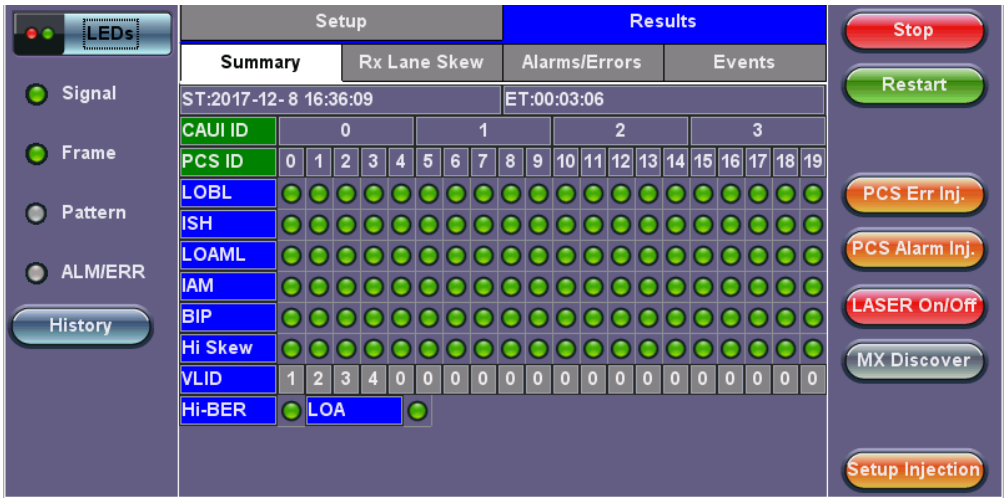
6.3.2 Results

6.3.2.1 Summary

PCS Results - Summary



Summary gives a quick view of all the PCS errors and alarms of all 20 virtual lanes and their corresponding mapped CAUI lanes. For details on any virtual lane go to the Alarms/Errors tab.

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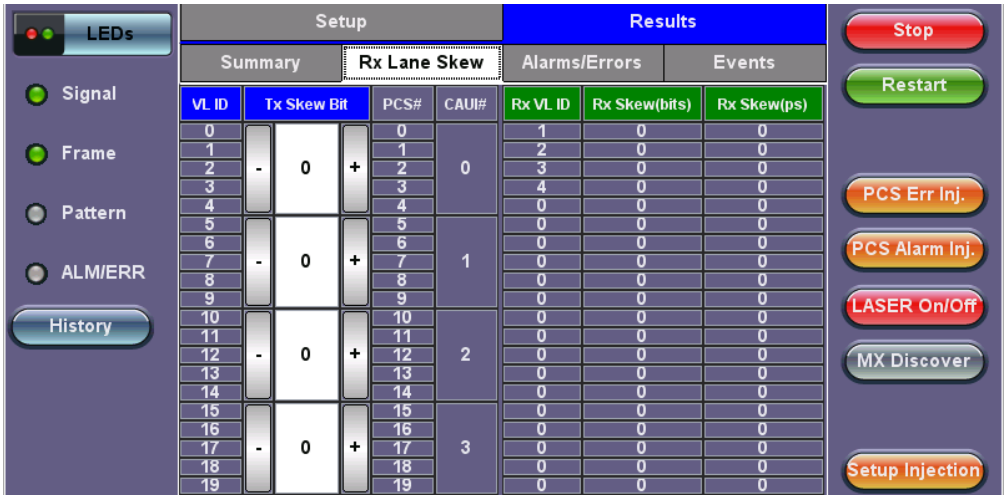
6.3.2.2 Rx Lane Skew

PCS Results - Rx Lane Skew



RX skew measurements in bits and pico seconds are displayed for each received virtual lane. TX Skew can be injected at the same time that the PCS test is running to see the real time effects on the receive lanes.

The increment/decrement button will inject the number of skew bits configured in the Skew Settings Inc./Dec/Size field in the PCS Setup tab.

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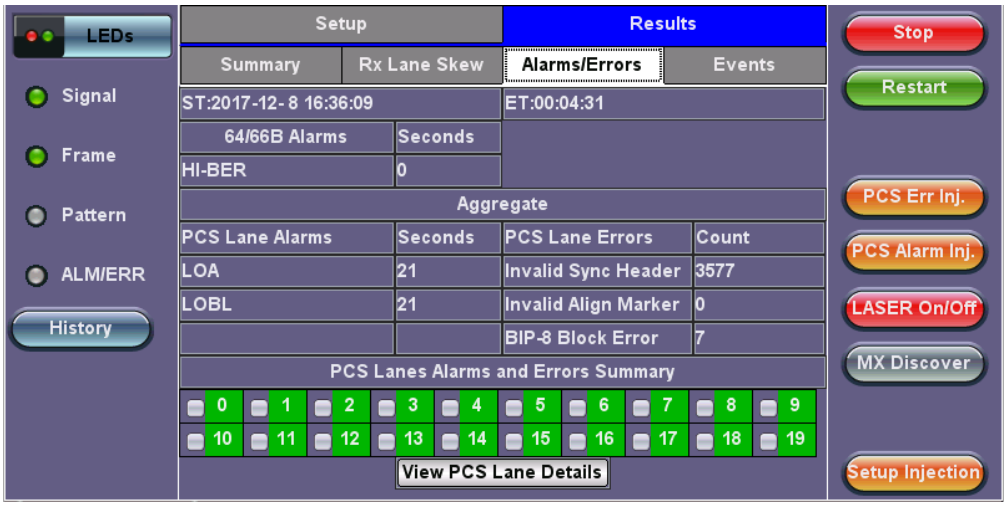
6.3.2.3 Alarms/Errors

PCS Results - Alarms/Errors



Alarms/Errors displays aggregate (all lanes) measurements and per virtual lane measurements of PCS errors and alarms.

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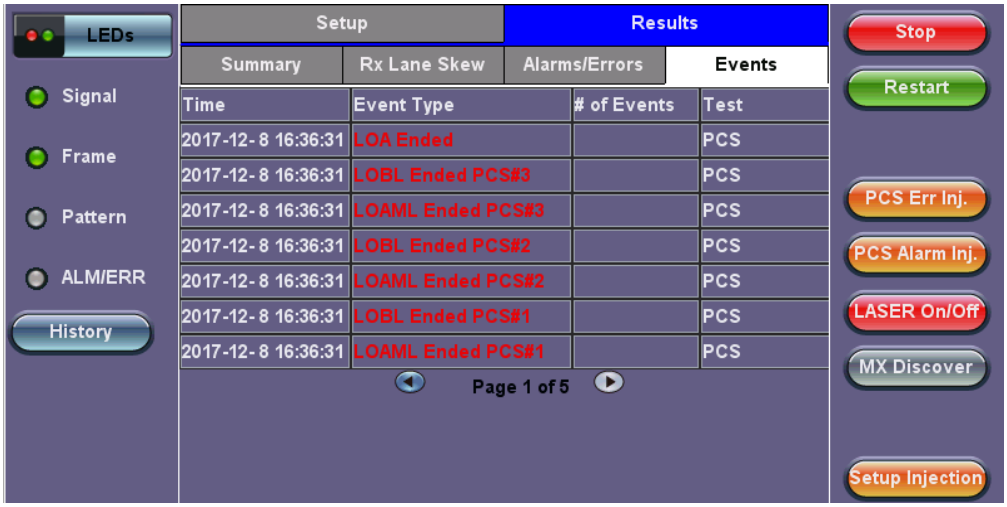
6.3.2.4 Events

PCS Results - Events



The Events log tab lists Error and Alarm events recorded during the test. The events are presented in chronological sequence with start time, event type, number of events, and test type.

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6.3.3 Saving PCS Results

Once the test has been stopped the results can be saved by pressing the Save key on the platform's keypad.

A window will open giving the option of naming the results file. Enter the desired name for the file and tap apply. The results will be saved.

PCS Results Save

Once the results are saved, they can be viewed or renamed by going to **Tools / System Settings screen> Files**. For information on managing saved results from the **File Manager**

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6.4 BERT

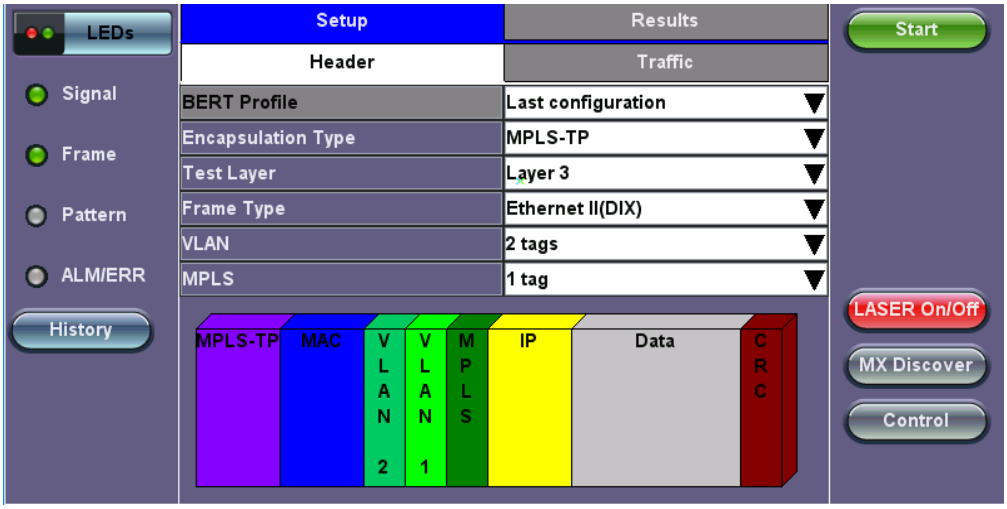
6.4.1 BERT Setup

Tap on **Advanced Tools** (Home Menu) > **BERT** icon to access BER testing features.

Overview:
BER testing at Layer 2 and 3 is supported. The BERT can be configured to use either regular PRBS test patterns, stress patterns (specifically for 10Gigabit Ethernet) or user defined test patterns to simulate various conditions. The test layer, frame header, traffic profile, error injection, and control settings of the far-end device (if applicable) must be configured prior to testing.

- **Layer 2:**
  - **Framed BERT:** Test pattern is encapsulated into a valid Ethernet frame with SOF, Preamble, and CRC field
  - **MAC Address:** A default or user configured Media Access Control (MAC) address is added to the frame
- **Layer 3:** Framed BERT
  - **MAC Address:** A default or user configured Media Access Control (MAC) address is added to the frame
  - **IP Address:** A default or user configured IP address is added to the frame

BERT Setup - Header (Layer 3)



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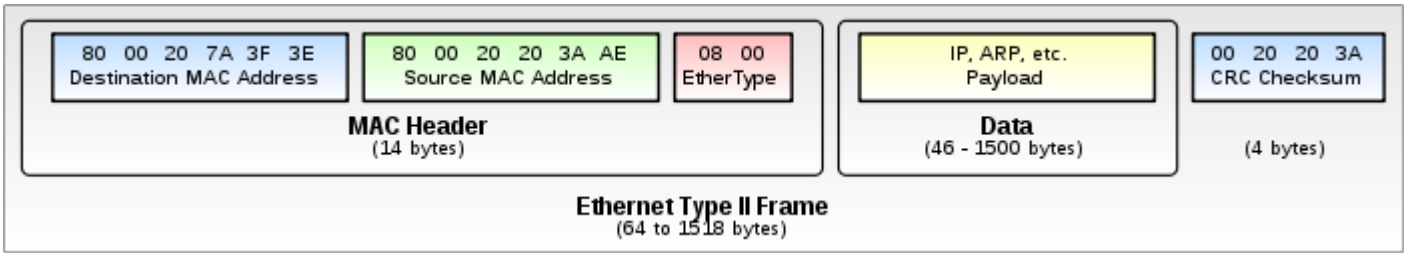
6.4.1.1 Header Settings

- **BERT Profile:** Load a previously configured test profile or create a new profile from existing settings. Currently its set to "Default". Please see the **Profiles** section in the **ReVeal MTX300 manual** for more details on how to create new profiles using ReVeal software.
- **Encapsulation Type:** None, MPLS-TP, Provider Backbone Bridge (PBB-TE), or EoE (Ethernet over Ethernet). Tap on the encapsulation type block to configure the settings. All encapsulation type fields are configurable:
  - MAC Source
  - MAC Destination
  - Ethernet Type
  - I-SID (PBB-TE only)
  - LSP, PW (MPLS-TP only)
  - TTL (EoE only)
  - VLAN ID, Priority, Type
- **Test:** Select the test layer to perform the BERT
  - Options are Layer 2 and Layer 3
- **Frame Type:**
  - Layer 2: 802.3 Raw (IEEE 802.3 frame without LLC) and Ethernet II (DIX) (named after DEC, Intel, and Xerox, this is the most common frame type today)
  - Layer 3: Ethernet II (DIX)
- **MAC/IP:** Tap the MAC and IP blocks on the Frame image to access the setup menus

  - Set the Source and Destination MAC address for Layer 2
  - Set the Source and Destination MAC and IP addresses for Layer 3
- **VLAN:** Off, 1 tag, 2 tags, 3 tags
  - The user is able to configure up to 3 VLAN tags (VLAN stacking, for Q-in-Q applications)
    Note: VLAN stacking is an option
- **MPLS:** (For Layer 3 only) Off, 1 tag, 2 tags, 3 tags
  - The user is able to configure up to 3 MPLS tags
    Note: MPLS tag configuration is only available when the MPLS option is purchased

The most common Ethernet Frame format, Type II



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EoE, MAC, VLAN, MPLS, IP, and Test Pattern Configurations:

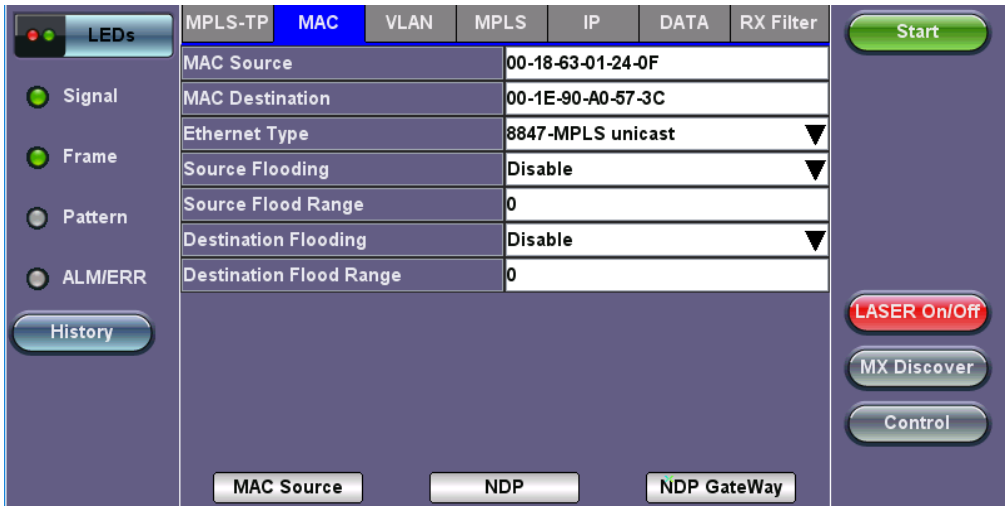
To configure the EoE, MAC addresses, IP addresses, VLAN tag(s), MPLS tag(s), and test pattern, tap on the frame image displayed on the screen. This brings up the configuration screens for all the header fields.

- **EoE (Ethernet Over Ethernet)**: EoE is an alternative to PBB with its own MAC, VLAN, TTL (Time To Live), EID (Extended ID), and FCS (Frame Check Sequence). ***Note:*** *EoE is only used in Japan as of the time of this publication.*

- **MAC Header Tab:**
  - **MAC Source:** Use the default source address of the test set or configure a new or different address.
  - **MAC Destination**: Configure the destination MAC address of the far-end partner test set or use the ARP or ARP GW keys to determine the MAC address of the destination IP address (ARP) or the Gateway (ARP GW). Note that a valid IP connection needs to be up to use these functions. Refer to IP Connection for instructions on establishing IP connection.
  - **Ethernet Type:** For Layer 3 testing, the Ethertype is set to 0800-IP. For Layer 2, the default is 0700.
  - **Source (SRC) and Destination (Dest) flooding**: Enable or Disable.
  - **Flood Range**: Specifies the number of MAC source and/or destination addresses. Enter a number from 0-4095. The source and/or destination MAC addresses will be incremented by 1 until it reaches the number of times entered in the flood range.

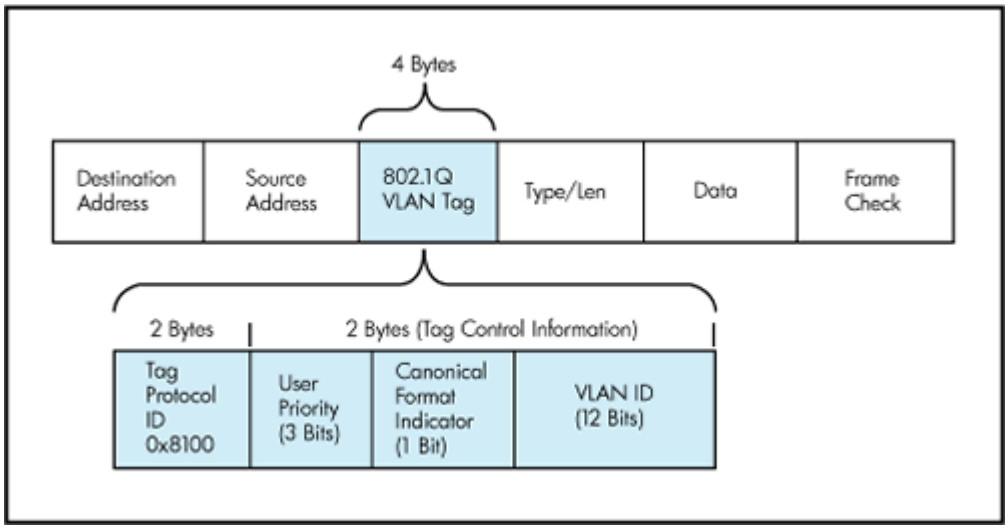
Tap on **Mac Source**, **ARP**, and **ARP Gateway** buttons to populate the fields with default test port settings.

BERT Setup MAC Layer 3



- **VLAN Tab:** In the VLAN tab the following parameters are configured:
    - **VLAN ID:** Configurable in the range 1 to 4094.
        - VLAN ID is the identification of the VLAN, which is basically used by the standard 802.1Q.
        - It has 12 bits which allows the identification of 4096 (2^12) VLANs.
        - Of the 4096 possible VIDs, a VID of 0 is used to identify priority frames and value 4095 (FFF) is reserved.
        - Maximum possible VLAN configurations are therefore set to 4094.
    - **VLAN Priority:** Configurable in the range 0 to 6
        - Set by the Priority Code Point (PCP), a 3-bit field which refers to the IEEE 802.1p priority.
        - It indicates the frame priority level from 0 (lowest) to 7 (highest), which can be used to prioritize different classes of traffic (voice, video, data, etc.).
    - **Type:** The following selections are possible:
        - 8100 (IEEE 802.1Q tagged frame)
        - 88a8 (IEEE 802.1ad Provider Bridging)
        - User Defined
    - **Drop Eligible:** If enabled, drop eligibility flag will be set.

IEEE 802.1Q VLAN Tag in an Ethernet Frame



BERT Setup - VLAN Tag configuration (Layer 2 & 3)

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- **MPLS Tab (Only for Layer 3):** In the MPLS tab the following parameters are configured:
    - **MPLS label:** Configurable in the range 16 through 1,048,575 (labels 0 to 15 are reserved).
      Note: *Composed of 20 bits which allows for the creation of over one million labels.*
    - **CoS:** Configurable in the range 0 to 6.

Note: *This field is three bits in length and maps directly to IP Precedence TOS bits to provide Class of Service (COS).*

- **S-bit:** Configurable 0 or 1.
  Note: *The S field is one bit in length and is used for stacking labels. This is important as it is used to indicate the last label in the label stack.*
- **TTL:** Configurable in the range 0 to 255. The default setting is 128 hops.
  Note: *Used to decrement the time-to-live counter.*

BERT Setup - MPLS configuration (Layer 3)

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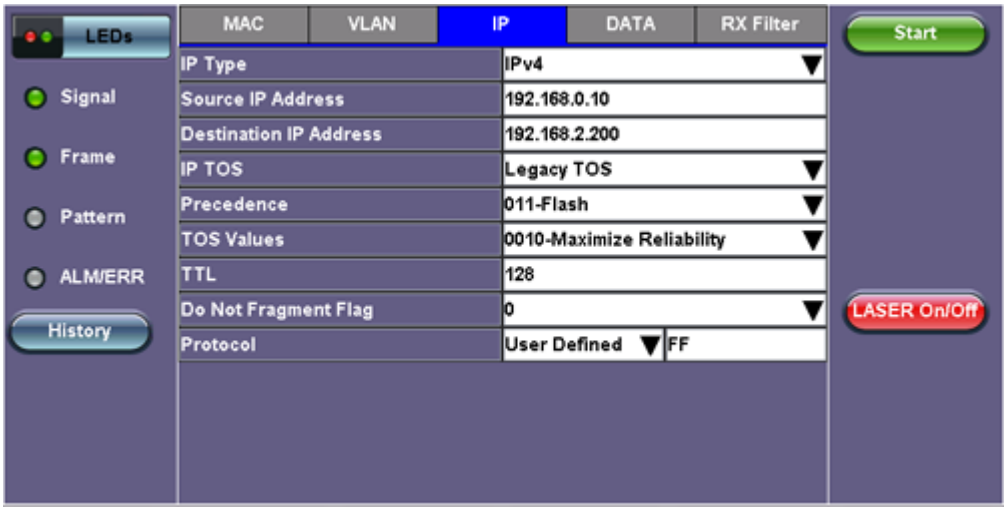
- **IP Tab:** In the IP tab the user must configure the destination IP address and source address. The user may also configure the following IP header fields:
  - **IP Type:** IPv4, IPv6
  - **IP Source and IP Destination:** For IP Src, if the IP connection is up, refer to to IP Connection. The source address is fixed to the IP address from the IP setup menu.
  - **IP TOS (for Quality of Service testing):** Legacy TOS or DSCP
    - **Legacy TOS :** The first three bits of the IP TOS field can be edited:
      - **Precedence:**
        - 000 - Routine
        - 001 - Priority
        - 010 - Immediate
        - 011 - Flash
        - 100 - Flash Override
        - 101 - Critical
        - 110 - Internetwork Control
        - 111 - Network Control
      - **TOS Values:**
        - 1000 - Minimize Delay
        - 0100 - Maximize Throughput
        - 0010 - Maximize Reliability
        - 001 - Minimize Monetary Cost
        - 0000 - Normal Service
    - **DSCP (Differentiated Services Code Point):** The first six bits of the IP TOS can be edited to provide more granular service classification.
    - **Time To Live (TTL):** Configurable in the range 0 to 255.
    - **Fragment offset byte:** Configurable in the range 0 to 65.528.
      Note: *The fragment offset field, measured in units of eight-byte blocks, is 13 bits long and specifies the offset of a particular fragment relative to the beginning of the original unfragmented IP datagram.*
    - **Protocol field:** UDP (0x11), TCP (0x06), User Defined.

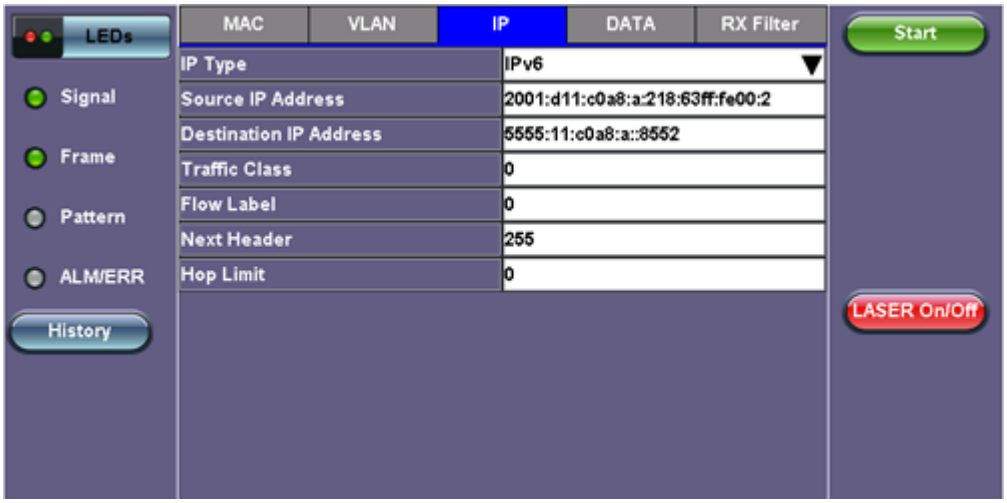
BERT Setup - IP Address Setting Layer 3 (IPv4 Legacy TOS)



IPv6:

- Source IP Address
- Destination IP Address
- Traffic Class
- Flow Label
- Next Header
- Hop Limit

BERT Setup - IP Address Setting Layer 3 (IPv6)



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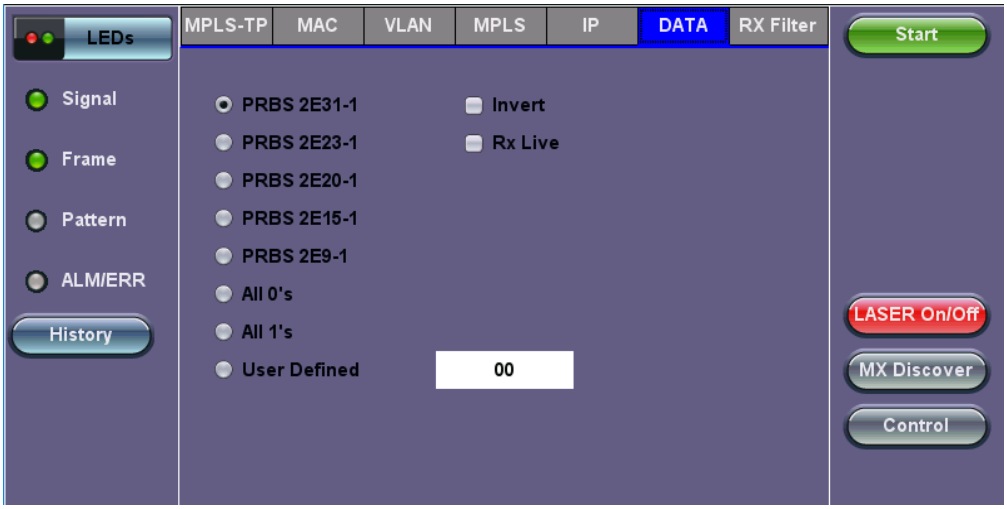
- **Data Tab:** User selects a test pattern that will be encapsulated in the Ethernet frame payload (for framed mode). For both Layer 2 and 3 the following pattern is available:
  - **PRBS:**
    - 2^31 -1
    - 2^23 -1
    - 2^15 -1
    - 2^11 -1
    - 2^9 -1
  - **Fixed:** All 0s or All 1s
  - **User Defined pattern:** Length depends on size of frame
  - **Inversion:** Normal or inverted
  - **RX Live**

BERT Setup - Data selection



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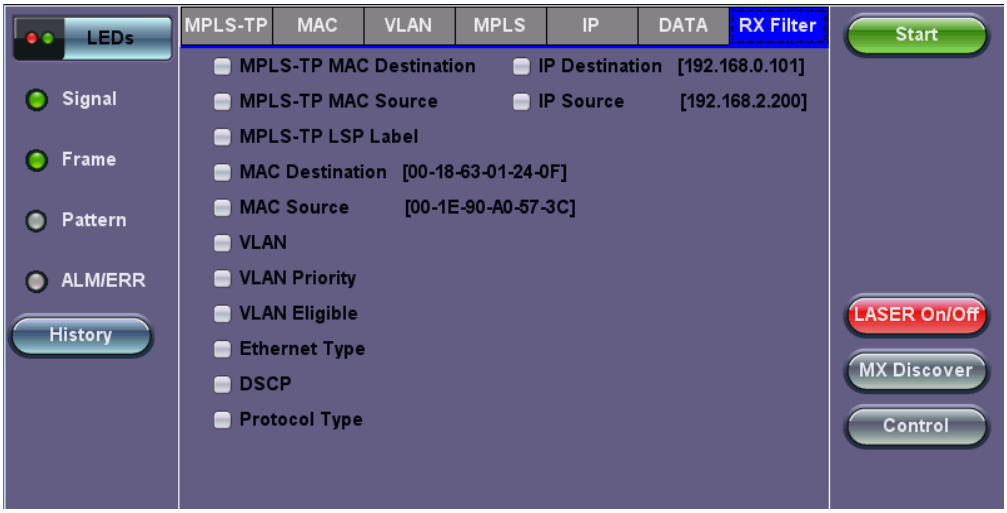
- **RX Filter Tab:** Allows the user to filter incoming streams. When checked, the incoming traffic flows not matching these criteria will not be considered for these results.
  - MAC Destination address
  - MAC Source address
  - VLAN
  - VLAN Priority
  - VLAN Eligible
  - Frame Type
  - Traffic Class (for Layer 3)
  - Flow Label (for Layer 3)
  - Next Header (for Layer 3)

BERT Setup RX Filter (Layer 3)



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6.4.1.2 Traffic Settings

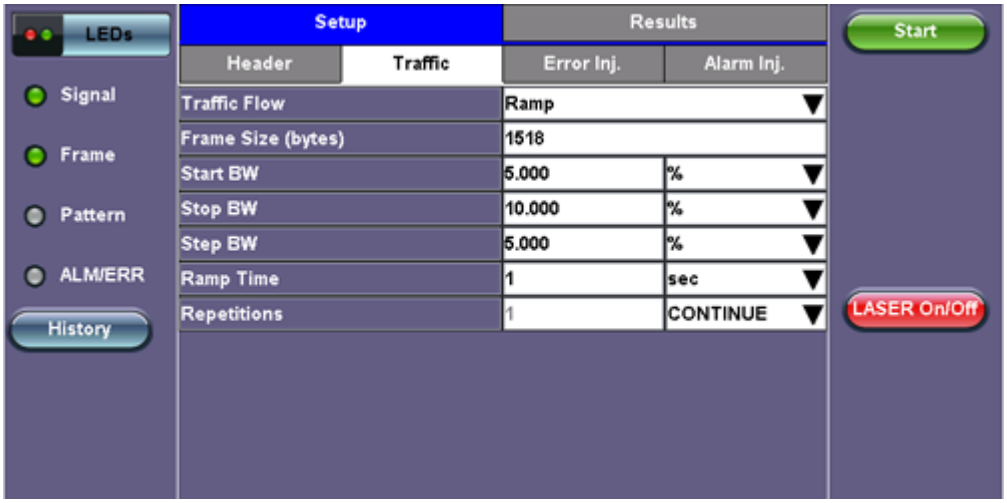
The user configures the traffic profile for the stream, including traffic flow, frame size, frame type, and transmit rate.

- **Traffic Flow:** Select from the following traffic flows:
  - **Constant:** The selected frame is transmitted continuously according to the selected bandwidth %.
  - **Ramp:** The selected frame is transmitted at maximum bandwidth according to the selected duty cycle and burst period.
  - **Burst:** The selected frame is transmitted in a staircase profile according to user selectable step time, number of steps, and maximum bandwidth.
  - **Single Burst:** Configure the number of frames to be transmitted in the burst along with the bandwidth. For

example, if 100000 frames are transmitted at 12.5% of bandwidth, on a 1Gbps line, 100000 frames will transmit at a rate of 125Mbps and then the burst will stop.

- **Frame Size Type:** Fixed or Uniform min and max frame length values. Uniform traffic is traffic generated with a uniform distribution of frame lengths.
- **Frame Size (bytes):** Frame sizes can be from 64 bytes to 1518 bytes, in addition to jumbo frames up to 10000 bytes
- **BW (Transmit Bandwidth):** Configure the transmit rate for the test
  - When traffic flow is equal to Burst, two burst bandwidths are configured with burst time
  - When traffic flow is equal to Ramp, starting and an ending bandwidth are configured along with the bandwidth step size and duration

BERT Setup - Ramp Traffic



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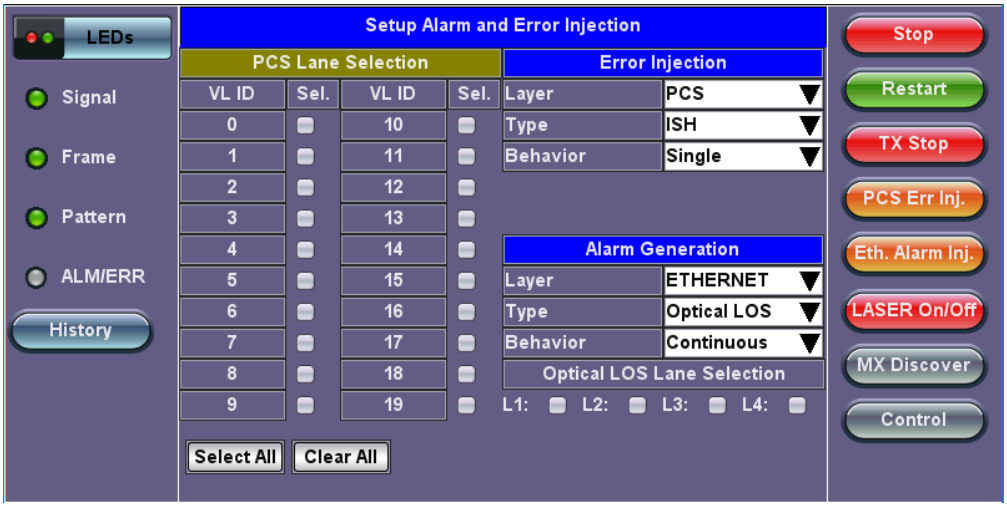
6.4.1.3 Error Injection

Error injection can be performed during testing. The error type and injection rate are configured in the **Setup Injection** tab, which appears after pressing **Start**. Once the test is running, error injection can be performed by pressing the **Err Inj.** button on the right side of the screen.

- **Layer:** Ethernet or PCS
- **Ethernet:**
  - **Type:** Select from CRC, IP Checksum, Pause, Bit, and Runt. With Pause selected, the unit will transmit a pause frame when **Error Injection** icon is pressed. The Pause time duration is configurable in units of 512 bit time. At Gigabit Ethernet speed, this is equivalent to 512 ns. For example, if pause time is set to 1000, the pause duration will be set to 1000x512 ns.
- **PCS**
  - **Type**: ISH, IAM, and BIP. Use the checkbox to select the PCS Lanes for error injection.
- **Behavior:** The error injection flow determines how the selected errors will be injected.
  - Select a single, single burst, or rate error injection.
- **Count:** Configures the error count via a numeric keypad for single burst injection.
- **Error Rate:** Configure the error injection rate for rate error injection.

BERT Setup - Error Injection



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6.4.1.4 Alarm Injection Settings

Alarm injection can be performed during testing. The type of alarms and alarm injection are configured in the Setup Injection tab. Once the test is running, alarm injection can be performed by pressing the **Alarm Inj.** button on the right side of the screen.

- **Layer:** Select from Ethernet or PCS
- **Ethernet**
  - **Type:** Local Fault, Remote Fault, Optical LOS. Four optical LOS lanes are available for selection.
- **Alarm Flow:** The alarm flow determines how the selected alarms will be injected. Single burst or continuous can be selected.
- **Duration:** Duration for single burst flow; 1s, 10s, or 100s.

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6.4.1.5 Starting/Stopping a BERT

Once all configurations have been made, the user can start the BERT test (press the **Start** icon on the top right section of the screen). The following are three scenarios of how to prepare and start the unit for BERT testing.
Note: *If testing on the fiber ports, make sure the LASER is turned on before starting the test.*

- **End-to-End Testing**
  - Connect the UX400 to another unit that supports BERT testing.
  - After configuring test settings on both units, start the tests.

- **Far-End Unit in Manual Loopback Mode**
  - If the far-end unit is already in a manual loopback mode, do not send a loop up command since it is not necessary.
  - Once the correct control settings are configured, the user can start the test.

The selected tests will run automatically. When all the tests are complete the test will stop automatically. If the BERT test suite needs to be stopped before they are done, then simply press the **Stop** button, located in the actions drop-down menu. The status of each selected test can be seen in the Results tab.

- **Far-End Unit Controlled with Loop Up/Down Commands**
  - If the far-end unit is not manually looped back, then it must first receive a loop up command from the control unit before the BERT test suite can be started.
  - To loop up the far-end unit with the manual mode loop up/down commands, configure the control settings mode to manual.
  - Enter the MAC and/or IP address of the far-end unit.
  - Send the loop up command by pressing **Loop Up**.

Once the far-end unit has been looped back, start the test by pressing the **Start** button. When all of the selected test are completed, the BERT test suite will stop automatically. Once all tests have been completed and there is no need to test again, go back to the Control tab, and press the **Loop Down** button. This will send a loop down command to the far-end unit to remove the loopback that is in place.

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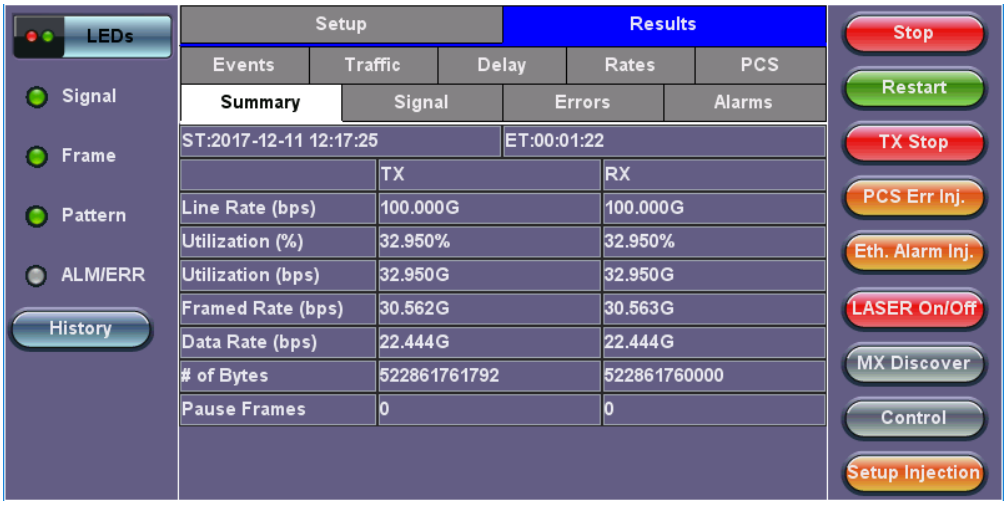
6.4.2 BERT Results

6.4.2.1 Summary

Summary tab: The following results including the Start (ST) and Elapsed (ET) times are displayed:

- **Line Rate** (Mbps)**:** Negotiated rate of the interface (10M, 100M, or 1000M). This value is always fixed since it depends on the maximum capacity of the link under test, hence the test interface that is configured.
- **Utilization:** % of Line Rate. For example, if we transmit 100Mbps on a 1Gbps interface then the utilization value is 10% (or 100Mbps) of the total link capacity (or Line Rate).
- **Utilization (bps)**
- **Framed Rate:** (Payload + MAC/IP Header + VLAN Tag + Type/Length + CRC) / (Payload + Total Overhead) * Line Rate % (in Mbps).
- **Data Rate:** Payload / (Payload + Total Overhead) * Line Rate %.
- **Number of bytes**
- **Pause Frames:** Total number of transmitted and received ethernet pause flow-control frames.

BERT Results - Summary



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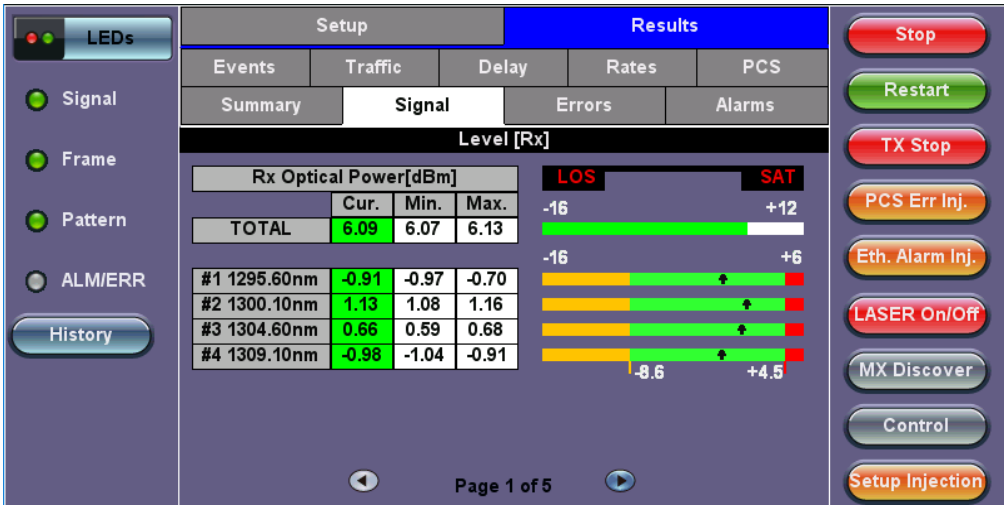
6.4.2.2 Signal

Signal (Page 1-2)

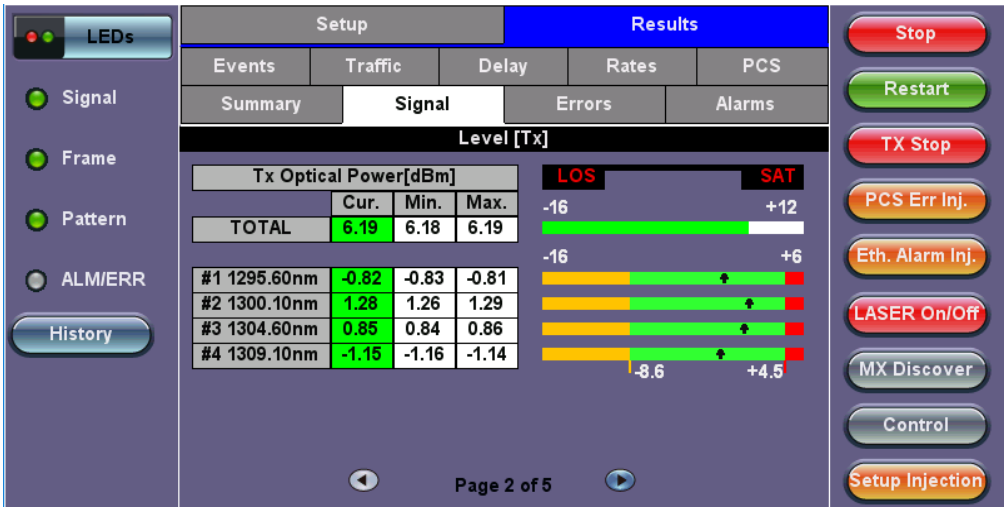
The Signal tab (fiber ports only) displays the receiving (RX) and transmitting (TX) optical level measured by the CFP, CFP2, CFP4, QSFP28, or QSFP+ (40G), depending on the 100G module in use.

Loss of Signal (LOS) and the Saturation level for optical signals are shown graphically including the level measurement in dBm for each lane.

BERT Results - Signal (Page 1)



BERT Results - Signal (Page 2)

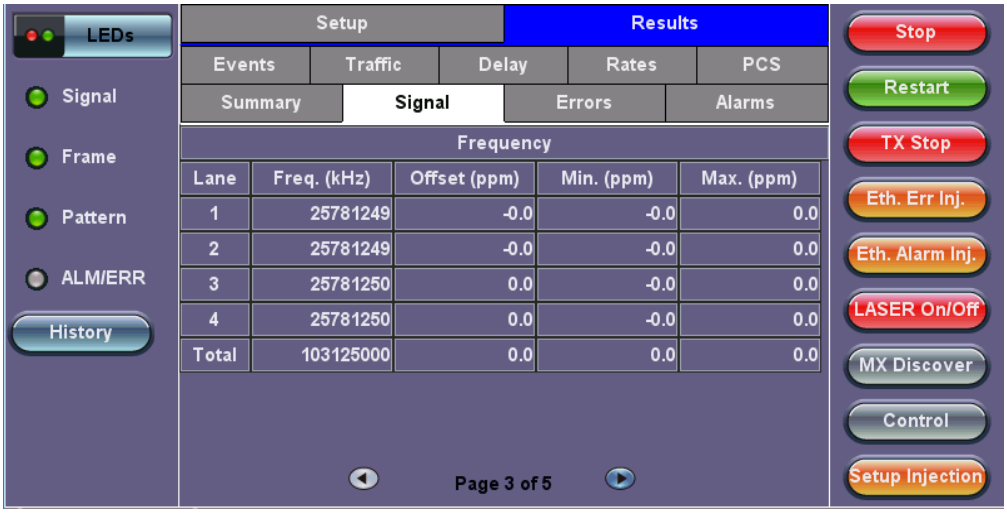


Signal (Page 3)

The received signal frequency and offset is measured and performed on the optical interface. The latest test sets and software versions may display signal measurements for each lane, depending on supported versions.

- **Frequency:** Indicates the frequency of the input signal.
- **Offset:** Indicates the difference between the standard rate and the rate of the input signal.
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal.
- **Max (ppm):** Indicates the difference between the standard rate and the maximum deviation detected in the input signal.

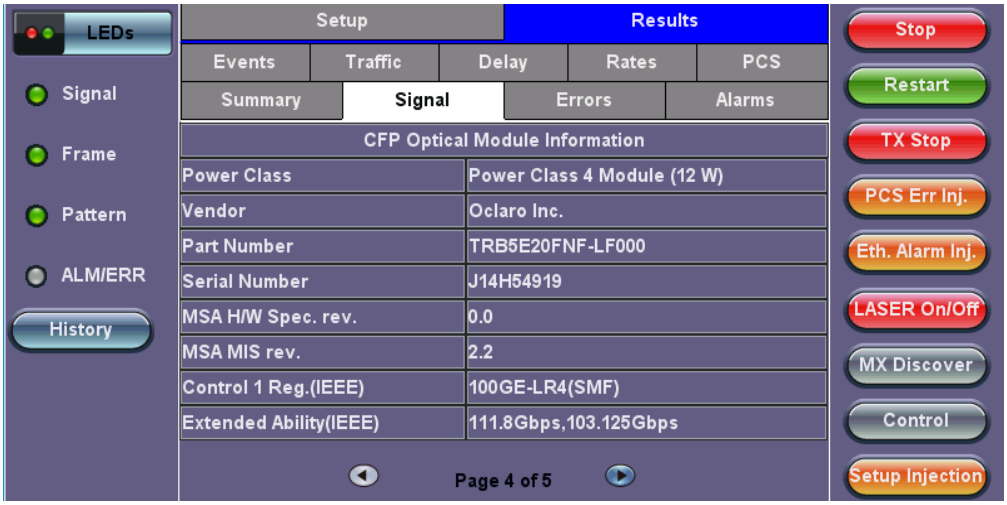
BERT Results - Signal (Page 3)



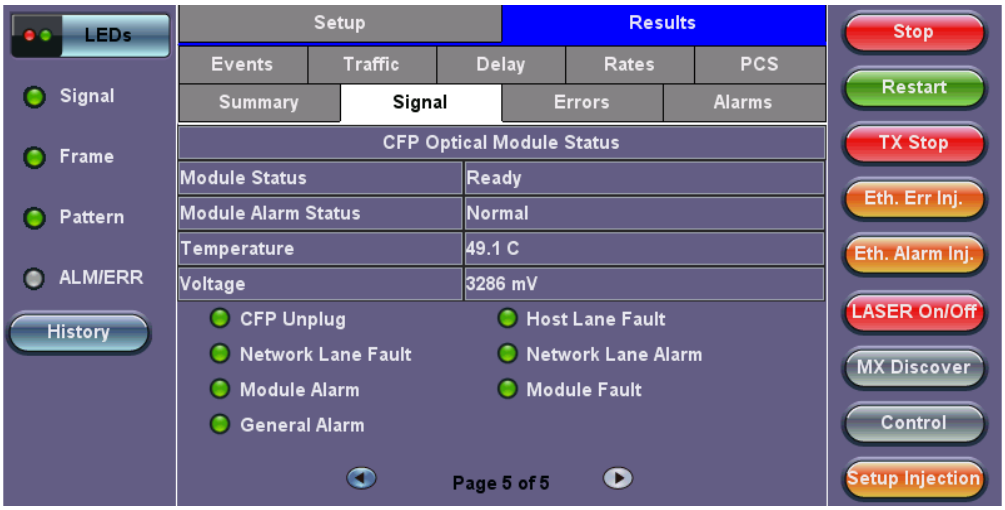
Signal (Page 4-5)

Page 4-5 displays the Optical module information and status.

BERT Results - Signal (Page 4)



BERT Results - Signal (Page 5)



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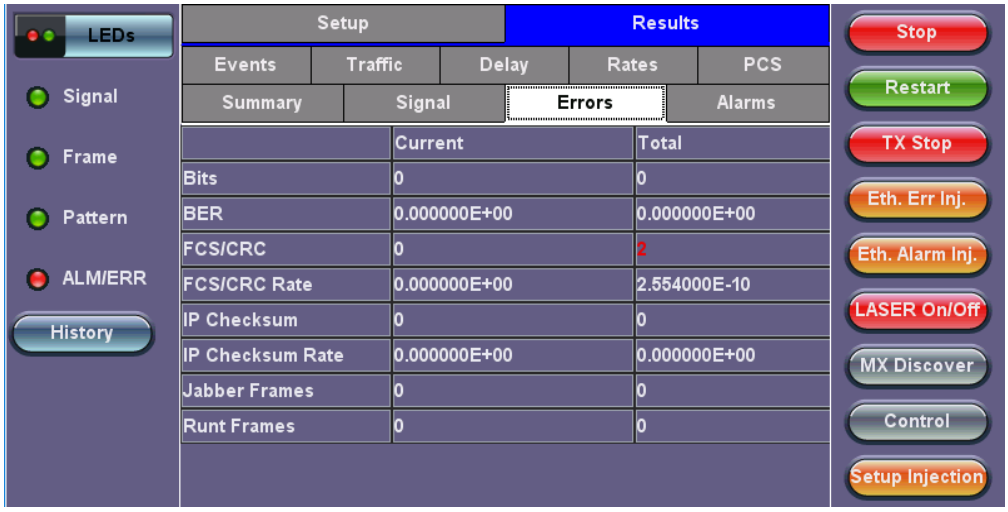
6.4.2.2 Errors

Errors tab: The following errors (Current and Total) are displayed:

- **Bits:** Indicates errors related to test pattern (Bit Error or LSS [Pattern Loss])
- **BER:** Bit Error Ratio
- **Symbol:** Declared when an invalid code-group in the transmission code is detected
- **FCS/CRC:** Number of received frames with an invalid FCS
- **IP Checksum** (Layer 3 only)
- **Jabber frames:** Number of received frames larger than 1518 bytes containing an invalid FCS
- **Runt frames:** Number of received frames smaller than 64 bytes containing an invalid FCS

BERT Results - Errors



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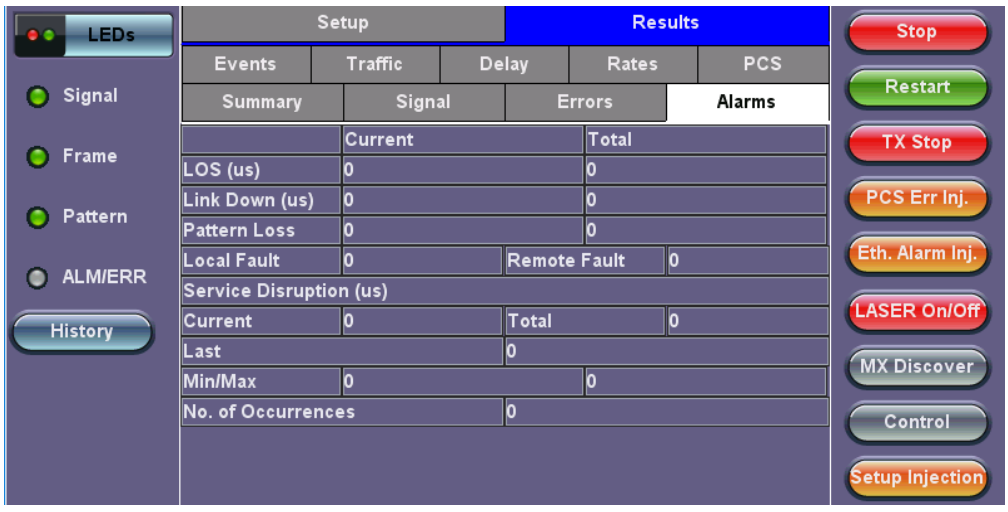
6.4.2.3 Alarms

Alarms tab: The following Alarms (Current and Total) are displayed:

- **LOS:** Loss of Signal
- **LOS Sync:** Loss synchronization
- **Pattern Loss:** Indicates errors related to test pattern
- Service disruption associated with loss of signal:
  - **Current:** Duration of the current service disruption
  - **Total:** Total accumulated duration of the service disruptions
  - **Last:**
  - **Min/Max:** Minimum and maximum duration of the service disruption events
  - **No. of Occurrences:** Counter of service disruption events
  - **Local Fault**
  - **Remote Fault**

BERT Results - Alarms



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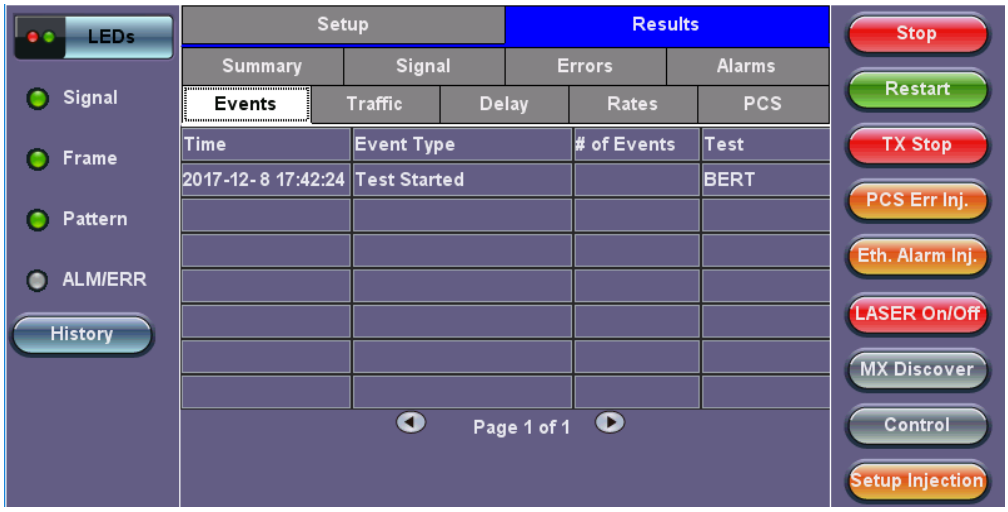
6.4.2.5 Events

Events tab: A time stamped record or log of anomalies, alarms, test status (start/stop) and test application are displayed.

BERT Results - Events



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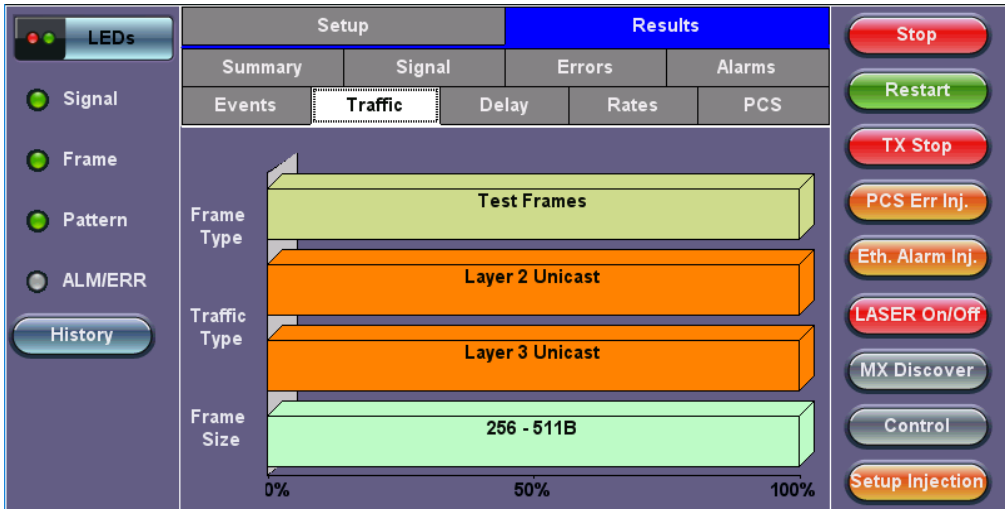
6.4.2.6 Traffic

Traffic tab: The following Traffic statistics are displayed:

- **Frame type:** Test and non-test frames
- **Traffic type:** Layer 2 and Layer 3 Unicast, Broadcast, and Multicast frame percentage
- **Frame size distribution**

Tap on the graph for detailed screens.

BERT Results - Traffic



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Frames tab: The following Frame distribution statistics are displayed in Count (#) and Percentage (%):

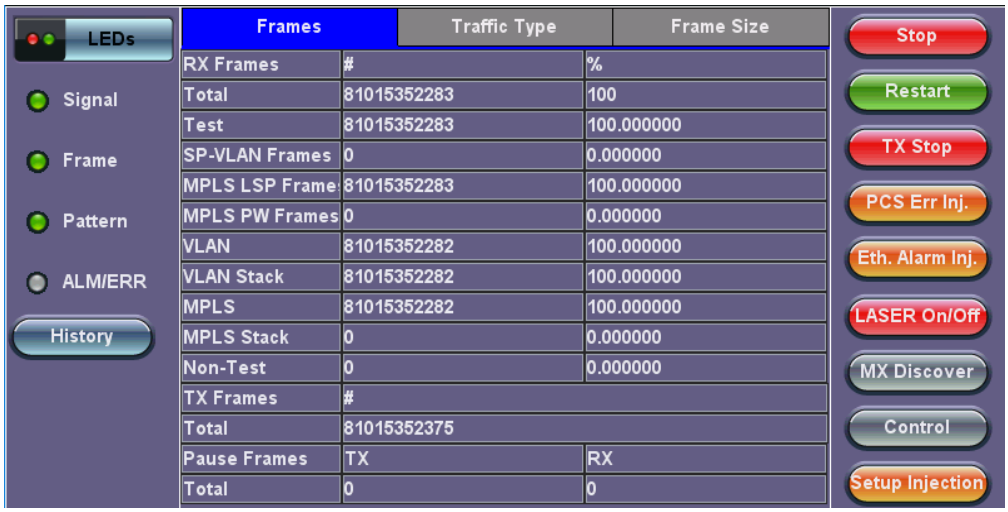
- **Received (RX) frames:**
  - Total frames
  - Test frames
  - VLAN tagged frames
  - Q-in-Q VLAN stacked frames

  - Non-test frames

- **Transmitted (TX) frames:**
  - Total frame - Total # frames transmitted

- **Pause frames:** Total number of transmitted and received Ethernet pause flow-control frames

BERT Results - Frames



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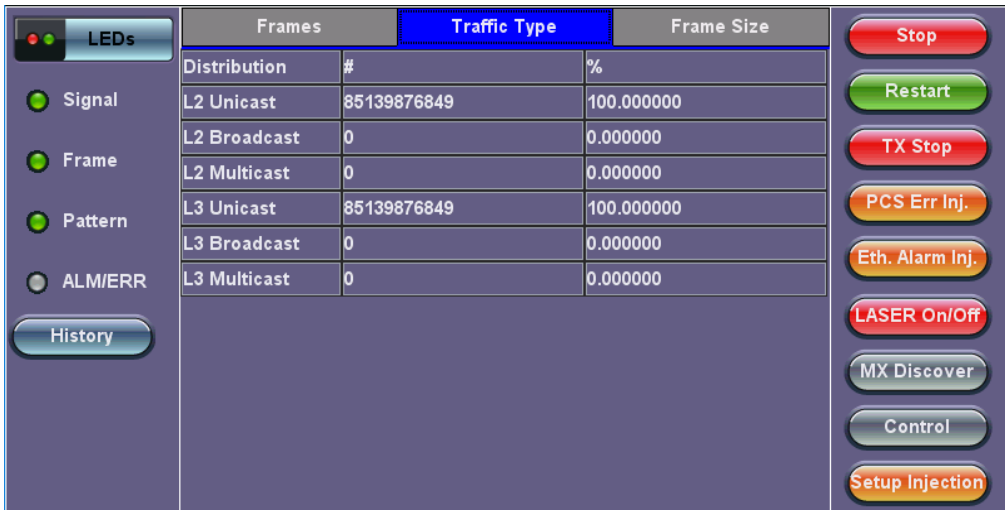
Traffic Type tab: The following Traffic distribution statistics are displayed in Count (#) and Percentage (%):

- **Layer 2 Unicast frames:** Number of Unicast frames received without FCS errors.
- **Layer 2 Broadcast frames:** Number of Broadcast frames received without FCS errors. Broadcast frames have a MAC address equal to FF-FF-FF-FF-FF-FF.
- **Layer 2 Multicast frames:** Number of Multicast frames received without FCS errors.

BERT Results - Traffic Type



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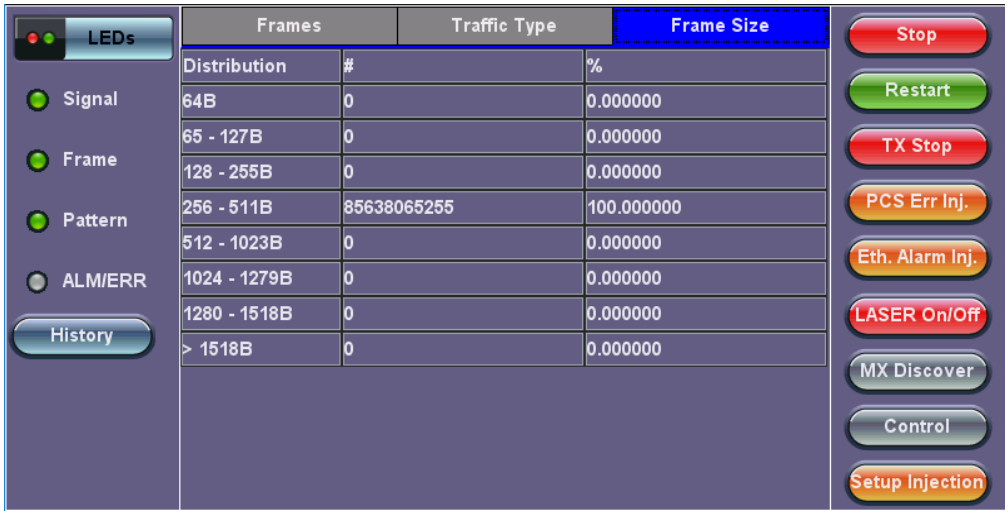
Frame Size tab: The following Frame distribution statistics are displayed in Count (#) and Percentage (%):

- 64 bytes frames
- 64-127 byte frames
- 128-255 byte frames
- 256-511 byte frames
- 512-1023 byte frames

- 1024-1279 byte frames
- 1280-1518 byte frames
- > 1518 byte frames - Jumbo frames

BERT Results - Frame Size



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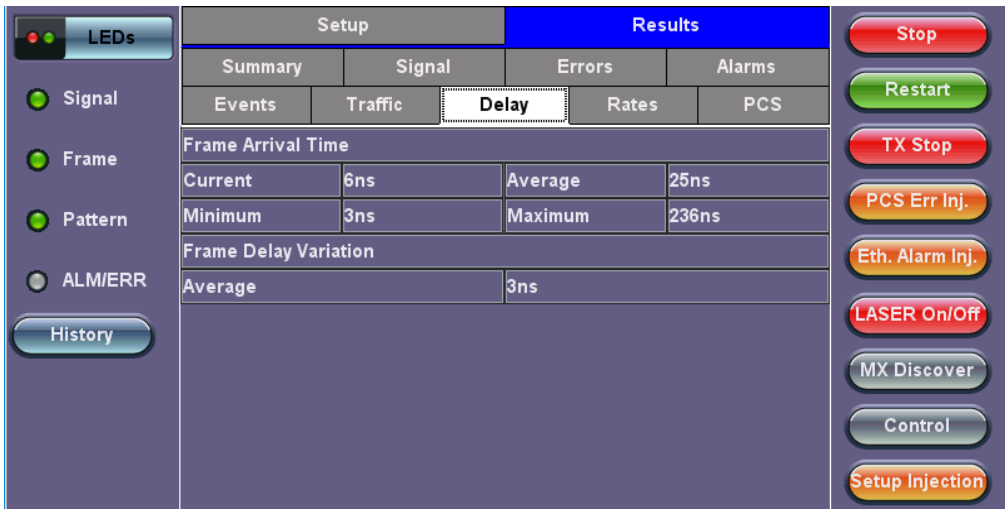
6.4.2.7 Delay

Delay tab: Delay measures the interpacket gap, start of the frame, and preamble duration. Frame arrival statistics are displayed in tabular format:

- Current
- Minimum
- Maximum
- Variation (Current) - Interframe delay variation

BERT Results - Delay



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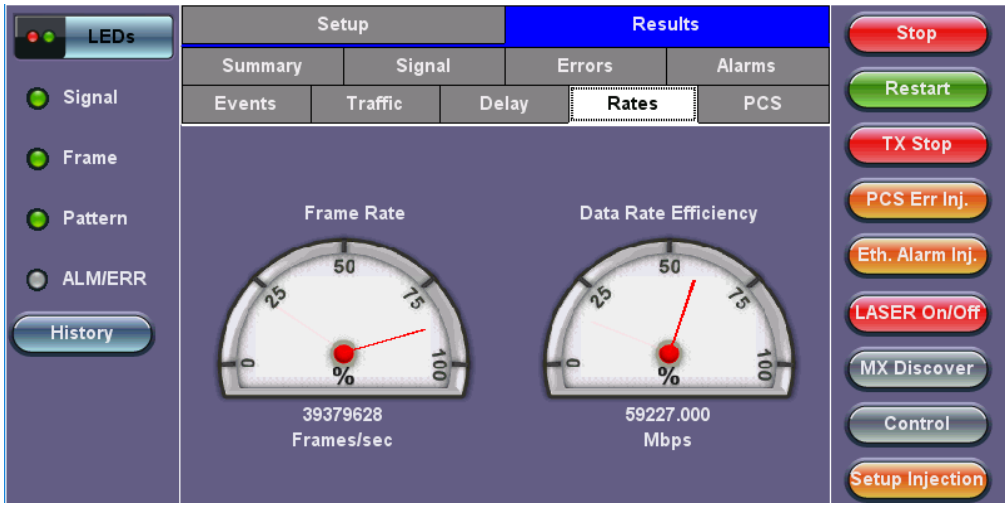
6.4.2.8 Rates

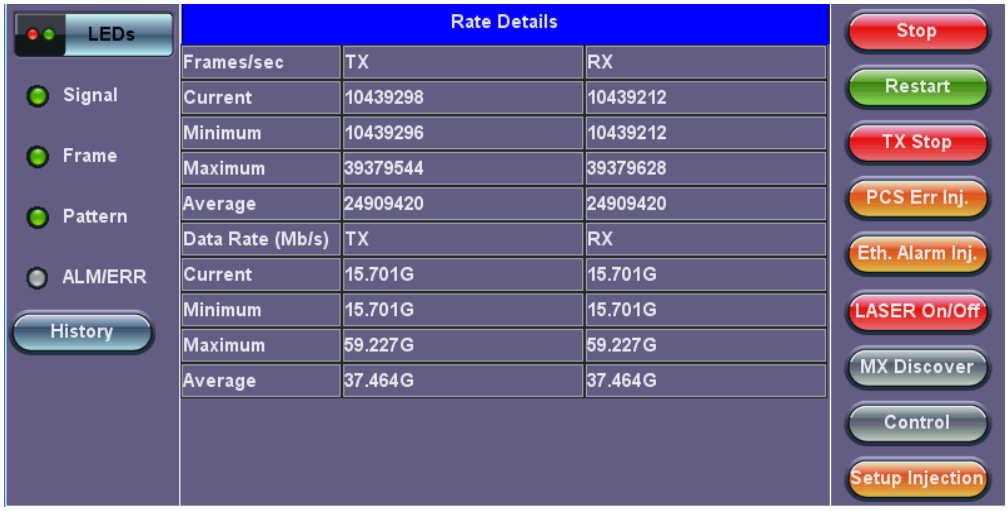
Rates tab: Rate statistics are displayed in a graph format. Tap on either gauge to see rate details in table form. The table shows transmitted **(Tx)** and received **(Rx)** current, minimum, maximum and average frame rates **(FPS)** and Data Rates **(Mbps)**.

- **Frame rate in Frames per second (FPS):** Number of received frames (including bad frames, Broadcast frames and Multicast frames)
- **Data rate in Mbps:** Received data rate expressed in Mbps

BERT Results - Rates



BERT Results - Rate Details



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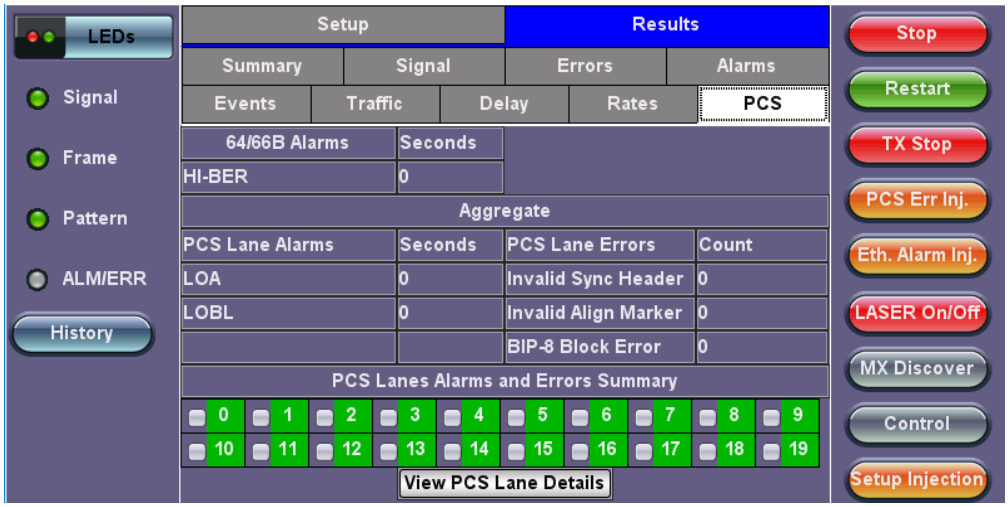
6.4.2.9 PCS

PCS layer testing helps validate and test all aspects of the PCS layer, which plays a significant role in 100G traffic generation/reception. Lane mapping and skew generation allows for the realignment of the virtual lanes and the injection of skew bits into each physical lane in order to stress and validate the PCS receiver.

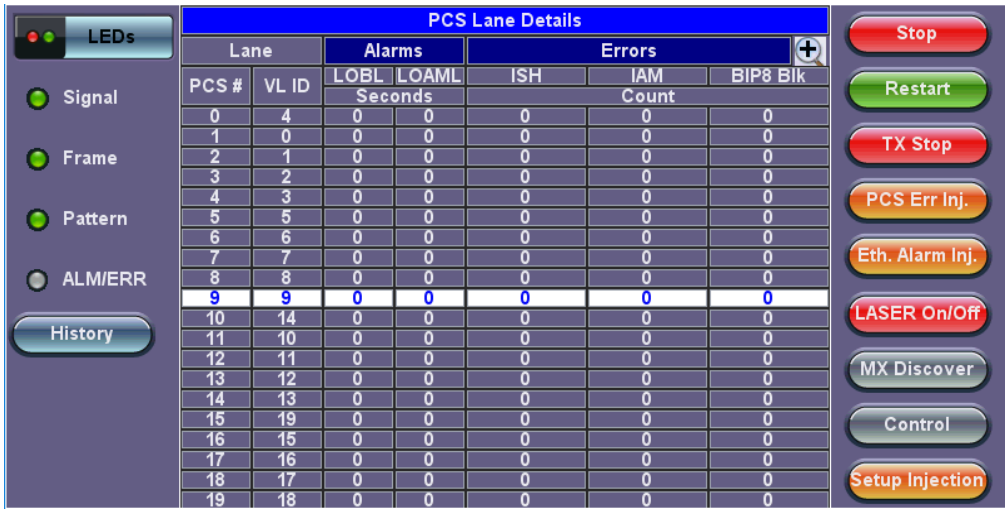
- **HI-BER:** High bit error rate of sync header
- **LOA:** Loss of Alignment marker
- **LOBL:** Loss of block lock
- **Invalid Sync header:** First 2 bits of the 64/66 block header
- **Invalid alignment marker:** Inserted every 16383 block on each virtual lane it contains the Virtual lane identifier
- **BIP:** Generates Bit Interleave Parity Error

Tap on **View PCS Lane Details** to see additional details such as PCS # and VL ID for each alarm/error. The magnifying glass displays Count and Rate error details.

BERT Results - PCS



BERT Results - PCS Lane Details



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6.4.3 Saving BERT Results

Once the test has been stopped the results can be saved by pressing the Save key on the platform's keypad.

A window will open giving the option of naming the results file. Enter the desired name for the file and tap apply. The results will be saved.

BERT Results Save

Once the results are saved, they can be viewed, renamed, or exported to USB in the **Utilities** > **Files** > **Saved** section. Refer to the **File Manager** section in the RXT1200, TX300S, or UX400 Platform manual for more information on managing saved test results.

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6.5 RFC2544

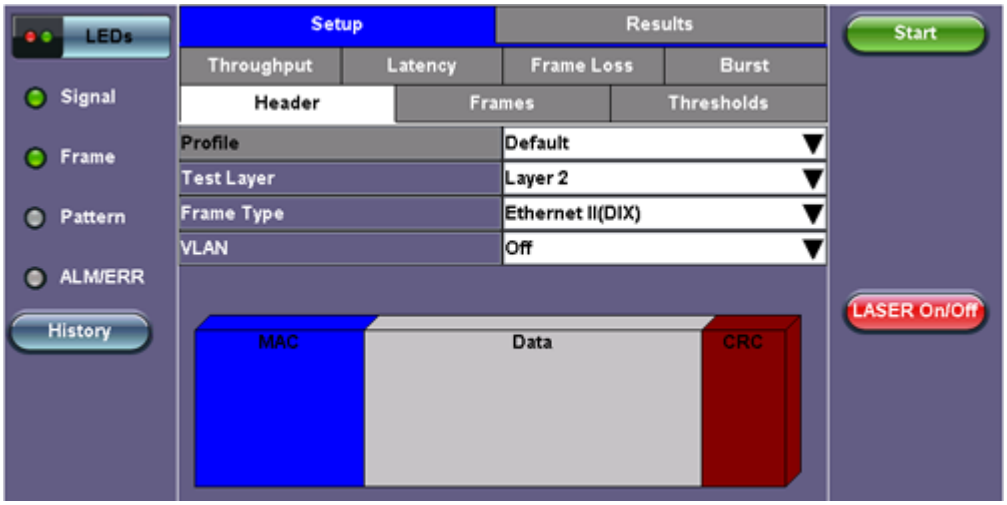
6.5.1 Setup

Overview:
RFC 2544 recommendations are well accepted in the test and measurement industry for network performance testing. The RFC 2544 test suite consists of and performs a set of four automated tests (throughput, latency, frame loss, and burst or back-to-back) to qualify the performance of a network link under test. The tests are especially popular for the verification of network links with certain service level agreements (SLA).

The following settings must be configured prior to RFC 2544 testing:

- Test layer (Layer 2 & 3)
- Frame header (MAC, VLAN, IP, UDP, and Data)
- Test frames selection
- Pass/fail thresholds (optional)
- Throughput
- Latency
- Frame loss
- Burst (back-to-back)

RFC2544 Home



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6.5.1.1 Header Settings

Unless otherwise noted, Frame Header setup is identical to the setup described in the BERT Application. Refer to the BERT application for details.

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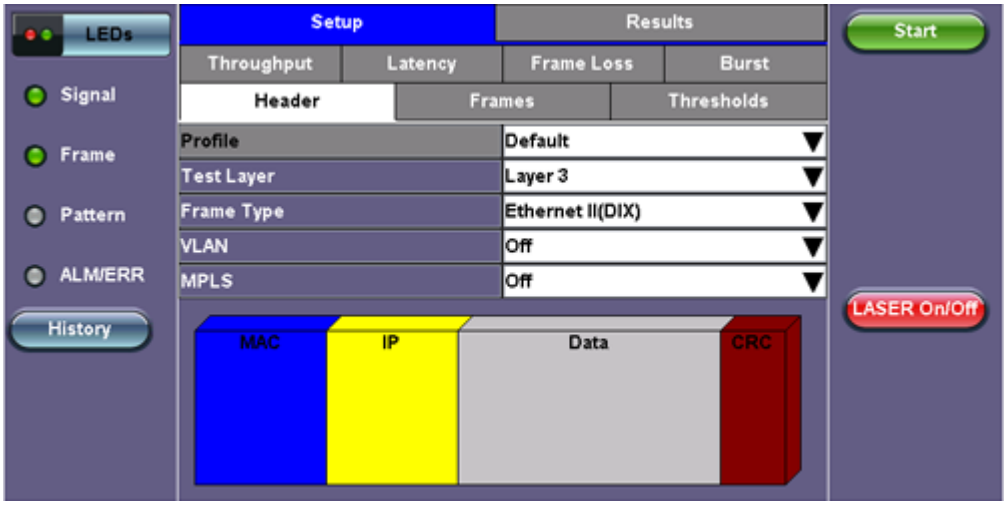
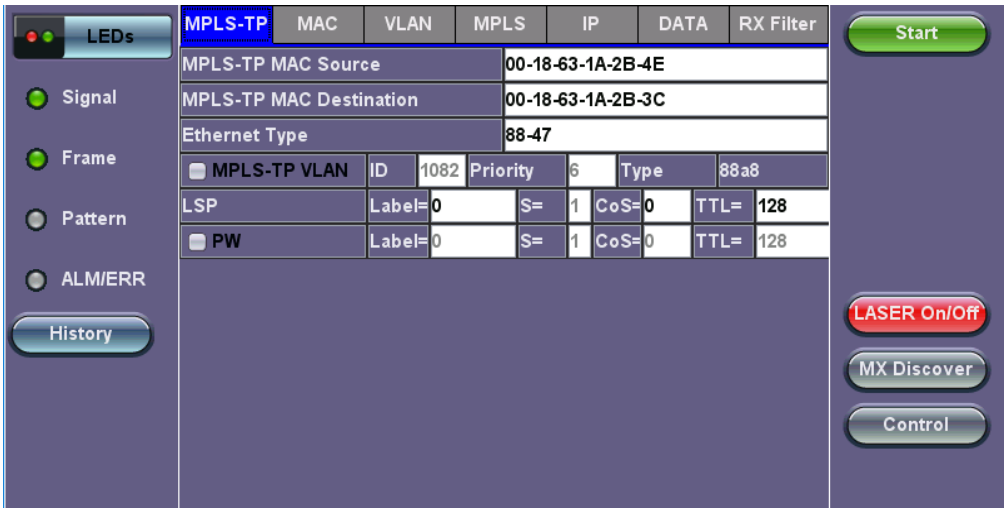
RFC2544 Setup Layer 3



RFC2544 Setup MPLS-TP



RFC 2544 Header Setups

The MAC, VLAN, MPLS, and IP configuration procedures are the same as in BERT mode. Please refer to the BERT Application section for details.

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6.5.1.2 Frames Settings

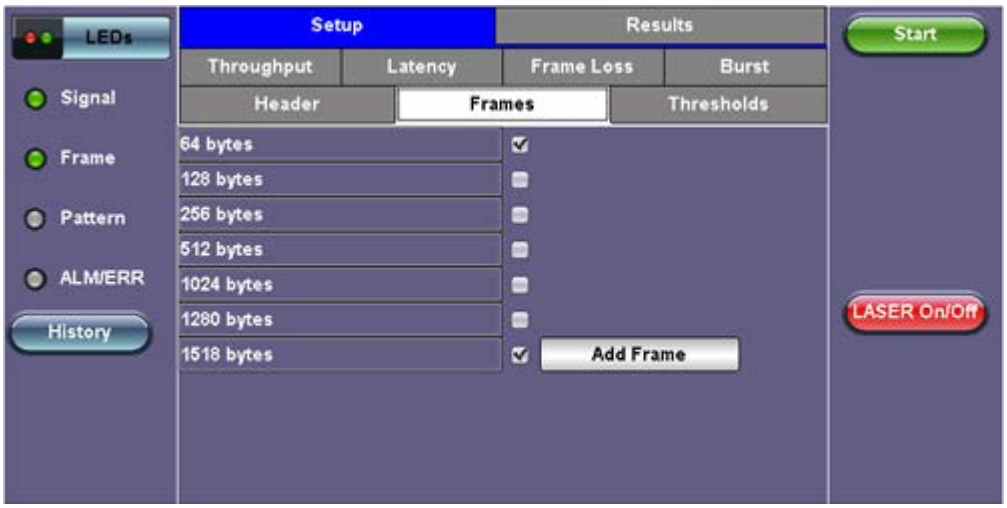
The following can be configured under the Frames tab of the RFC2544 Setup:

- **Preset Frames:** Select from a list of recommended test frame sizes defined in RFC 2544:
  - Test frames are 64, 128, 256, 512, 1024, 1280, and 1518 bytes.
  - The default selected frame is 1518 bytes.
  - To select/deselect any of the recommended test frames, check the box to the right of the desired frame.

- **Add frame:** Two additional user configurable test frames of any size ranging from 64 bytes to 9000 bytes can be added.
  - To add additional test frames, tap the **Add Frame** button.
  - Enter the frame size using the numeric keypad and click apply.

- Press the back button to return to the frames screen.
- The new custom frame size is displayed (it can be enabled or disabled as needed).

RFC2544 Frames Setup



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6.5.1.3 Threshold Settings

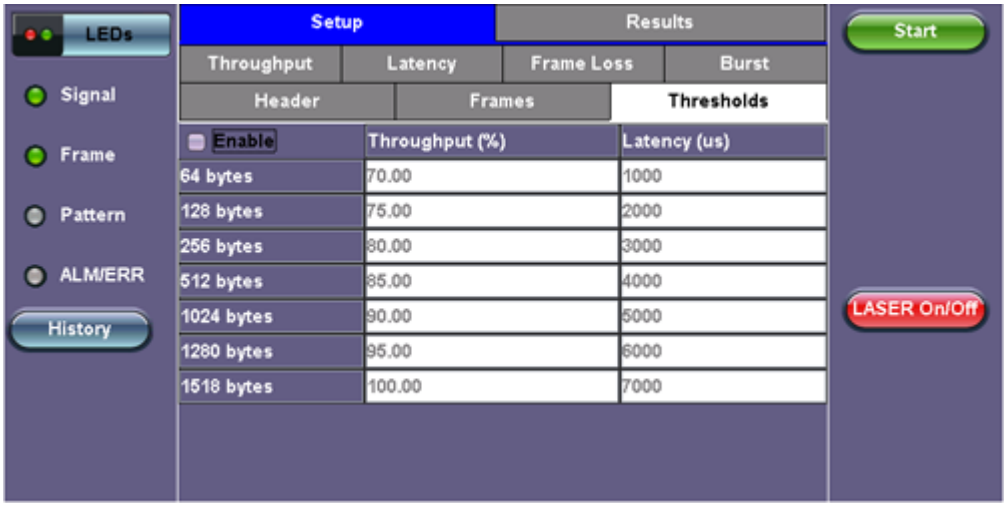
Threshold settings can be enabled or disabled for the throughput and latency tests.

When enabled, threshold settings can be configured for all of the test frames selected in the frame settings tab.

A Pass/Fail criteria will be applied when the threshold settings are enabled. For example, if the throughput threshold value for a 64 byte frame is configured for 80%, then a Pass criteria is assigned if the throughput rate is 80% or better.

The threshold values for Throughput and Latency can be customized per user requirements. Tap on the selected value to edit.

RFC2544 Thresholds Setup



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6.5.1.4 Throughput, Latency, Frame Loss, and Burst Settings

The RFC 2544 test suite allows the user to run all four tests, one of the four tests, or a combination of any of the four tests. The user simply has to enable/disable which tests to perform by checking/unchecking a selection box in the respective tab for each test. By default all four tests are enabled. Throughput test can not be disabled.

The following parameters must be configured before running the RFC 2544 conformance test suite.

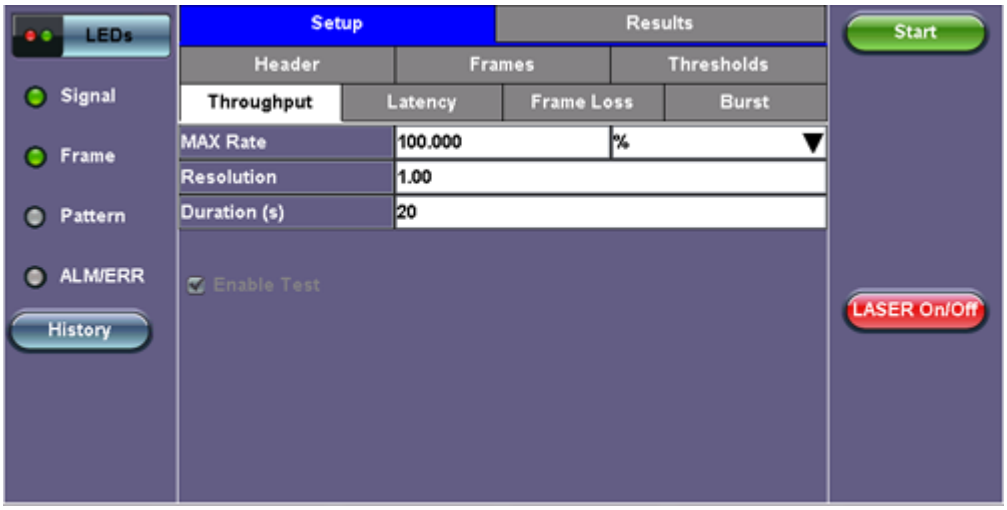
Throughput:

- **Max Rate:** Up to 100% of the negotiated line rate. The default value is 100%.
  - This is the maximum transmit rate to perform the throughput test for each test frame size.
  - This rate may be configured as a % of the total line rate or in Mbps. For example the Max Rate is configured to be 90% and the negotiated line rate of the link is 100Mbps, then the maximum transmit rate will be 90Mbps or 90% of the line rate.

- **Resolution:** Input any value between 0.001% and 1%. The default value is 1%. Resolution refers to the resolution in searching for the throughput rate. If 1% is selected, the throughput rate will be searched with ±1% accuracy.

- **Duration:** 5 to 999 seconds. The default value is 20 seconds.
  - The duration is the amount of time the throughput test is run for, for each frame size at a given rate.

RFC2544 Throughput Settings



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Latency: The following parameters can be configured:

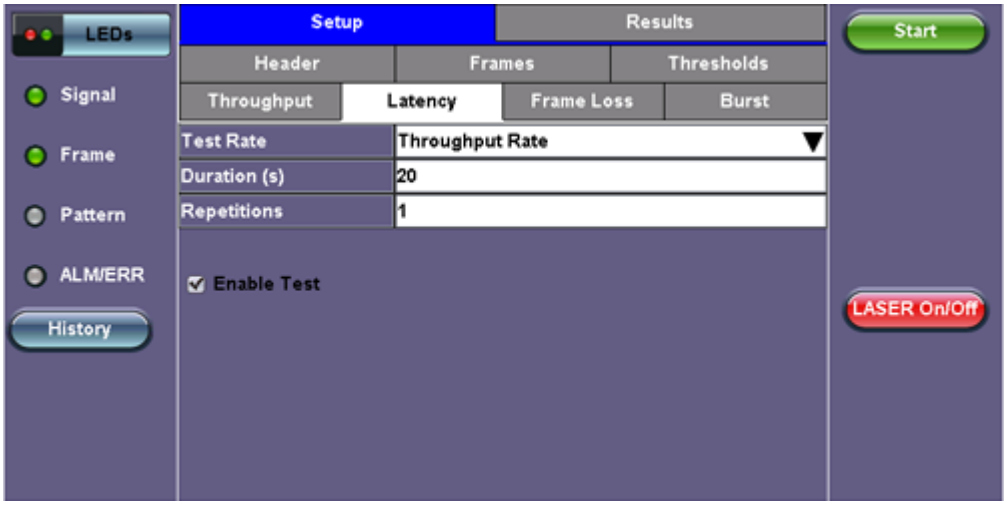
- **Test Rate:** Throughput Rate or Custom Rate. The default value is Throughput.
  - **Throughput rate**: Latency test will be performed at the Throughput rate found for each of the tested frame sizes.
  - **Custom rate:** A custom rate in % or Mbps can be configured.

- **Rate:** Only available if Custom Rate is selected. Enter up to 100% of the negotiated line rate or enter the rate in Mbps.

- **Duration:** 5 to 999 seconds. The default value is 20 seconds.
  This is the amount of time that the latency test will be performed for each test frame size.

- **Repetitions:** 1 to 100. The default value is 1.
  This is the amount of times that the latency test will be repeated for each test frame size.

RFC2544 Latency Settings



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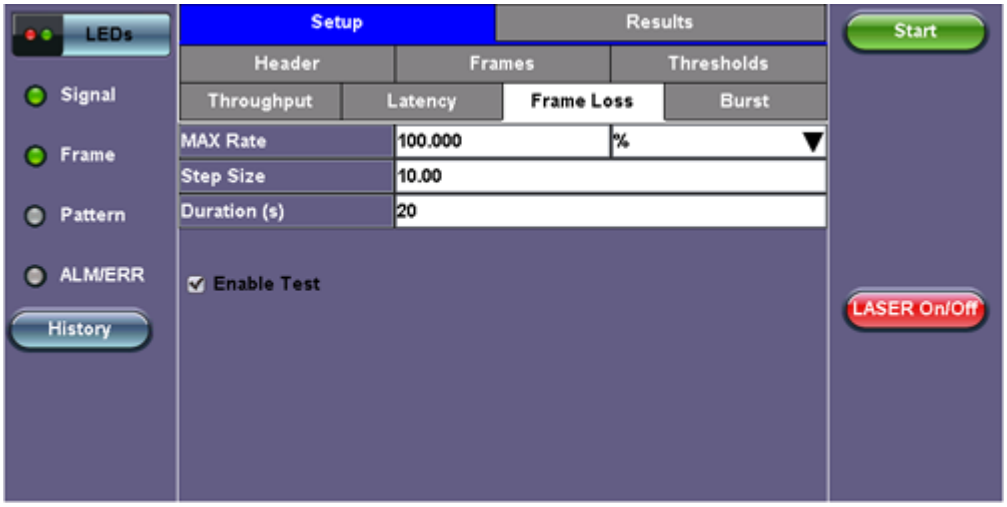
Frame Loss: The following parameters can be configured:

- **Max Rate:** Up to 100% of the negotiated line rate. The default value is 100%.
  This is the maximum transmit rate to perform the frame loss test for each test frame size. The user may configure this rate as a % of the total line rate or in Mbps. For example if the user configures the Max Rate to be 90% and the negotiated line rate of the link is 100Mbps, then the maximum transmit rate will be 90Mbps or 90% of the line rate.

- **Step Size:** 1 to 10%. The default value is 10%.
  The step size is the rate % that the frame loss test will be reduced by in the event of any frame loss. For example if the Max Rate is 100Mbps (or 100%) and frames are lost at this rate, then the transmit rate will be reduced to 90Mbps (or 90%). The frame loss test will now be performed at the new rate until there is zero frame loss at two consecutive rate settings. This means that the test will have to be performed at 80% (assuming that there was zero frame loss at 90%).

- **Duration:** Selectable in the range 5 to 999 seconds. The default value is 20 seconds.
  The duration is the amount of time the throughput test is run for, for each frame size at a given rate.

RFC2544 Frame Loss Settings



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Burst (Back-to-Back): The following parameters can be configured:

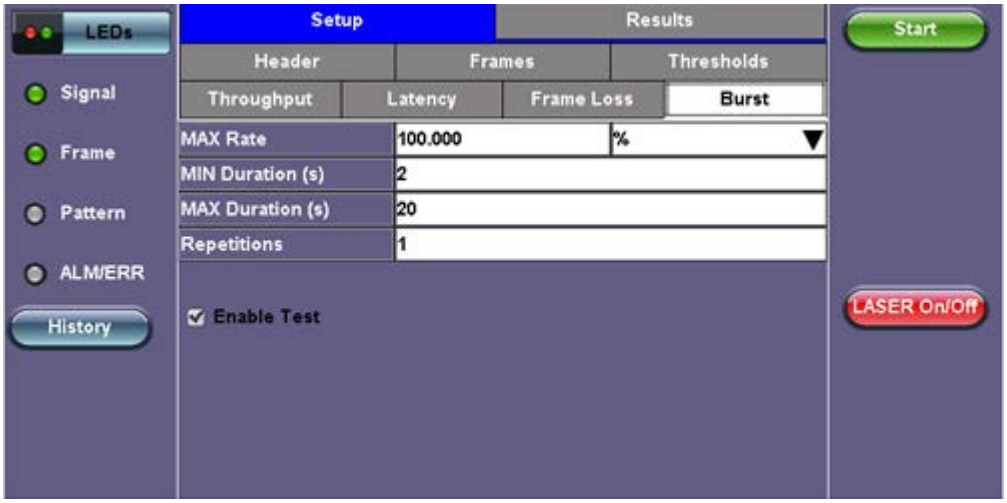
- **Max Rate:** The default value is 100%.
  In the burst test, frames are always transmitted at the maximum rate for a given minimum and maximum burst duration.

- **Minimum Duration:** Selectable in the range 2 to 999 seconds. Default value is 2 seconds.
  This is the duration of the first burst.

Maximum Duration: Selectable up to 999 seconds. The default value is 20 seconds.
This is the duration of the second burst, which must be greater than the minimum burst.

- **Repetitions:** Selectable in the range 1 to 100. The default value is 1.
  This is the amount of times that the burst test will be repeated for each test frame size.

RFC2544 Burst Settings



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6.5.1.5 Starting/Stopping a RFC 2544 Measurement

Once all configurations have been made, tap the **Start** button on the right section of the screen to start the measurements.

Note: If testing on the fiber ports, make sure the LASER is turned On before starting the test.

The selected tests will run automatically. When all the tests are complete the test will stop automatically. If the RFC 2544 test suite needs to be stopped before they are done, then simply tap the **Stop** button. The status of each selected test can be seen in the Results tab.

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6.5.2 Results

The progress and current result of the RFC 2544 can be viewed as the test is in progress.

Navigate the respective sub-tabs (throughput, latency, frame loss, or burst) to view the results for each test. For the burst test, the results can be viewed in summary table format or test log format.

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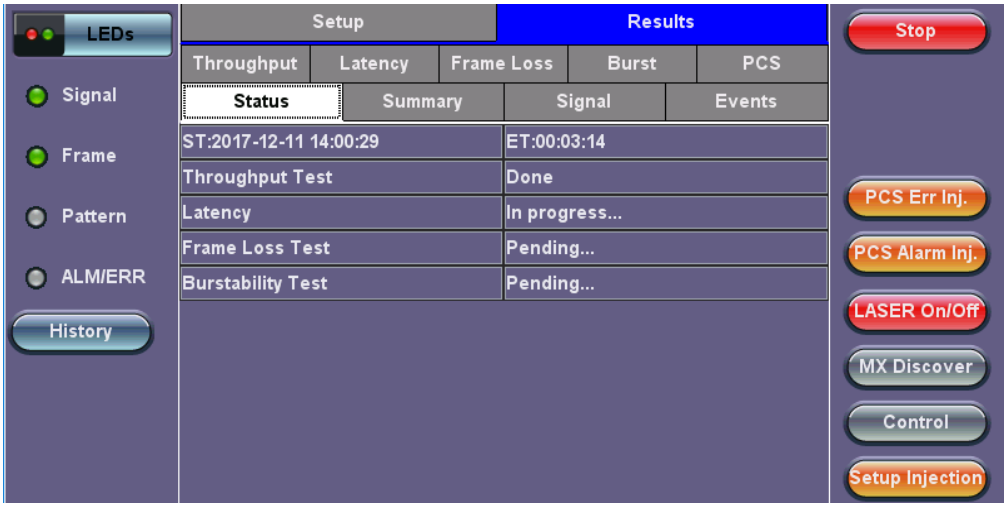
6.5.2.1 Status: The status of each test is displayed including a stamped log of each test.

RFC2544 Results Status



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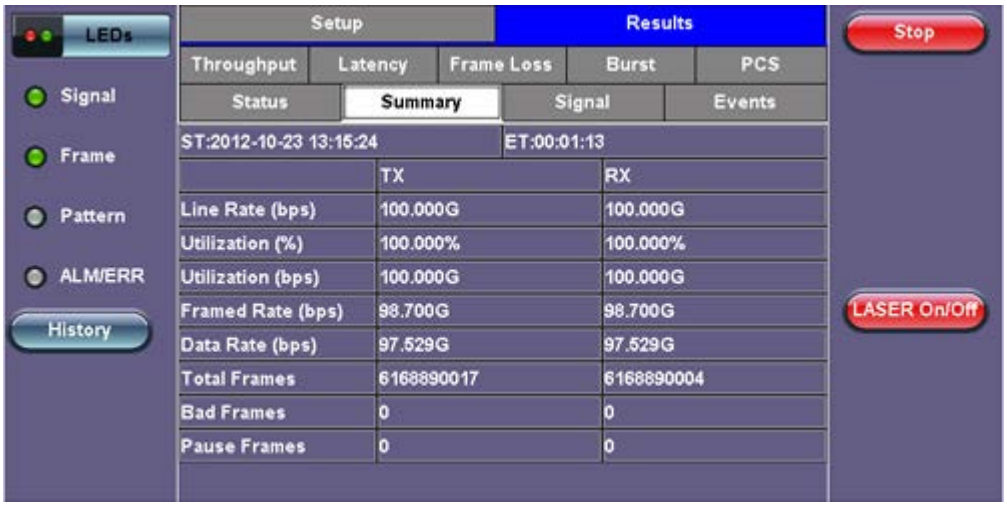
6.5.2.2 Summary: The following results including the Start (ST) and Elapsed (ET) times are displayed:

- **Line Rate (bps):** Negotiated rate of the interface (10M, 100M, or 1000M). This value is always fixed since it depends on the maximum capacity of the link under test, hence the test interface that is configured.
- **Utilization:** % of Line Rate. For example, if we transmit 100Mbps on a 1Gbps interface then the utilization value is 10% (or 100Mbps) of the total link capacity (or Line Rate).
- **Utilization (bps)**
- **Framed Rate:** (Payload + MAC/IP Header + VLAN Tag + Type/Length + CRC) / (Payload + Total Overhead) * Line Rate % (in Mbps).
- **Data Rate:** Payload / (Payload + Total Overhead) * Line Rate %.
- **Total Frames**
- **Bad Frames**
- **Pause Frames:** Total number of transmitted and received ethernet pause flow-control frames.

RFC 2544 Results Summary



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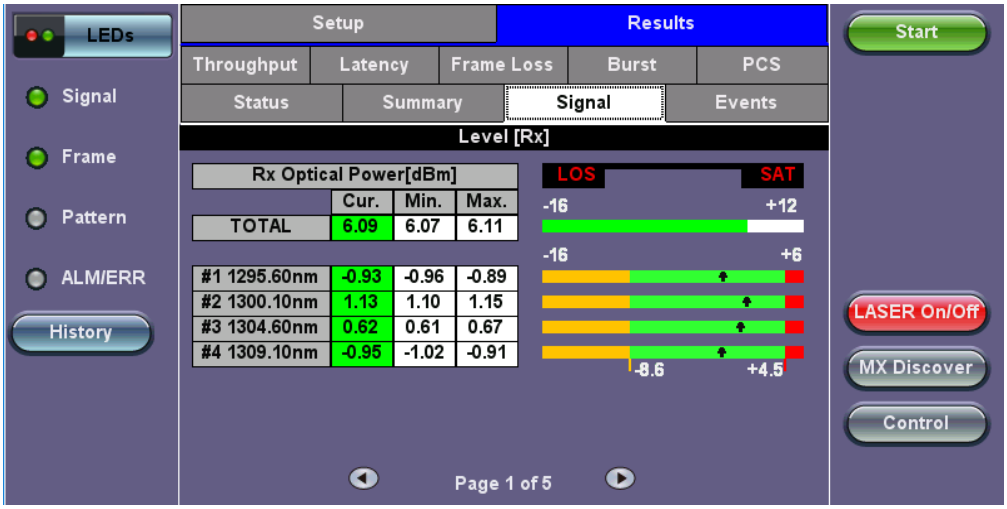
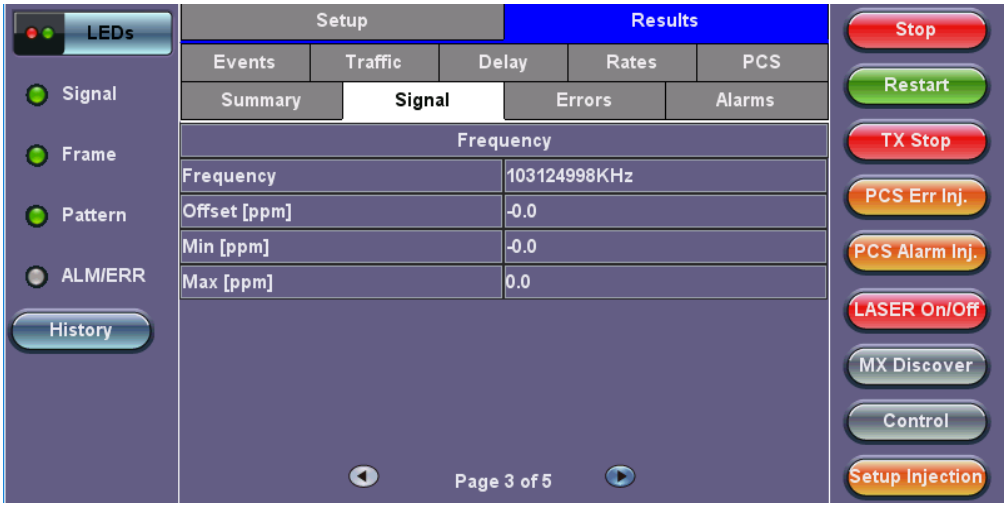
6.5.2.3 Signal: The Signal tab displays the optical level measured by the CFP2 or QSFP+ transceiver.

RFC2544 Results Signal Page 1

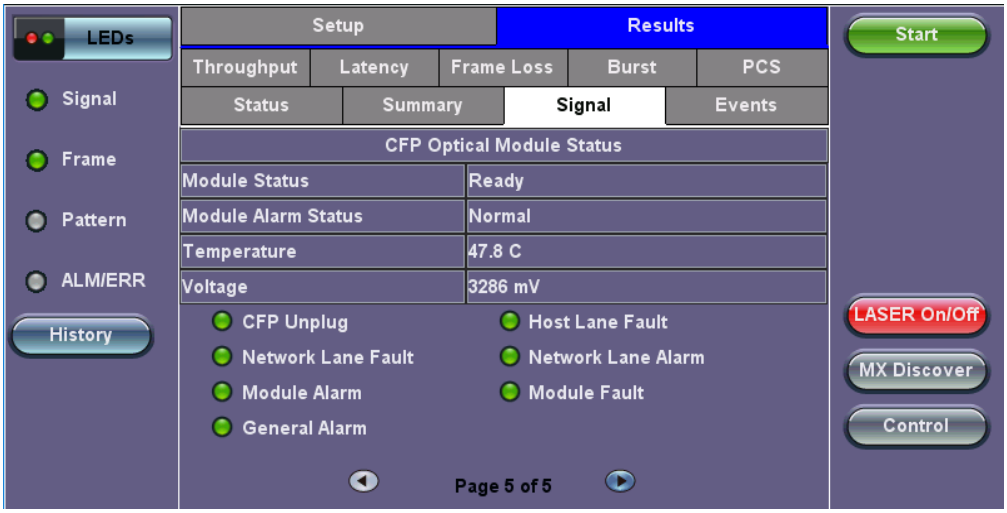


RFC2544 Results Signal Page 3



RFC2544 Results Signal Page 4

Signal (Page 5) - CFP Optical Module Status



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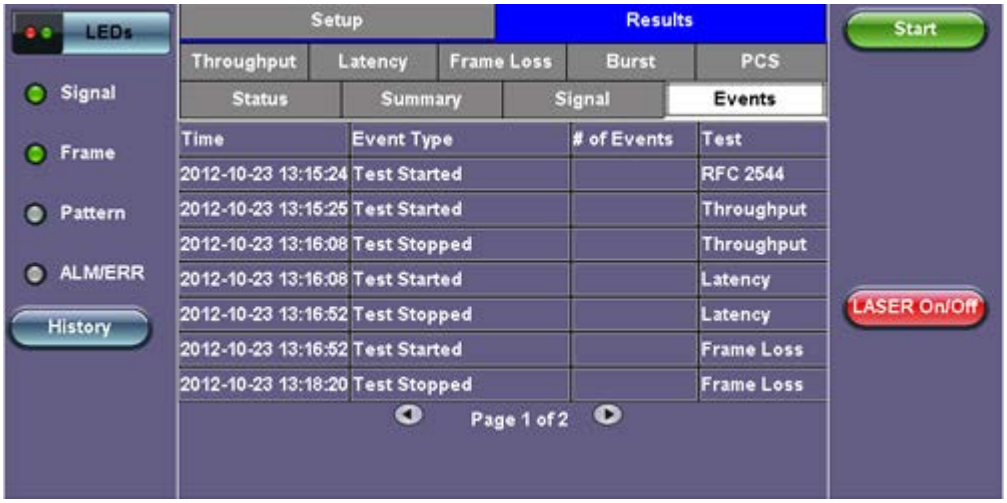
6.5.2.4 Events: A time stamped log of each test is displayed.

RFC 2544 Results Events



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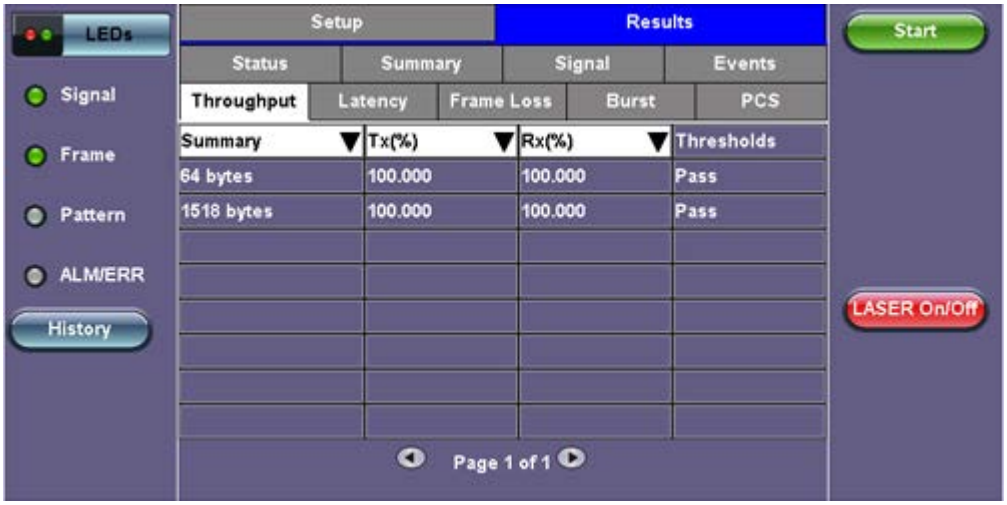
6.5.2.5 Throughput:

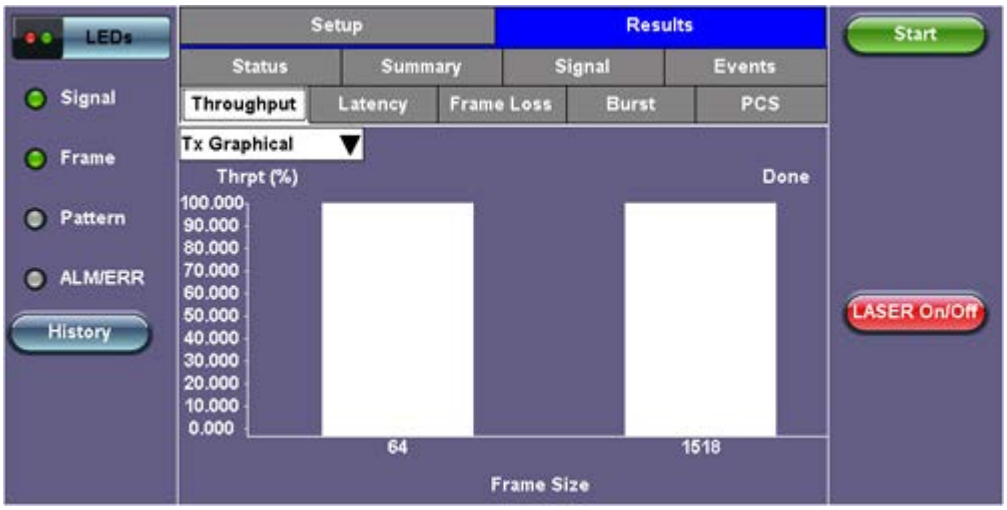
The Throughput tab displays the maximum throughput rate of the link under test. Results are displayed in graphical and table formats. Use the drop-down menu to change the display format.

- **Graphical:** Throughput results are displayed in a bar graph form
- Summary table and test log table display:
  - byte size
  - **Tx(%):** Percentage of test frames transmitted by the unit
  - **Rx(%):** Percentage of test frames received by the unit
  - **P/F:** Pass/Fail test status determined by test criteria set in the Threshold tab

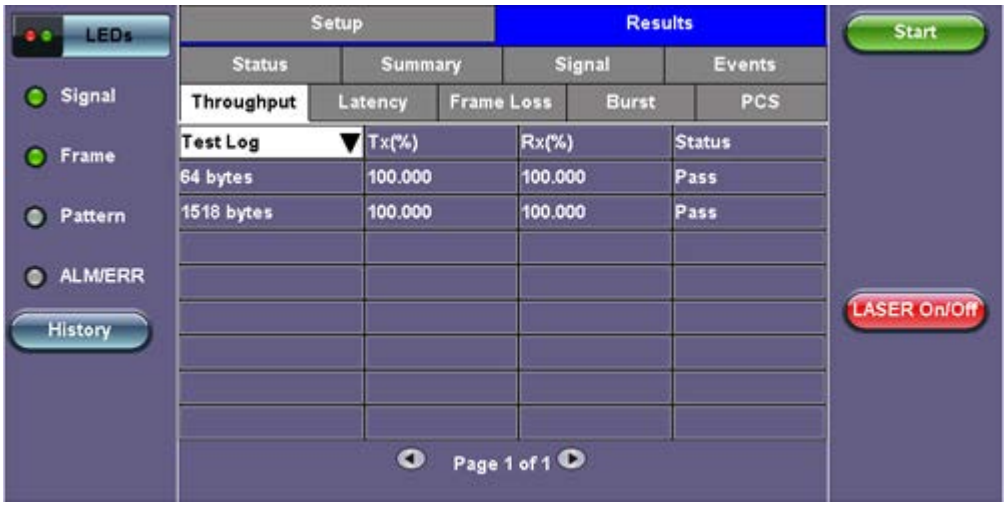
RFC2544 Results Throughput Summary



RFC2544 Results Throughput Tx Graphical



RFC2544 Results Throughput Test Log



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6.5.2.6 Latency and Jitter

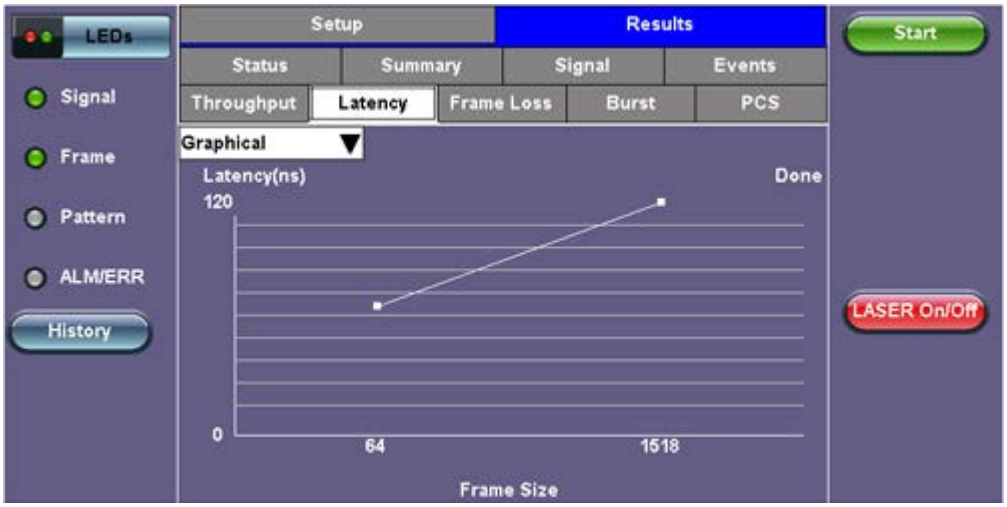
Latency and frame jitter measurements results are displayed under the Latency tab in the following formats:

- **Graphical:** Latency results displayed in line graph form (Latency [us] vs Frame size [bytes]).
- **Summary** and **Test Log** tables display:

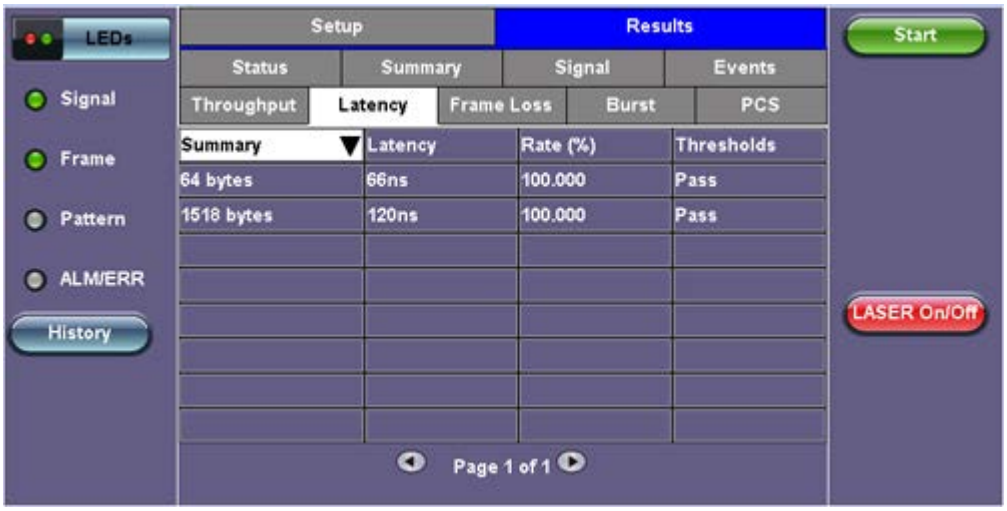
- byte size
- **Latency (us):** Round trip delay latency.
- **Rate (%):** Percentage of frames transmitted. Data rate used for latency test.
- **Pass/Fail** test status.

Use the drop-down menu to select the Latency format.

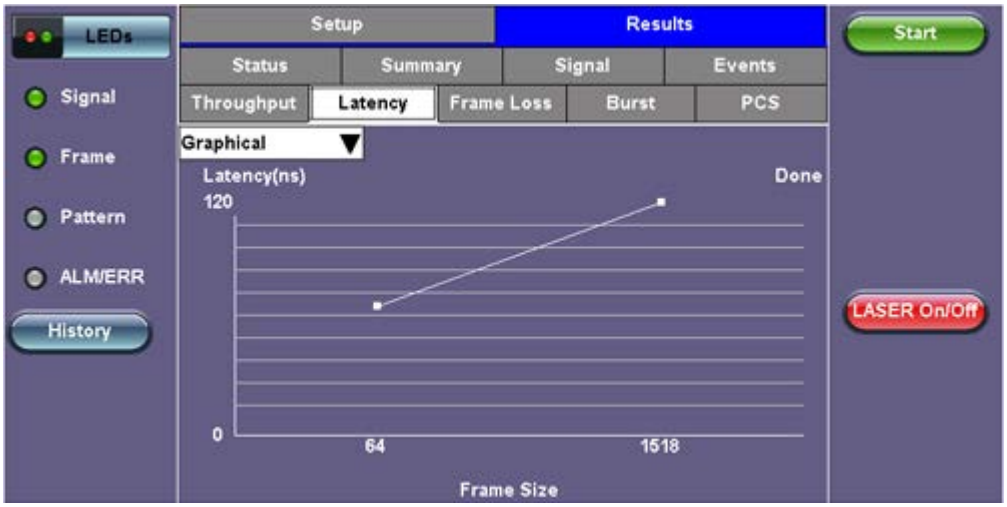
RFC2544 Latency Results Graphical



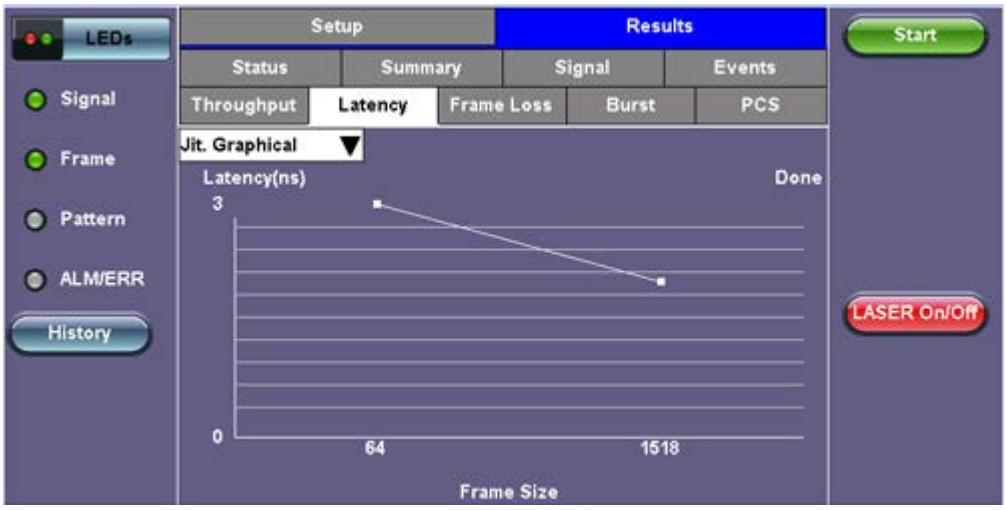
RFC2544 Latency Results Summary



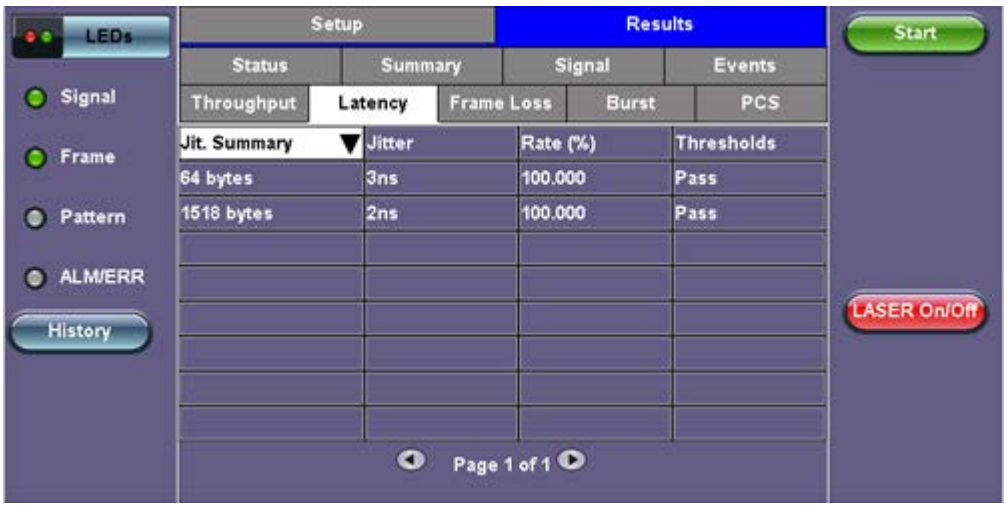
RFC2544 Latency Results Test Log



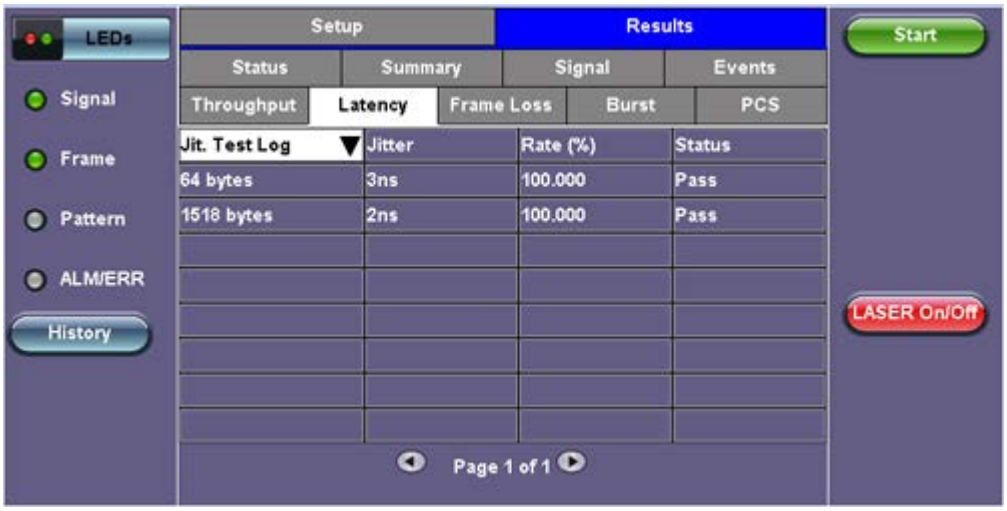
RFC2544 Jitter Results Graphical



RFC2544 Jitter Results Summary



RFC2544 Jitter Results Test Log



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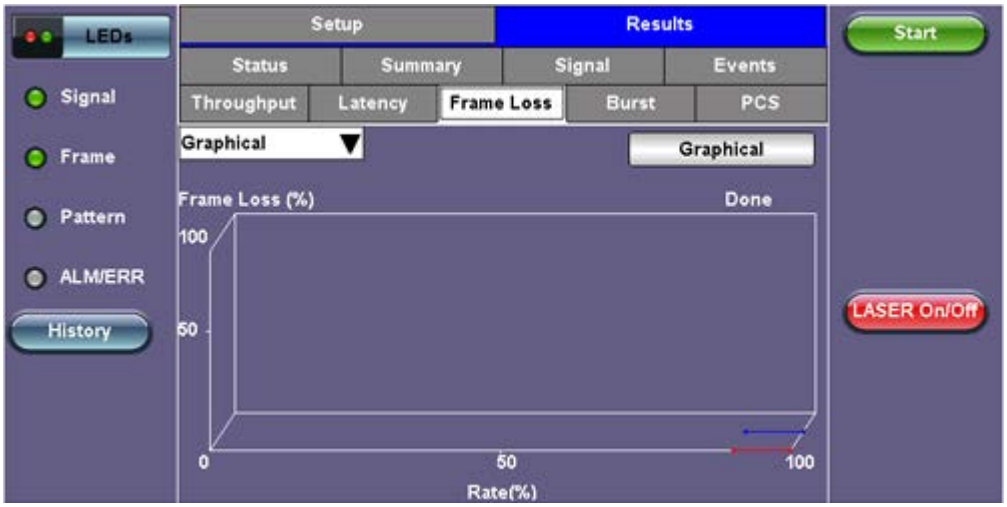
6.5.2.7 Frame Loss

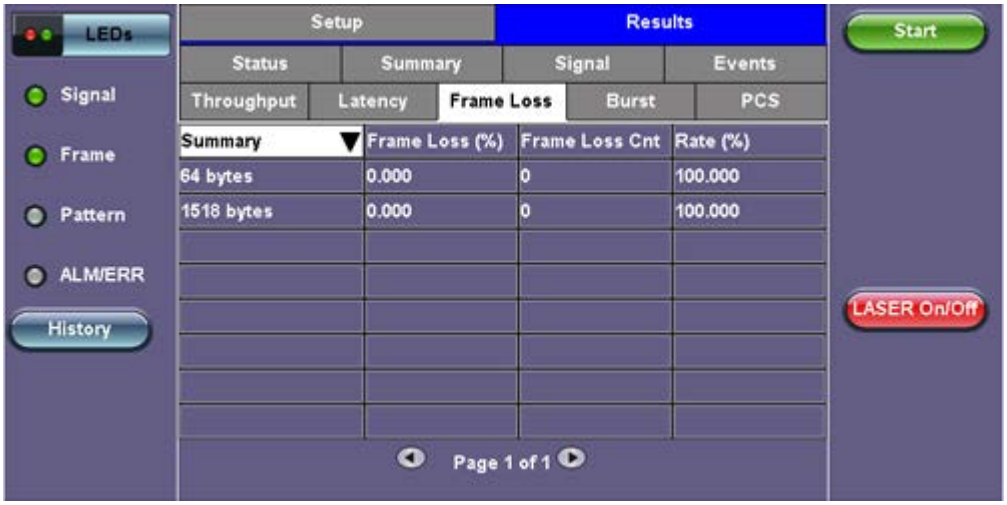
Frame loss displays the percentage of frames not received. Use the drop-down menu to select the Frame Loss format:

- Summary and Test log tables display test frame length, byte size, **frame loss (%)** from received traffic, and **rate (%)** transmitted.
- **Graphical:** Frame Loss displayed in line graph form (Frame size [bytes] vs Rate [%]). Tap the **Graphical** button to see the legend.

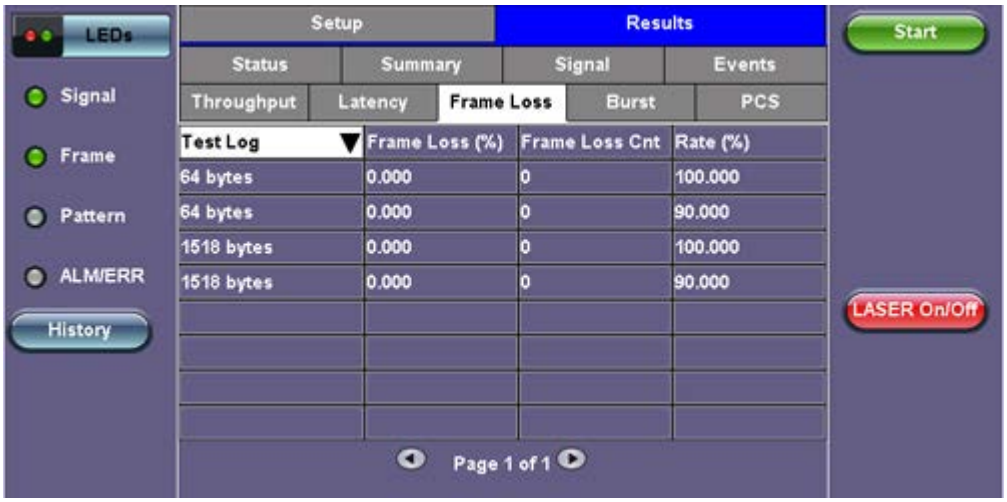
RFC2544 Results - Frame Loss Graphical



RFC2544 Results - Frame Loss Summary



RFC2544 Results - Frame Loss Test Log



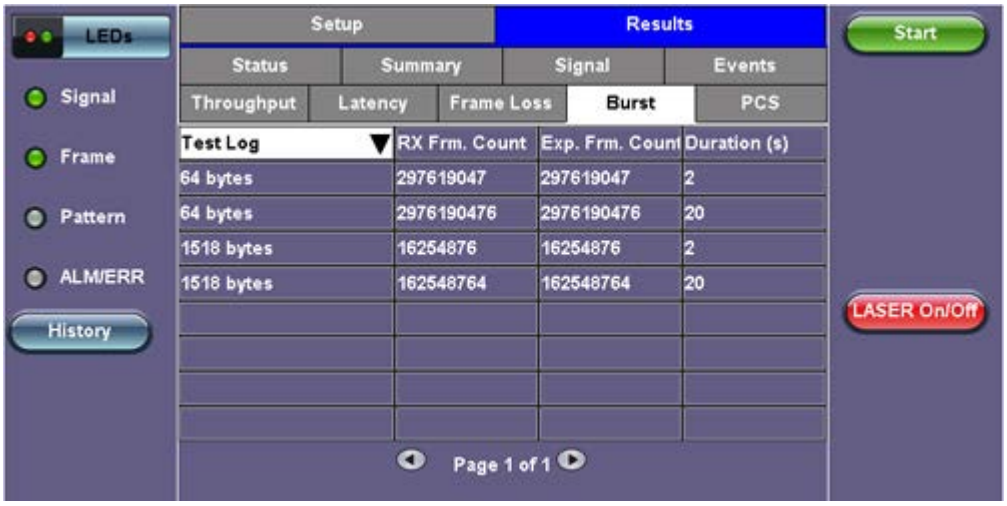
6.5.2.8 Burst

Burstability (back-back) results are the number of frames successfully transmitted/received at the line rate. It is displayed in the following formats:

- **Summary table:** Displays **Average Frame Count** received for each test frame length
- **Test log table:** Displays **Average Frame Count** and **Duration** (seconds) for each test frame length

RFC2544 Results - Burst Summary

RFC2544 Results - Burst Test Log



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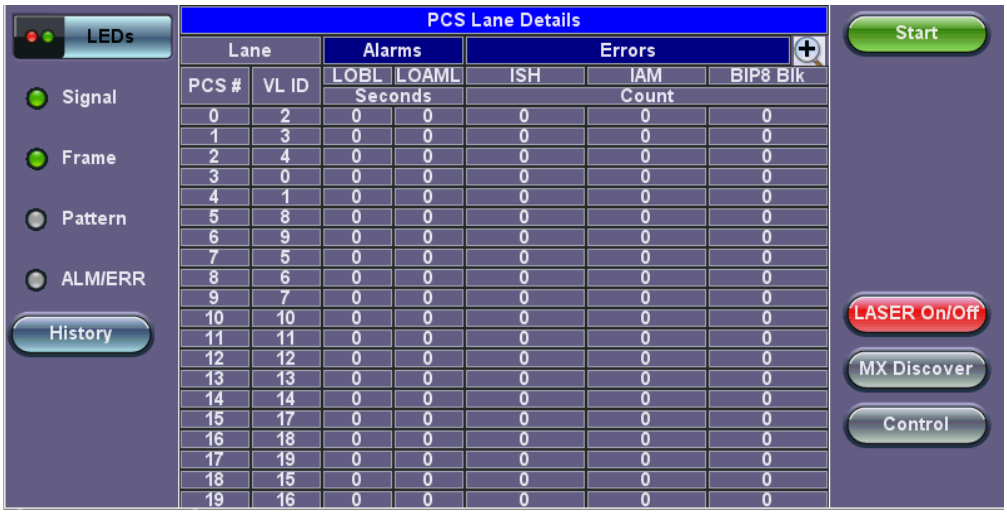
6.5.2.9 PCS

- **HI-BER:** high bit error rate of sync header
- **LOA:** Loss of Alignment marker
- **LOBL:** Loss of block lock
- **Invalid Sync header:** first 2 bits of the 64/66 block header
- **Invalid alignment marker:** inserted every 16383 block on each virtual lane it contains the Virtual lane identifier
- **BIP:** generates bit interleave parity error

RFC2544 Results - PCS

RFC2544 Results - PCS Lane Details



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6.5.3 Saving RFC 2544 Results

Once the test has been stopped the results can be saved by pressing the **Save** key on the platform's keypad.

A window will open giving the option of naming the results file. Enter the desired name for the file and tap apply. The results will be saved.

RFC2544 Results Save

Once the results are saved, they can be viewed, renamed, or exported to USB in the **Utilities** > **Files** > **Saved** section. Refer to the **File Manager** section in the RXT1200, TX300S, or UX400 Platform manual for more information on managing saved test results.

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6.6 V-SAM

Overview

V-SAM (VeEX Service Activation Methodology) is an automated Ethernet service activation test feature conforming to the ITU-T Y.1564 standard, created to address and solve the deficiencies of RFC 2544:

• RFC 2544 was limited to test at the maximum throughput line rate for a single service. SAM is able to run multiple services on a single 10/100/1000 or 10G Ethernet line at a bandwidth ranging from 0 to the line rate, allowing for more realistic stream testing

• The Frame Delay Variation, also known as (packet) jitter was not included in RFC 2544. Jitter is a critical parameter for real time voice and video services. It is now part of the SAM test suite.

• RFC 2544 validates the service parameters like frame loss, throughput and latency, one after the other, while SAM allows testing all the service critical parameters simultaneously. This results in significant time saving compared to RFC 2544.

Comparison of RFC 2544 and Y.1564

	RFC2544	Y.1564
Key Test Objective	Device performance	Network Service verification/activation
Service validation	One service at a time	Multiple services simultaneously
Throughput	Yes	Yes
Latency	Yes	Yes
Frame Loss	Yes	Yes
Burstability	Yes	Yes
Packet Jitter	No	Yes
Multiple Streams	No	Yes
Test Duration	Long (serialized test procedure)	Short (simultaneous test/service)
Test Result	Link performance limit	Related to SLA, fast, simple, Pass/Fail

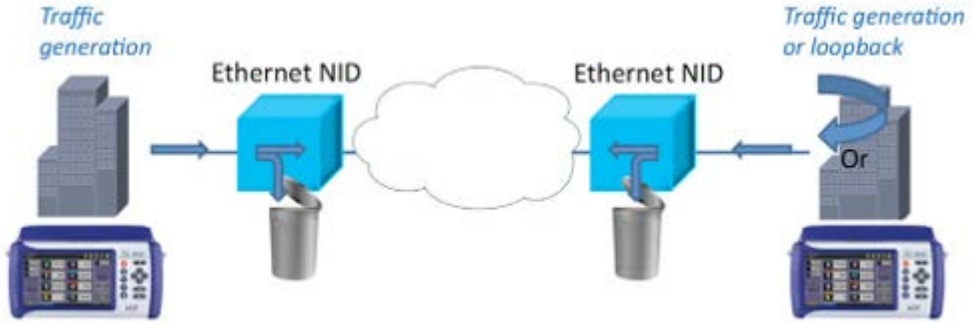
Test Methodology

The purpose of the SAM test suite is to verify that the service is compliant to its Bandwidth Profile and Service Acceptance Criteria. The test is broken down into two phases:

- **Phase 1: Service Configuration test**: The services running on the same line are tested one by one to verify the correct service profile provisioning.

- **Phase 2: Service Performance test**: The services running on the same line are tested simultaneously over an extended period of time, to verify network robustness.

Test Application



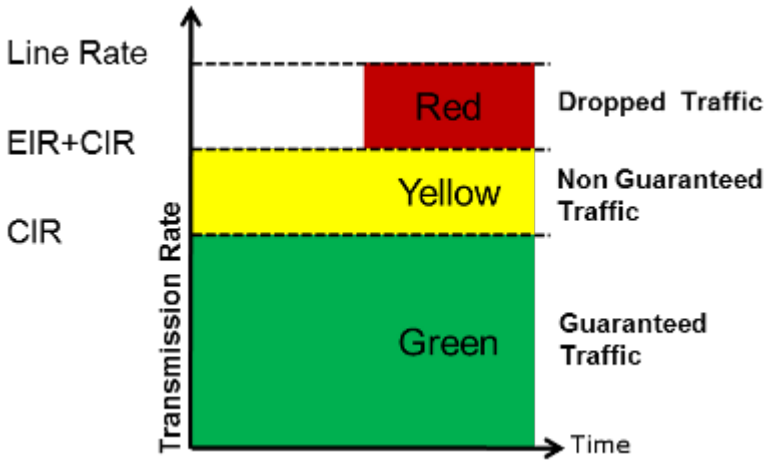
Phase 1: Service Configuration Test

The service configuration test is broken down into three steps. The steps are tested individually for all the services delivered on the same line.

- **Step 1: Committed Information Rate (CIR) Test**: Traffic is transmitted at the CIR for a short period of time and the received traffic is evaluated against the Service Acceptance Criteria (FLR, FTD, FDV) measured simultaneously. The CIR test passes if the measurements on the received traffic stay below the performance objectives.
- **Step 2: Excess Information Rate (EIR) Test**: Traffic is transmitted at the CIR+EIR rate for a short period of time; the EIR test passes if the received traffic rate is between the CIR (minus the margin allowed by the FLR) and CIR+EIR.

- **Step 3: Traffic Policing (Overshoot Test)**: The purpose of the Traffic Policing Test is to ensure that when transmitting at a rate higher than the allowed CIR+EIR, the excess traffic will be appropriately blocked to avoid interference with other services. For this test, traffic is transmitted at 25% higher than the CIR+EIR for a short period of time. The test passes if the received traffic rate is at least at the CIR (minus the margin allowed by the FLR) but does not exceed the allowed CIR+EIR.
- At this time the **Committed Burst Size (CBS)** and **Excess Burst Size (EBS)** tests are considered experimental and not an integral part of the standard.

Service Bandwidth Profile



Phase 2: Service Performance Test

Services running on the same line are tested simultaneously over an extended period of time, to verify network robustness. Service Acceptance Criteria (SAC) including Frame Transfer Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR) and Availability (AVAIL) are verified for each service.

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6.6.1 V-SAM Setup

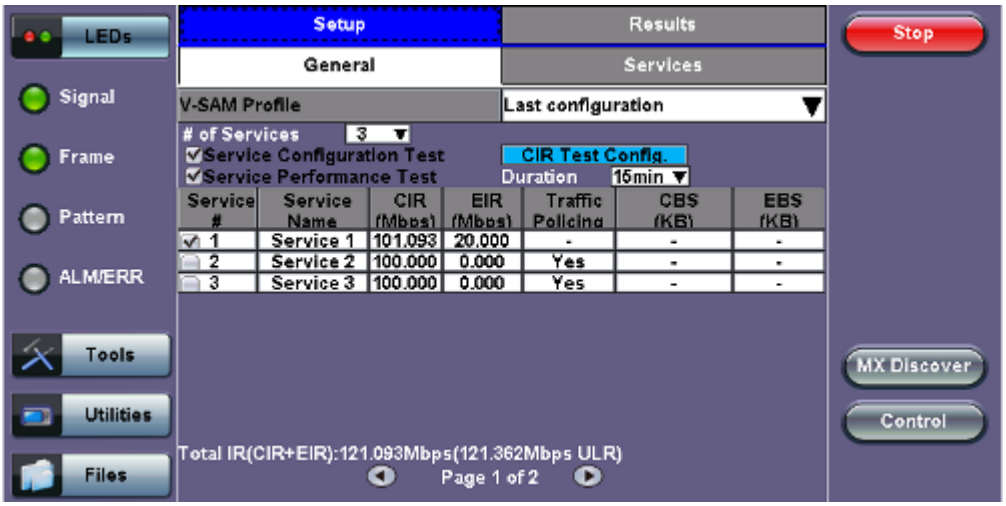
General (Page 1 and 2)

- **V-SAM Profile:** Delete, Save, Save as..., Default, or Last Configuration.
- **# of Services:** Select the number of services to run. Up to 8 services can be chosen for a 1 GE interface and up to 10 services can be chosen for a 10 GE interface.
- **Display:** ULR or IR. See the Service Attributes section for more information.
- **Service Configuration Test:** Enable or Disable the configuration test.
- **Service Performance Test:** Enable or Disable the performance test.
- **Service Configuration** and **Performance Tests** can be enabled independently.
- **CIR Test Config:** Tap on the box to configure the Committed Information Rate Test on another screen.
- **Duration:** Select the **Service Performance Test** duration. Options are 15min, 30min, 1hr, 2hr, 24hr or user defined. If user-defined is selected, input a duration between 1-10000 min.

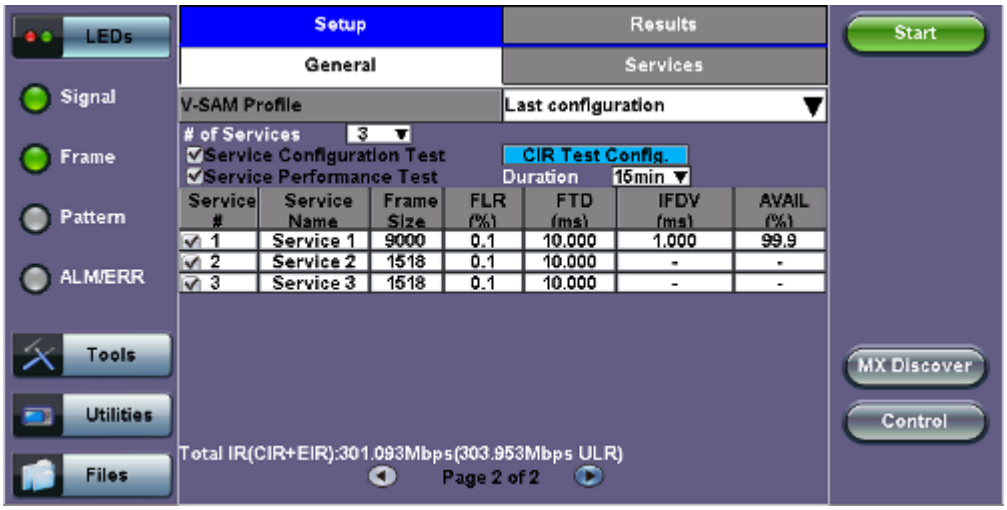
Enabling/Disabling Tests

A check next to the Service number in the Service Summary table indicates that the test for the corresponding service is set to run. Tap on the box to remove the check and cancel the test for that service.

V-SAM - Setup - General (Page 1)



V-SAM - Setup - General (Page 2)



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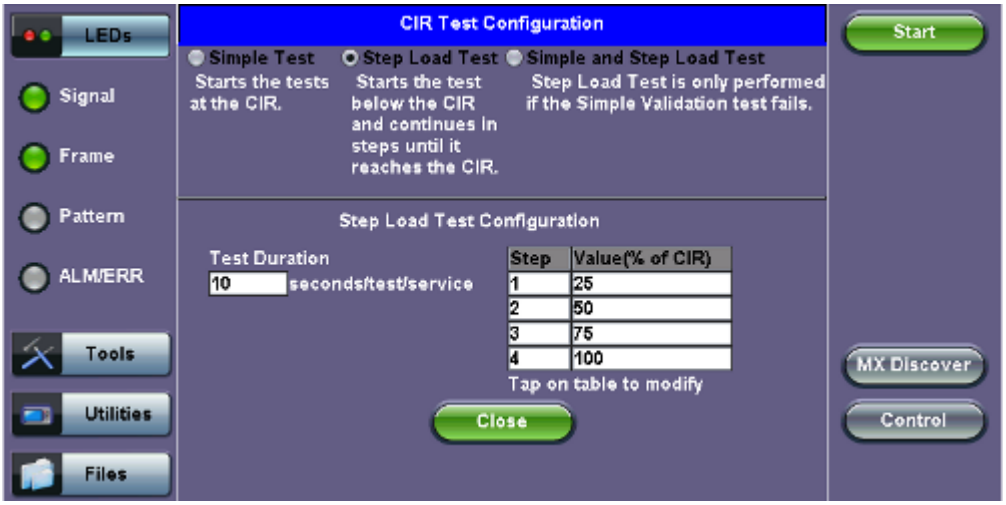
CIR Test Configuration

- **CIR Test Config.:** Select Simple Test, Step Load Test, or Simple and Step.
  - **Simple Test:** Starts the tests at the CIR.
  - **Step Load Test:** Starts the test below the CIR and continues in steps until it reaches the CIR.
  - **Simple and Step Load Test:** Step Load Test performs only if the Simple Validation test fails.
- Tap on the **Test Duration** box to input a test duration (test duration must be less than 999 sec).
- Tap on the table to modify the CIR value percentage for each step.

CIR Test Config



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6.6.1.1 Header Settings

- **Service #:** Select a service to configure
- **Service Name:** Assign a name to the service if desired.
- **Frame Size Type:** Fixed or EMIX (1GE only). A fixed frame size is chosen as default
- **Frame Size:**
  - **For Fixed Traffic Flow:** Input a fixed frame size within the range of 64-10000 bytes by tapping the value box.
  - **For EMIX (1GE only):** The default value is abceg. Tap the zoom (magnifying glass) icon to define other values. Select the values from the drop down lists on the next screen.
    Note: *Any EMIX configuration of 5 frames is allowed.*
- **Encapsulation Type:** None, Provider Backbone Bridge (PBB-TE), or Multiprotocol Label Switching (MPLS-TP). MPLS-TP is a simplified version of MPLS. Provider Backbone Bridge MAC-in-MAC (IEEE 802.1ah) encapsulation are configured trunks that add resiliency and configurable performance levels in the provider backbone network. Both options are available for 1GE Copper/Fiber and 10GE port for all Ethernet tests (Layer 2,3 and 4) - BERT, RFC2544, Throughput, V-SAM.

  Tap the PBB or MPLS-TP block to configure the settings. All fields are configurable.

  PBB:

  - Backbone MAC Source
  - Backbone MAC Destination
  - Ethernet Type
  - I-SID
  - VLAN ID, Priority, Type

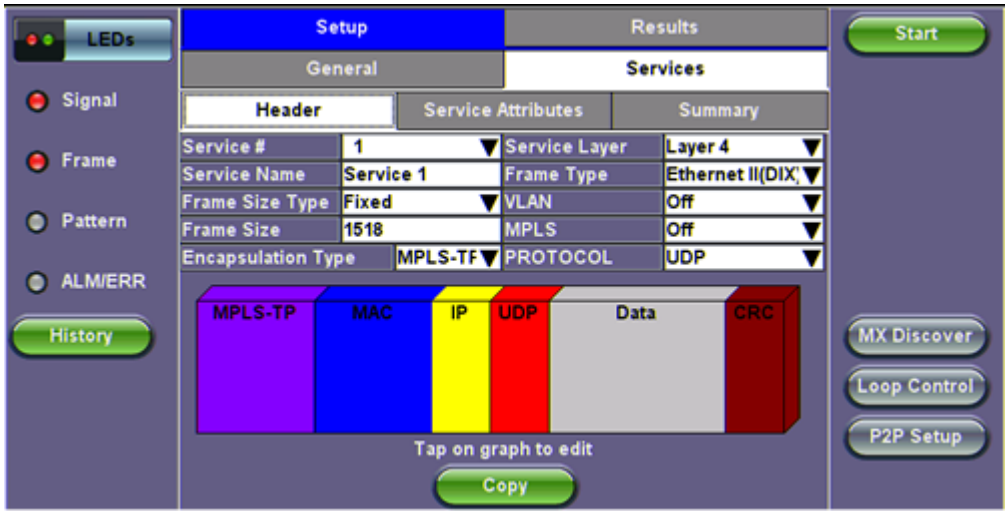
  MPLS-TP:

  - MPLS-TP MAC Source

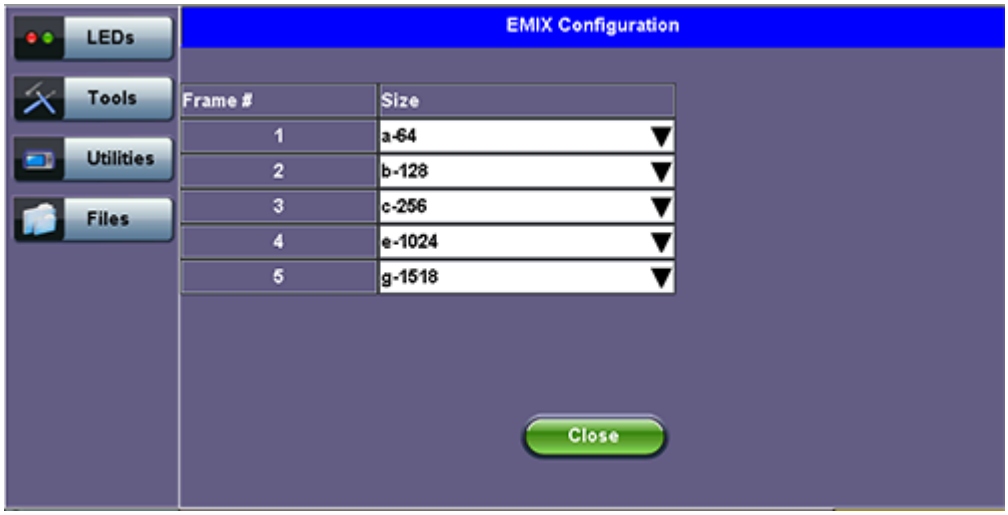
- MPLS-TP MAC Destination
- Ethernet Type
- VLAN ID, Priority, Type
- LSP, PW, CW

After making changes, tap **Apply to All**, for MPLS-TP configuration.
Please see RFC 2544 Setup and follow the setup procedure to configure the remaining Header Settings for V-SAM.

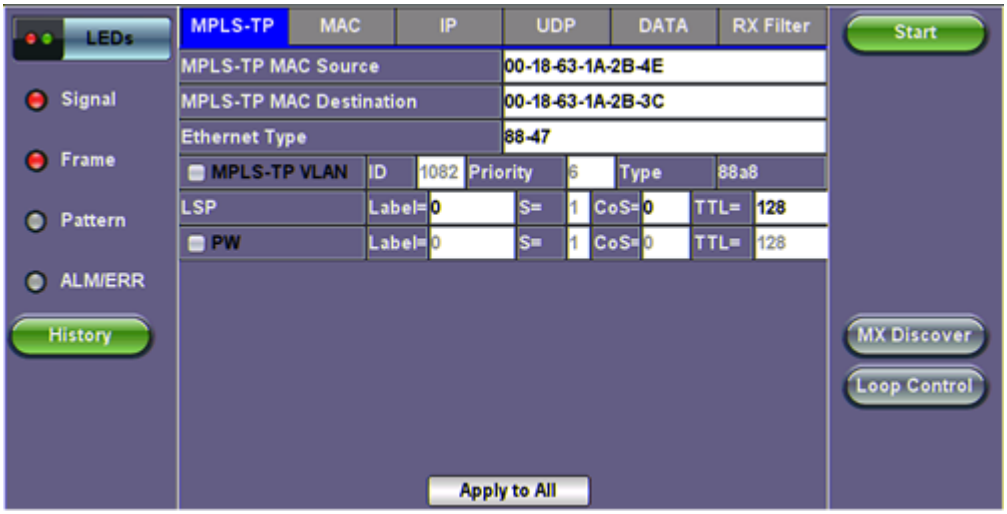
V-SAM Setup - Services - Header Settings



V-SAM Setup - Services - EMIX Frame Size Settings



V-SAM Setup - Services - MPLS-TP Settings



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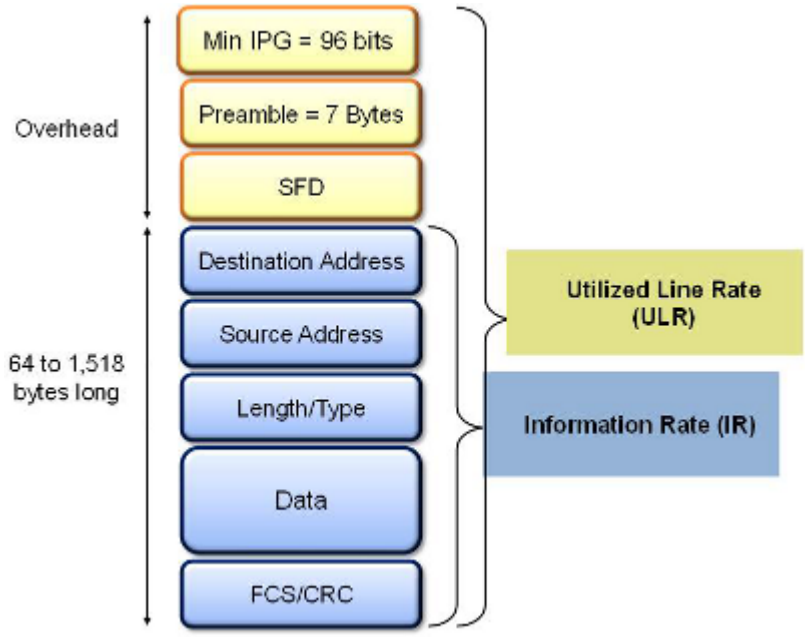
6.6.1.2 Service Attributes

Bandwidth Profile Parameters

The Bandwidth Profile specifies how much traffic the customer is authorized to transmit and how the frames are prioritized within the network. In the Bandwidth table, the user specifies the following bandwidth criteria:

- **CIR:** Committed Information Rate. This is the guaranteed maximum rate at which the customer can send frames that are assured to be forwarded through the network without being dropped. Tap on the box to enter a rate and choose between **IR Mbps** or **ULR Mbps**. Allowed values range from 0.01Mbps to the line bandwidth.
  - **Information Rate (IR):** Measures the average Ethernet frame rate starting at the MAC address field and ending at the CRC.
  - **Utilized Line Rate (ULR):** Measures the average Ethernet frame rate starting with the overhead and ending at the CRC.

V-SAM Services - Header

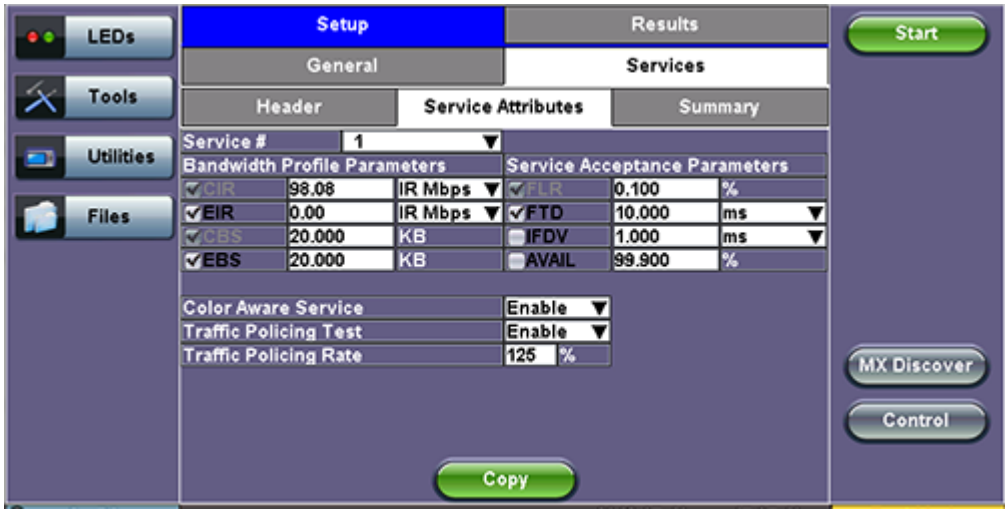


- **Excess Information Rate (EIR):** Maximum rate above the CIR at which the customer can send frames that will be forwarded on a best effort basis, but may be dropped in the event of congestion within the network. The combined CIR and EIR must not exceed the line bandwidth. Traffic beyond CIR + EIR will be dropped when it enters the carrier's network. Tap on the box to enter a rate. EIR is expressed in terms **IR Mbps** or **ULR Mbps**. Select a term to express EIR or select **Disable** to disable the test.
- **Traf. Policing:** Enable or Disable the traffic policing test. For this test, traffic is transmitted at 25% higher than the

CIR+EIR. The Policing test fails if the higher traffic rate is allowed through the network.

- **Color Aware:** Enable, Disable. When Color Aware is enabled, the Drop Eligible parameter in the VLAN header configuration screen is not available for configuration. If no VLAN is configured for the service traffic, the Color Aware parameter is ignored.
- **CBS** and **EBS**: Committed Burst Size (CBS) and Excess Burst Size (EBS).
  - CBS can be enabled without enabling EBS
  - If EBS is enabled, then CBS is automatically enabled too
  - Values between 4 KBytes and 100 KBytes can be input for both CBS and EBS

V-SAM Setup - Services - Service Attributes



Enabling/Disabling Tests

A check next to the parameters in the Service Attributes table indicates that the test for the corresponding service is set to run. Tap on the box to remove the check and cancel the test for that service.

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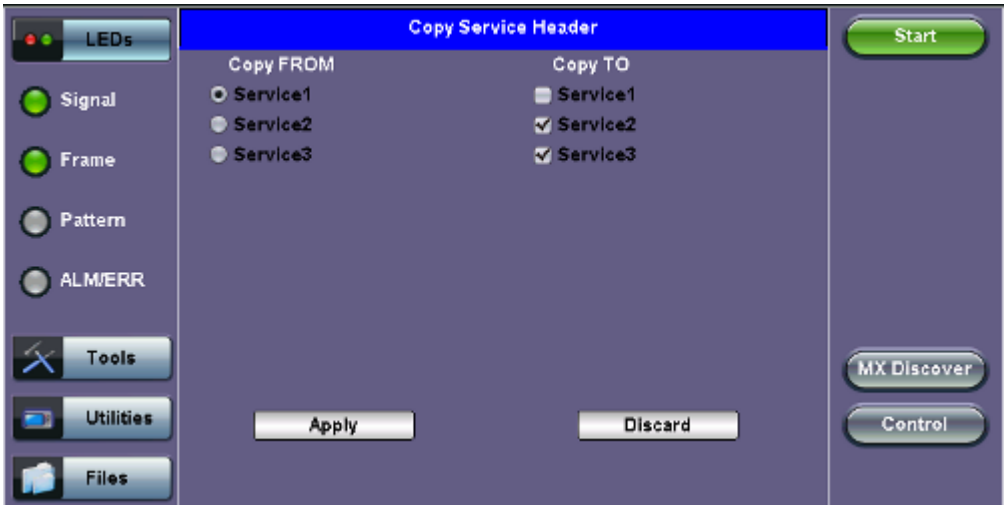
Service Acceptance Parameters

The user establishes Pass/Fail test criteria for the following Service Acceptance Criteria. Values define the minimum requirements to ensure that the service meets the Service Level Agreement (SLA):

- **FLR:** Maximum ratio of lost frames to the total transmitted frames allowed to still be compliant with the SLA. FLR is only guaranteed for traffic conforming to the CIR. Enter a percentage from 0-100.
- **FTD:** Maximum transfer time that the frames can take to travel from source to destination, and still be compliant with the SLA. FTD is only guaranteed for traffic conforming to the CIR. Values are measured in us, ms, or sec. Input a value within the digital range of .001-999 and 1 us-999sec. The user can also choose to **Disable** the FTD threshold evaluation. FTD will be measured anyway but the value will not contribute toward passing or failing the service.
- **IFDV:** Maximum frame jitter allowed to still be compliant with the SLA. FDV is only guaranteed for traffic conforming to the CIR. Values are measured in us, ms, or sec. Input a value within the digital range of .001-999 and 1 us-999sec. The user can also choose to **Disable** the IFDV threshold evaluation. IFDV will be measured anyway but the value will not contribute toward passing or failing the service.
- **AVAIL:** Minimum percentage of service availability allowed to still be compliant with the SLA. The service becomes unavailable if more than 50% of the frames are errored or missing in a one second interval. Availability is only guaranteed for traffic conforming to the CIR. Enter a percentage from 0-100. The user can also choose to **Disable** the AVAIL threshold evaluation. AVAIL will be measured anyway but the value will not contribute toward passing or failing the service.

Copying Services



Copying Services

Tap on the **Copy** button on the bottom of the **Header** or **Service Attributes** tabs to copy frame parameters specific to that tab to other services. For example, pressing Copy on the Header tab will only transfer header parameters to other services.

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MX Discover and Control Settings

For instructions on how to loop up/down the test set with another test set or device, please refer to MX Discover and Control.

The **Control** button offers additional loopback control settings including User Defined and OAM Discover. These features are described in **MX Discover and Control**.

Peer-to-Peer Setup

Peer-to-Peer and asymmetric testing via the **P2P Setup** button is also available. Refer to Peer-to-Peer and Asymmetric Testing section for more information.

Packet Capture

To capture packets, tap on **P1 Cap Start**. Stopping packet capture automatically names and saves results in pcap format. A message displays the name of the saved file located in **Files** > **Saved** section of the test set. The file and can be exported to a PC and analyzed using Wireshark. Refer to **Files** > **Viewing Saved Files and Results** section in **TX300S, MTTplus, RXT-1200, or UX400 platform manuals** for more information on retrieving and managing saved files.

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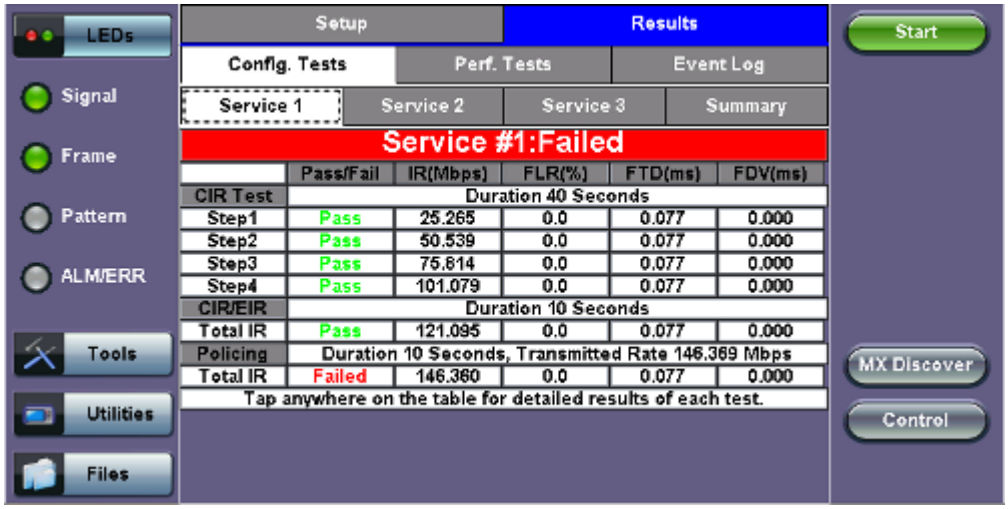
6.6.2 Results

Results - Config. Tests - Service 1



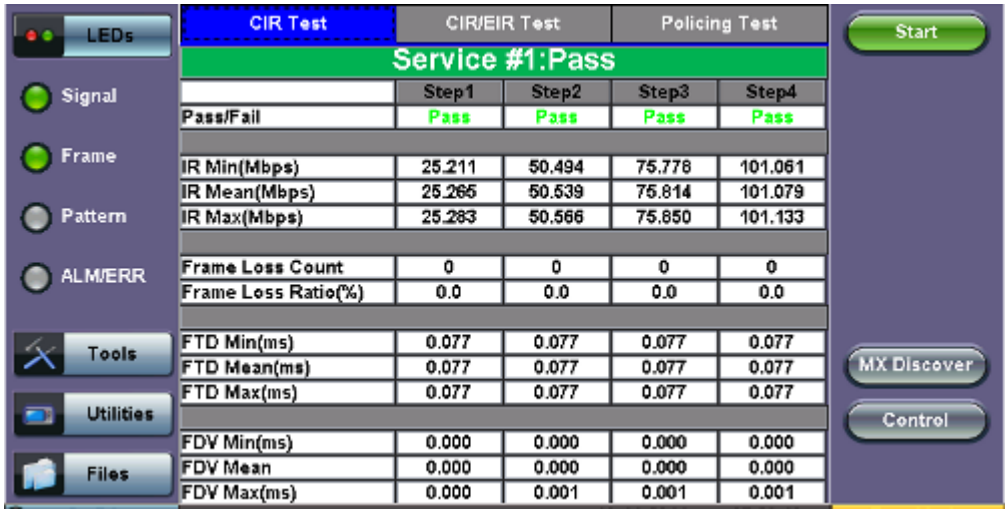
***Note**: To run the test, make sure that traffic is being looped back at the far-end of the network under test.*

Configuration Test

The **Config. Tests** tab lists the Pass/Fail status of each service and test. Tapping on the table brings up a screen with **CIR**, **CIR/EIR** and **Policing Test** results for the chosen Service. **CIR**, **CIR/EIR Test**, and **Policing** tabs display min, mean, and max values for **IR Mbps**, **FTD**, **FDV**, **Frame Loss Count**, and **Frame Loss Ratio (%).** If Step Load was selected for the CIR Test, these values will be displayed for each step. If any measured values do not meet the service test parameters set in the Bandwidth and Threshold tabs, the test fails.

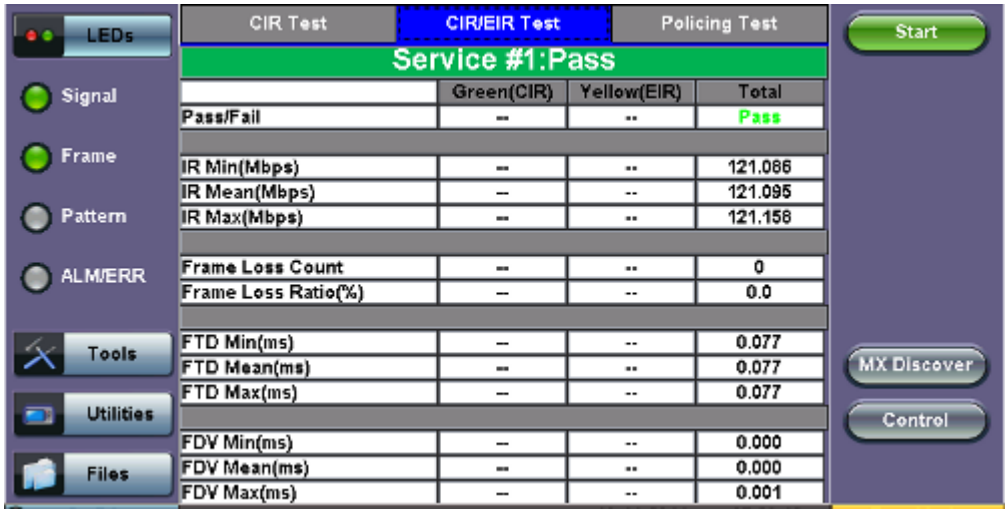
- **IR Mbps:** Information Rate. Measures the average Ethernet frame rate starting at the MAC address field and ending at the CRC.
- **FTD:** Measures the time that the frames can take to travel from source to destination.
- **FDV:** Measures the frame jitter.
- **Frame Loss Count:** Counts the number of lost frames.
- **Frame Loss Ratio:** Ratio of lost frames to the total transmitted frames.

CIR Test - Service 1



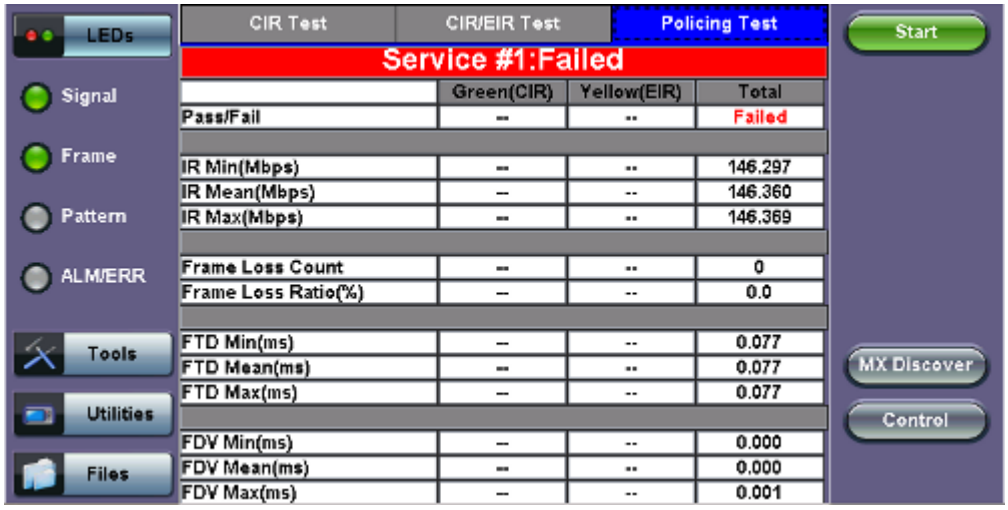
CIR test: The test passes if all measured values are below the thresholds configured. If a threshold is disabled, it will not be evaluated towards pass/fail criteria.

CIR/EIR Test - Service 1



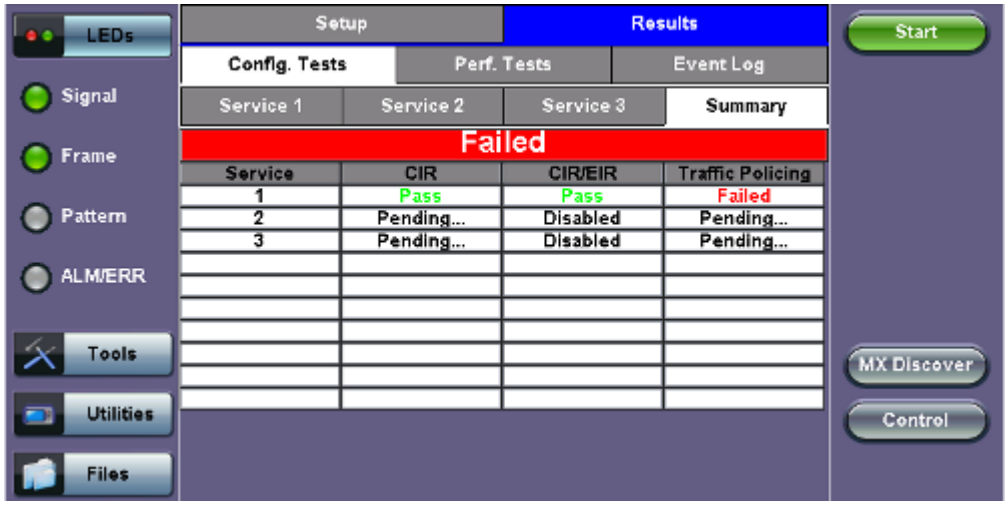
CIR/EIR test: The test passes if the received IR value is between the CIR (minus the margin allowed by the FLR) and CIR+EIR.

Policing Test - Service 1



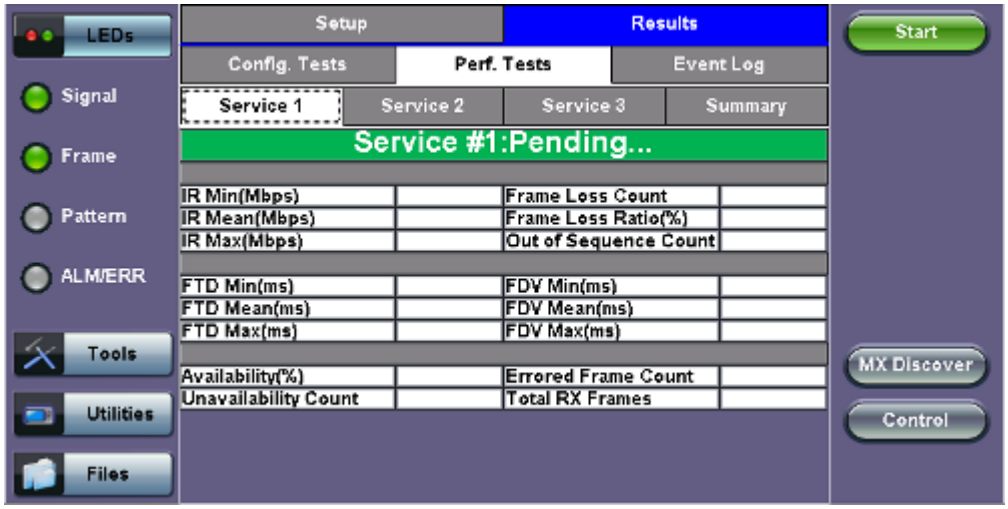
Policing test: The test passes if the received traffic rate is at least at the CIR (minus the margin allowed by the FLR) but does not exceed the allowed CIR+EIR.

Results - Config. Tests - Summary



Summary: The Summary tab displays the status of each service and test as Pass, Failed, Pending, or Disabled.

Perf. Test - Service 1



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Performance Test

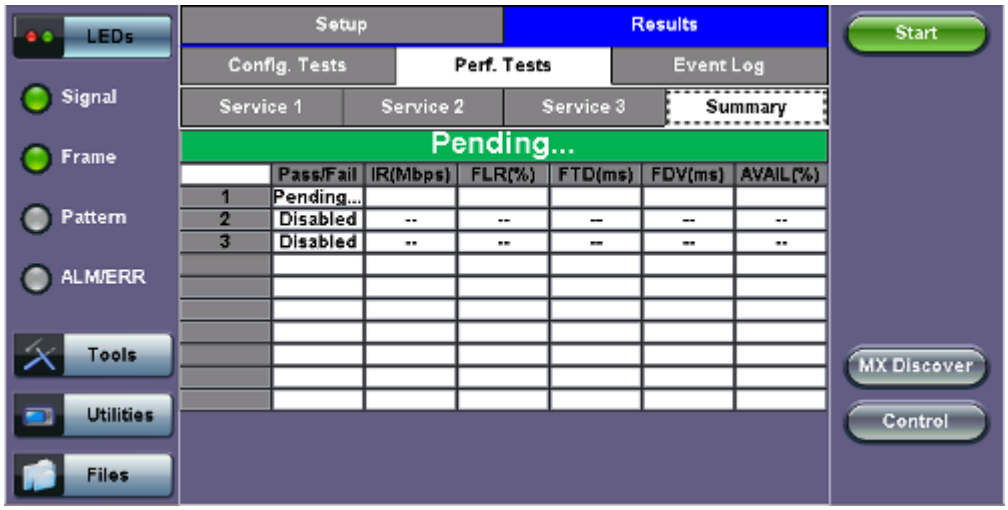
The **Service** # tabs display min, mean, and max values for **IR Mbps**, **FTD**, **FDV**, **Frame Loss Count**, **Frame Loss Ratio (%)**, **Availability**, and **Errored Frame Count**. Pass/Fail/Pending status of each test is displayed on the top of each table.

- **IR Mbps**, **FTD**, **FDV**, **Frame Loss Count**, **Frame Loss Ratio (%)** definitions are listed in the **Configuration Test** section.
- **Availability:** Minimum percentage of service availability allowed to still be compliant with the SLA. The service becomes unavailable if more than 50% of the frames are errored or missing in a one second interval. Availability is only guaranteed for traffic conforming to the CIR.
- **Total RX Frames:** Total number of frames received
- **Errored Frame Count:** Number of frames with CRC or IP Checksum errors

Measured values that do not meet the service test parameters set in the Bandwidth and Threshold tabs cause the test to fail.

The **Summary** tab displays the status of each service and test as **Pass**, **Failed**, **Pending**, or **Disabled**.

Perf. Tests - Summary



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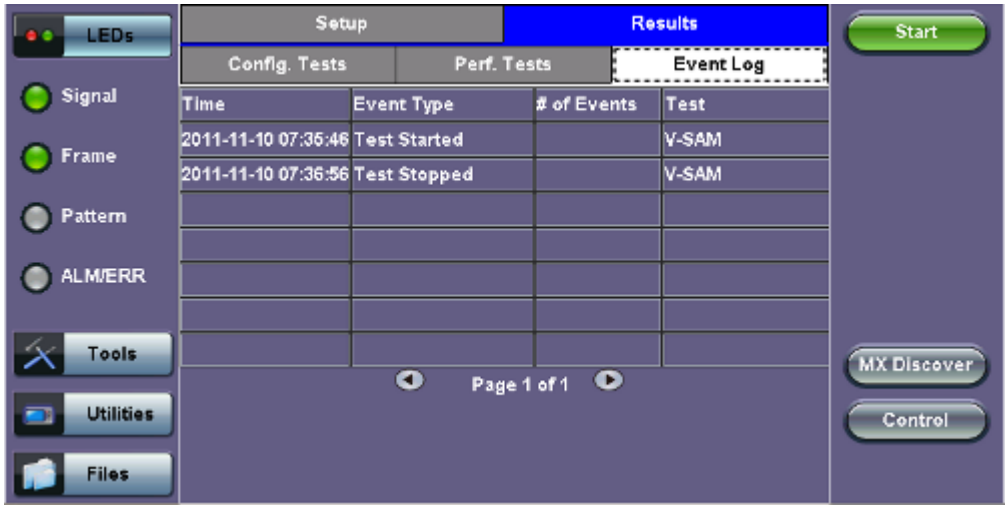
Event Log

A time stamped record or log of test types and test statuses (start/stop).

Event Log



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6.7 Throughput Testing

6.7.1 Setup

Overview:

The Throughput application performs the following measurements: Throughput performance, Frame Loss analysis, Delay analysis, Frame/Packet arrival analysis, received Traffic Type analysis, and received Traffic Frame Size analysis. On the transmit side, the Throughput application currently allows only one stream with its MAC and IP address, VLAN tags (up to 3), bandwidth/rate, frame size, and L2 and/or L3 quality of service (QoS) parameters. On the receiver end the traffic is analyzed on a per stream basis as well as a global or aggregate measurement.

This application is very useful in verifying the transport of traffic with different prioritization settings across a network link. The test helps verify that the network can handle high priority traffic and low priority traffic accordingly.

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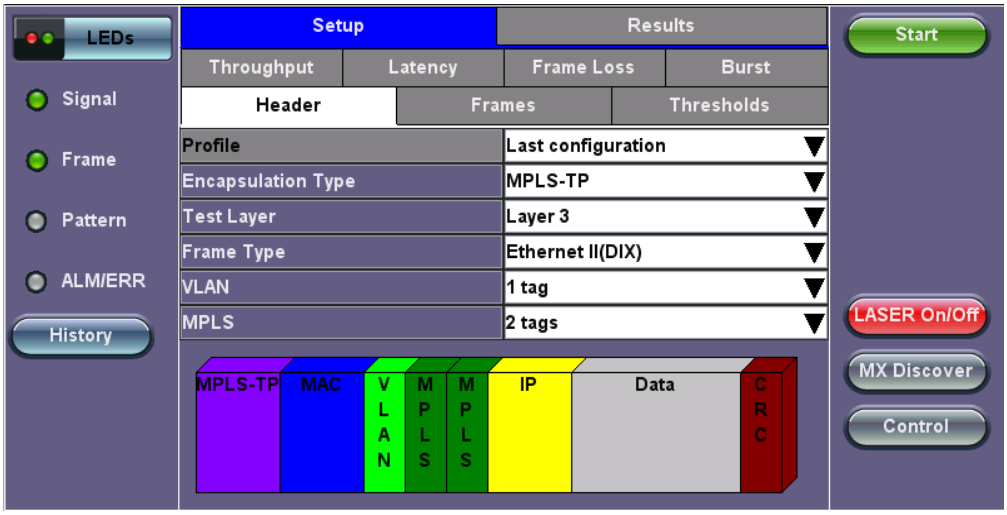
6.7.1.1 Header Settings

Unless otherwise noted, Frame Header, MAC, VLAN, MPLS, and IP configuration procedures are identical to the setup described in RFC 2544 and BERT. Refer to the BERT application for details. The following parameters must be configured prior to performing a Throughput test:

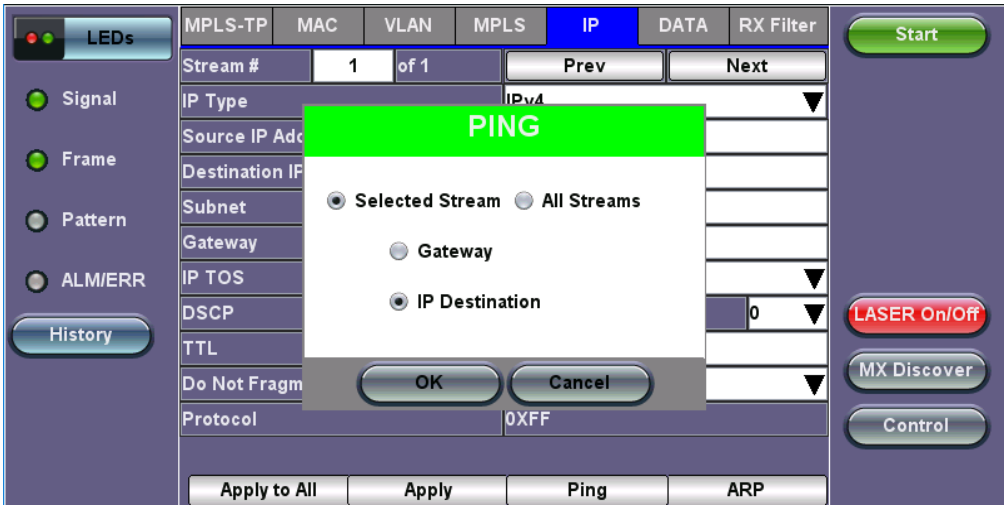
Throughput Header Settings



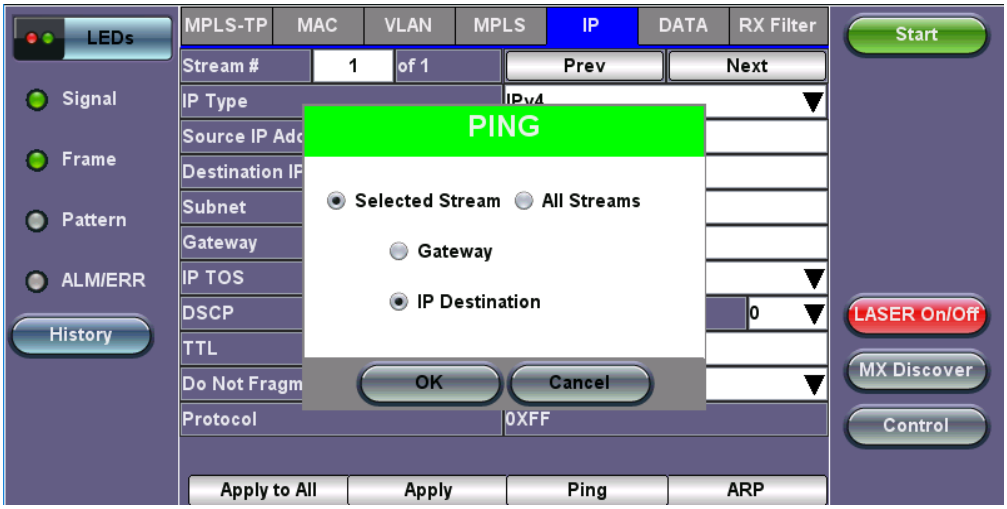
- Number of streams (See **General Settings** below)
- Bandwidth per stream (See **General Settings** below)
- Test layer
- Frame Type
- VLAN tag(s)
- MPLS tag(s)
- Frame header per stream (if applicable)
- Traffic profile per stream (if applicable)
- Error injection per stream (if applicable)
- Control settings of the far-end device(s) (if applicable)

The IP header features additional **Ping** and **ARP** features which can be applied to selected streams or all streams by Gateway or IP Destination. Refer to the **UX400 40G/100G**, **TX300s-100G**, or **RXT-1200 platform manual** for information on setup and results for Ping and ARP.

Throughput Header - IP - Ping Settings



Throughput Header Settings



Multiple Streams - MAC/IP Address Setup

If all of the streams are going to the same far-end unit, then the MAC/IP destination addresses must be the same on all of the streams.

If any of the traffic streams are going to more than one far-end unit then ensure the correct MAC/IP destination addresses are configured for the respective streams.

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6.7.1.2 Traffic Settings (Per Stream Configuration)

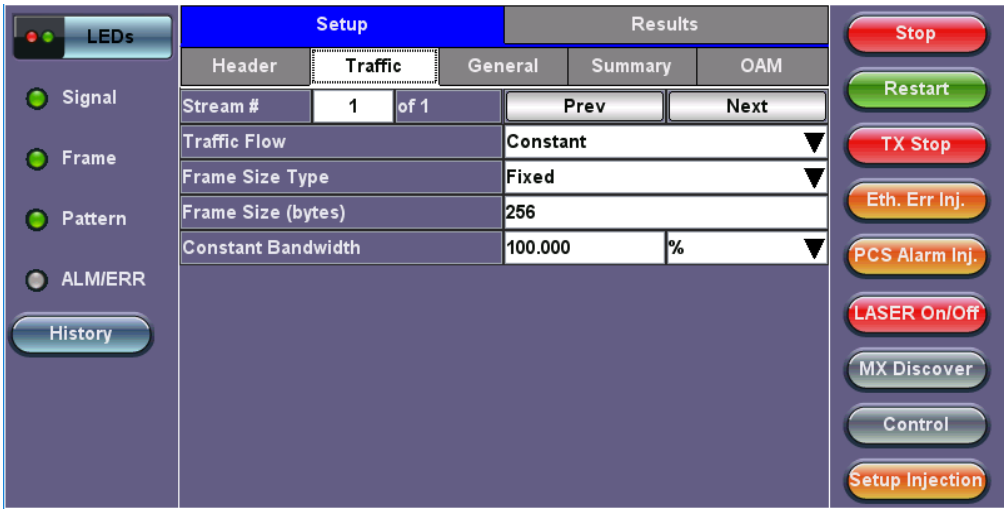
In the Traffic tab the user is able to configure the traffic profile per stream, including frame size selection, traffic type, and transmit rate.

- **Stream #:** Select a stream number to configure.
- **Traffic Flow:** Select from Constant, Ramp, Burst, or Single Burst traffic flow.
- **Frame Size (Type):** Fixed, increment, decrement, random
- **Frame Size (bytes):** If a fixed frame size is chosen, this option is enabled. Enter the frame size when a Layer 2 or 3 is selected. Frame sizes can be from 64bytes to 1518bytes, in addition to jumbo frames up to 9k bytes.
- **Bandwidth:** Configure the transmit rate for the stream. The parameters depend on the Traffic Flow selected.
    - Constant Traffic Flow: Constant Bandwidth

- Ramp: Start BW, Stop BW, Step BW, Ramp Time, Repetitions
- Burst: Burst 1 Bandwidth, Burst 1 Time, Burst 2 Bandwidth, Burst 2 Times
- Single Burst: Single Burst Bandwidth

Note: *The bandwidth allocation per stream is already configured in the* ***General Settings*** *tab, but can be modified in this screen as well.*

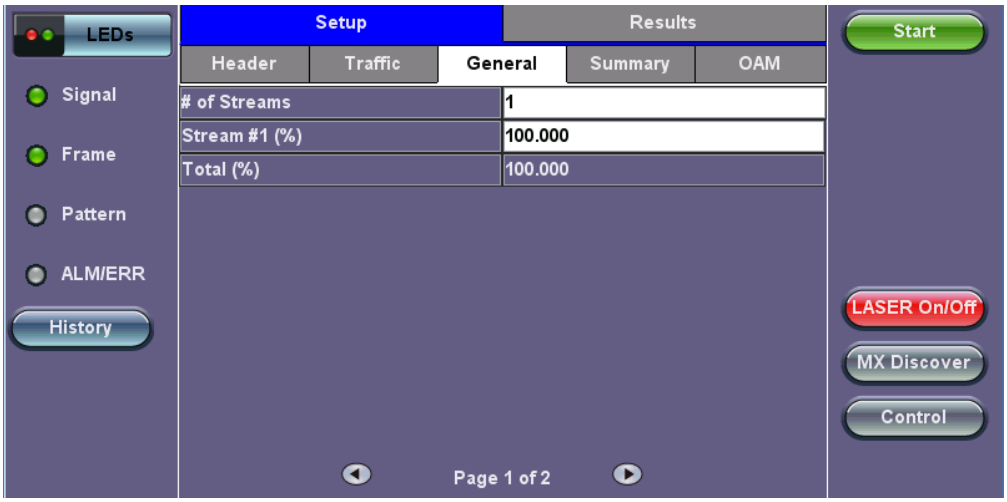
Throughput Traffic Settings



6.7.1.3 General Throughput Settings (Global Configuration)

- **# of Streams:** Only 1 for now. 256 in the future.
- **Stream #:** Allocated Bandwidth per Stream: The total bandwidth for all streams cannot exceed 100%.
- **Total (%):** Sum of all stream rates in %.

Throughput General Setup

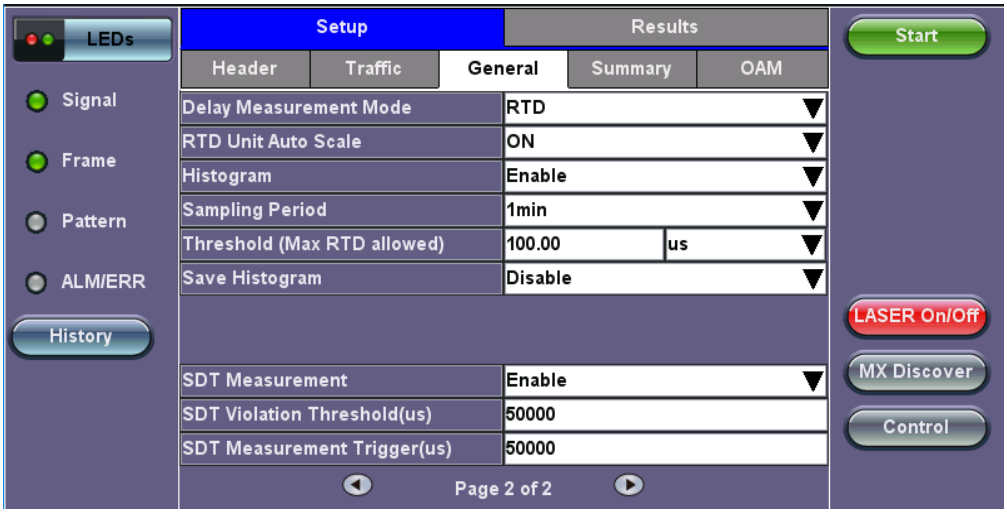


Page 2 features Round Trip Delay (RTD) measurement and Service Disruption Test (SDT) measurement settings.

- **Delay Measurement Mode:** Enable/disable the round trip delay measurement. It should only be enabled when running the test to a remote loopback.
- **RTD Unit Auto Scale:** ON/OFF
- **Histogram:** Enable / Disable
- **Sampling Period:** 1sec, 10secs, 30secs, 1min, 10min, 30min, 1hr. Defines how often the RTD (round trip delay) measurement is evaluated against the RTD threshold.
- **Threshold (Max RTD allowed):** Input the value in us, ms or sec. Defines the maximum allowed round trip delay value. If the RTD value exceeds the threshold, an event is logged with corresponding time stamp.
- **Save Histogram:** Enable/Disable
- **SDT Measurement**: Enable/Disable. The Service Disruption Test is triggered based on user established thresholds.

- ***SDT Violation Threshold (us)***:Triggers an SDT Violation event in the event log. This is helpful for historical purposes during any given test. If the measured SDT is equivalent or greater than the configured threshold an SDT Violation event is counted.
- ***SDT Measurement Trigger (>us)***: Any inter-frame gap that is equivalent or greater than the configured threshold will trigger the SDT measurement. This is useful if a known threshold is expected from a given network under test. For example, if the known switchover time is 50ms, the trigger can be set to a value slightly below 50ms to assure that the SDT is measured.

Throughput General Setup - Round Trip Delay (RTD), Service



Multiple Streams

All streams are configured for the same test layer - if Layer 2 is selected, all streams will be Layer 2 traffic.

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6.7.1.4 Error Injection Settings (Per Stream Configuration)

Error injection can be performed during test. The type of errors and error injection are configured in the Error Injection tab. Once the test is running, error injection can be performed by pressing the **Error Inject** button on the right side of the screen.

- **Stream #:** Select the stream to configure.
- **Error type:** Select from CRC, Pause, or Bit. With Pause selected, the unit will transmit a pause frame when the **Error Inj.** icon is pressed. The Pause time duration is configurable in units of 512 bit time. At Gigabit Ethernet speed, this is equivalent to 512 ns. For example, if pause time is set to 1000, the pause duration will be set to 1000x512 ns.
- **Injection Flow:** The error injection flow determines how the selected errors will be injected. The user can select a single error or a specific count.
- **Count:** Set a count using the numeric keypad.

Throughput Error Injection Setup

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6.7.1.5 Alarm Injection Settings

Alarm injection can be performed during test. The type of alarms and alarm injection are configured in the Alarm Injection tab. Once the test is running, alarm injection can be performed by pressing the **Alarm Inj.** button on the right side of the screen.

- **Alarm Type:** Local Fault, Remote Fault, Laser 1 Off, Laser 2 Off, Laser 3 Off, Laser 3 Off, Laser 4 Off
- **Alarm Flow:** The alarm flow determines how the selected alarms will be injected. A specific Count or Conitnue (continuous) can be selected.
- **Alarm Length:** 1s, 10s, or 100s.

Throughput Alarm Injection Setup

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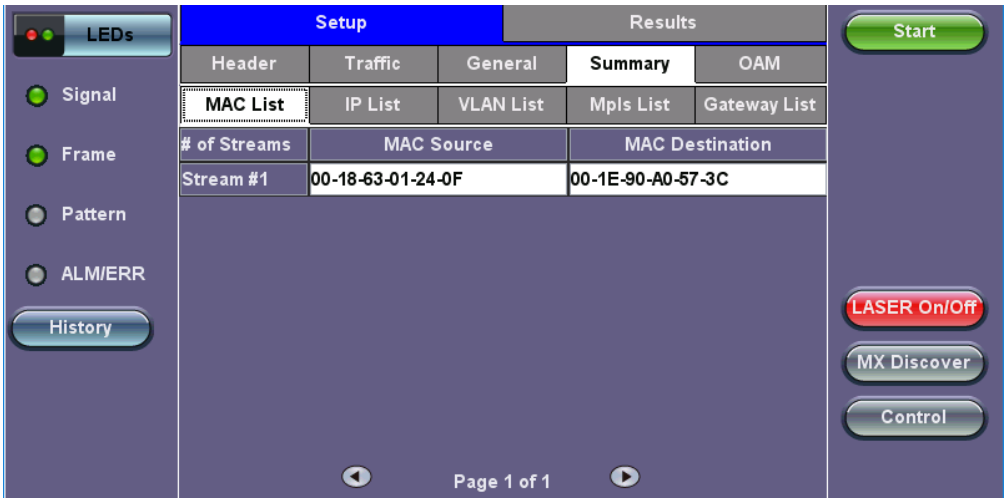
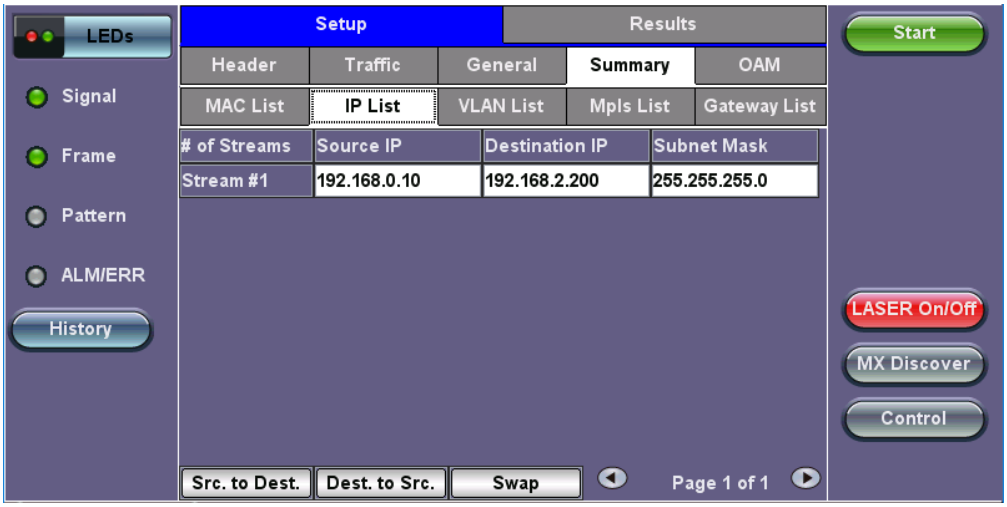
6.7.1.6 Summary

The summary screen lists the MAC source, MAC destination and VLAN information of each stream. Tap on the appropriate box of each tab to reconfigure the source, destination, or VLAN information if desired.

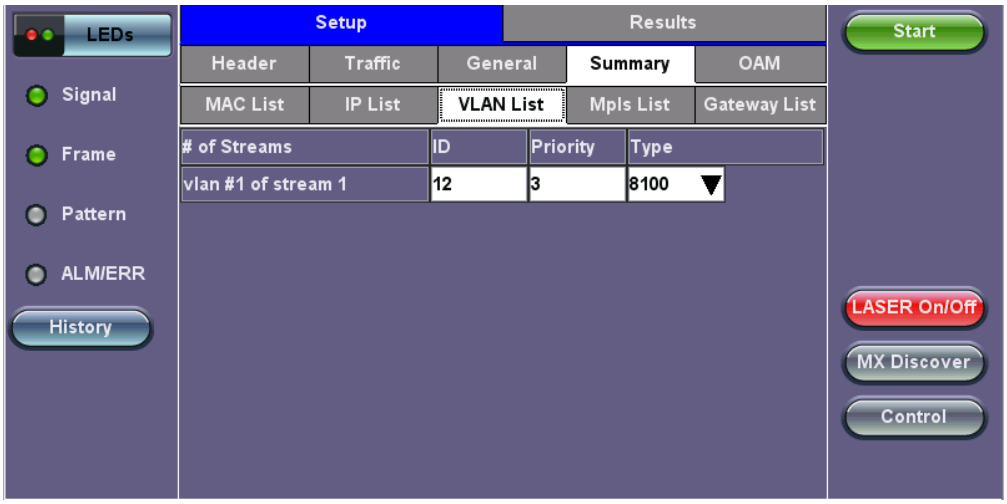
Throughput Summary MAC List



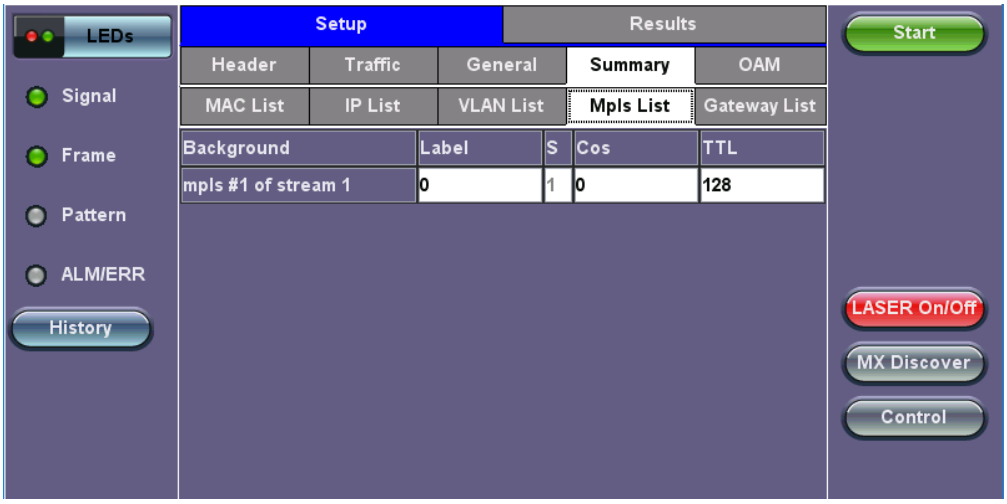
Throughput Summary IP List



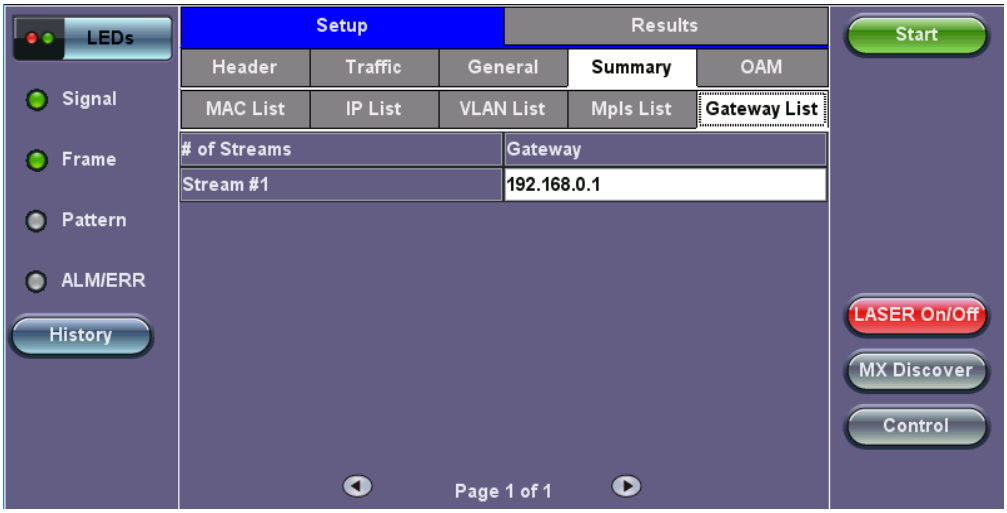
Throughput Summary VLAN List



Throughput Summary MPLS List



Throughput Summary Gateway List



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OAM Discover

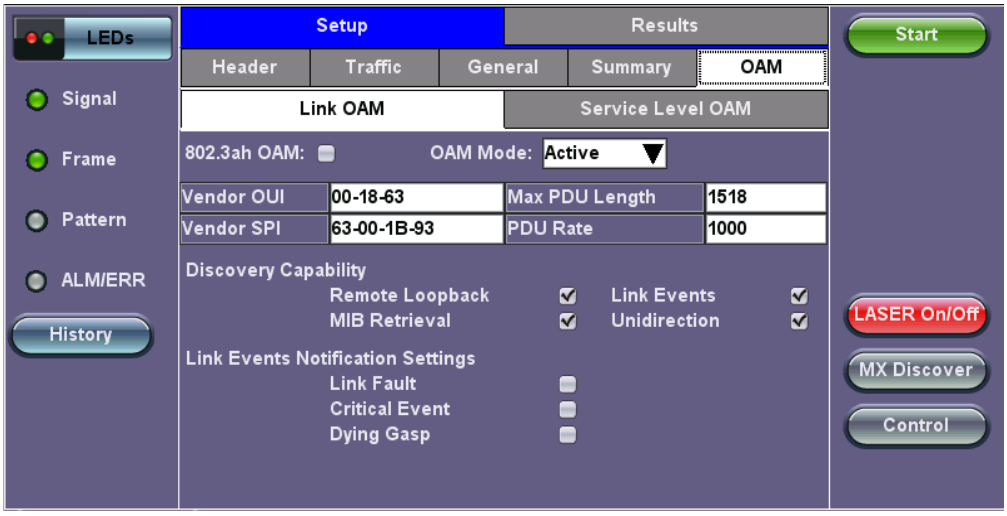
Like MX Discover, OAM Discover can also be used to discover far-end test units without manually configuring the local or remote unit's destination address. If OAM is enabled on the test set, any link partner that supports the IEEE 802.3ah protocol will be discovered automatically and displayed under the OAM Discover tab.

To Access OAM Discover:

1. Go to **Throughput** > **OAM** > **Link OAM** tab. Tap on the 802.3ah check box to activate Link OAM.
2. Select **Active** from the **OAM Mode** drop-down menu (only Active mode can send loop commands).
3. Tap on the **Loop Control** button and select **OAM Discover** from the **Partner Address** drop-down window to see a list of discovered OAM devices.
4. Select an OAM device and press the **Loop Up** button to send a loop up command to the selected remote unit.

For detailed descriptions of Discovery Capabilities and Link Events Notification Settings, see the Link Level 802.3ah OAM Setup section.
For information on Service Level OAM setup, see the Service Level OAM section.

Activating 802.3ah Link OAM



6.7.1.7 Starting/Stopping a Throughput (Multiple Streams) Test

Once all configurations have been made, tap the **Start** button on the right section of the screen to start the measurements.

The following are three scenarios of how to prepare and start the unit for Throughput testing.

Note: *If testing on the fiber ports, make sure the LASER is turned On before starting the test.*

- **End-to-End Testing**
  - Connect the test set to another unit that supports BERT testing.
  - After configuring test settings on both units, start the tests.

- **Far-End Unit in Manual Loopback Mode**
  - If the far-end unit (another MX) is already in a manual loopback mode, do not send a loop up command since it isnot necessary.
  - Once the correct control settings are configured, the user can start the test.

The selected tests will run automatically. When all the tests are complete the test will stop automatically. If the Throughput test suite needs to be stopped before they are done, then simply tap the **Stop** button. The status of each selected test can be seen in the Results tab.

- **Far-End Unit Controlled with Loop Up/Down Commands**
  - If the far-end unit is not manually looped back, then it must first receive a loop up command from the control unitbefore the Throughput test suite can be started.
  - To loop up the far-end unit with the manual mode loop up/down commands, configure the control settings mode to manual.
  - Enter the MAC and/or IP address of the far-end unit.
  - Send the loop up command by tapping on the **Loop Control** button and pressing **Loop Up**.

Once the far-end unit has been looped back, start the test by pressing the **Start** button. When the all of the selected test are completed, the Throughput test suite will stop automatically. Once all tests have been completed and there is no need to test again, go back to the Control tab, and press the **Loop Down** button. This will send a loop down command to the far-end unit to remove the loopback that is in place.

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6.7.2 Throughput Results

When the test is first started, the screen automatically changes to the Global/Aggregate results screen.

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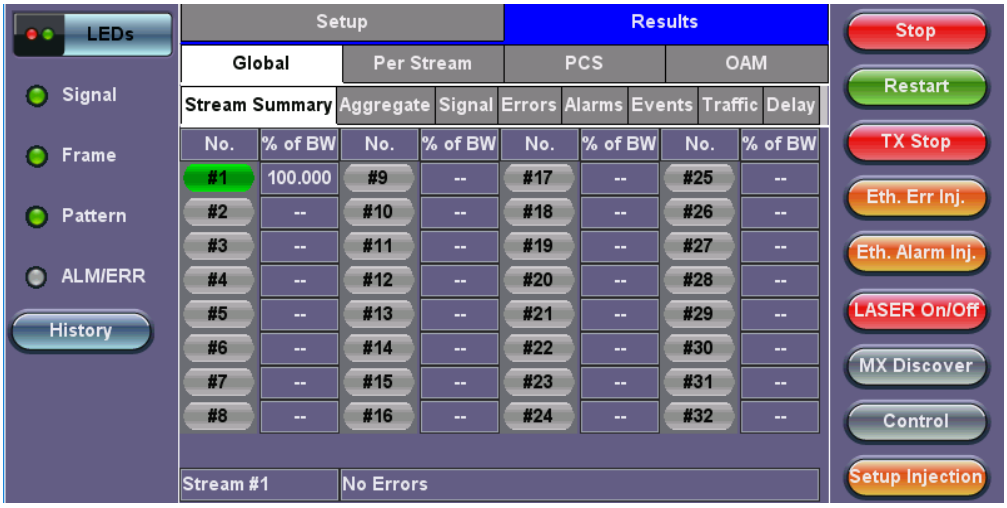
6.7.2.1 Global/Aggregate Results

The Global results pages display measurements for all traffic streams as well as non test traffic.

The **Global Stream Summary** screen displays:

- Stream number (#)
- % of bandwidth per stream
- Errors/alarms associated with the stream
- Quality of Service (QoS) performance verification associated with each stream

Throughput Results - Global Stream Summary



QoS

QoS values are based on packet statistic thresholds for roundtrip delay, jitter, frame loss, and IP checksum from the ITU-T Y.1541 standard. Below is a list of IP network QoS class definitions and network performance objectives from Y.1541.

"U" denotes "unspecified" or "unbounded" and signifies that no objective was established for this parameter and default Y.1541 objectives do not apply. Parameters designated with "U" are occasionally inconsistent and poor.

IP Network QoS Class Definitions and Network Performance Objectives (Classes 0-3)				
Network Performance Parameter	QoS Classes			
	Class 0	Class 1	Class 2	Class 3
IPTD	≤ 200 ms/2 (100 ms one-way)	≤ 800 ms/2 (400 ms one-way) AND > 200 ms/2	≤ 200 ms/2 (100 ms one-way)	≤ 800 ms/2 (400 ms one-way) AND > 200 ms/2
IPDV	≤ 50ms	≤ 50ms	U	U
IPLR	> 1/100,000 AND ≤ 1/1000	> 1/100,000 AND ≤ 1/1000	> 1/100,000 AND ≤ 1/1000	> 1/100,000 AND ≤ 1/1000
IPER	> 1/1,000,000 AND ≤ 1/10,000	> 1/1,000,000 AND ≤ 1/10,000	> 1/1,000,000 AND ≤ 1/10,000	> 1/1,000,000 AND ≤ 1/10,000

IP Network QoS Class Definitions and Network Performance Objectives (Classes 4-7)				
Network Performance Parameter	QoS Classes			
	Class 4	Class 5	Class 6	Class 7
IPTD	≤ 2 s /2 (1 s one-way) AND > 800 ms/2	U	≤ 200 ms/2 (100 ms one-way)	≤ 800 ms/2 (400 ms one-way) AND > 200 ms/2
IPDV	U	U	≤ 50ms	≤ 50ms
IPLR	> 1/100,000 AND ≤ 1/1000	U	≤ 1/100,000	≤ 1/100,000
IPER	> 1/1,000,000 AND ≤ 1/10,000	U	≤ 1/1,000,000	≤ 1/1,000,000

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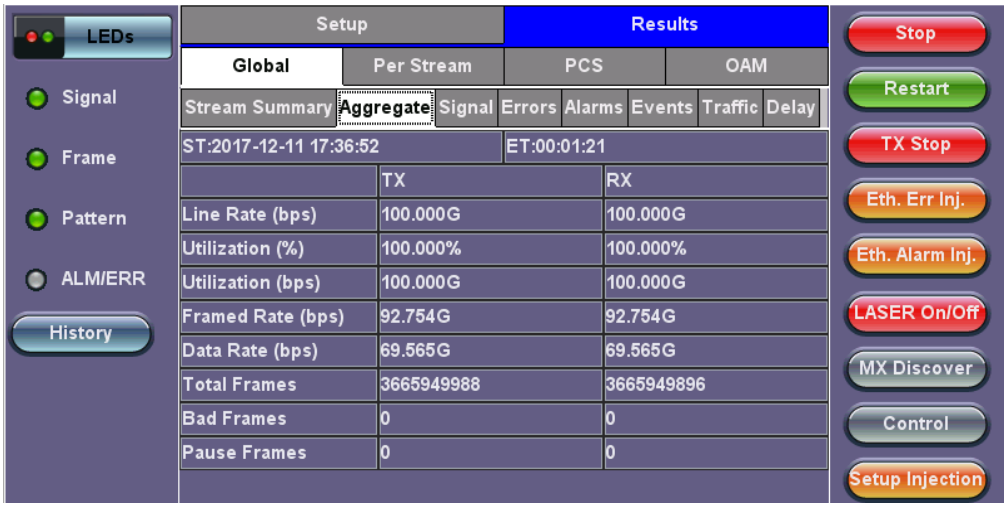
The **Aggregate** screen displays these parameters:

- **Line Rate** (bps)**:** Negotiated rate of the interface (10M, 100M, or 1000M). This value is always fixed since it depends on the maximum capacity of the link under test, hence the test interface that is configured.
- **Utilization:** % of Line Rate. For example, if we transmit 100Mbps on a 1Gbps interface then the utilization value is 10% (or 100Mbps) of the total link capacity (or Line Rate).
- **Utilization (bps)**
- **Framed Rate:** (Payload + MAC/IP Header + VLAN Tag + Type/Length + CRC) / (Payload + Total Overhead) * Line Rate % (in Mbps).
- **Data Rate:** Payload / (Payload + Total Overhead) * Line Rate %.
- Total # of frames, bad frames, and pause frames.

Throughput Results - Global Aggregate



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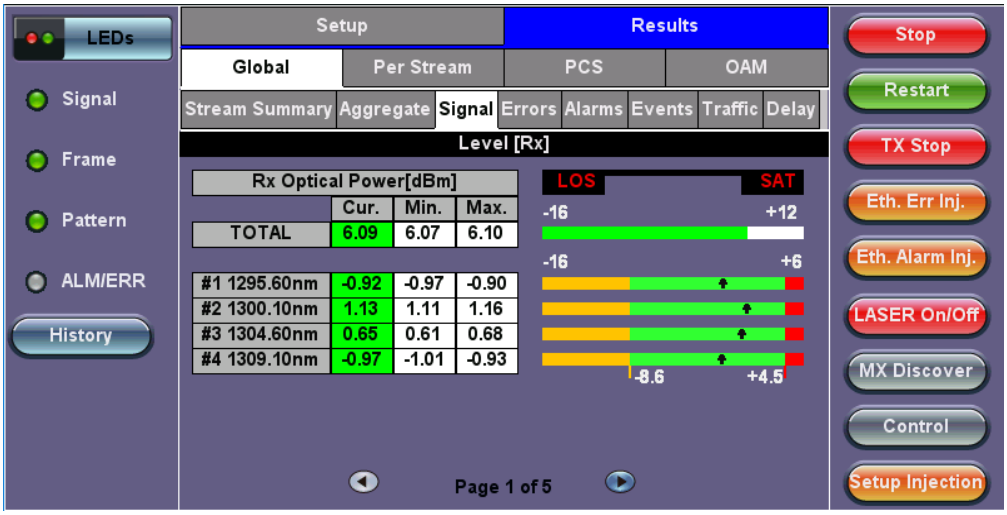
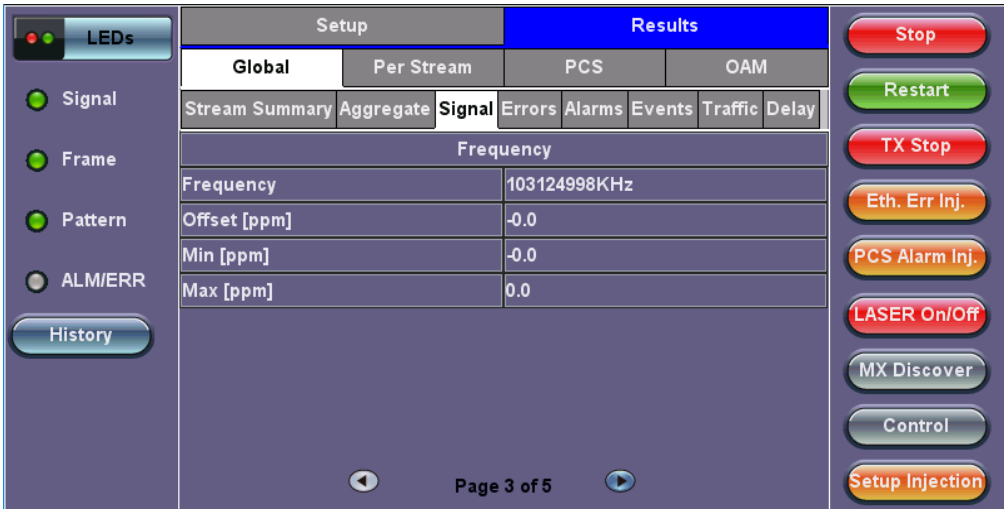
The **Global Signal** screen (fiber ports only) displays the optical level measured by the CFP2 or QSFP+ transceiver.

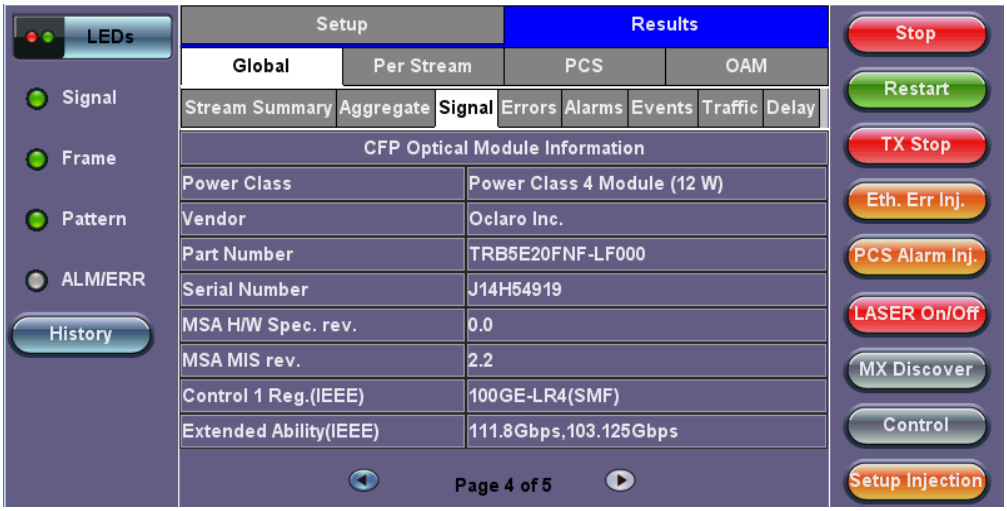
Throughput Results - Global Signal Page 1



Throughput Results - Global Signal Page 3



Throughput Results - Global Signal Page 4



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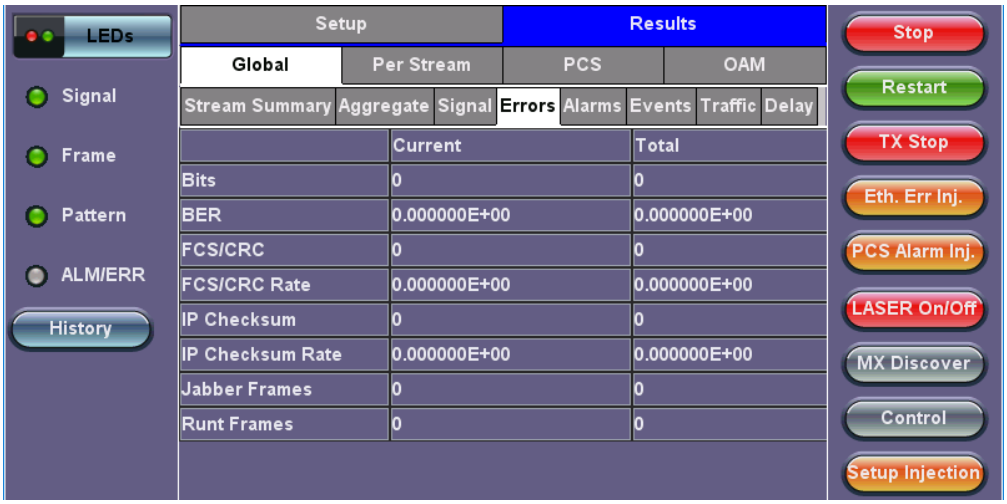
The **Global Errors** screen displays the Current and Total error count of all streams:

- Sync Header Error
- Block Type Error
- **FCS/CRC:** Number of received frames with an invalid Frame Check Sequence (FCS)
- **IP Checksum:** Invalid IP Frame Check sequence
- **TCP/UDP Checksum** (Layer 4 only)
- **Jabber frames:** Number of received frames larger than 1518 bytes containing an invalid FCS
- **Runt frames:** Number of received frames smaller than 64 bytes containing an invalid FCS
- **Giant frames** (Advanced Monitoring - Pass Through Results only): Number of received frames larger than 1518 bytes

Throughtput Results - Global Errors



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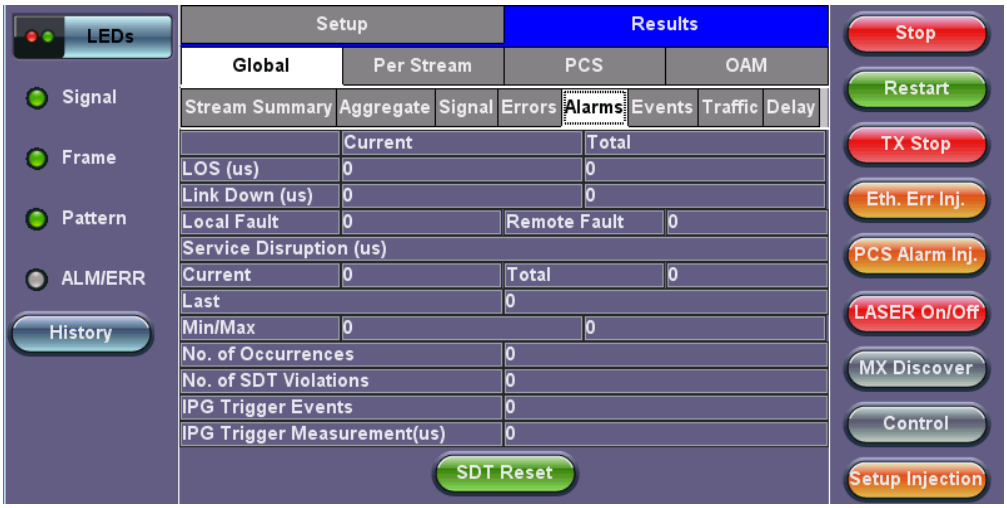
The **Global Alarms** screen displays the Current and Total alarm count of all streams:

- **LOS (ms):** Loss of Signal
- **Link Down (ms)**
- **Service disruption** associated with loss of signal:
  - **Current:** Duration of the current service disruption
  - **Total:** Total accumulated duration of the service disruptions
  - **Min/Max:** Minimum and maximum duration of the service disruption events
  - **No. of Occurrences:** Counter of service disruption events

- **Local/Remote Fault**
- **SDT alarm measurements**

Throughtput Results - Global Alarms



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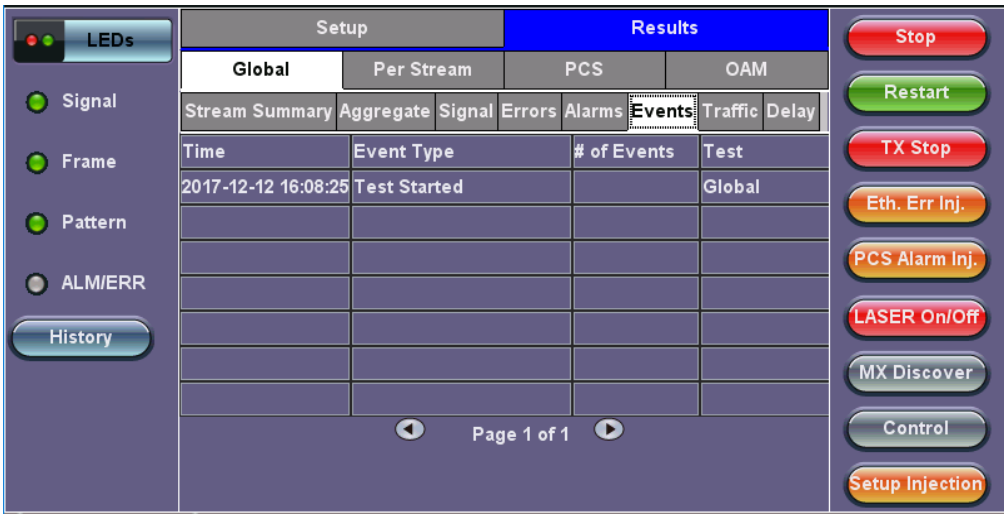
The **Global Events** screen displays the **Time**, **Event Type**, **Number of Events**, and **Test Type**.

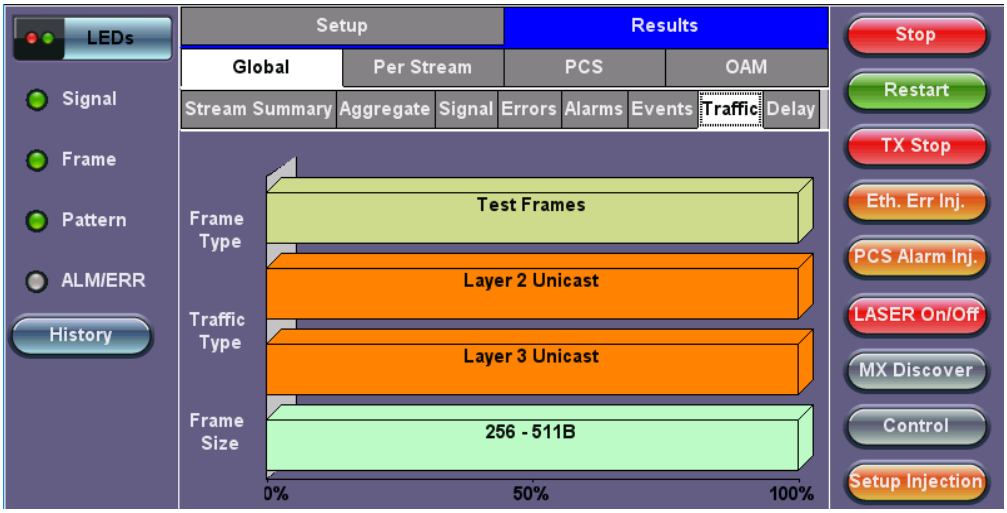
Throughtput Results - Global Events



The **Global Traffic** screen displays:

- Frame Type of all streams
- Traffic Type of all streams
- Frame size of all streams

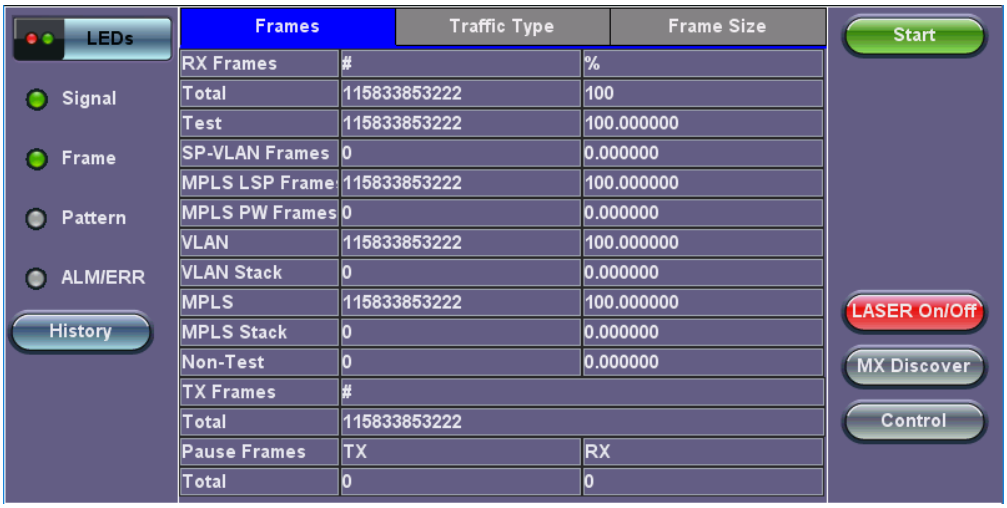
Throughtput Results - Global Traffic



Tap on the bar graph for frame and traffic distribution statistics.
Frames tab: The following Frame distribution statistics are displayed in Count (#) and Percentage (%):

- Received (RX) frames: Total frame
- Total/Test frames
- VLAN tagged frames
- Q-in-Q VLAN stacked frames
- Non-test frames
- Transmitted (TX) frames: Total frame - Total # frames transmitted
- Pause frames: Total number of transmitted and received Ethernet pause flow-control frames

Throughtput Results - Global Traffic Details



Traffic Type tab: The following Traffic distribution statistics are displayed in Count (#) and Percentage (%):

- Layer 2/3 Unicast frames: Number of Unicast frames received without FCS errors.
- Layer 2/3 Broadcast frames: Number of Broadcast frames received without FCS errors. Broadcast frames have a MAC address equal to FF-FF-FF-FF-FF-FF.
- Layer 2/3 Multicast frames: Number of Multicast frames received without FCS errors.

Frame Size tab: The following Frame distribution statistics are displayed in Count (#) and Percentage (%):

- < 64 bytes frames
- 64-127 byte frames
- 128-255 byte frames
- 256-511 byte frames
- 512-1023 byte frames
- 1024-1279 byte frames
- 1280-1518 byte frames

> 1518 byte frames - Jumbo frames

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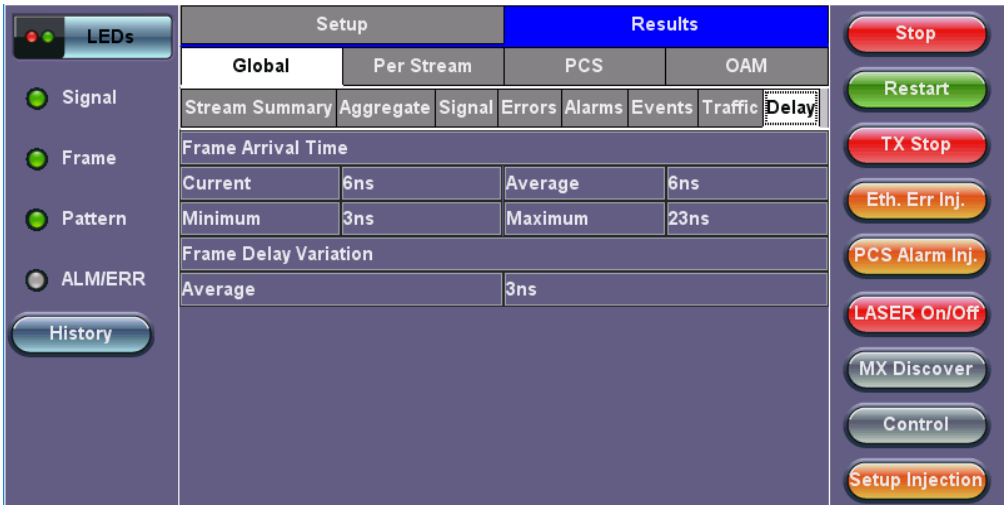
The **Global Delay** tab: Delay measures the interpacket gap, start of the frame, and preamble duration. Frame arrival statistics are displayed in tabular format:

- Frame Arrival Time:
  - Current, minimum, average, and maximum frame arrival time
- Frame Delay Variation:
  - Average

Throughtput Results - Global Delay



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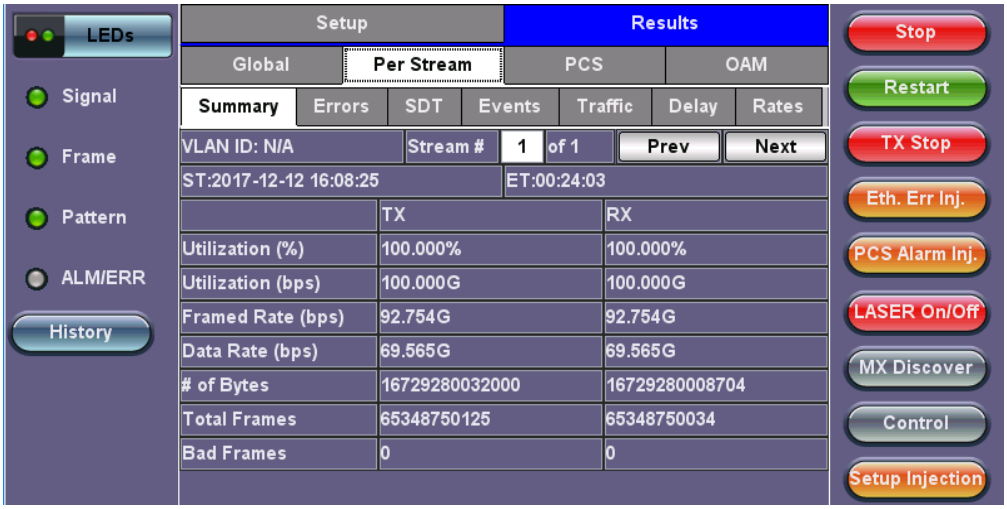
6.7.2.2 Per Stream Results

The **Per Stream** tab displays the same type of statistics as seen in Global Results, but for each stream. For descriptions of the parameters in each tab, with the exception of **Rates**, please refer back to the corresponding section in Global/Aggregate Results.

- **Summary:** Framed rate, data rate, # of bytes, total # of frames associated with each stream.
- **Errors:** Errors associated with each stream.
- Service Disruption Test results for each stream.
- **Events:** Events associated with each stream.
- **Traffic:** Traffic statistics associated with each stream.
- **Delay:** Delay associated with each stream. ***Note:*** *Round Trip Delay measurements are only available in the per-stream results screen. Round trip delay measurement requires a traffic loop at the far-end.*
- **Rates:** Rate information associated with each stream.

Throughtput Results - Per Stream Summary



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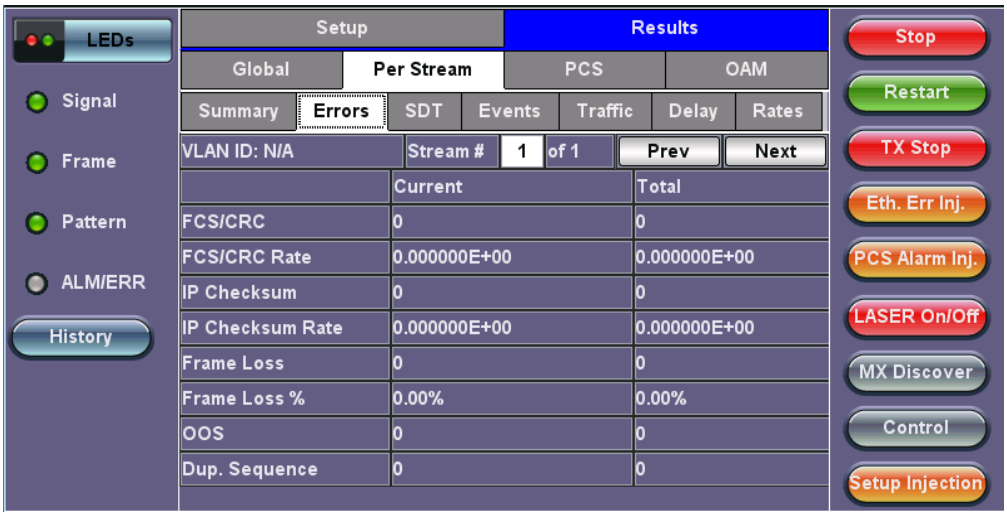
The **Per Stream Errors** screen displays the Current and Total error count of each stream.

- **Bit:** Indicates errors related to test pattern (Bit Error or LSS [Pattern Loss])
- **BER:** Bit Error Ratio
- **FCS/CRC:** Number of received frames with an invalid Frame Check Sequence (FCS)
- **IP Checksum:** Invalid IP Frame Check sequence
- **TCP/UDP Checksum** (Layer 4 only)
- **Jabber frames:** Number of received frames larger than 1518 bytes containing an invalid FCS
- **Runt frames:** Number of received frames smaller than 64 bytes containing an invalid FCS
- **Frame Loss**
- **Frame Loss %**
- **OOS**
- **Duplicate Sequence**

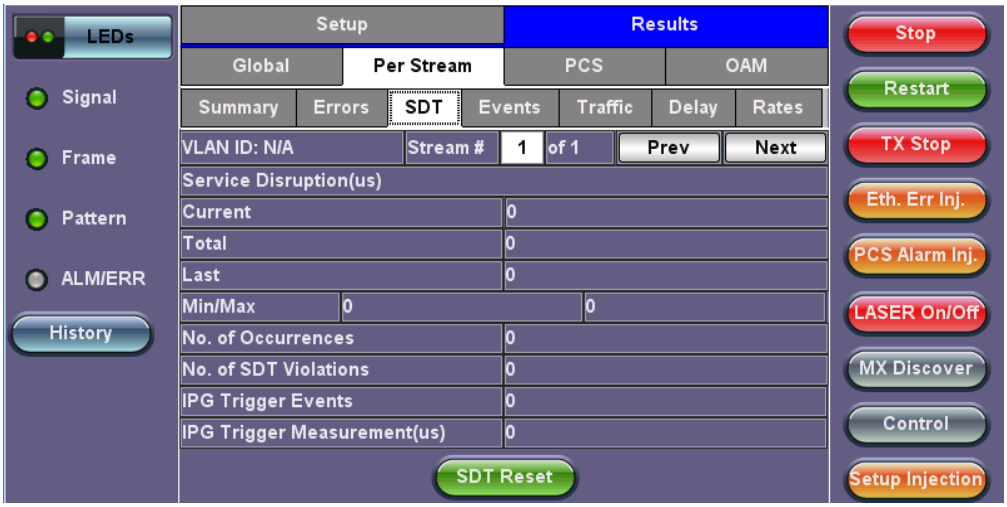
Throughput Results - Per Stream Errors Page 1



Service Disruption Test

- **Total:** Total cumulative service disruption for the duration of the test.
- **Last:** Last SDT measured during the test.
- **Min/Max:** Minimum and maximum SDT measured during the test.
- **No. of Occurrences:** Number of service disruption events (SDTs).
- **No. of SDT Violations:** Number of instances the SDT threshold was met or exceeded.

Throughput Results - Per Stream Errors Page 1



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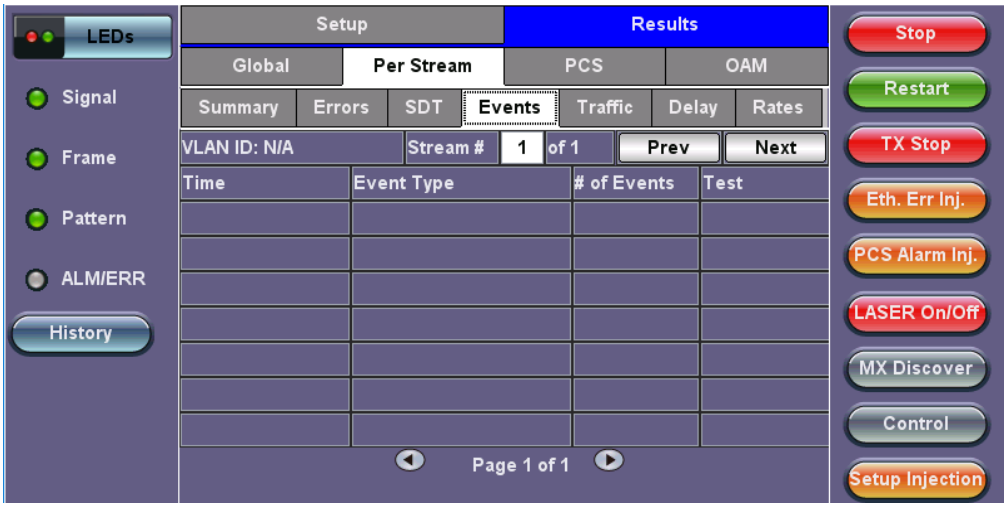
The **Per Stream Events** screen displays a Date and Time stamped record of bit errors, alarms and other anomalies pertaining to each stream.

Throughtput Results - Per Stream Events



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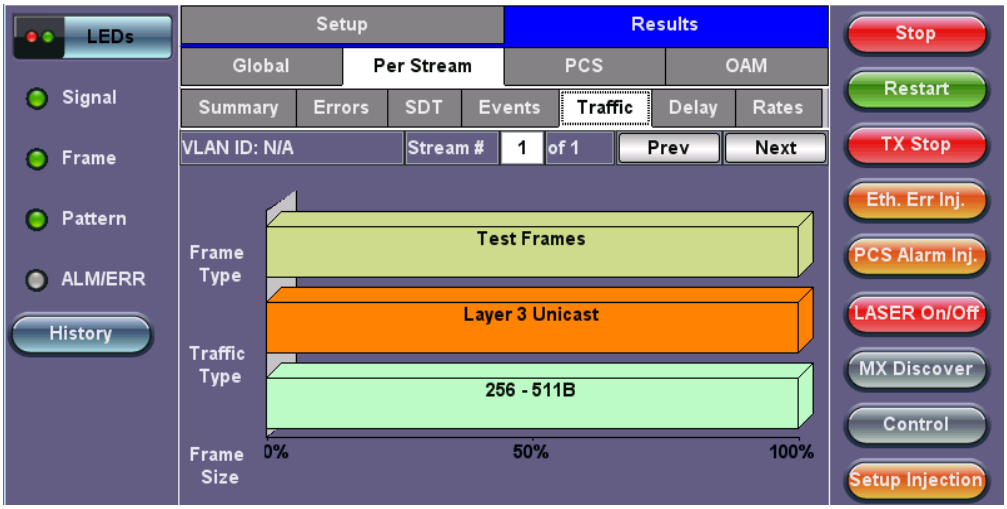
The **Per Stream Traffic** screen displays the frame type and frame size distribution pertaining to each stream.

Throughtput Results - Per Stream Traffic



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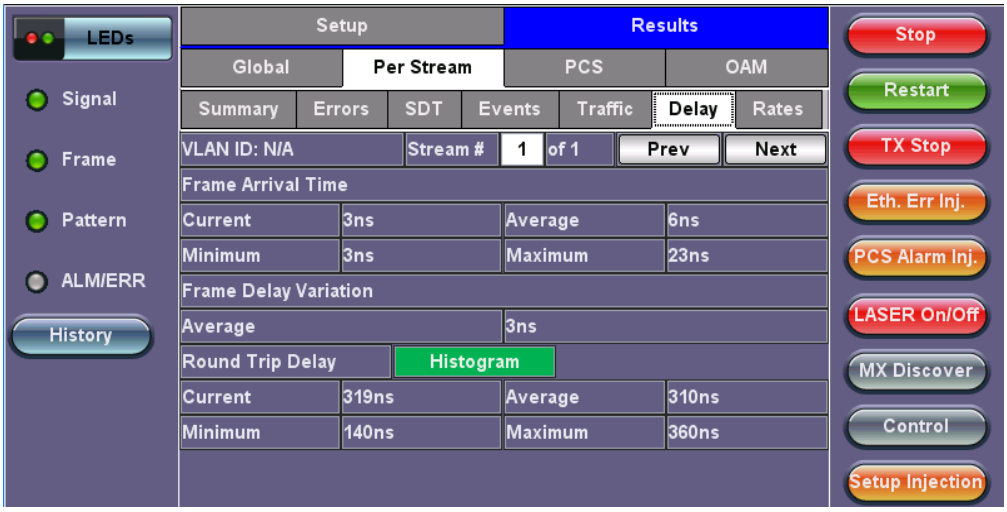
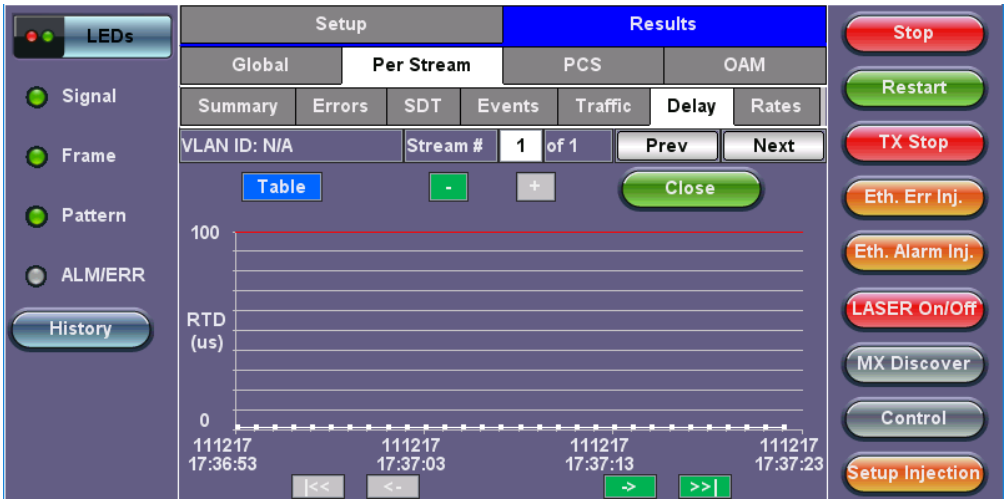
The **Per Stream Delay** screen displays the frame delay information pertaining to each stream.

The Histogram shows the sampling points for the delay.

Throughtput Results - Per Stream Delay



Throughtput Results - Per Stream Delay - Histogram



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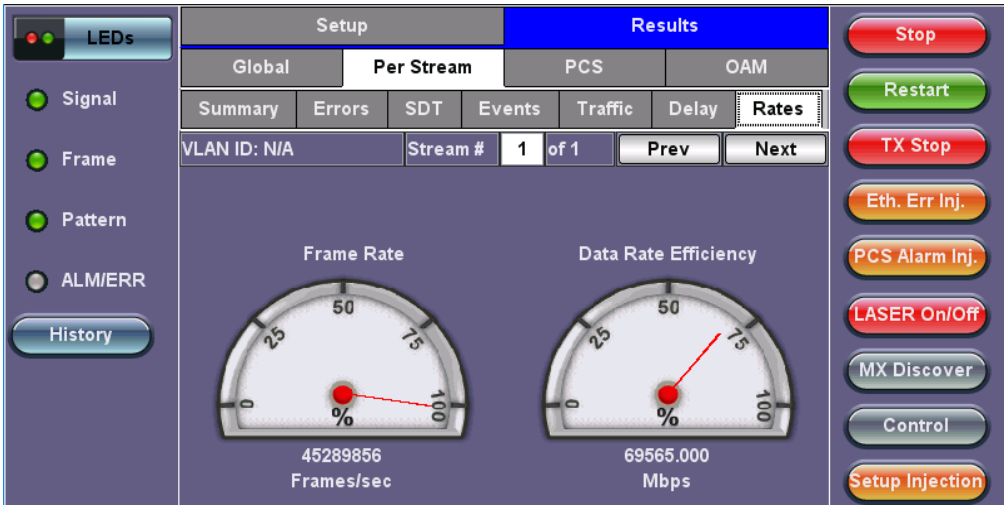
The **Per Stream Rates** screen displays the frame rate and data rate pertaining to each stream. Tap on either dial to see rate details.

Throughtput Results - Per Stream Rates



Throughtput Results - Per Stream Rate Details

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6.7.3 Saving Throughput Results

Once the test has been stopped the results can be saved by pressing the Save key on the platform's keypad.

A window will open giving the option of naming the results file. Enter the desired name for the file and tap apply. The results will be saved. For more information on retrieving saved test results, refer to **File Management** in the **TX300S**, **MTTplus**, **RXT-1200**, or **UX400** platform manuals for more information.

Throughput Results Save

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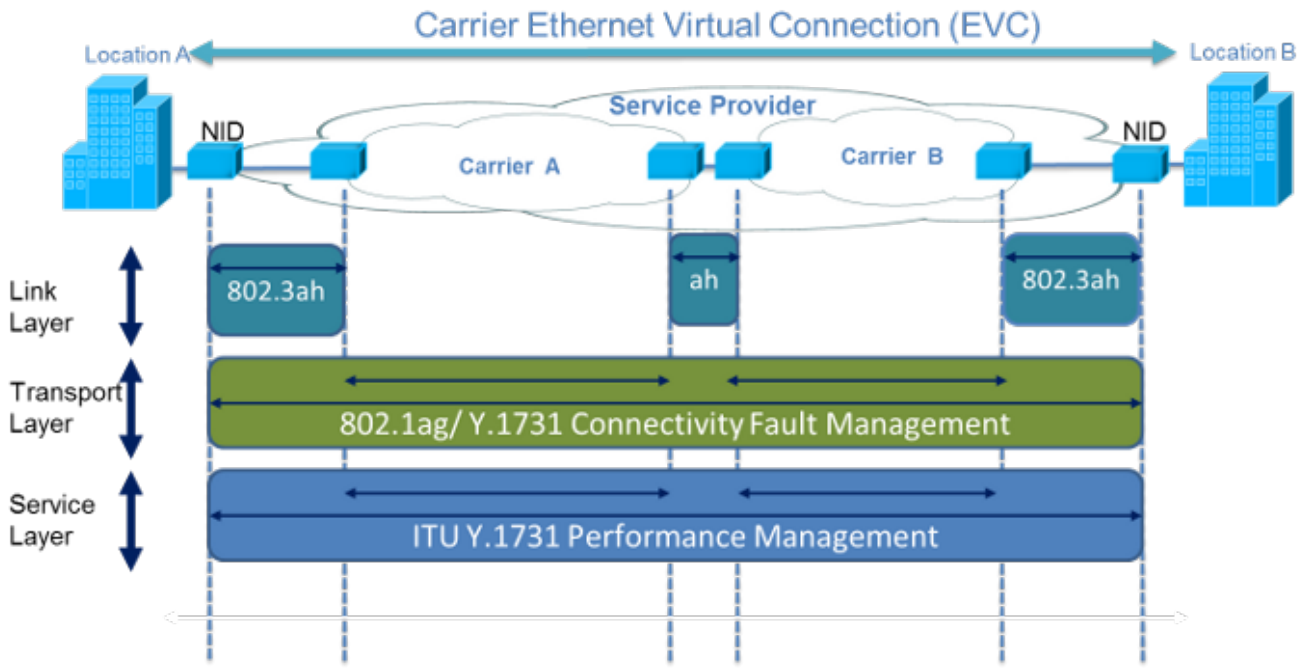
6.8 Ethernet OAM Testing



Ethernet OAM provides automatic defect detection, fault management and performance monitoring tools for network links and end-to-end Ethernet Virtual Circuits (EVC). The OAM service supports IEEE 802.3ah, IEEE 802.1ag, ITU-T Y.1731, and G.8113.1.

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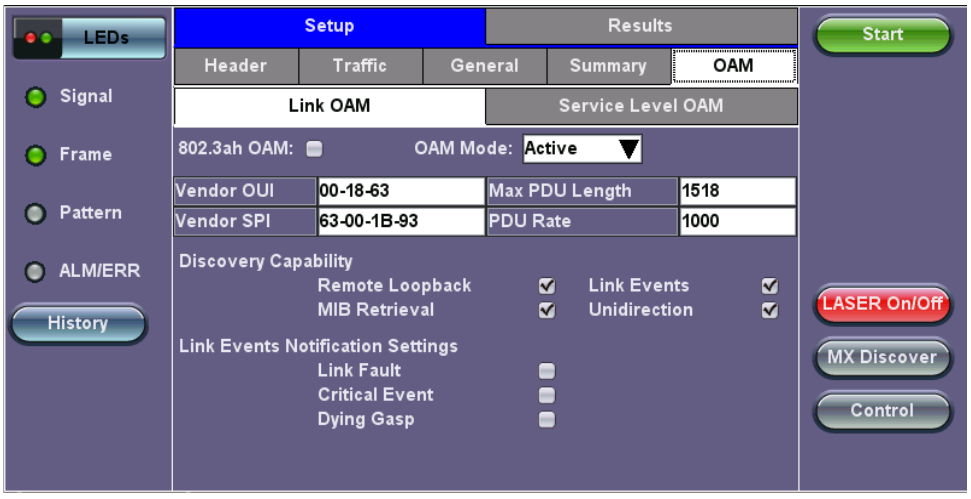
6.8.1 OAM Setup

6.8.1.1 Link Level 802.3ah OAM Setup

802.3ah functions include:

- Discovery
- Link Performance Monitoring
- Remote loopback
- Fault detection

Link OAM Setup



- **802.3ah OAM**
  Tap on the check box to start 802.3ah protocol testing. Transmission of OAM PDUs starts as soon as the box is checked.

- **OAM Mode**
  Select Active or Passive mode from the drop-down menu. Active and passive mode determines the type of actions the test set will take. For more on acceptable Active/Passive mode combinations and actions, see section 802.3ah OAM Discovery.

- **Vendor OUI and SPI**
  Organization Unique identifier and Vendor specific information (similar to MAC address fields).

- **Max PDU Length**
  Advertised Max OAM PDU size (64 to 1518). After Discovery, the lowest of the local and remote will be used.

- **PDU Rate**
  100 to 10000 ms between consecutive OAM PDUs.

- **Discovery Capability**
  Enables OAM enabled devices to exchange their OAM capabilities, configuration, and identity to link partners. Check on the boxes to advertise selected capabilities during Discovery.

- **Link Events Notification Settings**
  Enable Event Notifications for Link Fault, Critical Event, and Dying Gasp.

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802.3ah OAM Discovery

Discovery is the first phase of the 802.3ah protocol. During Discovery, local and remote units exchange Information OAM PDUs indicating capabilities and configuration information (mode, PDU size, loopback support, etc.). After successful negotiation the OAM protocol is enabled on the link. If no OAM PDU is received after 5 seconds, Discovery is restarted. The device can be configured in Active or Passive mode combinations.

OAM Mode Active/Passive Actions

Action	Mode Passive	Mode Active
Initiates OAM discovery	No	Yes
Responds to OAM discovery	Yes	Yes
Peer must be in active mode	Yes	Yes
Sends Information OAM PDU	Yes	Yes
Sends Event Notification OAM PDU	Yes	Yes
Sends Variable Request OAM PDU	No	Yes
Sends Loopback Control	No	Yes
Reacts to Loopback Control	Yes	Yes

OAM Mode - Acceptable Active/Passive Combinations

	Local Active	Local Passive
Remote Active	Yes	Yes
Remote Passive	Yes	No

Notice that each device can be placed in any mode as long as the remote and local device are not both in passive mode.

Discovery Capabilities: Capabilities advertised during discovery process

- Remote Loopback
- Link Events: Supported, but no stateful
- MIB Retrieval: Can be advertised but is not supported in current release
- Unidirection

Remote Loopback: The user can transmit a loopback command to place the remote unit into loopback mode. Every frame received is transmitted back on the same port to ensure the quality of links during installation or troubleshooting and for fault isolation testing.

Link Events: Event OAMPDU is transmitted when the link error exceeds the threshold. Events may be sent once or multiple times. In the current software release, link events are only transmitted upon user request, not based on threshold crossing.

MIB Retrieval: Retrieves information on network devices and interfaces.

Unidirection: Checks for unidirectional transmission.

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6.8.1.2 Service Level OAM: 802.1ag/Y.1731/G.8113.1 Setup

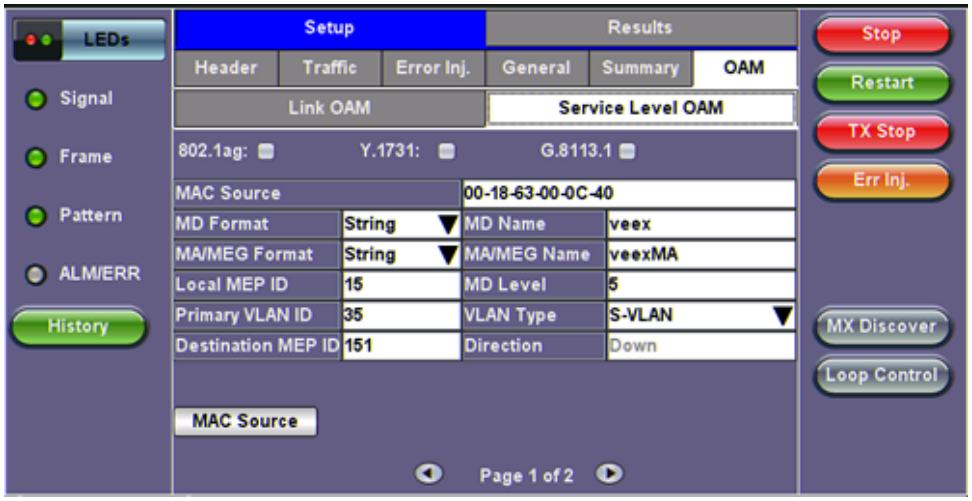
Under the **Service Level OAM** tab, the user has the option of starting the 802.1ag, Y.1731, or G.8113.1 test.

- Fill out the given parameters.

  MD Name, **MA Name**, **VLAN**, and **MD Level** input values must match for both connected OAM devices in order for the test to work. The **Destination MEPID** and **Local MEP ID** must also be inverted for the tests to work.

- Tap the box next to 802.1ag, Y.1731, or G.8113.1 to start the selected test. The transmission of OAM PDUs become active as soon as the checkmark is added to the test.

OAM - Service Level OAM (Page 1)



Service Level OAM Configuration Parameters

- **MAC Source:** Enter the source address of the test set or tap the **MAC Source** button to assign a default MAC address.
- **MD Format:** Configure the format of the Maintenance Domain Name:
  - **None**: No Maintenance Domain name
  - **MAC+2octet**: User configurable MAC address + 2 octets
  - **String**: User configurable ASCII character string
- **MD Name:** Name of the Maintenance Domain (only for 802.1ag)
- **MA/MEG Format:** Configure the format of the Maintenance Association name:
  - **VID**: User configurable ASCII character string
  - **String**: User configurable ASCII character string
  - **2 octet**: 2 octet integer
  - **ICC-Based**: User configurable ITU-T Y.1731 ITU Carrier Code (ICC) based
- **MA/MEG Name:** Enter the name of the 802.1ag MA or Y.1731 MG
- **Local MEP ID:** Local end point identifier along the path (1 to 8191)
- **MD Level:** Maintenance domain level (0 to 7)
- **MEP ID:** End point identifier (1 to 8191)
- **Primary VLAN ID:** VLAN ID associated with the MA or MEG
- **VLAN Type:** C-VLAN, S-VLAN, or None
- **Destination MEP ID:** MEP ID of the MEP end point
- **Direction**
  - **Up:** Inward facing MEP used for MA/MEG with a wider reach (i.e., end-to-end, beyond a single link)
  - **Down:** Outward facing MEP used for MA/MEG spanning a single link

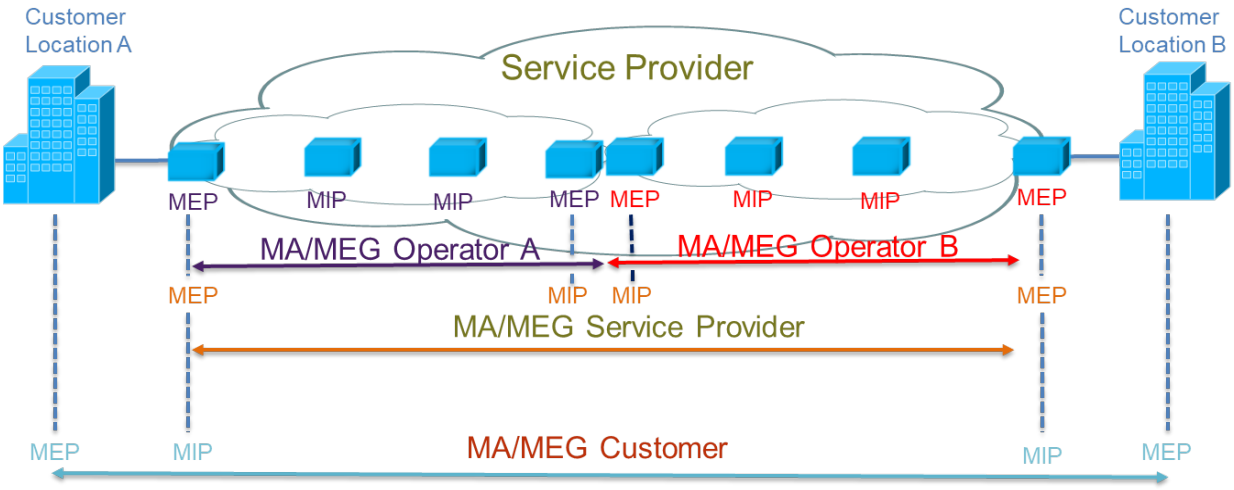
Differences between 802.1ag, Y.1731, and G.8113.1

Selecting **802.1ag** enables Continuity Check Messages (CCM), Loopback Message (LBM) and Link

Trace Message (LTM). **ITU-T Y.1731** provides all of the 802.1ag functionality with additional performance monitoring capabilities including Frame Loss (LM), and Delay (DM). **ITU-T G.8113.1** provides further monitoring of MPLS-TP traffic.

IEEE 802.1ag Definitions

- **Maintenance Domain (MD) :** Management space on a network that is owned and operated by a single network provider. There is a maintenance level (from 0 to 7) to define the hierarchical relationship between domains. Maintenance domains can be nested but never intersect. MD is defined by Operational or Contractual Boundaries (e.g., Customer/Service Provider/Operator).
- **Maintenance Association (MA):** Association of Maintenance. Elements that comprise the Maintenance domain.
- Maintenance Elements can either be MEPs (End points) or MIPs (Intermediate Points)
  - MEPs are at the edge of the network. They can generate and respond to OAM messages. A point-to-point EVC has only 2 MEPs, a multi-point EVC has multiple MEPs.
  - MIPs are located between the MEPs and can be used to isolate network problems. MIPs cannot generate OAM messages but can respond.
- **Maintenance Level:** Identifies the network hierarchy. Higher Level = Largest network. Level information present in all OAM PDU frames.
  - Level 0,1,2 = Operator domain
  - Level 3,4 = Service Provider domain
  - Level 5,6,7 = Customer domain



Some terms differ between IEEE 802.1ag and ITU Y.1731 protocols.The chart below describes the differences.

Definition Equivalencies

IEEE 802.1ag	ITU Y.1731 / G.8113.1
Maintenance Domain (MD)	No equivalent
Maintenance Association (MA)	Maintenance Entity Group (MEG)
Maintenance End Point (MEP)	Maintenance entity Group End Point (MEP)
Maintenance Intermediate Point (MIP)	Maintenance entity Group Intermediate Point (MIP)

Maintenance Point Roles

Function	MEP	MIP
Initiates CCM messages	Yes	No
Initiates Loopback and Linktrace messages	Yes	No
Responds to Loopback and Linktrace messages	Yes	Yes
Y.1731 Performance Management messages (AIS,LCK, TST,LM, etc) initiates and responds	Yes	No
Forwards messages	Yes (upper maintenance layer) No (lower maintenance layer)	Yes (upper maintenance layer) No (lower maintenance layer)

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OAM Services Setup

Under the same tab, OAM Services pertaining to 802.1ag, Y.1731, and/or G.8113.1 can be enabled. The tests listed include:

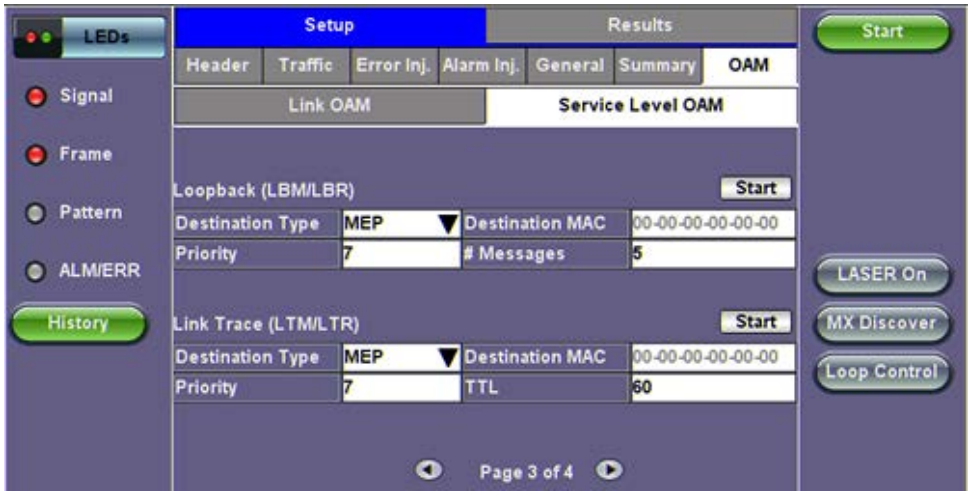
- Continuity Check (CCM)
- Loopback (LBM/LBR)
- Link Trace (LTM/LTR)
- Loss Measurement (LMM/LMR) (Y.1731 and G.8113.1)
- Delay Measurement (DMM/DMR) (Y.1731 and G.8113.1)
- Multi Protocol Label Switching Transport Profile (MPLS-TP) (G.8113.1 only)

General Setup

- To run any 802.1ag/Y.1731/G.8113.1 test, tap on the checkbox next to the corresponding test.
- To initiate testing for individual OAM services, press **Start** next to the desired service (NOT the green start button which initiates Throughput testing).
- **CCM** testing is initiated by selecting Enable from a drop-down menu.

Details on individual test parameters will be listed in the specified section.

Pressing Start next to Loopback (LBM/LBR) initiates testing for that OAM service



802.1ag/Y.1731/G.8113.1 Connectivity Fault Management Functions

Connectivity Fault Management Functions supported by the test set are as listed:

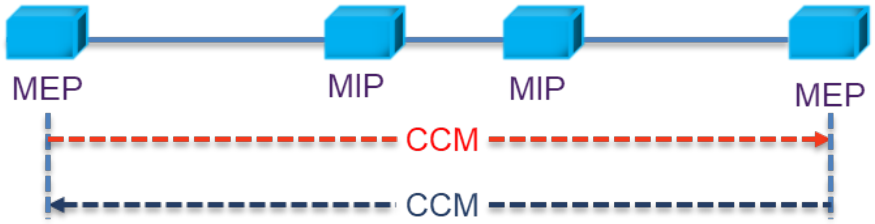
- Fault Detection – Continuity Check:
  - CCM "heartbeat" messages are transmitted at a configurable periodic interval by MEPs.
- Network/Path Discovery – Link trace message:
  - Equivalent to a traceroute test. MIPs and MEPs along the path send a response.
- Fault verification and isolation – Loopback:
  - Verify connectivity to a specific point in the message. Equivalent to ping test.

Continuity Check Messages (CCM)

CCM Messages are multicast messages sent from MEP to MEP at configurable intervals. Loss of continuity is detected after no CCM is received for 3.5 times the CCM interval.

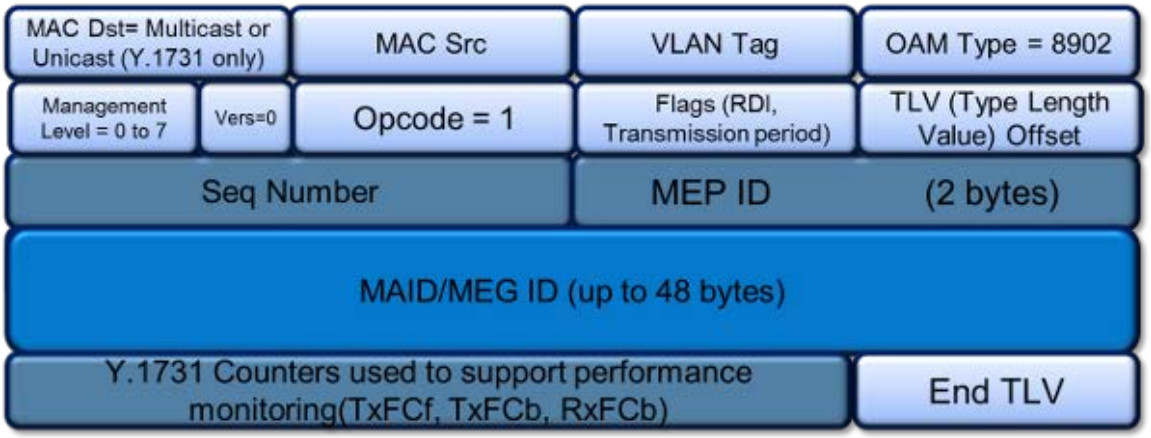
***Note**: There can be 4,094 VLANs per port and up to eight maintenance levels. This yields a worst case CCM transmission rate of 9.8 million CCMs per second if 3.3ms interval is used.*

Continuity Check Message (CCM)



RDI Flags added in CCM Messages indicates loss of continuity in the remote direction.

CCM Message Format

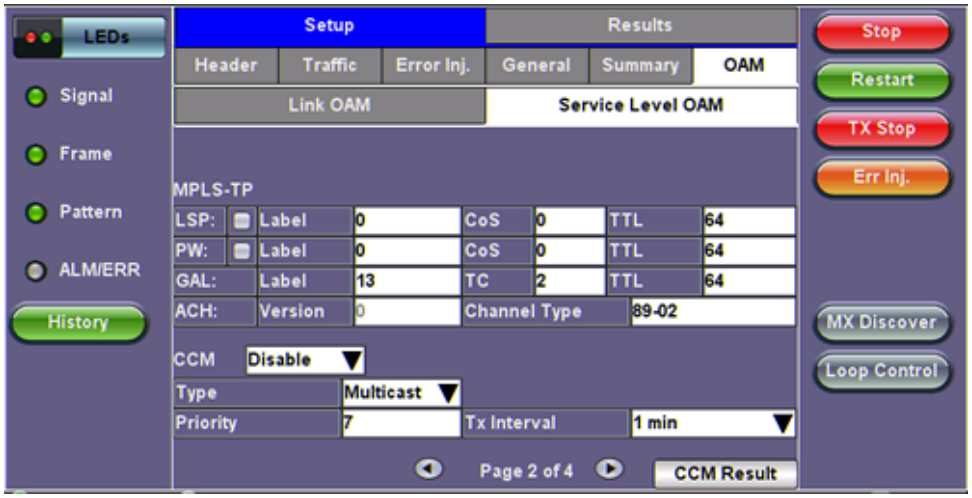


CCM Configuration Parameters

- **CCM:** Enable/Disable sending Continuity Check messages.
- **Type:** Unicast/Multicast. If CCM is set to Enable, this field is ignored. In unicast mode you must enter the MAC address of the destination unit.
- **Priority:** 802.1p priority in the CCM VLAN Tag.
- **Tx Interval:** Choose from the supported CCM intervals: 1 s, 10 s, 1 min, 10 min.

The **CCM Result** button is a shortcut that brings the user directly to the CCM Results tab.

MPLS-TP, CCM Settings - Service Level OAM (Page 2)



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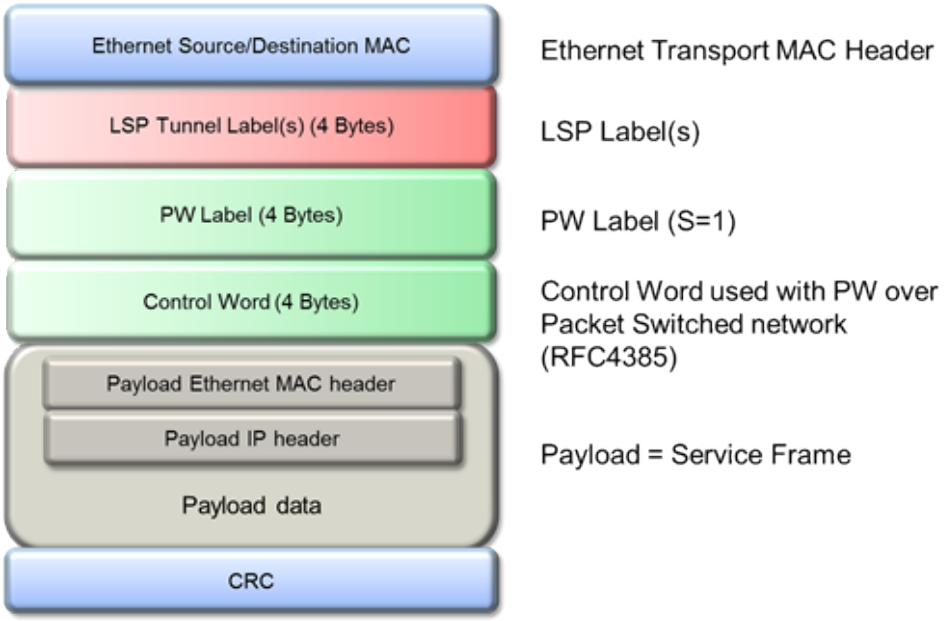
G.8113.1 Performance Management Functions

MPLS-TP

MPLS-TP over Ethernet with PW Label



MPLS-TP is a Layer 2 technology that combines the benefits of MPLS and removes the complexity of IP networking. It uses the MPLS Label switching mechanism, but with static route provisioning (no Label Distribution Protocol LDP or RSVP-TE). MPLS-TP supports an advanced set of OAM functions and path protection mechanisms. In-band OAM traffic is on the same path as data traffic.

Multi Protocol Label Switching Transport Profile (MPLS-TP) Configuration Parameters

- For the path and tunnel, select **LSP** (Label Switched Path) and **PW** (Pseudowire).
  - **Label**: Configure in the range of 16-1,048,575 (labels 0-15 are reserved).
    ***Note**: Composed of 20 bits which allows for the creation of over one million labels.*
  - **CoS**: Enter the Classes of Service.
  - **TTL**: Enter the Time to Live. It will be decremented by 1 each time it crosses a hop. Frame is not forwarded after TTL reaches 0.
- **ACH** : Enter the Generic Associate Label
  ***Note:** For Pseudowires, the ACH used the first four bits of the PW control word.*
- **Version**: Enter the G-Ach version. The default is set to 0.
- **Channel Type**: Enter the channel type (16-bit field).

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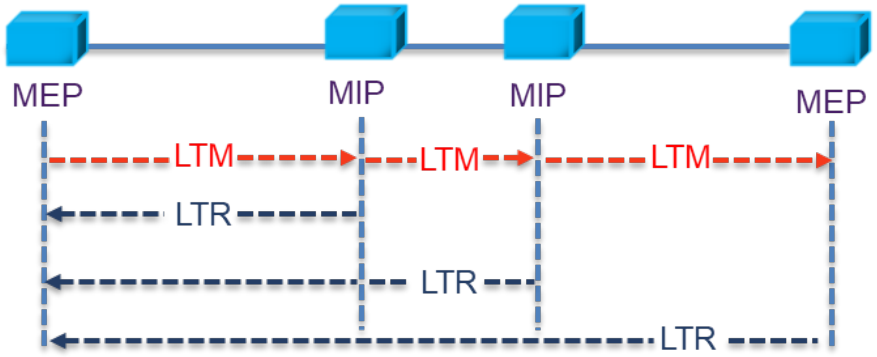
Link Trace and Loopback Messages

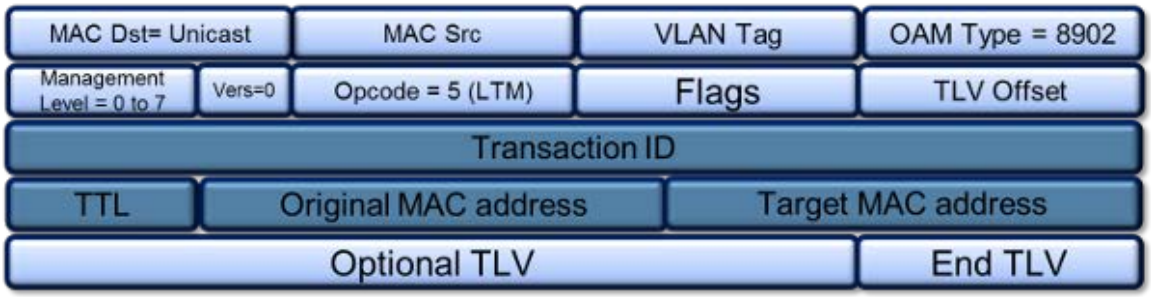
Link Trace Messages (LTM/LTR)

LTM (Link Trace Message) Multicast messages are transmitted on demand to a destination MAC address. All MIPs and destination MEPs respond with LTR (Link Trace Reply) and forward the LTM on to its destination.

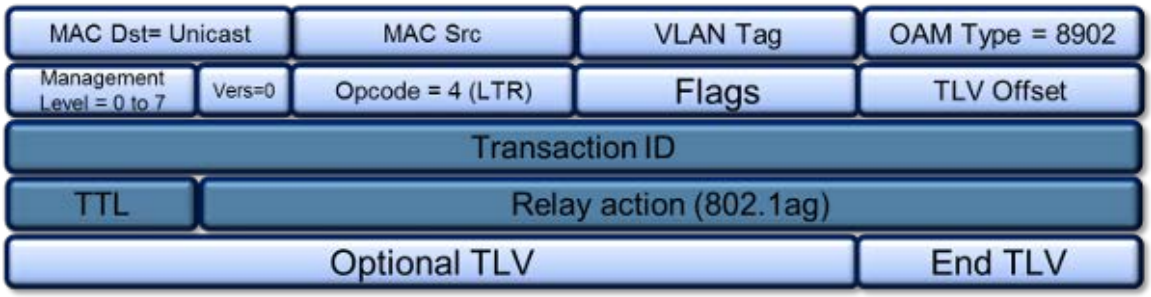
LTM Diagram (LTM/LTR)



Link Trace Message Format



Link Trace Response Format



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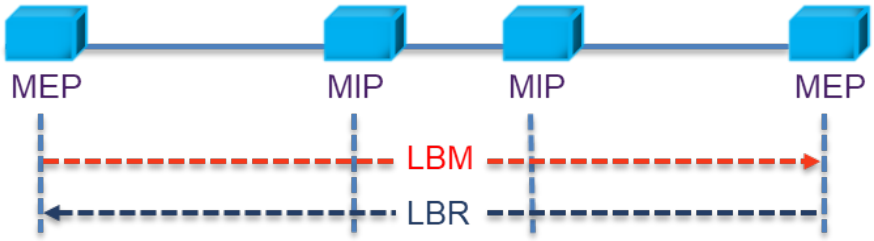
Loopback Message (LBM/LBR)

LBM (Loopback Message) are unicast messages transmitted on demand to a destination MAC address. A destination address responds with an LBR (Loopback Reply Message).

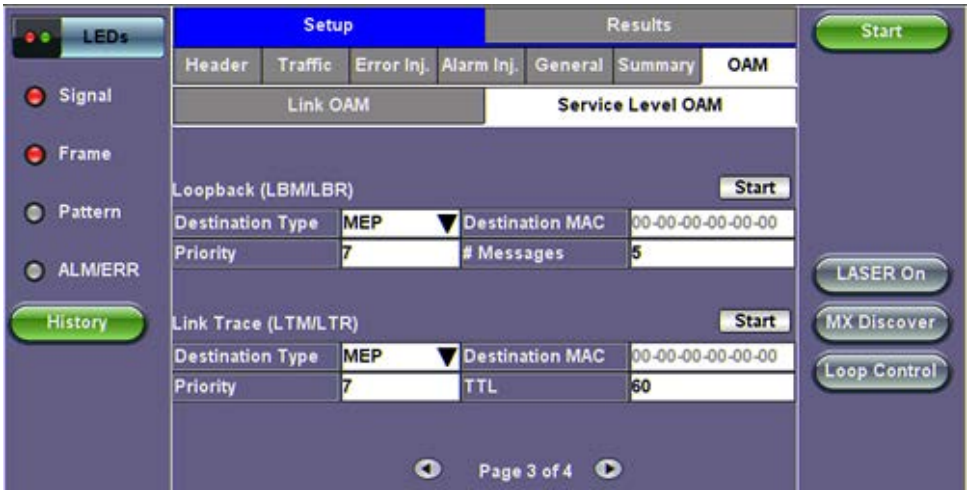
LBM Diagram (LBM/LBR)



Loopback Message Format

MAC Dst= Unicast or Multicast (Y.1731 only)	MAC Src	VLAN Tag	OAM Type = 8902
Management Level = 0 to 7 / Vers=0	Opcode = 3 (LBM) Opcode = 2 (LBR)	Flags (0)	TLV (Type Length Value) Offset
Loopback transaction ID/Sequence #			
Optional TLV			End TLV

LBM/LBR, LTM/LTR Settings - Service Level OAM (Page 3)



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Link Trace (LTM/LTR) and Loopback Message (LBM/LBR) Config. Parameters

- **Destination**
  - **MEP**: Sends LTM/LBM to the destination MEP as configured on Page 1.
  - **MAC**: Sends LTM/LBM to a destination MAC address.
- **Priority:** 802.1p priority in the LTM/LBM VLAN Tag.
- **Destination MAC:** Configure the destination MAC address used for the LTM/LBM. This field is only used if Destination is set to MAC. If destination is set to MEP, this field is ignored.
- **# Messages:** Enter the number of Loopback messages to be sent (LBM test only).
- **TTL:** Enter the Time to Live field in the LTM message. TTL will be decremented each time it crosses a hop (MIP) (LTM test only).

Press **Start** to initiate testing.

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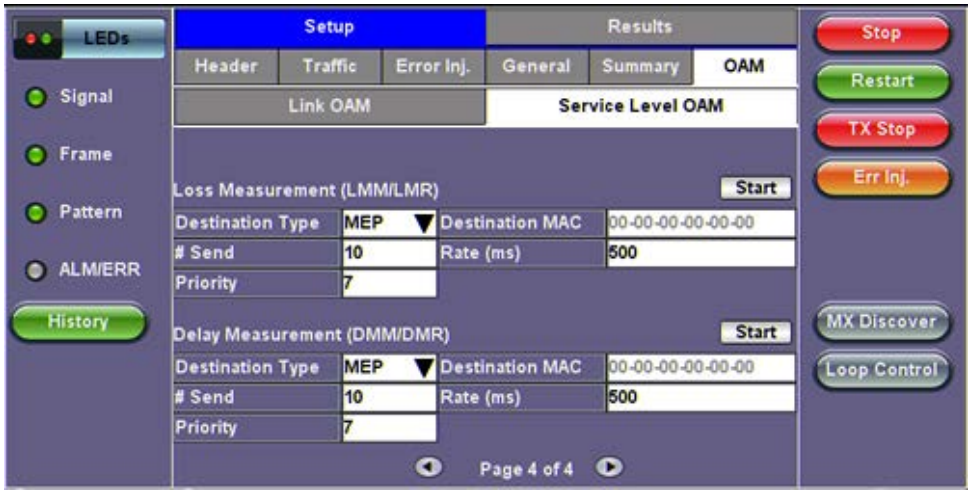
Y.1731/G.8113.1 Performance Management Functions

OAM - Service Level OAM (Page 4)



Loss (LMM/LMR) and Delay Measurement (DMM/DMR) Configuration Parameters

- **Destination**
  - **MEP**: Sends LMM/DMM to the destination MEP as configured on Page 1
  - **MAC**: Sends LMM/DMM to a destination MAC address
- **Priority**: 802.1p priority in the LMM/DMM VLAN Tag
- **Destination MAC:** Configure the destination MAC address used for the LMM/DMM. This field is only used if Destination is set to MAC. If destination is set to MEP, this field is ignored.
- **# Send** - Configure the number of LMM/DMM frames to send up to 50
- **Rate:** Configure the LMM/DMM frame interface rate (min: 100 ms; max: 10 seconds)

Press **Start** to initiate testing.

Frame Loss Measurement

Two local counters for each peer MEP:

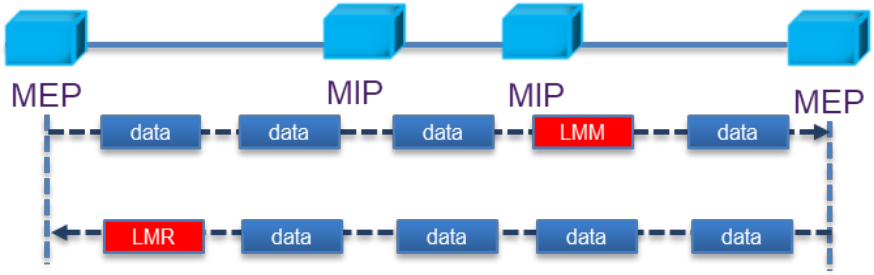
- TxFCf: Counter for in-profile data frames transmitted towards peer MEP
- RxFCf: Counter for in-profile data frames received from peer MEP

Single-ended ETH-LM:

- On demand OAM
- MEP sends LMM frame (Unicast DA or Multicast Class 1 DA) and receives LMR frame (Unicast DA) with counters

CCM frames contain frame counters.

Single Ended Frame Delay Measurement



LMM frames contain frame counters.

Delay Measurement

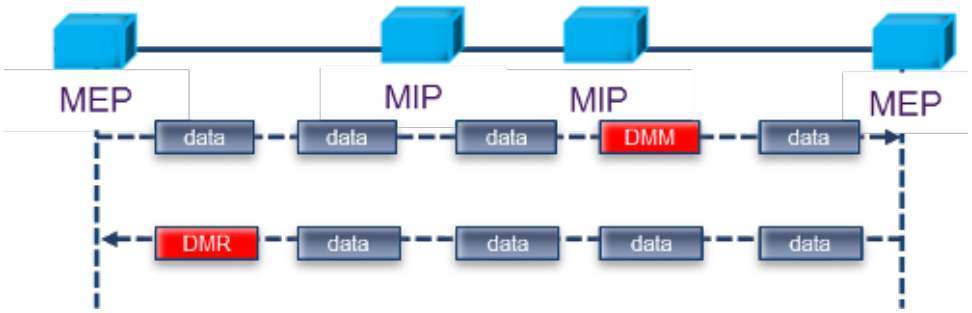
On demand OAM for measuring Frame Delay (FD) and Frame Delay Variation (FDV):

- TxTimeStampf = Timestamp transmission of DMM frame
- RxTimef = Reception time of the DMM frame
- RxTimeb = Reception of DMR frame

Two-way ETH-DM:

- DMM frame (Unicast DA or Multicast Class 1 DA for multipoint measurement) & DMR frame (Unicast DA)
- FD = RxTimeb – TxTimeStampf

Dual Ended Frame Delay Measurement



DMM and DMR frames contain timestamp info.

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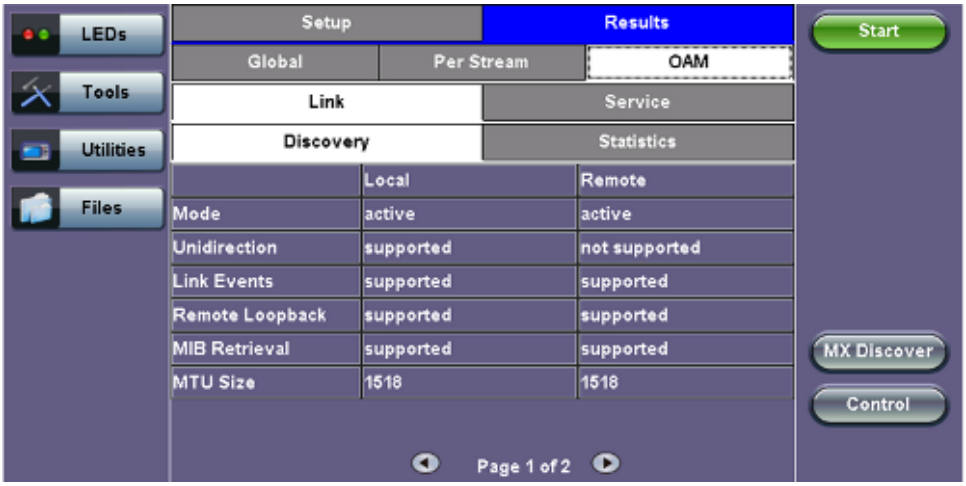
6.8.2 OAM Results

6.8.2.1 Link OAM Results

Link OAM Discovery

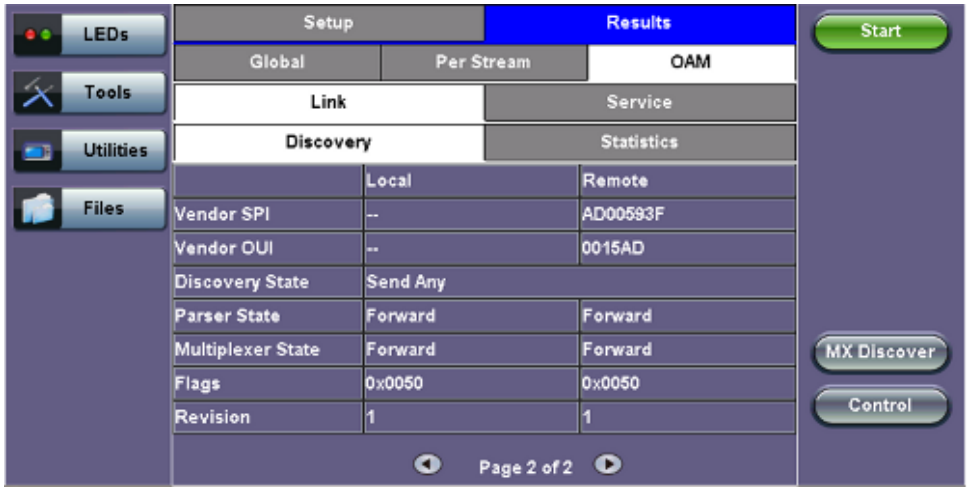
The discovery page lists **Local** (the current test unit) and **Remote** (far-end device) parameters.

OAM - Link - Discovery (Page 1)



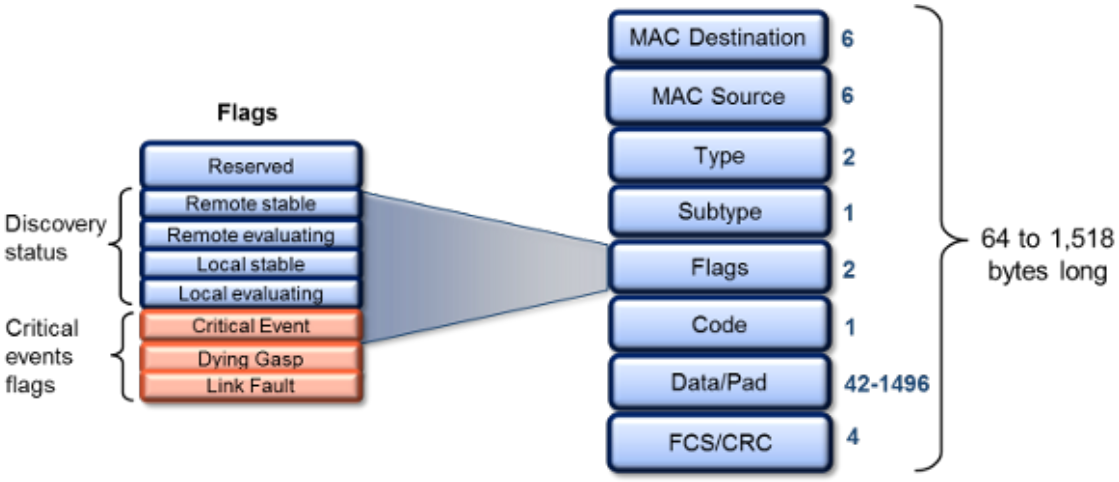
- **Mode:** Lists Active or Passive mode configuration.
- Supported and unsupported capabilities advertised during Discovery are listed, including: Unidirection, Link Events, Remote Loopback, MIB Retrieval, and MTU Size.

OAM - Link - Discovery (Page 2)

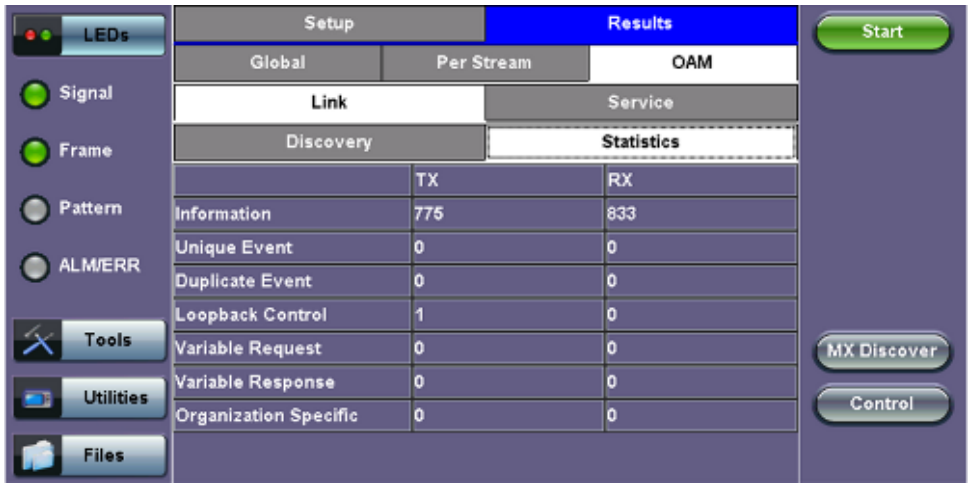


- **Vendor SPI and OUI:** Organization Unique identifier and Vendor specific information (similar to MAC address fields).
- **Discovery State:** Send Any indicates the device was successfully discovered.
- **Parser/Multiplexer state:** Forward indicates the device is forwarding regular traffic transmission. **Loopback/drop** indicates loopback is enabled.
- **Flags:** Flag decode is listed in the graphic below.
- **Revision:** Number of times the configuration has been modified since discovery.

Flag Decode



OAM PDU



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OAM PDU

Transmitted and received 802.3ah OAM PDU are displayed with other Link OAM statistics:

- **Information:** Information OAM PDU acts as a "heartbeat" message. Discovery must be restarted if no OAM PDU is received after 5 seconds.
- **Unique** and **Duplicate** Events are Threshold crossing events not supported in the current test set release.
- Number of **Loopback Control** frames.
- **Variable Request** and **Response** are MIB query messages not supported in the current test set release.

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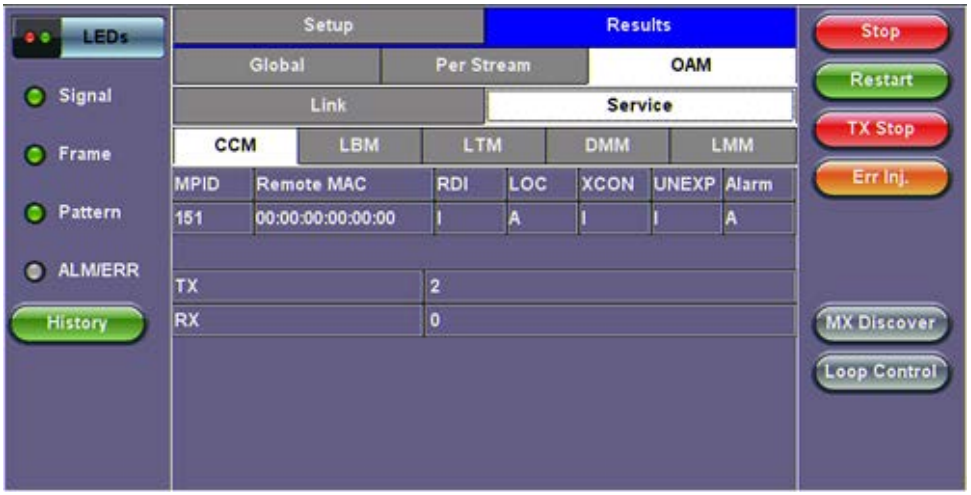
6.8.2.2 OAM Service Results

802.1ag/Y.1731/G.8113.1 Connectivity Fault Management Functions Results

OAM - Service - CCM



OAM CCM Results

RDI, **LOC**, **XCON**, **UNEXP**, and **Alarm** will display an I or A status with **I = Inactive**, **A = Active**.

- **MPID:** MEP ID of the remote MEP.
- **Remote MAC:** MAC address of the remote MEP.
- **RDI:** The CCM received contains the RDI flag set.
- **LOC:** The MEP detects loss of connectivity.
- **XCON:** Possible cross-connect, the CCM received could be from another MA.
- **UNEXP:** Unexpected MEP ID or non-matching CCM interval.
- **Alarm:** A fault alarm is triggered if a defect is present for a time period of 10s. The fault alarm is cleared if a defect condition is not present for a time period of 10s.

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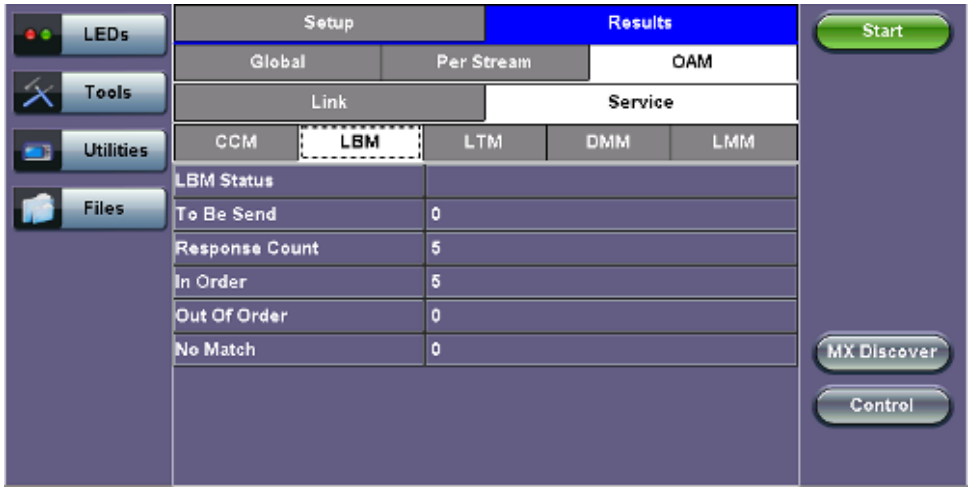
OAM - Service - LBM



OAM LBM Results

- **LBM Status**
  - **Pass**: At least 1 Loopback response received
  - **Fail**: No Loopback responses received
- **To be sent:** Outstanding number of LBM to be sent
- **Response Count**
- **In Order:** Number of LBR received in order
- **Out of Order:** Number of LBR received out of order
- **No Match:** The loopback transaction ID between the LBM and LBR do not match

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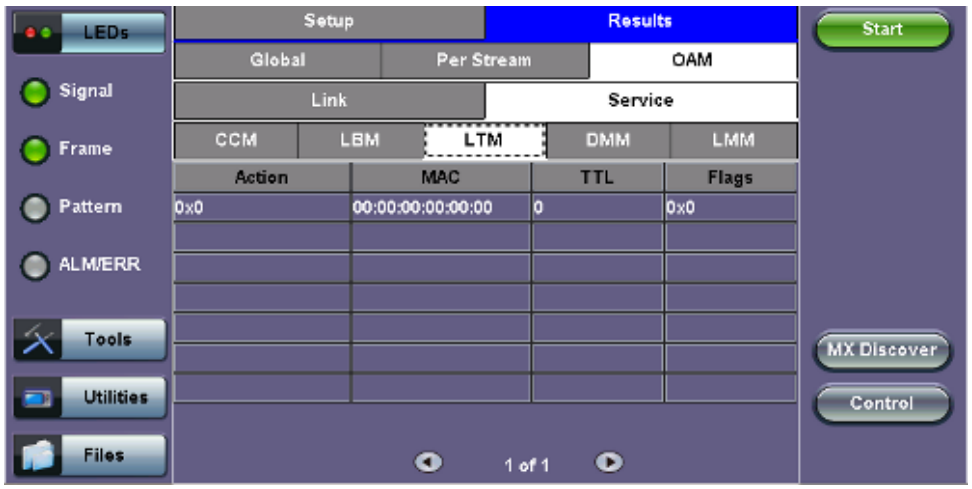
OAM - Service - LTM



OAM LTM Results

- **Action:** RlyHit indicates that the LTM has reached the destination MAC/MEP (i.e., final point)
- **MAC:** MAC address of the responder
- **TTL:** TTL field on the response, indicated how many hops have been traversed
- **Flags:** If set, indicates that only MAC addresses learned in a Bridge's Filtering Database, and not information saved in the MIP CCM Database, is to be used to determine the Egress Port

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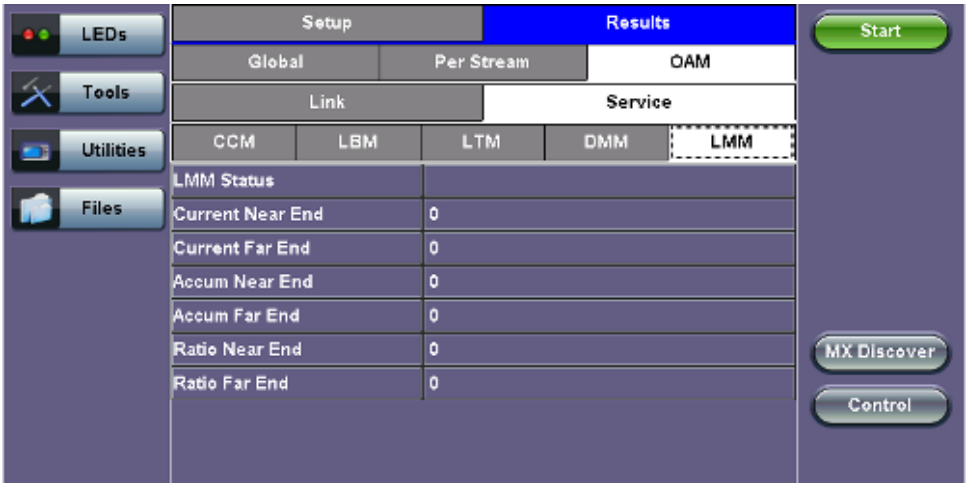
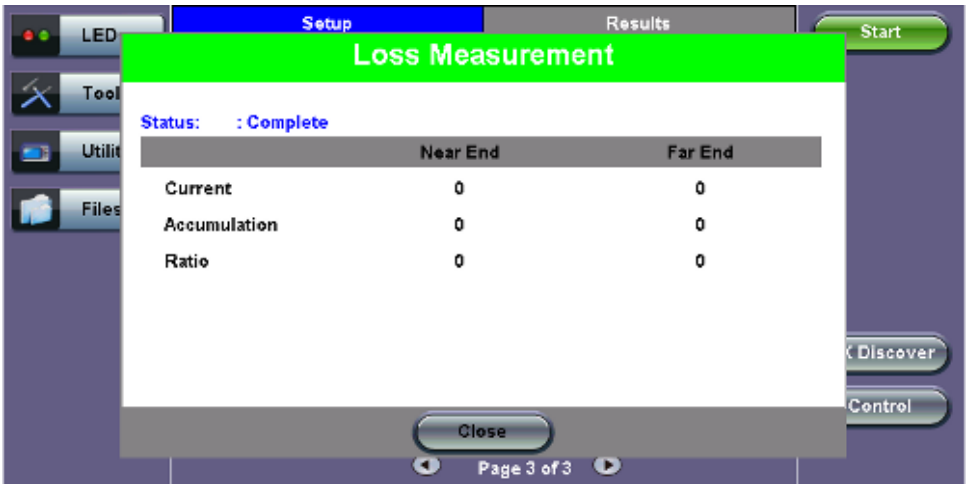
Y.1731 and G.8113.1 Performance Management Functions Results

OAM LMM

OAM - Service - LMM



OAM - LMM Message



OAM LMM Parameters

Parameter	Near End	Far End
Current	Value of the current number frames lost in the receive direction	Value of the current number of frames lost in the transmit direction
Accumulation	Total number of frames lost in the receive direction	Total number of transmitted frames lost in the transmit direction
Ratio	Percentage of frames lost in the receive direction	Percentage of frames lost in the transmit direction

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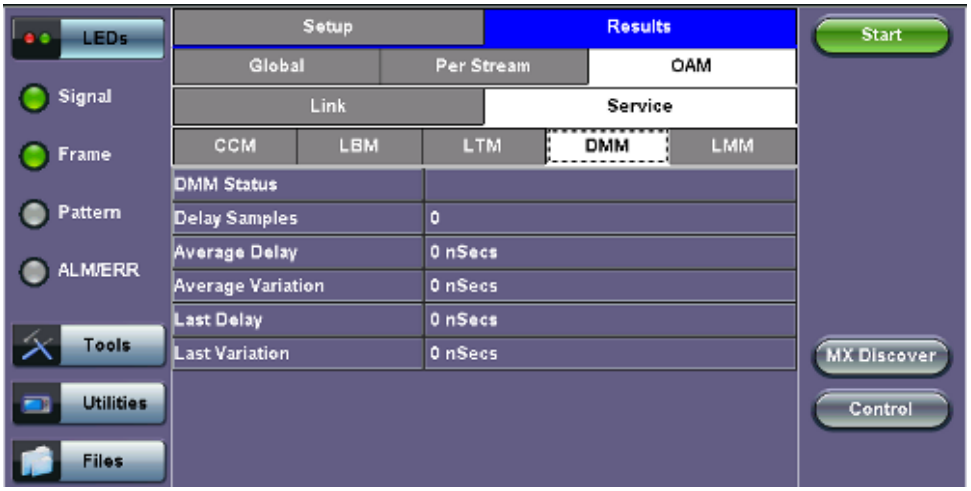
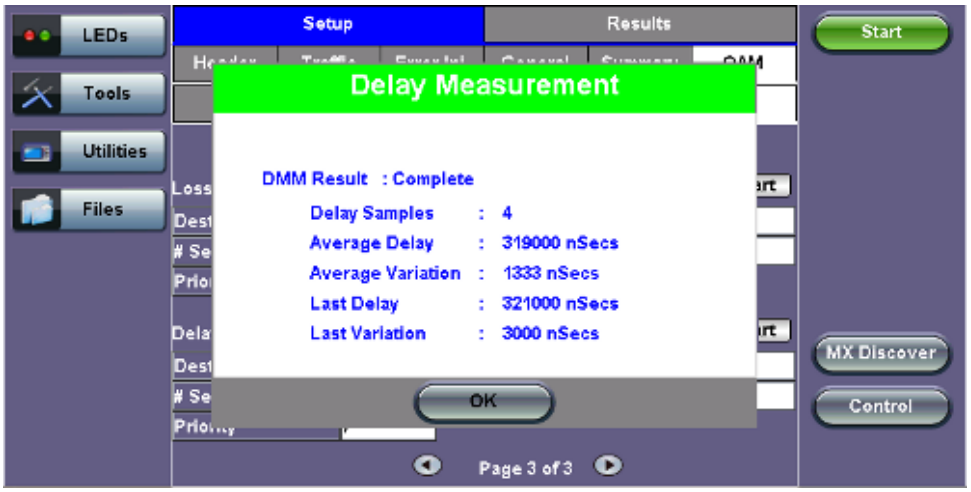
OAM - Service - DMM



OAM - DMM Message



OAM DMM Parameters

- **DMM Status:** Lists status (In progress, Fail, or Complete)
- **Delay Samples:** Number of frames transmitted
- **Average Delay:** Average round trip delay over the number of delay samples
- **Average Variation:** Average round trip delay variation over the number of delay samples
- **Last Delay:** Last round trip delay value measured
- **Last Variation:** Last round trip delay variation value measured

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6.9 Loopback

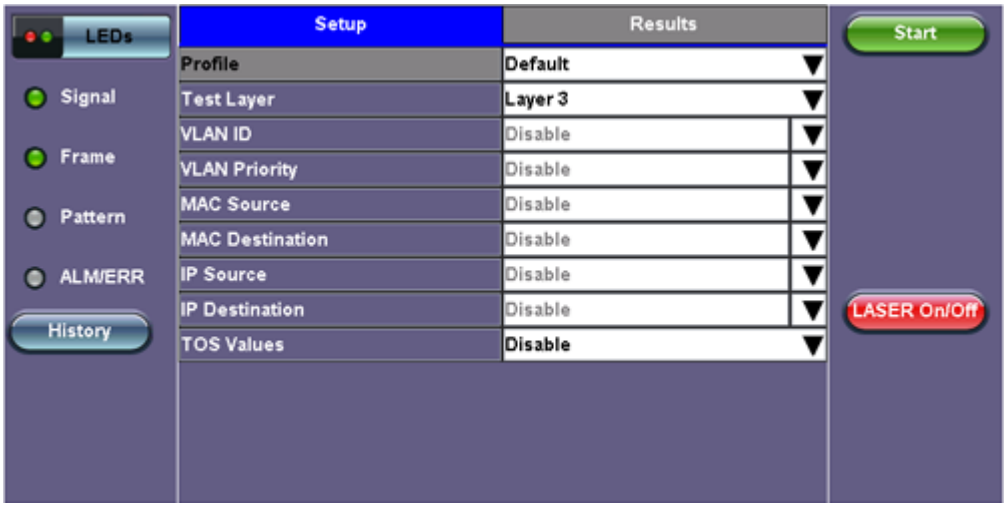
The Loopback application can be accessed from the main menu on the home screen. It allows the user to establish a manual loopback on the test set. The loopback function is used when an end-to-end test needs to be performed with one of the test partners in software loopback mode. The loopback function will loopback the incoming traffic to the test set back into the network under test.

The type of traffic that the loopback function loops back will depend on the type of test layer configured (Layer 2 or 3). Additional criteria can be set to allow only messages with specific criteria to be looped back. To specify loopback parameters, select the desired parameter and choose Enable from the drop-down menu. Tap on the box and input a value or select one of the drop-down menu choices.

Layer 2 & 3:

- All incoming test traffic will be looped back.
- The loopback function will swap the MAC destination and MAC Source addresses (for Layer 2) or MAC and IP destination and source addresses (for Layer 3).
- All incoming frames with CRC errors will be dropped, similar to what an Ethernet switch does.
- All broadcast and multicast frames will be dropped including any incoming unicast frames that have the MAC Source address equal to the MAC Destination address.
- **Loopback Parameters:** The following parameters are available on Layer 2, 3 and 4. For more information on the parameters, please see BERT Header Settings in the BERT section. It is possible to enable any of these parameters to create a customer loopback filter. For example, enabling a filter with VLAN 64, Priority 7, will only loop back traffic corresponding to these values.
  - VLAN ID
  - VLAN Priority
  - MAC Source
  - MAC Destination
  - IP Source Address (Layer 3 only)
  - IP Destination (Layer 3 only)
  - TOS Values (Layer 3 only)

Loopback Setup Layer 3



Press Start to begin loopback. indicates that loopback is in progress. The **Results** tab displays current test results. Per Stream results are available for Multi-stream setup. Results for each stream can be viewed in **Results** > **Per Stream** > **Summary** and selecting the **Stream** #. Please see BERT Results for information on the Results tabs.

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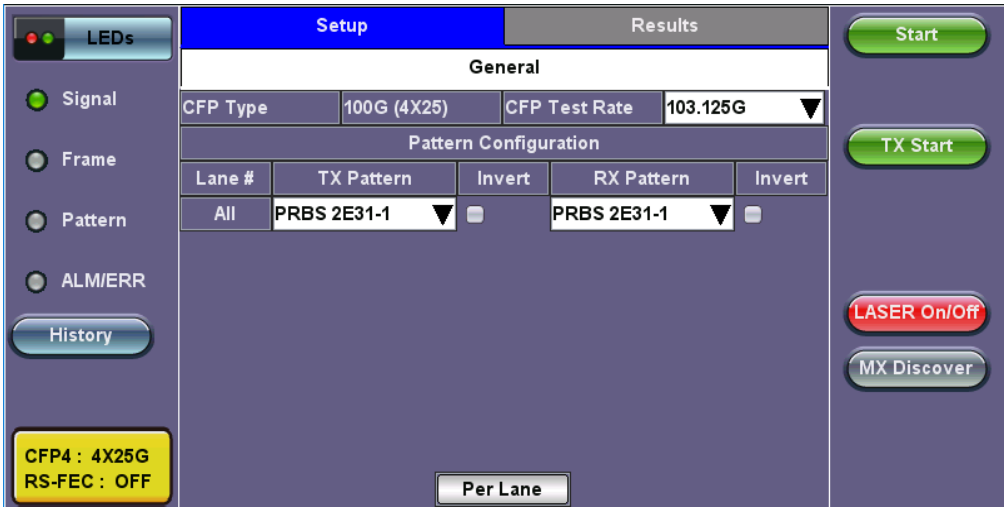
6.10 Lane BERT

The Lane BERT test is used for validating the physical interface of the optical module (CFP, QSFP28, QSFP+). It helps verify the performance and integrity of the optical module by checking bit error and BER per optical lane and frequency offset measurements per lane. The rates supported are dependent on the optical module capabilities.

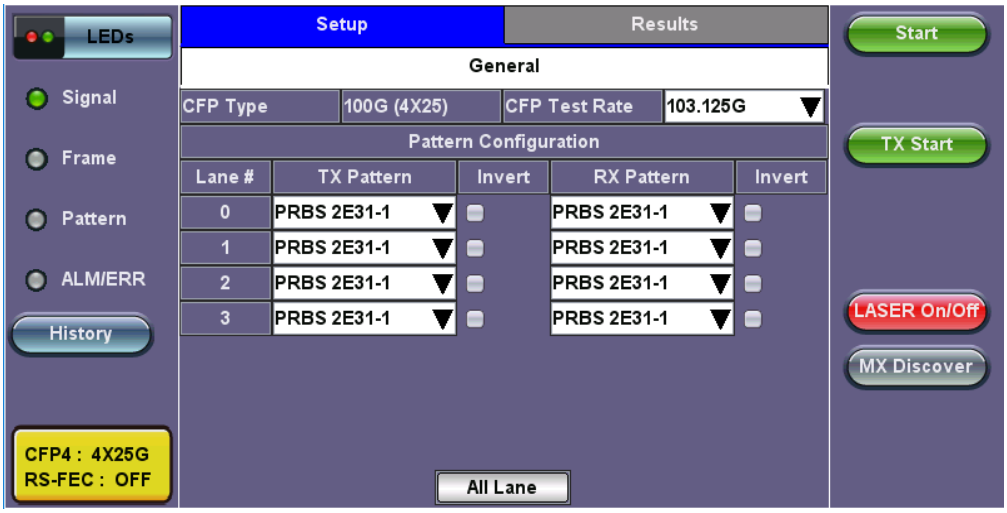
6.10.1 Setup

In newer test sets, the unit will be able to toggle between single frequency or per lane frequency measurements.

Setup - General (All Lane)



Setup - General (Per Lane)



1. Select the test rate and test pattern. The same test pattern can be configured for all lanes or a different test pattern can be configured per lane.
2. Press **TX Start**, then press Start.

The option to set PRBS patterns per lane or for all lanes is available in newer 40G/100G modules, depending on the test set and software version.

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6.10.2 Results

Aggregate and per optical lane BER and bit error count are measured, as well as pattern loss in seconds.

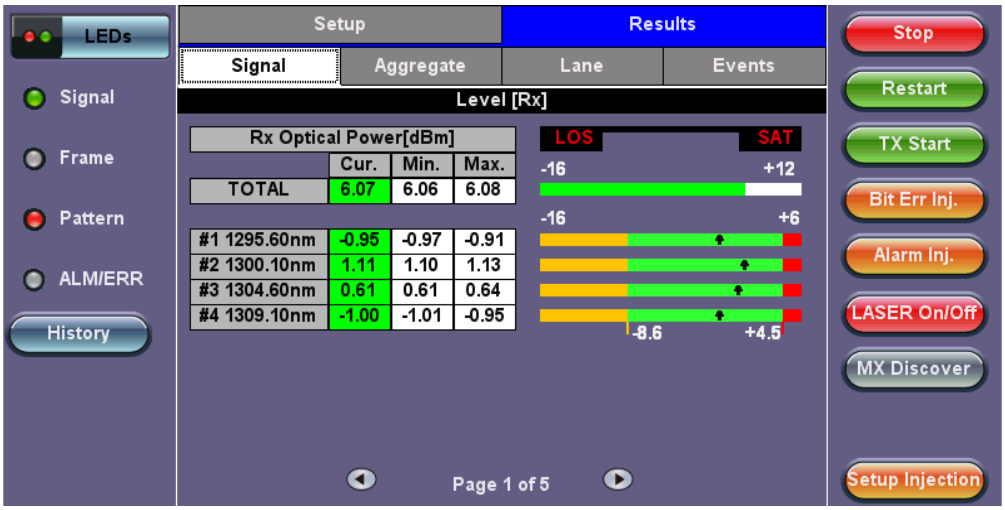
6.10.2.1 Signal

Signal (Page 1-2)

The Signal tab (fiber ports only) displays the receiving (RX) and transmitting (TX) optical level measured by the CFP2 or QSFP+ transceiver.

Loss of Signal (LOS) and the Saturation level for optical signals are shown graphically including the level measurement in dBm for each lane.

Signal (Page 1)



Signal (Page 3)

The received signal frequency and offset is measured and performed on the optical interface.

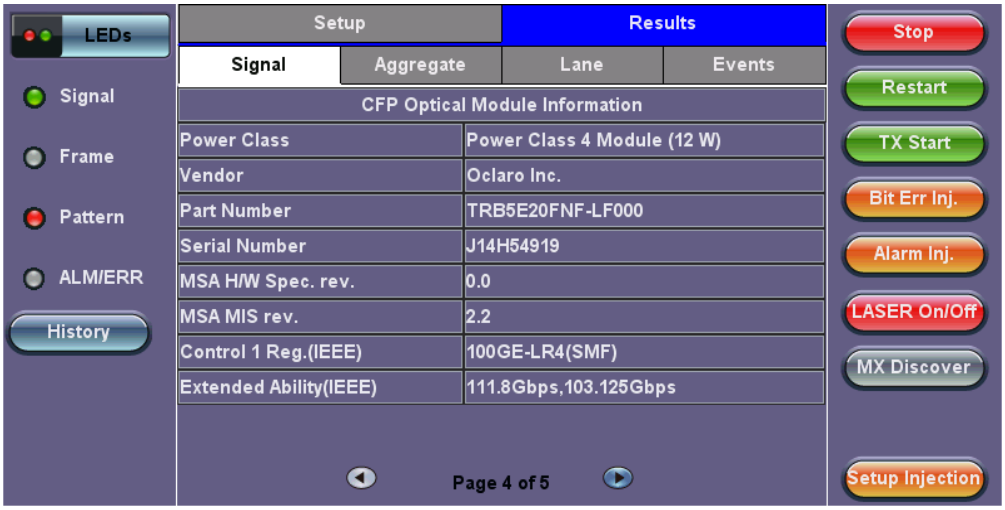
- **Current:** Indicates the frequency of the input signal.
- **Offset:** Indicates the difference between the standard rate and the rate of the input signal.
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal.
- **Max (ppm):** Indicates the difference between the standard rate and the maximum deviation detected in the input signal.

Signal (Page 3)

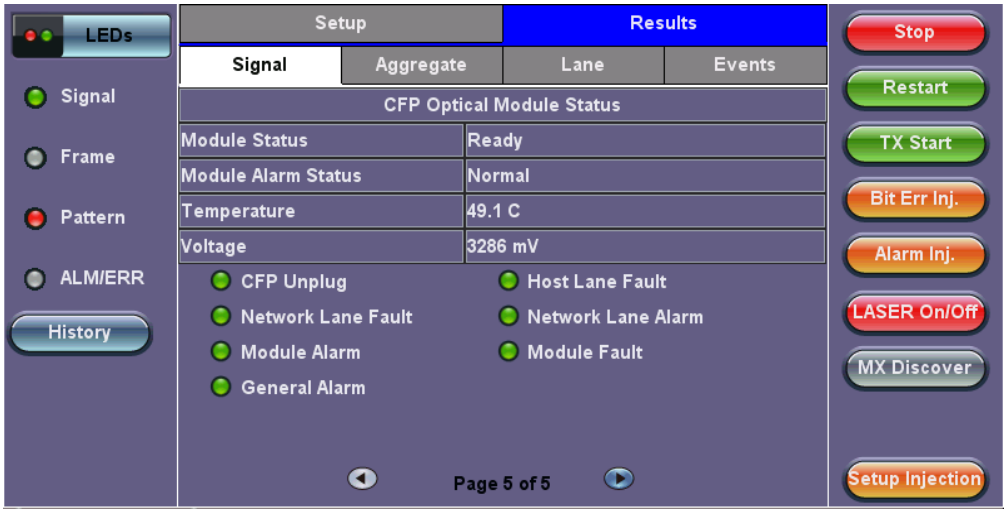
Signal (Page 4-5)

Page 4-5 displays the Optical module information and status.

Signal (Page 4)



Signal (Page 5)



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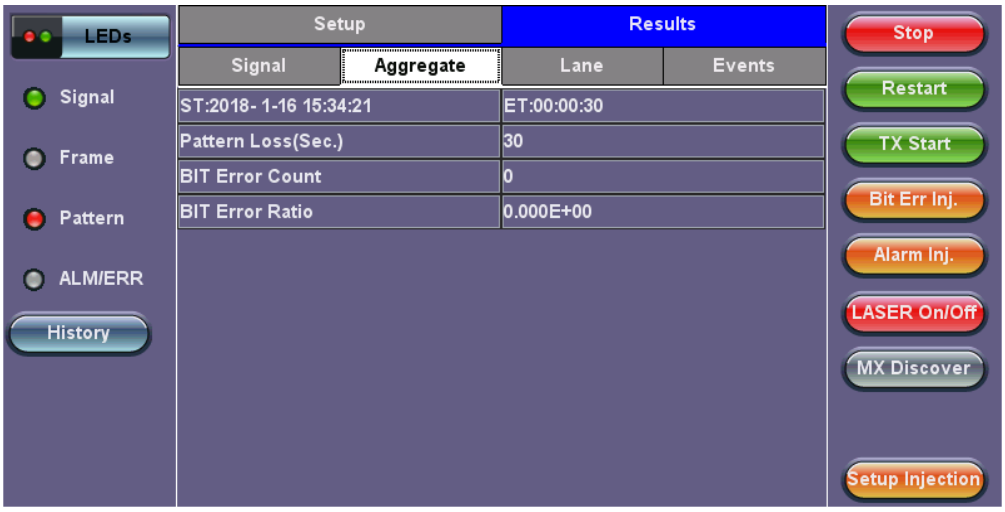
6.10.2.2 Aggregate

The Aggregate tab displays errors related to the test pattern (Bit Error or Pattern Loss).

Aggregate



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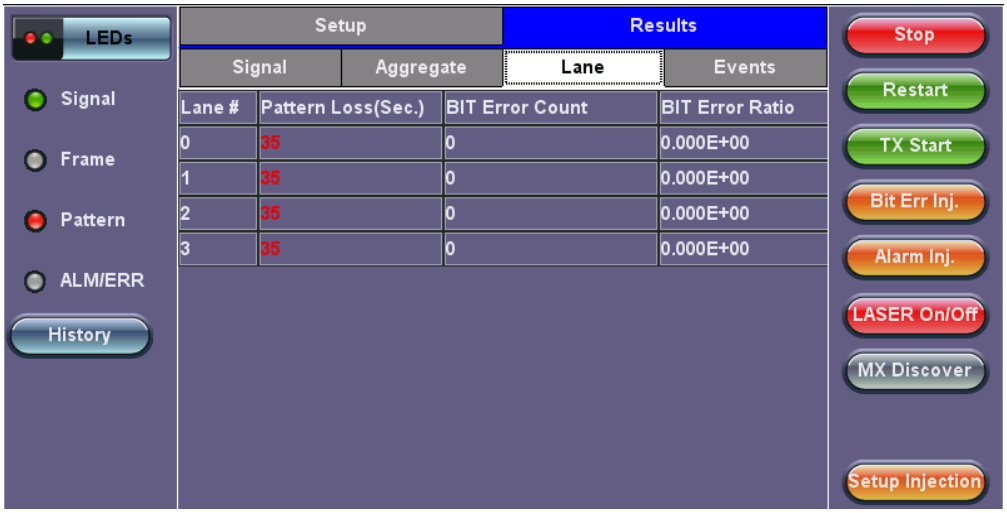
6.10.2.3 Lane

The Lane tab displays Pattern Loss and Bit Errors for each lane.

PCS Results - Alarms/Errors



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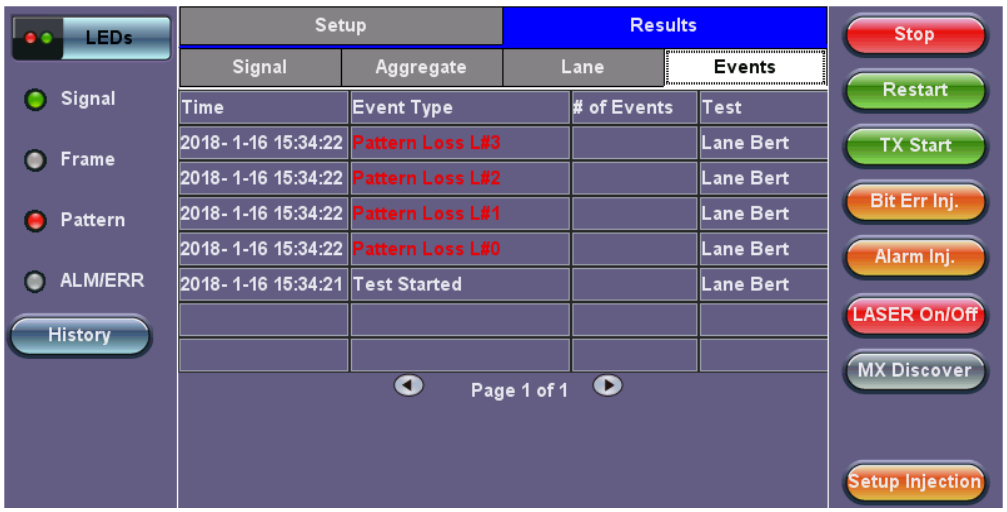
6.10.2.4 Events

A time stamped record or log of anomalies, alarms, test status (start/stop) and test application are displayed.

PCS Results - Events



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6.11 Packet Capture

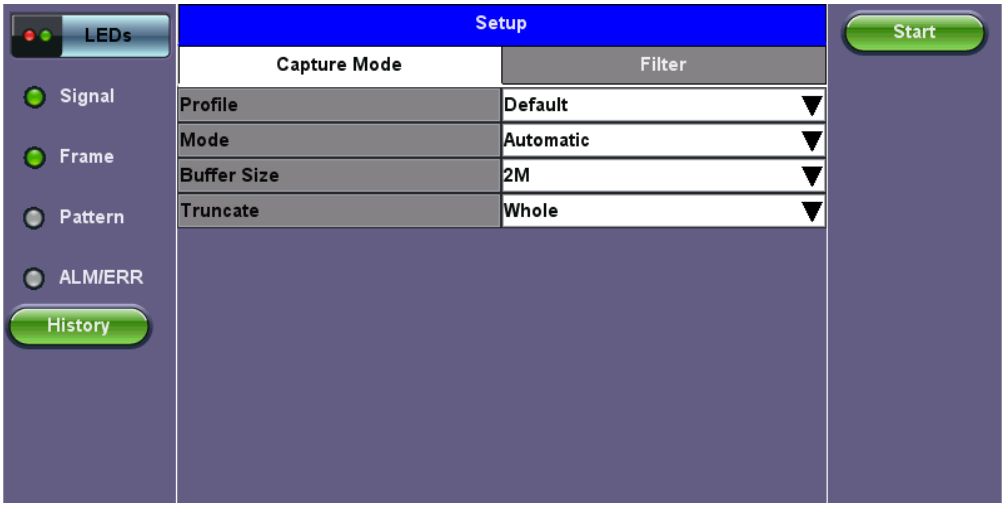
6.11.1 Packet Capture Setup

The packet capture function can be used to capture packets to Ethernet test ports. The packet capture format is compatible with Wireshark and can be viewed on a PC.

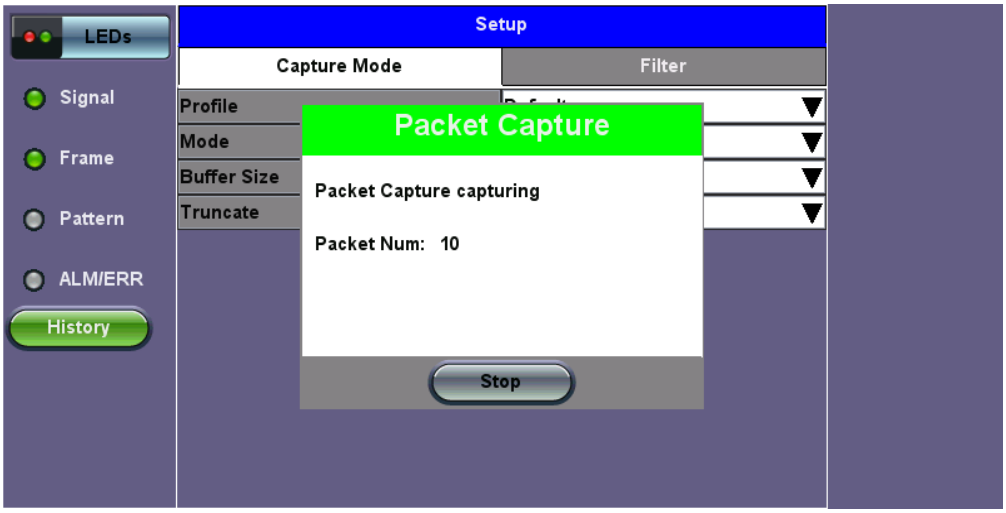
Configure the following **Capture Mode** parameters:

- **Profile:** Drop-down selections are Default, Delete, Save, Save As...
- **Mode:** Automatic. Packet capture is automatically started when pressing the **CAP ON** function key.
- **Buffer Size:** Defines the size of the storage allocated to packet capture.
- **Truncate:** Captures the whole frame or first number of bytes of that frame.

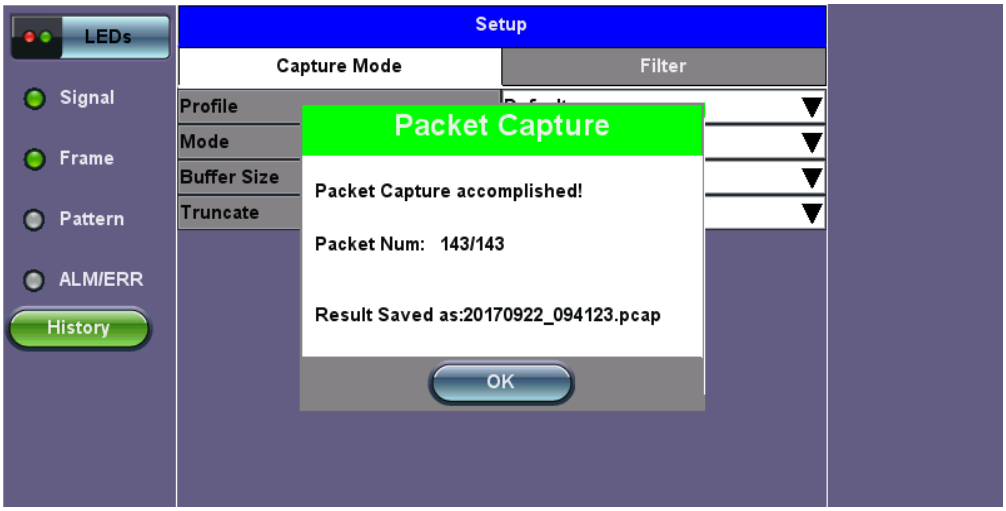
Capture Mode Setup



Packet Capture In Progress



Packet Capture Save



Select from the following Filter options:

MAC and IP Mode

- **Disable:** All IP packets to and from the unit are captured
- **MAC and IP:** Only traffic frames matching the MAC and IP source and destination addresses are captured
- **UDP and TCP:** Only TCP, Only UDP or both TCP/UDP are captured

Press the green Start button to begin packet capture. A display message shows the number of packets being captured.

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6.11.2 Packet Capture Results

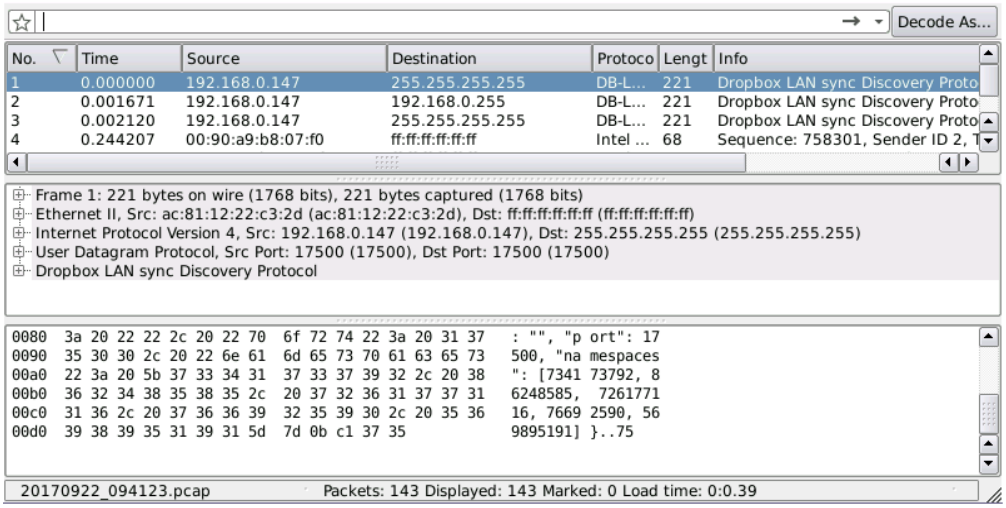
To finish packet capture and manage packet capture results, press **Stop**.

To save result packets and view results, tap YES when asked to view results. Results are saved in PCAP format and are automatically named. Wire shark will launch afterwards and display the results.

The file is stored in the Files folder. It can be viewed on the test set or exported and analyzed on PC Wireshark. Refer to **File Management** in the **TX300S, RXT-1200, or UX400 platform manuals** for instructions on viewing and exporting files.

The Packet Capture results screen is divided into three parts with all details of the capture. The size of each part can be manually
adjusted.

Packet Capture Results on Wireshark



Top section:

- Time

- Source
- Destination
- Protocol
- Length
- Info

Middle and Lower Sections:

- Frame details
- Ethernet frame details

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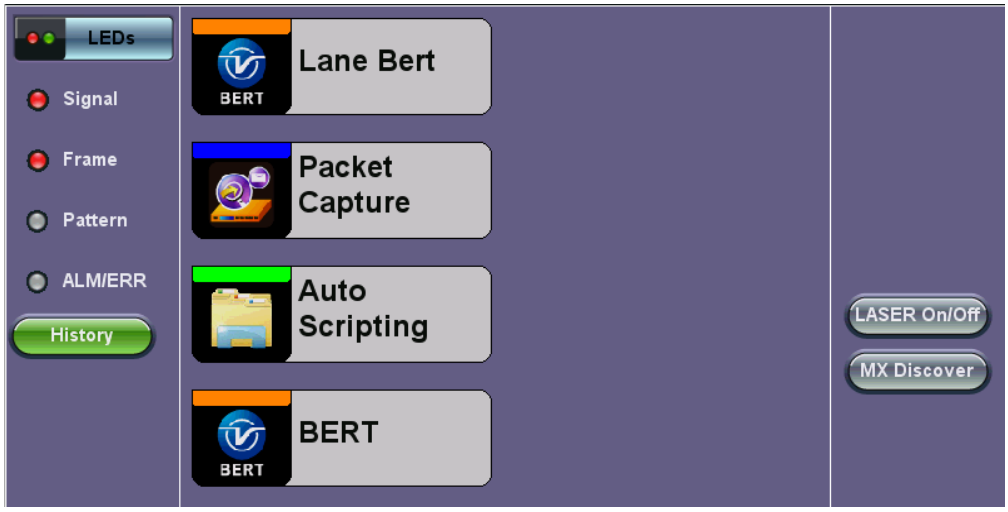
6.12 Autoscripting/Ethernet Auto Profile Testing

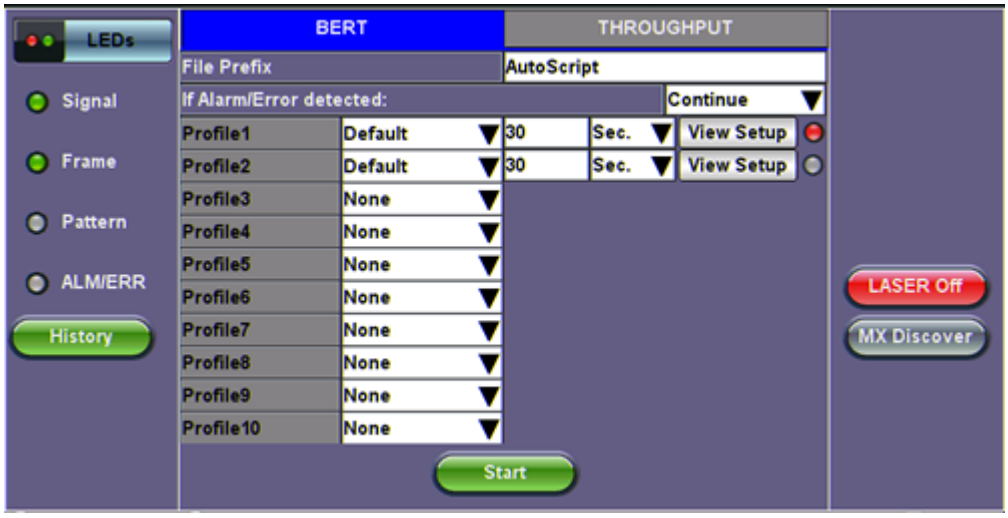
Autoscripting is available from the Ethernet Test Mode Selection menu and from within the Advanced Tools menu.

Advanced Tools > Auto Scripting



Autoscripting runs BERT and Throughput test profiles in succession. Profiles are configured from the test application or ReVeal software.

Autoscripting - BERT Setup



Autoscripting Setup

- **File Prefix:** Prefix added to name of test results. The default prefix is "Autoscript."
- **If Alarm/Error detected:** Choose to **Continue** or **Exit** testing if an alarm/error is detected.
- **Profile:** Select Default, Last Configuration, or None.
- Testing duration can be set for seconds, minutes, hours, or days.
- Tap on **View Setup** to view test setup parameters. Setup cannot be configured from this menu.

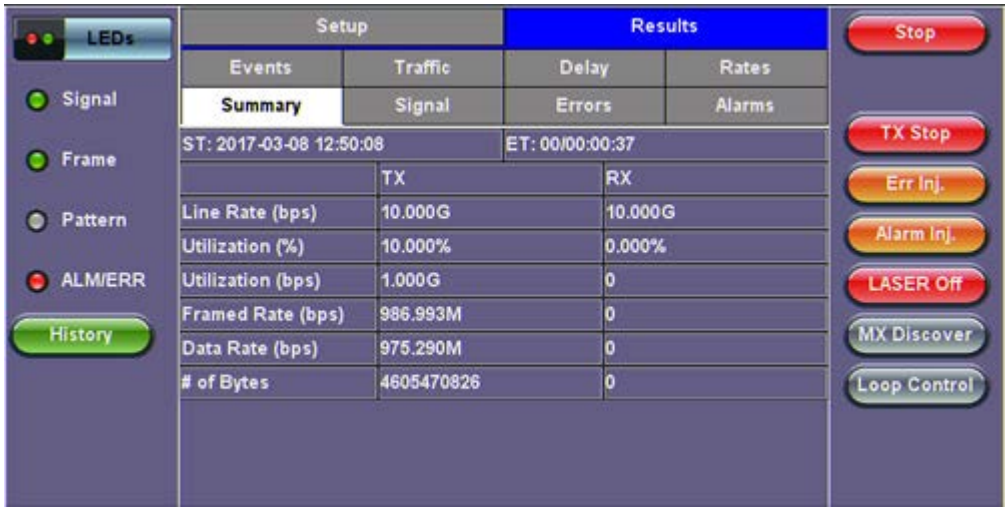
Tap on the green **Start** button to begin Autoscripting.

The soft LED light indicates the status of finished tests:

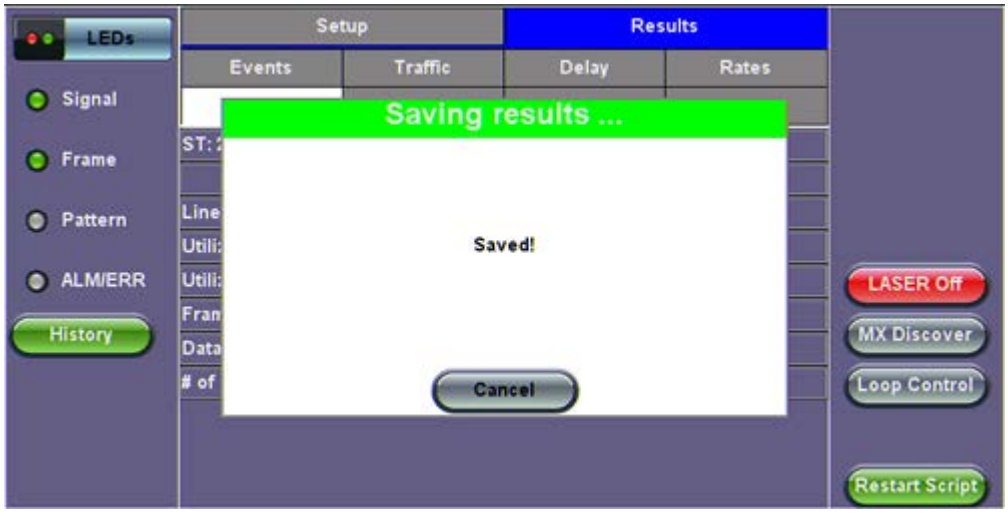
- **Green:** No error or alarm was detected.
- **Red:** An error or alarm was detected.

Starting the test brings up the BERT/Throughput Results tab. Test status is displayed in green on the bottom of the screen. When testing finishes, results are automatically saved. Refer to **File Management** in the **TX300S, MTTplus, RXT-1200, or UX400 platform manuals** for information on accessing saved results.

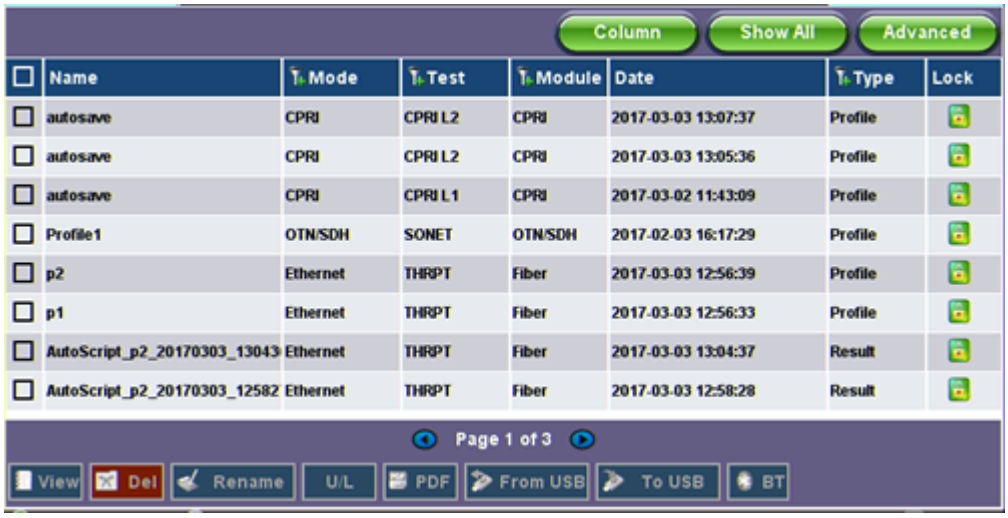
Autoscripting - BERT Results



Autoscripting - Saving Results



File Manager - Saved Results



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7.0 OTU3/OTU4 (Ethernet/Bulk) and STL256.4 (Basic)

Refer to the TX300S, UX400, or RXT-1200 platform manuals for instructions on assigning test modules or launching test applications.

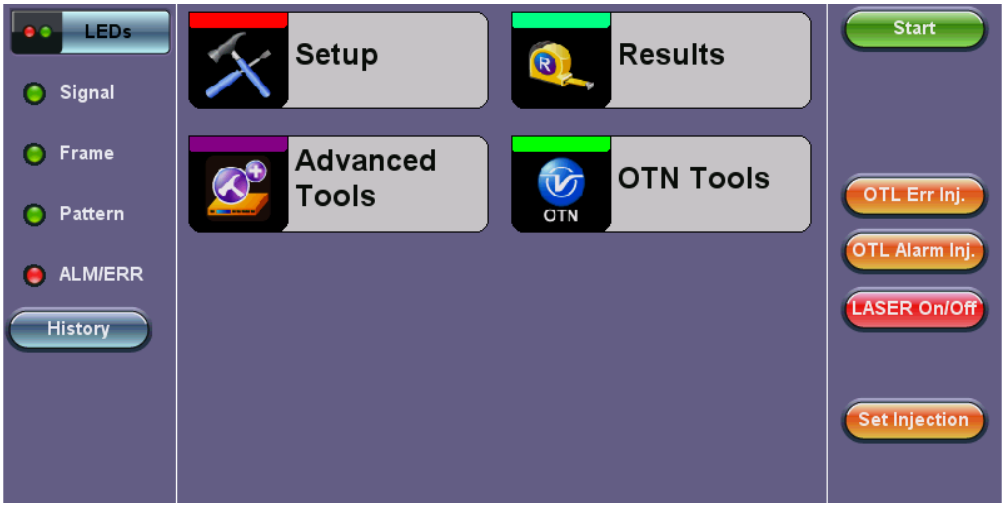
For safety reasons the transmitter laser is OFF by default. After making all the right connections, tap the **Laser On/Off** button on the right side of the screen.

The Laser On/Off button will turn Red, and the yellow Laser ON warning icon should show on the top of the screen. The soft LEDs for Signal and Frame may start blinking, indicating the historical LOS condition.

Tap the **History** button displayed below the soft LEDs. The LEDs will now turn steady green and the test tab will also turn green, indicating the module is ready to perform different tests.

Note: *Actual screens may differ depending on the installed TX, UX, or RXT series module.*

OTU4 Setup Home



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7.1 Setup

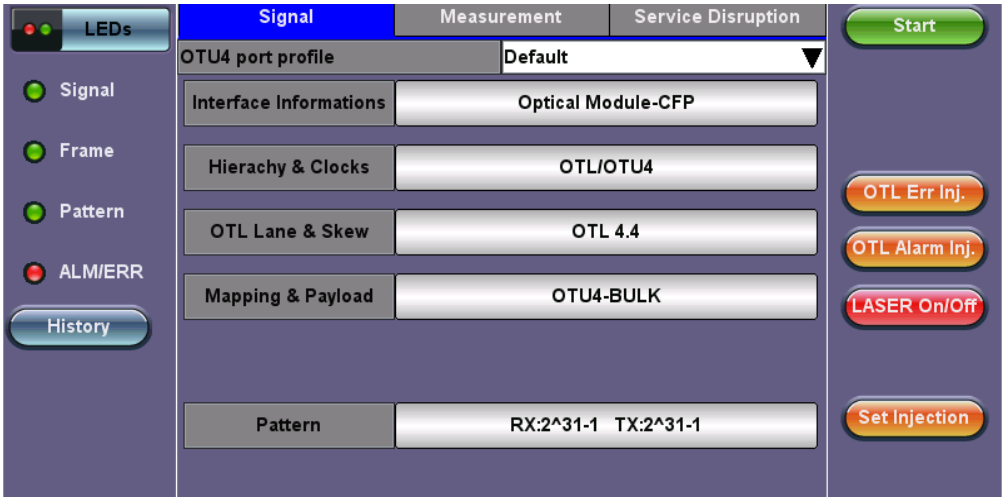
7.1.1 Signal

The following Signal parameters can be configured under the **Setup** tab on the OTU4 or OTU3 Home screen:

- Interface Informations
- Hierarchy & Clocks
- OTL Lane & Skew
- Mapping & Payload
- Pattern

The parameters for TX and RX settings are Coupled. TX and RX configurations are grouped as one block with identical configuration. Tap on a block to configure the parameters applicable to each of the layers.

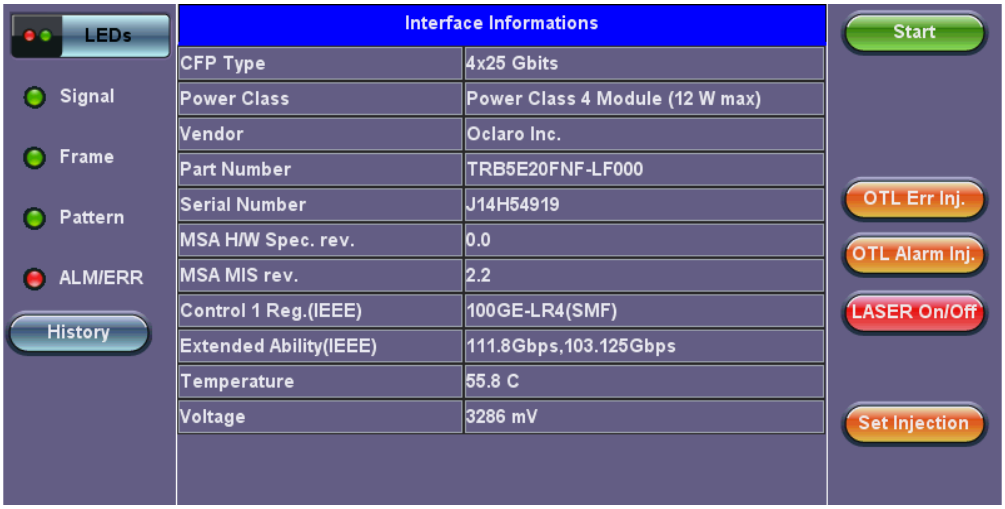
Signal Setup parameters



7.1.1.1 Interface Informations

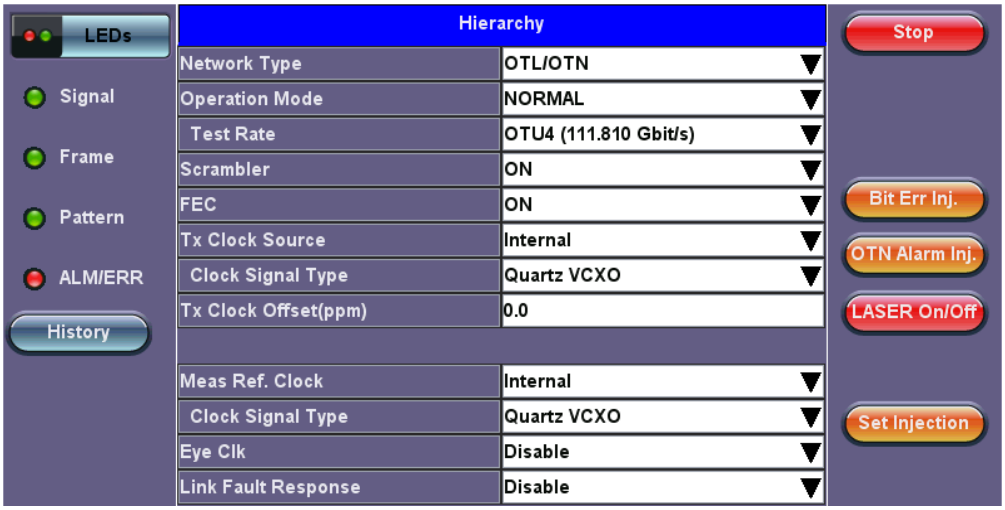
Interface Information displays the capabilities and details relevant to the selected pluggable optical module (CFP, CFP2, CFP4, QSFP+, QSFP28, etc.).

Interface Informations

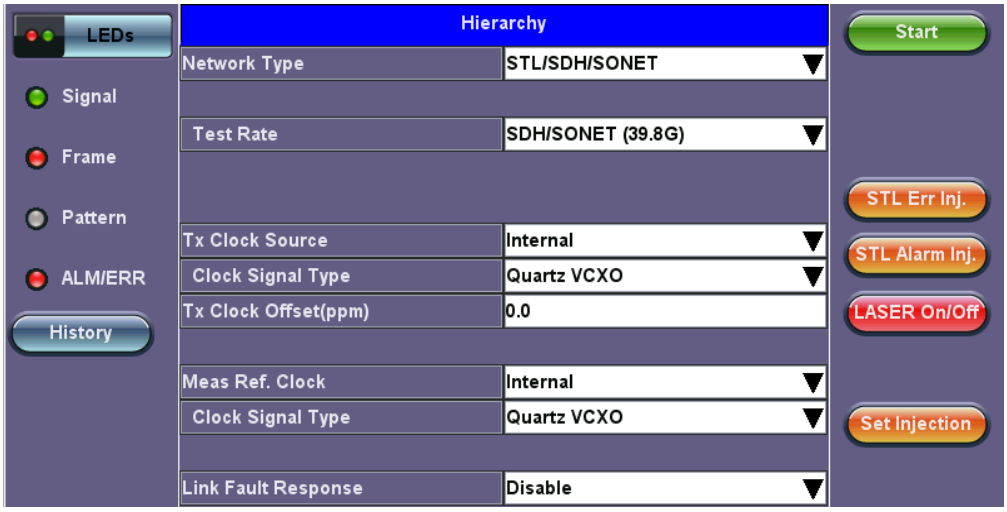


7.1.1.2 Hierarchy & Clocks

OTU3/OTU4 Hierarchy & Clocks



STL/SDH/SONET Hierarchy & Clocks



Tap the Hierarchy tab to enter the configuration screen for the physical test interface. Configuration options for the OTN signal and network types include the bit rate and higher order mapping, if applicable.

From the **Network Type** parameter, select OTL/OTN or STL/SDH/SONET (basic version). Menu options will vary depending on the selected Network Type.

- **Operation Mode** *(OTL/OTN only)*:
  - **Normal:** The test set terminates the link. The test signal and its payload is internally generated by the test set and compared to the received signal.
  - **Payload Thru:** The test set acts as a repeater, regenerating the signal received by the RX port and retransmitting it on its TX port, keeping the payload undisturbed. This allows the test set monitor the overhead bytes, payload and to intrusively modify non-critical overhead bytes to introduce (simulate) error and alarms.
  - **Line Thru:** The test set acts as a transparent repeater, regenerating the signal received by the RX port and retransmitting it on its TX port. The test set can monitor the incoming signal, but no errors or alarms ca be injected, besides using the Laser button to turn it off and generate LOS.
- **Test Rate:** OTU4 (111.819 Gbits/s) or SDH/SONET (39.8 G)
- **Scrambler** *(OTL/OTN only)*: On
- **FEC** *(OTL/OTN only)*: On/Off
- **Tx Clock Source:**
  - **Internal:** The clock for the transmitter is derived from the internal clock. The internal clock has an accuracy of +/- 3.5ppm conforming to G.812 recommendations.
  - **Received:** The clock for the transmitter is derived from the received signal and the jitter of the incoming signal is suppressed.
  - **External (BNC):**
    - **Clock Signal Type:** 1PPS (BNC), 10MHz, 5MHz, 1544KHz, 2048KHz, 2048Kbit/s, 1544Kbit/s, 64 Kbit/s signals are present on the SMA connector.
    - **Line code:** HDB3, B8ZS, AMI
- **Clock Signal Type:** Quartz oscillator (Internal)
- **Measurement Reference Clock:** Internal
- **Eye Clk:** Disable, 1/8 of network lane rate
- **Link Fault Response:** Disable/enable

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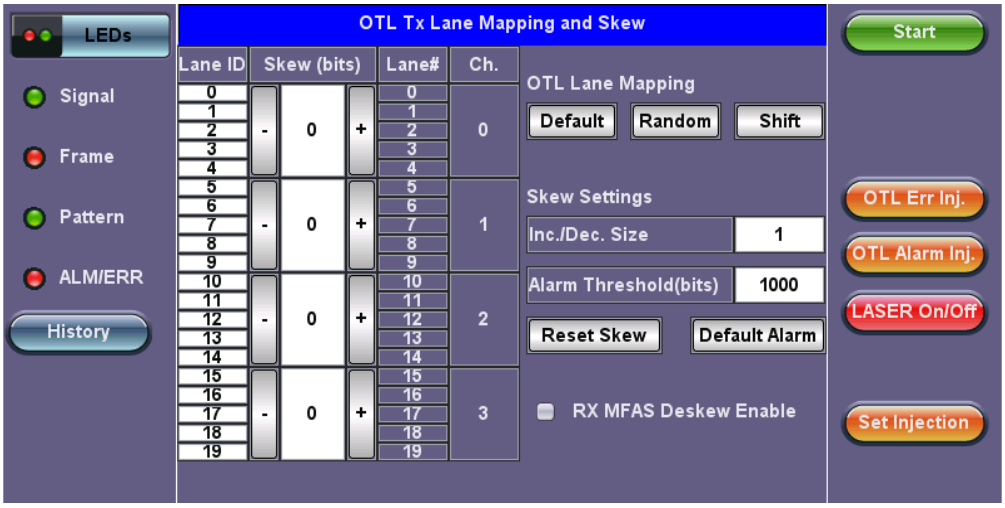
7.1.1.3 OTL Lane & Skew

Advanced users can enter the OTL tab on the Setup screen to configure the OTL Tx Lane Mapping and Skew, as well as tolerance thresholds (to generate alarms).

- **Lane ID:** Manually edit and assign specific Lane IDs to Lane #. Use the **Random** button to assign them arbitrarily, the **Shift** button to slide the Lane IS vs Lane # correlation, or the **Default** button to realign them back.
- **Skew (bits):** Enter the desired skew values by tapping directly on the fields or use the **+** and **–** buttons to increment/decrement them by the amount set in the **Inc/Dec Size** field.
- **Alarm Threshold:** Defines the maximum skew value allowed. If the system exceeds the set value, a flag (alarm) is raised

by the test set to notify users.

OTL Tx Lane Mapping and Skew



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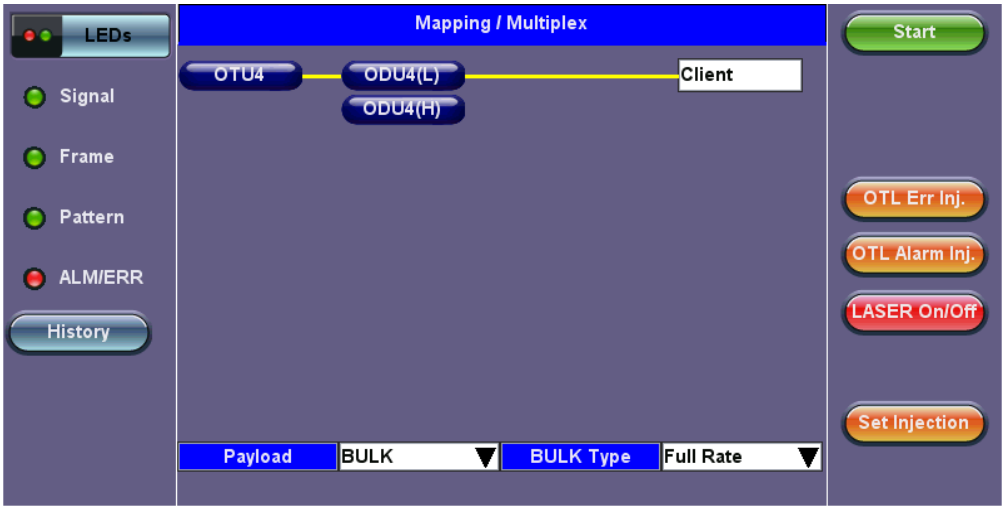
7.1.1.4 Mapping and Payload

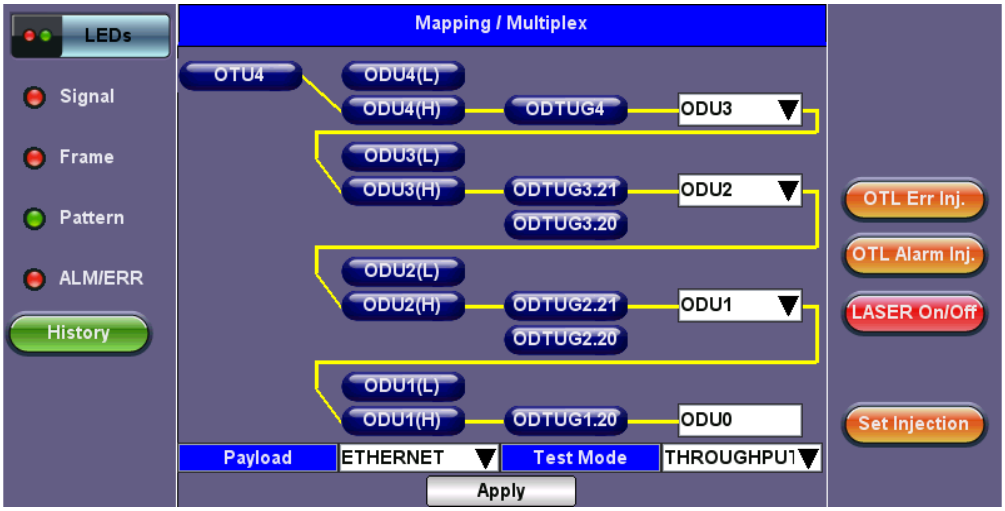
The mapping and multiplex structure is displayed. It supports one-stage (direct mapping) to multi-stage mapping and multiplexing.

- Select the ODUk(L) button to add a test payload (client) or ODUk(H) to add another multiplexing level for lower rate clients.
- The payload can be Bulk (PRBS test sequence) or Ethernet. Ethernet payload selection is only available when compatible ODUk(L) containers are selected, such as ODU4, ODU3, ODU2e, or ODU0.
- If an Ethernet test payload is selected, users have the option to run a BERT or Throughput test within the payload;Throughput test is recommended. Make sure to press the **Apply** button to reconfigure the test signal structure.

Mapping & Payload - Single Stage Mapping



Mapping & Payload - Multi-stage Mapping/Multiplexing



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7.1.1.5 OTN Channels and GFP-T Settings

The OTN Channel level (menu block) allows advanced users to modify individual tributary slots (T/S) or channels for the transmitted and received (expected) signal. This also allows users to set the physical port to which lower rate payloads may be mapped to when demultiplexed from the OTU4 test signal. In **Show Channels** mode, the test set offers a **CH# Detect** function that displaysthe channels available in the RX, in case they need to match the existing signal.

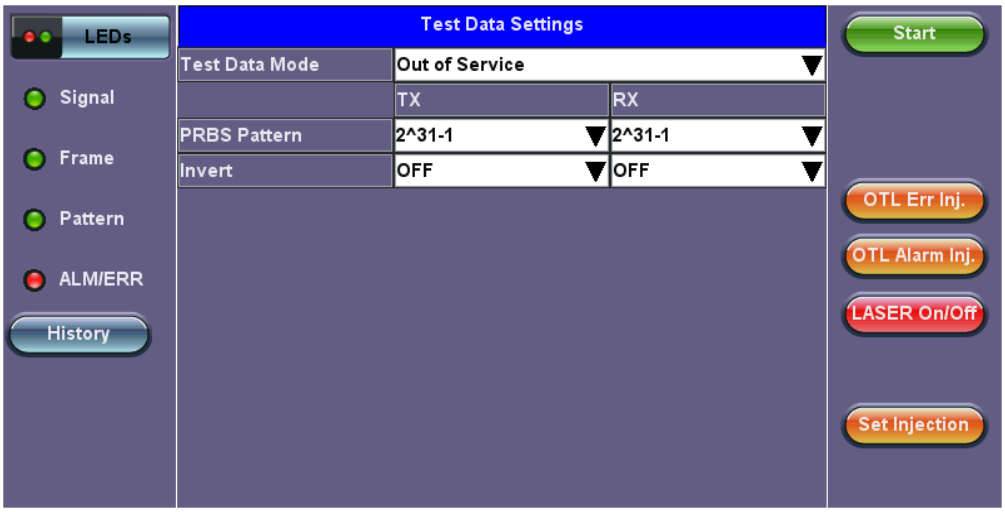
If ODU0 is selected as the Ethernet mapping level, the test set will add a GFP-T sublayer to the signal structure. Advanced users can use this block if a different payload header type needs to be set (transmitted or expected).

7.1.1.6 Test Pattern (Test Sequence or PRBS)

Tap the Pattern tab to configure the Test Data Settings. The following parameters are available:

- **Test Data Mode:** In Services (Live), Out of Service
- **PRBS Pattern (TX and RX):** Pseudo Random Bit Sequences (PRBS) defined by ITU-T 0.150 and 0.151 standards, fixed words and 24-bit or 32 bit user defined patterns are available.
- **Invert** (Logic pattern inversion)**:** On / Off

OTU4 Setup - Test Data Settings



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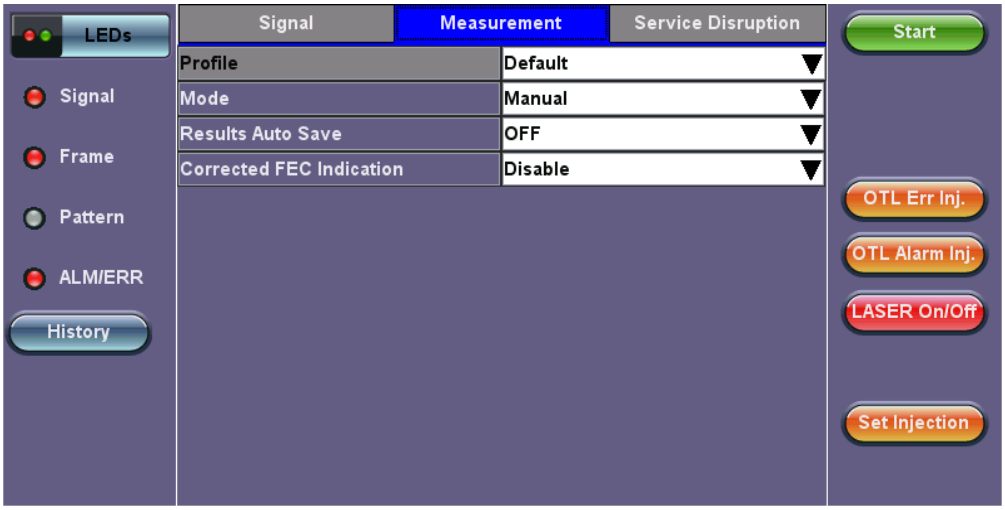
7.1.2 Measurement

Measurement Setup



- **Mode**: Manual and Timed selections are available.
  - **Manual:** This is directly linked to the Start/Stop function on the drop-down menu. The test starts as soon as the **Start** button is pressed.
  - **Timed:** The test duration can be set by the user in seconds, minutes, hours or days. The test is activated by the Start/Stop function on the drop-down menu and stops automatically when the defined time has elapsed.
- **Results Auto Save:** Tap Auto Save and set it to ON to automatically save the results file.
- **Corrected FEC Indication**

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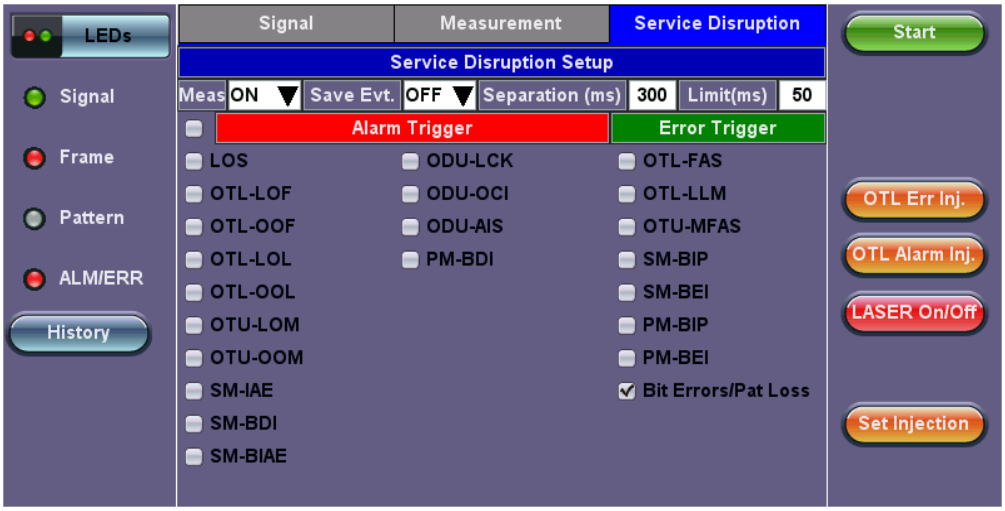
7.1.3 Service Disruption Test (SDT)

Service Disruption Setup



A service disruption is triggered by any qualifying error or alarm determined by the user and continues to count until the error-free condition (Gate Time) is met. If SDT is enabled and alarm/error triggers are selected, the results will appear in the Results section under the SDT tab.

Testing Process

The test set measures how long the event remains present after it is first recognized and will continue to measure the total service disruption time in the event of multiple disruptions.

Before starting, ensure that no errors or alarms are present on the transmission system because this will impact the measurement.

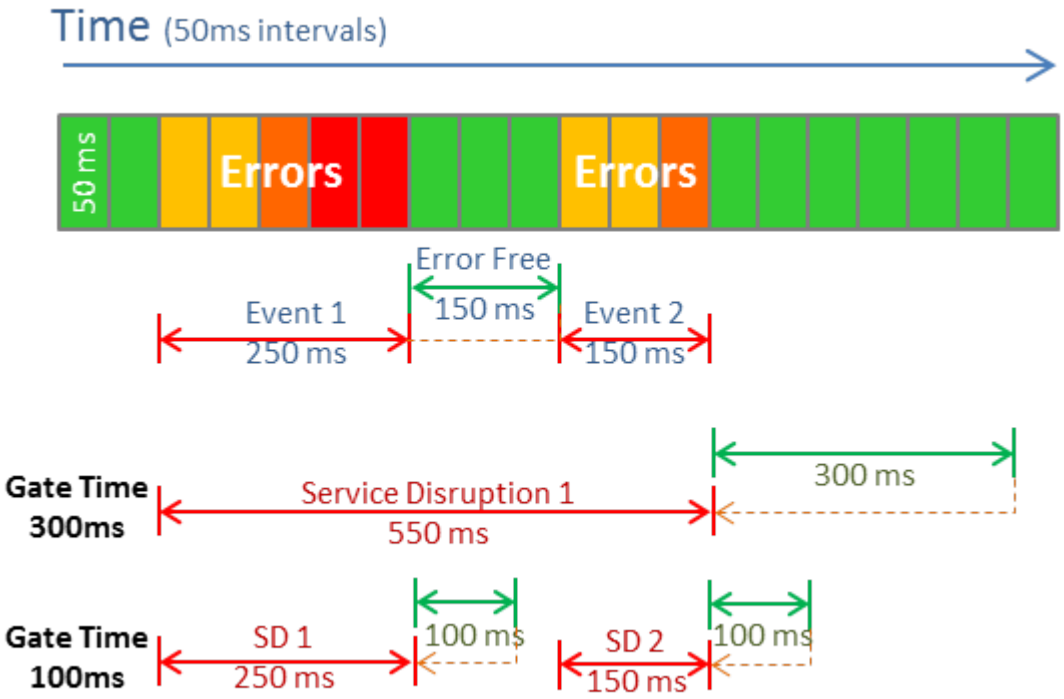
In the past, Automatic Protection Switching (APS) was used to measure physical service cuts, especially in optical links. Service disruption measurements are meant to measure the total time the service is not available to customers, which isnot limited by the optical path cut. Therefore, it configures to include the time the whole system takes to recover.

Service Disruption can still be used to measure APS time, if the trigger selected is LOS only. This will just measure the physical protection switch time.

Setup

1. Set Measurement to ON to activate SDT testing during BER tests.
2. Set a limit time and separation time. Limit and Gate Time counters begin at the onset of the first valid event.
    - **Limit Time:** Specifies pass/fail criteria for SDT events. This represents the acceptable amount of time for the customer to experience a service disruption. Events greater than the limit time are considered a fail. Configurable from 20 to 1000 ms.
    - **Gate Time:** Specifies the length of error free signal time used to determine the number of service disruptions. Configurable from 20 to 10000 ms. The Gate Time is not included in the service disruption time calculation.
3. (Optional) Turn **Save Event** to ON when SDT Measurement is enabled to include the Events Table details in the test report (including individual events within each of the disruptions recorded). When Save Event is turned OFF, the saved test results will only display general results (Current, Last, longest event, shortest events, total number of events detected and a PASS/FAIL verdict).
4. Select the type of errors/alarms from the SONET, PDH, BERT, OTN tabs that will trigger the SDT test.
5. Press the **Start** button to begin testing.

Service Disruption Time diagram



In the simplified example above, two events occur with 150ms of error free time in between. A gate time of 300ms counts them as one service disruption because the error-free section is less that the gate time. Using a gate time of 100ms to evaluate the same situation would count two service disruptions, because the Gate Time condition is met within the error-free section.

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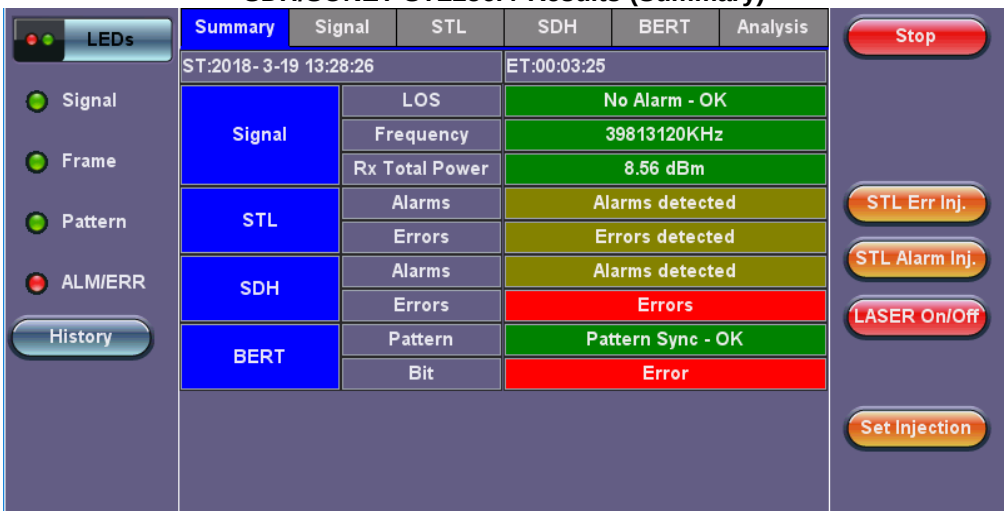
7.2 Results

Test measurements can be accessed from the **Results** icon in the main menu.

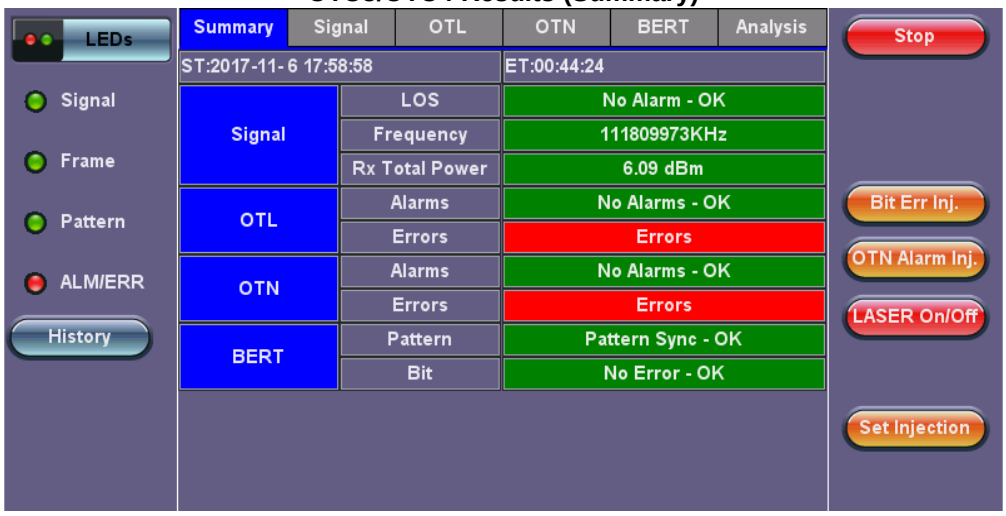
7.2.1 Results Summary

The Results Summary screen displays a summary of all the test results with start time (ST) and elapsed time (ET), alarms, errors, or signal failure pertaining to OTL, OTN, STL, SDH, or BERT signal and its payload.

SDH/SONET STL256.4 Results (Summary)



OTU3/OTU4 Results (Summary)



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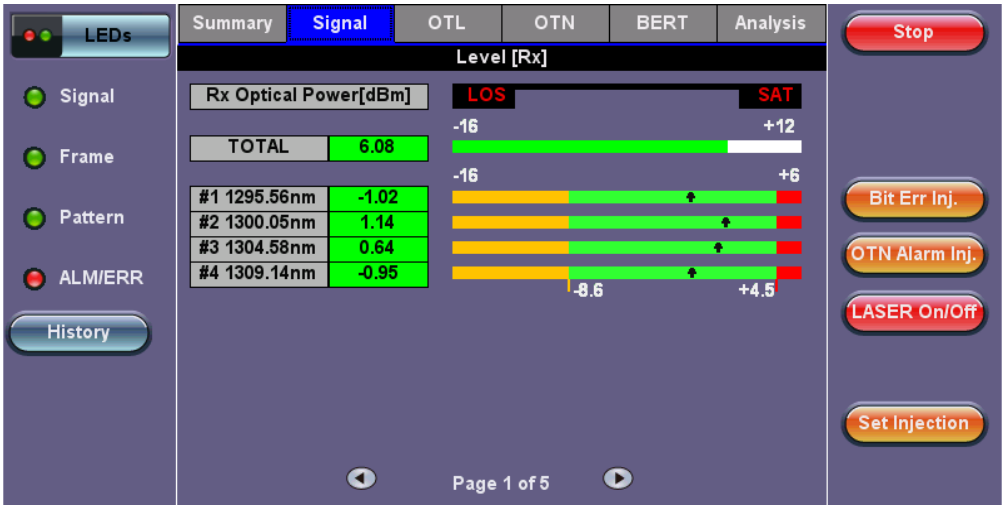
7.2.2 Signal

The signal tab displays the Signal Level, Frequency and related measurements.

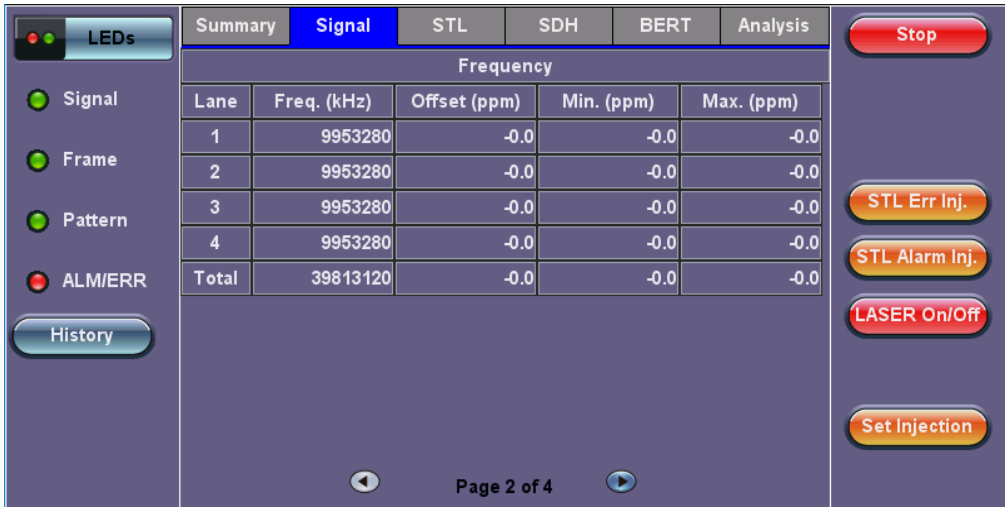
RX/TX Optical Level (Page 1-2)

- The optical level measurement for each available wavelength (channel) is displayed in dBm.
- Loss of Signal (LOS) and the Saturation levels is shown both graphically and in dBm.

Signal - RX Optical Power Level



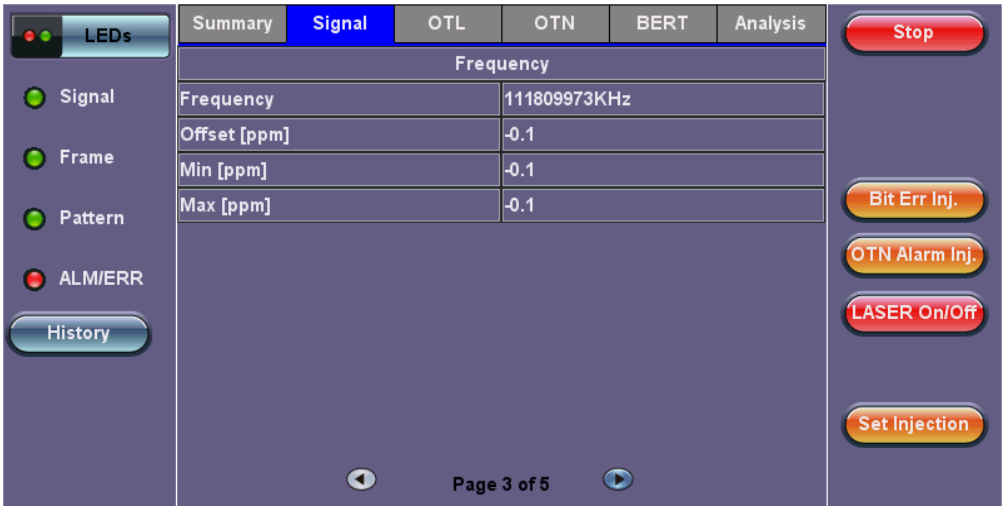
Signal - Frequency (Per Lane)



Frequency (Page 3)

- The received signal frequency and offset is measured and displayed. The Signal page may display frequency measurements per lane for newer 40G/100G modules, depending on the test set and software version.
- For OTN signals, the measurement is performed on the optical interfaces CFP, CFP2, CFP4, QSFP28, and QSFP+.
- **Frequency:** Indicates the frequency of the input signal
- **Offset (ppm):** Indicates the difference between the standard rate and the bit rate of the input signal
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal
- **Max (ppm):** Indicates the difference between the standard rate and the maximum deviation detected in the input signal

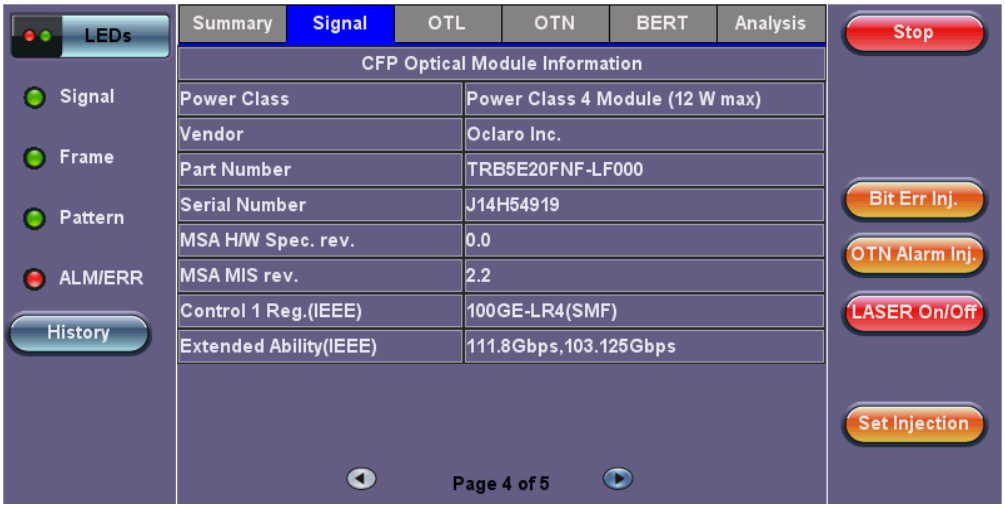
Signal - Frequency (All Lanes)



CFP Optical Module Information (Page 4)

The information and capabilities of the CFP in use are listed.

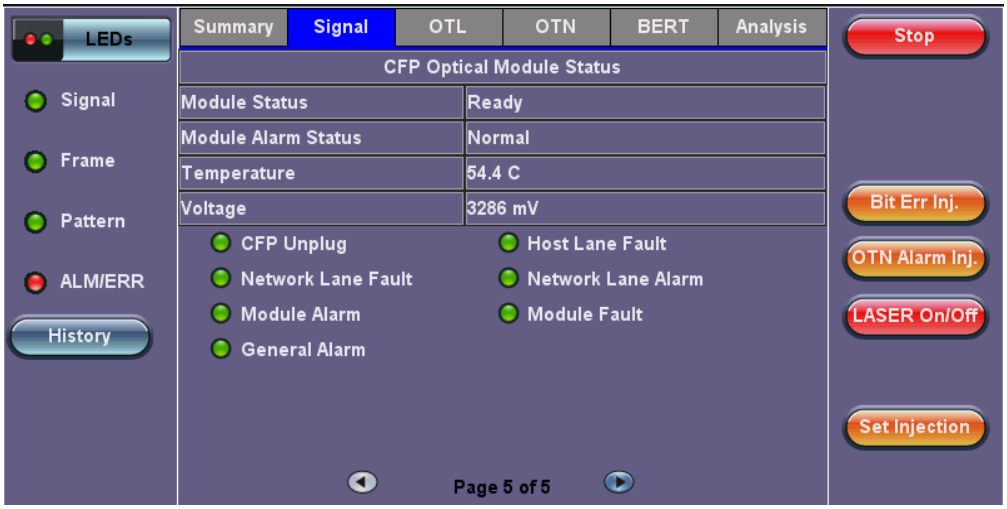
Signal (Page 4) - CFP Optical Module Information



CFP Optical Module Status (Page 5)

CFP Optical Module Status displays the internal diagnostics status of the pluggable CFP optics. Color-coded LEDs indicate status of alarms and errors.

Signal (Page 5) - CFP Optical Module Status



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7.2.3 OTL and STL Results

Depending on the test configuration, OTL measurements are displayed for OTU3/OTU4 and STL measurements displayed for SDH/SONET STL256.4.

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7.2.3.1 Summary

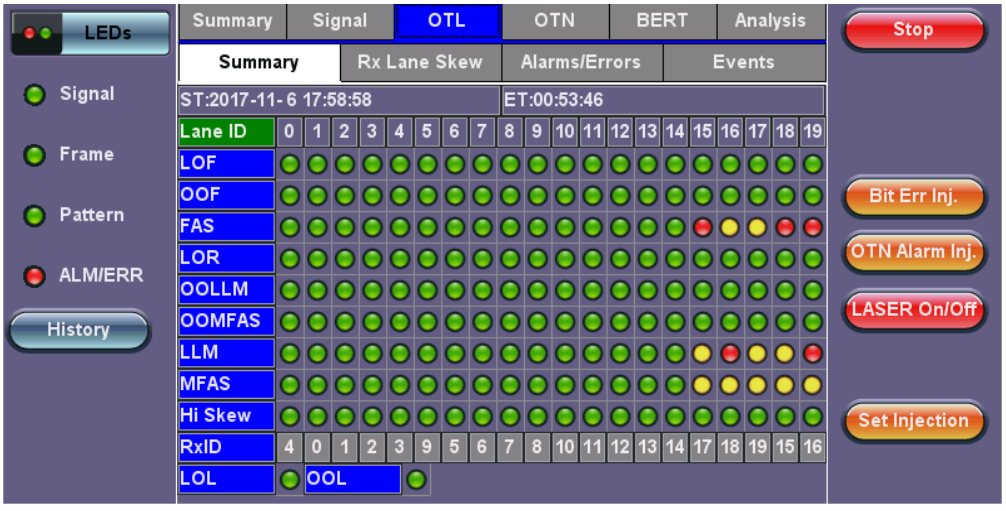
Color-coded LEDs indicating alarm and error status for each individual lane are listed.

Green: No error or alarm is present.

Red: An error or alarm condition is detected and is currently present.

Yellow: Indicates a history condition. An error or alarm was detected during the measurement interval but it is no longer present or active.

OTL Summary



Note: *SDH Alarm definitions are listed in* ***Results: SDH/SONET STL256.4 (Advanced)****.*

OTL Alarm/Error Definitions per ITU-T G.709 and G.798	
LLM	Logical Lane Marker Error

FAS	Logical Lane Frame Alignment Error
MFAS	LL Multi-Frame Alignment Error
LOL	Loss of logical Lane alignment • Two or more logical lanes with the same marker • Consecutive LLM errors for ≥ 5 frames
OOL	Out of logical Lane alignment
OOF	LL Out of Frame (FAS error for ≥ 5 frames)
LOF	LL Loss of Frame (consecutive OOF for ≥ 3ms)
OOR	Out of Recovery (wrong LLM value for ≥ 5 cycles)
LOR	Loss of Recovery (consecutive OOR for ≥ 3ms)
OOLLM	Out of Logical Lane Marker (LLM errors for ≥ 5 frames)
OOMFAS	Out of LL MFAS (MFAS errors for ≥ 5 frames)
High Skew	Skew for any of the lanes is greater than a threshold (limit) value set for the application

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7.2.3.2 Rx Lane Skew

Note: *Lane skew is only available on 100G test modules.*

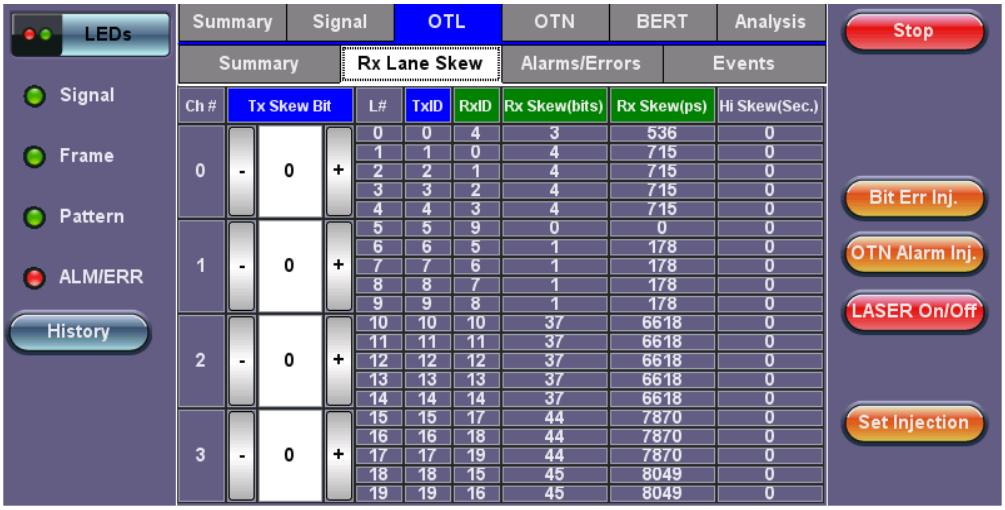
Lane Skew

In OTU4 and 100GE implementations, the transmit data stream is split into 10 electrical lanes and 20 logical lanes, which are scrambled to ensure sufficient transition density (pulses) for clock recovery. The OTL/PCS layer is responsible for inserting Lane Alignment Markers into each of the logical lanes in the transmit direction, so the original 100G data stream can be reconstructed at the far end. The receiver's OTL/PCS layer is responsible for detecting the lane alignment markers and aligning recovered data in the receive direction. The alignment process ensures properly formatted data. Skew accumulation occurs downstream from the OTL/PCS and it is the responsibility of the receiver's OTL/PCS layer to remove skew and re-align the receive data.

Fixed Skew
Fixed or static skew represents the constant difference in arrival time for two signals generated from the same source. It is generated by physical lane-to-lane differences in the time a signal reaches a destination relative to the data on any other lane. This usually related to implementation factors, such as differences in electrical trace lengths (0.5 UI/cm), fiber optics dispersion, and lane-dependent clock recovery circuits (CDR).

Dynamic (Variable) Skew
Lane-to-lane skew can change or wander over time due to many physical and environmental factors, including uneven temperature, data rate, and supply voltage fluctuations.

OTL Rx Lane Skew



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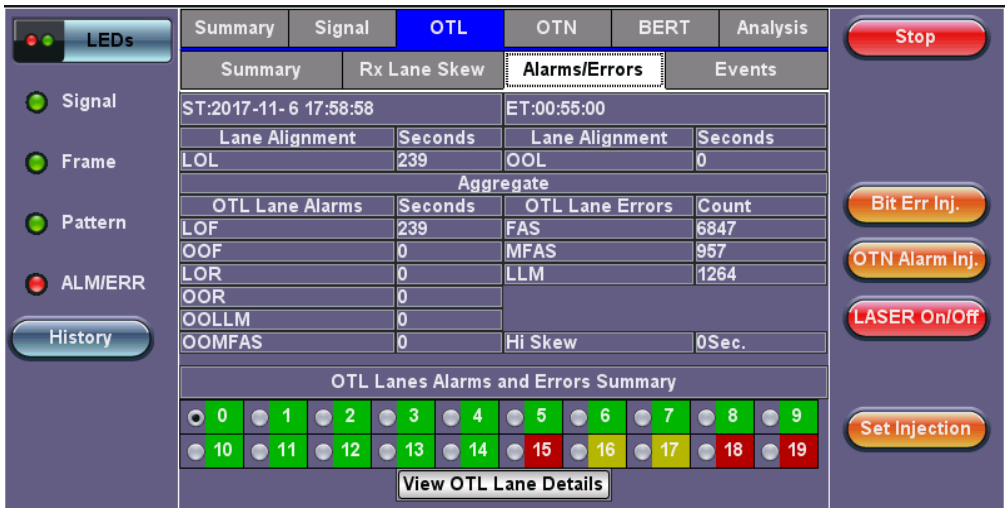
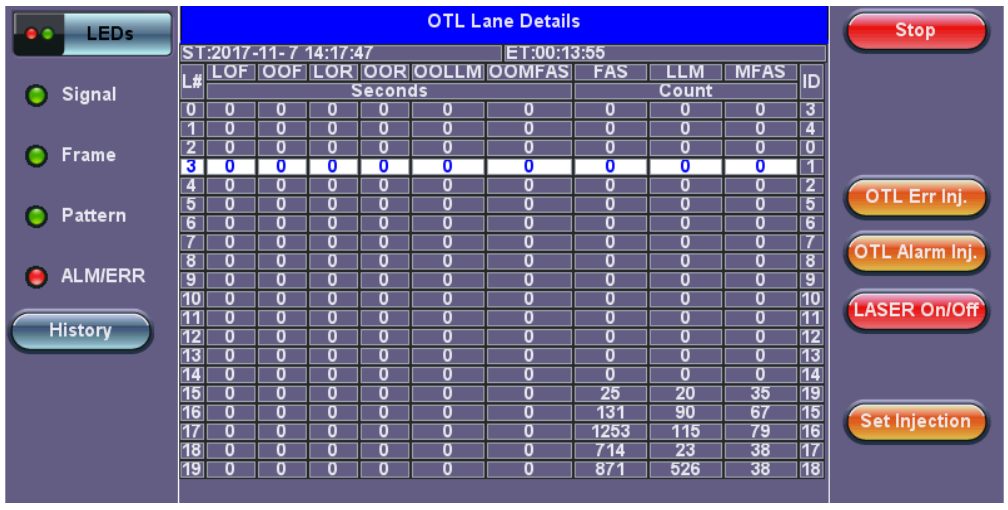
7.2.3.3 Alarms/Errors

Detailed aggregate Alarm and Error count, as well as per-lane counters. Select the desired lane to be highlighted and press the **View OTL** or **STL Lane Details** button. Lanes are color-coded to indicate alarms and errors status. Refer to **Summary** for a description of LED color statuses.

OTL Alarms/Errors



OTL Lane Details



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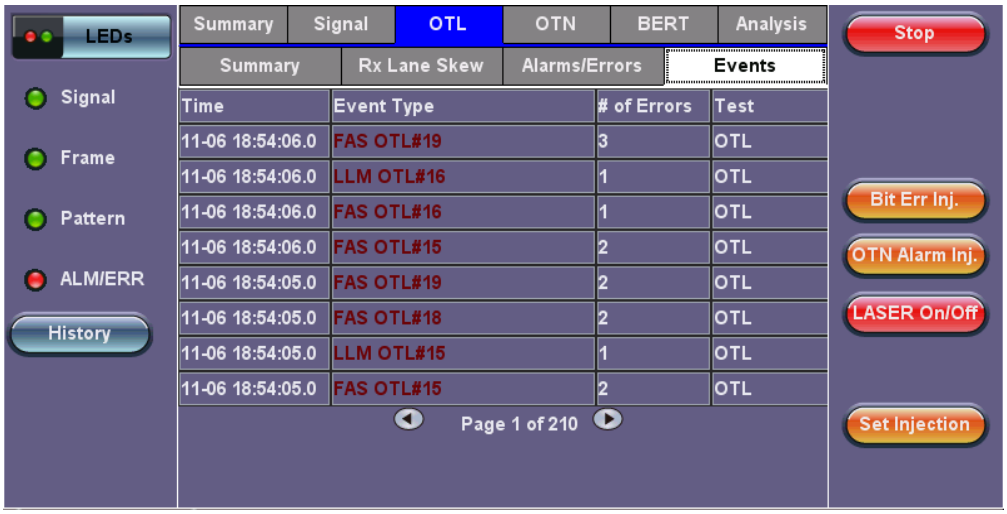
7.2.3.4 Events

The Events log tab lists Error and Alarm events recorded during the test. The events are presented in chronological sequence with start time and duration (alarms), event type, sequence number, ratio/count (errors), and test type.

OTL Events



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7.2.4 OTN and SDH Results

Depending on the test configuration, OTN measurements are displayed for OTU3/OTU4 and SDH measurements displayed for SDH/SONET STL256.4.

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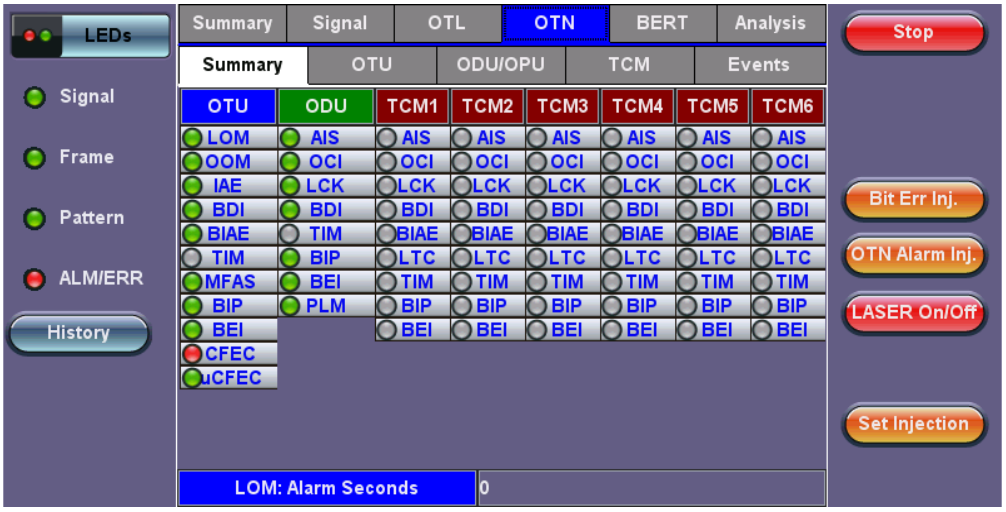
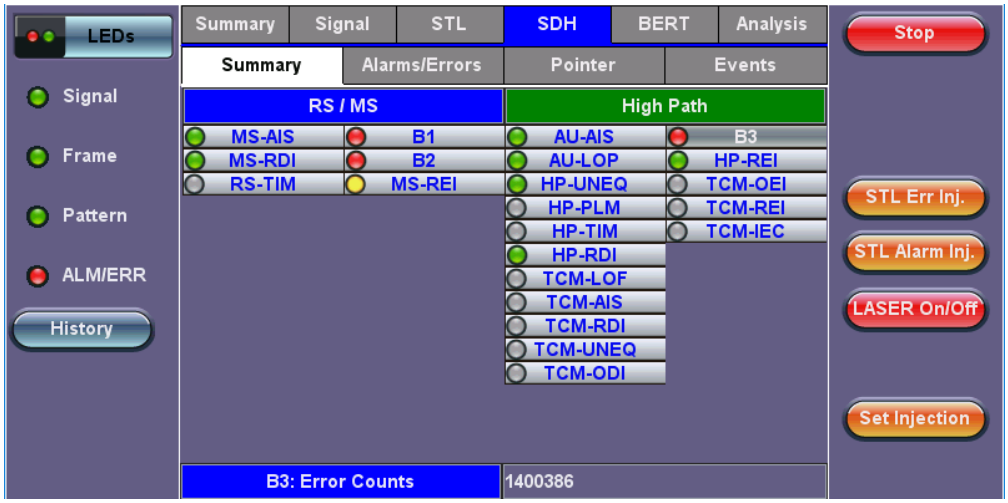
7.2.4.1 Summary

The OTN Results Summary screen displays a summary of alarms/errors pertaining to OTU, ODU, and TCM. Tap on the alarm/error for count and duration details.

OTN Summary Results



SDH Summary Results



Note: *SDH Alarm definitions are listed in* ***Results: SDH/SONET STL256.4 (Advanced)****.*

OTU Error Definitions per ITU-T G.709 and G.798	
FAS	Frame Alignment Signal Error (mismatch) • One or more framing bits in error
MFAS	Multi-Frame Alignment Signal error (mismatch) • MFAS indicator (0 to 255) is in error (out of sequence)
TIM	Trail Trace Identifier Mismatch • Received and expected TTI are different
BIP-8	Bit Interleaved Parity - level 8 code error (mismatch) • Received and calculated BIP are different
BEI	Backward Error Indication (BEI/BIAE bits) • 0 .. 8 Number of BIP-8 violations detected • 9 .. A No BIP-8 error detected • B Refer to BIAE • C .. F No BIP-8 error detected
BIAE	Backward Incoming Alignment Error (BEI/BIAE bits) • B (1011) ≥ 3 consecutive frames
cFEC	Corrected FEC errors (don't affect ODUk)
uFEC	Uncorrectable FEC errors (ODUk is affected)

OTU Alarm Definitions per ITU-T G.709 and G.798	
OOF	Out of Frame • FAS errors ≥ 5 consecutive frames
LOF	Loss of Frame • OOF condition for ≥ 3 ms
OOM	Out of Multiframe • MFAS errors for ≥ 5 consecutive frames
LOM	Loss of Multiframe • OOM condition for ≥ 3 ms
BDI	Backward Defect Indication • Defect: Set to 1 for ≥ 5 consecutive frames • Normal: Set to 0 for ≥ 5 consecutive frames
IAE	Incoming (Frame) Alignment Error

	Defect: Set to 1 for ≥ 5 consecutive frames • Normal: Set to 0 for ≥ 5 consecutive frames
AIS	Alarm Indication Signal • Repetitive PN-11 sequence (2^{11}-1) completely filling OTUk frames

ODU Alarm/Error Definitions per ITU-T G.709 and G.798	
BIP-8	Bit Interleaved Parity - level 8 code error (mismatch) • Received and calculated BIP are different
BEI	Backward Error Indication (BEI/BIAE bits) • 0 .. 8 Number of BIP-8 violations detected • 9 .. F No BIP-8 error detected
BDI	Backward Defect Indication • Defect: Set to 1 for ≥ 5 consecutive frames • Normal: Set to 0 for ≥ 5 consecutive frames
LCK	Locked • Defect: STAT = 101 for ≥ 3 consecutive frames • Normal: STAT = 001
OCI	Open Connection Indication • Defect: STAT = 110 for ≥ 3 consecutive frames • Normal: STAT = 001
AIS	Alarm Indication Signal • Defect: STAT = 111 for ≥ 3 consecutive frames • Normal: STAT = 001
PLM	Payload Mismatch • Declared if the accepted payload type is not equal to the expected payload type(s) as defined by the specific adaptation function
TIM	Trail Trace Identifier Mismatch • Received and expected TTI are different

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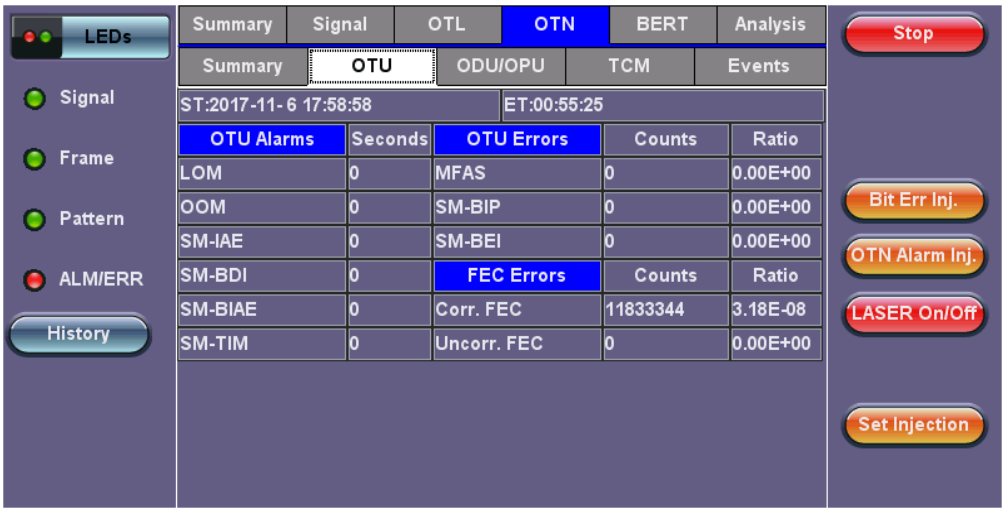
7.2.4.2 OTU and SDH/SONET

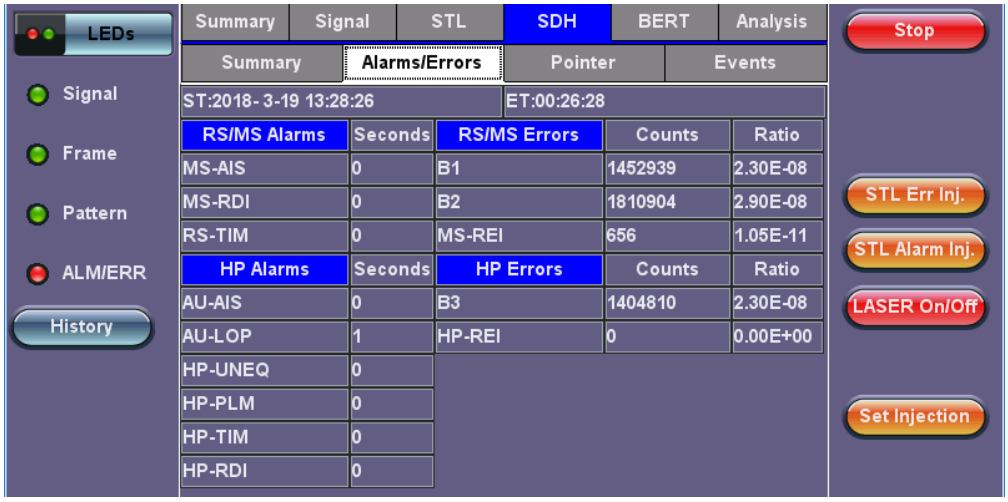
OTU alarms/errors are displayed for OTU3/OTU4 test configuration, while SDH alarms/errors are displayed for SDH/SONET STL256.4.

Results are displayed in logical order that are associated with the signal under test. All errors are evaluated and stored. The Elapsed Time [ET] is shown in the right hand corner of the header.

OTN Results - OTU



SDH Results - STL256.4



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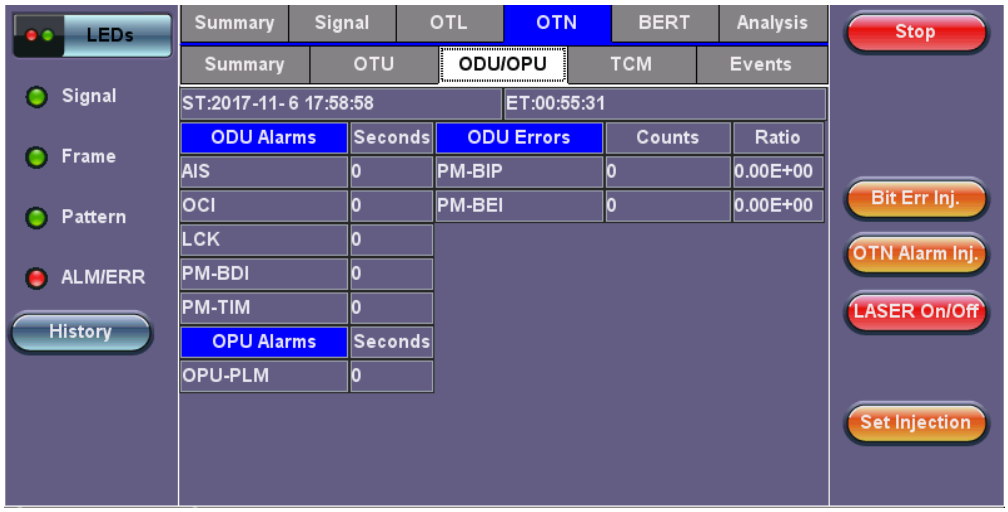
7.2.4.3 ODU/OPU

ODU/OPU for OTU3/OTU4 test configuration displays errors and alarms in a logical order that are associated with the signal under test. All alarms are evaluated and stored.

OTN Results - ODU / OPU



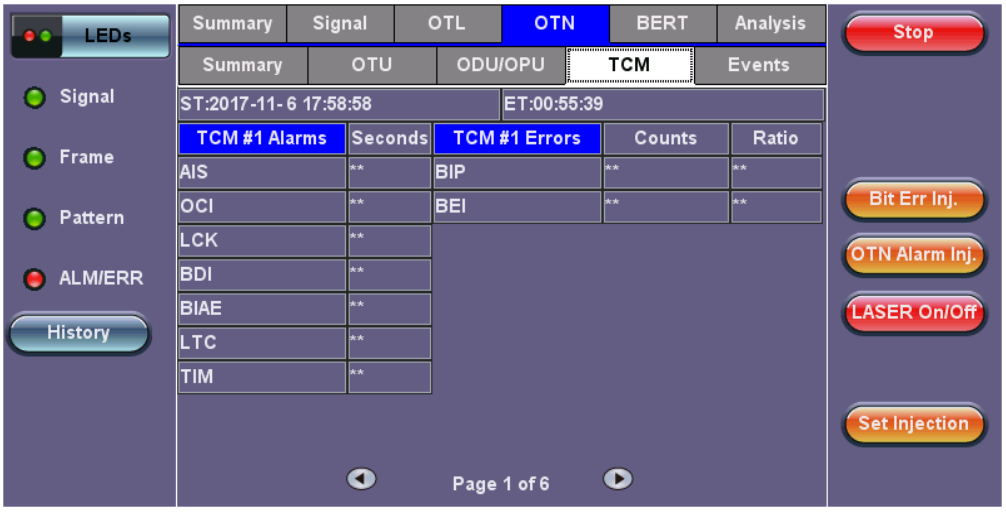
7.2.4.4 Tandem Connection Monitoring (TCM)

Results are available for up to six tandem connections. Use the page buttons to navigate through TCM1 to TCM6 results. Tandem connections and corresponding source and sink functions are defined in ITU-T G.707, G.709, and G.783.

TCM enables the user and its signal carriers to monitor the quality of the traffic that is transported between segments or connections in the network. SONET/SDH allowed a single level of TCM to be configured, while ITU G.709 allows six levels of tandem connection monitoring to be configured. The assignment of monitored connections is currently a manual process that involves an understanding between the different parties. There are various types of monitored connection topologies: cascaded, nested, and overlapping.

Counts are measured in number of errored bits. Ratio measures the bit error ratio.

OTN Results - TCM



Tandem Connection Monitoring (TCM) Definitions per ITU-T G.707, G.709, and G.783	
BIP-8	Bit Interleaved Parity - level 8 code error (mismatch) • Received and calculated BIP are different
BEI	Backward Error Indication (BEI/BIAE bits) • 0 .. 8 Number of BIP-8 violations detected • 9 .. F No BIP-8 error detected
BDI	Backward Defect Indication • Defect: Set to 1 for ≥ 5 consecutive frames • Normal: Set to 0 for ≥ 5 consecutive frames
LCK	Locked • Defect: STAT = 101 for ≥ 3 consecutive frames • Normal: STAT = 001
OCI	Open Connection Indication • Defect: STAT = 110 for ≥ 3 consecutive frames • Normal: STAT = 001
AIS	Alarm Indication Signal • Defect: STAT = 111 for ≥ 3 consecutive frames • Normal: STAT = 001
PLM	Payload Mismatch • Declared if the accepted payload type is not equal to the expected payload type(s) as defined by the specific adaptation function

TIM	Trail Trace Identifier Mismatch • Received and expected TTI are different

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7.2.4.5 Pointer Analysis

Pointers keep SDH signals synchronous by compensating for timing differences without having to use stuffing bits. Pointers are allowed to move up or down every three frames however the actual rate should be slower. The Administrative Unit (AU) and theTributary Unit (TU) each has its own pointer and the unit has two tabs for displaying the values and measurements.

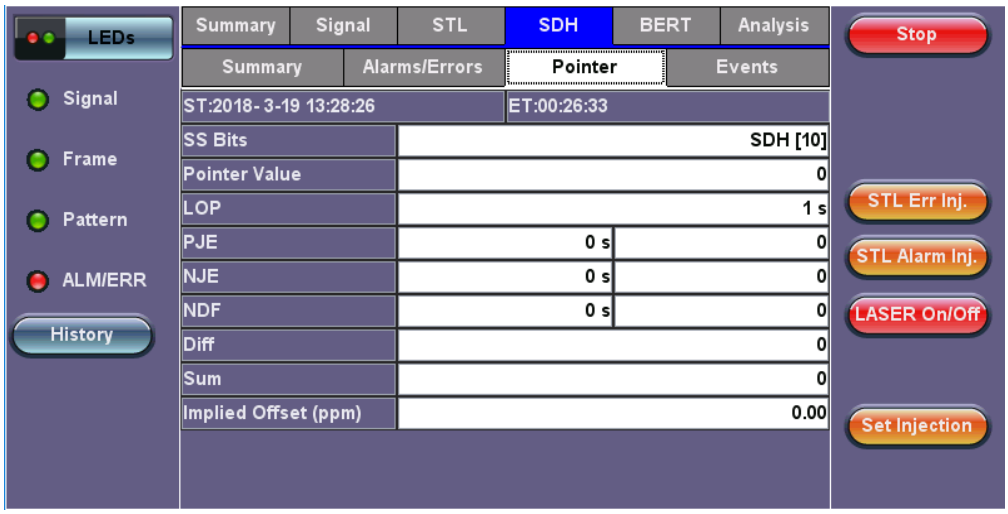
For AU pointers:

- SS bits – Displays bits 5 and 6 of the H1 byte to indicate SDH [10], SONET [00], Unknown [01] and [11] signal type
- Pointer value – Displays the H1 and H2 values (addresses) indicating the offset in bytes between the pointer andfirst byte of the AU-n
- LOP (Loss of Pointer)
- PJE and NJE
- NDF or New Data Flag. NDF is enabled when all bits match “1001” (or "0001", "1101", "1011" and "1000") and is disabled when all bits match "0110" (or "1110", "0010", "0100", "0111").
- Difference and Sum

For TU pointers:

- Pointer value
- LOP (Loss of Pointer)
- PJE and NJE
- NDF or New Data Flags
- Difference and Sum

OTN Results - TCM



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7.2.4.6 Events

The Events log tab lists Error and Alarm events recorded during the test. The events are presented in chronological sequence with start time and duration (alarms), event type, sequence number, ratio/count (errors), and test type.

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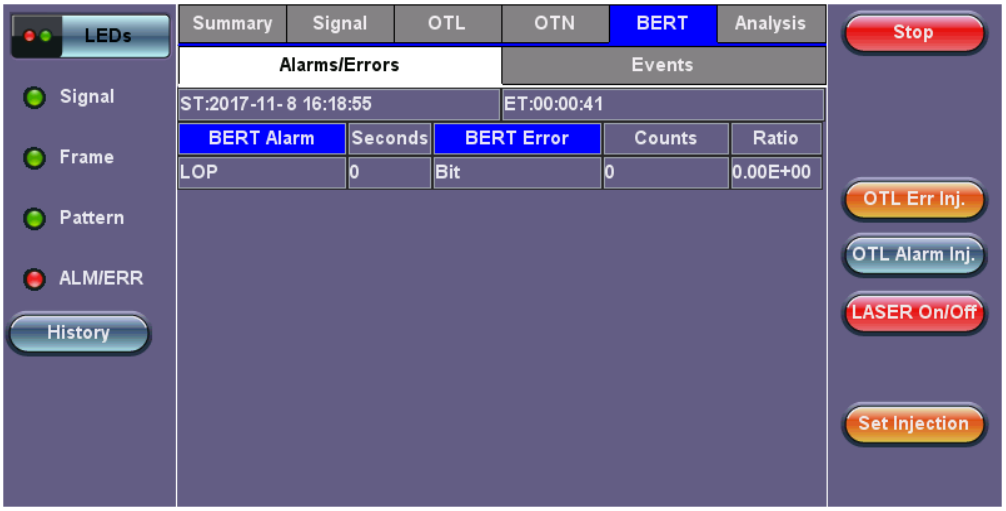
7.2.5 BERT

BERT alarms/errors results and Events are displayed in their respective tabs. Refer to BERT > Errors for a description of BERT

alarms/errors.

BERT Results - Alarms/Errors



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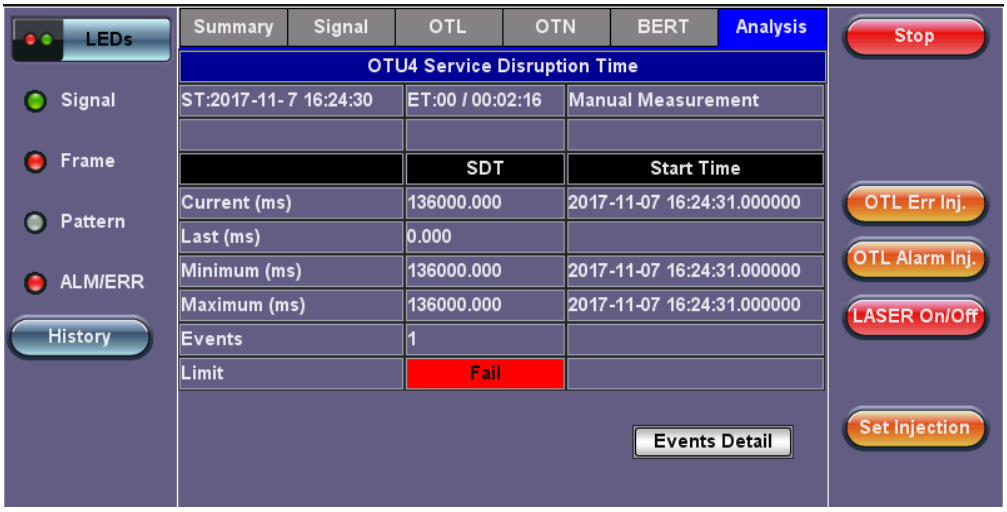
7.2.6 Analysis

Analysis

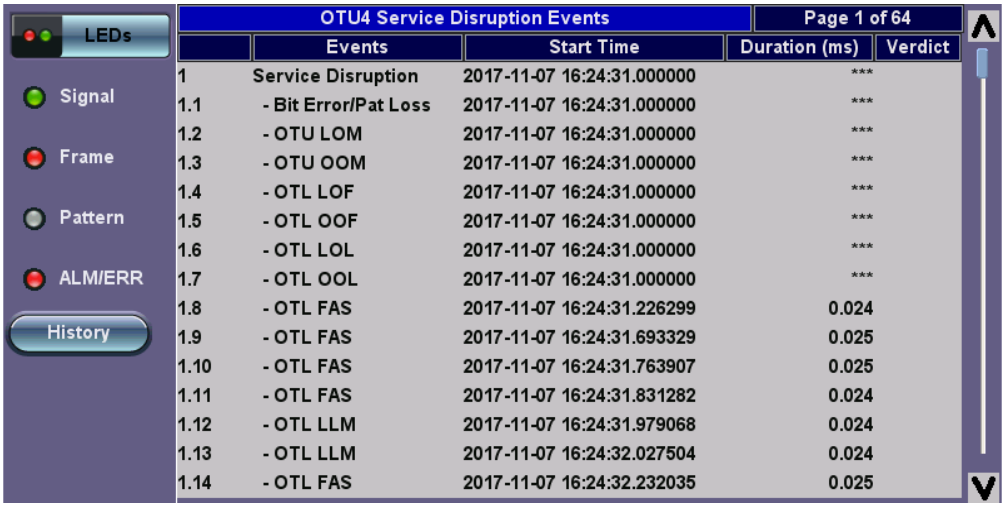


Displays Service Disruption Time (SDT) results and start time and duration for each:

- **Current:** Current SDT measurement
- **Last:** Last SDT measured during the test
- **Min/Max:** Minimum and maximum SDT measured during the test
- **Events:** Number of service disruption events (SDTs)
- **Limit:** Displays Pass/fail results based on established threshold criteria

Tap on **Events Detail** for additional details on measured SDT events.
The event type for each service disruption and start and duration information is listed.

Analysis Details



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7.3 Alarm / Error Injection

Alarms and Errors can be injected into different signals. At any time during the test process, tap the **Error Injection** or **Alarm Injection** buttons to inject errors or generate alarms.

To access the setup for the alarms and errors, tap the **Set Injection** button on the right side of the screen.

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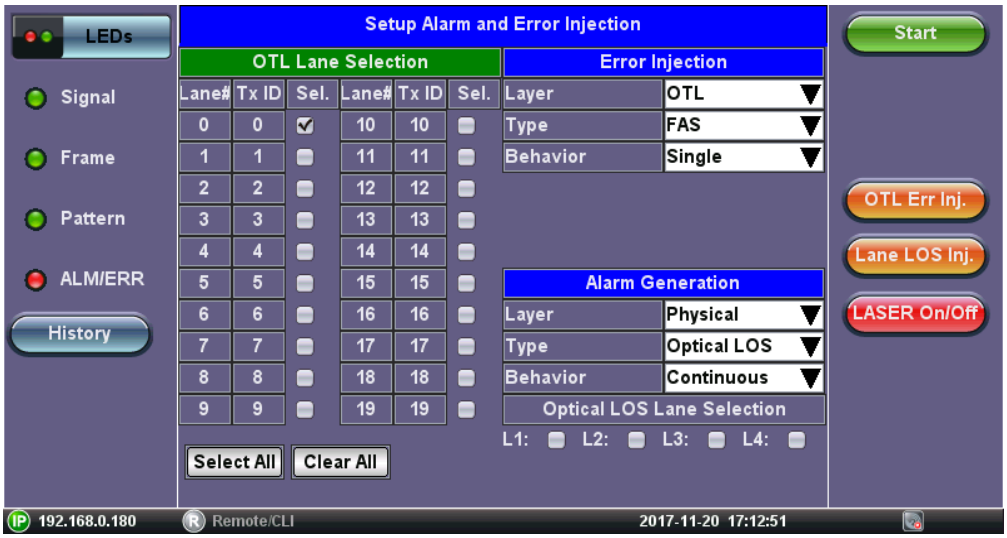
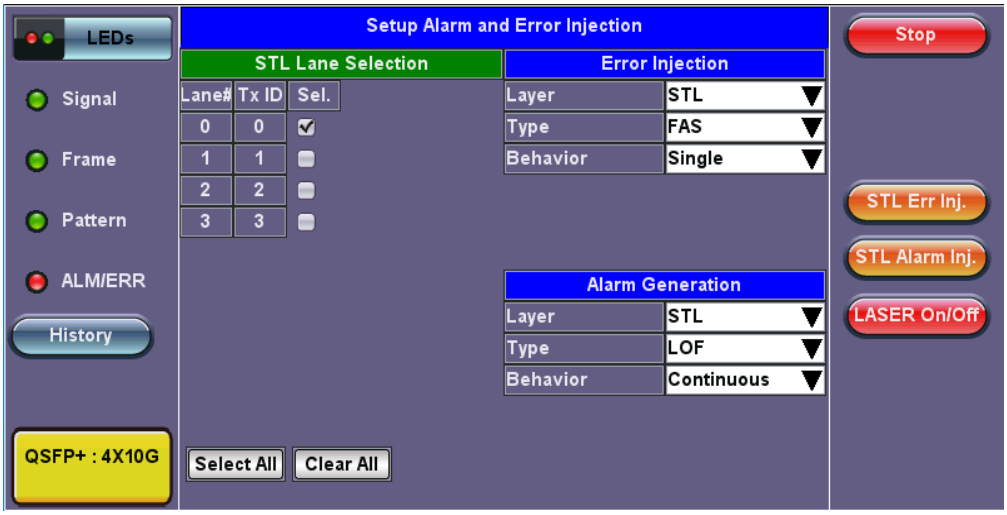
Alarm and Error Injection Setup

OTL Alarm and Error Injection Setup



STL Alarm and Error Injection Setup



Menu options will vary depending on whether the network is set as OTU or SDH/SONET.

OTL/STL Lane Selection: For OTL and STL layers only

Error Injection:

- **Layer:** OTL, OTN, SDH, STL, BERT
- **Type:**
  - **OTL:** FAS, MFAS, LLM
  - **OTN:** MFAS, SM-BIP, SM-BEI, Corr. FEC, Uncorr. FEC, PM-BIP, PM-BEI, TCM1 to 6-BIP/BEI
  - **BERT:** Bit
  - **STL:** FAS, LLM

- **SDH:** B1, B2, MS-REI, B3, HP-REI
- **Behavior:** Single, Single Burst, Cont. Burst, Rate

Alarm Injection:

- **Layer:** Physical, OTN, OTL, STL, SDH. Selecting the physical layer will display four optical lanes, L1-L4 or L1 to L10. Use these check boxes to select which lanes would be affected by the error generation. Note that, if no optical lane is selected, then no errors would be injected.
- **Type:**
  - **Physical:** LOS
    - LOS Lane Selection
  - **OTL:** OTL-LOF, OTL-OOF, OOLLM, OOMFAS
    - Continuous, Single Burst, Cont. Burst.
  - **OTN:** OTU-LOM, OTU-OOM, SM-IAE, SM-BDI, SM-BIAE, SM-TIM, ODU-AIS, ODU-OCI, ODU-LCK, PM-BDI, PM-TIM, OPU-PLM, and TCM1 to 6 ACI / OCI / LCK / BDI / TIM / BIAE / LTC
  - **STL:** LOF, OOF, STL-AIS
  - **SDH**: MS-AIS, MS-RDI, RS-TIM, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-RDI, HP-TIM
- **Behavior:** Continuous, Single Burst, Continuous Burst

Note: *Click here to refer to OTU Alarm and Error Definitions. SDH Alarm and Error Definitions can be found here.*

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7.4 SDH/SONET Tools

For information on SDH/SONET Tools in the basic version of SDH/SONET STL256.4, refer to STL256.4 SDH/SONET (Basic).

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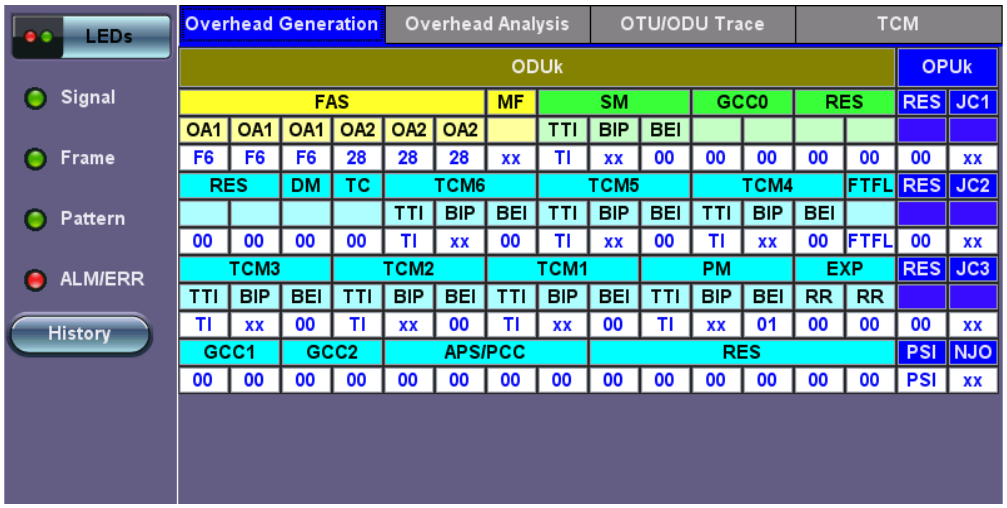
7.5 OTN Tools

Note: *This section refers to OTN Tools for OTU3/OTU4 Testing, not OTN Tools for SDH/SONET mapping with PDH/DSn multiplexing.*

OTN Tools Home Menu for OTU3/OTU4 Testing

7.5.1 Overhead Generation and Analysis

Overhead Application Menu



The Overhead Generator and Analysis tabs generate and analyze bytes, respectively.
The Overhead is color-coded for easy viewing.

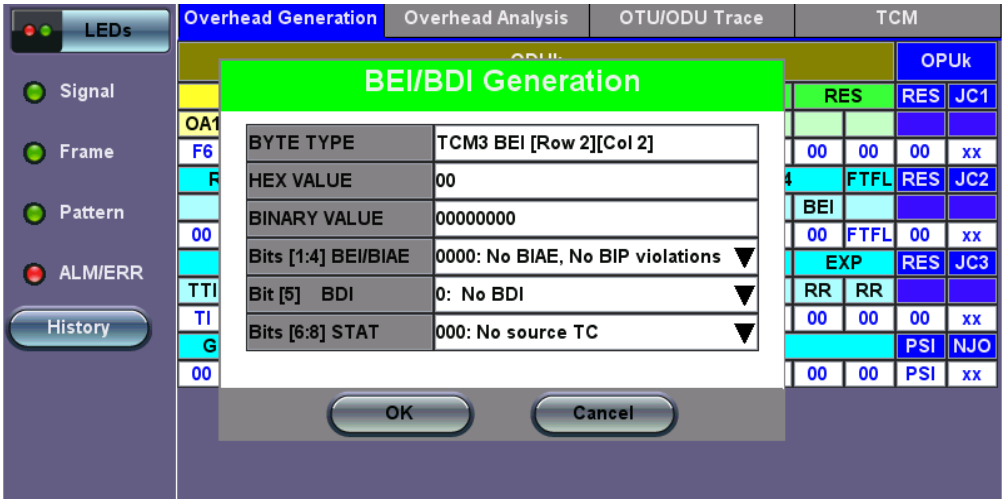
Decoding Bytes

Tapping the applicable byte enables an automatic decode – a byte description including the Hexadecimal and Binary value is

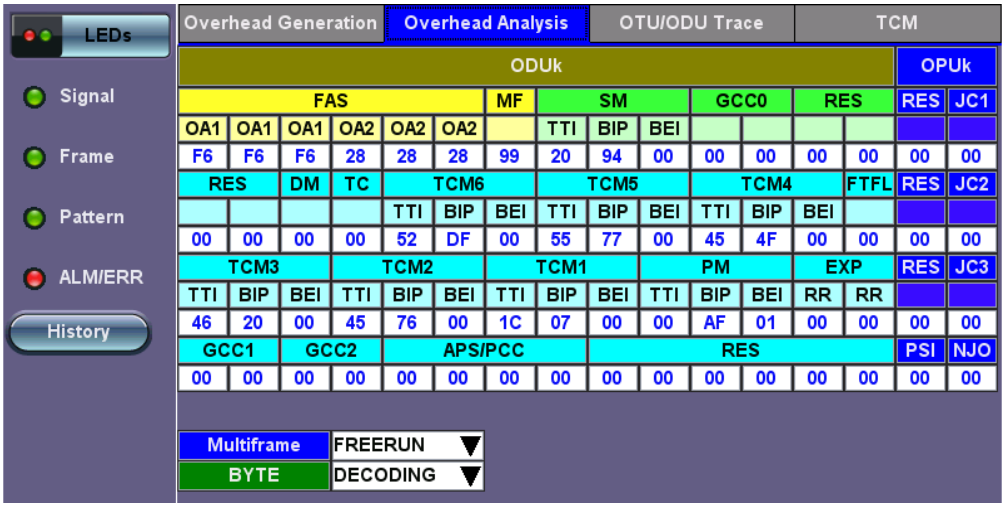
provided. For some bytes, an advanced decode of the various bits is also available.

For Overhead Generation, programming some overhead bytes is possible after tapping on the applicable byte, however dedicated test functions are available for OTU/ODU Trace and TCM testing. In some instances, more advanced editing is possible using the dedicated functions.

Byte Analyzer - Advanced Decode



Overhead Analysis



- **Multiframe:** Free Run starts capturing bytes after tapping on the byte block, Locked-aligns the bytes with multiframe.
- **Byte**: Select Decoding-to view current status and description of the byte Capture. Captures up to 256 bytes from a particular field.

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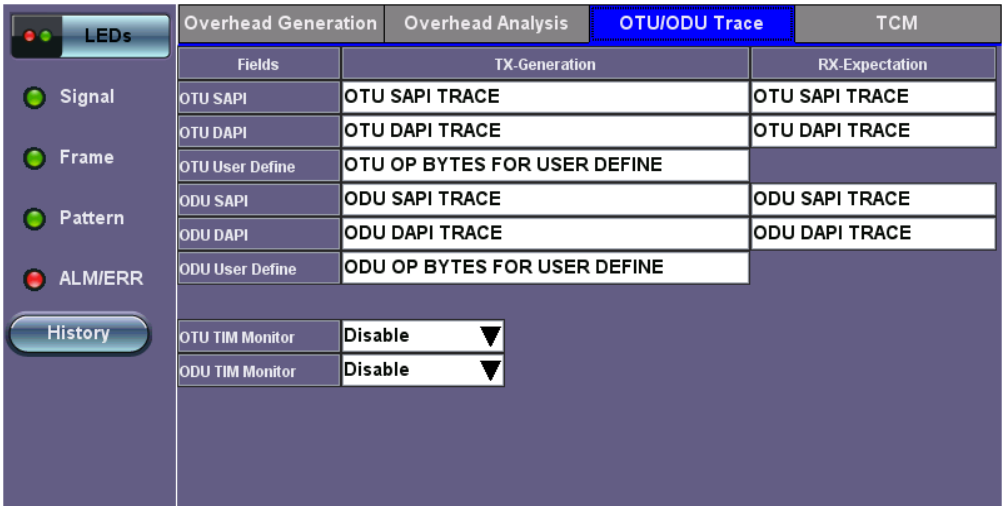
7.5.2 OTU/ODU Trace (Trail Trace Identifier)

OTU/ODU Trace



TTI is used to identify the signal from the source to the destination within the network. The TTI contains the so called Access Point Identifiers (API), which are used to specify the Source Access Point Identifier (SAPI) and Destination Access Point Identifier (DAPI). The APIs contain information regarding the country of origin, network operator and administrative details.

OTU/ODU TIM Monitor: When enabled, the unit verifies whether TX Generation and RX-Expectation match. If they do not match, a trace identification mismatch flag is generated.

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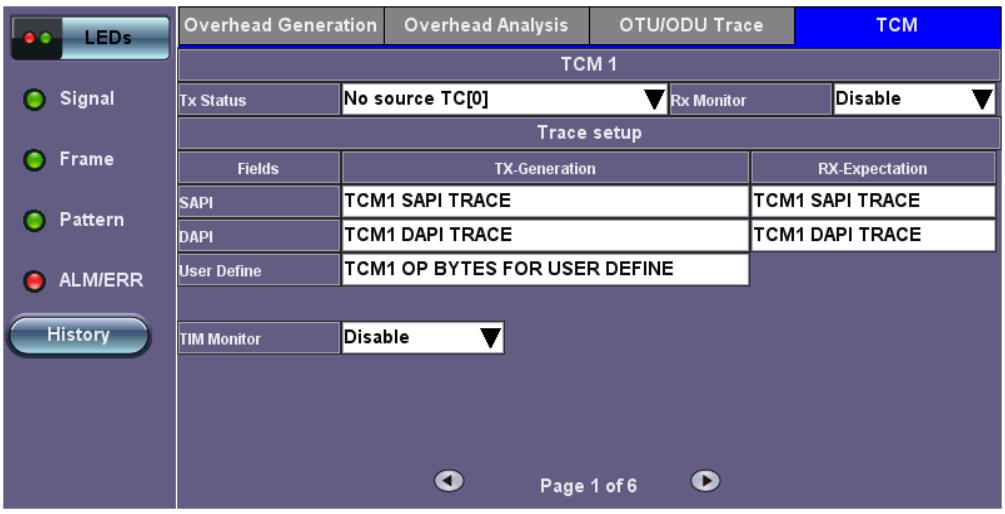
7.5.3 TCM (Tandem Connection Monitoring)

Tap the TCM tab to display the TCM parameters.

OTN Tools - TCM



Results are available for up to six tandem connections. The counts are numbers of seconds containing the error or indication.

Tandem connections and corresponding source and sink functions are defined in ITU-T G.707, G.709, and G.783.

TCM enables the user and its signal carriers to monitor the quality of the traffic that is transported between segments or connections in the network. SONET/SDH allowed a single level of TCM to be configured, while ITU G.709 allows six levels of tandem connection monitoring to be configured. The assignment of monitored connections is currently a manual process that involves an understanding between the different parties. There are various types of monitored connection topologies: cascaded, nested, and overlapping.

- **LTC:** Loss of Tandem Connection Signal
- **OCI:** Open Connection Indication
- **AIS:** TC Alarm Indication Signal

- **LCK:** Locked Defect
- **BDI:** Backward Defect Indication
- **IAE:** Incoming Alignment Error
- **BIAE:** Backward Incoming Alignment Error
- **BEI:** TC Backward Error Indication

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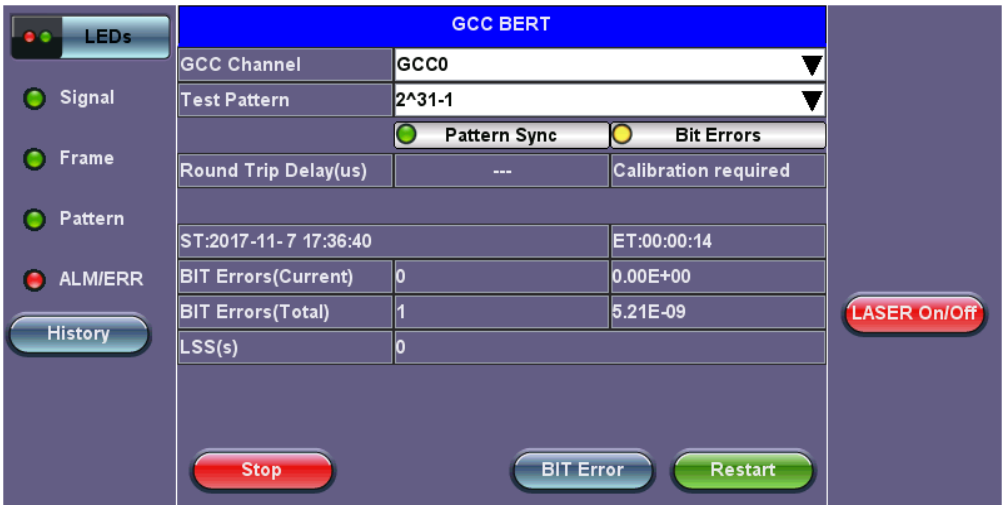
7.5.4 GCC BERT

GCC BERT



General Communication Channel 0 (GCC0) is a 2-byte clear channel, in the OTUk overhead, used for transmission of maintenance or information between regeneration points. The GCC1 and 2 channels are part of the ODUk overhead and carry information related to the client between the two ends of the link (not modified or affected by transit OTN network equipment).

GCC BERT inserts a test pattern in the selected GCC channel to verify error free transmission. Select from GCC0, GCC1, GC22 channels and the test patterns to be inserted.

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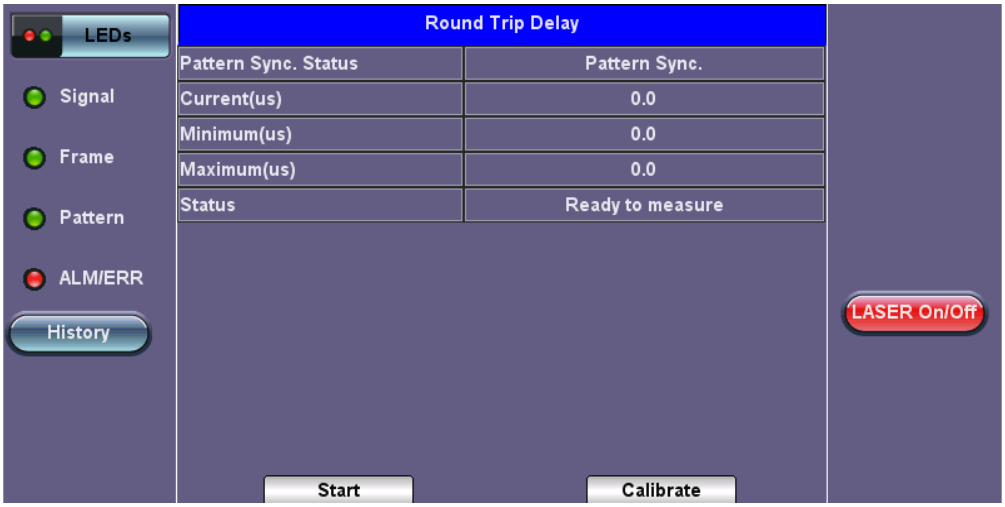
7.6 Advanced Tools

7.6.1 Round Trip Delay

Before running RTD, insert a short loopback and calibrate the unit. If the Status displays “Ready to measure”, then press **Start**. The calibration function measures the test set’s internal delay for the selected configuration, so it doesn’t affect the measurement.

Round Trip Delay Setup



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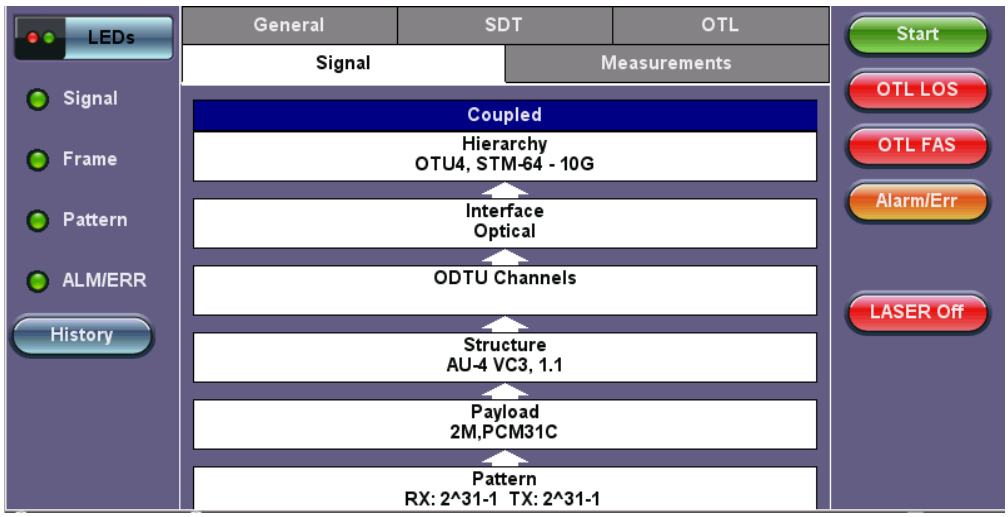
8.0 OTU3/OTU4 with SDH/SONET Mapping

Note: *SDH/SONET STL256.4 (Advanced) is an additional feature that requires separate purchase and may not be available for all modules. For Setup and Results information on the basic version, click here. For an overview of the Basic and Advanced versions, refer to STL256.4 SDH/SONET Basic and Advanced Version Overview.*

8.1 Signal Overview

Tap on the Signal tab to set up the Transmitter and Receiver interfaces and associated test parameters prior to running a test.

Signal tab



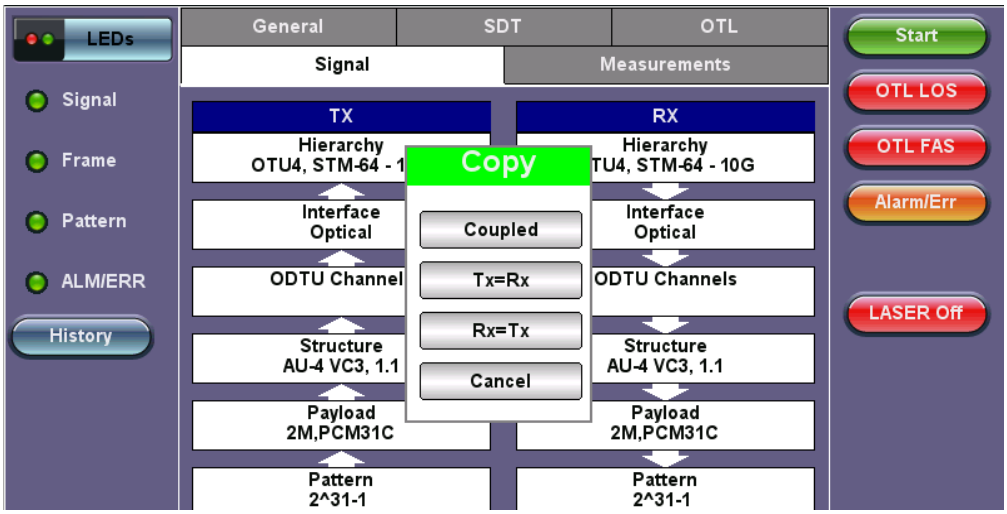
TX and RX Configurations

The Transmitter (TX) and Receiver (RX) signal structure are coupled or set to be identical by default. The coupled signal parameter can be modified by tapping the applicable block which brings up a new dialog window displaying additional input and specific selection settings. The Transmitter transmits as soon as a valid configuration is entered. The Receiver will check for a valid signal on its input so the measurement function is synchronized. When a test is not running, the LEDs will still indicate errors and alarms, but any other results displayed will be the results of a previous test.

Uncoupling TX and RX

When the TX and RX signal structures are required to be independent configurations, tap on the blue “Coupled” header to bring up the Copy menu. Copy menu options are Coupled, Tx=Rx, and Rx=Tx.

Accessing the Copy Menu



Copy Menu Options

- **Coupled:** TX and RX configurations are grouped as one block; TX and RX will have identical configuration. To uncouple TX and RX settings, tap on the blue "Coupled" heading and select Independent from the Copy Menu.
- **Tx=Rx:** Tx blocks will copy the settings made in the Rx blocks
- **Rx=Tx:** Rx blocks will copy the settings made in the Tx blocks

Setup Parameters

Changes to the Setup are applied immediately unless an invalid parameter has been selected.

- **Hierarchy:** Allows the user to configure OTN/SDH, OTN/SONET, PDH signal and network types, including the bit rate and higher order mapping, if applicable.
- **Interface:** Allows the user to select optical or electrical test ports. Optical test ports apply to OTN/SDH signal types only, while electrical ports can apply to STM-1E or PDH signals. Clock source and offset options are also configured in this screen.
- **Structure:** Applies to SDH/SONET signals only and allows the user to configure lower order mapping and the channel number.
- **Payload:** Applies to both SDH/SONET and PDH signals and allows the user to configure low rate signal (if applicable) and associated framing.
- **Pattern:** Applies to both SDH/SONET and PDH signals and allows the user to configure the test pattern to be used. Use the pattern drop-down box to select the test pattern which will be inserted into the transmitted signal. Pseudo Random Bit Sequences (PRBS) defined by ITU-T 0.150 and 0.151 standards, fixed words and 24-bit or 32 bit user defined patterns are available. ***Note****: If the 32 bit user pattern entered is incorrect, the default pattern will be 0xFFFFFFFF.*

Warning Message
While a test is running, it is possible to view the signal configuration, but it is not possible to change the setup or modify other measurement settings. This warning screen is only shown during initial setup to alert the user.

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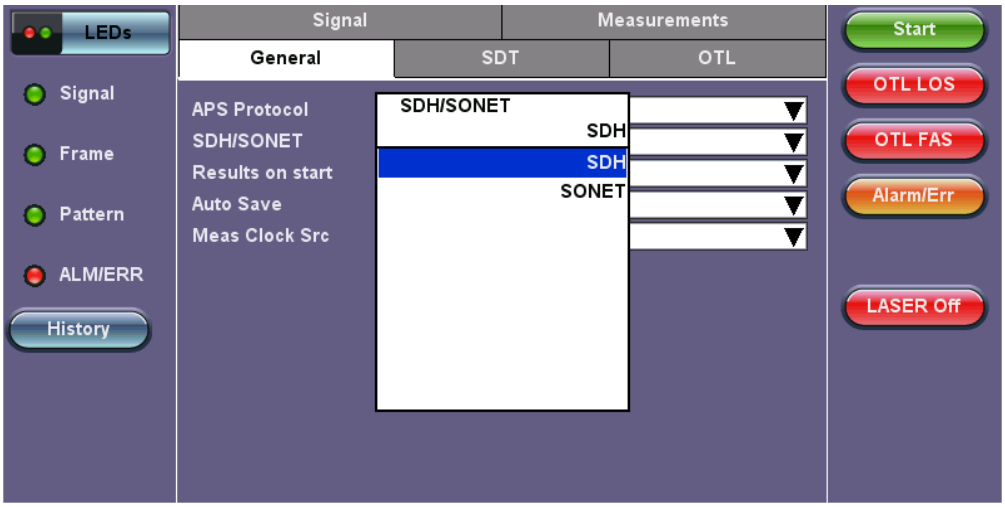
8.2 Setup: SDH/PDH

SDH/SONET selection from the General tab



Accessing SDH Testing

To display SDH options for the block configuration, tap on the **General** tab from the Setup screen and select SDH from the **SDH/SONET** drop-down menu.

Note: *Depending on whether SDH or SONET is selected from the* ***SDH/SONET*** *option under the* ***General*** *tab, TX and RX configuration screens will look slightly different.*

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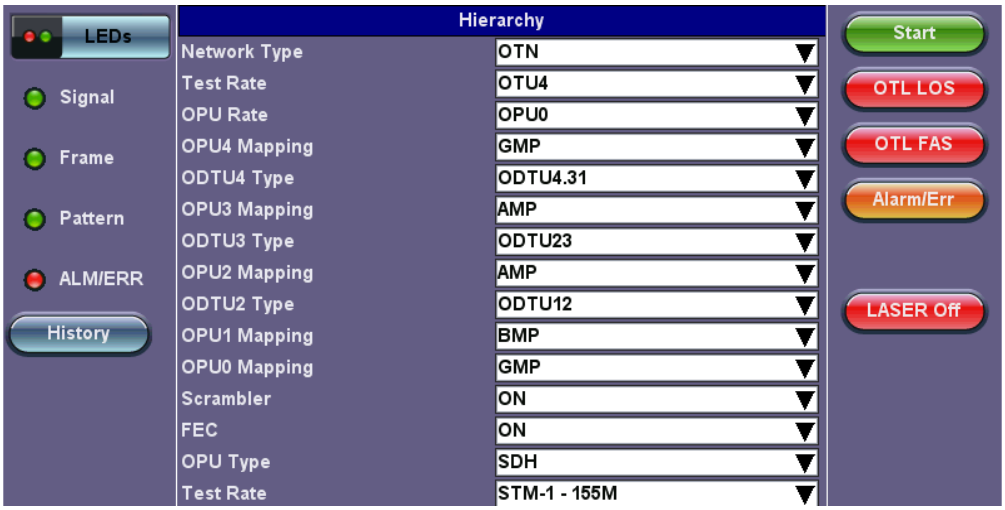
Coupled Transmitter and Receiver Setup

This section of the manual describes the SDH configuration capabilities. The block diagram of the Tx and Rx structure is described in Signal Overview. Tap on a block diagram to open the setup menu for the selected parameter.

Note: *Depending on the platform and module(s) installed as well as the chosen OTU test application, available options will vary.*

Hierarchy

Hierarchy Setup



Available options will vary depending on the selected type and rates. The following options are available:

- **Network Type:** In the OTN mode, only optical interface options are available
- **Test Rate:** OTU4 or OTU3
- **OPU Rate:** OPU0 to OPU4
- **OPU4 to OPU0 Mapping:** GMP, BMP, APM
- **ODTU Types:**
  - ODTU4 Type: ODTU4.1, ODTU4.2, ODTU4.8, ODTU4.31
  - ODTU3 Type: ODTU13, ODTU23, ODTU3.1
  - ODTU2 Type: ODTU12, ODTU2.1
- **Test Rate:** STM-1-155M, STM-4-622M, STM-16-2.5G, STM-64-10G, STM-256-40G
- **OPU Type:** PRBS, SDH
- **Scrambler:** ON/OFF
- **FEC:** ON/OFF

Through modes are used to test network behavior under certain conditions, such as alarms. To select Payload Through, the payload has to be the same for the relevant ports.

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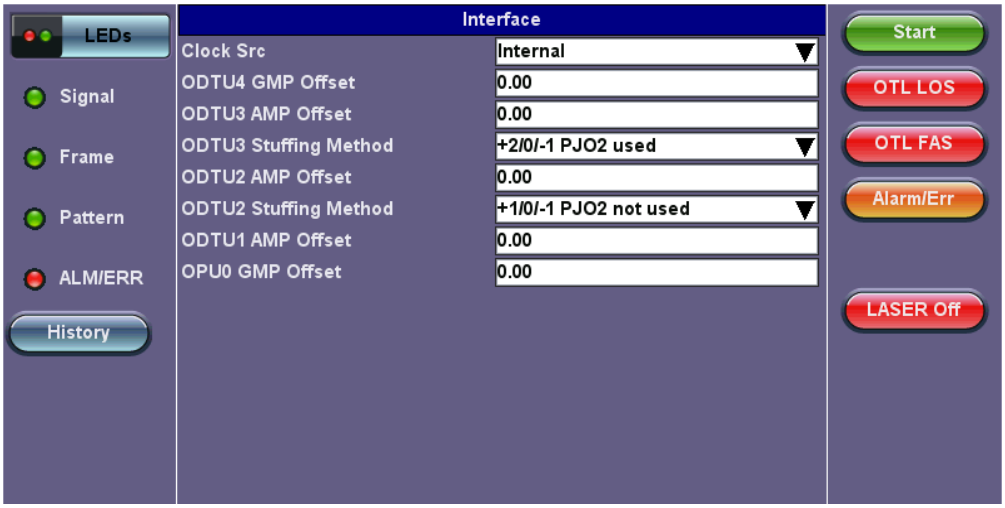
Interface

Interface Setup



- **Clock Source:** Can be configured as follows:
  - ***Internal clock:*** The clock for the transmitter is derived from the internal clock. The internal clock has an accuracy of +/- 3.5ppm conforming to G.812 recommendations.
  - ***External clock:*** The clock for the transmitter is derived from a 1.5MHz, 2MHz, 1.5Mbps, or 2Mbps signal on the SMA.
  - ***Rx:*** The clock for the transmitter is derived from the received signal, and the jitter of the incoming signal is suppressed.
  - ***Offset:*** The clock for the transmitter is derived from the internal clock generator. It can change the offset while measurements are running. Use the numeric key to increase and decrease the frequency shift, up to 0.01ppm. Frequency offset: ± 50ppm with 1, 0.1, 0.01ppm resolution.
  - ***Atomic 10 MHz (optional):*** Built-in Atomic Clock option provides 10 MHz reference and can be disciplined to the built-in GPS receiver option.
- Enter an **ODTU, OPU GMP/AMP Offset** value
- ODTU Stuffing Method: +1/0/-1 PJO2 not used, +2/0/-1 PJO2 used

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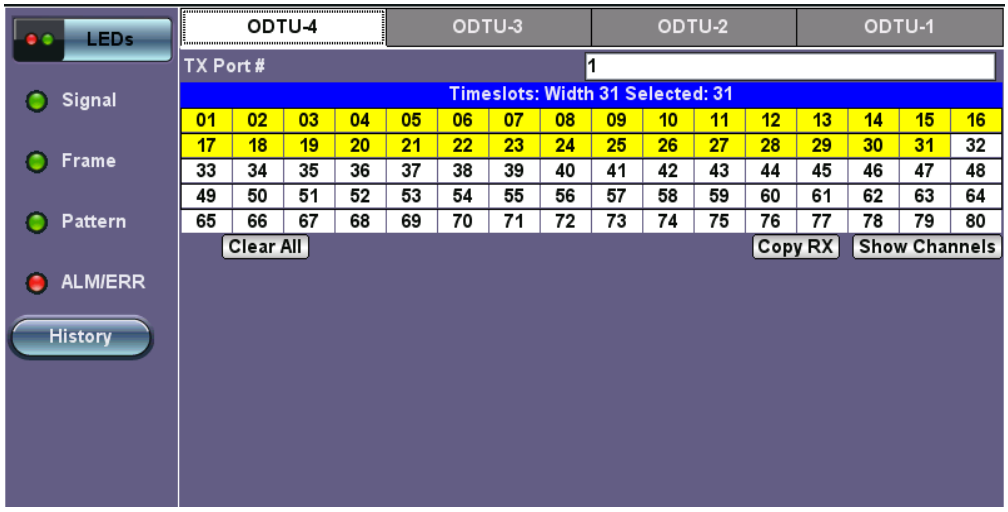
ODTU Channels



Tap on a timeslot to select a timeslot. Selections are displayed in yellow.

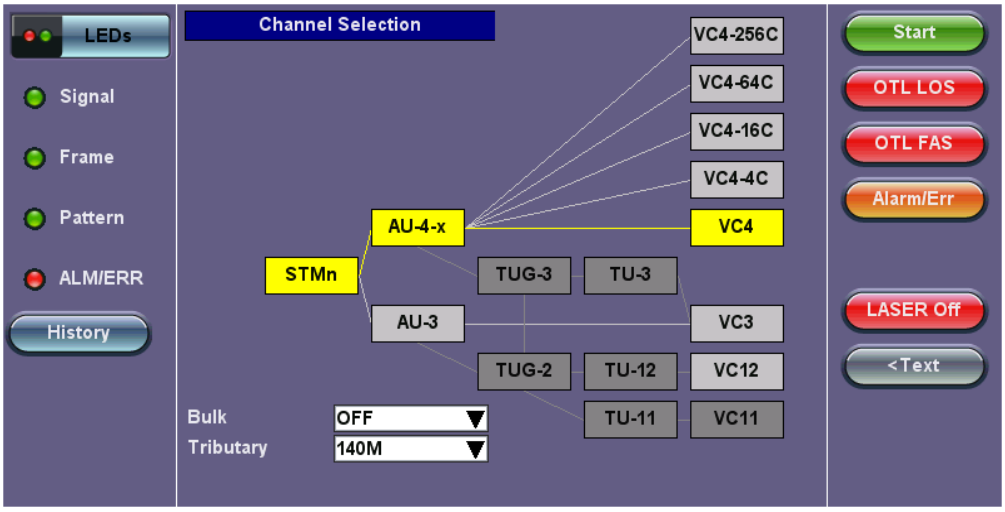
- **Clear All:** Clear all selected timeslots
- **Copy RX:** Copies Rx timeslot selections
- **Show Channel/Show TS:** Toggle between viewing channels and timeslots

PT selections and entering the TX Port # is also available.

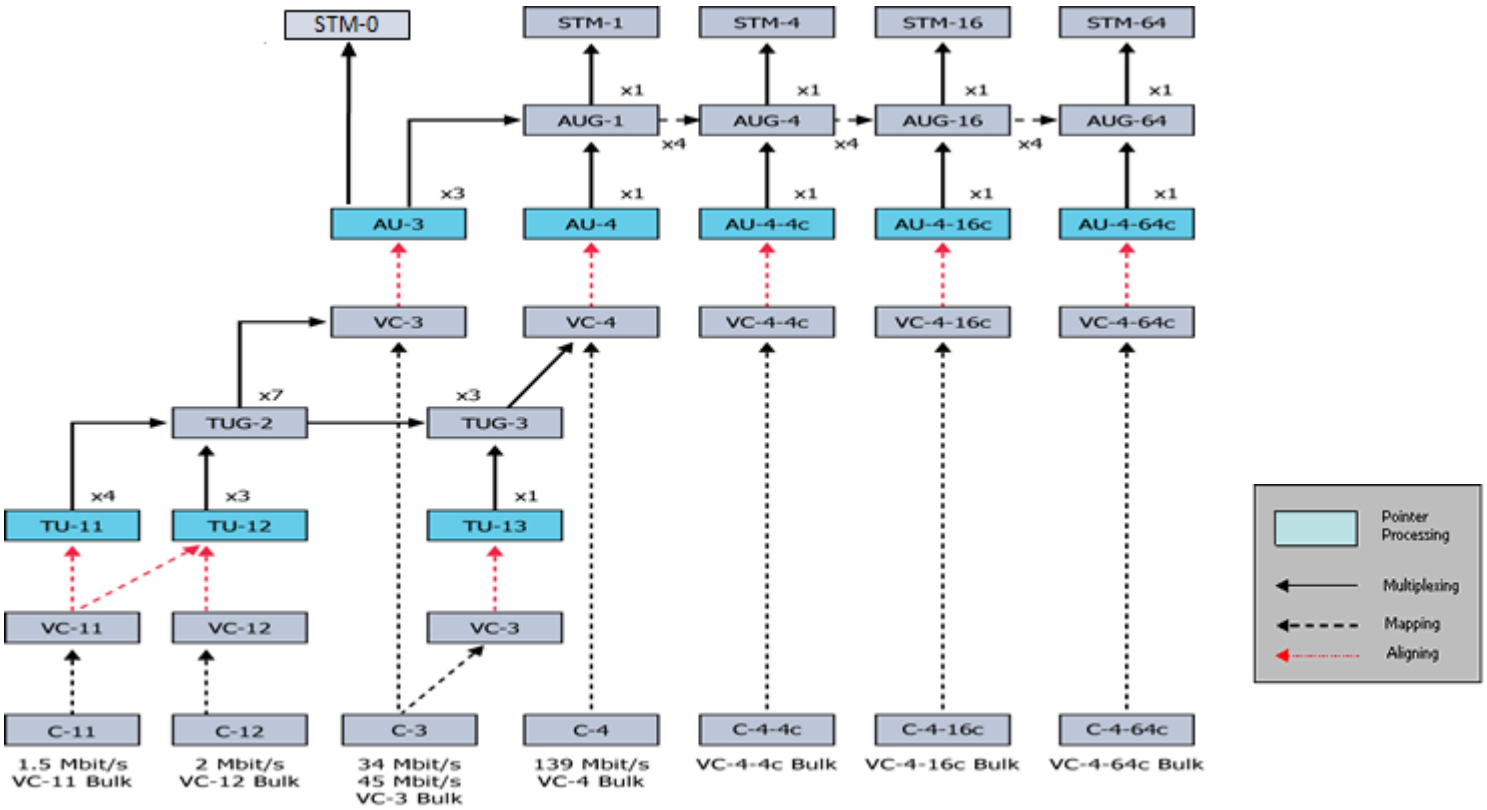
Structure

The Structure Setup screen is displayed in two modes: Text mode and Graphical mode. Tap on the **Text/Graphical** button to switch between display modes.

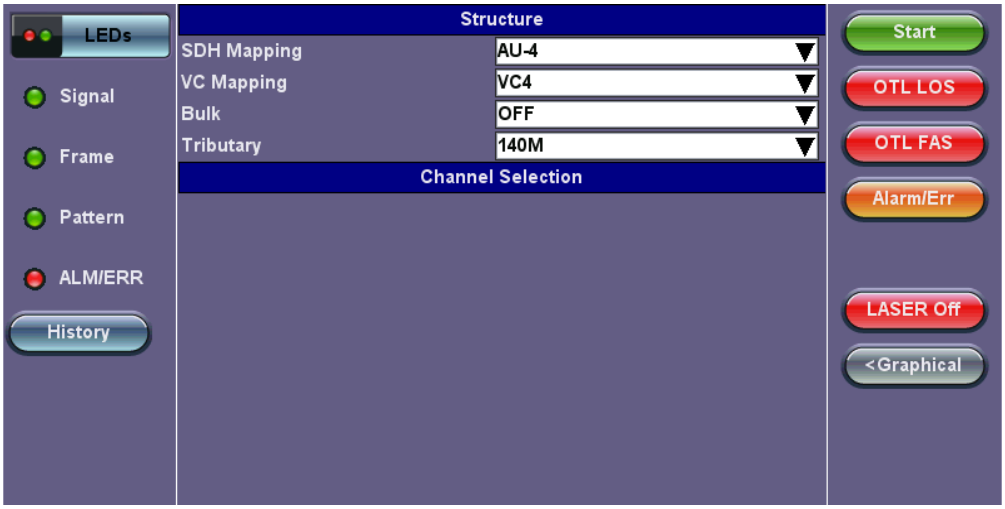
Structure Setup - Graphical Mode



SDH Mapping: Both AU-4 and AU-3 signal mappings per G.707 recommendations are supported. The multiplexing structure is shown below.



Structure Setup - Text Mode



- **AU4 Mapping:** VC-256C, VC4-64C, VC4-16C, VC4-4C, VC4, VC3, and VC12 are available.
- **AU3 Mapping:** VC3,VC12, and TU11/VC11 are available.
- **Bulk:** Tap the check box to enable the setting. In bulk mode, the entire VT container is filled with a test pattern per ITU-T 0.181 recommendations.
- **Tributary:** Preset to DS1, E1, DS3, and E3 rates depending upon the options and mapping.

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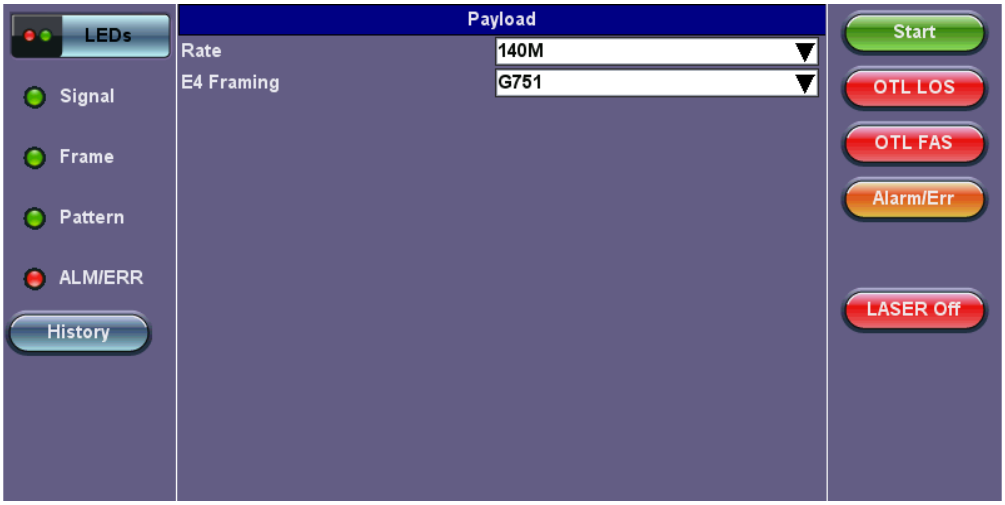
Payload

Payload Setup



Rate: Depends on mapping selected.

In TU11/VC11 mapping mode, the Low Rate options are 1.544M or Fractional DS1 (Nx64 or Nx56) where:

- 1.544M: Configures the transmitter for full rate testing at 1.544Mbps
- Fractional DS1 (Nx64 or Nx56): Configures the transmitter for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

In VC3 mapping mode/Tributary set to DS3, the Low Rate options are 45M, 1.544M Mux (DS3/DS1 Mux), or Fractional DS1 (Nx64 or Nx56) Mux where:

- 45M: Configures the transmitter for full rate testing at 45Mbps
- 1.544M Mux mode: Configures the transmitter for full rate testing at 45Mbps signal with DS1 payloads (1 to 28 channels)
- Fractional DS1 Mux mode: Configures the transmitter for full rate testing at 45Mbps signal with DS1 payloads (1 to 28 channels) for fractional testing using N or M 64kbps or 56kbps timeslots (contiguous or non-contiguous timeslots)

In VC12 mapping mode, the Low Rate options are 2M or Fractional E1 (N x64) where:

- 2M: Configures the transmitter for full rate testing at 2.048Mbps
- Fractional E1: Configures the transmitter for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

In VC3 mapping mode/Tributary set to E3, the Low Rate option are 34M or 2M Mux (E3//E1 Mux) or Fractional E1 Mux (E3//E1 Mux w/Nx64) where:

- 34M: Configures the transmitter for full rate testing at 34Mbps
- 2M Mux mode: Configures the transmitter for full rate testing at 34Mbps signal with E1 payloads (1 to 16 channels)
- Fractional E1 Mux mode: Configures the transmitter for full rate testing at 34Mbps signal with E1 payloads (1 to 16 channels) for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

Framing: Depends on low rate selected.

- In DS1 mode, the options are unframed, D4 (SF), and ANSI T1.107 (ESF).
- In DS3 mode, the options are unframed, M13, and C-Parity.
- In E1 mode, the options are unframed, PCM31, PCM31C, PCM30, and PCM30C. Framing conforms to G.704 and G.706 recommendations and are briefly described below.
- In E3 mode, the options are unframed, framed G.751.

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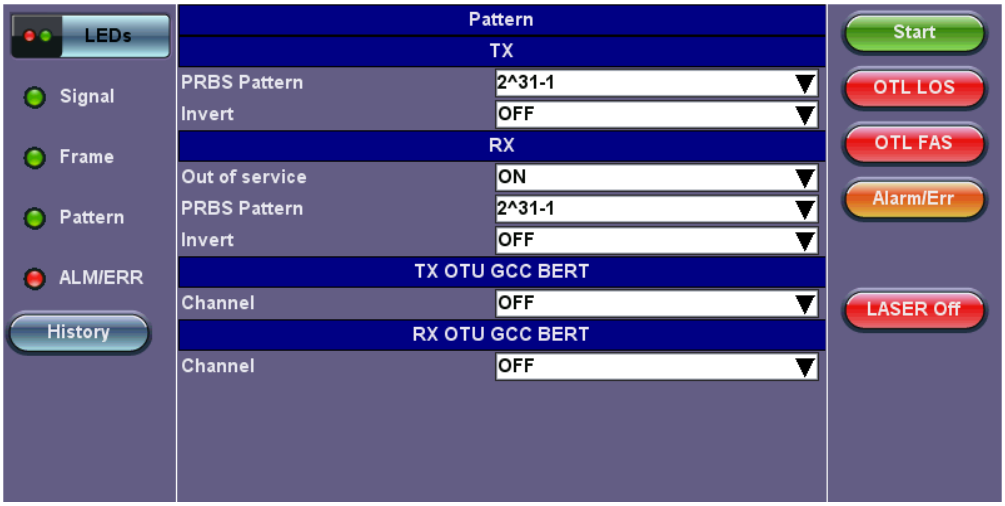
Pattern

Pattern Setup



- **PRBS Pattern:** Use the pattern drop-down box to select the test pattern which will be inserted into the transmitted signal. Pseudo Random Bit Sequences (PRBS) defined by ITU-T 0.150 and 0.151 standards, fixed words and 24-bit or 32 bit user defined patterns are available.
- **Invert:** Inversion of polarity is also available.
- **Out of Service (RX only):** Should be selected if the incoming signal is expected to contain a known test pattern. Deselect this option if signal is expected to contain live traffic.
- **OTU GCC BERT:** OFF, GCC0, GCC1, GCC2. If enabled, select a PRBS Pattern.

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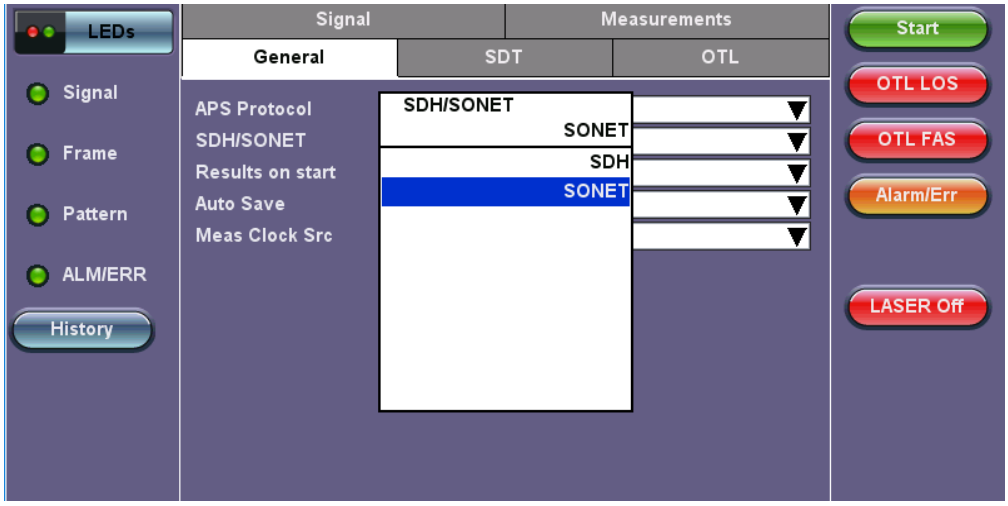
8.3 Setup: SONET

SDH/SONET selection from the General tab



Setting up SONET Testing

To display SONET options for the TX and RX block configuration, tap on the **General** tab from the Setup screen and select SONET from the **SDH/SONET** drop-down menu.

Note: *Depending on whether SDH or SONET is selected from the* ***SDH/SONET*** *option under the* ***General*** *tab, TX and RX configuration screens will look slightly different.*

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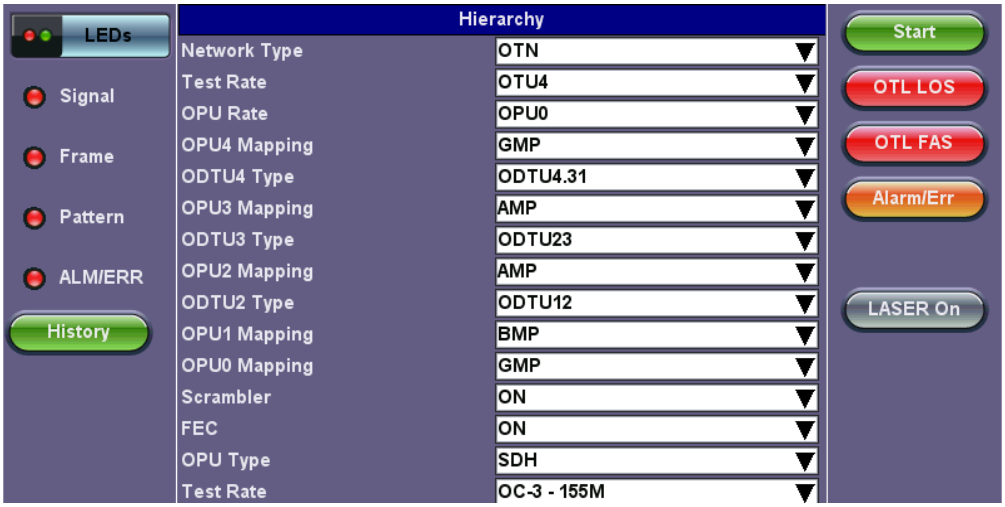
Coupled Transmitter and Receiver Setup

This section of the manual describes the SONET configuration capabilities. The block diagram of the Tx and Rx structure is described in Signal Overview. Tap on a block diagram to open the setup menu for the selected parameter.

Note: *Depending on the platform and module(s) installed as well as the chosen OTU test application, available options will vary.*

Hierarchy

Hierarchy Setup



Available options will vary depending on the selected type and rates. The following options are available:

- **Network Type:** In the OTN mode, only optical interface options are available

- **Test Rate:** OTU4 or OTU3
- **OPU Rate:** OPU0 to OPU4
- **OPU4 to OPU0 Mapping:** GMP, BMP, APM
- **ODTU Types:**
  - ODTU4 Type: ODTU4.1, ODTU4.2, ODTU4.8, ODTU4.31
  - ODTU3 Type: ODTU13, ODTU23, ODTU3.1
  - ODTU2 Type: ODTU12, ODTU2.1
- **Test Rate:** OC-3-155M, OC-12-622M, OC-48-2.5G, OC-192-10G, OC-768-10G
- **OPU Type:** PRBS, SDH
- **Scrambler:** ON/OFF
- **FEC:** ON/OFF

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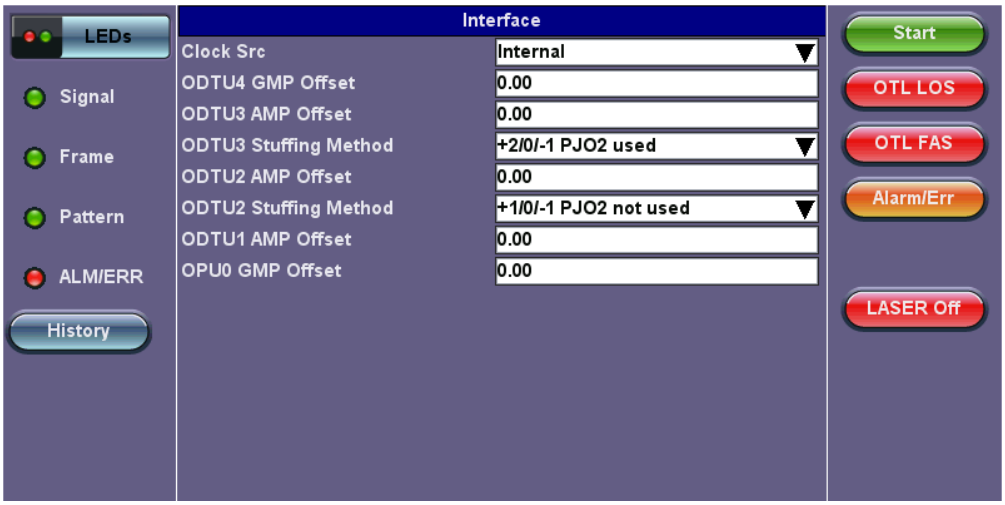
Interface

Interface Setup



Use this menu to configure the clock sources used to time the OTN signal, multiplexing levels and payloads. Users can enter individual frequency offsets and select the desired stuffing methods. The content of this screen changes depending on the selected test signal structure.

Clock Source: Can be configured as follows.

- **Internal clock:** The clock for the transmitter is derived from the internal clock. The internal clock has an accuracy of +/- 3.5ppm conforming to G.812 recommendations.
- **External clock:** The clock for the transmitter is derived from a 1.5MHz, 2MHz, 1.5Mbps, or 2Mbps on the SMA.
- **Rx**: The clock for the transmitter is derived from the received signal, and the jitter of the incoming signal is suppressed.
- **Offset:** The clock for the transmitter is derived from internal clock generator. It can change the offset while measurements are running. Use the numeric key to increase and decrease the frequency shift, up to 0.01ppm. Frequency offset: ± 50ppm with 1, 0.1, 0.01ppm resolution.

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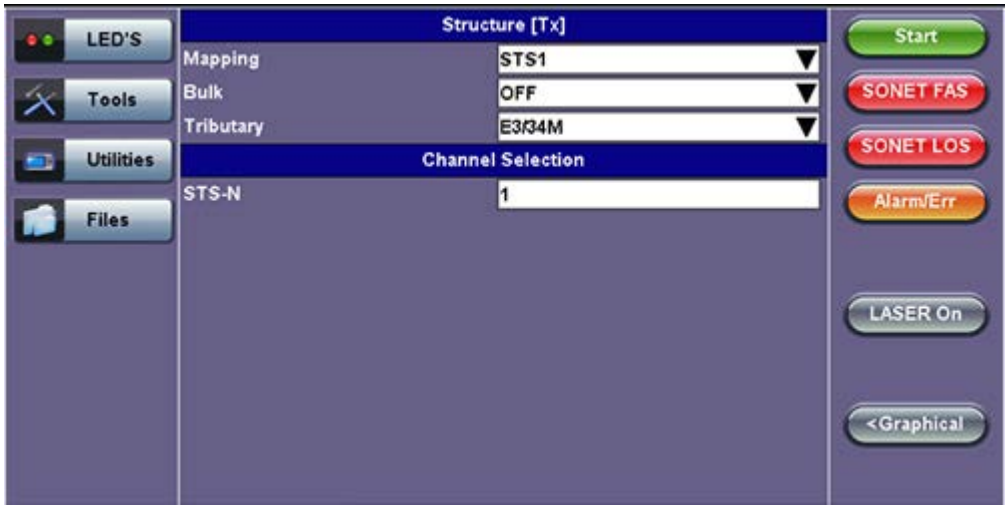
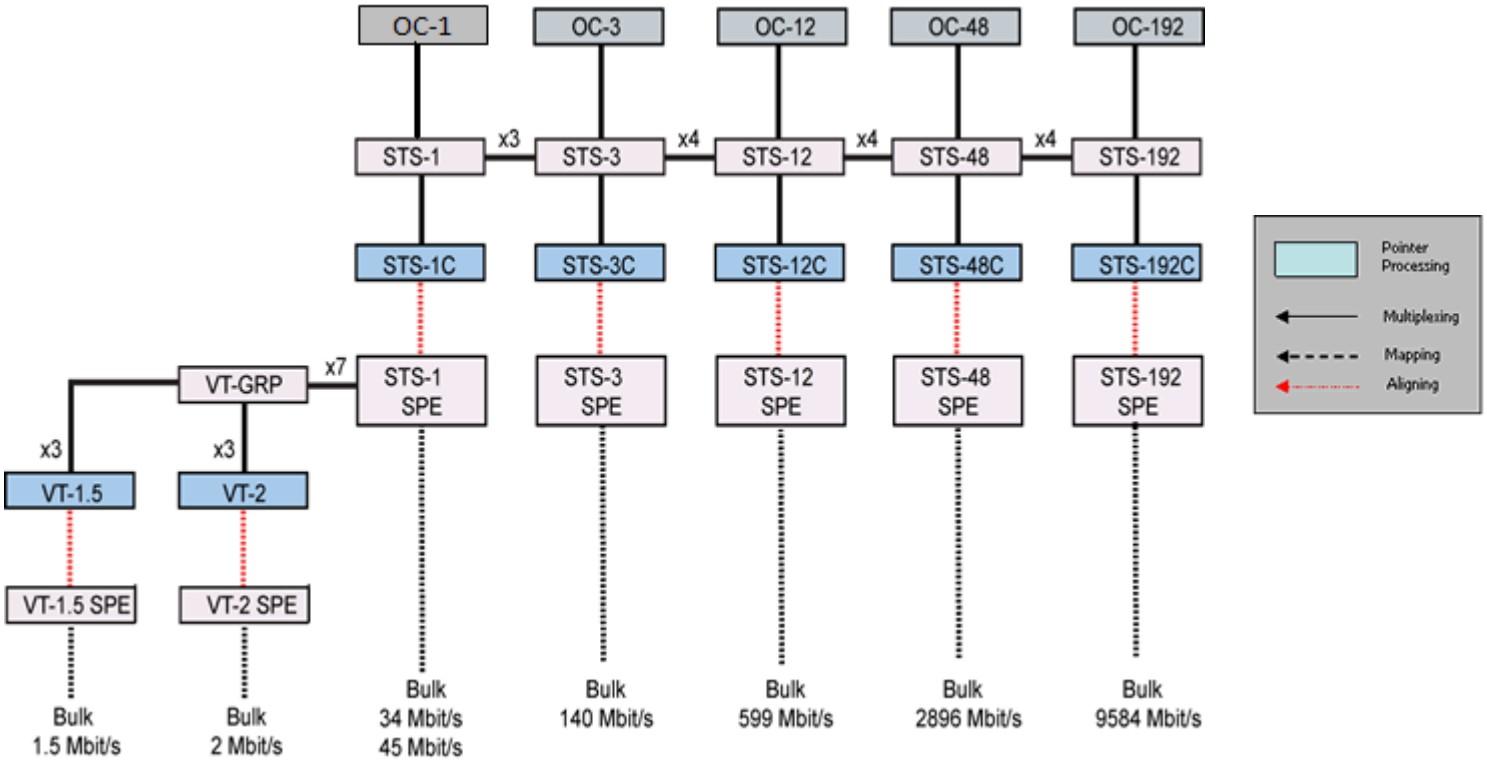
ODTU Channels

Structure

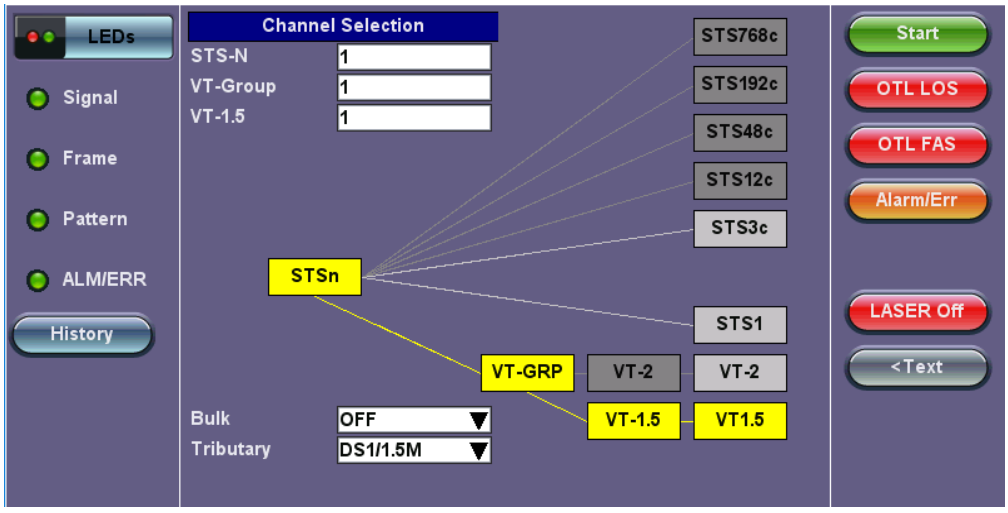
The Structure Setup screen is displayed in two modes: Text mode and Graphical mode. Tap on the **Text/Graphical** button to switch between display modes.

Tx Structure Setup - Text Mode





Tx Structure Setup - Graphical Mode



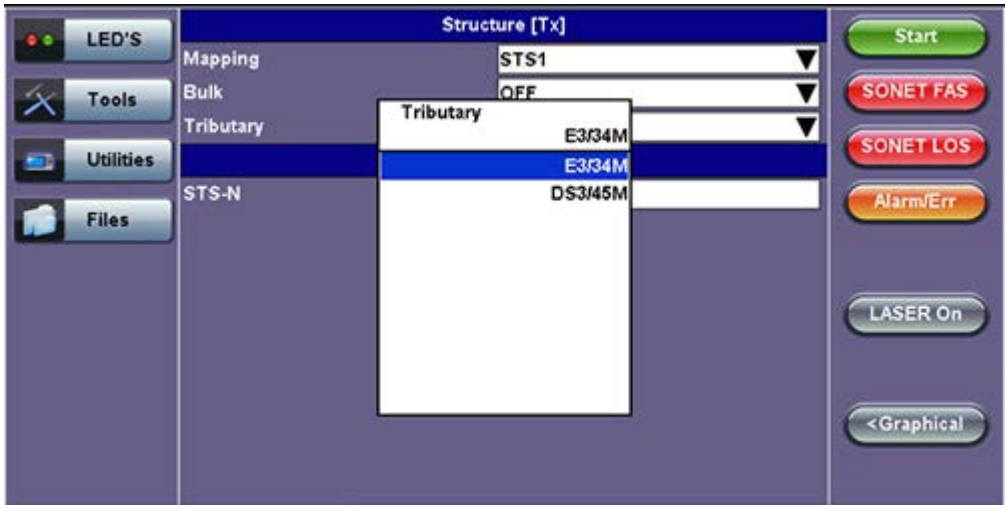
Bulk: Tap on the selection box to enable the setting. In Bulk mode, the entire container is filled with a test pattern per ITU-T 0.181 recommendations.

- **Tributary:** Preset to DS1, E1, DS3, and E3 depending upon the options and mapping.
- **Other channels:** Select Unequipped to mark the rest of the tributaries (non-test channels) as not equipped. Select Broadcast to transmits the same test channel structure and test pattern in all the tributaries.
- **Sync:** Asynchronous, Bit synchronous and Byte synchronous payload mapping selection

Channel Selection: The Tx channel is selected by entering the KLM position of the SDH/SONET channel within the signal channel. K (STS-N), L (VT-GRP), and M (VT-1.5 or VT-2) refer to the tributaries at each multiplexing levels and depend on the test signal configuration.

Note:

- **VT-GRP:** In order to carry multiple VTs in a STS-1 SPE in an efficient manner, VT Group (VTG) is defined. The size of the VTG is 12 columns, which is the least common multiple of the four sizes of VTs. Only one type of VT can be contained within each VTG. Therefore, a VTG can be formed by byte interleave multiplexing 3 VT-2s and 4 VT-1.5s
- **VT-1.5**: Each VT 1.5 frame consists of 27 bytes (3 columns of 9 bytes) These bytes provide a transport capacity of 1.728Mbps, and thus, can accommodate the transport of a DS1 signal. 28 VT 1.5s may be multiplexed into the STS-1 SPE.
- **VT-2**: Each VT-2 frame consists of 36 bytes (4 columns of 9 bytes) These bytes provide a transport capacity of 2.304Mbps, and can accommodate the transport one E1 signal. 21 VT-2s may be multiplexed into the STS-1 SPE.
- The tributary numbering used above is per Bellcore GR.253/ANSI T1.105 standard.



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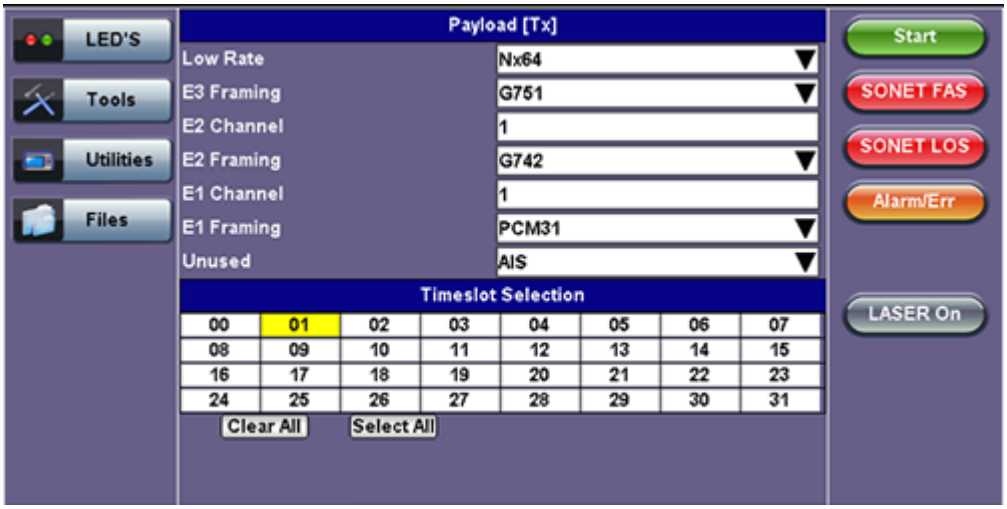
Payload

Tapping the Tx Payload box opens the Tx Payload Setup screen. The options presented will depend on the test signal structure programmed. **Low Rate** indicates the lowest data rate in the structure, containing the test pattern.

Tx Payload Setup



Rate: Depends on mapping selected.

In VT-1.5 mapping mode, The Low Rate options are 1.544M or Fractional DS1 (Nx64 or Nx56) where:

- 1.544M: Configures the transmitter for full rate testing at 1.544Mbps

Fractional DS1 (Nx64 or Nx56): Configures the transmitter for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

In STS-1 mapping mode/Tributary set to DS3, the Low Rate option are 45M or 1.544M Mux (DS3/DS1 Mux) or Fractional DS1 (Nx64 or Nx56) Mux where:

- 45M: Configures the transmitter for full rate testing at 45Mbps
- 1.544M Mux mode: Configures the transmitter for full rate testing at 45Mbps signal with DS1 payloads (1 to 28 channels)

In VT-2 mapping mode, the Low Rate options are 2M or Fractional E1 (Nx64) where:

- 2M: Configures the transmitter for full rate testing at 2.048Mbps
- Fractional E1: Configures the transmitter for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

In STS-1 mapping mode/Tributary set to E3, the Low Rate options are 34M or 2M Mux (E3/E1 Mux) or Fractional E1 Mux (E3/E1 Mux w/Nx64) where:

- 34M: Configures the transmitter for full rate testing at 34Mbps
- 2M Mux mode: Configures the transmitter for full rate testing at 34Mbps signal with E1 payloads (1 to 16 channels)
- Fractional E1 Mux mode: Configures the transmitter for full rate testing at 34Mbps signal with E1 payloads (1 to 16 channels) for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

Framing: Depends on low rate selected:

In DS1 mode, the options are unframed, D4 (SF) and ANSI T1.107 (ESF).

In DS3 mode, the options are unframed, M13 and C-Parity.

In E1 mode, the options are unframed, PCM31, PCM31C, PCM30, and PCM30C. Framing conforms to G.704 and G.706 recommendations and are briefly described below.

In E3 mode, the options are unframed, framed G.751.

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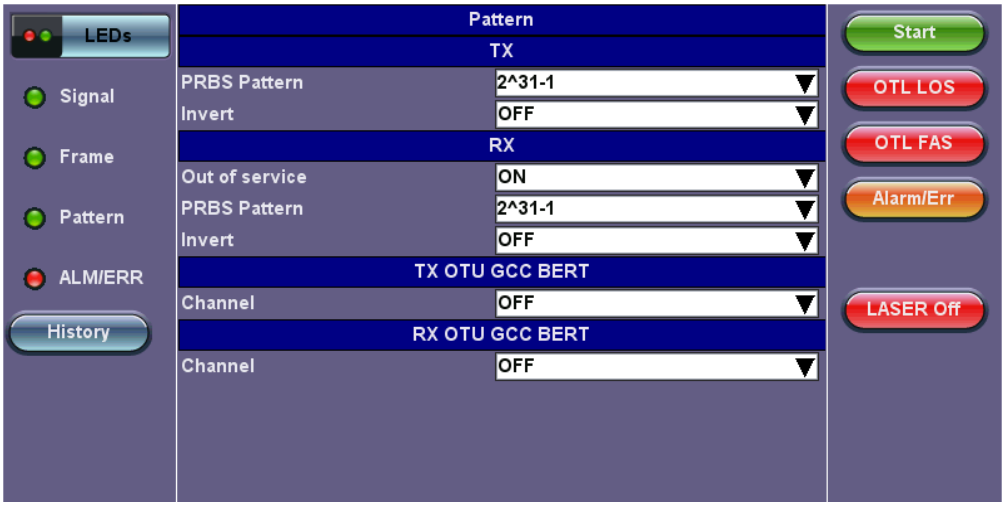
Pattern

Tapping the Tx Pattern box opens the Tx Pattern Setup screen.

Tx Pattern Setup



Pattern: Use the pattern drop-down box to select the test pattern which will be inserted into the transmitted signal. Pseudo Random Bit Sequences (PRBS) defined by ITU-T 0.150 and 0.151 standards, fixed words and 24-bit or 32 bit user defined patterns are available.

***Note**: If the 32 bit user pattern entered is incorrect, the default pattern will be 0xFFFFFFFF.*

Invert: Inversion of polarity is also available.

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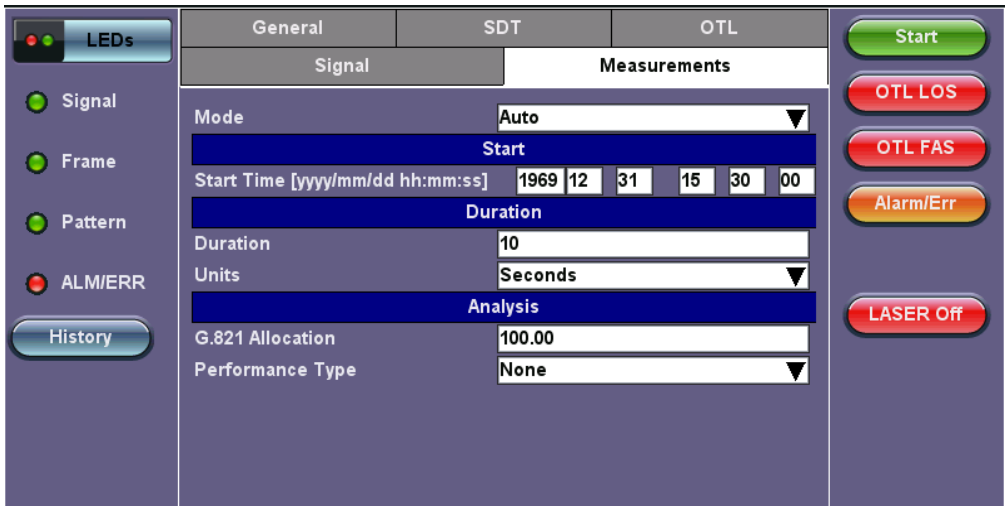
8.4 Measurement Configuration

Tapping the **Measurements** tab opens the setup screen for the Timer, Performance Analysis, and General configurations.

Measurements tab



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8.4.1 Timer Setup

Configure a test to run for a fixed duration and/or a delayed start.

Mode: Manual, Timed, and Auto selections are available.

- **Manual:** This is directly linked to the Start/Stop function on the drop-down menu. The test starts as soon as the **Start** button is pressed. Press **Stop** to stop the test.
- **Timed:** The test duration can be set by the user in seconds, minutes, hours or days. The test is activated by the Start button on the drop-down menu and stops automatically when the defined time has elapsed.
- **Auto:** A predetermined start time can be set by the user. The test duration can be set in seconds, minutes, hours or days. After programming the start time and duration, press the **Start** button and the test will be activated automatically when the programmed start time is reached.

Note: *M.2100 and M.2101 performance objectives are only available in Timed and Auto Mode.*

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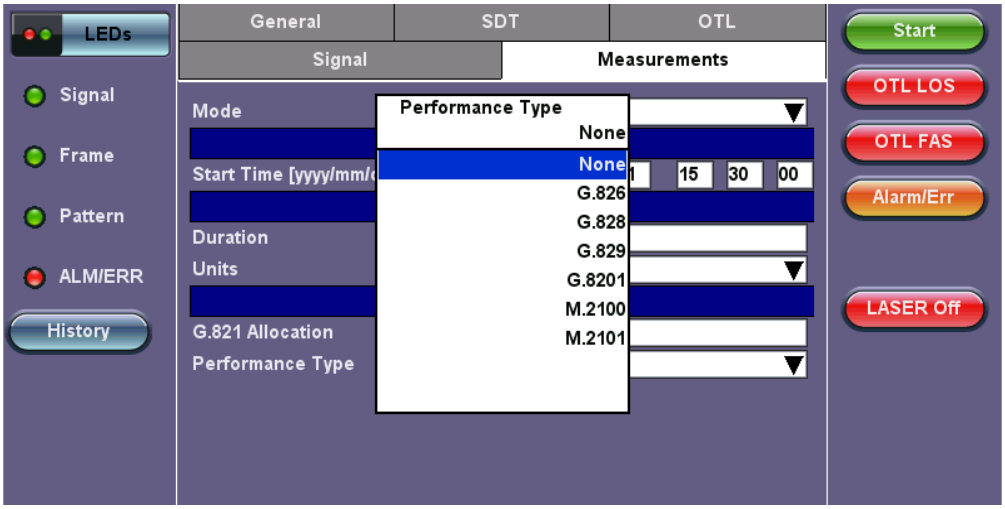
8.4.2 Performance Analysis

The Analysis setup page selects the type of ITU-T performance evaluation that will be performed by the unit. Depending on Test mode, the selections include None, G.821, G.826, G.828, G.829, G.8201, M.2100, and M.2101. The available options may vary depending on configuration.

Analysis



The recommendations are briefly defined as follows:

- **G.821:** Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Service Digital Network (ISDN)
  - Long term error performance conducted Out of Service (OOS)
  - Based on measuring bit errors
  - Evaluation period of 30 days
  - Since there is no overhead structure at these bit rates, in-service measurements are not recommended
- **G.826:** End-to-end error performance parameters and objectives for international, constant bit rate digital paths and connections
  - Long term error performance for Out of Service (OOS) and In-Service Monitoring (ISM)
  - Based on measuring bit errors for connections and block errors for paths
  - Evaluation period of 30 days
- **G.828 Analysis**: Error performance parameters and objectives for international constant bit rate synchronous digital paths
  - Deals exclusively with SDH paths
  - Long term error performance for Out of Service (OOS) and In-Service
  - Based on measuring block errors
  - Evaluation period of 30 days
- **G.829 Analysis:** Error performance events for SDH Regenerator and Multiplexer sections
  - Deals exclusively with SDH sections
  - Error event definition
  - Based on measuring block errors
- **G.8201:** Error performance parameters and objectives for multi-operator international paths within optical transport networks (OTN) addressing the objectives for international (and national) ODUk paths. This is a block-based measurement concept using error detection code (EDC) and EDC usage inherent to the path under test. This simplifies in-service measurements.
  - Error performance for Out of Service (OOS) and In-Service Monitoring (ISM)
- **M.2100:** Performance limits for bringing into service and maintenance of international multi-operator PDH paths and connections
  - Deals exclusively with PDH paths, sections and systems
  - Based on measuring bit errors and block errors
  - Bring-into-Service (BIS) limits for OOS/ISM
  - Evaluation periods of 15 minutes, 2 hours and 24 hours
  - First step is a continuity test for 15 minutes
  - PDH paths are composed of sub-elements of different lengths each with its own set Reference Performance Objectives (RPO)
- **M.2101 Analysis:** Performance limits and objectives for maintenance and bringing into service SDH paths and multiplex sections.
  - Deals exclusively with SDH paths and sections
  - Based on measuring block errors
  - BIS limits for OOS/ISM
  - Evaluation periods of 15 minutes, 2 hours, 24 hours and 7 days
  - First step is a continuity test for 15 minutes

Note: *Only one performance analysis can be performed at a time. To view or enable the M.2100 and M.2101 analyses, the*

measurement timer has to be set to a determined period. The table below describes the anomalies evaluated for the performance analysis selected.

OTL Alarm/Error Definitions per ITU-T G.709 and G.798			
Analysis	**PDH**	**SDH**	**Anomalies**
G.821	●	●	TSE based on bit errors
G.826 (Out of service)	●	●	TSE based on block errors
G.826 (In service)		●	B1, B2, B3, LP-BIP, E1/E3/E4 FAS, E1, CRC
G.828 (In service)		●	B1, B2, TSE
G.829 (In service)		●	B1, B2, B3, LP-BIP, TSE
M.2100	●		E1/E3/E4 FAS, E1, CRC, TSE
M.2101		●	B1, B2, B3, HP, LP-BIP, TSE

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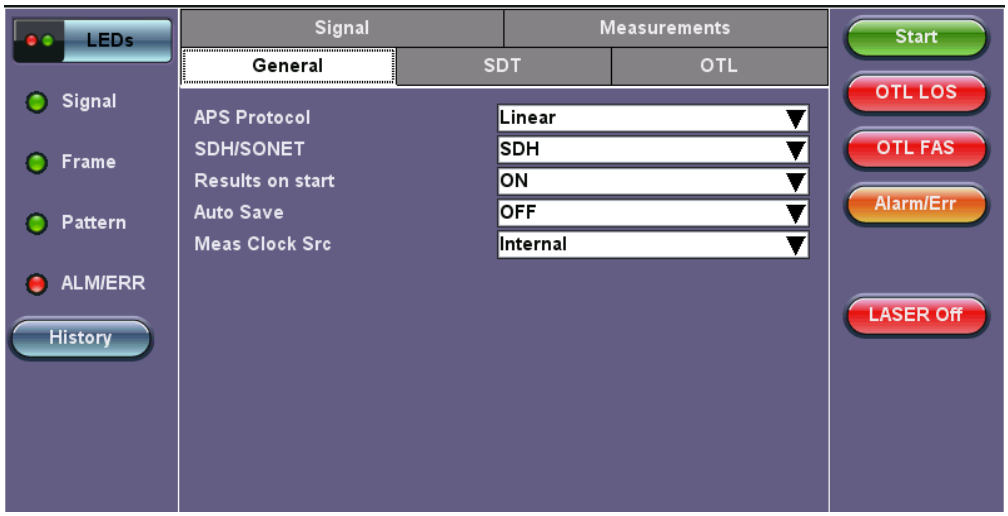
8.4.3 General

The General setup page configures the audible alarm and APS protocol settings. Audible alarms may not be supported by all test sets, technologies and applications.

General tab



- **APS Protocol:** Linear or Ring architectures are selectable. This determines how the APS bytes (K1/K2) are decoded in the SDH Overhead Analyzer or how they are generated in the SDH Overhead Generator. It also determines how the APS measurement will be made.
- **SDH/SONET:** SDH or SONET modes are available options. Defines the reference standard to be used for GUI terminology and functionality. Select SDH for SDH and PDH applications. Select SONET for North American SONET and DSn (T1 and T3). This may also change the behavior of certain menus and function.
- **STS-1 Bulk data** (SONET only): The STS-1 bulk mode fills the entire payload, except for the POH.
- **Result on start:** On or Off. Provides an automatic move to Result screen when it starts.
- **Auto Save:** Tap Auto Save and set it to **ON** to automatically save the results file.
- **Measurement Clock Source:** Internal Clock or Tx Clock Source; the measurement is synchronized to the Transmitted (Tx) Clock.

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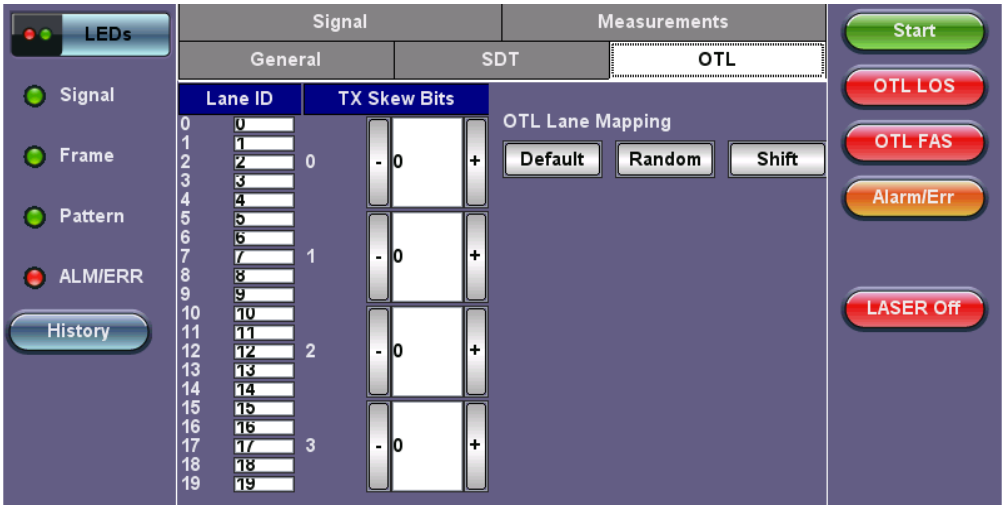
8.4.4 OTL

Advanced users can enter the OTL tab on the Setup screen to configure the OTL Tx Lane Mapping and Skew, as well as

tolerance thresholds (to generate alarms).

- **Lane ID:** Manually edit and assign specific Lane IDs to Lane #. Use the **Random** button to assign them arbitrarily, the **Shift** button to slide the Lane IS vs Lane # correlation, or the **Default** button to realign them back.
- **Skew (bits):** Enter the desired skew values by tapping directly on the fields or use the **+** and **–** buttons to increment/decrement them by the amount set in the **Inc/Dec Size** field.

OTL tab



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8.4.5 Service Disruption Test (SDT)

Refer to Service Disruption Test (SDT) in the OTU3 & OTU4 Test Application section for more information.

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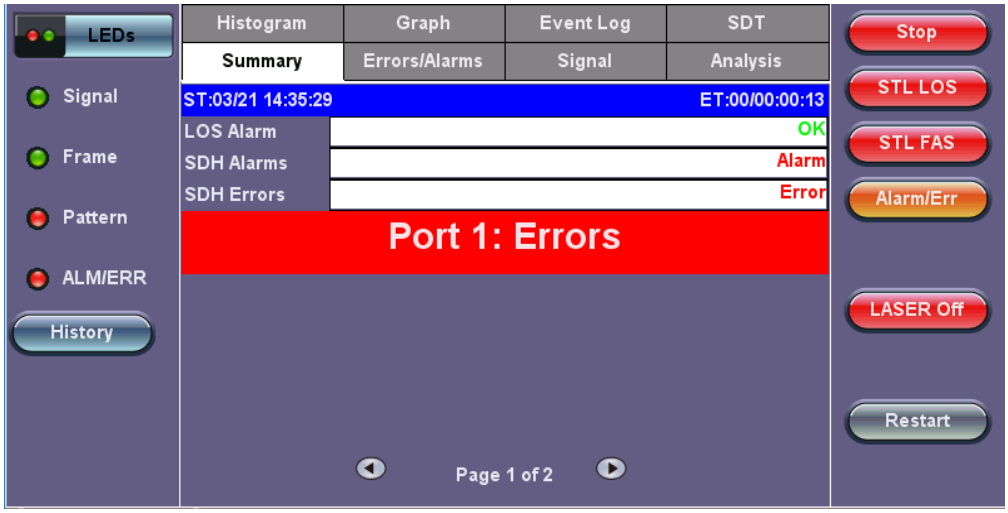
8.5 Results: OTN, PDH/DSn Multiplexing, and SDH/SONET

OTU3/OTU4 with PDH/DSn Multiplexing and SDH/SONET STL256.4 (Advanced) test results feature the same measurements and are displayed in an identical format. Test measurements can be accessed from the **Results** icon in the main menu.

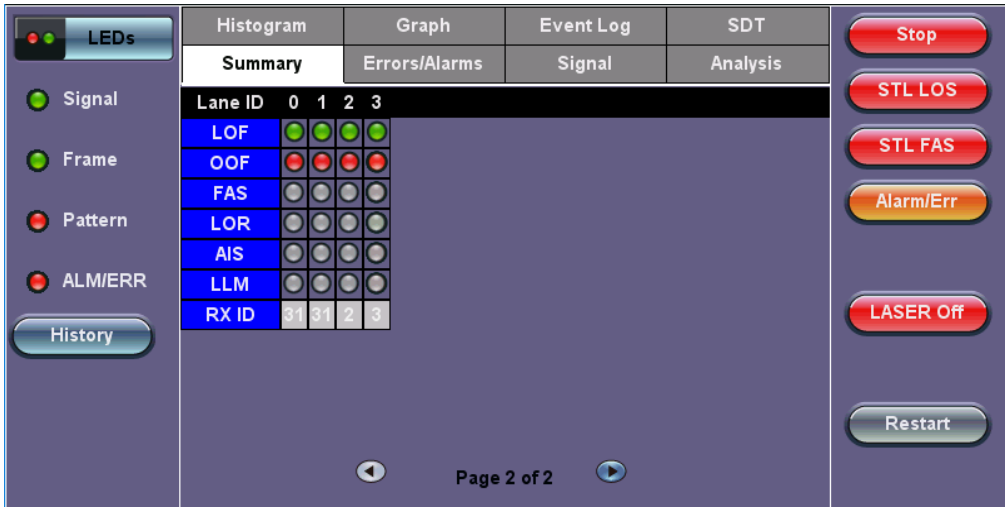
8.5.1 Summary

The Summary tab displays a summary of test results and parameters. At a glance, the user is able to see if there are any alarms, errors, or signal failure pertaining to the SDH/SONET signal and its payload.

Summary - STL256.4 (Advanced)



Summary displaying alarms/errors per lane



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8.5.2 Errors and Alarms

The Errors/Alarms tab brings up several pages showing the errors and alarms status.

Page 1 provides an overview of all the Errors and Alarms applicable to the signal or network under test. The color of the page tab is normally blue; however, it will turn red when an alarm error condition has been detected or recorded.

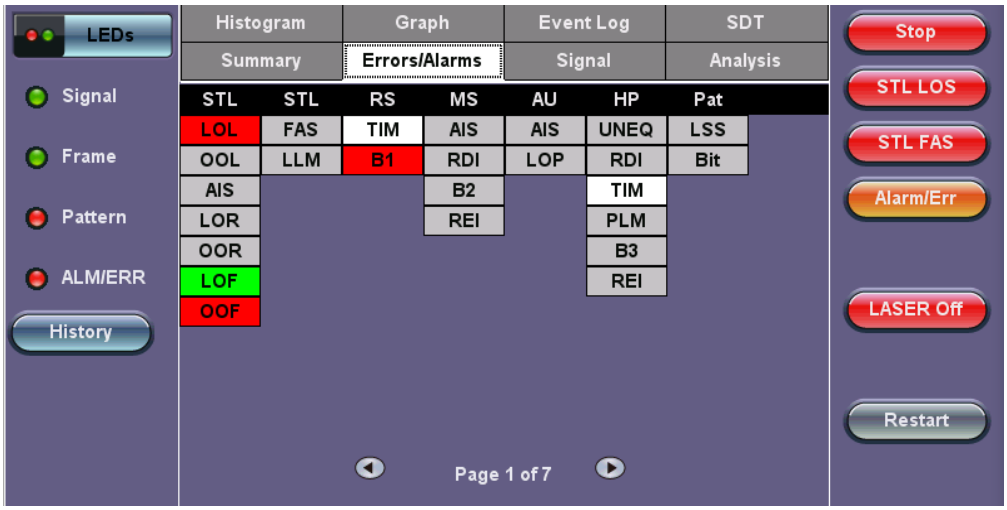
The soft LEDs on screen are arranged logically and will depend on signal hierarchy, structure, payload, and framing selected. The soft LEDs have a tricolor function:

- **Green:** No error or alarm is present.

Red: An error or alarm condition is detected and is currently present.

Yellow: Indicates a history condition. An error or alarm was detected during the measurement interval but it is no longer present or active.

Errors/Alarms (Page 1)



Note: *Tapping the individual soft LED will automatically link directly to the applicable result screen which provides detailed information. Depending on the settings chosen in* ***Setup*** *>* ***Signal****, the Alarms/Errors displayed and page length will vary, but the order in which they are presented remain the same.*

SDH LED headers are described in the tables below:

SDH Alarm Definitions and Descriptions	
RS	Regenerator Section
MS	Multiplexer Section
AU	Administrative Unit
HP	High Order Path
TU	Tributary Unit
LP	Low Order Path
E1	2Mbit/s signal (depends on payload selected)
Pat	Pattern detection (PRBS, user, fixed words)

SDH Error and Alarm definitions per ITU-T G.707 and O.150 recommendations:

Signal and BER - Alarm Definitions	
LOS	Loss of Signal • LOS is raised when the synchronous signal (STM-N) level drops below the threshold at which a BER of 1^{-3} is predicted. It could be due to a cut cable, excessive attenuation of the signal, or equipment fault. The LOS state will clear when two consecutive framing patterns are received and no new LOS condition is detected.
TSE	Test Sequence Error
	Loss of Sequence Synchronization

LSS	• Out-of-service bit error measurements using pseudo-random sequences of PRBS can only be performed if the reference sequence produced on the receiving side of the test set-up is correctly synchronized to the sequence coming from the object under test. Sequence synchronization shall be considered lost and re-synchronization shall be started if: 1. The bit error ratio is ≥ 0.20 during an integration interval of 1 second; or 2. It can be unambiguously identified that the test sequence and the reference sequence are out of phase.

Regenerator Section - Alarm Definitions	
LOF	Loss of Frame • Declared when OOF state exists for up to 3 ms. If OOFS are intermittent, the timer is not reset to zero until an in-frame state persists continuously for 0.25ms.
OOF	Out of Frame • Declared when 4 consecutive SDH frames are received with invalid (errored) framing patterns. Maximum OOF detection time is 625µs.
B1	Regenerator section error monitoring • Parity errors evaluated by the B1 byte (BIP-8) of an STM-N. If any of the eight parity checks fail, the corresponding block is assumed to be in error.

Multiplexer Section - Alarm Definitions	
MS-AIS	Multiplexer Section Alarm Indication Signal • Declared when bits 6, 7, 8 of the K2 byte contain a "111" pattern for five consecutive frames
MS-RDI	Multiplexer Section Remote Defect Indication • Declared when bits 6, 7, 8 of the K2 byte contain a "110" pattern for five consecutive frames
MS-REI	Multiplexer Section Remote Error Indication • For STM-1 signals, declared when the M1 byte located in TS #3 is different • For STM-4/16 signals, declared when the M1 byte located in TS #7 is different
B2	Multiplexer Section Error Monitoring • Parity errors evaluated by the B2 byte (BIP-24 x N) of an STM-N. If any of the Nx24 parity checks fail, the corresponding block is assumed to be in error

Administrative Unit- Alarm Definitions	
AU-AIS	Administrative Unit Alarm Indication Signal • Alarm is declared when H1 and H2 pointer bytes contain an all ones pattern for three consecutive frames
AU-LOP	Administrative Unit Loss of Pointer • Indicates that a valid pointer is not found in N consecutive frames where N=8, 9, or 10 or a 1001 pattern is detected (NDF)

AU-NDF	Administrative Unit New Data Flag

High Order Path - Alarm Definitions	
HP-UNEQ	HO path Unequipped • Declared when the C2 byte contains "00H" in five consecutive frames
HP-RDI	HO path Remote Defect Indication • Alarm is declared when bits 5, 6, 7, of the G1 byte contain 100 or 111 in five consecutive frames
HP-TIM	HO path Trace Identifier Mismatch • Indicates that the J1 path trace does not match the expected message value. The TIM function must be enabled for this alarm to be active
HP-PLM	HO path Payload Mismatch • Declared after receiving five consecutive frames with mismatched VC signal labels
B3	HO path Error Monitoring of VC-3, VC-4 • Parity errors evaluated by the B3 byte (BIP-8) of a VC-N (N=3, 4). If any of the eight parity checks fail, the corresponding block is assumed to be in error.
HP-REI	HO path Remote Error Indication • Alarm is declared when bits 5, 6, 7, of the G1 byte contain 100 or 111 in five consecutive frames

Tributary Unit - Alarm Definitions	
TU-AIS	Tributary Unit Alarm Indication Signal • Declared when the V1 and V2 bytes for the TU path contain an all ones pattern for five consecutive super-frames
TU-LOP	Tributary Unit Alarm Indication Signal • Declared when no valid pointer is detected in N consecutive superframes (N>8 and <10), or if N consecutive NDFs "1001" patterns are detected
TU-LOM	Tributary Unit Loss of Multiframe (H4)

Low Order Path - Alarm Definitions	
LP-UNEQ	LO path Unequipped • Declared when bits 5, 6, 7, of the V5 byte contain "000" for five consecutive frames
LP-RDI	LO path Remote Defect Indication • Declared when bit 5 of the V5 byte contains a "1" in five consecutive TU super-frames while bits 6, 7 of the K4 byte contain "00" or "11"
LP-RFI	LO path Remote Failure Indication • Declared when bit 4 of the V5 byte contains "1" in five consecutive frames
LP-TIM	LO path Trace Identifier Mismatch • Indicates that the J2 path trace does not match the expected message value. The TIM function must be enabled for this alarm to be active
LP-PLM	LO path Payload Mismatch

	• Declared when bits 5, 6, 7 of the V5 byte are set to "000", "001", or "111" which indicate a mismatch LP signal label
LP-REI	LO path Remote Error Indication • Declared when bit 3 of the V5 byte is set to "0"
LP-BIP	LO path Bit Interleaved Parity (VC-11, VC-12) • A BIP-2 parity error calculated over all the bytes of the previous VC frame

SONET LED headers are described in the table below:

SONET Alarm Definitions and Descriptions	
Section	Section Layer
Line	Line Layer
STS Path	STS Path Layer
VT Path	Virtual Tributary Path Layer
DS1	1.5 Mbit/s signal (depends on payload selected)
Pat	Pattern detection (PRBS, user, fixed words)

SONET Error and Alarm definitions per Bellcore GR.253 and ANSI T1.105 recommendations:

Signal and BER - Alarm Definitions	
LOS	Loss of Signal
TSE	Test Sequence Error
LSS	Loss of Sequence Synchronization
AIS	Alarm Indication Signal

Regenerator Section - Alarm Definitions	
LOF	Loss of Frame (A1, A2)
OOF	Out of Frame (A1, A2)
B1	Regenerator Section Error Monitoring (B1)
TIM-S	Trade Identifier Mismatch (J0)

Line - Alarm Definitions	
AIS-L	Line AIS (K2)
RDI-L	Line Remote Defect Indication (K2)
REI-L	Line Remote Error Indication (M1)
B2	Error Monitoring (B2)

STS Path - Alarm Definitions	
LOP-P	Loss of STS Pointer (H1, H2)
AIS-P	Administrative Unit AIS (STS-1 SPE include. H1, H2, H3)
RDI-P	STS path Remote Defect Indication (G1)

REI-P	STS path Remote Error Indication (G1)
TIM-P	STS path Trace Identifier Mismatch (J1)
PLM-P	STS path Payload Label Mismatch (C2)
B3	Error Monitoring (B3)
UNEQ-P	STS path Unequipped

Virtual Tributary Path (VT) - Alarm Definitions	
LOP-V	Loss of TU Pointer (V1, V2)
AIS-V	TU Alarm Indication Signal (VT incl. V1 to V4)
LOM	TU Loss of Multiframe (H4)
UNEQ-V	VT Path Unequipped (V5)
RDI-V	VT Path Remote Defect Indication (V5)
REI-V	VT Path Remote Error Indication (V5)
RFI-V	VT Path Remote Failure Indication (V5)
TIM-V	VT Path Trace Identifier Mismatch (J2)
PLM-V	VT Path Payload Label Mismatch (V5)
BIP-2	VT Path Error (V5)

SONET Error and Alarm detection criteria per Bellcore GR.253 and ANSI T1.105/231:

Section/Line Layer - Detection Criteria	
LOS	Loss of Signal • All-zero pattern for 2,3 µs ≤ T ≤ 100µs
LOF	Loss of Frame • A1, A2. No valid framing pattern for 3 ms (24 frames)
B1	Section BIP Error • Mismatch of the recovered and computed BIP-8 covers the whole STS-N frame
B2	Line BIP error • Mismatch of the recovered and computed NxBIP-8 covers the whole STS-N frame
AIS-L	Line-AIS • K2 (bits 6, 7, 8) = 111 for 5 frame
REI-L	Line Remote Error Indication • Number of detected B2 errors in the sink side encoded in the byte M0 or M1 of source side
RDI-L	Line Remote Defect Indication • K2 (bits 6, 7, 8) = 110 for z frame (z=5-10)

STS Path Layer - Detection Criteria	
AIS-P	STS Path AIS • All "1" in the STS pointer bytes H1, H2 for ≥ 3 frames
LOP-P	STS Path Loss of Pointer • 8-10 NDF enable, 8-10 invalid pointers

B3	STS Path BIP error • Mismatch of the recovered and computed BIP-8 covers the entire STS-SPE
UNEQ-P	STS Path Unequipped • C2 = "0" for ≥ 5 (≥ 3 as per T1.231) frames
TIM-P	STS Path Trace Identifier Mismatch • Mismatch of the accepted and expected Trace Identifier in byte J1 (64 bytes sequence)
REI-P	STS Path Remote Error Indication • Number of detected B3 errors in the sink side encoded in byte G1 (bits 1, 2, 3, 4) of the source side
RDI-P	STS Path Remote Defect Indication • G1 (bit 5) = 1 for 10 frames
PLM-P	STS Path Payload Label Mismatch • Mismatch of the accepted and expected Payload Label in byte C2 for ≥ 5 (≥3 as per T1.231) frames

VT Path Layer - Detection Criteria	
LOM	Loss of Multiframe • Loss of synchronization on H4 (bits 7, 8) superframe sequence
AIS-V	VT Path AIS • All "1" in the VT pointer bytes V1, V2 for ≥ 3 frames
LOP-V	VT Path Loss of Pointer • 8-10 NDF enable, 8-10 invalid pointers
BIP-2	VT Path BIP Error • Mismatch of the recovered and computed BIP-2 (V5 bits 1, 2) covers entire VT
UNEQ-V	VT Path Unequipped • V5 (bits 5, 6, 7) = 000 for ≥ 5 (≥ 3 as per T1.231) superframes
TIM-V	VT Path Trace Identifier Mismatch • Mismatch of the accepted and expected Trace Identifier in byte J2
REI-V	VT Path Remote Error Indication • If one or more BIP-2 errors detected in the sink side, byte V5 (bit 3) = 1 on the source side
RDI-V	VT Path Remote Defect Indication • V5 (bit 5) = 1 for 10 super frames
PLM-V	VT Path Payload Label Mismatch • Mismatch of the accepted and expected Payload Label in byte V5 (bits 5, 6, 7) for ≥ 5 (≥3 as per T1.231) superframes

Errors/Alarms definitions for OTU, OTL, ODU are listed in OTN Results.

Go back to top Go back to TOC Go to **OTL and STL Results** for SDH/SONET STL256.4 (Basic Version)

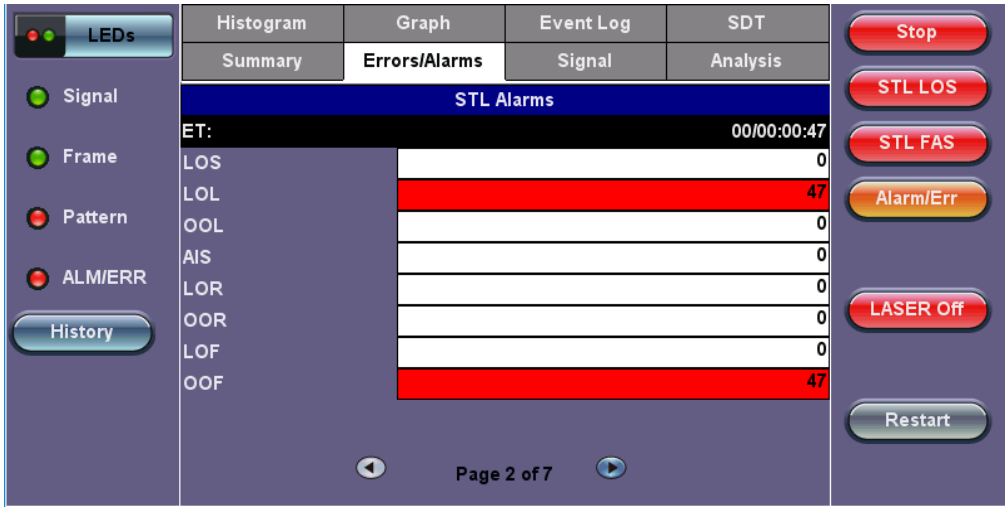
Errors/alarms listed on each page are presented in a logical order associated with the signal under test. All errors are evaluated and stored. The Elapsed Time [ET] is shown in the right hand corner of the header. Error conditions are displayed in red including count and rate. The Errors/Alarms tab brings up several pages of the following errors and alarms statuses:

- OTL/OTU/ODU/ODTU/OPU Alarms/Errors

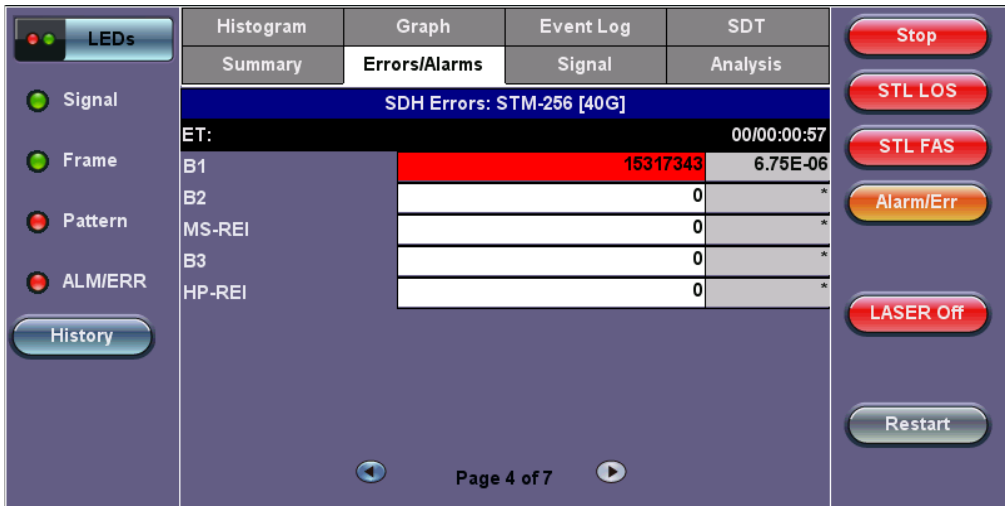
- SDH/SONET/STL Errors/Alarms
- PDH Alarms/Errors
- BERT Errors
- Section (SOH) and Line Overhead Alarms
- High Order Path and Low Order Path
- STS path and VT path

Refer to the SDH or SONET Error and Alarm definitions tables for error/alarm definitions.

Errors/Alarms - STL Alarms



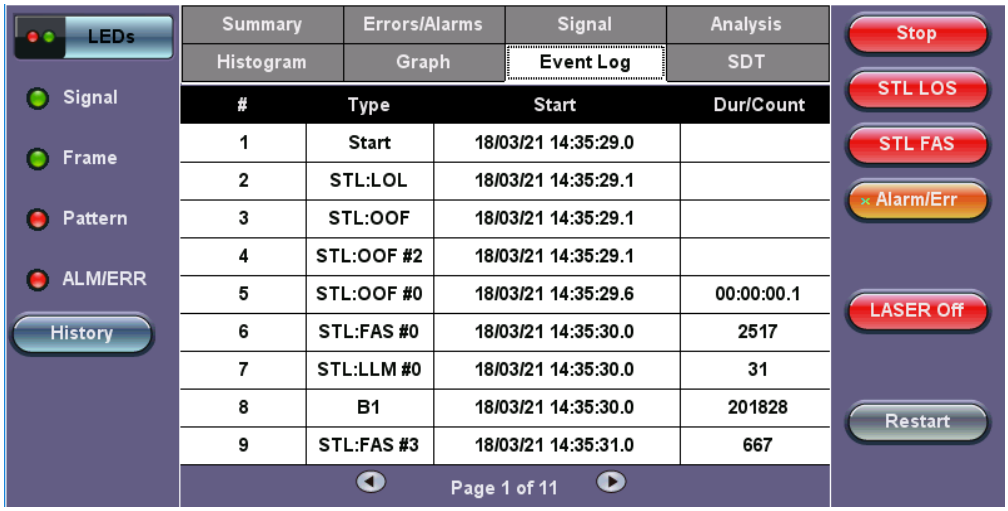
Errors/Alarms - SDH Errors



8.5.3 Event Log

The Event Log tab brings up the screen listing the Error and Alarm events recorded during a test. The events are presented in chronological sequence - number, type of event, start time, duration (alarms), and ratio/count (errors) are displayed.

Event Log



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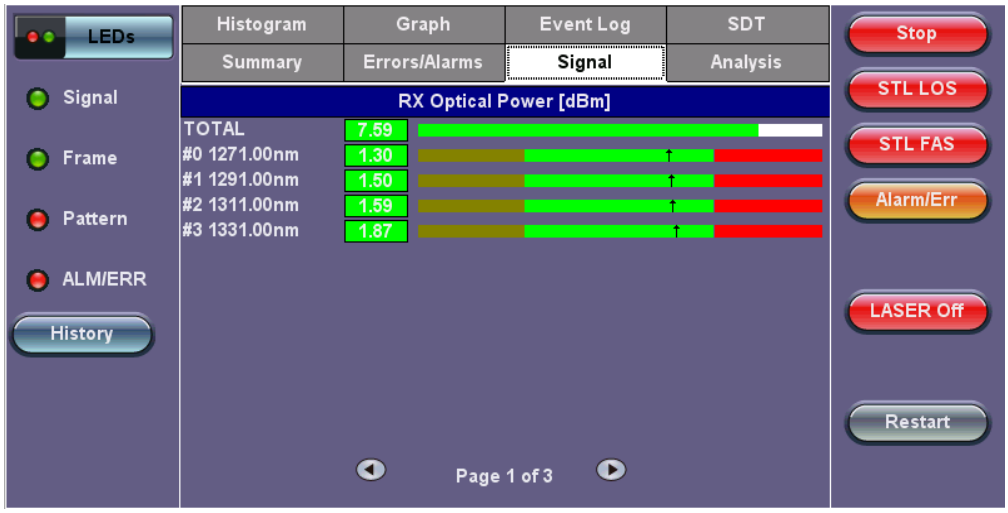
8.5.4 Signal

The signal tab displays the Level and Frequency screen. Page 1 and 2 display the level measurement in electrical units (volts) for STS1, STS3, STM1e and dBm for STM-1, STM-4, STM-16, STM-64 and OC-1, OC-3, OC-12, OC-48, OC-192 signals received (RX) and transmitted (TX).

Loss of Signal (LOS) and the Saturation level for optical signals is shown graphically including the level measurement in dBm.

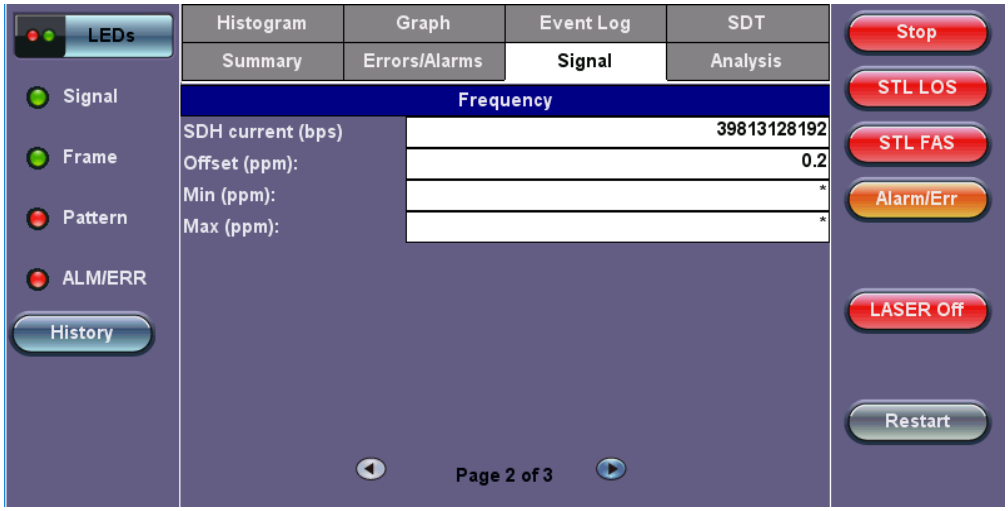
Signal - RX Power



Frequency (Page 3)

The received signal frequency and offset is measured and displayed. The Signal page may display frequency measurements per lane for newer 40G/100G modules, depending on the test set and software version.

Signal - Frequency

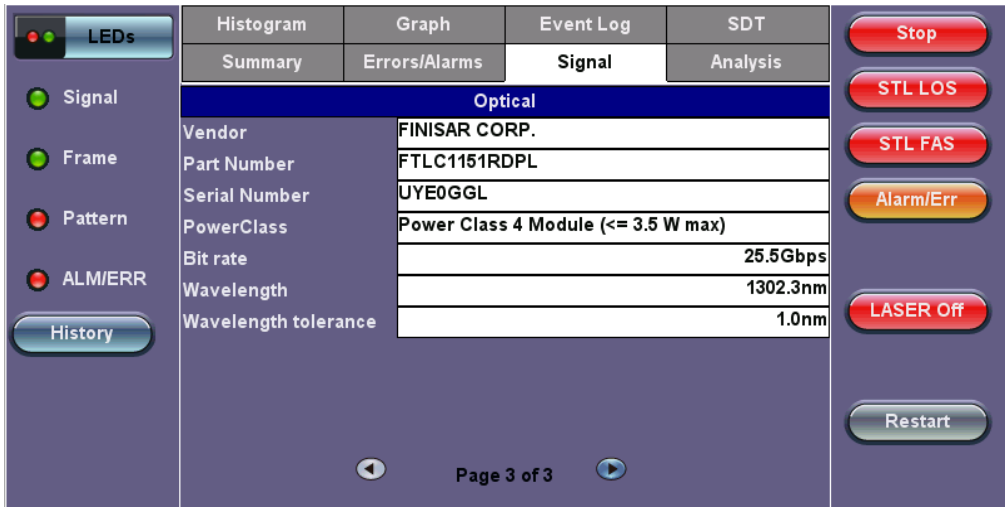


Frequency: The received signal frequency and offset is measured and displayed.

- **SDH/SONET Current:** Indicates the frequency of the SDH or SONET payload.
- **Offset:** Indicates the difference between the standard rate and the rate of the input signal.
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal.
- **Max (ppm):** Indicates the difference between the standard rate and the maximum deviation detected in the input signal.
- **Current:** Indicates the frequency of any applicable PDH/DSn payload data. Options are 34M, 8M, 2M, 1.5M, 45M, and 140M.
- A Min (ppm) and Max (ppm) function can be used to ensure that the received signal is within a certain clock tolerance and that the network element is transmitting correctly. The frequency limits for the various signal types according to ITU-T recommendations are presented in the table below.

Optical Information (Page 4)

Signal - Optical Module Information



Page 4 displays the Optical module information.

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8.5.5 Histogram

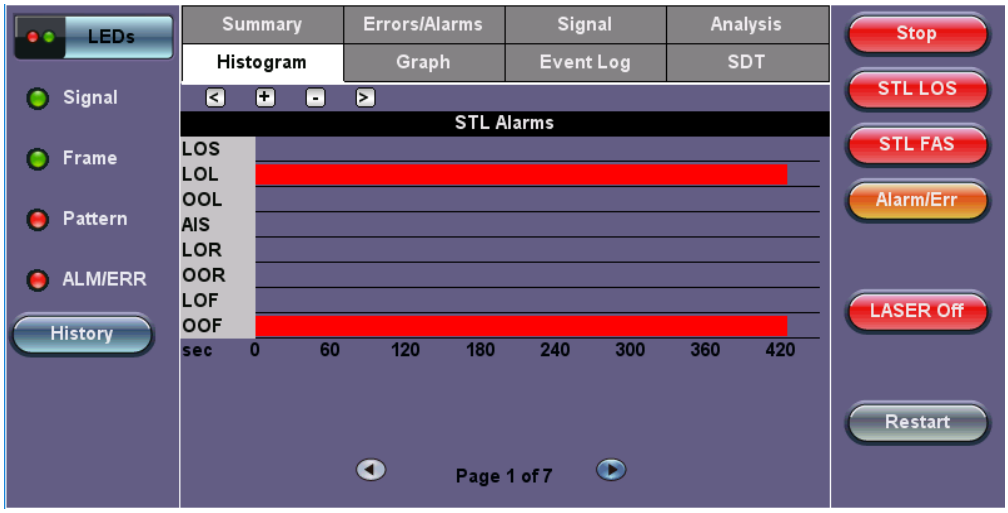
The Histogram tab displays the screen showing a historical record of the Alarms and Errors recorded during the measurement interval. A dedicated page is available for errors and alarms including BER. The following Errors/Alarms are displayed:

- OTL/OTU/ODU/ODTU/OPU Alarms/Errors
- Section (SOH) and Line Overhead Alarms/Errors
- SDH/SONET/STL Errors/Alarms

- P Alarms/Errors
- E4 Alarms/Errors
- STS Path Alarms/Errors
- Virtual Tributary (VT)
- PDH Alarms/Errors
- High Order Path and Low Order Path (HP, LP, SDH)
- BERT Alarms/Errors

Refer to the SDH or SONET Error and Alarm definitions tables for a description of each error/alarm.

Histogram - STL Alarms (Page 1)



Note: *The alarms and errors presented depend on the signal type and structure selected. A graphical timeline on the horizontal axis indicates when the event occurred. The upper left and right arrows allow the user to scroll through the measurement period while the + and – keys allow zooming in/out of the time axis.*

Histogram (Multiple Pages)

Depending on the test signal configuration, mapping and multiplexing structure, the test set groups the errors and alarms layer by layer and are displayed as events over time, so they can be compared and correlated (e.g. visually identify the sequence of events that happened before a major problem occurred).

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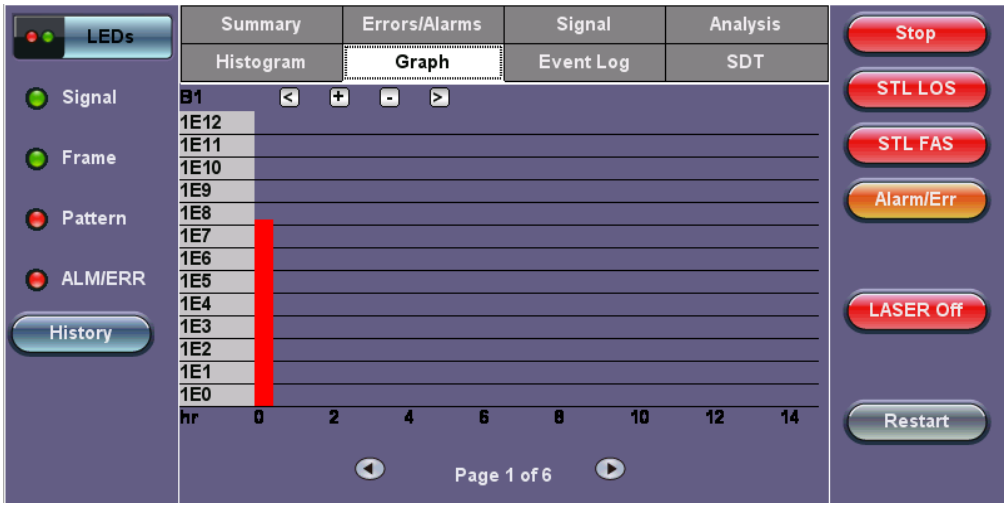
8.5.6 Graph

The Graph tab displays a visual log of the Errors or Alarm severity over time recorded during the measurement interval. A dedicated page is available for each of the error types applicable to the test signal structure.

Scroll through the various pages to display the anomaly of interest. A status pop-up screen can be accessed by tapping on the graph area.

Graph



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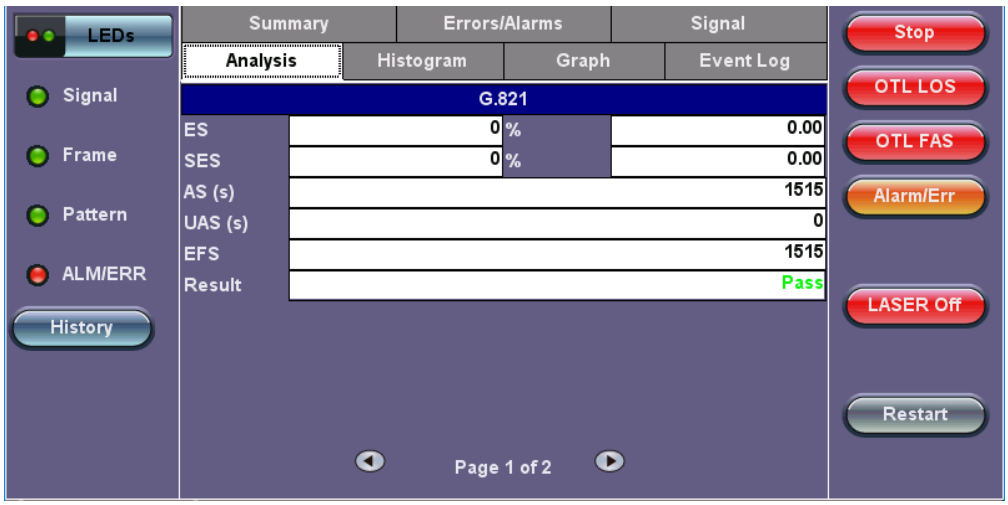
8.5.7 Performance Analysis

G.821 Analysis



The Analysis tab displays measured objectives from ITU-T performance tests selected from the Measurements tab (**Setup** > **Measurements**). For a brief description of supported G-Series and M-Series performance tests as well as setup instructions, please see Performance Analysis in the Measurement Configuration section.

Evaluation According to ITU-T G.821

This recommendation was originally specified for international circuit-switched N x 64kbps connections and later expanded to include higher bit rates.

ES, SES, AS and UAS are evaluated and can be performed on the following events:

- FAS bit errors (FAS 2, FAS 34)
- CRC errors
- E bit errors
- Bit errors (TSE, Test Sequence Error)

The following signals can be measured when performing G.821 evaluation of bit errors (TSE):

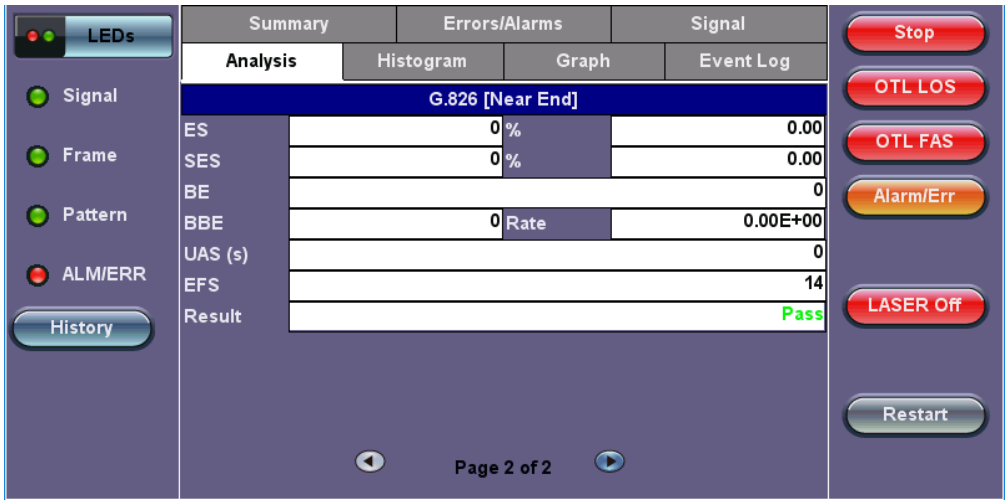
- Unframed patterns
- N x 64kbps
- Framed patterns and bulk signals
- Pass/Fail result is in conjunction with path allocation between 0.1 and 100%

Note: *ITU-T G.821 evaluates bit errors, therefore, facilities for evaluating block errors are disabled. G.821 relies on the evaluation of bit errors, thus the test channel must be taken out of service to perform the measurement.*

Definitions:

- **Errored Second (ES):** A one-second time interval in which one or more bit errors occur.
- **Severely Errored Second (SES):** A one-second interval in which the bit error ratio exceeds 10^{-3}.
- **Unavailable Second (UAS):** A circuit is considered to be unavailable from the first of at least ten consecutive SES. The circuit is available from the first of at least ten consecutive seconds which are not SES.
- **Available Second (AS):** A one-second time interval in which no bit errors occur.
- **Errored Free Second (EFS):** A one-second time interval in AS during which no errors and no pattern slips have been detected.

G.826 Analysis



Evaluation According to ITU-T G.826

G.826 recommendation makes provision for higher bit rates and allows in-service measurement using the evaluation of block errors.

The following are evaluated: ES, SES, BE, BBE, and UAS.

Pass/Fail result depends on path allocation of 0.1 to 100%.

In-Service Measurement (ISM): Simultaneous in-service measurement of “near end” and “far-end” of a selected path.

Out-of-Service Measurement (OOS): Out-of-service measurement using bit errors in a test pattern.

Definitions:

- **Errored Second (ES):** A one-second time interval containing one or more errored blocks.
- **Severely Errored Second (SES):** A one-second time interval in which more than 30% of the blocks are errored.
- **Block Error (BE):** A block containing one or more errored bits.
- **Background Block Error (BBE):** An errored block that is not a SES.
- **Unavailable Second (UAS):** A circuit is considered to be unavailable from the first of at least ten consecutive SES. The circuit is available from the first of at least ten consecutive seconds which are not SES.

Note: The recommended measurement time for G.821 and G.826 is 30 days.

Evaluation According to ITU-T G.828

G.828 provides a precise block length for each bit rate as opposed to G.826.

- ES, SES, BBE, UAS and SEP are evaluated.
- Pass/Fail result is in conjunction with path allocation between 0.1 and 100%.

G.828 evaluation can be performed on the following events:

- B1
- B2
- MS-REI
- B3
- HP-REI
- LP-BIP
- LP-REI
- Bit errors (TSE)

Evaluation of the near end and far-end is possible, however far-end evaluations can only be made if REI is available.

Bit errors can be evaluated for:

- Unframed patterns
- Framed patterns and bulk signals
- Overhead bytes E1/E2 (order wire), F1/F2 (user), D1 - D3 and D4 - D12 (DCC) in the SDH overhead (SOH and POH)

Note: Bit error evaluation is disabled because G.828 evaluates block errors.

Evaluation According to ITU-T G.829

G.829 is based on the principle of monitoring block errors in service.

ES, SES, BBE and UAS are evaluated.

G.829 evaluation can be performed on the following events:

- B1
- B2
- MS-REI
- Bit errors (TSE)

Evaluation of the near end and far-end is possible, however far-end measurement can only be made if REI is available.

Bit errors can be evaluated for:

- Unframed patterns
- Framed patterns and bulk signals
- Overhead bytes E1/E2 (order wire), F1/F2 (user), D1 - D3 and D4 - D12 (DCC) in the SDH Overhead (SOH and POH)

Evaluation According to ITU-T M.2100

M.2100 applies to commissioning and maintenance. Commissioning consists of a 15-minute line up phase followed by a 24-hour in-service measurement. Once the line up phase is completed successfully, errors may occur within certain limits.

ES, SES and UAS are evaluated.

Pass/Fail results are based on threshold values S1 and S2 for ES and SES.

Settings for S1 and S2:

- Path allocation: 0.1 to 100%
- BISO multiplication factor: 0.1 to 100

The M.2100 evaluation can be performed on the following events:

- FAS bit errors (FAS2, FAS34, and FAS140)
- CRC-4 errors
- EBIT errors
- Bit errors (TSE)

Evaluation is made at the “Near End” and at the “Far End” for PCM-30/31 signals with CRC.

Bit errors can be evaluated for:

- Unframed patterns

- Framed patterns and bulk signals
- N x 64kbps

Since M.2100 evaluates bit errors, facilities for evaluating block errors are disabled.

Evaluation According to ITU-T M.2101

M.2101 is very similar to M.2100 except it deals with SDH systems only.

ES, SES, BBE, SEP and UAS are evaluated.

Pass/Fail results are based on the threshold values S1 and S2 for ES, SES, BBE and SEP.

Settings for S1 and S2:

- Path allocation: 0.1 to 100%
- BISO Multiplier: 0.1 to 100%

The M.2101 evaluation can be performed on the following events:

- B1
- B2
- MS-REI
- B3
- HP-REI
- LP-BIP
- LP-REI
- Bit errors (TSE)

Evaluation of the near end and far-end is possible but far-end evaluations can only be made if REI is available.

Bit errors can be evaluated for:

- Unframed patterns
- Framed patterns and bulk signals
- Overhead bytes E1/E2 (order wire), F1/F2 (user), D1 - D3 and D4 - D12 (DCC) in the SDH Overhead (SOH and POH)

Note: *M.2101 measures block errors, therefore bit error evaluation is disabled.*

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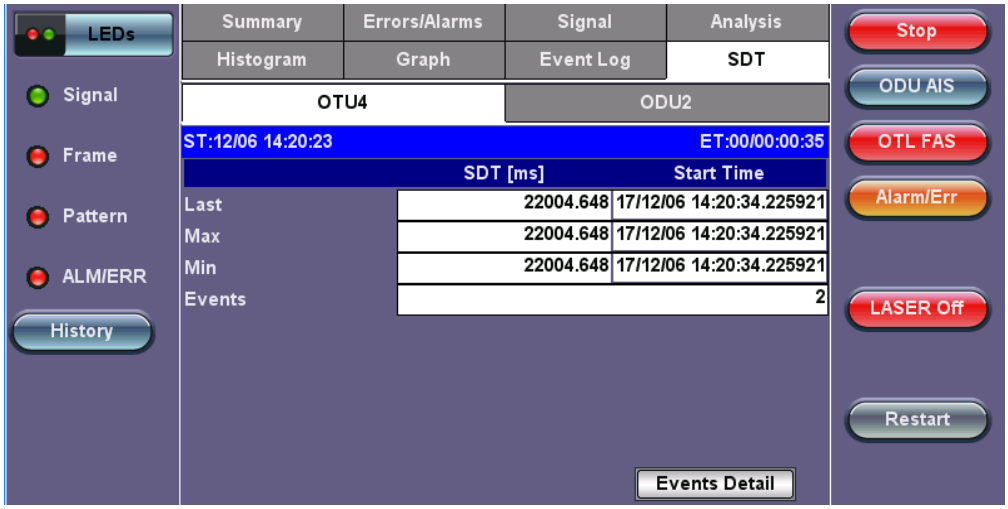
8.5.8 Service Disruption Test (SDT) Results

SDT Results - OTL



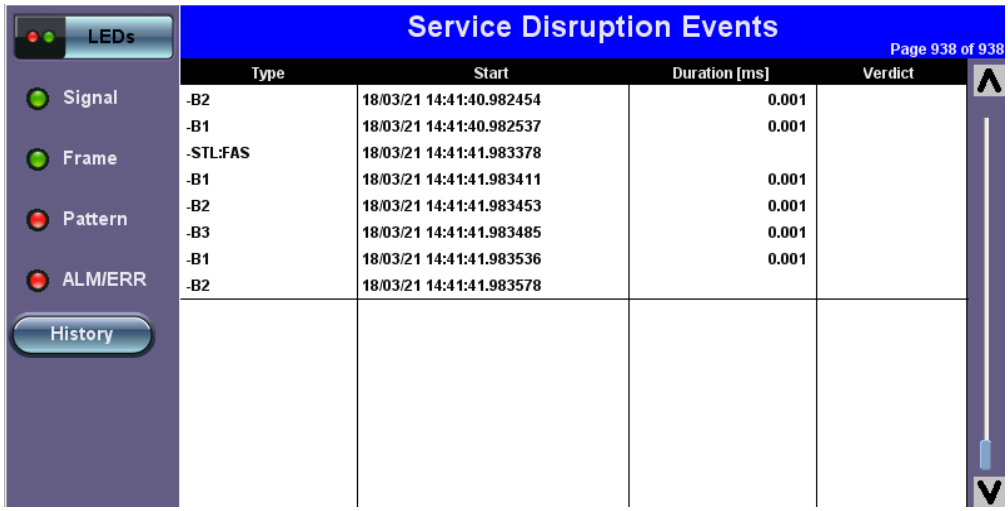
If SDT is enabled in Setup, the SDT tab will display time measurements of detected errors/alarms specified by the user in SDT

setup.

- **Last SDT**: The duration of the last service disruption detected
- **Min/Max**: Shortest and longest service disruption duration
- **Result**: Waiting for trigger or Measure
  - Waiting for trigger: Testing is in progress and the unit is waiting to detect an error/alarm
  - Measure: Error/alarm is in progress
- **Events**: Number of errors/alarms detected

Events Detail displays additional details such as error/alarm type and Pass/Fail status.

SDT Events Detail - STL



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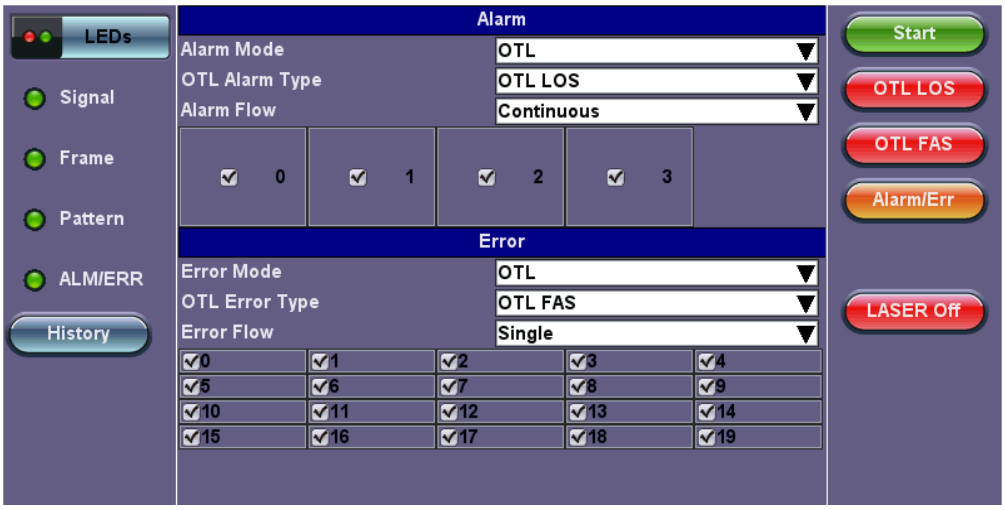
8.6 Alarm / Error Injection

Alarms and Errors can be injected into different signals. At any time during the test process, tap on the red alarm and error buttons on the right side of the screen to inject errors or generate alarms.

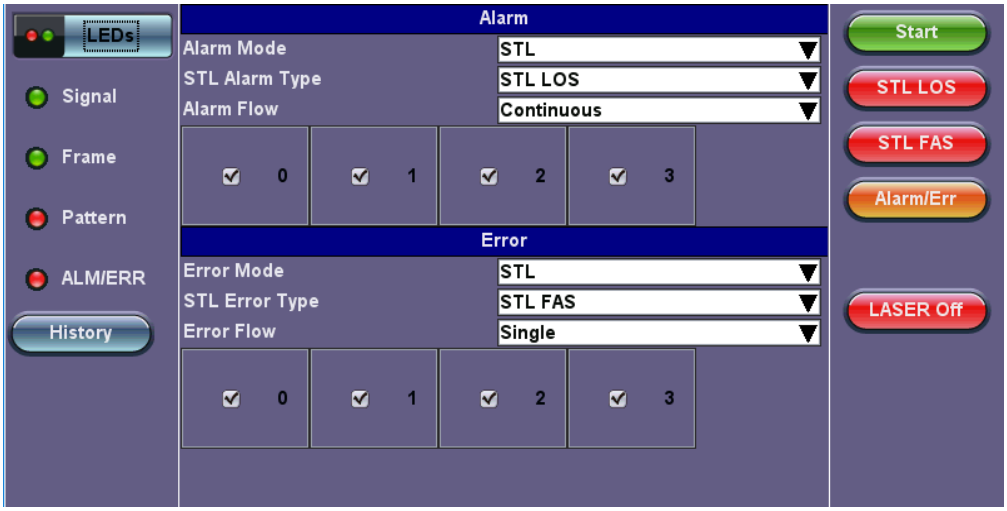
To access the setup for the alarms and errors, tap the **Alarm/Err** button on the right side of the screen or the Alarm/Error icon on the main menu.

The Alarm/Error Injection menu for **OTU3 & OTU4 Test Applications** present the same setup options, but with a different presentation. Refer to Alarm/Error Injection in OTU3 & OTU4 Testing section for setup instructions.

OTL Alarm and Error Injection Setup



STL Alarm and Error Injection Setup



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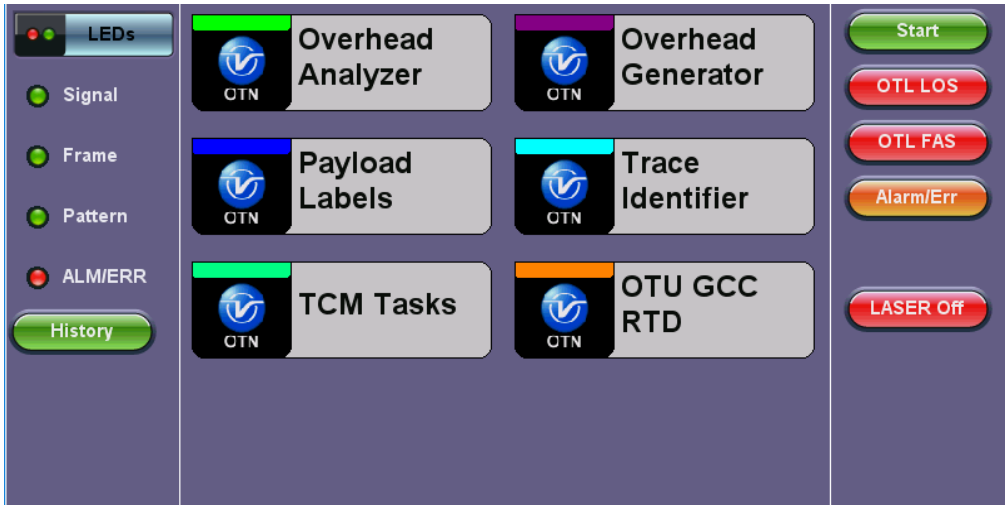
8.7 OTN Tools

Note: *This section refers to OTN Tools for SDH/SONET mapping with PDH/DSn multiplexing, not OTN Tools for OTU3, OTU4 Testing.*

8.7.1 Shortcuts

OTN Tools Menu



Note: *Depending on the selected OTU test rate, screens may look slightly different.*

OTN Tools for OTU4 SDH/SONET mapping with PDH/DSn multiplexing features the following test applications:

- **Overhead Analyzer**
  - Displays the Optical Channel Transport Unit (OTU)
  - Displays Optical Channel Data Unit (ODU)
  - Displays Optical Channel Payload Unit (OPU) bytes of the received channel
- **Overhead Generator**
  - Used to edit Optical Channel Transport Unit (OTU)
  - Used to edit Optical Channel Data Unit (ODU)
  - Used to edit Optical Channel Payload Unit (OPU) bytes of the transmitted channel
- **Trail Trace Identifier**
  - TTI is similar to the J0 byte in SONET/SDH. It is used to identify the signal from the source to the destination within the network.
  - TTI contains the so called Access Point Identifiers (API) which are used to specify the Source Access Point Identifier (SAPI) and Destination Access Point Identifier (DAPI).
  - The APIs contain information regarding the country of origin, network operator and administrative details.
- **Payload Structure Identifier (Labels)**
  - PSI field transports a 256-byte message aligned with the ODU multiframe.
  - PSI0 contains the Payload Type (PT) identifying the payload being transported.
    - The OPU Payload Type (PT) is a single byte defined within PSI to indicate the composition of the OPU signal, or in other words, the type of payload being carried in the OPU.
- **TCM Tasks**
  - Used to analyze or edit the sequence of TCMi (i = 1 to 6) bytes by generating alarms and errors in the Tandem connection sub-layer.
- **OTU GCC RTD (General Communication Chanel Round Trip Delay)**

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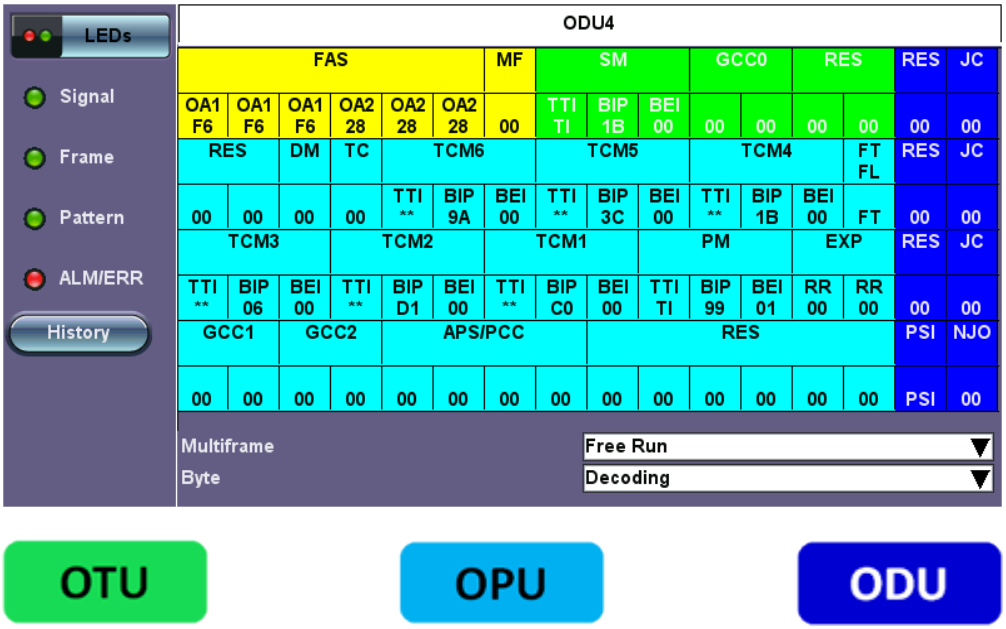
8.7.2 Overhead Analyzer & Generator

Tap the Overhead Analyzer icon to display the OH screens shown below.

Overhead Analyzer Menu

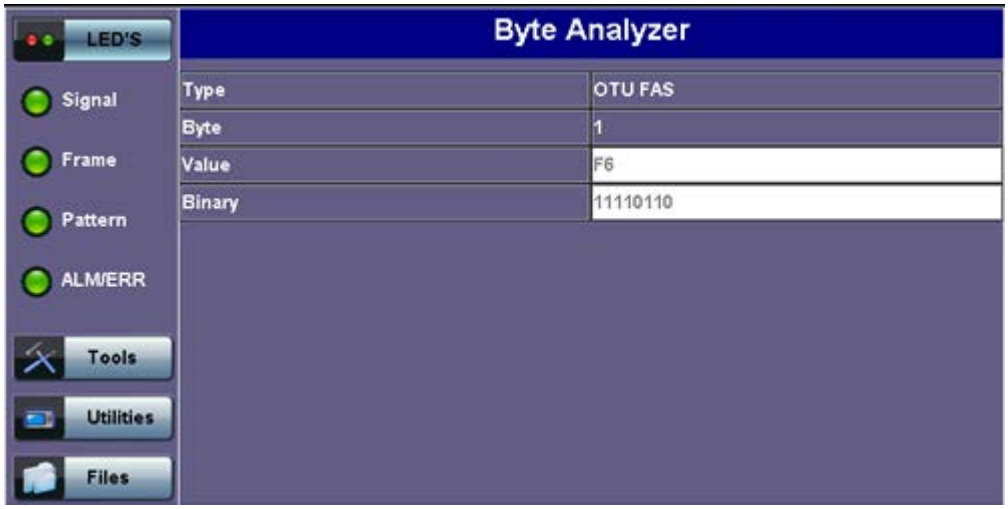


The Overhead is color coded for simplified viewing.

Decoding Bytes

Tapping the applicable byte enables an automatic decode – a byte description including the Hexadecimal and Binary value is provided. For some bytes, an advanced decode of the various bits is also available.

Byte Analyzer - Advanced Decode



Multiframe: Freerun starts capturing bytes after tapping on the byte block, Locked-Aligns the bytes w/multiframe.

Byte: Select Decoding-to view current status and description of the byte Capture. Captures up to 256 bytes from a particular field.

8.7.2.1 OTN Frame Analysis

The OTU framing is divided into two portions: FAS and MFAS.

- **Frame Alignment Signal (FAS)**
  - Uses the first six bytes and, similar to SONET/SDH, it is used to provide framing for the entire signal
  - In order to provide enough 1/0 transitions for synchronization, scrambling is used over the entire OTU frame, except for the FAS bytes

- **MultiFrame Alignment Signal (MFAS)**
  - Byte is used to extend command and management functions over several frames
  - The MFAS counts from 0 to 255, providing a 256 multiframe structure

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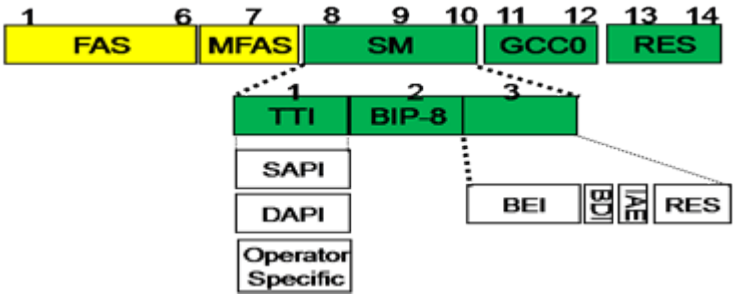
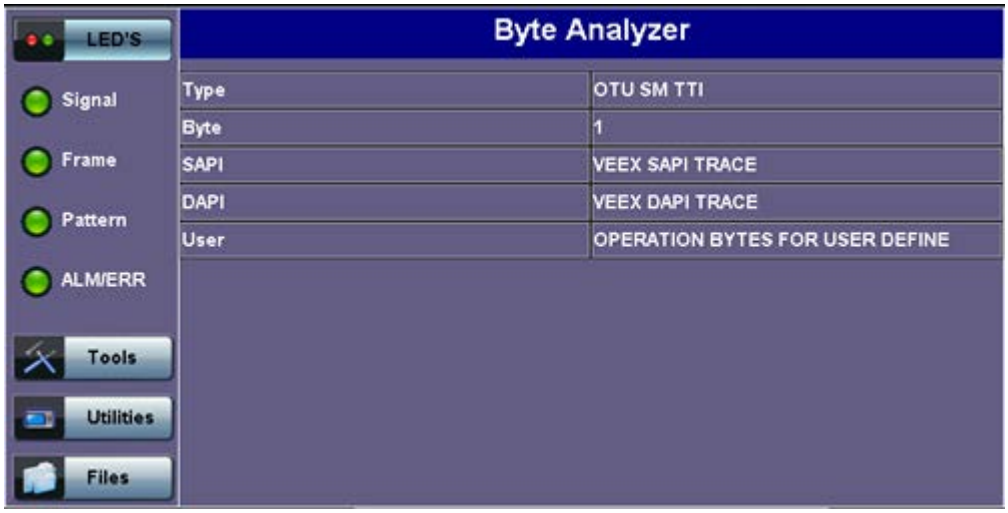
8.7.2.2 Optical Transport Unit (OTU) Analysis

The OTU overhead is comprised of the SM, GCC0, and RES bytes.



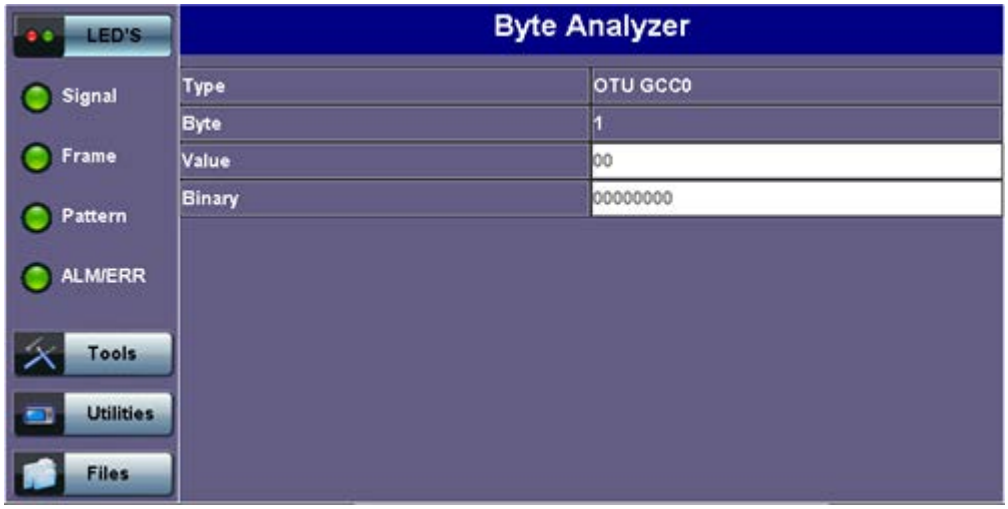
- **Section Monitoring (SM)**
  - Bytes are used for the Trail Trace Identifier (TTI), Parity (BIP-8) and the Backward Error Indicator (BEI) (also known as the Backward Incoming Alignment Error [BIAE]), Backward Defect Indicator (BDI), and Incoming Alignment Error (IAE).
  - The TTI is distributed over the multiframe and is 64 bytes in length. It is repeated four times over the multiframe.

SM TTI Type



- **General Communication Channel 0 (GCC0)**
  - Clear channel used for transmission of information between OTU termination points

GCCO Type



Reserved (RES) bytes are currently undefined in the standard.

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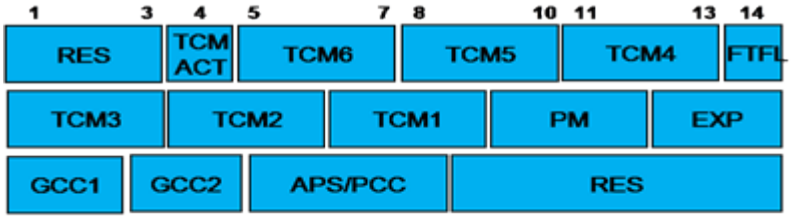
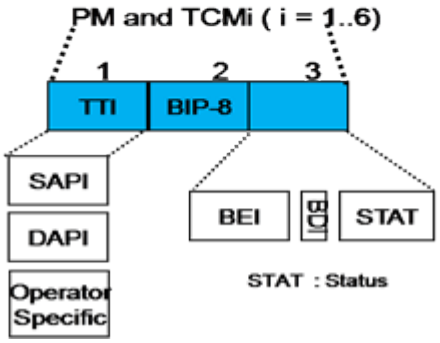
8.7.2.3 Optical Data Unit (ODU) Analysis

The ODU overhead is divided into several fields: RES, PM, TCMi, TCM ACT, FTFL, EXP, GCC1/GCC2 and APS/PCC.

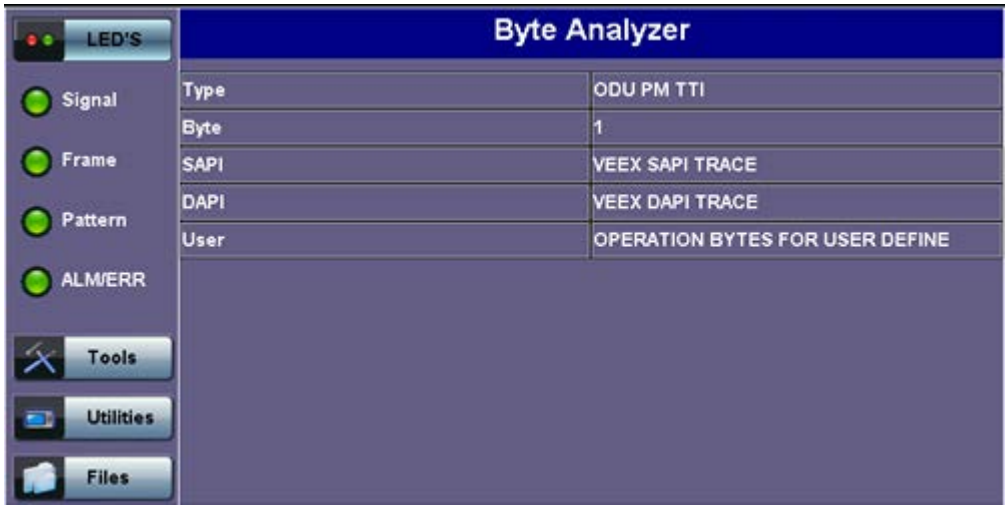




Reserved (RES) bytes are undefined and set aside for future applications.

- **Path Monitoring (PM)**
  - Field is similar to the SM field described above. It contains the TTI, BIP-8, BEI, BDI, and Status (STAT) subfields.

PM TTI Type



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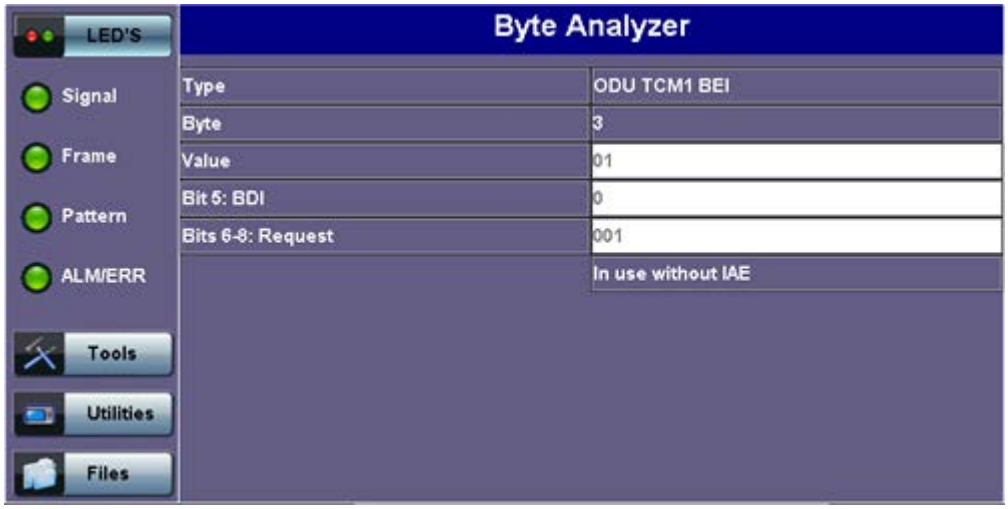
- **TCMi:**
  - There are six Tandem Connection Monitoring (TCMi) fields that define the ODU TCM sub-layer, each containing TTI, BIP-8, BEI/BIAE, BDI, and STAT subfields associated to each TCM level (i=1 to 6).
  - The STAT subfield is used in the PM and TCMi fields to provide an indication of the presence or absence of maintenance signals.

TCM1 BEI Type



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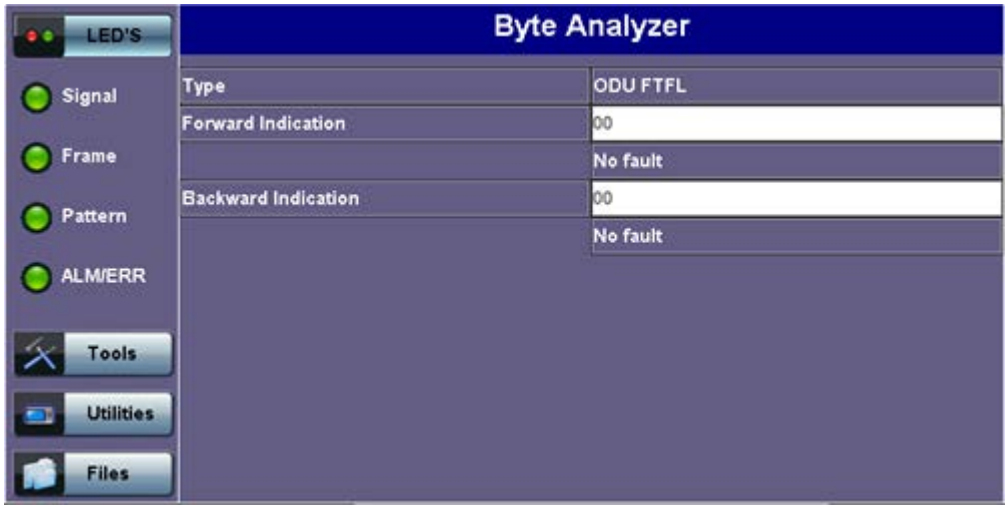
- **Fault Type and Fault Location (FTFL)**
  - Reporting communication channel field used to create a message spread over a 256-byte multiframe
  - Provides the ability to send forward and backward path-level fault indications

FTFL Type



ITU-T G.709 Figure 15-20

FTFL message structure								
0	1		126	127	128	129		255
Forward field					Backward field			

0	1	9	10	127
Fault indication field	Operator identifier field	Operator specific field		
Forward field				

ITU-T G.709 Figure 15-20

128	129	137	138	255
Fault indication field	Operator identifier field	Operator specific field		
Backward field				

ITU-T G.709 Figure 15-21

Fault indication codes	
Fault Code	Definition
0000 0000	No fault
0000 0001	Signal fail
0000 0010	Signal degrade
0000 0011 .. .. 1111 1111	Reserved for future standardization

ITU-T G.709 Figure 15-6

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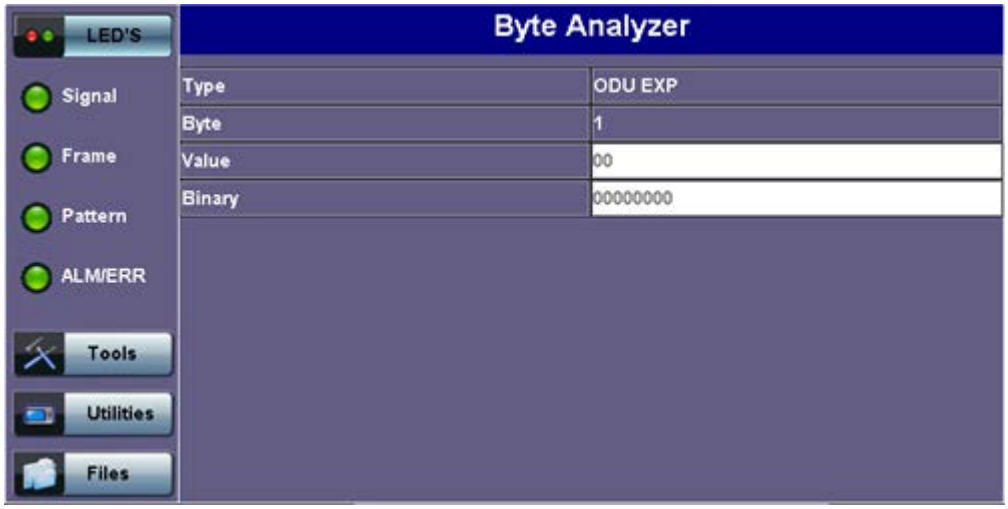
- **Experimental (EXP)**
  - Field not subject to standards and is available for network operator applications

EXP Type



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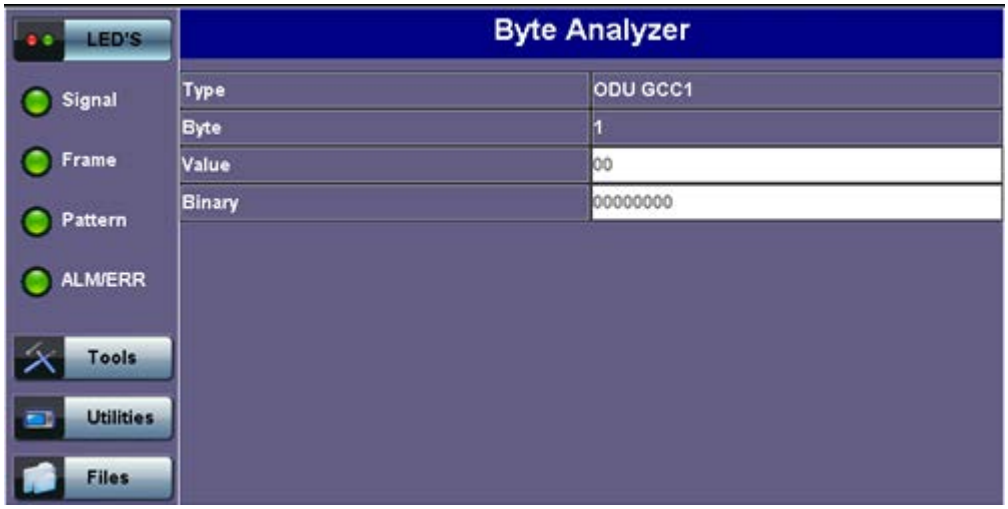
- **General Communication Channels 1 and 2 (GCC1/GCC2)**
  - Fields are very similar to the GCC0 field, except that each channel is available in the ODU

GCC1 Type



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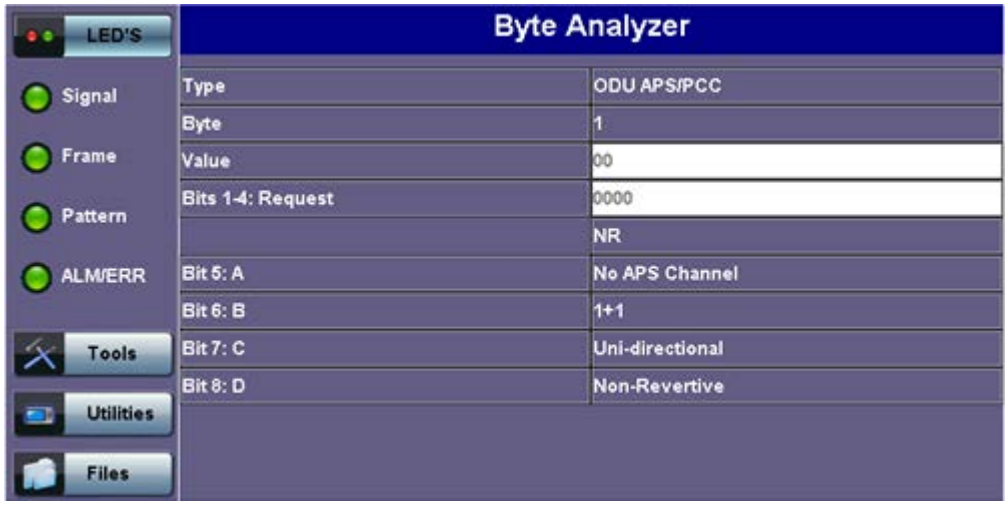
- **Automatic Protection Switching and Protection Communication Channel (APS/PCC)**
  - Supports up to eight levels of nested APS/PCC signals associated to a dedicated-connection monitoring level depending on the value of the multiframe

APS/PCC Type



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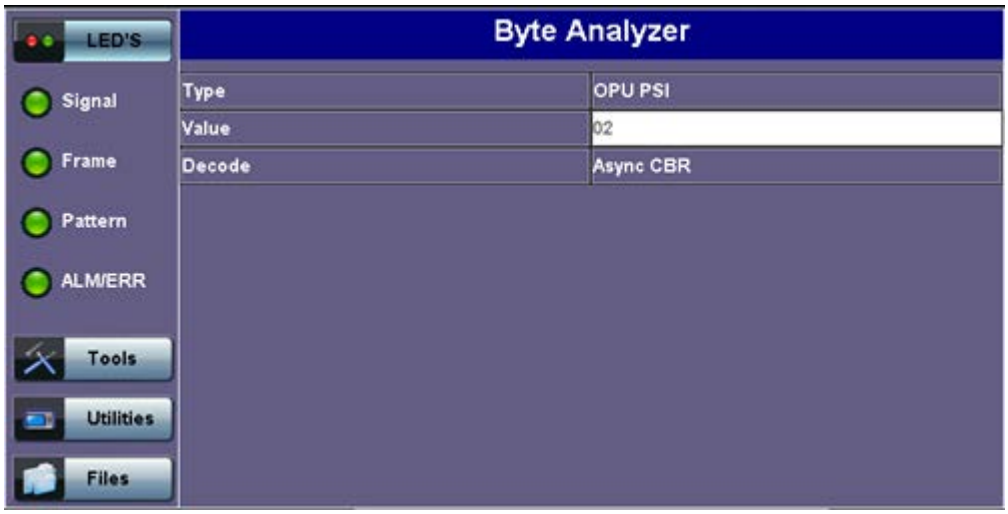
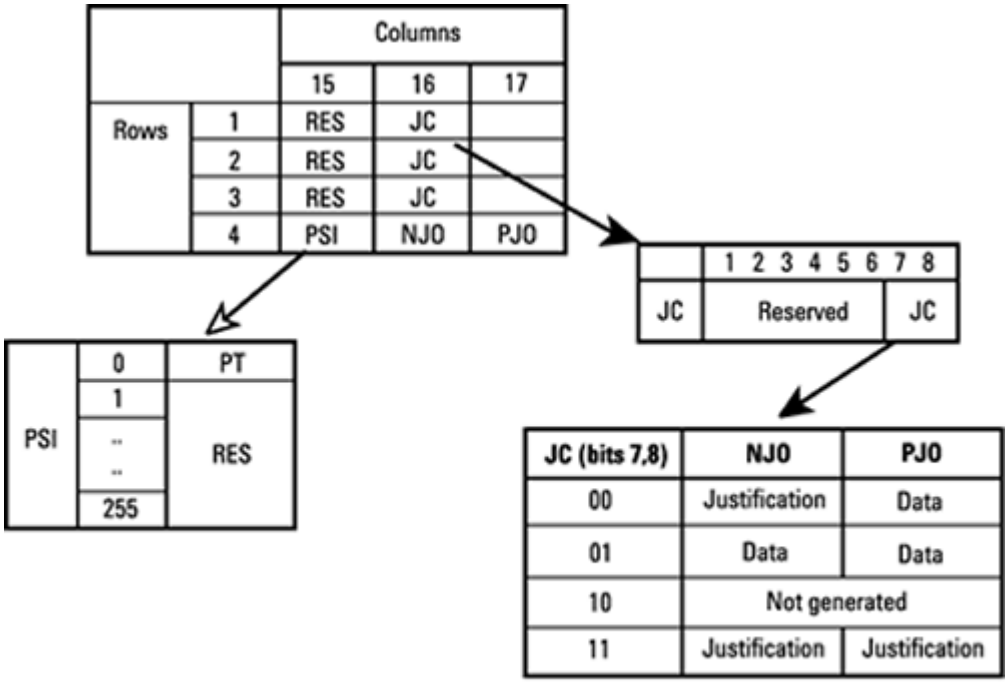
8.7.2.4 Optical Payload Unit (OPU) Analysis

- **Payload Structure Identifier (PSI)**
  - Primary overhead field associated with the OPU
  - A 256-byte multiframe whose first byte is defined as the Payload Type (PT). The remaining 255 bytes are currently reserved.

OPU PSI Type



The other fields in the OPU overhead are dependent on the mapping capabilities associated to the OPU. For an asynchronous mapping (the client signal and OPU clock are different), Justification Control (JC) bytes are available to compensate for clock rate differences. For a purely synchronous mapping (client source and OPU clock are the same), the JC bytes become reserved. Further details on mapping are available in ITU G.708.7.



OPU2, O/H for synch mapping of 10 Gb/s SDH/SONET

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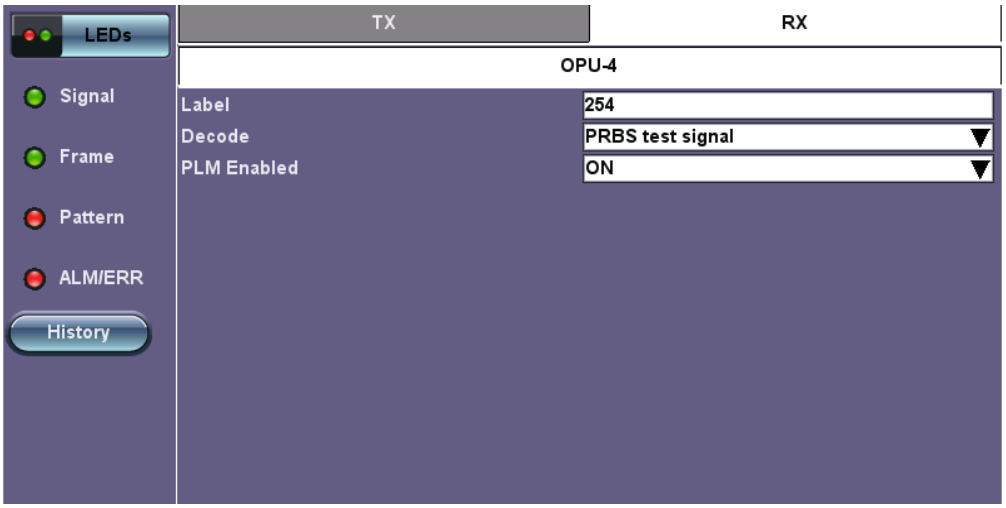
8.7.3 Payload Label (Payload Structure Identifier)

Tap the Payload Label icon to display the screen shown below. Tabs for Tx and Rx label settings are provided.

Payload Label



PSI[0] contains a one-byte Payload type. PSI[1] to PSI[255] are mapping and concatenation specific.

C2 Byte Structure per ITU-T G.707 Recommendations	
Hex Code	**Interpretation**
01	Experimental mapping
02	Asynchronous CBR mapping
03	Bit synchronous CBR mapping
04	ATM mapping

05	GFP mapping
06	Virtual Concatenated signal
10	Bit stream with octet timing mapping
11	Bit stream without octet timing mapping
20	ODU multiplex structure
55	Not available
66	Not available
80-8F	Reserved codes for proprietary use
FD	NULL test signal mapping
FE	PRBS test signal mapping
FF	Not available
07	PCS Ethernet
08	FC-1200 into OPU2e
0A	STM-1 mapping into OPU0
0B	STM-4 mapping into OPU0

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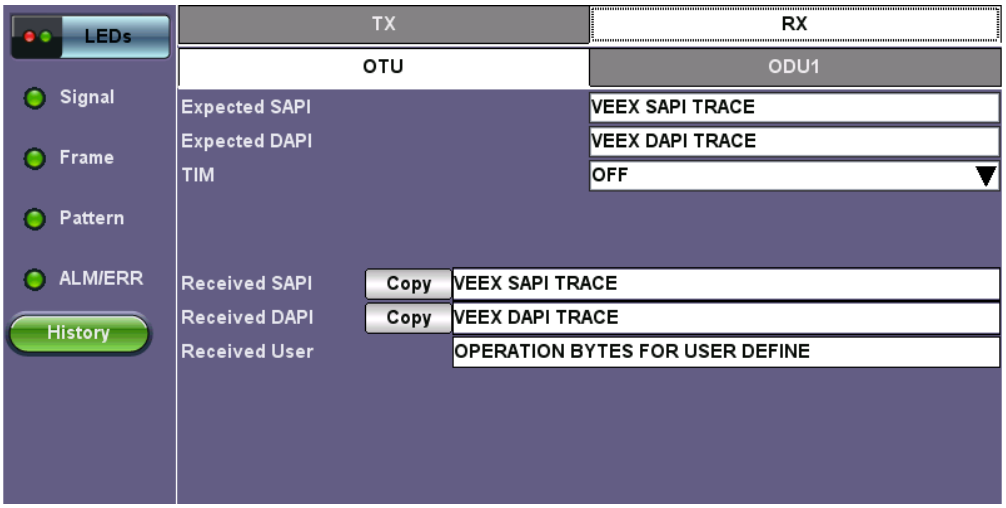
8.7.4 Trace Identifier (Trail Trace Identifier)

Tap the Trace Identifier icon to display the screen shown below. There are tabs for Tx and RX settings of the TTI.

Trace Identifier (Trail Trace Identifier)



Trail Trace Identifier

TTI similar to the J0 byte in SONET/SDH, is used to identify the signal from the source to the destination within the network. The TTI contains the so called Access Point Identifiers (API) which are used to specify the Source Access Point Identifier (SAPI) and Destination Access Point Identifier (DAPI). The APIs contain information regarding the country of origin, network operator and administrative details.

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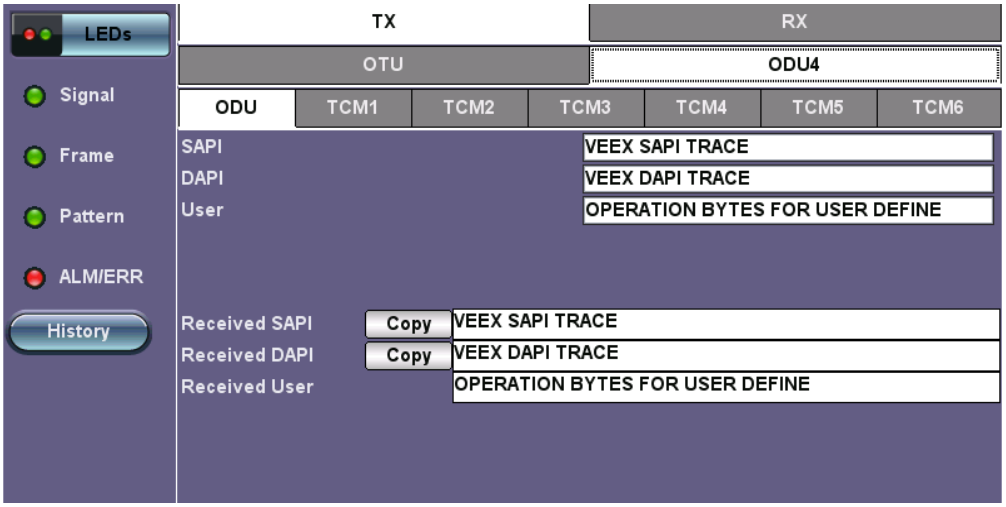
8.7.5 TCM Tasks (Tandem Connection Monitoring)

Tap the TCM Tasks icon to display the screen shown below.

TCM Tasks



Results are available for up to six tandem connections. The counts are numbers of seconds containing the error or indication.

Tandem connections and corresponding source and sink functions are defined in ITU-T G.707, G.709, and G.783.

TCM enables the user and its signal carriers to monitor the quality of the traffic that is transported between segments or connections in the network. SONET/SDH allowed a single level of TCM to be configured, while ITU G.709 allows six levels of tandem connection monitoring to be configured. The assignment of monitored connections is currently a manual process that involves an understanding between the different parties. There are various types of monitored connection topologies: cascaded, nested, and overlapping.

- **LTC:** Loss of Tandem Connection Signal
- **OCI:** Open Connection Indication
- **AIS:** TC Alarm Indication Signal
- **LCK:** Locked Defect
- **BDI:** Backward Defect Indication
- **IAE:** Incoming Alignment Error
- **BIAE:** Backward Incoming Alignment Error
- **BEI:** TC Backward Error Indication

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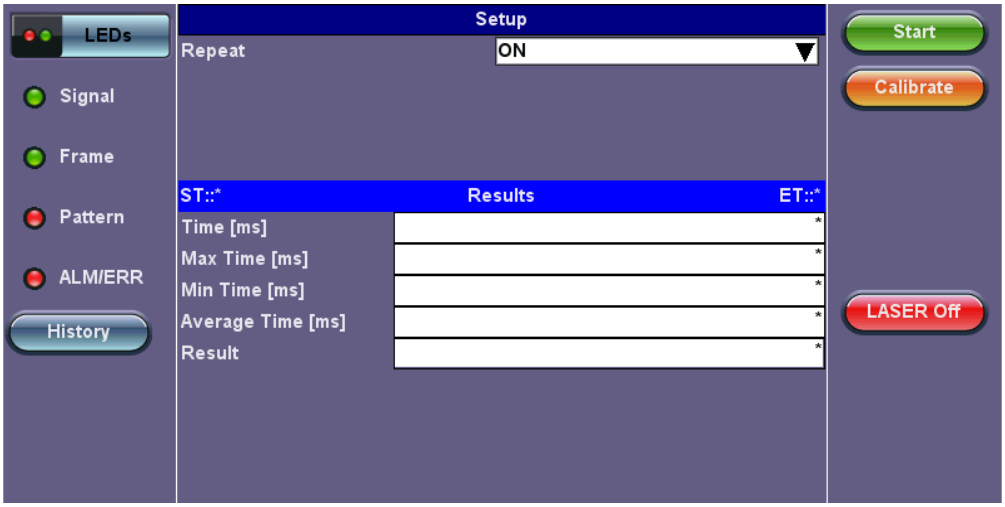
8.7.6 OTU GCC RTD

GCC RTD



To access this feature, make sure that a GCC channel is selected from Pattern setup (Setup > Signal > Pattern).

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8.8 SDH/SONET Tools

The Advanced version of SDH/SONET Tools offers the same features as the basic version as well as additional functions. The SDH/SONET Tools (Basic) is referred to here.

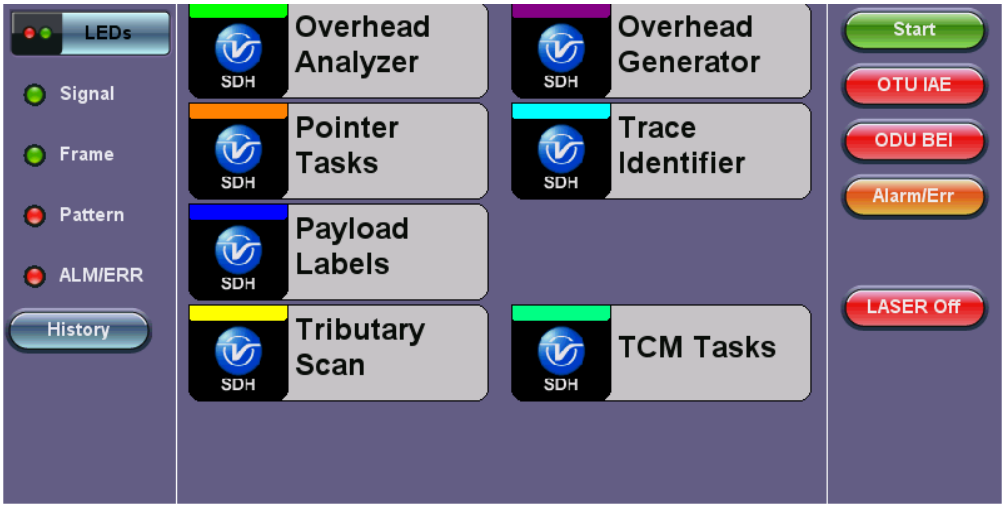
Accessing SDH/SONET Tools

Tap on Home (main menu) > **SONET/SDH Tools**.

Go back to top Go back to TOC Go to STL256.4 SDH/SONET (Basic Version)

8.8.1 Shortcuts

SDH/SONET Tools Menu



- **Overhead Analyzer:** Displays the Section Overhead (SOH) and Path Overhead (POH) bytes of the received channel.
- **Overhead Generator:** SDH mode. Used to edit Section Overhead (SOH) and Path Overhead (POH) bytes of the transmitted channel.
- **Pointer Tasks:** Displays both AU and TU pointer values and generates AU and TU pointer movements.
    - Pointer sequences according to ITU-T G.783 recommendations are also possible.
- **Trace Identifier:** Used to generate and edit J0, J1, and J2 path traces and set expected trace for received channel according to G.831 recommendations.
- **Payload Labels:** Used to set the C2 and V5 Path Signal Labels which indicate the content of the High order/STS path and Low order VCs/ VTs.
- **Tributary Scan:** Used to scan individual or multiple tributaries to verify routing and error free operation. Only available in VC-12 or VC-11 mode.
- **TCM Tasks:** Used to analyze or edit the sequence of N1 and N2 TCM bytes by generating alarms and errors in the Tandem connection sub-layer.

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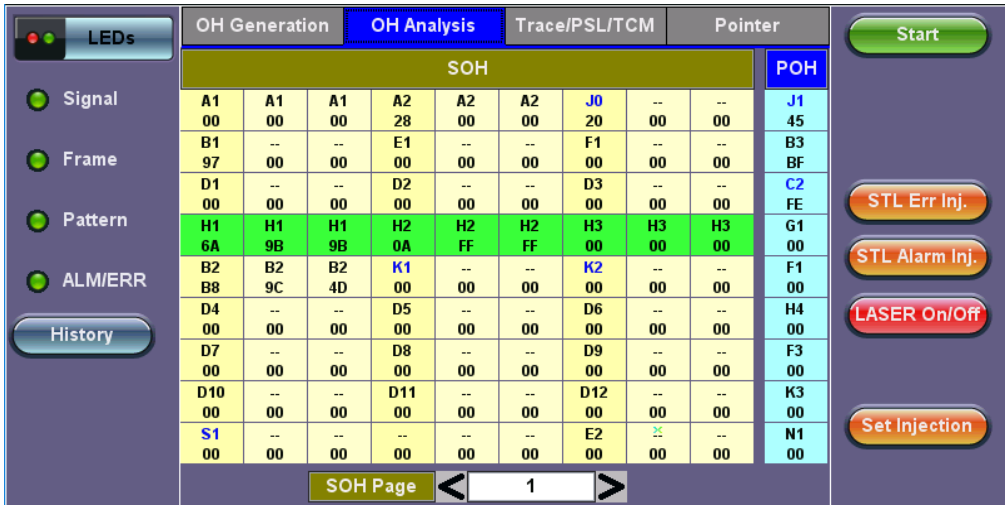
8.8.2 Overhead Analyzer

Tap the Overhead Analyzer icon to display the OH screens shown below. There are tabs for:

- SOH RX, which displays the bytes associated with the Section/LINE Overhead
- POH RX, which displays the bytes associated with the Path Overhead
- Summary, which displays the Path Traces (J0, J1, J2), APS (K1, K2), Synchronization status (S1), STS Path (C2), and VT Path (v5) Signal Label bytes

Overhead Analyzer - SDH/SONET Tools (Advanced)

Overhead Analyzer - SDH/SONET Tools (Basic)



Tapping the applicable byte enables an automatic decode – a byte description including the Hexadecimal and Binary value is provided. For some bytes, an advanced decode of the various bits is also available.

Section Overhead

SOH pages are available to scroll through in SDH/SONET Tools (Basic). The following is a partial list of SOH bytes and their corresponding functions:

Section Layer

Framing Bytes (A1/A2)

- The A1/A2 bytes indicate the beginning of the STM-N frame and provide a frame alignment pattern
  - A1 is the 1st framing byte: 11110110 (Hex F6)
  - A2 is the 2nd framing byte: 00101000 (Hex 28)
- Both A1 and A2 bytes are unscrambled
- The Frame Alignment Word of a STM-N frame is composed of (3 x N) A1 bytes followed by (3 x N) A2 bytes

A1 [Framing] Byte

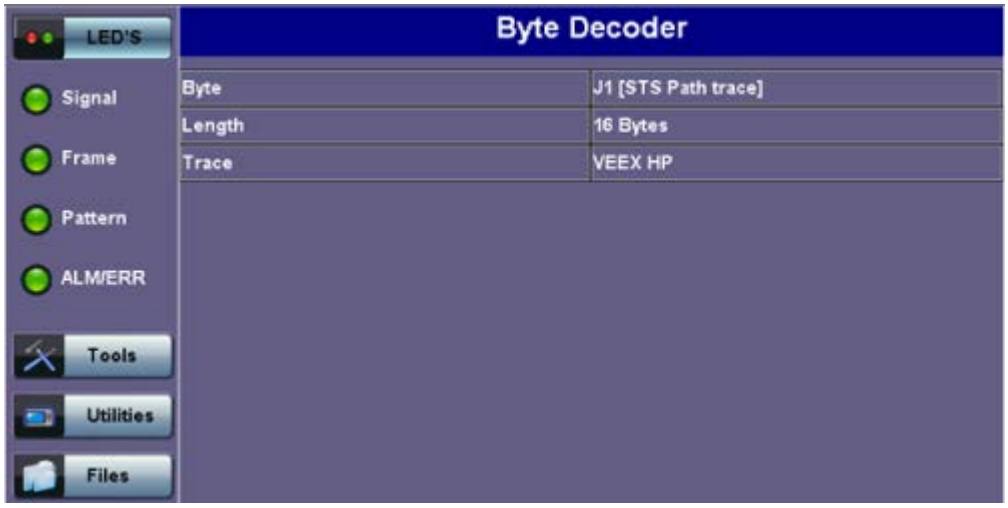
Path Trace Byte (J0)

- Regenerator section trace
- Used to transmit a 16 or 64-byte identifier (trace) (including a CRC-7 byte) repeatedly so that all regenerators can verify their connection
- Used for continuity testing between regenerators

B1 Byte (RS-BIP)

- An 8-bit even parity code used to check for transmission errors over the regenerator section
- Its value is calculated over all the bits of the STM-1 frame before scrambling
- The checksum value is placed in the RS overhead of the following STM-1 before scrambling

Path Trace Byte (J0)



Order Wire Byte (E1)

- Local order wire channel for voice communication between regenerators, cross connects, hubs and remote terminal locations

F1 Byte

- Section user channel
- Byte is allocated for user purpose to carry proprietary messages
- The channel is terminated at each regenerator location

Data Communications Channel Bytes (D1/D2/D3)

- Data Communications Channel (DCC)
- D1, D2 and D3 together form a 192kbps message channel for OAM purposes

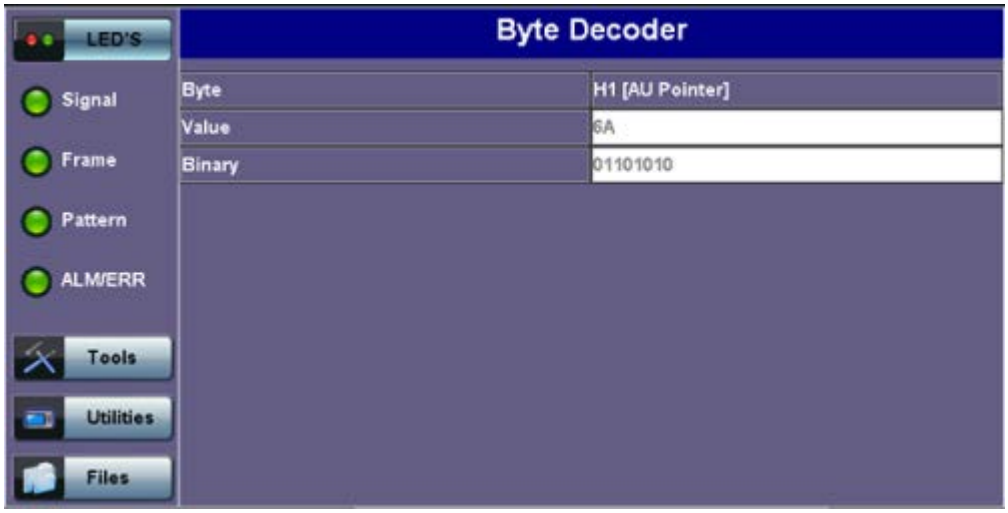
- It can generate internal or external messages
- It can also be used as a BER function

Pointers

AU Pointers Bytes (H1/H2/H3)

- Enable transfer of STM-1 frames with STM-N frames and are processed by the MS terminating equipment

AU Pointer Byte



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Line Layer / Multiplexer Section

B2 Byte (MS-BIP)

- A 24-bit interleaved even parity code used to determine if transmission errors have occurred over the Multiplexer Section
- Its calculated over all the bits of the STM-1 frame except those in the Regenerator Section overhead
- The computed checksum is placed in the MSOH of the following STM-1 frame

K1 Byte (APS-Linear)

- Used to activate and deactivate the switching between the main and protection paths on a multiplexer section
- APS message type conforms to ITU-T G.783 and Bellcore GR.253 for Linear network architectures
    - Bits 1-4 (G.783 Protocol)
        - 1111 Lockout of protection
        - 1110 Forced switch
        - 1101 Signal fail, high priority (1:n only)
        - 1100 Signal fail, low priority
        - 1011 Signal degrade, high priority (1:n only)
        - 1010 Signal degrade, low priority
        - 1000 Manual switch
        - 0110 Wait to restore
        - 0100 Exercise
        - 0010 Reverse request (bidirectional systems only)
        - 0001 Do not revert
        - 0000 No request
        - Other codes are unused
    - Bits 5-8 selects channel used by APS messages
        - 0000 Null channel
        - 0001 to 1110 Channels 1 thru 14
        - 1111 Extra traffic channel

K1 Byte (APS-Linear)

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K1 Byte (APS-Ring)

- Used to activate and deactivate the switching between the main and protection paths on a multiplexer section
- APS message type conforms to ITU-T G.841/ Bellcore GR.253 Ring Network architectures
    - Bits 1-4 are the condition
        - 1111 Lockout of protection
        - 1110 Forced switch (span)
        - 1101 Forced switch (ring)
        - 1100 Signal fail (span)
        - 1011 Signal fail (ring)
        - 1010 Signal degrade (protection)
        - 1001 Signal degrade (span)
        - 1000 Signal degrade (ring)
        - 0111 Manual switch (span)
        - 0110 Manual switch (ring)
        - 0101 Wait to restore
        - 0100 Exercise (span)
        - 0011 Exercise (ring)
        - 0010 Reverse request (span)
        - 0001 Reverse request (ring)
        - 0000 No request
    - Bits 5-8 are the destination node ID
        - 0000 Null channel
        - 0001 to 1110 Channels 1 thru 14
        - 1111 Extra traffic channel

K2 Byte (APS-Linear)

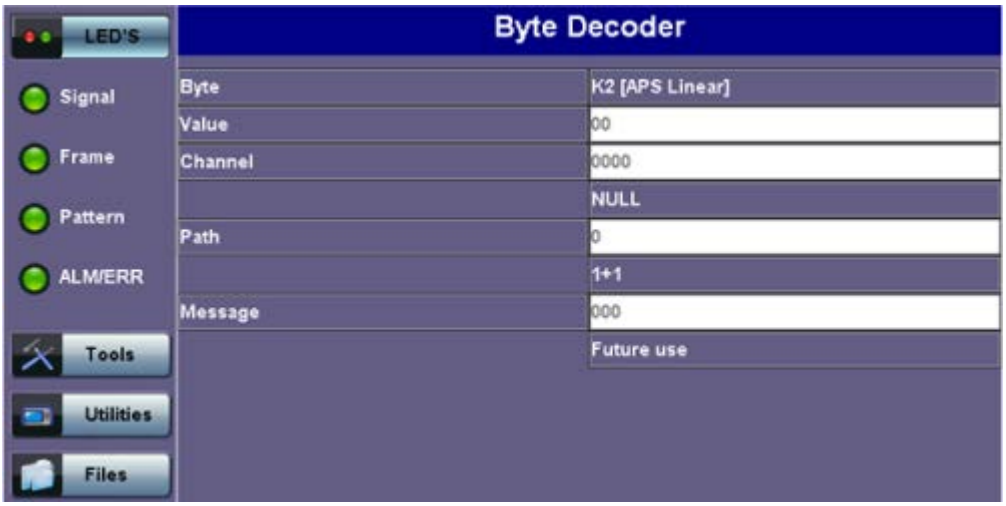
- Conforms to ITU-T G.783 and Bellcore GR.253
- Used to activate and deactivate the switching between the main and protection paths on a multiplexer section
- Used to communicate Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) conditions
    - Bits 1-4 selects bridged channel used
    - Bit 5 determines APS architecture
        - 1+1
        - 1:N
    - Bits 6-8
        - 110 MS-RDI
        - 111 MS-AIS
        - Others Not used

K2 Byte (APS-Ring)

- Conforms to and follows ITU-T G.841 Bellcore GR.253 recommendations
- Used to activate and deactivate the switching between the main and protection paths on a multiplexer section

- Used to communicate Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) conditions
  - Bits 1-4 are the source node ID
  - Bit 5 is the path code
    - 0 Short path
    - 1 Long path
  - Bits 6-8
    - 000 Idle
    - 001 Bridged
    - 010 Bridged and switched
    - 110 MS-RDI
    - 111 MS-AIS
    - Others Not used

K2 Byte (APS-Linear)



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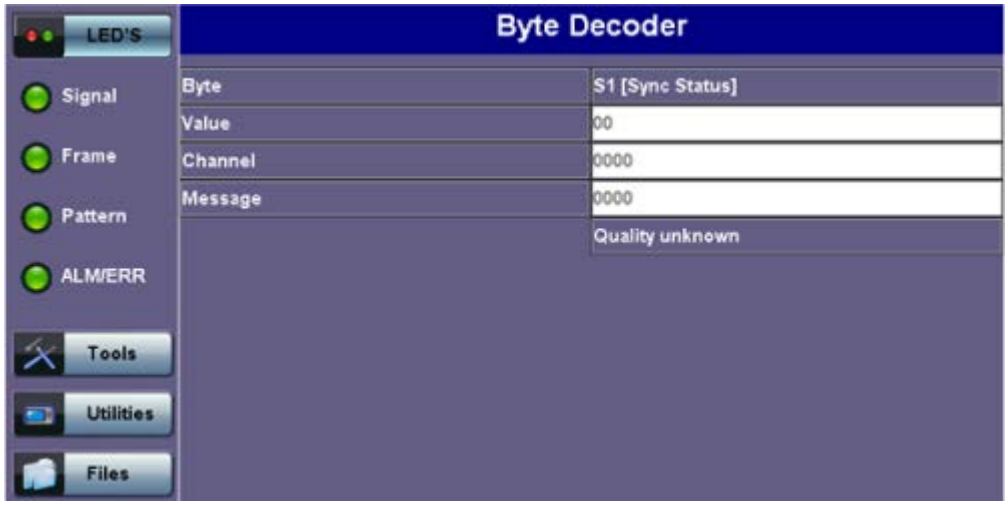
Data Communications Channel (DCC) Bytes (D4-D12)

- DCC – together these nine bytes form a 576kbps message channel for OAM purposes.
- They can be used for internally or externally generated messages or BER function.

S1 Byte (Synchronization Status)

- Synchronization status message byte contains information about the quality of the embedded timing and is used to inform the remote Multiplexer of the clock quality used to generate signals.
  - Bits 1-4 carry synchronization messages
  - Bits 5-8
    - 0000 Synchronized - Traceability Unknown
    - 0001 Stratum 1
    - 0100 Transit Node Clock
    - 0111 Stratum 2
    - 1010 Stratum 3
    - 1100 SDH Minimum Clock
    - 1101 Stratum 3e
    - 1110 Previsional by the Network Operator
    - 1111 Not used for synchronization
    - Other bytes are reserved

S1 Byte (Synchronization Status)



Order Wire Byte (E2)

- A 64kbps voice communication channel between multiplexers.
- It's a channel used by craft persons and will be ignored as it passes through regenerators.
- The relief byte is used for ring protection

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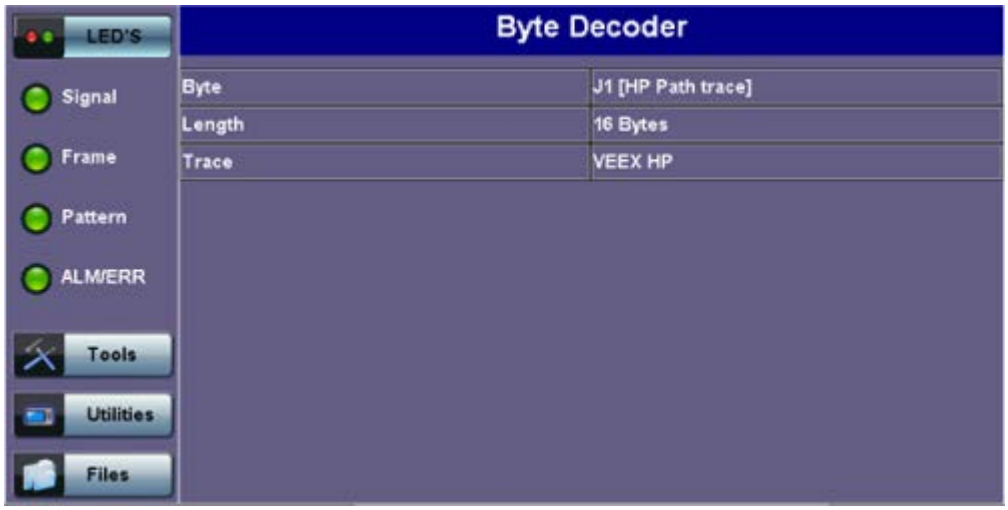
Path Overhead Layer

The following is a partial list of POH bytes and their corresponding functions:

- **J1 byte (STS Path Trace)**
  - High Order VC-N path trace byte
  - A unique message is assigned to each path in a SDH network – therefore the path trace can be used to check continuity between any location on a transmission path and the path source
  - This user programmable byte repeatedly transmits a 15-byte string plus 1 (CRC-7) byte so that a receiver can continually verify its connection with the transmitter
  - A 64-byte free-format string is also permitted
  - The message is transmitted one byte per VC-4 frame

J1 Byte (HP Path Trace)

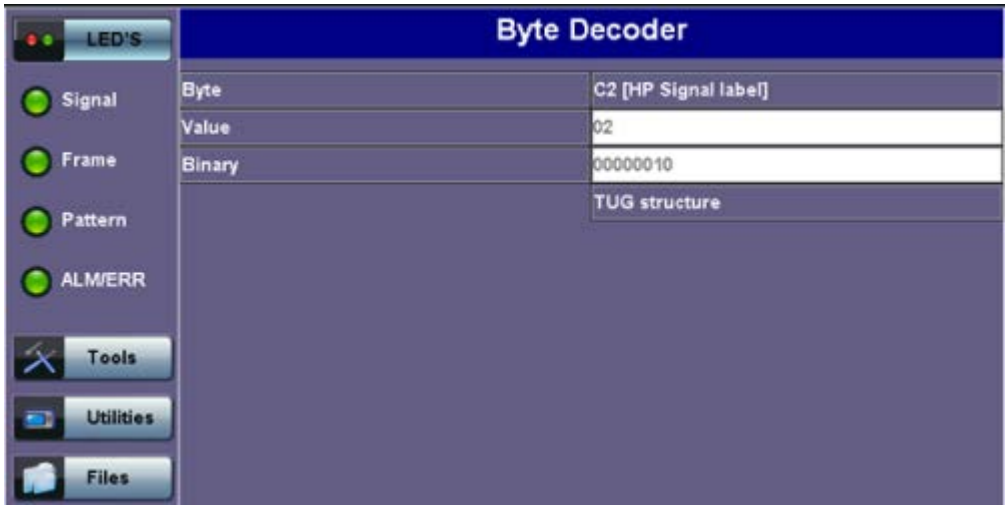


- **B3 byte**
  - Even code parity which determines if a transmission error has occurred over a path
  - Its value is calculated over all the bits of the previous VC-4
  - The computed checksum is placed in the B3 byte before scrambling

- **C2 byte (HP signal label) for SDH mode**

- Indicates mapping of the VC-n.
- The table below indicates the standard C2 binary values:

C2 Byte (HP signal label)



C2 Byte Structure per ITU-T G.707 Recommendations			
Bits 1 to 4	**Bits 5 to 8**	**Hex value**	**Description**
0000	0000	00	Unequipped
0000	0001	01	Equipped non-specific
0000	0010	02	TUG structure
0000	0011	03	Locked TU-n
0000	0100	04	Asynchronous mapping of 34 Mbit/s or 45Mbit/s into a C3 container
0001	0010	12	Asynchronous mapping of 140Mbit/s into a C4 container
0001	0011	13	ATM mapping
0001	0100	14	MAN DQDB mapping
0001	0101	15	FDDI mapping
0001	1000	18	HDLC/LAPS
0001	1010	1A	10 Gigabit Ethernet mapping (IEEE 802.3)
0001	1011	1B	Generic Framing Protocol (GFP)
0001	1100	1C	10 Gigabit Fiberchannel mapping
0010	0000	20	Asynchronous mapping of ODUk
1111	0000	FE	ITU-T 0.181 test signal mapping
1111	1111	FF	VC-AIS (TCM)

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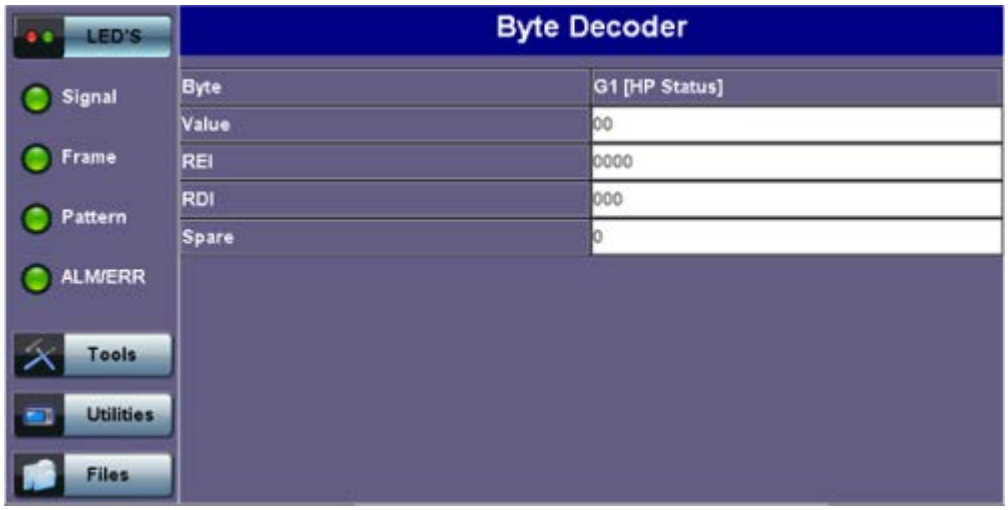
- **G1 byte (Path status)**
  - High Order path status byte
  - Used to convey the path terminating status back to the originating path, thus allowing bidirectional monitoring of the

complete path
- Bits 1-4: Remote Error Indication (HP-REI) indicates number of bit errors detected by B3
- Bit 5: Remote Defect indication (HP-RDI) set to 1 if signal failure is detected
- Bits 6-7: Enhanced RDI information to differentiate between payload defects (HP-PLM), connectivity defects (HP-TIM, HP-UNQ) and server defects (HP-AIS, LOP)

G1 Byte (HP Status)



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- **F2 byte (HP user channel)**
  - High Order Path user channel
  - VC-4 path user channel used for communication between path elements

- **H4 byte (TU Indicator)**
  - Position or Sequence Indicator
  - Multiframe phase indicator used for tributary structured payloads

- **F3 byte (LP) user channel**
  - Used for communication between path elements and is payload dependent.

- **K3 byte (HP APS)**
  - Bits 1-4 are used for protection switching of VC-3 & 4 paths.
  - Bits 5-8 are a currently not used

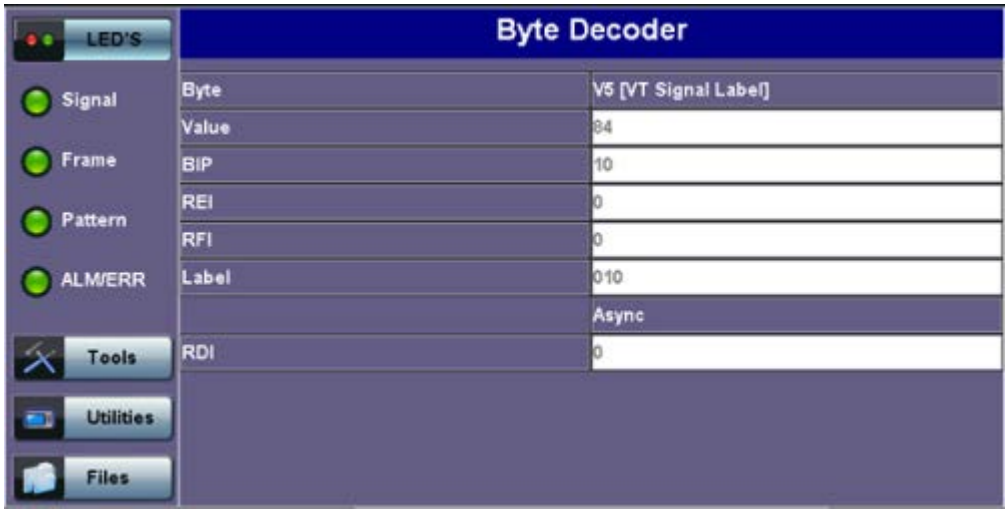
- **N1 byte (HP)**
  - Allocated to provide a High Order (HP) Tandem Connection monitoring function for contiguously concatenated VC-4, VC-4 and VC-3 levels.
    - Bits 1-4: Used as an Incoming Error Count (IEC) per G.707
    - Bit 5: Operates as the TC-REI to indicate errored blocks occurring within the tandem connection
    - Bit 6: Operates as the OEI to indicate errored blocks egressing the VC-n
    - Bits 7-8: Operate in 76 multi-frame structure;
  - Frames 1-8 > Frame Alignment Signal (FAS)
    - Frames 9-72 > The Access Point Identifier of the tandem connection (TC-API)
    - Frames 73-76 > TC-RDI indicating defects that have occurred in the tandem connection to the far-end
    - Frame 74 > ODI indicating to the far-end that AU/TU-AIS has been inserted into egressing AU-n TU-n due to defects before or within the tandem connection
    - Frames 73-76 > Reserved capacity

- **V5 byte (LP signal label)**
  - Byte contains error analysis, signal label and path status information
  - Continuous monitoring of anomalies or defects and payload composition at the path end or along the path
    - Bits 1-2 provides error checking (BIP-2)
    - Bit 3 is the LP-REI (0 = no error, 1 = errors)
    - Bit 4 is the LP-RFI (0 = no error, 1 = errors)
    - Bits 5-7 provide the VC-12 signal label

- 000 Unequipped
- 001 Equipped (non-specific)
- 010 Asynchronous
- 011 Bit synchronous
- 100 Byte synchronous
- 101 Extended
- 110 0.181 test signal (TSS4)
- 111 VC-AIS

- Bit 8 is the VC12 path LP-RDI normally set to zero unless there is an error condition (AIS)

V5 Byte (VT signal label)



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- **J2 byte (LP)**
  - Used to transmit a configurable 16-byte identifier that enables the receiving path to continuously verify its connection with the transmitter
  - Uses the same byte structure as the J0 and J1 bytes

- **N2 byte (LP)**
  - Provides LP/VT tandem connection monitoring function (LP-TCM) for the VC-11 and VC-12 levels
    - Bits 1-2: even parity error checking BIP-2 for the tandem connection
    - Bit 3: Set to “1”
    - Bit 4: Incoming AIS indicator (0 = no defect; 1 = defect occurred before tandem connection)
    - Bit 5: TC-REI indicating errored blocks caused in the tandem connection
    - Bit 6: OEI indicating errored blocks of the egressing VC-n
    - Bits 7-8: Operate in a 76 multi-frame structure:
  - Multiframe structure consists of:
    - Frames 1-8 >Frame Alignment Signal (FAS)
    - Frames 9-72 > The Access Point Identifier of the tandem connection (TC-API)
    - Frames 73-76 > TC-RDI indicating defects that have occurred in the tandem connection to the far-end
    - Frame 74 > ODI indicating to the far-end that AU/TU-AIS has been inserted into egressing AU-n/ TU-n due to defects before or within the tandem connection
    - Frames 73-76 > Reserved capacity

N2 Byte Structure per ITU-T G.707 Recommendations							
Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
BIP-2		Fixed [1]	I-AIS	TC-REI	OEI	TC-API, TC-RDI, ODI, Reserved	

- **K4 byte (LP path Extended Label)**
  - When bits 5-7 of V5 byte are set to 101 (value = 5), then the signal label in K4 byte becomes valid where:
    - Bit 1 is allocated to the extended signal label
    - Bit 2 is allocated to virtual concatenation

Bits 3 and 4 are unassigned and are reserved for LP APS signaling
- Bits 5, 6, 7 are allocated for optional use
- Bit 8 is unassigned
- Bits 12-19

K4 Multiframe Structure per ITU-T G.707 Recommendations																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	27	29	30	31	32
Multiframe Alignment Signal											Extended Signal Label								0	R	R	R	R	R	R	R	R	R	R	R
Frame Count					Seq. Indicator																									

K4 Byte Structure per ITU-T G.707 Recommendations							
Bit 1	Bit 2	Bit 3	Bit4	Bit 5	Bit 6	Bit 7	Bit 8
Extended Signal Label	Virtual concatenation overhead	Unassigned		Optional Use			Unassigned

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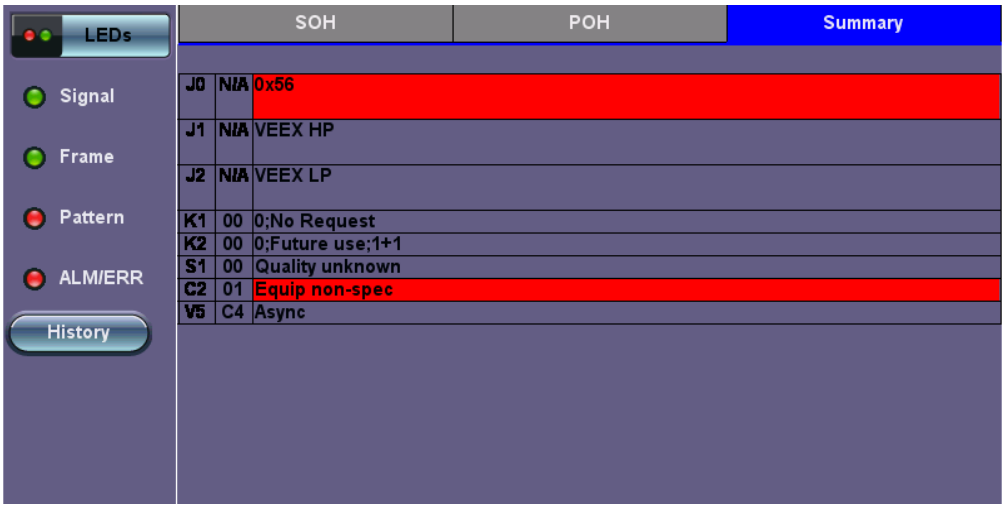
- **Summary**
  - The Summary tab displays the summary screen listing the major bytes of the received SDH signal.
  - Displays the Path Trace Identifiers (J0, J1, J2), APS (K1, K2), Synchronization status (S1), and HP (C2) and LP (V5) Signal Label bytes.
    - Column #1 - Indicates the byte type
    - Column #2 - Provides the hexadecimal value of the byte (if applicable)
    - Column #3 - Provides a byte decode (Please refer to the byte definitions for an explanation of the listed bytes)

Summary



Path Traces

(SP) indicates a space between the message characters.
The message is displayed in red when an alarm condition is detected.

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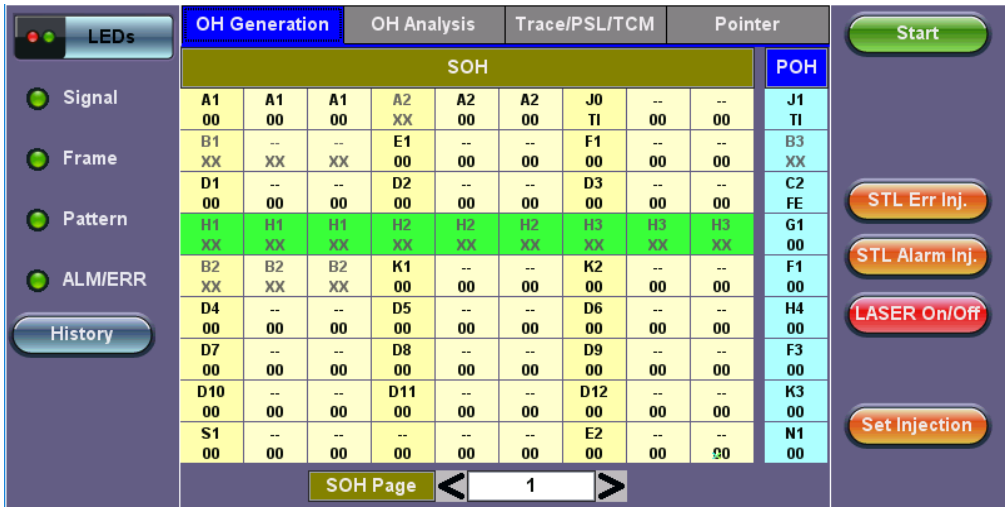
8.8.3 Overhead Generator

Overhead Generator - SDH/SONET Tools (Advanced)

Overhead Generator - SDH/SONET Tools (Basic)

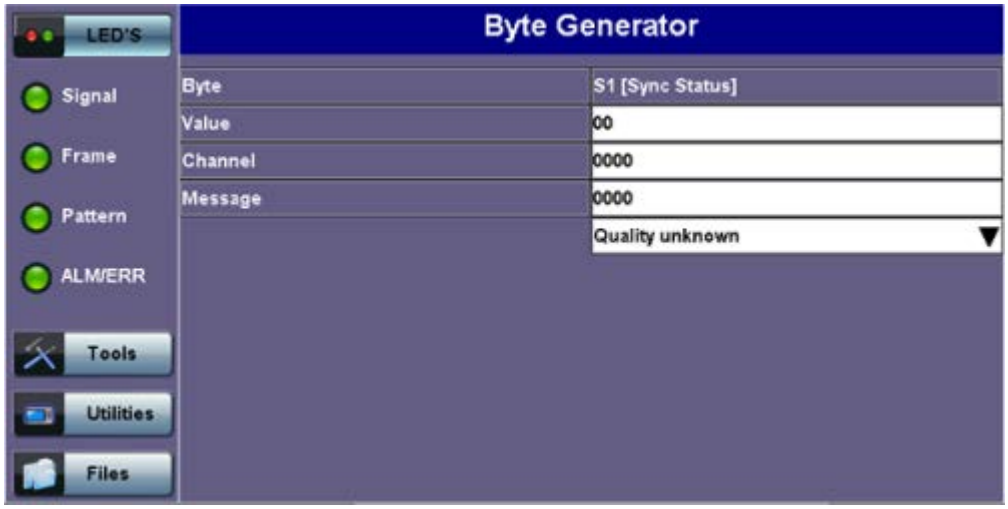


Tap the Overhead Generator icon to display the OH screens shown below. There are three tabs:

- **SOH TX**, which allows editing of select bytes associated with the Section Overhead. SOH pages are available to scroll through in SDH/SONET Tools (Basic). Editing of J0, K1, K2, S1 is permitted as follows:
  - Hexadecimal value using pop-up keypad.
  - Binary values using simple on-screen bit toggle or pop-up keypad.
  - Convenient drop-down selections. In some instances, the selections will be available over multiple pages.

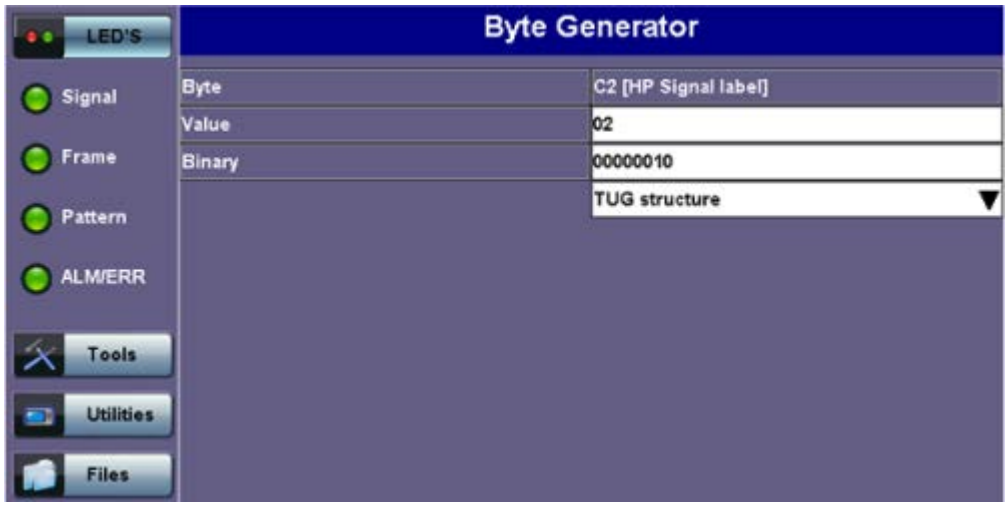
Note: *While programming of most overhead bytes is possible using the OH Generator feature, dedicated functions are available for Pointer Tasks, Payload Labels, Trace Identifier, APS Testing, TCM testing. In some instances, more advanced editing is possible using the dedicated functions.*

S1 Byte from SOH



- **POH TX**, which allows editing of select bytes associated with the Path Overhead.
  - Editing of J1, C2, H4, G1, Z5, and J2, V5, Z6 is permitted as follows:
    - Hexadecimal value using pop-up keypad.
    - Binary values using simple on-screen bit toggle or pop-up keypad.
    - Convenient drop-down selections. In some instances, the drop-down options will be available over multiple pages.

C2 Byte from POH



Overhead Generator

Programming most overhead bytes is possible using the OH Generator feature, however dedicated test functions are available for Pointer Tasks, Payload Labels, Trace Identifier, APS Testing, TCM testing.
In some instances, more advanced editing is possible using the dedicated functions.

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8.8.4 Pointer Tasks

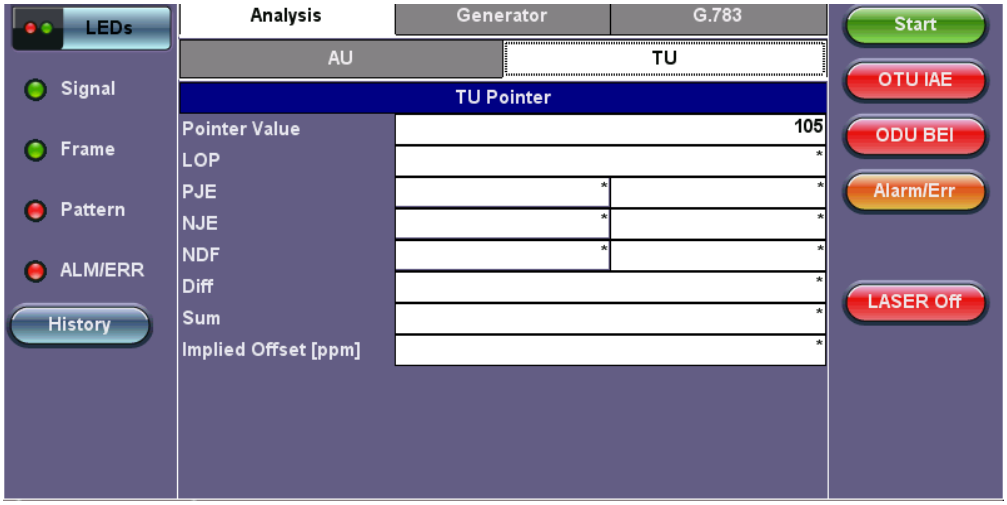
Tap the Pointer Tasks icon to display the Pointer testing screens.

8.8.4.1 Pointer Analysis

Pointers keep SDH signals synchronous by compensating for timing differences without having to use stuffing bits. Pointers are allowed to move up or down every three frames however the actual rate should be slower. The Administrative Unit (AU) and the Tributary Unit (TU) each has its own pointer and the unit has two tabs for displaying the values and measurements.

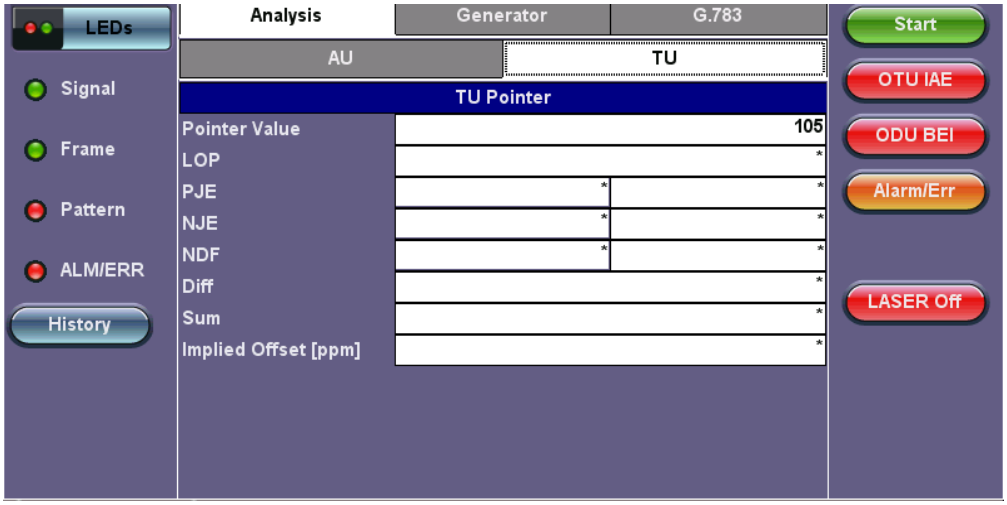
- **For AU pointers:**
  - SS bits – Displays bits 5 and 6 of the H1 byte to indicate SDH [10], SONET [00], Unknown [01] and [11] signal type
  - Pointer value – Displays the H1 and H2 values (addresses) indicating the offset in bytes between the pointer and first byte of the AU-n
  - LOP (Loss of Pointer)
  - PJE and NJE
  - NDF or New Data Flag. NDF is enabled when all bits match “1001” (or "0001", "1101", "1011" and "1000") and is disabled when all bits match "0110" (or "1110", "0010", "0100", "0111").
  - Difference and Sum
  - Implied offset

Analysis > AU tab



- **For TU pointers:**
  - Pointer value
  - LOP (Loss of Pointer)
  - PJE and NJE
  - NDF or New Data Flags
  - Difference and Sum

Analysis > TU tab



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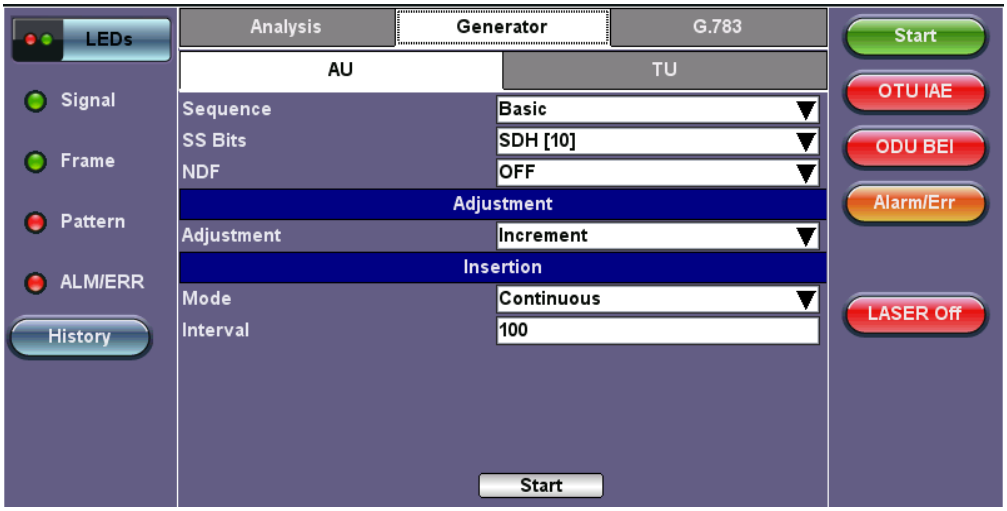
8.8.4.2 Pointer Generation

The Pointer generator is able to generate individual pointer movements as follows:

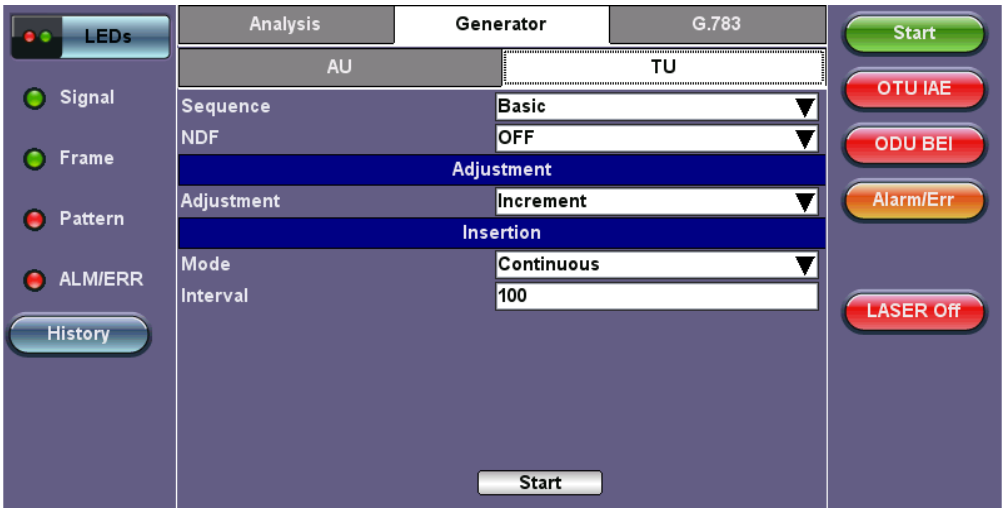
- **For AU pointers:**
  - SS bits: Program bits 5 and 6 of the H1 byte to be either SDH [10], SONET [00], Unknown [01] or [11].
  - Pointer value: Transmits a new pointer address or value with or without a new data flag (NDF). Configurable in a range of 0 to 782 pointers.
  - Increment (INC) or Decrement (DEC) pointers with identical polarity by 1 byte in single steps.
  - Insert pointers continuously or singularly. Set the interval value in frames for continuous insertion.

Generator > AU tab



- **For TU pointers**
  - TU Pointer value: Set value in a range of 0 to 784 (TU-3) and 0 to 139 (TU-12)
  - TU-11 Pointer value: Set value in a range of 0 to 109 (TU-11)
  - Increment (INC) or Decrement (DEC) pointer value by 1 byte is single steps

Generator > TU tab



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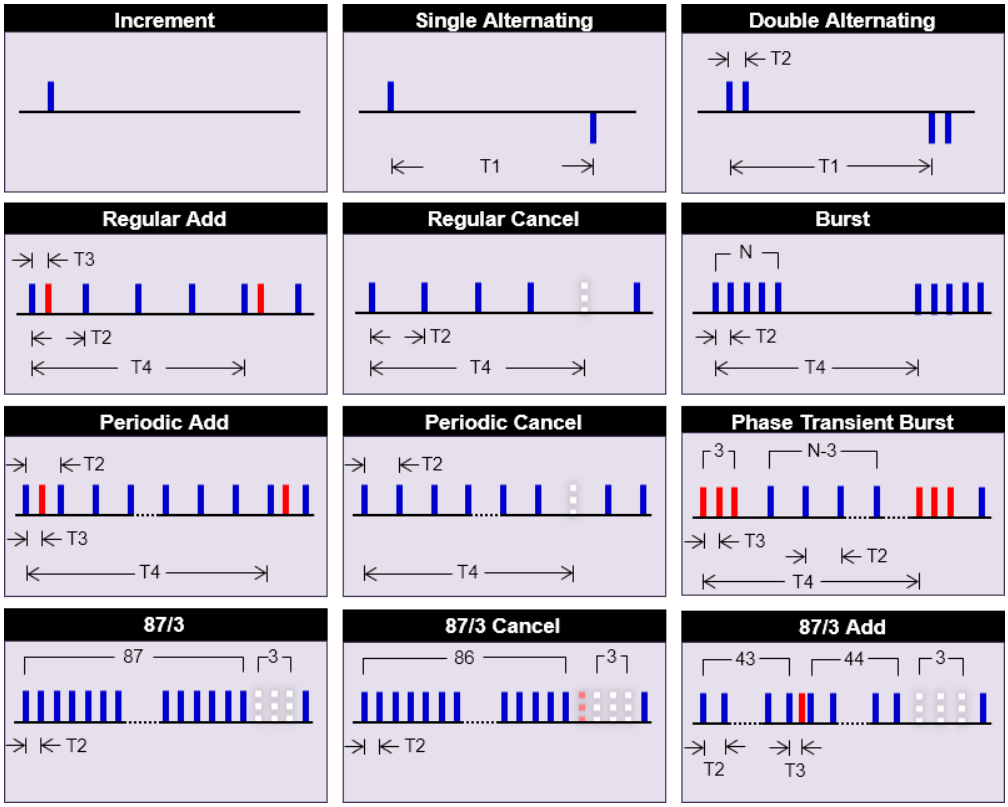
8.8.4.3 Pointer Sequences

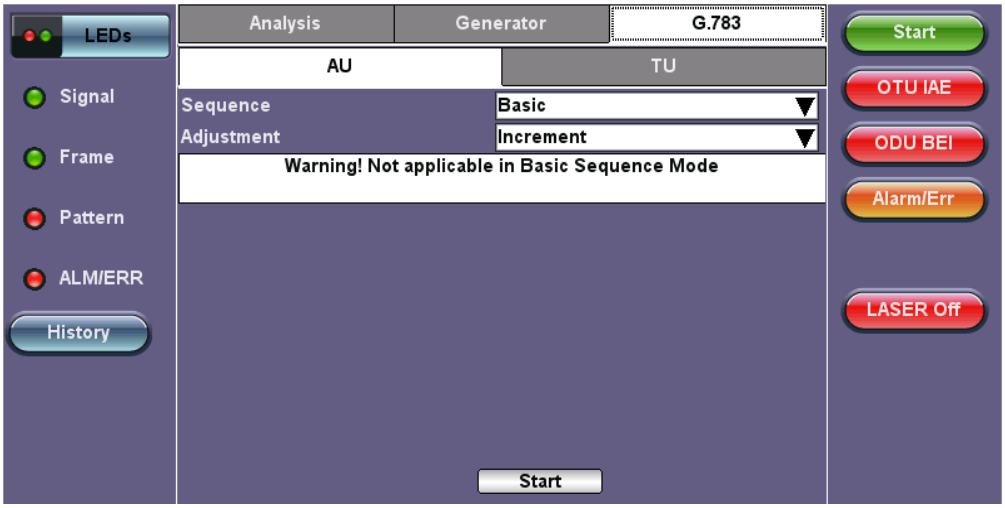
The Pointer generator is also able to generate Standard ITU-T G.783 and ANSI T1.105.03 and Bellcore GR-253 sequences as follows:

Pointer Sequences



- **Sequence:** Decide how to affect the pointer sequence
- **Basic:** Specify whether the pointer is increasing or decreasing
    - Select Inc to increase the pointer value
    - Select Dec to decrease the pointer value
    - Select New Value to set new pointer value
- **Single Alternating:** Increase or decrease the pointer value
- **Burst:** Generate a sequence of changes in the pointer value in one direction only (increase or decrease)
- **Transient Burst:** Generate changes in the phase of the pointer adjustment
- **Periodic:** Generate periodic changes in the pointer value
- **87-3:** Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, with no adjustments)
- **87-3 Add**: Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, added to have an additional pointer value)
- **87-3 Cancel**: Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, reduced the number of adjustments by one)
- **Unit**: Select the type of unit to count: Frames
    - N: Specify the number of pointer adjustments in a row: 1—9999 (default=6)
    - T: Specify the average pointer spacing in time. T is known as T1 to T5 in G.783: (default=4)
        - T1, T4: 0.25ms to 600s or 2 to 4,800,000 frames/multiframes
        - T2, T3: 0.25ms to 10s or 2 to 80,000 frames/multiframes
        - T5: 0ms to 600s or 0 to 4,800,000 frames/multiframes

G.873 > AU tab



G.783 Identifier	Pointer Adjustments	Mnemonic
Single Alternating	Single of opposite polarity	+-
Regular Add	Regular plus one double	+&Add
Regular Cancel	Regular with one missing	+&Cancel
Double Alternating	Double of opposite polarity	++-
Single	Single	+
Burst	Burst	+++Burst
87-3	STS periodic 87-3 pattern	+87/3
87-3 Add	STS periodic 87-3 Add position	+87/3 & Add
87-3 Cancel	STS periodic 87-3 Cancel position	+87/3 & Cancel
Periodic Add	Periodic Add position	+Periodical & Add
Periodic Cancel	Periodic Cancel position	+Periodical & Cancel

Pointer Sequence Testing

- It is recommended to run one sequence with positive adjustments followed by a sequence with negative adjustments. Performing the measurement at the maximum positive and negative frequency offset applicable to the line rate increases the stress on the pointer processor.
- The test procedure includes an initialization period followed by a cool down period of 30 seconds with no pointer movements.

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8.8.5 Trace Identifier

Tap the Trace Identifier icon to display the path trace testing application and screens.

There are dedicated tabs for Transmitted and Received (expected) path traces and setups.

8.8.5.1 Transmitted Traces (TX)

- J0 [RS]: Regenerator section trace
  - Program a 1 or 16-byte identifier to check the connection between regenerators

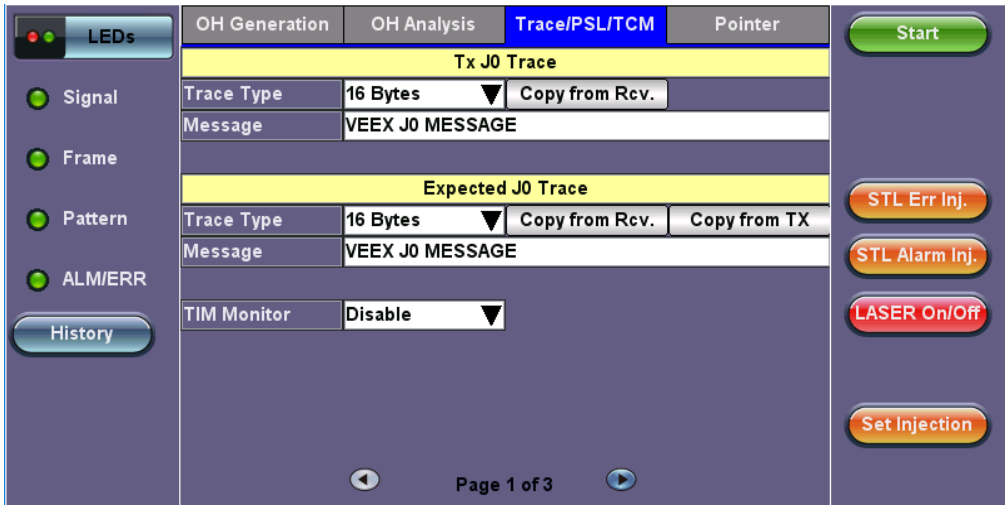
J1 [HP]: High order path section trace
- Program a 16 or 64-byte identifier to check the high order transmission path

- J2 [LP]: Low order path section trace
  - Program a 16 or 64-byte identifier to check the low order transmission path

Note: *To program or edit the transmitted trace, tap the applicable trace box to display the pop-up keyboard.*

TX - JO [RS]

TX - JO [RS] - STL256.4 SDH/SONET (Basic)



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8.8.5.2 Received Traces (RX)

- J0 [RS]: Regenerator section trace
  - Program a 1 or 16-byte identifier to set and check the expected trace
  - Enable or disable the TIM (Trace Identifier Mismatch) alarm
- J1 [HP Path]: High order path section trace.
  - Program a 16 or 64-byte identifier to set and check the expected trace
  - Enable or disable the TIM (Trace Identifier Mismatch) alarm
- J2 [LP Path]: Low order path section trace
  - Program a 16 or 64-byte identifier to set and check the expected trace
  - Enable or disable the TIM (Trace Identifier Mismatch) alarm

RX - JO [S]

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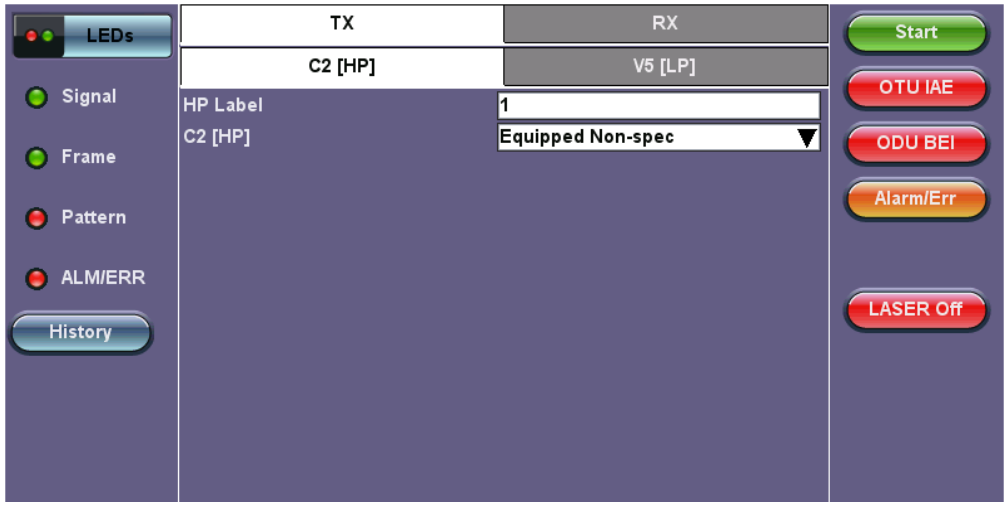
8.8.6 Payload Labels

This function is used to set the C2 and V5 Path Signal Labels which indicate the content of the High order and Low order VCs.

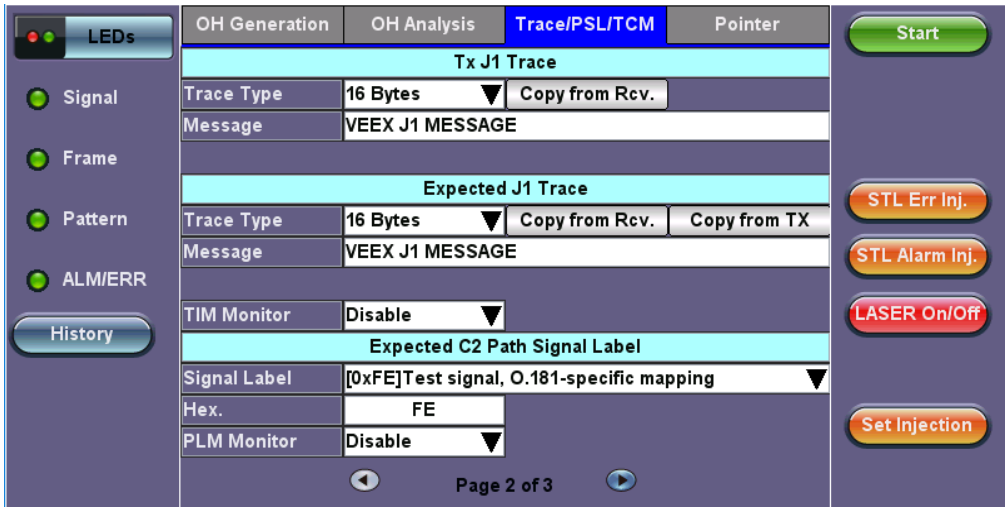
Tap the Payload Label icon to display the payload label screens. There are dedicated tabs for Transmitted and Received payload labels and setups:

- **C2 [HP Path]: Path signal label**
  - Specifies the mapping type in the VC-n
  - Program the TX or RX label by editing the hexadecimal value or by using the convenient drop-down menu selection
  - For the RX label, enable or disable the Payload Mismatch (PLM) Alarm

TX C2 [HP]



C2 Path Signal Label - STL256.4 SDH/SONET (Basic)



- **V5 [LP Path]: Path signal label**
  - Program the TX and RX label by editing the hexadecimal value or by using the convenient drop-down menu selection
  - For the RX label, enable or disable the Payload Mismatch (PLM) Alarm

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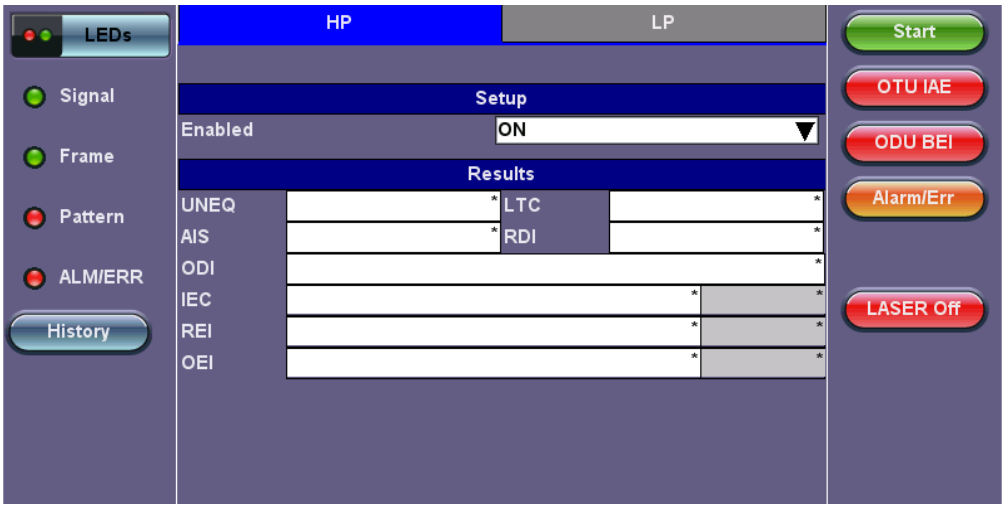
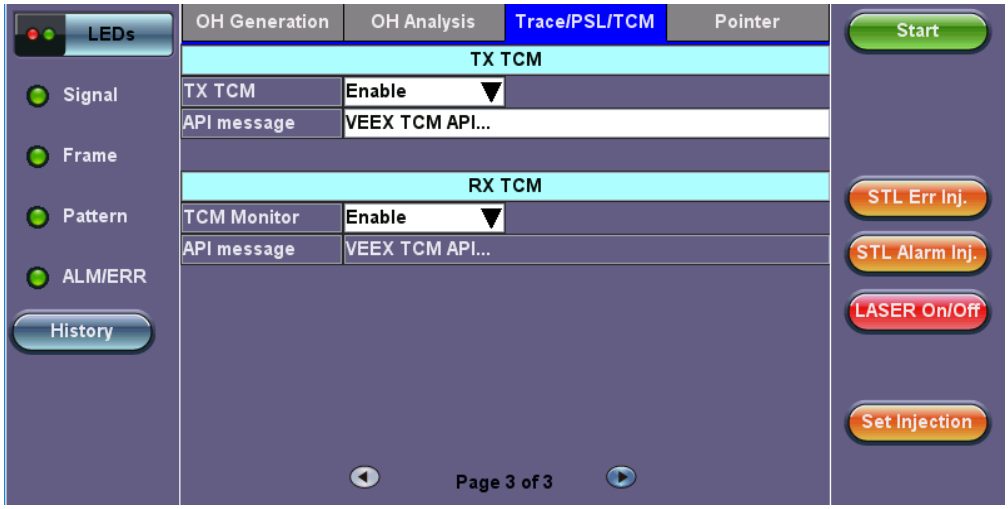
8.8.7 Tandem Connection Monitoring (TCM)

HP Setup



TCM - STL256.4 SDH/SONET (Basic)



- **TCM Standards**
  The Tandem paths are defined in ITU recommendation G.707 Annex D and Annex E
  - G.707 Annex D for VC4 and VC3
  - G.707 Annex E for VC2 and VC1
  - G.707 defines a tandem connection source and sink and describes the responses of each when defect (alarm) and error conditions are detected
  - Tandem connection maintenance signals are carried in:
    - N1 byte for VC4 and VC3
    - N2 byte for VC2 and VC
    - These two bytes are structured similarly, but their functions are not identical

N1 Byte Structure							
b1	b2	b3	b4	b5	b6	b7	b8
IEC [IAIS]				TC-REI	OEI	TC-APId, TC-DI, ODI, reserved	

N2 Byte Structure							
b1	b2	b3	b4	b5	b6	b7	b8
TC-BIP		"1"	IAIS	TC-REI	OEI	TC-APId, TC-DI, ODI, reserved	

- **IEC:** Incoming Error Count. Indicates IAIS when set to "1110" (see below)
- **IAIS:** Incoming AIS alarm
- **TC-REI:** Tandem Connection Remote Error Indication
- **OEI:** Outgoing Error Indication
- **TC-APId:** Tandem Connection Remote Defect Indication
- **ODI**: Outgoing Defect Indication
- **TC-BIP:** 2-bit Bit Interleaved Parity for Tandem Connection

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8.8.8 Tributary Scan

This function requires VC12 or VT-1.5 mapping and allows for a quick check of the signal structure, trace identifier, and the payload.

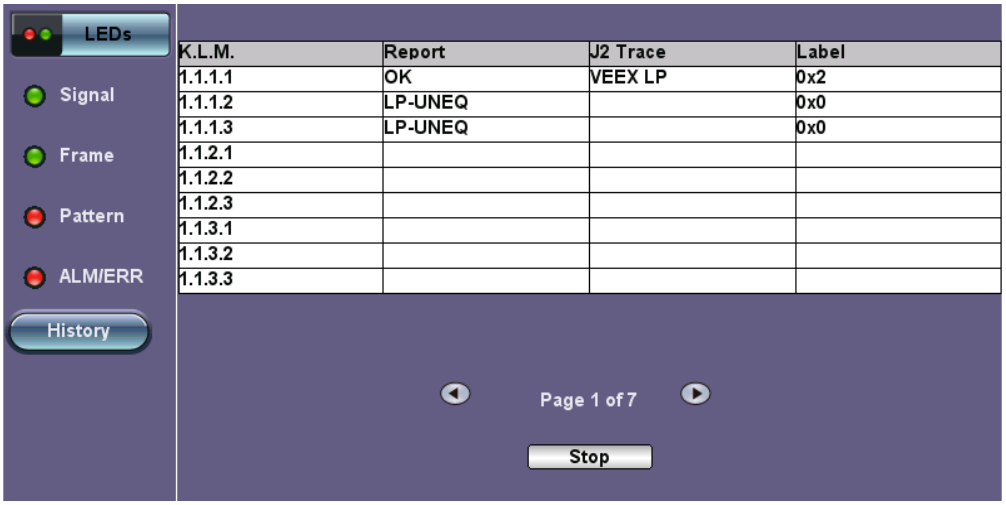
An important part of any Add Drop Multiplexer (ADM) installation process is the verification of the path routing. Considering that an STM-1 contains 63 x VC-12's and a STM-4 contains 252 x VC-12's checking each path manually can be very time consuming.

The unit automatically performs a sequential BER test on each SDH tributary (C12 channel) - mapping can be either via AU-4 or AU-3. The unit checks for alarms in the received signal, the SDH structure, and for synchronization of the selected test pattern in all channels. The result for each channel is entered in a table:

- K.L.M.: ITU-T Tributary numbering scheme

- Report: Pass (OK)
- J2 trace: Corresponds to the VT trace being transmitted
- Label: Corresponds to the V5 byte signal label being transmitted

Tributary Scan



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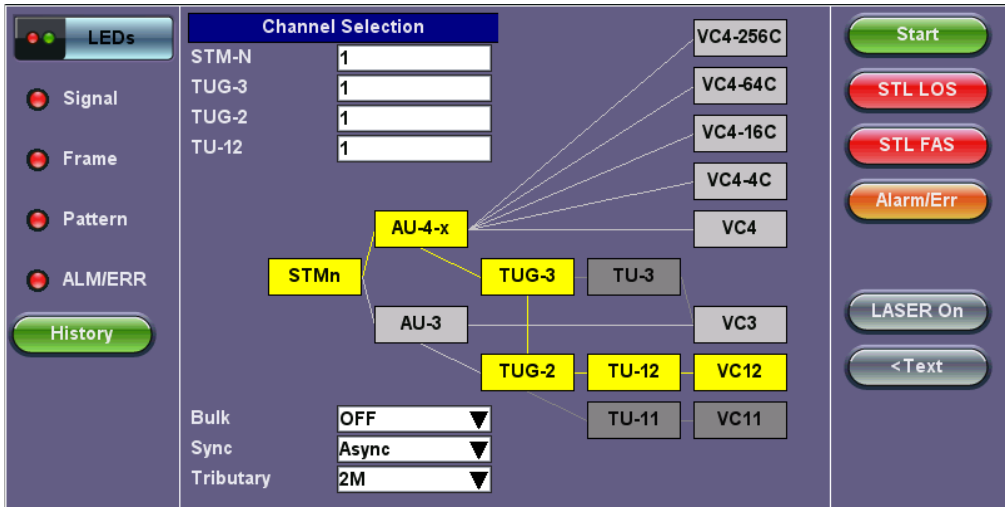
9.0 STL256.4 SDH/SONET

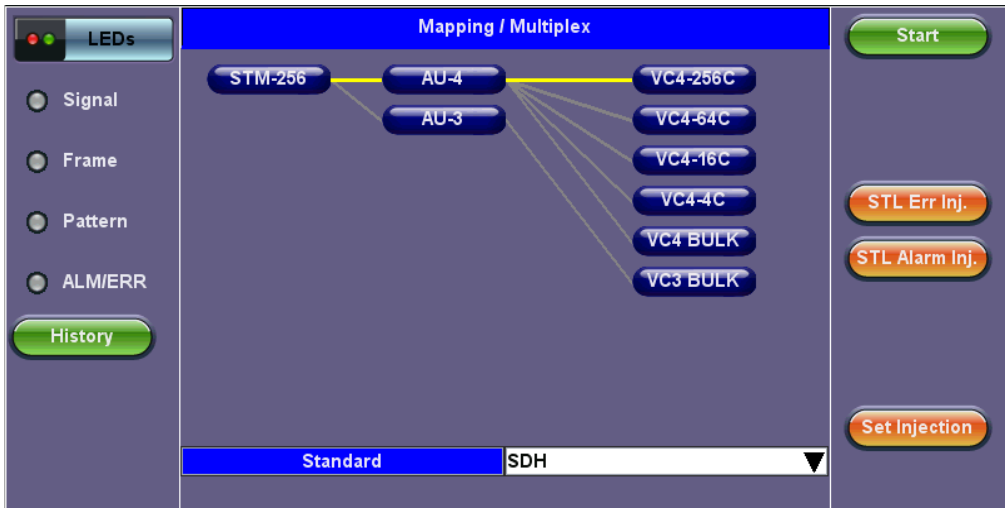
STL256.4 SDH/SONET Basic and Advanced Version Overview

The basic version of STL256.4 SDH/SONET included with the purchase of the test set, supports SDH/SONET testing and is found in the OTU3 and OTU4 Test Modes. If the STL256.4 license was purchased, the advanced version will be available from the Test Mode Selection Menu. The purchased license offers the most complete STL256.4 testing capabilities including PDH/DSn payloads and mapping options.

STL256.4 SDH/SONET Advanced Mapping Options



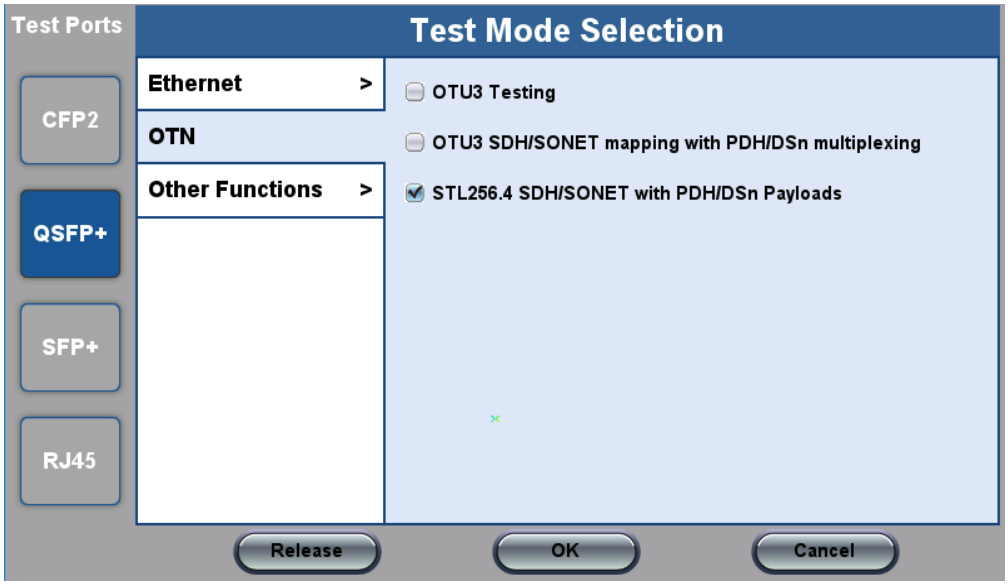
STL256.4 SDH/SONET Basic Mapping Options



Accessing STL256.4 with PDH/DSn Multiplexing (Advanced Version)

The advanced version is available from the Test Mode Selection Menu of the QSFP+ > OTN menu.

STL256.4 SDH/SONET (Advanced) Available from the Test Mode Selection Menu

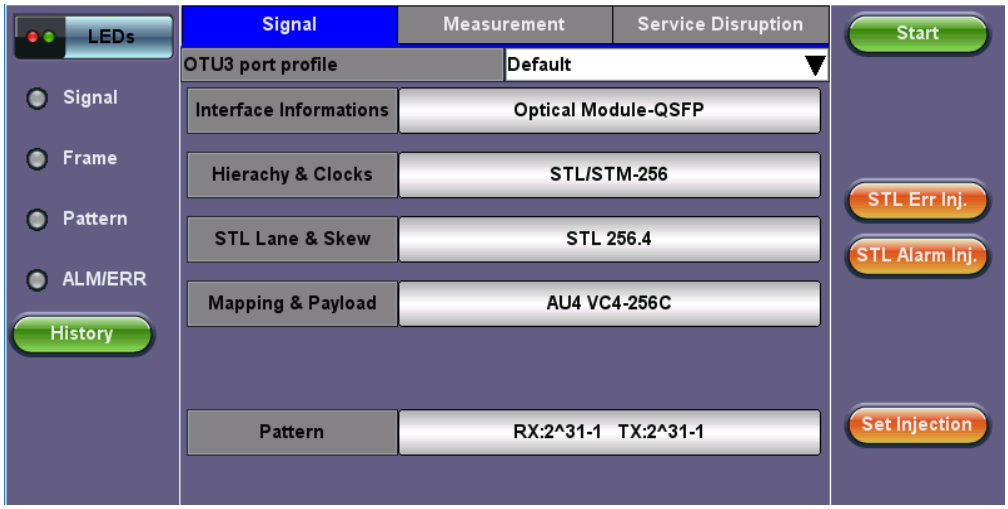


Accessing STL256.4 SDH/SONET (Basic Version)

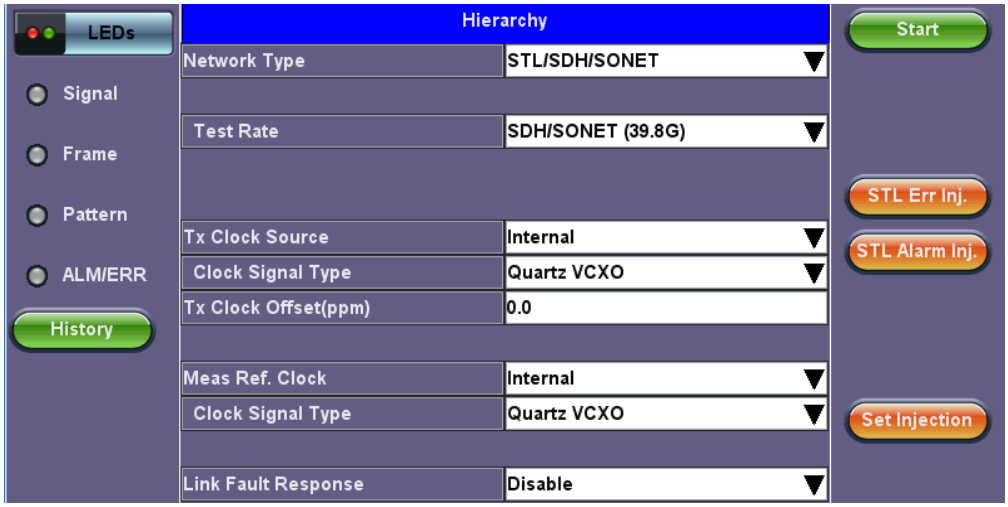
The basic version of STL256.4 SDH/SONET is accessed from these menu options:

1. Tap on the Test Application icon to access the Test Mode Selection menu.
2. Select QSFP+ > OTU 3 Testing > OK.
3. Select Setup > Hierarchy & Clocks (OTL/OTU3).
4. Select STL/SDH/SONET from Network Type.

STL256.4 SDH/SONET (Basic Version) - Signal tab



STL256.4 SDH/SONET (Basic Version) - Hierarchy tab



9.1 STL256.4 SDH/SONET (Basic Version)

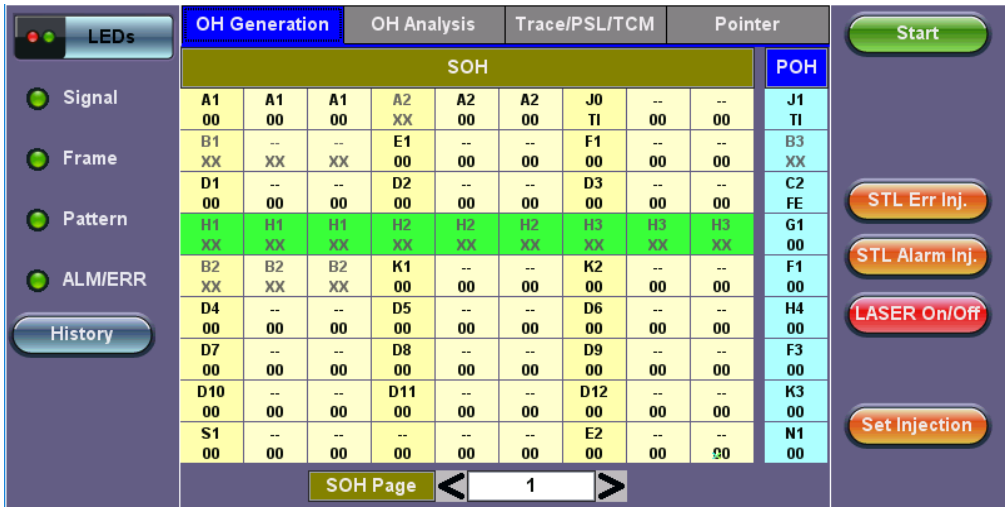
STL256.4 SDH/SONET (Basic) is accessible from the OTU3 and OTU4 Test applications. Refer to OTU3 & OTU4 (Ethernet/Bulk) and STL256.4 (Basic) for information on setup, results, alarm/error injection instructions.

SDH/SONET Tools (Basic)

SDH/SONET Tools (Advanced) offers the same features as the basic version as well as additional tools. Refer to SDH/SONET Tools (Advanced) for information on the tabs in this section. Screens will differ depending on the SDH/SONET Tools version. The links below redirect to the corresponding OTU3/OTU4 section:

- OH Generation
- OH Analysis
- Trace/PSL/TCM: Trace, PSL, TCM
- Pointer Generation

SDH Tools (Basic)



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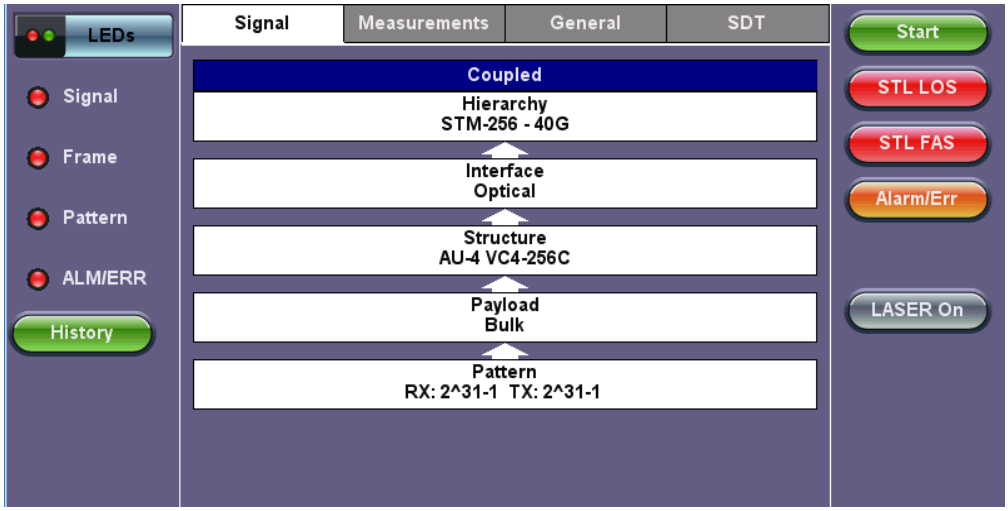
9.2 STL256.4 SDH/SONET with PDH/DSn (Advanced Version)

The menu structure for STL256.4 SDH/SONET testing with PDH/DSn is identical to OTU3 & OTU4 SDH/SONET mapping with PDH/DSn Multiplexing. Refer to OTU3 & OTU4 SDH/SONET Mapping for more information on Setup, Results, Alarm/Error, and Tools.

Setup



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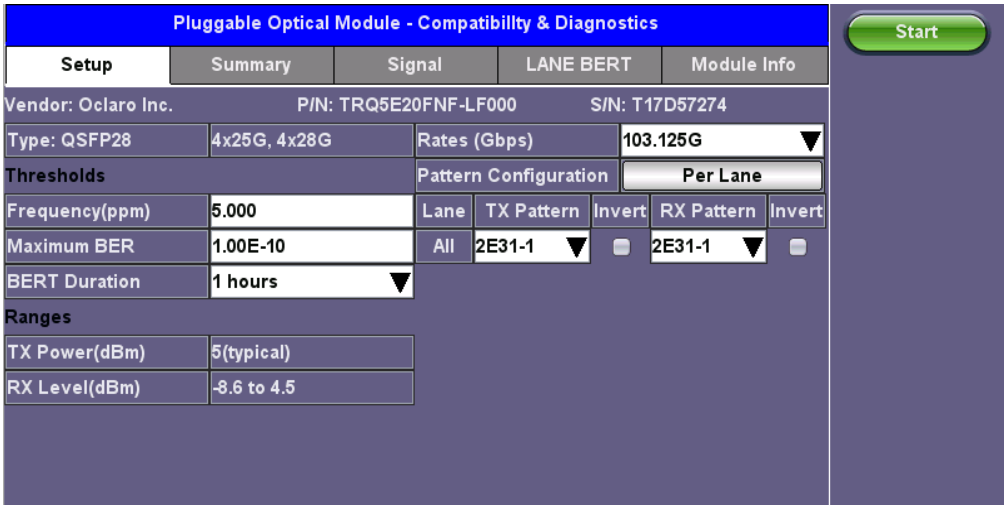
10.0 Pluggable Optical Module Diagnostics

Pluggable Optical Module Diagnostics is a diagnostics test that verifies and troubleshoots CFP2, QSFP28, and QSFP+ pluggable optical modules. It runs through a series of tests that check optical module status, signal level, frequency, and Lane BERT measurements. A physical loopback (TX to RX) is required to run the diagnostics. Users can configure a frequency offset up to 150 ppm to stress the optical module and setup BER thresholds to determine a PASS/FAIL condition for the duration of the test.

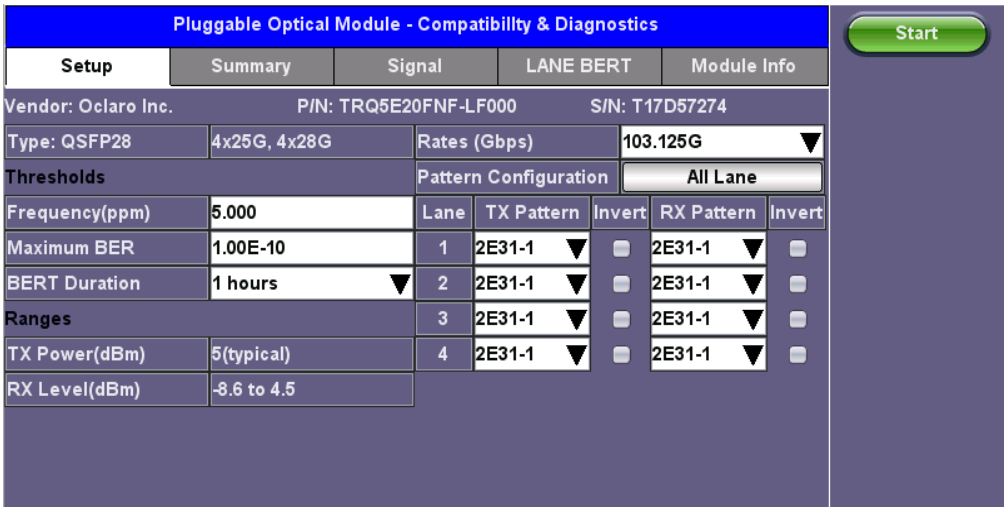
Setup

Press **Start** to initiate testing. The laser automatically turns on when starting the test.

Setup (All Lane Configuration)



Setup (Per Lane Configuration)



Summary

Displays the test progress, optical module information, and pass/fail status for each measurement in the process. Measurement status is represented by the following icons:

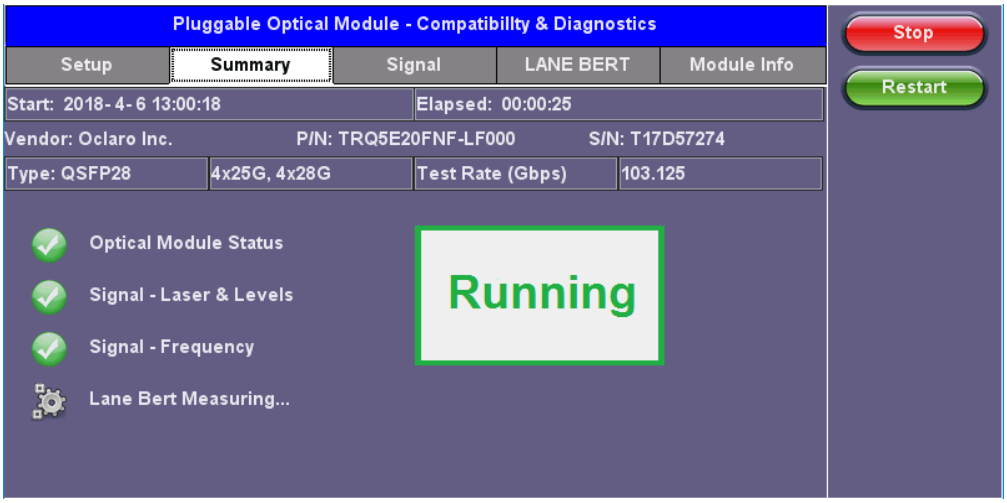
Measurement Not Started

Pass

Fail

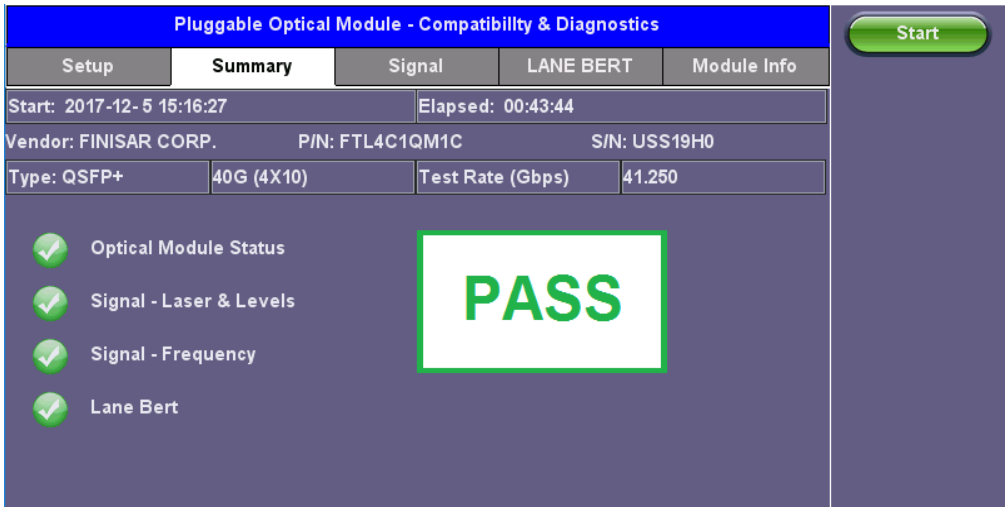
In Progress

Summary - Test Running In Progress



A final pass/fail grade for the module compatibility is displayed at the end of the test.

Passed Diagnostics Test



Signal

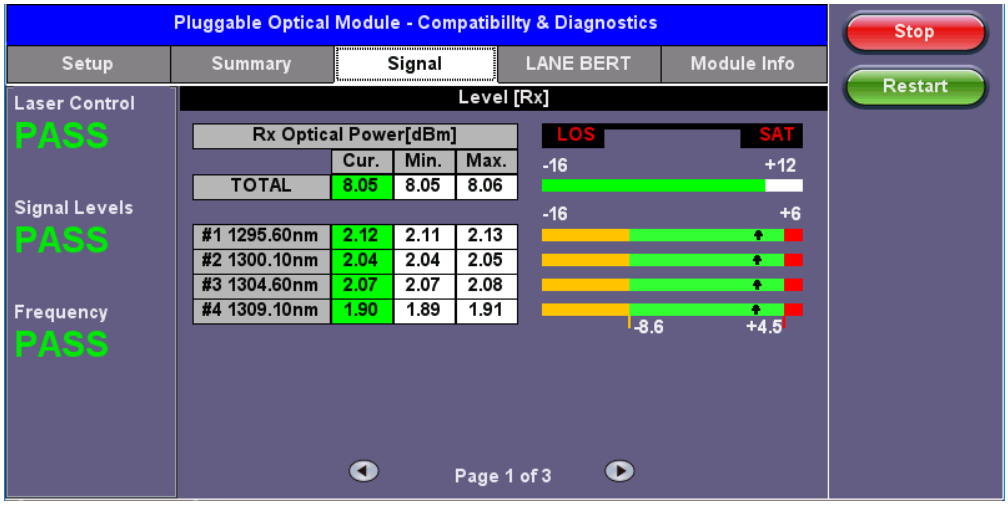
Level

The Signal tab displays the level and frequency screens. Page 1 and 2 display the level measurements for the transmitting (TX) and receiving signal (RX) along with a table displaying current, minimum, and maximum frequency.

Loss of Signal (LOS) and the Saturation level for optical signals is shown graphically including the level measurement in dBm.

Pass/Fail status for Laser Control, Signal Levels, and Frequency are displayed on the left.

Signal Rx - Page 1

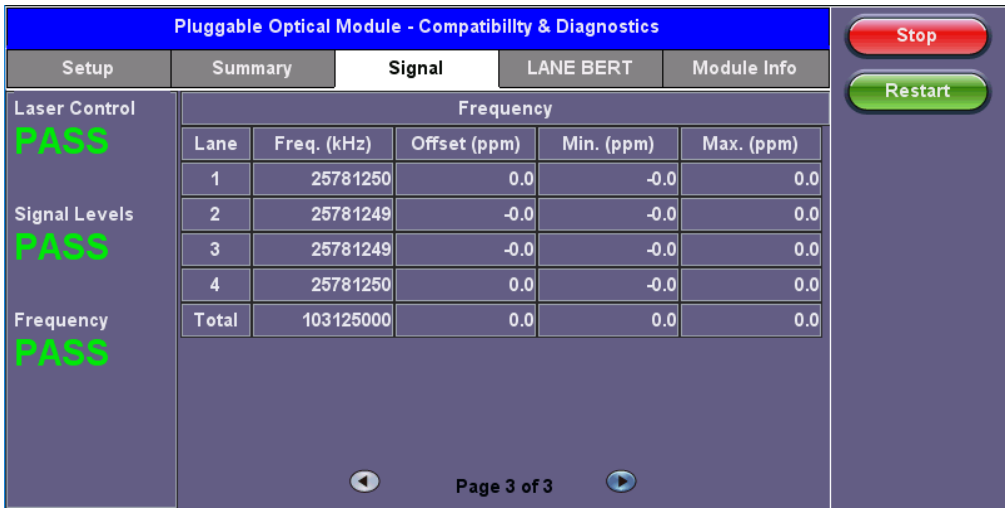


Frequency

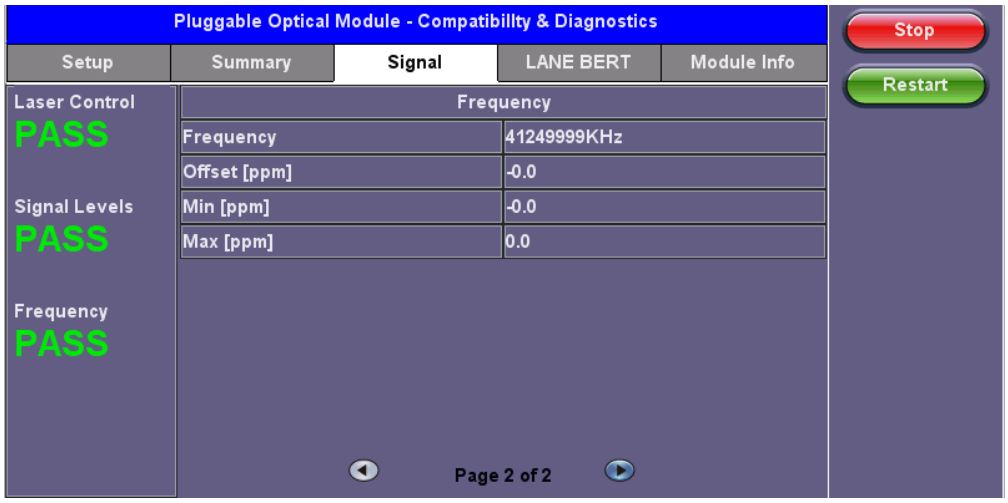
Depending on the test set model and version, newer units may display per lane frequency measurements.

- **Frequency:** Current frequency of the input signal. Depending on the unit, some models will display aggregate (all lanes) or per lane frequency in newer versions.
- **Offset:** Indicates the difference between the standard rate and the rate of the input signal.
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal.
- **Max (ppm):** Indicates the difference between the standard rate and the maximum deviation detected in the input signal.

Signal - Frequency (Per Lane)



Signal - Frequency (All Lane)



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LANE BERT

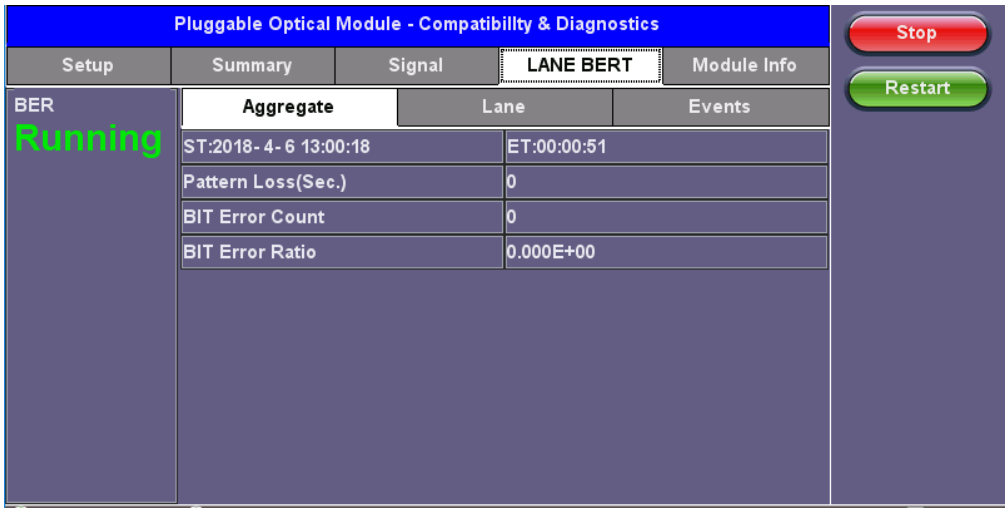
Pass/Fail BER status is displayed on the left.

Aggregate

The Aggregate screen displays

- Pattern Loss (Sec)
- BIT Error Count
- BIT Error Ratio

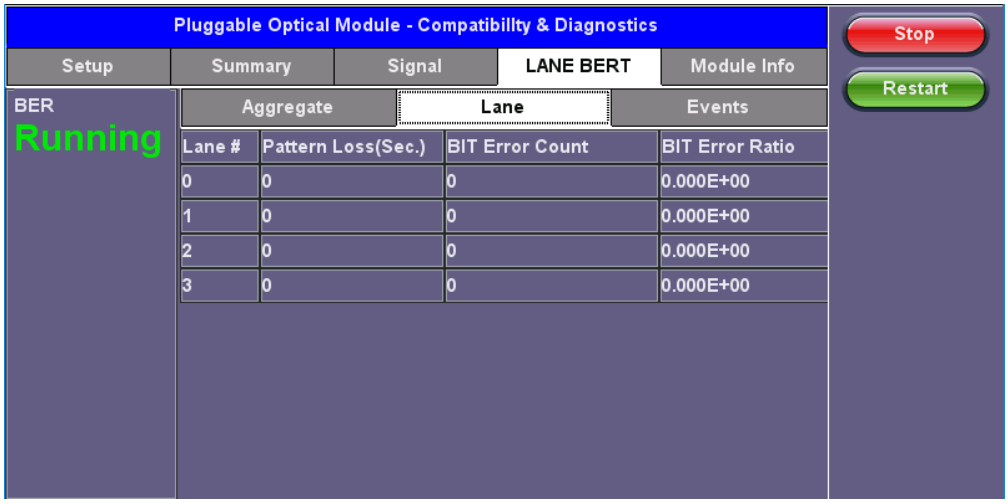
Aggregate



Lane

The Lane tab displays Pattern Loss and Bit Errors for each lane.

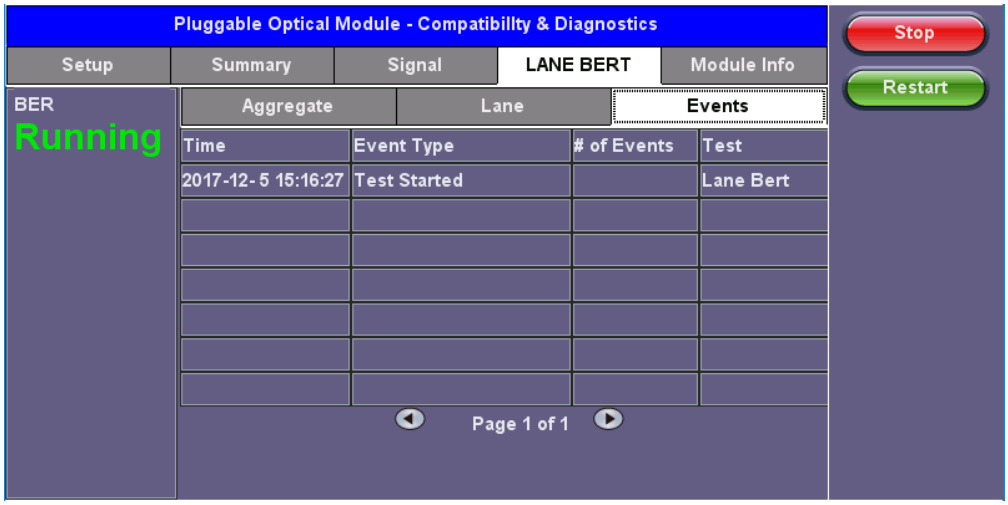
Lane



Events

A time stamped record or log of anomalies, alarms, test status (start/stop) and test application are displayed.

Events

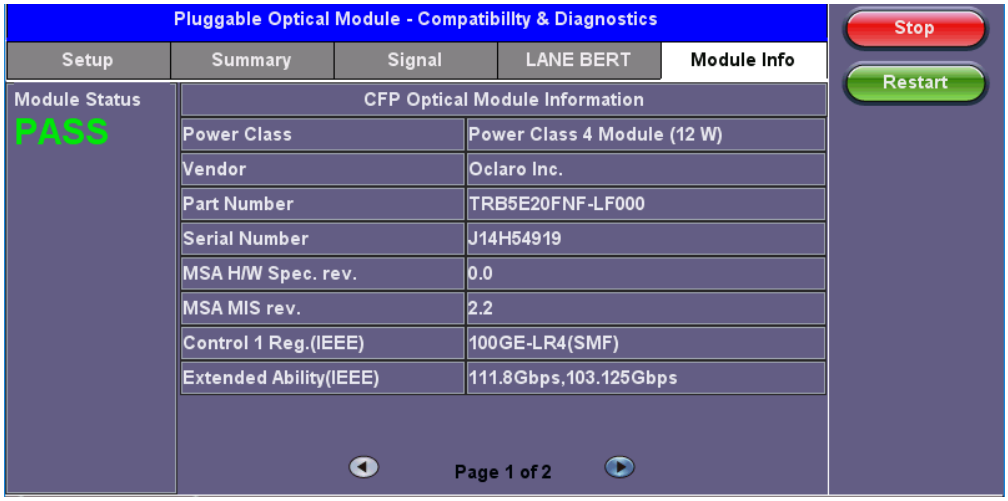


Module Information

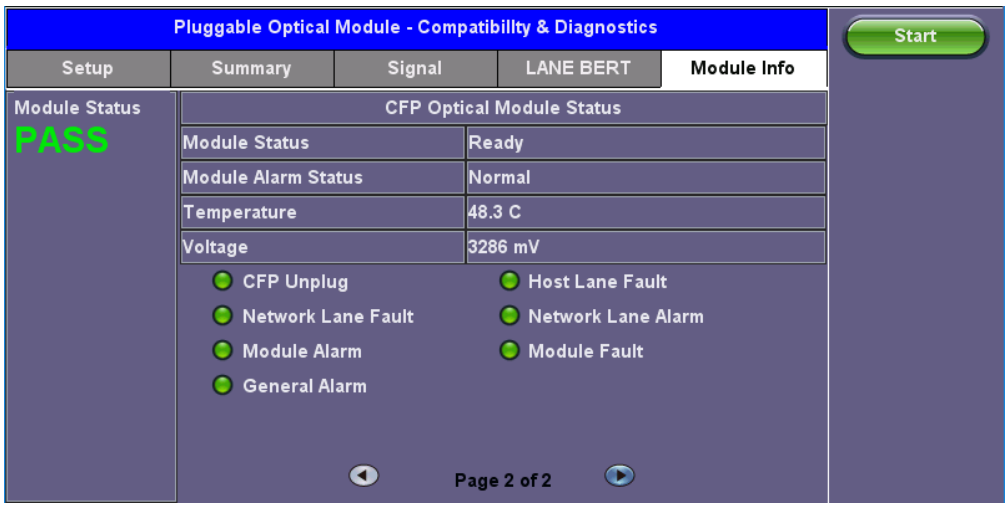
The Module Info tab displays Optical module information and status.

Pass/Fail Module status is displayed on the left.

Optical Module Information



Optical Module Status



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11.0 Warranty and Software

Warranty Period: The warranty period for hardware, software and firmware is three (3) years from the date of shipment to the customer. The warranty period for battery pack, LCD, LCD touch panel, LCD protective cover, and accessories (including but not limited to patch cords, AC adaptor, SFP, USB adaptors, carrying case, carrying pouch) is limited to one (1) year.

Hardware Coverage: VeEX Inc. warrants hardware products against defects in materials and workmanship. During the warranty period, VeEX will, at its sole discretion, either

- Repair the products
- Replace hardware which proves to be defective

provided that the products that the customer elects to replace is returned to VeEX Inc. by the customer along with proof of purchase within thirty (30) days of the request by the customer, freight prepaid.

Software Coverage: VeEX Inc. warrants software and firmware materials against defects in materials and workmanship. During the warranty period, VeEX will, at its sole discretion, either

- Repair the products
- Replace the software and/or firmware which prove to be defective

provided that the products that the customer elects to replace is returned to VeEX Inc. by the customer along with proof of purchase within thirty (30) days of the request by the customer, freight prepaid.

Additionally, during the warranty period, VeEX Inc. will provide, without charge to the customer, all fixes, patches and enhancements to the purchased software, firmware and software options. VeEX Inc. does not warrant that all software or firmware defects will be corrected. New enhancements attached to a software option require the option to be purchased (at the time of order or the time of upgrade) in order to benefit from such enhancements.

Limitations: The warranty is only for the benefit of the customer and not for the benefit of any subsequent purchaser or licensee of any merchandise (hardware, software, firmware and/or accessories).

Revoking the warranty: VeEX Inc. does not guarantee or warrant that the operation of the hardware, software or firmware will be uninterrupted or error-free. The warranty will not apply in any of the following cases:

- Improper or inadequate maintenance by the customer
- Damage due to software installed by the customer on the unit without prior authorization (written) from VeEX Inc.
- Unauthorized alteration or misuse
- Damage occurred from operating the unit from outside of the environmental specifications for the product
- Improper installation by the customer

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12.0 Product Specifications

Product specifications are available for download in PDF format on the VeEX customer website. Please note that Adobe Reader version 9.0 or higher is needed to open and view the file.

To get the latest free version of Adobe Reader, click here.

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13.0 Certifications and Declarations

Declaration of Conformity

What is CE?

The CE marking is a mandatory European marking for certain product groups to indicate conformity with the essential health and safety requirements set out in European Directives. To permit the use of a CE mark on a product, proof that the item meets the relevant requirements must be documented.
Use of this logo implies that the unit conforms to requirements of European Union and European Free Trade Association (EFTA). EN61010-1

For a copy of the CE Declaration of Conformity relating to VeEX products, please contact VeEX customer service.

ROHS Statement

What is RoHS?

RoHS is the acronym for Restriction of Hazardous Substances. Also known as Directive 2002/95/EC, it originated in the European Union and restricts the use of specific hazardous materials found in electrical and electronic products. All applicable products imported into the EU market after **July 1, 2006** must pass RoHS compliance.

Click here for ROHS Statement relating to VeEX products

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14.0 About VeEX

VeEX Inc., the Verification EXperts, is an innovative designer and manufacturer of test and measurement solutions addressing numerous technologies. Global presence through a worldwide distribution channel provides uncompromised product support.

Visit us online at www.veexinc.com for latest updates and additional documentation.

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