USER MANUAL

- TX300sm
- TX320sm
- MTTplus-320
- RXT-3000
- UX400-Combo

Multi-Service Test Modules

OTN, SDH/SONET, PDH/DSn, Ethernet, Fibre Channel, CPRI/OBSAI, Teleprotection, Synchronization

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Table of Contents

1.0 About This User Manual

2.0 Introduction

3.0 Safety Information

4.0 Basic Operations

5.0 Utilities

6.0 Setup

6.1 Signal Overview

6.2 Setup: PDH

6.2.1 Transmitter Setup

6.2.2 Receiver Setup

6.3 Setup: SDH

6.3.1 Transmitter Setup

6.3.2 Receiver Setup

6.4 Setup: SONET

6.4.1 Transmitter Setup

6.4.2 Receiver Setup

6.5 Setup: OTN/SDH

6.5.1 Transmitter Setup

6.5.2 Receiver Setup

6.6 Setup: OTN/SONET

6.6.1 Transmitter Setup

6.6.2 Receiver Setup

6.7 Measurement Configuration

6.7.1 Timer Setup

6.7.2 Performance Analysis

6.7.3 General

6.7.4 Auto-Config

7.0 Results

7.1 Results: PDH

7.1.1 Summary

7.1.2 Errors and Alarms

7.1.3 Event Log

7.1.4 Signal

7.1.5 Histogram

7.1.6 Graph

7.1.7 Performance Analysis

7.2 Results: SDH

7.2.1 Summary

7.2.2 Errors and Alarms

7.2.3 Event Log

7.2.4 Signal

7.2.5 Histogram

7.2.6 Graph

7.2.7 Performance Analysis

7.3 Results: SONET

7.3.1 Summary

7.3.2 Errors and Alarms

7.3.3 Event Log

7.3.4 Signal

7.3.5 Histogram

7.3.6 Graph

7.3.7 Performance Analysis

7.4 Results: OTN

7.4.1 Summary

7.4.2 Errors and Alarms

8.0 Alarms/Errors

8.1 Alarm Generation

8.1.1 PDH Alarms

8.1.2 SDH Alarms

8.1.3 OTN Alarms

8.2 Error Insertion

8.2.1 PDH & T-Carrier Errors

8.2.2 SDH Errors

8.2.3 OTN Errors

9.0 OTN Tools

9.1 Shortcuts

9.2 Overhead Analyzer & Generator

9.2.1 OTN Frame Analysis

9.2.2 Optical Transport Unit (OTU) Analysis

9.2.3 Optical Data Unit (ODU) Analysis

9.2.4 Optical Payload Unit (OPU) Analysis

9.3 Payload Label

9.4 Trace Identifier

9.5 TCM Tasks

10.0 SDH/SONET Tools

10.1 SDH/SONET Tools

10.1.1 Shortcuts

10.1.2 Overhead Analyzer

10.1.3 Overhead Generator

10.1.4 Pointer Tasks

10.1.4.1 Pointer Analysis

10.1.4.2 Pointer Generation

10.1.4.3 Pointer Sequences

10.1.5 Trace Identifier

10.1.5.1 Transmitted Traces (TX)

10.1.5.2 Received Traces (RX)

10.1.6 Payload Labels

10.1.7 APS Tasks

10.1.7.1 APS Timing

10.1.7.2 APS Sequence

10.1.8 Tandem Connection Monitoring (TCM)

10.1.9 Tributary Scan

10.1.10 Round Trip Delay

10.1.11 Jitter and Wander

10.2 SONET Tools

10.2.1 Shortcuts

10.2.2 Overhead Analyzer

10.2.3 Overhead Generator

10.2.4 Pointer Tasks

10.2.4.1 Pointer Analysis

10.2.4.2 Point Generator

10.2.4.3 Pointer Sequences

10.2.5 Trace Identifier

10.2.5.1 Transmitted Traces (TX)

10.2.5.2 Received Traces (RX)

10.2.6 Payload Labels

10.2.7 APS Tasks

10.2.7.1 APS Timing

10.2.7.2 APS Sequence

10.2.8 Tandem Connection Monitoring (TCM)

10.2.9 Tributary Scan

10.2.10 Round Trip Delay

10.2.11 Jitter and Wander

11.0 PDH Tools

11.1 E1 Pulse Mask

11.2 E3 Pulse Mask

11.3 E1 APS Testing

11.4 E1 Frame Words

11.5 Round Trip Delay

11.6 E1 RX Data

11.7 E1 ISDN PRI

11.7.1 ISDN PRI Call

11.7.1.1 Setup (PRI Call Setup)

11.7.1.2 Signal

11.7.1.3 Call - Voice and 3.1K Audio Setup

11.7.1.4 Call - Data Setup

11.7.1.5 Data Call BERT Results (Result tab)

11.7.1.6 Supplementary Service Scan

11.7.1.7 Multi Call

11.7.1.8 DTMF

11.7.2 ISDN PRI Monitor

11.8 E1 VF

11.9 Jitter & Wander

12.0 DS1/3 Tools

12.1 DS1 Pulse Mask

12.2 DS1 Loop

12.3 Round Trip Delay

12.4 DS1 RX Data

12.5 DS3 Pulse Mask

12.6 DS3 FEAC

12.7 DS1 ISDN PRI

12.8 DS1 VF Tasks

12.9 Jitter & Wander

12.10 CSU/NIU Emulation

13.0 Jitter and Wander Application

13.1 Jitter Measurement & Generation (Jitter icon)

13.2 Max Jitter Tolerance

13.3 Jitter Transfer Function

13.4 Wander Measurement

13.4.1 Setup

13.4.2 Wander Result

13.4.3 Wander Analysis PC Software

14.0 OTU-Xe

14.1 OTU-Xe Overview

14.2 OTN Setup

14.2.1 Signal Setup

14.2.1.1 Hierarchy

14.2.1.2 Interface

14.2.1.3 Pattern

14.2.2 Measurements

14.2.3 General

14.3 OTN Results

14.3.1 Summary

14.3.2 Errors/Alarms

14.3.3 Event Log

14.3.4 Signal

14.4 OTU-Xe Ethernet Applications

14.4.1 OTU-Xe with 10GE BERT

14.4.2 OTN/10GE RFC 2544 Conformance Testing

14.4.3 OTN/10GE Throughput Testing (Multiple Streams)

15.0 Ethernet

15.1 Ethernet Setup

15.1.1 Test Port Selection

15.1.2 Port Setup

15.1.3 Measurement Settings

15.1.3.1 Clock Synchronization Process

15.1.4 MX Discover and Control

15.1.5 ViPAG Router Test

15.2 BERT

15.2.1 BERT Setup

15.2.1.1 Header Settings

15.2.1.2 Traffic Settings

15.2.1.3 Error Injection

15.2.1.4 Starting/Stopping a BERT

15.2.2 Results

15.2.2.1 Summary

15.2.2.2 Errors

15.2.2.3 Events

15.2.2.4 Traffic

15.2.2.5 Rates

15.2.2.6 Delay

15.2.2.7 Alarms

15.2.2.8 Signal

15.3 RFC 2544 Conformance Testing

15.3.1 Setup - Standard Mode

15.3.1.1 Header Settings

15.3.1.2 Frame Settings

15.3.1.3 Threshold Settings

15.3.1.4 Peer-to-Peer and Asymmetric Testing

15.3.1.5 Throughput, Latency, Frame Loss, and Burst Settings

15.3.1.6 Starting/Stopping a RFC 2544 Measurement

15.3.2 Results - Standard Mode

15.3.3 Saving RFC 2544 Results

15.3.4 Advanced SLA Mode

15.3.5 Background Results - Advanced SLA Mode

15.4 V-SAM

15.4.1 V-SAM Setup

15.4.1.1 Header Settings

15.4.1.2 Service Attributes

15.4.2 Results

15.5 Throughput Testing (Multiple Streams)

15.5.1 Setup

15.5.1.1 General Throughput Settings (Global Configuration)

15.5.1.2 MX Discover and Control Settings

15.5.1.3 Per Stream Configurations

15.5.1.4 Traffic Settings (Per Stream Configuration)

15.5.1.5 Error Injection Settings per Stream

15.5.1.6 Summary

15.5.1.7 Starting/Stopping a Throughput (Multiple Streams) Test

15.5.2 Throughput Results

15.5.2.1 Viewing Throughput (Multiple Streams) Test Results

15.5.2.2 Global/Aggregate Results

15.5.2.3 Per Stream Results

15.5.2.4 Saving Throughput (Multiple Streams) Results

15.6 Ethernet OAM Testing

15.6.1 OAM Setup

15.6.1.1 Link Level 802.3ah OAM Setup

15.6.1.2 Service Level OAM: 802.1ag/Y.1731 Setup

15.6.2 OAM Results

15.6.2.1 Link OAM Results

15.6.2.2 OAM Service Results

15.7 Monitor (Pass Through) Mode

15.7.1 Setup

15.7.2 Results

15.8 Loopback Mode

15.9 Advanced Tools

15.10 SyncE

15.10.1 SyncE Setup

15.10.2 SyncE Wander Measurements

15.11 1588v2

15.11.1 IP and Port Setup

15.11.2 Mode Setup

15.11.2.1 Master Emulation Mode Setup

15.11.2.2 Master Clock Settings

15.11.2.3 Slave Emulation Mode Setup

15.11.2.4 Slave Clock Settings

15.11.3 Test Results

15.11.4 Protocol Monitor

16.0 Fiber Channel

16.1 Setup

16.1.1 Test Applications

16.1.2 Port Configuration

16.2 BERT/Throughput

16.2.1 Overview

16.2.2 Setup

16.2.3 Traffic Generation and Error Injection

16.2.4 Starting Measurements

16.2.5 Results

16.3 RFC 2544

16.4 Loopback

17.0 CPRI Optical Testing

17.1 Interface Specifications

17.2 CPRI Testing

17.2.1 CPRI Unframed Setup

17.2.1.1 Test Pattern

17.2.1.2 Traffic Pattern

17.2.1.3 Error Injection

17.2.2 Results

17.2.2.1 Summary

17.2.2.2 Signal

17.2.2.3 Errors

17.2.2.4 Alarms

17.2.2.5 Events

17.2.2.6 Saving and Retrieving Results

17.3 CPRI Layer 1 Framed Testing

17.3.1 Setup

17.3.2 Results

17.4 CPRI Layer 2 Framed Testing

17.4.1 Setup

17.4.2 Results

17.4.3 CPRI Round Trip Delay

17.4.4 SDT

17.4.5 Control Words

18.0 IEEE C37.94™ Testing (TX320s only)

18.1 Introduction

18.2 Getting Started

18.3 Testing C37.94

18.3.1 Test Setup

18.3.2 Test Results

18.3.3 Test Profiles

18.3.4 Round Trip Delay (RTD)

18.3.5 C37.94 Data (Received)

19.0 Profiles

20.0 Common Functions

21.0 Warranty and Software

22.0 Product Specifications

23.0 Certifications and Declarations

24.0 About VeEX

Go back to top

1.0 About This User Manual

This user manual is suitable for novice, intermediate, and experienced users and is intended to help you successfully use the features and capabilities of the different modules for test platforms. It is assumed that you have basic computer experience and skills, and are familiar with IP and telecommunication concepts, terminology, and safety.

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.

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For more technical resources, visit the VeEX Inc. web site at www.veexinc.com. For assistance or 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 product serial number and software version ready. Please go to the Basic Operations section of the TX300S Platform Manual for details on locating the unit serial number in the menus or locate the serial number on the back of the chassis. Please provide this number when contacting VeEX customer service.

Customer Care:

Phone: + 1 510 651 0500

E-mail: customercare@veexinc.com

Website: www.veexinc.com

Go back to top Go back to TOC

2.0 Introduction to Multi-Service Test Modules

VeEX offers a variety of flexible Multi-Service Test Modules covering a wide range of transmission technologies, protocols, verification and troubleshooting test features, from 64 kbit/s up to 11Gbit/s. They also share similar user interfaces to ease the transitioning from one product or platform to another.

This manual describes all the features that may be available to any of the following test sets or modules:

- TX300S with one or two TX300sm blades
- TX300S with TX320sm blade
- RXT-3000 module
- MTTplus-320 module
- UX400-Combo module

These Multi-service Test Modules are based on an all-inclusive hardware that includes all physical interfaces to cover legacy and modern transmission technologies. They provide all the flexibility to allow the activation of new technologies, rates, protocols and test features via licenses, as required, without having to return the test set to a service center.

Features and functions availability may vary depending on the installed modules, so please refer to the latest datasheet and become familiar with the version you have.

- XFP and SFP Optical Test Ports or Dual SFP/SFP+ Optical Test Ports
- RJ45 10/100/1000Base-T Test Ports
- BNC and RJ48/Bantam Electrical Test Ports (PDH/DSn and clock output)
- External Clock Reference Input (SMA, 75 Ohms)
- May use Platforms' GPS or Atomic Clock References (optional HW)
- Headset audio jack (2.5mm TRS) on the module or test platform
- VeExpress Client (not available for UX400)
    - Test features and technologies can be added on the go, via VeExpress (cloud based) or manually (using license keys), directly on the test set.
    - Keeps test platform and modules software up-to-date
    - Keeps licenses up-to-date
    - Allows License Sharing among TX300S users
- R-Server Client option
    - Upload Test Results and Test Profiles to a centralized server

Transport Networks:

- OTN
    - OTU1, OTU2, OTU1e, OTU2e Line Rates
    - ODU0, ODUflex mappings
    - Bulk (PRBS), SDH/SONET+PDH/DSn and Ethernet Payloads
- SDH/SONET
    - STM-0 to STM-64
    - STS-1 to OC-192
    - Bulk (PRBS) and PDH/DSn Payloads
- PDH/DSn
    - DS1, DS3, E1, E3, E4
    - Unframed, Framed and Structured (Channelized) Payloads
    - ISDN PRI, VF Channel Access
    - G.703 64k Codirectional Interface
- Teleprotection
    - IEEE C37.94 (TX320sm and MTTplus-320 only)

Packet Switched Networks

- Ethernet
    - From 10 Mbps to 10 Gbps LAN/WAN, copper and fiber
    - IPv4/IPv6, VLAN, MPLS, MPLS-TP, PBB, VoIP, IPTV,…
    - RFC2544 SLA, Y.1564 V-SAM, OAM/MPLS-TP OAM (802.3ah, 802.1ag, Y.1731, G.8113.1)
    - Layer 4 Throughput applications: V-PERF (TCP), VeTest (HTTP), FTP
- SyncE

    - Master and Slave Emulation
    - Clock Recovery and Translation
    - Wander Measurements
- 1588v2 PTP (Precision Timing Protocol)
    - Master and Slave Emulation with Clock Recovery and Translation
    - PTP Message Capture, Decode and Export (pcap)
    - Wander and Phase Measurements
- Fibre Channel (Storage Area Networks)
    - 1, 2, 4, 8 and 10 Gbps

Wireless Networks

- CPRI
    - Common Public Radio Interface
    - From 614.4 Mbps up to 9.8304 Gbps
- OBSAI
    - Open Base Station Architecture Initiative
    - From 768 Mbps up to 6.144 Gbps
- Clock Accuracy and Stability Assessment
    - Wander Measurement and Analysis
    - Absolute Phase (Timing) Error Measurement and Analysis (1PPS clocks)
    - External or built-in precision reference clocks (GPS and Atomic options)
- Backhaul Testing
    - Ethernet, VLAN, Q-in-Q, MPLS-TP, OAM,…
    - 1588v2 PTP, SyncE
    - Clock Stability (Wander) and Timing Accuracy (Phase)

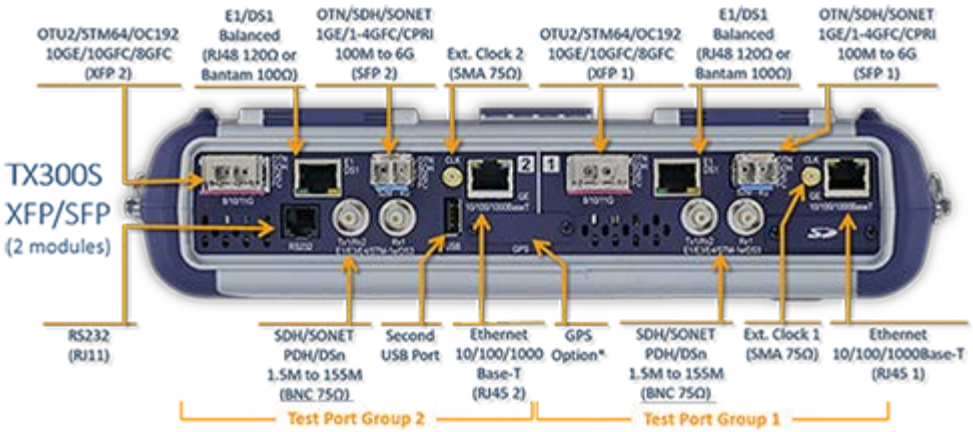
Network Synchronization

- Synchronous Ethernet (SyncE)
    - Master/Slave Emulation with clock recovery/translation and SSM/ESMC Monitor
- 1588v2 / PTP (Precision Timing Protocol)
    - Master/Slave Emulation with clock recovery/translation, PDV Analysis and SSM/ESMC Monitor
- Wander Measurement & Analysis
    - Recovered Clock Accuracy and Stability assessment
    - Long term TIE log and MTIE/TDEV post processing with Pass/Fail analysis based on standard or user-defined masks
- Built-in Precision Reference Clock Options (TX300S Platform)
    - GPS provides accurate phase aligned to the standard UTC second
    - Atomic Clock provides high stability, required for field wander and phase measurements
    - Portability - No physical reference signal or power are required
- One-way Delay Measurements
    - 1588v2 PTP requires the links to be symmetrical (similar delay both directions)

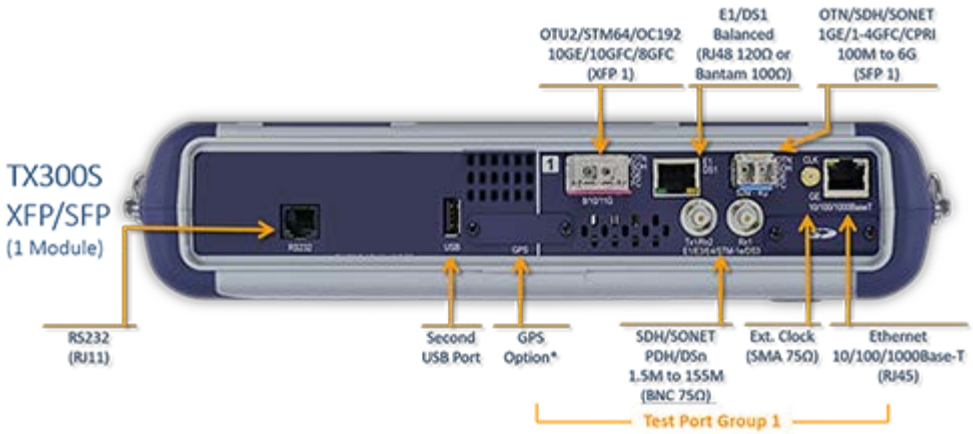
Not all features and options described in this manual may be available or installed in your test set, since they depend on the specific configuration and options purchased. Please refer to those that apply to your particular test set configuration. Please check the product datasheet for further details.

2.1 Connector Panels & Test Ports

TX300S with two TX300SM blades

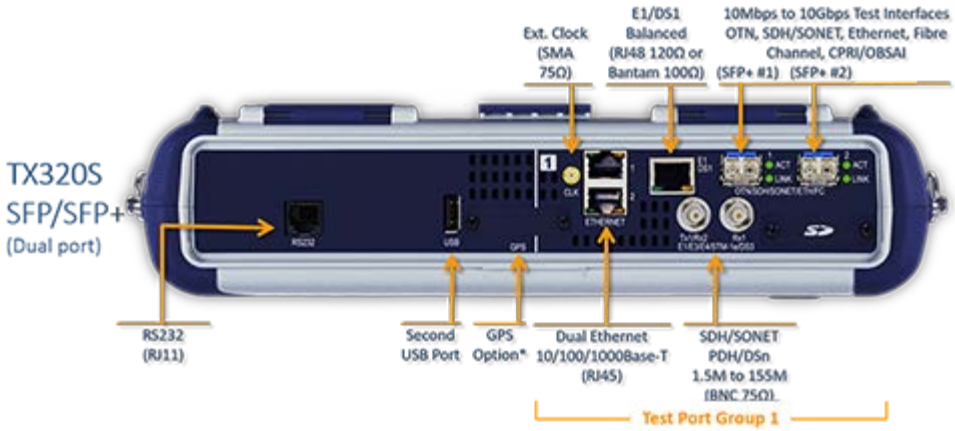


TX300S with one TX300SM blade



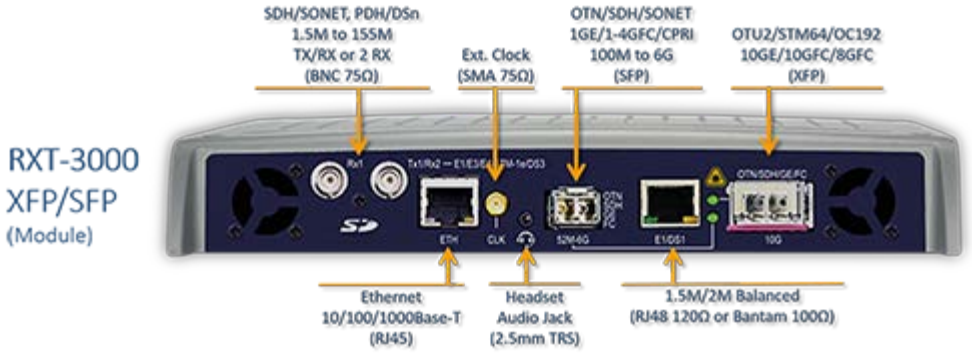
Note: A separate test module may also be installed in the test port group 2 (e.g. OTDR module)

TX300S with one TX320SM blade

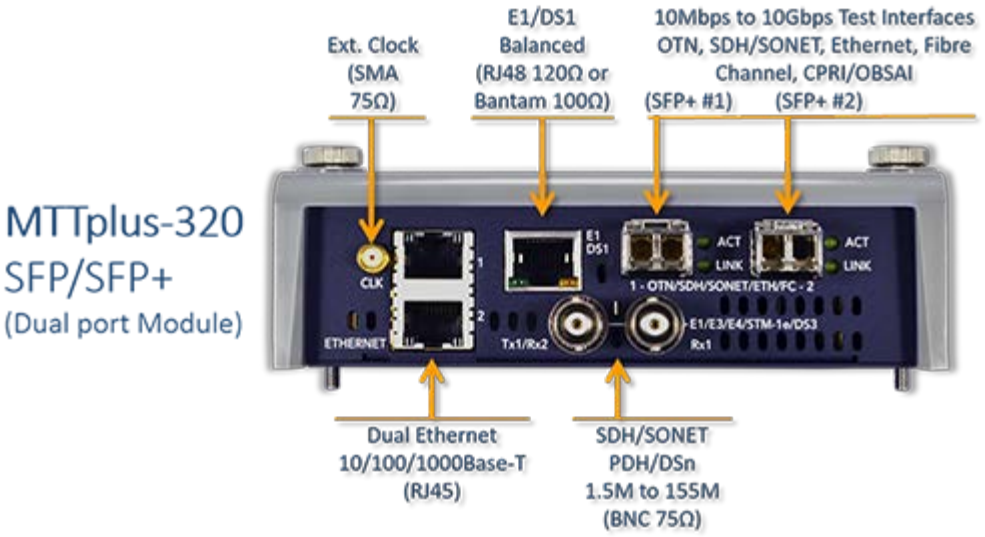


Note: A separate test module may also be installed in the test port group 2 (e.g. OTDR or 100G/40G module)

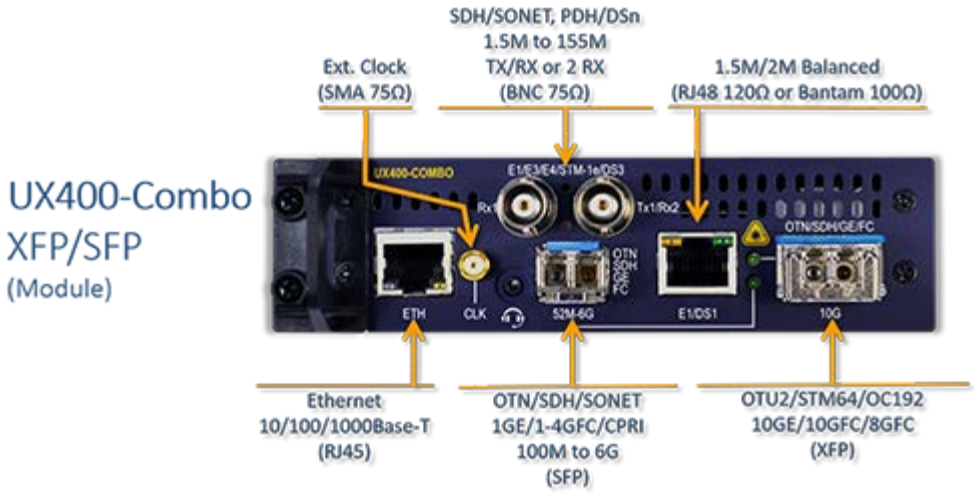
RXT-3000 module



MTTplus-320 module



UX400-Combo module



Go back to top Go back to TOC

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 XFP's or SFP's connector interface while the laser is enabled. Even though XFP and SFP 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.

Electrical Connectors

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

Go back to TOC

4.0 Basic Operations

Refer to the TX300S Platform Manual for information about Basic Operations, Home menu, Launching Test Applications etc.

Go back to top Go back to TOC

5.0 Utilities

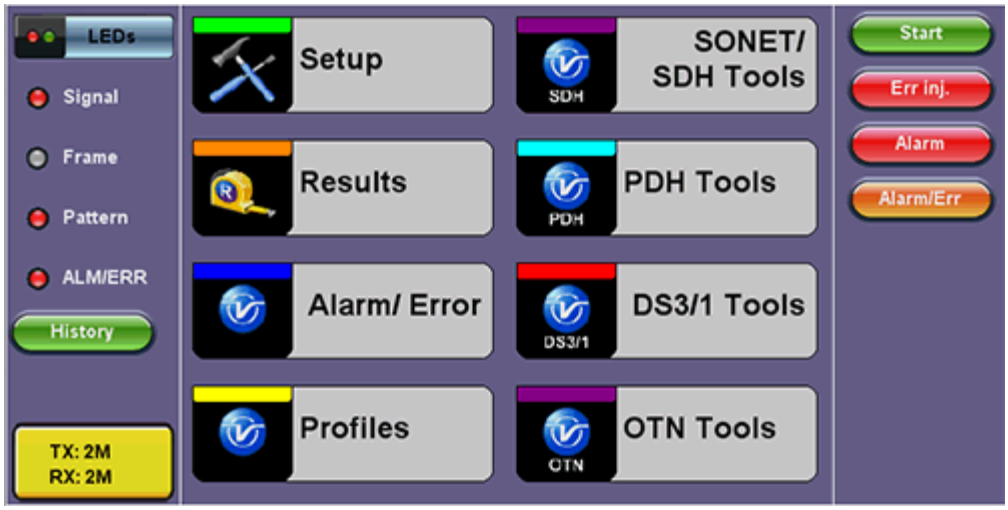
Refer to the TX300S Platform Manual for information about all Utilities and Tools available.

Go back to top Go back to TOC

6.0 OTN, SDH/SONET, PDH/DSn Test Mode

Accessing Setup: Please see the TX300S Platform manual Getting Started section to launch Test Applications.

SONET Home Menu



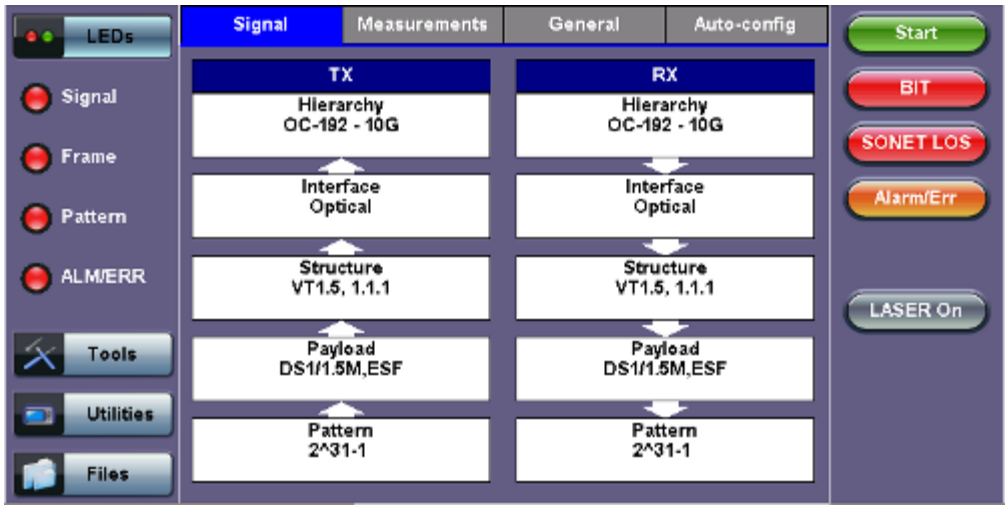
The Setup page has four tabs for setting the OTN, SDH/SONET, and PDH parameters: Signal, Measurements, General, and Auto-Config tabs.

Go back to top Go back to TOC

6.1 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



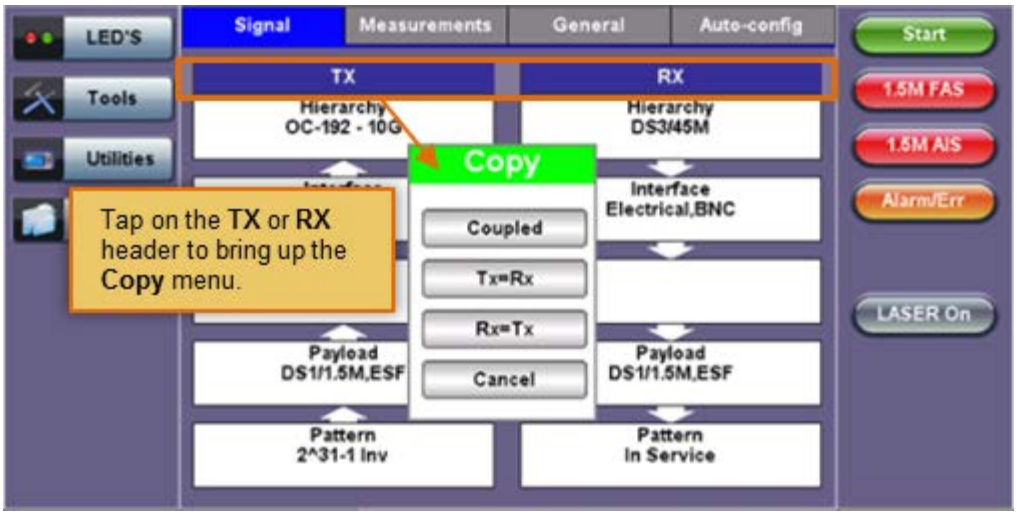
TX and RX Configurations

The Transmitter (TX) and Receiver (RX) configurations are grouped into a simple yet intuitive block diagram. The TX and RX signal parameters 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.

Coupling TX and RX

When the TX and RX signal structures are required to be identical or symmetrical, coupling the Transmitter and Receiver is possible. Tap on the blue "TX" or "RX" 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

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

When the TX and RX signal structures need to be independent or asymmetrical, uncoupling the transmitter and receiver is possible. For example, the TX could be sending a PRBS of 2^23-1 in a VC12 carried within an optical STM-64, while the RX could be expecting to receive a PRBS of 2^23-1 in a 2Mbps E1 signal.

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 STTM-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.

Warning Message

Go back to top Go back to TOC

6.2 Setup: PDH

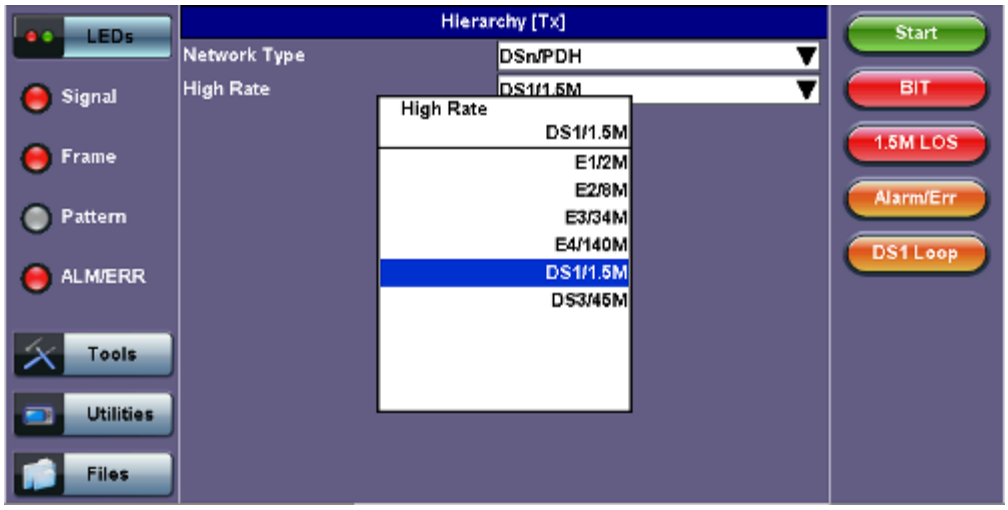
6.2.1 Transmitter Setup

Note: Depending on whether SDH or SONET was selected from the **SDH/SONET** option under the **General** tab (see 6.3 SDH Setup), TX and RX configuration screens will look slightly different, but feature the same options described in this section.

Hierarchy

Tapping the Hierarchy box opens the Tx Hierarchy setup screen. The screen examples shown in this part of the manual depict and describe the settings for 1.5M or DS1 signals. Options for other bit rates and modes are described in text format.

Tx Hierarchy Setup



Network Type: Select PDH as the network type

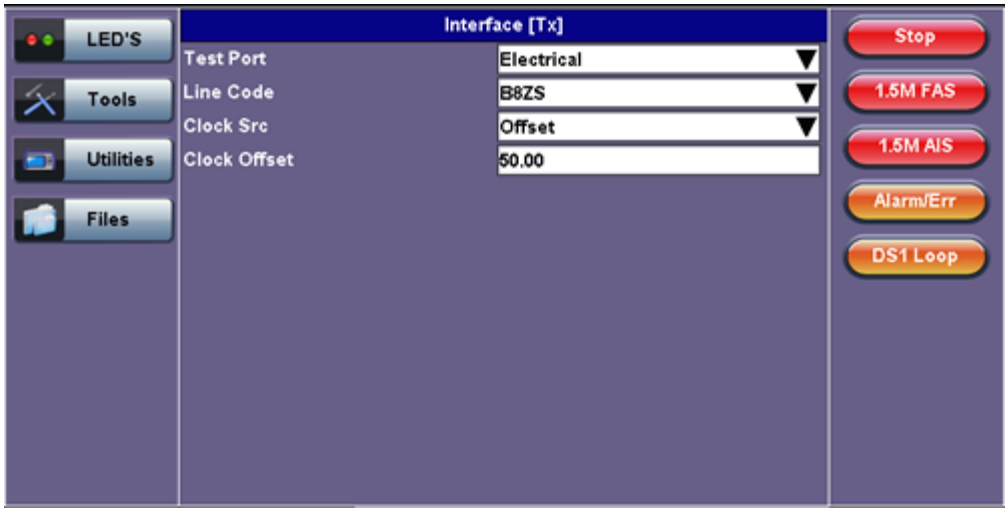
High Rate: Options are 1.5Mbps (DS1), 2Mbps (E1), 8Mbps (E2), 34Mbps (E3), 45Mbps (DS3), 140Mbps (E4)

Go back to top Go back to TOC

Interface

Tapping the Tx Interface box opens the Tx Interface Setup screen shown below.

Tx Interface Setup



Test Port: In PDH mode, only the electrical interface selection is possible.

Line Code:

- In DS1 mode, the line code options default to B8ZS or AMI
- In DS3 mode, the line code is B3ZS or AMI
- In E1 mode, the line code options default to HDB3 or AMI. Normal E1 systems use HDB3 line coding while AMI is reserved for special applications
- In E3 mode, the line code is HDB3 or AMI

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:** 1.5MHz, 2MHz, 1.5Mbps, 2Mbps, and 64kbps signals are present on the SMA connector. Only 2Mbps signals are available on the RX2 balanced and RX2 BNC unbalanced ports.
- **From 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 numeric key to increase and decrease the frequency shift, up to 0.01ppm. Frequency offset: ±50ppm with 1, 0.1, 0.01ppm resolution.

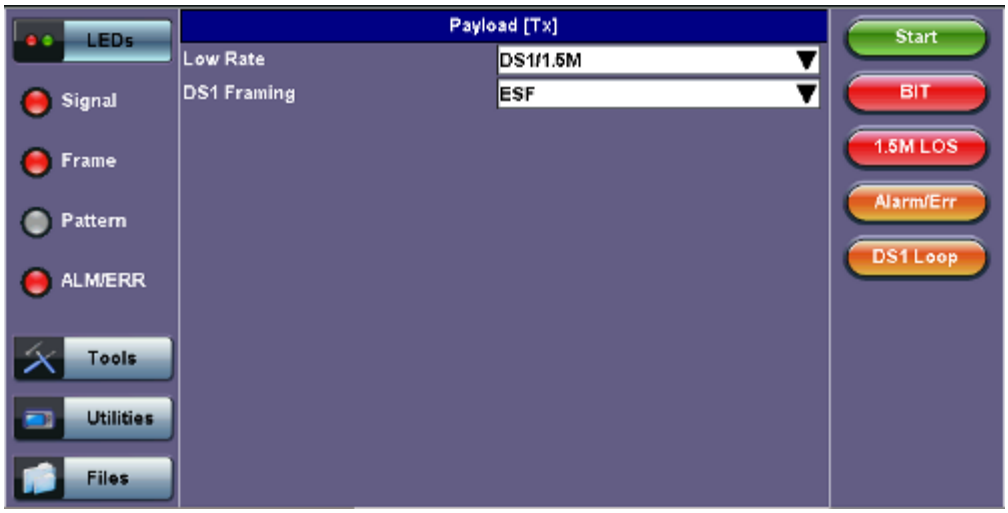
Balanced: Check when using the RJ-45 connectors. The transmitter output impedance will be set to 120 ohms. The Primary test port is "1" on top panel. If unchecked, the unit will assume that testing is taking place on the 75 ohms unbalanced BNC connector for E1 mode.

Go back to top Go back to TOC

Payload

Tapping the Payload box opens the Tx Payload Setup screen.

Tx Payload Setup



Rate:

In DS1 (1.544Mbps) mode, the 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 or 56kbps timeslots (contiguous or non-contiguous timeslots)

In DS3 (45Mbps) mode, the options are 45M, 1.544M Mux (DS3/DS1 Mux) or Fractional DS1Mux where:

- 45M: Configures the transmitter for full rate testing at 45Mbps
- 1.544M (DS3/DS1 Mux): Configures the transmitter for full rate testing at 45Mbps signal with DS1 payloads (1 to 28

channels)
- Fractional DS1 Mux: 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 2M mode, the options are 2M or Fractional E1 (N x64) where:

- 2M: Configures the transmitter for full rate testing at 2.048Mbps
- Fractional E1 (N x64): Configures the transmitter for fractional testing using N or M 64kbps timeslots (contiguous or non-contiguous timeslots)

In E3 (34Mbps) mode, the options are 34M or 2M Mux (E3/E1 Mux) or Fractional E1 (Nx64) Mux where:

- 34M: Configures the transmitter for full rate testing at 34Mbps
- 2M (E3/E1 Mux): Configures the transmitter for full rate testing at 34Mbps signal with E1 payloads (1 to 16 channels)
- Fractional E1 (E3/E1Mux w/ Nx64): 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:

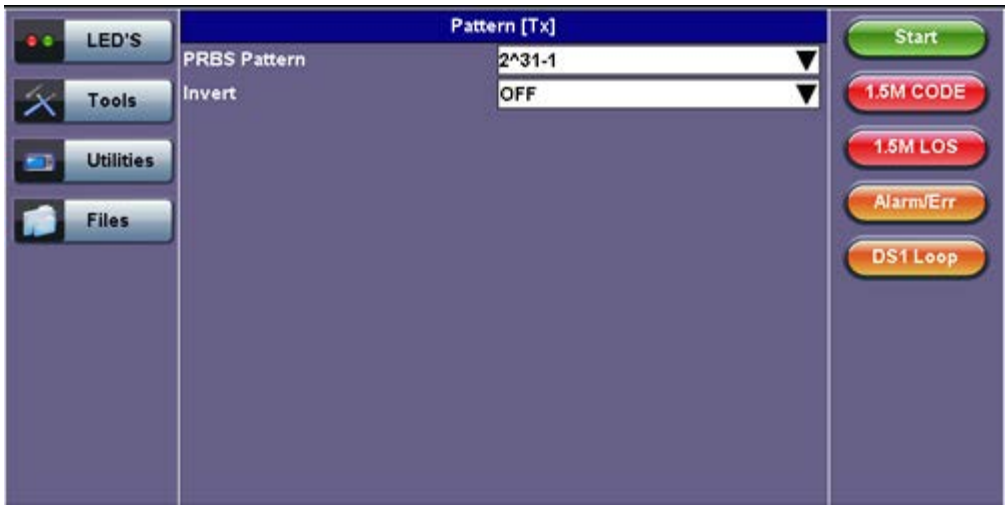
- In DS1 mode, the options are unframed, D4 (SF) and ANSI T1.107 (ESF).
- In DS3 mode, the options are unframed, M13 and C-Parity.
- In E1 mode, the options are unframed, PCM31, PCM31C, PCM30, and PCM30C. Framing conforms to G.704 and G.706 recommendations and are briefly described below.
- In E3 mode,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

Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Tx Pattern Setup screen shown below. The test patterns can be applied to all PDH and SDH rates; however, ITU-T recommends certain sequences depending on the bit rate under test.

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.

Note: ITU-T specification 0.150 recommends the following test patterns:

Test Sequences for PDH signals according to ITU-T 0.150 recommendation		
PRBS	Zeros	Application
2^9-1	8	Error measurements for bit rates ≤ 14,400 kbits/s
2^11-1	10	Error & jitter measurements for bit rates of n x 64 kbit/s & 64 kbits/s
2^15-1	15	Error & jitter measurements for T1, E1, E3 and DS3 bit rates
2^20-1	14	Error & jitter measurements for T1, E1, E3 and DS3 bit rates
2^23-1	23	Error & jitter measurements for E3 and E4 bit rates
2^31-1	31	Delay measurements for E3, DS3 and E4 bit rates

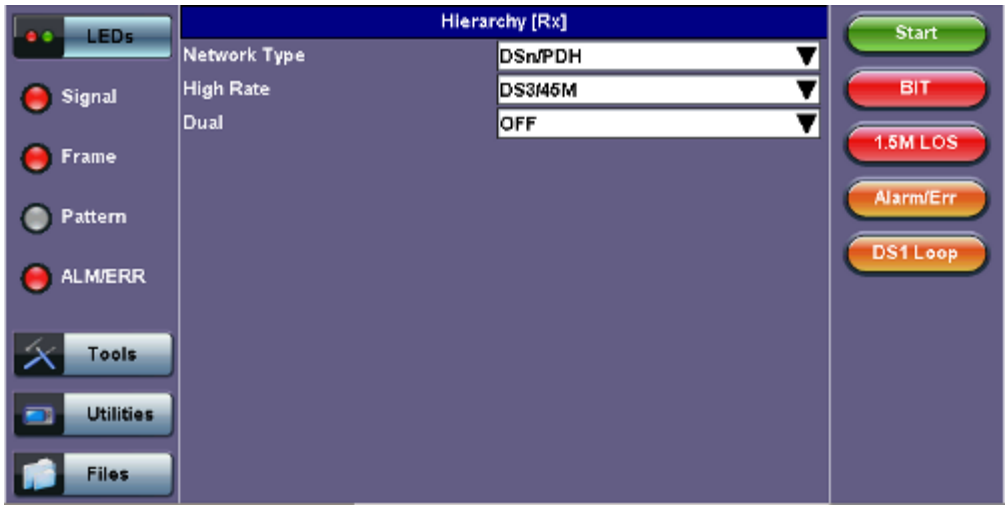
Go back to top Go back to TOC

6.2.2 Receiver Setup

Hierarchy

Tapping the Hierarchy box opens the Rx Hierarchy Setup screen.

Rx Hierarchy Setup



Network Type: Select PDH as the network type

High Rate: Options are 1.5Mbps (DS1), 2Mbps (E1), 8Mbps (E2), 34Mbps (E3), 45Mbps (DS3), 140Mbps (E4)

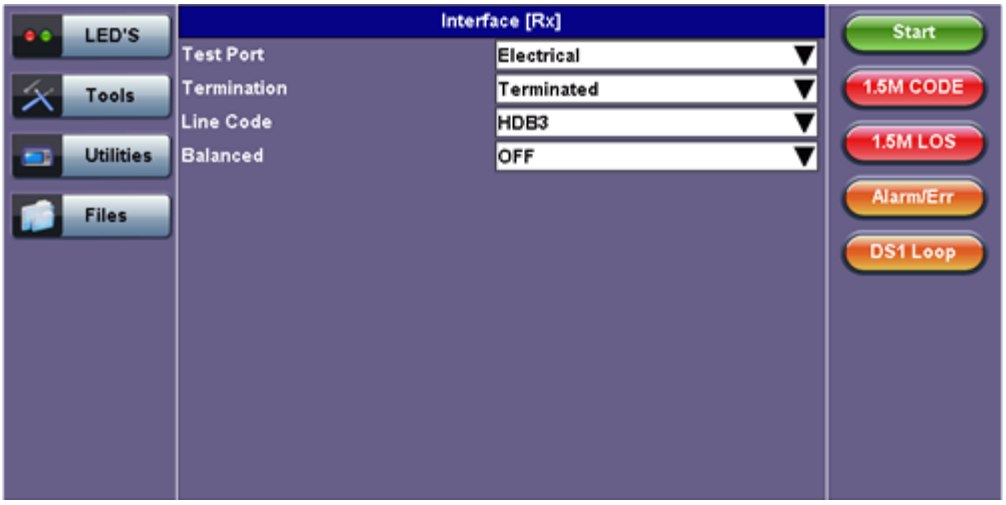
Dual: Dual DS1 or E1 Receiver Option ON/OFF: Receiver 2 sets exact same configuration as Receiver 1

Go back to top Go back to TOC

Interface

Tapping the Interface box opens the Rx Interface Setup screen shown below.

Rx Interface Setup



Test Port: If a PDH structure has been selected in the Hierarchy setup, the optical options will be disabled under the test port menu.

Termination: The sensitivity of the receiver can be set for ITU-T and ANSI, Protected Monitoring Points (PMP) or High Impedance connections. The options under the termination menu are as follows:

- **Terminated:** The received signal is terminated with a 75 ohm or 100 ohm (120 ohm in E1) impedance enabling the unit to decode the signal over a wide range of cable losses.
- **Monitor:** To be used when the measurement is made at a Protected Monitoring Point (PMP) of network equipment. The PMP level can range between -20 and -26dB.
- **Bridge:** Available on in DS1 or E1 mode. Select this mode for a high impedance monitor test or when the receiver is connected directly in parallel to an DS1 or E1 line carrying live traffic. The isolation circuit of the unit protects the DS1 or E1 signal from any possible disruption.

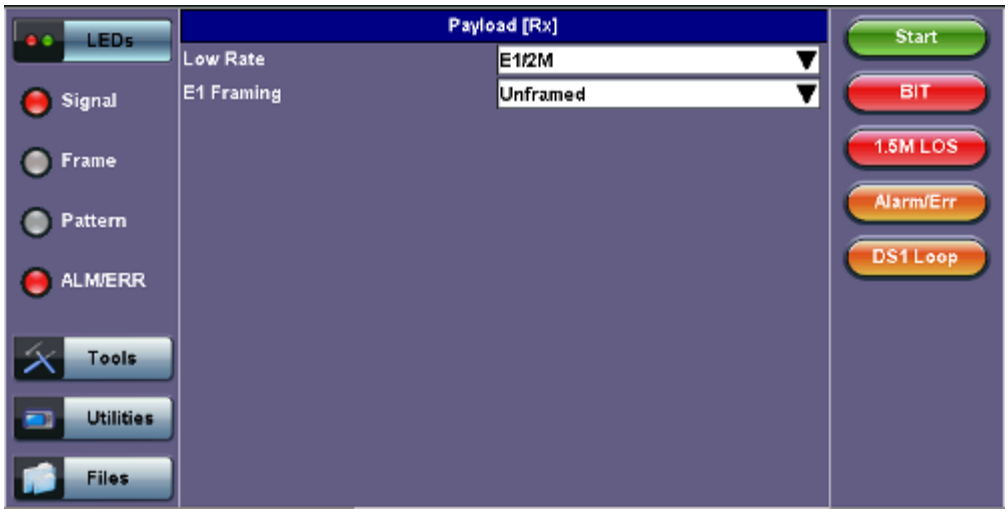
Line Code: The line code for testing at the various Rx bit rates is the same for the Tx described previously. The termination settings in this Rx setup, however, have no effect on the TX.

Go back to top Go back to TOC

Payload

Tapping the Payload box opens the Rx Payload Setup screen. The Rx Payload setup options are the same as for the Tx Payload options described previously.

Rx Payload Setup

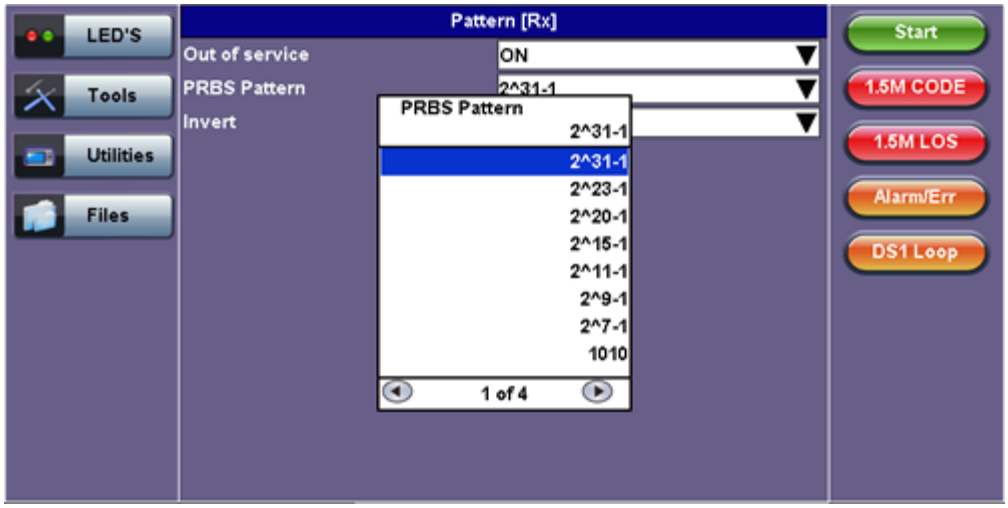


Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Rx Pattern Setup screen shown below.

Rx Pattern Setup



Out of Service: 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 network traffic – this will disable the pattern detection process and will enable the reporting of LSS.

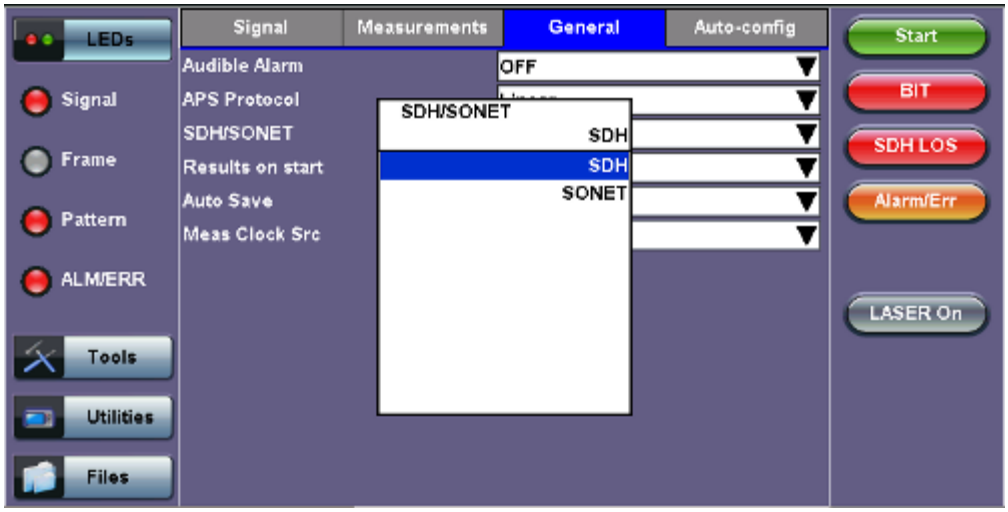
PRBS Pattern: Same options as Transmitter described previously.

Invert: Same options as Transmitter described previously.

Go back to top Go back to TOC

6.3 Setup: SDH

Selecting SDH from the General tab



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

Go back to top Go back to TOC

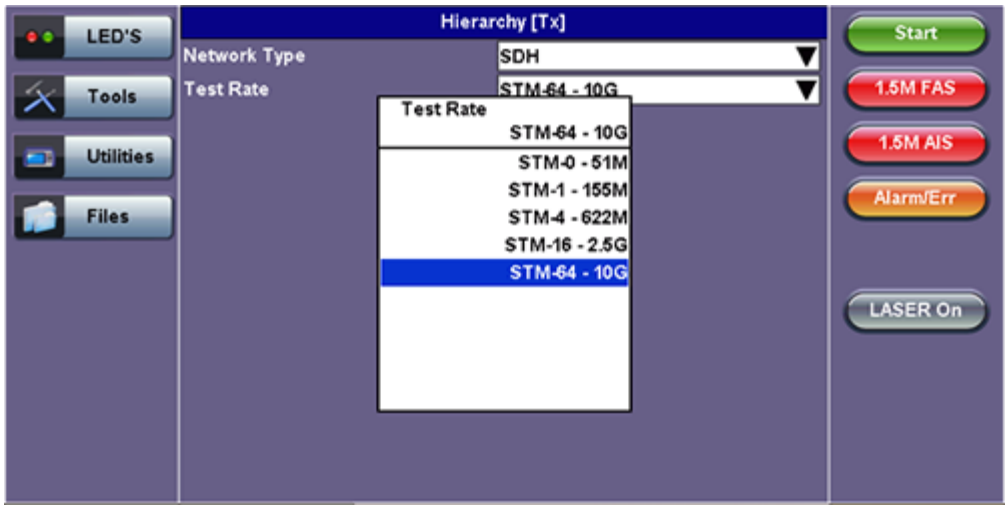
6.3.1 Transmitter Setup

This section of the manual describes the SDH configuration capabilities. The block diagram of the Tx and Rx structure is described in 6.1 Signal Overview.

Hierarchy

Tapping the Hierarchy box opens the Tx Hierarchy Setup screen.

Tx Hierarchy Setup

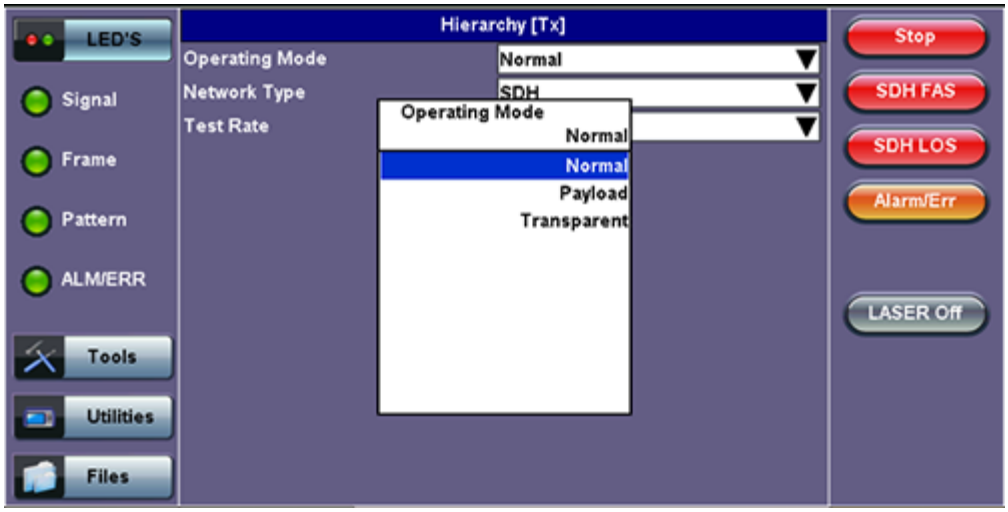


Network Type: In the SDH mode, only optical interface options are available.

Test Rate: Options are STM-0, STM-1, STM-4, STM-16 and STM-64 (referring to 51M, 155M, 622M, 2.5G and 9.953G respectively).

Go back to top Go back to TOC

Tx Hierarchy - Normal Operating Mode



Operating Mode: Normal, Payload, or Transparent

- **Normal Mode:** Unit working as normal SDH mode.
- **Payload Through Mode:** Overhead overwrite Editing Thru mode allows for some intrusive error and alarm injection through overhead manipulation.
- **Transparent Through Mode:** All the traffic goes through the unit untouched and the unit can monitor it. It is comparable to Monitor mode with a 10/90 splitter. In Transparent mode, the unit regenerates the signal in amplitude. The clock is recovered from the received signal.

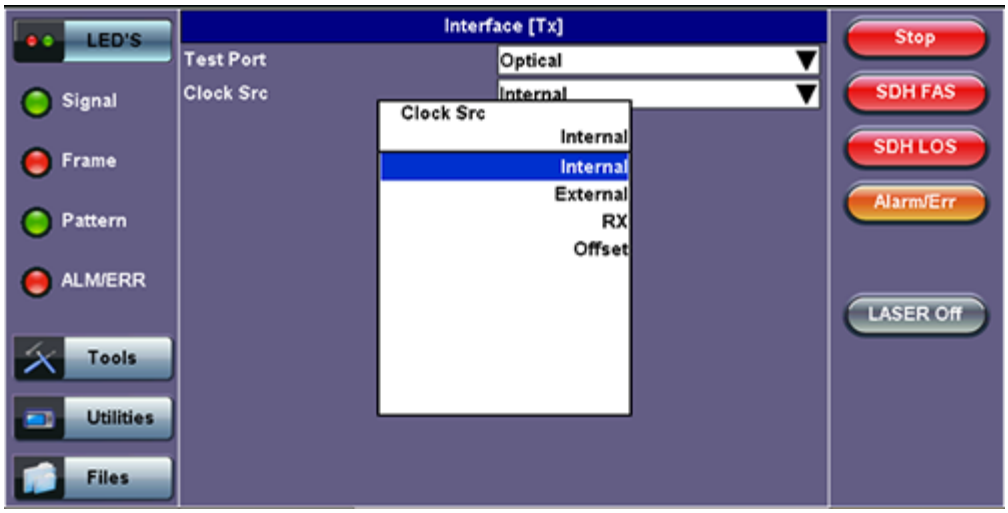
Through modes are used to test network behavior under certain conditions, such as alarms and APS. To select Payload Through, the payload has to be the same for the relevant ports.

Go back to top Go back to TOC

Interface

Tapping the Tx Interface box opens the Tx Interface Setup screen. In this screen, both electrical and optical options can be selected.

Tx Interface Setup



Test Port: Optical or Electrical.

- Optical interface is available for STM-0, STM-1, STM-4, STM-16 and STM-64 signals.
- Electrical interface is available for STM-0E, STM-1E signals.

Clock Source: Can be configured as follows:

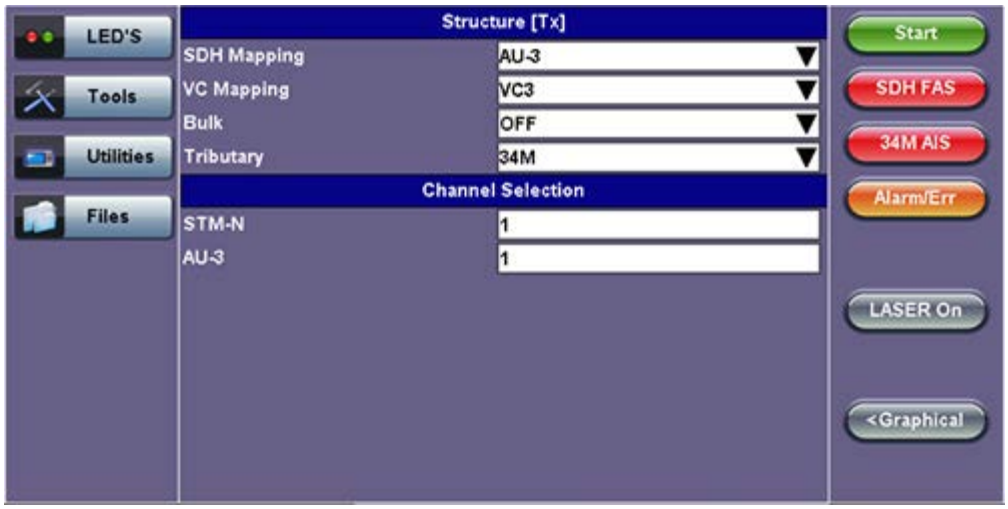
- **Internal clock:** The clock for the transmitter is derived from the internal clock. The internal clock has an accuracy of +/- 3.5ppm conforming to G.812 recommendations.
- **External clock:** The clock for the transmitter is derived from a 1.5MHz, 2MHz, 1.5Mbps, 2Mbps, or 64kbps signal on the SMA, RX2 balanced, or RX2 BNC unbalanced interfaces.
- **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.

Go back to top Go back to TOC

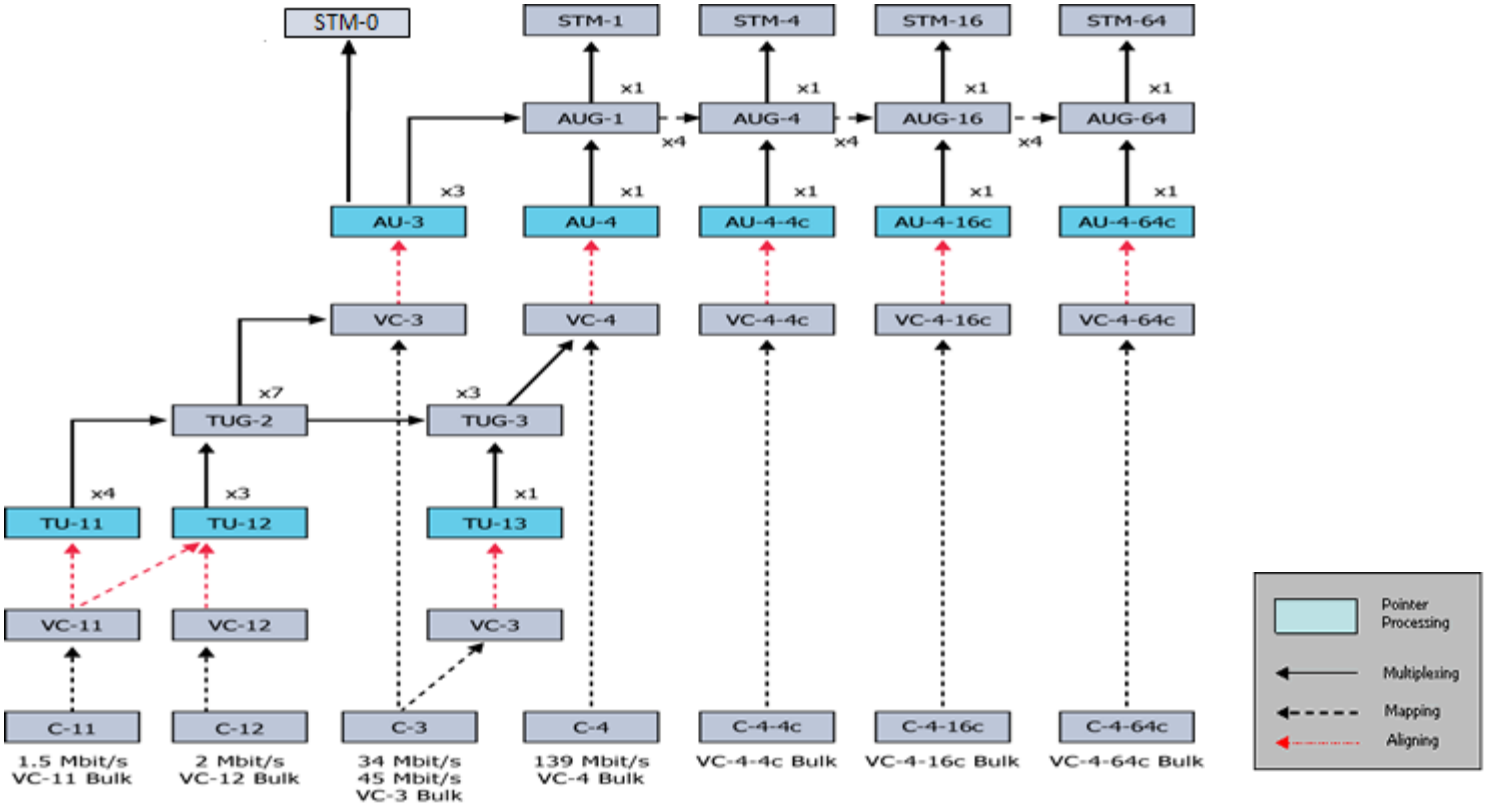
Structure

Tapping the Tx Structure box opens the Tx Structure Setup screen which shows two display modes: Text mode and Graphical mode. Tap on the **Text/Graphical** button to switch between the two modes.

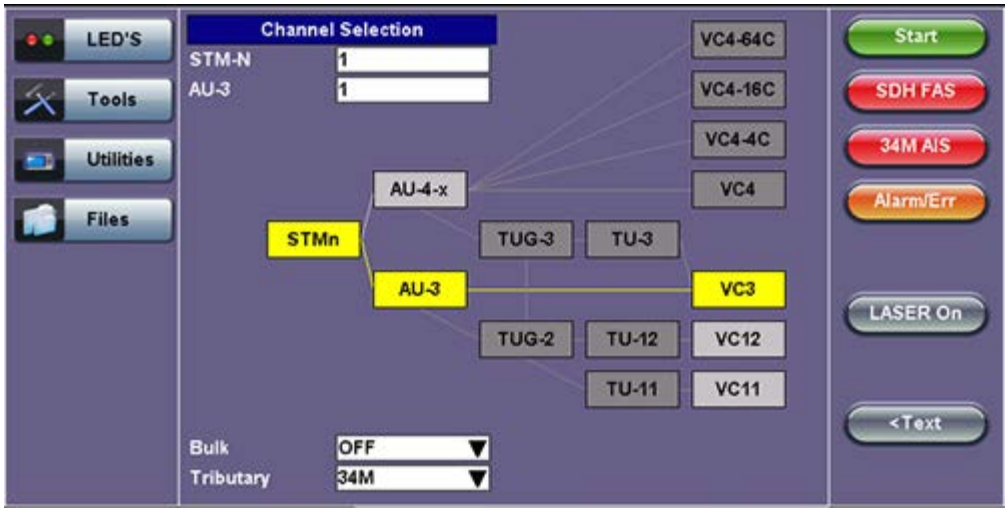
Tx Structure Setup - Text Mode



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



Tx Structure Setup - Graphical Mode



AU4 Mapping: 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 depending upon the options and mapping.

Channel Selection: The Tx channel is selected by entering the STM-N, TUG-3, TUG-2, and TU-12 numbers for the channel.

Note:

- **TUG:** A Tributary Unit Group is the structure generated by combining several lower level tributaries into the next higher level tributary
- **TU-12**: Each TU-12 frame consists of 36 bytes, structured as 4 columns of 9 bytes
    - At a frame rate of 8000Hz, these bytes provide a transport capacity of 2.304Mbps and accommodate the mapping

of a 2.048Mbps signal
- 63 x TU-12s may be multiplexed into a STM-1 VC-4

The tributary numbering used above is per ITU-T G.707 standard.

The high order paths are named using a C, B, A convention as follows:

- C: The AUG-4 are numbered 1 to 4
- B: The AUG-1 are numbered 1 to 4
- A: The AU-3 are numbered 1 to 3

Thus the naming convention per SDH rate is as follows:

- For STM-16: [C, B, A] convention is used
- For STM-4: [B, A] convention is used
- For STM-1 using AU-3 mapping: [A] convention is used
- For STM-1 using AU-4 mapping: [0] convention is used

The low order paths are named using a K, L, M convention as follows:

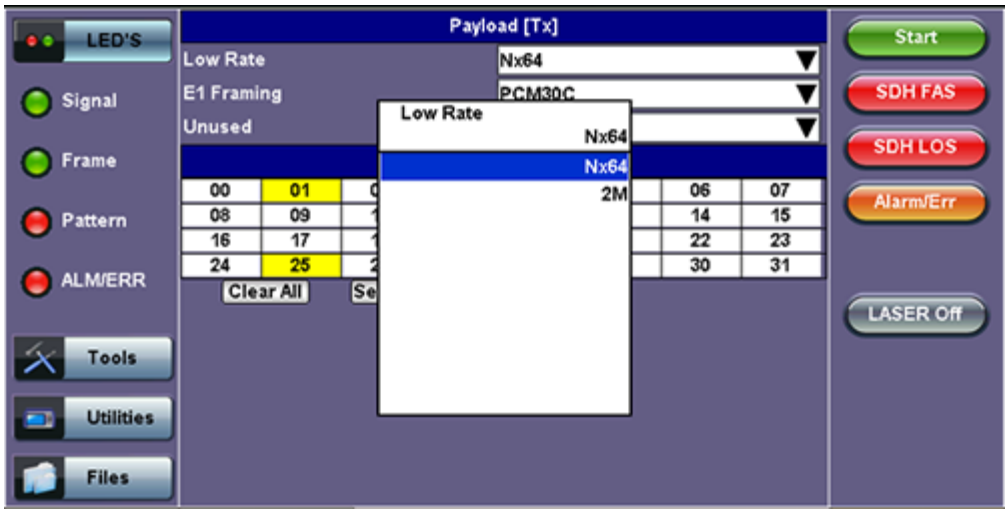
- K: TUG-3 are numbered 1 to 3
- L: TUG-2 are numbered 1 to 7
- M: TU-11, TU12, within the TUG-2 are numbered 1 to 4

Go back to top Go back to TOC

Payload

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

Tx 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:

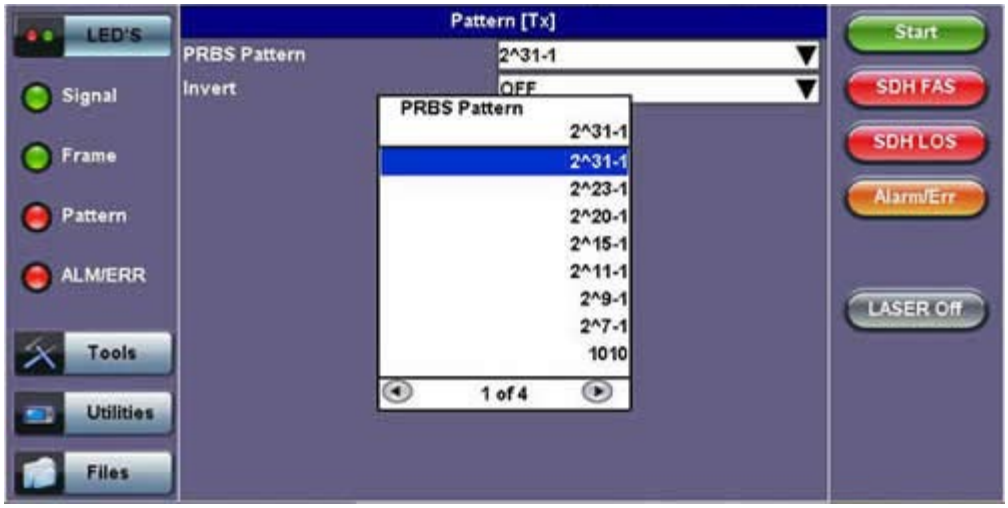
- In DS1 mode, the options are unframed, D4 (SF), and ANSI T1.107 (ESF).
- In DS3 mode, the options are unframed, M13, and C-Parity.
- In E1 mode, the options are unframed, PCM31, PCM31C, PCM30, and PCM30C. Framing conforms to G.704 and G.706 recommendations and are briefly described below.
- In E3 mode,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

Go back to top Go back to TOC

Pattern

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

Tx 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. Note, if the 32 bit user pattern entered is incorrect, the default pattern will be 0xFFFFFFFF.

Invert: Inversion of polarity is also available.

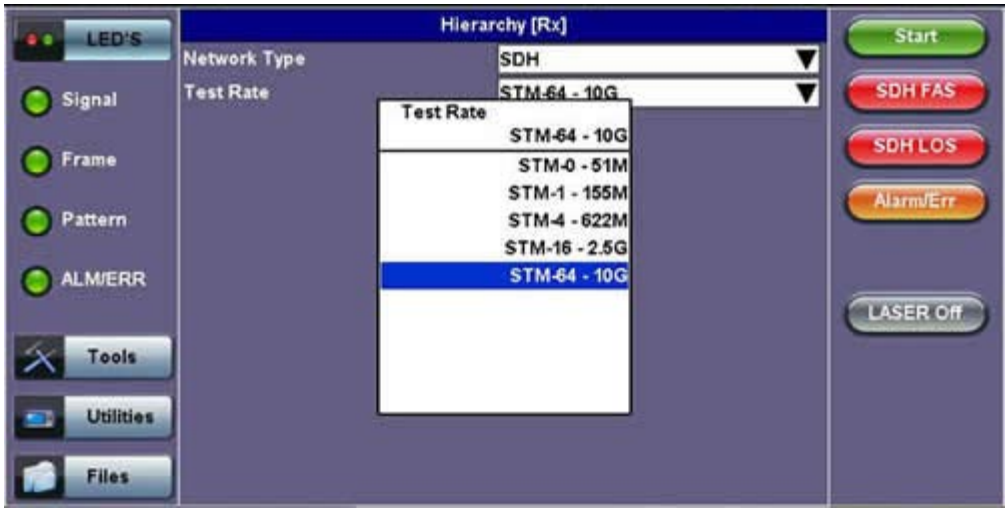
Go back to top Go back to TOC

6.3.2 Receiver Setup

Hierarchy

Tapping the Hierarchy setup box opens the Rx Hierarchy screen. The Hierarchy setup options for the Rx are the same as for the Tx described previously.

Rx Hierarchy Setup

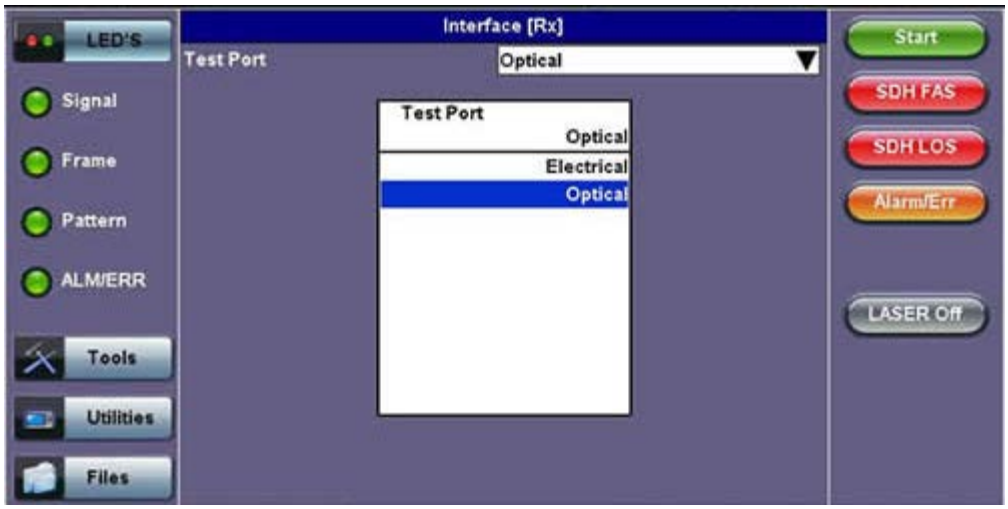


Go back to top Go back to TOC

Interface

Tapping the Interface setup box opens the Rx Interface screen. The Interface setup options for the Rx are the same as for the Tx described previously, except for clock offset, which is only available in Tx.

Rx Interface Setup



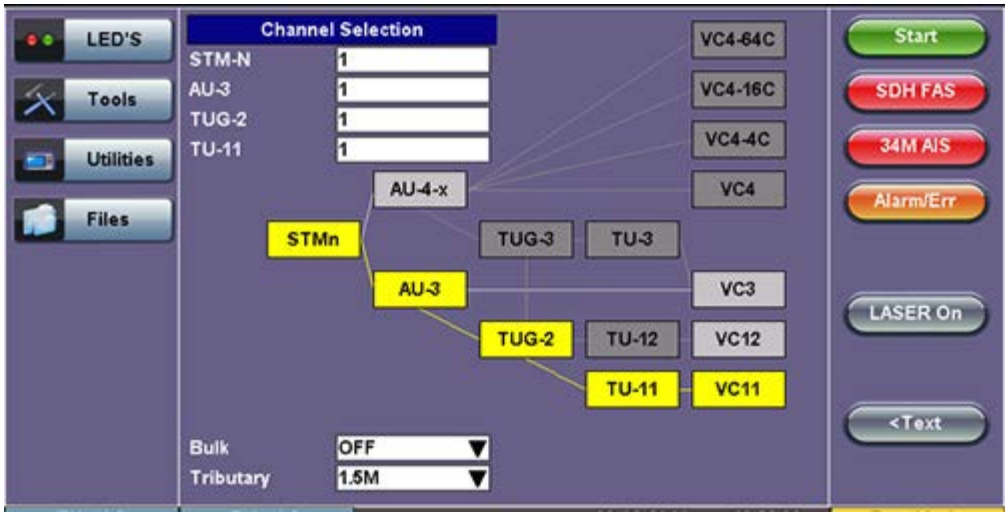
Note: Remember to use an optical attenuator to prevent receiver overload or damage – refer to the SFP chart below to determine safe levels. Avoid looping back the Tx and Rx on a 1550nm XFP or SFP using a patchcord only – this will damage the SFP.

Go back to top Go back to TOC

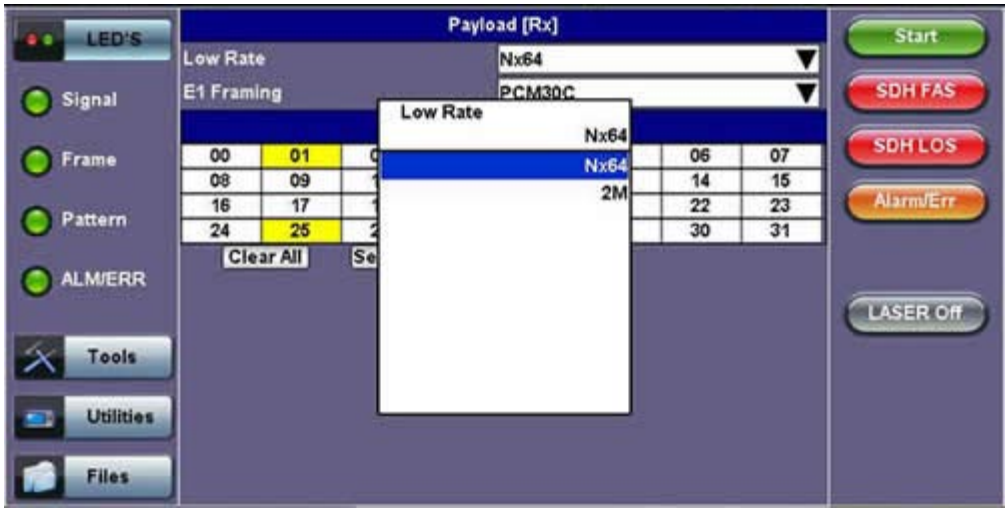
Structure and Payload

SDH Rx Structure and Payload configurations are the same as for SDH Tx setup described previously.

Rx Structure Setup



Rx Payload Setup

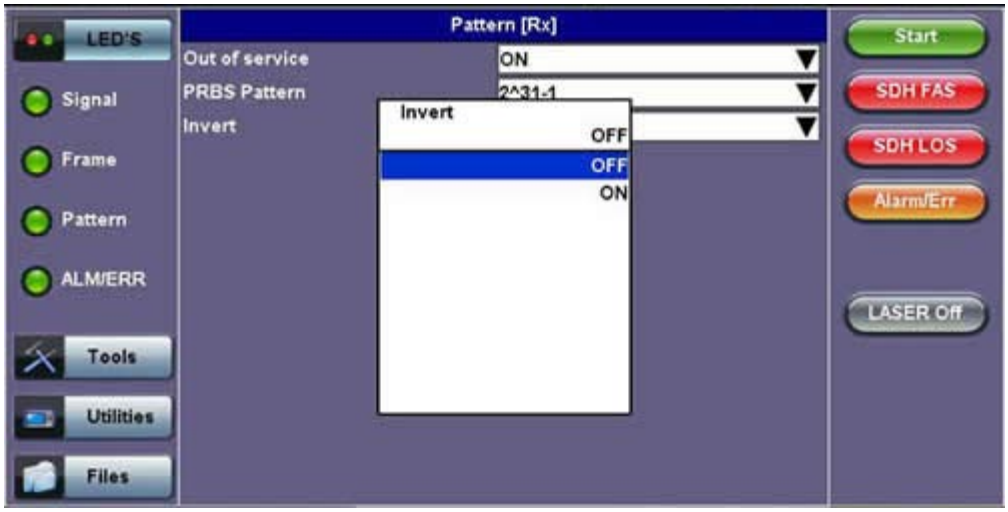


Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Rx Pattern setup screen. The pattern setup options for the Rx are the same as for the Tx described previously, except for the Out of Service selection, which 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.

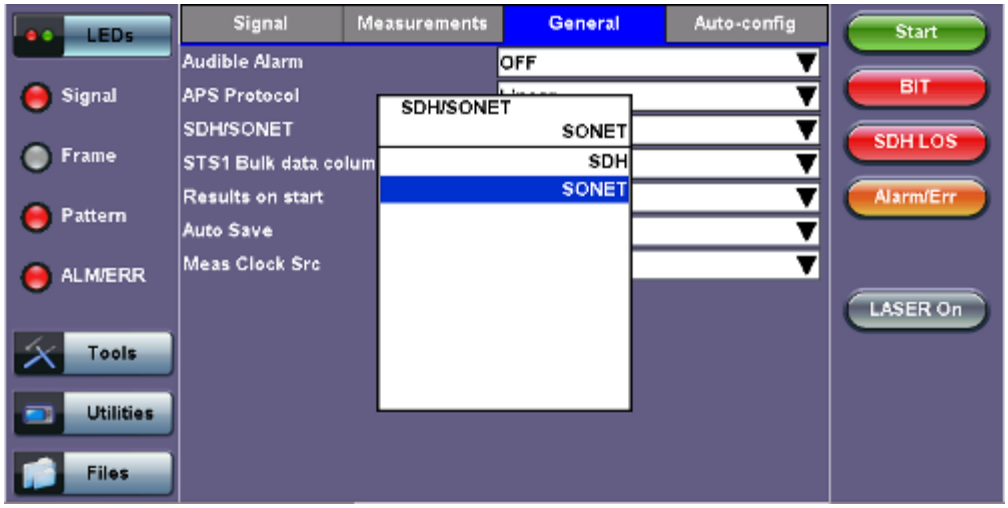
Rx Pattern Setup



Go back to top Go back to TOC

6.4 Setup: SONET

Selecting SONET from the General tab



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.

Go back to top Go back to TOC

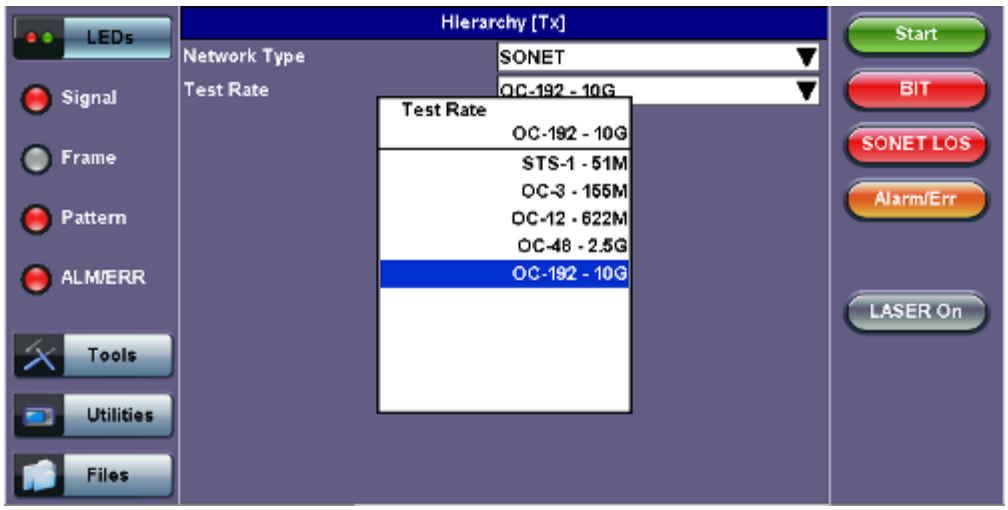
6.4.1 Transmitter Setup

This section of the manual describes the SONET configuration capabilities. The block diagram of the Tx and Rx structure is described in 6.0 Setup.

Hierarchy

Tapping the Hierarchy box opens the Tx Hierarchy Setup screen.

Tx Hierarchy Setup



Network Type: In the SONET mode, only optical interface options are available.

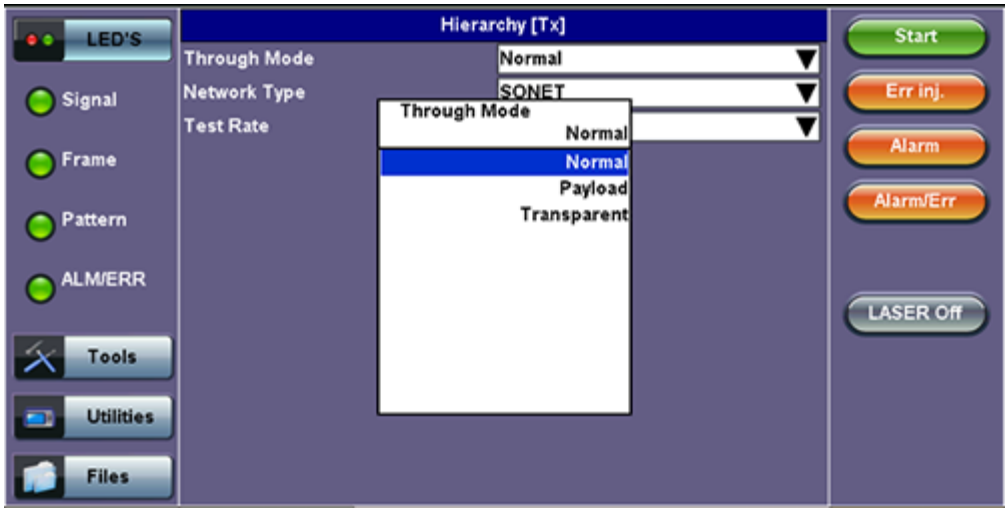
Test Rate: Options are STS-1, OC-3, OC-12, OC-48, OC-192 (referring to 51M, 155M, 622M, 2.5G and 9.953G respectively).

Go back to top Go back to TOC

Hierarchy > Through Mode

Tapping the Hierarchy box opens the Tx Hierarchy Setup screen.

Tx Hierarchy Setup - Through Mode



Through Mode:

- **Normal Mode:** Unit working as normal SONET mode.
- **Payload Through Mode:** Overhead overwrite Editing Thru mode allows for some intrusive error and alarm injection through overhead manipulation.
- **Transparent Through Mode:** All the traffic goes through the unit untouched and the unit can monitor it. It is comparable to Monitor Mode with a 10/90 splitter. In Transparent Mode, the unit regenerates the signal in amplitude. The clock is recovered from the received signal.

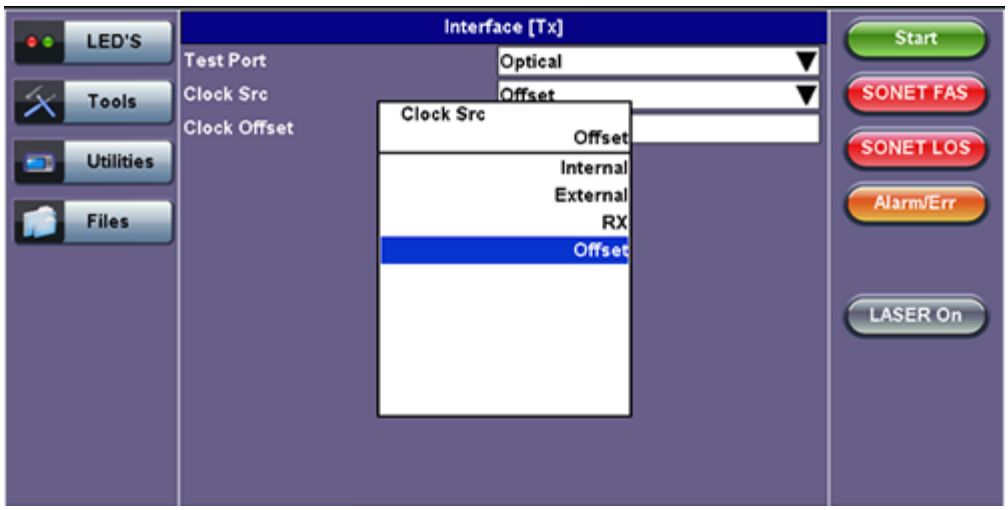
Through modes are used to test network behavior under certain conditions, such as alarms and APS. To select Payload Through, the payload has to be the same for the relevant ports.

Go back to top Go back to TOC

Interface

Tapping the Tx Interface box opens the Tx Interface Setup screen. In this screen both electrical and optical options can be selected.

Tx Interface Setup



Test Port: Optical or Electrical.

Optical interface is available for OC-1, OC-3, OC-12, OC-48 and OC-192 signals.
- Electrical interface is available for STS-1 and STS-3 signals.

Clock Source: Can be configured as follows.

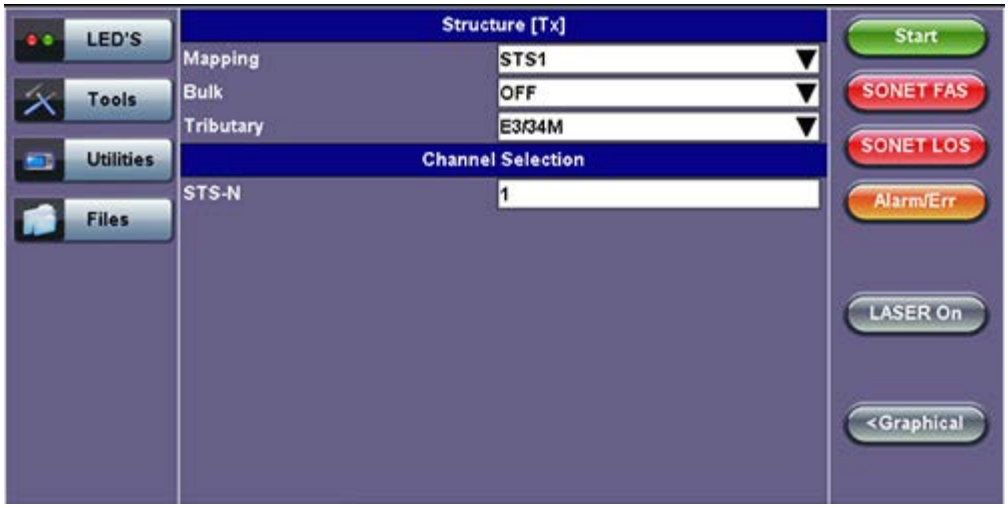
- **Internal clock:** The clock for the transmitter is derived from the internal clock. The internal clock has an accuracy of +/- 3.5ppm conforming to G.812 recommendations.
- **External clock:** The clock for the transmitter is derived from a 1.5MHz, 2MHz, 1.5Mbps, 2Mbps, or 64kbps signal on the SMA, RX2 balanced, or RX2 BNC unbalanced interfaces.
- **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.

Go back to top Go back to TOC

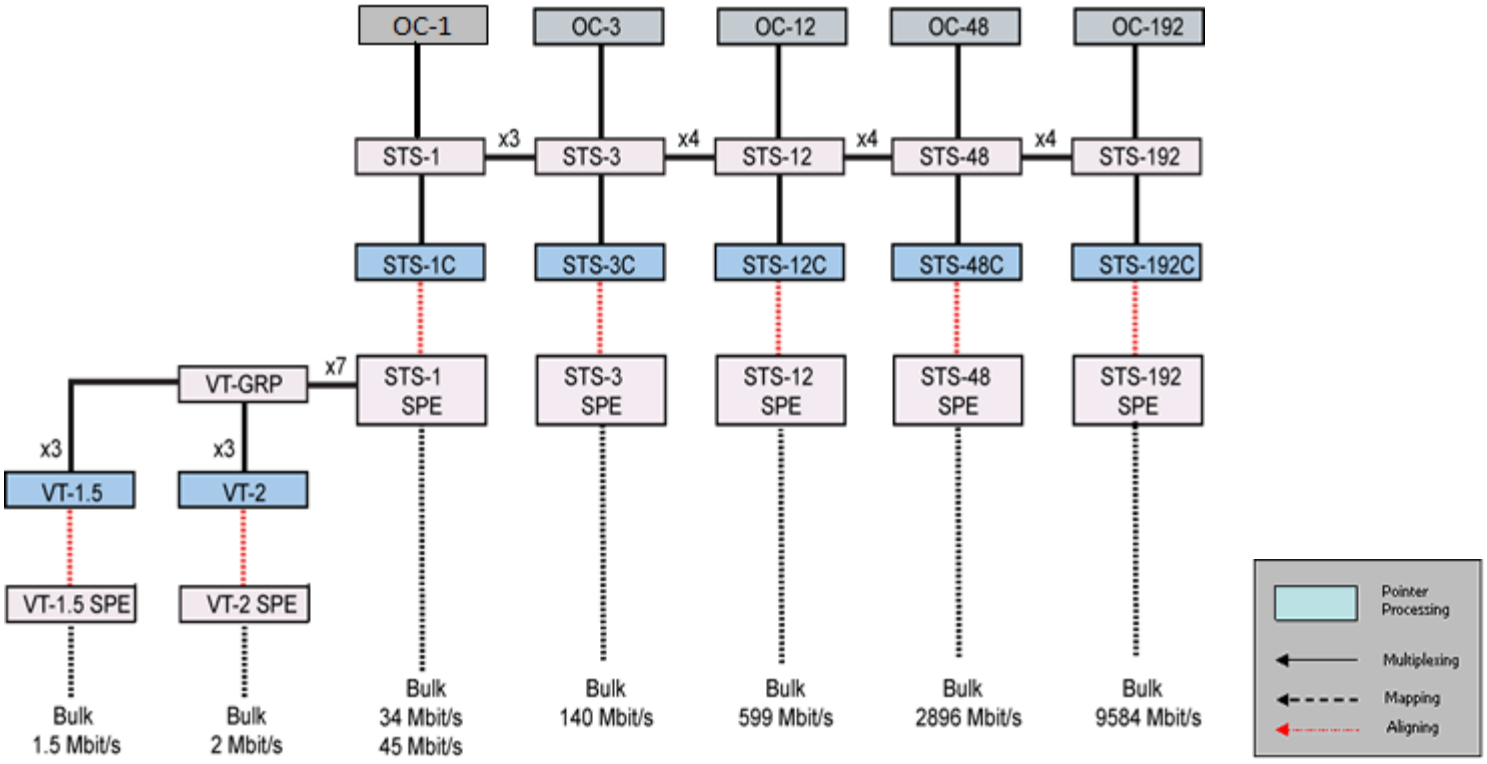
Structure

Tapping the Tx Structure box opens the Tx Structure Setup screen which shows two display modes: Text mode and Graphical mode. Tap on the **Text/Graphical** button to switch between the two modes.

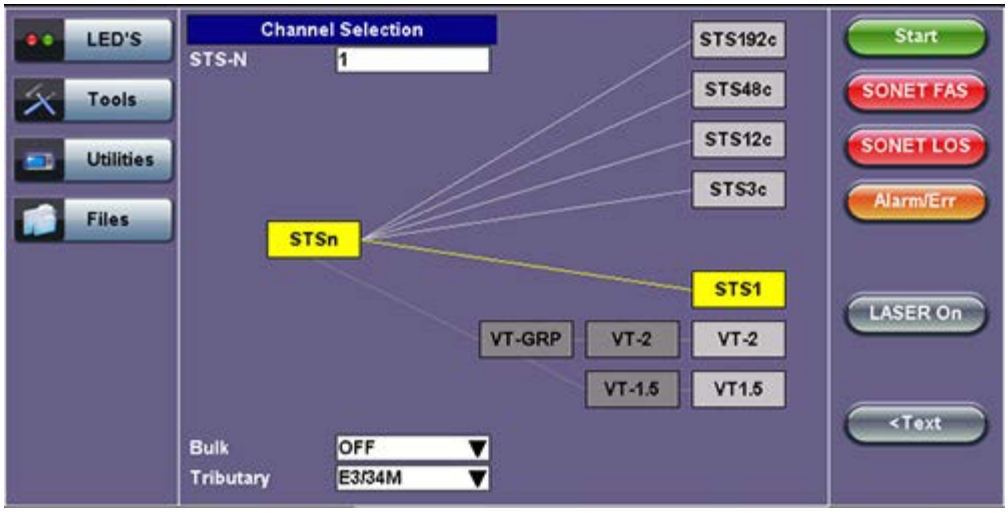
Tx Structure Setup - Text Mode



Mapping: STS-192C, STS-48C, STS-12C, STS-3C, STS-1 and VT1.5 is available. VT-2 is optional. STS mappings per Bellcore GR-253 and ANSI T1.105 recommendations are supported. The multiplexing structure is shown below.



Tx Structure Setup - Graphical Mode

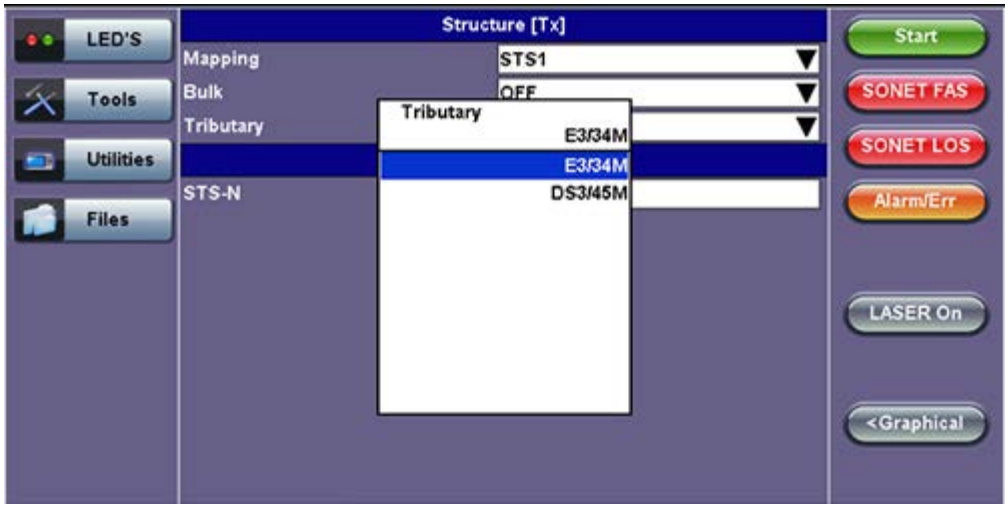


Channel Selection: The Tx channel is selected by entering the STS-N, VT-GRP, and VT-1.5 SPE channel.

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 depending upon the options and mapping.

Tx Structure Setup - Tributary



Note:

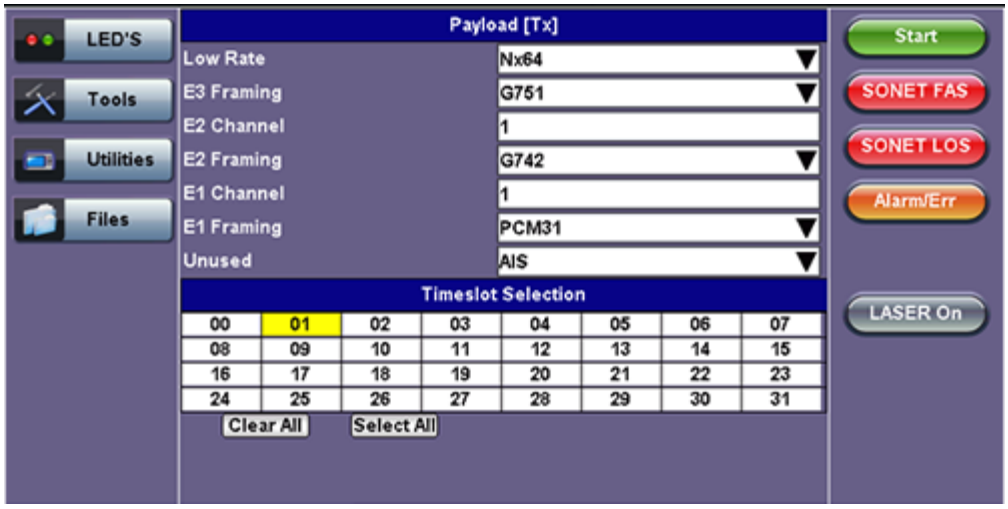
- **VT-GRP:** In order to carry a mixed size of VTs in a STS-1 SPE in an efficient manner, VT Group (VTG) is defined. The size of the VTG is 12 columns, which is the least common multiple of the four sizes of VTs. Only one type of VT can be contained within each VTG. Therefore, a VTG can be formed by 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.

Go back to top Go back to TOC

Payload

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

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)

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 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.

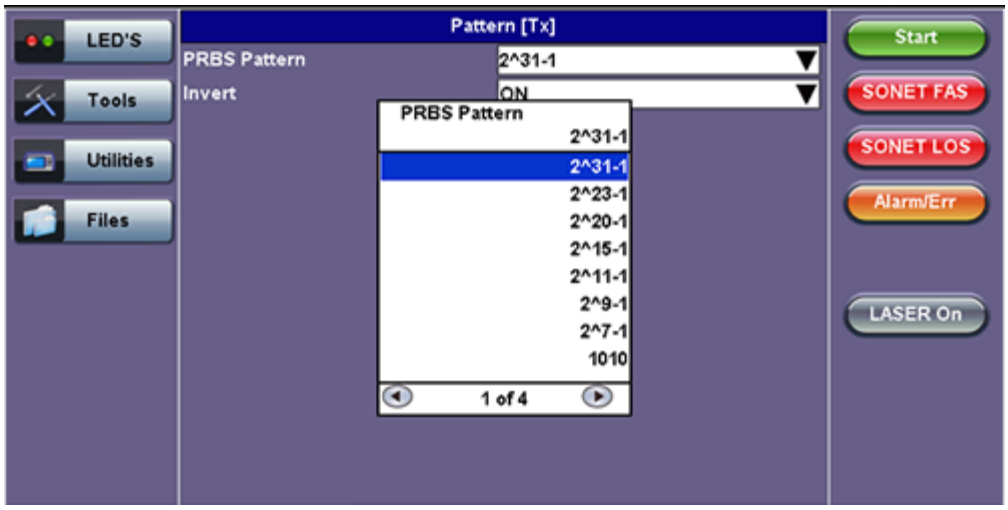
In E3 mode, the options are unframed, framed G.751.

Go back to top Go back to TOC

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.

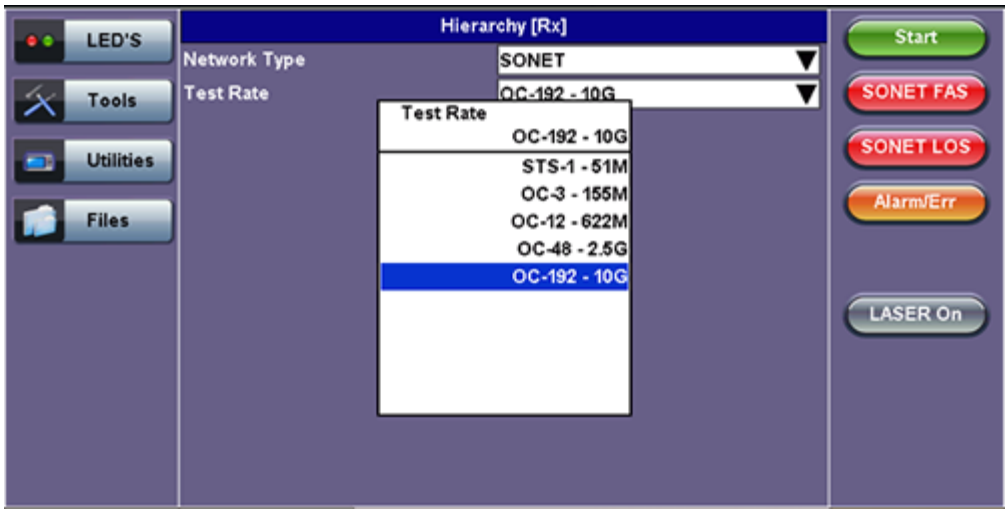
Go back to top Go back to TOC

6.4.2 Receiver Setup

Hierarchy

Tapping the Hierarchy setup box opens the Rx Hierarchy screen. The Hierarchy setup options for the Rx are the same as for the Tx described previously.

Rx Hierarchy Setup



Go back to top Go back to TOC

Interface

Tapping the Interface setup box opens the Rx Interface screen. The Interface setup options for the Rx are the same as for the Tx described previously, except for clock offset, which is not possible.

Interface Rx Setup

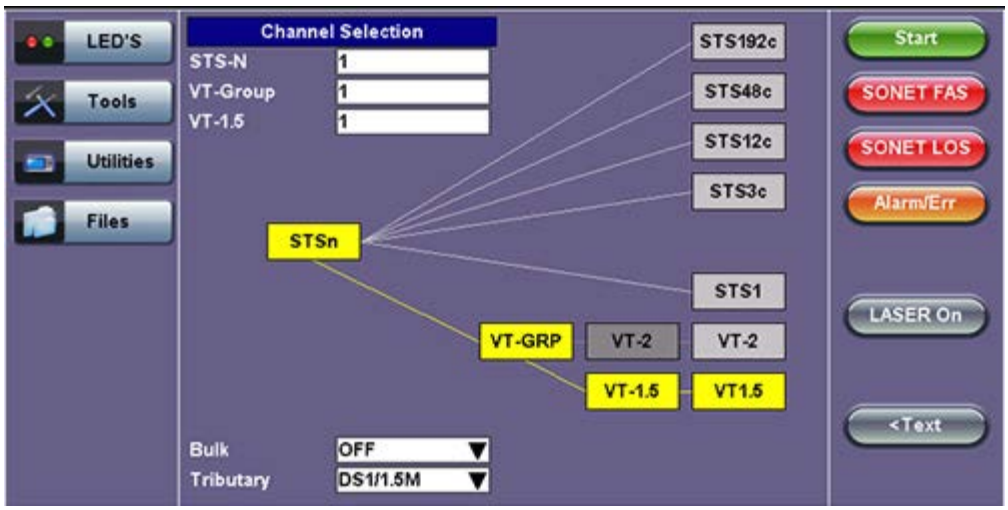
Note: Remember to use an optical attenuator to prevent receiver overload or damage – refer to the SFP chart below to determine safe levels. Avoid looping back the Tx and Rx on a 1550nm XFP or SFP using a patchcord only as this will damage the SFP.

Go back to top Go back to TOC

Structure

Tapping the Structure setup box opens the Rx Structure screen. The Structure setup options for the Rx are the same as for the Tx described previously.

Rx Structure Setup - Graphical Mode

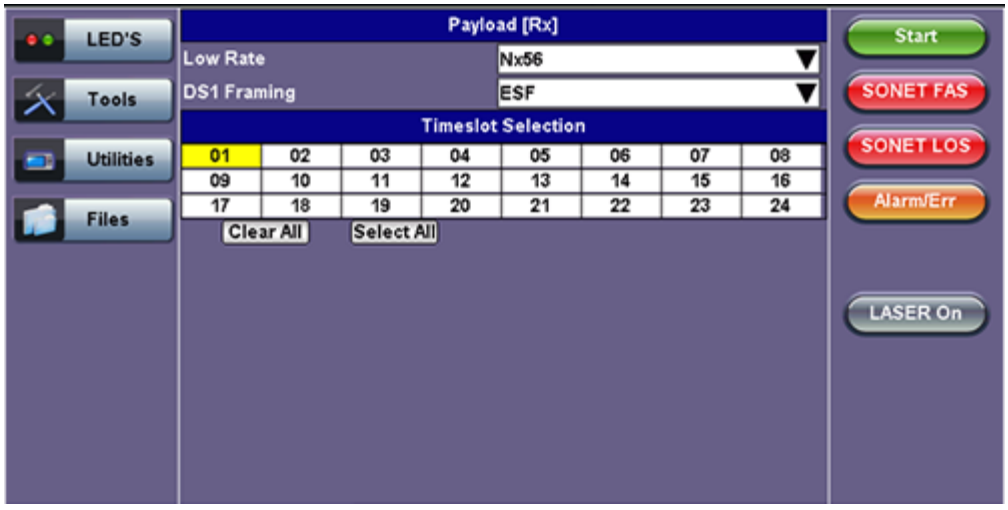


Go back to top Go back to TOC

Payload

Tapping the Payload setup box opens the Rx Payload screen. The Payload setup options for the Rx are the same as for the SONET Tx setup described previously.

Rx Payload Setup

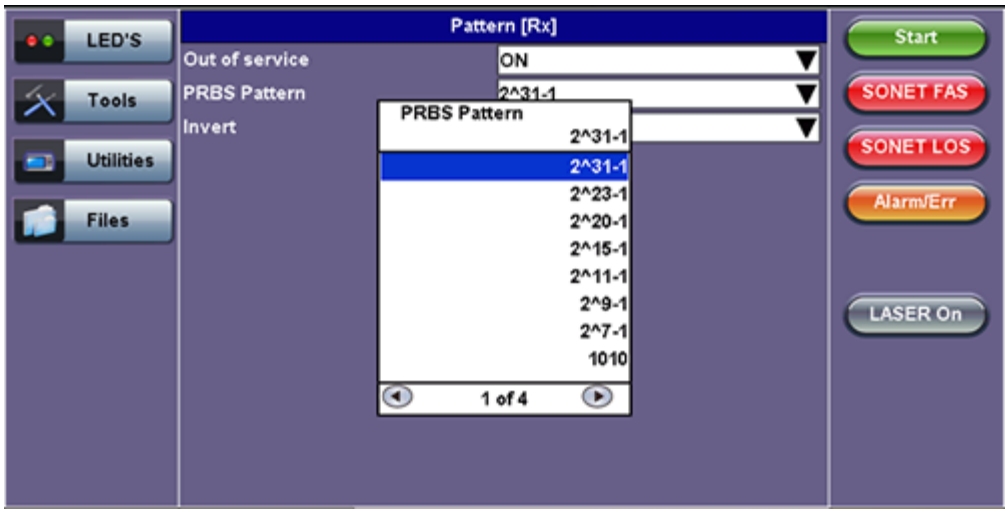


Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Rx Pattern setup screen. The pattern setup options for the Rx are the same as for the Tx described previously, except for the Out of Service selection, which 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.

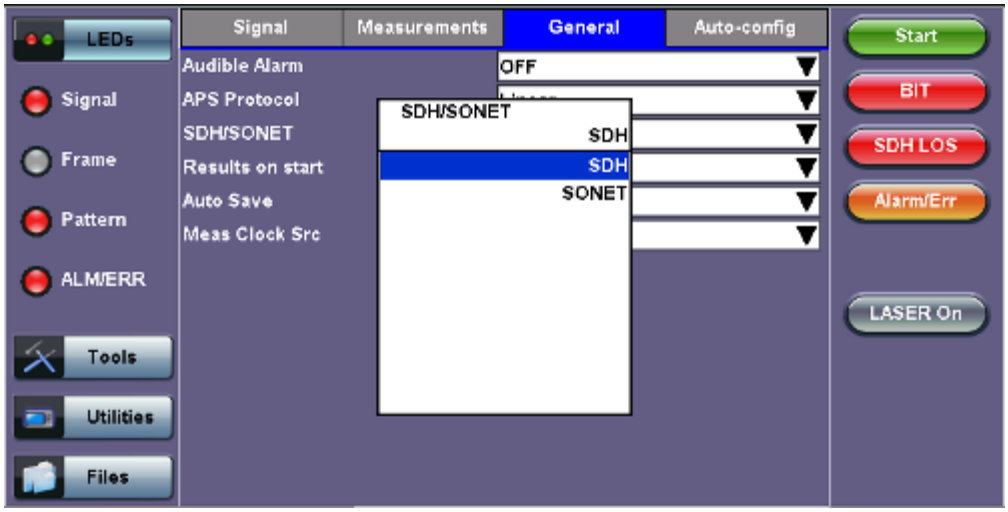
Rx Pattern Setup



Go back to top Go back to TOC

6.5 Setup: OTN/SDH

Selecting SDH from the General tab



To verify that the Tx and Rx block diagrams are OTN/SDH, verify that SDH is selected from the **SDH/SONET** drop-down menu under the **General** tab.

Go back to top Go back to TOC

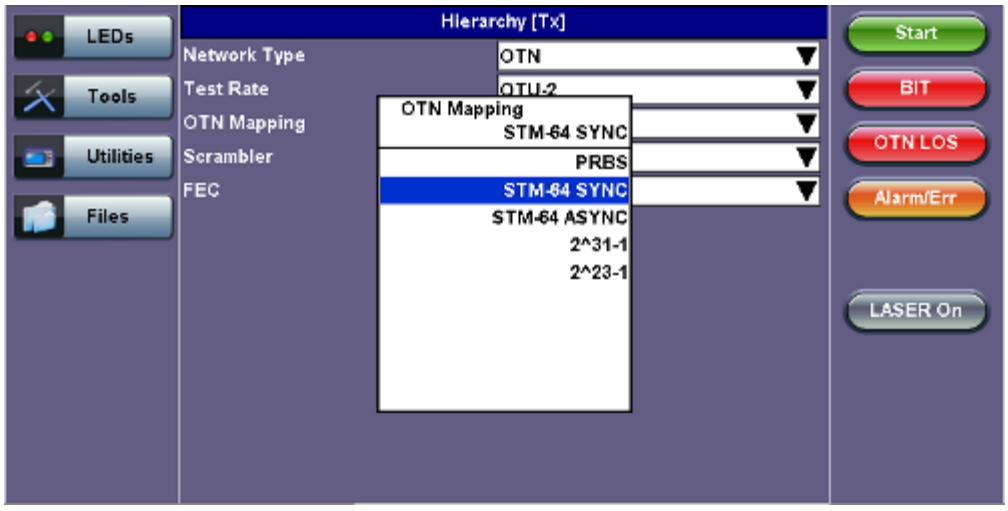
6.5.1 OTN Transmitter Setup

This section of the manual describes the OTN configuration capabilities. The block diagram of the Tx and Rx structure has been described in 6.0 Setup.

Hierarchy

Tapping the **Hierarchy** box opens the Tx Hierarchy Setup screen.

Tx Hierarchy Setup



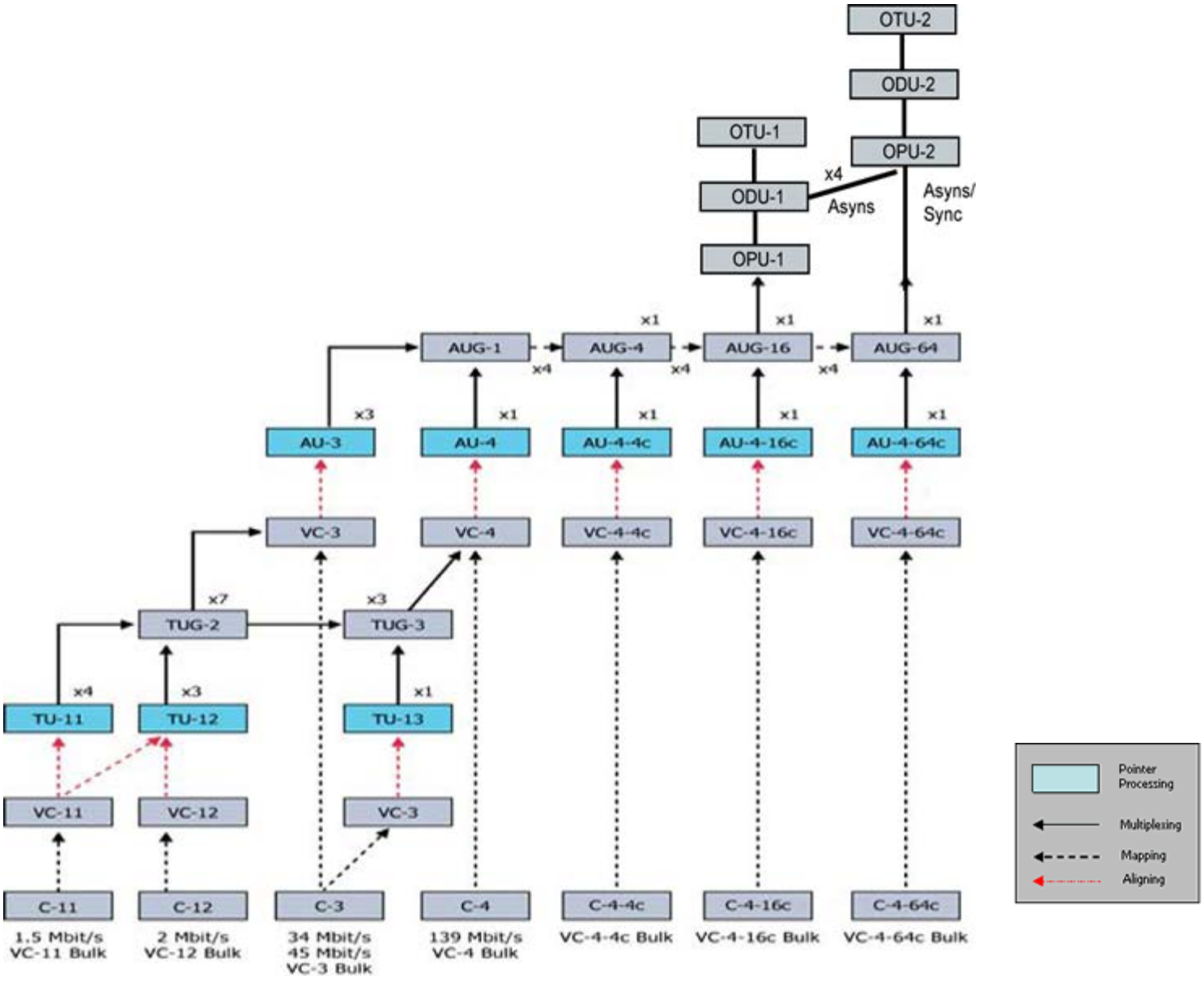
Network Type: In the OTN mode, only optical interface options are available

Test Rate: Options are OTU-1 and OTU-2 (referring to 2.66G and 10.709G respectively)

OTN Mapping: SYNC, ASYNC, and PRBS pattern

Note: ITU-T G.709 and both AU-4 and AU-3 signal mappings per G.707 recommendations are supported. The multiplexing

structure is shown below.



Scrambler: ON/OFF

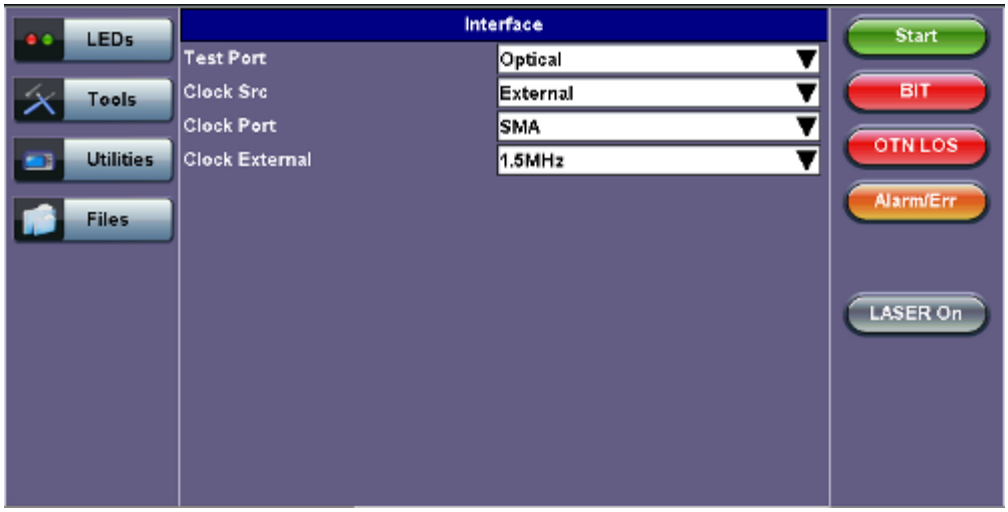
FEC: FEC encoder can be ON/OFF (activated / deactivated)

Go back to top Go back to TOC

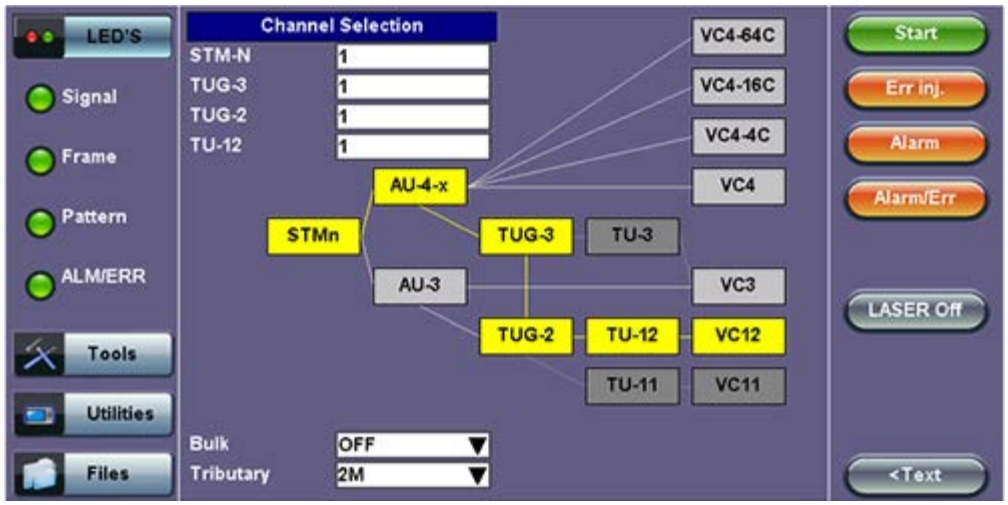
Interface, Structure, Payload, and Pattern

Interface, Structure, Payload, and Pattern TX block configurations are identical to configurations in 6.4.1 Transmitter Setup in the SONET chapter. Please refer to that section for further details.

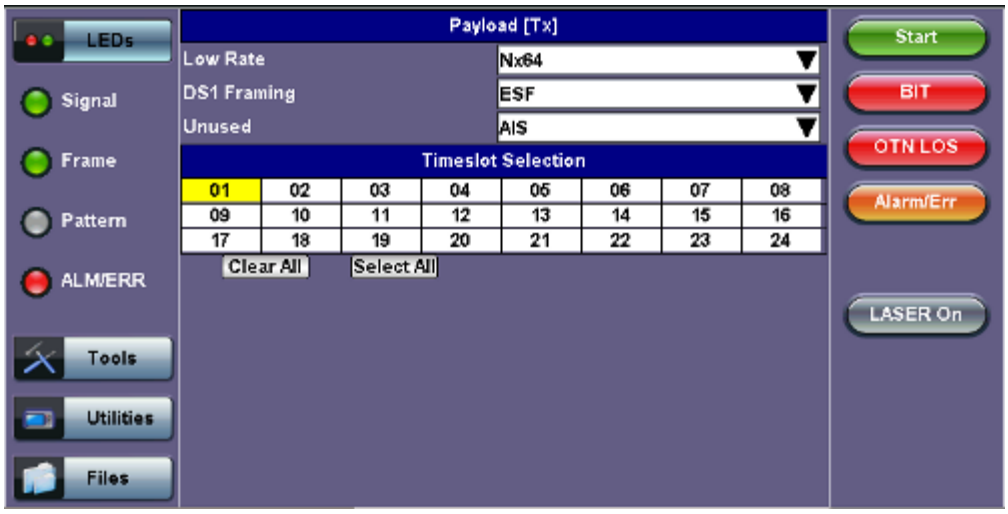
Tx Interface Setup



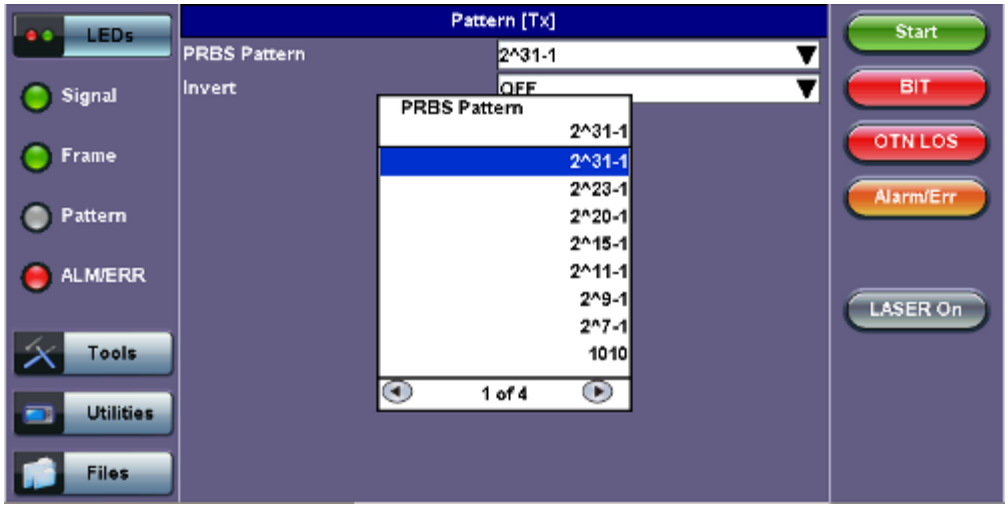
Tx Structure Setup - Graphical Mode



Tx Payload Setup



Tx Pattern Setup



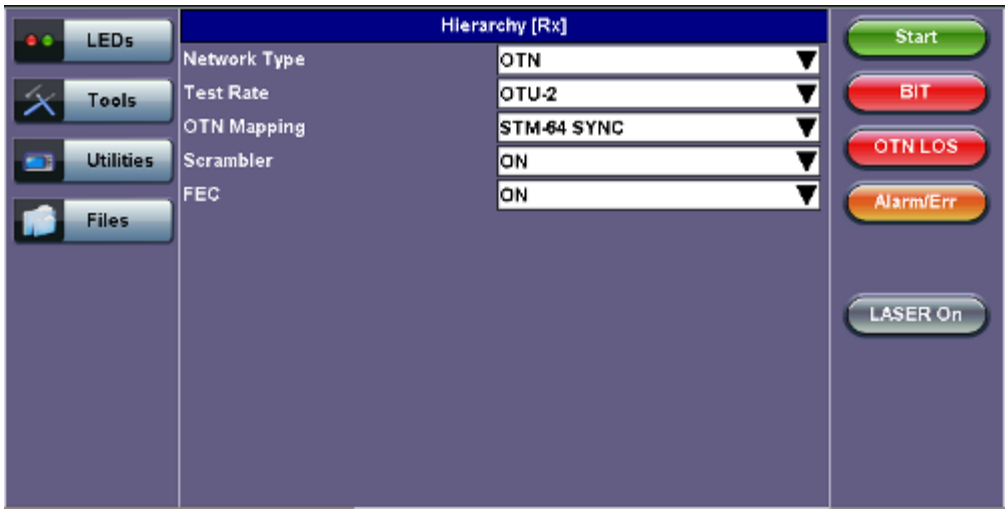
Go back to top Go back to TOC

6.5.2 Receiver Setup

Hierarchy

Tapping the **Hierarchy** setup box opens the Rx Hierarchy screen. The Hierarchy setup options for the Rx are the same as for the Tx described previously.

Rx Hierarchy Setup

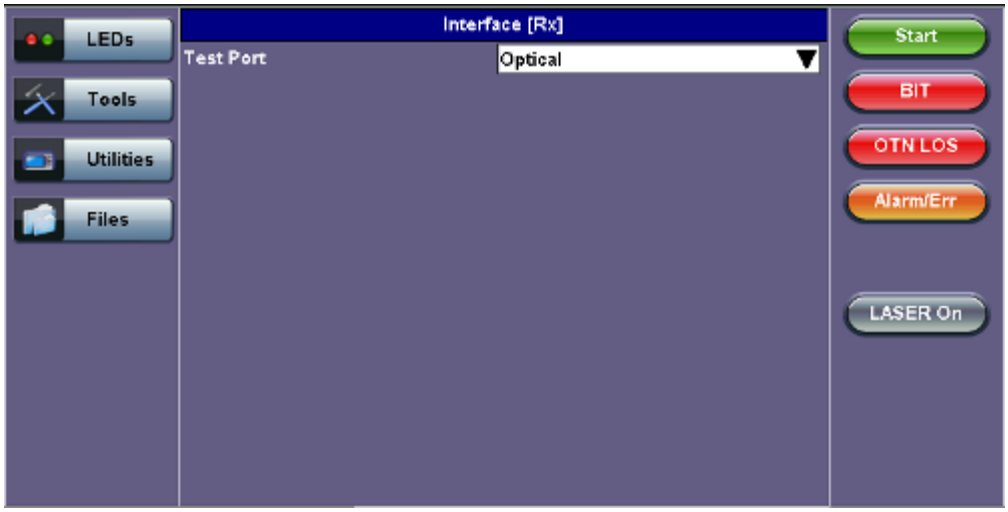


Go back to top Go back to TOC

Interface

Tapping the **Interface** setup box opens the Rx Interface screen. The Interface setup options for the Rx are the same as for the Tx described previously, except for clock offset, which is only available in Tx.

Rx Interface

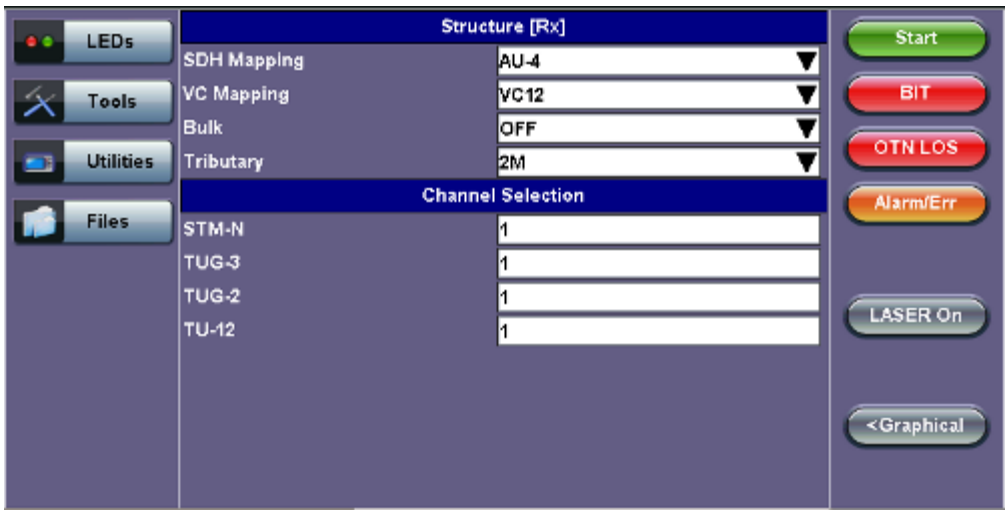


Go back to top Go back to TOC

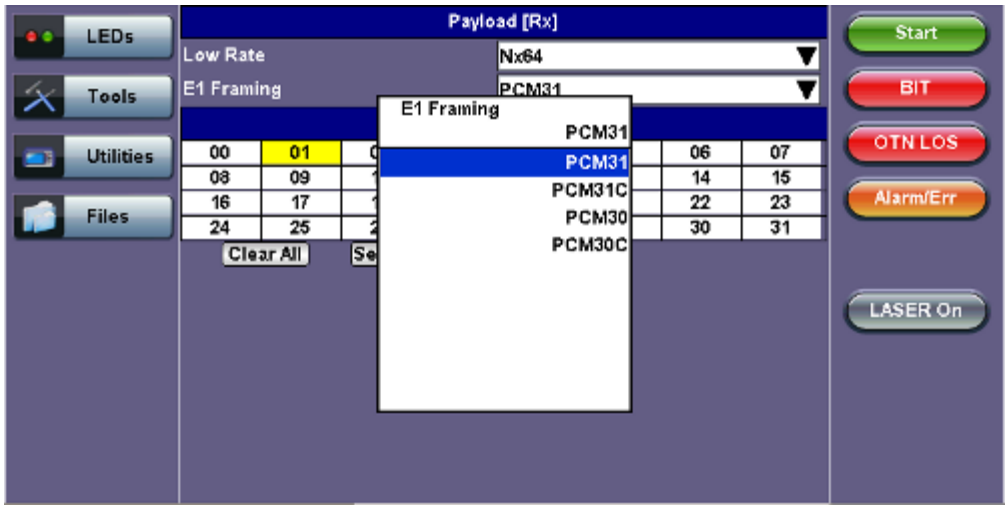
Structure and Payload

OTN/SDH Rx Structure and Payload configurations are the same as for OTN/SDH Tx setup described previously.

Rx Structure



Rx Payload

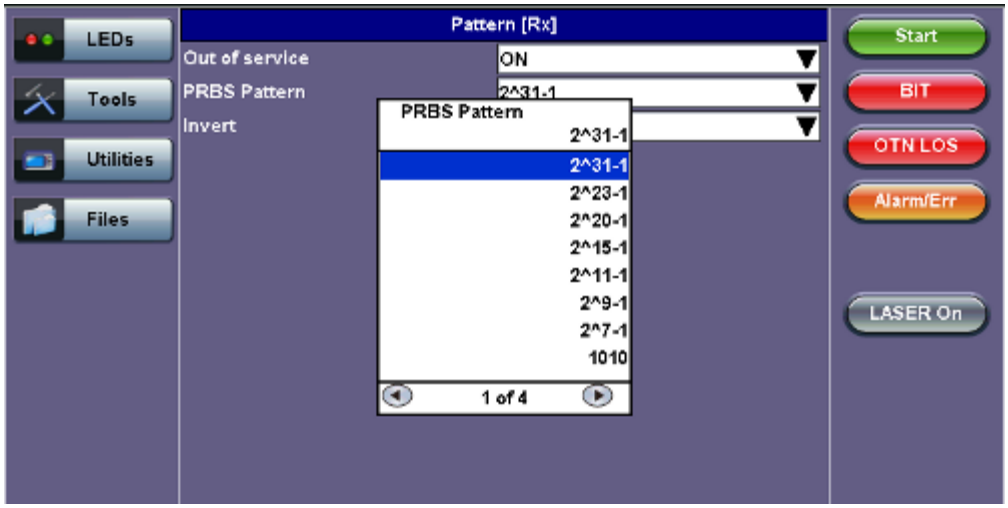


Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Rx Pattern setup screen. The Pattern setup options for the Rx are the same as for the Tx described previously, except for the **Out of Service** selection, which should be selected if the incoming signal is expected to contain a known test pattern. Deselect this option if the signal is expected to contain live traffic.

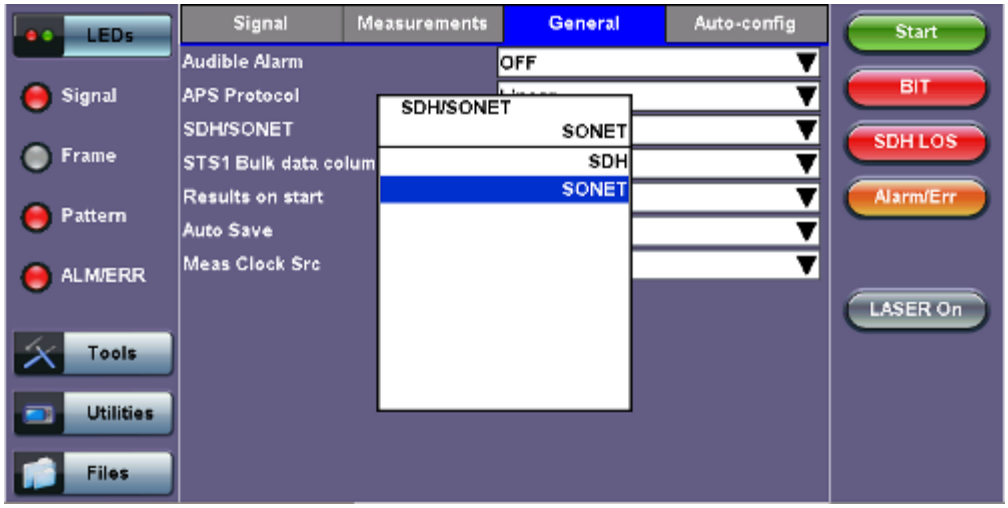
Rx Pattern



Go back to top Go back to TOC

6.6 Setup: OTN/SONET

Selecting SONET from the General tab



To verify that the Tx and Rx block diagrams are OTN/SONET, make sure that SONET is selected from the **SDH/SONET** drop-down menu under the **General** tab.

Go back to top Go back to TOC

6.6.1 Transmitter Setup

This section of the manual describes the OTN configuration capabilities. The block diagram of the Tx and Rx structure is described in 6.0 Setup.

Hierarchy

Tapping the **Hierarchy** box opens the Tx Hierarchy Setup screen.

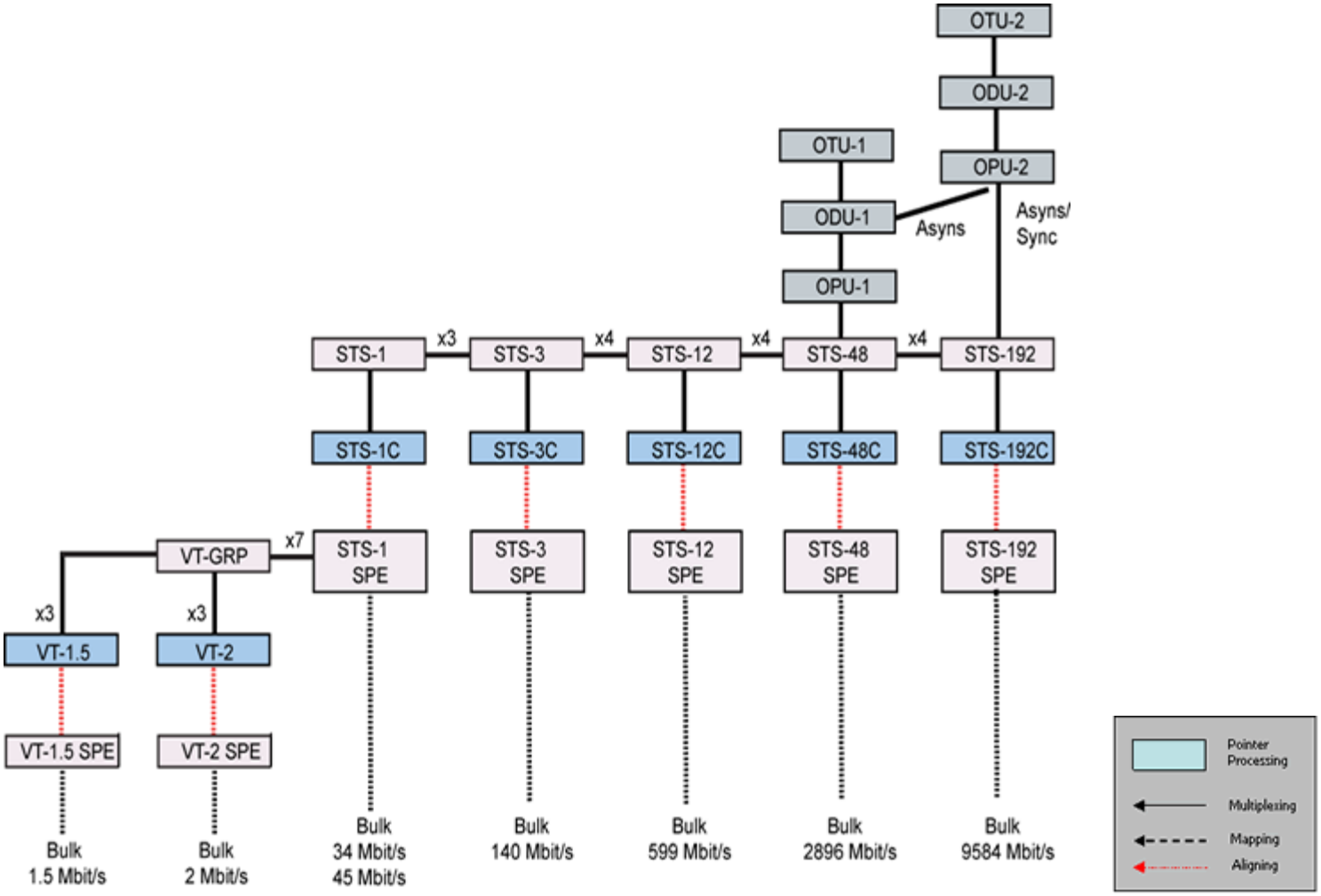
Tx Hierarchy Setup

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

Test Rate: Options are OTU-1 and OTU-2 (referring to 2.66G and 10.709G respectively)

OTN Mapping: SYNC, ASYNC, and PRBS pattern

Note: ITU-T G.709 and STS mappings per Bellcore GR-253 and ANSI T1.105 recommendations are supported. The multiplexing structure is shown below.



Scrambler: ON/OFF

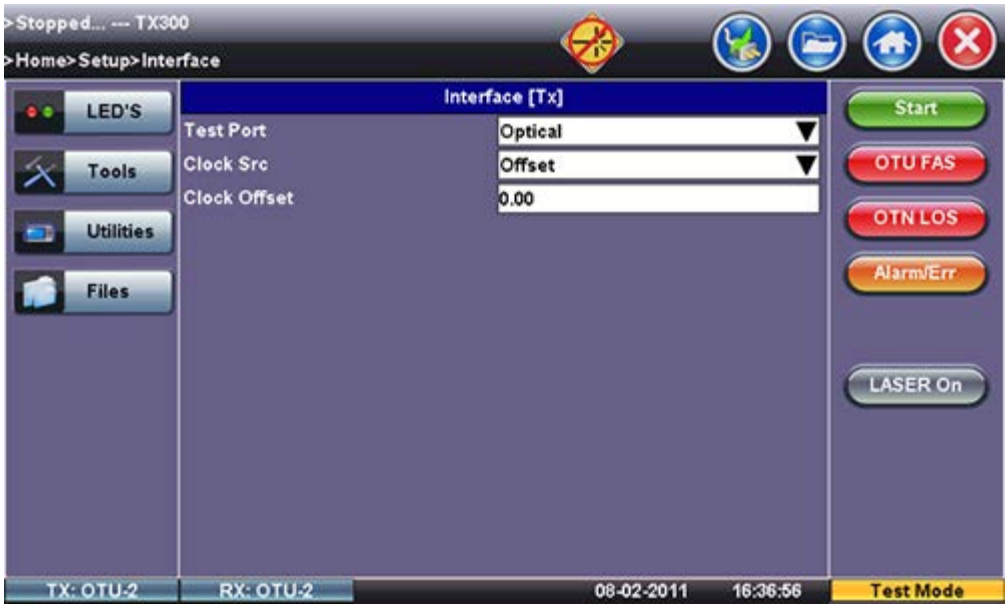
FEC: FEC encoder can be ON/OFF (activated / deactivated)

Go back to top Go back to TOC

Interface, Structure, Payload, and Pattern

Interface, Structure, Payload, and Pattern TX block configurations are identical to configurations in 6.4.1 Transmitter Setup in the SONET chapter. Please refer to that section for further details.

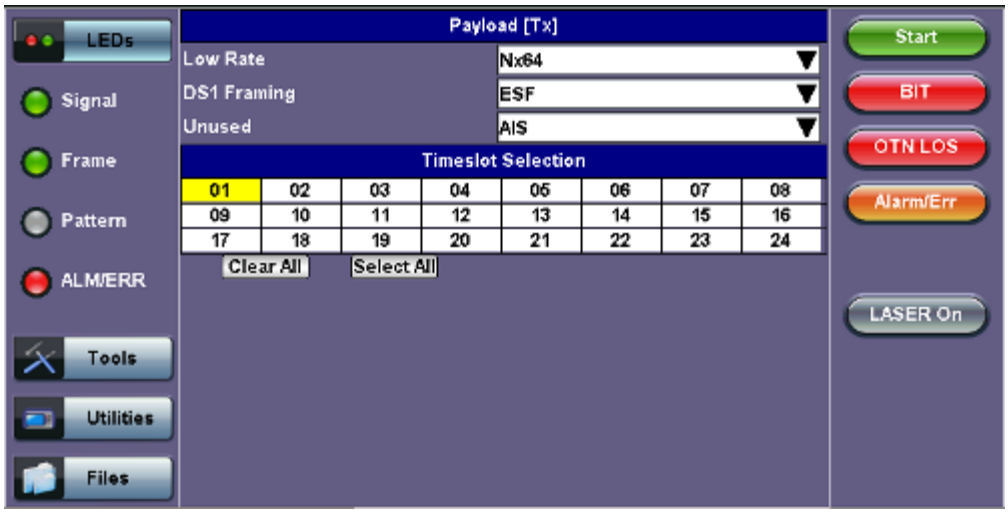
Tx Interface Setup



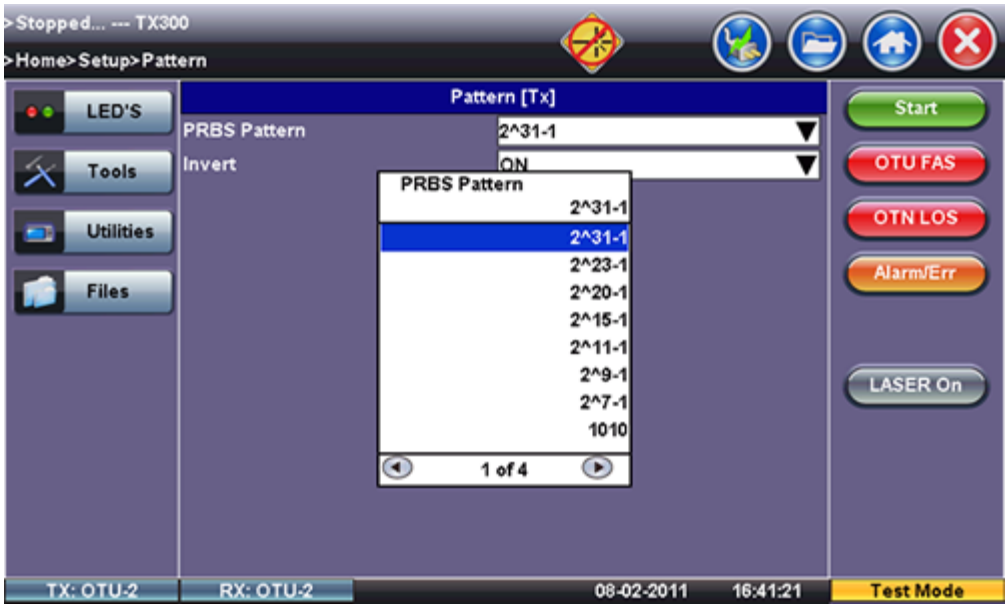
Tx Structure Setup - Text Mode

Tx Structure Setup - Graphical Mode

Tx Payload Setup



Tx Pattern Setup



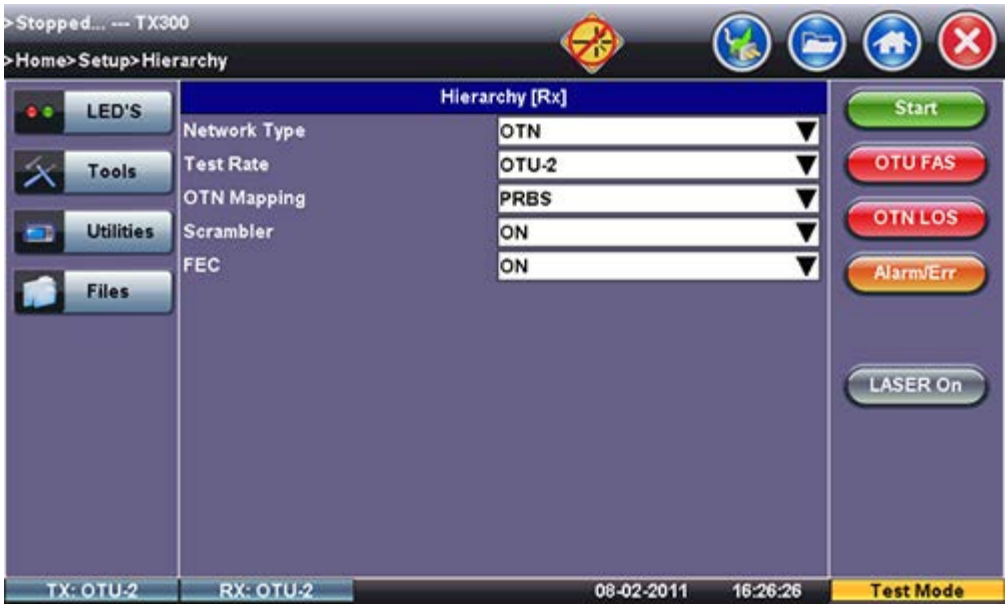
Go back to top Go back to TOC

6.6.2 Receiver Setup

Hierarchy

Tapping the **Hierarchy** setup box opens the Rx Hierarchy screen. The Hierarchy setup options for the Rx are the same as for the Tx described previously.

Rx Hierarchy Setup



Go back to top Go back to TOC

Interface

Tapping the **Interface** setup box opens the Rx Interface screen. The Interface setup options for the Rx are the same as for the Tx described previously, except for clock offset, which is only available in Tx.

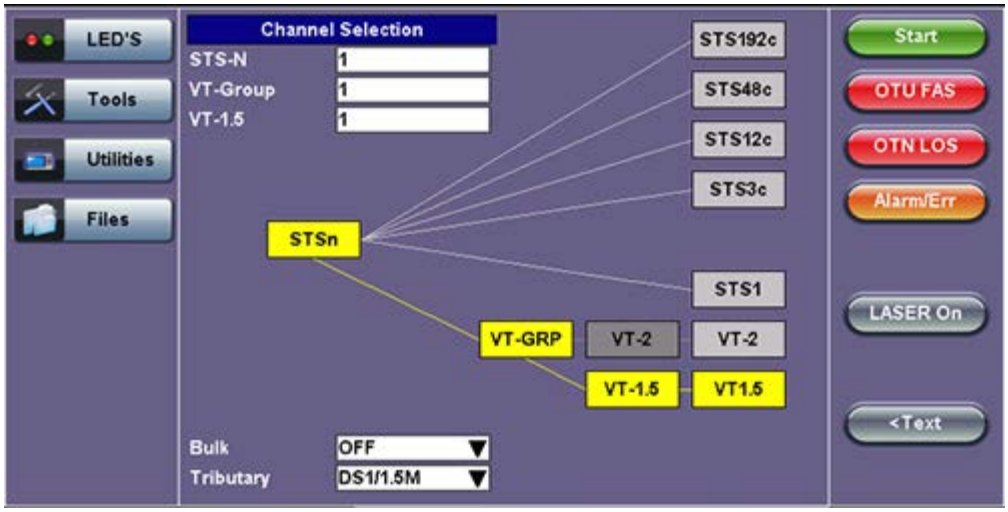
Rx Interface

Go back to top Go back to TOC

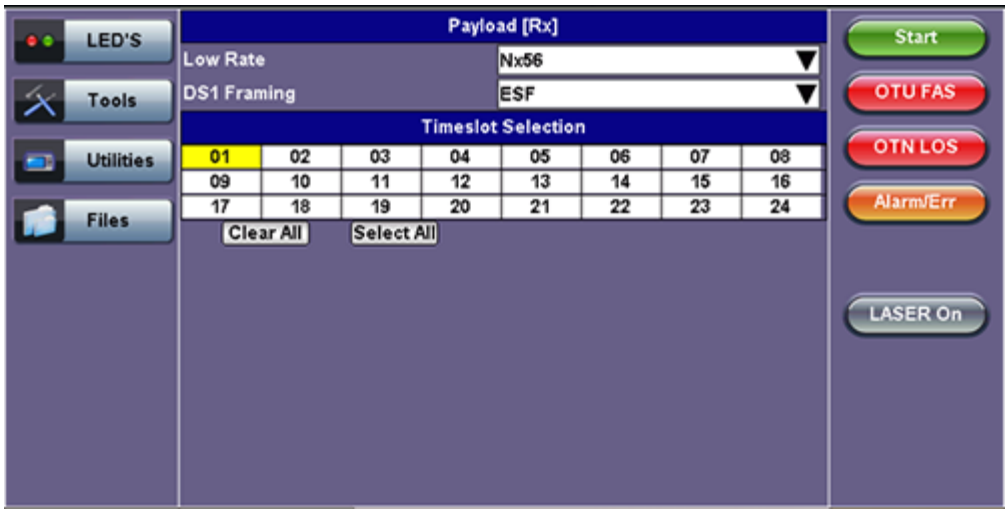
Structure and Payload

OTN/SONET Rx Structure and Payload configurations are the same as for OTN/SONET Tx setup described previously.

Rx Structure



Rx Payload

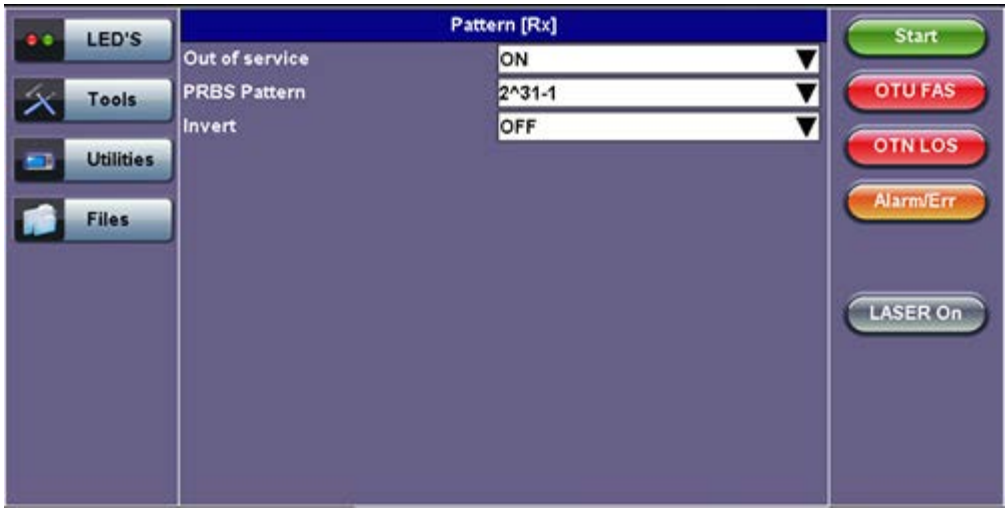


Go back to top Go back to TOC

Pattern

Tapping the Pattern box opens the Rx Pattern setup screen. The Pattern setup options for the Rx are the same as for the Tx described previously, except for the **Out of Service** selection, which 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.

Rx Pattern

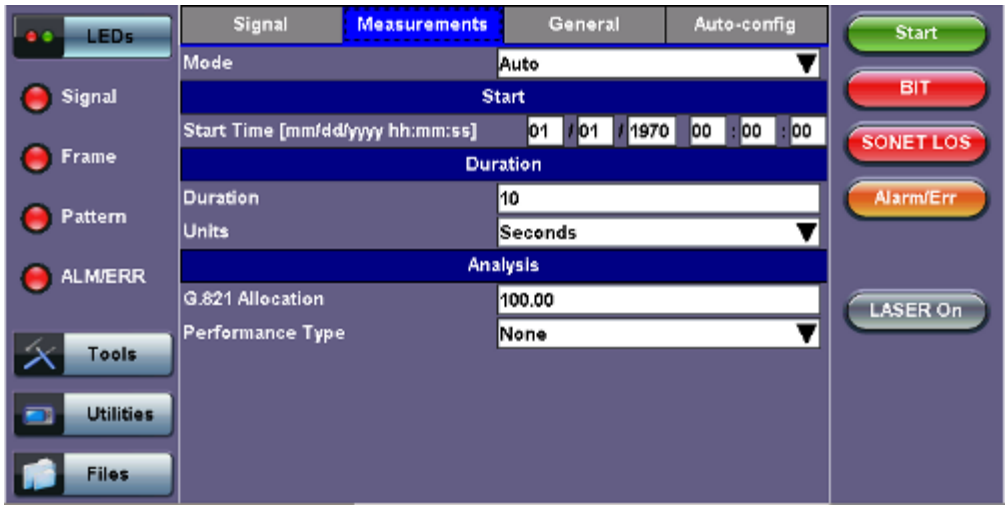


Go back to top Go back to TOC

6.7 Measurement Configuration

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

Measurements tab



Go back to top Go back to TOC

6.7.1 Timer Setup

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

Mode: Manual, Timed, and Auto selections are available

- **Manual:** This is linked to the Start/Stop function on the drop-down menu
- **Timed:** The test duration can be set by the user. The test duration can be set in seconds, minutes, hours or days. The test is activated by the Start/Stop function on the drop-down menu
- **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 on the drop-down menu and the test will be activated automatically when the programmed start time is reached.

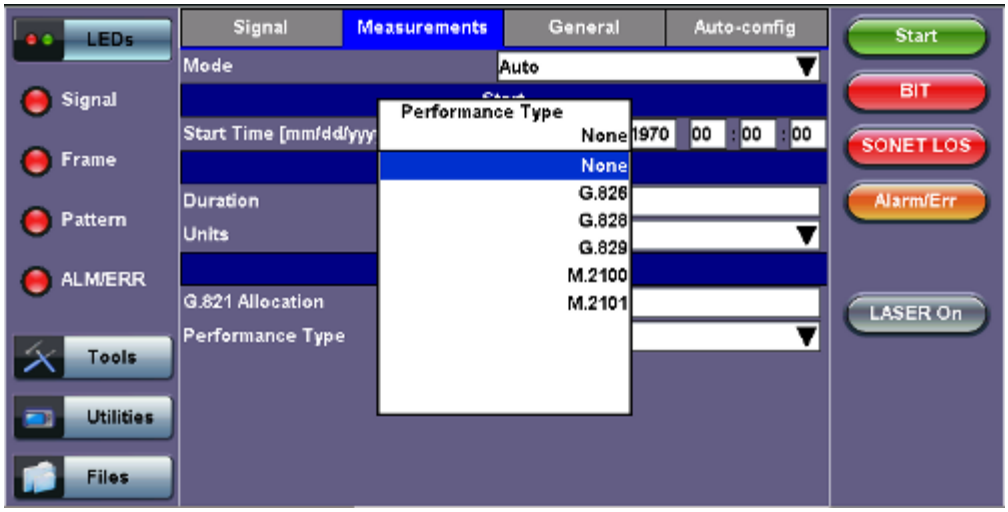
Note: The timed mode will be required when running a M.2100 or M.2101 performance objective.

Go back to top Go back to TOC

6.7.2 Performance Analysis

The Analysis setup page selects the ITU-T performance test that will be performed by the unit. Depending on Test mode, the selections include None, G.821, G.826, G.828, G.829, M.2100, and M.2101.

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 extremely difficult
- **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 Measurement (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
- **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
  - 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.

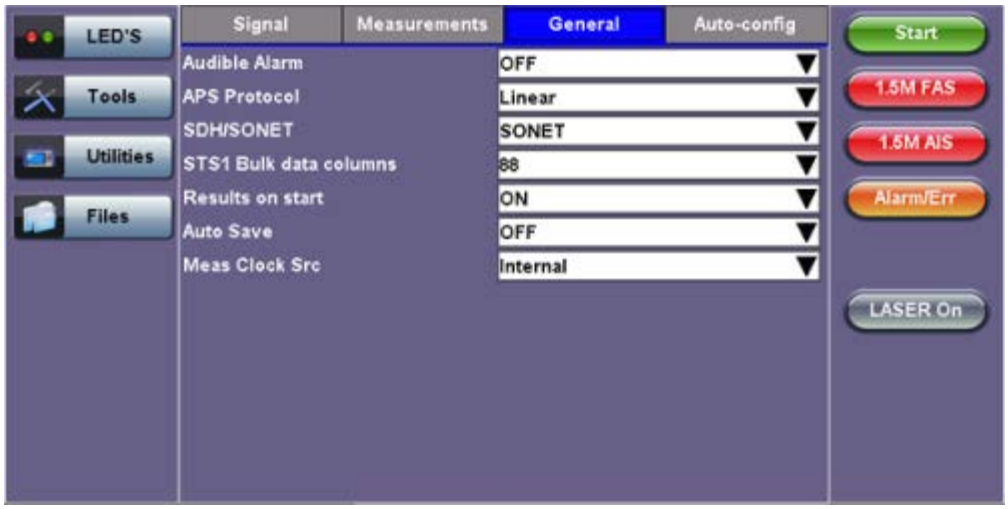
ITU-T Performance Analysis for PDH and SDH systems			
Analysis	**PDH**	**SDH**	**Anomalies**
G.821	☑	☑	TSE based on bit errors
G.826 (Out of service)	☑	☑	TSE based on block errors
G.826 (In service)		☑	B1, B2, B3, LP-BIP, E1/E3/E4 FAS, E1 CRC
G.828 (In service)		☑	B1, B2, TSE
G.829 (In service)		☑	B1, B2, B3, LP-BIP, TSE
M.2100	☑		E1/E3/E4 FAS, E1 CRC, TSE
M.2101		☑	B1, B2, B3 HP, LP-BIP, TSE

Go back to top Go back to TOC

6.7.3 General

The General setup page configures the audible alarm and APS protocol settings.

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.
- **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.
- **Tx Laser Override:** (SONET/SDH MUX measurement) Enabling the Tx Laser Override causes whichever optical device the Rx is using to produce a signal. The Tx data produced is random. The signal is of use to multiplexers that require an input signal before they can transmit an optical signal. Tx Laser Override is only available when Rx is optical and Tx is in PDH mode, (i.e. a Mux).

Go back to top Go back to TOC

6.7.4 Auto-Config

The Auto-Configuration function is described below.

Auto-config tab

The **Auto-Config** function automatically sets the receiver of the test set. A search for SDH and PDH signals at both the electrical or optical inputs is performed to determine the signal structure. For electrical signals, both Terminated and PMP voltage ranges are searched and supported.

Procedure

Tap on the **Start** button

to begin the search. The received signal is checked for network type, hierarchy and bit rate, payload structure, payload framing, test pattern and signal level. If the search is successful, a “PASS” result is displayed.

Search parameters and criteria

- **Interface:** Checks physical parameters (bit rate line code).
- **Mapping:** Checks mapping structure using the signal label and pointer bytes.
- **Payload:** Only test patterns defined in ITU-T or ANSI standards will be recognized. If no test pattern is detected, the unit assumes live traffic.

PDH Signals: Unframed or framed payloads at all hierarchies. For 1.5M signals containing 64kbps timeslots, the test set will assume live traffic and will not search for a test pattern.

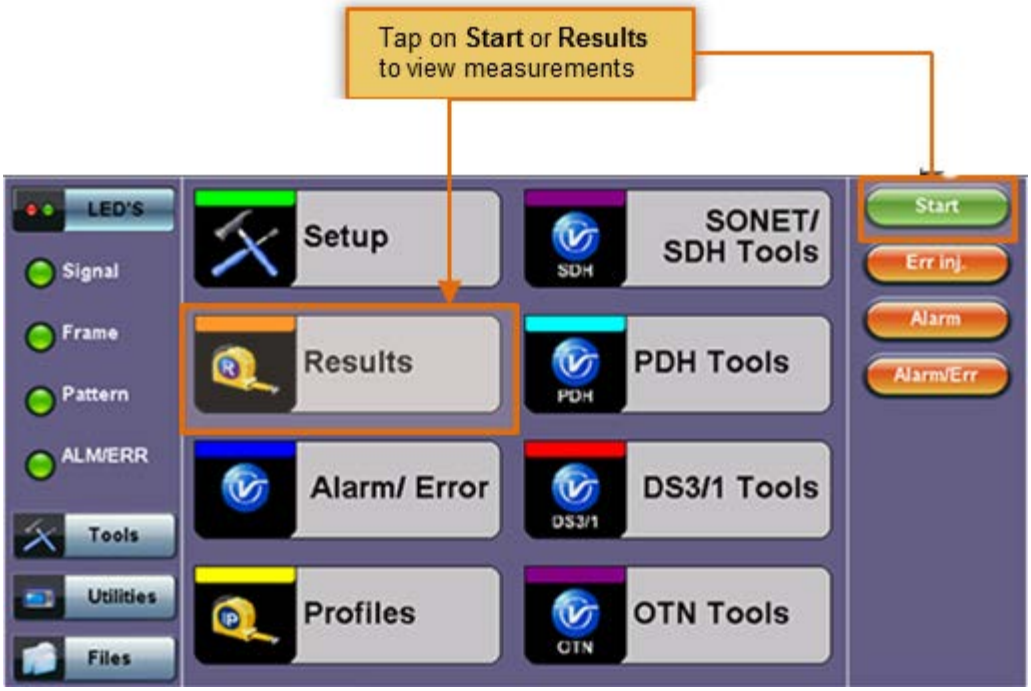
Go back to top Go back to TOC

7.0 Results

Accessing Results

To access measurements for PDH, SDH, SONET, and OTN, tap on **Start**, which starts testing, or **Results**.

Results icon



Go back to top Go back to TOC

7.1 Results: PDH

7.1.1 Summary

The Summary tab displays an overview of the major test parameters. At a glance, the user is able to see if there are any alarms, errors, or signal failure.

Summary tab

Go back to top Go back to TOC

7.1.2 Errors and Alarms

The Error/Alarm tab brings up several pages showing the errors and alarm status. Alarms/Errors results 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)

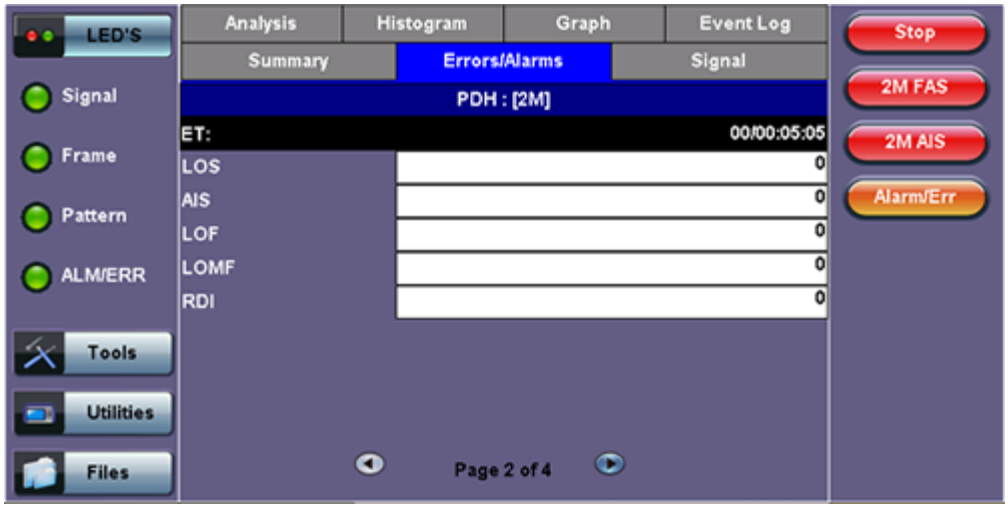
Note: Tapping the individual soft LED will automatically link directly to the applicable result screen which provides detailed information.

Go back to top Go back to TOC

Errors/Alarms (Page 2)

Page 2 lists the Alarms in logical order that are associated with the signal under test. All alarms are evaluated and stored. The time resolution of alarms is 100ms.

Errors/Alarms - PDH (Page 2)

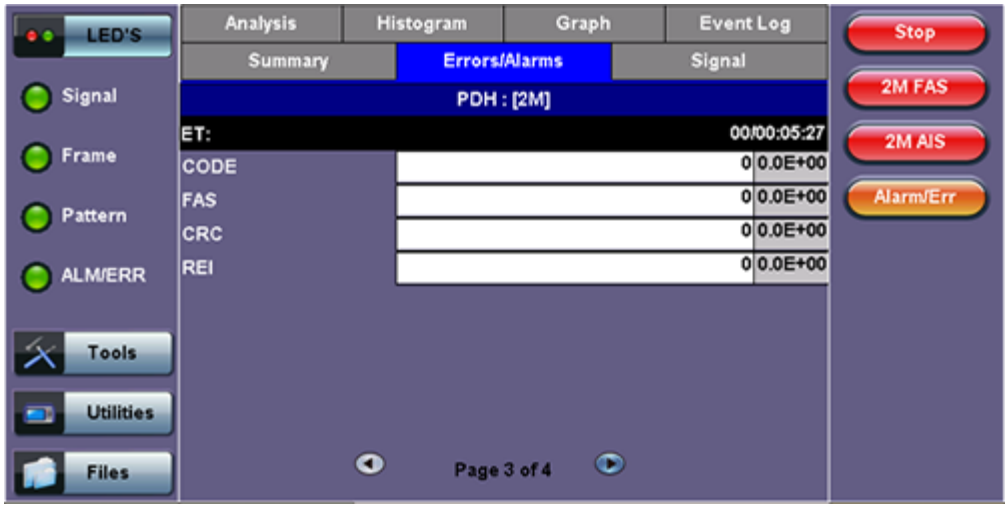


Go back to top Go back to TOC

Errors/Alarms (Page 3)

Page 3 lists the Errors in logical order that are associated with the signal under test. All errors are counted simultaneously and stored.

Errors/Alarms - PDH (Page 3)

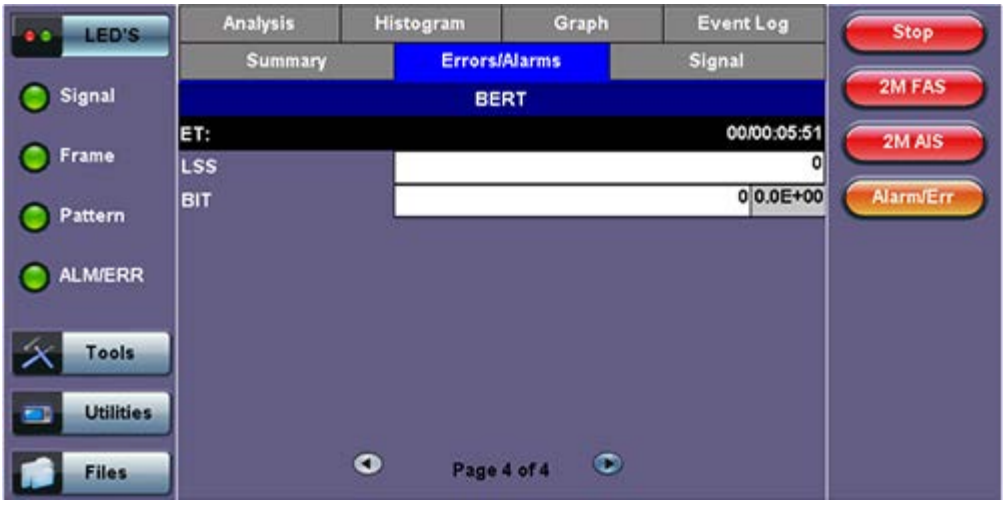


Go back to top Go back to TOC

Errors/Alarms (Page 4)

Page 4 lists the Bit Error Performance (BERT) associated with the signal under test.

Errors/Alarms - BERT (Page 4)



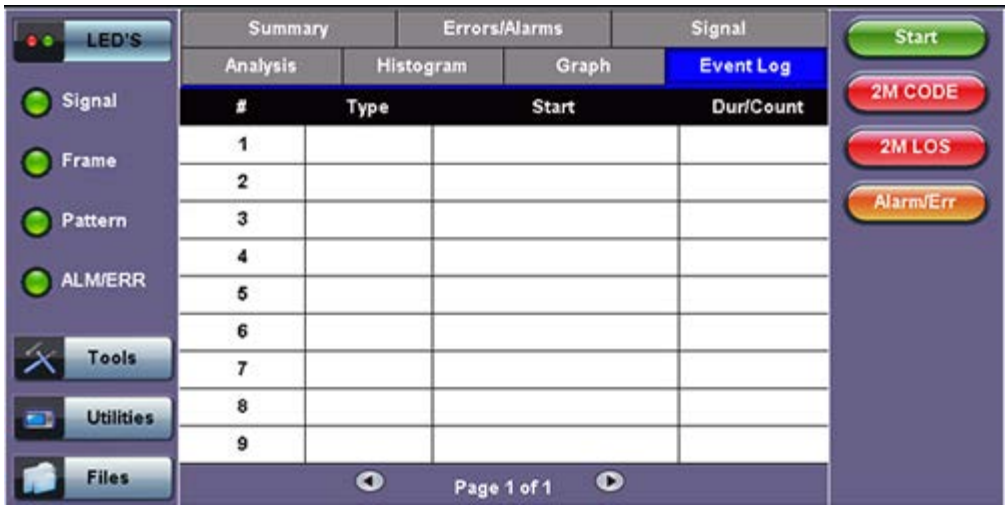
Go back to top Go back to TOC

7.1.3 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 (#):** Event number, events are numbered sequentially
- **Type:** Indicates alarm or error type
- **Start:** Indicates when the alarm or error was detected
- **Dur/Count:** Indicates for how long the alarm or error was detected and provides duration (alarms) and ratio/count (errors). The duration format is day:hour:minute:second
- **Pages:** Scroll through the pages depending on the number of events recorded

Event Log

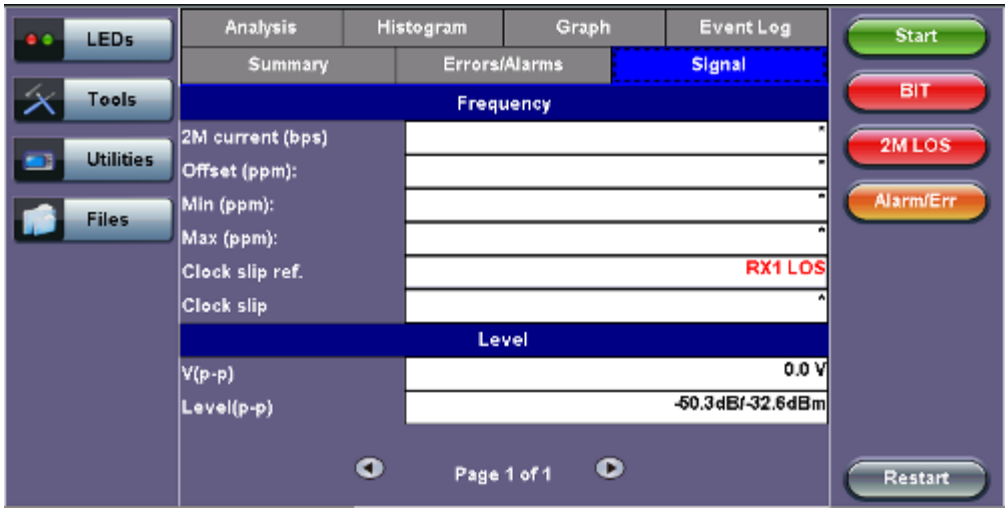


Go back to top Go back to TOC

7.1.4 Signal

The Signal tab brings up the frequency and level result screen.

Signal tab



Frequency: The received signal frequency and offset is measured and displayed. For E1 signals, the measurement is performed on both balanced 100 ohm and unbalanced 75 ohm interfaces.

- **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

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.

Frequency Tolerances for PDH and T-Carrier Systems	
Signal	**Frequency Specification**
E1 PDH	2,048 Mbps ± 112 bps (± 54.6 ppm)
E3 PDH	34,368 Mbps ± 846 bps (± 24.6 ppm)
E4 PDH	139,264 Mbps ± 2730 bps (± 19.6 ppm)
DS1 T-Carrier	1,544 Mbps ± 57 bps (± 36.6 ppm)
DS3 T-Carrier	44,736 Mbps ± 1101 bps (± 24.6 ppm)

Level: Measures the Peak and Peak-Peak voltage values of the incoming signal. The levels for the various signal types according to ITU-T G.703 recommendations are presented.

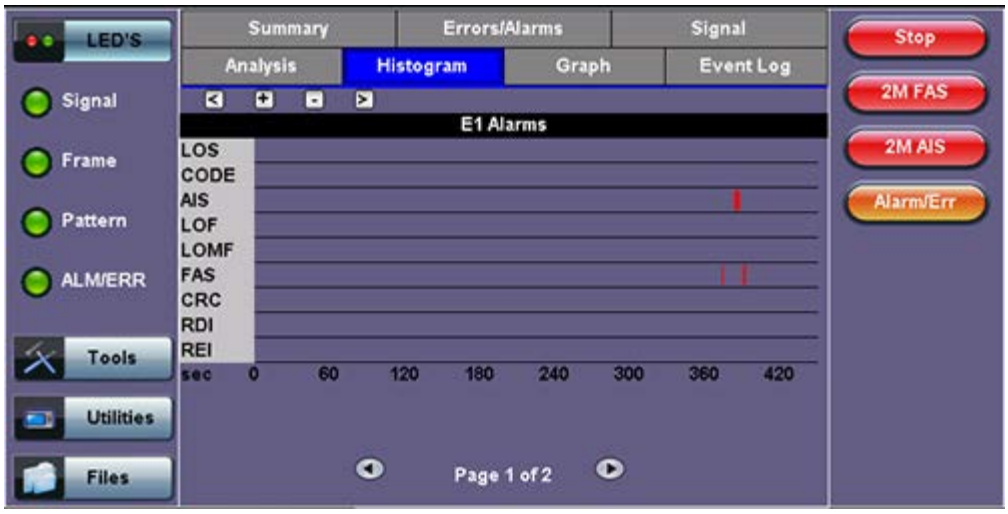
PDH Signal Levels per ITU-T G.703 Recommendations				
Signal	**Bit Rate**	**Line code**	**Input**	
			Termination	**Level**
E1	2 Mbit/s	HDB3	75 ohm unbalanced BNC 120 ohm balanced RJ45	Terminate: 2.37 Volt peak Monitor: 2.37 Volt peak with 20 or 26dB gain Terminate: 3.0 Volt peak Monitor: 3.0 Volt peak with 20 or 26dB gain
E3	34 Mbit/s	HDB3	75 ohm unbalanced BNC	Terminate: 1.0 Volt peak Monitor: 1.0 Volt peak with 20 or 26dB gain
E4	140 Mbit/s	CMI	75 ohm unbalanced BNC	Terminate: 1.0 Volt peak Monitor: 1.0 Volt peak with 20 or 26dB gain

Go back to top Go back to TOC

7.1.5 Histogram

The Histogram tab displays a historical record of the Alarms and Errors recorded during the measurement interval. A dedicated page is available for errors and alarms including BER. Scroll through the various pages to display the anomalies of interest.

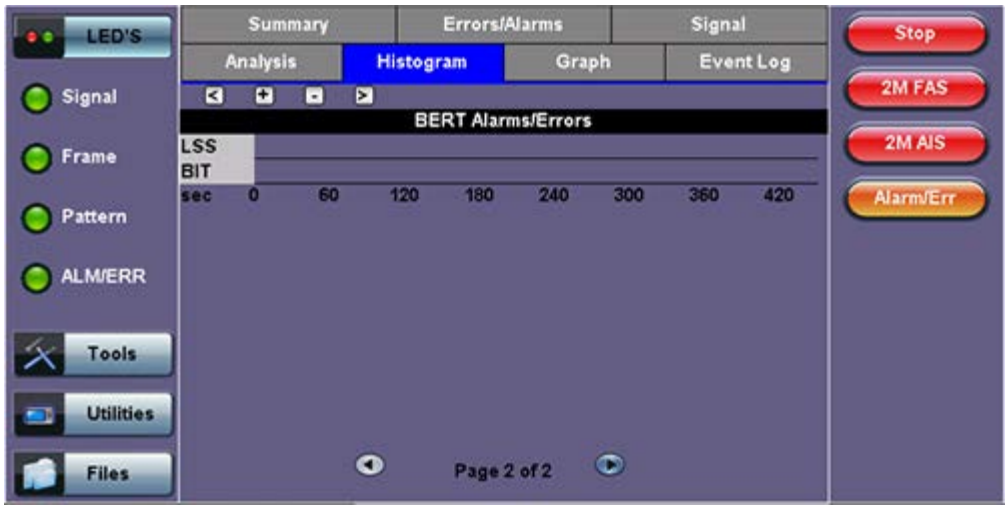
Histogram - E1 Alarms (Page 1)



The alarms and errors presented will depend on the signal type and structure selected. A graphical timeline on the horizontal axis indicates when the event occurred since the test was started. 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. The events presented above are shown in the table below.

The screen below depicts BER and bit errors (LSS stand for Loss of Sequence Synchronization).

Histogram - BERT Alarms/Errors (Page 2)

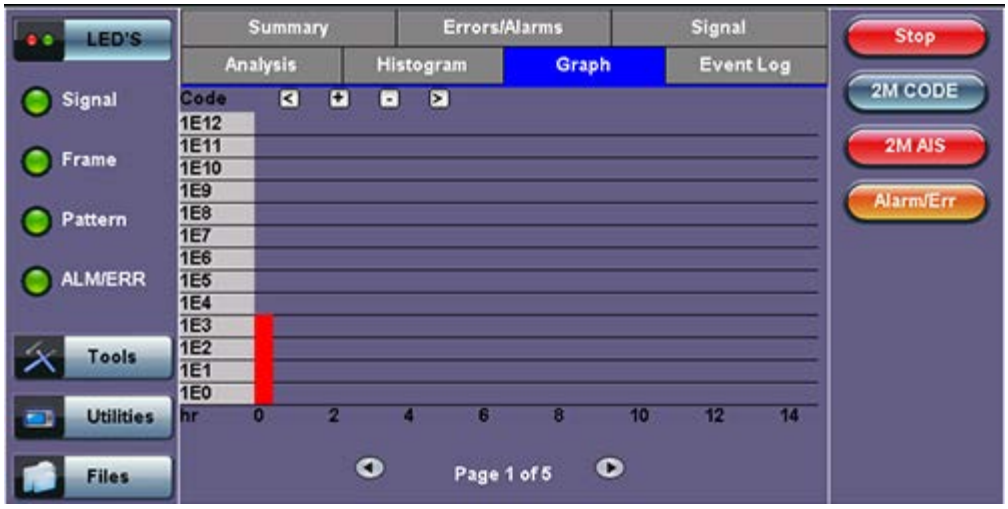


Go back to top Go back to TOC

7.1.6 Graph

The Graph tab brings up a screen displaying a log of the errors recorded during the measurement interval. A dedicated page is available for each error type. Scroll through the various pages to display the anomaly of interest.

Graph tab

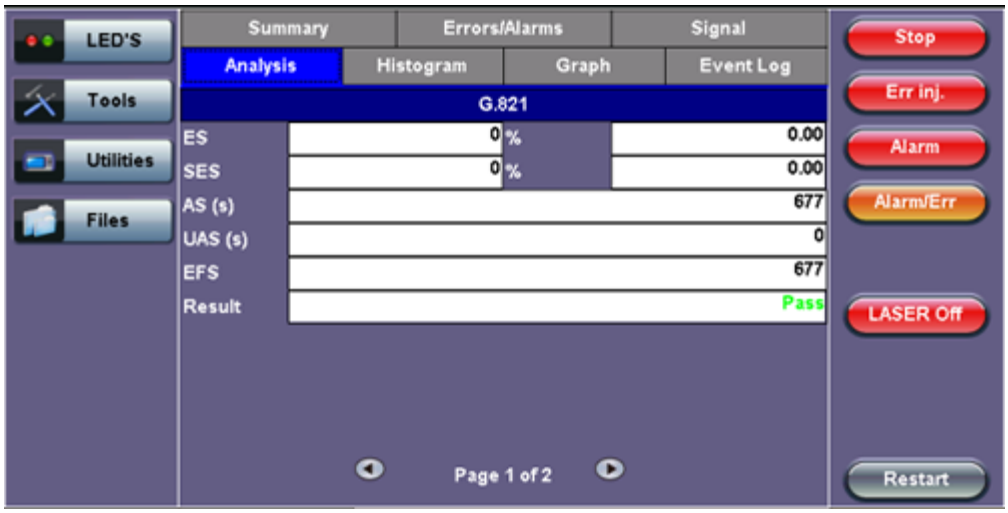


A graphical timeline on the horizontal axis indicates when the event occurred while the vertical axis indicates the logarithmic scale of errors. The upper left and right arrows allow the user to scroll through the measurement period, while the + and – keys allow zooming in/out of the time axis.

Go back to top Go back to TOC

7.1.7 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 6.7.2 Performance Analysis.

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

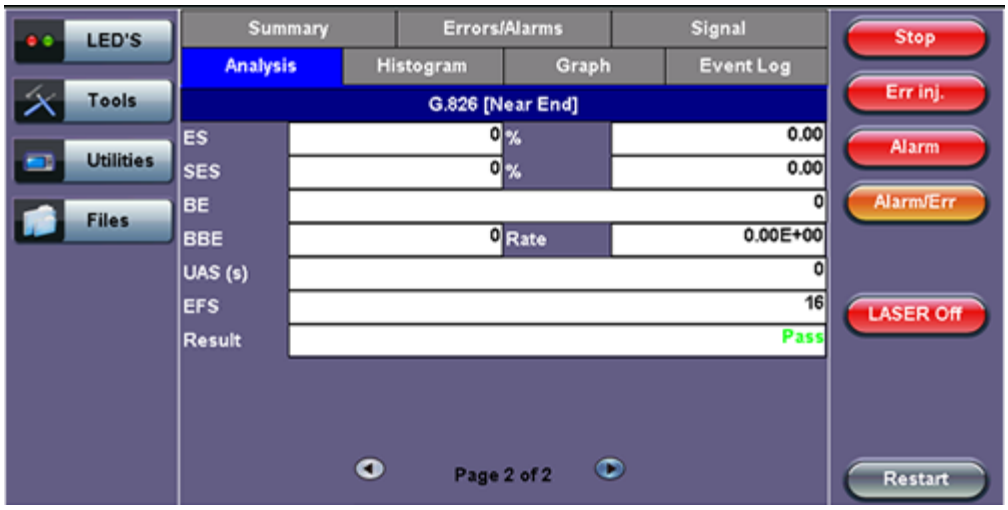
- N x 64kbps
- Framed patterns and bulk signals
- Pass/Fail result is in conjunction with path allocation between 0.1 and 100%

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.

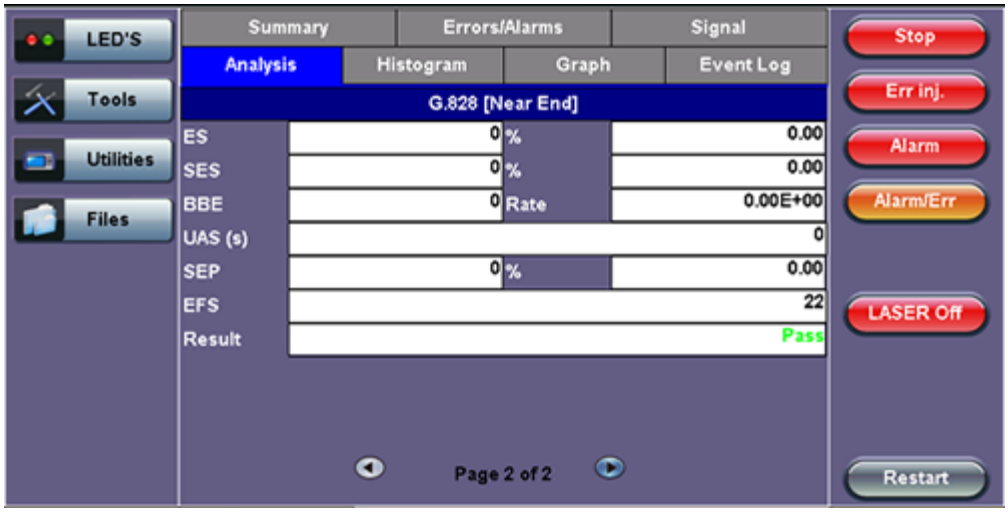
Out-of-Service Measurement (OOS): Out-of-service measurement using bit errors in a test pattern.

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.

G.828 Performance Analysis



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)

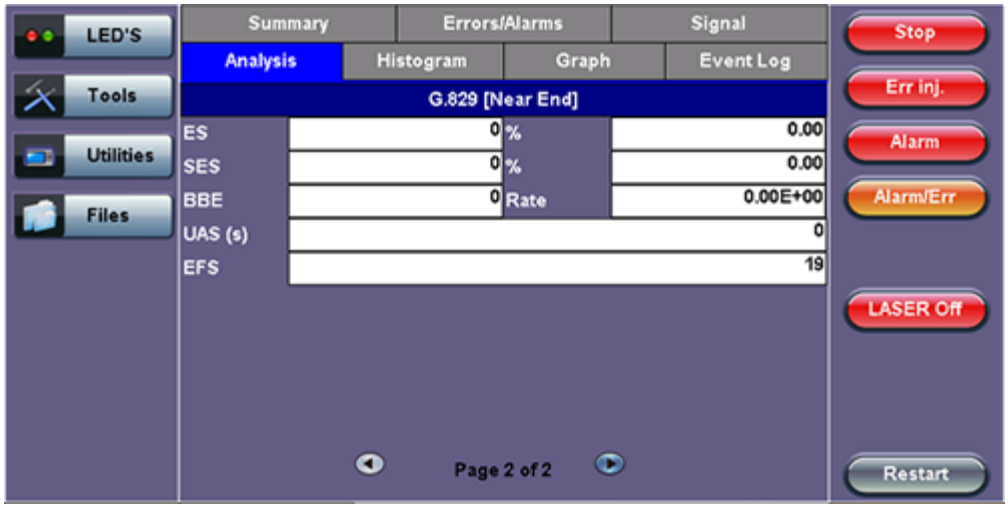
Evaluation of the near end and far-end is possible, however far-end evaluations can only be made if REI is available.

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.

G.829 Analysis



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:

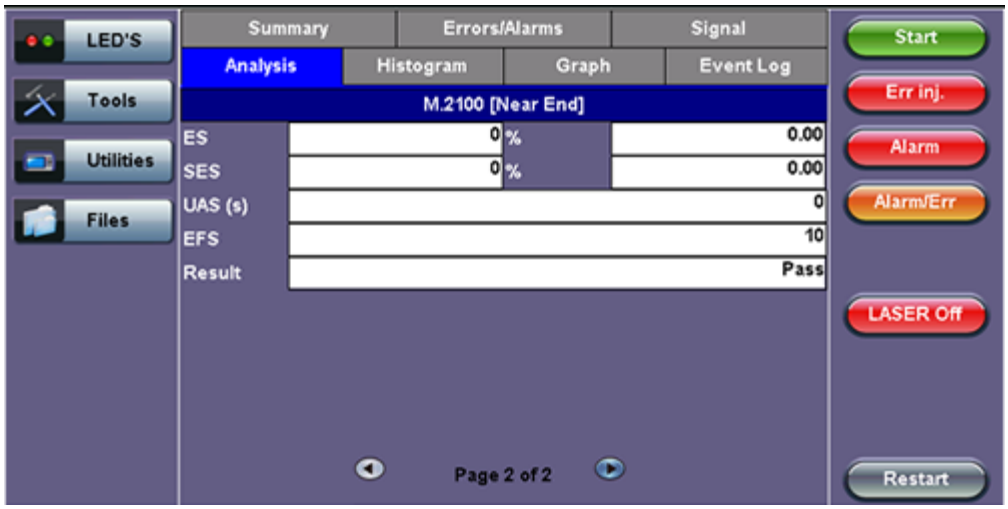
- B1
- B2
- MS-REI
- Bit errors (TSE)

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)

M.2100 Analysis



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)

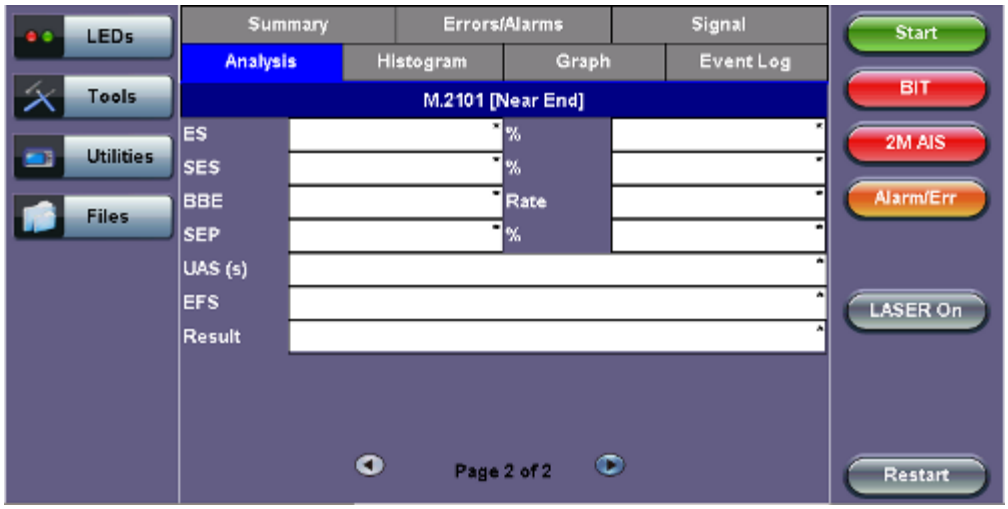
Evaluation is made at the “Near End” and at the “Far End” for PCM-30/31 signals with CRC.

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.

M.2101 Analysis



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.

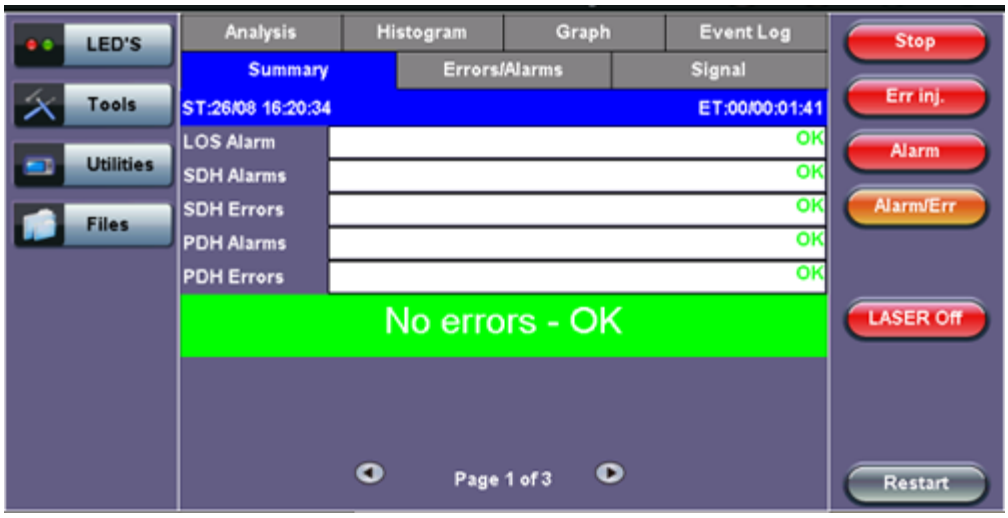
Go back to top Go back to TOC

7.2 Results: SDH

7.2.1 Summary

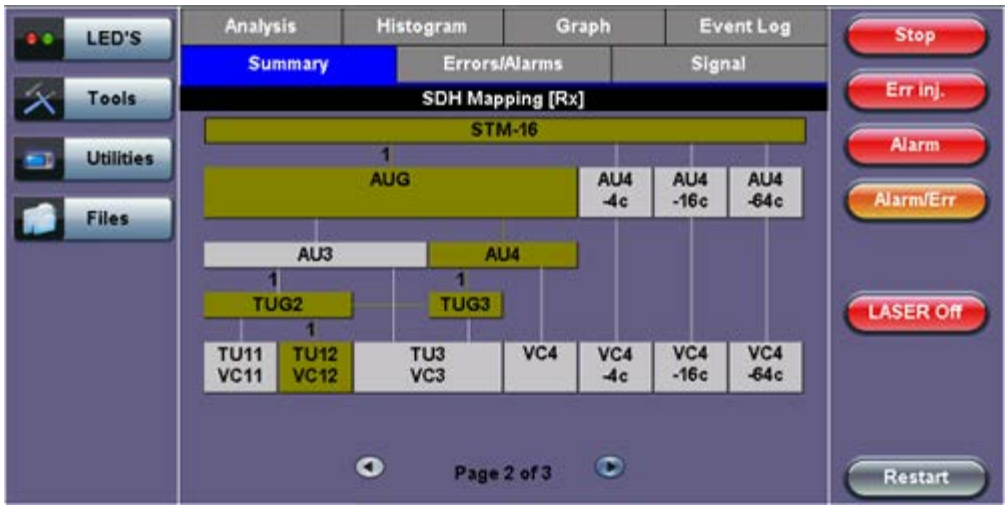
The Summary tab displays a summary of test results and parameters. At a glance, the user is able to see if there are any alarms, errors, or signal failure pertaining to the SDH signal and its payload.

Summary (Page 1)

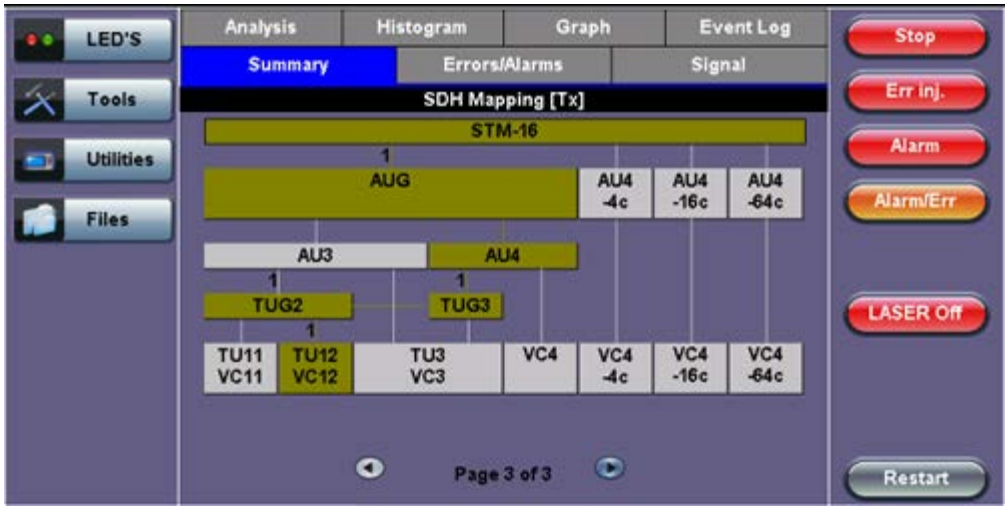


SDH mapping information is displayed on page 2 and 3.

Summary (Page 2)



Summary (Page 3)



Go back to top Go back to TOC

7.2.2 Errors and Alarms

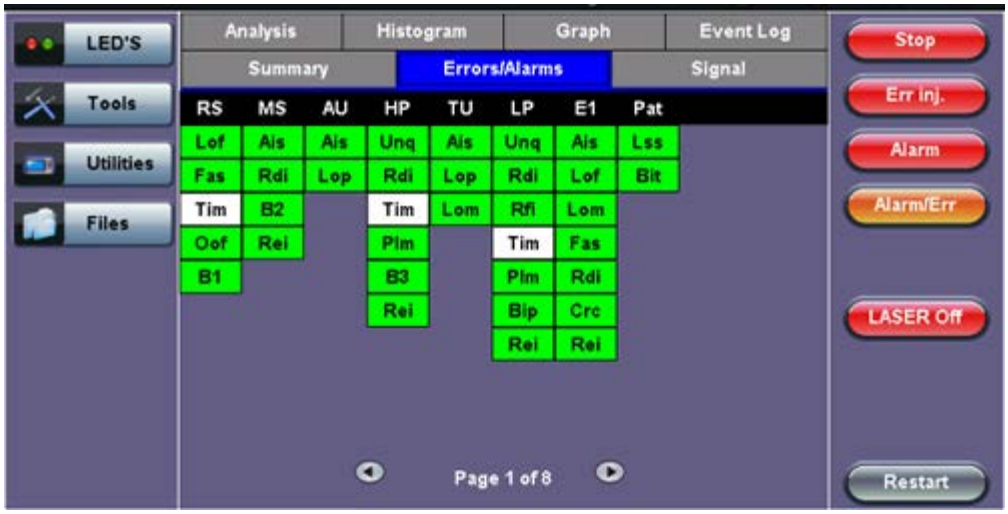
The Errors/Alarms tab brings up several pages showing the errors and alarms status.

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.

The LED headers are described in the table 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 defection criteria 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
LSS	Loss of Sequence Synchronization - Out-of-service bit error measurements using pseudo-random sequences or 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 0.25 ms.
OOF	Out of Frame - Declared when 4 consecutive SDH frames are received with invalid (errored) framing patterns. Maximum OOF detection time is 625 µs
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.

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

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 N x 24 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 - Declared when bits 1-4 of the G1 byte contain 0001 to 1000 pattern

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 Loss of Pointer - Declared when no valid pointer is detected in N consecutive super-frames (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

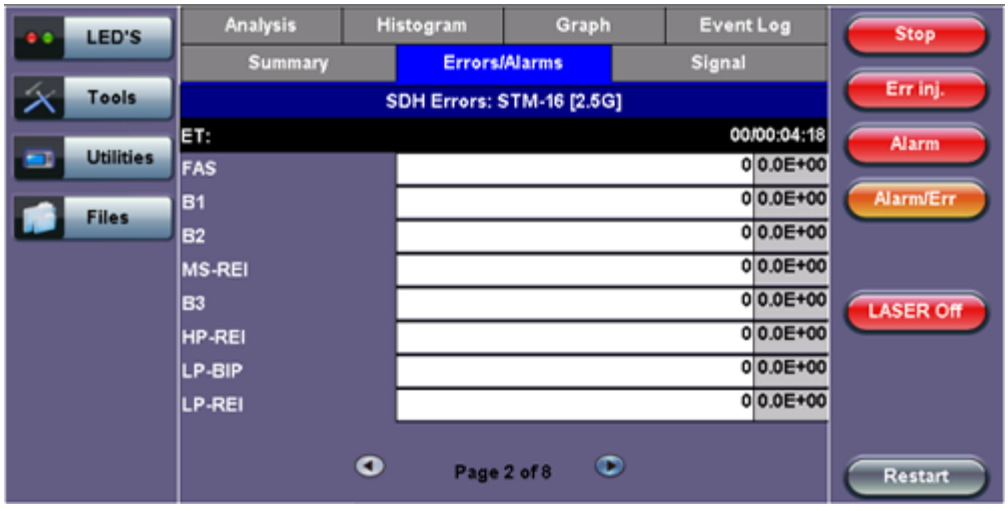
PDH alarms are described in 7.0 Results.

Go back to top Go back to TOC

Errors/Alarms (Page 2)

Page 2 lists the SDH Errors 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. Error conditions are displayed in red including count and rate.

Errors/Alarms (Page 2)



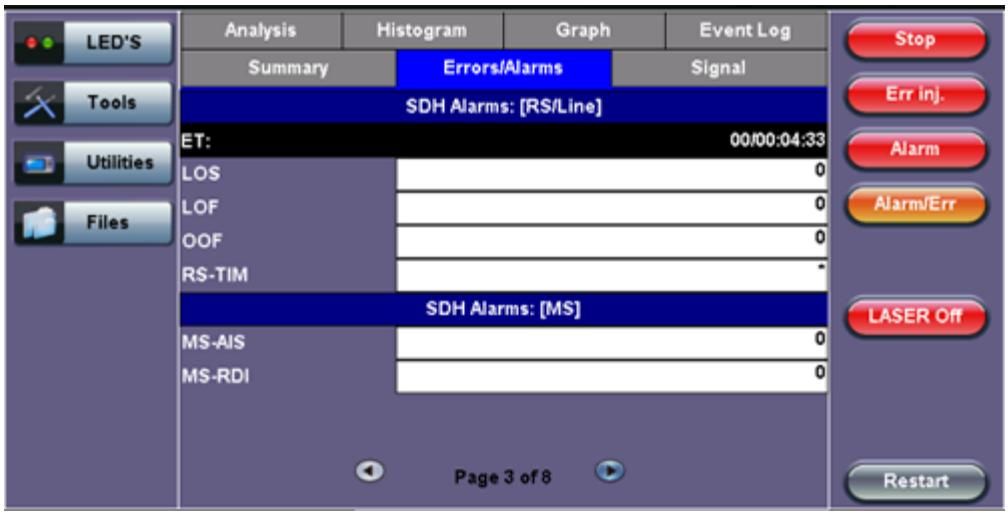
Go back to top Go back to TOC

Errors/Alarms (Page 3)

Page 3 lists the Section and Line Overhead Alarms in logical order associated with the signal under test. All alarms are evaluated and stored. The Elapsed Time [ET] since the start of the test is shown in the upper right hand corner.

The alarms associated with the Section and Line are displayed separately for ease of interpretation.

Errors/Alarms (Page 3)

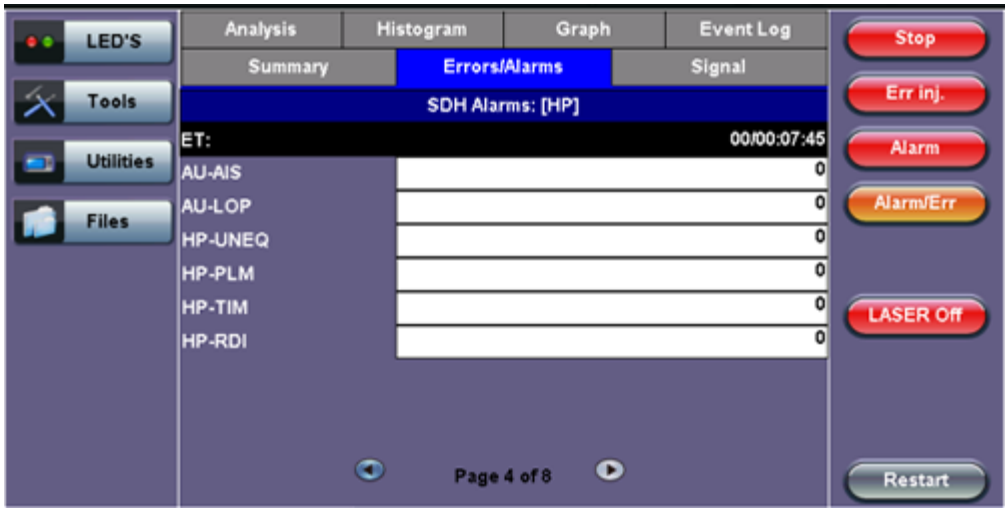


Go back to top Go back to TOC

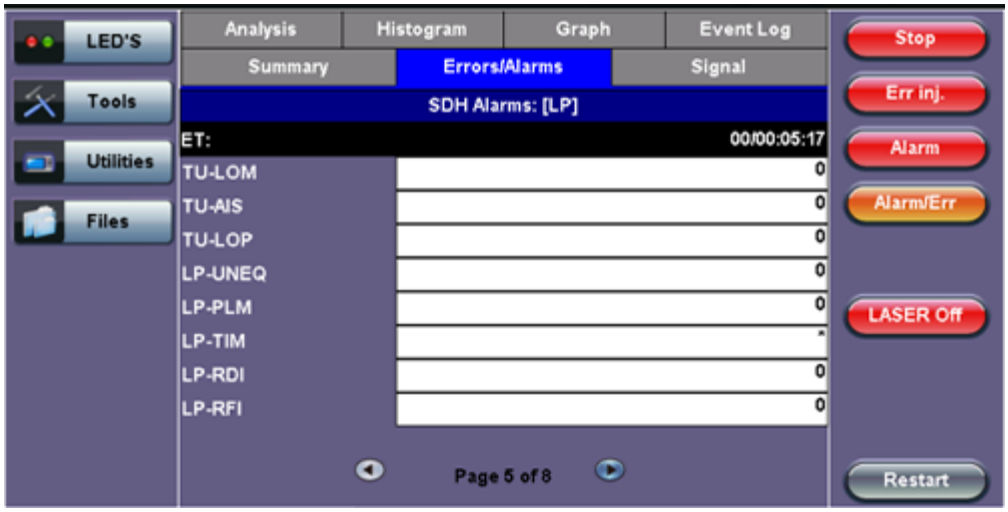
Errors/Alarms (Page 4 & 5)

Page 4 & 5 lists the High Order Path and Low Order path in logical order that are associated with the signal under test. All alarms are evaluated and stored.

Errors/Alarms (Page 4)



Errors/Alarms (Page 5)

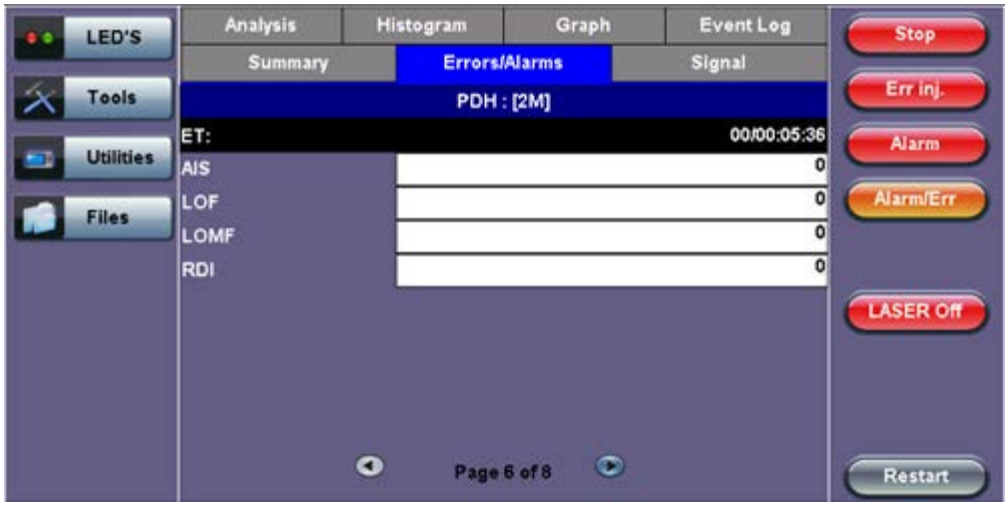


Go back to top Go back to TOC

Errors/Alarms (Page 6)

Page 6 lists the PDH Alarms in logical order that are associated with the signal and payload under test. All alarms are evaluated and stored.

Errors/Alarms (Page 6)

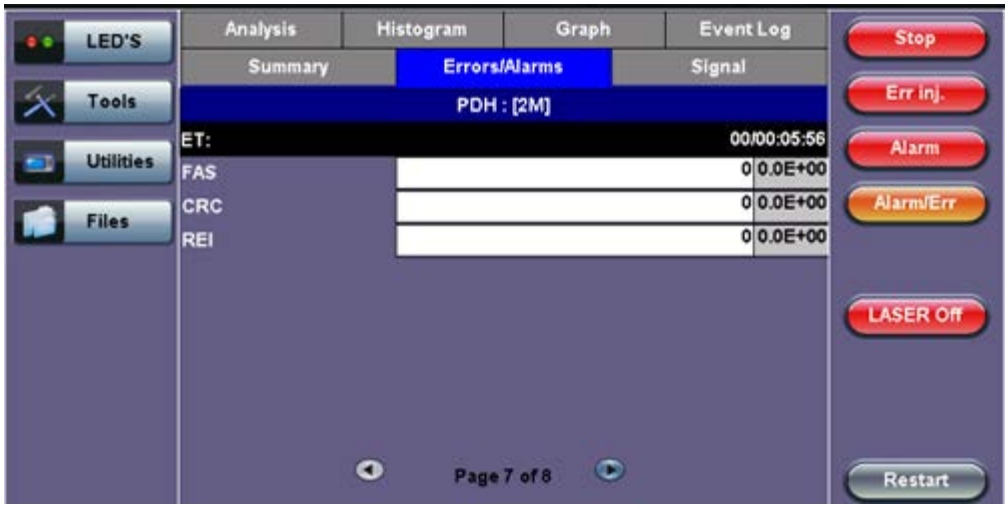


Go back to top Go back to TOC

Errors/Alarms (Page 7)

Page 7 lists the PDH Errors in logical order that are associated with the signal and payload under test. All errors are evaluated and stored.

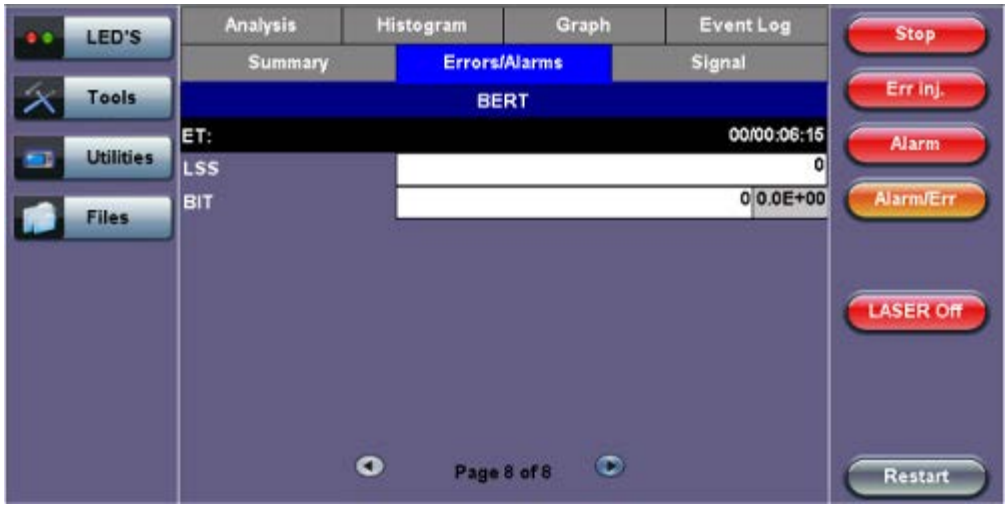
Errors/Alarms (Page 7)



Errors/Alarms (Page 8)

Page 8 lists the BERT Errors in logical order that are associated with the signal and payload under test. All errors are evaluated and stored.

Errors/Alarms (Page 8)

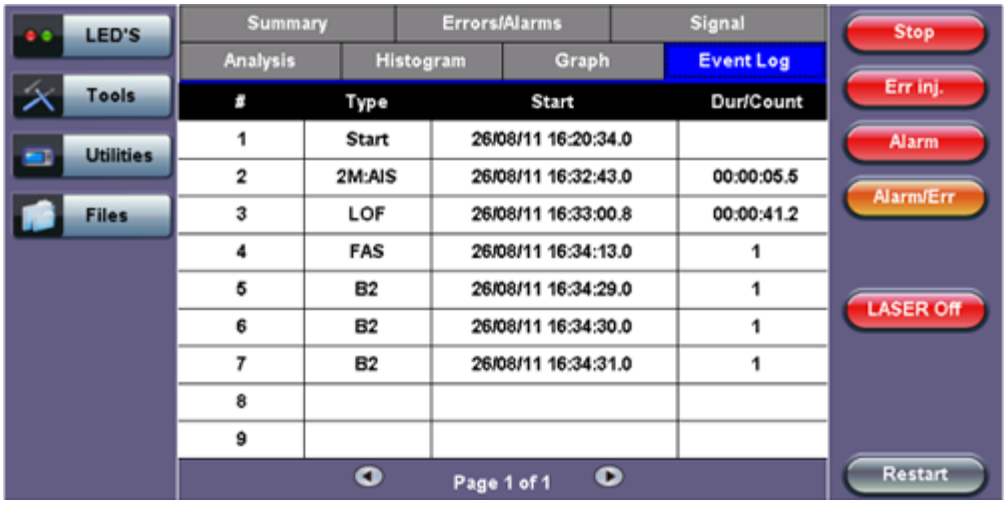


Go back to top Go back to TOC

7.2.3 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



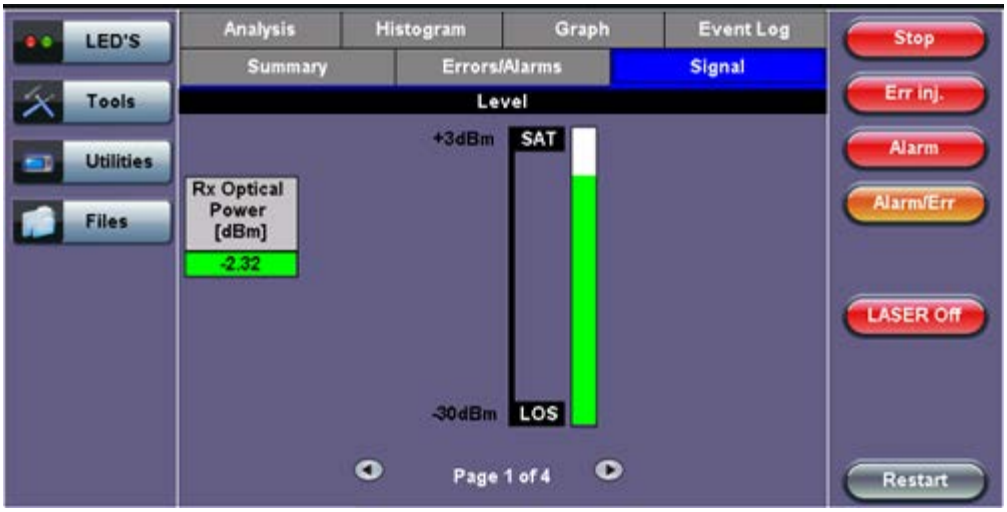
Go back to top Go back to TOC

7.2.4 Signal

The signal tab displays the Level and Frequency screen. Page 1 displays the level measurement in electrical units (volts) for STM-1, STM-4, STM-16 and STM-64 signals.

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

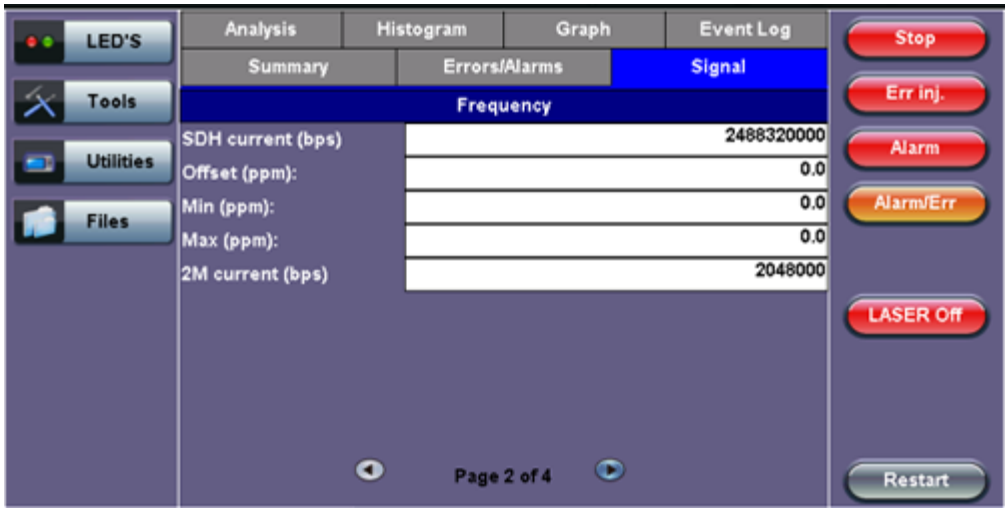
Signal (Page 1)



Frequency (Page 2)

The received signal frequency and offset is measured and displayed. For SDH signals, the measurement is performed on both electrical (BNC) and optical interfaces (SFP or XFP).

Signal - Frequency (Page 2)



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

- **SDH 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.
- **2M Current:** Indicates the frequency of the payload data. Options 1.5M, 45M, 34M are displayed.

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.

Low quality clock sources that deviate from the nominal value cause problems in the operation of network elements. It is necessary and recommended to measure the signal frequency at all hierarchies to reduce synchronization risks. To measure line frequency in service, the test set must be connected to a Protected Monitoring Point (PMP). The frequency of the signal is normally reported in Hz, while the deviation is reported in ppm. Tolerances for the various clock frequencies of SDH hierarchies are presented in the table below.

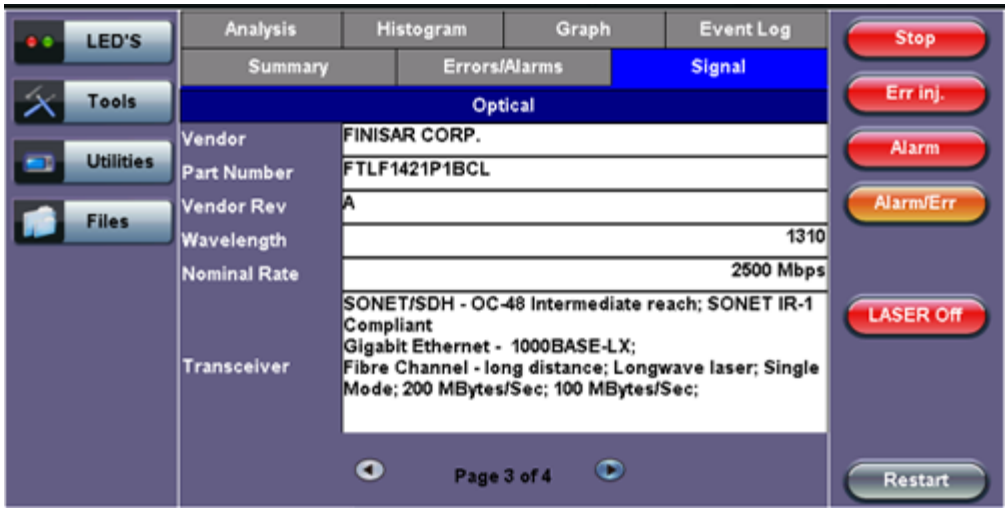
SONET/SDH Clock Frequencies and Tolerances	
Bit rate (Mbps)	**Tolerance (ppm)**
155,520	< 4.6ppm
622,080	< 4.6ppm
2,488,320	< 4.6ppm
9,953,280	< 4.6ppm

Level: Measures the Peak and Peak-Peak voltage values or optical power of the incoming signal.

Signal > Optical Information (Page 3)

Page 3 displays the Optical module (SFP or XFP) information which includes Vendor name, Part number, and Optical Wavelength.

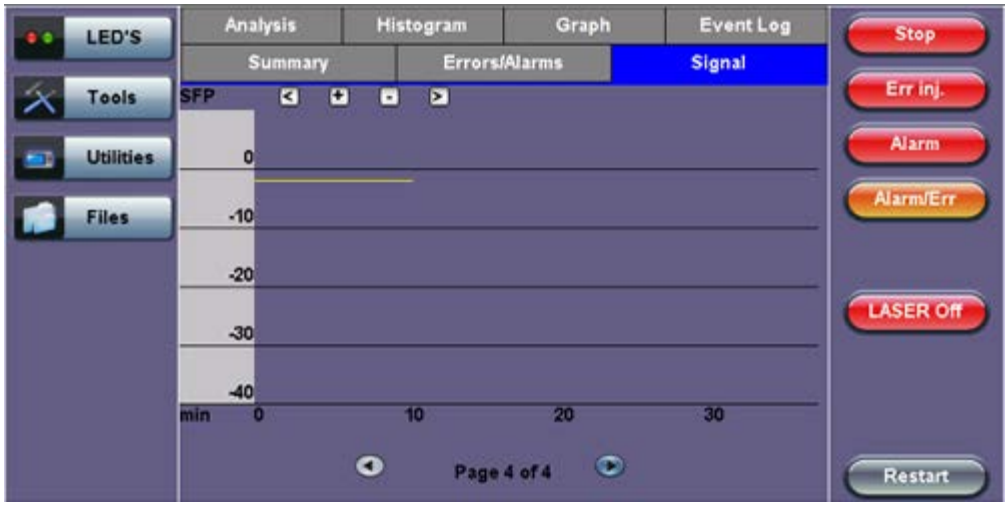
Signal - Optical (Page 3)



Signal > Optical Information (Page 4)

Page 4 displays the Optical module (SFP or XFP) Power Measurement Graph.

Signal - Optical (Page 4)



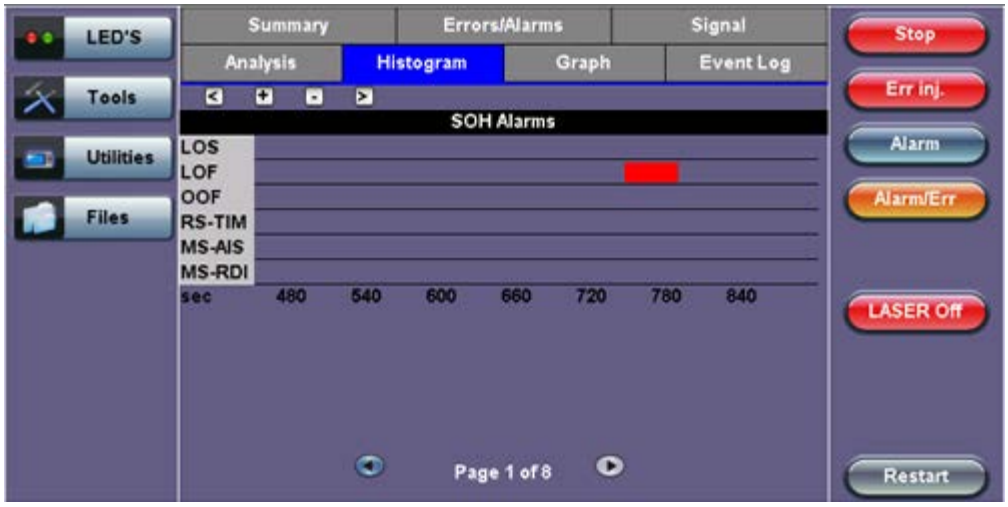
Go back to top Go back to TOC

7.2.5 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.

Page 1 displays the **Alarms** associated with the **Section Overhead (SOH) Alarm**.

Histogram - SOH Alarms (Page 1)



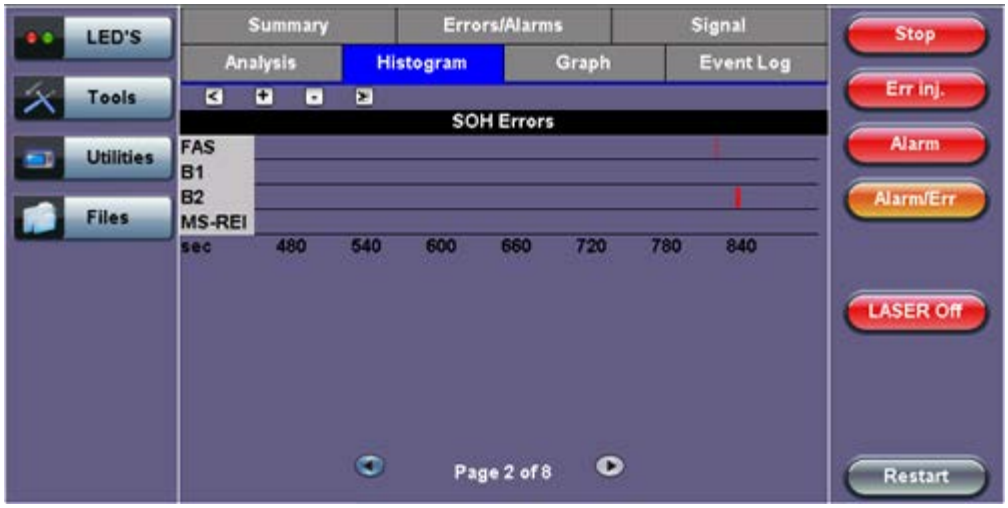
Note: The alarms and errors presented depend on the signal type and structure selected. A graphical timeline on the horizontal axis indicates when the event occurred. The upper left and right arrows allow the user to scroll through the measurement period while the + and – keys allow zooming in/out of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

Go back to top Go back to TOC

Histogram (Page 2)

Page 2 displays the **Errors** associated with the **Section Overhead (SOH)**.

Histogram - SOH Errors (Page 2)



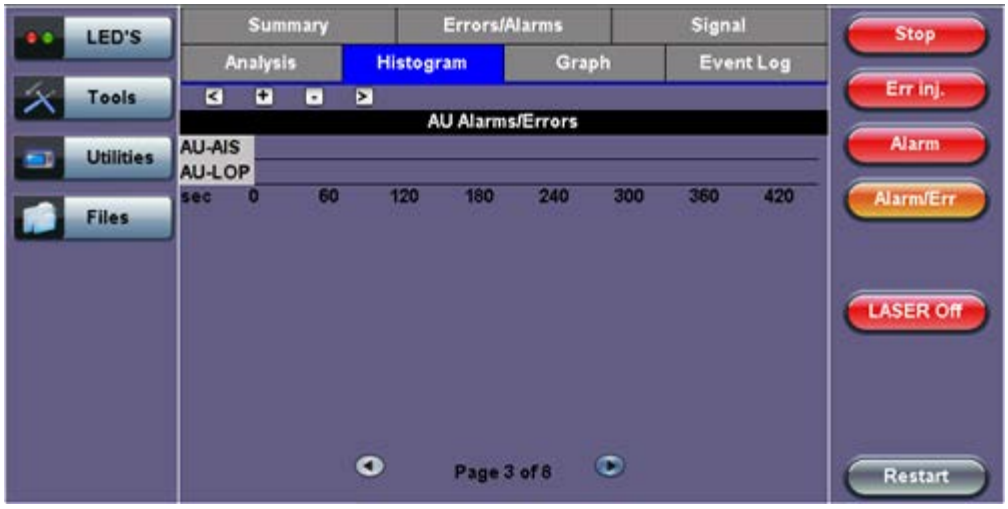
Go back to top Go back to TOC

Histogram (Page 3)

Page 3 displays the **Alarms and Errors** associated with the **Administrative Unit (AU, SDH)**. The measured parameters are:

- AU-AIS (AU - Alarm Indication Signal)
- AU-LOP (AU - Loss of Pointer)

Histogram - AU Alarms/Errors (Page 3)



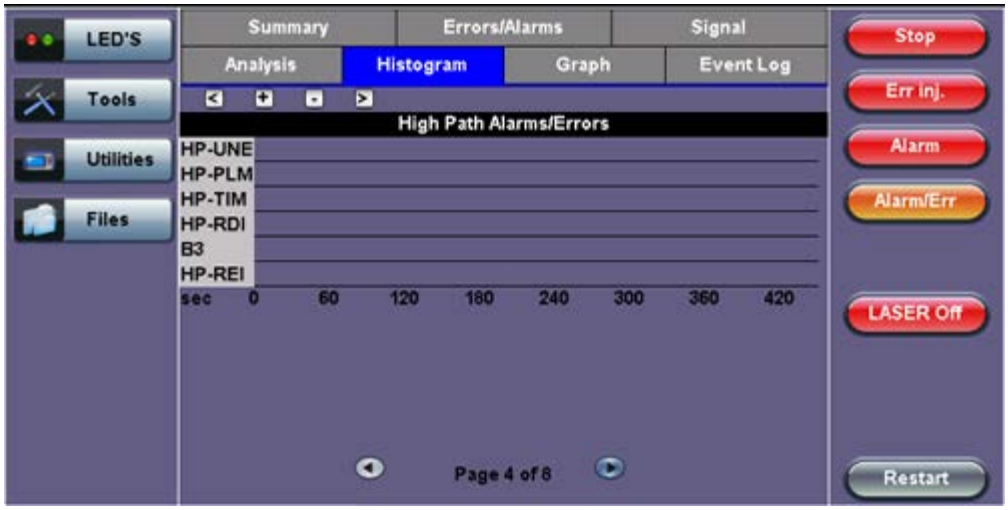
Go back to top Go back to TOC

Histogram (Page 4)

Page 4 displays the **Alarms and Errors** associated with the **High Order Path (HP, SDH)**. The measured parameters are:

- HP-UNE (HP-Unequipped)
- HP-PLM (HP-Payload Mismatch)
- HP-TIM (HP-Trace Identifier Mismatch)
- HP-RDI (HP-Remote Defect Indication)
- B3 errors
- HP-REI (HP-Remote Error Indication)

Histogram - High Path Alarms/Errors (Page 4)



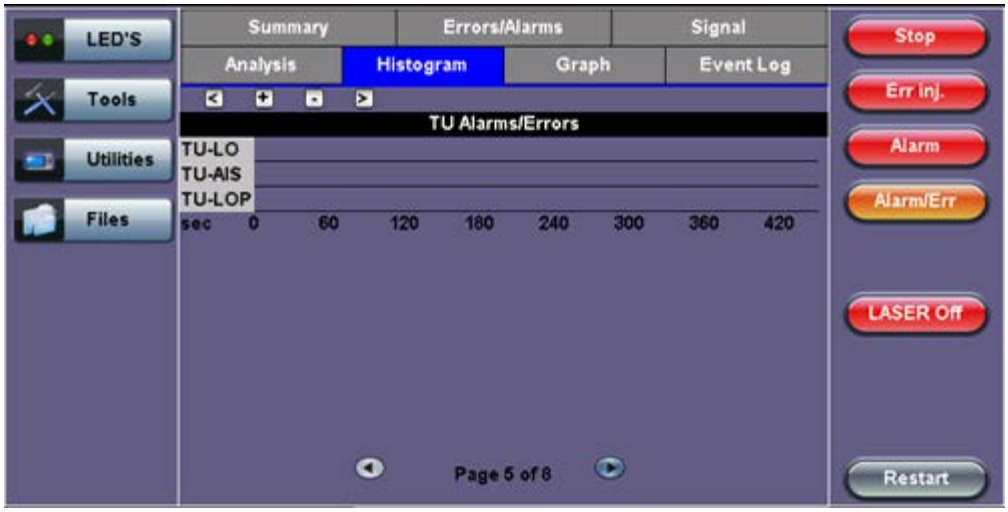
Go back to top Go back to TOC

Histogram (Page 5)

Page 5 displays the **Alarms and Errors** associated with the **Tributary Unit (TU)**.

- TU-AIS (TU-Alarm Indication Signal)
- TU-LOP (TU-Loss of Pointer)

Histogram - TU Alarms/Errors (Page 5)



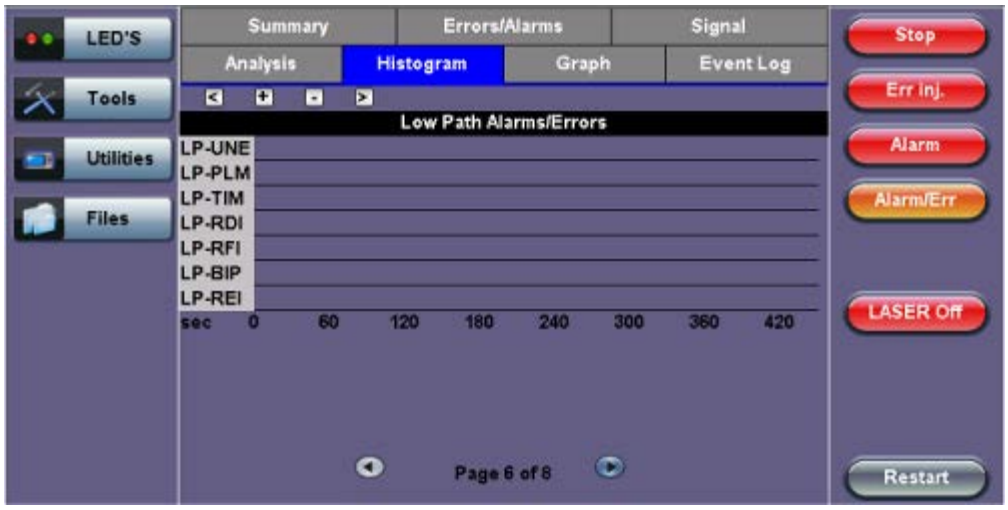
Go back to top Go back to TOC

Histogram (Page 6)

Page 6 displays the **Alarms and Errors** associated with the **Low Order Path (LP,SDH)**. The measured parameters are:

- LP-UNE (LP-Unequipped)
- LP-PLM (LP-Payload Mismatch)
- LP-TIM (LP-Trace Identifier Mismatch)
- LP-RDI (LP-Remote Defect Indication)
- LP-RFI (LP-Remote Fault Indication)
- LP-BIP (LP-Bit Interleaved Parity)
- LP-REI (LP-Remote Error Indication)

Histogram - Low Path Alarms/Errors (Page 6)

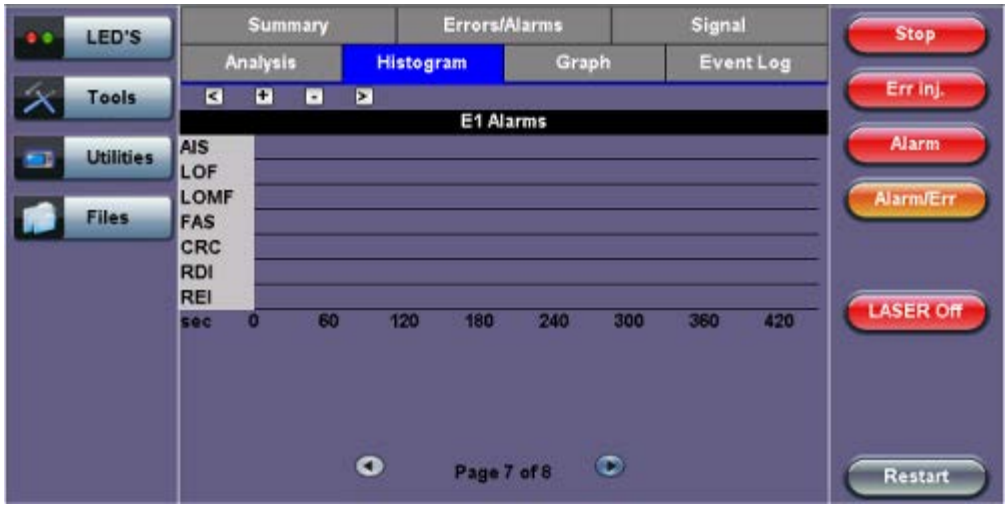


Go back to top Go back to TOC

Histogram (Page 7)

Page 7 displays the **Alarms** associated with the payload. The measured parameters depend on the payload selected.

Histogram - E1 Alarms (Page 7)

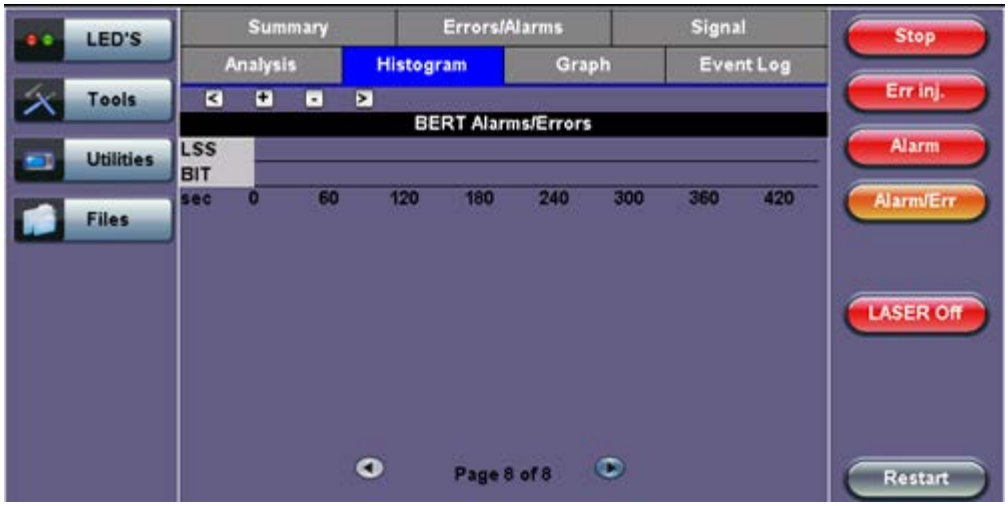


Go back to top Go back to TOC

Histogram (Page 8)

Page 8 displays the **Errors** associated with the test pattern.

Histogram - BERT Alarms/Errors (Page 8)



Go back to top Go back to TOC

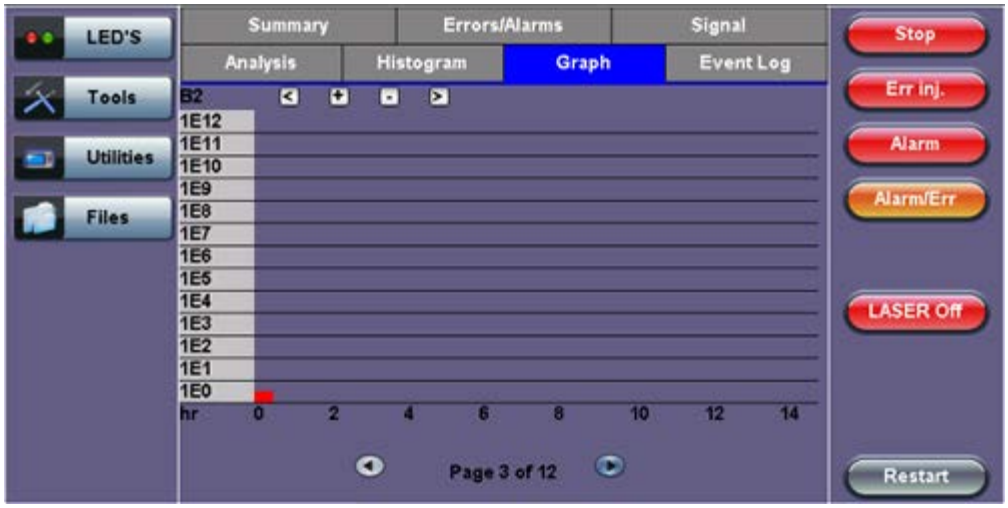
7.2.6 Graph

The Graph tab brings up the screen displaying a log of the Errors recorded during the measurement interval. A dedicated page is available for each of the following error types:

- FAS
- B1
- B2
- MS-REI
- B3
- HP-REI
- LP-BIP
- LP-REI
- PDH errors depending on payload

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.

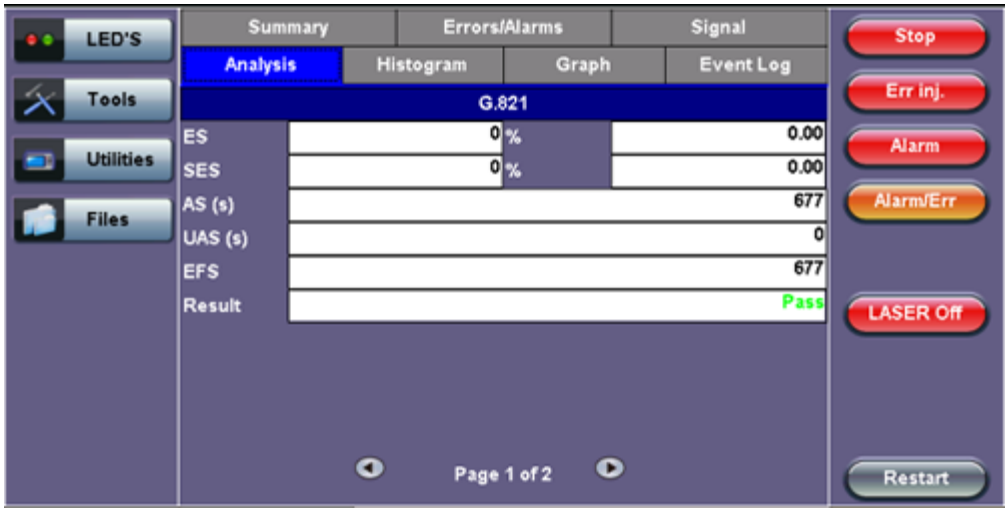
Graph (Page 3)



Go back to top Go back to TOC

7.2.7 Performance Analysis

G.821 Analysis



The Analysis tab displays measured objectives from ITU-T performance tests selected from the Measurements tab (**Setup** > **Measurements**). Please see 7.1.5 Analysis for information on the Analysis tab and test definitions. For a brief description of supported G-Series and M-Series performance tests as well as setup instructions, please see 6.7.2 Performance Analysis.

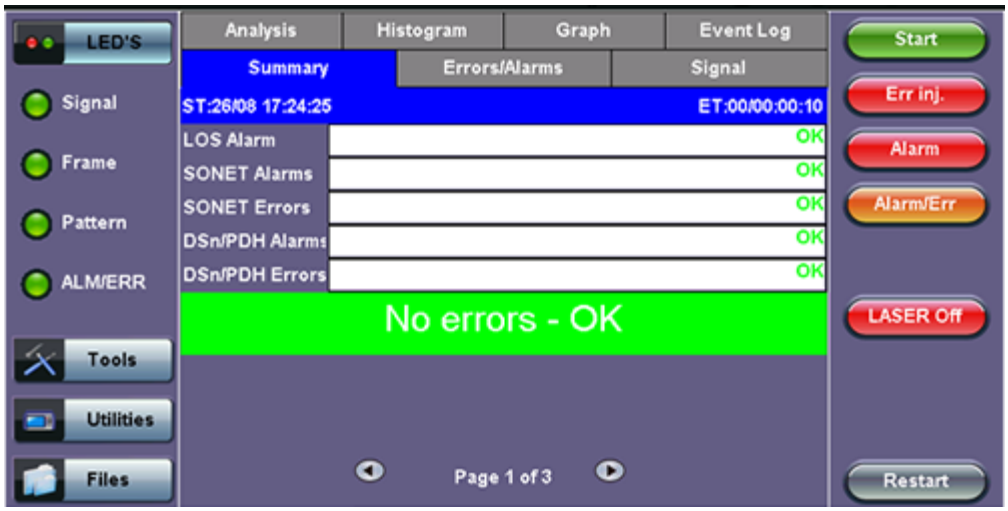
Go back to top Go back to TOC

7.3 Results: SONET

7.3.1 Summary

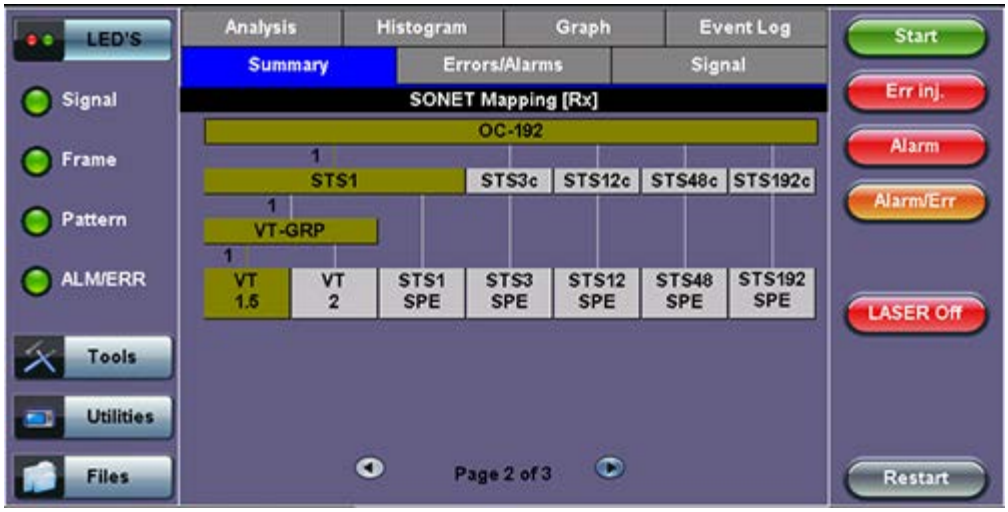
The Summary tab displays a summary of test results and parameters. At a glance, the user is able to see if there are any alarms, errors, or signal failure pertaining to the SONET signal and its payload.

Summary (Page 1)

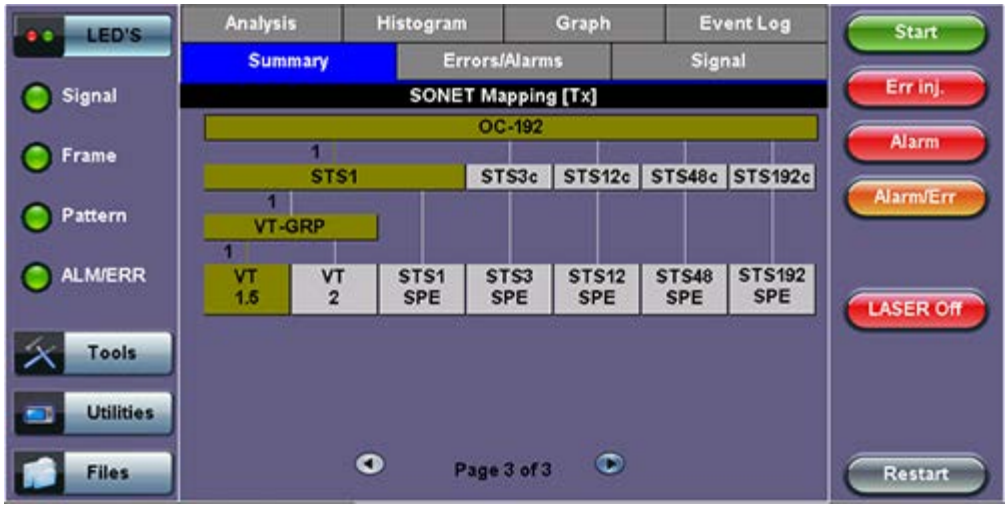


SONET mapping information is displayed on page 2 and 3.

Summary (Page 2)



Summary (Page 3)



7.3.2 Errors/Alarms

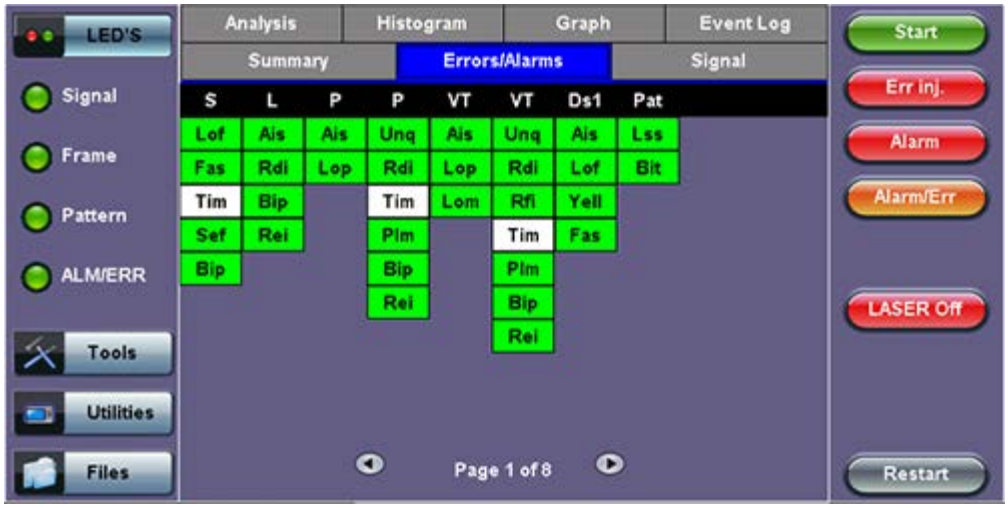
The Errors/Alarms tab brings up several pages showing error and alarm statuses.

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 you to the applicable result screen which provides detailed information.

The 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:

Abbreviation	Name	OH byte
LOS	Loss of Signal	
TSE	Test Sequence Error(bit error)	
LSS	Loss of Sequence Synchronizartion	
AIS	Alarm Indication Signal	
SECTION		
OOF	Out of Frame	A1,A2
LOF	Loss of Frame	A1,A2
B1(8bits)	Regenerator Section Error Monitoring	B1
TIM-S	Trace Identifier Mismatch	J0
LINE		
AIS-L	Line AIS	K2
RDI-L	Line Remote Defect Indication	K2
REI-L	Line Remote Error Indication	M1
B2(24bits)	Error Monitoring	B2
STS-PATH		
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(8bits)	Error Monitoring	B3
UNEQ-P	STS path Unequipped	C2
VIRTUAL TRIBURTARY PATH (VT)		
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 defection criteria per Bellcore GR.253 and ANSI T1.105/231:

	Anomalies/Defect	Detection Criteria	Bellcore ANSI
Section/Line Layer			
LOS	Loss of Signal	All-zero pattern for 2,3 us≤ T ≤ 100us	GR-253 T1.231
LOF	Loss of Frame	A1, A2 No valid framing pattern for 3 ms (24 frames)	GR-253 T1.231
B1	Section BIP error	Mismatch of the recovered and computed BIP-8 covers the whole STS-N frame	GR-253 T1.105
B2	Line BIP error	Mismatch of the recovered and computed NxBIP-8 covers the whole STS-N frame	GR-253 T1.105
AIS-L	Line-AIS	K2(bits 6, 7, 8) = 111 for 5 frame	GR-253 T1.231
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	GR-253 T1.105
RDI-L	Line Remote Defect Indication	K2(bits 6, 7, 8) = 110 for z frame (z= 5 – 10)	GR-253 T1.231

	Anomalies/Defect	Detection Criteria	Bellcore ANSI
STS Path Layer			
AIS-P	STS Path AIS	All "1" in the STS pointer bytes H1, H2 for ≥ 3 frames	GR-253 T1.231
LOP-P	STS Path Loss of Pointer	8 – 10 NDF enable, 8 – 10 invalid pointers	GR-253 T1.231
B3	STS Path BIP error	Mismatch of the recovered and computed BIP-8 covers the entire STS-SPE	GR-253 T1.105
UNEQ-P	STS Path Unequipped	C2 = "0" for ≥ 5 (≥ 3 as per T1.231) frames	GR-253 T1.231
TIM-P	STS Path Trace Identifier Mismatch	Mismatch of the accepted and expected Trace Identifier in byte J1 (64 bytes sequence)	GR-253 T1.105
REI-P	STS Path Remote Error Indication	Number of detected B3 errors in the sink side encoded in bye G1 (bits 1, 2, 3, 4) of the source side	GR-253 T1.105
RDI-P	STS Path Remote Defect Indication	G1 (bit 5) = 1 for 10 frames	GR-253 T1.231
PLM-P	STS Path Payload Label Mismatch	Mismatch of the accepted and expected Payload Label in bye C2 for ≥ 5 (≥ 3 as per T1.231) frames	GR-253 T1.231

	Anomalies/Defect	Detection Criteria	Bellcore ANSI
VT Path Layer			
LOM	Loss of Multiframe	Loss of synchronization on H4 (bits 7, 8) superframe sequence	GR-253 T1.105
AIS-V	VT Path AIS	All "1" in the VT pointer bytes V1, V2 for ≥ 3 frames	GR-253 T1.231
LOP-V	VT Path Loss of Pointer	8 – 10 NDF enable, 8 – 10 invalid pointers	GR-253 T1.231
BIP-2	VT Path BIP Error	Mismatch of the recovered and computed BIP-2 (V5 bits 1, 2) covers entire VT	GR-253 T1.105
UNEQ-V	VT Path Unequipped	V5 (bits 5, 6, 7) = 000 for ≥ 5 (≥ 3 as per T1.231) superframes	GR-253 T1.231
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	GR-253 T1.105
RDI-V	VT Path Remote Defect Indication	V5 (bit 5) = 1 for 10super frames	GR-253 T1.231
PLM-V	VT Path Payload Label Mismatch	Mismatch of the accepted and expected Payload Label in bye V5 (bits 5, 6, 7) for ≥ 5 (≥ 3 as per T1.231) superframes	GR-253 T1.231

PDH alarms are described in 7.0 Results.

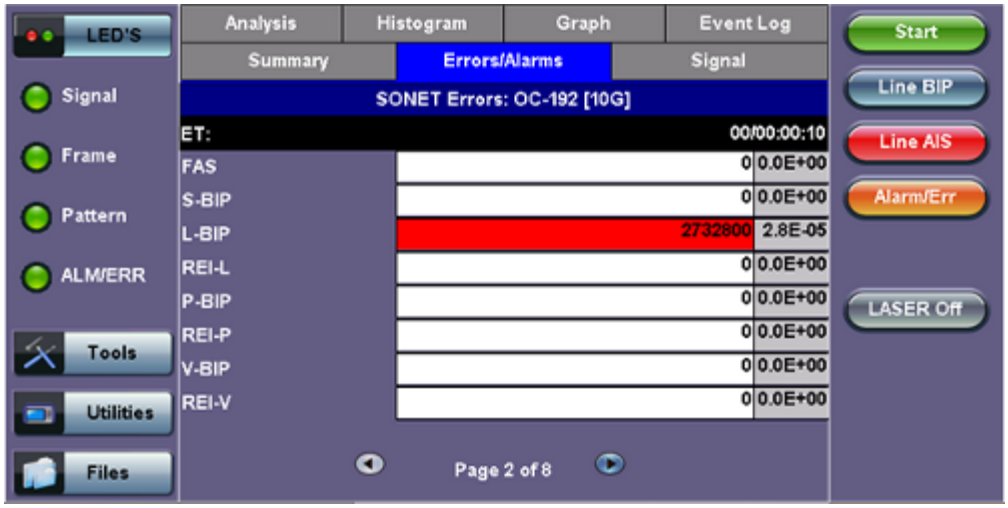
Go back to top Go back to TOC

Errors/Alarms (Page 2)

Page 2 lists the SONET Errors 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. Error conditions are displayed in red including count and

rate.

Errors/Alarms (Page 2)

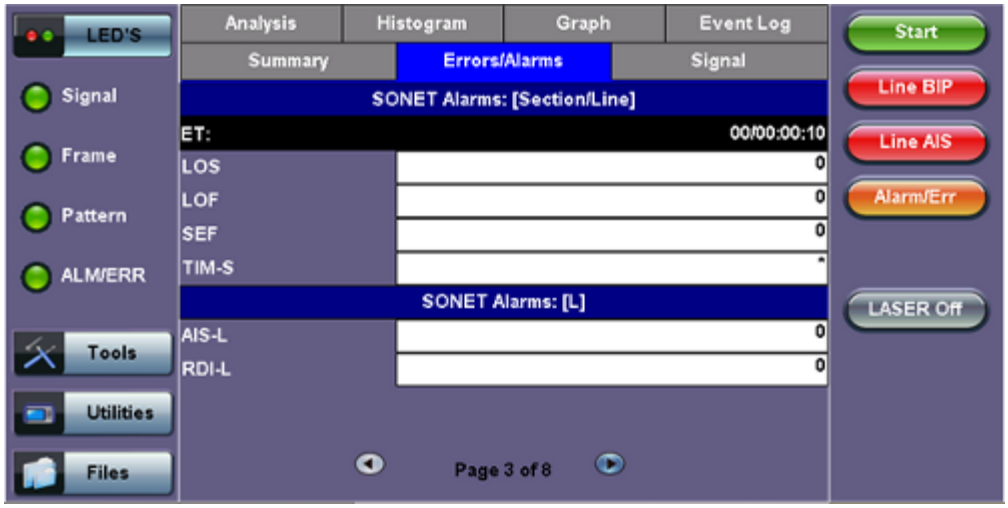


Go back to top Go back to TOC

Errors/Alarms (Page 3)

Page 3 lists the Section and Line Overhead Alarms in logical order associated with the signal under test. All alarms are evaluated and stored. The Elapsed Time [ET] since the start of the test is shown in the upper right hand corner.

Errors/Alarms (Page 3)



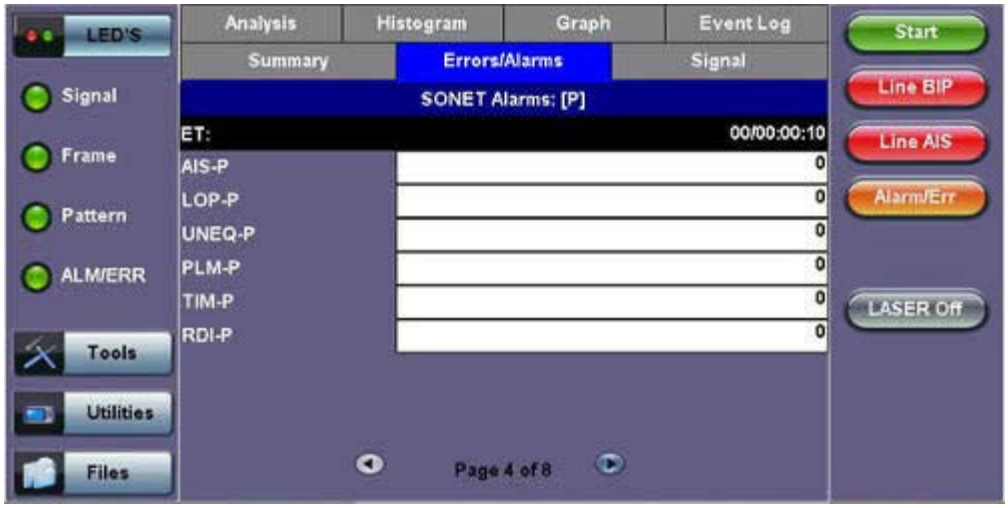
The alarms associated with the Section and Line are displayed separately for ease of interpretation.

Go back to top Go back to TOC

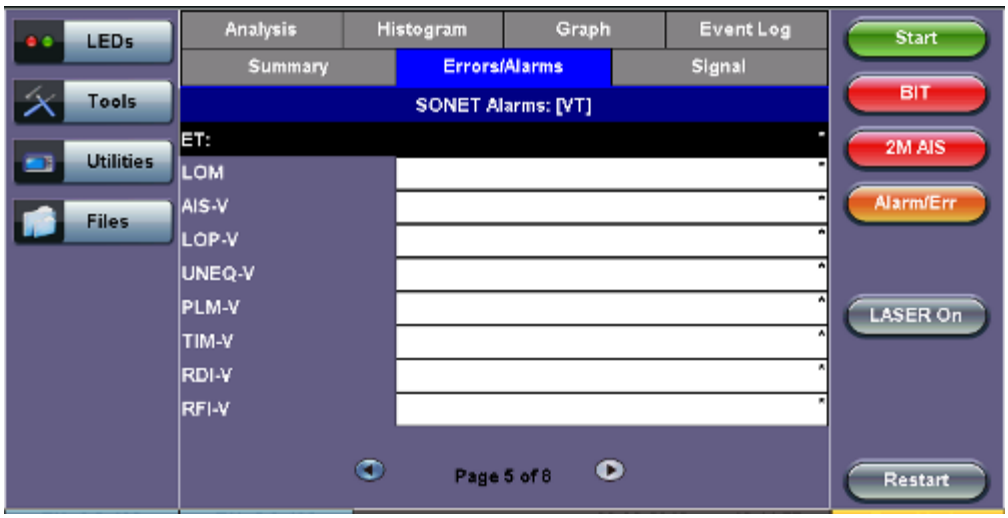
Errors/Alarms (Page 4 & 5)

Page 4 & 5 lists the STS Path and VT path in logical order that are associated with the signal under test. All alarms are evaluated and stored.

Errors/Alarms (Page 4)



Errors/Alarms (Page 5)

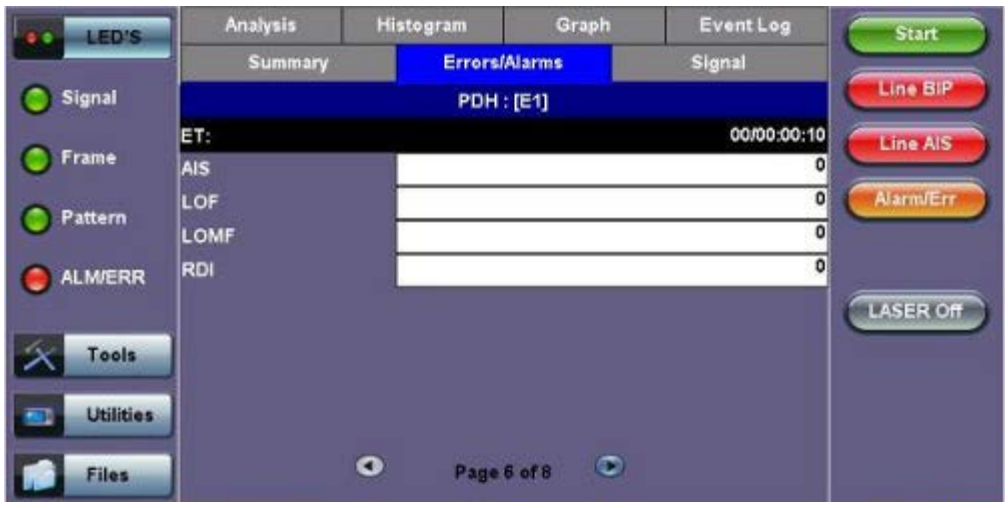


Go back to top Go back to TOC

Errors/Alarms (Page 6)

Page 6 lists the **PDH/DSn Alarms** in logical order that are associated with the signal and payload under test. All alarms are evaluated and stored.

Errors/Alarms (Page 6)

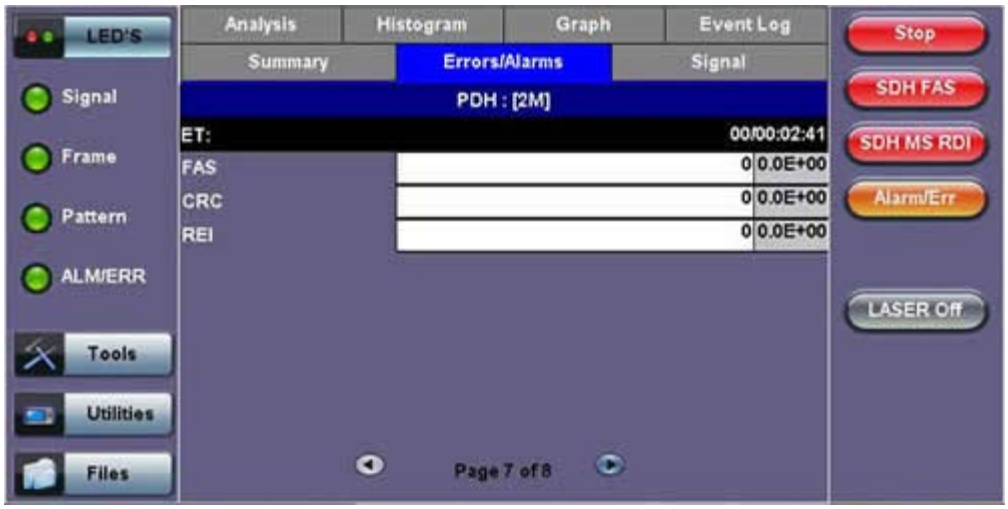


Go back to top Go back to TOC

Errors/Alarms (Page 7)

Page 7 lists the **PDH/DSn Errors** in logical order that are associated with the signal and payload under test. All errors are evaluated and stored.

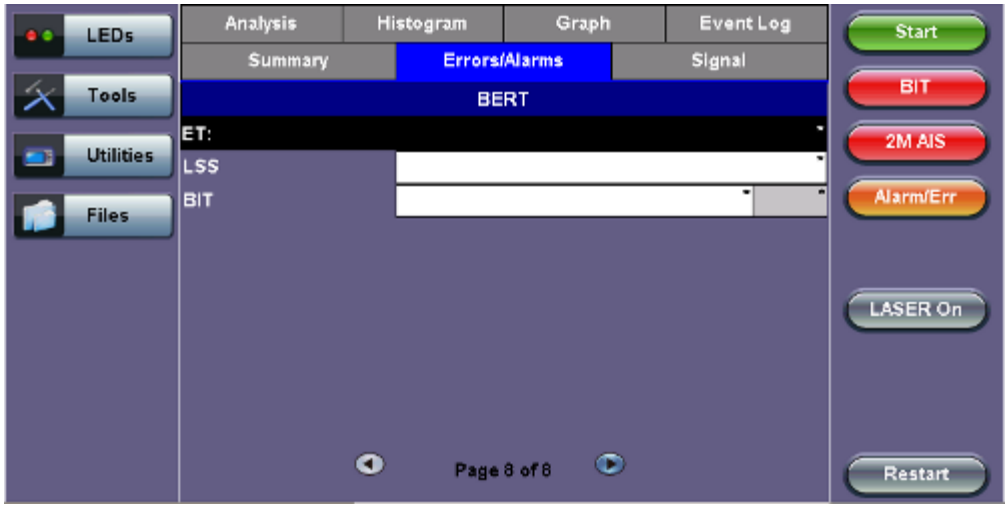
Errors/Alarms (Page 7)



Errors/Alarms (Page 8)

Page 8 lists the BERT Errors in logical order that are associated with the signal and payload under test. All errors are evaluated and stored.

Errors/Alarms (Page 8)



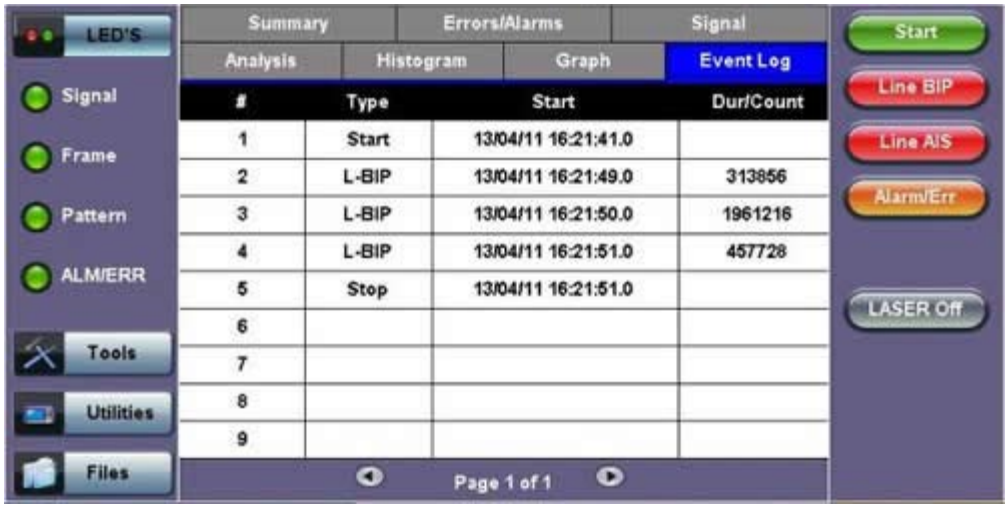
Go back to top Go back to TOC

7.3.3 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 and duration and duration (alarms) and ratio/count (errors) are displayed.

See Results: PDH > Event Log for details

Event Log



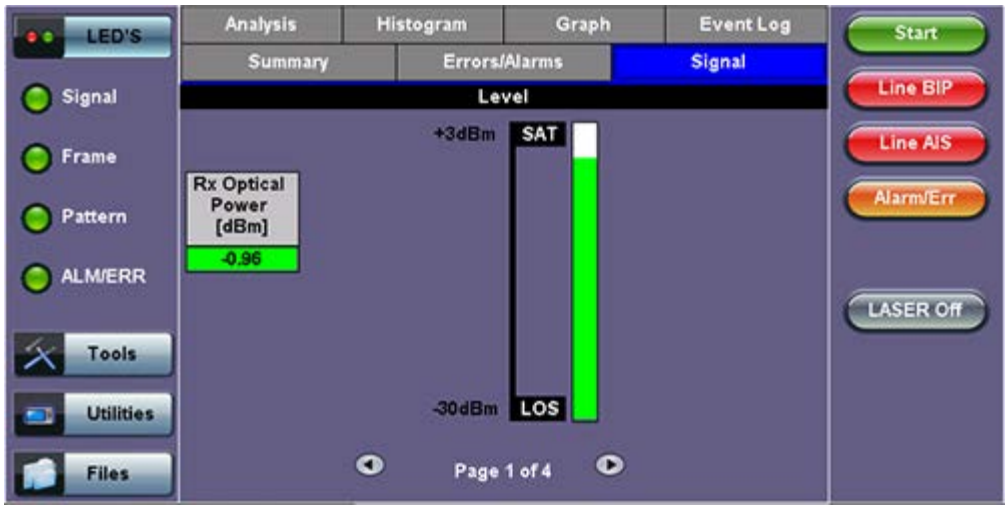
Go back to top Go back to TOC

7.3.4 Signal

The Signal tab displays the Level and Frequency screen. Page 1 displays the level measurement in electrical units (volts) for OC-3, OC-12, OC-48 and OC-192 signals.

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

Signal (Page 1)

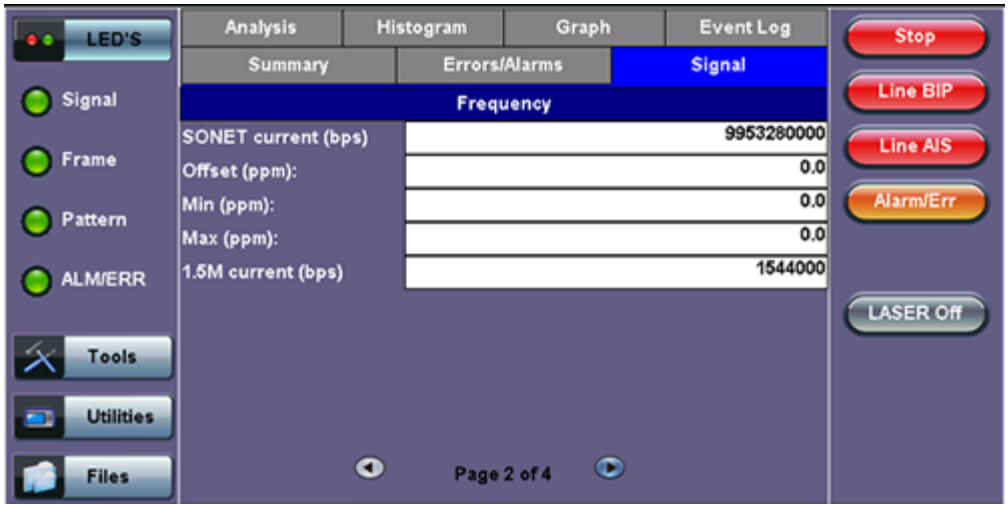


Go back to top Go back to TOC

Signal > Frequency (Page 2)

The received signal frequency and offset is measured and displayed. For SONET signals, the measurement is performed on both electrical (BNC) and optical interfaces (SFP or XFP).

Frequency (Page 2)



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

- **SONET 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.
- **45M Current:** Indicates the frequency of the payload data. Options are 1.5M, 2M, 34M are displayed.

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.

Low quality clock sources that deviate from the nominal value cause problems in the operation of network elements. It is necessary and recommended to measure the signal frequency at all hierarchies to reduce synchronization risks. To measure line frequency in service, the test set must be connected to a Protected Monitoring Point (PMP). The frequency of the signal is normally reported in Hz, while the deviation is reported in ppm. Tolerances for the various clock frequencies of SONET hierarchies are presented in the table below

SONET/SDH Clock Frequencies and Tolerances	
Bit rate (Mbps)	**Tolerance (ppm)**
155,520	< 4.6ppm
622,080	< 4.6ppm
2,488,320	< 4.6ppm
9,953,280	< 4.6ppm

Level: Measures the Peak and Peak-Peak voltage values of the incoming signal. The levels for STS-3 electrical signal according to GR.253 recommendations are presented.

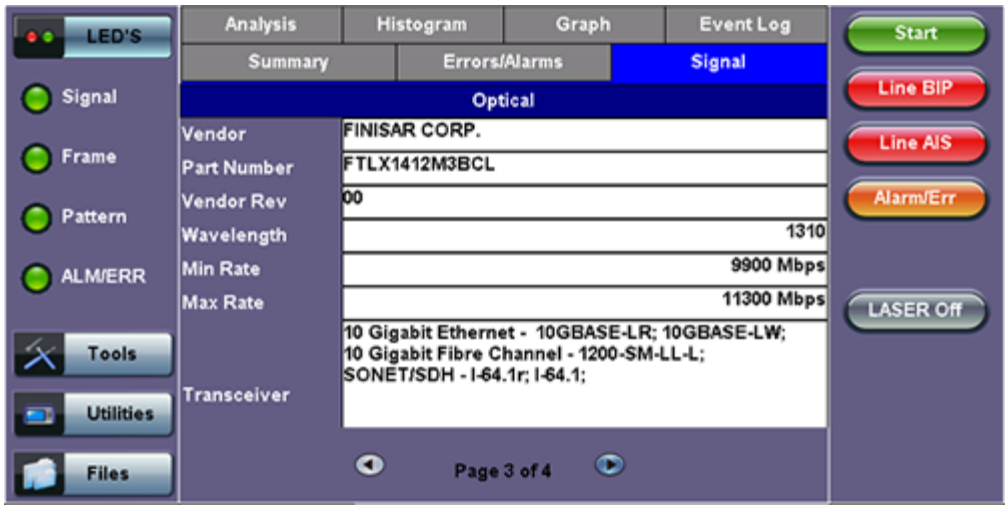
ITU-T/GR-253 Performance Analysis for PDH/DSn and SONET systems			
Analysis	**PDH/DSn**	**SONET**	**Anomalies**
G.821	✓	✓	TSE based on bit errors
G.826 (Out of service)	✓	✓	TSE based on block errors
G.826 (In service)		✓	B1, B2, B3, BIP-V, DS1/E1/DS3, E1 CRC
G.828 (In service)		✓	B1, B2, TSE
G.829 (In service)		✓	B1, B2, B3, BIP-V, TSE
M.2100	✓		DS1/E1/DS3 FAS, E1 CRC, TSE
M.2101		✓	B1, B2, B3, BIP-V, TSE

Go back to top Go back to TOC

Optical Information (Page 3)

Page 3 displays the Optical module (SFP or XFP) information which includes Vendor name, Part Number and Optical Wavelength.

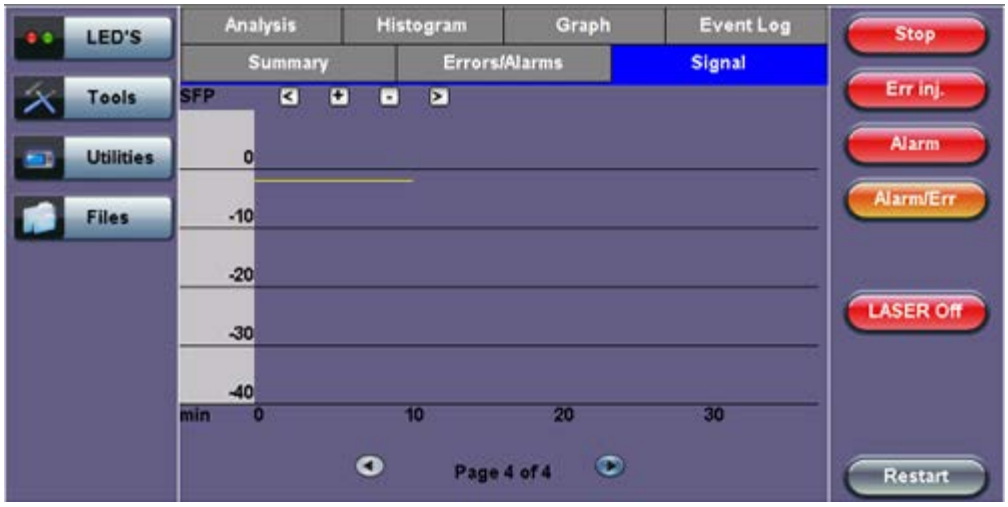
Signal - Optical (Page 3)



Signal > Optical Information (Page 4)

Page 4 displays the Optical module (SFP or XFP) Power Measurement Graph.

Signal - Optical (Page 4)



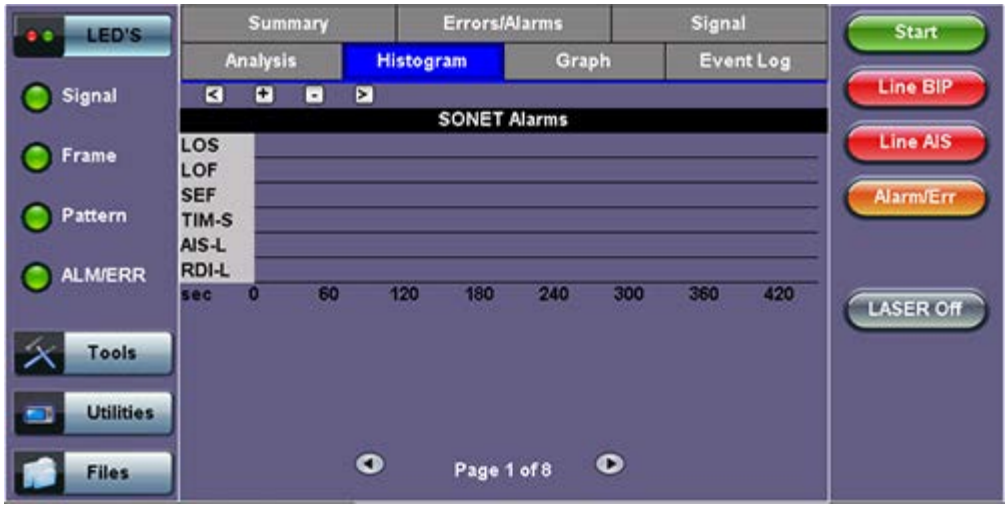
Go back to top Go back to TOC

7.3.5 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.

Page 1 displays the **Alarms** associated with the **SONET Alarm**.

Histogram - SONET Alarms (Page 1)



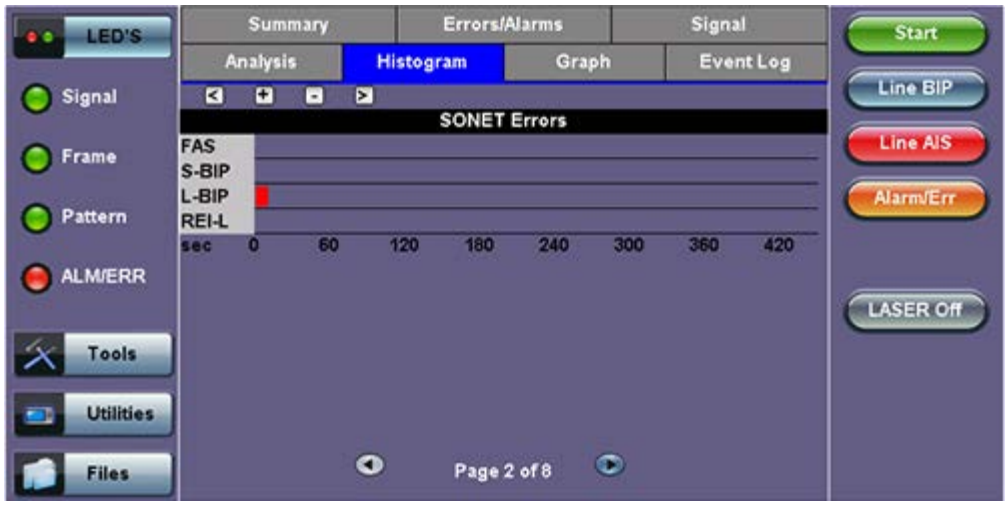
Note: The alarms and errors presented depend on the signal type and structure selected. A graphical timeline on the horizontal axis indicates when the event occurred. The upper left and right arrows allow the user to scroll through the measurement period while the + and – keys allow zooming in/out of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

Go back to top Go back to TOC

Histogram (Page 2)

Page 2 displays the Errors associated with the **SONET Errors**.

Histogram - SONET Errors (Page 2)



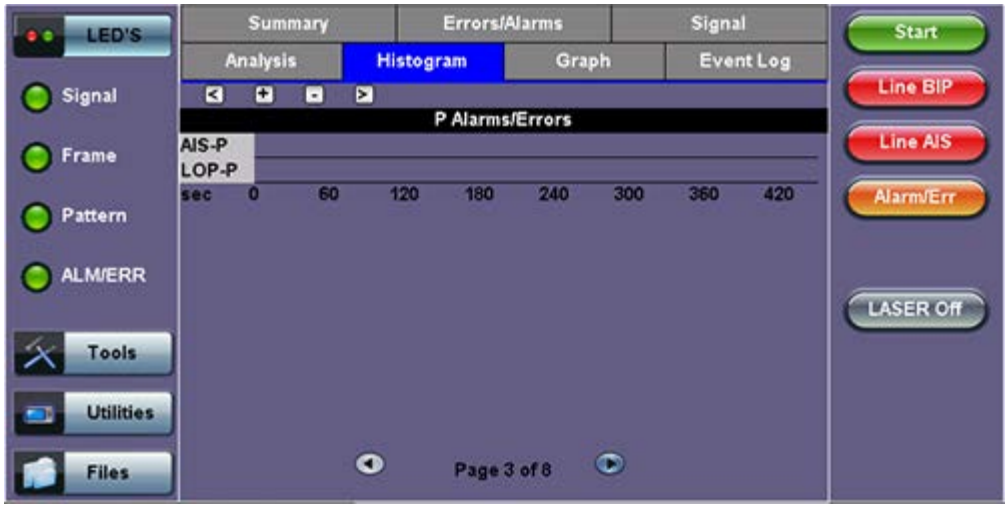
Go back to top Go back to TOC

Histogram (Page 3)

Page 3 displays the **Alarms and Errors** associated with the **STS PATH**. The measured parameters are:

- AIS-P, STS Path AIS
- LOP-P, STS Path LOP

Histogram - P Alarms/Errors (Page 3)



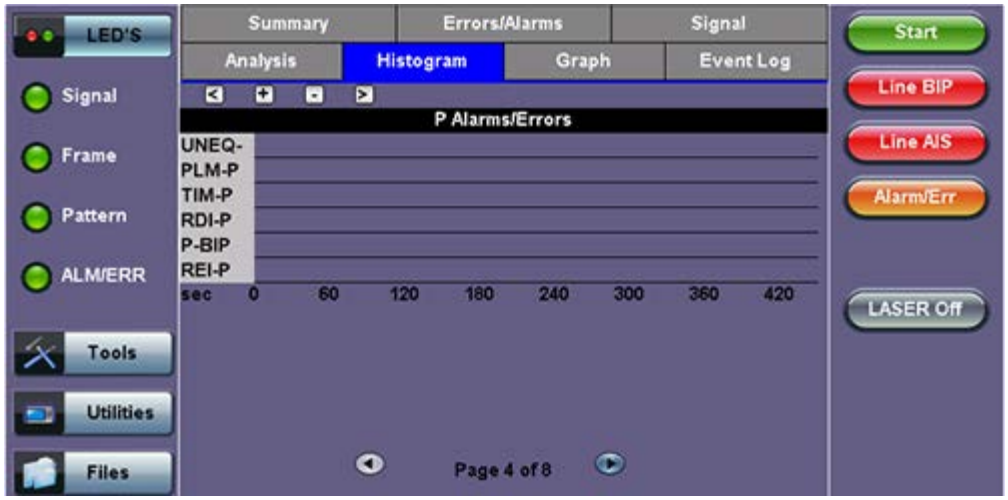
Go back to top Go back to TOC

Histogram (Page 4)

Page 4 displays the **Alarms and Errors** associated with the **STS Path**. The measured parameters are:

- UNEQ-P (STS Path-Unequipped)
- PLM-P (STS Path-Payload Mismatch)
- TIM-P (STS Path-Trace Identifier Mismatch)
- RDI-P (STS Path-Remote Defect Indication)
- B3 errors
- REI-P (STS Path-Remote Error Indication)

Histogram - P Alarms/Errors (Page 4)



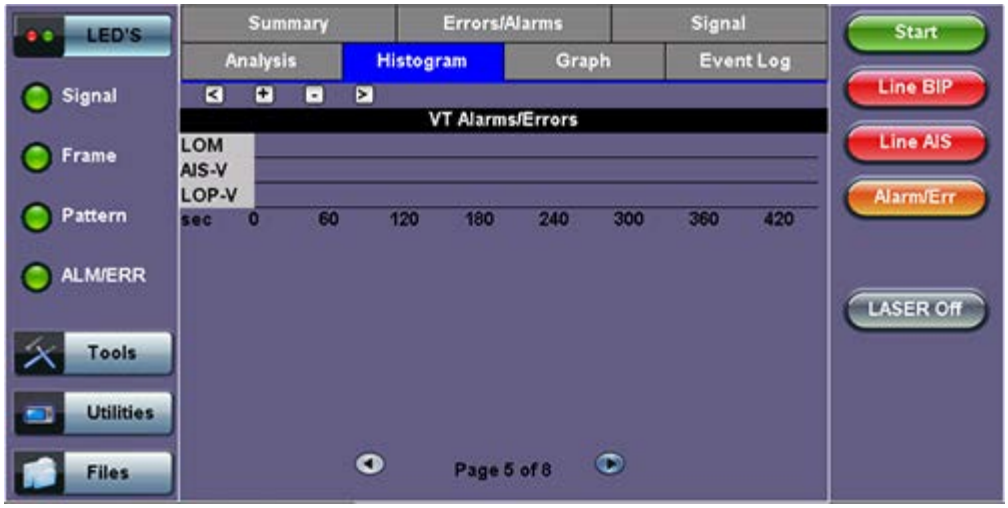
Go back to top Go back to TOC

Histogram (Page 5)

Page 5 displays the **Alarms and Errors** associated with the **Virtual Tributary (VT)**.

- AIS-V (VT-Alarm Indication Signal)
- LO-VP (VT-Loss of Pointer)

Histogram - VT Alarms/Errors (Page 5)



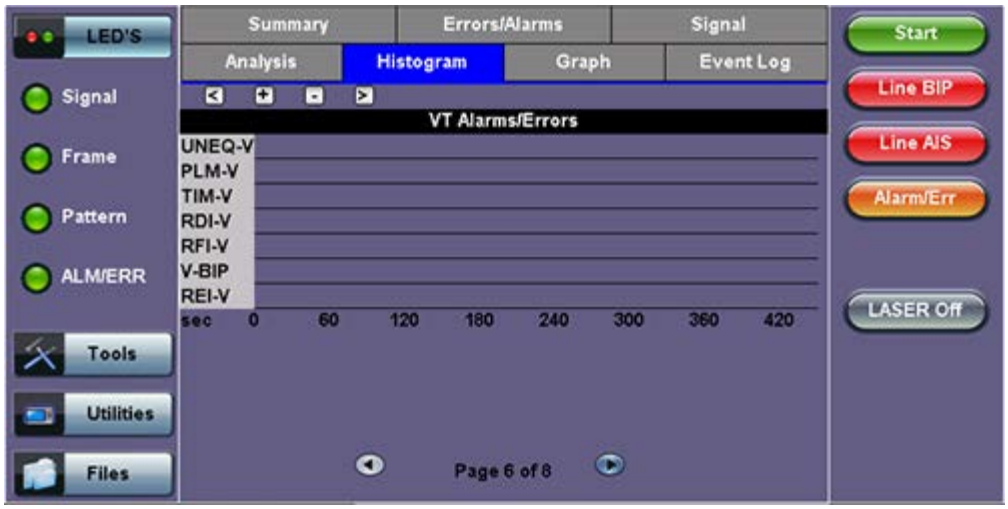
Go back to top Go back to TOC

Histogram (Page 6)

Page 6 displays the **Alarms and Errors** associated with the **VT Path.** The measured parameters are:

- UNEQ-V (VT-Unequipped)
- PLM-V (VT-Payload Mismatch)
- TIM-V (VT-Trace Identifier Mismatch)
- RDI-V (VT-Remote Defect Indication)
- RFI-V (VT-Remote Fault Indication)
- BIP-V (VT-Bit Interleaved Parity)
- REI-V (VT-Remote Error Indication)

Histogram - VT Alarms/Errors (Page 6)

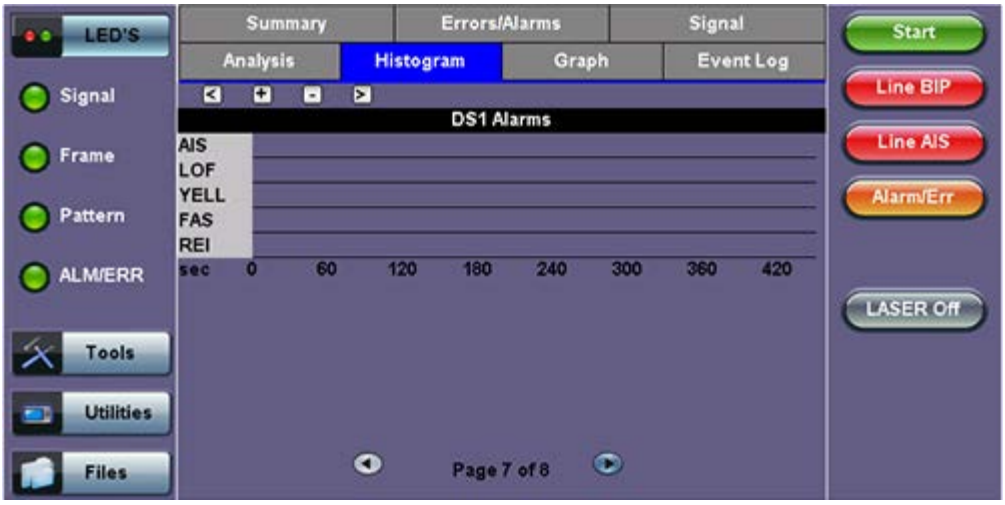


Go back to top Go back to TOC

Histogram (Page 7)

Page 7 displays the **Alarms** and **Errors** associated with the payload. The measured parameters depend on the payload selected.

Histogram - DS1 Alarms (Page 7)

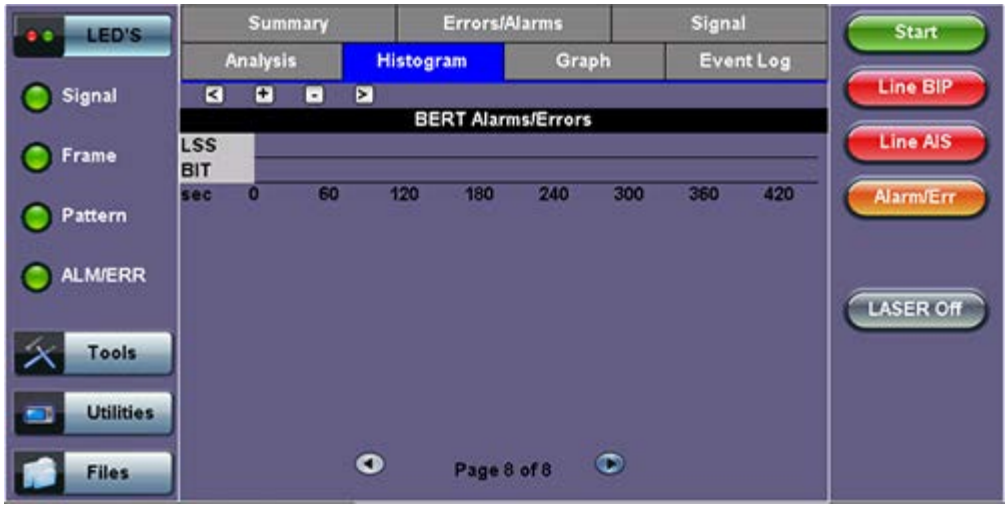


Go back to top Go back to TOC

Histogram (Page 8)

Page 8 displays the **Bit Errors** associated with the test pattern.

Histogram - BERT Alarms/Errors (Page 8)



Go back to top Go back to TOC

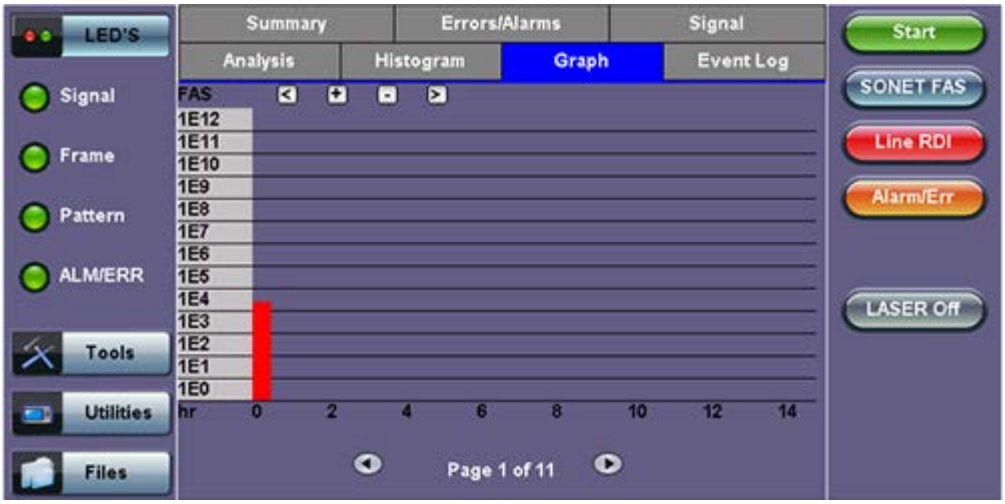
7.3.6 Graph

The Graph tab brings up the screen displaying a log of the Errors recorded during the measurement interval. A dedicated page is available for each of the following error types:

- FAS
- B1
- B2
- REI-S
- B3
- REI-P
- BIP-V
- REI-V
- PDH/DSn errors depending on payload

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.

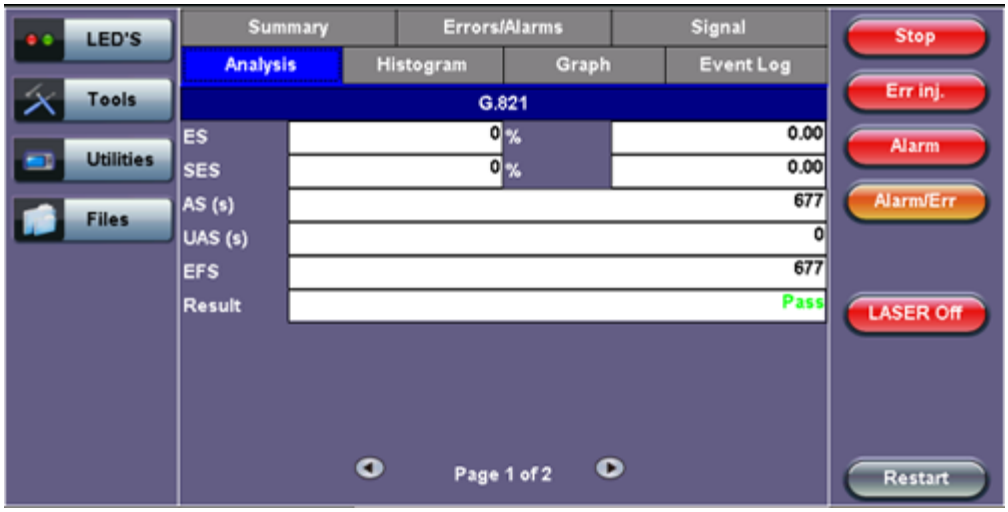
Graph (Page 1)



Go back to top Go back to TOC

7.3.7 Performance Analysis

G.821 Analysis



The Analysis tab displays measured objectives from ITU-T performance tests selected from the Measurements tab (**Setup** > **Measurements**). Please see 7.1.7 Analysis for information on the Analysis tab and test definitions. For a brief description of supported G-Series and M-Series performance tests as well as setup instructions, please see 6.7.2 Performance Analysis.

Go back to top Go back to TOC

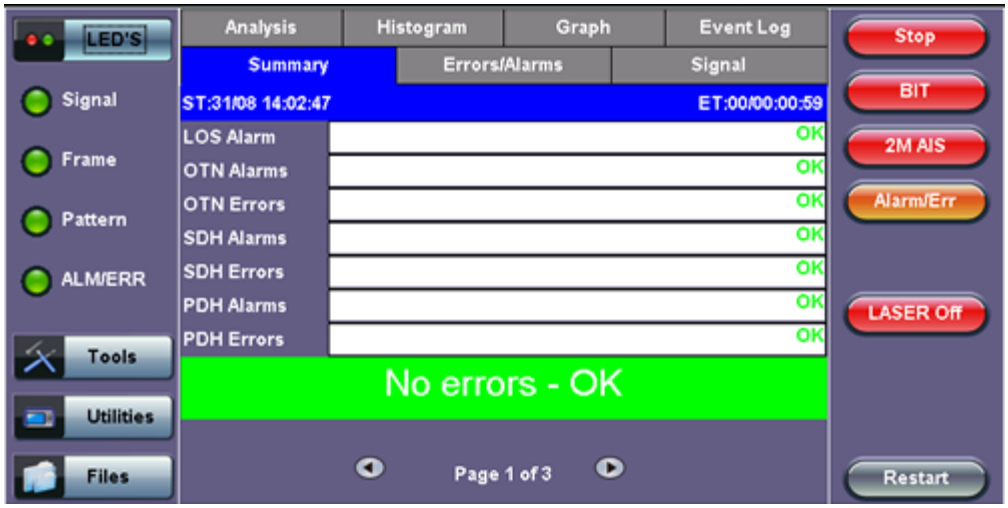
7.4 Results: OTN

Measurements are accessed by tapping the Results icon in the main menu. The results comprise a range of tabbed pages, similar to the setup pages.

7.4.1 Summary

The Summary tab displays a summary page 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 OTN/SDH signal and its payload. And also shows OTN/SDH mapping information that can identify the setup in results.

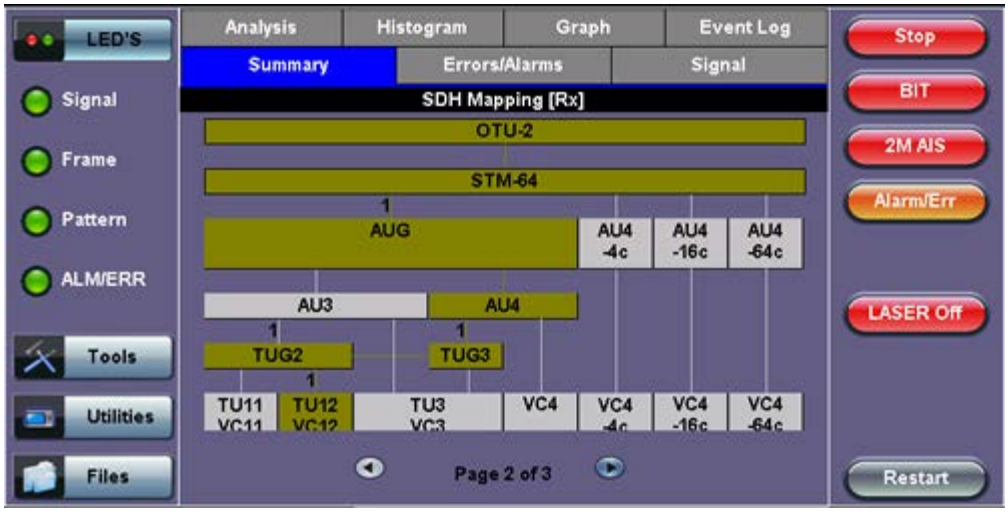
Summary (Page 1)



And also shows OTN/SDH (or OTN/SONET) mapping information that can identify the setup in results.

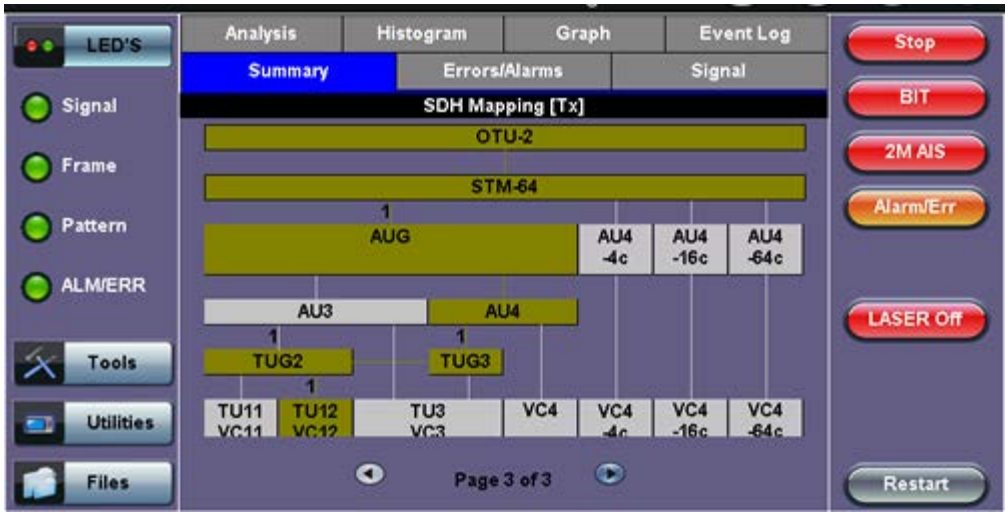
- **RX Mapping**

Summary (Page 2)



- **TX Mapping**

Summary (Page 3)



Go back to top Go back to TOC

7.4.2 Errors and Alarms

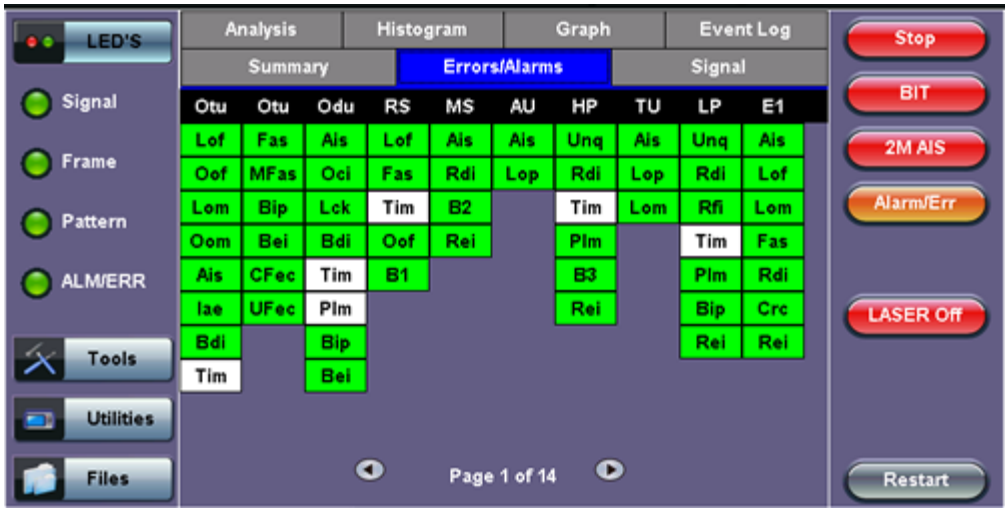
The Error/Alarm tab brings up several pages showing the errors and alarm status.

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.

The LED headers are described in the table below:

Alarm Definitions and Descriptions	
OTU	Optical channel Transport Unit
ODU	Optical channel Data Unit
OPU	Optical channel Payload Unit
RS	Regenerator Section
MS	Multiplexer Section
AU	Administrative Unit
HP	High Order Path
TU	Tributary Unit
LP	Lower Order Path
E1	2Mbit/s signal (depend on payload selected)
PAT	Pattern detection (PRBS, User, fixed words)

OTN Error and Alarm definitions per ITU-T G.709 recommendations:

OTU Alarm Definitions Detection criteria according to G.709 and G.798	
LOF	Loss of Frame - Declared when the OOF states have been constantly observed for 3 ms respectively
OOF	Out of Frame - Declared if it fails to find an FAS sub-pattern (FAS bytes 3, 4, and 5) for five consecutive frames.
LOM	Loss of Multiframe - Declared when the OOF states have been constantly observed for 3 ms respectively
OOM	Out of Multiframe - Declared when the received MFAS is out of sequence for five consecutive frames
OTU-AIS	Alarm Indication Signal - PN-11 sequence (covers complete Och) ≥ 3 x 8192 bits
OTU-IAE	Incoming Alignment Error - This bit allows the ingress to inform the egress that an alignment error in the incoming signal has been detected. • IAE = 1 with error • IAE = 0 no error • Status (STAT) These three bits indicate the presence of maintenance signals (AIS, OCI, TCM, IAE)
OTU-BDI	Backward Defect Indication - This single bit conveys information regarding signal failure in the upstream direction • BDI = 1 indicates OTUk backward defect • BDI = 0 otherwise
OTU-TIM	Trail Trace Identifier Mismatch

OTU Error Definitions Detection criteria according to G.709 and G.798	
FAS	Frame alignment signal - Uses the first six bytes and , to provide framing for the entire signal
MFAS	Multiframe alignment signal - Used to extend command and management functions over several frames. The MFAS counts from 0 to 255, providing a 256 multiframe structure.
BIP-8	Bit interleaved parity-8 code
BEI	Backward error indication -SM byte 3, bit 1 to 4: value 0 to 8: SM BIP-8 error count value 9 to 15: no SM BIP-8 errors value 11: SM BIAE
BIAE	Backward incoming alignment error - SM byte 3, bit 1 to 4: " 1011" ≥ 3 frames
CFEC	Correctable FEC error
UFEC	Uncorrectable FEC error

ODU Alarm/Error Definitions Detection criteria according to G.709 and G.798	
ODU-BEI	Backward error indication -PM byte 3, bit 1 to 4: value 0 to 8: SM BIP-8 error count value 9 to 15: no SM BIP-8 errors
ODU-AIS	Alarm Indication Signal - PM byte 3, bit 6 to 8: " 111" ≥ 3 frames
ODU-OCI	Open connection indication - PM byte 3, bit 6 to 8: " 110" ≥ 3 frames
ODU-LCK	Locked - PM byte 3, bit 6 to 8: " 101" ≥ 3 frames
ODU-BDI	Backward Defect Indication - PM byte 3, bit 5 = 1 ≥ 5 frames
ODU-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.
ODU-TIM	Trail Trace Identifier Mismatch

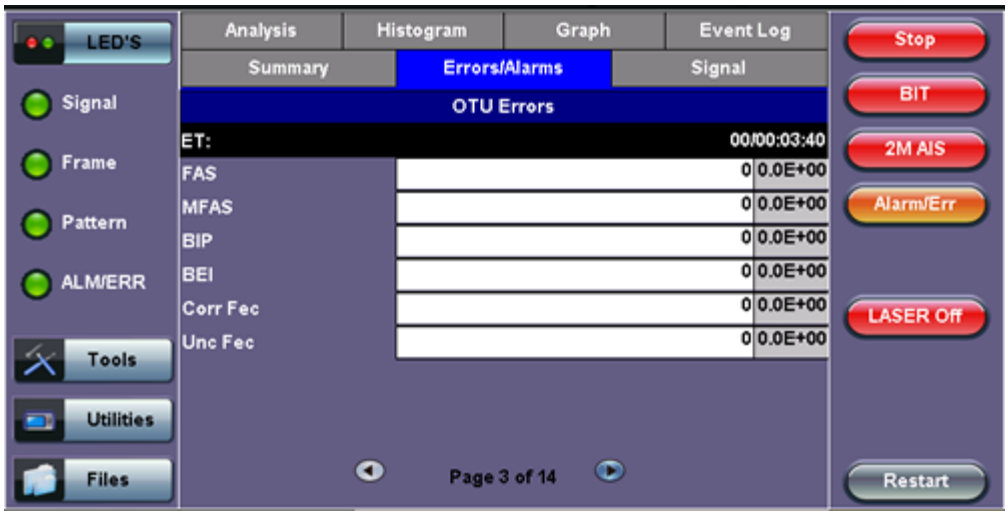
SDH/PDH alarms are described previously

Go back to top Go back to TOC

Errors/Alarms (Page 3)

Page 3 lists the **OTU Errors** 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. Error conditions are displayed in red including count and rate.

Errors/Alarms (Page 3)

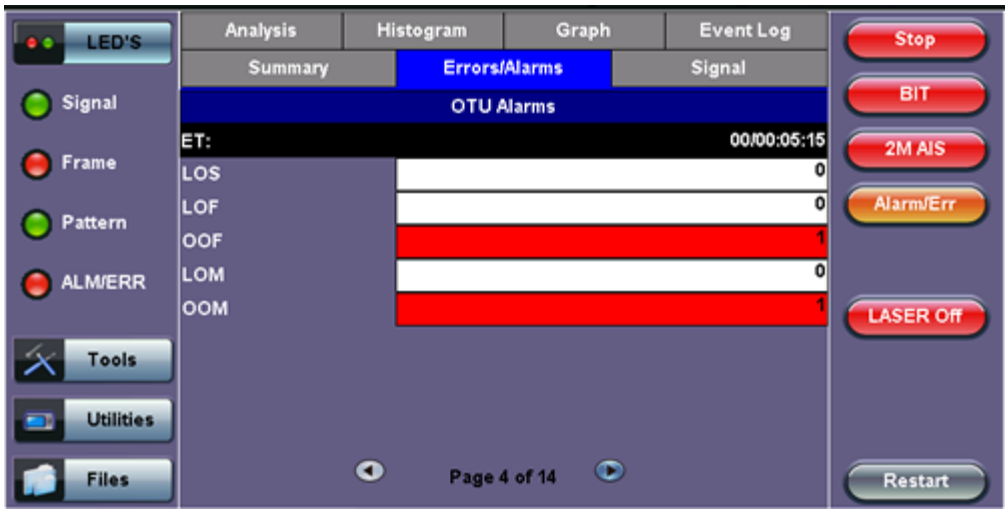


Go back to top Go back to TOC

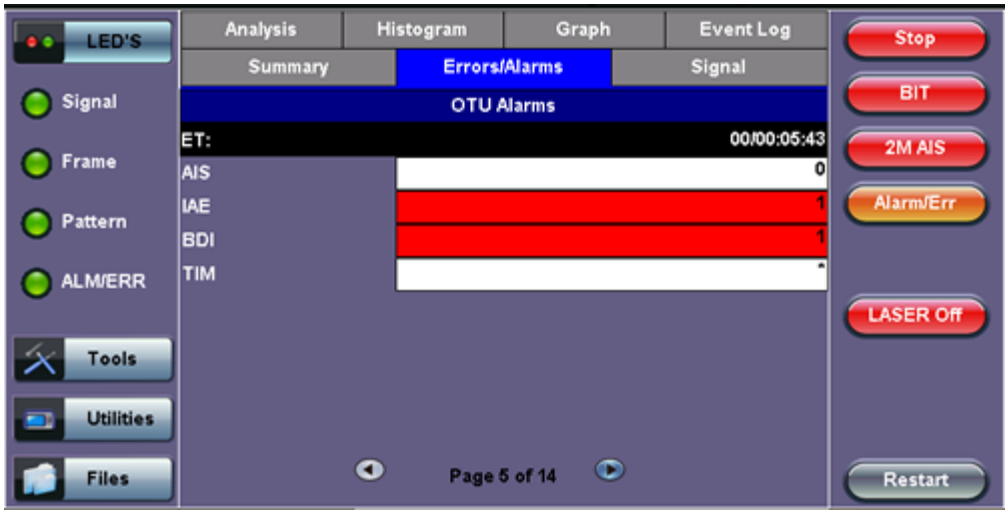
Errors/Alarms (Page 4 & 5)

Page 4 lists the **OTU Alarms** in logical order associated with the signal under test. All alarms are evaluated and stored. The Elapsed Time [ET] since the start of the test is shown in the upper right hand corner.

Errors/Alarms (Page 4)



Errors/Alarms (Page 5)



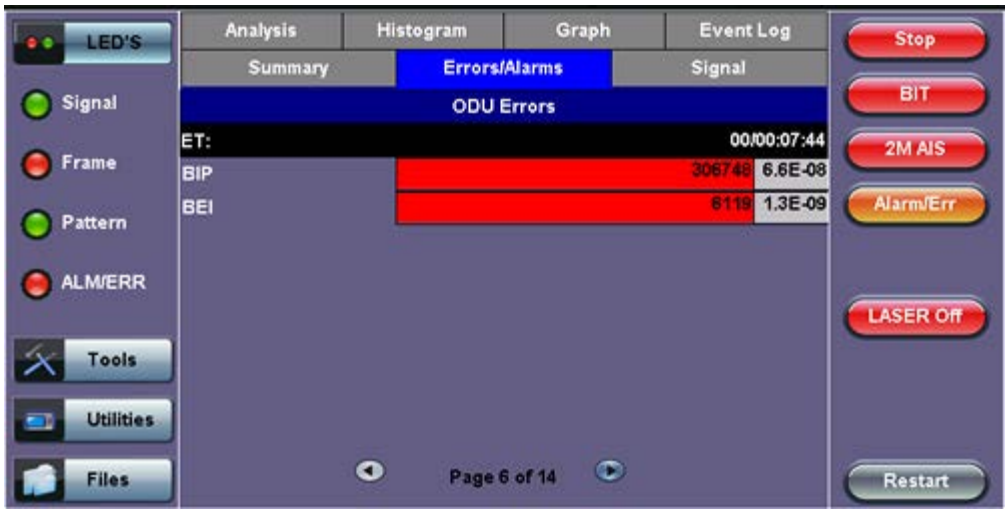
The alarms associated with the Section and Line are displayed separately for ease of interpretation.

Go back to top Go back to TOC

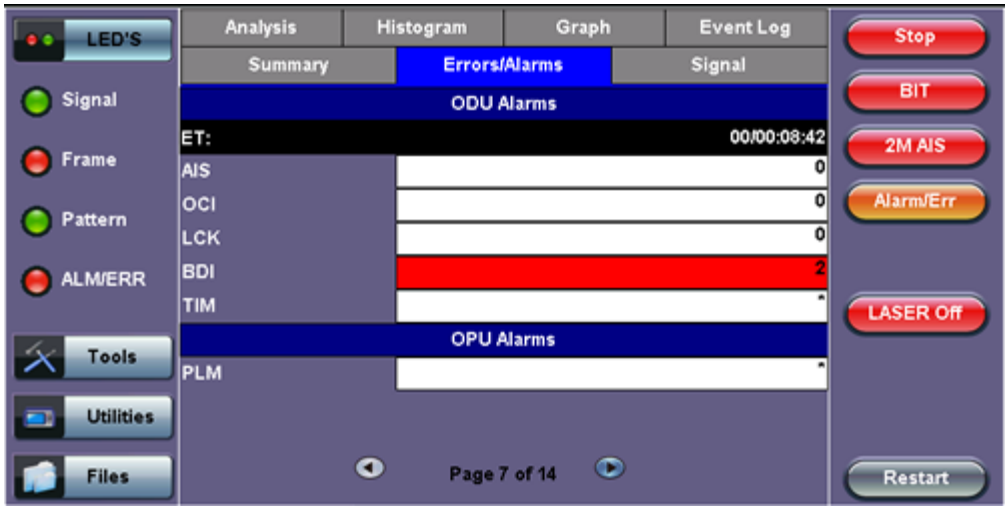
Errors/Alarms (Page 6 & 7)

Page 6 & 7 lists the **ODU/OPU errors and alarms** in logical order that are associated with the signal under test. All alarms are evaluated and stored.

Errors/Alarms (Page 6)



Errors/Alarms (Page 7)



Go back to top Go back to TOC

Errors/Alarms (Page 8 to 14)

Page 8 to 14 lists the **SDH/PDH Alarms** in logical order that are associated with the signal and payload under test. All alarms are evaluated and stored.

See PDH details in Section 7.1

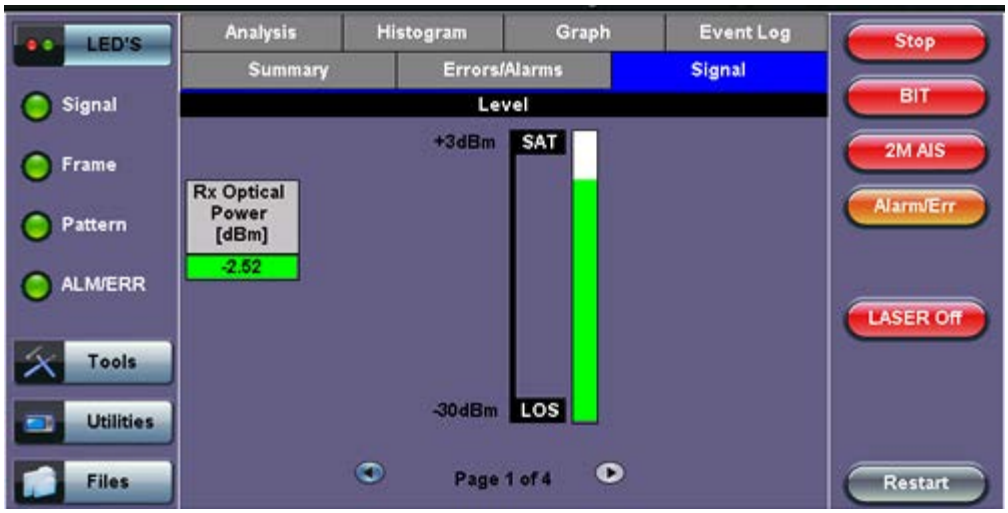
See SDH details in Section 7.2

Signal (Pages 1 to 4)

The signal tab displays the Level, Frequency and related screens.

- **Optical Level (Page 1):**
  - The optical level measurement for OTU-1 and OTU-2 signals is displayed in dBm.
  - Loss of Signal (LOS) and the Saturation levels is shown both graphically and in dBm.

Signal (Page 1)

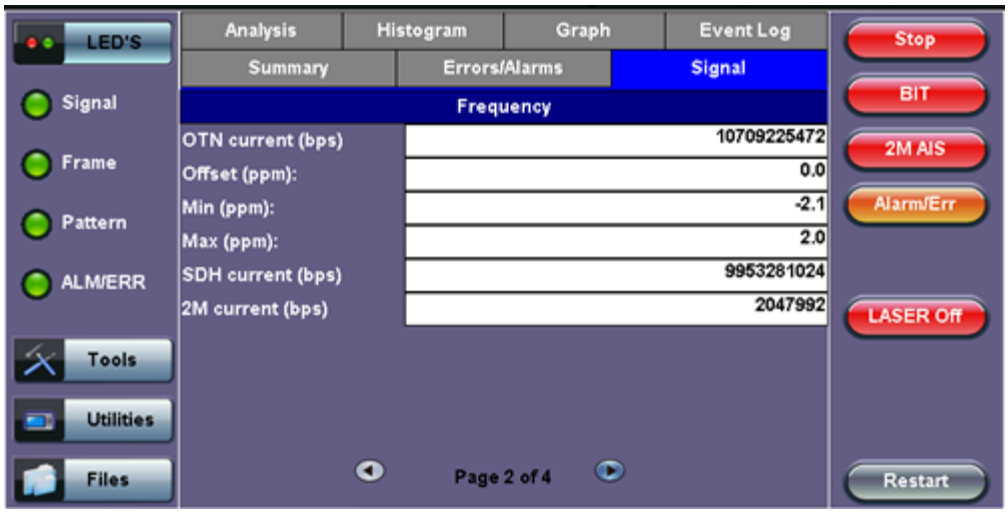


Go back to top Go back to TOC

- **Frequency (Page 2)**
  - The received signal frequency and offset is measured and displayed.
  - For OTN signals, the measurement is performed on the optical interfaces (SFP for OTU-1) or (XFP for OTU-2).
  - OTN Current: 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
- SDH Current: Indicates the frequency of the SDH or SONET signal carried with the OTU frame
- 2M Current: Indicates the frequency of the PDH or T-Carrier payload. Options 1.5Mbps, 45Mbps, 34Mbps, 139Mbps

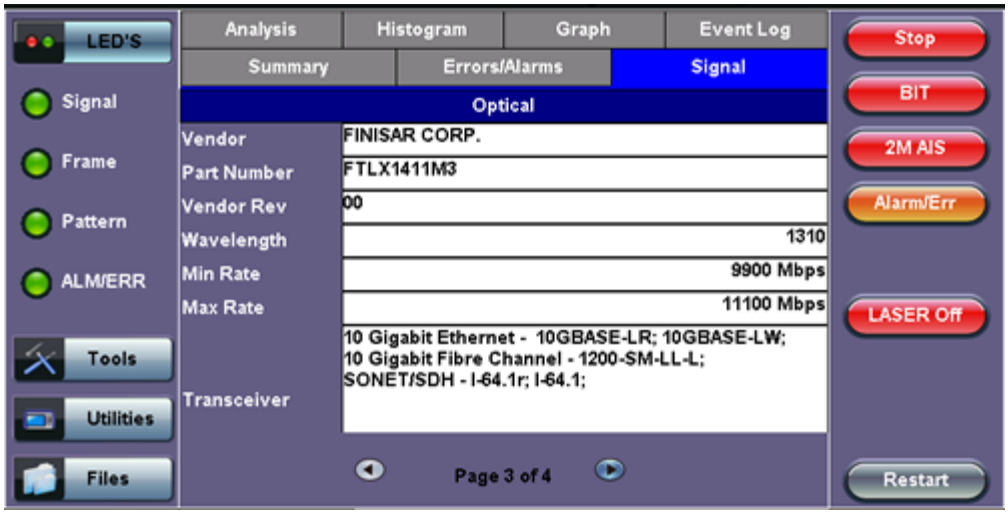
Signal (Page 2)



Go back to top Go back to TOC

- **Optical Information (Page 3)**
  - The Optical Transceiver (SFP or XFP) information including Vendor name, Part #, Firmware revision #, Optical Wavelength, Min/Max bit rates supported and Dynamic Range

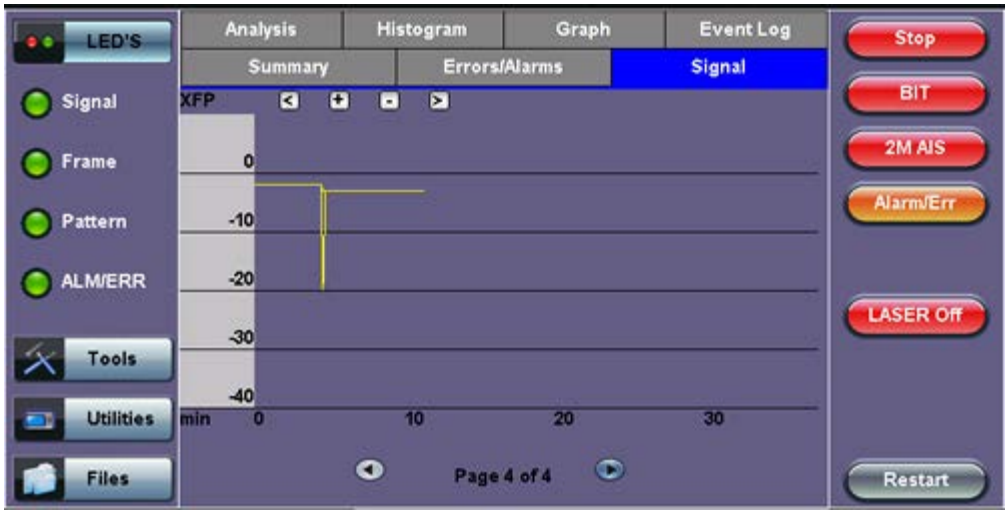
Signal (Page 3)



Go back to top Go back to TOC

- **Optical Histogram (Page 4)**
  - Displays the Optical Transceiver (SFP or XFP) Power Measurement Graph.
  - This is useful for troubleshooting defective XFPs or for monitoring intermittent optical power fluctuations

Signal (Page 4)



Go back to top Go back to TOC

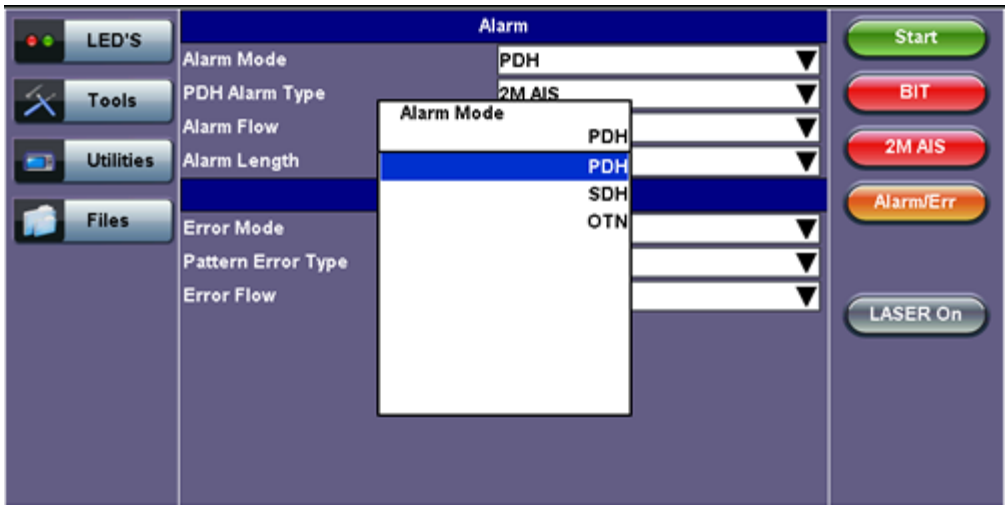
8.0 Alarm Generation and Error Insertion

Accessing Alarm Generation and Error Insertion

Tap on Home (main menu) > **Alarm/Error**

The alarm and error functions are used in conjunction with the drop-down menu which has dedicated buttons for error injection and alarm generation. Alarm and error selections will depend on PDH, SDH, or OTN signal types.

Alarm Setup



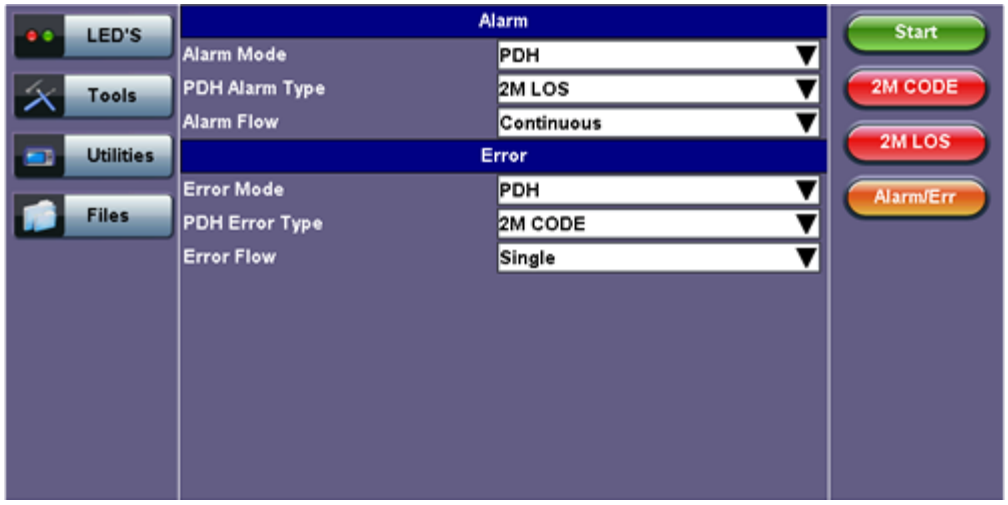
Go back to top Go back to TOC

8.1 Alarm Generation

Generation range of different anomalies into the transmit signal. Alarm generation modes include:

- **Alarm Flow**
  - **Continuous:** Generates a continuous alarm when button is tapped
  - **Count:** Specific count for 0.1s, 1s, 10s, 100s when button is tapped

Alarm/Error Generation



Go back to top Go back to TOC

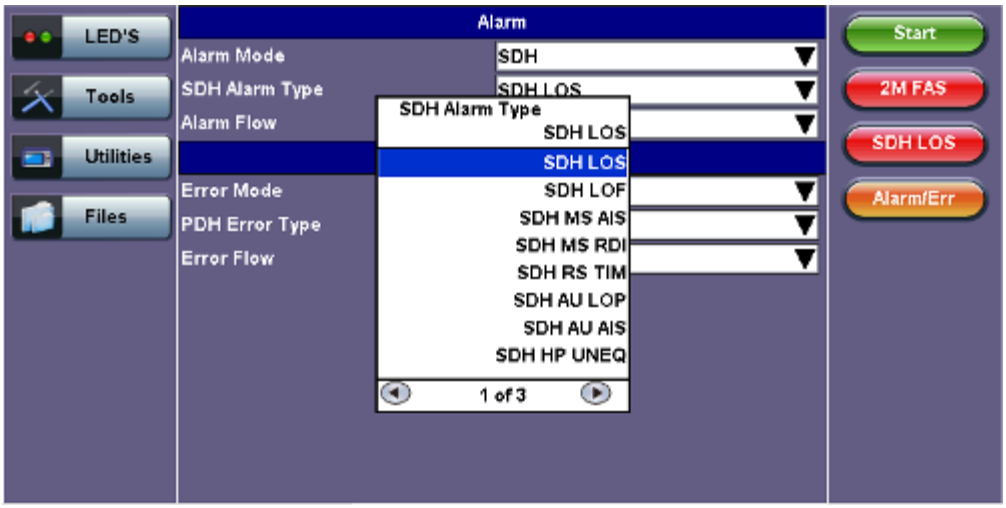
8.1.1 SDH Alarms

The following **SDH Alarms** can be generated:

- **STM-1/4/16/64 (depends on signal structure):** LOS, LOF, MS-AIS, MS-RDI, RS-TIM, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, HP-RDI, HP-TIM, TU-LOM, TU-LOP, TU-AIS, LP-UNEQ, LP-PLM, LP-RDI, LP-RFI, LP-TIM
- **Payload alarms (depends on payload):** DS1-AIS, DS1-LOF, 2M-AIS, 2M-RDI, 2M-LOF, 34M-AIS, 34M-LOF, 34M-RDI, 45M-AIS

Mode: Static (enable/disable) using drop-down menu function.

SDH Alarm Type



Go back to top Go back to TOC

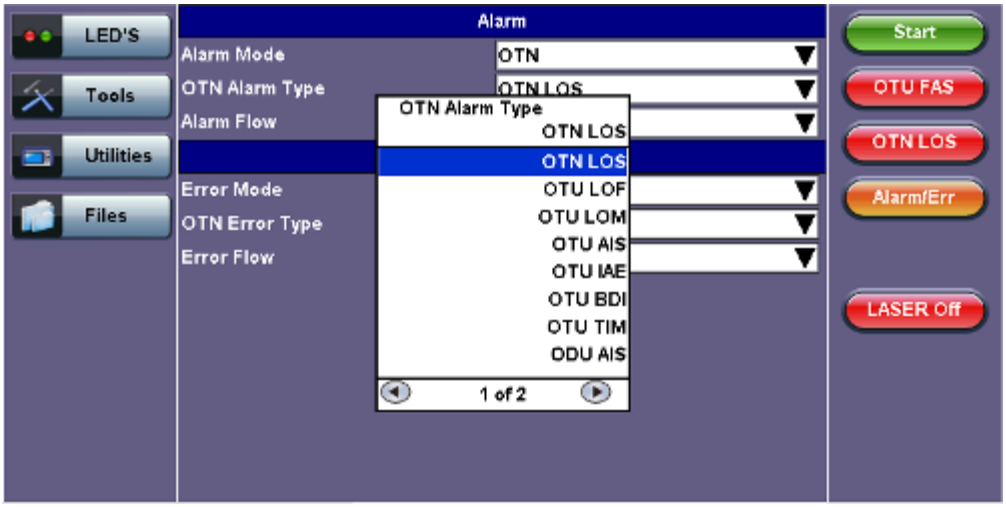
8.1.2 OTN Alarms

The following **OTN alarms** can be generated:

- **OTU-1/OTU-2:** LOS, LOF, OOF, OOM, LOM, AIS, IAE, BDI, TIM
- **ODU-1/OPU-2:**AIS, OCI, LCK, BDI, TIM
- **OPU-1/OTU-2:** PLM
- **SDH Payload alarms:** LOF, MS-AIS, MS-RDI, RS-TIM, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, HP-RDI, HP-TIM, TU-LOM, TU-LOP, TU-AIS, LP-UNEQ, LP-PLM, LP-RDI, LP-RFI, LP-TIM
- **PDH Payload alarms (depends on payload):** DS1-AIS, DS1-LOF, 2M-AIS, 2M-RDI, 2M-LOF, 34M-AIS, 34M-LOF, 34M-RDI, 45M-AIS

Mode: Static (enable/disable) using drop-down menu function.

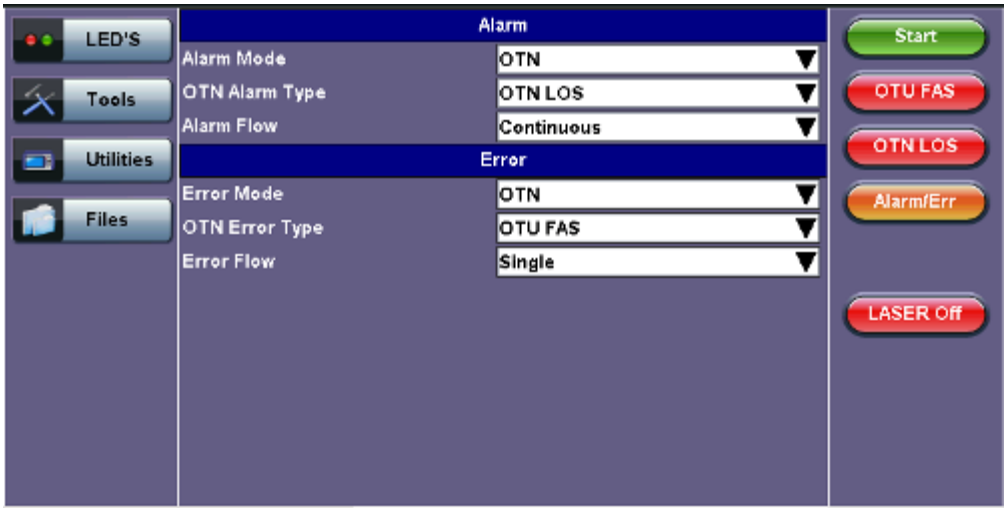
OTN Alarm Type



Go back to top Go back to TOC

8.2 Error Insertion

OTN, SDH, PDH and T-Carrier errors can be generated.



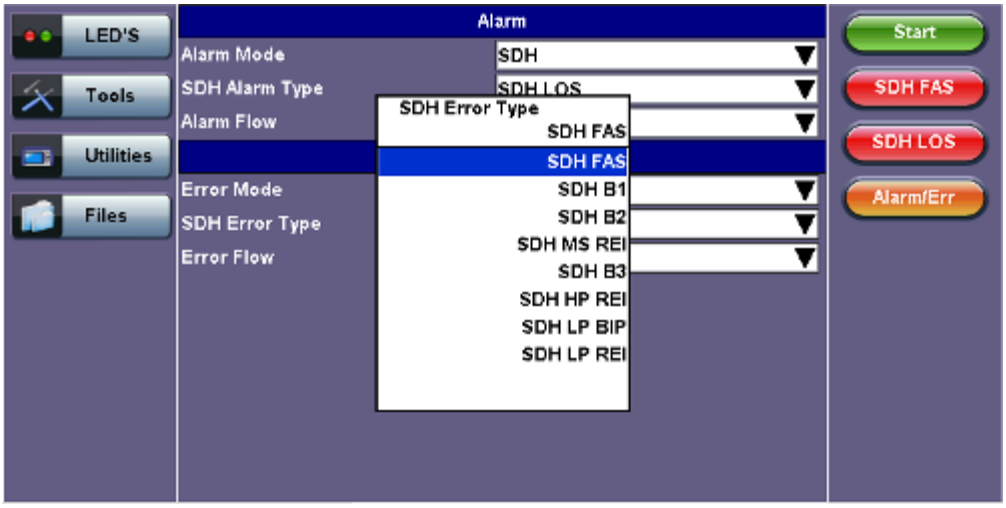
Go back to top Go back to TOC

8.2.1 SDH Errors

The following **SDH errors** can be generated:

- **STM-1/4/16/64 signals:** FAS, B1, B2, MS-REI, B3, HP-REI, LP-BIP, LP-REI,
- **Depends on payload:** 2M-FAS, 2M-CRC, 2M-REI, 34M-FAS, 45M-FAS, 1.5M-FAS

SDH Error Type

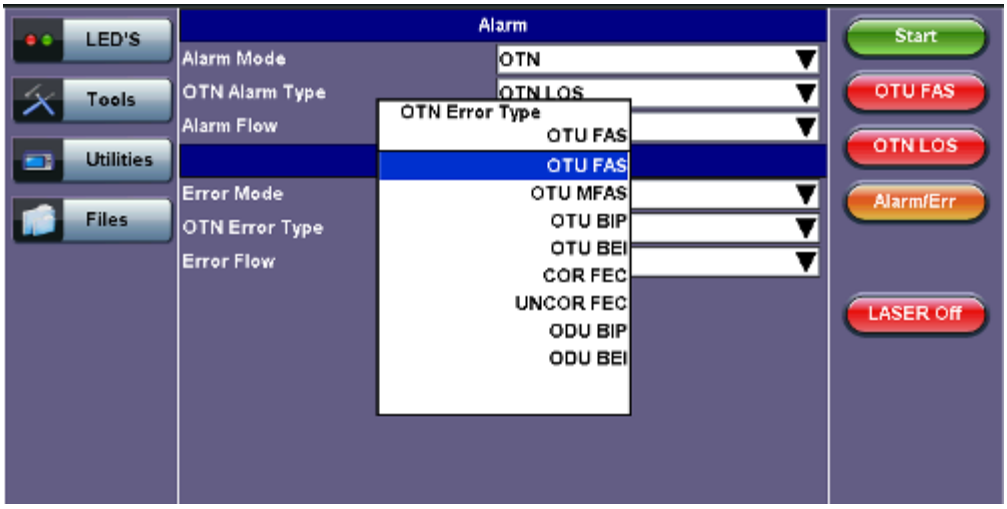


Go back to top Go back to TOC

8.2.2 OTN Errors

- **OTU-1/2 signals**: FAS, MFAS, BIP, BEI, Corrected FEC errors, Uncorrectable FEC
- **ODU-1/2 signals**: BIP, BEI
- **STM-16/64 signals:** FAS, B1, B2, MS-REI, B3, HP-REI, LP-BIP, LP-REI,
- **Depends on payload:** 2M-FAS, 2M-CRC, 2M-REI, 34M-FAS, 45M-FAS, 1.5M-FAS

OTN Error Type



Go back to top Go back to TOC

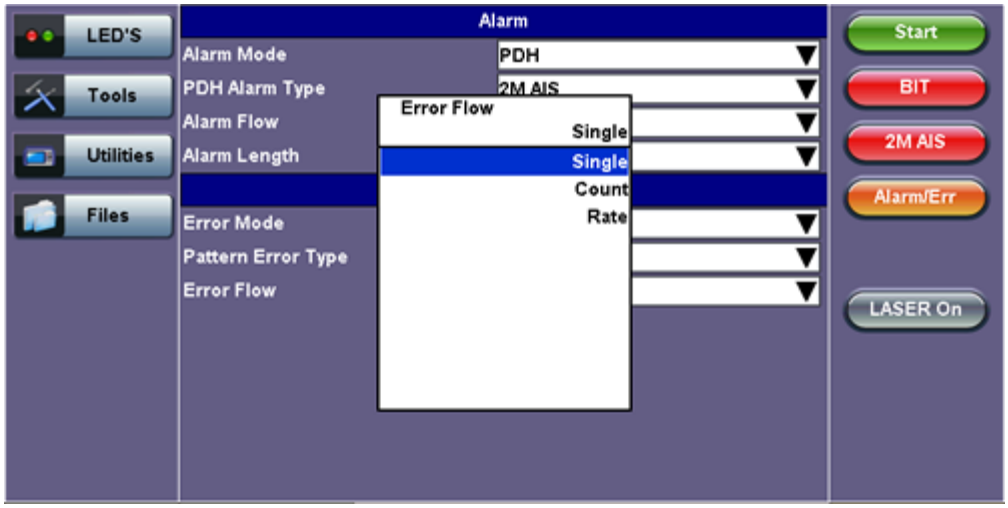
Error Flow: OTN, SDH, SONET, PDH signals

Injects different anomalies into the transmit signal. Error insertion flow modes include:

- **Single:** Inserts a single error every time the insertion button is tapped
- **Count:** Specific count or number of errors when the insertion button is tapped
- **Rate:** Specific rate between $1x10^{-3}$ and $5x10^{-6}$

The list of available error types depends on the type of framing being used and the SDH or PDH hierarchies and line interfaces that have been selected.

Error Flow



Alarm Generation/Error Insertion

At any time during the test process, tap the **Error Injection** or **Alarm Generation** buttons to inject errors or generate alarms.

Go back to top Go back to TOC

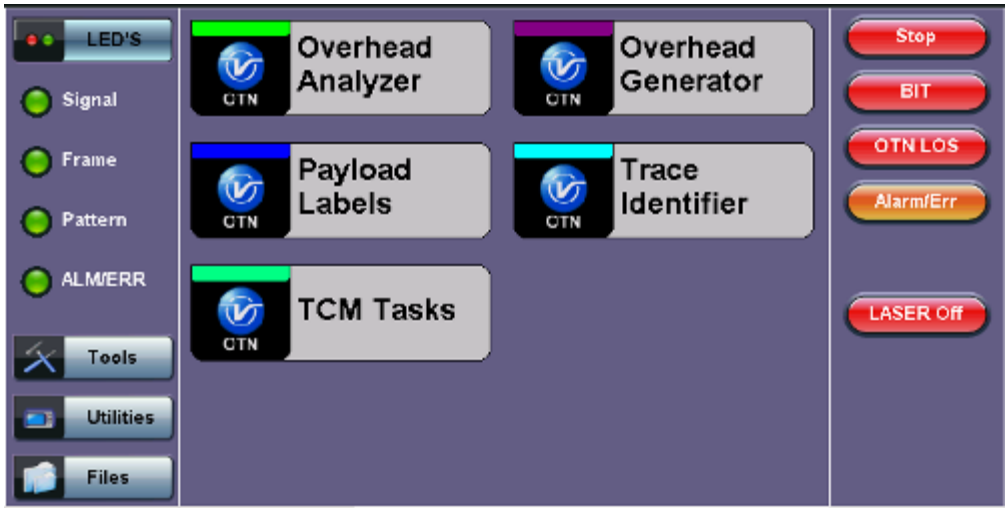
9.0 OTN Tools

9.1 Shortcuts

Accessing OTN Tools

Tap on Home (main menu) > **OTN Tools**

OTN Tools Menu



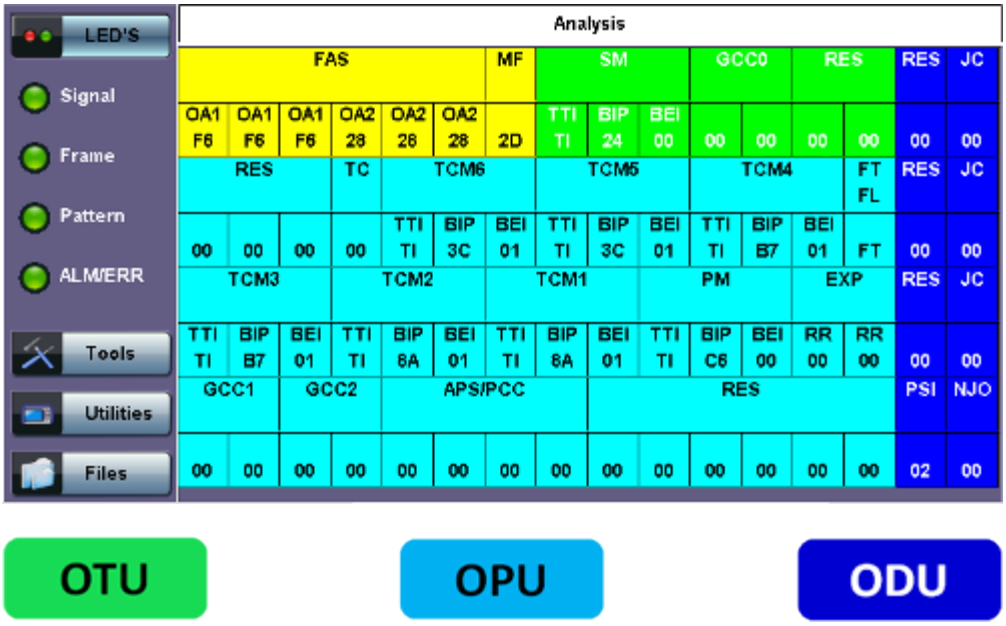
- **Overhead Analyzer:**
  - Displays the Optical Channel Transport Unit (OTU)
  - Displays Optical Channel Data Unit (ODU)
  - Displays Optical Channel Payload Unit (OPU) bytes of the received channel
- **Overhead Generator:**
  - Used to edit Optical Channel Transport Unit (OTU)
  - Used to edit Optical 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:**
  - 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.

Go back to top Go back to TOC

9.2 Overhead Analyzer & Generator

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

Overhead Analyzer Menu

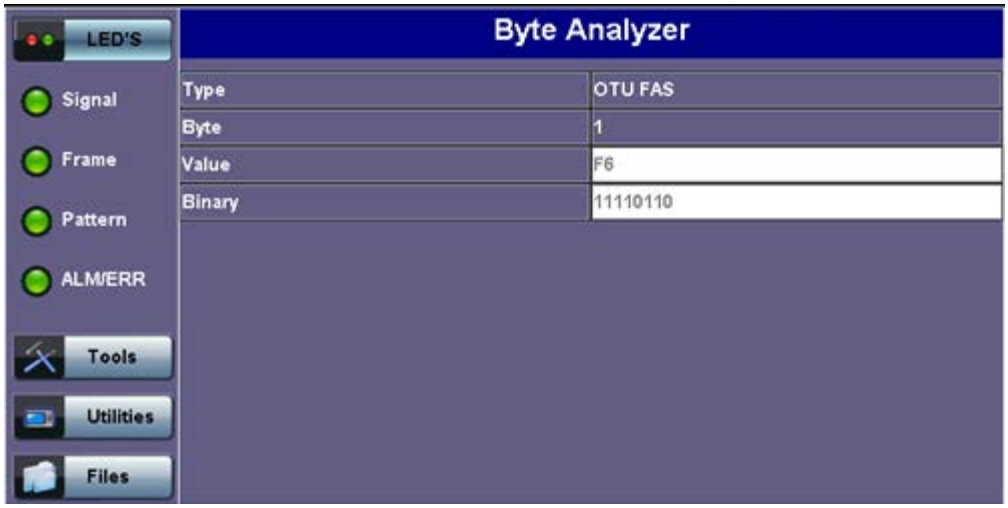


The Overhead is color coded for simplified viewing.

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



9.2.1 OTN Frame Analysis

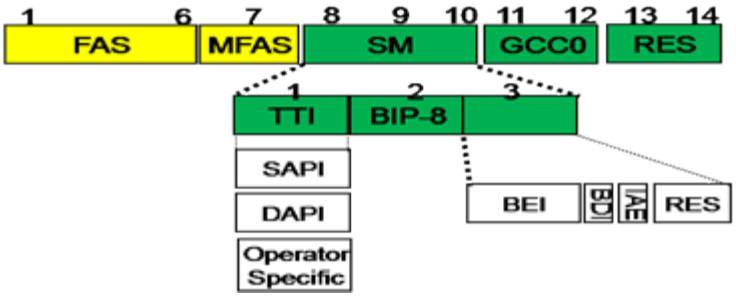
The OTU framing is divided into two portions: FAS and MFAS.

- **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

Go back to top Go back to TOC

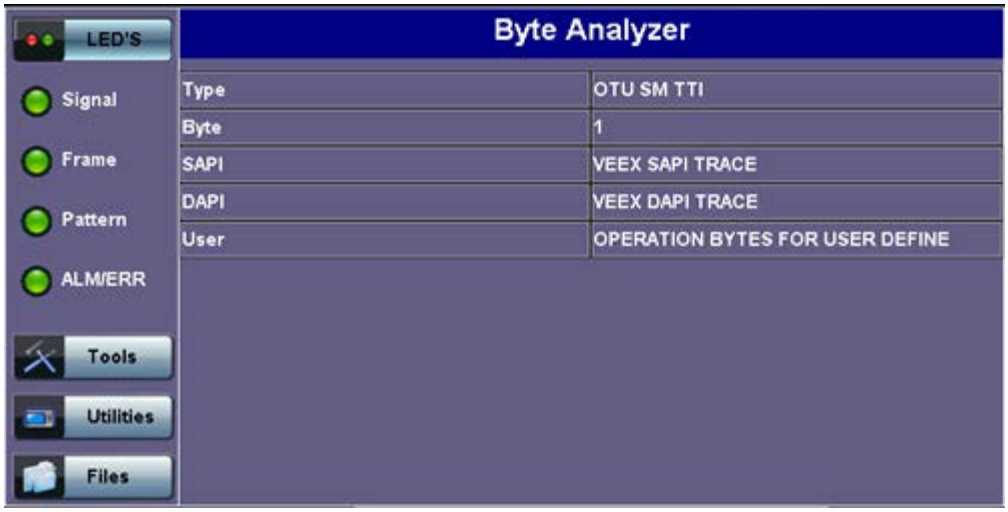
9.2.2 Optical Transport Unit (OTU) Analysis

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



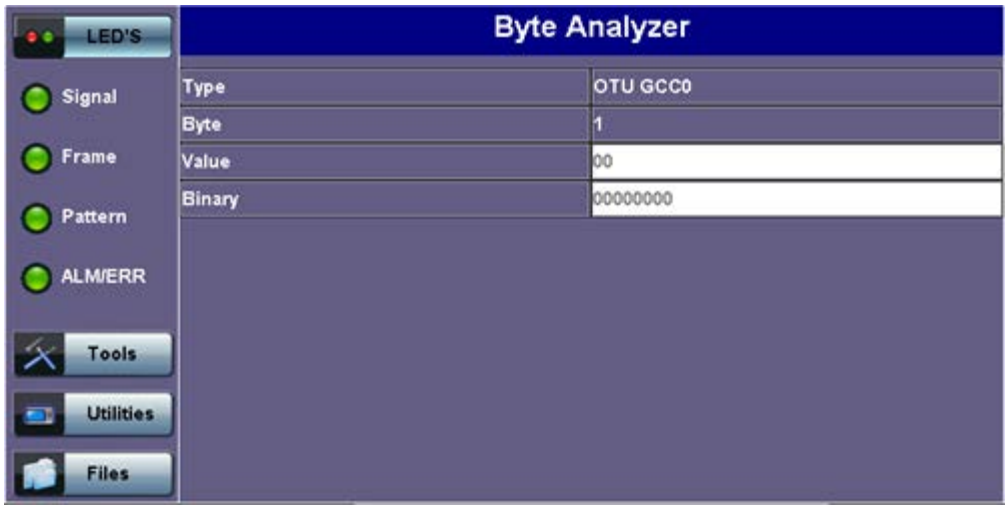
- **Section Monitoring (SM)**
  - Bytes are used for the Trail Trace Identifier (TTI), Parity (BIP-8) and the Backward Error Indicator (BEI) (also known as the Backward Incoming Alignment Error [BIAE]), Backward Defect Indicator (BDI), and Incoming Alignment Error (IAE).
  - The TTI is distributed over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

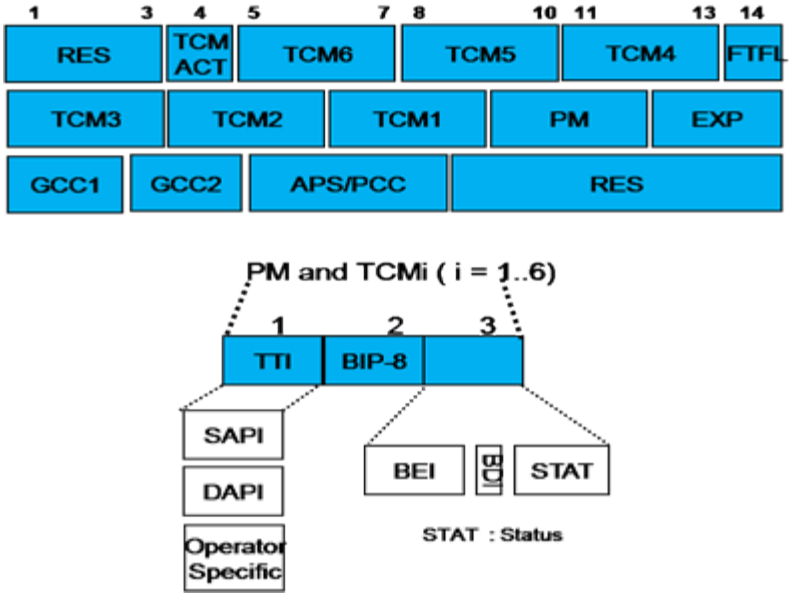


Reserved (RES) bytes are currently undefined in the standard.

Go back to top Go back to TOC

9.2.3 Optical Data Unit (ODU) Analysis

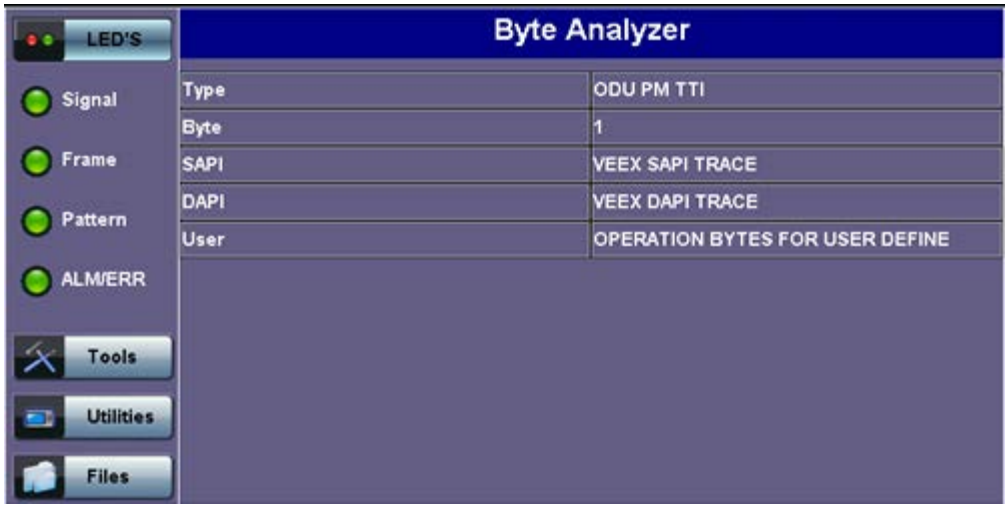
The ODU overhead is divided into several fields: RES, PM, TCMi, TCM ACT, FTFL, EXP, GCC1/GCC2 and APS/PCC.



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.

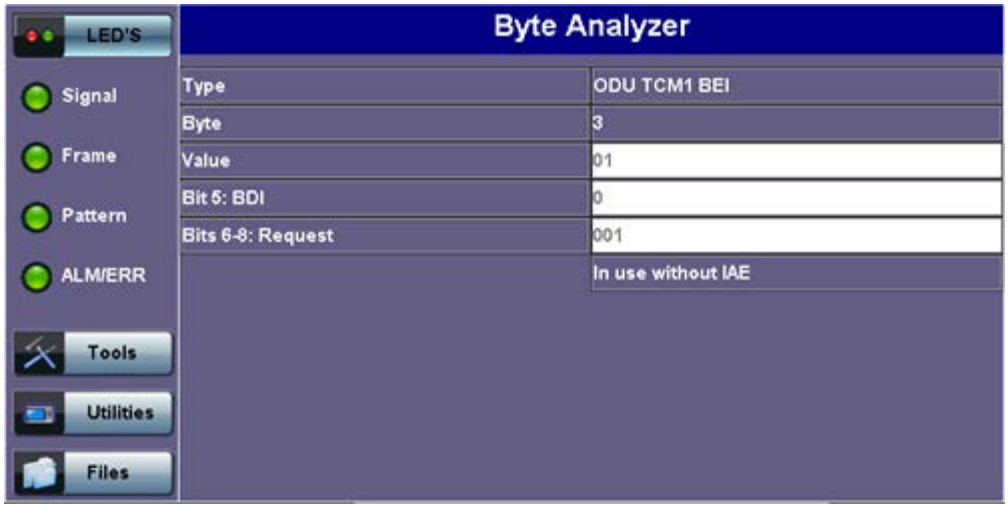
PM TTI Type



Go back to top Go back to TOC

- **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.

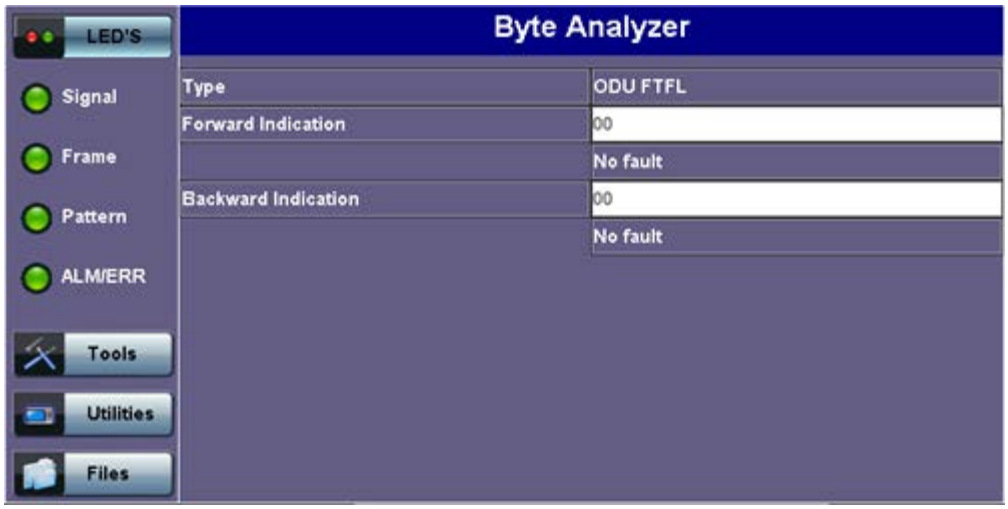
TCM1 BEI Type



Go back to top Go back to TOC

- **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

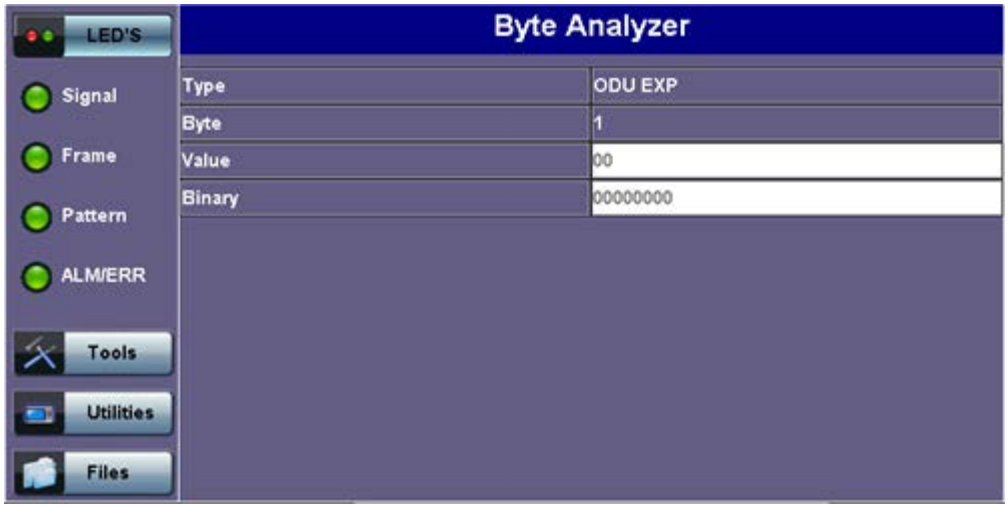
Fault indication codes	
Fault Code	Definition
0000 0000	No fault
0000 0001	Signal fail
0000 0010	Signal degrade
0000 0011 .. .. 1111 1111	Reserved for future standardization

ITU-T G.709 Figure 15-6

Go back to top Go back to TOC

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

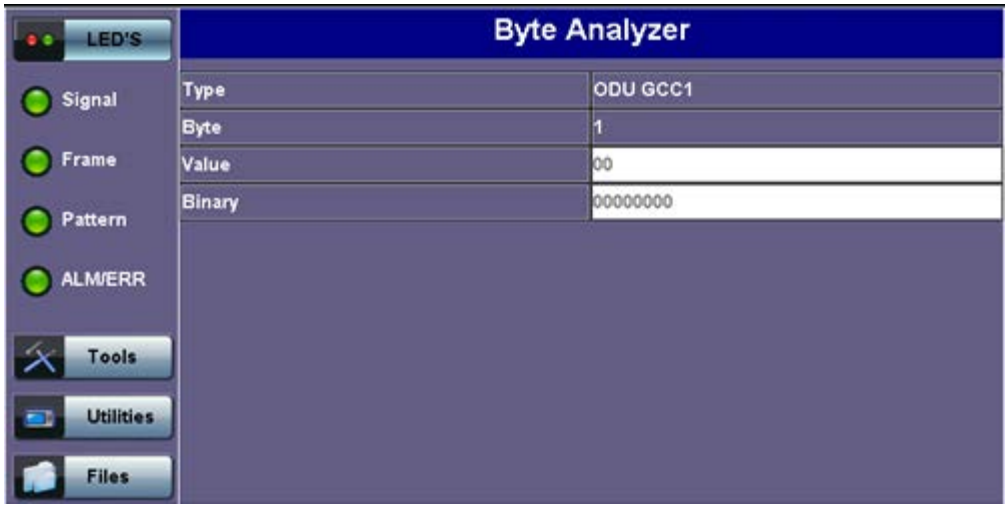
EXP Type



Go back to top Go back to TOC

- **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

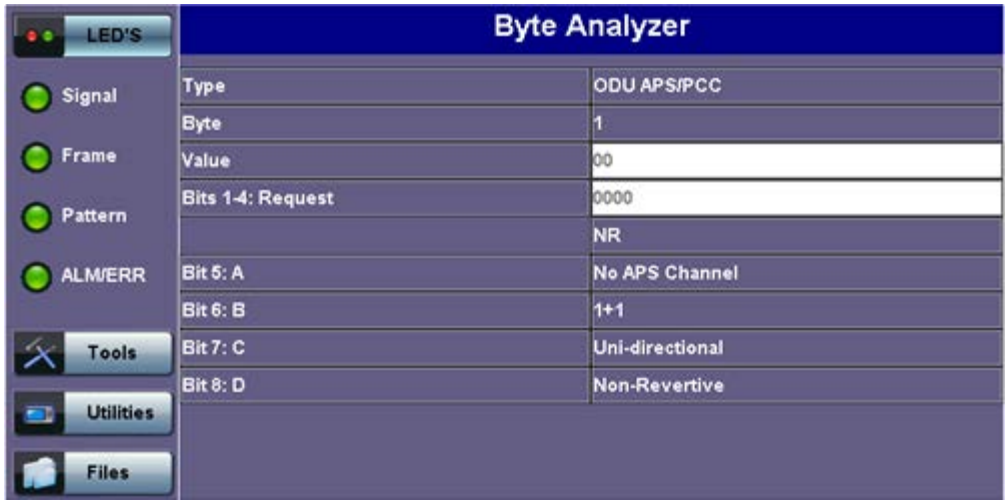
GCC1 Type



Go back to top Go back to TOC

- **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

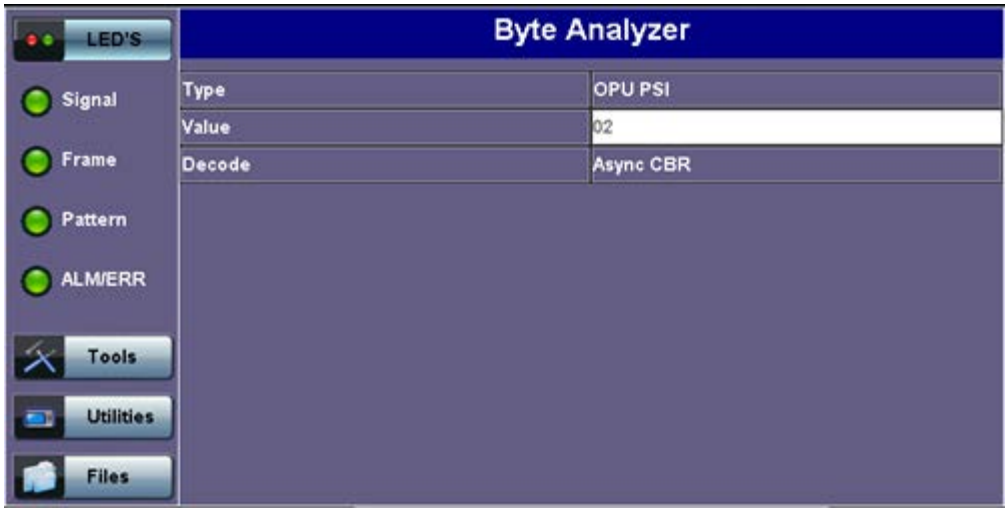


Go back to top Go back to TOC

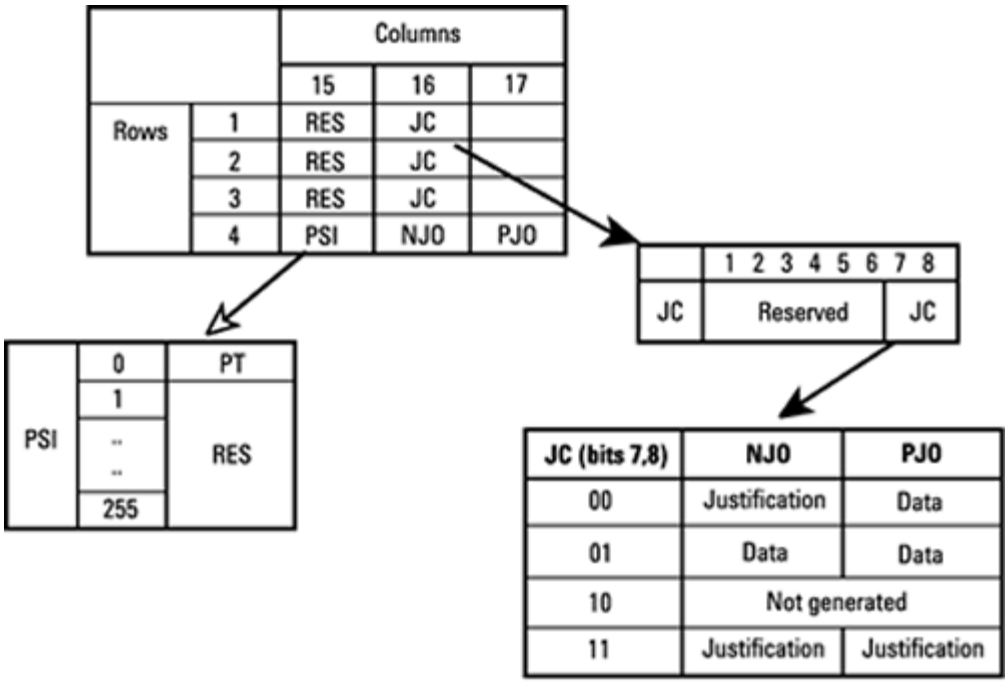
9.2.4 Optical Payload Unit (OPU) Analysis

- **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.709.



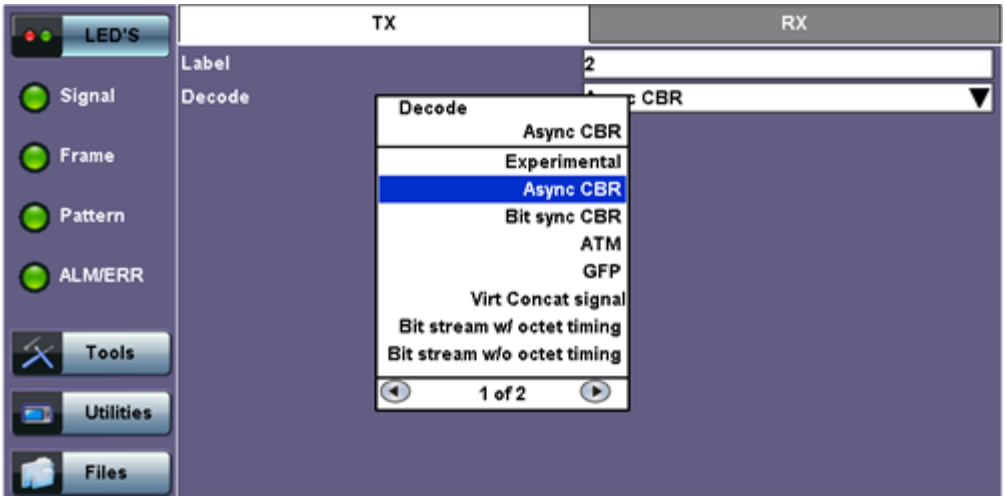
OPU2, O/H for synch mapping of 10 Gb/s SDH/SONET

Go back to top Go back to TOC

9.3 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.

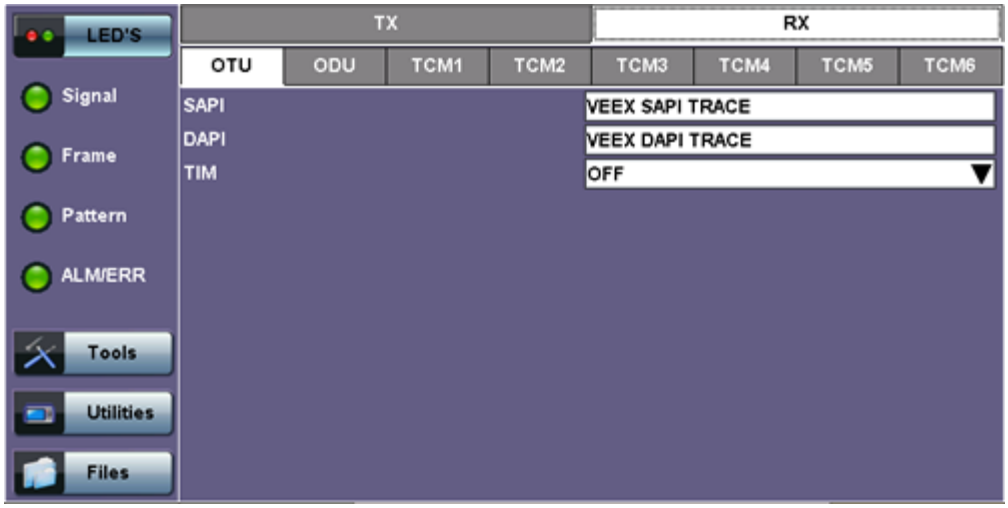
MSB 1 2 3 4	LSB 5 6 7 8	Hex code (Note 1)	Interpretation
0 0 0 0	0 0 0 1	01	Experimental mapping
0 0 0 0	0 0 1 0	02	Asynchronous CBR mapping
0 0 0 0	0 0 1 1	03	Bit synchronous CBR mapping
0 0 0 0	0 1 0 0	04	ATM mapping
0 0 0 0	0 1 0 1	05	GFP mapping
0 0 0 0	0 1 1 0	06	Virtual Concatenated signal
0 0 0 1	0 0 0 0	10	Bit stream with octet timing mapping
0 0 0 1	0 0 0 1	11	Bit stream without octet timing mapping
0 0 1 0	0 1 1 0	20	ODU multiplex structure
0 1 0 1	0 1 0 1	55	Not available
0 1 1 0	0 1 1 0	66	Not available
1 0 0 0	x x x x	80-8F	Reserved codes for proprietary use
1 1 1 1	1 1 0 1	FD	NULL test signal mapping
1 1 1 1	1 1 1 0	FE	PRBS test signal mapping
1 1 1 1	1 1 1 1	FF	Not available

Go back to top Go back to TOC

9.4 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

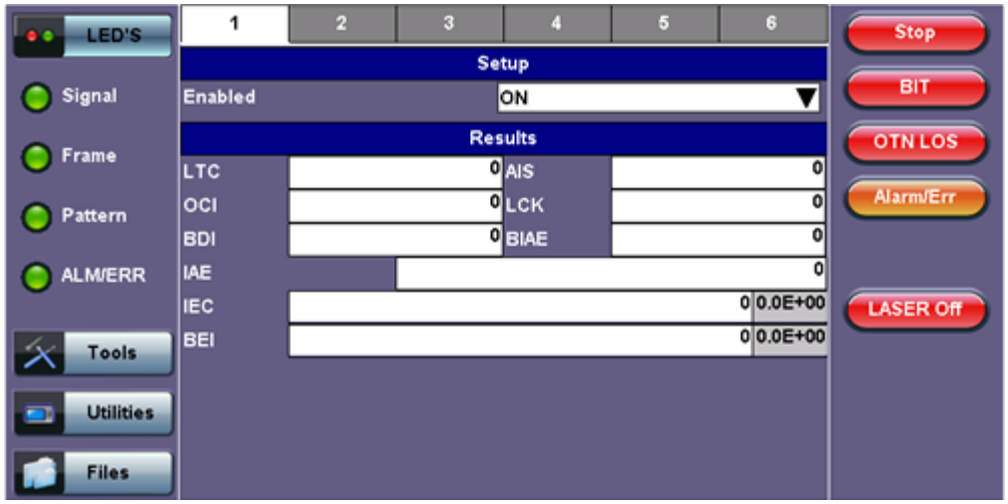
TTI similar to the J0 byte in SONET/SDH, is used to identify the signal from the source to the destination within the network. The TTI contains the so called Access Point Identifiers (API) which are used to specify the Source Access Point Identifier (SAPI) and Destination Access Point Identifier (DAPI).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

Go back to top Go back to TOC

9.5 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

Go back to top Go back to TOC

10.0 SDH/SONET Tools

10.1 SDH/SONET Tools

Accessing SDH/SONET Tools

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

10.1.1 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.
- **APS Testing:** Used to measure Automatic Protection Switching limits. Using selectable triggers, the drop out times of tributary connections are measured and compared with preset values.
- **Tributary Scan:** Used to scan individual or multiple tributaries to verify routing and error free operation. Only available in VC-12 or VC-11mode
- **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.
- **Round Trip Delay (Propagation Delay):** Measurement works by sending a test pattern. Bit errors are transmitted in the pattern. The time it takes for the error to reach the receiver is the propagation time through the network.

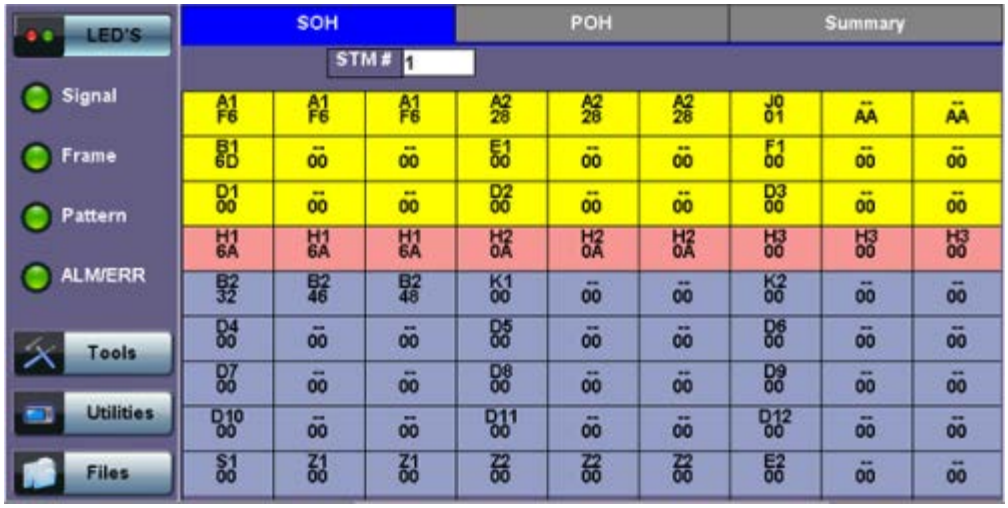
Go back to top Go back to TOC

10.1.2 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

SOH



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

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)

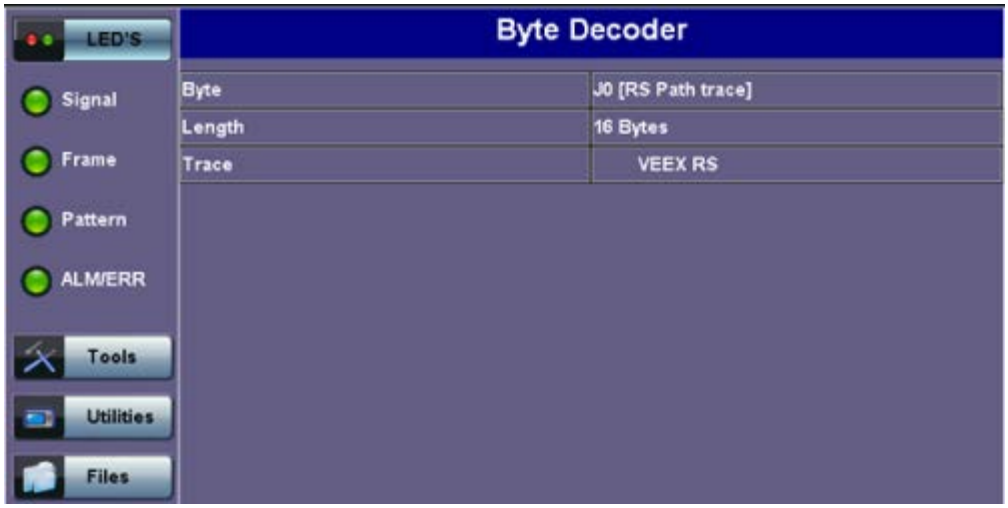
- Regenerator section trace
- Used to transmit a 16 or 64-byte identifier (trace) (including a CRC-7 byte) repeatedly so that all regenerators can verify their connection
- Used for continuity testing between regenerators

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)

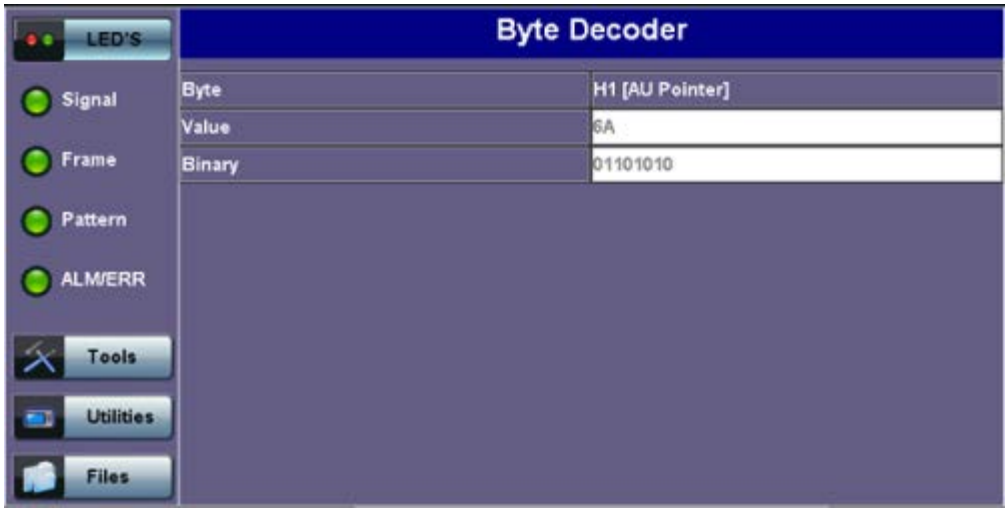
- Data Communications Channel (DCC)
- D1, D2 and D3 together form a 192kbps message channel for OAM purposes
- It can generate internal or external messages
- It can also be used as a BER function

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



Go back to top Go back to TOC

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)

Go back to top Go back to TOC

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)

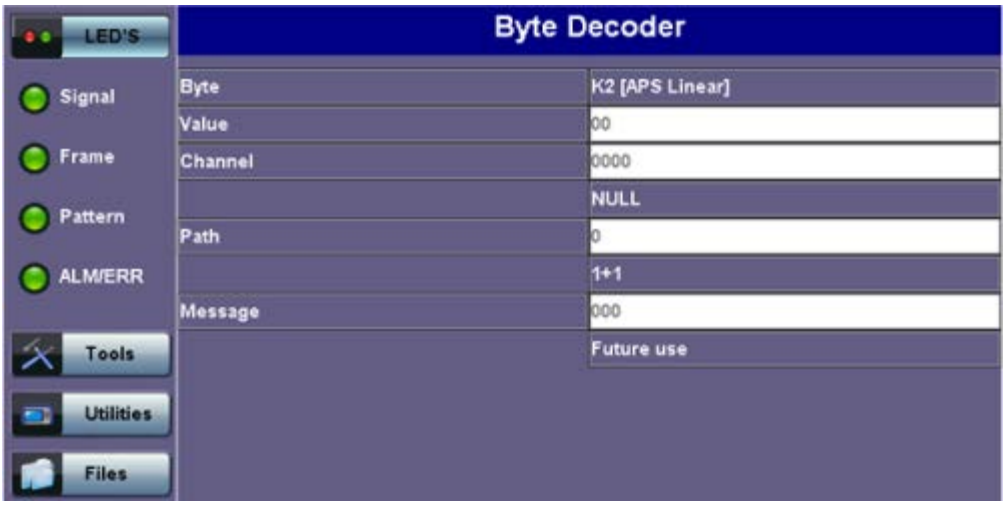
- Conforms to ITU-T G.783 and Bellcore GR.253
- Used to activate and deactivate the switching between the main and protection paths on a multiplexer section
- Used to communicate Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) conditions
    - Bits 1-4 selects bridged channel used
    - 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)



Go back to top Go back to TOC

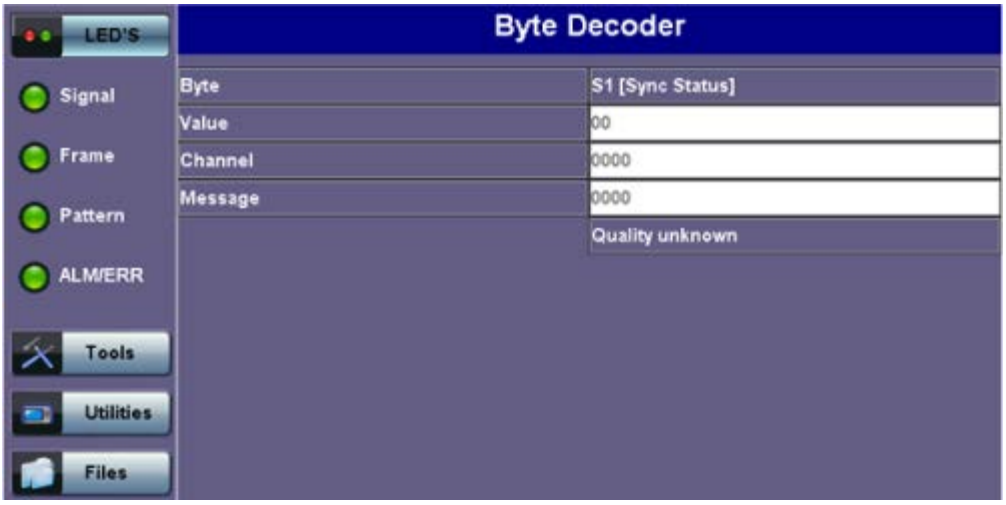
Data Communications Channel (DCC) Bytes (D4-D12)

- 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

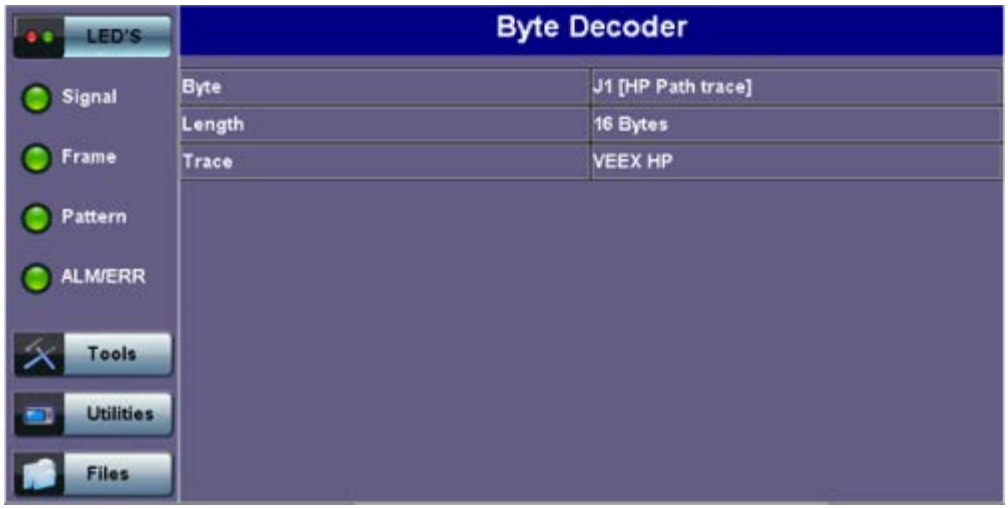
Go back to top Go back to TOC

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)

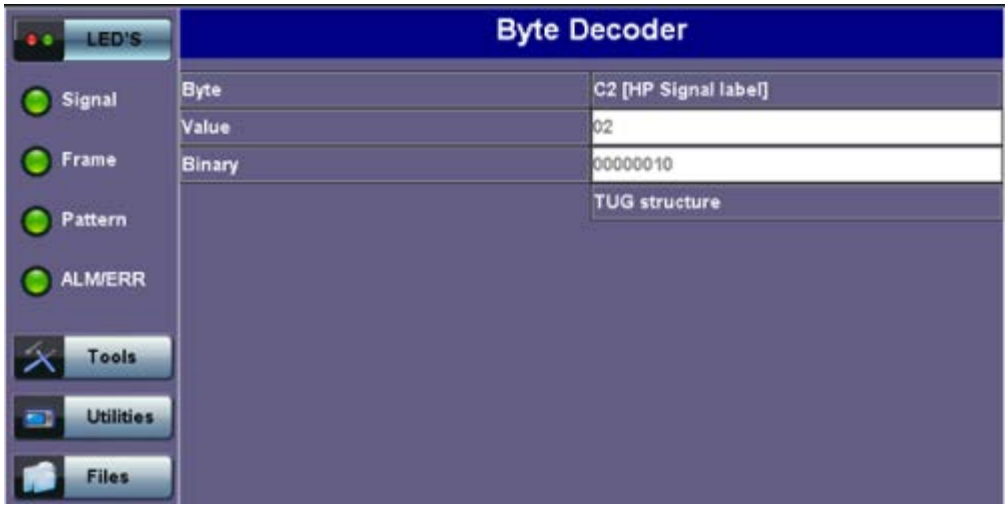


- **B3 byte**
  - Even code parity which determines if a transmission error has occurred over a path
  - Its value is calculated over all the bits of the previous VC-4
  - The computed checksum is placed in the B3 byte before scrambling

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)

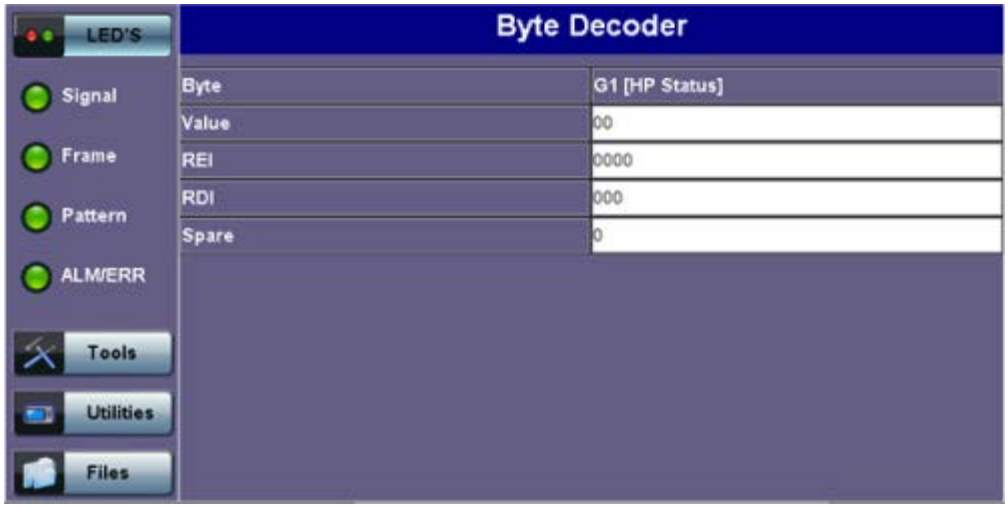


C2 byte structure per ITU-T G.707 recommendations			
Bits 1 to 4	**Bits 5 to 8**	**Hex value**	**Description**
0000	0000	00	Unequipped
0000	0001	01	Equipped non-specific
0000	0010	02	TUG structure
0000	0011	03	Locked TU-n
0000	0100	04	Asynchronous mapping of 34Mbit/s or 45Mbit/s into a C3 container
0001	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)

Go back to top Go back to TOC

- **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)

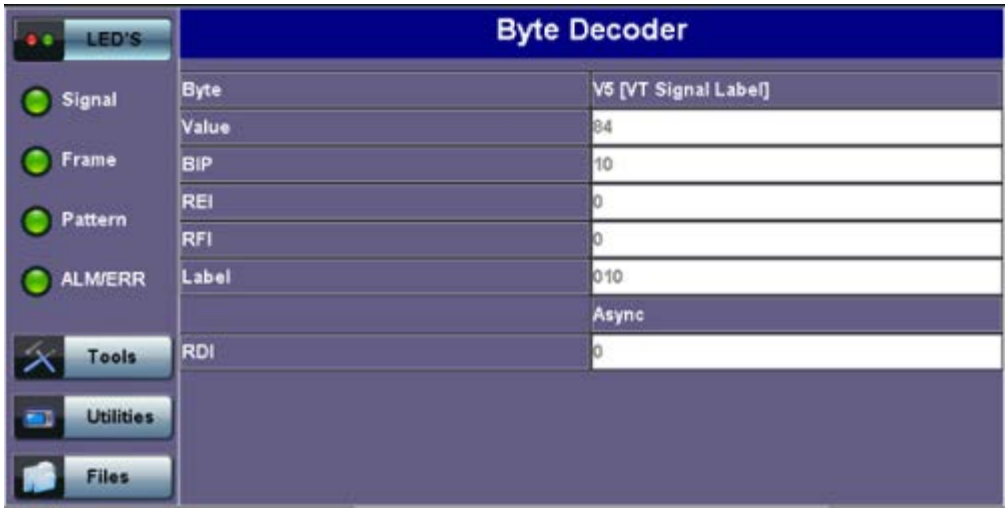


Go back to top Go back to TOC

- **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)



Go back to top Go back to TOC

- **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 contain the

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	28	29	30	31	32
Multiframe Alignment Signal											Extended Signal Label								0	R	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	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
Extended Signal Label	Virtual concatenation Overhead	Unassigned		Optional Use			Unassigned

Go back to top Go back to TOC

- **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

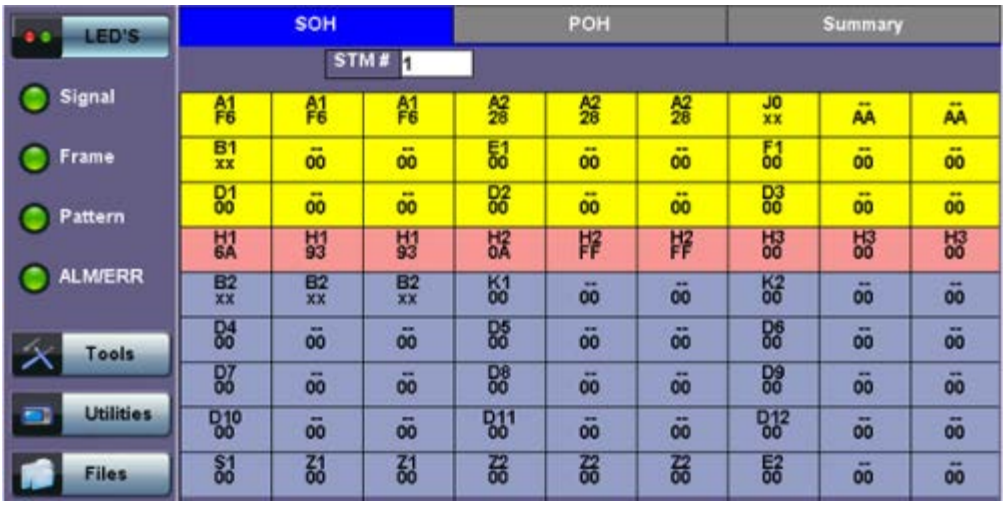
Path Traces

(SP) indicates a space between the message characters.
The message is displayed in red when an alarm condition is detected.

Go back to top Go back to TOC

10.1.3 Overhead Generator

SOH

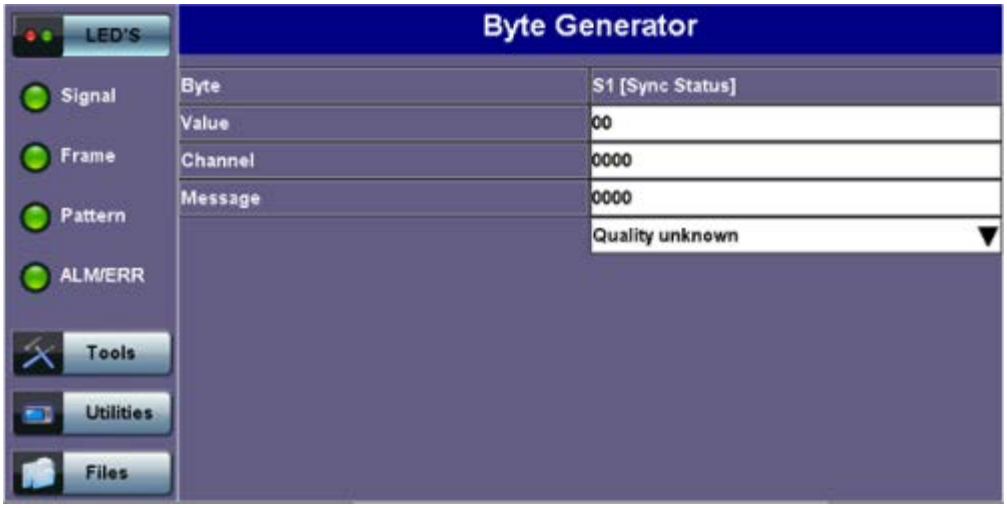


Tap the Overhead Generator icon to display the OH screens shown below. There are three tabs:

- **SOH TX**, which allows editing of select bytes associated with the Section Overhead. 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.

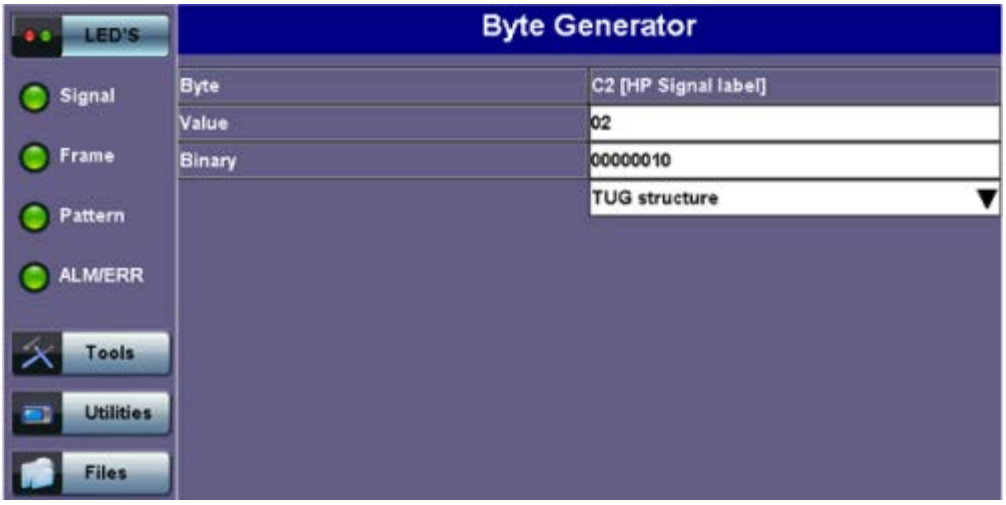
Note: While programming of most overhead bytes is possible using the OH Generator feature, dedicated functions are available for Pointer Tasks, Payload Labels, Trace Identifier, APS Testing, TCM testing. In some instances, more advanced editing is possible using the dedicated functions.

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.

Go back to top Go back to TOC

10.1.4 Pointer Tasks

Tap the Pointer Tasks icon to display the Pointer testing screens.

SDH/SONET Tools Menu

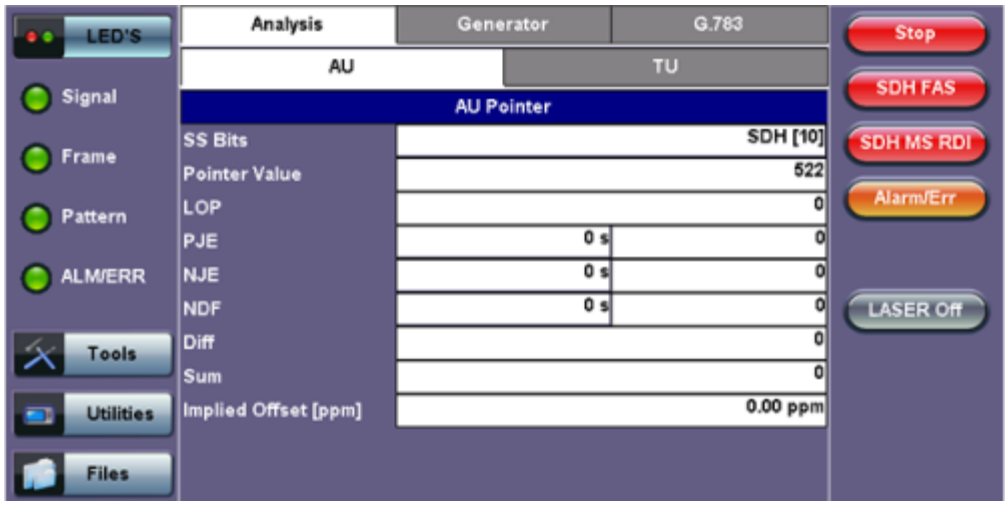
10.1.4.1 Pointer Analysis

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

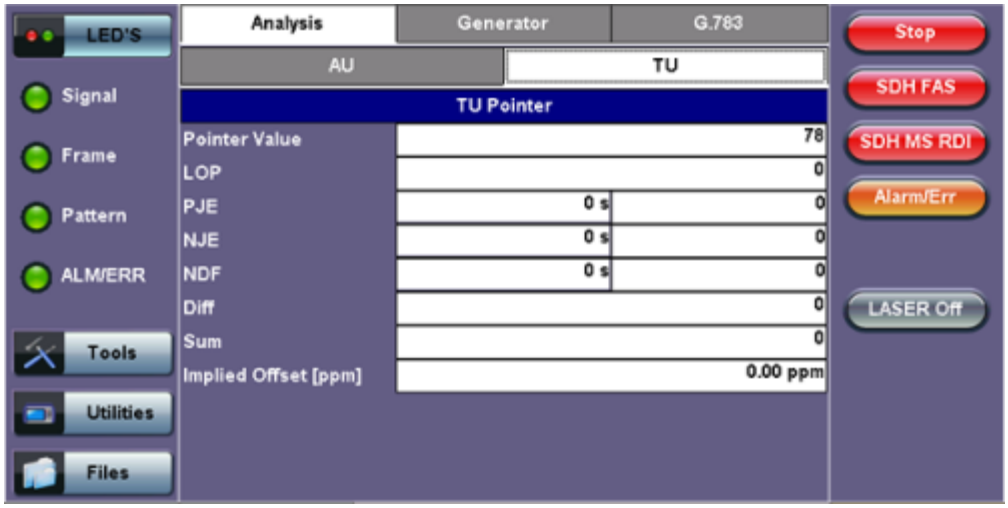
first byte of the AU-n
- LOP (Loss of Pointer)
- PJE and NJE
- NDF or New Data Flag. NDF is enabled when all bits match “1001” (or "0001", "1101", "1011" and "1000") and is disabled when all bits match "0110" (or "1110", "0010", "0100", "0111").
- Difference and Sum

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



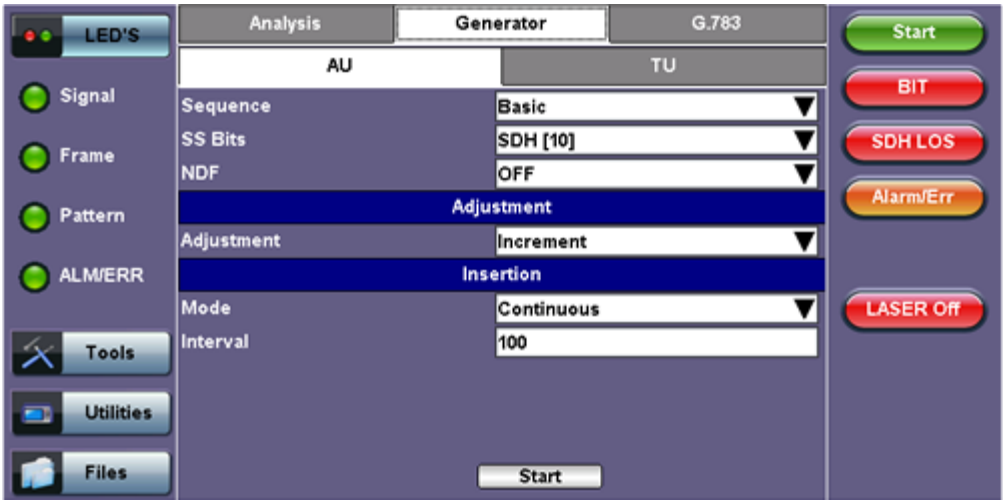
Go back to top Go back to TOC

10.1.4.2 Pointer Generation

The Pointer generator is able to generate individual pointer movements as follows:

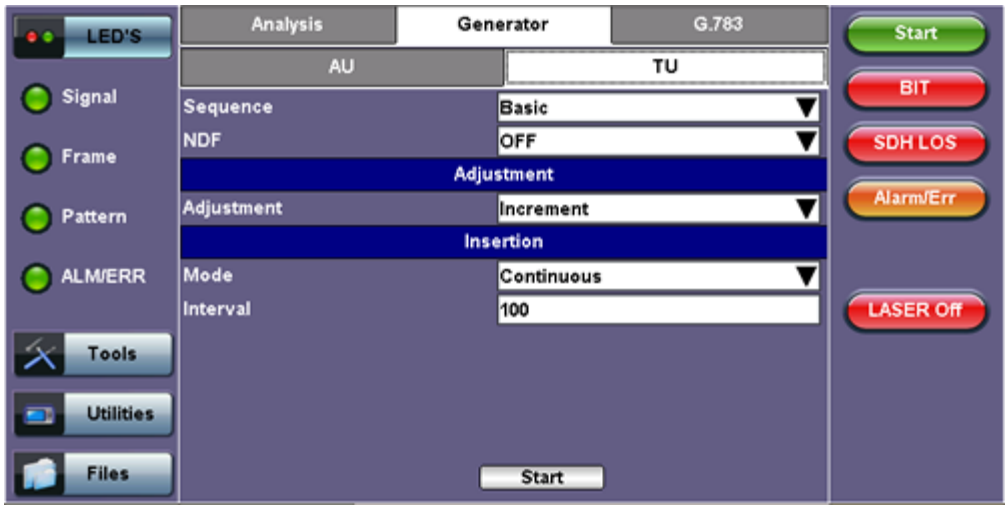
- **For AU pointers:**
  - SS bits: Program bits 5 and 6 of the H1 byte to be either SDH [10], SONET [00], Unknown [01] or [11].
  - Pointer value: Transmits a new pointer address or value with or without a new data flag (NDF). Configurable in a range of 0 to 782 pointers.
  - Increment (INC) or Decrement (DEC) pointers with identical polarity by 1 byte in single steps.

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



Go back to top Go back to TOC

10.1.4.3 Pointer Sequences

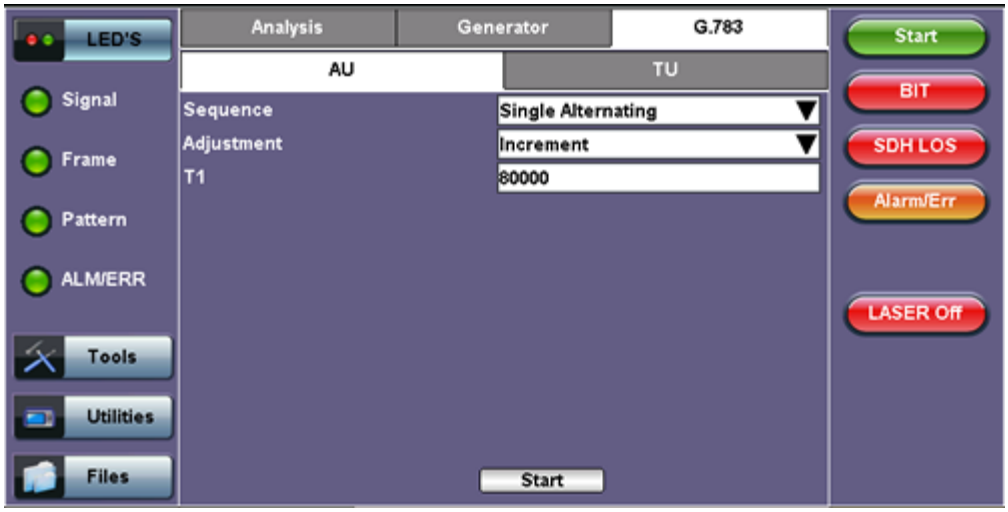
The Pointer generator is also able to generate Standard ITU-T G.783 and ANSI T1.105.03 and Bellcore GR-253 sequences as follows:

- **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)

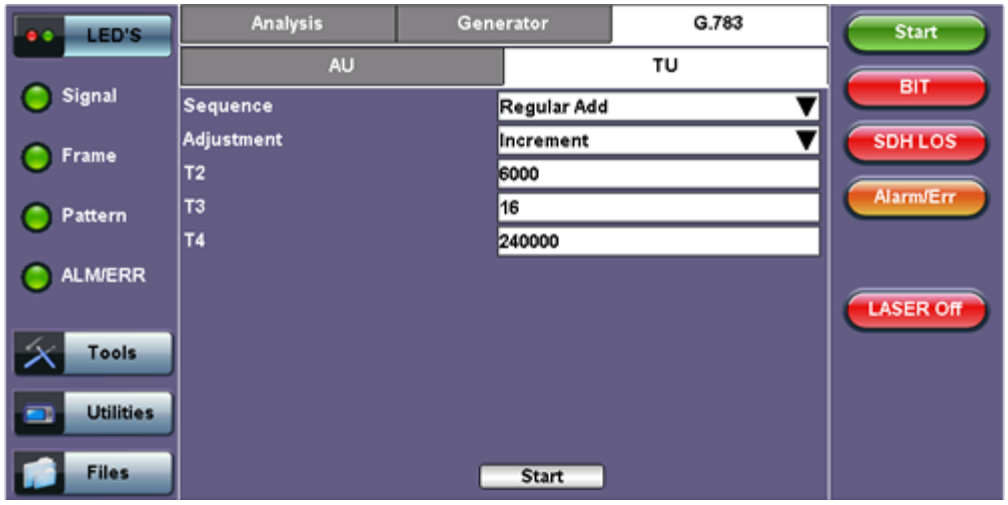
- **87-3 Cancel**: Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, reduced the number of adjustments by one)
- **Unit**: Select the type of unit to count: Frames
  - N: Specify the number of pointer adjustments in a row: 1—9999 (default=6)
  - T: Specify the 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

G.873 > TU tab



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.

Go back to top Go back to TOC

10.1.5 Trace Identifier

Tap the Trace Identifier icon to display the path trace testing application and screens.

SDH/SONET Tools Menu

There are dedicated tabs for Transmitted and Received (expected) path traces and setups.

10.1.5.1 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.

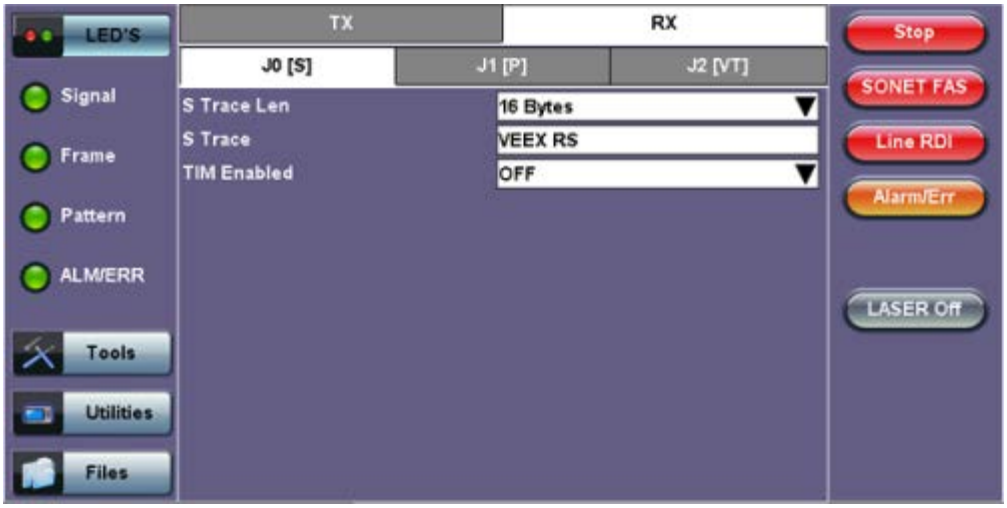
TX - JO [S]

Go back to top Go back to TOC

10.1.5.2 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]



Go back to top Go back to TOC

10.1.6 Payload Labels

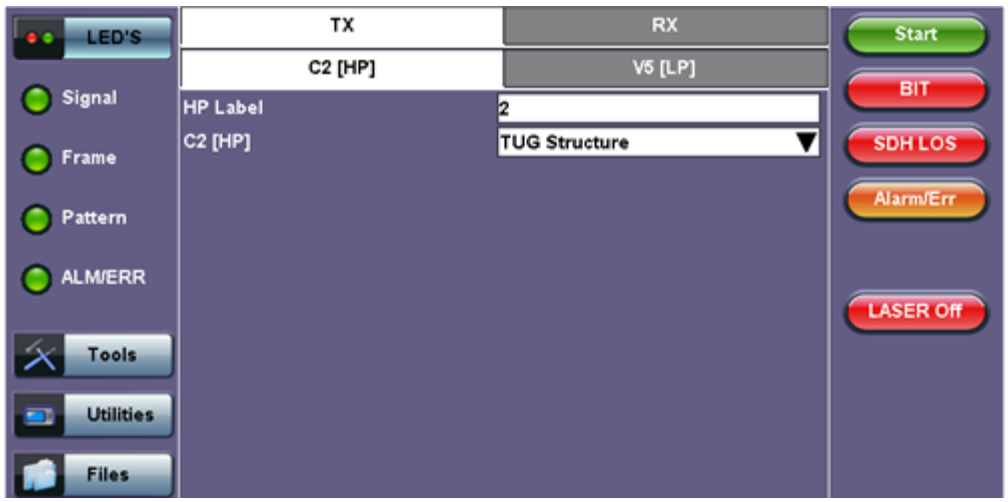
This function is used to set the C2 and V5 Path Signal Labels which indicate the content of the High order and Low order VCs.

SDH/SONET Tools Menu

Tap the Payload Label icon to display the payload label screens. There are dedicated tabs for Transmitted and Received payload labels and setups:

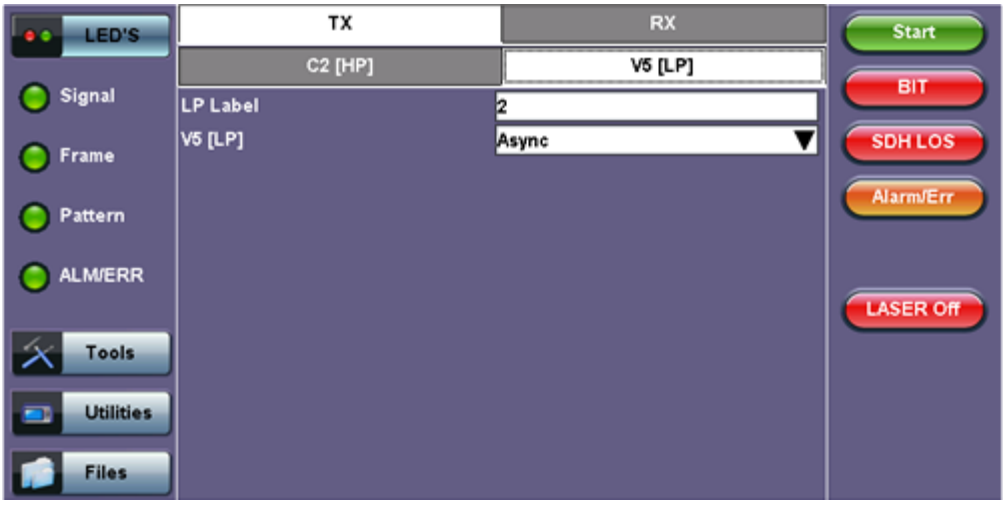
- **C2 [HP Path]: Path signal label**
  - Specifies the mapping type in the VC-n
  - Program the TX or RX label by editing the hexadecimal value or by using the convenient drop-down menu selection
  - For the RX label, enable or disable the Payload Mismatch (PLM) Alarm

TX C2 [HP]



- **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

TX V5 [LP]



Go back to top Go back to TOC

10.1.7 APS Tasks

10.1.7.1 APS Timing

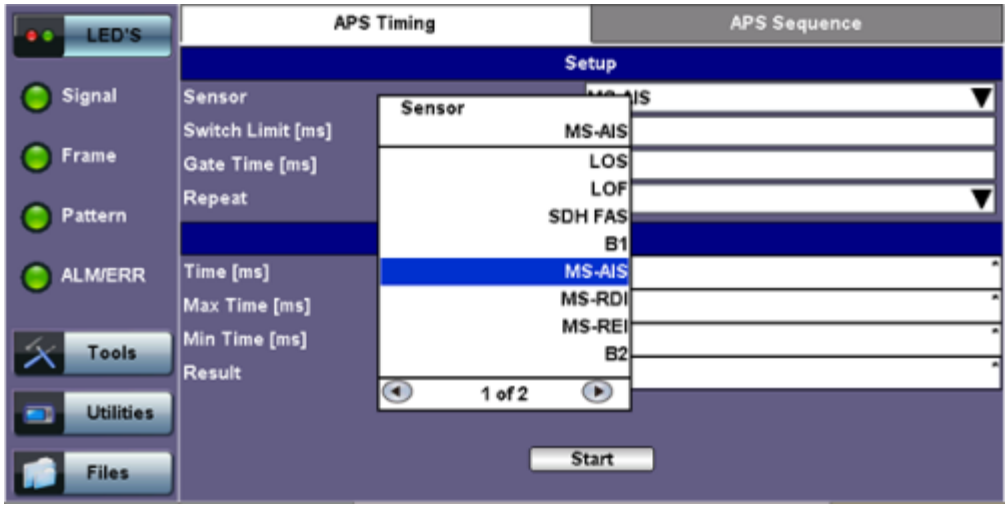
This function measures the Automatic Protection Switching (APS) limits of the network. APS applies only to the Multiplex sections of a SDH network and enables network elements to re-route traffic to a backup circuit in the event of network failure or problems. The protection mechanism is coordinated by the K1 and K2 bytes in the Multiplexer Section Overhead.

- **APS Standards**
  The principles and protocols of APS in SDH networks are defined in ITU-T G.783 and G.841 and Bellcore GR-253 recommendations for Linear and Ring network architectures respectively. According to recommendations, the re-routing of the signal has to occur within 50ms. Protection switching is initiated as a result of one of the following conditions:
  - "Hard" Failure (SF) condition – Loss of Signal (LOS), MS-AIS, BER > 1 x 10^{-3}.
  - "Soft" Failure (SD) condition – Signal degradation when BER exceeds a predetermined threshold. Normally over a provisioned range of 1 x 10^{-5} to 1 x 10^{-9}.

Tap the APS Testing icon to display the APS testing screen shown below.

- **Sensor:** Select the trigger that will initiate the APS measurement
  - The selections are LOS, LOF, SDH FAS, B1, MS-AIS, MS-RDI, MS-REI, B2, AU-AIS, AU-LOP, B3, HP-RDI, HP-REI, TU-AIS, 2M-AIS, 2M-LOF, LSS and TSE (bit errors)
- **Switch Time Limit**: Configurable in the range from 15ms to 200ms
  - Typically 50ms according to ITU-T recommendations
- **Gate Time**: Configurable in the range from 50ms to 4 seconds
  - Used to measure total service disruption when multiple switches or micro interrupts occur
- **Repeat**: ON/OFF
  - Configurable to measure on a continuous basis
- **Start**: Press to begin the test

APS Timing Setup



- **APS Test Procedure:**
  - The test set should be connected to a tributary port of network element or transmission system to ensure that the switching time is measured for the service transported by the SDH network
  - Ensure that no errors or alarms are present on the transmission system because this will impact the measurement
  - The measurement will be triggered depending on the condition configured
  - The test set measures how long the AIS event remains present after the event is first recognized and will continue to measure the total disruption time in the event of multiple disruptions

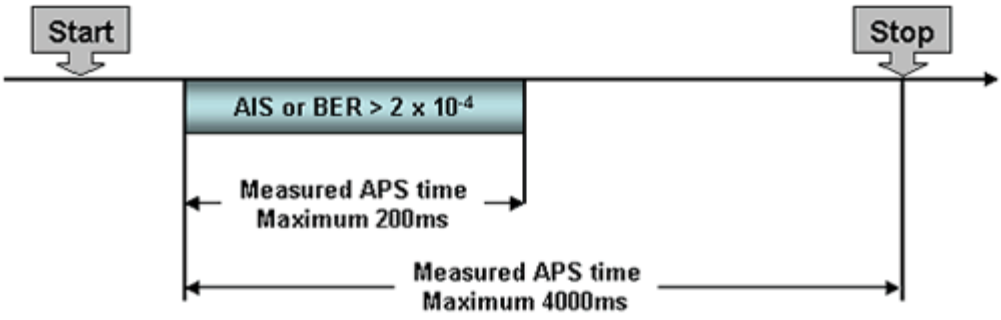


Figure 1: Perfect service disruption

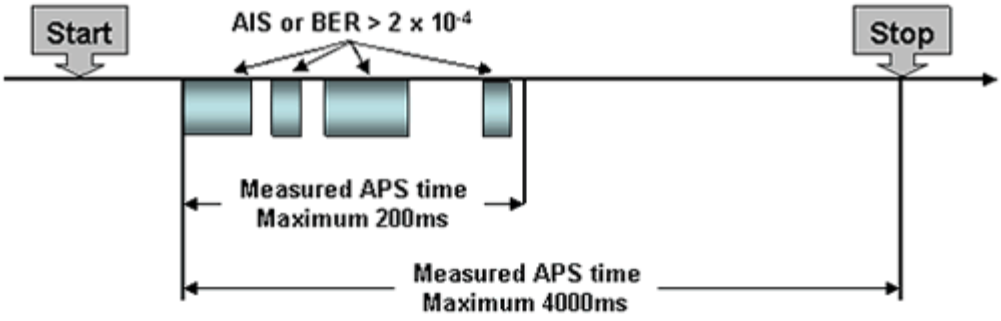
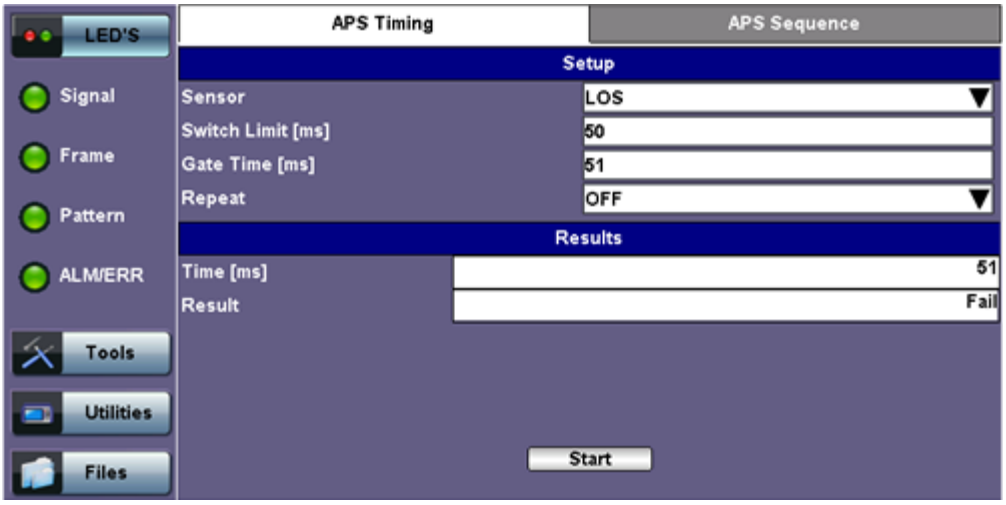


Figure 2: Multiple service disruption or micro interrupts

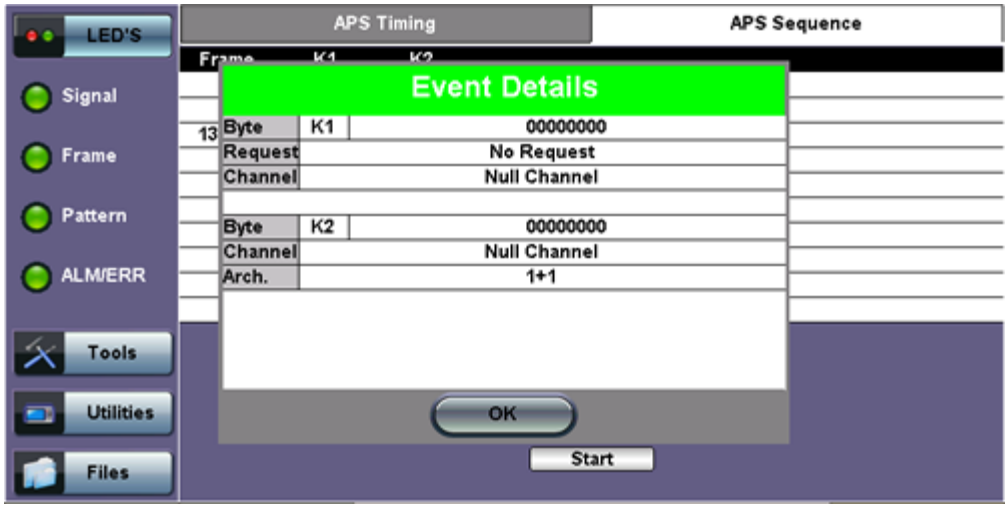


Go back to top Go back to TOC

10.1.7.2 APS Sequence

The associated K1/K2 sequence and received K1/K2 bytes may be captured.

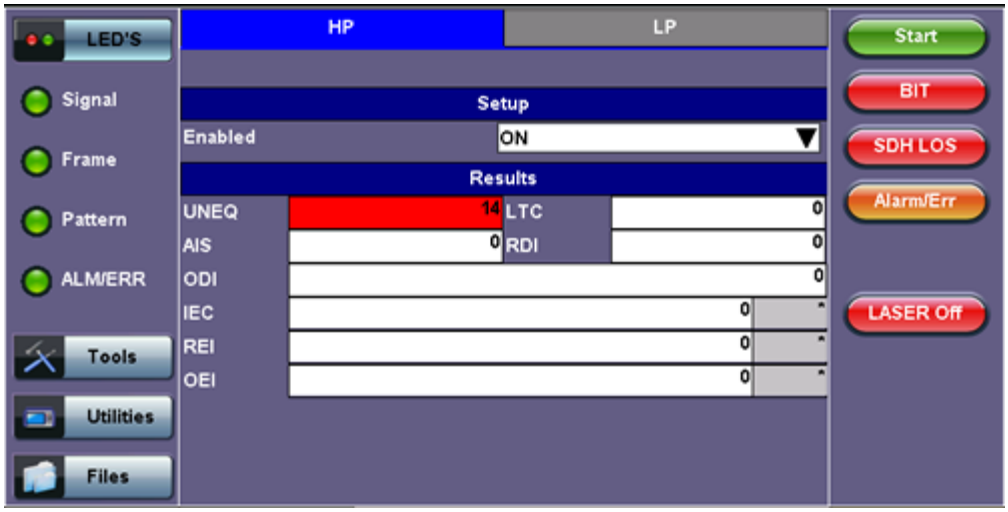
Event Details



Go back to top Go back to TOC

10.1.8 Tandem Connection Monitoring (TCM)

HP Setup



- **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-B1P		"1"	IAIS	TC-REI	OEI	TC-APId, TC-RDI,ODI, reserved	

IEC:	Incoming Error Count. Indicates IAIS when set to '1110' (seebelow)
IAIS:	Incoming AIS alarm
TC-REI:	Tandem Connection Remote Error Indication
OEI:	Outgoing Error Indication
TC-APId:	Tandem Connection Access Point Identifier (16-byte message)
TC-RDI:	Tandem Connection Remote Defect Indication
ODI:	Outgoing Defect Indication
TC-BIP:	2-bit Bit Interleaved Parity for Tandem Connection

Go back to top Go back to TOC

10.1.9 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.

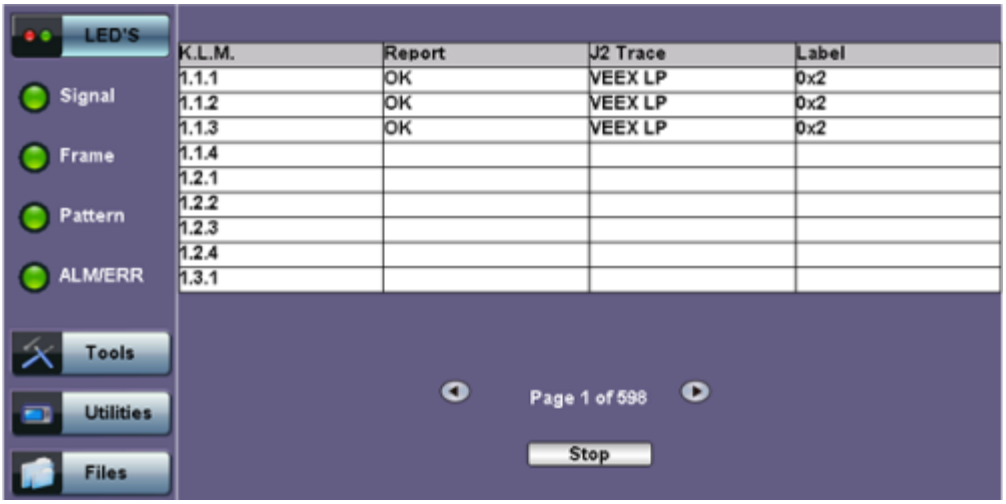
An important part of any Add Drop Multiplexer (ADM) installation process is the verification of the path routing. Considering that an STM-1 contains 63 x VC-12's and a STM-4 contains 252 x VC-12's checking each path manually can be very time consuming.

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



Go back to top Go back to TOC

10.1.10 Round Trip Delay

The Round Trip Delay (Propagation Delay) measurement works by sending a test pattern with an error. The time it takes for the error to reach the receiver is the propagation time through the network.

- Select SDH as TX/RX standard.
- View the Round Trip Delay of a looped back signal.
- Set check box on Setup RX pattern to Out-of-Service.

Round Trip Delay Results

Go back to top Go back to TOC

10.1.11 Jitter and Wander

For more information on Jitter and Wander, please see 13.0 Jitter and Wander Application.

Go back to top Go back to TOC

10.2 SONET Tools

Accessing SDH/SONET Tools

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

10.2.1 Shortcuts

SDH/SONET Tools Menu

- **Overhead Analyzer:** Displays the Section/Line Overhead (SOH) and STS Path Overhead (POH) bytes of the received channel.
- **Overhead Generator:** Used to edit Section/Line Overhead (SOH) and STS Path Overhead (POH) bytes of the received channel.
- **Pointer Tasks:** Displays both STS and VT pointer values and generates STS and VT pointer movements. Pointer sequences according to Bellcore GR.253 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 STS path and VTs.
- **APS Testing:** Used to measure Automatic Protection Switching limits. Using selectable triggers, the drop out times of tributary connections are measured and compared with preset values.
- **TCM Tasks:** Used to analyze or edit the sequence of Z5 and Z6 TCM bytes by generating alarms and errors in the Tandem connection sub-layer.
- **Tributary Scan:** Used to scan individual or multiple tributaries to verify routing and error free operation. Available in VT-1.5 or VT-2 mode
- **Round Trip Delay (Propagation Delay):** Measurement works by sending a test pattern. Bit errors are transmitted in the pattern. The time it takes for the error to reach the receiver is the propagation time through the network.

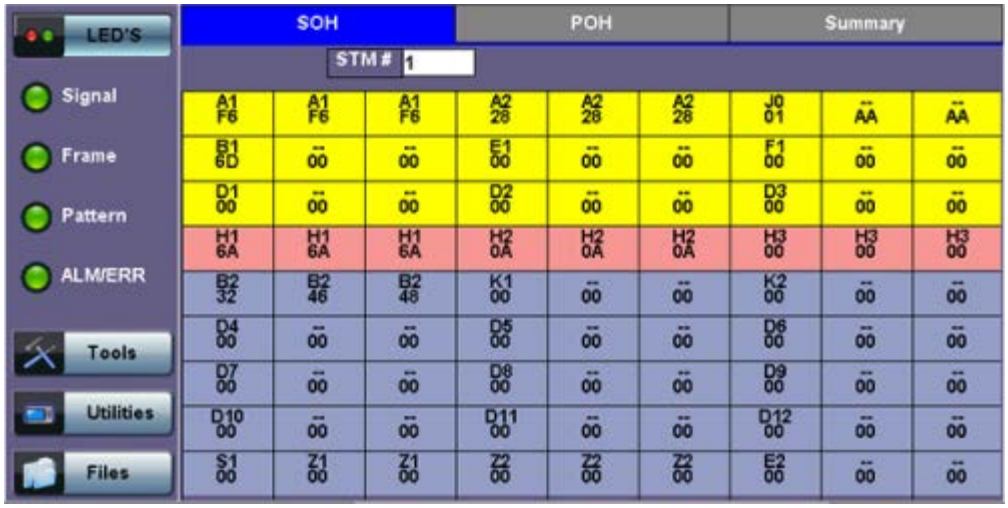
Go back to top Go back to TOC

10.2.2 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

SOH



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

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 STS-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 STS-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 STS-N frame before scrambling
- The checksum value is placed in the SECTION overhead of the following STS-N before scrambling

B1 (Section-BIP) Byte

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

D1 Byte

Pointers

H1/H2/H3 Bytes (STS Pointers)

- Enable transfer of STS-3 frames with STS-N frames and are processed by the MS terminating equipment

H1 Pointer Byte

Go back to top Go back to TOC

Line Layer

B2 Byte

- A 24-bit interleaved even parity code used to determine if transmission errors have occurred over the Section Layer
- Its calculated over all the bits of the STS-3 frame except those in the Section overhead
- The computed checksum is placed in the TOH of the following STS-N frame

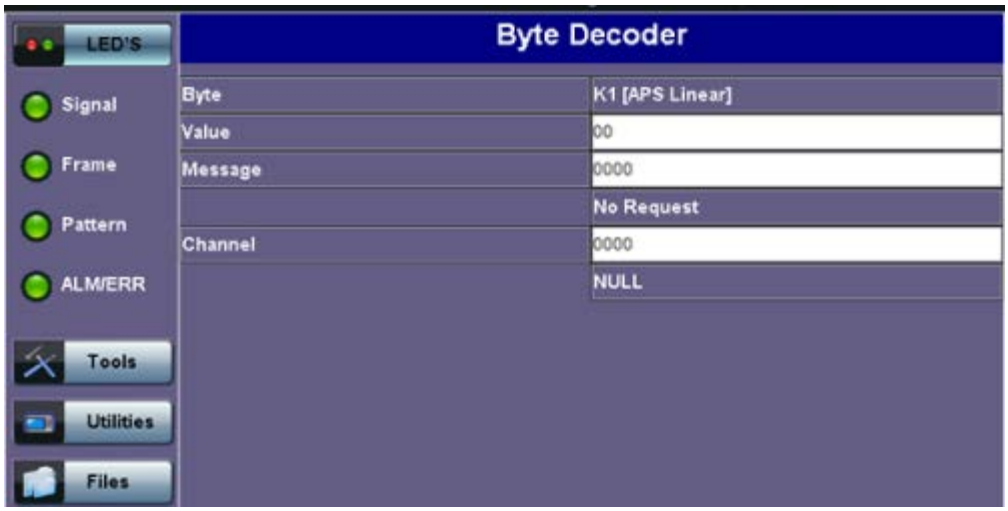
B2 Byte

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 channels

K1 Byte (APS-Linear)



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 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

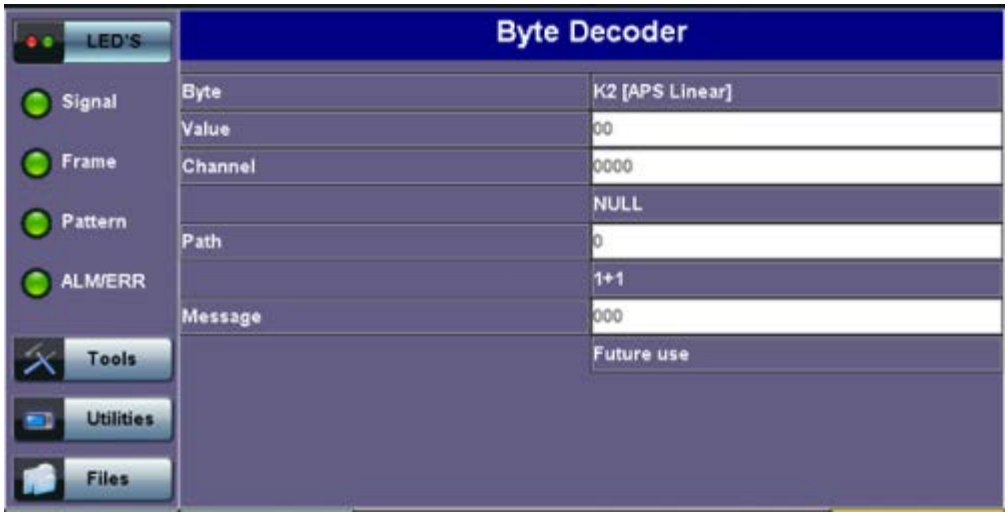
Bit 5 determines APS architecture
- 1+1
- 1:N

- Bits 6-8
  - 110 RDI-L
  - 111 AIS-L
  - 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 RDI-L
    - 111 AIS-L
    - Others Not used

K2 Byte (APS-Linear)



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

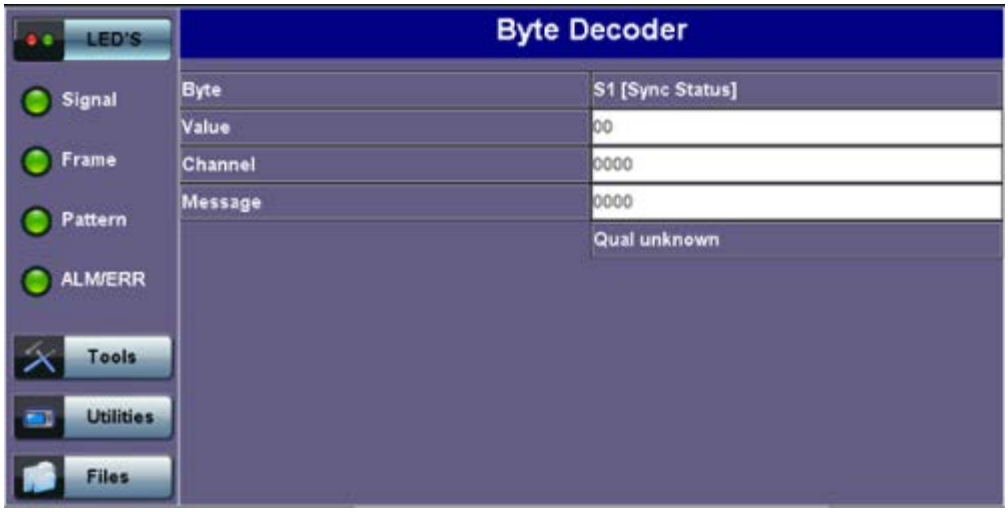
- Data Communications Channel (DCC) – together these nine bytes form a 576kbps message channel for OAM purposes.
- They can be used for internally or externally generated messages or BER function.

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 SONET Minimum Clock
    - 1101 Stratum 3e

1110 Provisionable by the Network Operator
- 1111 Not used for synchronization
- Other bytes are reserved

S1 Byte (Synchronization Status)



Order Wire Byte (E2)

- A 64 kbps 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

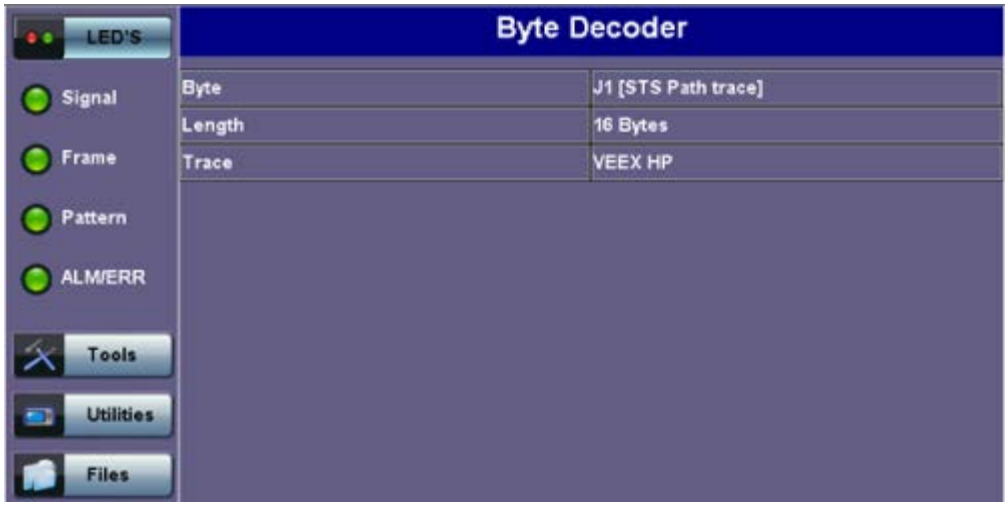
Go back to top Go back to TOC

Path Overhead Layer

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

- **J1 byte (STS Path Trace)**
  - High Order STS-N path trace byte
  - An unique message is assigned to each path in a SONET 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 STS-3 frame

J1 Byte (STS 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 STS-3
  - The computed checksum is placed in the B3 byte before scrambling

B3 Byte (STS Path BIP)

- **C2 byte (STS path signal label)**
  - Indicate the type of payload being transported in the STS, SPE, including the status of the mapped payloads.
  - The table below indicates the standard C2 binary values:

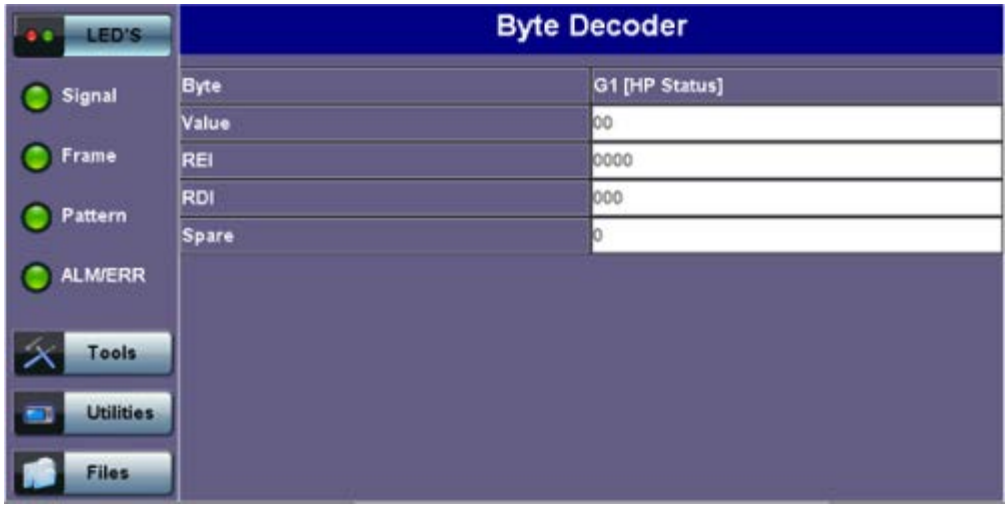
C2 Byte (STS Path signal label)

C2 byte structure per GR.253 recommendations	
Code[hex]	**Payload type**
00	Unequipped
01	Equipped non-specific (standard payload)
02	Floating VT mode
03	Locked VT mode
04	Asynchronous mapping for DS3
12	Asynchronous mapping for 139.264Mbps
13	Mapping for ATM
14	Mapping for DQDB
15	Asynchronous mapping for FDDI

16	Mapping for HDLC over SONET
E1	STS-1 payload with 1 VT-x payload defect
E2	STS-1 payload with 2 VT-x payload defects
E3	STS-1 payload with 3 VT-x payload defects
E4	STS-1 payload with 4 VT-x payload defects
E5	STS-1 payload with 5 VT-x payload defects
E6	STS-1 payload with 6 VT-x payload defects
E7	STS-1 payload with 7 VT-x payload defects
E8	STS-1 payload with 8 VT-x payload defects
E9	STS-1 payload with 9 VT-x payload defects
EA	STS-1 payload with 10 VT-x payload defects
EB	STS-1 payload with 11 VT-x payload defects
EC	STS-1 payload with 12 VT-x payload defects
ED	STS-1 payload with 13 VT-x payload defects
EE	STS-1 payload with 14 VT-x payload defects
EF	STS-1 payload with 15 VT-x payload defects
F0	STS-1 payload with 16 VT-x payload defects
F1	STS-1 payload with 17 VT-x payload defects
F2	STS-1 payload with 18 VT-x payload defects
F3	STS-1 payload with 19 VT-x payload defects
F4	STS-1 payload with 20 VT-x payload defects
F5	STS-1 payload with 21 VT-x payload defects
F6	STS-1 payload with 22 VT-x payload defects
F7	STS-1 payload with 23 VT-x payload defects
F8	STS-1 payload with 24 VT-x payload defects
F9	STS-1 payload with 25 VT-x payload defects
FA	STS-1 payload with 26 VT-x payload defects
FB	STS-1 payload with 27 VT-x payload defects
FC	STS-1 payload with 28 VT-x payload defects, or STS-1, STS-3C, etc., with a non-VT payload defect (DS3, FDDI, etc.)

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

G1 Byte (HP Status)



- **F2 byte (Path user channel)**
  - STS Path user channel
  - STS-3# path user channel used for communication between path elements
- **H4 byte (VT Indicator)**
  - Position or Sequence Indicator
  - Multiframe phase indicator used for tributary structured payloads

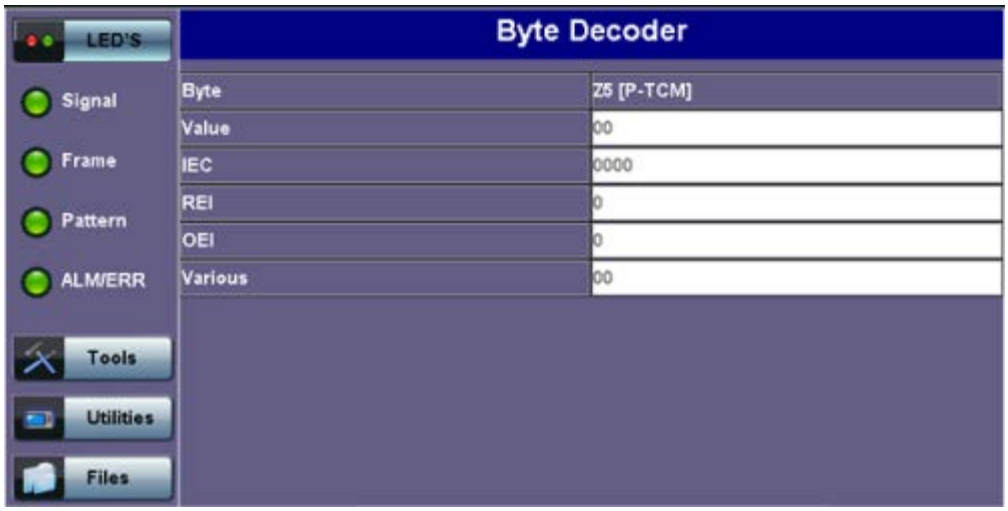
H4 Byte (VT Indicator)

- **Z3/Z4 byte (STS Path)**
  - Allocated for future use. Have no defined value. The receiver is required to ignore their content.
- **Z5 byte (STS Path TCM)**
  - Allocated to provide a STS Path Tandem Connection monitoring function for contiguously concatenated STS-3 levels.
    - Bits 1-4: Used as an Incoming Error Count (IEC)
    - 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 STS-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 STS-n VTG-n due to defects before or within the tandem connection
    - Frames 73-76 > Reserved capacity

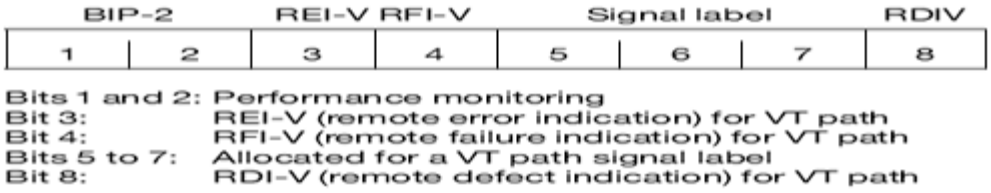
Z5 byte structure

b1	b2	b3	b4	b5	b6	b7	b8
IEC (IAIS)				TC-REI	OEI	TC-APId, TC-DI,ODI, reserved	

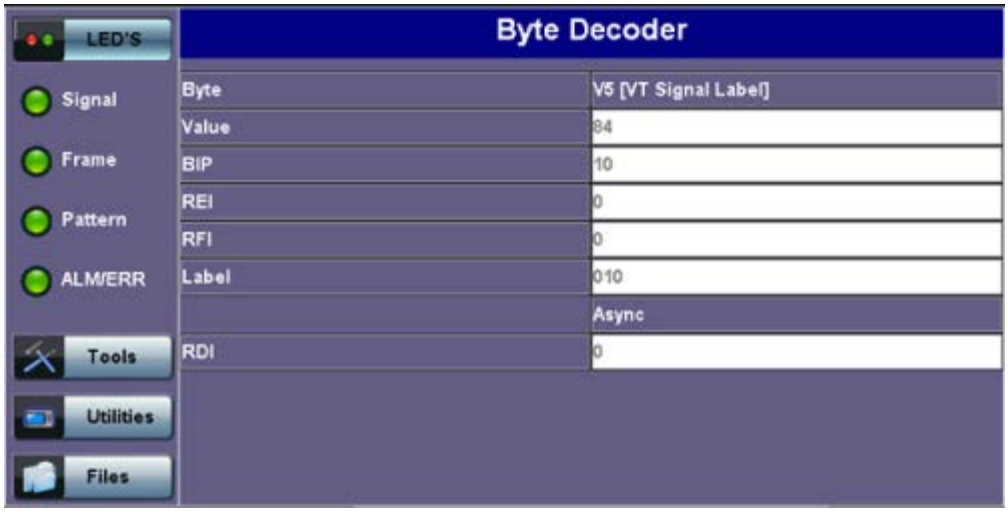
Z5 Byte (Path TCM)



- **V5 byte (VT path overhead)**
  - The first byte of a VT SPE provides the functions of error checking, signal label and path status.
  - 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 REI-V (0 = no error, 1 = errors), that is sent back towards an originating VT PTE if errors were detected by the BIP-2.
    - Bit 4 is reserved for mapping-specific functions.
    - Bits 5-7 provide the VT signal label
      - 000 Unequipped
      - 001 Equipped (non-specific)
      - 010 Asynchronous mapping for DS1
      - 011 Bit synchronous mapping for DS1
      - 100 Byte synchronous mapping for DS1
    - Bit 8 is the VT path RDI-V normally set to zero unless there is an error condition (AIS)



V5 Byte (VT signal label)



- **J2 byte (VT path trace)**
  - 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

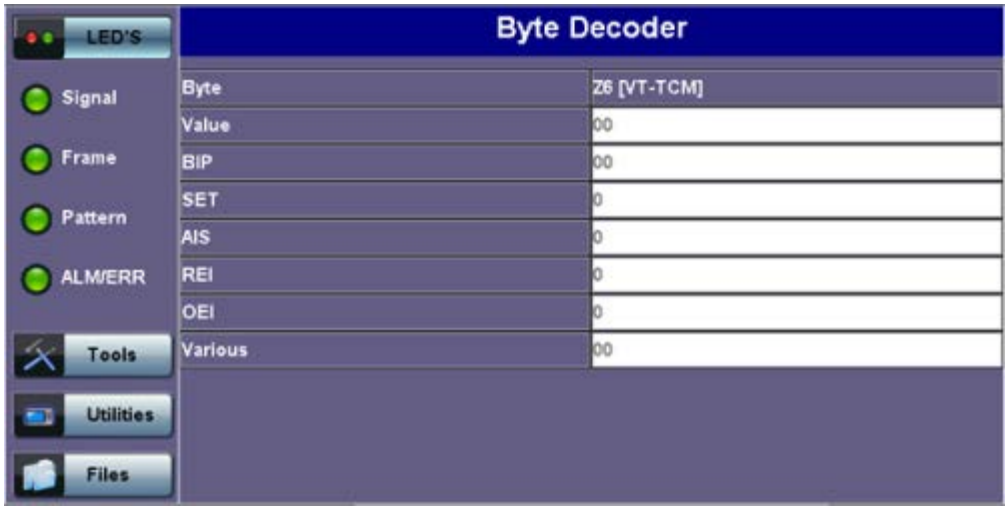
- **Z6 byte (VT-TCM)**
  - Provides VT tandem connection monitoring function (TCM-V) for the VT-1.5, VT-2 levels.
    - Bits 1-2: even parity error checking BIP-2 for the tandem connection
    - Bit 3: Set to “1”
    - Bit 4: Incoming AIS indicator (0 = no defect; 1 = defect occurred before tandem connection)
    - Bit 5: TC-REI indicating errored blocks caused in the tandem connection
    - Bit 6: OEI indicating errored blocks of the egressing STS-1n
    - 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 AIS-P/V has been inserted into egressing STS-1n VT-n due to defects before or within the tandem connection
  - Frames 73-76 > Reserved capacity

Z6 byte structure

b1	b2	b3	b4	b5	b6	b7	b8
TC-B1P		"1"	IAIS	TC-REI	OEI	TC-APId, TC-RDI,ODI, reserved	

Z6 Byte (VT-TCM)



- **Z7 byte (VT path Extended Label)**
  - If bits 5-7 of V5 byte are set to 101 (value = 5), then:
    - The signal label in Z7 byte becomes valid where:
      - This is a 32-bit multi-frame string
      - 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 VT APS signaling
      - Bits 5, 6, 7 are allocated for optional use
      - Bit 8 is unassigned

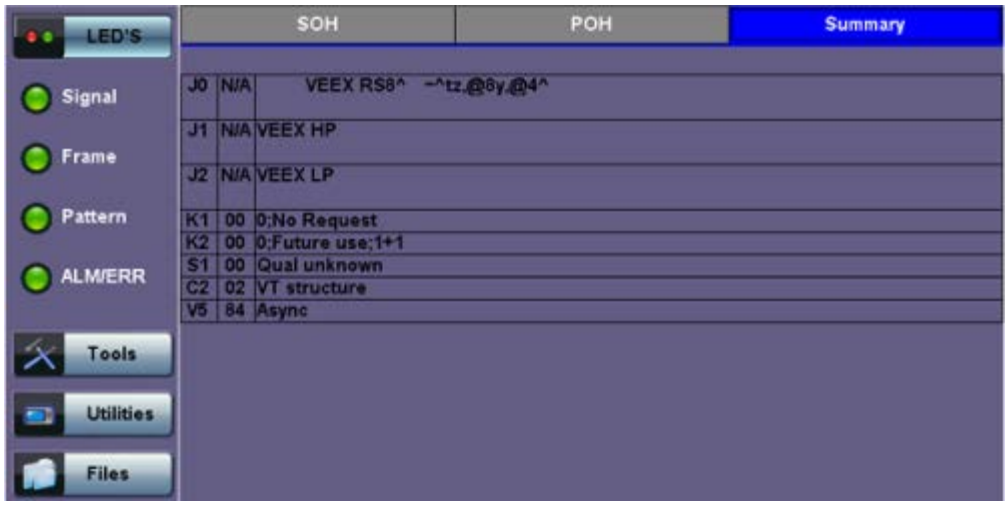
Go back to top Go back to TOC

- **Summary**
  - The Summary tab displays the summary screen listing the major bytes of the received SONET signal.
    - 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)

Note:

- For Path traces, (SP) indicates a space between the message characters.
- The message will be displayed in red when an alarm condition is detected. In the example below, the C2 byte has a PLM alarm (Payload Mismatch) (i.e., the received signal label does not match the transmitted signal label).

Summary



Go back to top Go back to TOC

10.2.3 Overhead Generator

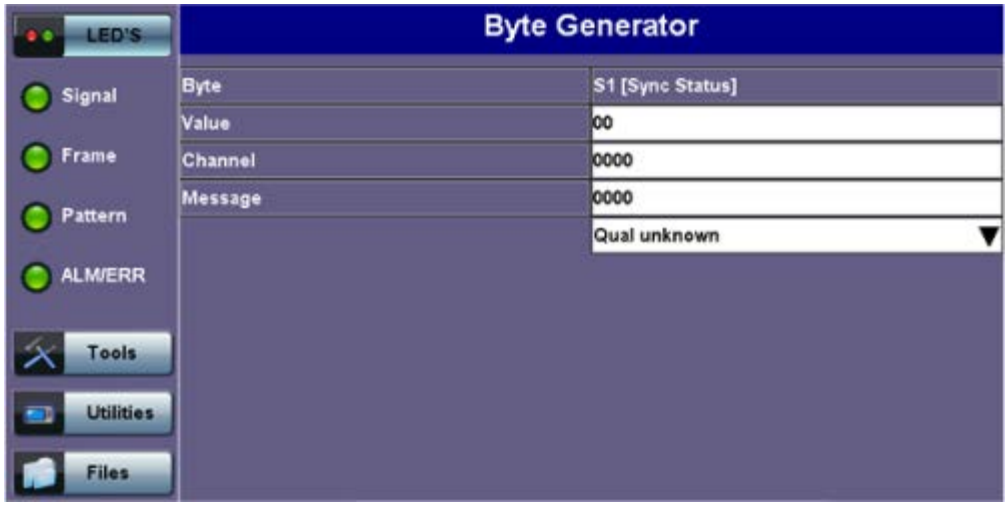
SOH

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. 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.

- **Summary** displays the Path Trace Identifiers (J0, J1, J2), APS (K1, K2), Synchronization status (S1), HP (C2), and LP (V5) Signal Label bytes. The operation is the same as the Overhead Analyzer function.

Go back to top Go back to TOC

10.2.4 Pointer Tasks

Tap the Pointer Tasks icon to display the Pointer testing screens.

SDH/SONET Tools Menu

Go back to top Go back to TOC

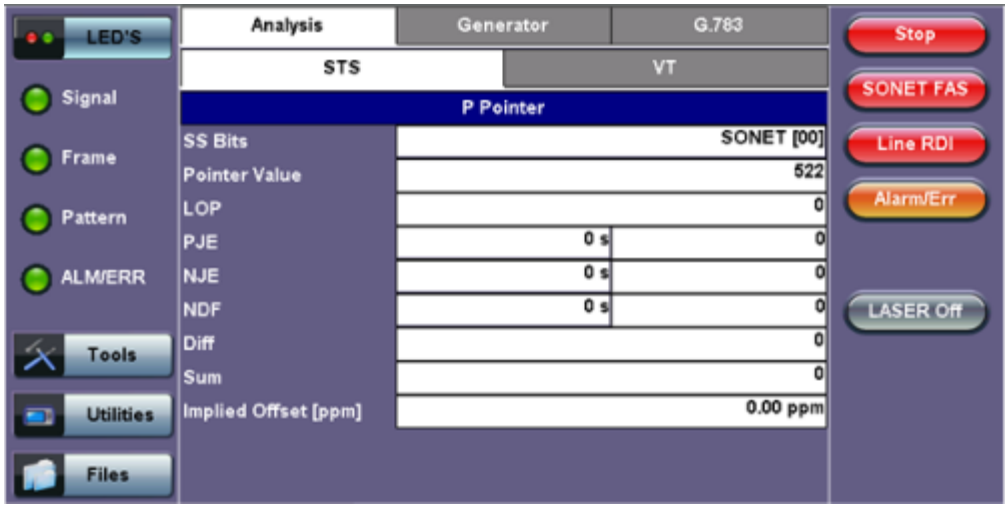
10.2.4.1 Pointer Analysis

Pointers keep SONET 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.

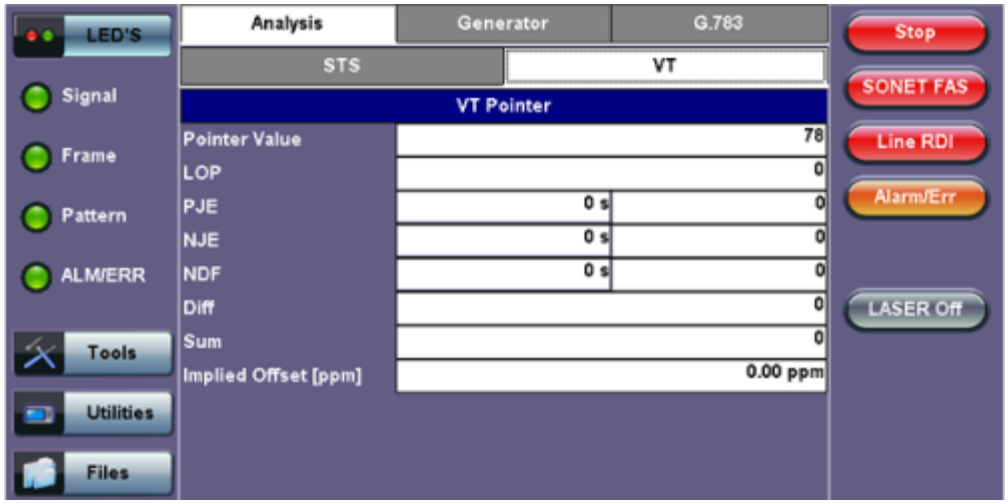
- **For STS pointers:**
  - SS bits – displays bits 5 and 6 of the H1 byte to indicate SONET [10], SONET [00], Unknown [01] and [11] signal type
  - Pointer value – displays the H1 and H2 values (addresses) indicating the offset in bytes between the pointer and first byte of the STS-n
  - LOP (Loss of 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

Analysis > P Pointer



- **For TV pointers:**
  - Pointer value
  - LOP (Loss of Pointer)
  - PJE and NJE
  - NDF or New Data Flags
  - Difference and Sum

Analysis > VT tab



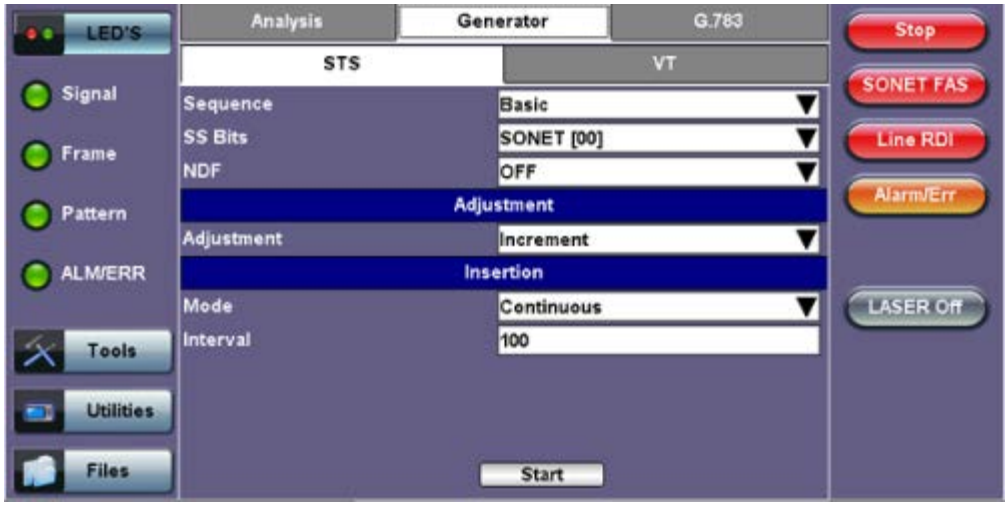
Go back to top Go back to TOC

10.2.4.2 Point Generator

The Pointer generator is able to generate individual pointer movements as follows:

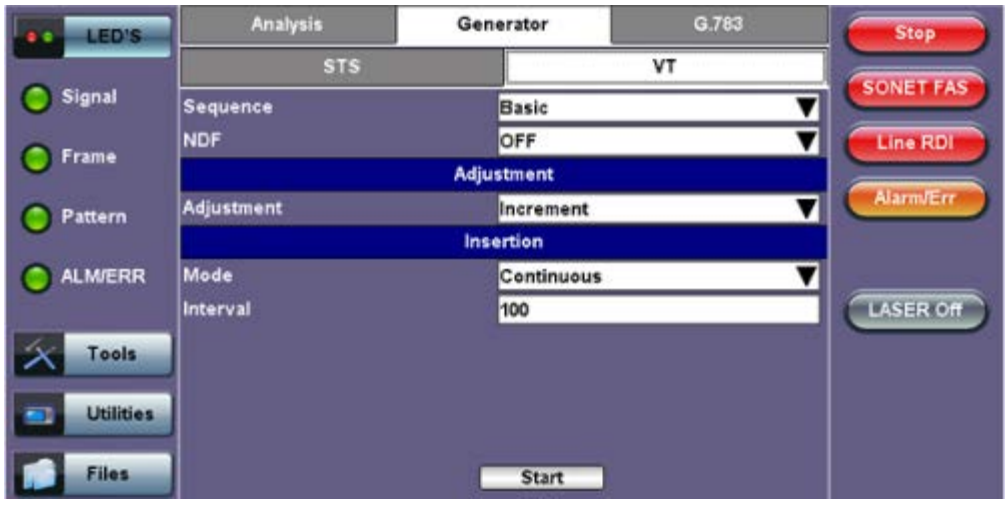
- **For STS pointers:**
  - SS bits: Program bits 5 and 6 of the H1 byte to be either SONET [10], SONET [00], Unknown [01] or [11].
  - Pointer value: Transmits a new pointer address or value with or without a new data flag (NDF). Configurable in a range of 0 to 782 pointers.
  - Increment (INC) or Decrement (DEC) pointers with identical polarity by 1 byte in single steps.

Generator > STS tab



- **For VT pointers**
  - VT Pointer value: Set value in a range of 0 to 109 (VT-1.5) and 0 to 139 (VT-2)
  - Increment (INC) or Decrement (DEC) pointer value by 1 byte is single steps

Generator > VT tab



Go back to top Go back to TOC

10.2.4.3 Pointer Sequences

The Pointer generator is also able to generate Standard ITU-T G.783 and ANSI T1.105.03 and Bellcore GR-253 pointer sequences as follows:

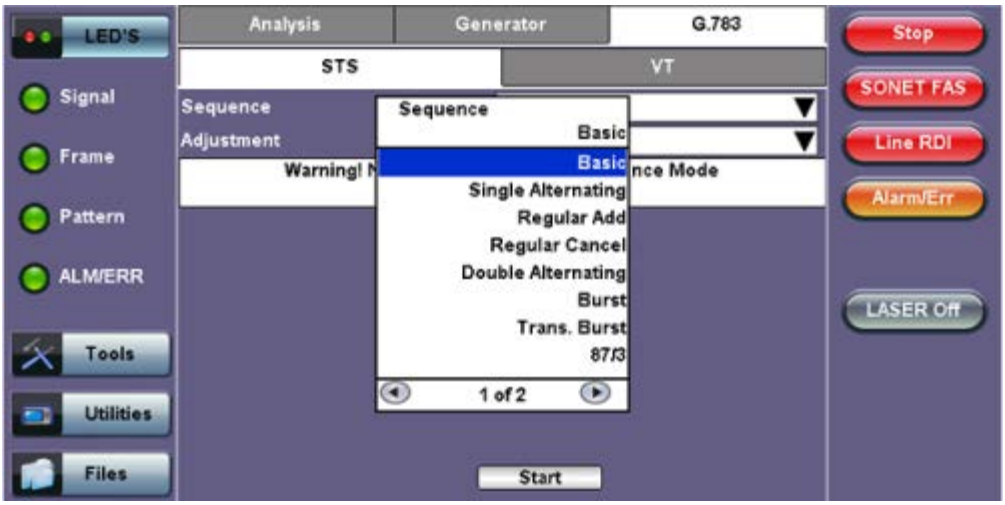
- **Sequence:** Decide how to affect the pointer sequence
  - **Basic:** Specify whether the pointer is increasing or decreasing
  - Select Inc to increase the pointer value
    - Select Dec to decrease the pointer value
    - Select New Value to set new pointer value

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, with added to have an additional pointer value)
- **87-3 Cancel**: Generate an 87-3 pattern (87 consecutive pointer adjustments, 3 consecutive pointer value, with reduce 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.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

G.873 > STS tab



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.

Go back to top Go back to TOC

10.2.5 Trace Identifier

Tap the Trace Identifier icon to display the path trace testing screens shown below. There are dedicated tabs for Transmitted and Received (expected) path traces and setups.

SDH/SONET Tools Menu

Go back to top Go back to TOC

10.2.5.1 Transmitted Traces (TX)

- J0 [Section]: Regenerator section trace
  - Program a 1 or 16-byte identifier to check the connection between regenerators
- J1 [STS Path]: High order path section trace
  - Program a 16 or 64-byte identifier to check the high order transmission path
  - The message is transmitted one byte per STS-3 frame
- J2 [VT Path]: 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.

Go back to top Go back to TOC

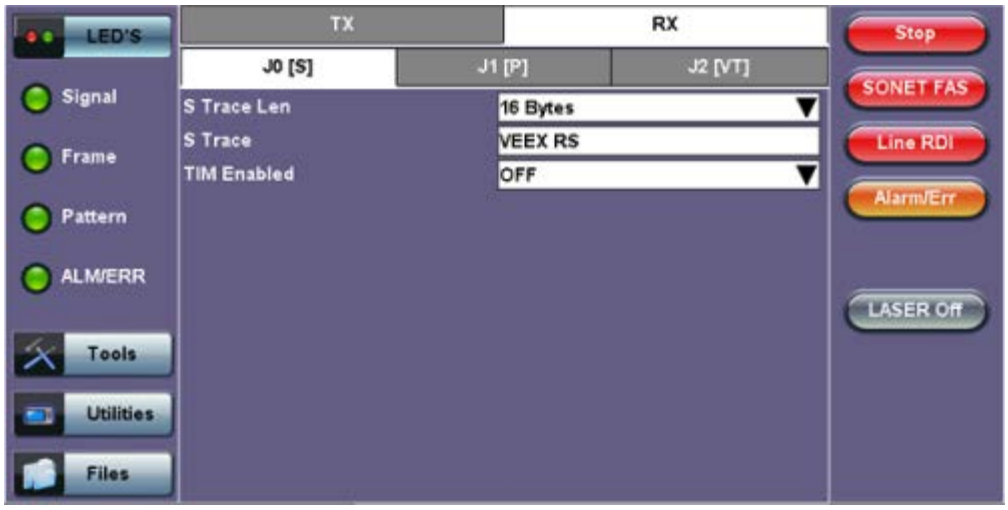
10.2.5.2 Received Traces (RX)

- J0 [Section]: Regenerator section trace/Section Layer 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 [STS Path]: High order path section trace/STS 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 [VT 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

Note: To program or edit the received trace, tap on the applicable trace box and this will launch the QWERTY keyboard.

RX - JO [S]



Go back to top Go back to TOC

10.2.6 Payload Labels

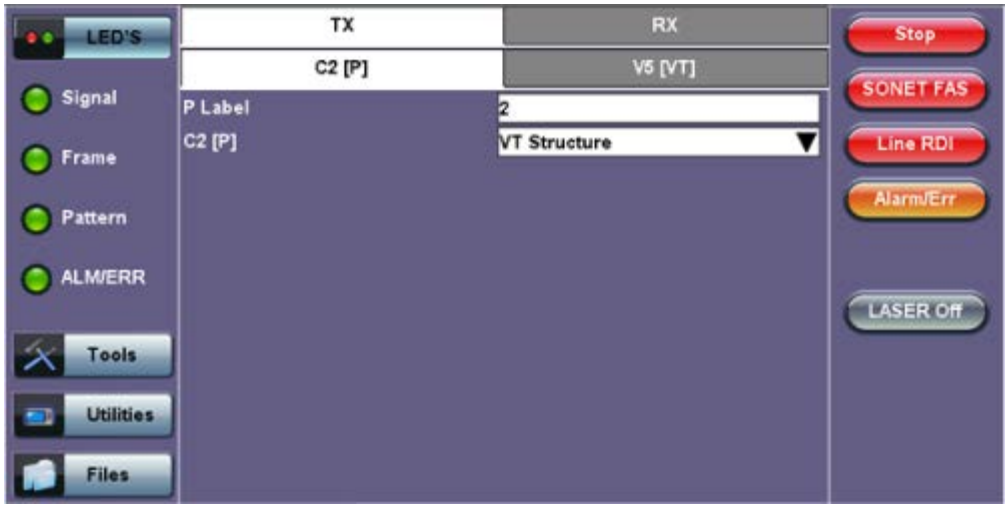
This function is used to set the C2 and V5 Path Signal Labels which indicate the content of the High order and Low order VCs.

SDH/SONET Tools Menu

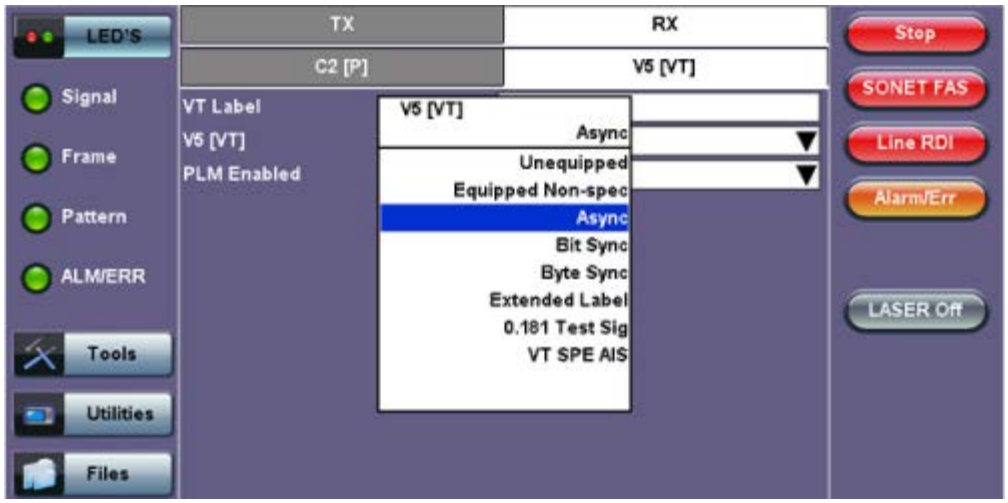
Tap the Payload Label icon to display the payload label screens. There are dedicated tabs for Transmitted and Received payload labels and setups:

- **C2 [STS Path]: Path signal label**
  - Specifies the mapping type in the STS-1n
  - Program the TX or RX label by editing the hexadecimal value or by using the convenient drop-down menu selection
  - For the RX label, you can enable or disable the Payload Mismatch (PLM) Alarm

TX C2 [P]



- **V5 [VT 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, you can enable or disable the Payload Mismatch (PLM) Alarm



Go back to top Go back to TOC

10.2.7 APS Tasks

10.2.7.1 APS Timing

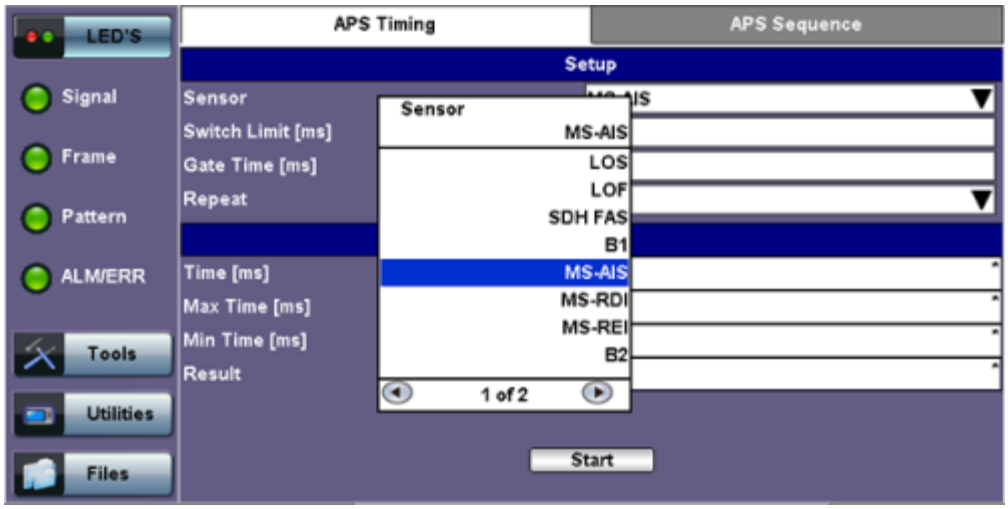
This function measures the Automatic Protection Switching (APS) limits of the network. APS applies only to the Multiplex sections of a SONET network and enables network elements to re-route traffic to a backup circuit in the event of network failure or problems. The protection mechanism is coordinated by the K1 and K2 bytes in the Multiplexer Section Overhead.

- **APS Standards**
  The principles and protocols of APS in SONET networks are defined in ITU-T G.783 and G.841 and Bellcore GR-253 recommendations for Linear and Ring network architectures respectively. According to these recommendations, the re-routing of the signal has to occur within 50ms. Protection switching is initiated as a result of one of the following conditions:
  - “Hard” Failure (SF) condition – Loss of Signal (LOS), MS-AIS, BER >1 x 10^{-3}.
  - “Soft” Failure (SD) condition – Signal degradation when BER exceeds a predetermined threshold. Normally over a provisioned range of 1 x 10^{-5} to 1 x 10^{-9}.

Tap the APS Testing icon to display the APS testing screens shown below.

Sensor: Select the trigger that will initiate the APS measurement.
  - The selections are: LOS, LOF, SONET FAS, B1, B2, B3, AIS-L, RDI-L, REI-L, AIS-P, LOP-P, RDI-P, REI-P, AIS-V, 2M-LOF, 2M-AIS, LSS and TSE (bit errors)
- **Switch Time Limit:** Configurable in the range from 15ms to 200ms.
  - Typically 50ms according to ITU-T recommendations.
- **Gate Time**: Configurable in the range from 50ms to 4 seconds.
  - Used to measure total service disruption when multiple switches or micro interrupts occur.
- **Repeat**: ON/OFF
  - Configurable to measure on a continuous basis.
- **Start**: Press to begin the test.

APS Timing Setup



APS Test Procedure:

- The test set should be connected to a tributary port of network element or transmission system to ensure that the switching time is measured for the service transported by the SONET network.
- Ensure that no errors or alarms are present on the transmission system because this will impact the measurement.
- The measurement will be triggered by an Alarm Indication Signal (AIS)
- The test set measures how long the AIS event remains present after the event is first recognized and will continue to measure the total disruption time in the event of multiple disruptions.

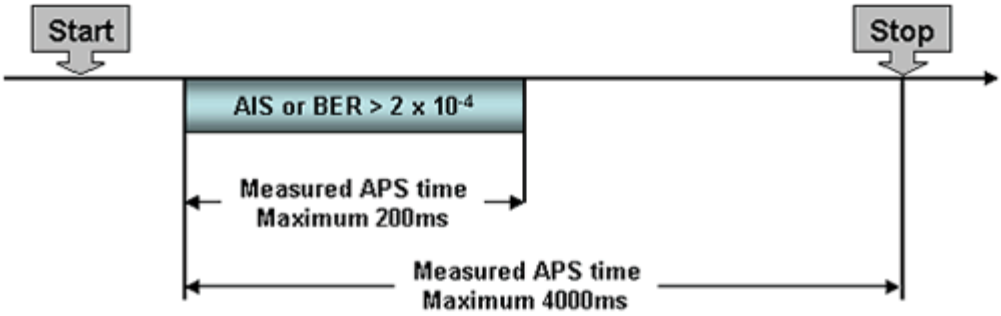


Figure 1: Perfect service disruption

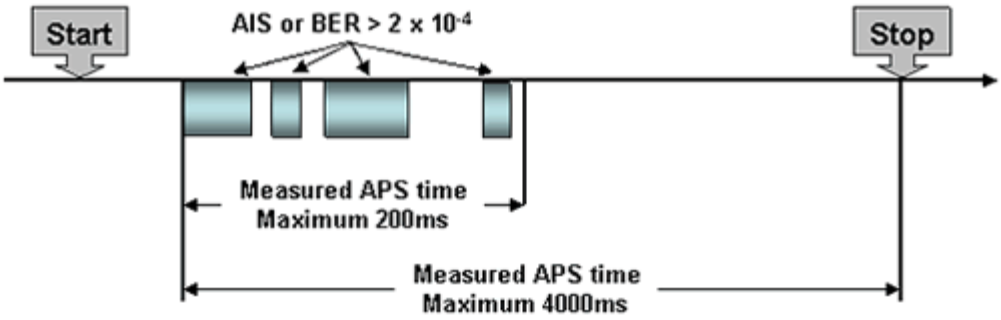


Figure 2: Multiple service disruption or micro interrupts

Go back to top Go back to TOC

10.2.7.2 APS Sequence

The associated K1/K2 sequence and received K1/K2 bytes may be captured.

Event Details

Go back to top Go back to TOC

10.2.8 Tandem Connection Monitoring (TCM)

HP Setup

TCM Standards

The Tandem paths are defined in ITU recommendation G.707 Annex D and Annex E. ITU-T recommendation 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 the Z5 byte for STS-N and in the Z6 byte for VT's. 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-B1P		"1"	IAIS	TC-REI	OEI	TC-APId, TC-RDI,ODI, reserved	

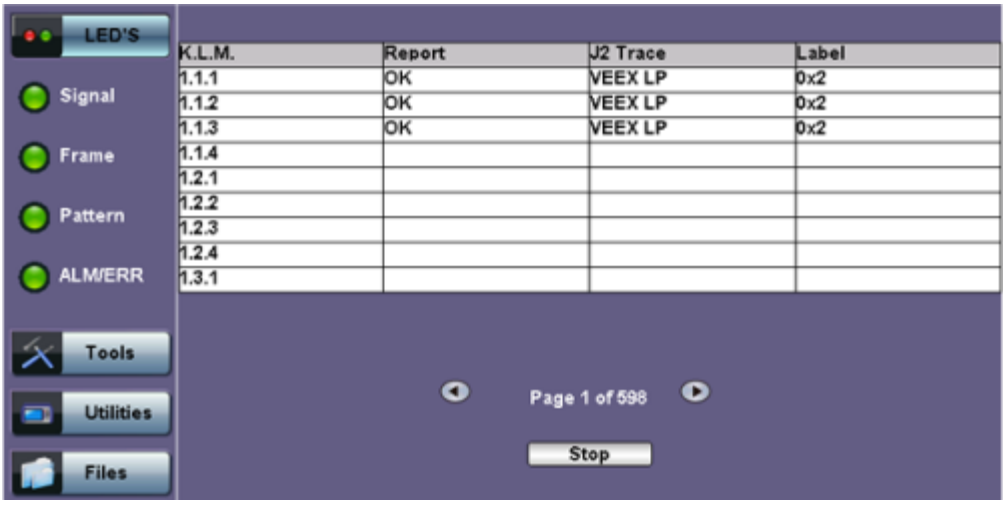
IEC:	Incoming Error Count. Indicates IAIS when set to '1110' (seebelow)
IAIS:	Incoming AIS alarm
TC-REI:	Tandem Connection Remote Error Indication
OEI:	Outgoing Error Indication
TC-APId:	Tandem Connection Access Point Identifier (16-byte message)
TC-RDI:	Tandem Connection Remote Defect Indication
ODI:	Outgoing Defect Indication
TC-BIP:	2-bit Bit Interleaved Parity for Tandem Connection

Go back to top Go back to TOC

10.2.9 Tributary Scan

This function requires VC12 or VT-1.5 mapping and allows you to quickly check the signal structure, trace identifier and the payload.

Tributary Scan



An important part of any Add Drop Multiplexer (ADM) installation process is the verification of the path routing. Considering that an STS-3 contains 84 x VT-1.5's and a STS-12 contains 336 x VT-1.5's checking each path manually can be very time consuming.

The test set automatically performs a sequential BER test on each SONET tributary (VT channel) - mapping can be via STS-N. The unit checks for any alarms in the received signal, the SONET 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

Go back to top Go back to TOC

10.2.10 Round Trip Delay

Round Trip Delay Results

The Round Trip Delay (Propagation Delay) measurement works by sending a test pattern. A errors is transmitted in the pattern. The time it takes for the error to reach the receiver is the propagation time through the network.

- Select SONET as TX/RX standard.
- View the Round Trip Delay of a looped back signal.
- Set check box on Setup RX pattern to Out-of-Service.

Go back to top Go back to TOC

10.2.11 Jitter and Wander

For more information on Jitter and Wander, please see 13.0 Jitter and Wander Application.

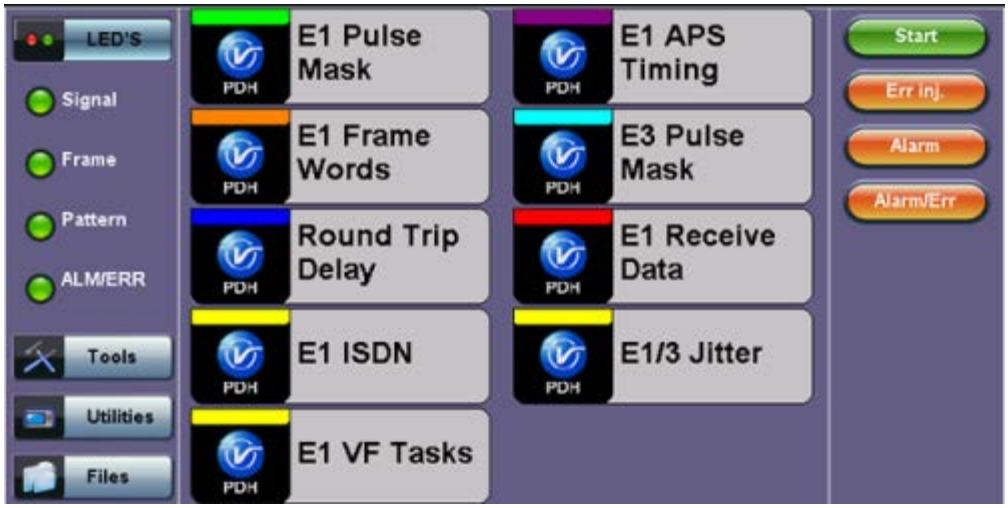
Go back to top Go back to TOC

11.0 PDH Tools

Accessing PDH Tools

Tap on Home (main menu) > **PDH Tools**

PDH Menu



Go back to top Go back to TOC

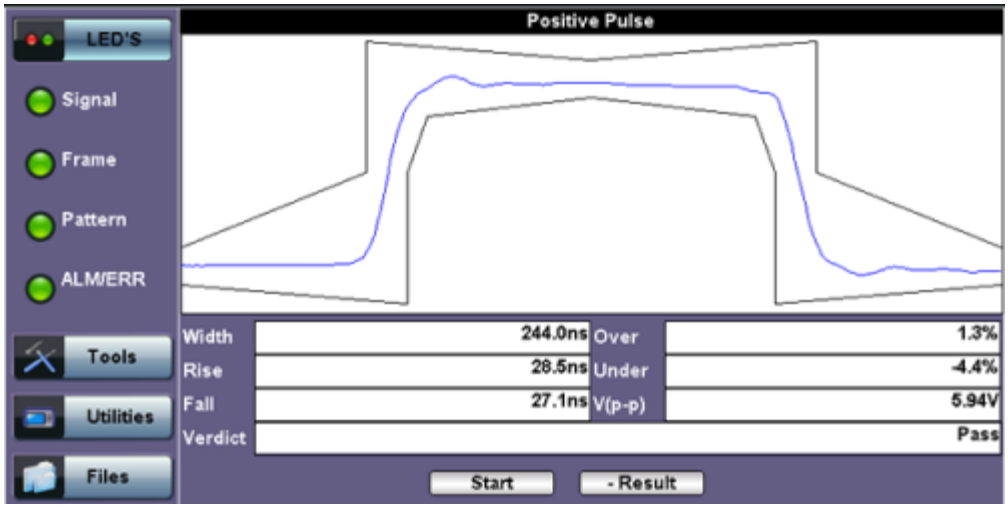
11.1 E1 Pulse Mask

This function captures and analyzes E1 (2.048Mbps) pulse shape. The purpose of maintaining the correct pulse shape is to reduce inter-symbol interference – if the logic 1s and 0s cannot be detected by the receiver correctly, bit and code errors will result.

The pulse amplitude and overall shape are superimposed and compared with the ITU-T G.703 pulse conformance template. Telecommunications signals require specific load impedance for pulse mask compliance testing to be accurate. When high frequency pulses are transmitted down a transmission line, a portion of the pulse will be reflected when and wherever it encounters an impedance mismatch. The reflection is proportional to the impedance mismatch (i.e., the greater the mismatch, the greater the reflection of the pulse). To avoid reflections impacting the E1 measurement, the test set will terminate twisted pair cables with 120 ohms and coax cable with 75 ohms impedance. Note that 75 Ohm and 120 Ohm twisted pair cables each have different nominal amplitudes associated with them; for the 75 Ohm coax cable, the pulse amplitude must be 2.37V ± 10% while for 120 Ohm twisted pair cables, the pulse amplitude must be 3.0V ± 10%.

According to the G.703 recommendation, E1 pulses need only be measured at the transmitter output, and are *not* required to meet the pulse template over a variety of cable lengths. This of course will not provide information on distortions caused by misalignment and other impairments of the line. The test set on the other hand can connect to a live system at the TX output port via a Protected Monitoring Point (PMP) or at the far-end of a transmission line. In either case, the signal will be attenuated or amplified as necessary to compensate for test point or cable attenuation characteristics.

E1 Pulse Mask



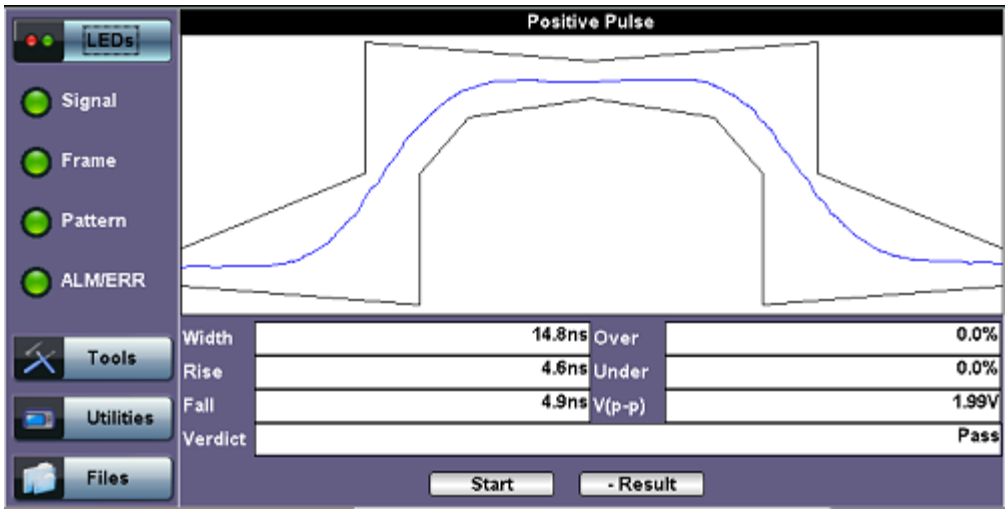
Go back to top Go back to TOC

11.2 E3 Pulse Mask

This function captures and analyzes E3 (34.368Mbps) pulse shape. The purpose of maintaining the correct pulse shape is to reduce inter-symbol interference – if the logic 1s and 0s cannot be detected by the receiver correctly, bit and code errors will result.

The pulse amplitude and overall shape are superimposed and compared with ITU-T G.703 pulse conformance template. Telecommunications signals require specific load impedance for pulse mask compliance testing to be accurate. When high frequency pulses are transmitted down a transmission line, a portion of the pulse will be reflected when and wherever it encounters an impedance mismatch. The reflection is proportional to the impedance mismatch (i.e., the greater the mismatch, the greater the reflection of the pulse).

E3 Pulse Mask



Go back to top Go back to TOC

11.3 E1 APS Testing

This function measures the Automatic Protection Switching (APS) limits of the network. APS applies the Multiple E1 Links and enables network elements to re-route traffic to a backup circuit in the event of network failure or problems.

APS Test Procedure:

- The test set should be connected to a transmission system to ensure that the switching time is measured for the service transported by the E1 links
- Ensure that no errors or alarms are present on the transmission system because this will impact the measurement

- The measurement will be triggered by an Alarm Indication Signal (AIS)
- The test set measures how long the AIS event remains present after the event is first recognized and will continue to measure the total disruption time in the event of multiple disruptions

E1 APS

Go back to top Go back to TOC

11.4 E1 Frame Words

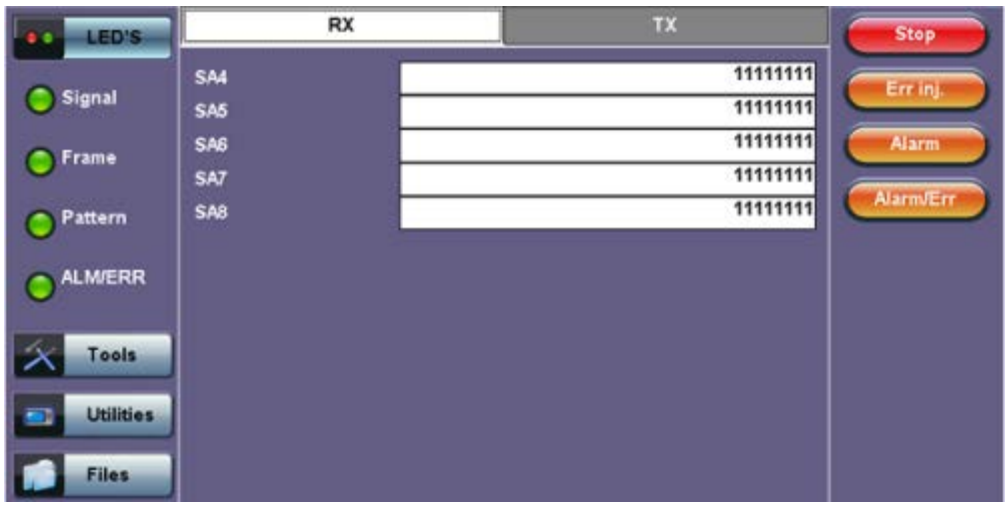
This function requires the E1 signal to be framed. The NFAS word is used to carry information about the status of the link and to provide control signals for primary rate multiplexers.

Not Frame Alignment Signal (NFAS)								
Bit	1	2	3	4	5	6	7	8
Value	Si (M)	1	A	Sa4	Sa5	Sa6	Sa7	Sa8

- Bit 1: Reserved for International use (M is used to transmit the CRC multiframe signal in PCM30C and PCM31C)
- Bit 2: Set to “1” to prevent simulation of FAS
- Bit 3: "A" shows the remote alarm indication
- Bits 4 to 8: Sa4 to Sa8 are spare bits

TX: Bits Sa4 to Sa8 are used to send optional network messages. The Sa bits should be set to “1” when they are not used or when links cross International borders.
RX: Bit Sa4 can be used as a message based data link for operations, maintenance and performance monitoring.

E1 Framed RX



Go back to top Go back to TOC

11.5 Round Trip Delay

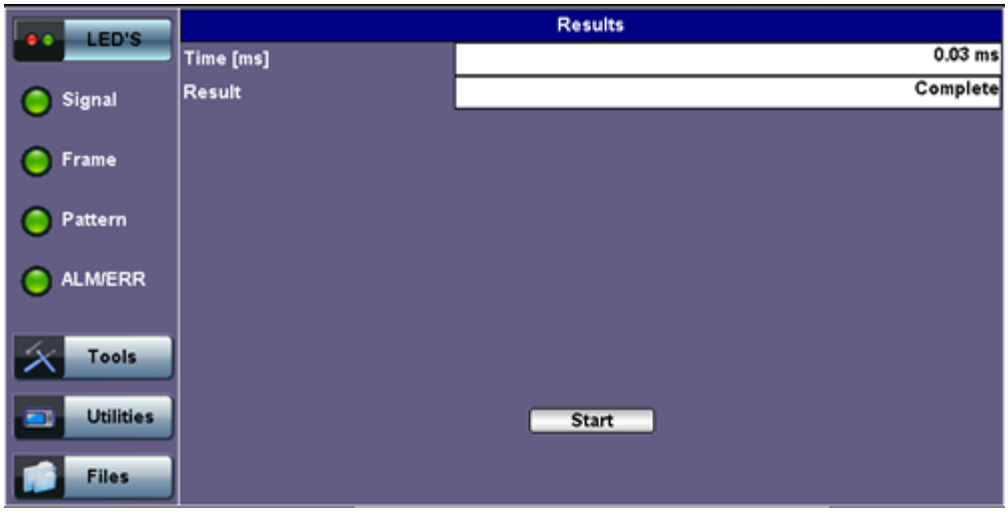
Tap the Round Trip Delay in the PDH Tools screen to perform a round trip delay measurement.

The Round Trip Delay (Propagation Delay) measurement works by sending a test pattern with an error. The time it takes for the error to reach the receiver is the propagation time through the network.

Setup:

- View the Round Trip Delay of a looped back signal
- Set check box on Setup RX pattern to Out-of-Service

RTD Results

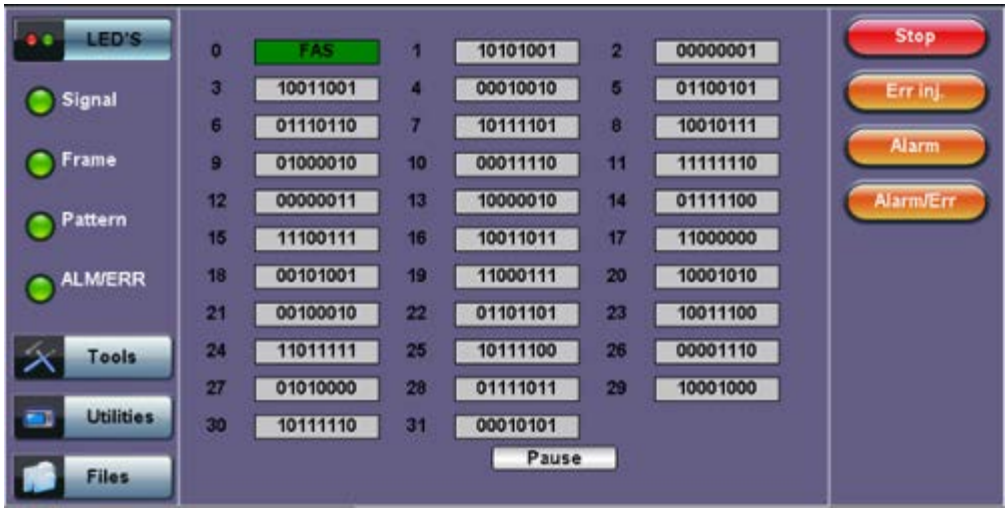


Go back to top Go back to TOC

11.6 E1 RX Data

The PDH E1 RX data shows received data and captures the current timeslots.

E1 RX Data



Go back to top Go back to TOC

11.7 E1 ISDN PRI

Note: E1 and DS1 ISDN PRI offer identical test options. Setup instructions for both E1 and DS1 are discussed below.

11.7.1 ISDN PRI Call

11.7.1.1 Setup (PRI Call Setup)

Configuration parameters for ISDN PRI Call are as follows:

Page 1

- **Mode:** TE, NT, or Monitor. In TE or NT mode, the test set can place up to 2 simultaneous data or audio calls on any primary line
  - **TE (PBX):** Terminating Equipment used when the test set is emulating customer equipment. TE generally uses the received signal to clock the transmitter.
  - **NT (CO):** Network Terminal is used when the test set is emulating an ISDN switch, such as DMS-100, 5ESS. NT generally uses the internal clock.
  - **Monitor**: Trace message details:
    - D Channel decodes help to verify that a call is successfully established, or determine why a call was not completed by examining the protocol cause values.

- **Call Control:** The Q.931 specification indicates which type of ISDN switch is to be tested. AT&T and NTI are only available for DS1.
  - AT&T relates to the 5ESS switch
  - NTI relates to the Northern Telecom DMS-100 switch
  - ETSI is the ETSI standard

- **Channel Config:** 23B+D and 30B+D

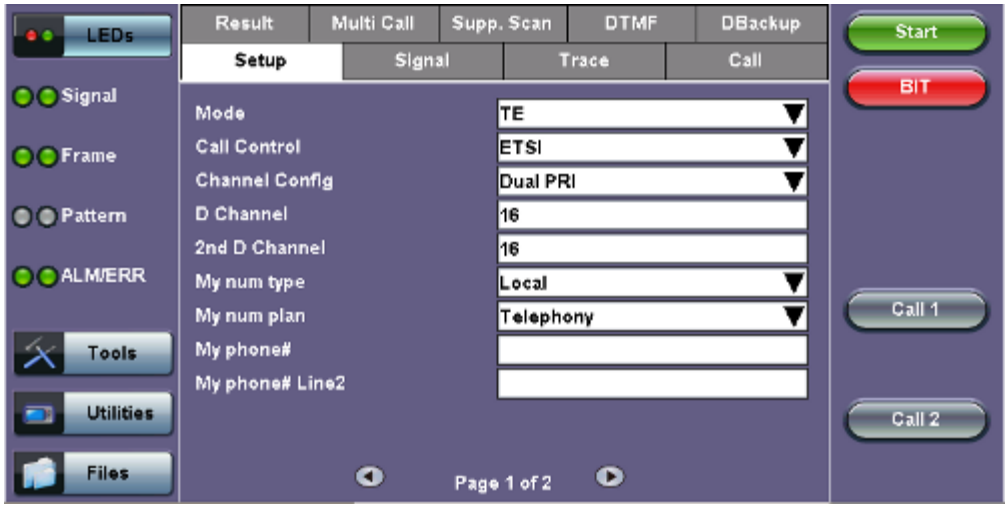
- **D Channel:** Designates the time slot to transmit D Channel messages. The D Channel decoder helps to verify that a call is successfully established, or determine why a call was not completed by examining the protocol cause values.

- **My num type:** Unknown, International, National, or Local

- **My num plan:** Unknown, Telephony, or Private

- **My phone#:** Tap on the box and enter the phone number using the alphanumeric keyboard

ISDN Setup (Page 1)

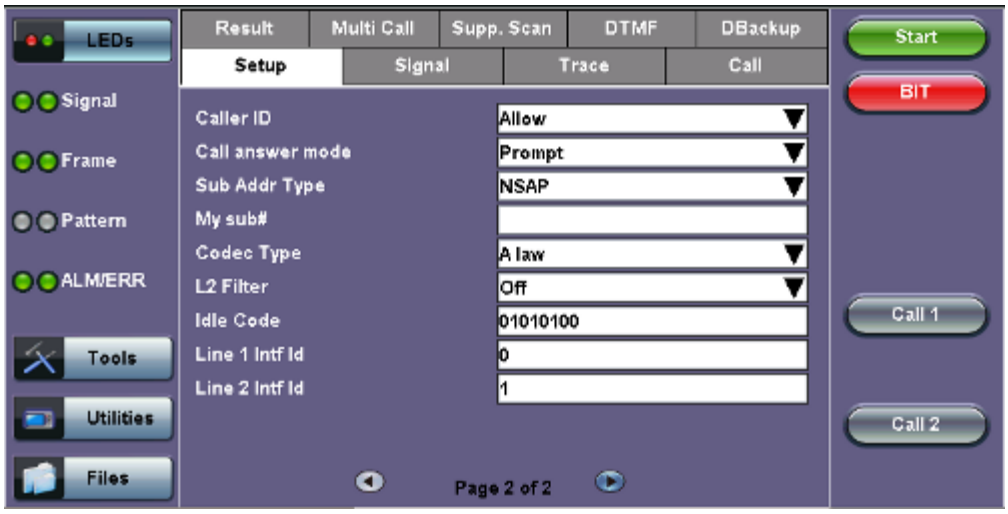


Page 2

- **Caller ID:** Blocked/Allow.
- **Call Answer:** Prompt, Accept or Cancel.

Prompt: Prompts the user to answer or reject incoming calls. Selecting Prompt displays an answer and reject button on the Call tab.
  - **Accept:** Automatically answers incoming calls.
  - **Cancel:** Automatically rejects incoming calls.
- **Sub Addr Type:** NSAP or User.
- **My sub#:** Tap on the box and enter the sub address number using the alphanumeric keyboard.
- **Codec Type:** A law or U law.
- **L2 Filter:** Turn ON or OFF layer 2 filter. Turning on the filter prevents layer 2 messages from displaying in the captured trace.
- **Idle Code:** Code to be transferred on unused channels. Tap on the box and use the alphanumeric keyboard to enter the code.
- **Line Intf Id:** Line interference ID. Tap on the box and enter the line interference ID using the alphanumeric keyboard.

Setup (Page 2)



The symbols RDY and OOS are port status indicators. Below each status is the port number.

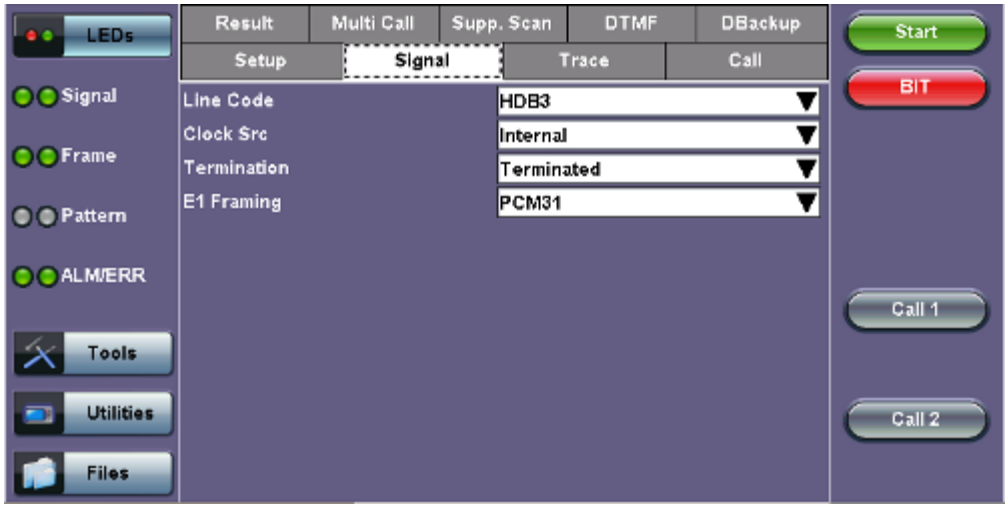
Status	Description
	OOS indicates that the port is **Out of Service** and will be unable to run any tests. If OOS displays on the unit, check for proper connection between the physical ports and cables and that both units' setup screens are configured correctly. The port number in this example is 2.
	RDY indicates that the test port is **Ready** for use. The port number in this example is 1.

Go back to top Go back to TOC

11.7.1.2 Signal

- **Line Code:** HDB3 or AMI
- **Clock Source:** Internal, External, Rx, or Offset. If the test set is in TE mode, select Rx to receive timing signals from the master clock
- **Termination:** Terminated, Monitor, or Bridge
- **DS1/E1 Framing:** Unframed, PCM31, PCM31C for E1; SF or ESF for DS1.

Signal



Main Setup

- Connect to the CPE or Network.
- Connect headsets to the 2.5mm audio jack port (or use the 3.5mm to 2.5mm headset adaptor)
- Select Call Control protocol type
- Select the emulation type (Should be TE on the other NT)

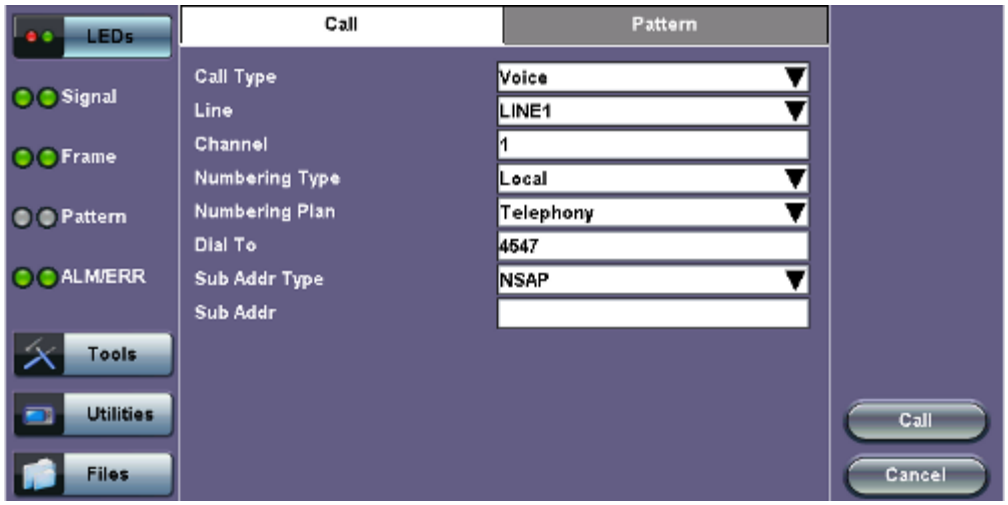
Go back to top Go back to TOC

11.7.1.3 Call - Voice and 3.1K Audio Setup

Press Call to bring up the Call Setup menu. Voice and 3.1K Audio calls follow the same setup procedure. Both are outlined below:

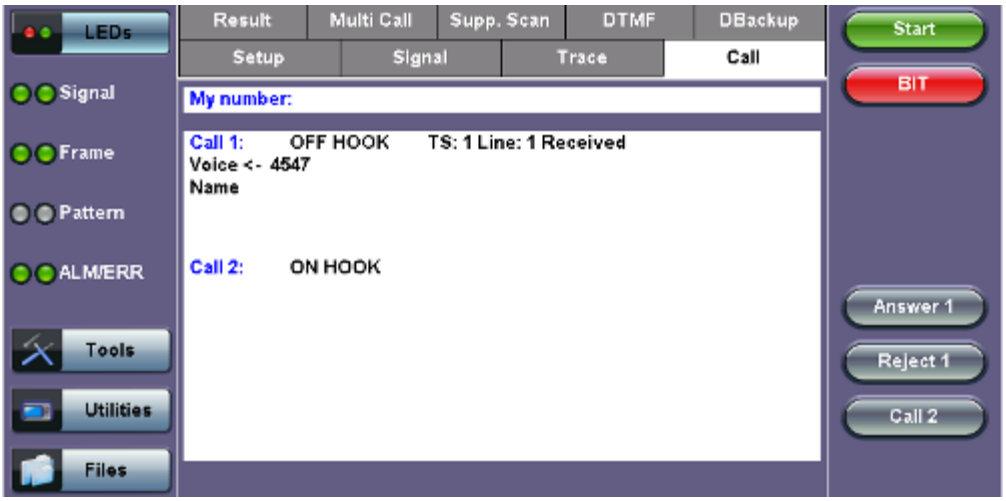
- **Call Type**: Select Voice or 3.1K Audio
- **Channel**
- **Numbering Type:** Unknown, International, National, or Local
- **Numbering Plan:** Unknown, Telephony, or Private
- **Dial To:** Tap on the corresponding box and use the alphanumeric keypad to enter the number of the receiving line.
- **Sub Addr Type:** NSAP or User
- **Sub Addr**: Tap on the corresponding box and use the alphanumeric keypad to enter a subaddress

Call - Voice Setup



Press the **Call** button to initiate a call to the receiving number. If Prompt was selected for Call Answer in the Setup tab, the unit receiving the call will ring and the user can press **Answer** or **Reject** to accept or reject the call.

Call In Progress

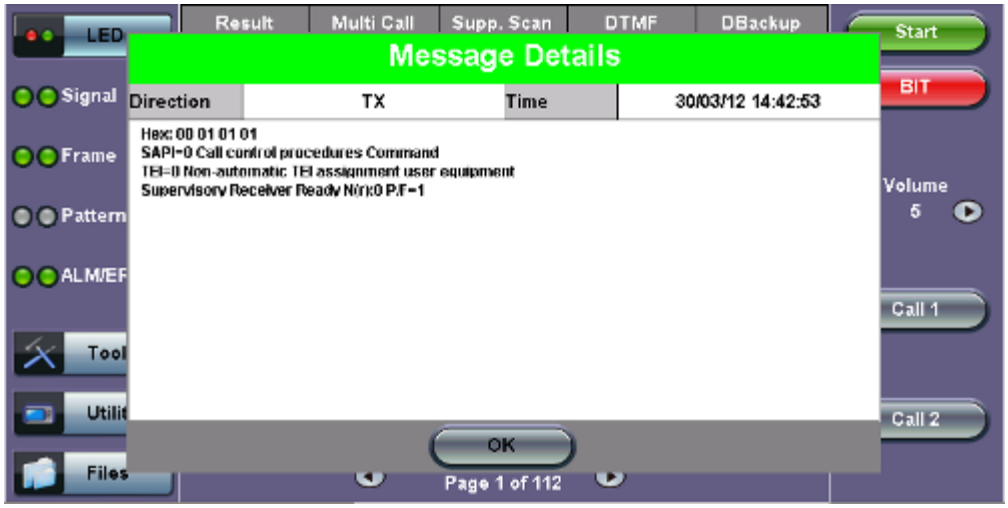


Trace: ISDN Protocol Decode

D-Channel Decodes help to verify that a call is successfully established or determine why a call was not completed by examining the protocol cause values. We can monitor Layer 2 (Q.921) and Layer 3 (Q.931) cause code messages on the D-channel in both terminate and monitor modes. Layer 2 results give technicians the ability to check link and D-channel status, verify LAPD frames and check utilization rates. Following link establishment, Layer 3 decodes allow technicians to verify such factors as call state, who made or dropped the call, why the call was dropped, where the call is being carried (Interface ID/B-Channel), and call types.

ISDN Trace

Message Details



Go back to top Go back to TOC

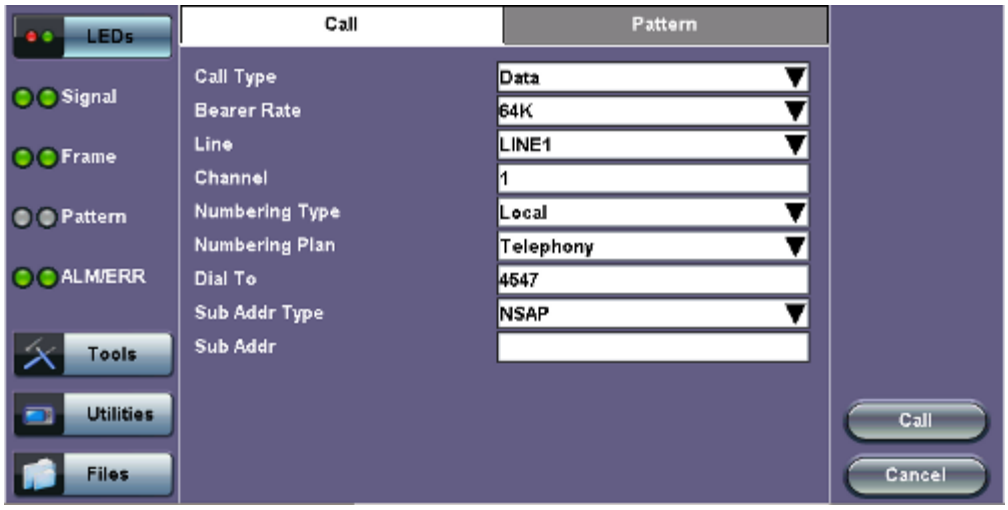
11.7.1.4 Call - Data Setup

Press the **Call** button to bring up the Call Setup menu. Data calls follow the same setup procedure as voice calls but with a few minor differences.

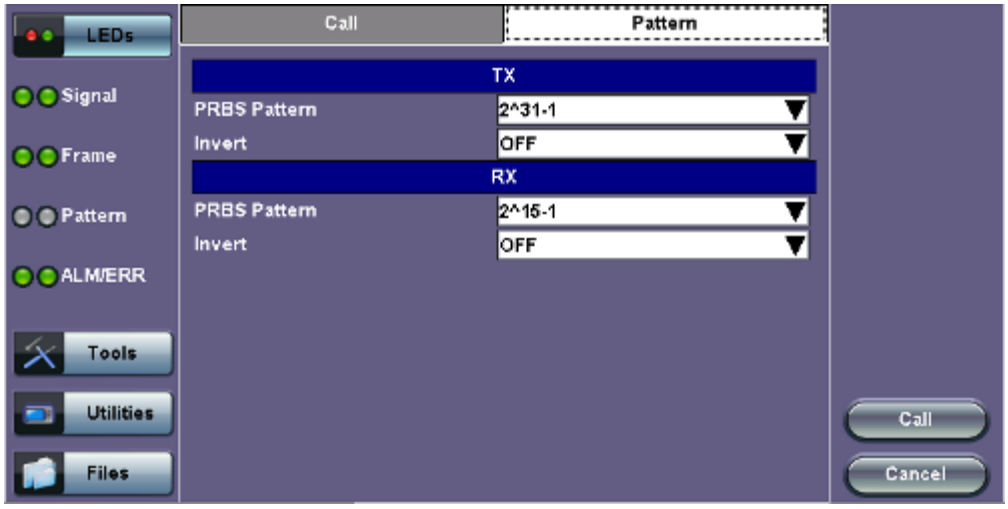
- Fill out the call setup as described in 11.7.1.3 Call - Voice and 3.1K Audio Setup, but select Data as the Call Type.
- Select a **Bearer Rate** in the call setup options.
- Press the **Pattern** tab and select a test pattern to be transmitted on the B channel during data calls.

Note: Test pattern is only applied when call button is pressed.

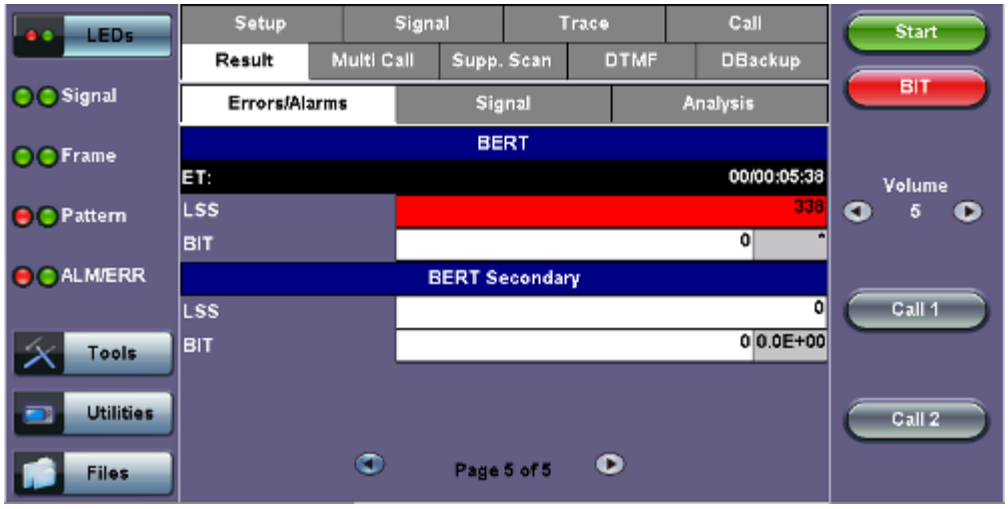
Call - Data Setup



Pattern Setup



Results > Errors/Alarms



Press **Call** and the other unit should ring.

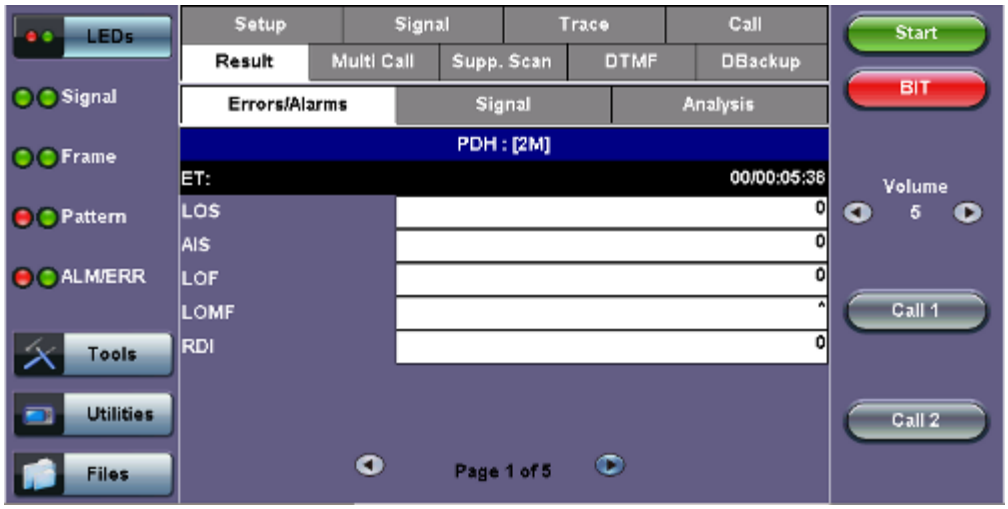
Go back to top Go back to TOC

11.7.1.5 Data Call BERT Results (Result tab)

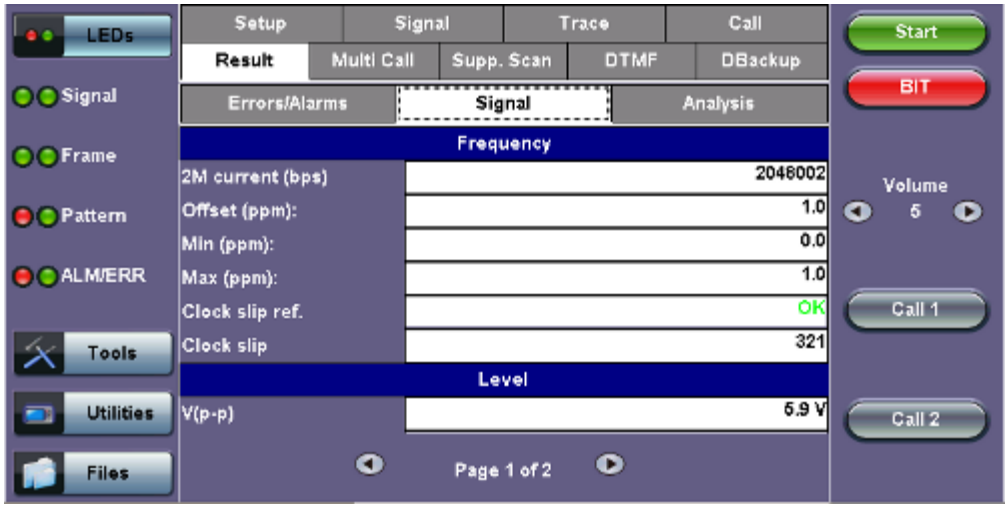
After successfully placing a data call, the BER is available. The Result tab presents the measurement parameters specified in G.821. Only DATA-64/56 and Nx64 Data Call Type in the CALL mode can give BER measurements. When viewing BER measurements, verify that both the PAT SYNC LED and the appropriate framing LED are green. These two LEDs signify that the patterns and framing match for the transmitting and receiving patterns.

PDH and SDH Results are discussed in 7.1 Results: PDH and 7.2 Results: SDH, respectively.

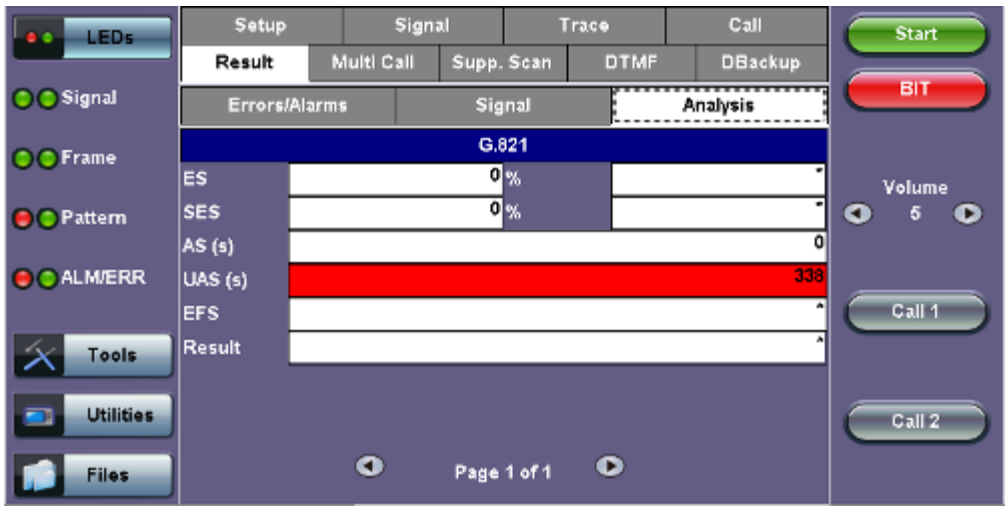
Data Call - BERT - Errors/Alarms



Data Call - BERT - Signal



Data Call - BERT - Analysis

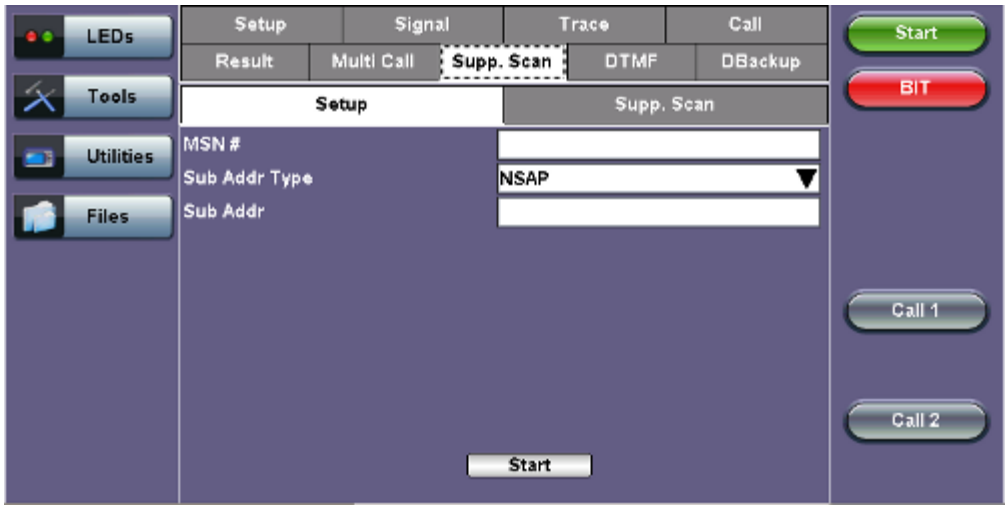


Go back to top Go back to TOC

11.7.1.6 Supplementary Service Scan

In ETSI protocol, a Supplementary Service Scan scans a line to determine which of a variety of supplementary services are available on it.

Supplementary Scan Setup

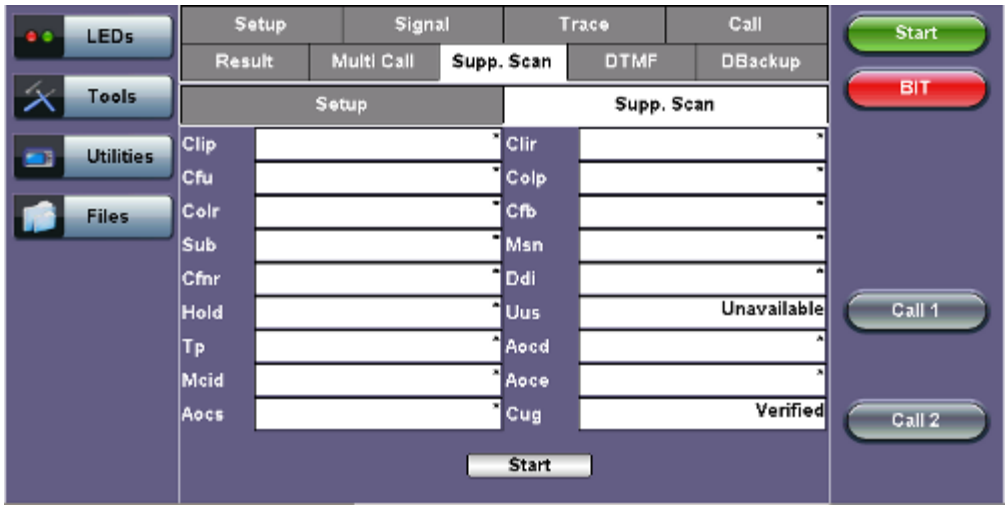


SubAddress Type:

- NSAP to select the Network Service Access Point subaddress
- User to use a subaddress defined by a user (no standard applied)

When the test is finished, the screen displays a list of these services:

Supplementary Scan Results



- **CLIP**: Calling Line Identification Presentation - presents the Calling Party Number to the called user.
- **CLIR**: Calling Line Identification Restriction - prevents the Calling Party Number from showing to the called user.
- **CFU**: Call Forwarding Unconditional - diverts a received call to a specified different number.
- **COLP**: Connected Line Identification Presentation - the answering party's number is conveyed to the calling party.
- **COLR**: Connected Line Identification Restriction - allows the connected subscriber to stop COLP from operating.
- **CFB**: Call Forwarding Busy - Calls are forwarded to a specified number only when the subscriber's (called party) number is busy.
- **SUB**: Sub Address - a digit is added to an incoming call to specify an extension.
- **MSN**: Multiple Subscriber Number - multiple full numbers are assigned to one BRI line.
- **CFNR**: Call Forwarding No Reply - Calls are forwarded to a specified number only when the subscriber (called party) does not pick up the line in a specified amount of time.
- **DDI**: Direct Dialing In - adds a number of telephone number to a circuit which can be used to dial that BRI (common use is a company number with individual 4 or 4 digit extension numbers that can be dialed)
- **HOLD**: Call Hold - the user may interrupt a call, then reestablish it later. Interruption frees the associated B-channel.
- **UUS**: User to User Signaling - allows a user to send an Information message in the Setup, Alerting, or Connect message on the D-channel, without connecting the call; the message shows on the ISDN phone display.
- **TP**: Terminal Portability; the ability to suspend and reconnect a call; for example, to move a phone from one plug to another.
- **AOC-D/E/S**: Advice of Charge - Determines when charging information is available to the served user; during the call, when the call is terminated, when the call is established.
- **MCID**: Malicious Call Identification - the called party, on a per call basis, requests the network to register the called party phone number, the calling party number, and the date and time of the calls.
- **CW**: Call Waiting - informs a user of an incoming call which has no B-ch available; user may accept, reject, or ignore.
- **CUG**: Closed User Group; a private network which restricts communication between members and nonmembers.

Go back to top Go back to TOC

11.7.1.7 Multi Call

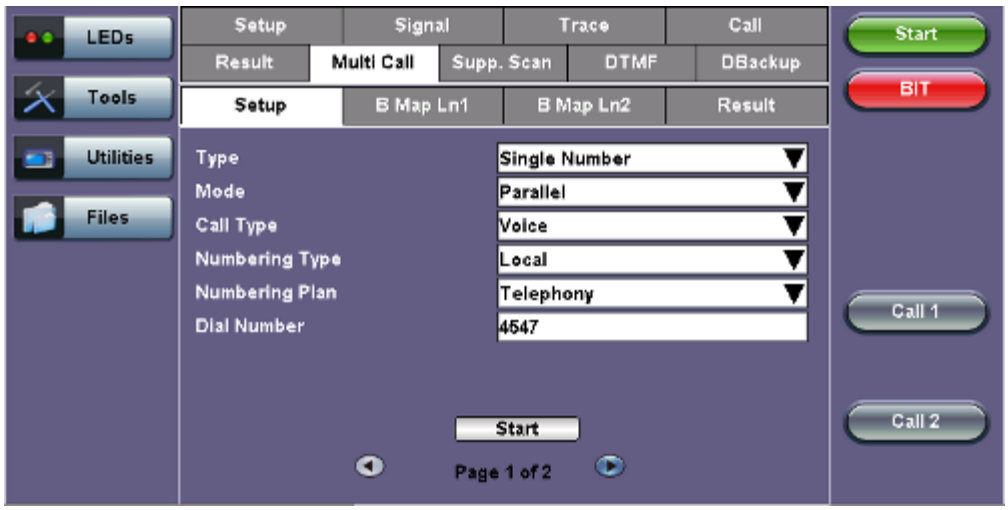
Multi Call mode is used to place multiple calls in sequence or in parallel. Setup parameters are described below:

Page 1

- **Type:** Single Number or Number Script
- **Mode:** Parallel or Sequential calling

See 11.7.1.3 Call - Voice and 3.1K Audio Setup for descriptions of other parameters on Page 1.

Multi Call Setup (Page 1)



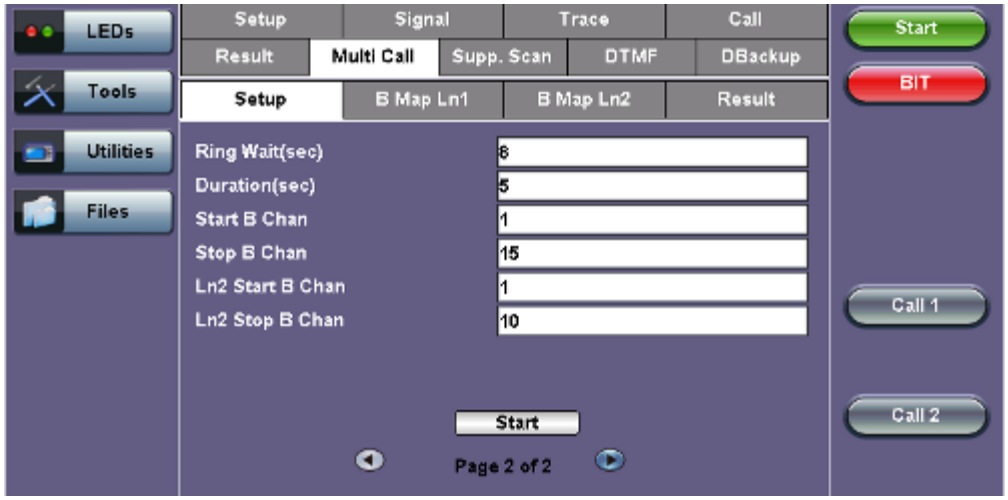
Page 2

Page 2 lists call settings, including:

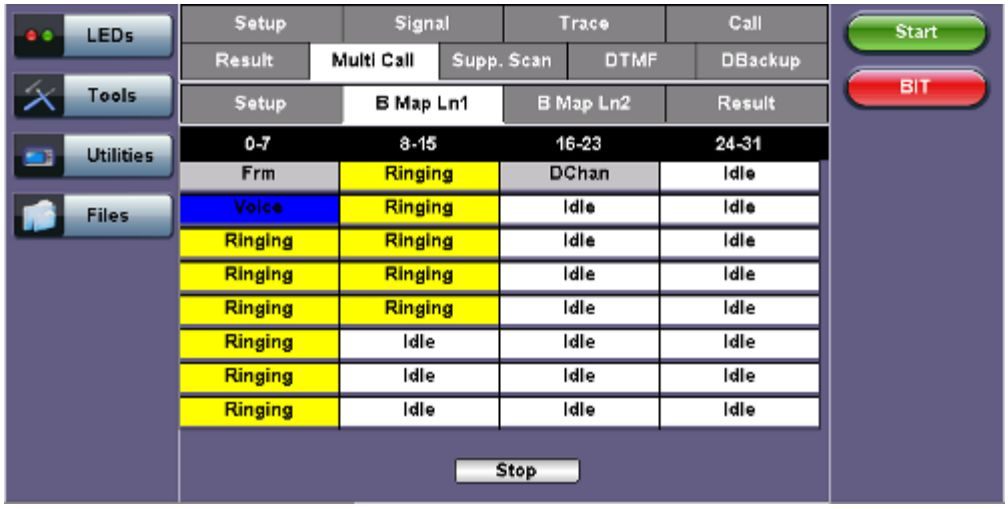
- Ring Wait (sec)
- Call duration (sec)
- Number of the starting and stopping B Channel
- Number of the starting and stopping B Channel line

Configure these options by tapping on the corresponding box.

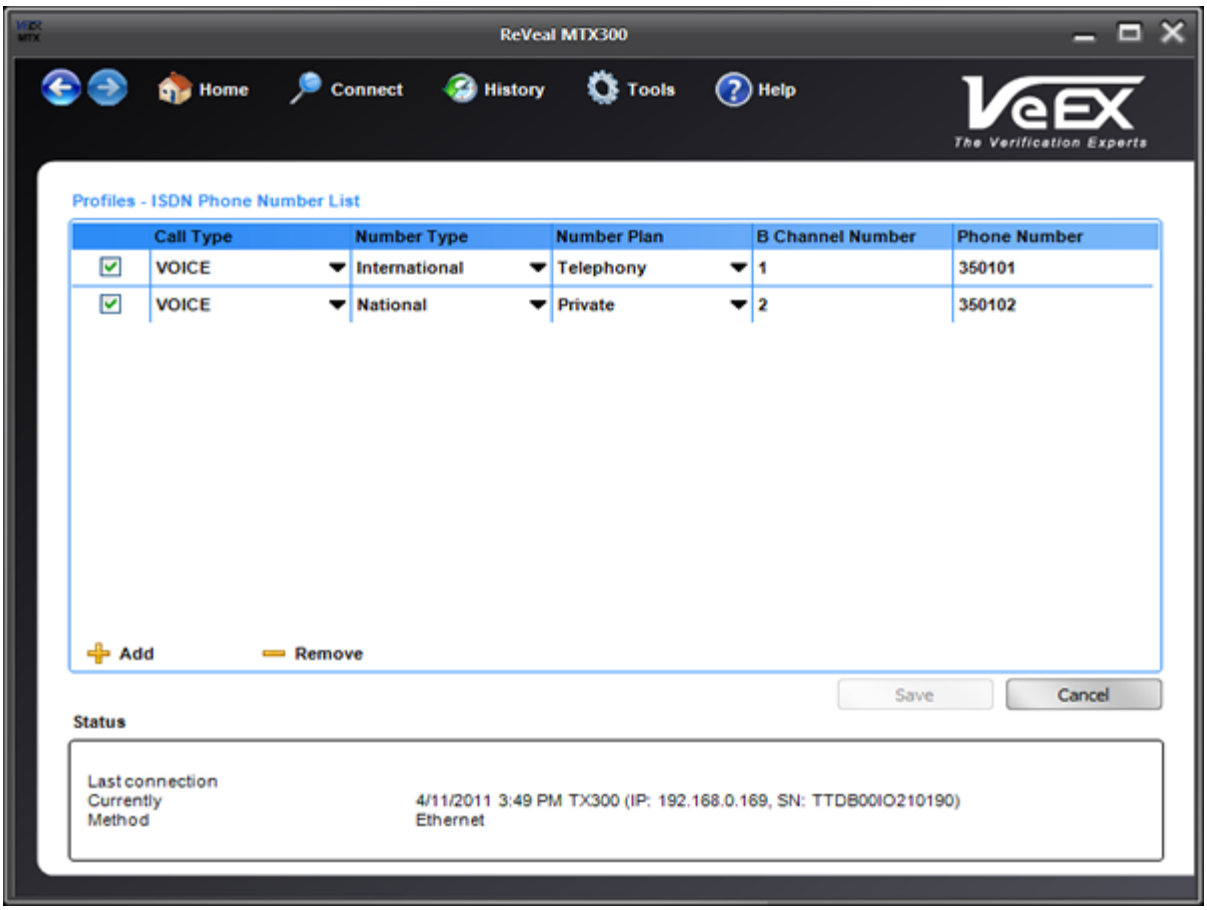
Multi Call Setup (Page 2)



Multi Call B Channel Map



Multi Call List Using ReVeal MTX300



Alternatively, the user can prepare a Multi Call list using ReVeal MTX software and upload the list to the test set.

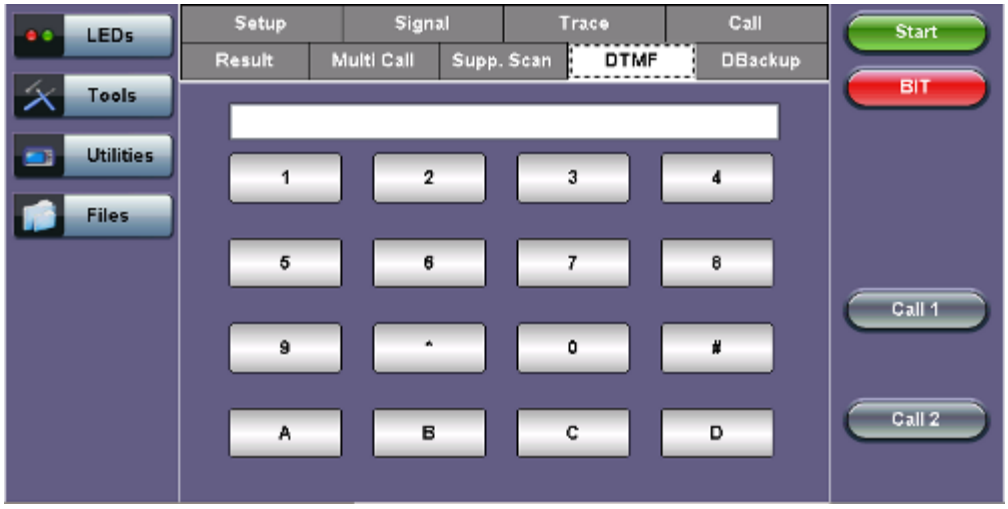
Go back to top Go back to TOC

11.7.1.8 DTMF

During the call DTMF tones can be transmitted.

To transmit DTMF tones, access the DTMF tab. An alphanumeric keypad will be displayed. DTMF tones are transmitted as soon as they are typed.

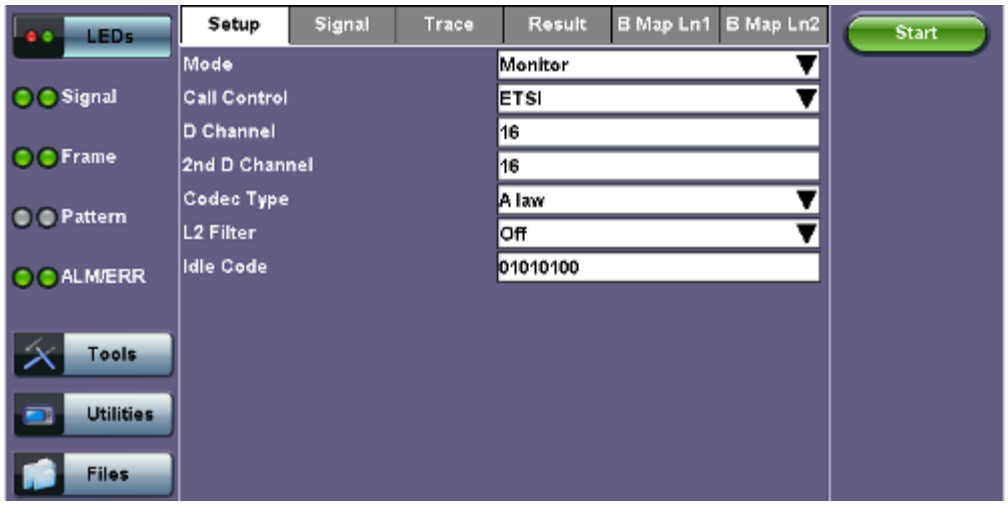
DTMF



Go back to top Go back to TOC

11.7.2 ISDN PRI Monitor

ISDN PRI Monitor Setup



The ISDN PRI Monitor's setup and results resemble those found in ISDN PRI Call. Please refer to 11.7.1 ISDN PRI Call for more information on these respective sections:

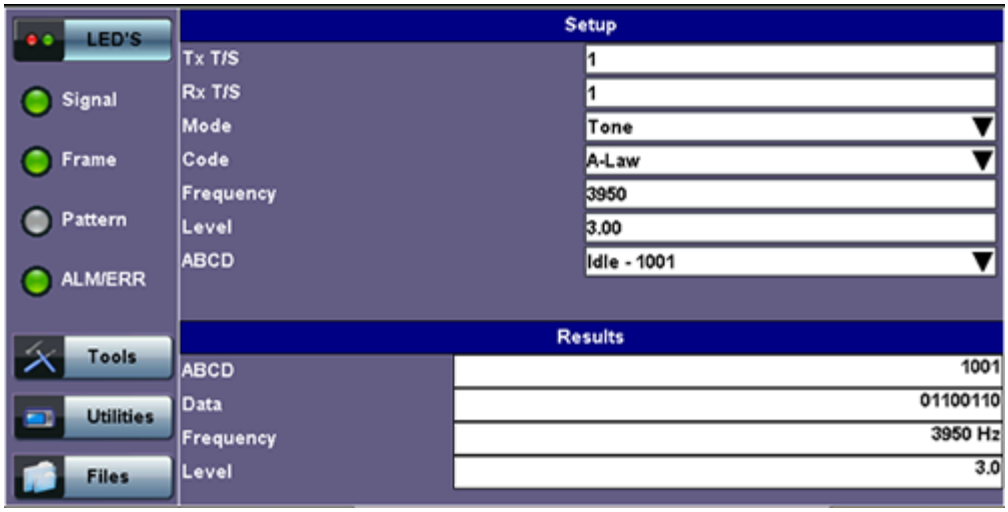
- **Setup**: 11.7.1.1 Setup (PRI Call Setup)
- **Signal**: 11.7.1.2 Signal
- **BMap Line**: Detects active traffic on the timeslots. The user can listen to the conversation by pressing on active call cells. Please see 11.7.1.7 Multi Call for more information.
- **Trace**: Please see **Trace: ISDN Protocol Decode** under 11.7.1.3 Call - Voice and 3.1K Audio Setup.
- **Result**: Press the green arrow to access the action menu and press Start to initiate BERT Testing. Please refer to 11.7.1.5 Data Call BERT Results for more details.

Go back to top Go back to TOC

11.8 E1 VF

Tapping the VF in the PDH Tools screen displays the VF Tasks. The VF menu performs a variety of talk/listen functions.

VF Tasks



VF Testing

Do not attempt to enter VF Tasks if the Frame LED is not green.
Green LEDs indicate that the framing found on the received signal matches the framing selected in the Setup screen.
It is impossible to talk, listen, or perform other channelized functions in the absence of frame synchronization, since channels can be identified only within a framed signal.

Setup:

- **Time Slot:** Channel to test for both transmitting and receiving. Input a number from 1 - 31.
- **Mode:** Talk or send a tone on the transmit signal. It is possible to transmit audio data from the external headset into selected timeslot.
- **Code:** u-Law or A-Law.
- **Transmitted Frequency:** 50 to 3950Hz.
- **Transmitted Level:** -60 to 3dBm.
- **Programmable ABCD:** Change the signalling bits transmitted with the associated transmit channel. These bits will be transmitted only if the test set is using MFAS (PCM-30) framing. Pressing IDLE(1001), SEIZE(0001), User (manually set) will place that signal onto the A/B/C/D position. D: Manual edit ABCD (User) or IDLE, SEIZE.

Results:

- Measure signal frequency and level in selected timeslot
- Listen to the voice channel in selected timeslot via external headset
- ABCD: View the received Channel Associated Signalling System (CAS) bits
- Data: View the live 8-bit channel data as it is received from the selected channel
- ABCD bits monitor and view data in selected T/S channel

Go back to top Go back to TOC

11.9 Jitter and Wander

For more information on Jitter and Wander, please see 13.0 Jitter and Wander Application.

Go back to top Go back to TOC

12.0 DS1/3 Tools

Accessing DS1/3 Tools

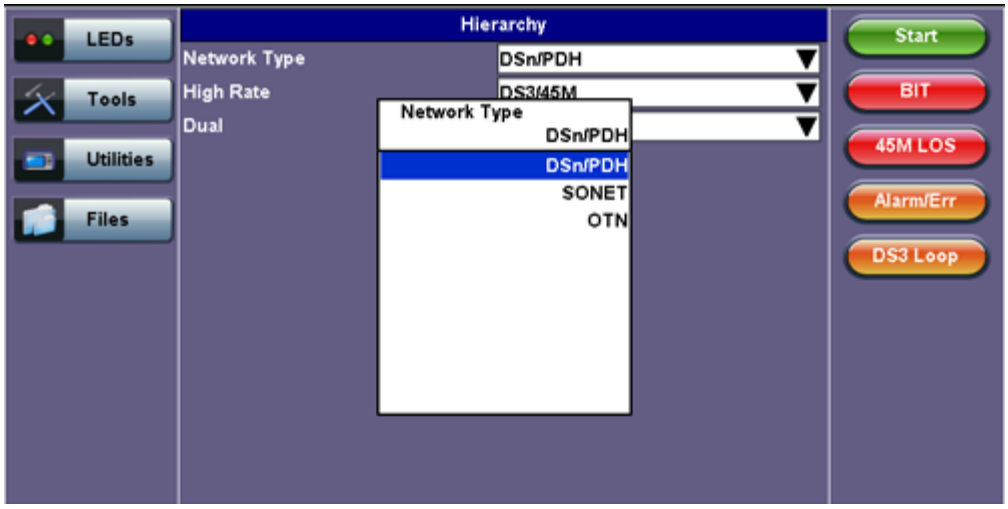
Tap on Home (main menu) > **DS3/1 Tools**

DS1/3 Tools Main Menu

If this error message appears,

Tap on **Setup** > **Hierarchy**, and select **DSn/PDH** from **Network Type**.

Select DSn/PDH



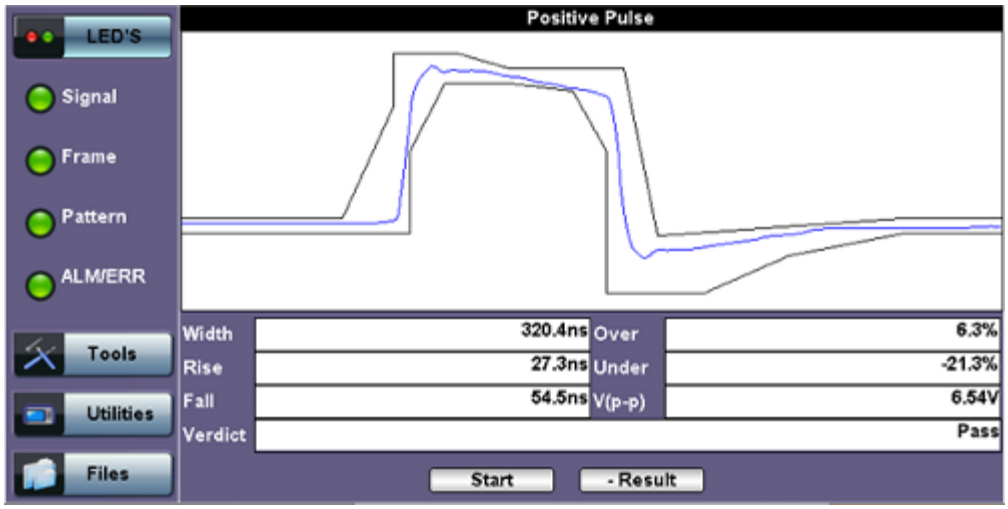
Go back to top Go back to TOC

12.1 DS1 Pulse Mask

This function captures and analyzes DS1 (1.544Mbps) pulse shape. The purpose of maintaining the correct pulse shape is to reduce inter-symbol interference – if the logic 1s and 0s cannot be detected by the receiver correctly, bit and code errors will result.

The pulse amplitude and overall shape are superimposed and compared with the Telcordia TR-TSY-000499 and ITU-T G.703 pulse conformance template. Telecommunications signals require specific load impedance for pulse mask compliance testing to be accurate. When high frequency pulses are transmitted down a transmission line, a portion of the pulse will be reflected when and wherever it encounters an impedance mismatch. The reflection is proportional to the impedance mismatch (i.e., the greater the mismatch, the greater the reflection of the pulse).

DS1 Pulse Mask



Go back to top Go back to TOC

12.2 DS1 Loop

When in DS1 mode, users can tap the **DS1 Loop** icon on the right side of the screen to access the DS1 Loopback feature. Select the appropriate loopback command set by pressing on the corresponding check box. Testing interfaces allow the user to troubleshoot problems and to check the quality of links at the T1 Layer.

DS1 Loop

Select the loopback command set.

Note: In-band, ESF DFL, and HDSL Abbreviated Loopbacks functions allow only one element in loopback mode. Loop down any previous element before addressing a new one, or else a warning message "Error - Pre-existing loop found" will display.

In-band

Use this mode to loop up and loop down CSU and NIU using in-band loop codes. **Loop up** sends the loop command and **Loop down** sends the release command. This function will only allow one element in loopback mode.

ESF (Out-of-band)

Uses the Extended Super Frame Facility Data Link control to send a repeating 16-bit ESF data link code word to the remote end requesting a Payload or Line loopback. ESF FDL loop codes require T1 framing to be set as ESF, otherwise the items will be grayed out.

HDSL Abbreviated Loopbacks (Short)

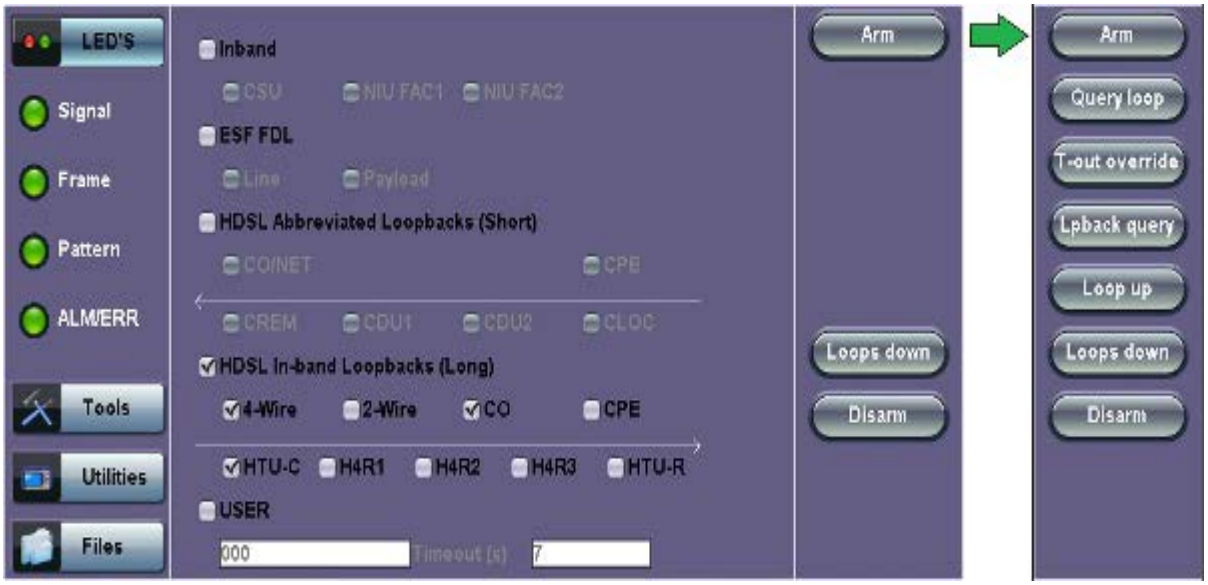
Also known as short loop codes, HDSL abbreviated loopbacks are used to loop specific network elements of a compatible line, including CO, repeaters, CPE equipment and line cards. Users must select the location from which the test is to be conducted (CO/Network or CPE), select the network element to be addressed and send the Loop up or Loops down command. The white arrow is used as a visual indicator to remind the user in which direction the codes are being sent.

HDSL In-band Loopbacks (Long)

Also known as long loopback codes, HDSL in-band loopbacks are a more complete loopback system that uses 16-bit code-words to loop specific network elements and provide confirmation and status. These confirmations are based on burst of errors sent back to the test set and the number of errors sent depend on type of confirmation and meaning. The status pop-up messages will show the meaning of those confirmation “codes” and the respective number of errors in brackets; for example: [111] indicates “Attenuation and Margin OK." See HDSL2 and HDSL4 Command Reference Table for code meanings.

User must select the type of HDSL cards being tested (2-wire vs. 4-wire), the location from which the test is to be conducted (CO/Network or CPE), the network element to be addressed, and the Loop up or Loop down command.

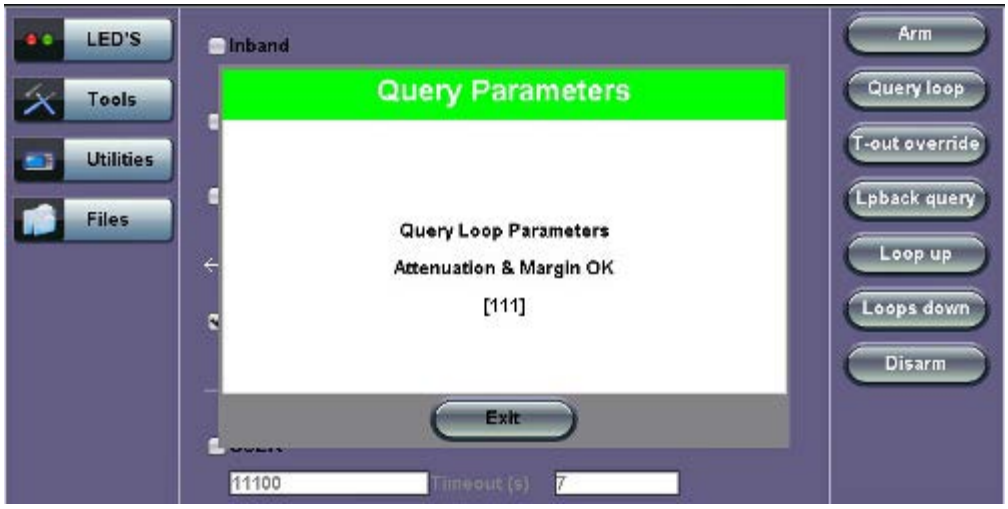
Before sending any loop command, the line must be armed, otherwise loop commands will be ignored. When the user enters the function, the GUI will only show commands to Arm the link, loop down any element previously looped up, or disarm an already armed link. Once the Arm command is sent, the GUI will make other functions available.



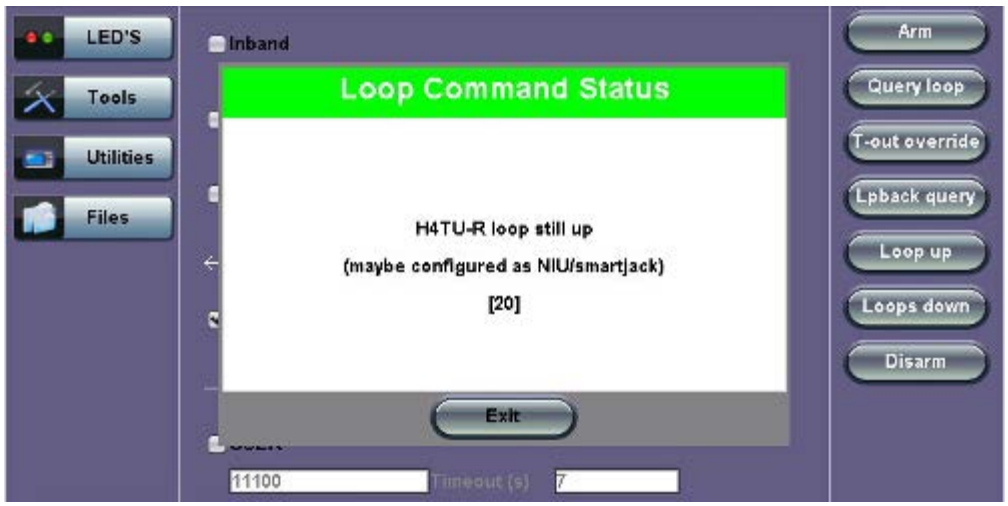
- **Arm**: Sends the arming code (11000b) to the link. The status of the link can be confirmed by looking a the Arm/Lbk LEDs on any of the line cards in the link. Note that some HTU-Rs configured in NIU/Smartjack mode will loop up with the Arm command. The test set will notify the user when this is the case.
- **Query Loop**: When sent from the CO and the HTU-C is in loopback mode, it reports the status of the physical link based on attenuation and margin characteristics.
- **Time Out Override**: Disables any automatic (timed) loop down feature in the link, so any loop will stay permanently until it is manually looped down.
- **Loopback Query**: Send the loopback query code to identify the first device in loopback mode. Once detected, the test set will display which device is in loopback mode.
- **Loop Up**: Sends the appropriate loop code to the selected network element (HTU-C, repeaters, or HTU-R), a confirmation message will be shown to indicate whether the loop was successful or not. Upon successful completion of a Loop up, a status message will display "Loop up success" and the user can press **Start Test** to proceed to BERT testing. The soft LEDs in the test set should all be green and can be used as a confirmation, as the test pattern should be coming back.
- **Loops down**: Sends the loop down without disarming code. The link will remain armed and ready to receive new commands. Note that some HTU-Rs configured as NIU/Smartjack will not loop down with this command and the instrument will notify the user if that is the case.
- **Disarm**: Sends the disarming code and brings down any loopbacks in the link, including the HTU-R in NIU/Smartjack mode.

"Loop up success" Message

Query Parameters Message



Loop Command Status Message



The long codes will allow multiple elements to be in loopback mode, as long as the elements are looped up from farthest to nearest. The white arrow on the DS1 Loop Setup screen is used as a visual indicator to remind the user in which direction the codes are being sent.

Adtran 4 Wire and 2 Wire Commands

4W	Arm	Disarm	HTUC	H4R1	H4R2	H4R3	HTUR Ext	HTUR Cust	Loop Down w/o Disarm	Timeout Override	Loop Back Query	Query Loop
From CO	11000	111000	D3D3	C741	C754	C743	C742	3F02	9393	D5D6	D5D5	DBDB
	2 in 5	3 in 5										
From CPE	11000	111000	D3D3	C741	C754	C743	C742	3F02	9393	D5D6	D5D5	
	2 in 5	3 in 5										
2w	Arm	Disarm	HTUC	H4R1	H4R2	H4R3	HTUR Ext	HTUR Cust	Loop Down w/o Disarm	Timeout Override	Loop Back Query	Query Loop
From CO	11000	111000	D3D3				C754	3F02	9393	D5D6	D5D5	DBDB
	2 in 5	3 in 5										
From CPE	11000	111000	D3D3				C754	3F02	9393	D5D6	D5D5	
	2 in 5	3 in 5										

HDSL2 and HDSL4 Command Reference Table

Command Responses				
Response (BIT Errors)	**4W**		**2W**	
	From CO	From CPE	From CO	From CPE
HTUC	231	231	231	231
HRE1	10	10		
HRE2	200	200		
HRE3	30	30		
HTUR	20	20	200	200
Query Loop	111 Loop Good	NA	111 Loop Good	NA
	11 Loop Bad		11 Loop Bad	
LoopBack query	Same as Above		Same as Above	Same as Above
LoopBack Time Out	Same as Above		HTUC 231	HTUC 231
			HTUR 20	HTUR 20

Note: Confirmation based on number of errors received.

User

The user code allows sending programmable codes of up to 16 bits (LSB first) and can be used for those codes or elements not directly supported by the DS1 Loopback feature. Tap in the binary field and use the on-screen keypad to enter the binary combination, and press the Apply button to return to the main screen. The Timeout field allows the user to set the exact time, in seconds, in which the code will be sent and constantly repeated. User can adjust the period between 1 to 99 seconds. Entering 0 would send the loop pattern continuously until a new loop pattern is sent. A confirmation message will be displayed once the time is up.

User Code

Send: Press this button to send the programmed code for the amount of time set in the time out field. The test set will stop sending the code once time is up.

Go back to top Go back to TOC

12.3 Round Trip Delay

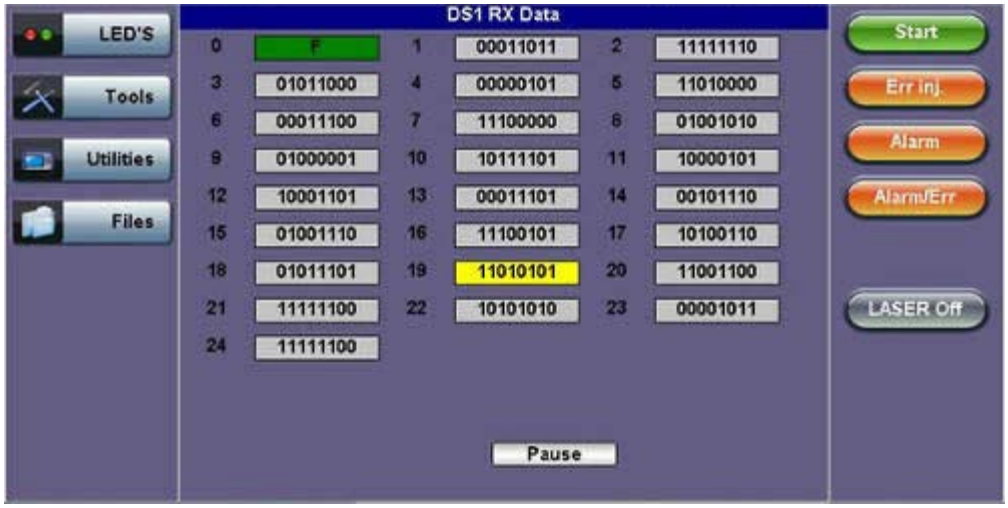
DS1/3 Round Trip Delay is the same measurement described as the Round Trip Delay in SDH/SONET Tools. Please see that section for more details.

Go back to top Go back to TOC

12.4 DS1 RX Data

DS1 RX data shows received data and captures the current timeslots.

DS1 Data



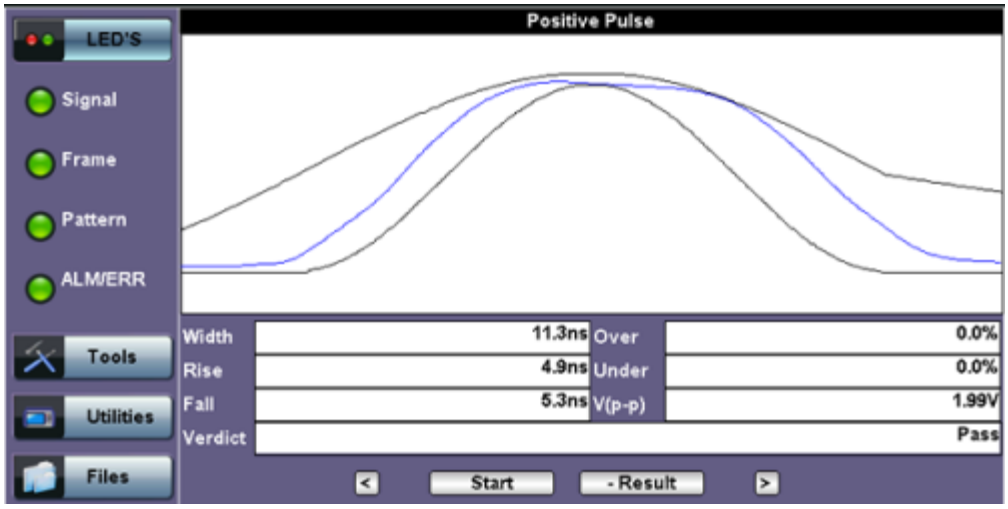
Go back to top Go back to TOC

12.5 DS3 Pulse Mask

This function captures and analyzes the DS3 (44.736Mbits/s) pulse shape. The purpose of maintaining the correct pulse shape is to reduce inter-symbol interference – if the logic 1s and 0s cannot be detected by the receiver correctly, bit and code errors will result.

The pulse amplitude and overall shape are superimposed and compared with the Telcordia TR-TSY-000499 and ITU-T G.703 pulse conformance template. Telecommunications signals require specific load impedance for pulse mask compliance testing to be accurate. When high frequency pulses are transmitted down a transmission line, a portion of the pulse will be reflected when and wherever it encounters an impedance mismatch. The reflection is proportional to the impedance mismatch (i.e., the greater the mismatch, the greater the reflection of the pulse).

DS3 Pulse Mask



Left/Right button: To move the pulse mask to the left or right, press the Left or Right button first and re-run the test.

Go back to top Go back to TOC

12.6 DS3 FEAC

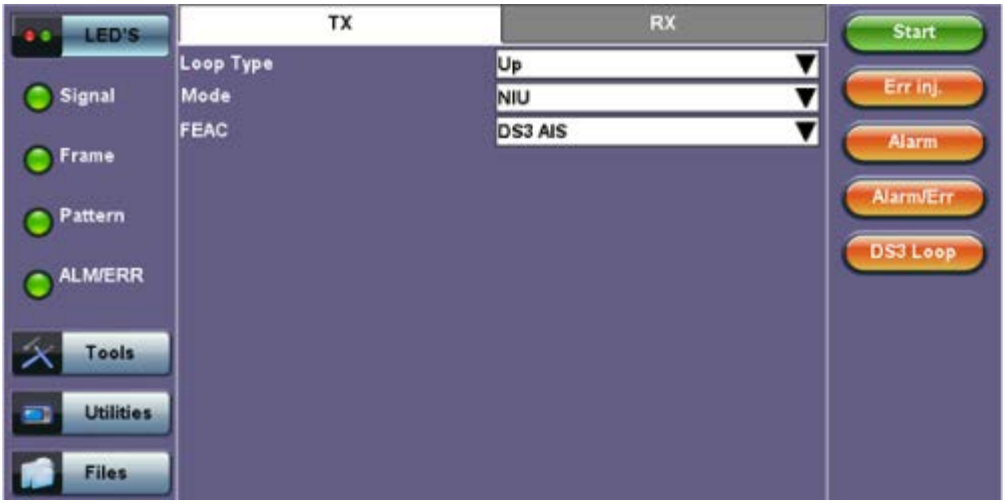
DS3 FEAC responses (Far End Alarm and Control Channel Responses)

Enabling this option allows loopback to be configured from any “far-end” equipment connected on the other end of the line. These can be used to send and receive loop up codes and information from the far-end T3 device. Enable or disable this option through a drop-down menu in this field.

- Loop Up Activate: 00010010 11111111 sent >10 repetitions
- Loop Down Deactivate: 00100100 11111111 sent >10 repetitions

FEAC alarms are sent from the remote end device towards the local device by means of the C bit in the Subframe. When a failure is declared on the remote end unit, this is how it notifies the near end unit. Some FEAC Codes are shown below.

FEAC Tasks TX Setup



Alarm TYPE

DS3 Equip. Failure (Service Affecting)
DS3 LOS
DS3 OOF
DS3 AIS RCV
DS3 IDLE RCV
DS3 EQUIQ FAIL (NON-SERVICE AFFECT)
COMMON EQUIP. FAIL (NSA)
MULTIPLE DS1 LOS
DS1 EQUIP FAIL
SINGLE DS1 LOS
DS1 EQUIP FAIL (NON-SERVICE AFFECT)

LOOP TYPE: Options: NIU, LINE

FEAC Tasks RX

Go back to top Go back to TOC

12.7 DS1 ISDN PRI

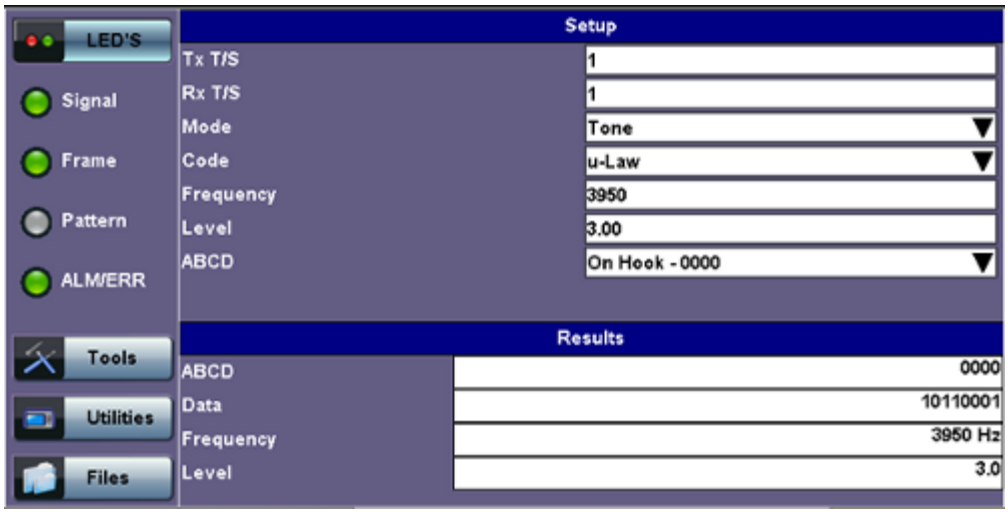
E1 and DS1 ISDN PRI offer identical test options. DS1 ISDN PRI instructions are discussed in 11.7 E1 ISDN PRI.

Go back to top Go back to TOC

12.8 DS1 VF Tasks

The VF Tasks menu performs a variety of talk/listen functions.

DS1 VF Tasks Setup



Note: Do not attempt to enter VF Tasks if the Frame LED is not green. Green LEDs indicate that the framing found on the received signal matches the framing selected in the Setup screen. It is impossible to talk, listen, or perform other channelized functions in the absence of frame synchronization, since channels can be identified only within a framed signal.

The VF Tasks screen features the following options:

Setup:

- **Tx and Rx T/S:** Input the number of channels (1-24) to test for transmitting and receiving time slots.
- **Mode:** Talk or send a tone on the transmit signal. Transmit audio data from the external headset into the selected timeslot.
- **Code:** Select u-Law or A-Law.
- **Transmitted Frequency:** Input a frequency to transmit from 50 to 3950 Hz.

Transmitted Level: Input a frequency to transmit from -60 to 3dBm.

- **ABCD:** Options are ON-HOOK, OFF-HOOK, WINK, or User (Manually set). Change the signalling bits transmitted with the associated transmit channel. In SF-D4 framing these will be A/B and ESF framing will place that signal onto the A/B/C/D position.
- **Programmable ABCD:** Manual (User) or IDLE, SEIZE.

Results:

- Measure signal frequency and level in selected timeslot
- Listen to the voice channel in selected timeslot via external headset
- **ABCD:** View the received Channel Associated Signalling System(CAS) bits
- **Data:** View the live 8-bit channel data as it is received from the selected channel
- ABCD bits monitor and view data in selected T/S channel

Go back to top Go back to TOC

12.9 Jitter and Wander

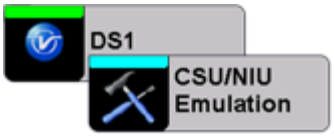
For more information on Jitter and Wander, please see 13.0 Jitter and Wander Application.

Go back to top Go back to TOC

12.10 CSU/NIU Emulation for DS1

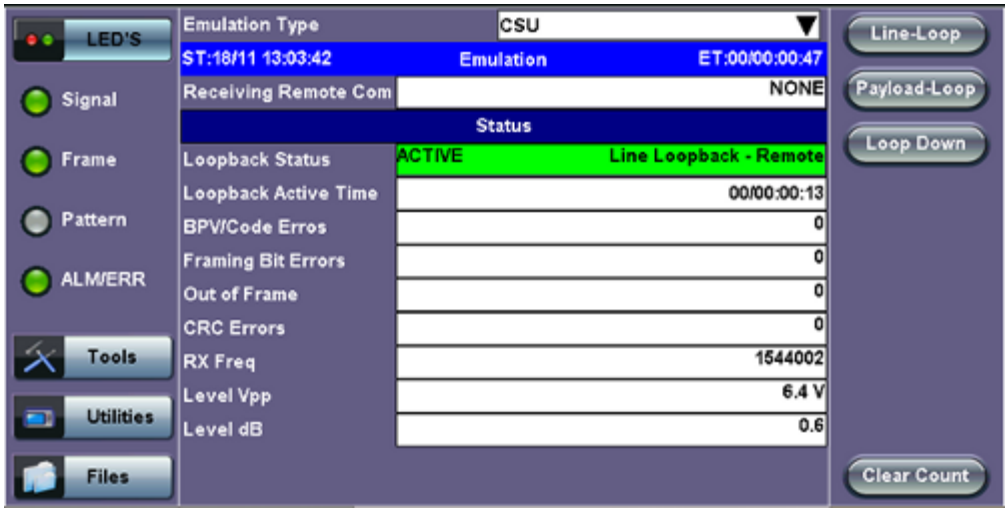
Accessing CSU/NIU Emulation

To access CSU/NIU from the OTN/SDH/SONET menu tap on Home (main menu) > **DS1** > **DSU/NIU Emulation**.



The test set can emulate DS1 customer premises equipment, simulating a CSU or NIU. CSU/NIU emulation allows the test set to be looped up from the central office to verify DS1 service across the entire length of the span.

CSU/NIU Emulation



Emulation Type: NIU or CSU

Receiving Remote Command: “None”. After the remote command disappears, “None” is displayed. When receiving command, the following are displayed:

- In-band loop up
- In-band loop down
- ESF FDL Line loop up
- ESF FDL Line loop down
- ESF FDL payload loop up

- ESF FDL payload loop down

When in un-loop state, Line 1 TX sends AIS

Loopback Statuses:

- Payload Loopback – Local: Activated by the Payload-Loop button
- Line Loopback – Local: Activated by the Line-Loop button
- Payload loopback – Remote: Activated when remote ESF FDL command has been received
- Line Loopback – Remote: Activated when remote ESF FDL command has been received
- None (when in un-loop state)

The **Status** screen also displays the following:

- Loopback Active Time: Loopback time elapsed (s)
- BPV/code errors
- Framing Bit Errors
- Out of Frame errors
- CRC Errors
- Receiving frequency (Hz)
- Peak-to-peak voltage and voltage level

CSU/NIU Buttons		
Button	**Command**	**Description**
	Line-Loop	Loopback RX to TX, unchanged
	Payload-Loop	Loopback RX to TX, only the payload
	Loop Down	Can be used to unloop at anytime
	Clear Count	Clear all the counters to 0. Loopback state, no change

In SF mode, only in-band commands can be checked.
In ESF mode, FDL and in-band commands are both checked.
Remote loopback control qualification time is 5 seconds (that is, must receive loopback commands for 5 seconds before activate or deactivate loopback state)

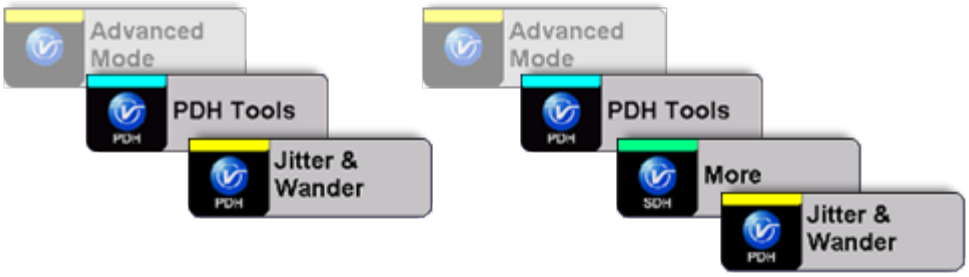
Go back to top Go back to TOC

13.0 Jitter and Wander

Accessing Jitter and Wander

Go to **OTN/SDH/SONET Testing** from the **Test Mode Selection**, then select the following:

- For **PDH** or **DS3/1 signals**: Home (Main Menu) > PDH or DS3/1 Tools > (DS1/3) Jitter & Wander
- For **SONET** or **SDH signals**: Home (Main Menu) > SONET/SDH Tools > More > Jitter & Wander



Jitter & Wander displays the Jitter Measurements showing measurements and analysis of jitter in received signal.

Jitter and Wander (PDH E3 Menu)

Jitter and Wander are usually described as the phase noise in digital signals. This is a natural occurrence in telecommunication networks.

Excessive jitter can lead to transmission errors and deterioration in network quality. ITU defines jitter as follows: "The short-term variations of the significant instances of a digital signal from their ideal positions in time (where short-term implies these variations are of frequency greater than or equal to 10 Hz)." The long-term variation (less than 10 Hz) of a digital signal is called wander.

In simple terms, jitter is an unwanted phase modulation of the digital signal that may cause errors or bit slips in a digital circuit and deteriorate the performance of a transmission network.

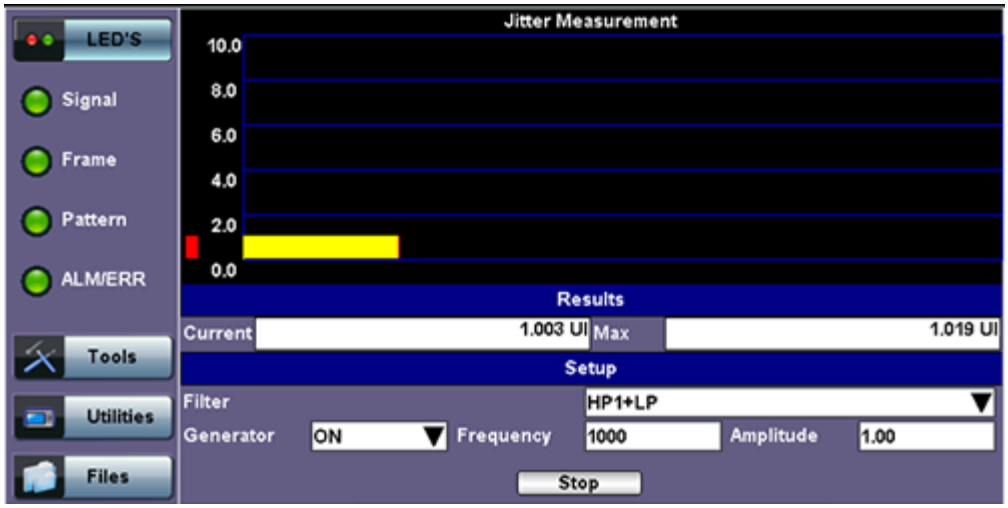
In lower-rate digital systems, systematic jitter is dominant. In higher-rate systems, random jitter may become more important. Test environment parameters that affect jitter performance are test sequences, bit rate, pulse shape, cable characteristics, temperature, cross-talk, and noise.

Go back to top Go back to TOC

13.1 Jitter Measurement & Generation (Jitter icon)

Tapping the Jitter icon brings up the **Jitter Measurement and Generation** screen.

Jitter Measurement and Generation Menu



The Jitter measurements menu allows the user to measure and analyze received signal jitter. The measurement example is shown above (the vertical grid spacing is 2.0 UIpp). The red bar indicates Max. peak jitter during testing and the yellow bar indicates the current peak jitter.

Setup

Configure the following settings before starting the test:

- **Filter:** HP1+LP or HP2+LP. The frequency for each filter varies depending on the setup mode (E1/E3, DS1/DS3). Frequency ranges for each filter and setup mode are listed as follows:
  - E1: HP1+LP (20Hz to 100KHz); HP2+LP (18 Hz to 100KHz)
  - E3: HP1+LP (100Hz to 800KHz); HP2+LP (10KHz to 800KHz)
  - DS1: HP1+LP (10Hz to 40kHz); HP2+LP (8kHz to 40kHz)
  - DS3: HP1+LP (10Hz to 400kHz); HP2+LP (30kHz to 400kHz)

- **Generator:** ON or OFF

- **Frequency:** 2 Hz to 10,000 Hz for E1(2M) options, 2 Hz to 800,000 Hz for E3 (34M) options. 2 Hz to 40,000 Hz for DS1 (1.5M) options, 2 Hz to 400,000 Hz for DS3(45M) options.

- **Amplitude:** Enter the amplitude at which peak to peak jitter generation occurs. See O.172 for the ITU recommendation on minimum jitter generation.

Press **Start** to start measurements.

Results

Results are displayed for the current jitter value and maximum jitter value during measurement.

Go back to top Go back to TOC

13.2 Max Jitter Tolerance (MTJ)

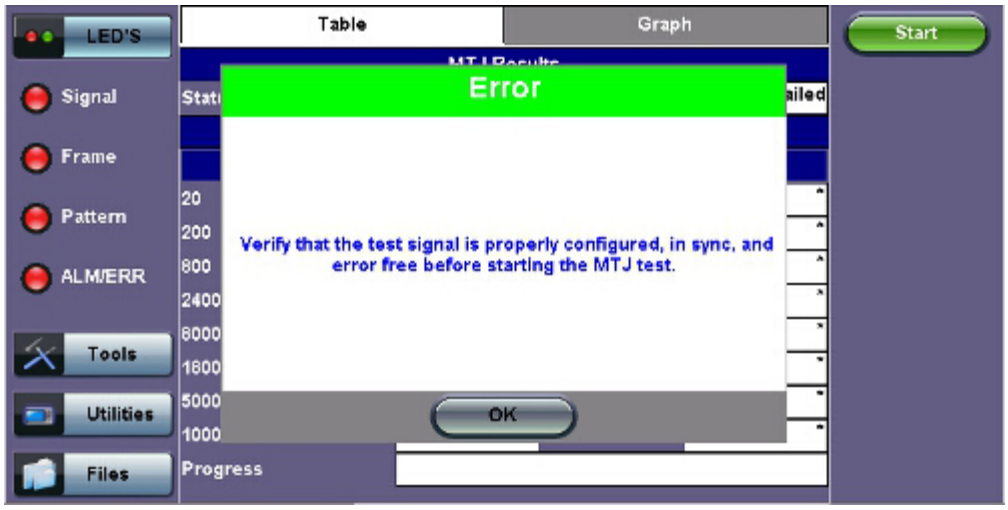
Jitter Tolerance or jitter accommodation is defined in terms of the sinusoidal jitter amplitude which causes a designated error when applied to digital equipment input. Jitter tolerance is a function of applied jitter's amplitude and frequency. Equipment must pass the lower limit of maximum jitter tolerance, which is specified in ITU-T G.823, G.824, and G.825 standards.

The unit will transmit jitter from point-to-point or low to high frequency at different amplitudes to determine where errors occur. This is known as maximum jitter tolerance (MTJ).

Defects and Anomalies Check

The Max Jitter Tolerance feature checks the health of the incoming signal prior to starting the test. If any alarms or errors are detected, the test set will notify the user that the test cannot be performed and present configuration suggestions to correct the problem.

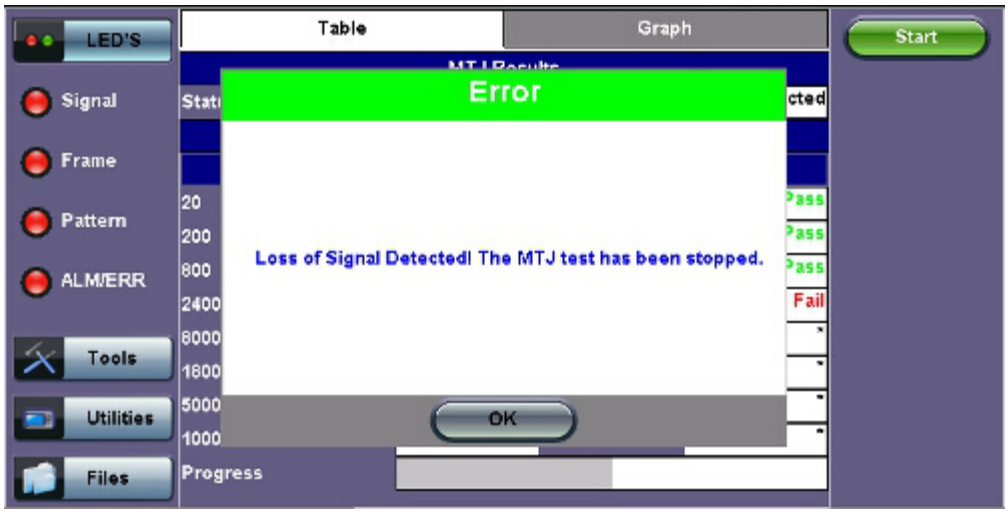
Error Message: Configuration Suggestions



Loss of Signal (LOS) Check

If the LOS condition is detected at any time during the MTJ test, the data will become invalid and the test will stop automatically. An error message will appear to notify the user to correct the condition before running the test again.

LOS Error Message

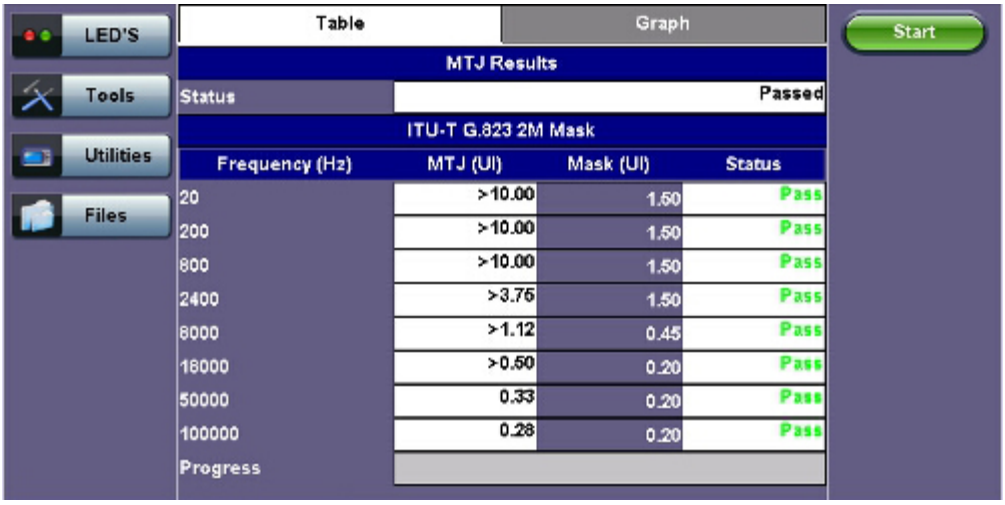


Table

Table values include:

- Frequency tested (Hz)
- **MTJ (UI):** Maximum Tolerable Jitter (in Unit Intervals).
- **Mask (UI):** Peak-to-Peak jitter limit (in UI) as defined by ITU standard. This is the minimum jitter value to pass (i.e., the MTJ value must exceed the Mask value for the data point to pass).
- **Status:** Pass/Fail status.
- **Start/Stop:** Starts or stops the test.
- **Progress:** A green bar at the bottom of the graph shows the test progress.

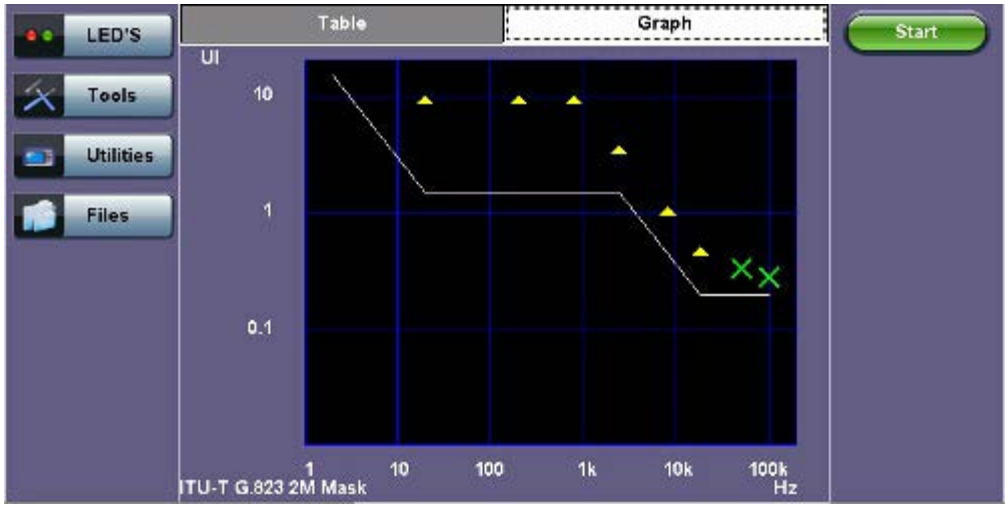
MTJ Table



Graph

A cross (x) indicates the maximum jitter value tolerated at the frequency.
Yellow triangles (▲) indicate that the data point is greater than, while the green "X" symbols represent actual measured values. Greater than implies that the jitter tolerance of the DUT (device under test) is much better than the value measured by the test set. Users should expect all data points above the mask (curve) to pass. For this example, the table results and graphical example confirm that all points have passed.

Graph



Go back to top Go back to TOC

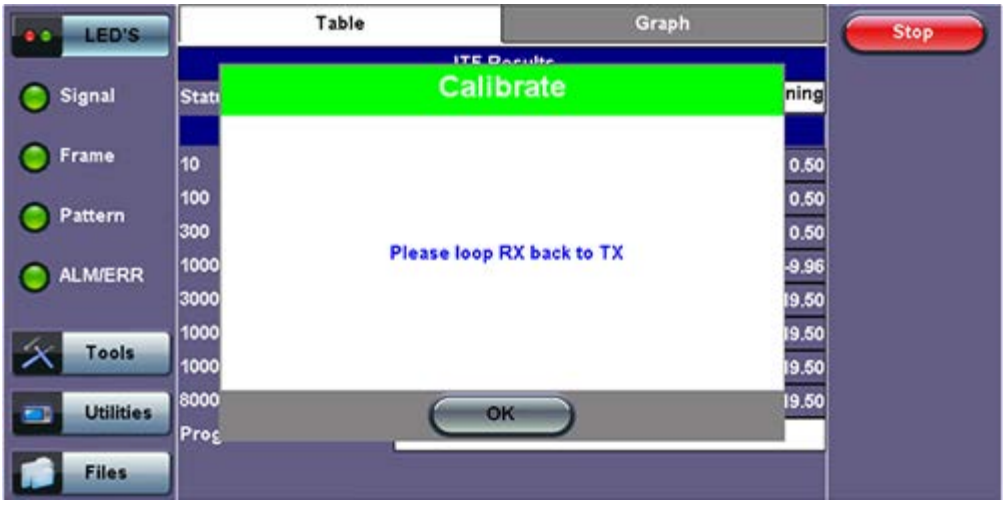
13.3 Jitter Transfer Function (JTF)

Jitter Transfer defines the ratio of output jitter to input jitter amplitude versus jitter frequency for a given bit rate.
Often, a portion of received jitter is transmitted at a piece of the equipment's output. If LOS is detected during the JTF test, the test will be stopped.

1. Calibration

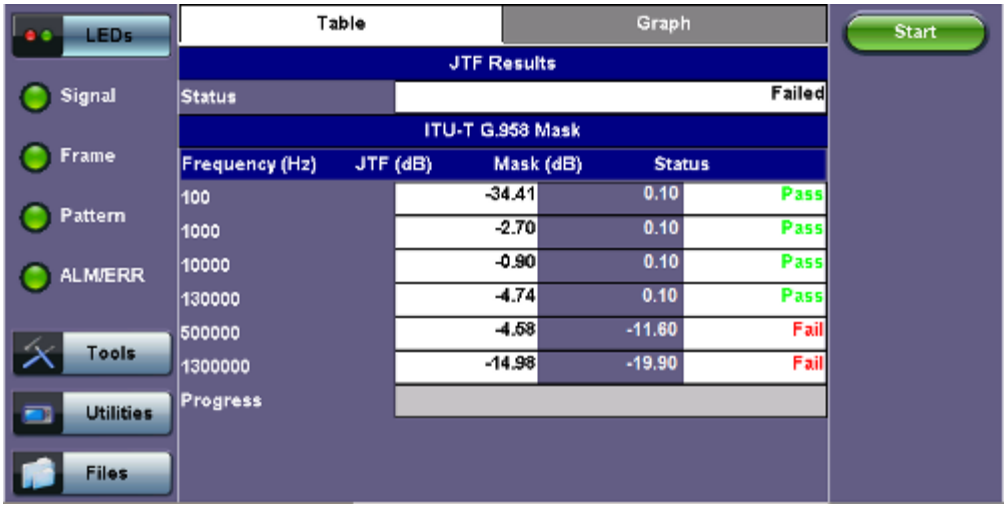
Using a short and clean patch cord, connect the test set's TX back to the RX to form a local reference loop.

Loop Message

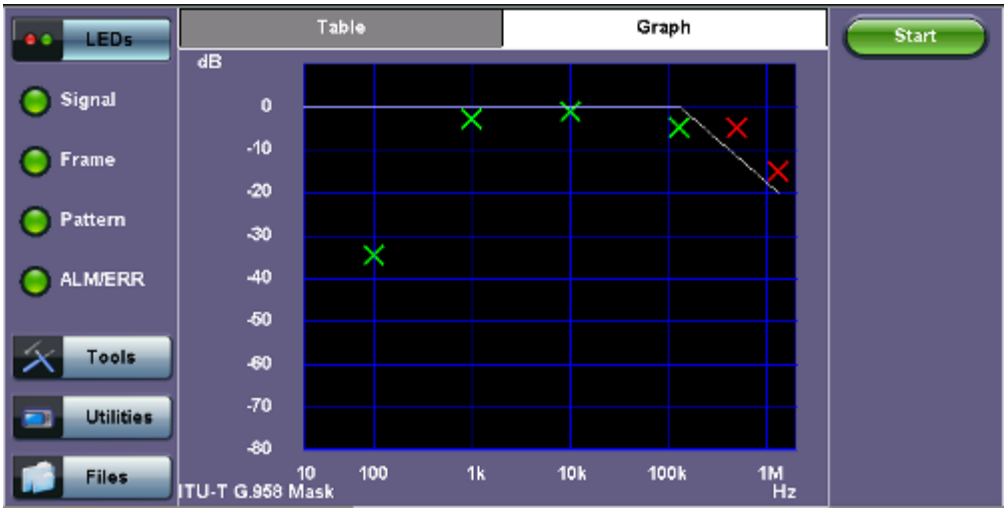


2. Device Under Test (DUT)

Before starting the test, "Connect Device Under Test" will appear. Connect the test set to the DUT then press **Start** to begin testing.



- **Frequency (Hz):** Frequency measured
- **JTF (Jitter Transfer Function) (dB):** Jitter in divided by jitter out value (in dB)
- **Mask (dB):** Jitter output in relationship to the input
- **Progress:** The bar at the bottom of the graph shows the test progress



A green cross (x) indicates the the jitter transfer value has passed.

A red cross (x) indicates that the jitter transfer value has failed.

Yellow triangles (▲) indicate that the jitter transfer value is greater than the value measured by the test set.

Go back to top Go back to TOC

13.4 Wander Measurements and Analysis

The test set may be equipped with wander measurement options (or licenses) that add verification of stability (wander) and accuracy for different types of data interfaces. Those signals under test could be physical clocks (1.544, 2.048, 10 MHz or 1PPS), SDH/SONET, PDH/DSn, SyncE slave or 1588v2 precision timing protocol.

Three main wander measurement and analysis applications may be offered by the test set (all optional), along with an off-line MTIE/TDEV analysis software for PC

- Recovered Clock Wander Measurements
- Advanced Clock Wander & Phase Measurements
- Built-in MTIE/TDEV Wander Analysis
- VeEX MTIE/TDEV Wander Analysis PC software

Individual screens, fields and selections may vary among products or technologies, and depend on the options/licenses loaded or available for each test set. Nonetheless, the concepts and procedure flow are very similar.

13.4.1 Recovered Clock Wander Measurements

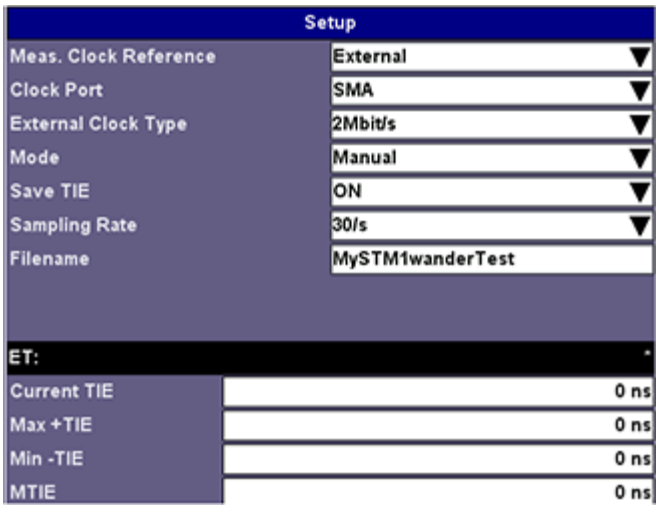
The test set may offer wander measurement options (or licenses) that add verification of stability (wander) and accuracy for different types of data interfaces. Those signals under test could be SDH/SONET, PDH/DSn, SyncE slave interfaces, or the clock recovered by the 1588v2 PTP. Each individual transmission technology may require its own wander measurement license.
The Recovered Clock Wander Measurements features can usually be found within the test options that the intended technology offers.

- In 1GE and 10GE test modes, the Wander Measurement function may be found under the Advanced Tools menu, provided that SyncE or 1588v2 slave modes have been enabled.
- In PDH test modes, the wander measurement function may be found in >PDH Tools >Jitter & Wander >Wander
- In SDH/SONET test modes, the wander measurement function may be found in >SONET/SDH Tools >Jitter & Wander >Wander
- In DSn test modes, the wander measurement function may be found in >DS1/DS3 Tools >DS1/3 Jitter & Wander >Wander

Go back to top Go back to TOC

13.4.1.1 Test Setup

Setup



1. Measurement Clock Reference or Reference Clock Source offers a selection of external or internal (optional) frequency references. Internal or built-in reference options could be “Atomic 10 MHz” or “Atomic 1PPS”, disciplined by GPS or free running.
2. Clock Port indicates the connector in which the traceable external clock reference source shall be connected. (Avoid using rigid BNC-to-SMA adapters to prevent any stress on the test set’s connector. Flexible adapters or cables are recommended.)
3. External Clock Type allows users to select from a list of supported clock signals (e.g. 1.544 MHz, 2.048 MHz, 1544 Mbps, 10 MHz, 2.048 Mbps, 1PPS)
4. Test Mode lets user select between Manual start/stop and Timed measurements. If Timed is selected, users can set the length of the test in seconds, minutes, hours or days. Once the selected time has elapsed the test automatically stops.
5. Save TIE can be turned ON to write all wander measurements to a FAT32 USB Memory stick in real time, to be analyzed later on.
6. The Sampling Rate (samples per second) can be set to 1/s, 5/s, 10/s or 30/s, depending on the application.
7. File Name identifies the new folder in which all configuration and measurement data will be stored. This folder will be created in the root of the memory stick.
8. Tap on the Start button to initiate the measurements and data logging.
9. Tap on the Stop button to force the measurement and data logging to stop. This will also stop a Timed test, even if the total time has not finished yet.
10. After stopping the test, and if the built-in MTIE/TDEV option is enabled, users can also tap on the Analysis button to view the TIE graph and perform the MTIE/TDE analysis on the recorded TIE data. Refer to the following sections for more details.

Go back to top Go back to TOC

13.4.1.2 Test Result

Numerical counters are provided to let users know the status of the test, with a basic summary of the TIE information.

1. **Current TIE:** Shows the current time interval error measurement.
2. **Max TIE:** Maximum positive TIE value that has been recorder since the beginning of the test
3. **Min TIE:** lowest or negative TIE value that has been recorded since the beginning of the test. Since wander measurements always start with a TIE=0, then the minimum value can only be zero or negative.
4. **MTIE:** Denotes the maximum span of TIE values recorded since the beginning of the test. In this summary, MTIE = MaxTIE – MinTIE. It gives users an idea of how much the signal under test is wandering

Go back to top Go back to TOC

13.4.2 Advanced Clock Wander & Phase Measurements

The test set may offer clock wander and phase error measurement options (or licenses) that add verification of stability (wander) and accuracy (absolute phase error) on external (physical) clock signals. Those signals could be from reference clocks or recovered clock outputs from remote or slave terminals (SDH/SONET, PDH/DSn, SyncE, PTP, GNSS/GPS, Rb clocks, etc.)

The results are the similar to the ones obtained by measuring wander on data interface ports (SDH/SONET, PDH/DSn, SyncE or PTP). The main difference is that the advanced clock wander measurements are performed on a physical (not internally recovered) clock signal.

This feature is usually an independent Test Mode and not linked to any particular data transmission interface.

13.4.2.1 Clock Wander and Phase Measurements (Optional)

The “Clock Wander & Phase Measurements” option offers short and long term Wander measurements for frequency sources (e.g. 1.544, 2.048Mbps or 1.544, 2.048, 10MHz or 1PPS) and Phase Error measurements for timing sources (i.e. 1PPS) and can save the TIE or TE measurements to a FAT32 USB Memory stick for further analysis. The test set itself may also offer a built-in MTIE/TDEV Wander Analysis option to analyze the data or it can also be done by using the free VeEX Wander Analysis PC Software that can be downloaded from www.veexinc.com

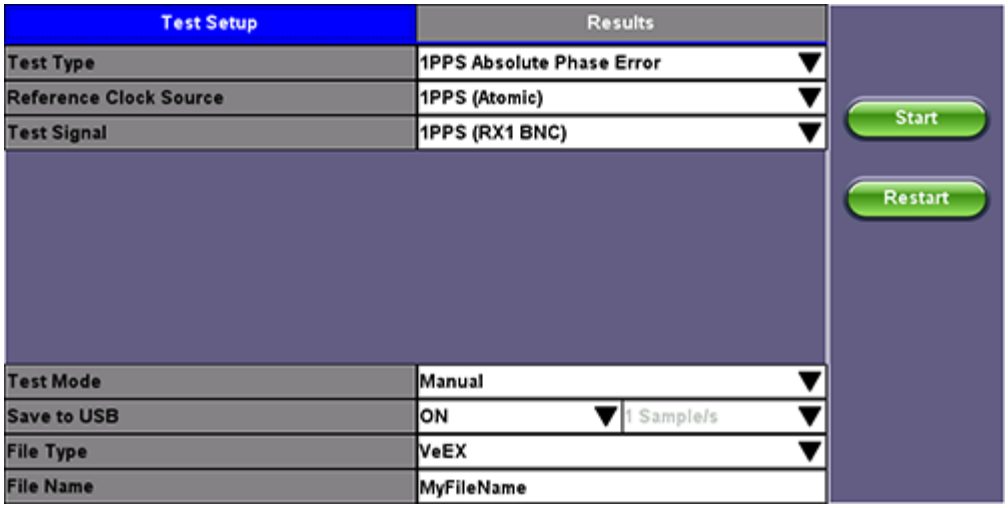
Both, Wander and Phase Error, measurements require a stable and accurate reference clock source, which can be an external source connected to the CLK (SMA) input port or optional optional built-in GPS and Chip-scale Atomic Clock references.

- The built-in GPS hardware option provides a (raw) 1PPS timing signal (clock), aligned to the standard second, and can be used to discipline the built-in atomic clock. The direct use of this raw “GPS 1PPS” alone is not recommended for wander or phase measurements. It should be combined with the Atomic Clock to filter and stabilize the timing signal
- The built-in Atomic Clock hardware option can provide highly stable frequency references on its own (Atomic 1PPS and Atomic 10 MHz), suitable for wander measurements
- When disciplined by the internal GPS receiver, the Atomic Clock 1PPS can also be used as a very stable and accurate absolute timing reference aligned to the standard second (1PPS) or very accurate and stable frequency reference (10 MHz)
- External clock signals, directly traceable to PRC or PRTC, can also be used as a reference for even more accurate results (e.g. high-quality GPS-disciplined OCXO, Rb or Cs clock sources)

While wander (stability) measurements use high precision frequency references, the absolute phase error (also known as Time Error ot TE) requires an accurate 1PPS timing signal, aligned to the standard second (UTC). The 1PPS can be sourced from a high precision GPS-disciplined clock (built-in option or external).
The Wander (TIE) and Phase (TE) data logs can be saved in real time to a USB Memory using VeEX proprietary format (to be analyzed by the built-in or PC-based MTIE/TDEV Analysis software) or exported to an open CSV format.

Test Setup

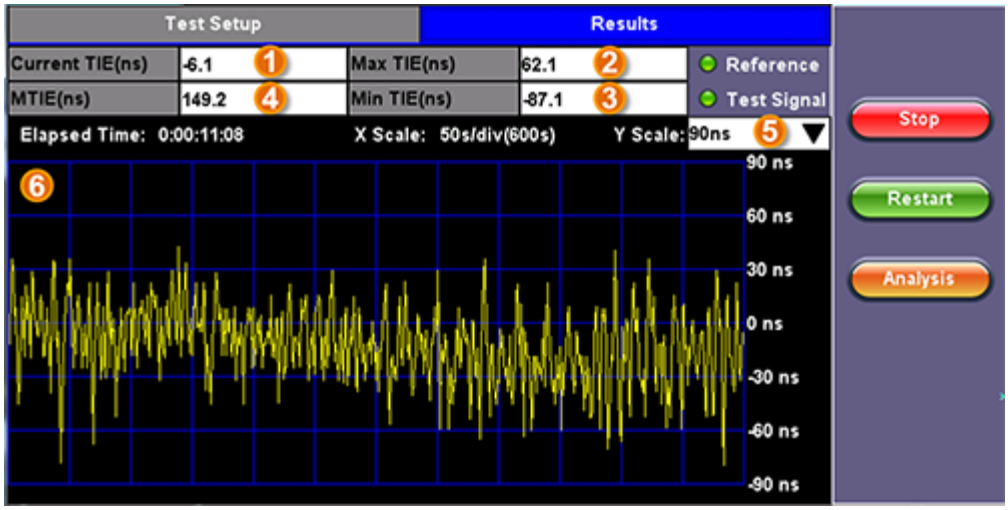
Setup



1. Test Type offers a selection of “1PPS Absolute Phase Error” for timing error measurements or “Clock Wander Measurement” for frequency stability measurements
2. Reference Clock Source offers a selection of external or internal (optional) frequency or timing references
3. The Test Signal is the clock that needs to be measured for stability and/or accuracy
4. Test Mode lets user select between Manual start/stop and Timed measurements. If Timed is selected, users can set the length of the test in seconds, minutes, hours or days. Once the selected time has elapsed the test automatically stops.
5. Save to USB can be turned ON to write all wander or phase measurements to a FAT32 USB Memory stick in real time, to be analyzed later on. User can also set the sampling rate (samples per second).
6. File Types available are the proprietary “VeEX” format (compatible with VeEX Wander Analysis PC software” and an open CSV format that can be analyzed or formatted with a spreadsheet program (e.g. Excel or Numbers) or could be imported to other analysis software.
7. File Name identifies the new folder in which all configuration and measurement data will be stored. This folder will be created in the root of the memory stick.
8. Tap on the Start button to initiate the measurements and data logging.
9. Tap on the Stop button to force the measurement and data logging to stop. This will also stop a Timed test, even if the total time has not finished yet.

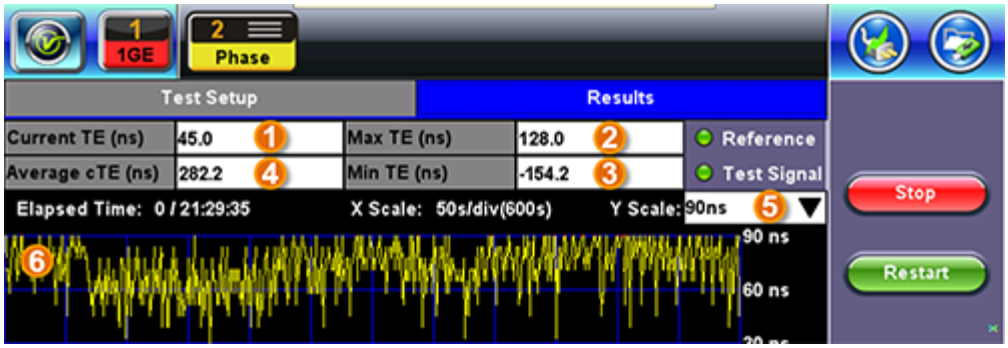
Results

Results



Wander results are presented in nanoseconds and include: (1) Current TIE, (2) Highest TIE recorded, (3) Lowest or negative TIE recorded, (4) MTIE for the whole test data, (5) Y scale zoom level, (6) the last 600s of TIE values, Start/Stop/Restart buttons, and Analysis button (if the built-in MTIE & TDEV Analysis option is loaded in the test set)

Results



Phase results are also presented as the difference in nanoseconds between the rise of the reference timing pulse and the signal under test. It includes (1) Current timing or phase error (TE), Maximum time error recorded, (3) Minimum or negative time error recorded, (4) Average time error (cTE) for the whole test.
The 600s graph is provided as a tool to confirm the settings and signals stability before running a long term test, so time is not wasted in testing an unstable signal or with frequency offset. It also gives users a glance of the current status of long term tests.

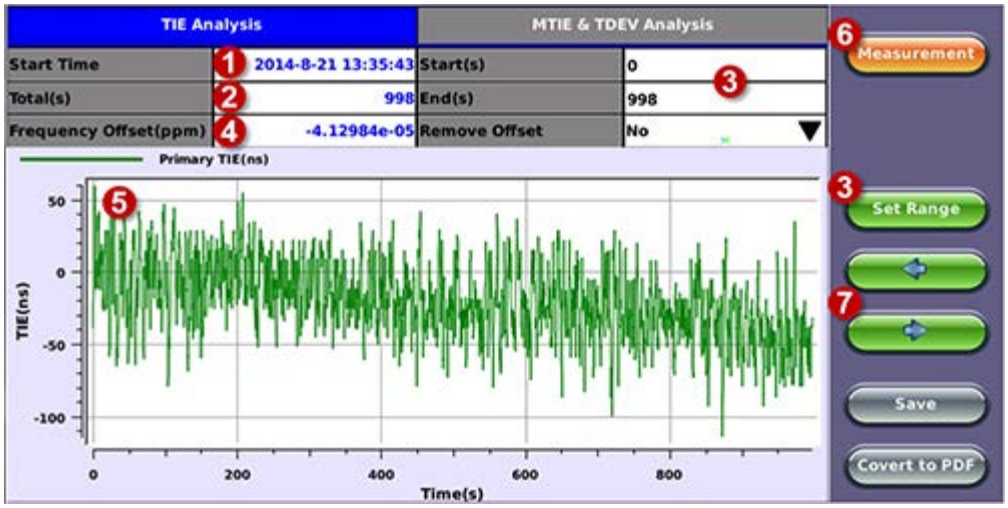
13.4.2.2 Built-in MTIE & TDEV Analysis (Optional)

This option enables the test set to analyze up to 72 hours' worth of wander measurement data and compare it against standard masks for a PASS/FAIL assessment, without the need for a PC. The test set may allow the analysis to be performed while the test is still running for run-time verification. Longer test take a lot longer to be analyzed, so the VeEX Wander Analysis PC Software is still recommended for tests longer than 24 hours.

Features:
- Provides further post-processing of clock stability data, such as MTIE and TDEV
- Frequency offset calculation and removal for relative TIE analysis
- Standard MTIE and TDEV masks can be selected
- MTIE and TDEV results and mask export to CSV for further report generation using spreadsheets
- Direct PDF report generation to USB

TIE Results

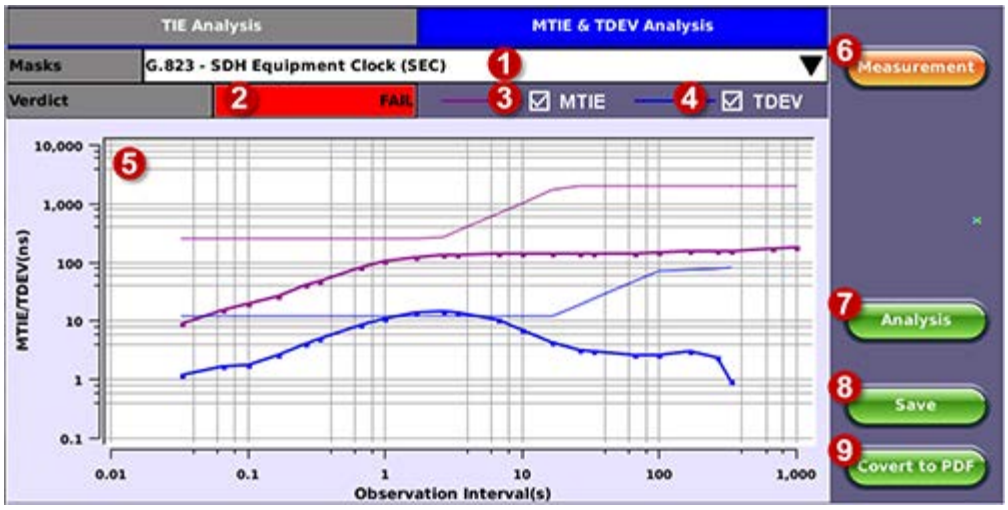
TIE Results



1. Date and Time stamp indicating when the test was started
2. Total of seconds recorded during the test
3. Beginning and end of the data set to be analyzed and displayed in the graph (5) below. Tap in the Start and/or End field and enter the desired time limits, then press the Set Range button to apply these changes.
4. Based on all the TIE measurements captured, the test set automatically calculates any small difference in frequency between the signal under test and the reference clock. Once the frequency difference is known, users can remove it to perform Relative TIE measurements. The offset removal tool is important for field tests when the local reference clock used is highly accurate and stable but not traceable to the PRC in the network core (e.g. a portable frequency reference). Even if the frequency of the local reference is a few ppb (parts per billion) different than the PRC, it can still be used for wander measurements, as long as it is highly stable, because the Offset Removal feature can mathematically remove the know difference and make it as if a traceable reference had been used. Once removed, user can perform relative MTIE (or MRTIE) and TDEV analysis.
5. Auto-scale TIE graph, based on the limits set.
6. Press the Measurement button to return to the current wander measurements
7. Fine cursor controls. User can use the stylus to tap on the screen to position the cursor and then use these arrow buttons to position the cursor and read specific TIE values. The rubber cursor keys can also be used to move the cursor.

MTIE & TDEV Pass/Fail Analysis

MTIE Results

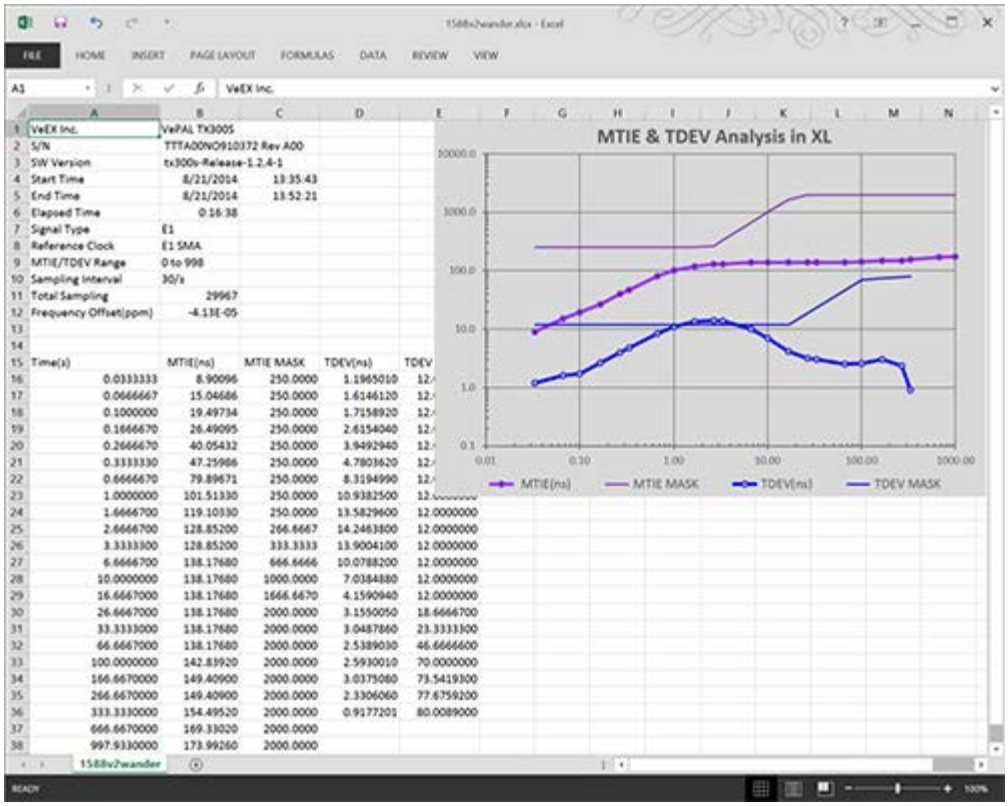


1. Standard MTIE & TDEV masks selection
2. Pass or Fail indicator, evaluated depending on selected masks
3. MTIE line color indicator and Enable/Disable check box
4. TDEV line color indicator and Enable/Disable check box
5. MTIE & TDEV logarithmic graphs and standard masks
6. Press this button to return to the wander measurements screen
7. Once the mask has been selected, press Analysis to run the MTIE and/or TDEV calculations. Depending on the number of

samples collected, this calculation could take a few minutes.

8. Save the MTIE, TDEV and mask calculations in CSV format to a USB Memory stick. The graph can be recreated using a spreadsheet program like Microsoft® Excel, printed as a report or shared via email or any other electronic media
9. Generates a MTIE and TDEV report in PDF format to a USB Memory stick.

MTIE & TDEV Results Exported to CSV



	A	B	C	D	E
1	VeEX Inc.	VePAL TX300S			
2	S/N	TTTA00NO910372 Rev A00			
3	SW Version	tx300s-Release-1.2.4-1			
4	Start Time	8/21/2014	13:35:43		
5	End Time	8/21/2014	13:52:21		
6	Elapsed Time	0:16:38			
7	Signal Type	E1			
8	Reference Clock	E1 SMA			
9	MTIE/TDEV Range	0 to 998			
10	Sampling Interval	30/s			
11	Total Sampling	29967			
12	Frequency Offset(ppm)	-4.13E-05			
13					
14					
15	Time(s)	MTIE(ns)	MTIE MASK	TDEV(ns)	TDEV
16	0.0333333	8.90096	250.0000	1.1965010	12.0
17	0.0666667	15.04686	250.0000	1.6146120	12.0
18	0.1000000	19.49734	250.0000	1.7158920	12.0
19	0.1666670	26.49095	250.0000	2.6154040	12.0
20	0.2666670	40.05432	250.0000	3.9492960	12.0
21	0.3333330	47.25986	250.0000	4.7803620	12.0
22	0.6666670	79.89671	250.0000	8.3194990	12.0
23	1.0000000	101.51330	250.0000	10.9382500	12.0
24	1.6666700	119.10330	250.0000	13.5829600	12.0000000
25	2.6666700	128.85200	266.6667	14.2463800	12.0000000
26	3.3333300	128.85200	333.3333	13.9004100	12.0000000
27	6.6666700	138.17680	666.6666	10.0788200	12.0000000
28	10.0000000	138.17680	1000.0000	7.0384880	12.0000000
29	16.6667000	138.17680	1666.6670	4.1590940	12.0000000
30	26.6667000	138.17680	2000.0000	3.1550050	18.6666700
31	33.3333000	138.17680	2000.0000	3.0487860	23.3333300
32	66.6667000	138.17680	2000.0000	2.5389030	46.6666600
33	100.0000000	142.83920	2000.0000	2.5930010	70.0000000
34	166.6670000	149.40900	2000.0000	3.0375080	73.5419300
35	266.6670000	149.40900	2000.0000	2.3306060	77.6759200
36	333.3330000	154.49520	2000.0000	0.9177201	80.0089000
37	666.6670000	169.33020	2000.0000		
38	997.9330000	173.99260	2000.0000		

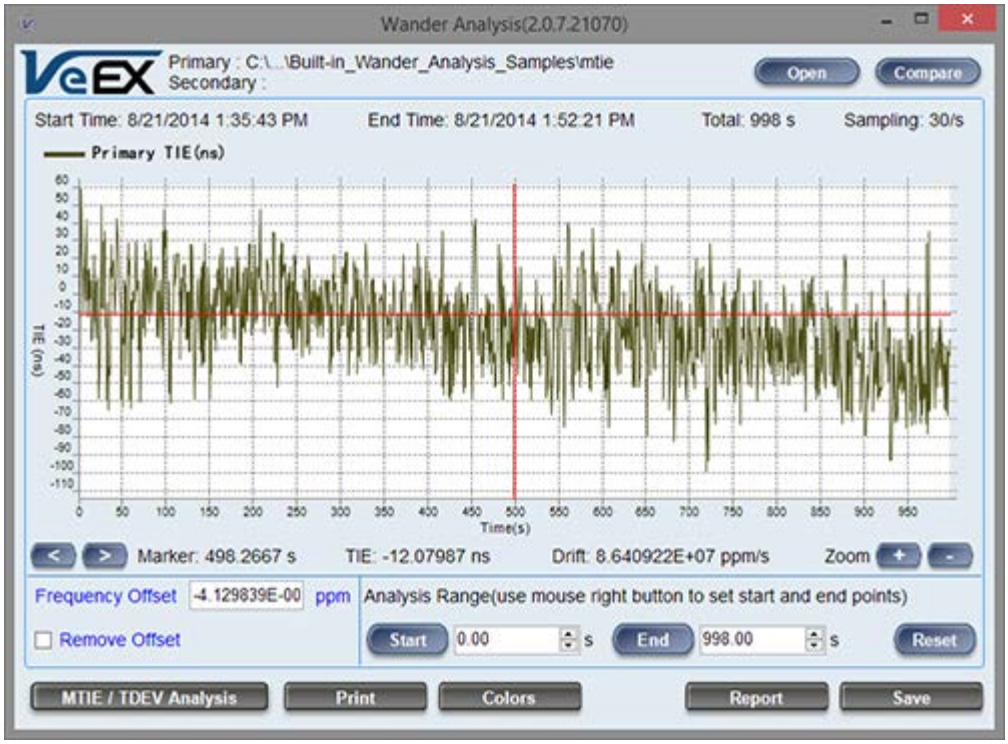
13.4.3 VeEX MTIE/TDEV Wander Analysis PC software

• Provides further post-processing of clock stability data, such as MTIE and TDEV for long-term tests
• Frequency offset calculation and removal for relative TIE analysis
• Standard and user-programmable masks
• PDF report generation
• Fully resizable window, to accommodate any screen size and provide detailed zoom levels
• Compact stand-alone Windows® software. It can be carried in the same USB memory as the TIE data. No installation is necessary.

For added convenience, the software doesn't need installation and can be stored on and run from the same USB stick where the wander log files are being stored.

13.4.3.1 TIE Measurement Results

Click on the Open button to load the desired MTIE of Phase file and see the TIE behavior on the screen. Use the Compare button to load a secondary trace for comparison purposes. Up to two traces can be displayed and analyzed simultaneously.



Click on the MTIE/TDEV Analysis button to go to the wander analysis function

13.4.3.2 MTIE & TDEV Analysis

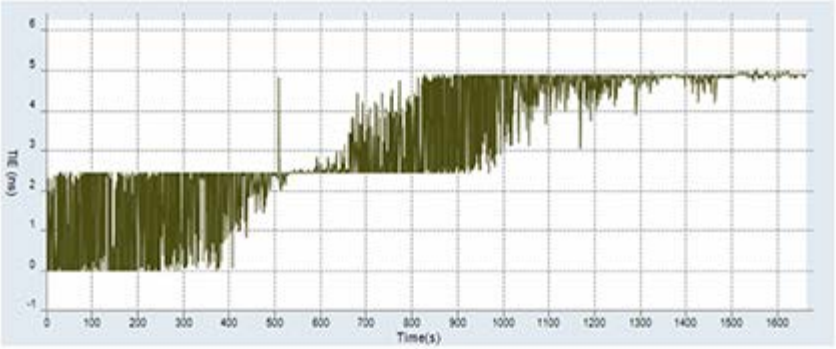
Select the desired tolerance masks from the pull-down list and click on the Analyze button to perform the MTIE and/or TDEV analysis.

13.4.3.3 MTIE & TDEV Analysis Report in PDF

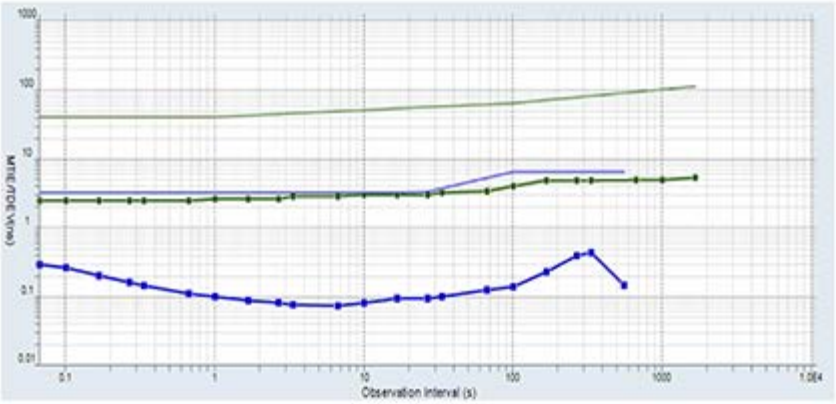
Click on the Report button to generate a copy of the measurement and analysis in PDF format.

Wander Expert Analysis v.1.00
Typical Standard Header information

File: C:\Users\ \Documents\TX Series\Wander Analysis\TIE log files\E1warmup 28min\mtie
Start Time: 1/17/2012 11:05:30 AM
End Time: 1/17/2012 11:33:13 AM
ET: 1663 s
MTIE/TDEV Range: 0 to 1663
Sampling Interval: 30/s
Total Sampling: 49916
Frequency Offset(ppm): -0.00000003628156 Not Removed
TIE (ns)



MTIE/TDEV Masks: G.813 - Option 1 SDH Equipment Slave Clock (SEC) at constant temperature √ Pass
MTIE
TDEV



Go back to top Go back to TOC

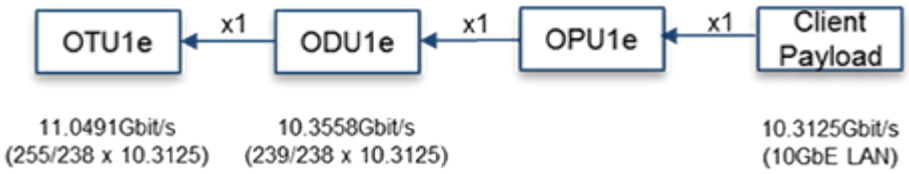
14.0 OTU-Xe

14.1 OTU-Xe Overview

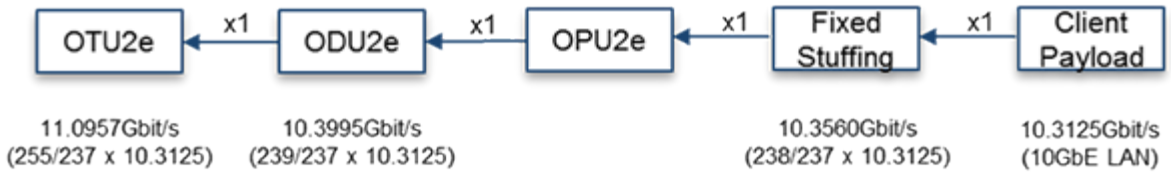
Overclocked OTN Testing

An Overclocked option verifies extended bit rates to ITU-T series G supplement 43 standards. Overclocked OTN compensates for the rate mismatch between 10 GbE LAN and OPU2 payload by raising the overall OTU2 data rate from the standard 10.709 Gbps to fit the 10GbE LAN client signal.

OTU1e (11.0491Gbps) bit rate support (without fixed stuffing)



OTU2e (11.0957Gbps) bit rate support (with fixed stuffing)



Overclocked OTN supports the following two optical line rates for mapping 10GbE LAN signals.

G.709 Interface	Line Rate	SONET/SDH and Ethernet rate	Line Rate
OTU-1	2.666 Gbit/s	STM-16/OC-48	2.488 Gbit/s
OTU-2	10.709 Gbit/s	STM-64/OC-192	9.953 Gbit/s
OTU-1e	11.0491 Gbit/s	10GbE LAN	10.3125 Gbit/s
OTU-2e	11.0957 Gbit/s	10GbE LAN	10.3125 Gbit/s

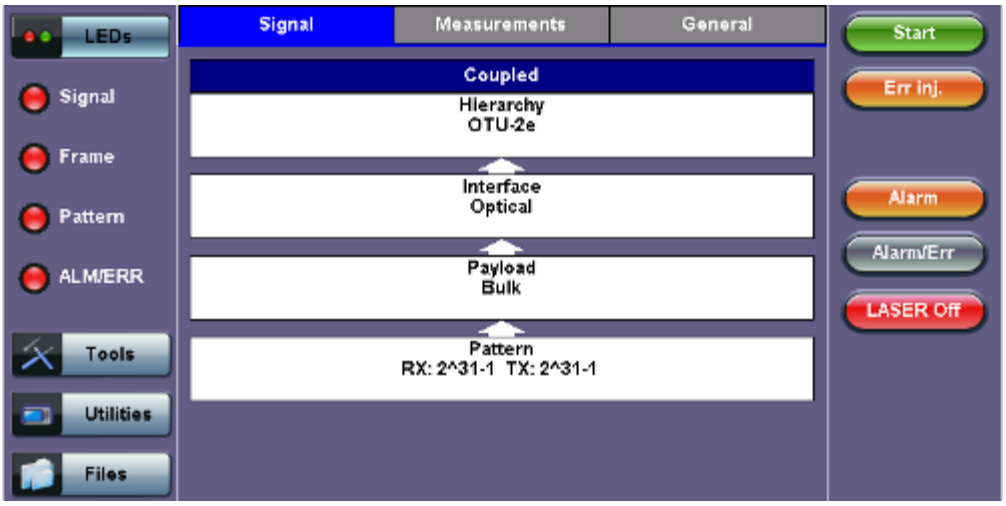
Go back to top Go back to TOC

14.2 OTN Setup

Tap on the Setup icon to access the tabs featured in this section.

14.2.1 Signal Setup

Signal Setup



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

14.2.1.1 Hierarchy

To access the Hierarchy setting, tap on the Hierarchy box from the Signal tab.

Hierarchy Setup

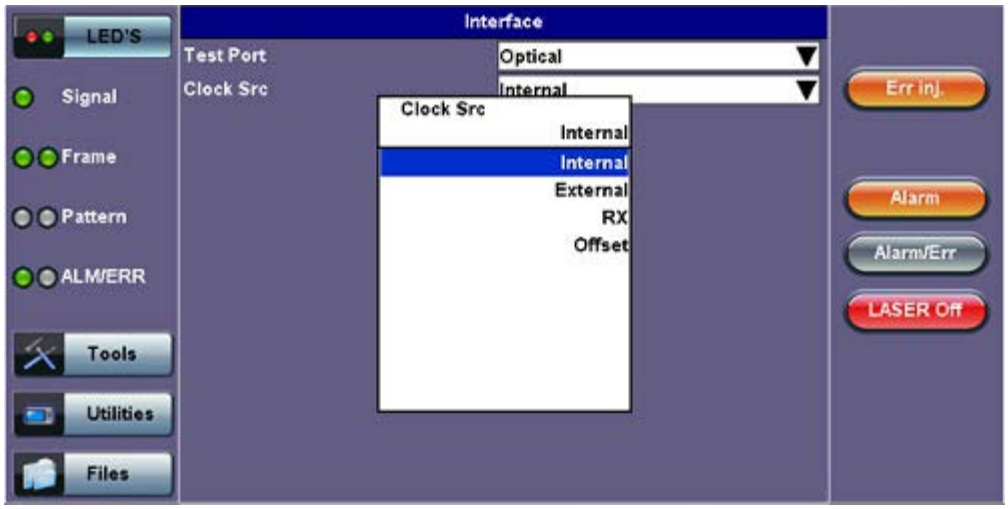
- **Test Rate:** Options are OTU-1e and OTU-2e (referring to 11.049G and 11.095G respectively).
- **OTN Mapping:** 10GE SYNC, 10GE ASYNC, and Test pattern. Overclocked OTN is technology that enables the transparent transportation of 10GbE LAN signals over OTN networks as per ITU-T series G supplement 43 are supported. The multiplexing structure is shown below.
- **Scrambler:** ON/OFF.
- **FEC:** FEC encoder can be ON/OFF (activated/deactivated).

Go back to top Go back to TOC

14.2.1.2 Interface

Tapping the Interface box opens the Interface Setup screen.

Interface Setup



- **Test Port:** Optical interface is available for OTU-1e, OTU-2e signals.
- **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
        - 2Mbps (or 1.5Mbps) signal
        - 2MHz (or 1.5MHz) BITS clock
        - 64Kbps (co-directional) present on the SMA connector
        - 2Mbps signal present on the RX2 balanced or RX2 BNC unbalanced

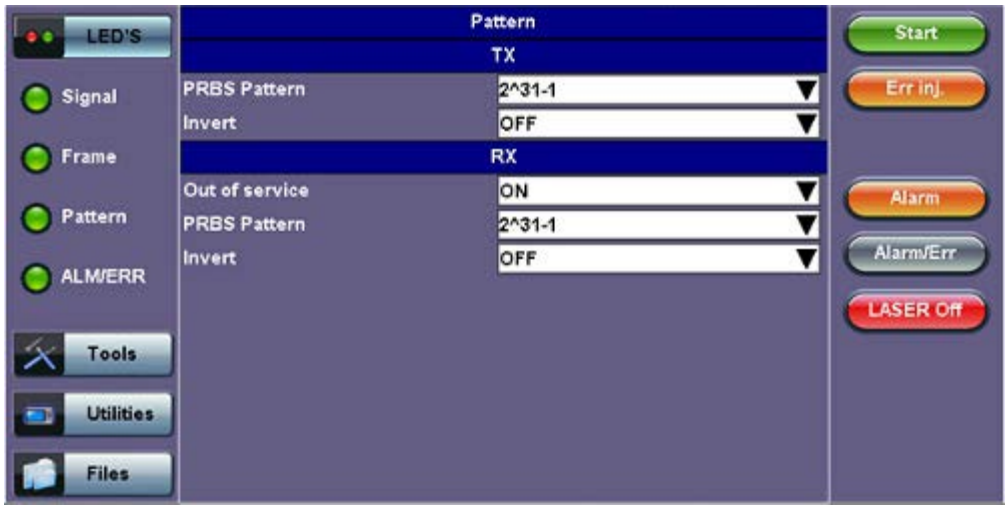
      These options can be selected from them **Clock External** box.
    - **Rx:** The clock for the transmitter is derived from the received signal and the jitter of the incoming signal is suppressed.
    - **Offset:** The clock for the transmitter is derived from the internal clock generator. It can change 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.
- **Aux Line Code** (1.5 Mbps, 2 Mbps only): HDB3, B8ZS, AMI

Go back to top Go back to TOC

14.2.1.3 Pattern

Tapping the Pattern box opens the Pattern Setup screen. The pattern setup will show when OTN Mapping is set to Test Pattern.

Pattern Setup

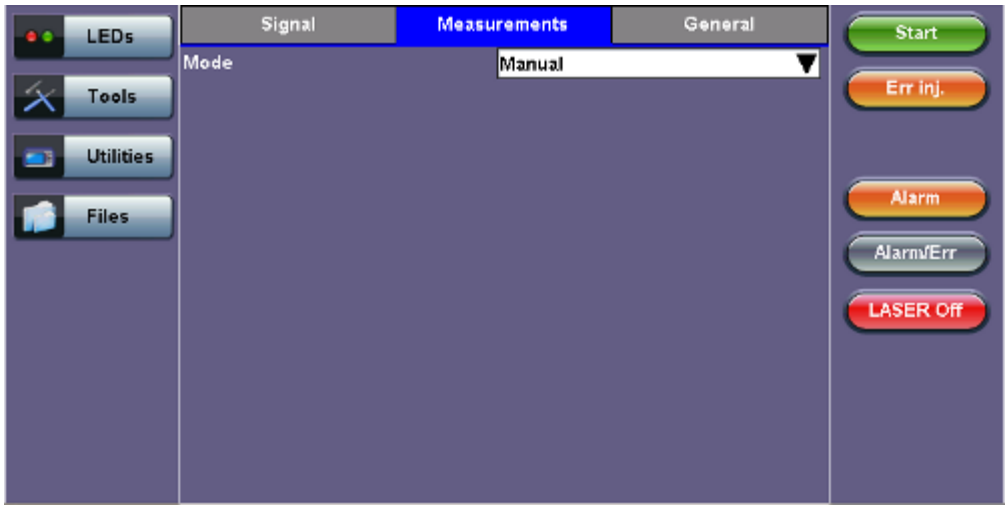


- **PRBS Pattern:** Use the pattern drop-down box to select the test pattern which will be inserted into the transmitted signal. Pseudo Random Bit Sequences (PRBS) defined by ITU-T 0.150 and 0.151 standards, fixed words and 24-bit or 32 bit user defined patterns are available. Note, if the 32 bit user pattern entered is incorrect, the default pattern will be 0xFFFFFFFF.
- **Invert:** Inversion of PRBS polarity is also available. Inversion of fixed words is not permitted.

Go back to top Go back to TOC

14.2.2 Measurements

Measurements tab

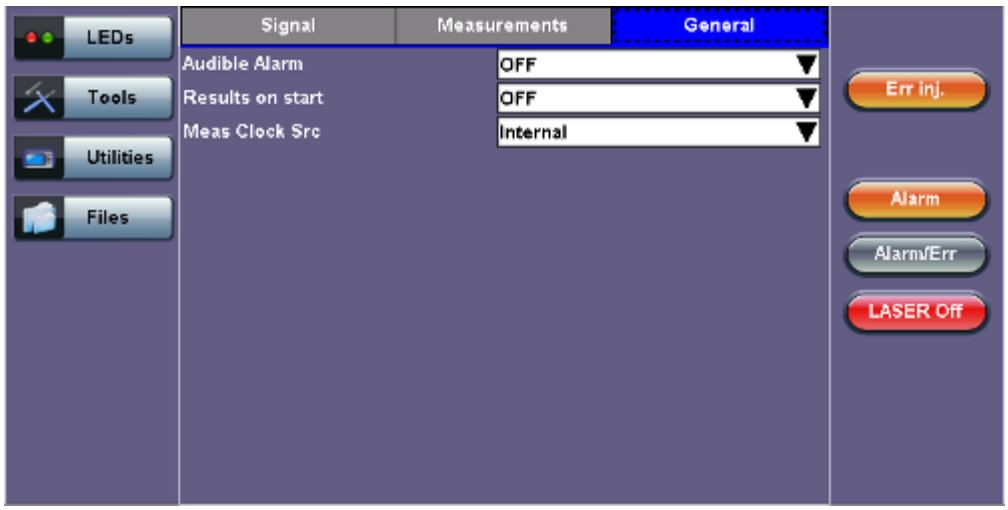


Manual mode is chosen as the default configuration for starting/stopping the test.

Go back to top Go back to TOC

14.2.3 General

General tab



- **Audible Alarm:** OFF, ON.
- **Results on start:** On or Off. Provides an automatic move to Result screen when it starts.
- **Measurement Clock Source:** Internal Clock or Tx Clock Source; the measurement is synchronized to the Transmitted (Tx) Clock.

Go back to top Go back to TOC

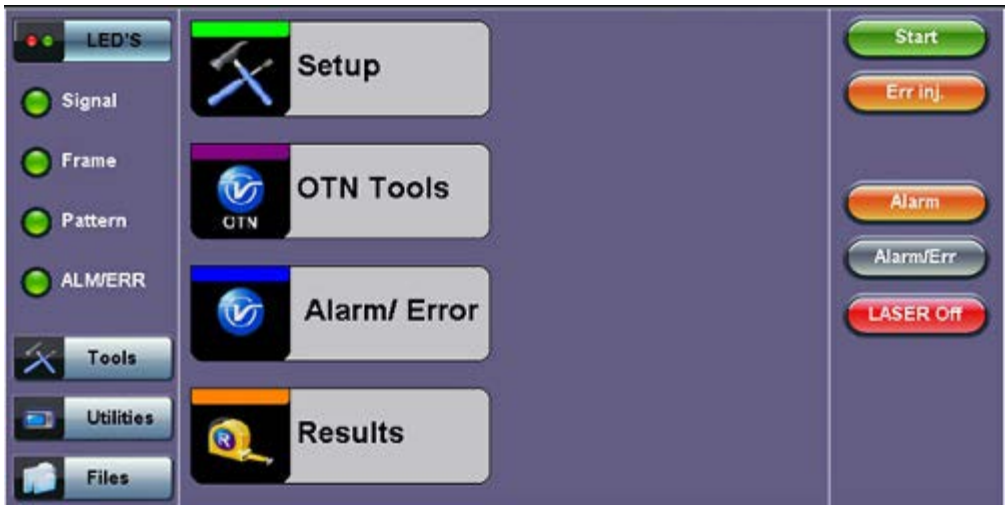
14.3 OTN Results

Accessing OTN Results

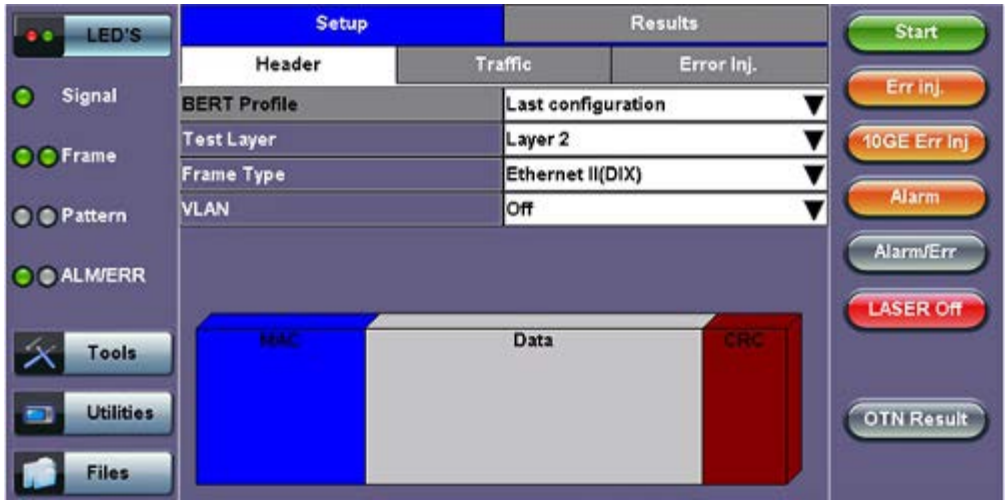
Measurements are accessed by tapping the **Results** icon in the main menu. The results comprise of a range of tabbed pages, similar to the setup pages. If Ethernet options are enabled, the Results icon will not be available on the Home menu. To access results, press the **OTN Results** button

from the selected Ethernet application.

OTN Menu



OTN Menu (Ethernet BERT application)



Go back to top Go back to TOC

14.3.1 Summary

The Summary tab displays a summary page 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 OTN signal and its payload.

Summary tab

Go back to top Go back to TOC

14.3.2 Errors/Alarms

The Error/Alarm tab brings up several pages showing the errors and alarm 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 to the applicable result screen which provides detailed information.

The LED headers are described in the table below:

Alarm Definitions and Descriptions	
OTU	Optical channel Transport Unit
ODU	Optical channel Data Unit
OPU	Optical channel Payload Unit
PAT	Pattern detection (PRBS, User, fixed words)

OTN Error and Alarm definitions per ITU-T G.709 recommendations:

OTU Alarm Definitions Detection criteria according to G.709 and G.798	
LOF	Loss of Frame - Declared when the OOF states have been constantly observed for 3 ms respectively
OOF	Out of Frame - Declared if it fails to find an FAS sub-pattern (FAS bytes 3, 4, and 5) for five consecutive frames.
LOM	Loss of Multiframe - Declared when the OOF states have been constantly observed for 3 ms respectively
OOM	Out of Multiframe - Declared when the received MFAS is out of sequence for five consecutive frames
OTU-AIS	Alarm Indication Signal - PN-11 sequence (covers complete Och) ≥ 3 x 8192 bits
OTU-IAE	Incoming Alignment Error - This bit allows the ingress to inform the egress that an alignment error in the incoming signal has been detected. • IAE = 1 with error • IAE = 0 no error • Status (STAT) These three bits indicate the presence of maintenance signals (AIS, OCI, TCM, IAE)
OTU-BDI	Backward Defect Indication - This single bit conveys information regarding signal failure in the upstream direction • BDI = 1 indicates OTUk backward defect • BDI = 0 otherwise
OTU-TIM	Trail Trace Identifier Mismatch

OTU Error Definitions Detection criteria according to G.709 and G.798	
FAS	Frame alignment signal - Uses the first six bytes and , to provide framing for the entire signal
MFAS	Multiframe alignment signal - Used to extend command and management functions over several frames. The MFAS counts from 0 to 255, providing a 256 multiframe structure.
BIP-8	Bit interleaved parity-8 code
BEI	Backward error indication -SM byte 3, bit 1 to 4: value 0 to 8: SM BIP-8 error count value 9 to 15: no SM BIP-8 errors value 11: SM BIAE
BIAE	Backward incoming alignment error - SM byte 3, bit 1 to 4: " 1011" ≥ 3 frames
CFEC	Correctable FEC error
UFEC	Uncorrectable FEC error

ODU Alarm/Error Definitions Detection criteria according to G.709 and G.798	
ODU-BEI	Backward error indication -PM byte 3, bit 1 to 4: value 0 to 8: SM BIP-8 error count value 9 to 15: no SM BIP-8 errors
ODU-AIS	Alarm Indication Signal - PM byte 3, bit 6 to 8: " 111" ≥ 3 frames
ODU-OCI	Open connection indication - PM byte 3, bit 6 to 8: " 110" ≥ 3 frames
ODU-LCK	Locked - PM byte 3, bit 6 to 8: " 101" ≥ 3 frames
ODU-BDI	Backward Defect Indication - PM byte 3, bit 5 = 1 ≥ 5 frames
ODU-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.
ODU-TIM	Trail Trace Identifier Mismatch

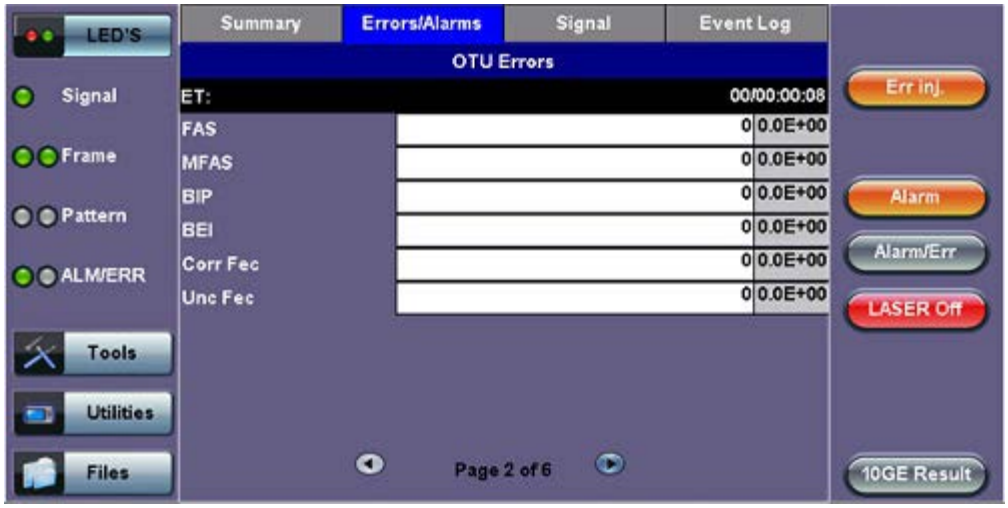
BERT	Description
LSS	Loss of Sequence Synchronization
Bit	Bit error

Go back to top Go back to TOC

Errors/Alarms (Page 2)

Page 2 lists the **OTU Errors** 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. Error conditions are displayed in red including count and rate.

Errors/Alarms (Page 2)

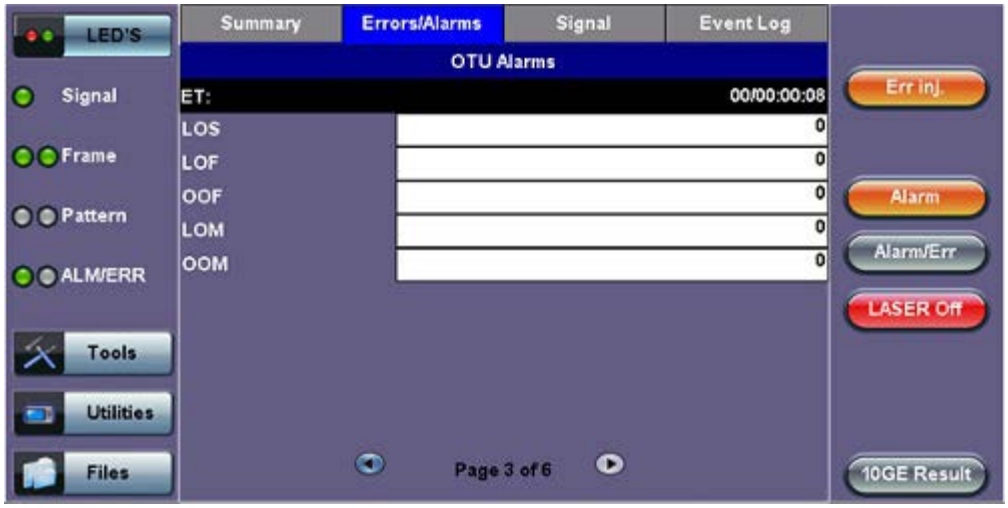


Go back to top Go back to TOC

Errors/Alarms (Page 3 & 4)

Page 3 & 4 lists the **OTU Alarms** in logical order associated with the signal under test. All alarms are evaluated and stored. The Elapsed Time [ET] since the start of the test is shown in the upper right hand corner.

Errors/Alarms (Page 3)



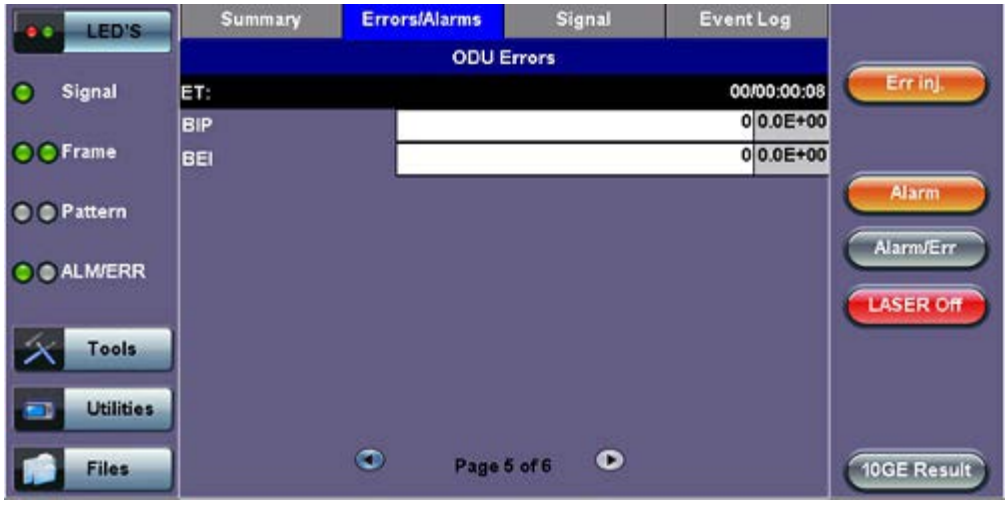
The alarms associated with the Section and Line are displayed separately for ease of interpretation.

Go back to top Go back to TOC

Errors/Alarms (Page 5 & 6)

Page 5 & 6 lists the **ODU/OPU Errors and Alarms** in logical order that are associated with the signal under test. All alarms are evaluated and stored.

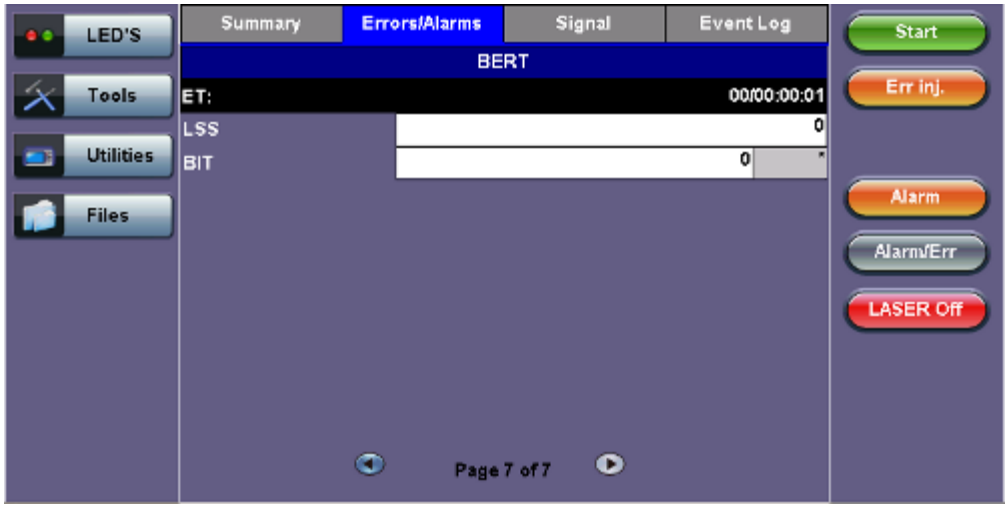
Errors/Alarms (Page 5)



Errors/Alarms (Page 7)

Page 7 lists the **BERT Errors/Alarms** in logical order that are associated with the signal under test. All alarms are evaluated and stored.

Errors/Alarms (Page 7)



Go back to top Go back to TOC

14.3.3 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.

- **Number (#):** Event number; events are numbered sequentially.
- **Type:** Indicates alarm or error type.
- **Start:** Indicates when the alarm or error was detected.
- **Dur/Count:** Indicates for how long the alarm or error was detected and provides duration (alarms) and ratio/count (errors). The duration format is day:hour:minute:second.

Event Log

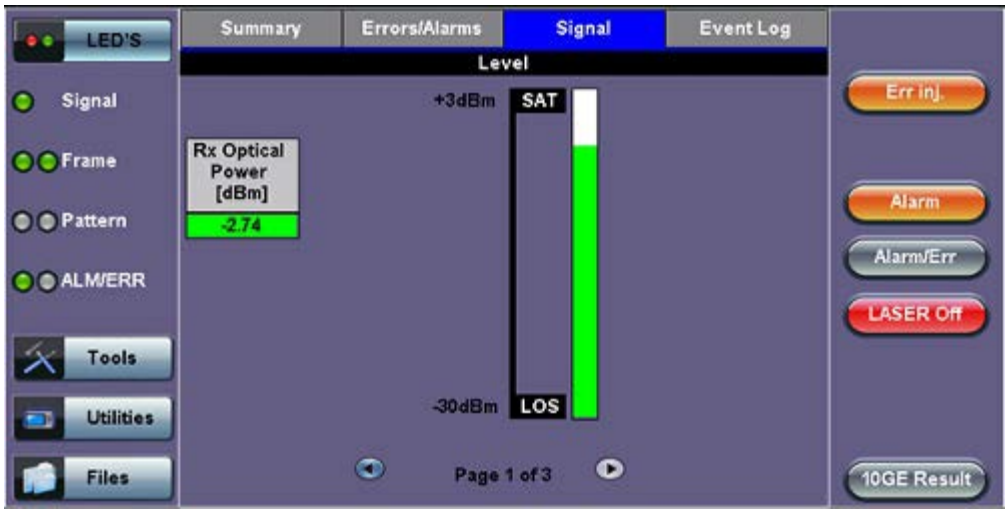
Go back to top Go back to TOC

14.3.4 Signal

Level (Page 1)

The Signal tab displays the Level and Frequency screen. Page 1 displays the level measurement Loss of Signal (LOS); the Saturation level for optical signals is shown graphically, including the level measurement in dBm.

Signal (Page 1)

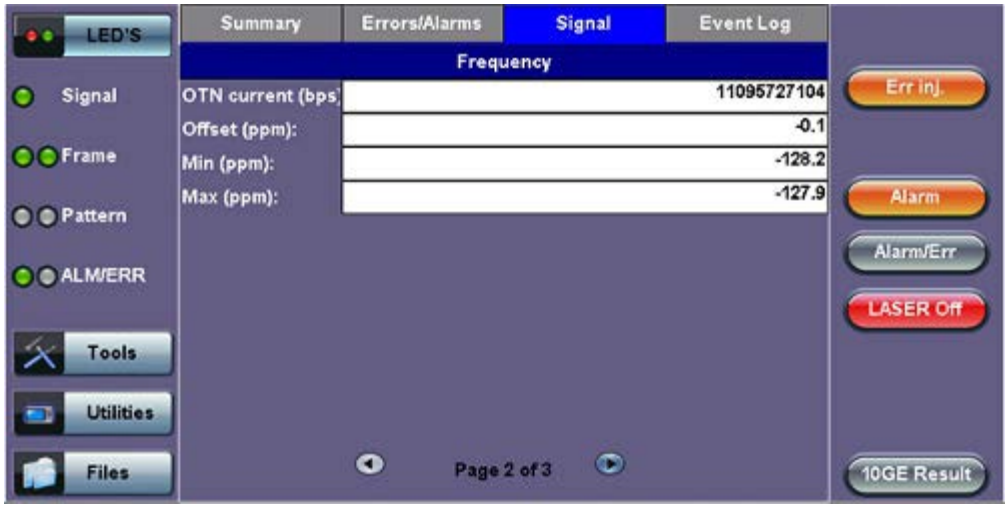


Go back to top Go back to TOC

Frequency (Page 2)

The received signal frequency and offset is measured and displayed. For OTN signals, the measurement is performed on optical interfaces (XFP).

Signal (Page 2)



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

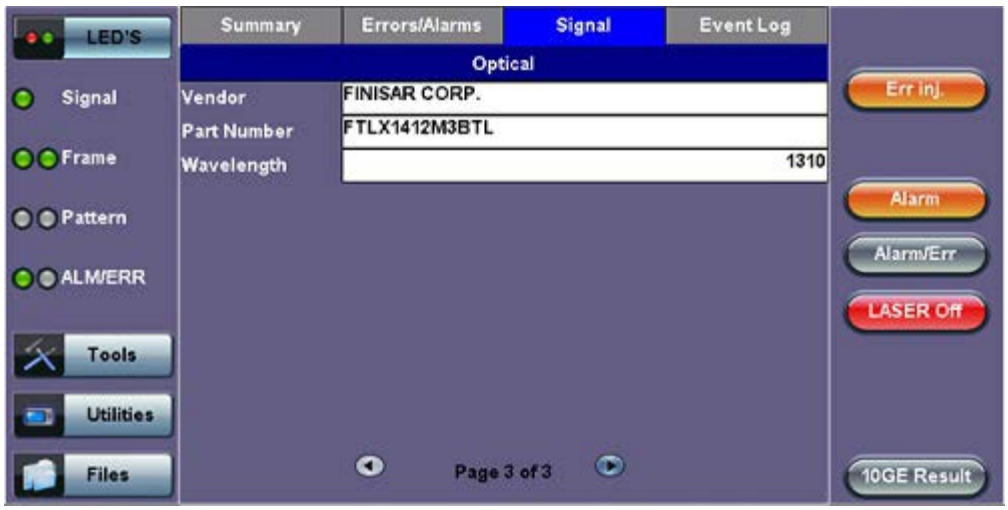
- **OTN Current (bps):** Indicates the frequency of the input signal
- **Offset (ppm):** Indicates the difference between the standard rate and the rate of the input signal
- **Min (ppm):** Indicates the difference between the standard rate and the minimum deviation detected in the input signal
- **Max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

Go back to top Go back to TOC

Optical Information (Page 3)

Page 3 displays the Optical module XFP information which includes Vendor name, Part number and Optical Wavelength.

Signal (Page 3)

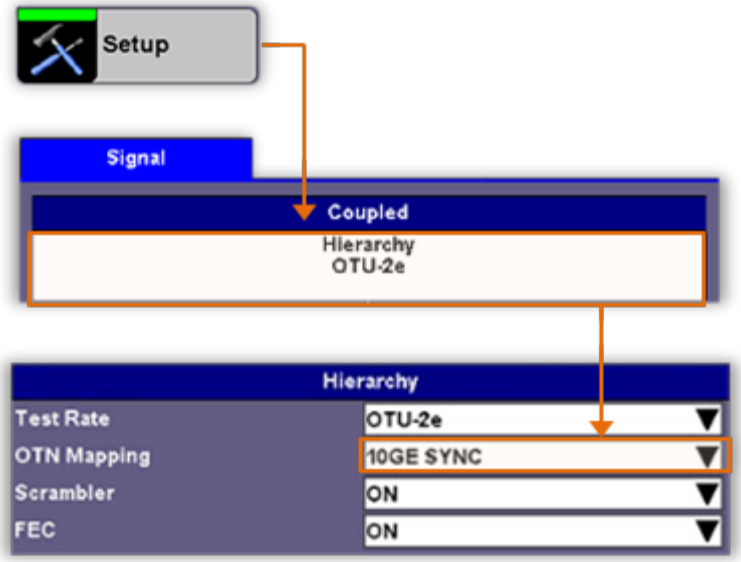


Go back to top Go back to TOC

14.4 OTU-Xe Ethernet Applications

Accessing Ethernet Applications from OTU-Xe

To enable and access Ethernet applications from the Home menu (RFC 2544, BERT, Throughput), tap on **Setup** [Home menu] > **Hierarchy** > **OTN Mapping** and select 10GE SYNC or 10GE ASYNC from the drop-down menu.



Hierarchy Setup

After configuring the OTU-Xe signal, press the **Home Key** on the keypad and tap on the desired Ethernet test.

OTN Home Menu with Ethernet Options

Setup and results for Ethernet applications featured in OTU-x (-1e, -2e) are the same as those featured in Ethernet Testing mode. Please refer to the corresponding Ethernet testing section for more information on the following applications:

- **14.4.1 OTU-Xe with 10GE BERT** redirects to 15.2 BERT
- **14.4.2 OTN/10GE RFC 2544 Conformance Testing** redirects to 15.3 RFC 2544 Conformance Testing
- **14.4.3 OTN/10GE Throughput Testing (Multiple Streams)** redirects to 15.5 Throughput Testing

Go back to top Go back to TOC

15.0 Ethernet

Test mode, test port(s), and network settings are required prior to performing any measurements or applications.

- Setup
  - Test Port Selection
  - Port Setup
  - 1GE Fiber Port
  - 1GE Copper Port
  - 10GE Port
- Measurement Settings
- Clock Synchronization Process
- MX Discover and Control
- OAM Discover
- ViPAG Router Test
  - ViPAG Setup
  - ViPAG Results

15.1 Ethernet Setup

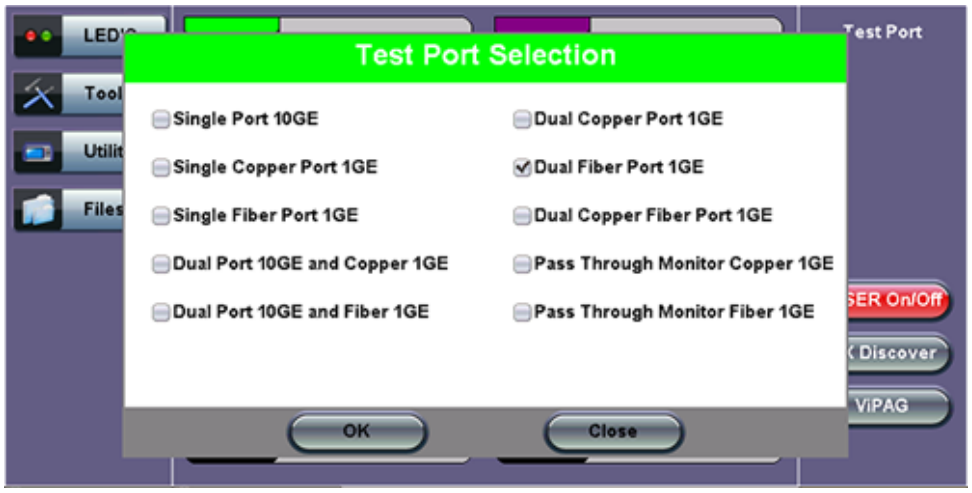
15.1.1 Test Port Selection

This menu is accessed via the Test Port button located at the top right hand side of the screen. Depending on interface options purchased, the following selections are possible:

- Single port 10GE (10 GE XFP Port 1)
- Single Copper port 1GE (1 GE Copper Port 1)
- Single Fiber port 1GE (1 GE Fiber Port 1)
- Dual port 10GE and Copper 1GE (10 GE XFP Port 1 and 1 GE Copper Port 2)
- Dual port 10GE and Fiber 1GE (10 GE XFP Port 1 and 1 GE Fiber Port 2)
- Dual Copper port 1GE (1 GE Copper Port 1 and 1 GE Copper Port 2)
- Dual Fiber port 1GE (1 GE Fiber Port 1 and 1 GE Fiber Port 2)
- Dual Copper Fiber port 1 GE (1 GE Copper Port 1 and 1 GE Fiber Port 1)
- Pass Through Monitor Copper 1 GE (1 GE Copper Port 1 and 1 GE Copper Port 2)
- Pass Through Monitor Fiber 1 GE (1 GE Fiber Port 1 and 1 GE Fiber Port 2)

After selecting the test interface click **OK** button located at the bottom of the pop-up window.

Test Mode Selection



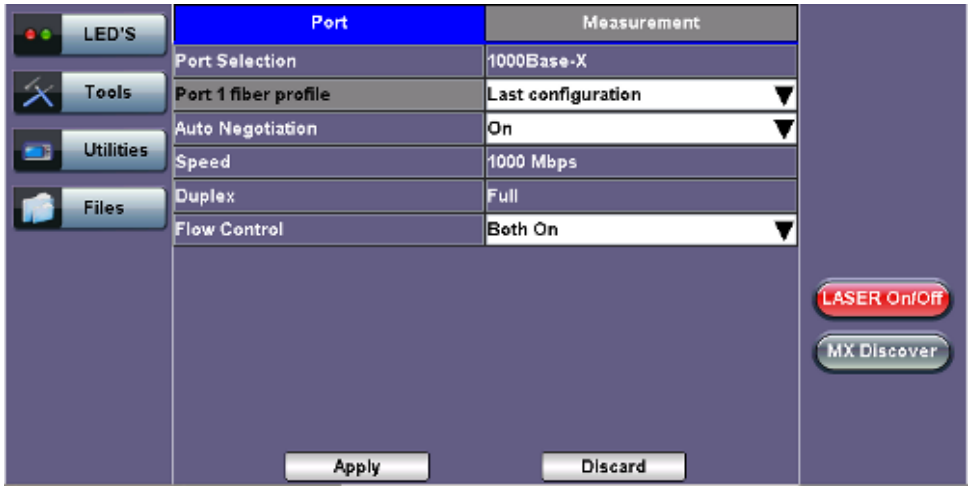
Go back to top Go back to TOC

15.1.2 Port Setup

Port setup or test interface configuration are accessed via the Setup menu located on the Home page. The available configuration settings depend on the interface selected in the Test Mode selection.

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

1 GE Fiber Port Setup

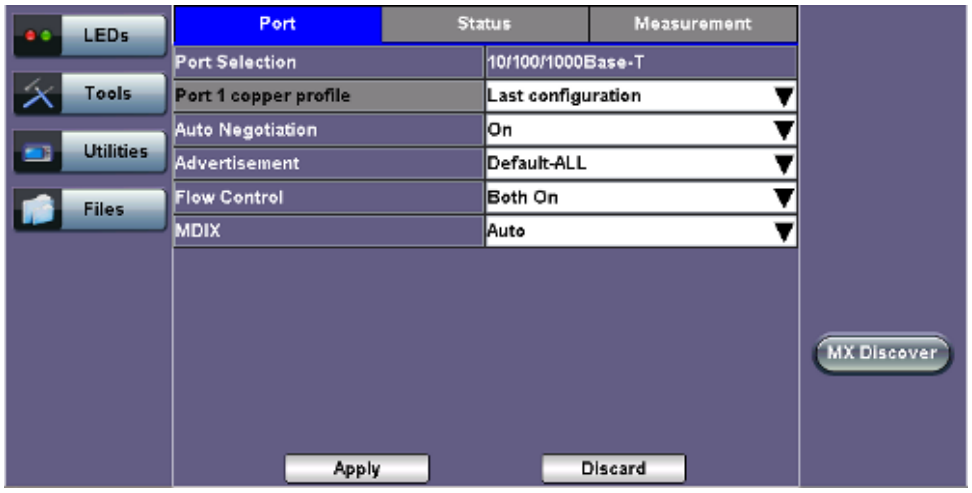


Go back to top Go back to TOC

1 GE Fiber Port

- **Auto Negotiation:** On or Off. Matches the test set's negotiation settings to those of the link partner
- **Speed:** Default set to 1000 Mbps
- **Duplex:** Default set to Full
- **Flow Control:** TX On, RX On, Both On, or Off
  - When flow control is enabled, the test set will respond to pause frames received by the link partner by adjusting the transmit rate
  - When flow control is disabled, the test set ignores all incoming pause frames from the link partner and continues transmitting at the configured transmit rate

1 GE Copper Port Setup



Go back to top Go back to TOC

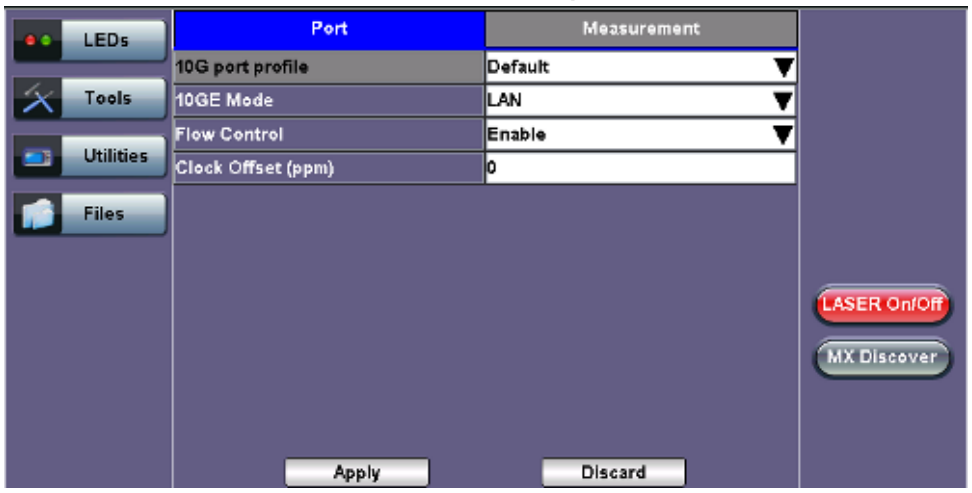
1 GE Copper Port

- **Auto Negotiation:** On or Off. Matches the test set's negotiation settings to those of the link partner.
  - **Speed** (only when Auto Negotiation is Off): 10 Mbps, 100 Mbps, 1000 Mbps.
  - **Duplex** (only when Auto Negotiation is Off): Half or Full.
  - **Advertisement** (only when Auto Negotiation is On): Default-All or Custom. Custom options include 10/100/1000M/Half or 10/100/1000M/Full.
- **Flow Control:** TX On, RX On, Both On, or Off.
  - When flow control is On, the test set will respond to pause frames received by the link partner by adjusting the transmit rate.

- When flow control is Off, the test set ignores all incoming pause frames from the link partner and continues transmitting at the configured transmit rate.

- **MDIX:** Off, On, or Auto. When MDIX is set to Auto, the test set detects the required cable connection type and configures the port connection properly for interfacing the partner device, eliminating the need for crossover cables.

10GE Port Setup



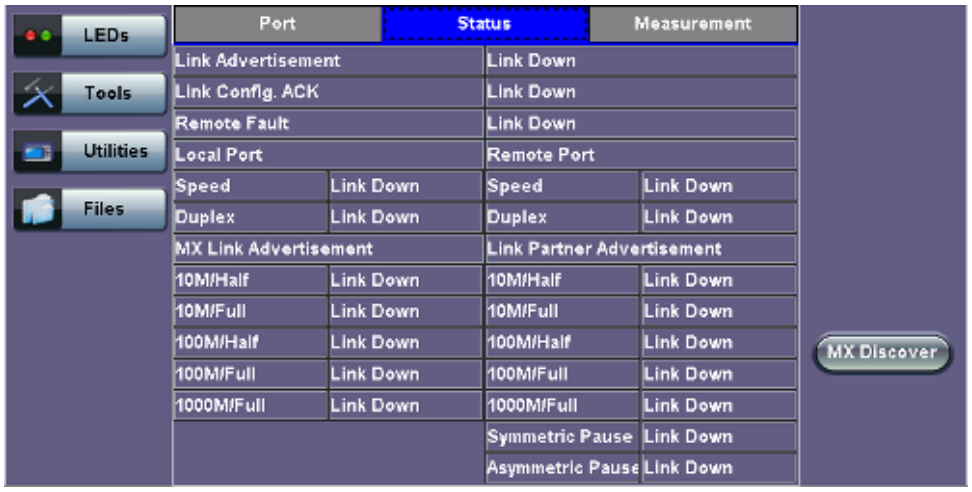
Go back to top Go back to TOC

10 GE Port

- **10GE Mode:** LAN or WAN
- **WIS Mode** (only available in WAN mode): SDH or SONET
- **Flow Control:** Enable chosen as default option
- **Clock Offset (ppm):** The frequency may be offset in parts per million

Status

Status tab



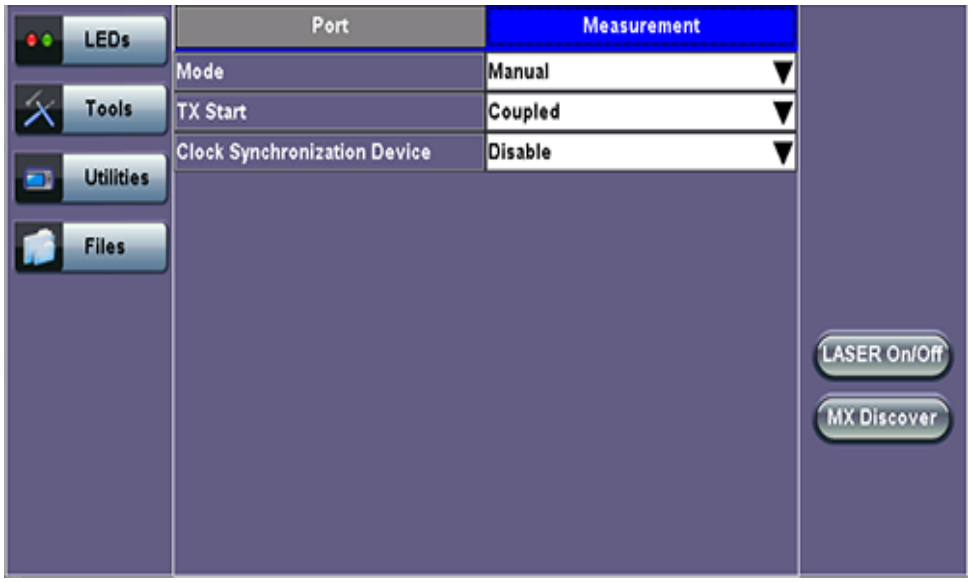
The **Status** tab lists current port settings. Please note that the Status tab is only available if a fiber port option is selected from the **Test Port Selection** menu.

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.*

Go back to top Go back to TOC

15.1.3 Measurement Settings

10GE Measurement Setup



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

- **Profile:** Last configuration, Delete, Save, Save as..., Default.
- **Mode:** Manual, timed, or auto mode are available.
  - **Manual mode:** User starts and stops the measurements manually.
  - **Timed mode:** User defines the duration of the test; after the test is started, the test will run for the configured duration and stop automatically.
- **TX Start:** Tx & Rx, or Tx Separate. Configure how the measurements are started when in BERT and Multiple Streams test modes.
  - **Tx & Rx:** 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.
  - **Tx Separate:** 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.
  - **Tx 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 Synchronization Device:** Disable, GPS, CDMA. Select the device to be used to synchronize the clock to perform the One Way Delay measurement. The choices are GPS and CDMA. The following devices are recommended by VeEX for best performance:
  - GPS: Trimble Thunderbolt E GPS Disciplined Clock
  - CDMA: EndRun Technologies Praecis2

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.*

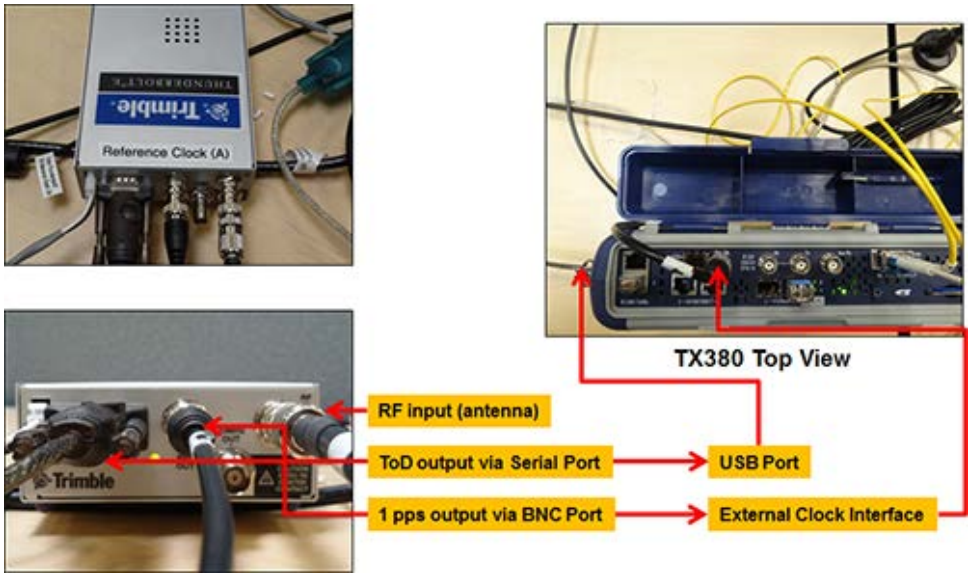
Note: *Clock Synchronization is not supported on all the test set models. Check with customer care for availability.*

Go back to top Go back to TOC

15.1.3.1 Clock Synchronization Process:

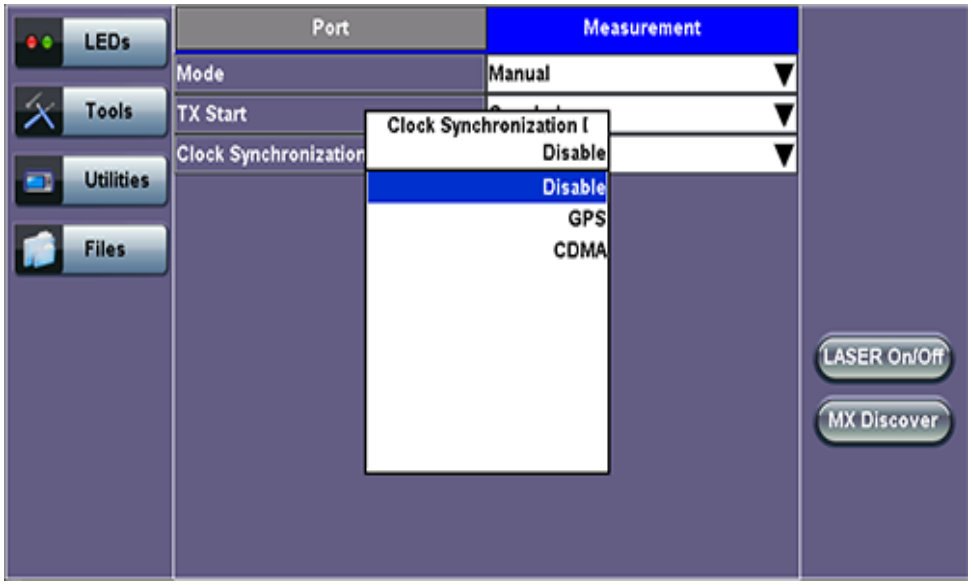
1. Connect the GPS/CDMA Hardware to the test set. The 1pps output of the GPS/CDMA receiver is to be connected to the SMA External Clock port on the test set. Connect the ToD output from the GPS/CDMA receiver to the USB port via a Serial-to-USB converter cable.

Ports Connection



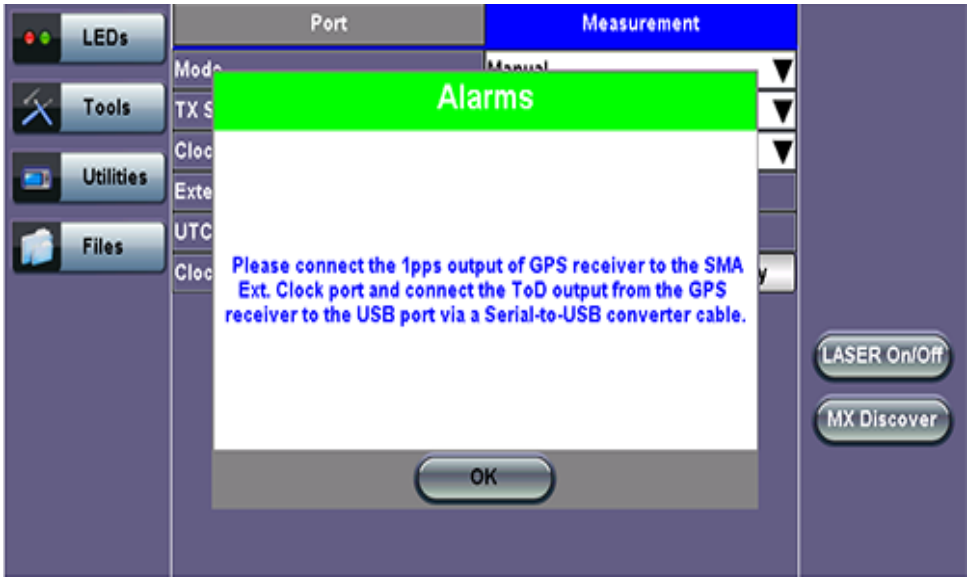
2. Select GPS/CDMA under Setup > Measurement > Clock Synchronization Device.

Clock Synchronization Device



2. The pop-up box asks to ensure that all the connections to the GPS/CDMA hardware are correctly made. Click OK.

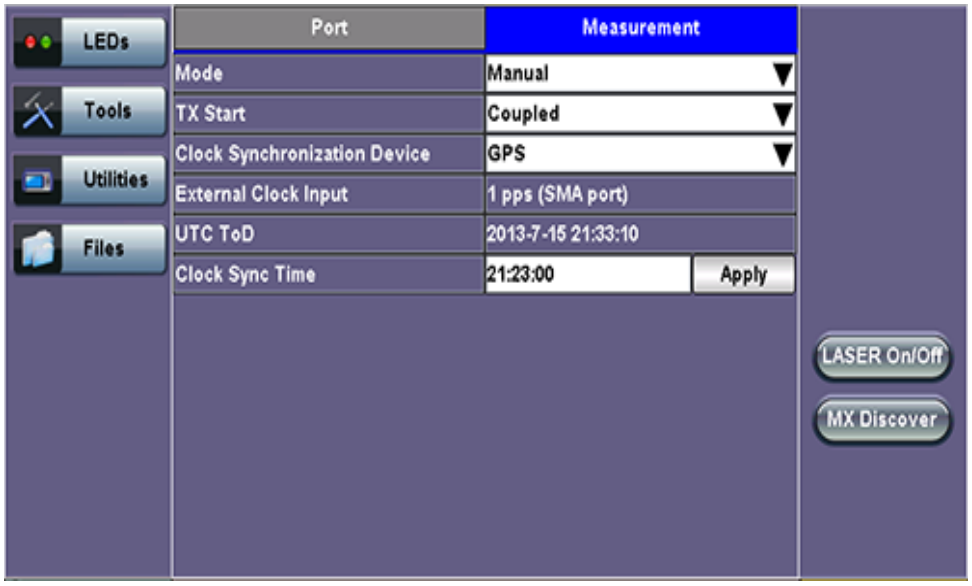
GPS Device Connection



The GPS/CDMA Device will be connected and External Clock Input, UTC ToD and Clock Sync Time fields will show on the screen.

The GPS?CDMA Connection icon on the top of the screen will turn Green if the ToD synchronization is acquired. It will be Red if no synchronization is acquired, and will be Yellow if there is an error / instability.

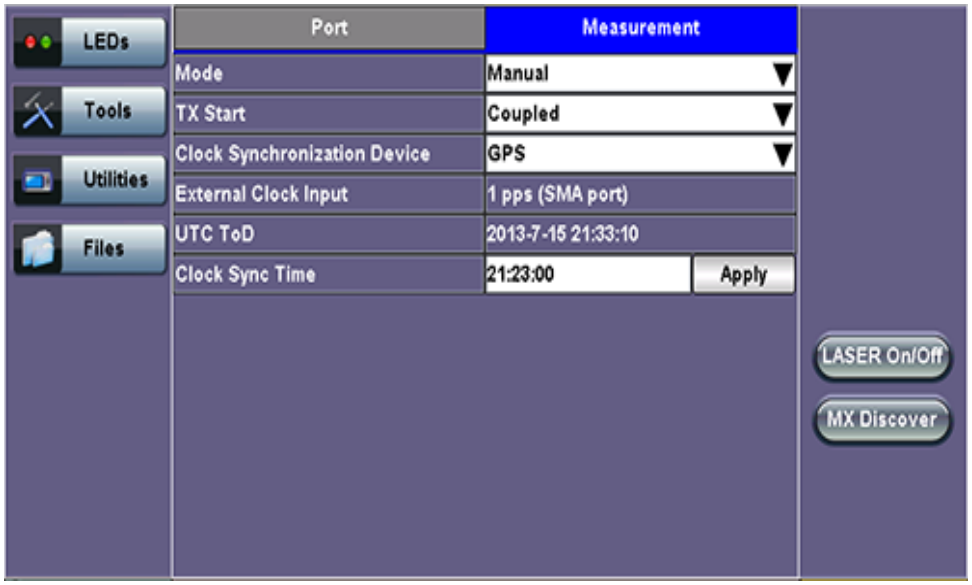
GPS Device Connected



3. Tap the Clock Sync Time field to enter a time to synchronize with the UTC ToD.

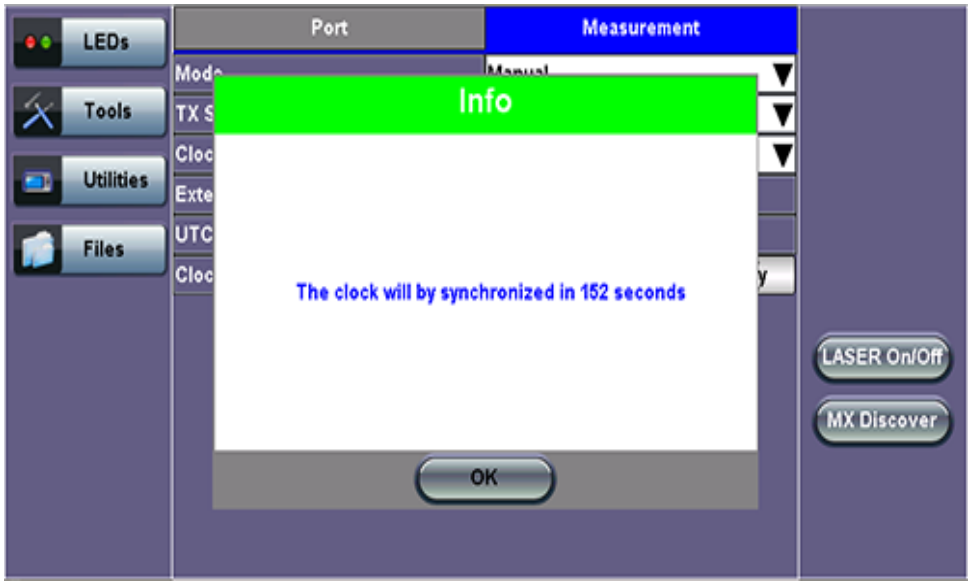
Note: *The same time settings need to be set in the other unit with which the One Way Delay test is to be conducted. Both units need to be synchronized together at the same time.*

GPS Device Connected



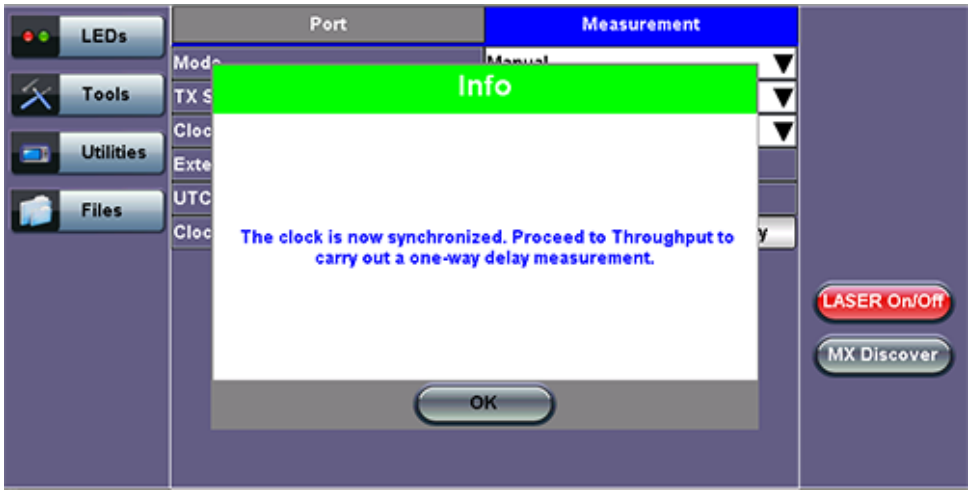
4. The pop-up box will indicate in how many seconds the clock will be synchronized. Click OK.

Clock Synchronization



A pop-up box will indicate when the clock is synchronized. Click OK. The unit is now ready to perform the One Way Delay test.

Clock Synchronized



Go back to top Go back to TOC

15.1.4 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.

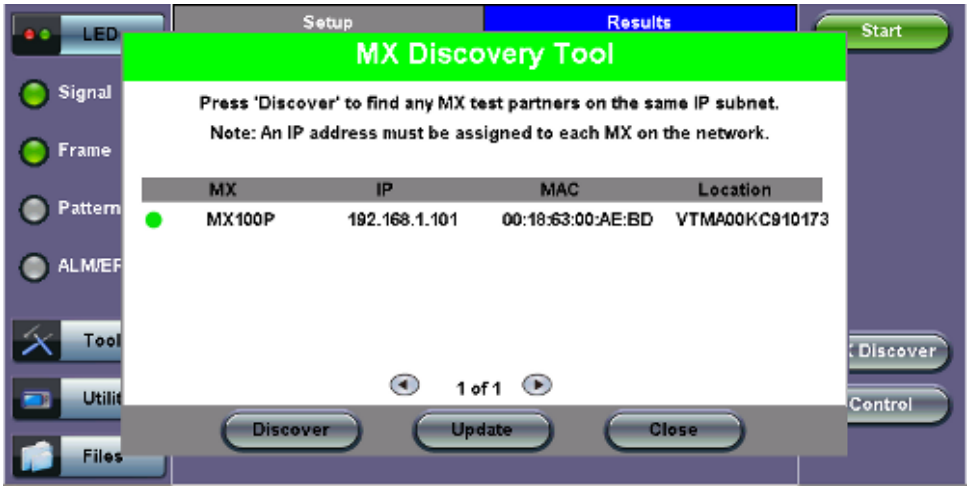
Note: If using OAM Discover, it is unnecessary to assign an IP address to the local or remote unit.

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**:

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

MX Discovery Tool



Control

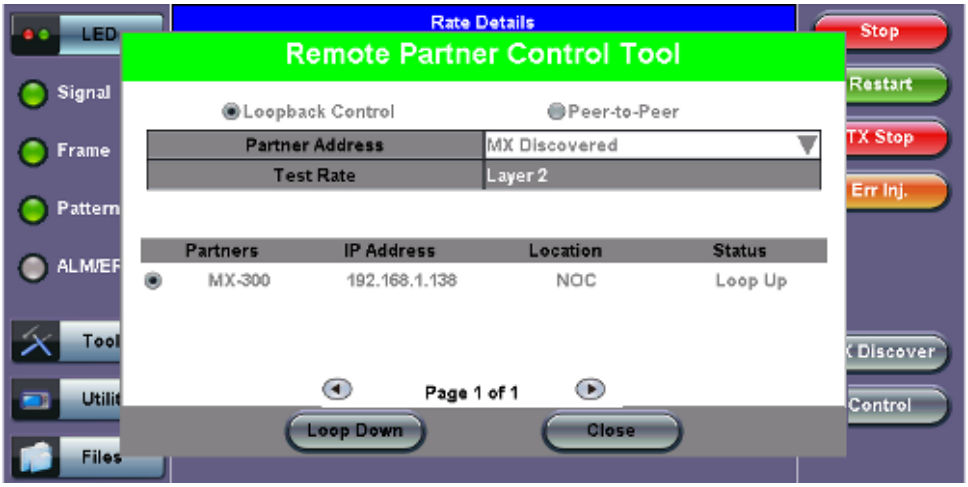
The **Control** button becomes available on the right side menu when any Ethernet application (V-SAM, RFC 2544, Throughput, BERT) is selected. Press the **Control** button to configure loop up and loop down commands necessary to control a far-end unit. The loop up command contains information about the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

Remote Partner Control



The **Peer-to-Peer** option is available only for RFC 2544 testing. For more information on **Peer-to-Peer** mode, please see 15.3.1.4 Peer-to-Peer and Asymmetric Testing.

Go back to top Go back to TOC

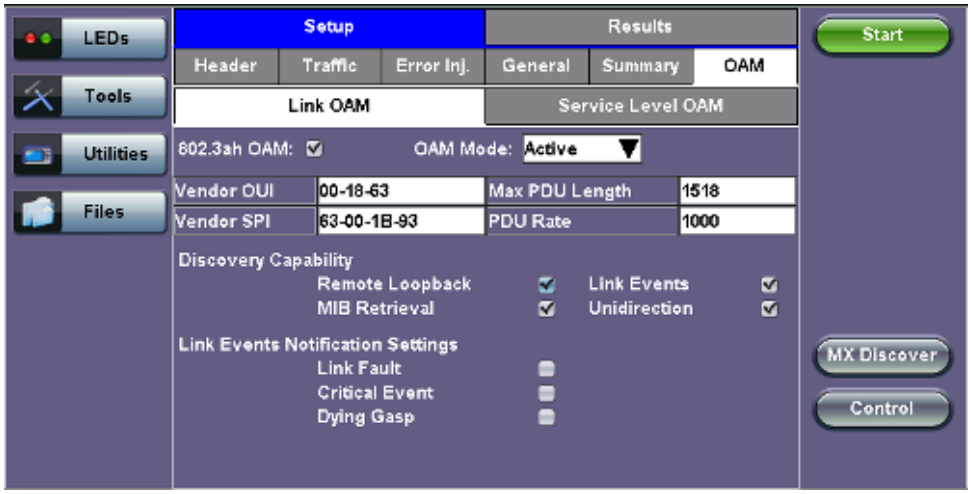
OAM Discover

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:

- Go to **Throughput** > **OAM** > **Link** 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).
- Tap on the **Control** button and select OAM Discover tab to see a list of discovered OAM devices. 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, please see 15.6 Ethernet OAM Testing.

Activating 802.3ah Link OAM



Go back to top Go back to TOC

15.1.5 ViPAG Router Test

The ViPAG function tests end-to-end routed testing for 1G and 10G interfaces. To access ViPAG Router testing:

- Select **Ethernet Test Mode** from the **Test Port Selection** screen, accessed by pressing the **Test Mode icon** Test Mode on the lower-right side of the screen
- Make sure that the 10GE Port is connected to the router 10GE interface and that the 1 GE Fiber Port 2 is connected to the router 1000Base-X or 10/100/1000Base-T interface

- Press the ViPAG icon

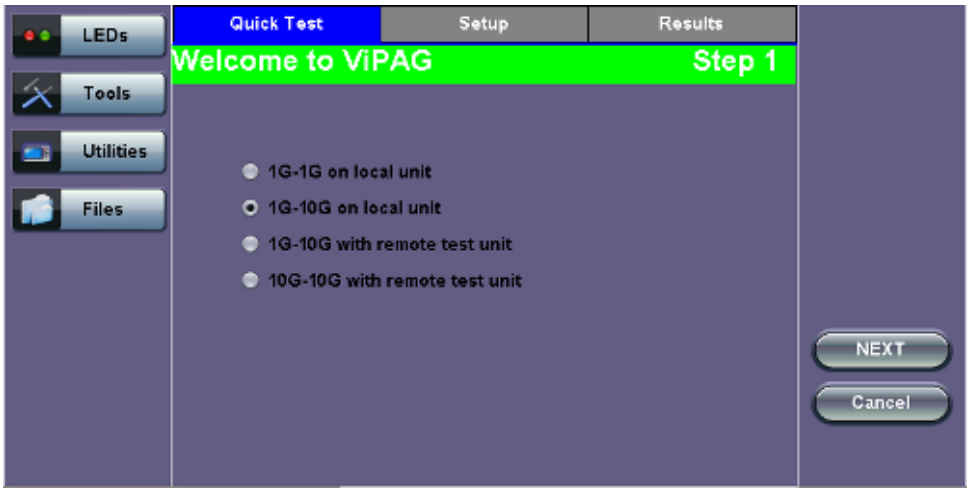
Two test selections are available on the unit:

- **Router Wrap Test:** "On local unit" testing on a single unit
- **End-to-End Test:** "With remote test unit" testing
  - Controller: Carries out the peer-to-peer/asymmetric handshaking, loads the remote profile to the remote unit, and initiates the test
  - Responder: Establishes IP connectivity and waits for the controller to connect/initiate the test

Go back to top Go back to TOC

ViPAG Setup

Step 1: Quick Test Setup

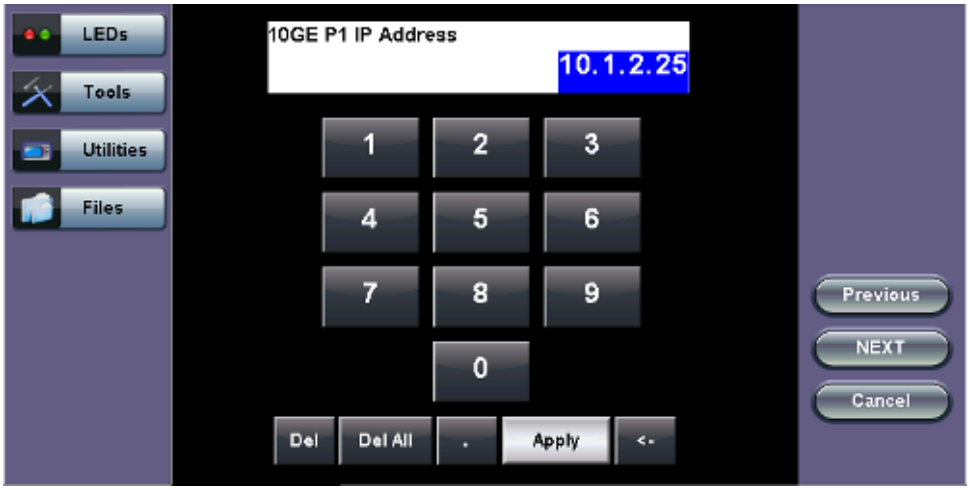


Quick Test Setup

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

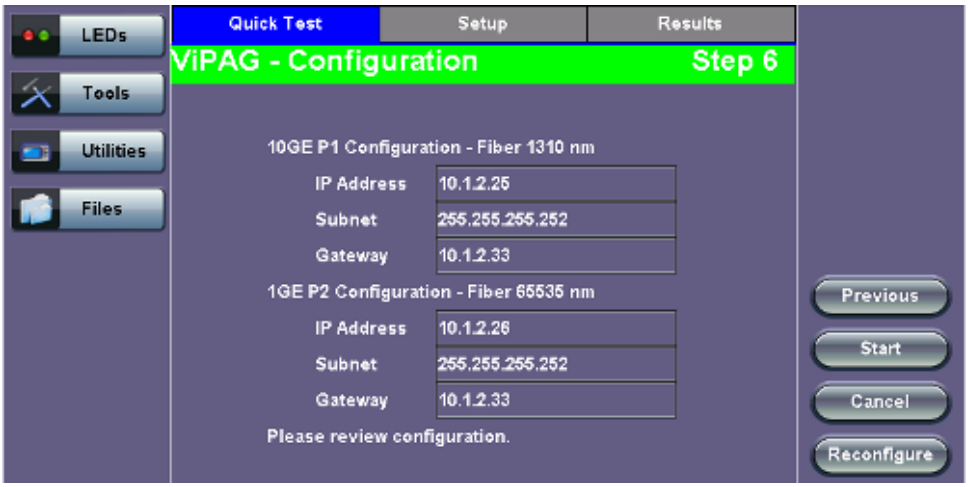
- **Step 1:** Select the router test interface. "Local unit" denotes a router wrap test while "end-to-end" conducts an end-to-end test. The frame size for each option listed below is 256 bytes. The following options are available:
  - 1G-1G on local unit: 1G interface is always set to 100% of the line rate.
  - 1G-10G on local unit: 10G interface is always set to 10% of the line rate.
  - 1G-10G with remote test unit: For Copper or Fiber, Controller is set to 100% of the line rate; remote is 100% of the line rate.
  - 10G-10G with remote test unit: Controller is set to 100% of the line rate; remote is 100% of line rate.
- **Step 2:** Select the copper/fiber ports to be used in the test. If the copper port is selected, configure the port settings: Auto Negotiation, Advertisement and Flow Control.
- **Step 3:** The wavelength for the test ports in use will display at the beginning of Step 3.

Step 4&5: Entering the IP Address



- **Step 4:** Enter the local IP address for port 1. Press **Apply** and configure the subnet mask address. Press **Apply** and enter the gateway address. At the end of Step 4, the screen will display a summary of the IP address, Subnet, and Gateway. Tap on any of the corresponding fields to make any changes, if necessary.
- **Step 5:** Enter the IP address, Subnet, and Gateway for port 2, following the same procedure detailed in Step 4.
- **Step 6:** 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.

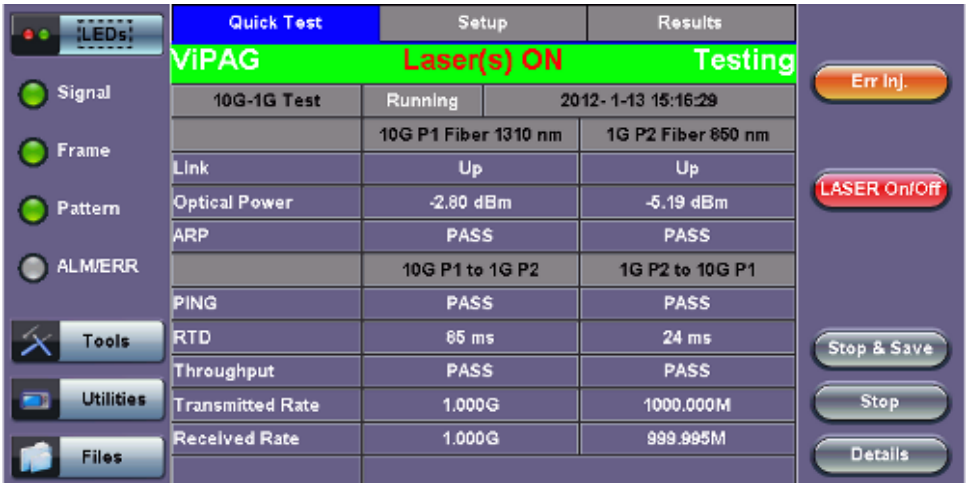
Step 6: Reviewing Configuration Settings



After starting the test, the Error Injection button becomes available and the screen displays Quick Test view and the following results for both ports:

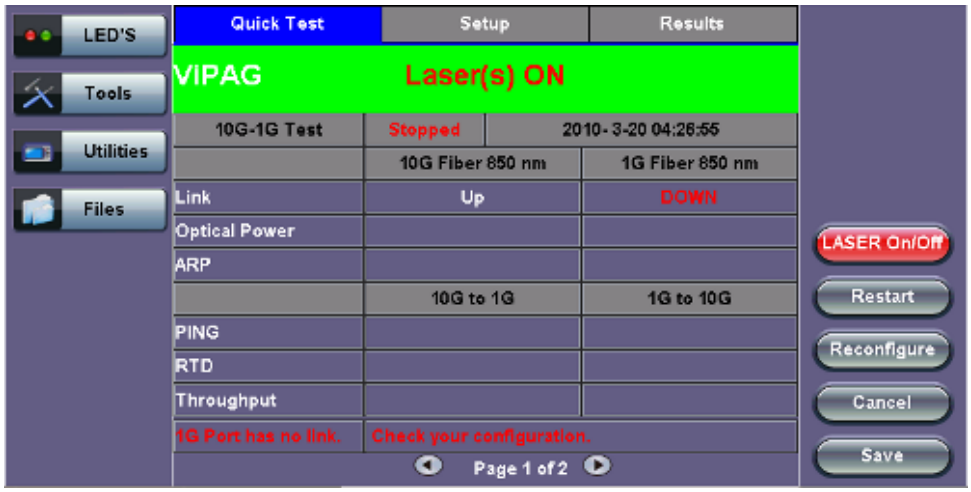
- Link Up/Down status
- Optical Power in dBm
- ARP - Pass/Fail status
- PING - Pass/Fail status
- Round Trip Delay (RTD) measurement in ms
- Throughput - Pass/Fail status
- Transmitted Rate
- Received Rate

Quick Test View



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.

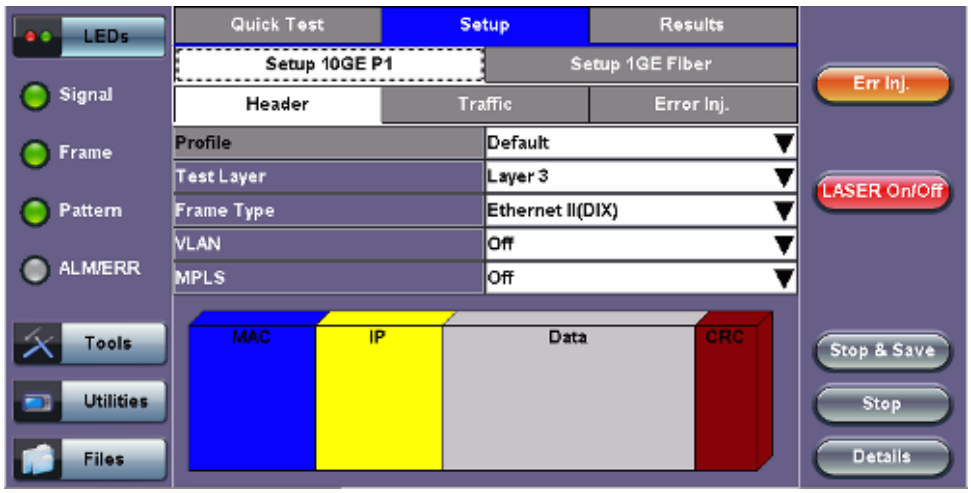
Test Failure



Setup

VePAL test sets come preconfigured. To customize settings for both ports, go to the **Setup** tab. For configuration instructions, please refer to 15.2 BERT.

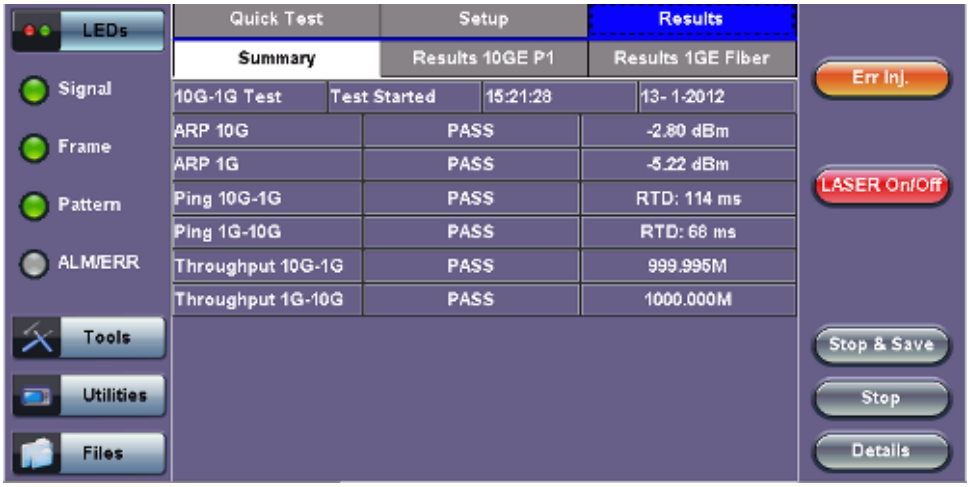
Setup



Go back to top Go back to TOC

Results

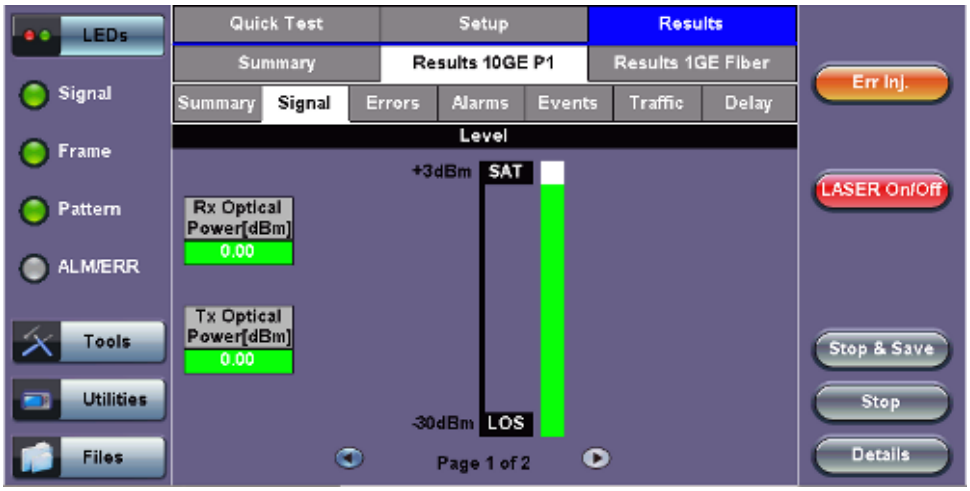
Summary Results



The **Summary** tab lists the Pass/Fail status of each ARP, Ping, and Throughput test along with test measurements.

The **Results** tabs for each port lists statistical results similar to those featured in the BERT Results section. Please see 15.2.2 BERT Results for more information.

Port Results



Go back to top Go back to TOC

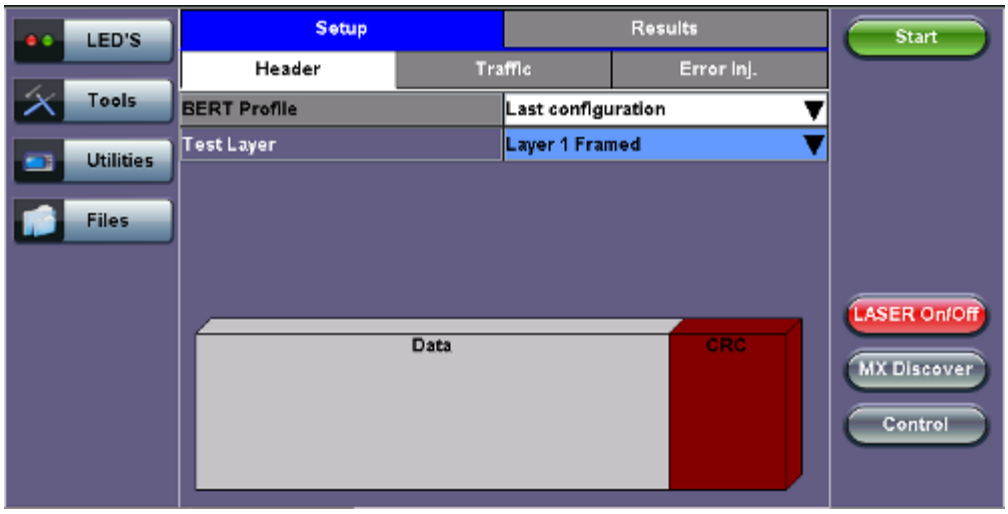
15.2 BERT

15.2.1 BERT Setup

Overview:
BER testing at Layer 1, 2, 3, and 4 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.

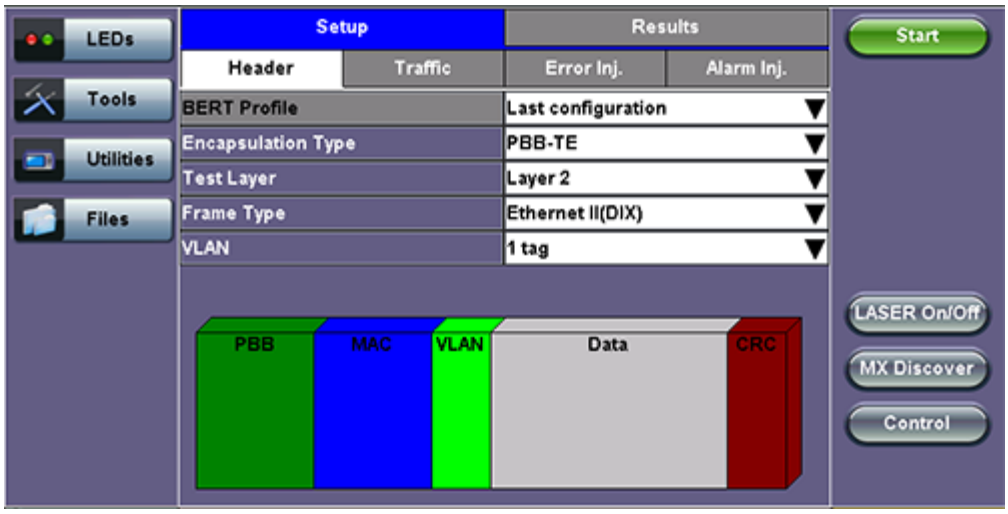
- **Layer 1:** Unframed mode (fiber ports only) or Framed mode
  - **Unframed mode:** Test traffic consists of a bit stream of the selected test pattern
  - **Framed mode:** Test pattern is encapsulated into a valid Ethernet frame with SOF, Preamble, and CRC field

BERT Setup - Header (Layer 1)



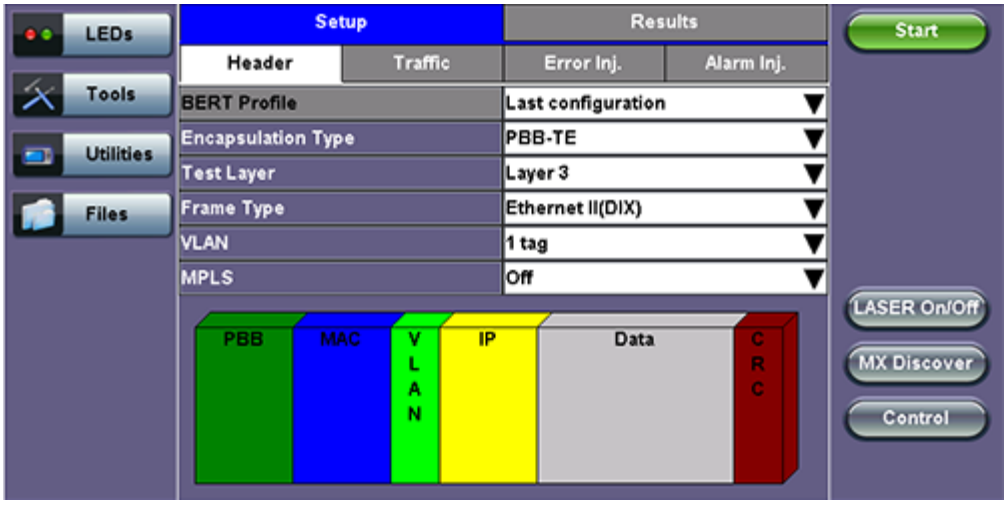
- **Layer 2:** Framed BERT (same as Layer 1 Framed)
  - **MAC Address:** A default or user configured Media Access Control (MAC) address is added to the frame

BERT Setup - Header (Layer 2)



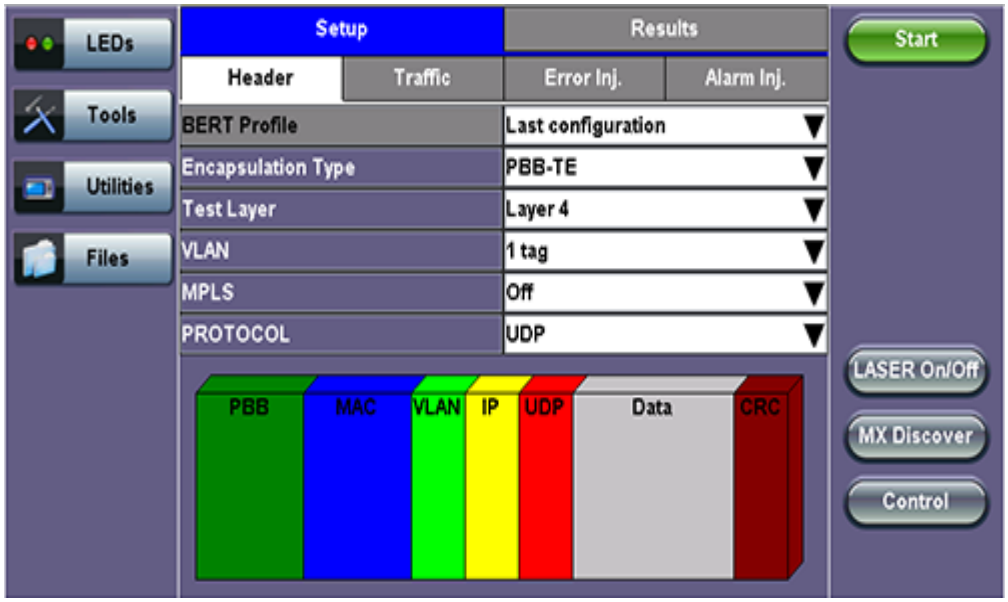
- **Layer 3:** Framed BERT (same as Layer 1 & 2 Framed)
  - **MAC Address:** A default or user configured Media Access Control (MAC) address is added to the frame
  - **IP Address:** A default or user configured IP address is added to the frame

BERT Setup - Header (Layer 3)



- **Layer 4:** Framed BERT (same as Layer 1, 2, & 3 Framed)
  - **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
  - **UDP Address:** A user defined source and destination port address is added to the frame

BERT Setup - Header (Layer 4)



Go back to top Go back to TOC

15.2.1.1 Header Settings

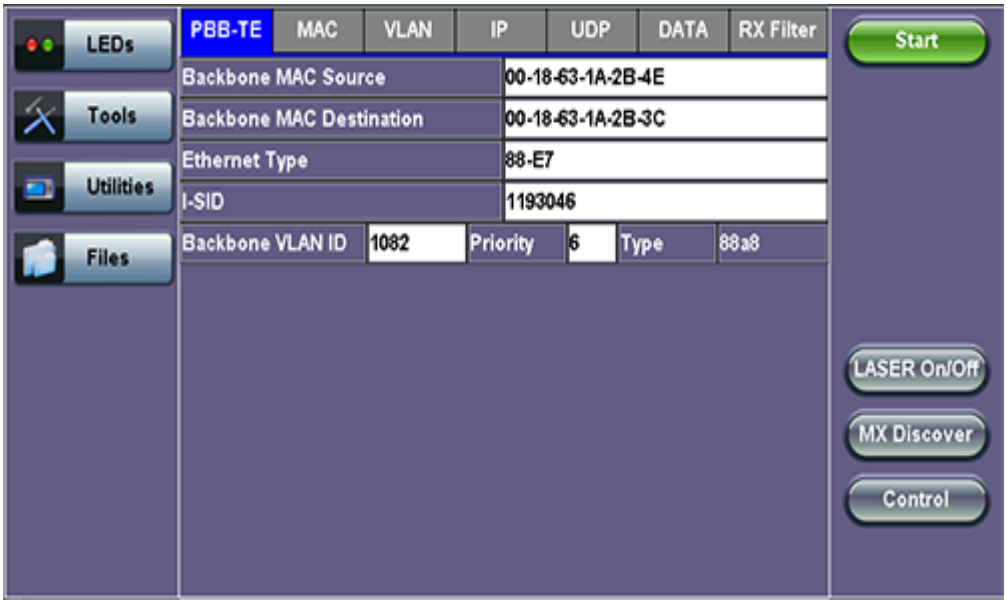
- **BERT Profile:** Load a previously configured test profile or create a new profile from existing settings.
  Please see **6.0 Profiles** in the **ReVeal MTX300 manual** for more details on how to create new profiles using ReVeal software.

- **Encapsulation Type:** None or **Provider Backbone Bridge (PBB-TE):** 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. Available for 1GE Copper/Fiber and 10GE port. PBB encapsulation is available for all Ethernet tests (Layer 2,3 and 4) - BERT, RFC2544, Throughput, V-SAM.

  Tap the PBB block to configure the settings. All PBB fields are configurable.

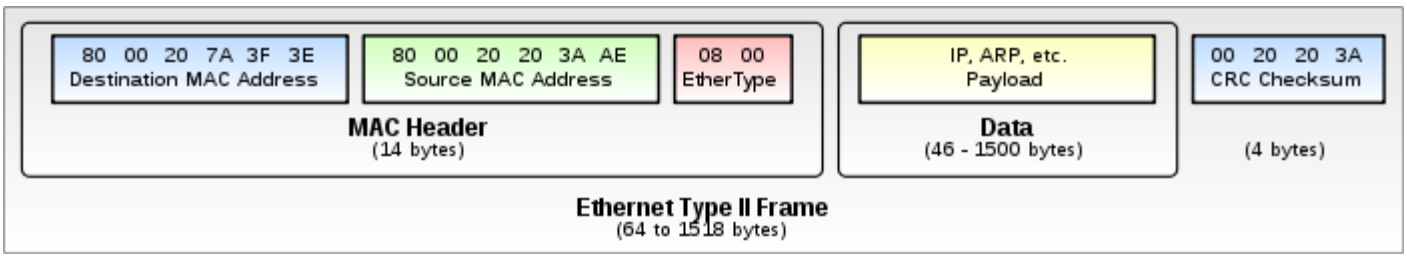
  - Backbone MAC Source
  - Backbone MAC Destination
  - Ethernet Type
  - I-SID
  - Backbone VLAN ID, Priority, Type

PBB



- **Test:** Select the test layer to perform the BERT
  - Options are Layer 1 Unframed, Layer 1 Framed, Layer 2, Layer 3, and Layer 4
- **Frame Type:** Select the Ethernet frame type for Layer 2 or Layer 3
  - 802.3 Raw (IEEE 802.3 frame without LLC) - Not available when Layer 3 is selected
  - 802.3 LLC (IEEE 802.3 frame with LLC header)
  - 802.3 SNAP (IEEE 802.3 frame with SNAP header)
  - Ethernet II (DIX) (named after DEC, Intel, and Xerox, this is the most common frame type today)
- **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 and Layer 4
- **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:** 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



Go back to top Go back to TOC

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

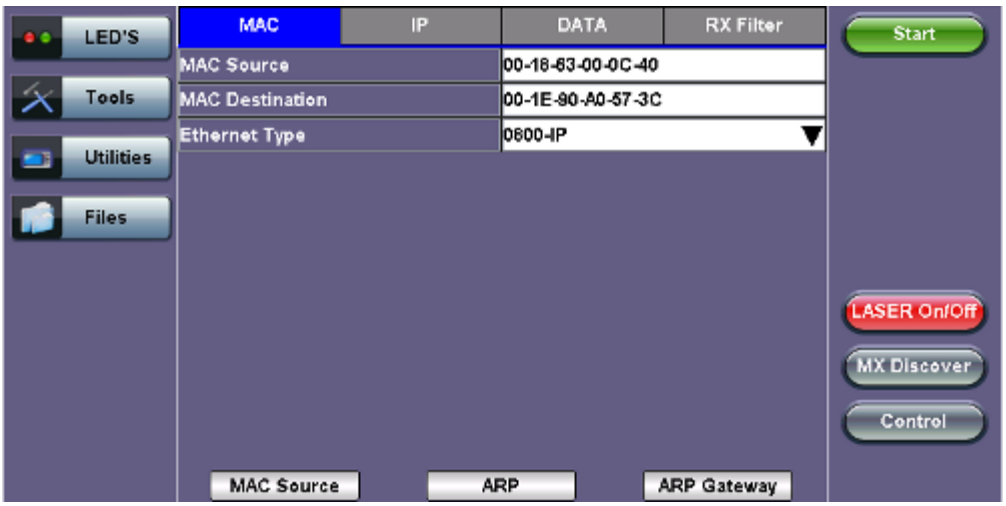
To configure the MAC addresses, IP addresses, VLAN tag(s), MPLS tag(s), and test pattern, tap on the frame image displayed on the screen. This brings up the configuration screens for all the header fields.

- **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 **9.1 IP** in the **V300 Common Functions manual** for details on IP connection.

- **Ethernet Type:** For Layer 3 testing, the user can also configure the Ethertype:
  - 0800-IP (Internet Protocol Version 4, IPv4)
  - 0600-Xerox
  - 0801-X.75 (X.75 Internet)
  - 0805-X.25 (X.25 Level 3)
  - 0806-ARP (Address Resolution Protocol [ARP])
  - 8035-RARP (Reverse Address Resolution Protocol [RARP])
  - 8137-IPX (Novell IPX)
  - 814C-SNMP
  - 8847-MPLS unicast
  - 8848-MPLS multicast
  - 86DD (Internet Protocol, Version 6 [IPv6]) - Future Release

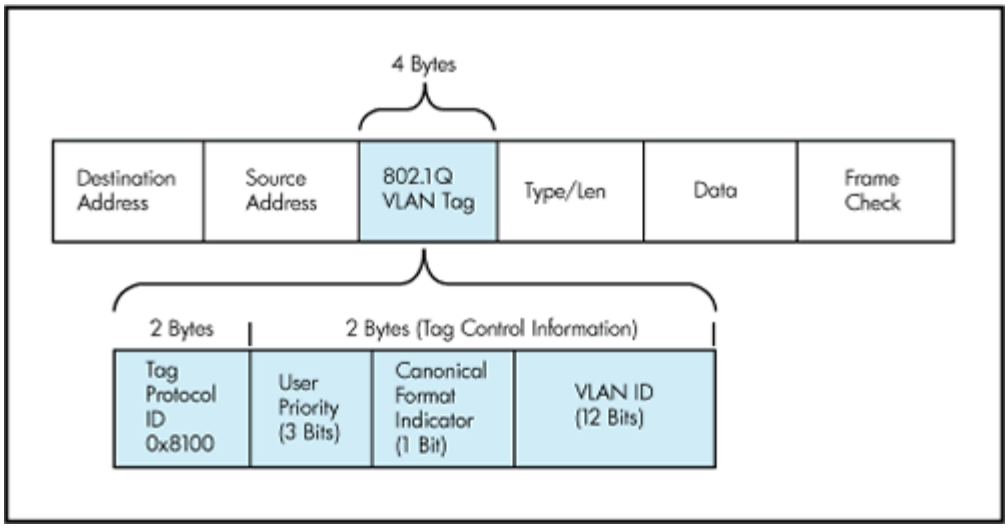
BERT Setup - MAC address settings (Layer 3)



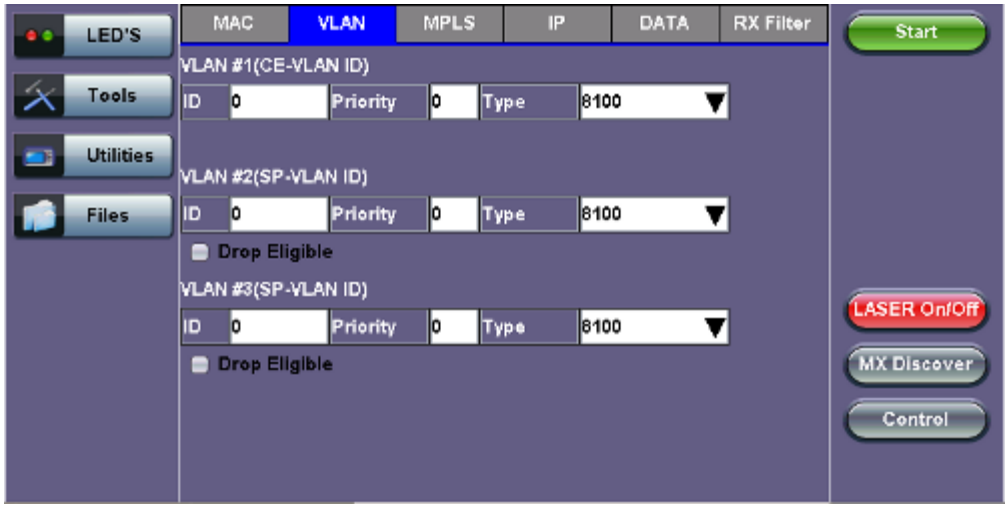
Go back to top Go back to TOC

- **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)
  - **Drop Eligible:** If enabled, drop eligibility flag will be set.
  - **VLAN Flooding:** Enable/Disable.
  - **VLAN Flooding Range:** Specifies the number of VLAN IDs. Enter a number from 0-4096. The VLAN IDs will be incremented by 1 until it reaches the number of times entered in the flood range.

IEEE 802.1Q VLAN Tag in an Ethernet Frame



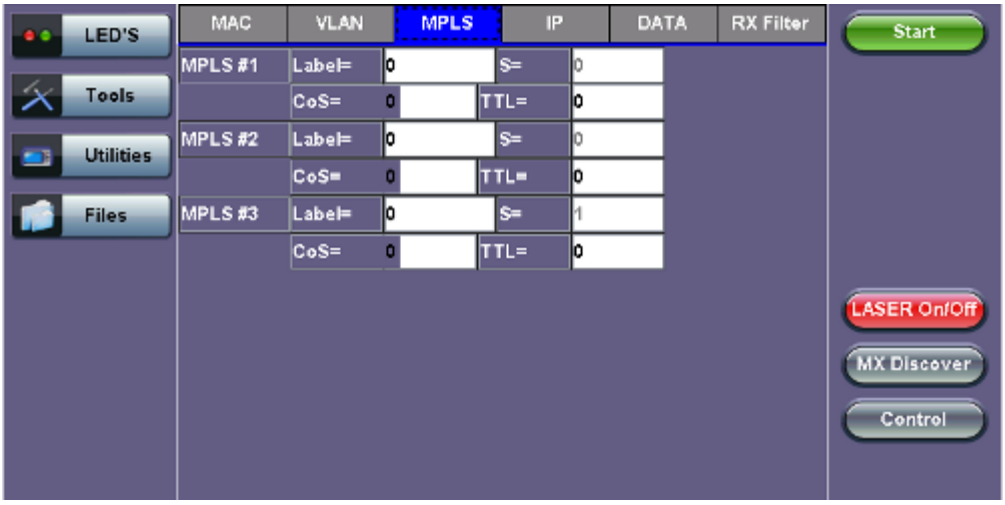
BERT Setup - VLAN Tag configuration (Layer 3)



Go back to top Go back to TOC

- **MPLS Tab:** 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.

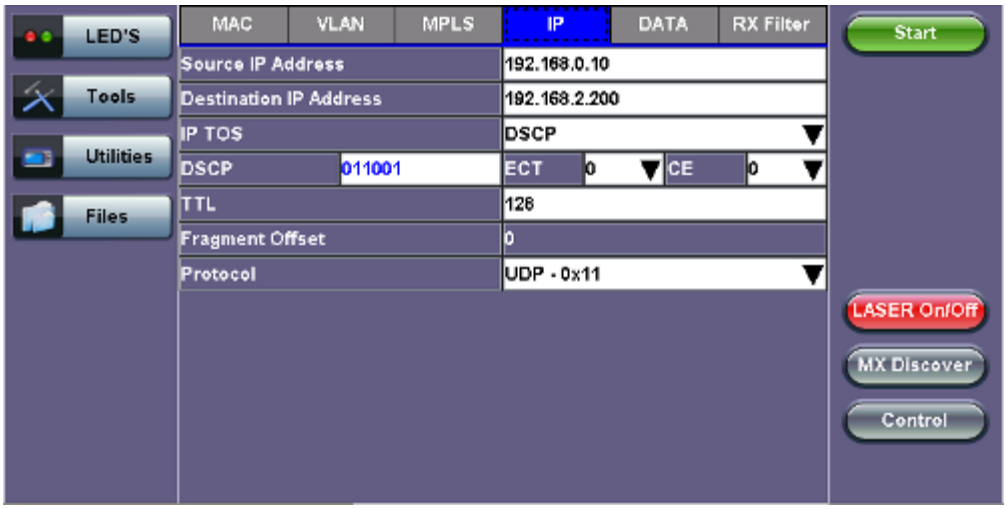
BERT Setup - MPLS label configuration



Go back to top Go back to TOC

- **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
  - **IP Src and IP Dest:** For IP Src, if the IP connection is up, refer to section **9.1 IP** in the **V300 Common Functions manual**. The source address is fixed to the IP address from the IP setup menu.
  - **IP TOS (for Quality of Service testing):**
    - **Legacy TOS (Precedence):** The first three bits of the IP TOS field can be edited:
      000 - Best Effort
      001 - Bulk Data
      010 - Transactional
      011 - Call Signaling
      100 - Streaming Video
      101 - Voice
      110 - Routing
      111 - Reserve
    - **DSCP (Differentiated Services Code Point):** The first six bits of the IP TOS can be edited to provide more granular service classification.
      For more information on the definition of DSCP field in IPv4 and IPv6 headers, refer to RFC2474.
    - **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.

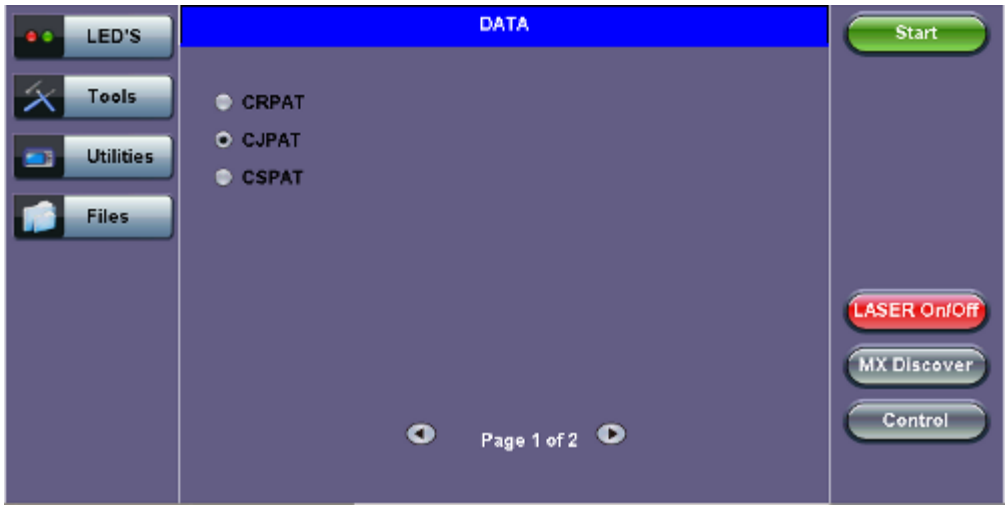
BERT Setup - IP Address settings (Layer 3)



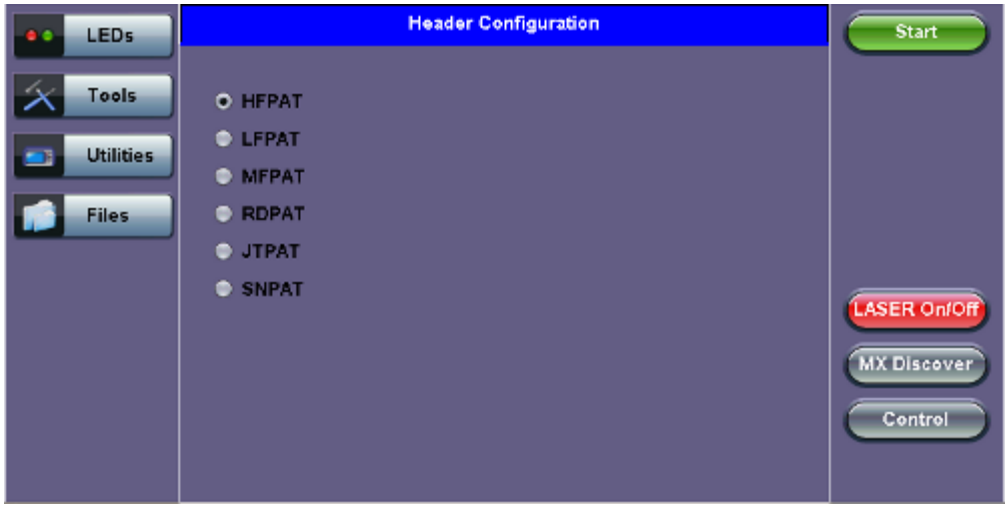
Go back to top Go back to TOC

- **Data Tab:** User selects a test pattern that will be encapsulated in the Ethernet frame payload (for framed mode). Depending on the test layer, different test pattern options are available.
  - **Layer 1 Framed Test Patterns**
    - **CRPAT:** Compliant Random Pattern provides broad spectral content and minimal peaking for the measurement of jitter at component or system level.
    - **CJTPAT:** Compliant Jitter Test Pattern is a Jitter Tolerance Pattern that stresses a receiver by exposing it to extreme phase jumps thereby stressing the clock data recovery (CDR) circuitry. The pattern alternates between repeating low transition density patterns and repeating high transition density patterns.
    - **CSPAT:** Compliant Supply Noise Pattern. Represents worst case power supply noise.

BERT Setup - Data selection (Layer 1 Framed)



BERT Setup - Data selection - (Layer 1 Unframed)



  - **Layer 1 Unframed Test Patterns**
    - **HFPAT (High Frequency Pattern):** This test pattern is to test random jitter (RJ) at a BER of 10-12, and also to test the asymmetry of transition times. This high frequency test pattern generates a one, or light on, for a duration of 1 bit time, followed by a zero, or light off, for a duration of 1 bit time. This pattern can be generated by the repeated transmission of the D21.5 code-group. Disparity rules are followed.
    - **LFPAT (Low Frequency Pattern):** The intent of this test pattern is to test low frequency RJ and also to test PLL tracking error. This low frequency test pattern generates a one, or light on, for a duration of 5 bit times, followed by a zero, or light off, for a duration of 5 bit times. This pattern can be generated by the repeated transmission of the K28.7 code-group. Disparity rules are followed.
    - **MFPAT (Mixed Frequency Pattern):** The intent of this test pattern is to test the combination of RJ and deterministic jitter (DJ). This mixed frequency test pattern generates a one, or light on, for a duration of 5 bit times, followed by a zero, or light off, for a duration of 1 bit times, followed by a one for 1 bit time followed by a zero for 1 bit time followed by a one for 2 bit times followed by a zero for 5 bit times followed by a one for 1 bit time followed by a zero for 1 bit time followed by a one for 1 bit time followed by a zero for 2 bit times.

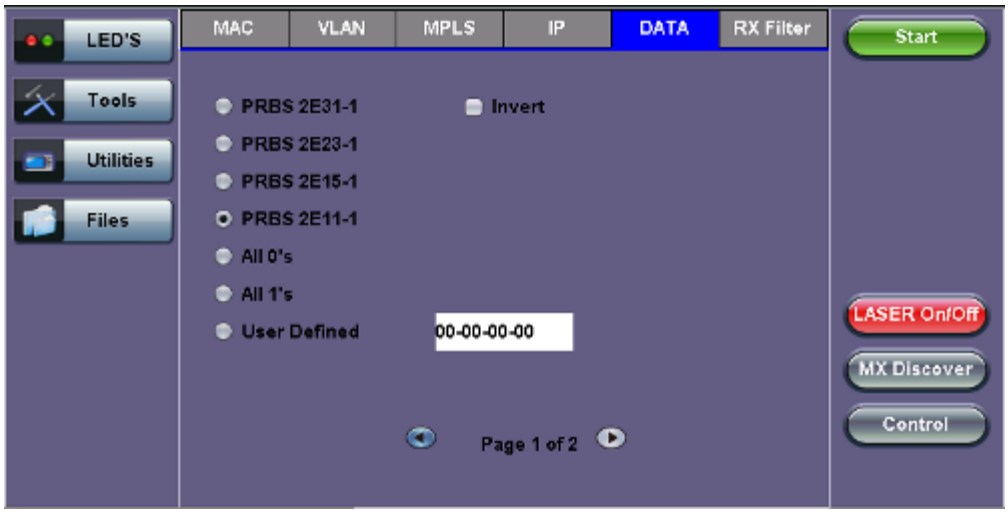
This pattern can be generated by the repeated transmission of the K28.5 code-group. Disparity rules are followed.

- **RDPAT (Random Data Pattern):** Designed to provide energy across the entire frequency spectrum providing good simple BER testing.
- **JTPAT (Jitter Tolerance Pattern):** Designed to verify jitter tolerance on the receivers by exposing a receiver's CDR to large instantaneous phase jumps. The pattern alternates repeating low transition density patterns with repeating high transition density patterns.
- **SNPAT (Supply Noise Pattern):** Designed to simulate the worst case power supply noise that could be introduced by a transceiver.

Go back to top Go back to TOC

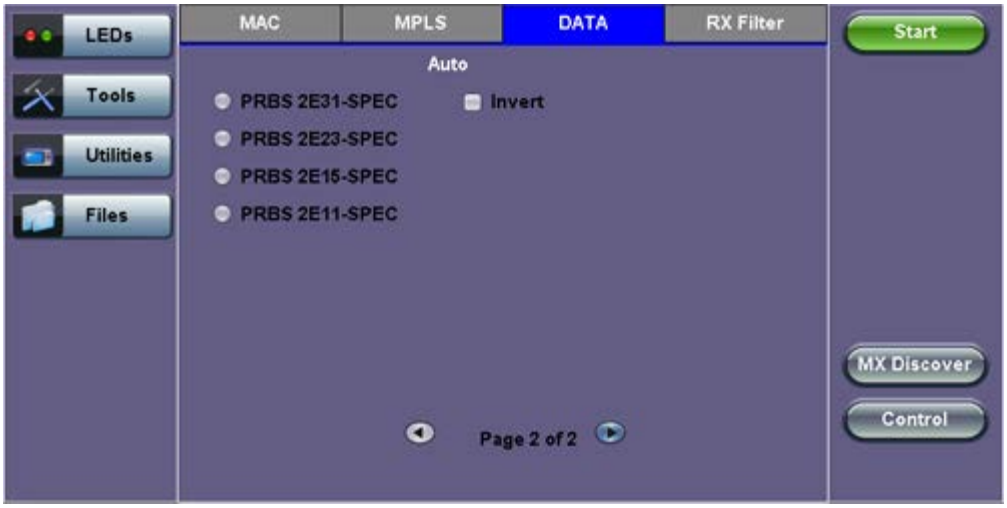
- **Layer 2, 3, & 4 test patterns**
  - **PRBS:**
    - 2^31 -1 (147 483 647-bit pattern used for special measurement tasks, [e.g., delay measurements at higher bit rates])
    - 2^23 -1 (8 388 607 bit pattern primarily intended for error and jitter measurements at bit rates of 34 368 and 139 264 kbps)
    - 2^15 -1 (32 767 bit pattern primarily intended for error and jitter measurements at bit rates of 1544, 2048, 6312, 8448, 32 064 and 44 736 kbps)
    - 2^11 -1 (2047 bit pattern primarily intended for error and jitter measurements on circuits operating at bit rates of 64 kbps and N x 64 kbps)
  - **Fixed:** All 0s or All 1s
  - **User Defined pattern:** Length depends on size of frame
  - **Inversion:** Normal or inverted

BERT Setup - Data selection - PRBS Patterns (Page 1)



- **Auto (Special Patterns):** For special patterns, the most significant bit of the test pattern is populated first into the payload frame, as opposed to non-special patterns, in which the least significant bit is populated first.

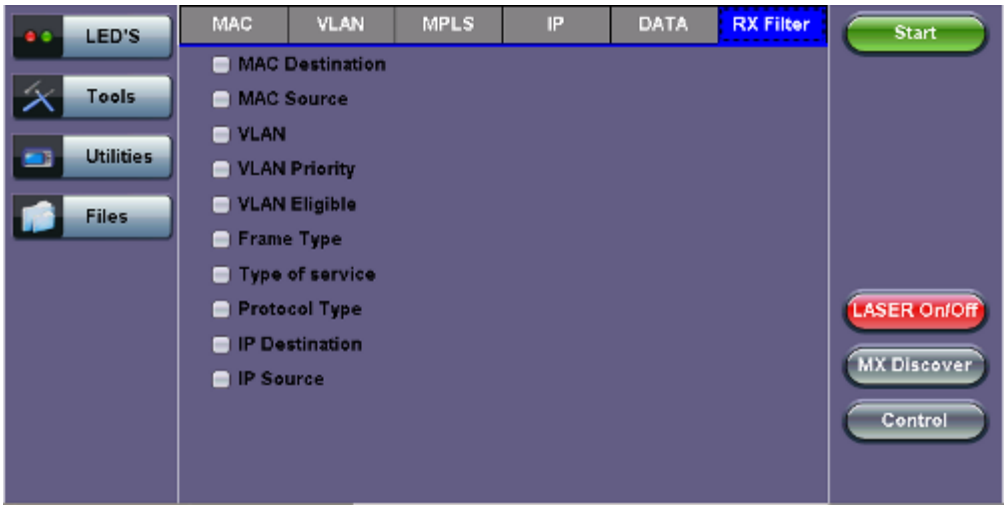
BERT Setup - Data selection - Special Patterns (Page 2)



Go back to top Go back to TOC

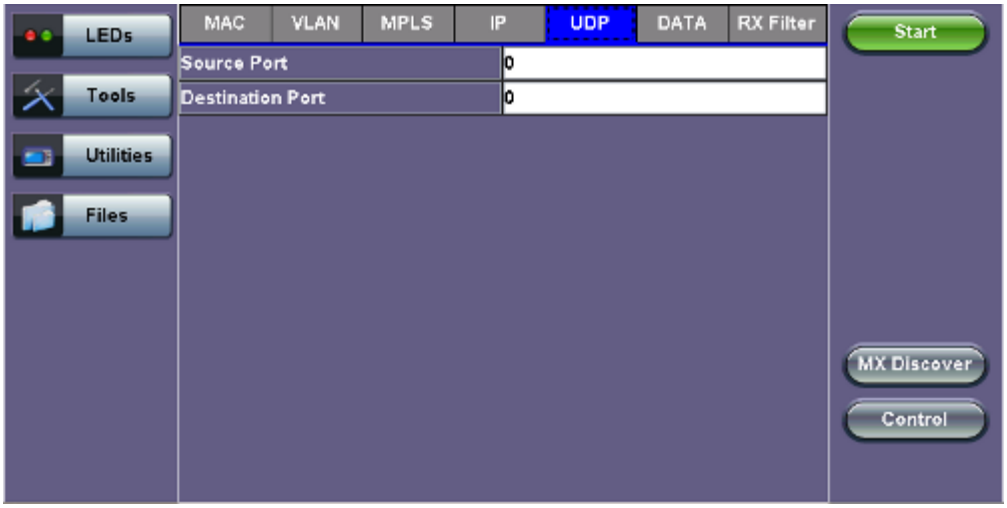
- **RX Filter Tab:** Allows the user to filter incoming streams. When checked, the incoming traffic flows not matching these criteria will not be considered for these results.
  - MAC Destination address
  - MAC Source address
  - VLAN
  - VLAN Priority
  - VLAN Eligible
  - Frame Type
  - Type of Service
  - Protocol Type
  - IP Destination address
  - IP Source address

BERT Setup - RX Filter selection



- **UDP/TCP:** Input Source Port and Destination Port.

BERT Setup - RX Filter selection



Go back to top Go back to TOC

15.2.1.2 Traffic Settings

Traffic tab:

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

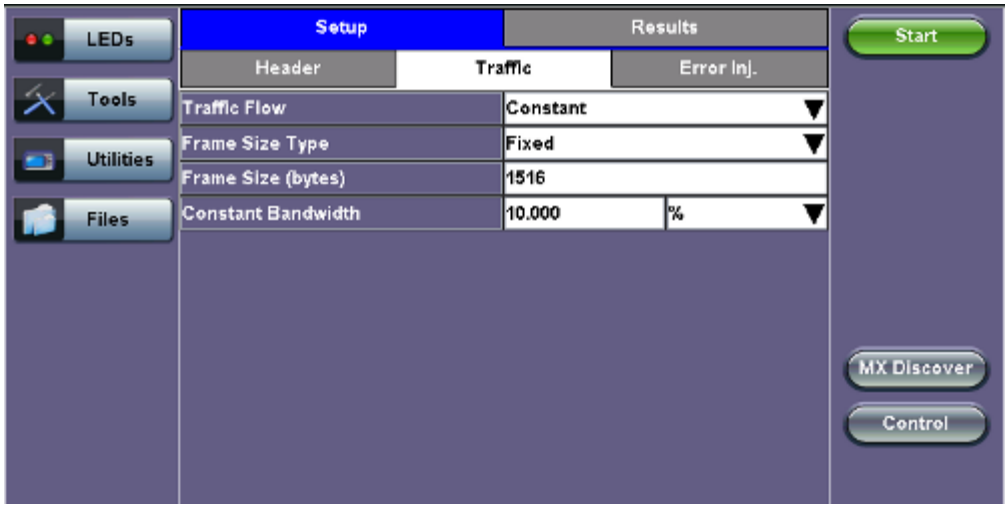
- **Traffic Flow:** Select from the following traffic flows:
  - **Constant:** The selected frame is transmitted continuously according to the selected bandwidth %.
  - **Ramp:** The selected frame is transmitted at maximum bandwidth according to the selected duty cycle and burst period.
  - **Burst:** 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):** Enter the frame size when a Layer 2, 3, or 4 BERT is selected
  - Frame size configuration is not available for Layer 1 BERT
  - 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 - Constant Traffic



Note: Frame Size Limitations

Layer 1 framed mode - Frame size configuration is not available.
Layer 1 unframed mode - Traffic profile is constant at 100% bandwidth.

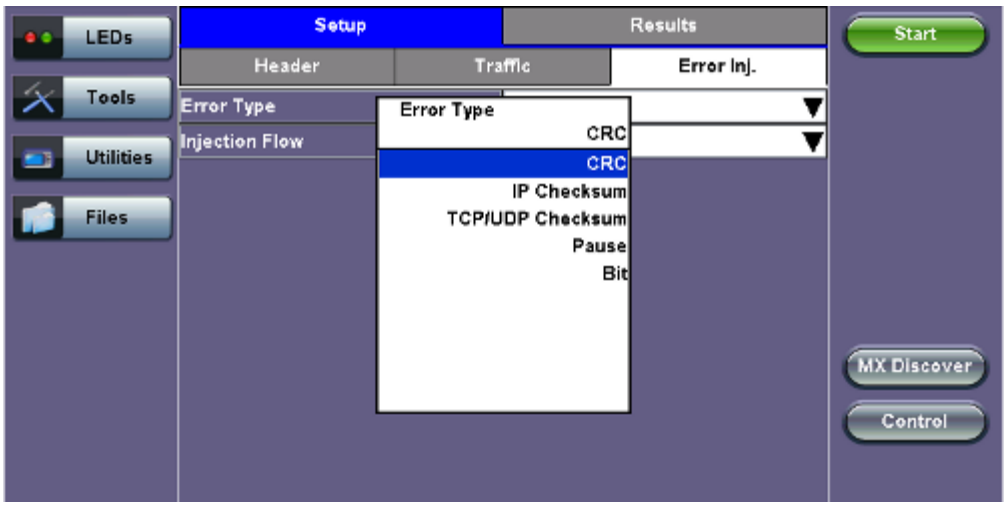
Go back to top Go back to TOC

15.2.1.3 Error Injection

Error injection can be performed during testing. The error type and injection rate are configured in the Error Injection tab.

- **Error type:** Select from Bit, CRC, IP Checksum (Layer 3, 4 only), Pause, TCP/UDP Checksum (Layer 4 only). 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.
- **Injection Flow:** The error injection flow determines how the selected errors will be injected.
  - Select a single error injection or specific count.
- **Count:** Configures the error count via a numeric keypad.

BERT Setup - Error Injection **Error Inj. Function**



Error Injection

After pressing **Start**, error injection can be enabled by pressing the **Error Inj.** button on the right side of the screen.

Go back to top Go back to TOC

15.2.1.4 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 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 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 the 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.

Go back to top Go back to TOC

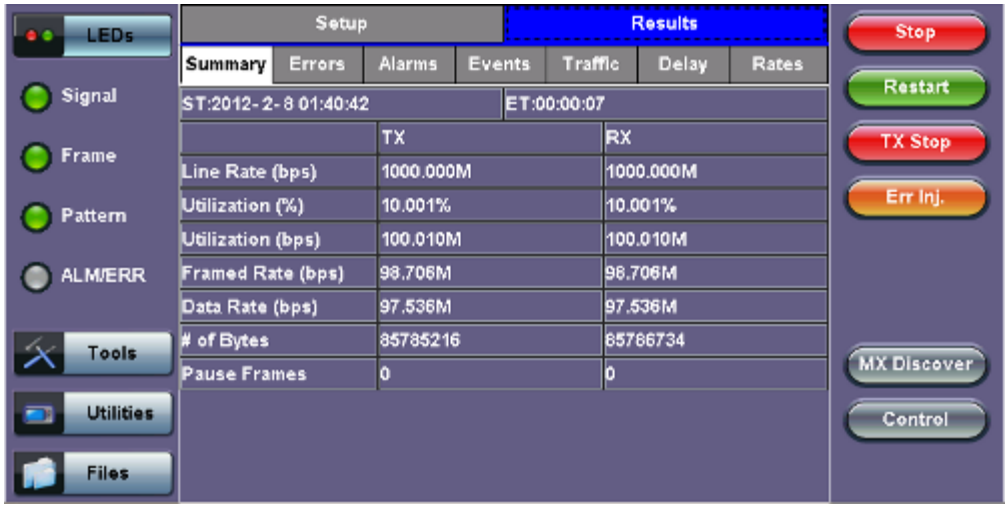
15.2.2 BERT Results

15.2.2.1 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.
- **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 %.
- **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).
- **Number of bytes**
- **Pause Frames:** Total number of transmitted and received ethernet pause flow-control frames.

BERT Results - Summary



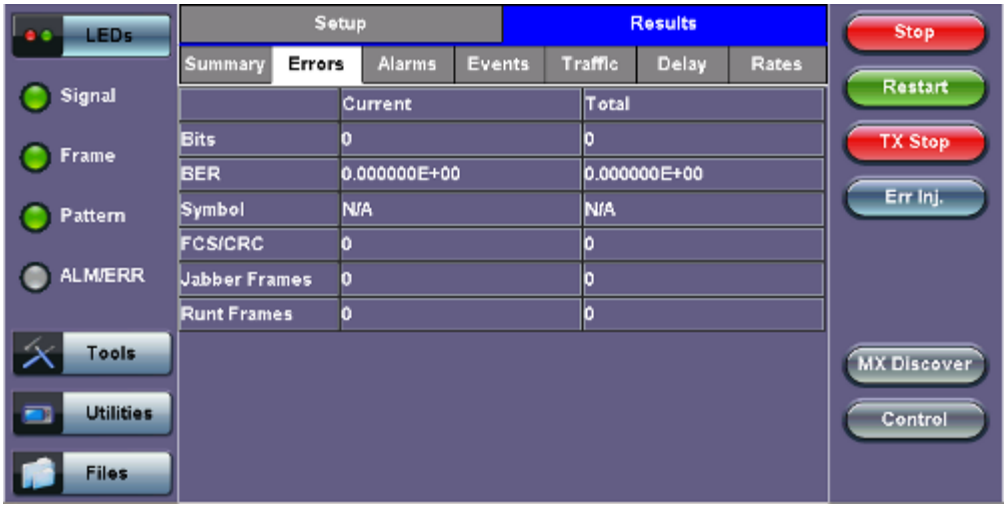
Go back to top Go back to TOC

15.2.2.2 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

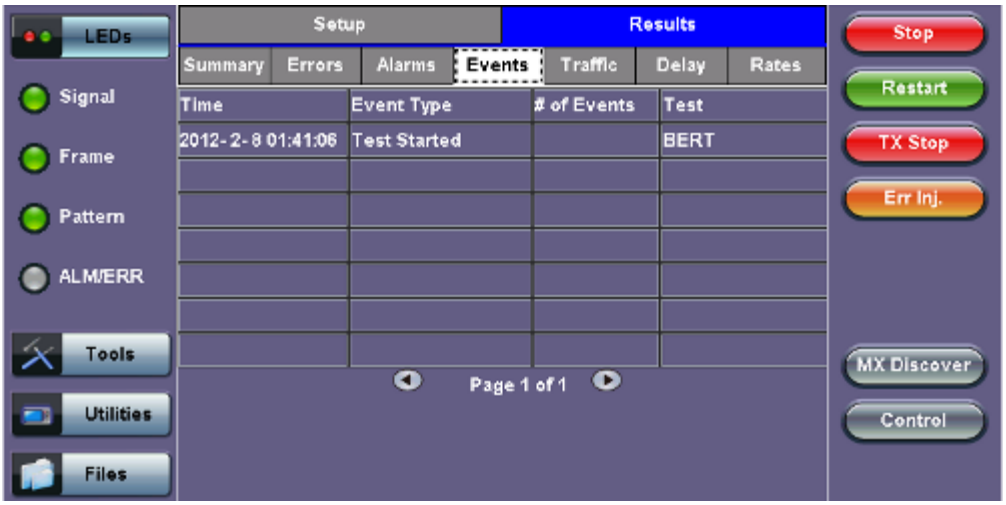


Go back to top Go back to TOC

15.2.2.3 Events

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

BERT Results - Events



Go back to top Go back to TOC

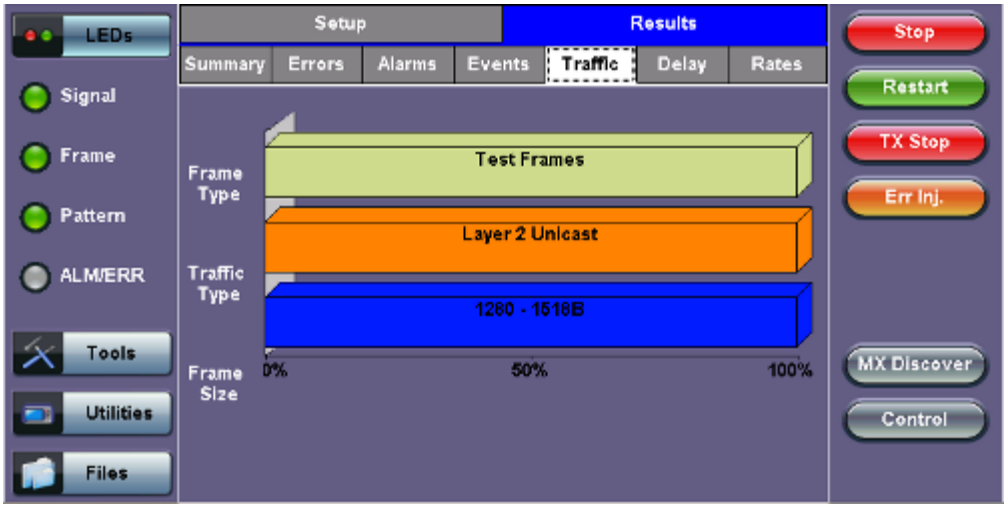
15.2.2.4 Traffic

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**
- **Pause frames**

Tap on the graph for detailed screens.

BERT Results - Traffic Distribution

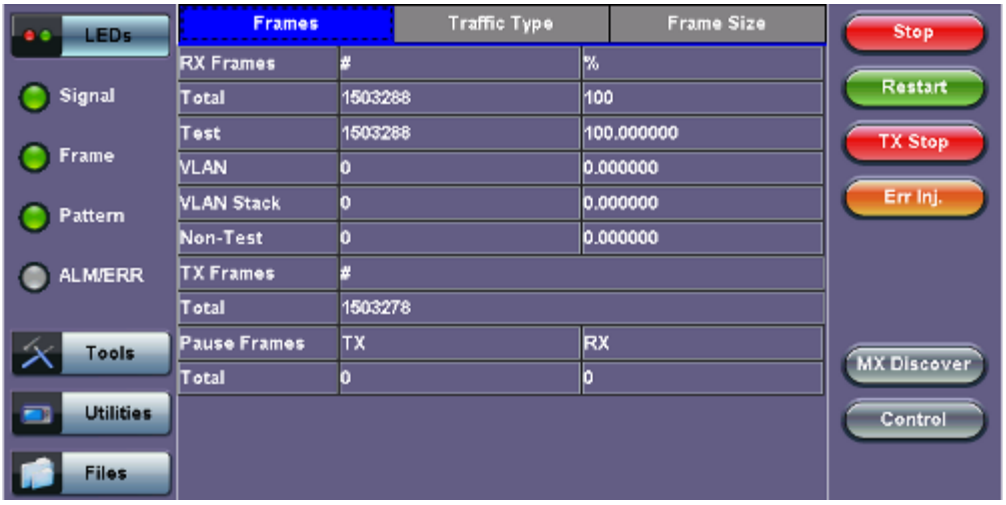


Go back to top Go back to TOC

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

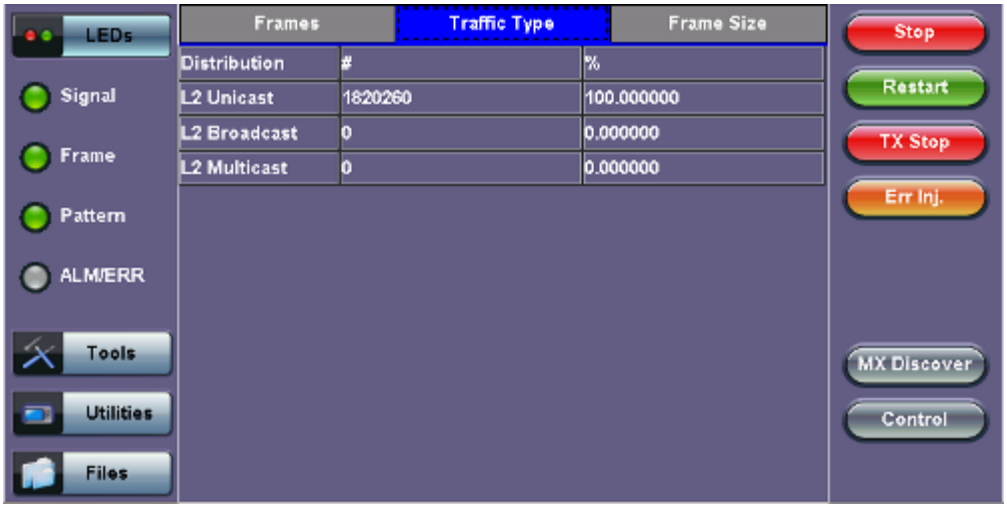


Go back to top Go back to TOC

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

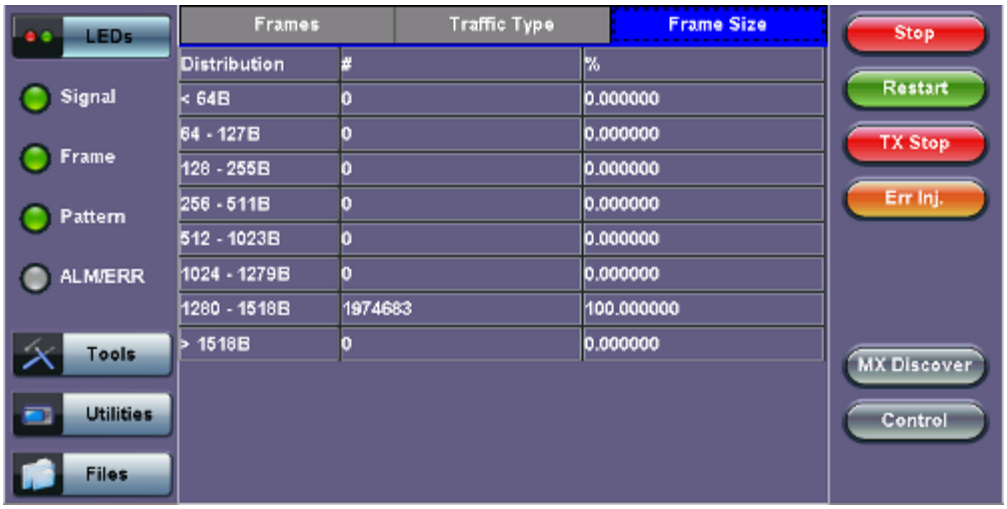


Go back to top Go back to TOC

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



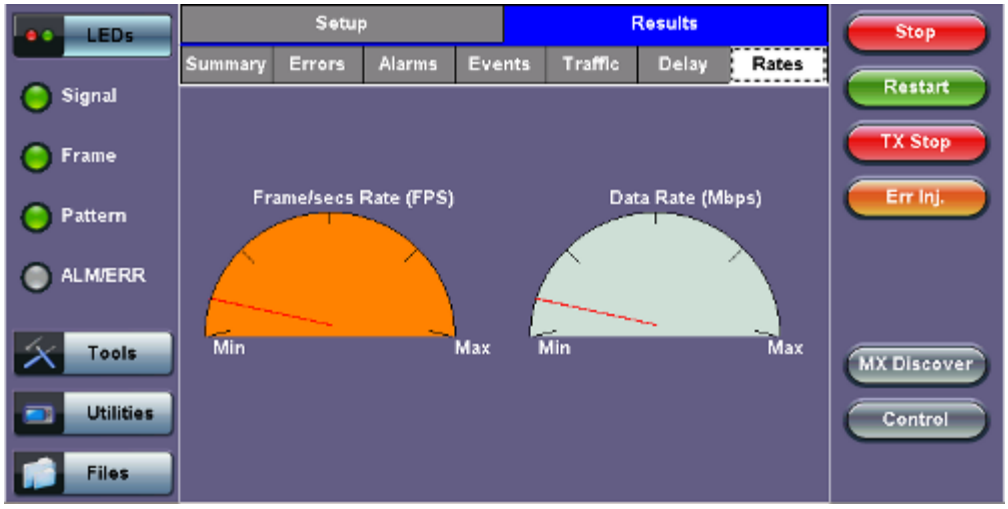
Go back to top Go back to TOC

15.2.2.5 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



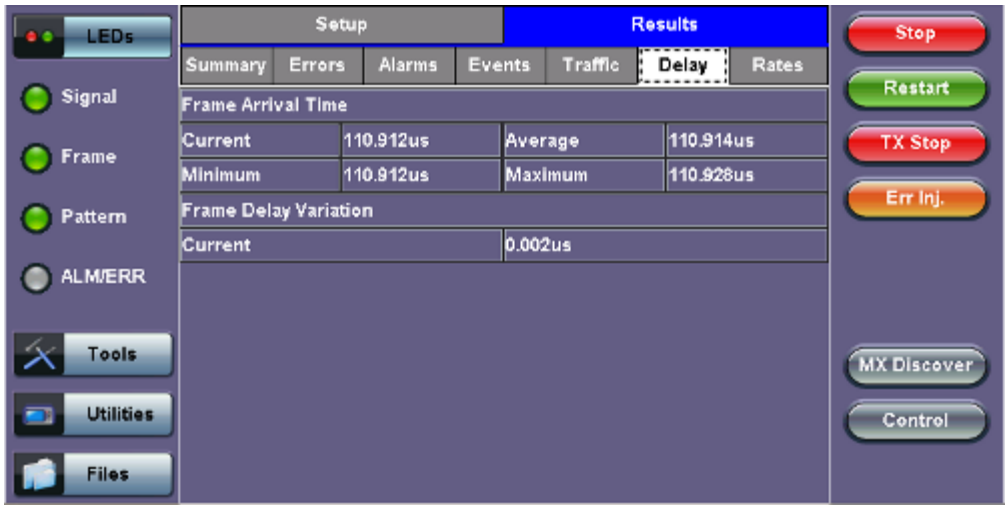
Go back to top Go back to TOC

15.2.2.6 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



Go back to top Go back to TOC

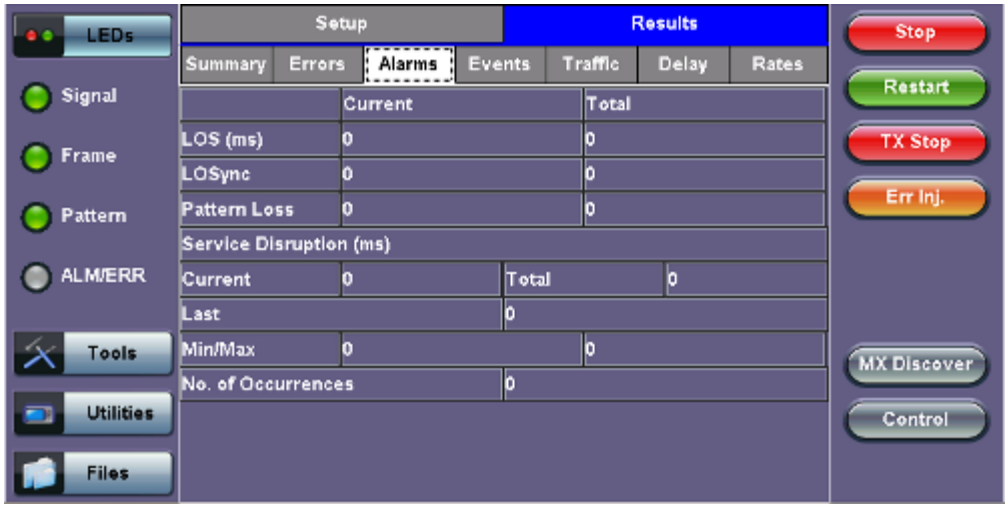
15.2.2.7 Alarms

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
- **Min/Max:** Minimum and maximum duration of the service disruption events
- **No. of Occurrences:** Counter of service disruption events

BERT Results - Alarms

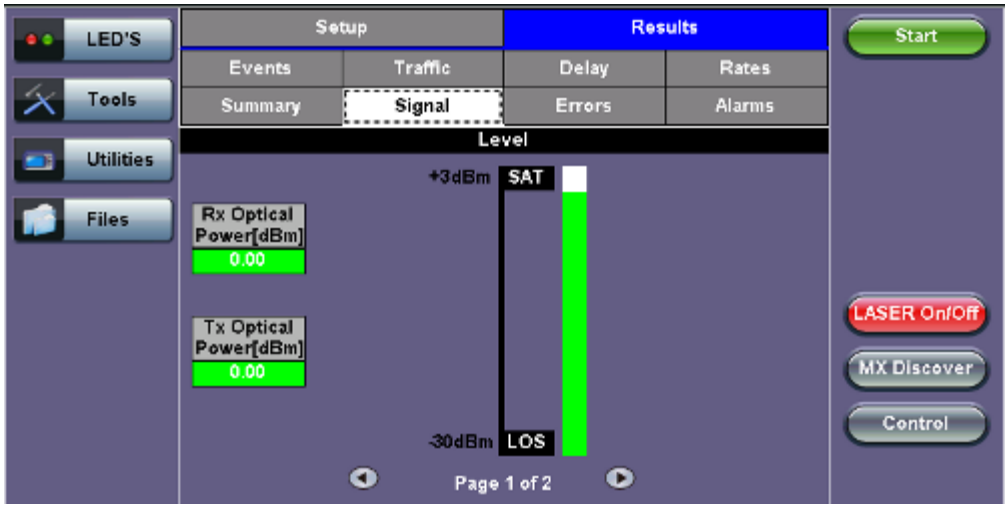


Go back to top Go back to TOC

15.2.2.8 Signal

The Signal tab (fiber ports only) displays the optical level measured by the SFP or XFP transceiver.

BERT Results - Signal



Go back to top Go back to TOC

15.3 RFC 2544 Conformance Testing

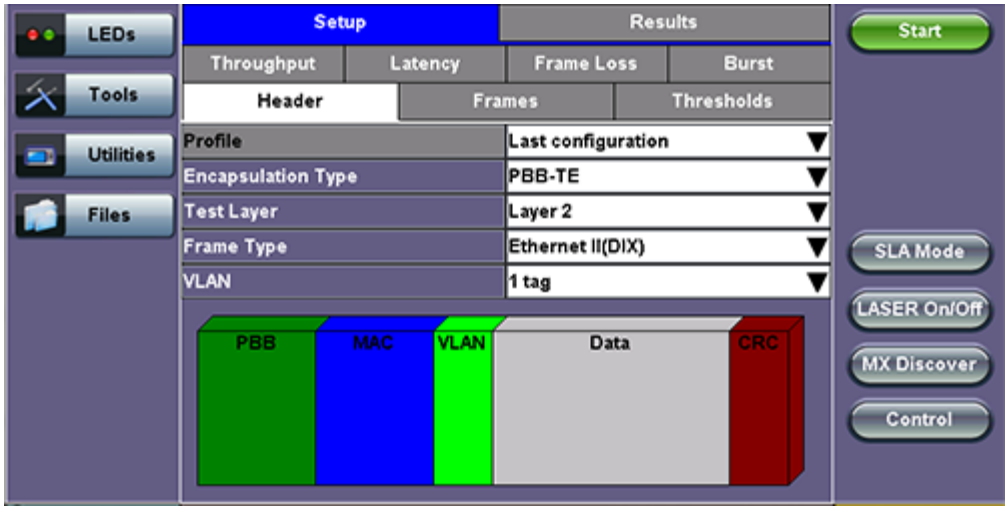
- Overview
- Setup - Standard Mode
  - Header Settings
  - Frames Settings
  - Threshold Settings
  - Peer-to-Peer Asymmetric Testing
    - Asymmetric Testing Setup
  - Throughput Settings
  - Latency Settings
  - Frame Loss Settings
  - Burst Settings
- Starting / Stopping a RFC2544 Measurement
- Results - Standard Mode
  - Status
  - Summary
  - Signal
  - Events
  - Latency / Jitter
  - Frame Loss
  - Burst
- Saving Results
- Advanced SLA Mode
  - Background General Setup
  - Background Traffic Setup
  - Background Results

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, & 4)
- Frame header (PBB, MAC, VLAN, IP, UDP, and Data)
- Test frames selection
- Pass/fail thresholds (optional)
- Far-end unit loop control
- Throughput
- Latency
- Frame loss
- Burst (back-to-back)

RFC 2544 Setup - Layer 2 parameters



Go back to top Go back to TOC

15.3.1 Setup - Standard Mode

Unless otherwise noted, the Frame Header and related setups are identical to the setups described in the BERT Application above. A summary of the RFC 2544 setup options are outlined below.

15.3.1.1 Header Settings

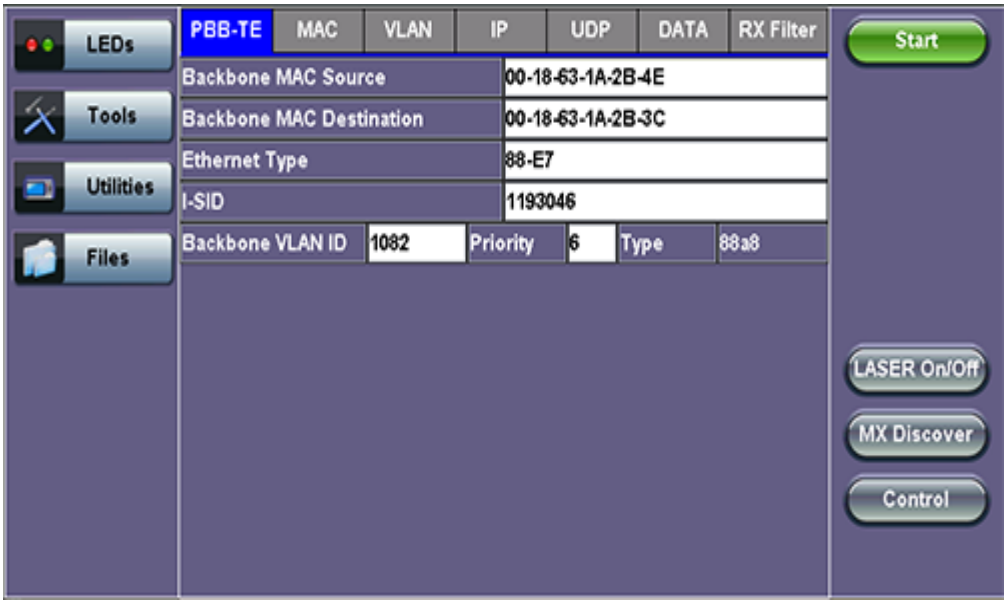
- **RFC 2544 Profile:** Load a previously configured test profile or create a new profile from existing settings.
  Please see **6.0 Profiles** in the **ReVeal MTX300 manual** for more details on how to create new profiles using ReVeal software.

- **Encapsulation Type:** None or **Provider Backbone Bridge (PBB-TE):** 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. Available for 1GE Copper/Fiber and 10GE port. PBB encapsulation is available for all Ethernet tests (Layer 2, 3 and 4) - BERT, RFC2544, Throughput, V-SAM.

  Tap the PBB block to configure the settings. All PBB fields are configurable.

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

PBB



- **Test:** Select the test layer to perform the test.
  - Options are Layer 2, Layer 3, and Layer 4.

- **Frame Type:** Select the Ethernet frame type for Layer 2, Layer 3 or Layer 4.
  - 802.3 Raw (IEEE 802.3 frame without LLC) - Not available when Layer 3 is selected
  - 802.3 LLC (IEEE 802.3 frame with LLC header)
  - 802.3 SNAP (IEEE 802.3 frame with SNAP header)
  - Ethernet II (DIX) (named after DEC, Intel, and Xerox, this is the most common frame type today)

- **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:** 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.

- **MAC, VLAN, MPLS, IP, and Test Pattern Configurations:**

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

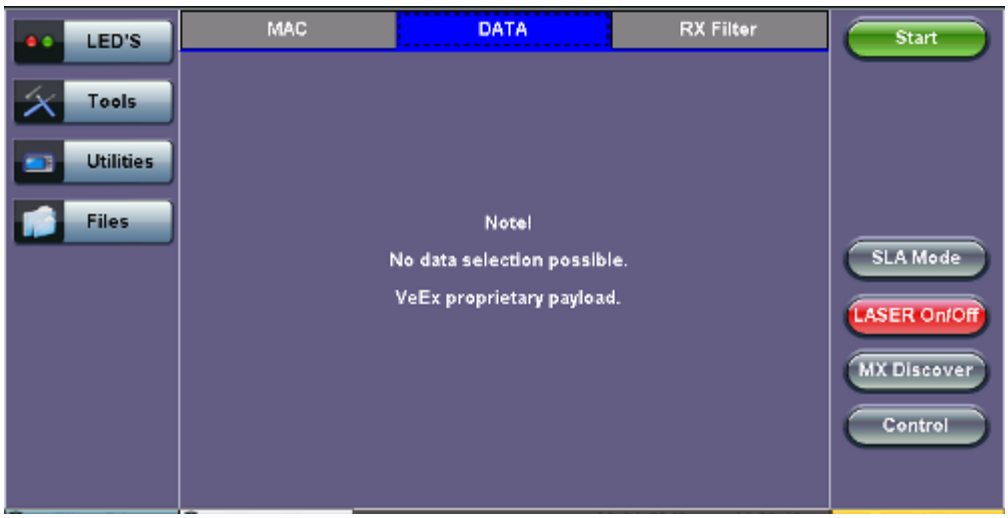
  Note: For more information on header configuration please see 15.2.1.1 Header Settings in the BERT section.

- **MAC Header Tab:**
  - **MAC Source:** Use the default source address of the test set or configure a new or different address. See MAC address editing screen shot below.
  - **MAC Destination**: Configure the destination MAC address of the far-end partner test set. See MAC address editing screen shot below.
  - **Ethernet Type:** For Layer 3 testing, the user can also configure the Ethertype:
    - 0800-IP (Internet Protocol Version 4, IPv4)
    - 0600-Xerox
    - 0801-X.75 (X.75 Internet)
    - 0805-X.25 (X.25 Level 3)
    - 0806-ARP (Address Resolution Protocol [ARP])
    - 8035-RARP (Reverse Address Resolution Protocol [RARP])
    - 8137-IPX (Novell IPX)
    - 814C-SNMP
    - 8847-MPLS unicast

8848-MPLS multicast
- 86DD (Internet Protocol, Version 6 [IPv6]) - Future Release

RFC 2544 Setup - MAC address editing

- **Data Tab:** No payload selection is possible.
  The payload area is populated with a VeEX signature field and other proprietary data.



- **RX Filter Tab:** Depending on test layer, allows the user to filter streams by:
  - MAC Destination address
  - MAC Source address
  - VLAN ID
  - IP Destination address
  - IP Source address

- **VLAN Tab:** VLAN ID, priority, and Tag Type (Ethernet Type) can be configured. Please refer to the BERT application for more details.

- **MPLS Tab:** MPLS label, CoS priority settings, TTL, and S-bit fields are configured for available MPLS tags. Please refer to the BERT application for more details.

- **IP Tab:** User configures the source and destination IP addresses.
  The user can also configure the following IP header fields; IP TOS (for quality of service testing), TTL, fragment offset byte, and the protocol field. Please refer to the BERT application for more details.

Go back to top Go back to TOC

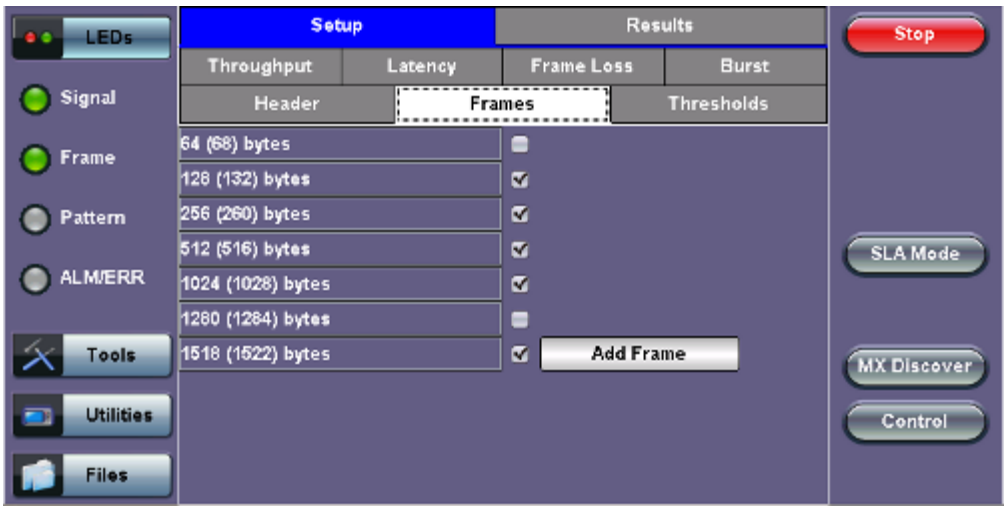
15.3.1.2 Frames Settings

Frames tab: User configures the following:

- **Preset Frames:** User selects 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 frames are 64 and 1518 bytes.
  - To select/deselect any of the recommended test frames, check the box to the right of the desired frame.
  - **Note:** When VLAN tagging or MPLS tagging is enabled, the value in parentheses reflects the actual frame size transmitted. For example one VLAN tag adds 4 bytes to the frame size, therefore a 64B frame becomes a 68 byte frame.

- **Add frame:** The user can add two additional user configurable test frames of any size ranging from 64 bytes to 10000 bytes.
  - 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).

RFC 2544 Setup - Frame Settings



Go back to top Go back to TOC

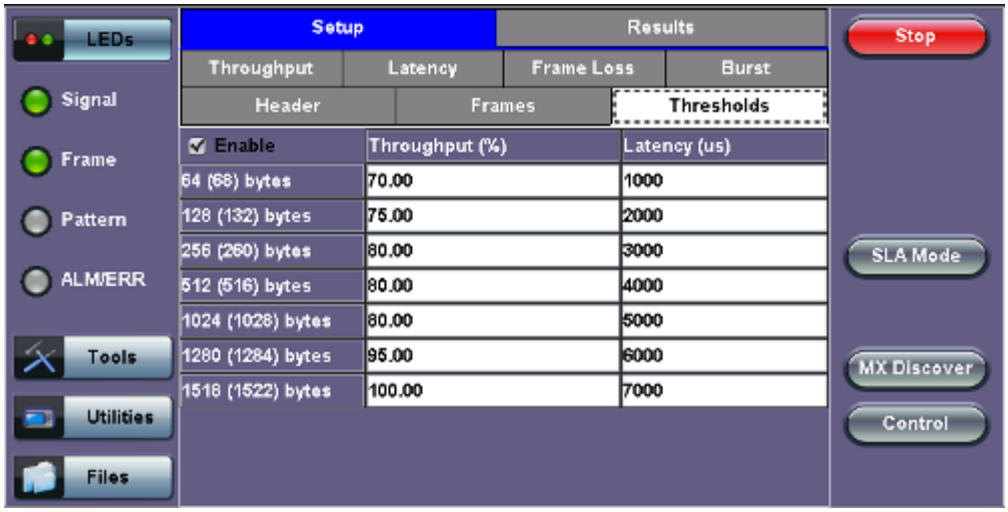
15.3.1.3 Threshold Settings

Threshold tab:

- User enables or disables threshold settings 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.

RFC 2544 Setup - Threshold Settings



Go back to top Go back to TOC

15.3.1.4 Peer-to-Peer and Asymmetric Testing

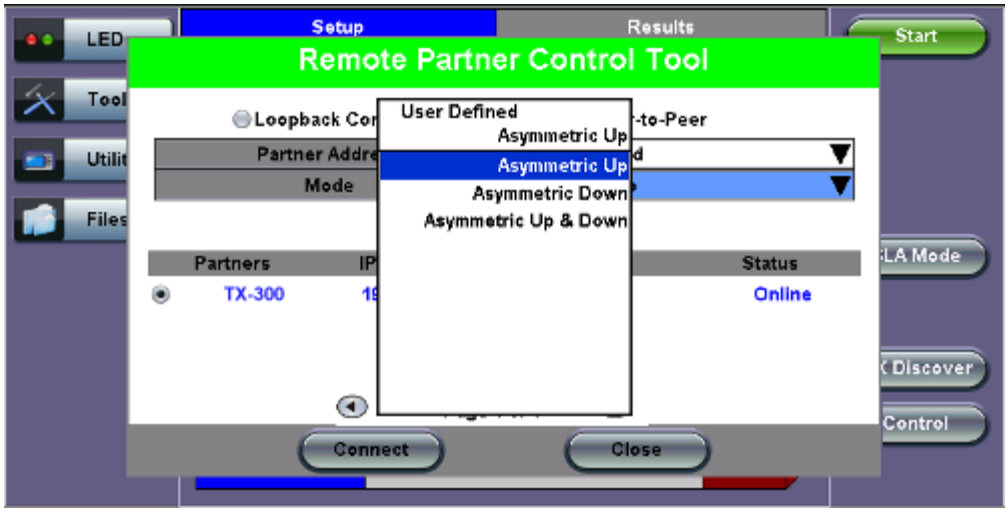
Remote Partner Control

When the local unit connects to the remote (peer) partner, it loads the same configuration profile (header, traffic, and frame size) to the remote partner, with the MAC and IP addresses inverted. From the peer-to-peer menu, asymmetric testing becomes available.

Asymmetrical links provide different line rates in the two directions. To verify the information for both the low and the high rates of the link, the user needs to send a test signal from one instrument located at one end of the link to an instrument at the other end of the link and vice versa to test traffic capacity. The two test instruments have to be synchronized because the tests defined in RFC 2544 require the receiver to know the contents of the test signal to be transmitted in detail.

The test set offers an automated RFC 2544 test application to perform throughput, frame loss, and burstability tests in a local-remote unit setup. The user first configures the test setup in the local unit. Once initiated, the local unit transfers the setup information to the remote unit via the line under test. Upon completion, the remote unit transfers the test results back to the local unit, enabling the user to read the results for both directions of the link on the local unit.

Asymmetric Control

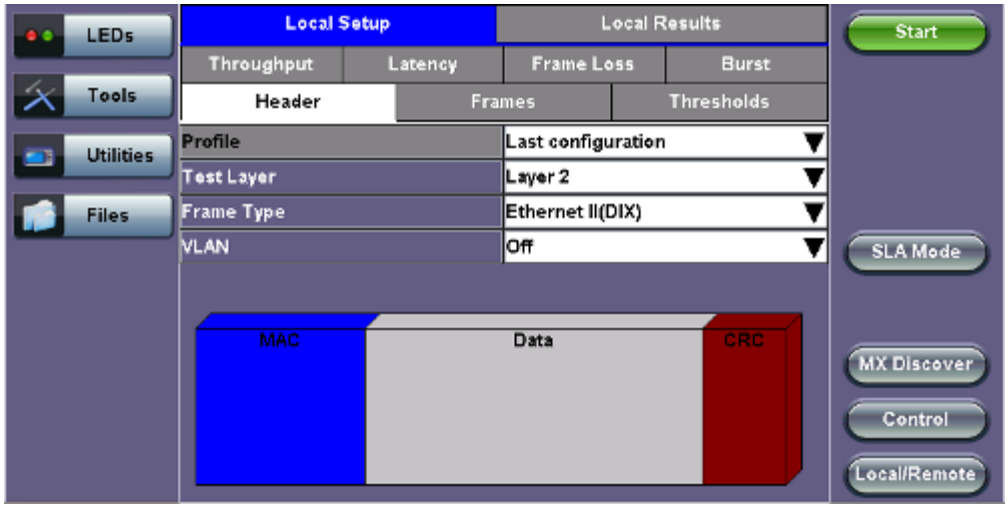


Asymmetric Testing Setup

- **Partner Address:** Select MX Discovered or User Defined. For instructions and further information on the MX Discovered and User Defined options, please see 15.1.4 MX Discover and Control.
- **Mode:** Select an asymmetric test configuration:
  - **Asymmetric Up:** Tests traffic in the upstream direction (local to remote direction).
  - **Asymmetric Down:** Tests traffic the downstream direction (remote to local direction).
  - **Asymmetric Up & Down:** Test traffic in both upstream and downstream directions.
- Press **Connect**.

The user is able to configure and view the local/remote unit's setup and results. Tap on the **Local/Remote** button on the right side menu to toggle between the two settings.

Local Setup



Go back to top Go back to TOC

15.3.1.5 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.

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

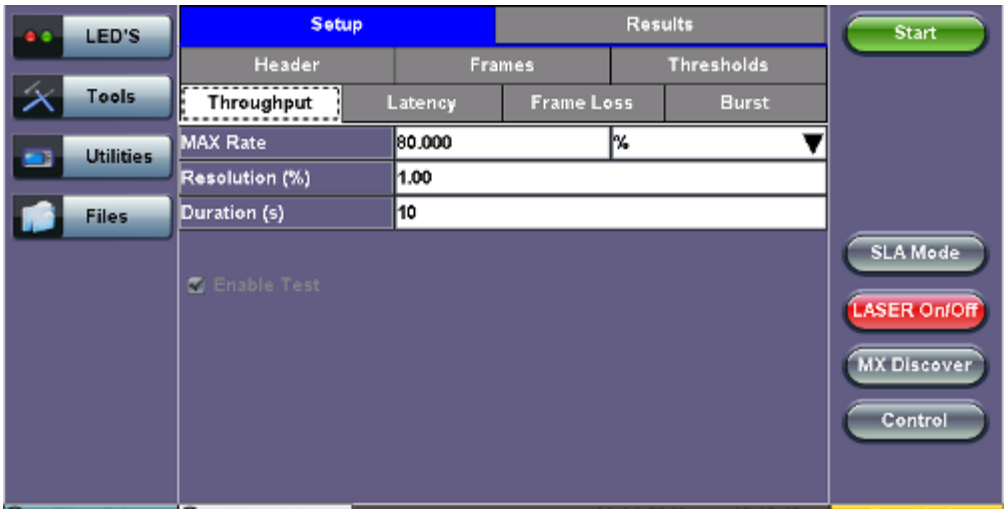
Throughput tab:

- **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.
  - 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.

- **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.

RFC 2544 Setup - Throughput Settings



Go back to top Go back to TOC

Latency tab: User configures the following:

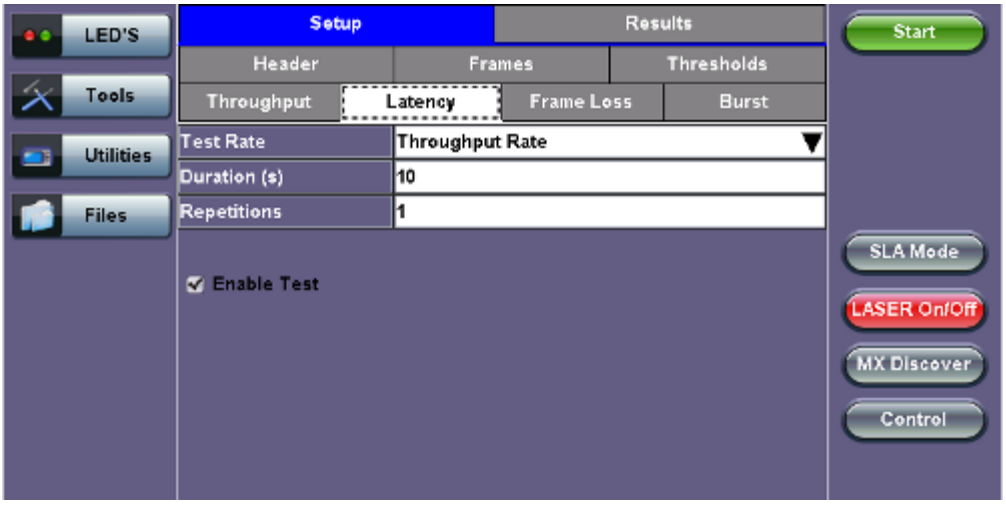
- **Test:** Throughput Rate or Custom Rate. The default value is throughput.
  - **Throughput rate**: Latency test will be performed at the throughput rate found for each of the tested frame sizes.
  - **Custom rate:** User configures a custom rate in % or Mbps.

- **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.

RFC 2544 Setup - Latency Settings



Go back to top Go back to TOC

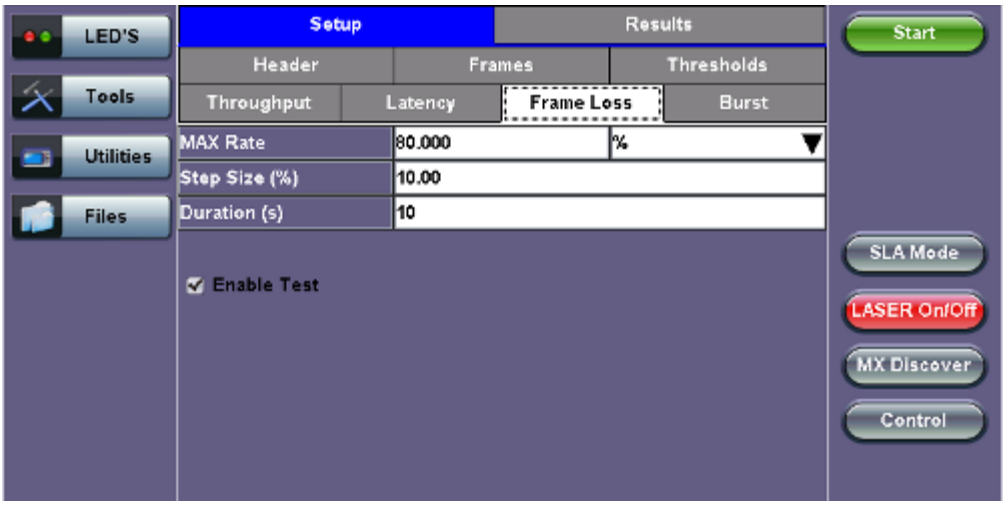
Frame Loss tab:

- **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.

RFC 2544 Setup - Frame Loss Settings



Go back to top Go back to TOC

Burst (Back-to-Back) tab:

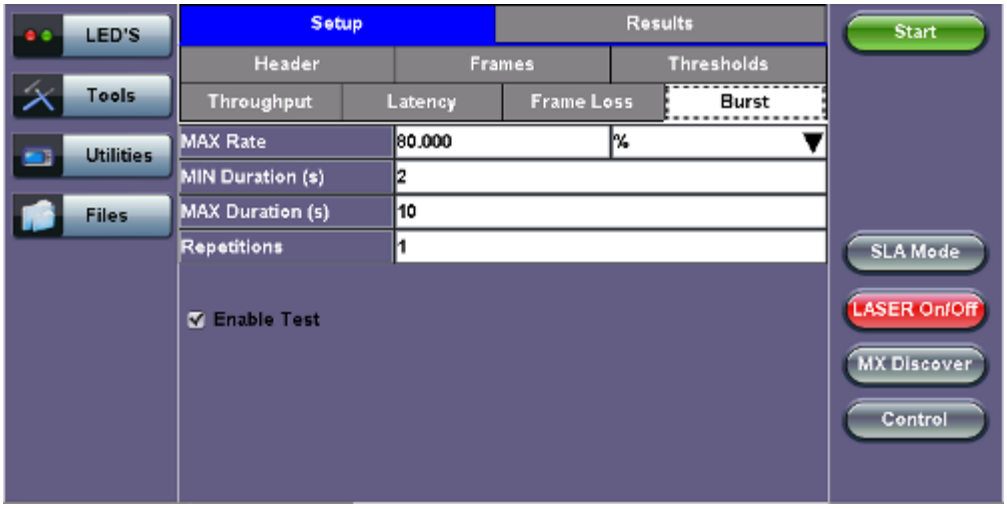
- **Max Rate:** The default value is 100%.
  In the burst test, frames are always transmitted at the maximum rate for a given minimum and maximum burst duration.

- **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.

RFC 2544 Setup - Burst Settings



Go back to top Go back to TOC

15.3.1.6 Starting/Stopping a RFC 2544 Measurement

Once all configurations have been made, the user can start the RFC 2544 test (press the **Start** icon on the top right section of the screen). The following are two scenarios of how to prepare and start the unit for RFC 2544 testing.
Note: If testing on the fiber ports, make sure the LASER is turned On before starting the test.

- **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 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 RFC 2544 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 RFC 2544 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 the all of the selected test are completed, the RFC 2544 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.

Note: If the unit is in Advanced SLA mode, the RFC 2544 test runs simultaneously with the background.

Go back to top Go back to TOC

15.3.2 Results - Standard Mode

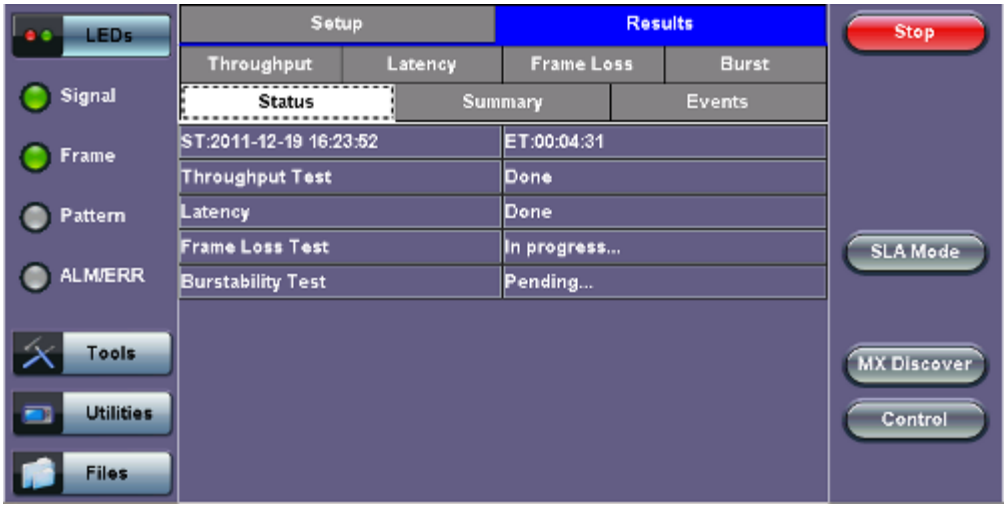
The progress and current result of the RFC 2544 can be viewed as the test is in progress.

Results tab:

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.

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

RFC 2544 Results - Status

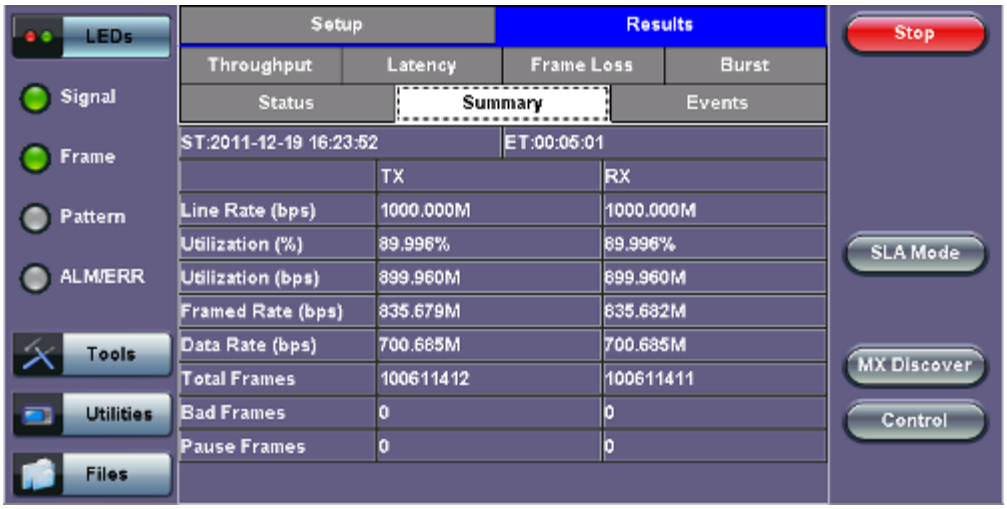


Go back to top Go back to TOC

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.
- **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 %.
- **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).
- **Number of bytes**
- **Pause Frames:** Total number of transmitted and received ethernet pause flow-control frames.

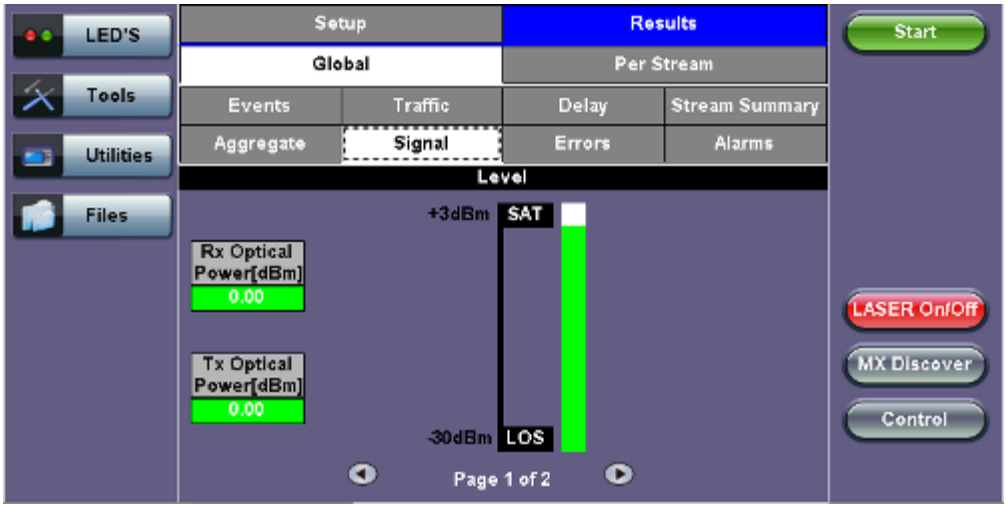
RFC 2544 Results - Summary



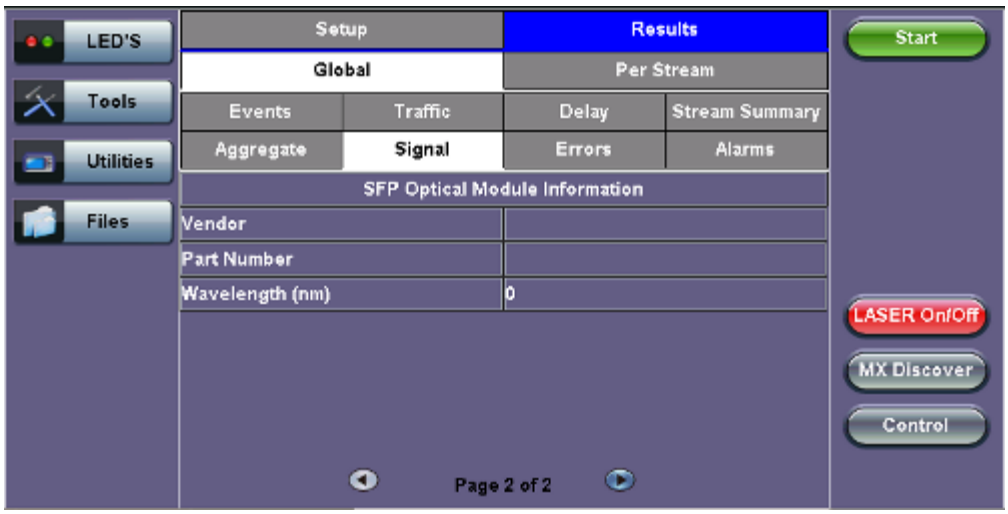
Go back to top Go back to TOC

Signal tab: The Signal tab (fiber ports only) displays the optical level measured by the SFP or XFP transceiver.

RFC 2544 Results - Signal



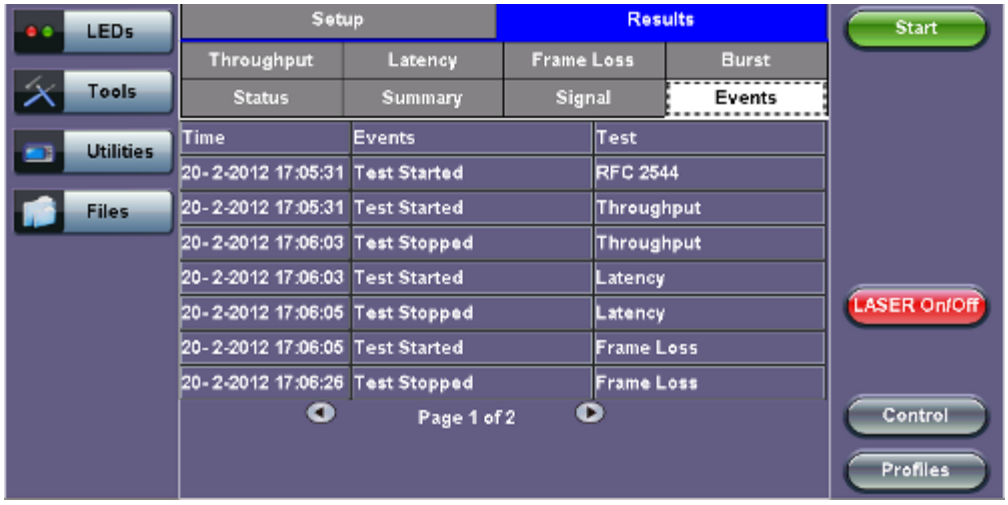
RFC 2544 Results - Signal (page 2)



Go back to top Go back to TOC

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

RFC 2544 Results - Events



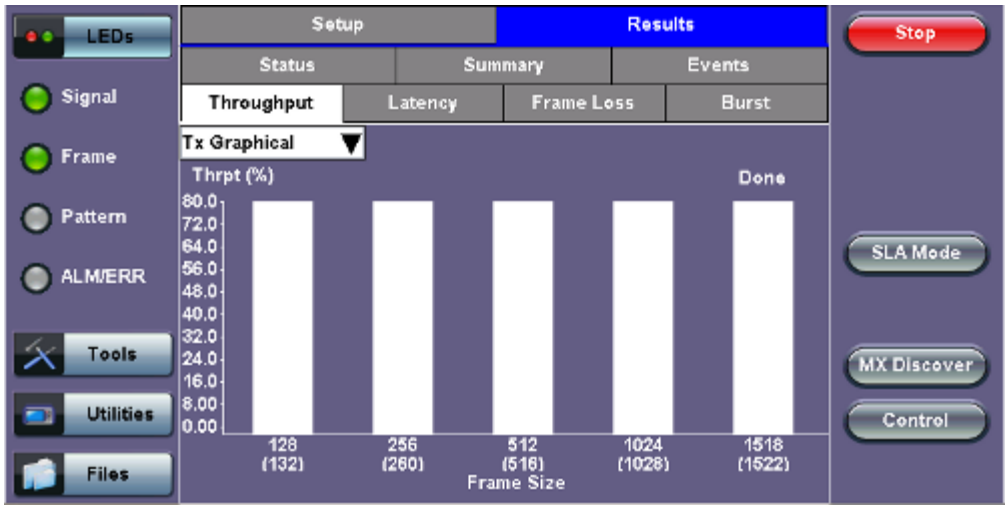
Go back to top Go back to TOC

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.

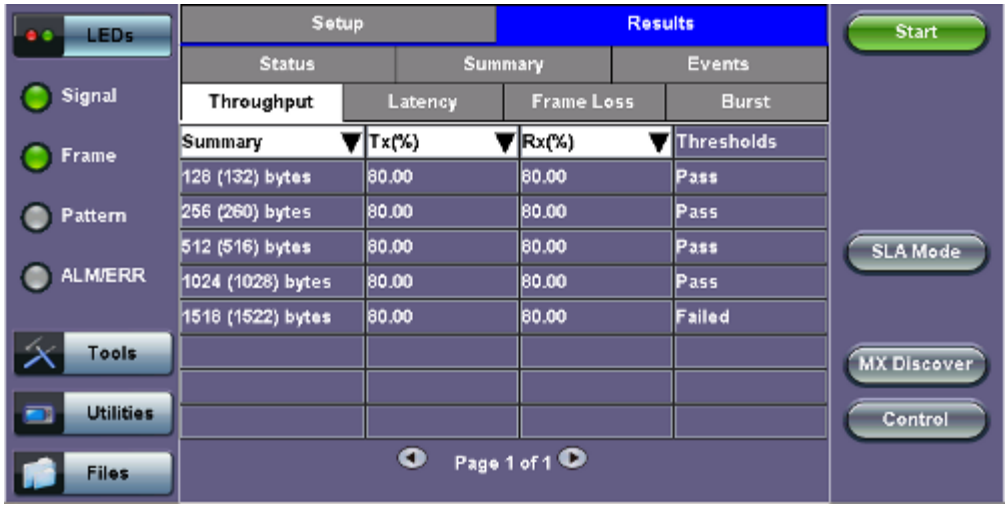
Graphical: Throughput results are displayed in a bar graph form

- 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

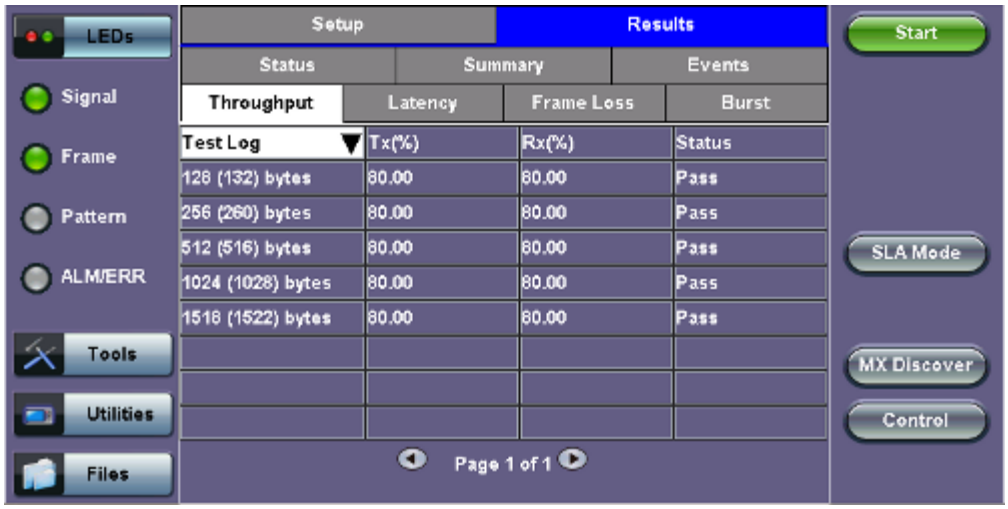
RFC 2544 Results - Throughput (Tx Graphical)



RFC 2544 Results - Throughput (Summary Table)



RFC 2544 Results - Throughput (Test Log Table)

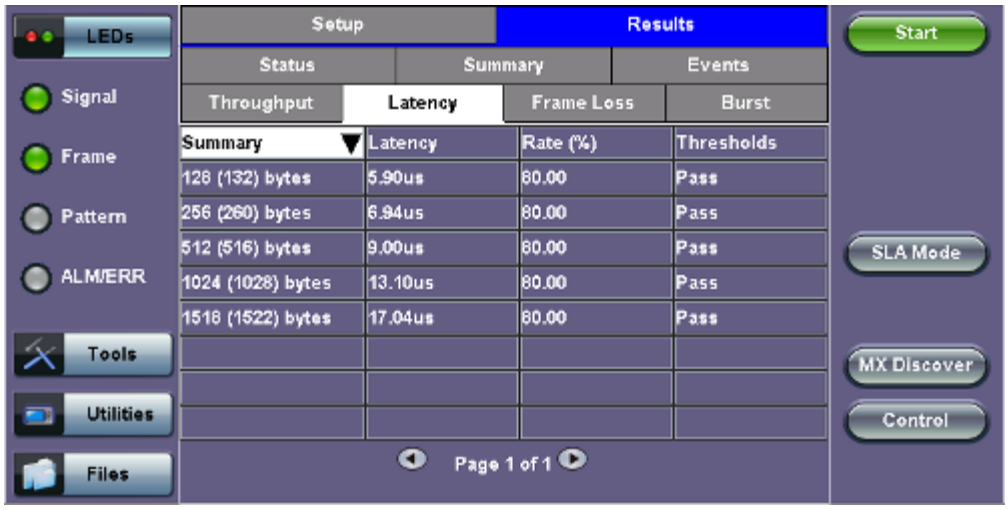


Go back to top Go back to TOC

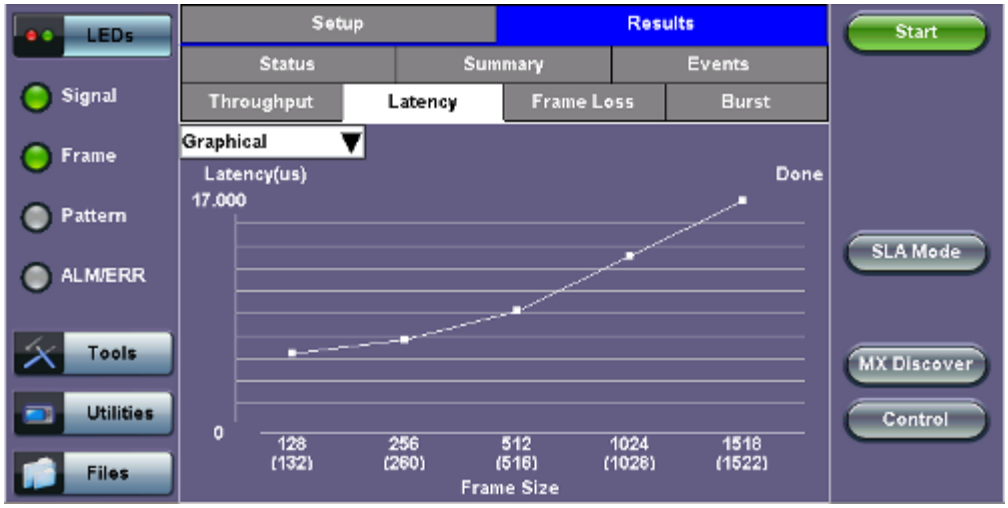
Latency and frame jitter measurements results are displayed in the following formats. Use the drop-down menu to select the Latency format:

- **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.

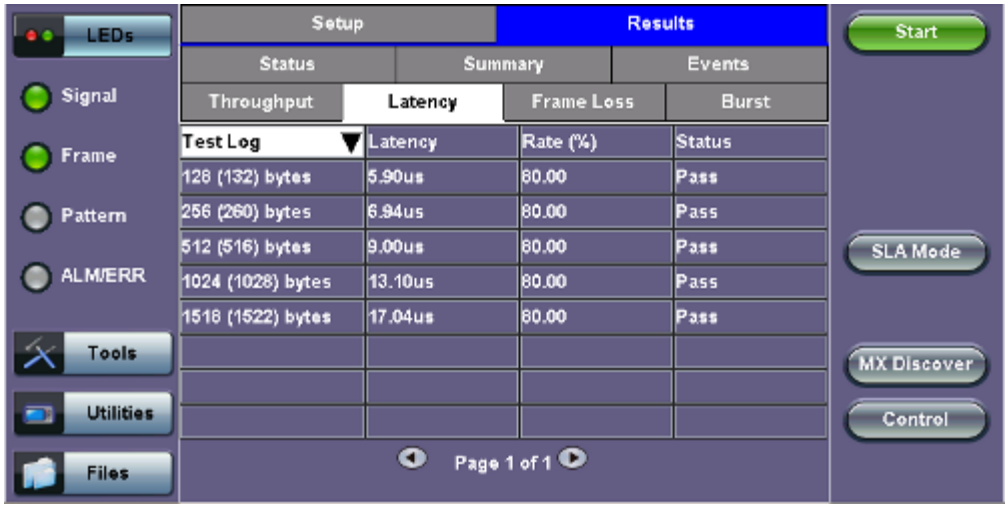
RFC 2544 Results - Latency (Summary)



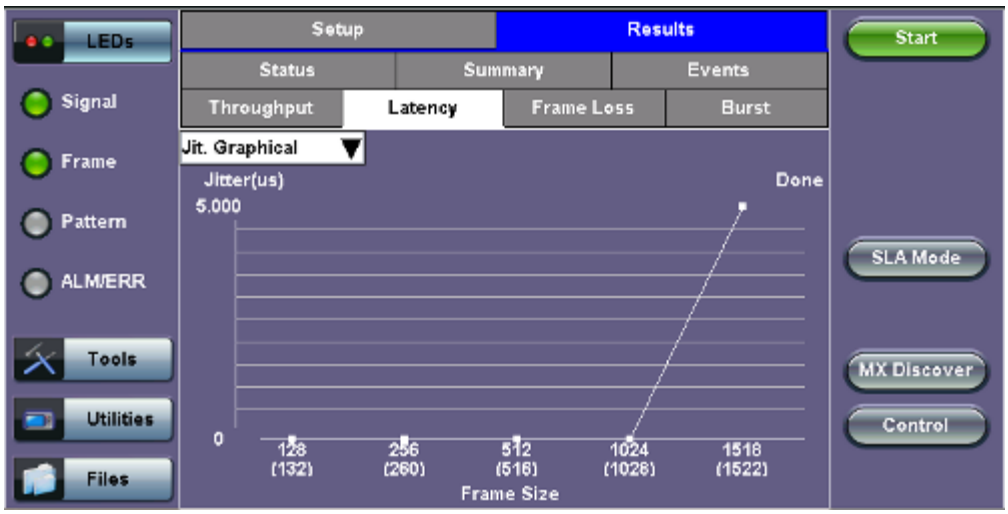
RFC 2544 Results - Latency (Graphical)



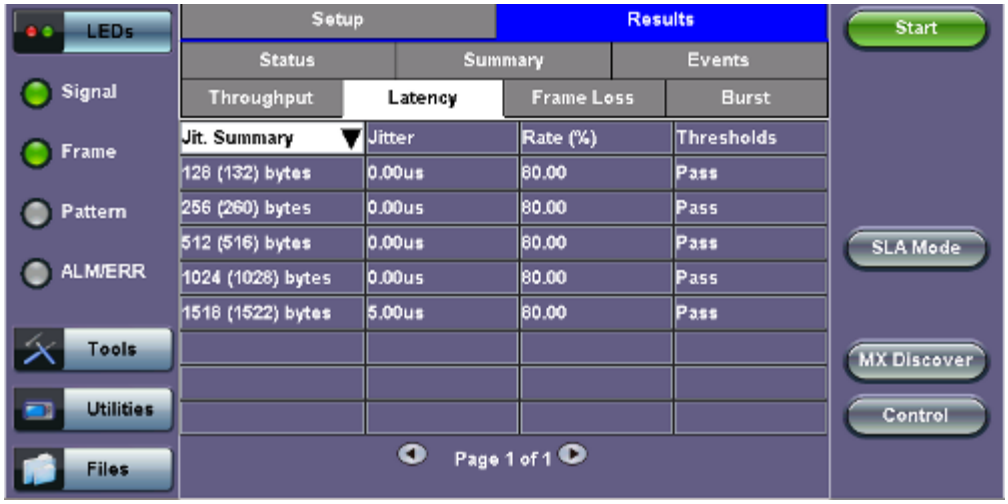
RFC 2544 Results - Latency (Test Log)



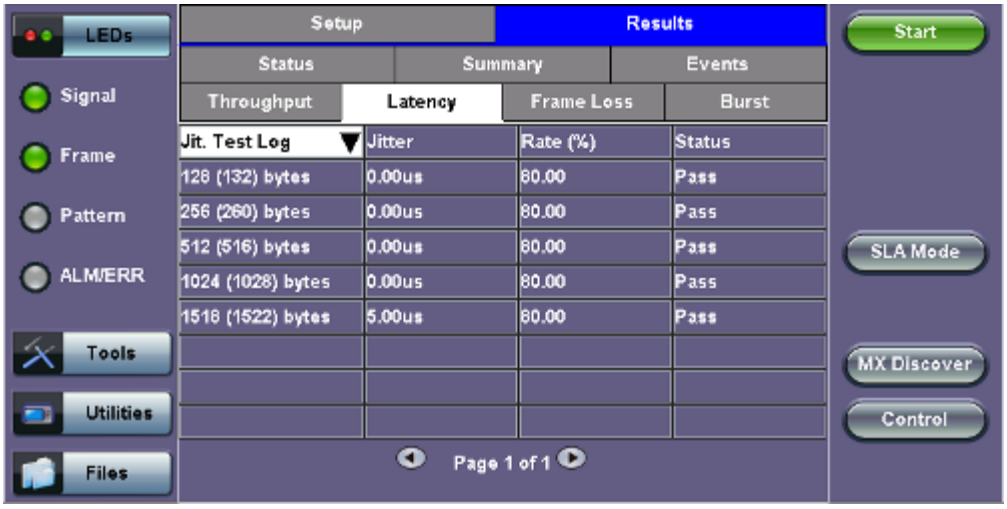
RFC 2544 Results - Latency (Jitter Graphical)



RFC 2544 Results - Latency (Jitter Summary)



RFC 2544 Results - Latency (Jitter Test log)

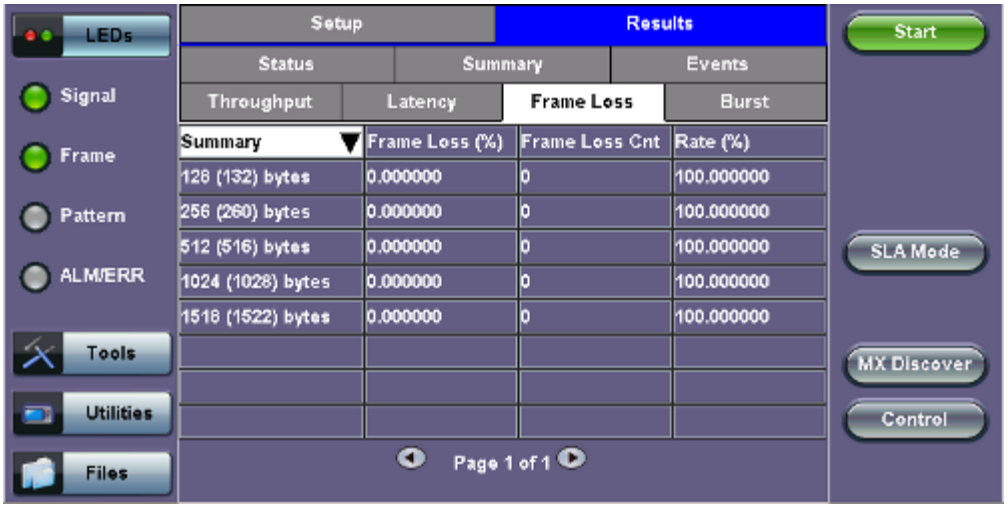


Go back to top Go back to TOC

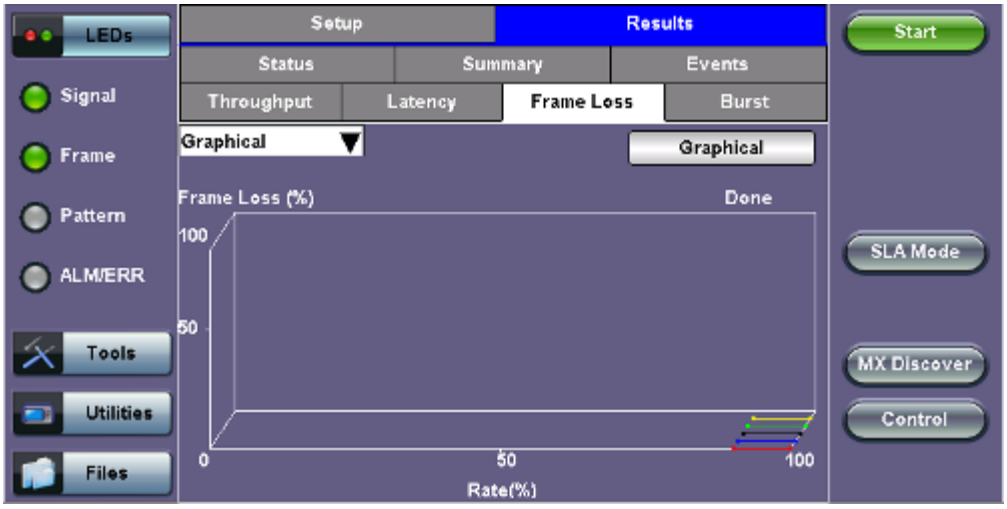
Frame Loss tab: Frame loss displays the percentage of frames not received. Use the drop-down menu to select the Frame Loss format:

- 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 on the magnifying glass to see the legend.

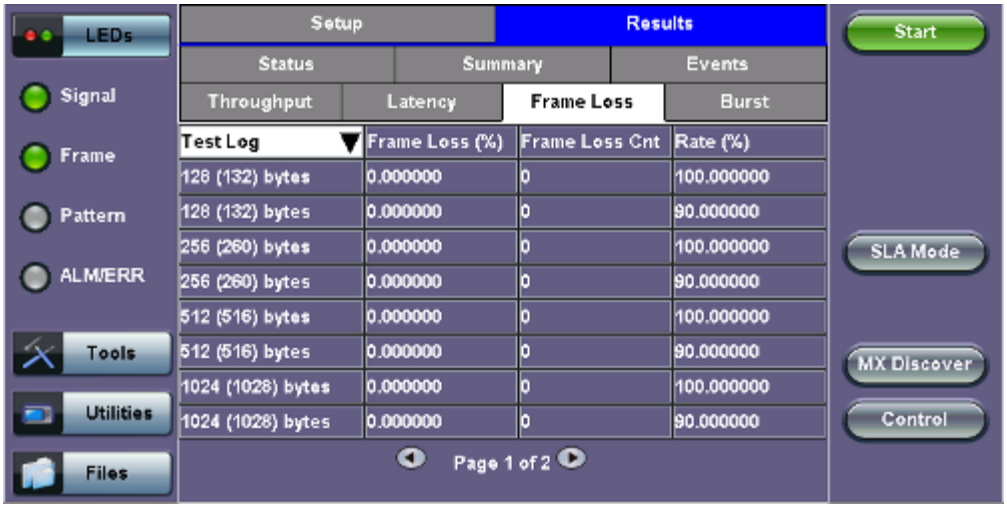
RFC 2544 Results - Frame Loss (Summary)



RFC 2544 Results - Frame Loss (Graphical)



RFC 2544 Results - Frame Loss (Test log)

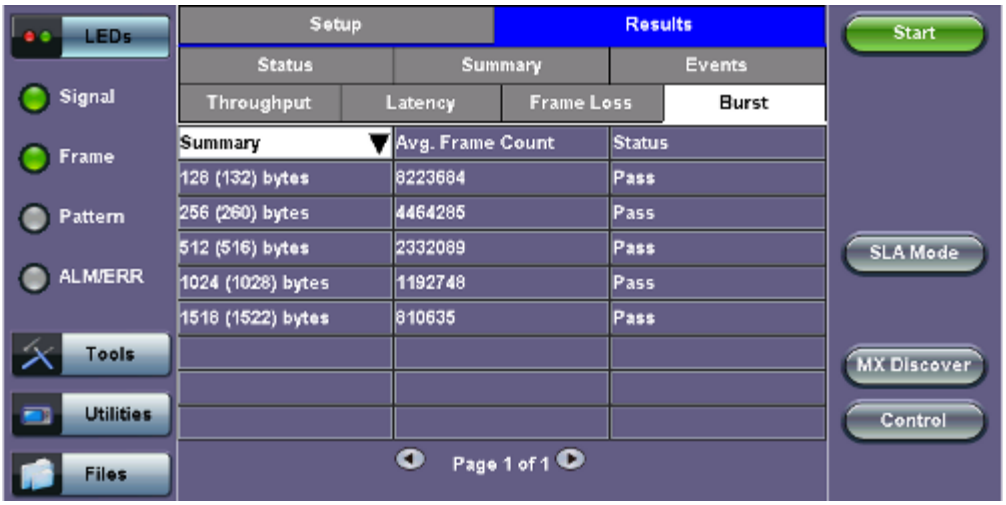


Go back to top Go back to TOC

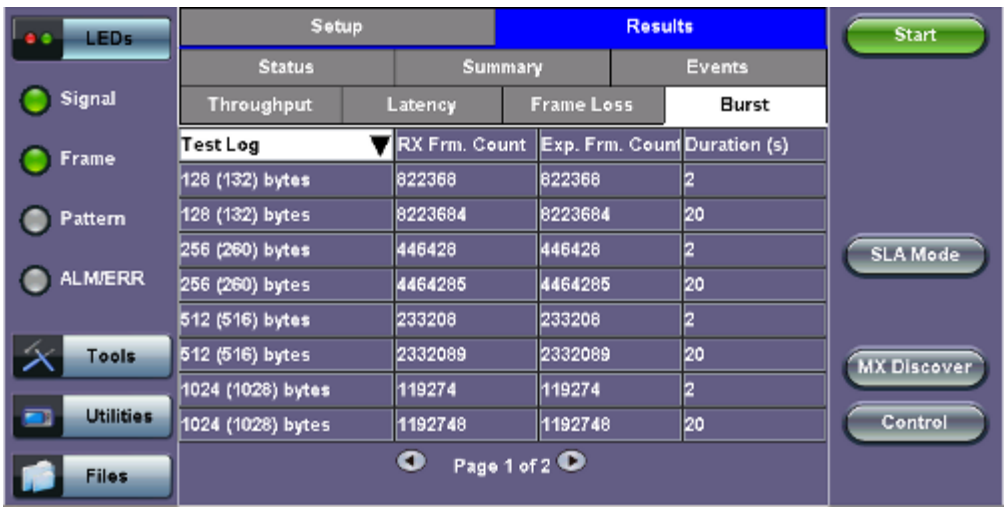
Burst tab: Burstability (back-back) results are the number of frames successfully transmitted/received at the line rate. It is displayed in the following formats:

- **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

RFC 2544 Results - Burstability (Summary)



RFC 2544 Results - Burstability (Test Log)



Go back to top Go back to TOC

15.3.3 Saving RFC 2544 Results

Once the test has been stopped the results can be saved by pressing the **Save** key on the VePAL's keypad. The results will be saved and named automatically. Once the results are saved, the user may view or rename the results file by going to **Home** > **Files** > **Saved**. Please see **10.2 Recalling or Viewing Files and Test Results** in the **V300 Common Functions manual** for more information.

Go back to top Go back to TOC

15.3.4 Advanced SLA Mode

Using this test function, users are able to verify SLAs while end-to-end QoS is assessed properly. By configuring one primary test stream and up to seven background streams each with independent frame size, bandwidth, and more importantly QoS levels, simulating different service applications is now realized. The Advanced RFC 2544 SLA mode provides detailed visibility of the test parameters for each of the traffic streams being measured, providing an efficient in-depth qualification in a fast and automated way.

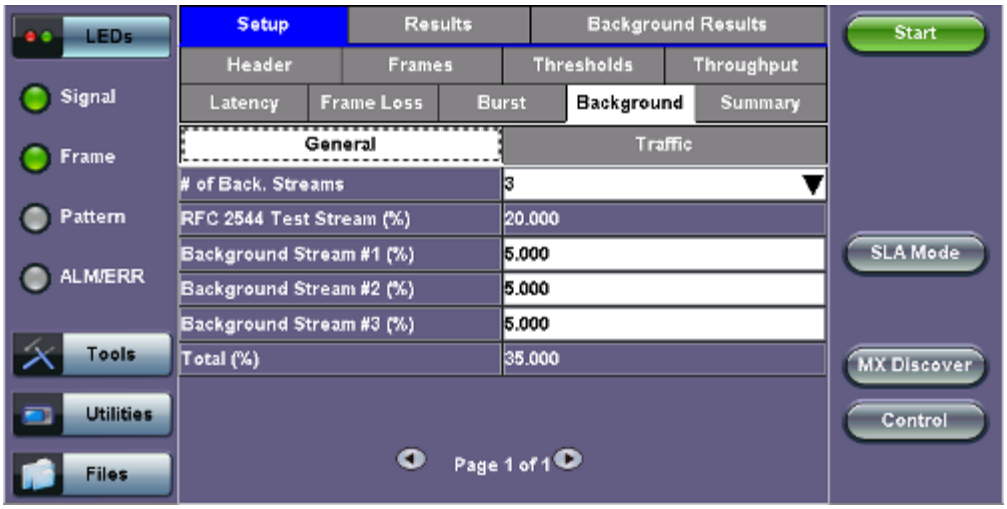
Setup

For **Header**, **Frames**, **Thresholds**, **Throughput**, **Latency**, **Frame Loss**, and **Burst**, please refer to Setup - Standard Mode.

Background - General

- **# of Back. Streams:** From 1 to 7 streams
- **RFC 2544 Test Stream (%):** This is the max rate set in frame loss
- **Background Stream # (%):** Allocated Bandwidth per Stream: The total bandwidth for all streams cannot exceed 100%
- **Total (%):** Sum of all stream rates in %

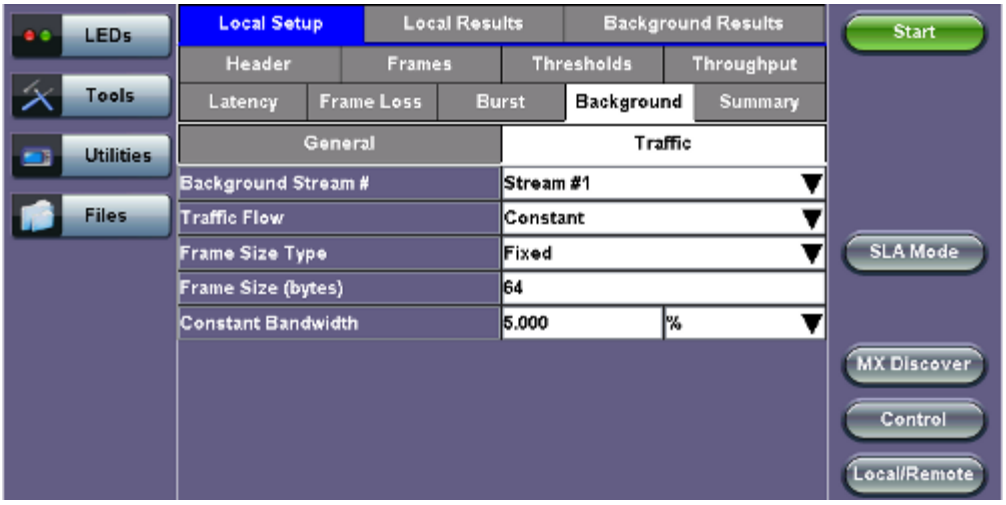
Setup - Background - General



Background - Traffic

- **Background Stream #:** Select a stream number to configure.
- **Traffic Flow:** Select from Constant, Ramp, Burst, or Single Burst traffic flow.
- **Frame Size (Type):** Fixed or Uniform. If uniform is chosen, the user will have to input a minimum and maximum frame size.
- **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 10k bytes.
- **BW (Transmit Bandwidth):** Configure the transmit rate for the stream.
  Note: The bandwidth allocation per stream is already configured in the **General Settings** tab, but can be modified in this screen as well.

Setup - Background - Traffic



Starting/Stopping an Advanced SLA Mode

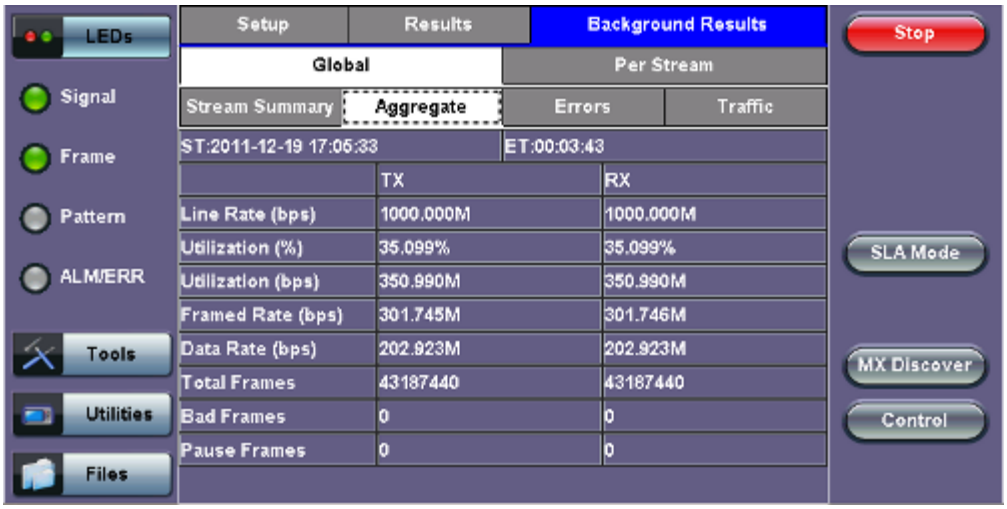
Please see Starting/Stopping a RFC 2544 Test for information on starting/stopping the test.

Go back to top Go back to TOC

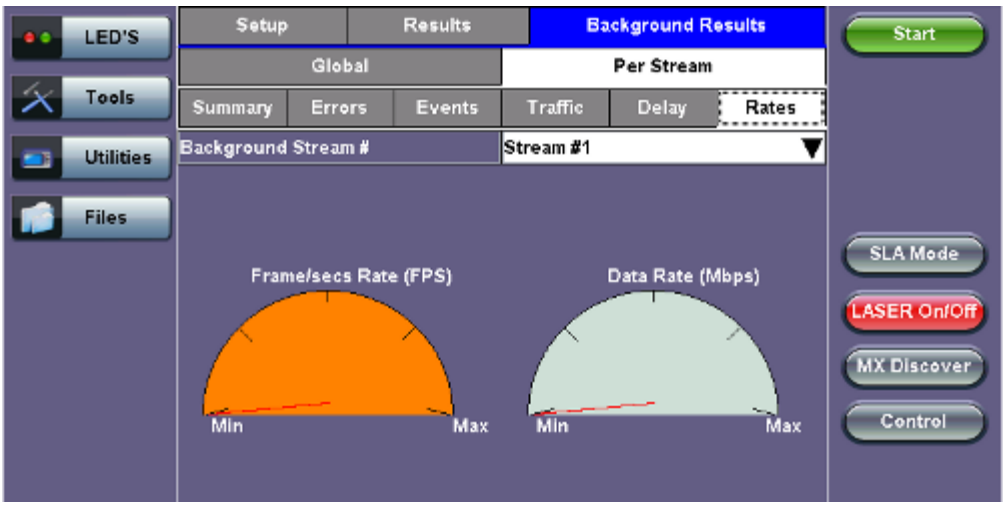
15.3.5 Background Results - Advanced SLA Mode

For information on Global and Per Stream Results in Advanced SLA Mode, please refer to 15.5.2 Throughput Results.

Background Results - Global



Background Results - Per Stream



Go back to top Go back to TOC

15.4 V-SAM

- Overview
- Setup
  - General
  - CIR Test Configuration
  - Header Settings
  - Service Attributes - Bandwidth Profile
  - Service Acceptance Parameters
  - MX Discover / Control Settings
- Results
  - Configuration Test
  - Performance Test
  - Event Log

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

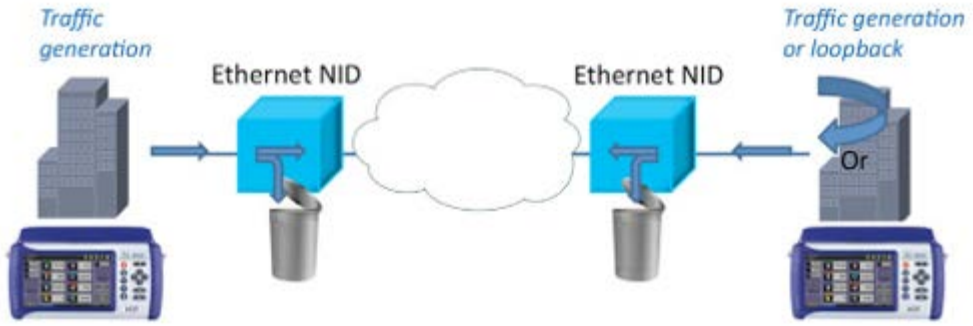
Test Methodology

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



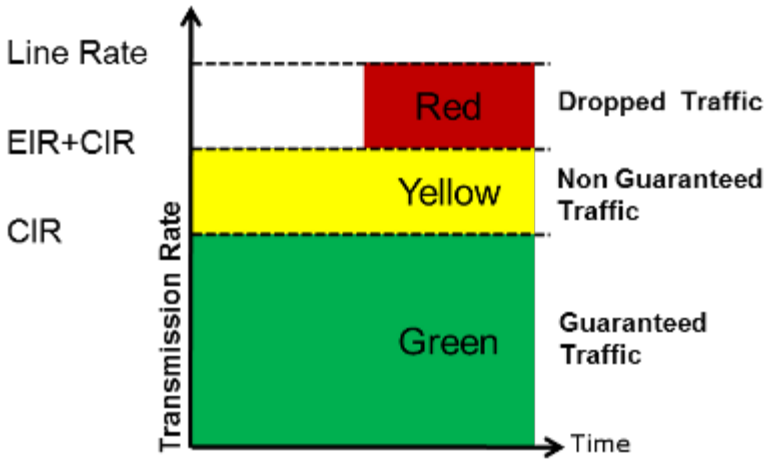
Phase 1: Service Configuration Test

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.

Go back to top Go back to TOC

15.4.1 V-SAM Setup

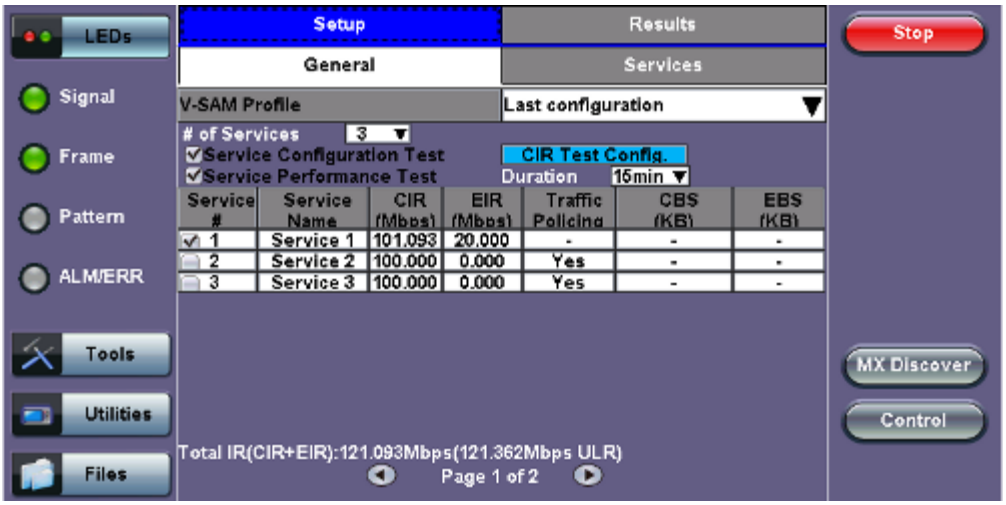
General (Page 1 and 2)

- **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.
- **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.

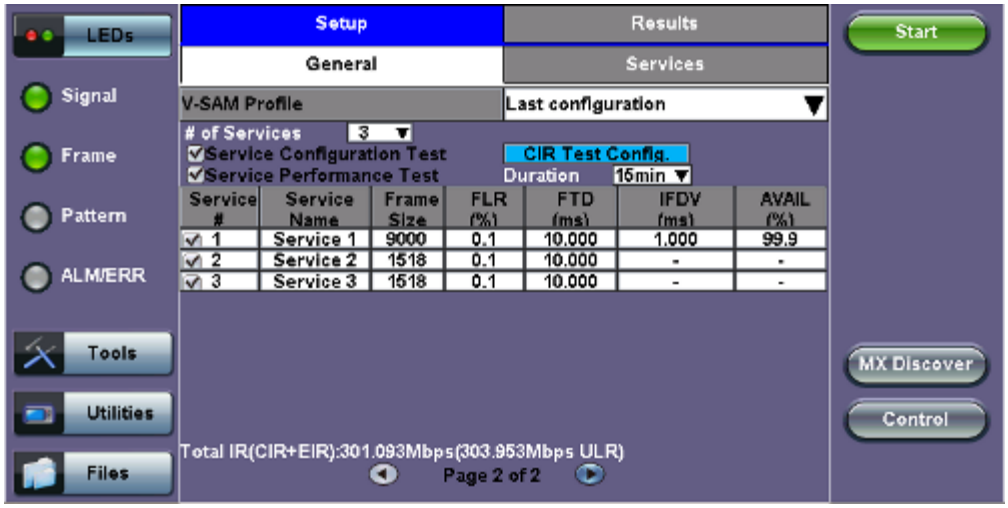
Enabling/Disabling Tests

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)



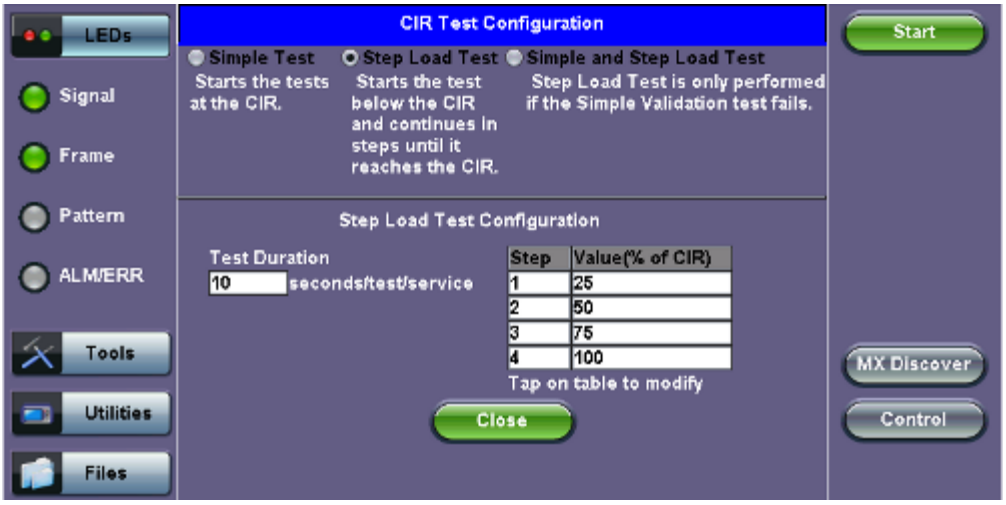
V-SAM - Setup - General (Page 2)



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



Go back to top Go back to TOC

15.4.1.1 Header Settings

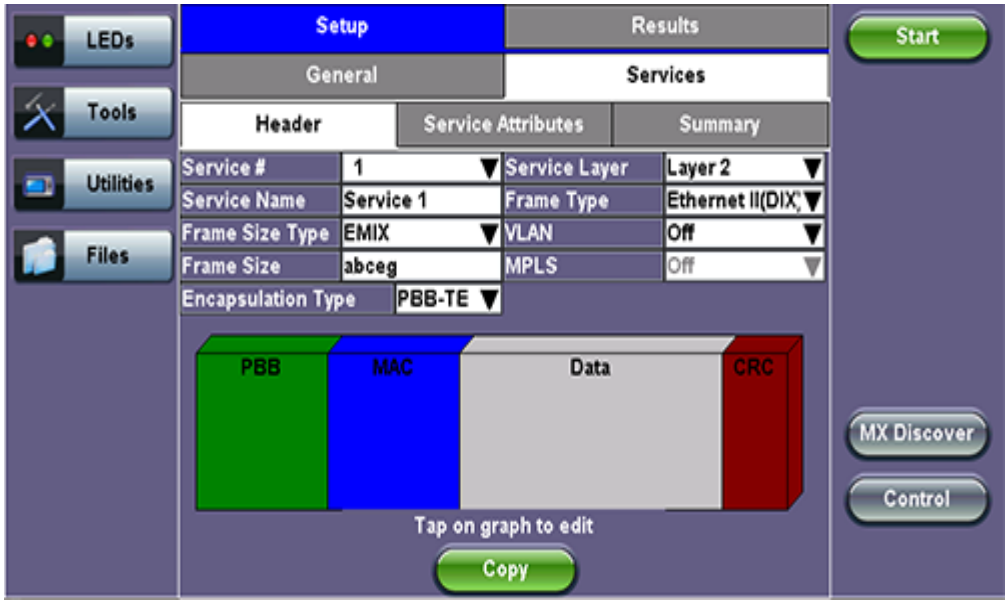
- **Service #:** Select a service to configure
- **Service Name:** Assign a name to the service if desired.
- **Frame Size Type:** Fixed or EMIX (1GE only). A fixed frame size is chosen as default
- **Frame Size:**
  - **For Fixed Traffic Flow:** Input a fixed frame size within the range of 64-10000 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.*
- **Encapsultaion Type:** None or **Provider Backbone Bridge (PBB-TE):** 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. Available for 1GE Copper/Fiber and 10GE port. PBB encapsulation is available for all Ethernet tests (Layer 2,3 and 4) - BERT, RFC2544, Throughput, V-SAM.

  Tap the PBB block to configure the settings. All PBB fields are configurable.

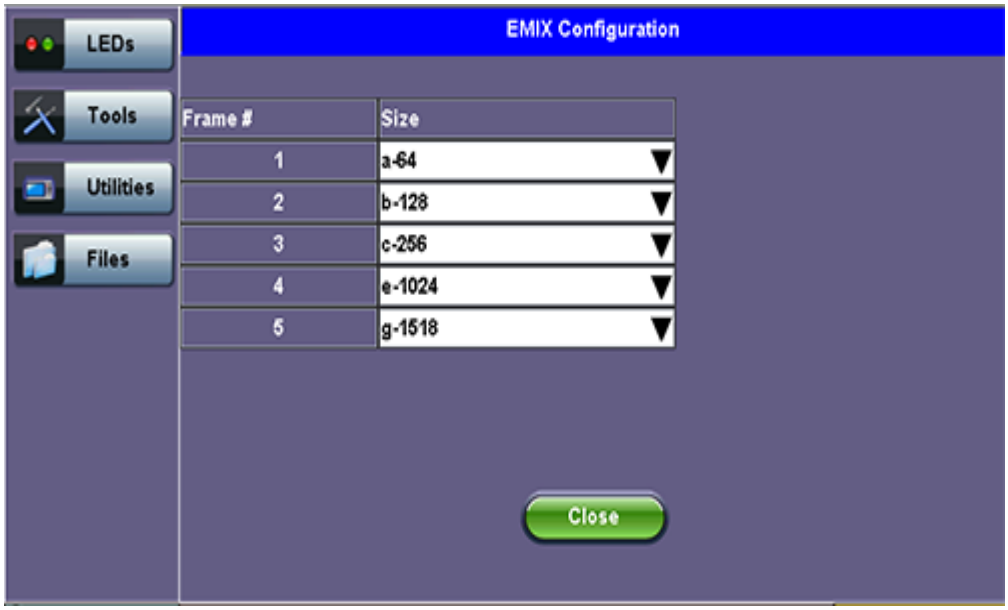
  - Backbone MAC Source
  - Backbone MAC Destination
  - Ethernet Type
  - I-SID
  - Backbone VLAN ID, Priority, Type

Please see 15.3.1 RFC 2544 Setup and follow the setup procedure to configure the remaining Header Settings for V-SAM.

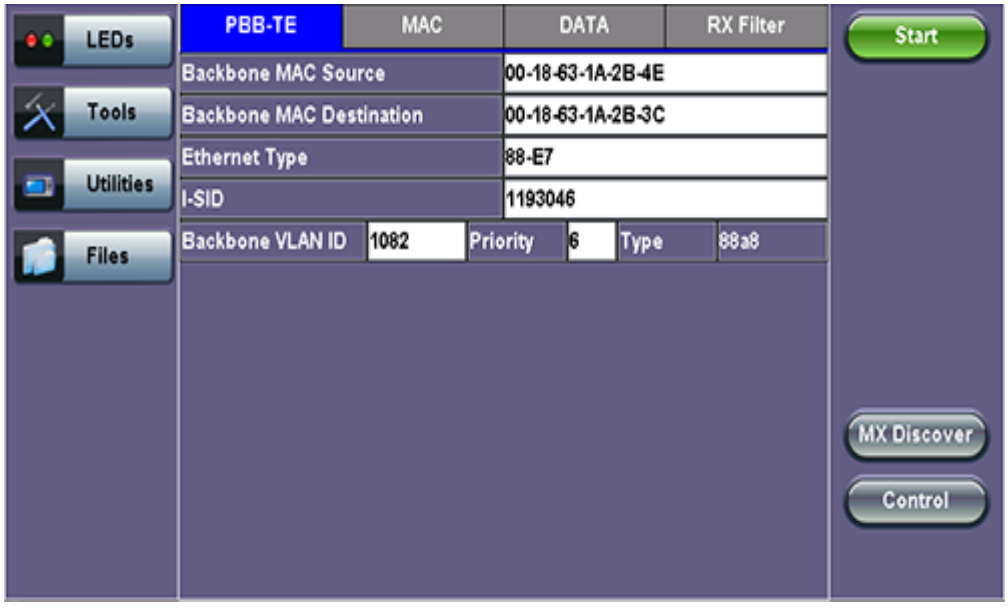
V-SAM Setup - Services - Header Settings



V-SAM Setup - Services - EMIX Frame Size Settings



V-SAM Setup - Services - PBB Settings



Go back to top Go back to TOC

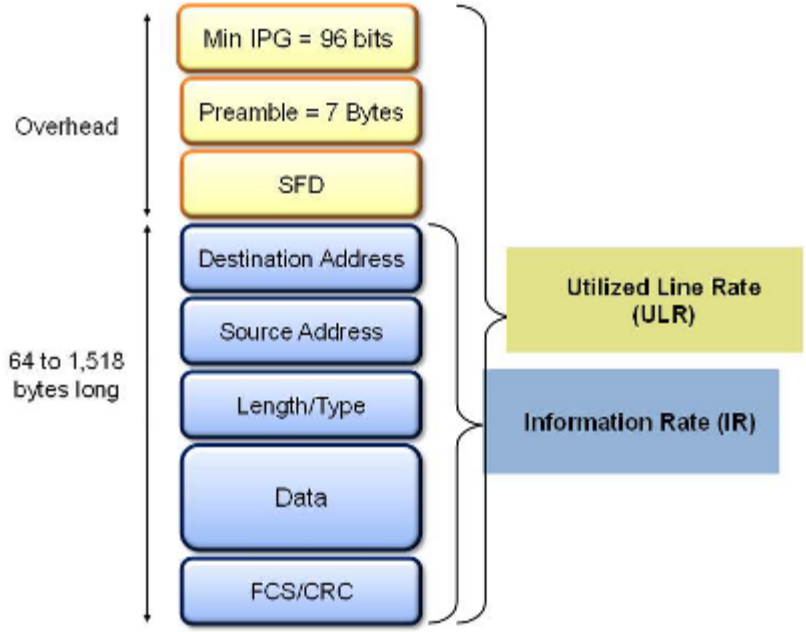
15.4.1.2 Service Attributes

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:

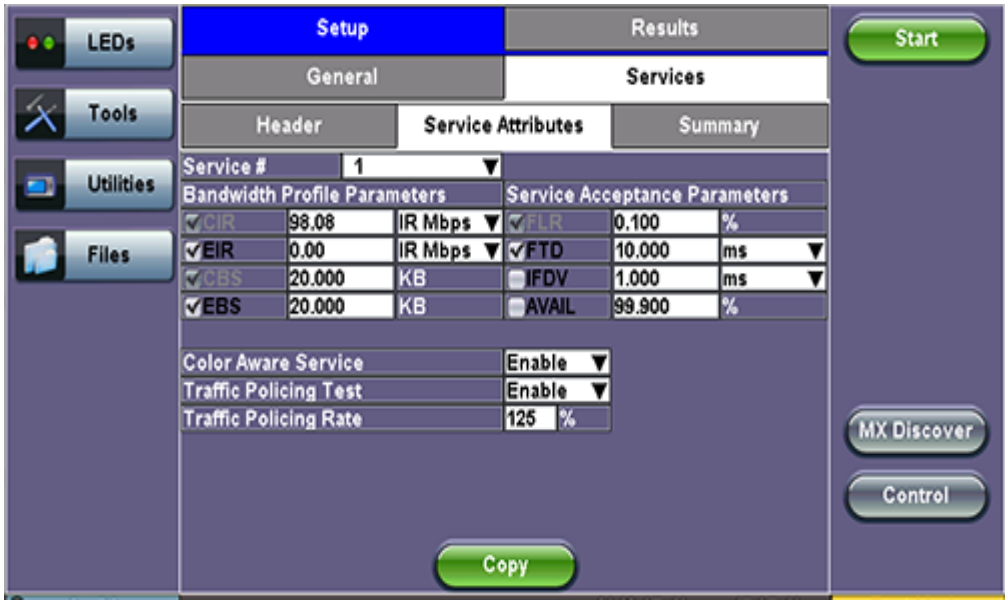
- **CIR:** Committed Information Rate. This is the guaranteed maximum rate at which the customer can send frames that are assured to be forwarded through the network without being dropped. Tap on the box to enter a rate and choose between **IR Mbps** or **ULR Mbps**. Allowed values range from 0.01Mbps 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

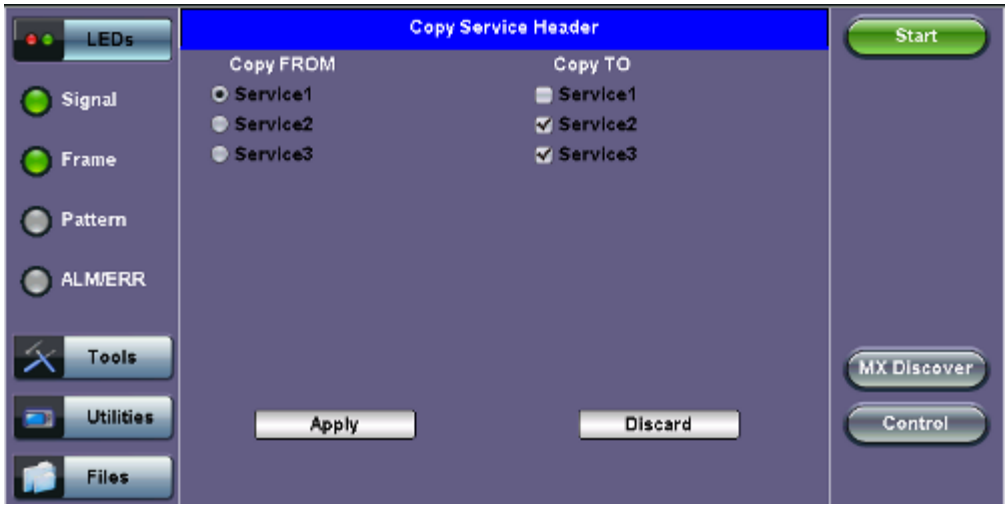
A check next to the parameters in the Service Attributes table indicates that the test for the corresponding service is set to run. Tap on the box to remove the check and cancel the test for that service.

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.

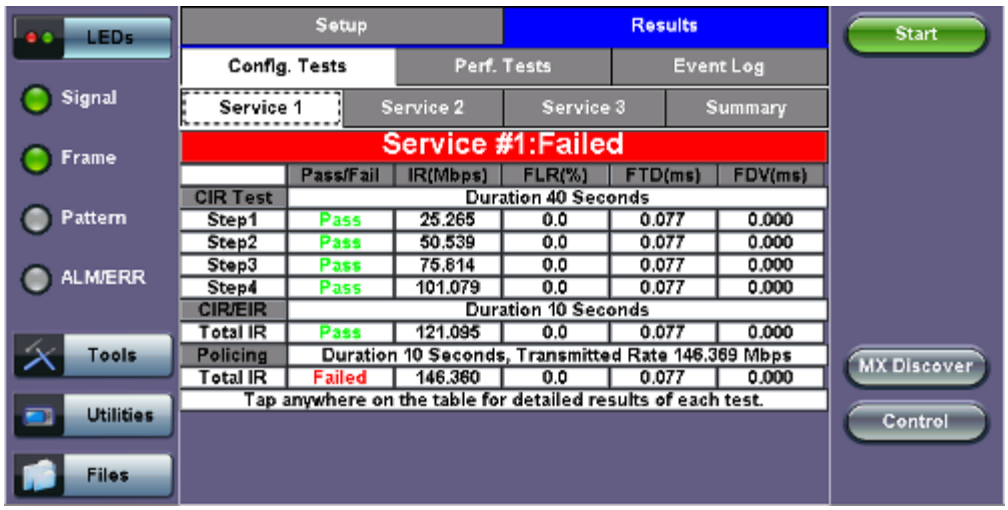
MX Discover and Control Settings

For instructions on how to loop up/down the test set with another test set or device, please refer to 15.1.4 MX Discover and Control.

Go back to top Go back to TOC

15.4.2 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.

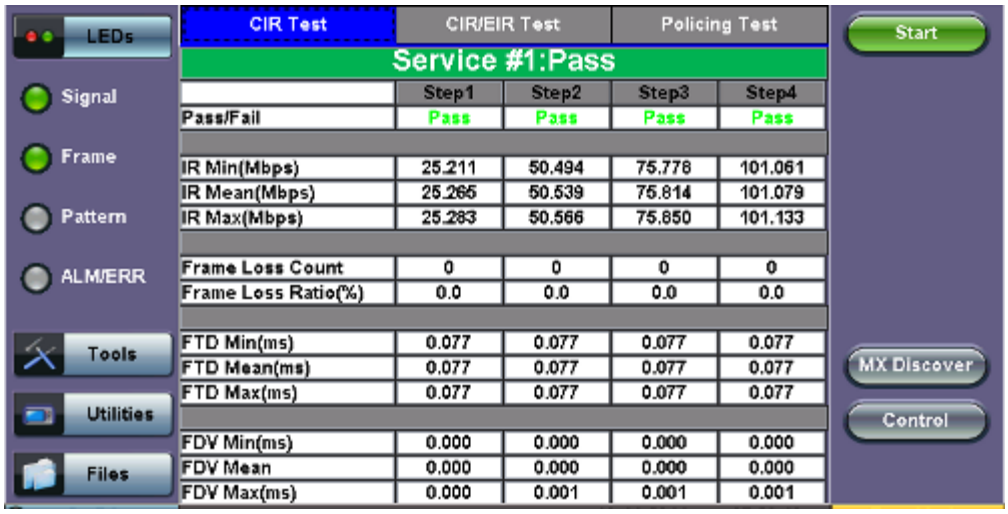
Configuration Test

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

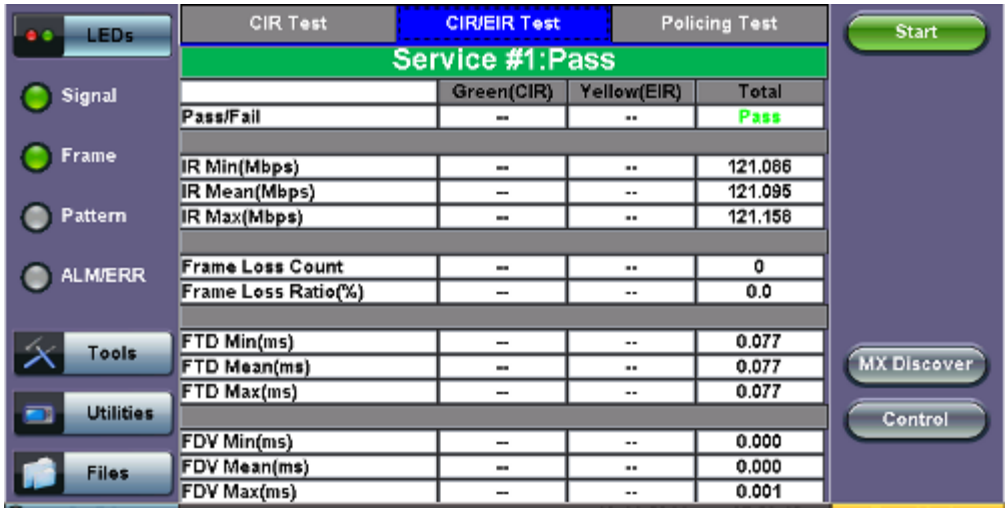


Service #1:Pass

	Step1	Step2	Step3	Step4
Pass/Fail	Pass	Pass	Pass	Pass
IR Min(Mbps)	25.211	50.494	75.776	101.061
IR Mean(Mbps)	25.265	50.539	75.814	101.079
IR Max(Mbps)	25.283	50.566	75.850	101.133
Frame Loss Count	0	0	0	0
Frame Loss Ratio(%)	0.0	0.0	0.0	0.0
FTD Min(ms)	0.077	0.077	0.077	0.077
FTD Mean(ms)	0.077	0.077	0.077	0.077
FTD Max(ms)	0.077	0.077	0.077	0.077
FDV Min(ms)	0.000	0.000	0.000	0.000
FDV Mean	0.000	0.000	0.000	0.000
FDV Max(ms)	0.000	0.001	0.001	0.001

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

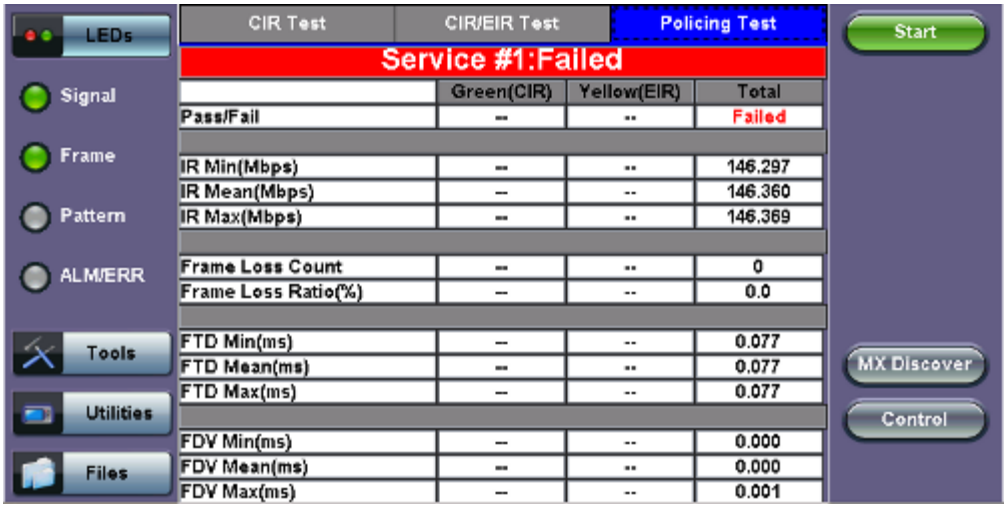


Service #1:Pass

	Green(CIR)	Yellow(EIR)	Total
Pass/Fail	--	--	Pass
IR Min(Mbps)	--	--	121.086
IR Mean(Mbps)	--	--	121.095
IR Max(Mbps)	--	--	121.158
Frame Loss Count	--	--	0
Frame Loss Ratio(%)	--	--	0.0
FTD Min(ms)	--	--	0.077
FTD Mean(ms)	--	--	0.077
FTD Max(ms)	--	--	0.077
FDV Min(ms)	--	--	0.000
FDV Mean(ms)	--	--	0.000
FDV Max(ms)	--	--	0.001

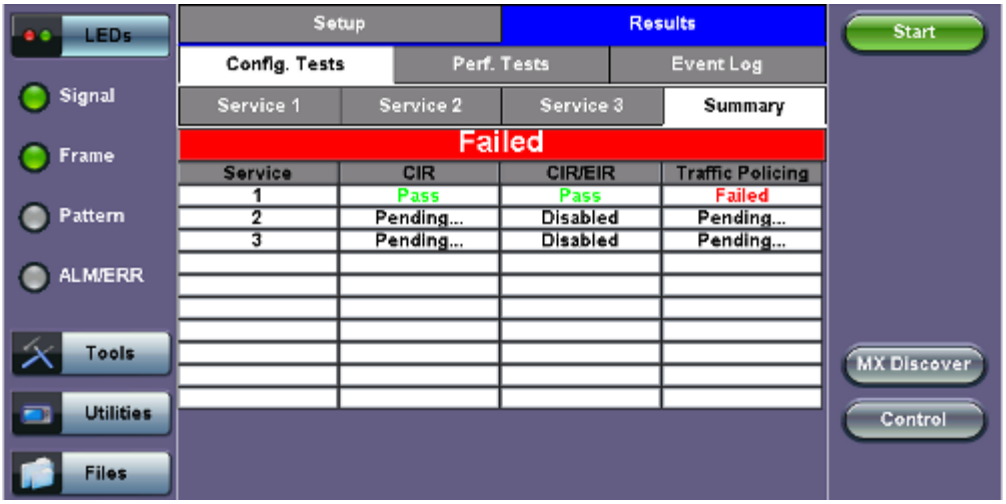
CIR/EIR test: The test passes if the received IR value is between the CIR (minus the margin allowed by the FLR) and CIR+EIR.

Policing Test - Service 1



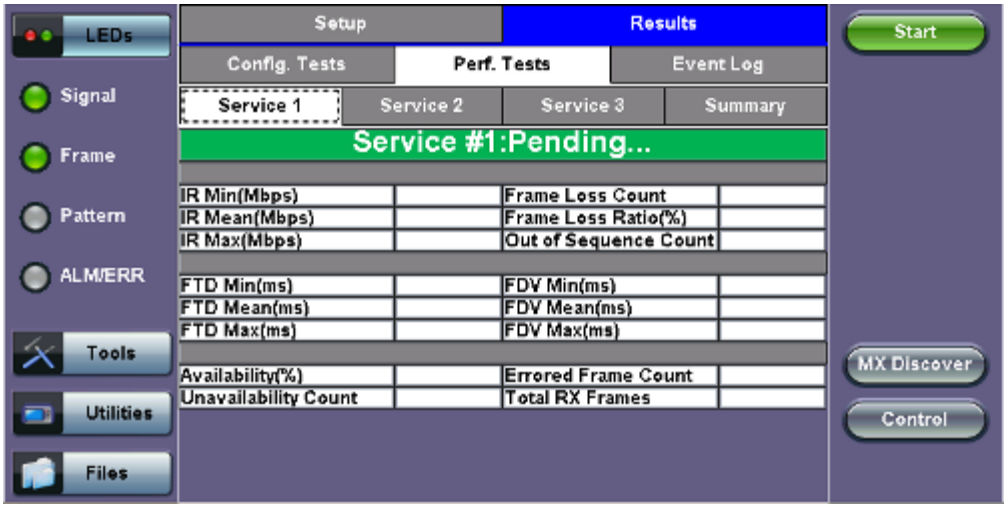
Policing test: The test passes if the received traffic rate is at least at the CIR (minus the margin allowed by the FLR) but does not exceed the allowed CIR+EIR.

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



Performance Test

The **Service** # tabs display min, mean, and max values for **IR Mbps**, **FTD**, **FDV**, **Frame Loss Count**, **Frame Loss Ratio (%)**,

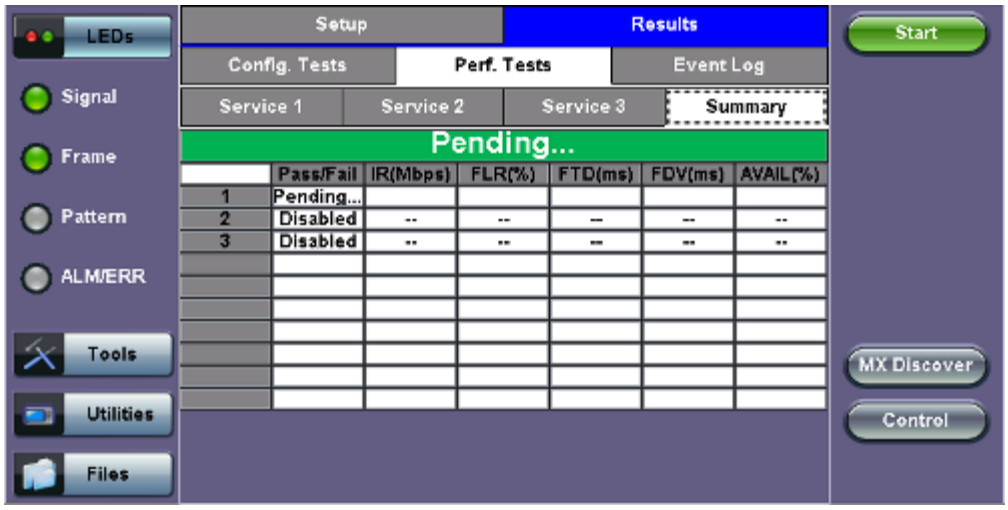
Availability, and **Errored Frame Count**. Pass/Fail/Pending status of each test is displayed on the top of each table.

- **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**.

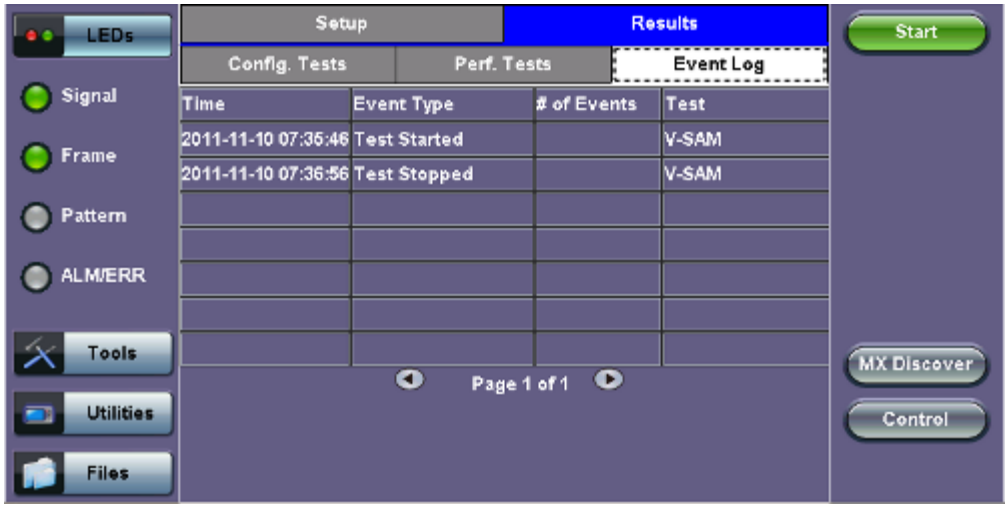
Perf. Tests - Summary



Event Log

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

Event Log



Go back to top Go back to TOC

15.5 Throughput Testing (Multiple Streams)

Overview:

The throughput application (or the multiple streams 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 allows for the configuration of up to 8 traffic streams with their own MAC and IP addresses, VLAN tags (up to 3 per stream), 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 (up to 8 streams) 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.

- **Setup**
  - **General Settings**
  - **MX Discover and Control Settings**
  - **Per Stream Configurations**
  - **Traffic Settings**
  - **Error Injection Settings**
  - **Alarm Injection Settings**
  - **Summary**
- **Starting/ Stopping a Throughput Test**
- **Results**
  - **Global Aggregate Results**
  - **Per Stream Results**
  - **Saving Results**

Go back to top Go back to TOC

15.5.1 Setup

Unless otherwise noted, the Frame Header and related setups are the same as the ones described in section 15.2 BERT and 15.3 RFC 2544. The following parameters must be configured prior to performing a Throughput test:

- 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)

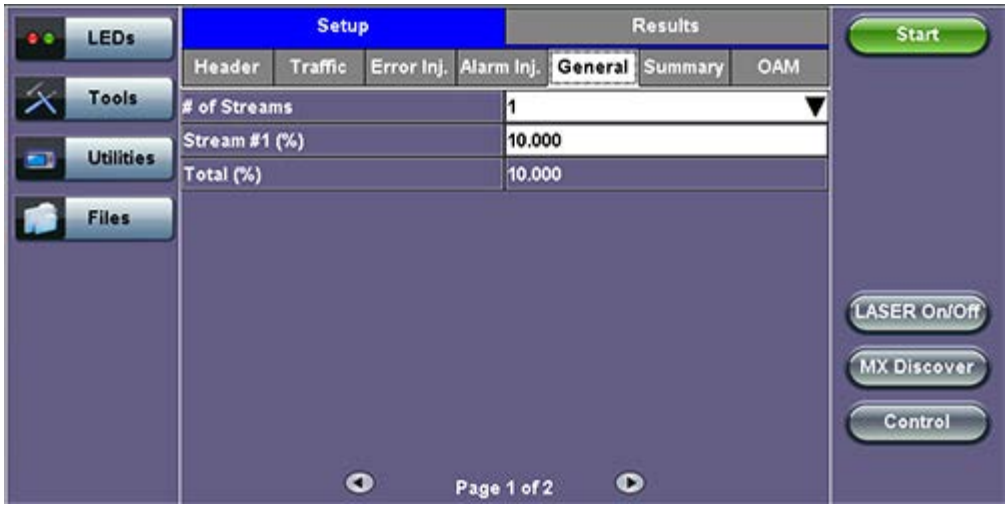
Go back to top Go back to TOC

15.5.1.1 General Throughput Settings (Global Configuration)

Page 1:

- **# of Streams:** From 1 to 10 streams.
- **Stream #:** Allocated Bandwidth per Stream: The total bandwidth for all streams cannot exceed 100%.
- **Total (%):** Sum of all stream rates in %.

Throughput Setup - General Settings



Page 2:

- **#of Streams:** From 1 to 10 streams. ***Note:*** *# of Streams can be specified either on Page 1 or Page 2. It will be reflected on both pages.*
- **Delay Measurement Mode:** Disable, Round Trip Delay, One-Way Delay with GPS/CDMA or Local One-Way Delay (for Dual Port Mode).
    - **Round Trip Delay:** Round Trip Delay should only be enabled when running the test to a remote loopback.
    - **One-Way Delay with GPS/CDMA:** One Way Delay (OWD) measurements can be carried out between two units only when their clocks are synchronized. In order to achieve synchronization, both units must be synchronized to the same timing source and at the same time. See Chapter 15-1_Ethernet_Setup for a detailed description of the synchronization process.
- **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.

Throughput Setup - General Settings Page 2

Throughput - General Settings Delay Measurement Mode

Multiple Streams

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

Go back to top Go back to TOC

15.5.1.2 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 15.1.4 MX Discover and Control.

Go back to top Go back to TOC

15.5.1.3 Per Stream Configurations

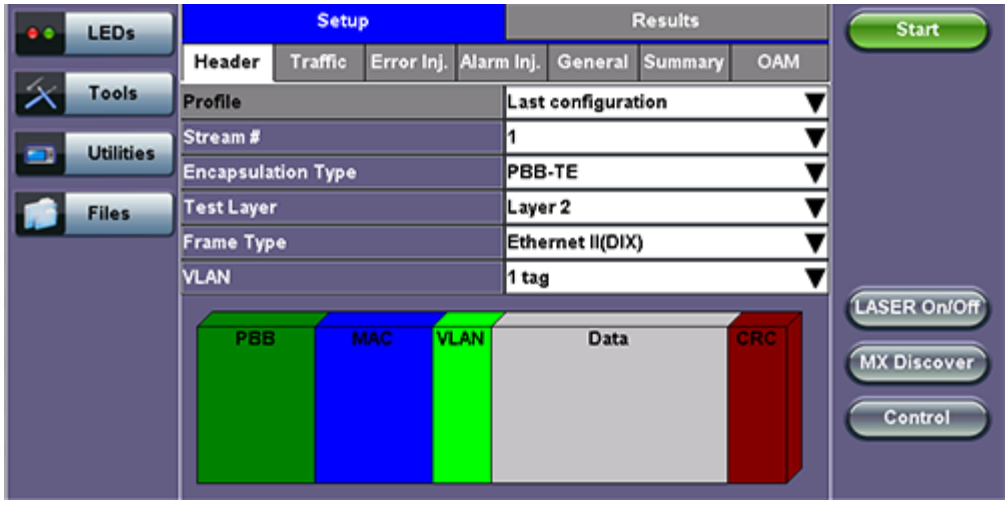
MAC Setup

MAC configuration in the Throughput section features MAC flooding for buffering verification and performance testing of Ethernet switches.

- **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.

Note: For information on header configuration please see 15.2.1.1 BERT Header Settings in the BERT section.

Throughput Setup - Header Settings per Stream



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.

Go back to top Go back to TOC

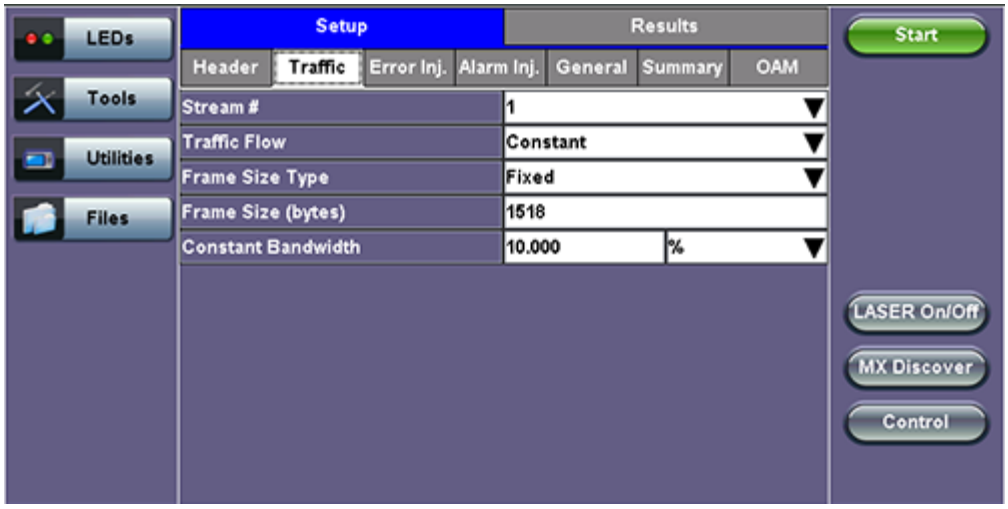
15.5.1.4 Traffic Settings (Per Stream Configuration)

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 or Uniform. If uniform is chosen, the user will have to input a minimum and maximum frame size.
- **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 10k bytes.
- **BW (Transmit Bandwidth):** Configure the transmit rate for the stream.
  Note: The bandwidth allocation per stream is already configured in the **General Settings** tab, but can be modified in this screen as well.

For more information on Traffic Settings, please see 15.2.1.2 BERT Traffic Settings.

Throughput Setup - Traffic Setup - Constant Traffic Flow



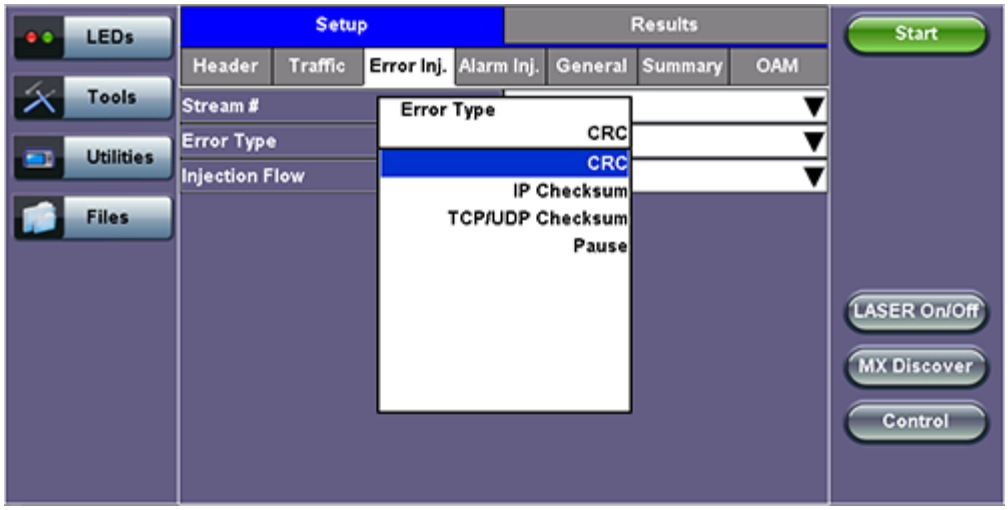
Go back to top Go back to TOC

15.5.1.5 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, IP Checksum (Layer 3, 4 only), TCP/UDP Checksum (Layer 4 only), or Pause. With Pause selected, the unit will transmit a pause frame when the **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.
- **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:** The user will be able to configure the error count via numeric keypad.

Throughput Test - Error Injection Settings per Stream



Go back to top Go back to TOC

15.5.1.6 Alarm Injection Settings

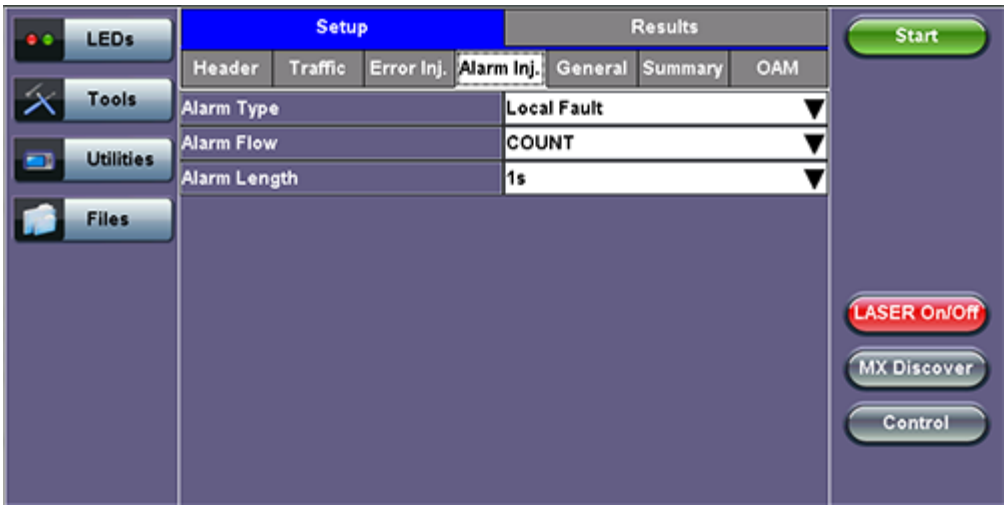
Alarm injection can be performed during test. The type of alarms and alarm injection are configured in the Alarm Injection tab. Once the test is running, alarm injection can be performed by pressing the **Alarm Inject** button on the right side of the screen.

Note: *Alarm Injection is available only with 10GE Port Tests.*

- **Alarm Type:** Local Fault, Remote Fault

- **Alarm Flow:** The alarm flow determines how the selected alarms will be injected. A specific Count or Continue (continuous) can be selected.
- **Alarm Length:** 1s, 10s, or 100s.

Throughput Alarm Injection Setup

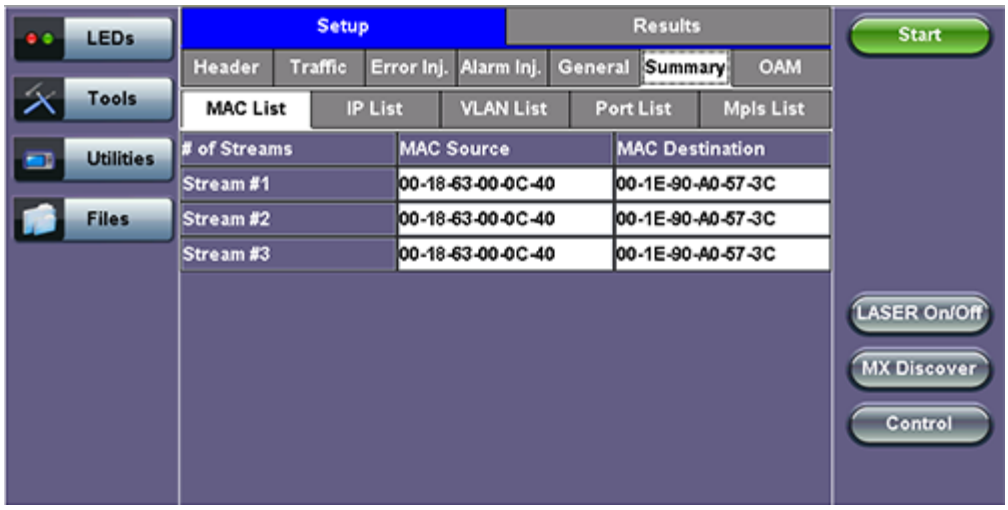


Go back to top Go back to TOC

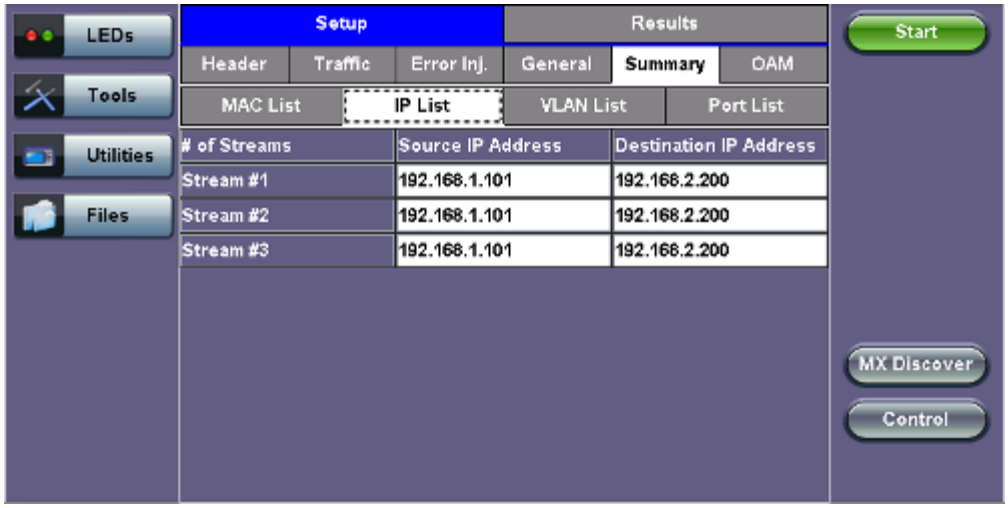
15.5.1.7 Summary

The summary screen lists the source, 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.

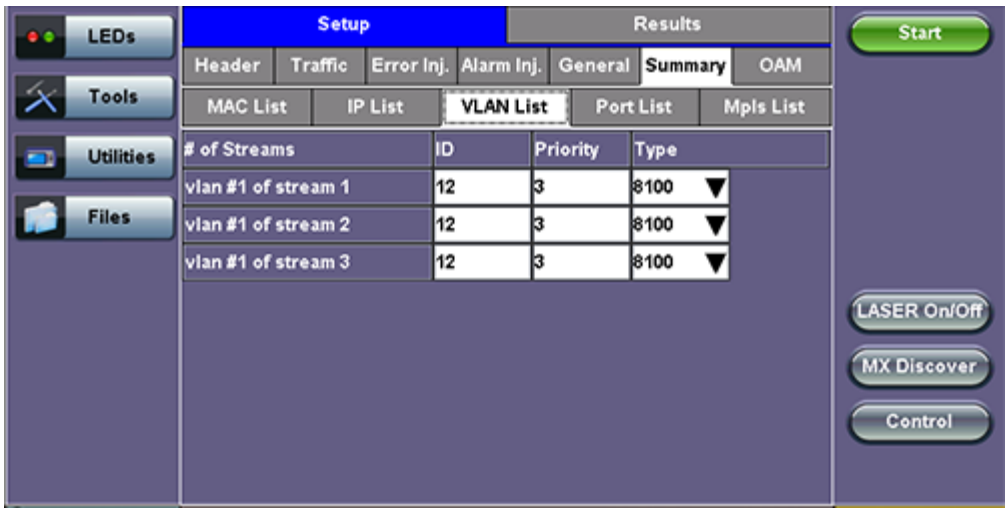
Throughput Test - Summary (MAC List)



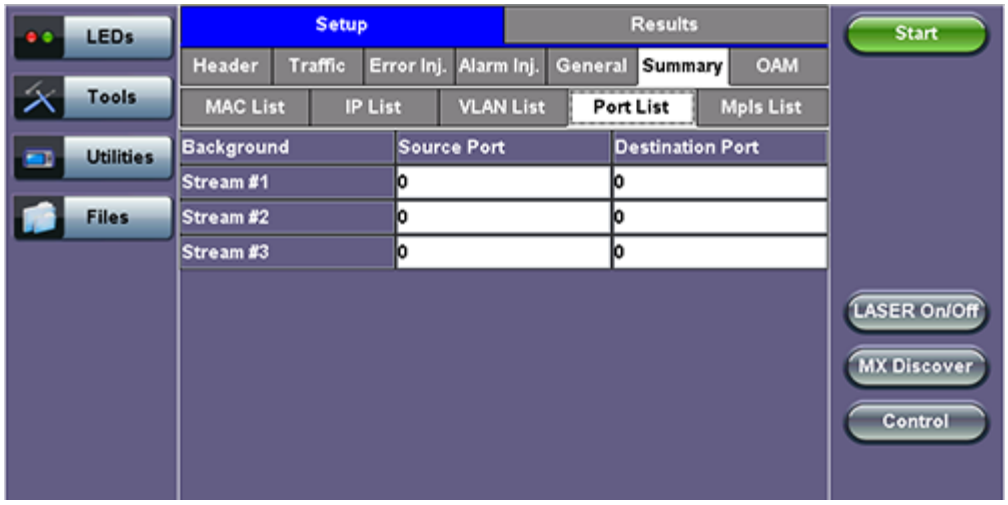
Throughput Test - Summary (IP List)



Throughput Test - Summary (VLAN List)



Throughput Test - Summary (Port List)



Go back to top Go back to TOC

15.5.1.8 Starting/Stopping a Throughput (Multiple Streams) Test

Once all configurations have been made, the user can start the Throughput 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 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 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 Throughput 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 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 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.

Go back to top Go back to TOC

15.5.2 Throughput Results

15.5.2.1 Viewing Throughput (Multiple Streams) Test Results

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

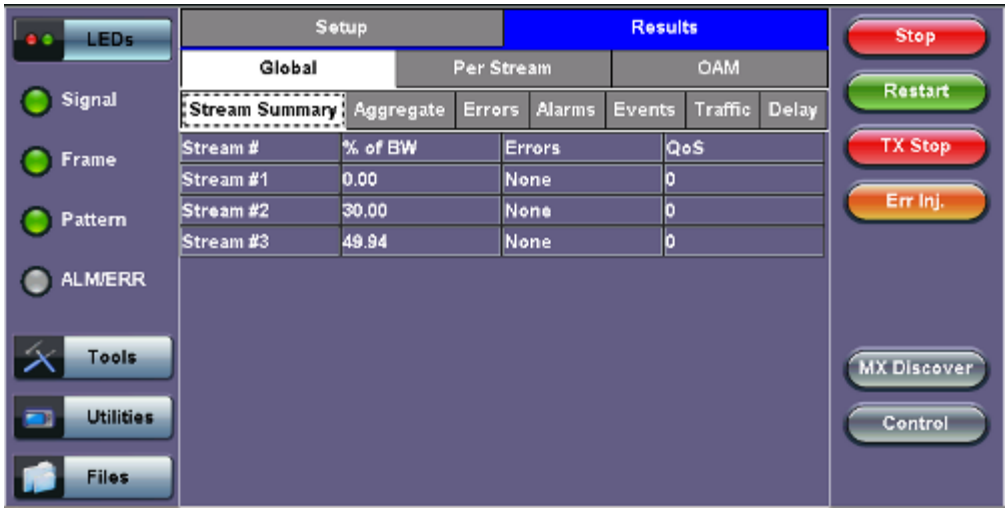
15.5.2.2 Global/Aggregate Results

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

The **Global Stream Summary** screen displays:

- Stream number (#)
- Total received 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	≤ 50 ms	≤ 50 ms	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)

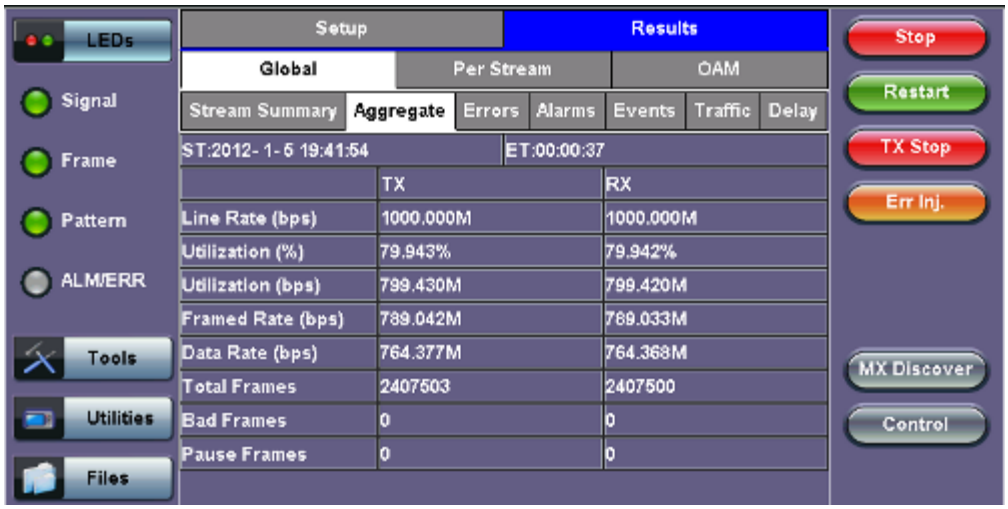
Network Performance Parameter	QoS Classes			
	Class 4	Class 5	Class 6	Class 7
IPTD	≤ 2 s / 2 (1 s one-way) **AND** > 800 ms /2	U	≤ 200 ms / 2 (100 ms one-way)	≤ 800 ms / 2 (400 ms one-way) **AND** > 200 ms/2
IPDV	U	U	≤ 50 ms	≤ 50 ms
IPLR	> 1/100,000 **AND** ≤ 1/1000	U	≤ 1 / 100,000	≤ 1/100,000
IPER	>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

Go back to top Go back to TOC

The Aggregate screen displays these parameters:

- **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.
- **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 %.
- **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).
- Total # of frames, bad frames, and pause frames.

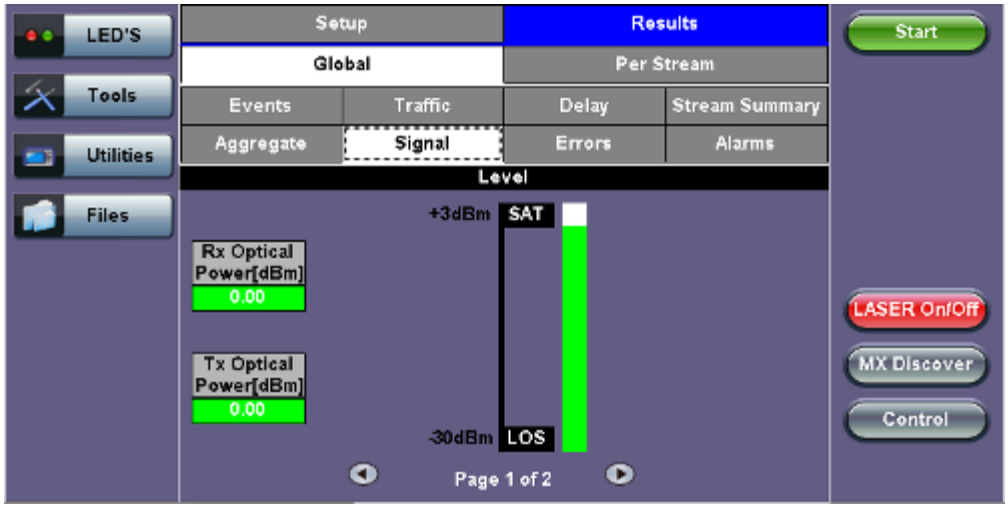
Throughput Results - Global Aggregate



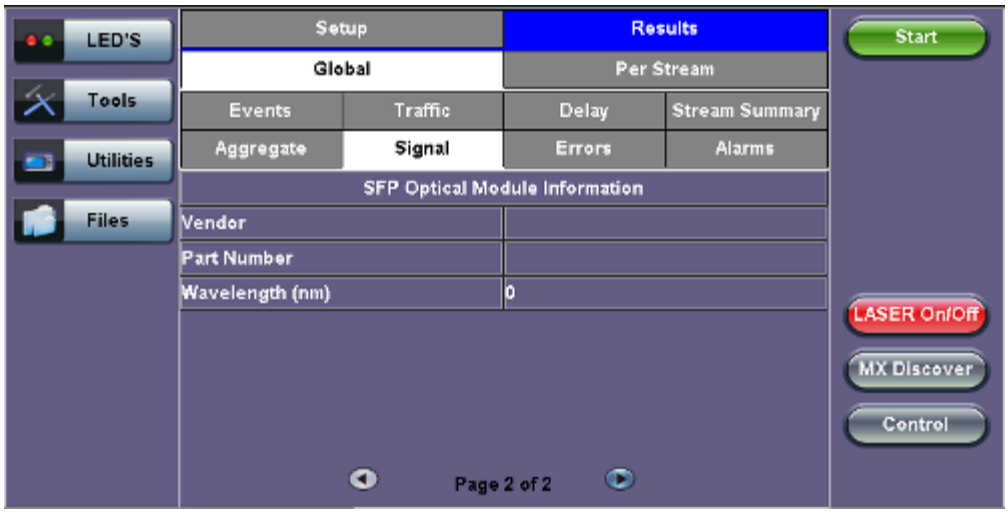
Go back to top Go back to TOC

The **Global Signal** screen (fiber ports only) displays the optical level measured by the SFP or XFP transceiver.

Throughput Results - Global Signal



Throughput Results - Global Signal (page 2)

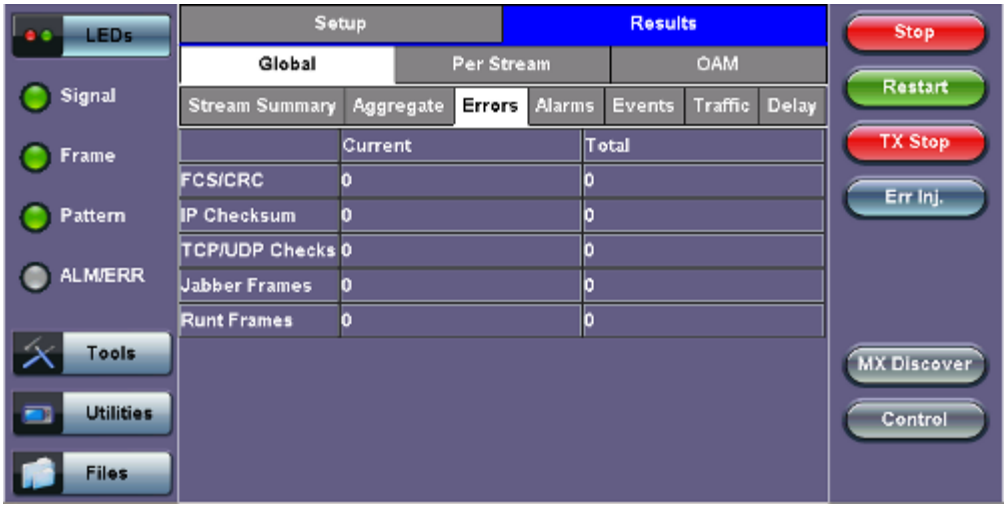


Go back to top Go back to TOC

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

- **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

Throughput Results - Global Errors

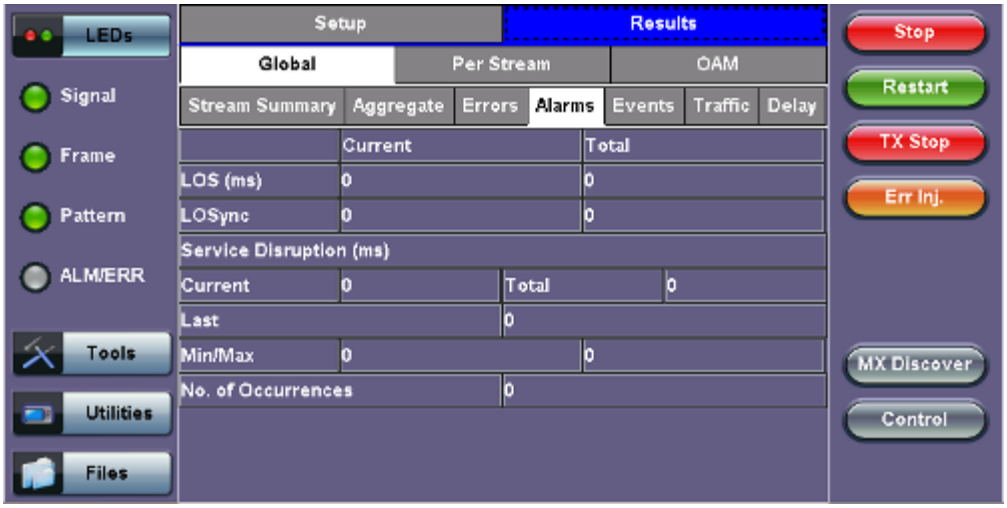


Go back to top Go back to TOC

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

- **LOS:** Loss of Signal
- **LOSync:** Loss synchronization
- 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

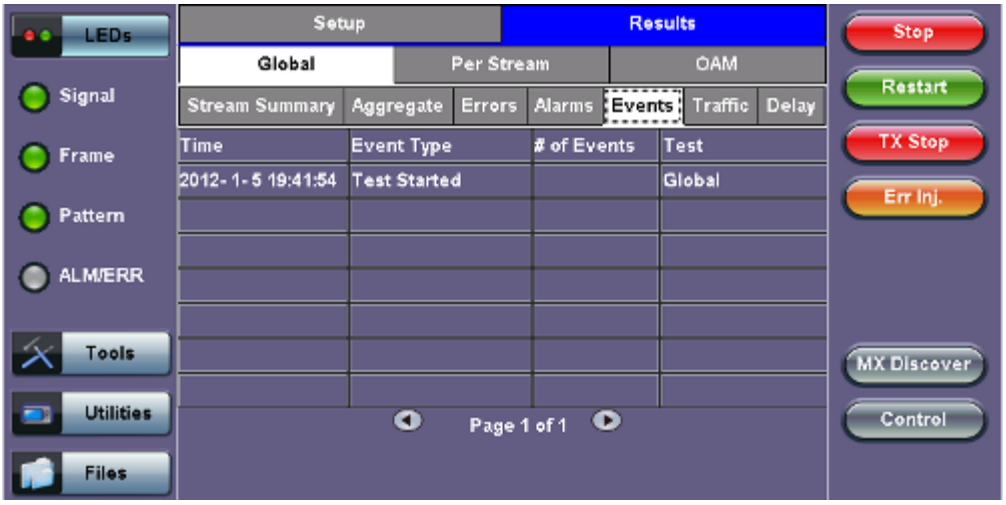
Throughput Results - Global Alarms



Go back to top Go back to TOC

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

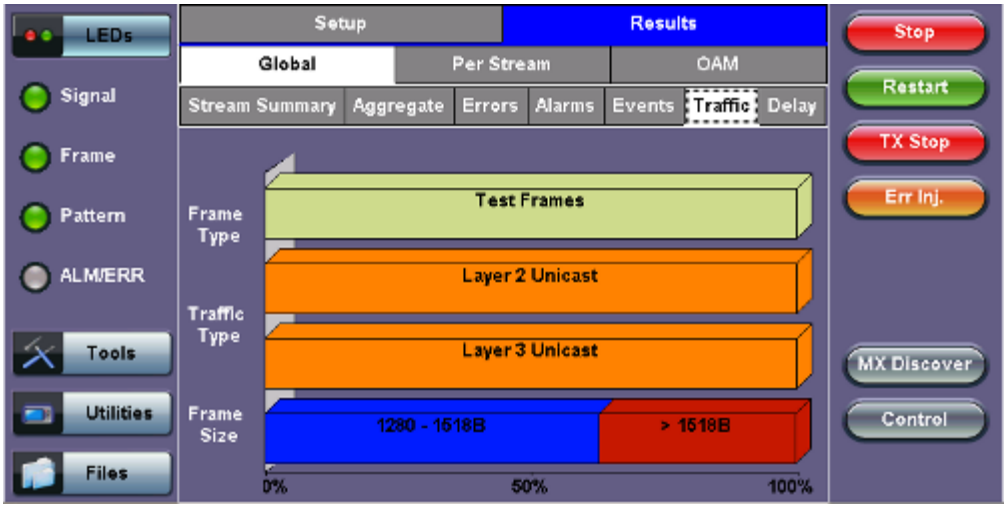
Throughput Results - Global Events



The **Global Traffic** screen displays:

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

Throughput Results - Global Traffic Summary

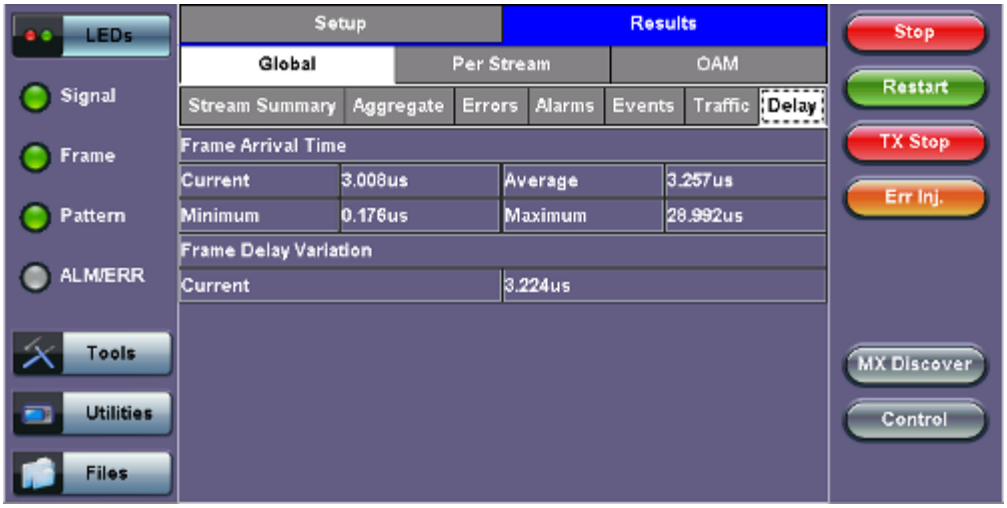


Go back to top Go back to TOC

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

- Current, minimum, average, and maximum frame arrival time
- Current Frame Delay Variation

Throughput Results - Global Delay



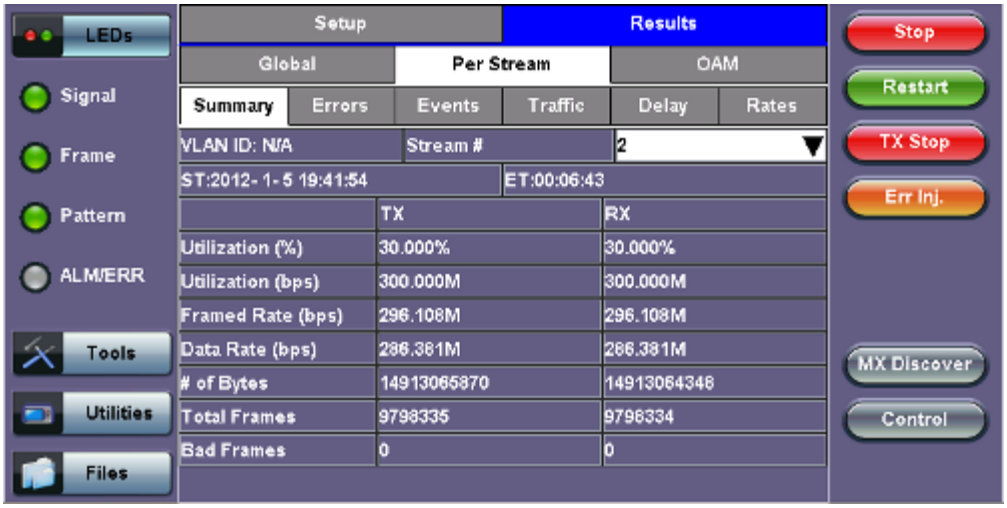
Go back to top Go back to TOC

15.5.2.3 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 15.5.2.2 Global/Aggregate Results.

- **Summary:** Framed rate, data rate, # of bytes, total # of frames associated with each stream.
- **Errors:** Errors associated with each stream.
- **Events:** Events associated with each stream.
- **Traffic:** Traffic statistics associated with each stream.
- **Delay:** Delay associated with each stream. Note that 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.

Throughput Results - Summary per Stream



Go back to top Go back to TOC

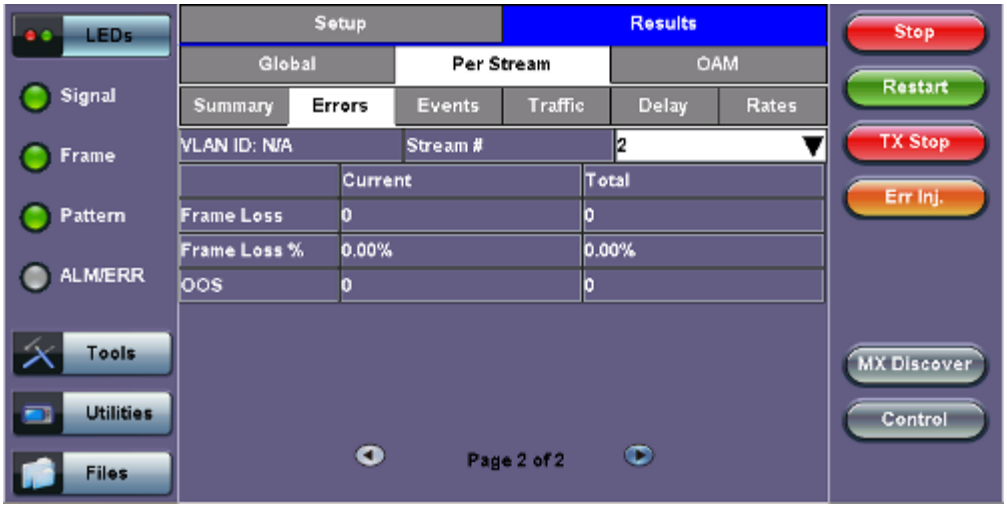
The **Per Stream Errors** screen displays the Current and Total error count of each stream.

- **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**

Throughput Results - Errors per Stream

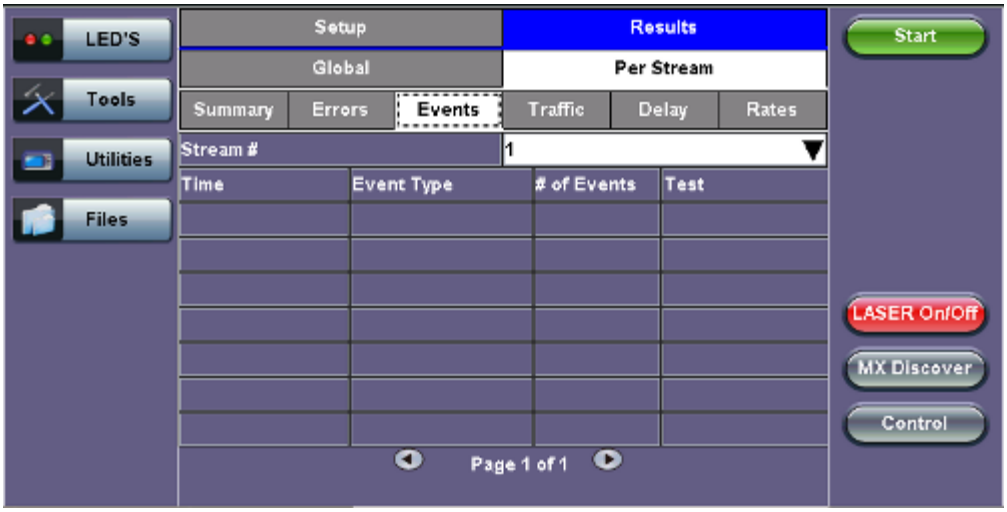
Throughput Results - Errors per Stream (page 2)



Go back to top Go back to TOC

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

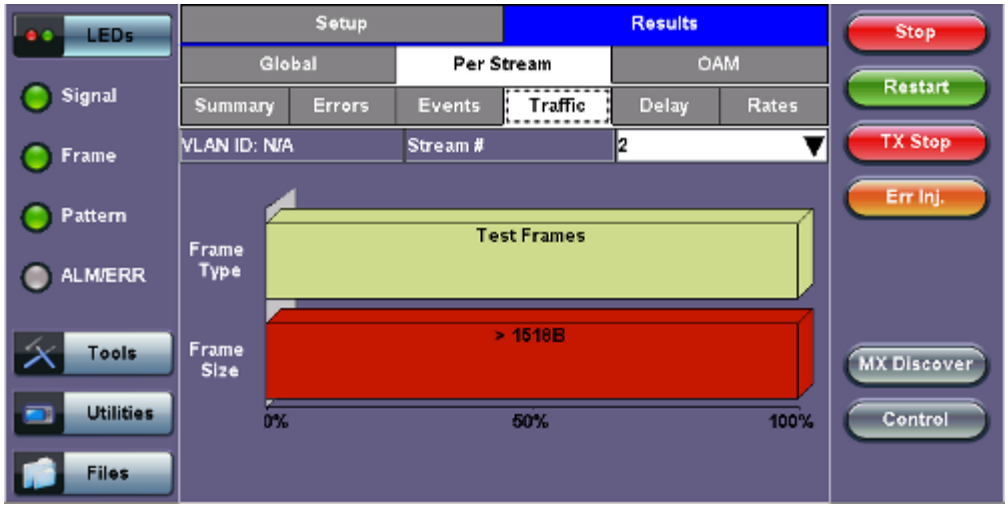
Throughput Results - Events per Stream



Go back to top Go back to TOC

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

Throughput Results - Traffic per Stream



Go back to top Go back to TOC

The **Per Stream Delay** screen displays the frame delay information pertaining to each stream. The Histogram shows the sampling points for the delay.

Round Trip Delay Results and Histogram:

Throughput Results - Delay per Stream

Throughput Results - Round Trip Delay Histogram

One Way Delay Results and Histogram (Table and Graph):

Throughput Results - Delay per Stream (One Way Delay)

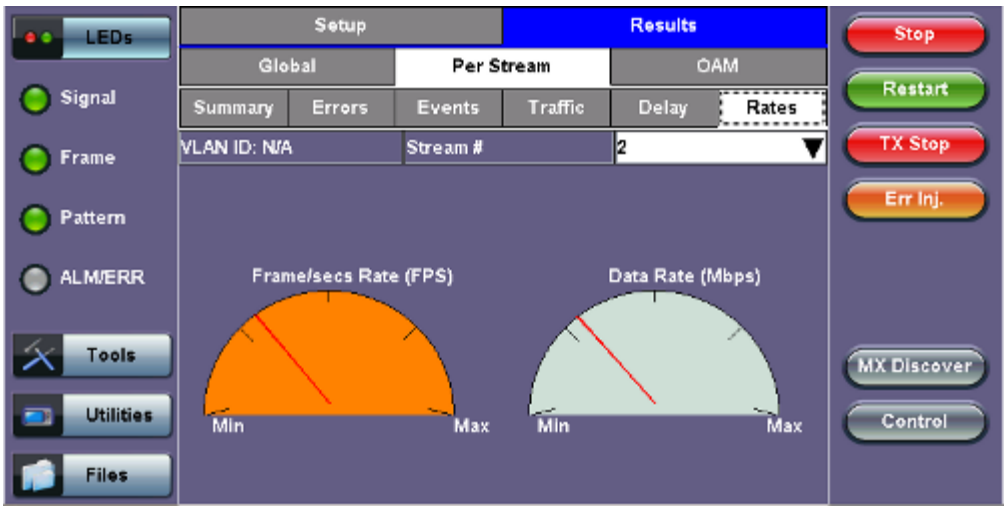
Throughput Results - One Way Delay Histogram Graph

Throughput Results - One Way Delay Histogram Table

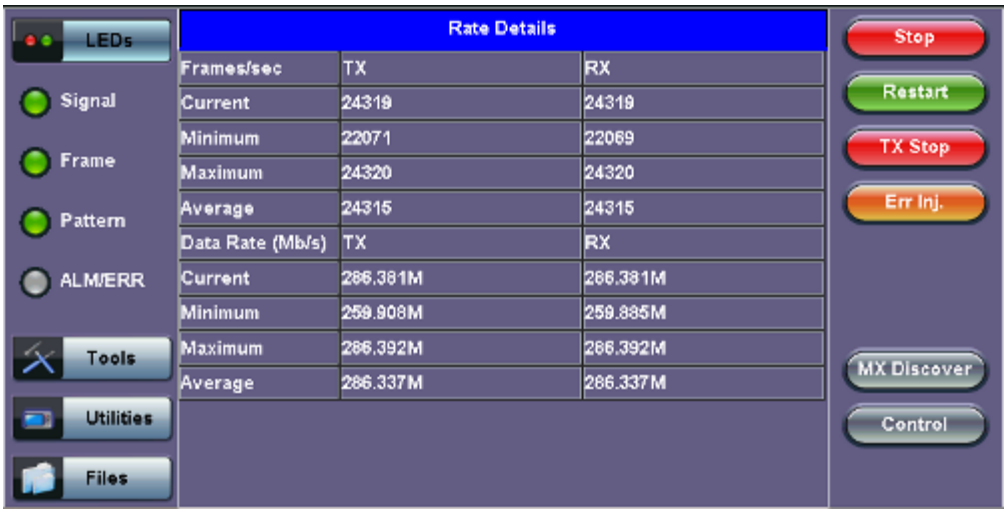
Go back to top Go back to TOC

The **Per Stream Rate** screen displays the frame rate and data rate pertaining to each stream.

Throughput Results - Rates per Stream



Throughput Results - Rates per Stream (Rate Details)



Go back to top Go back to TOC

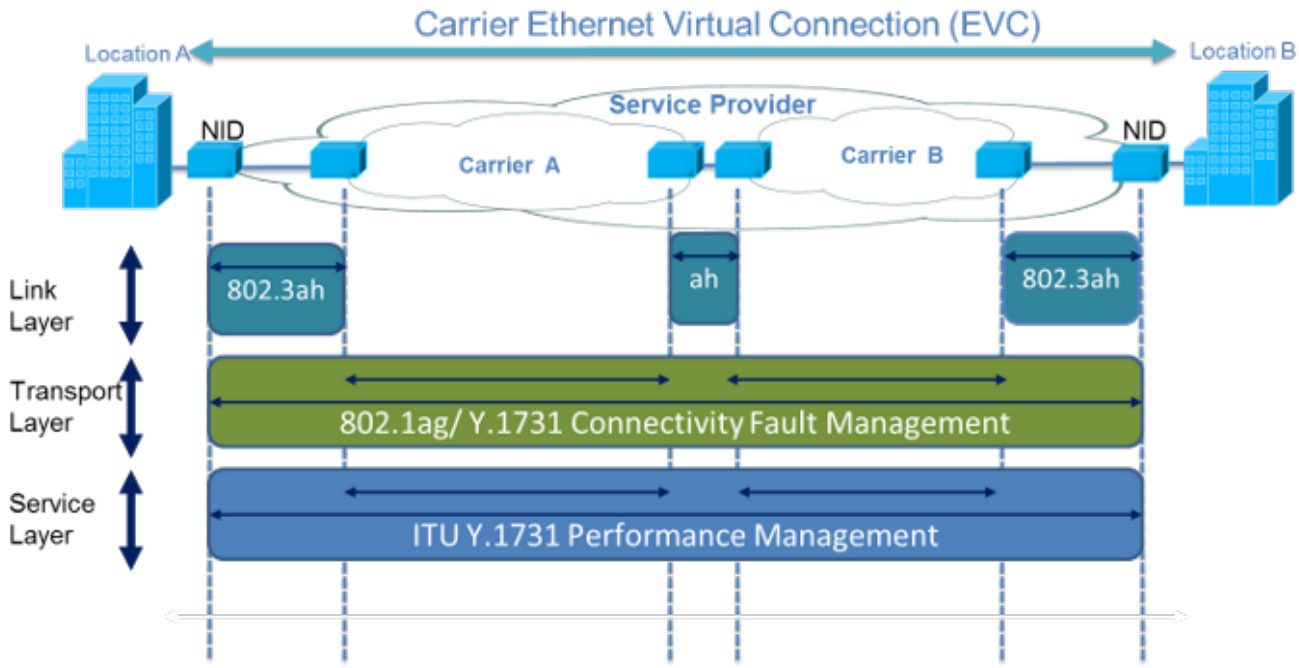
15.5.2.4 Saving Throughput (Multiple Streams) Results

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

saved and named automatically. Once the results are saved, the user may view or rename the results file by going to **Home** > **Files** > **Saved**. Please see **10.2 Recalling or Viewing Files and Test Results** in the **V300 Common Functions manual** for more information.

Go back to top Go back to TOC

15.6 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, and ITU-T Y.1731.

Go back to top Go back to TOC

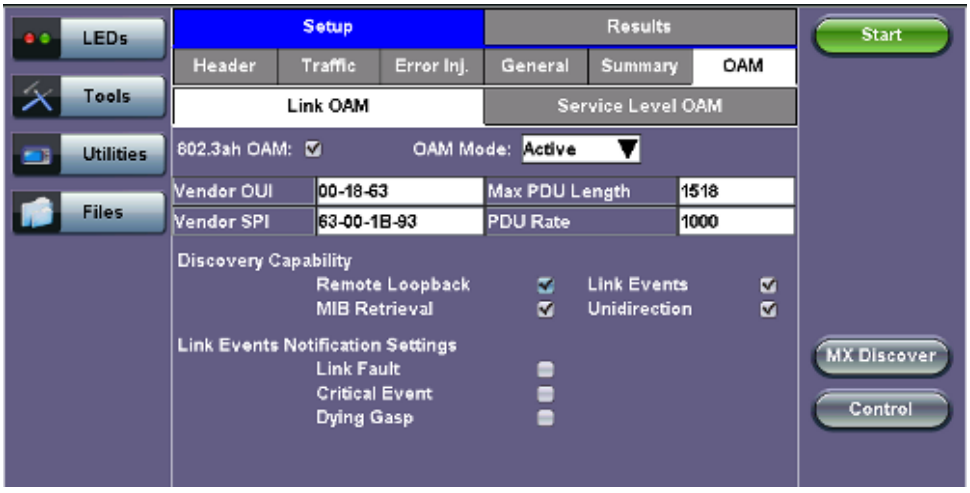
15.6.1 OAM Setup

15.6.1.1 Link Level 802.3ah OAM Setup

802.3ah functions include:

- Discovery
- Link Performance Monitoring
- Remote loopback
- Fault detection
- Collecting Performance Statistics (Function not supported in current software release)
- Organizational Specific Extensions (Function not supported in current software release)

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.

Go back to top Go back to TOC

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.

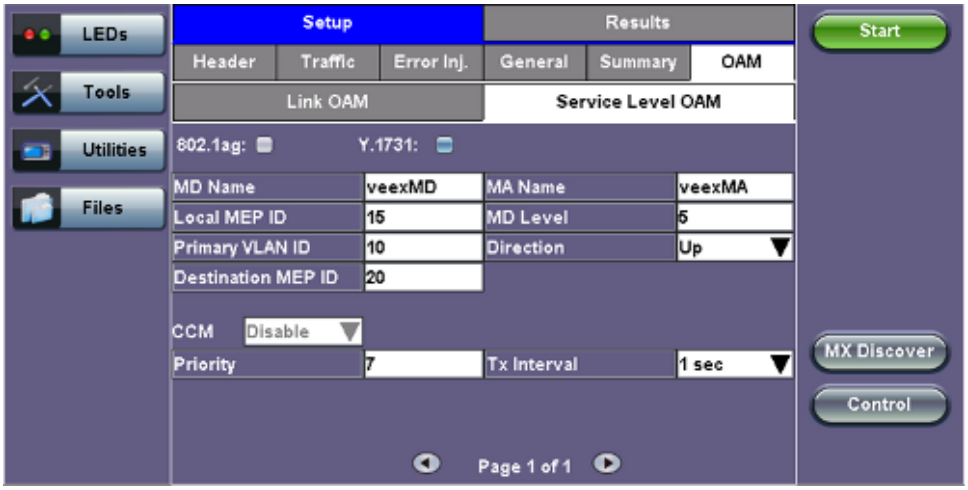
Go back to top Go back to TOC

15.6.1.2 Service Level OAM: 802.1ag/Y.1731 Setup

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

- **MD Name:** Name of the Maintenance Domain (only for 802.1ag)
- **MA Name:** Enter the name of the 802.1ag MA or Y.1731 MG
- **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
- **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
- **Destination MEP ID:** MEP ID of the MEP end point

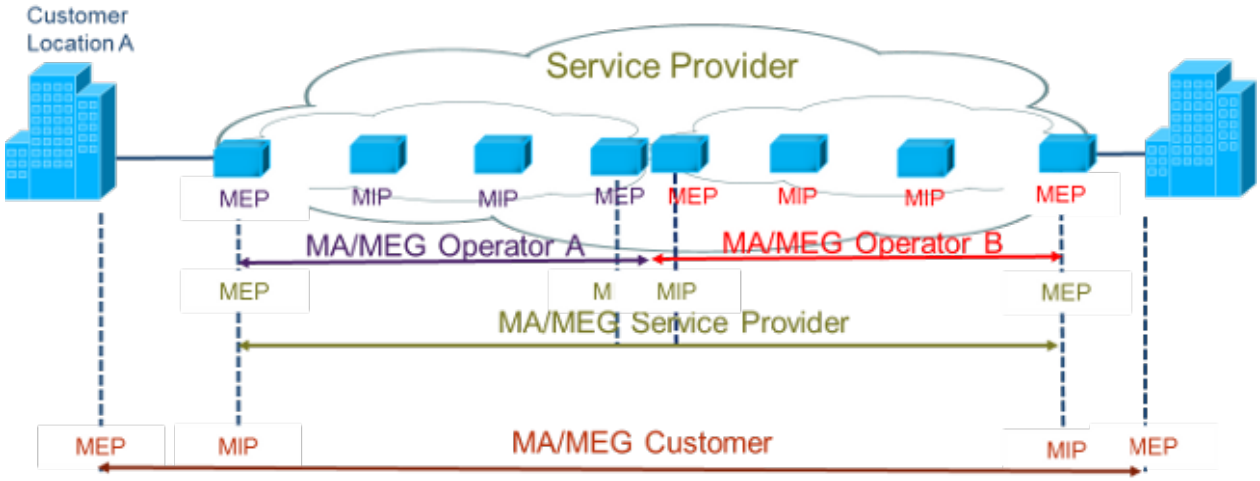
Differences between 802.1ag and Y.1731

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).

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 the two protocols. The chart below describes the differences.

Definition Equivalencies

IEEE 802.1ag	ITU Y.1731
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)

Go back to top Go back to TOC

OAM Services Setup

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

- Continuity Check (CCM)
- Loopback (LBM/LBR)
- Link Trace (LTM/LTR)
- Loss Measurement (LMM/LMR) (Y.1731 Only)
- Delay Measurement (DMM/DMR) (Y.1731 Only)

General Setup

To run any 802.1ag/Y.1731 Tests, fill out the listed parameters and press **Start**. In the case of **CCM**, select **Enable** from the drop-down menu to run that test. Details on individual test parameters will be listed in the specified section.

802.1ag/Y.1731 Connectivity Fault Management Functions

802.1ag/Y.1731 Connectivity Fault Management Functions supported by the test set are as listed:

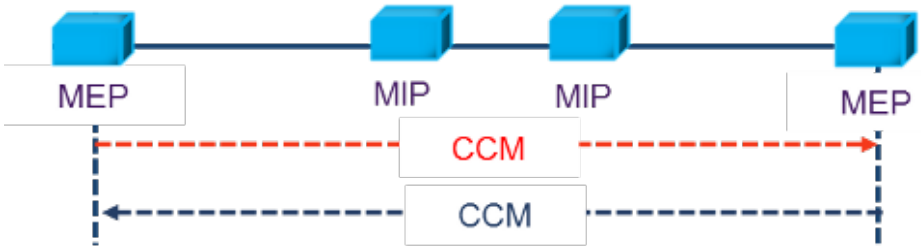
- Fault Detection – Continuity Check:
  - CCM "heartbeat" messages are transmitted at a configurable periodic interval by MEPs.
- Network/Path Discovery – Link trace message:
  - Equivalent to a traceroute test. MIPs and MEPs along the path send a response.
- Fault verification and isolation – Loopback: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

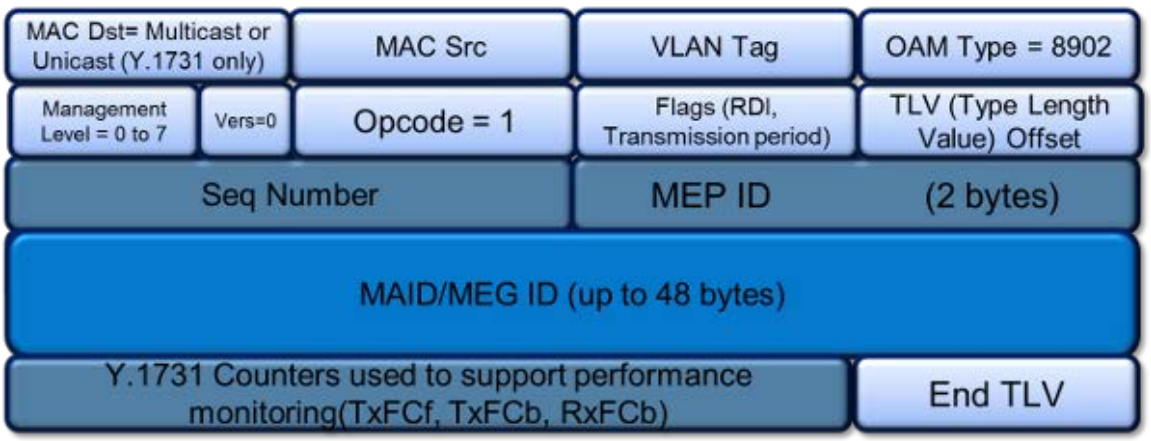
Note: There can be 4,094 VLANs per port and up to eight maintenance levels. This yields a worst case CCM transmission rate of 9.8 million CCMs per second if 3.3ms interval is used.

Continuity Check Message (CCM)

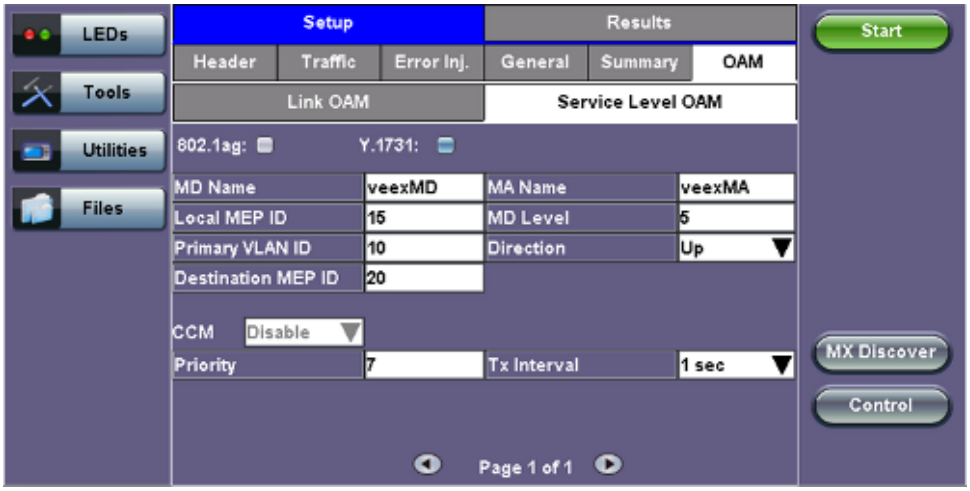


RDI Flags added in CCM Messages indicates loss of continuity in the remote direction.

CCM Message Format



Service Level OAM (Page 1)

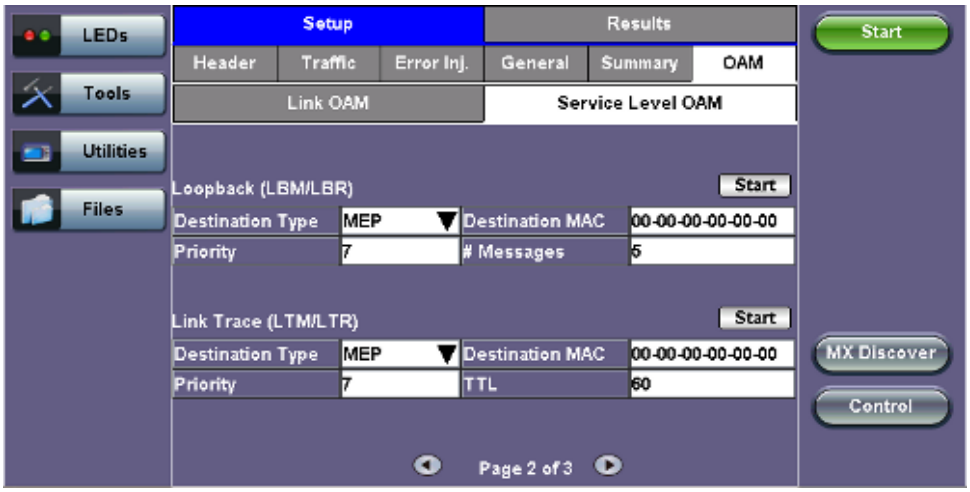


CCM Configuration Parameters

- **CCM**
  - **Enable**: Enable sending Continuity Check messages
  - **Disable**: Disable sending Continuity Check messages
- **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.

Link Trace and Loopback Messages

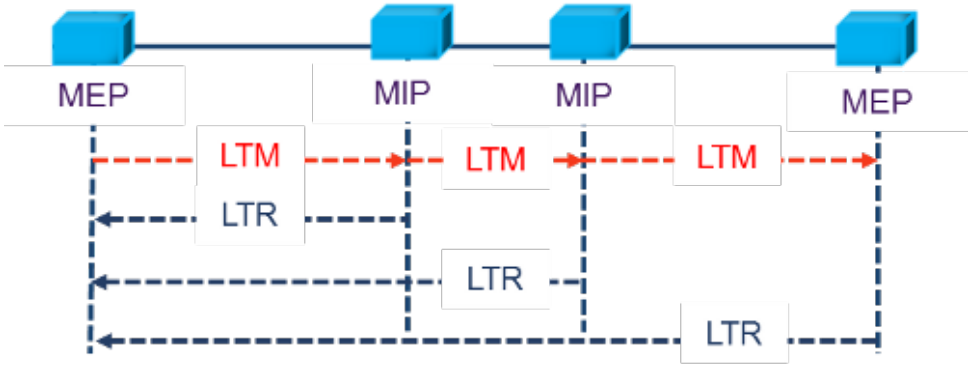
OAM - Service Level OAM (Page 2)



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



Link Trace Message Format

MAC Dst= Unicast	MAC Src	VLAN Tag	OAM Type = 8902
Management Level = 0 to 7 / Vers=0	Opcode = 5 (LTM)	Flags	TLV Offset
Transaction ID			
TTL	Original MAC address	Target MAC address	
Optional TLV			End TLV

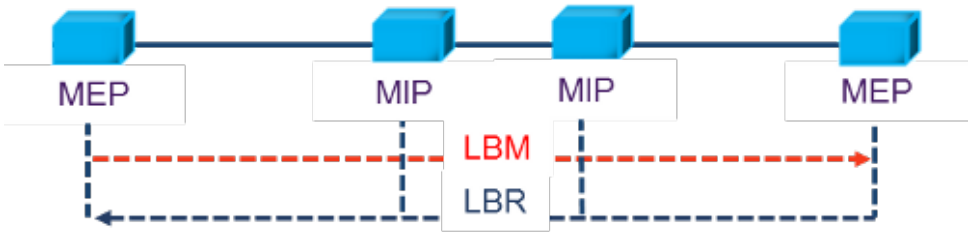
Link Trace Response Format

MAC Dst= Unicast	MAC Src	VLAN Tag	OAM Type = 8902
Management Level = 0 to 7 / Vers=0	Opcode = 4 (LTR)	Flags	TLV Offset
Transaction ID			
TTL	Relay action (802.1ag)		
Optional TLV			End TLV

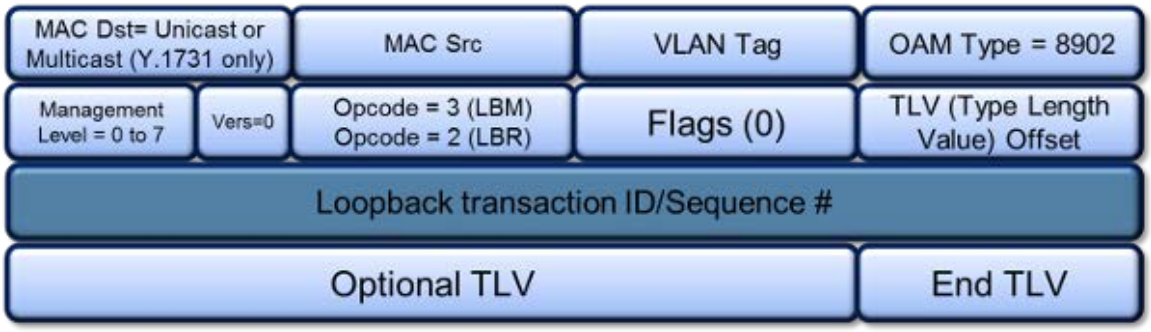
Loopback Message (LBM/LBR)

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



Loopback Message Format



Link Trace and Loopback Message Config. Parameters

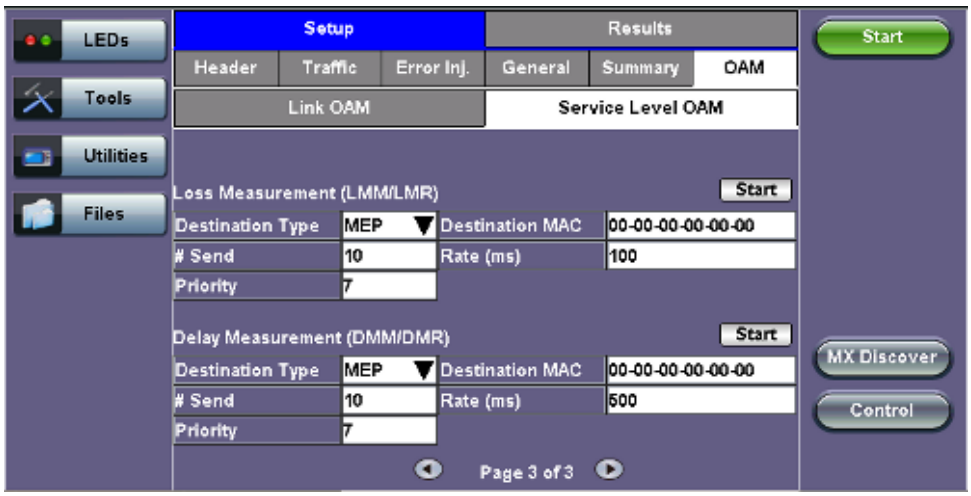
- **Destination**
  - **MEP**: Sends LTM/LBM to the destination MEP as configured on Page 1.
  - **MAC**: Sends LTM/LBM to a destination MAC address.
- **Priority:** 802.1p priority in the LTM/LBM VLAN Tag.
- **Destination MAC:** Configure the destination MAC address used for the LTM/LBM. This field 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.

Go back to top Go back to TOC

Y.1731 Performance Management Functions

OAM - Service Level OAM (Page 3)



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:

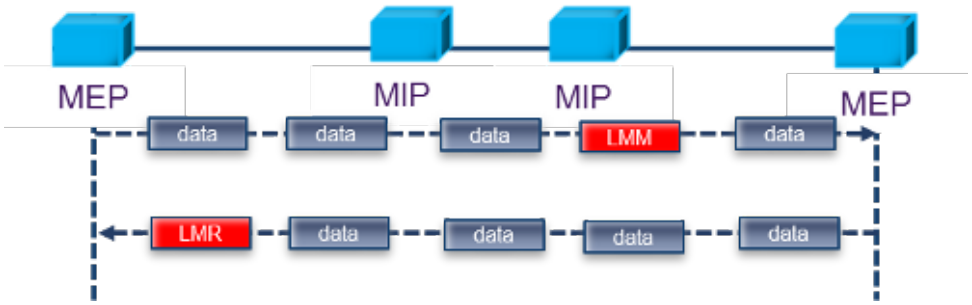
- TxFCf: Counter for in-profile data frames transmitted towards peer MEP
- RxFCf: Counter for in-profile data frames received from peer MEP

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

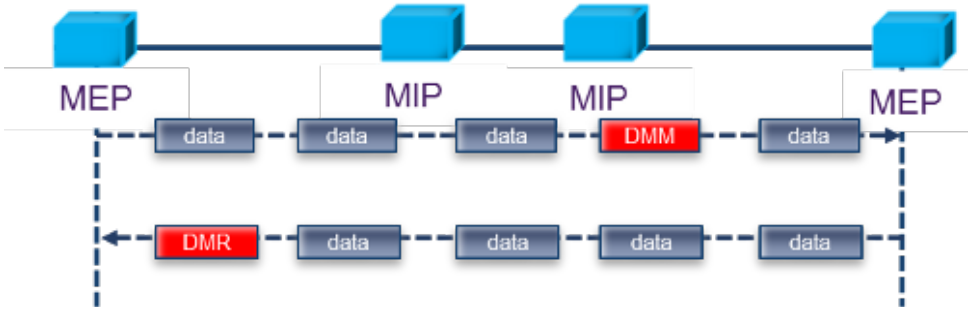
On demand OAM for measuring Frame Delay (FD) and Frame Delay Variation (FDV):

- 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.

Go back to top Go back to TOC

15.6.2 OAM Results

15.6.2.1 Link OAM Results

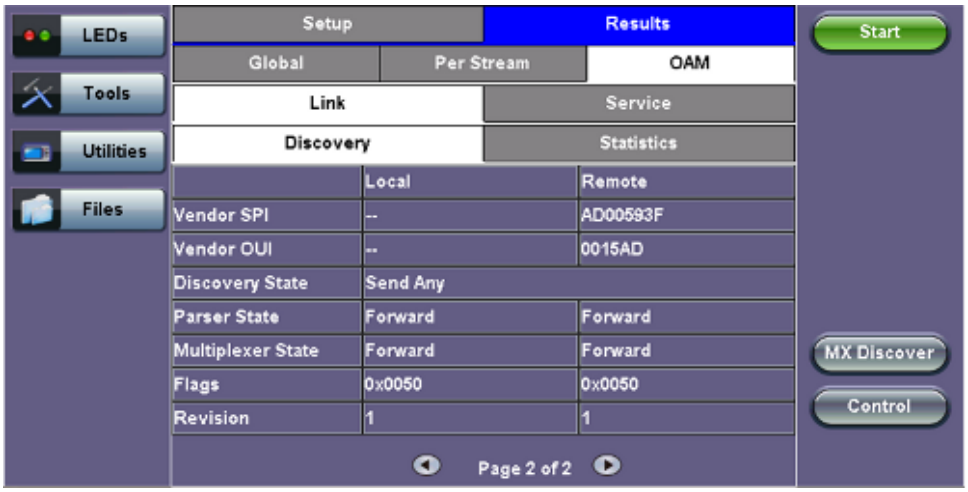
Link OAM Discovery

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

OAM - Link - Discovery (Page 1)

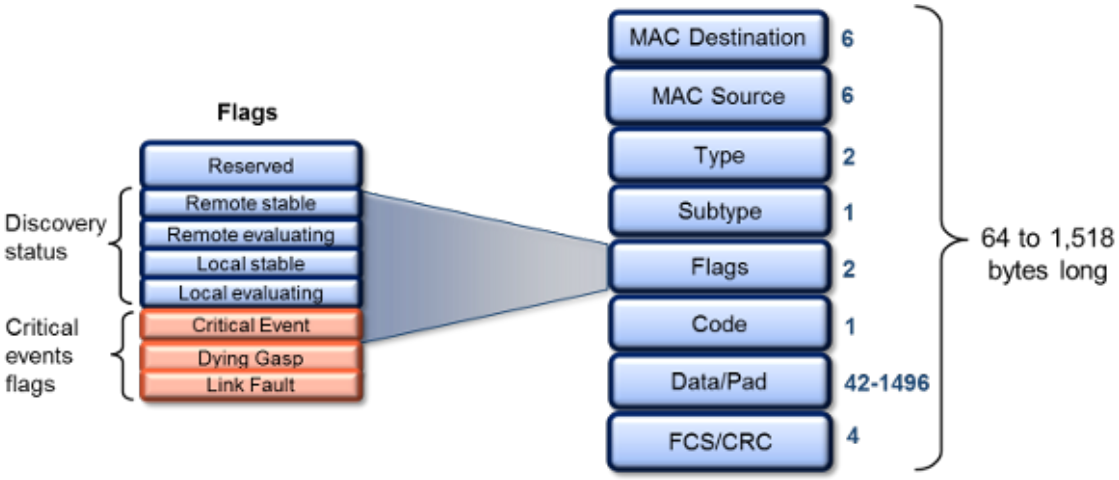
- **Mode:** Lists Active or Passive mode configuration.
- Supported and unsupported capabilities advertised during Discovery are listed, including: Unidirection, Link Events, Remote Loopback, MIB Retrieval, and MTU Size.

OAM - Link - Discovery (Page 2)

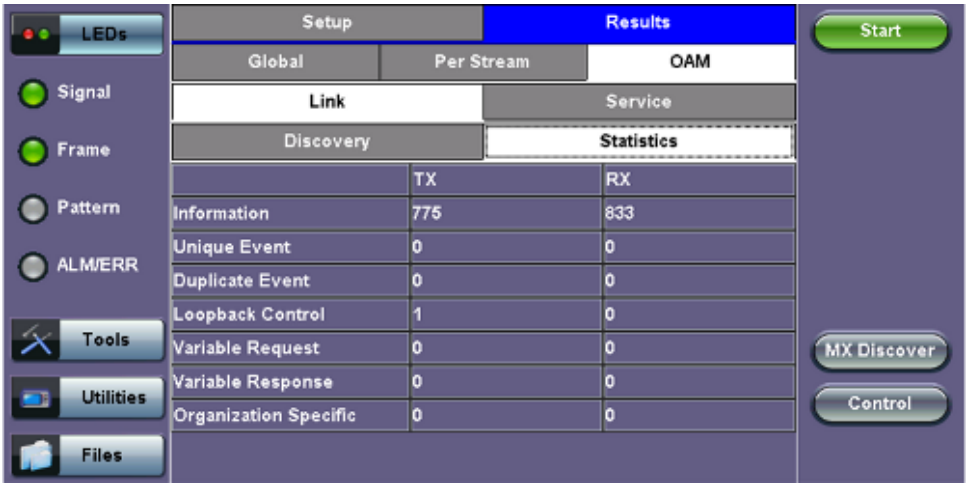


- **Vendor SPI and OUI:** Organization Unique identifier and Vendor specific information (similar to MAC address fields).
- **Discovery State:** Send Any indicates the device was successfully discovered.
- **Parser/Multiplexer state:** Forward indicates the device is forwarding regular traffic transmission. **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



OAM PDU

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

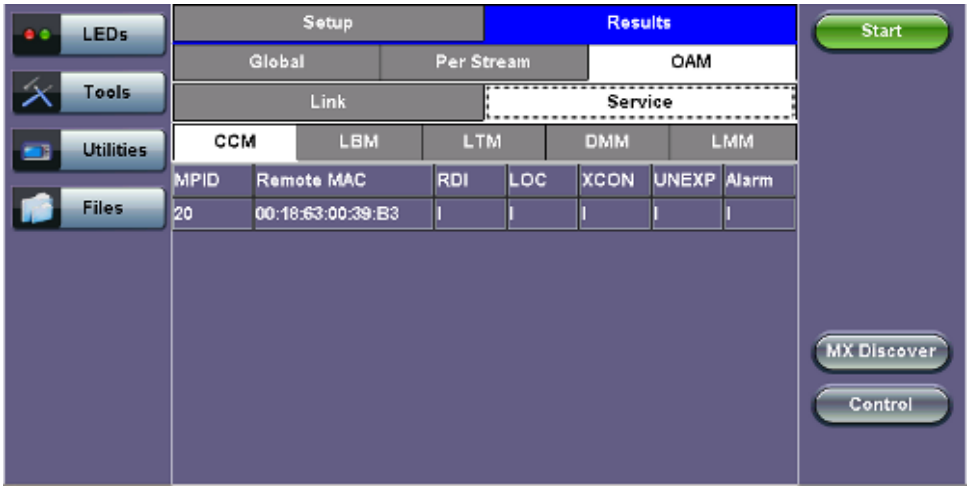
- **Information:** Information OAM PDU acts as a "heartbeat" message. Discovery must be restarted if no OAM PDU is received after 5 seconds.
- **Unique** and **Duplicate** Events are Threshold crossing events not supported in the current test set release.
- Number of **Loopback Control** frames.
- **Variable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

Go back to top Go back to TOC

15.6.2.2 OAM Service Results

802.1ag/Y.1731 Connectivity Fault Management Functions Results

OAM - Service - CCM

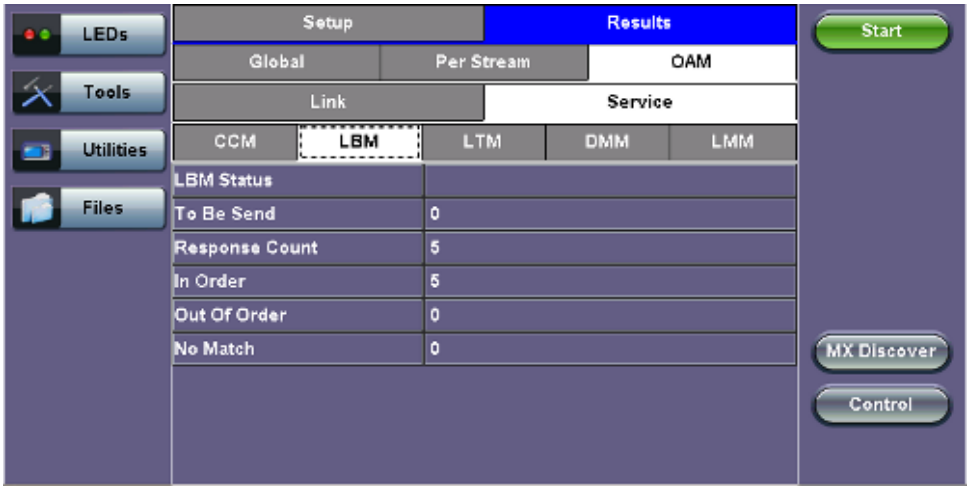


OAM CCM Results

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.

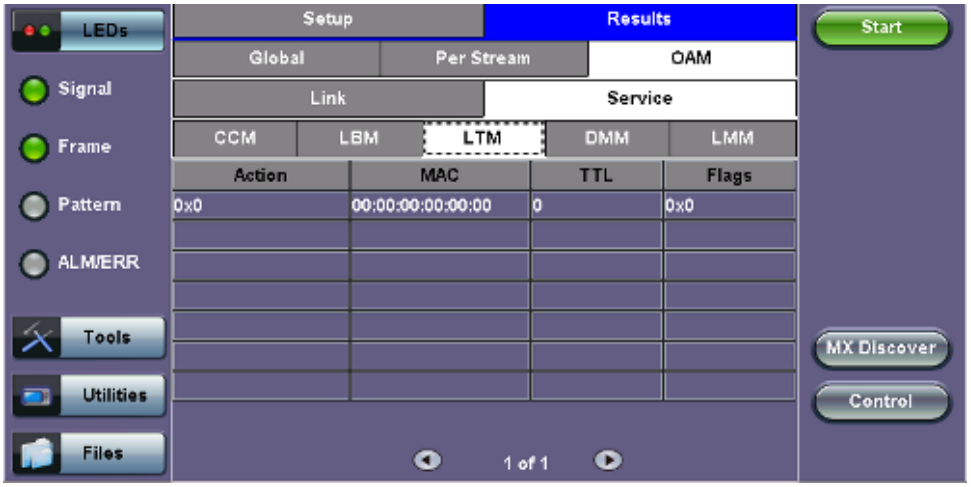
OAM - Service - LBM



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

OAM - Service - LTM

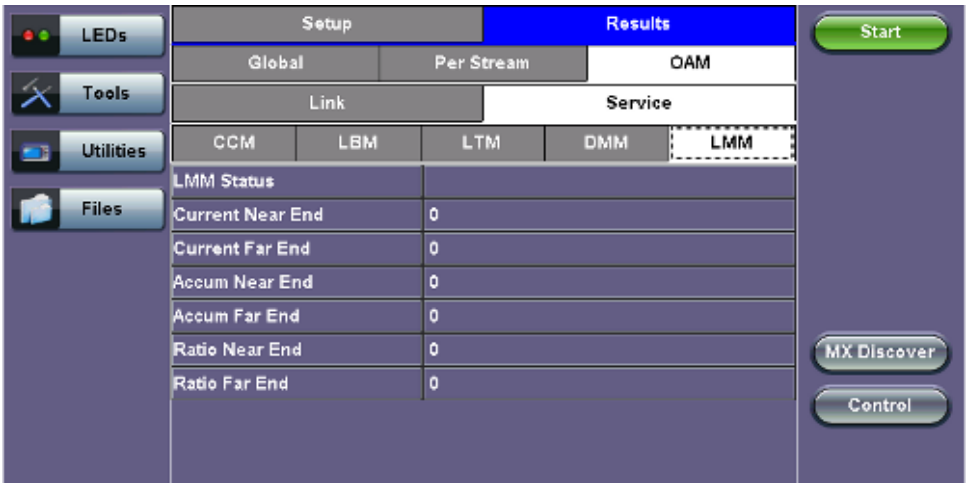


OAM LTM Results

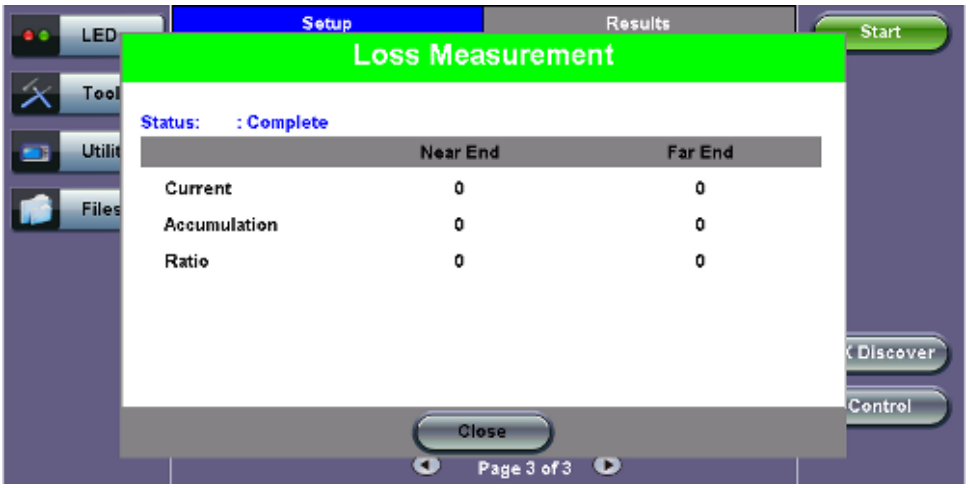
- **Action:** RlyHit indicates that the LTM has reached the destination MAC/MEP (i.e., final point)
- **MAC:** MAC address of the responder
- **TTL:** TTL field on the response, indicated how many hops have been traversed
- **Flags:** If set, indicates that only MAC addresses learned in a Bridge's Filtering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

Y.1731 Performance Management Functions Results

OAM - Service - LMM



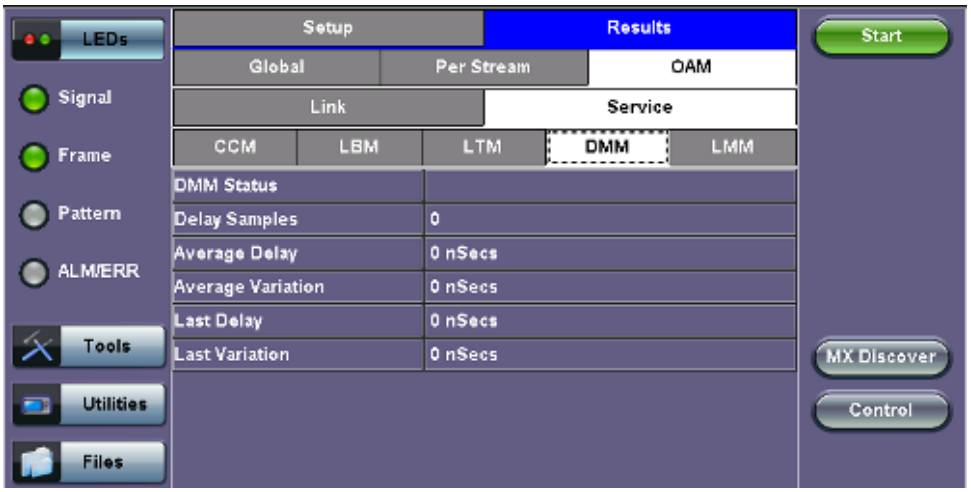
OAM - LMM Message



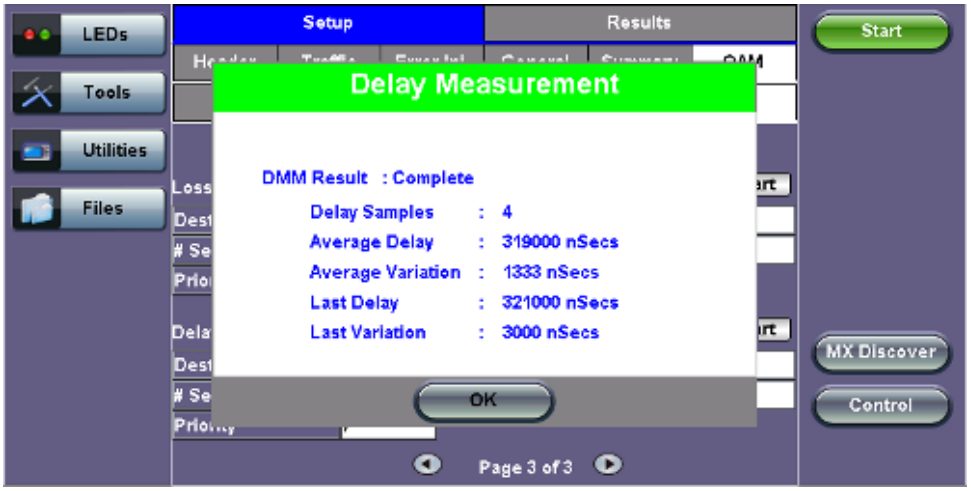
OAM LMM Parameters

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

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

Go back to top Go back to TOC

15.7 Monitor (Pass Through)

Pass through monitor mode enables the test set to be used for long term in-service testing. This allows for bi-directional monitoring of up to full gigabit Ethernet line rate on the two 1000Base-X ports or the two 10/100/1000T ports.

The Pass Through functionality allows:

- In-line traffic monitoring in both directions
- Long or short term network monitoring for troubleshooting network traffic problems
- Isolate network problems to the customer network or the service provider/operator network
- Monitor traffic between 1000Base-X links or 10/100/1000T links

- **Pass through monitor operation**
  - Pass Through Monitor Copper 1GE
  - Pass Through Monitor Fiber 1GE
  - Pass through monitor mode enables bidirectional monitoring between the two 1000Base-X ports or the two 10/100/1000 Base-T ports

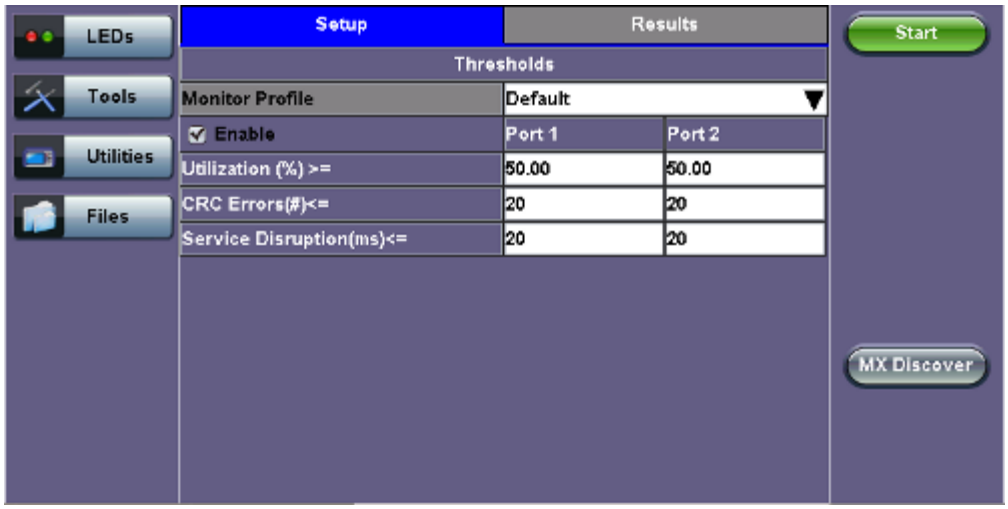
Go back to top Go back to TOC

15.7.1 Setup

The pass through monitor setup and operation is straight forward and simple:

- Press the **Test Port** button on the right side of the screen and select a pass through mode option
- Connect to both 1000Base-X fiber ports (port 1 and port 2) or both 10/100/1000T copper ports (port 1 and port 2), depending on the interfaces to be monitored
- Once the cable/interface connections are in place, press **Start**

Monitor Mode Setup

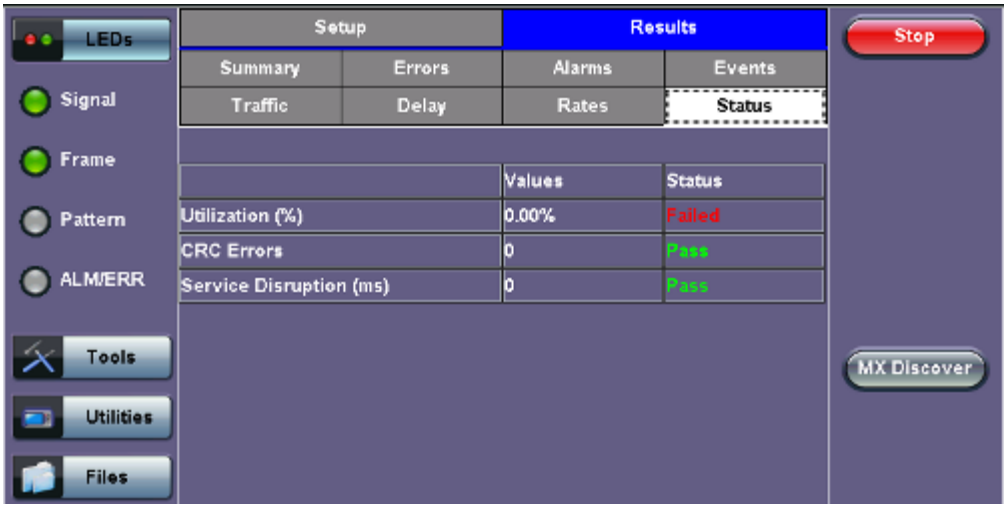


- Thresholds: Set values for Port 1 and Port 2. The thresholds can be enabled or disabled depending on test requirements. When enabled, the pass through will show a pass/fail status based on the configured threshold values.
  - Utilization in %
  - CRC error count
  - Service Disruption in ms
  - Optical Power level in dBm (1000Base-X connections only)
- Once the cable/interface connections are in place and the thresholds have been set, press **Start**.

Go back to top Go back to TOC

15.7.2 Results

Monitor Mode Results



Monitor Mode Results features the same statistics as BERT Results. Please see 15.2.2 BERT Results. The Status screen displays the following statistics:

- Utilization (%)
- CRC Errors
- Service Disruption (ms)

Go back to top Go back to TOC

15.8 Loopback Mode

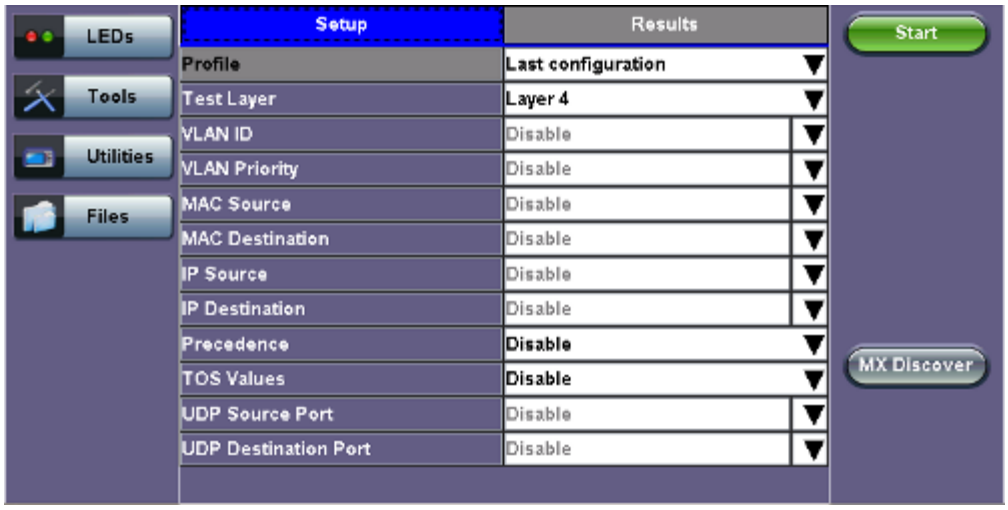
The Loopback application in the main menu allows the user to establish a manual loopback on the test set. The loopback function is used when an end-to-end test needs to be performed with one of the test partners in software loopback mode. The loopback function will loopback the incoming traffic to the 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 1, 2, 3, or 4). 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 1**: All incoming traffic to the Rx loopback interface will be sent out unaltered to the Tx loopback interface.
- **Layer 2, 3, & 4**: In a Layer 2 or 3 loopback 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 15.2.1.1 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 & 4 only)
    - IP Destination (Layer 3 & 4 only)
    - Precedence (Layer 3 & 4 only)
    - TOS Value (Layer 3 & 4 only)
    - UDP SPort (Layer 4 only)
    - UDP DPort (Layer 4 only)

Press **Start** to begin loopback. indicates that loopback is in progress. The **Results** tab displays current test results. Please see 15.2.2 BERT Results for information on the Results tabs.

Loopback Setup



Loopback In Progress

Go back to top Go back to TOC

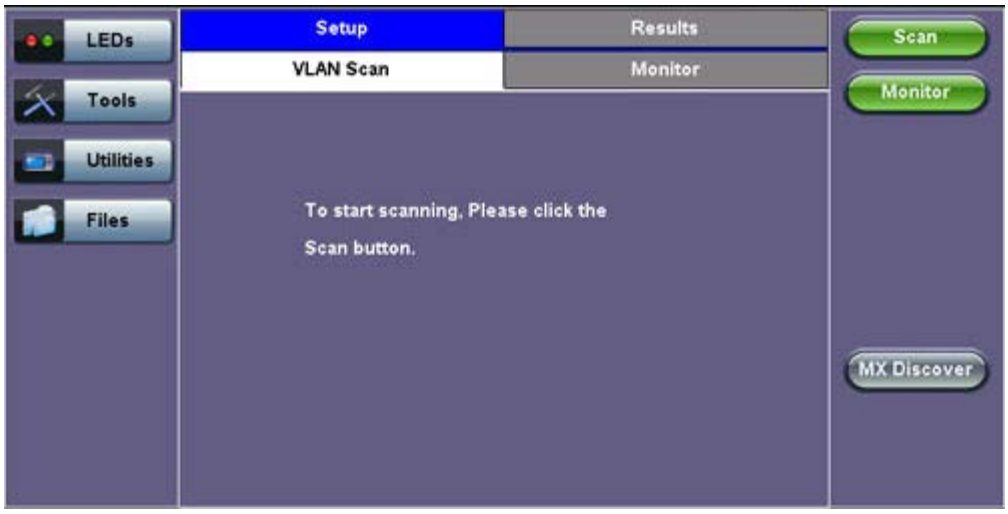
15.9 Advanced Tools

See the Advanced Tools section of the TX300S Platform Manual.

Go back to top Go back to TOC

Scan

VLAN Scan Setup

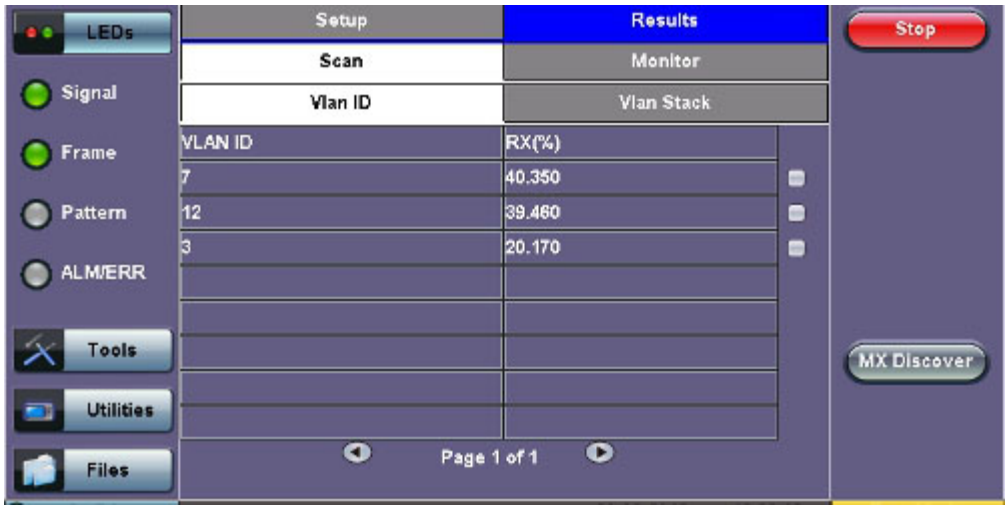


VLAN Scan scans up to 4096 VLAN IDs for switch configuration and displays VLAN ID bandwidth rates, useful for identifying top bandwidth users based on VLAN ID. Monitor mode monitors up to eight live traffic streams (in terminate mode) and filters them based on VLAN ID configuration, providing key traffic metrics such as frame type, rates, and errors and alarms.

VLAN Scan

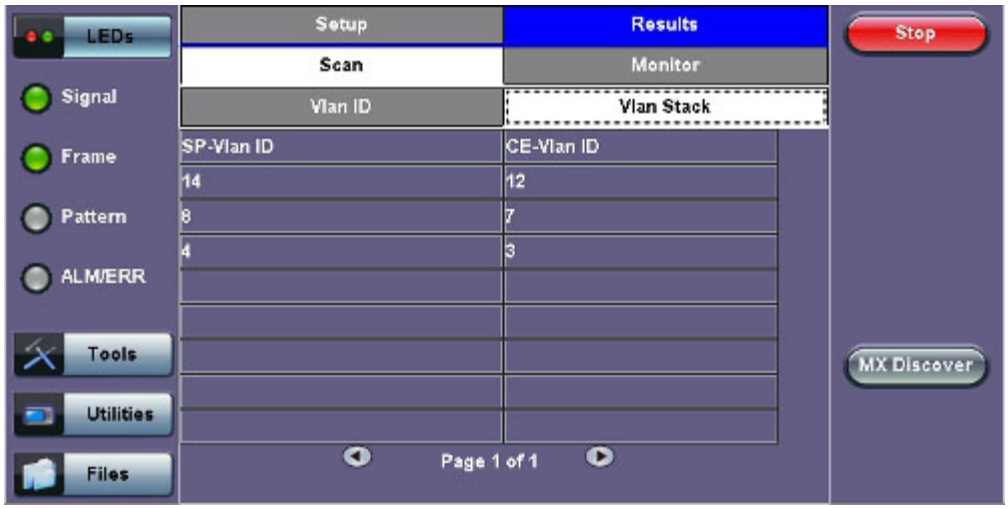
- While traffic is being received, press **Scan**. The Results tab displays a list of detected VLAN IDs and the percentage of traffic marked with those IDs. Check up to 8 streams to monitor.

VLAN ID



- The VLAN Stack tab displays detected SP and CE VLAN tags (if stack VLAN tags are used).

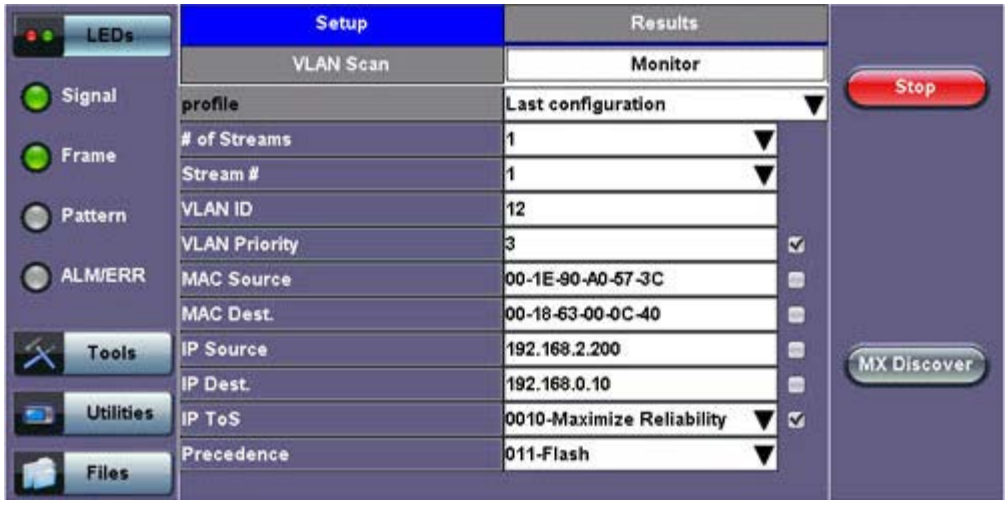
VLAN Stack



Monitoring Traffic

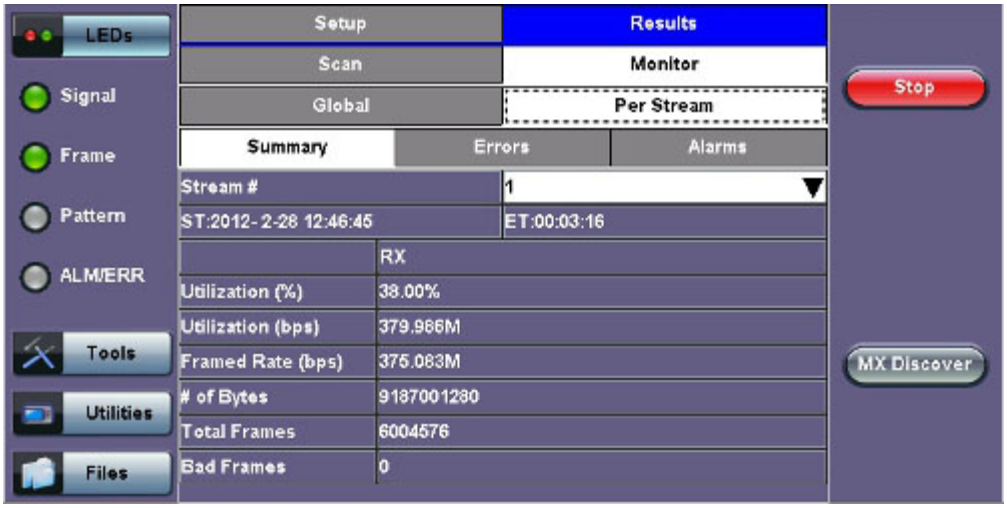
- To only receive traffic streams meeting specific criteria, stop the scan and go to the Monitor tab to configure filter criteria.
- Tap on a parameter box to configure it. Place a check next to a parameter to only receive traffic that matches this criteria. For descriptions of each parameter, please see, 15.5.1 Setup for Throughput Testing (Multiple Streams).
- Press **Monitor** to monitor selected traffic. For a description of traffic parameters from Global and Per Stream Results tabs, please see 15.5.2 Throughput Results.

Monitor Setup



Monitor Global Results

Monitor Per Stream Results



Note: If no stream information is displayed in the **Per Stream** tab, return to the VLAN ID tab (**Results** > **Scan** > **VLAN ID**) and verify that the VLAN ID boxes are checked.

Go back to top Go back to TOC

15.10 SyncE

- **Setup**
  - Port Selection
  - Mode
- **SyncE Wander Measurements**
  - Setup
  - Results
  - Built-in TIE, MTIE & TDEV Analysis (Optional)
- **ESMC SSM**
  - Overview
  - Setup
  - Results
  - Monitor
  - Capture

Go back to top Go back to TOC

15.10.1 SyncE Setup

Port (Test Port selection)

Prior to starting the SyncE operation, the selected test port must be connected to a network that supports SyncE timing synchronization. Port selections include 10/100/1000T and 100/1000BaseX. It is also available on 10GE port. After setting up the port, IP connection is not required for SyncE tests. Please see section 15.1.2 Port Setup for port configuration instructions.

Port Setup

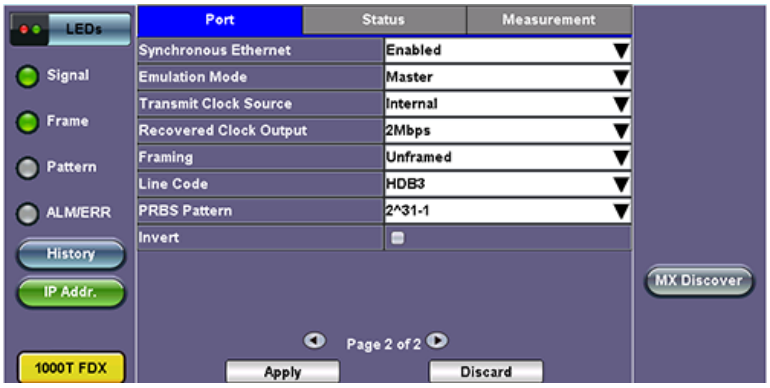
Go back to top Go back to TOC

Port Page 2 - Mode Selection

Master Mode

Master Mode emulates a SyncE Master clock device out of the Ethernet test port (10/100/1000BaseT, 100/1000BaseX or 10GE). Uses an internal or external reference clock.

SyncE Master-Emulation Mode



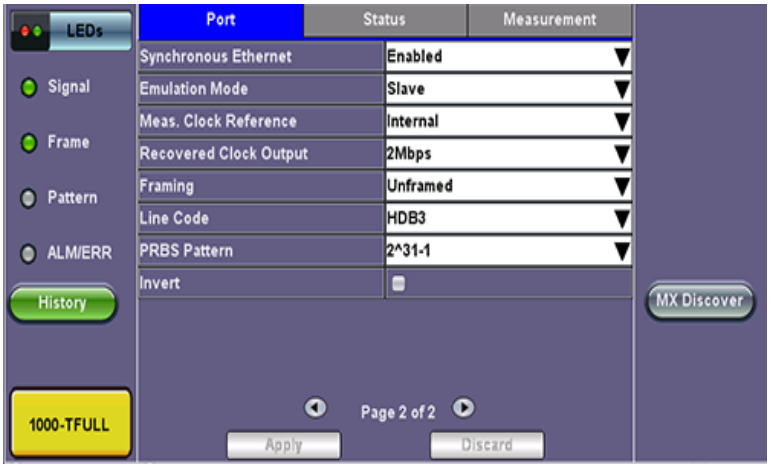
- **Synchronous Ethernet:** Enabled or Disabled
- **Emulation Mode**: Select Master Emulation
- **Transmit Clock Source:** Select between an internal or external clock source. This clock is used as a reference clock for SyncE Master. Possible external clock sources: 1.5444MHz,1.544Mbps, 2 MHz, 2Mbps (E1 signal), 10MHz, 25MHz, 125MHz or External1 pps. The external clock source is connected to the SMA port on each Test Module, this port is marked CLK on the connector panel.
  Possible Internal Clock sources: Internal Clock (+/-3.5ppm accuracy), Internal GPS 1 PPS (Requires GPS option and Antenna), Internal Atomic 1 PPS (Requires High Precision Atomic Clock option).
- **Recovered Clock Output:** The reference clock used by the SyncE master can be regenerated out of the PDH TX port (marked Tx on the connector panel) with a different clock format in order to synchronize other network elements.
  The clock can be formatted to: 2Mbps (E1 signal), 2MHz, 10MHz, 25MHz, 125MHz, 1PPS and None.
- If 2Mbps clock is selected then the following parameters need to be set:
  - **Line Code:** HDB3 or AMI
  - **Framing:** Unframed, PCM31, PCM31C, PCM30, or PCM30C
  - **PRBS Pattern**
  - **Invert**

Press Apply once all the parameters are set.

Slave Mode

Slave mode emulates a SyncE Slave clock device from the Ethernet test port (10/100/1000BaseT, 100/1000BaseX or 10GE). The SyncE Slave recovered clock can be regenerated out of the PDH TX port with a different clock format and is synchronized.

SyncE Slave-Emulation Mode

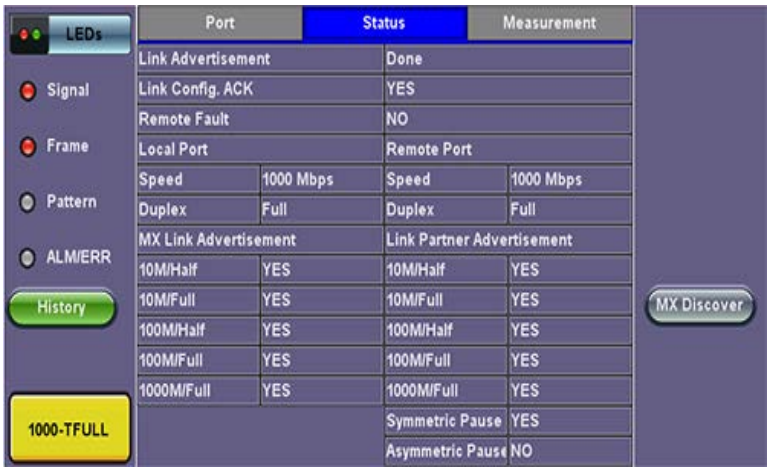


- **Synchronous Ethernet:** Enabled or Disabled
- **Emulation Mode**: Select Slave Emulation
- **Measurement Clock Reference:** Select between an internal or external clock source. This clock is used as a reference clock for SyncE Slave Wander Measurement. Possible external clock sources: 1.5444MHz,1.544Mbps, 2 MHz, 2Mbps (E1 signal), 10MHz, 25MHz, 125MHz or External1 pps. The external clock source is connected to the SMA port on each Test Module, this port is marked CLK on the connector panel.
  Possible Internal Clock sources: Internal Clock (+/-3.5ppm accuracy), Internal GPS 1 PPS (Requires GPS option and Antenna), Internal Atomic 1 PPS (Requires High Precision Atomic Clock option).
- **Recovered Clock Output:** The reference clock used by the SyncE master can be regenerated out of the PDH TX port (marked Tx on the connector panel) with a different clock format in order to synchronize other network elements.
  In Slave mode the Reference Clock Output is the regenerated clock recovered by the SyncE slave.
  The clock can be formatted to: 2Mbps (E1 signal), 2MHz, 10MHz, 25MHz, 125MHz, 1PPS and None.
- If 2Mbps clock is selected then the following parameters need to be set:
  - **Line Code:** HDB3 or AMI
  - **Framing:** Unframed, PCM31, PCM31C, PCM30, or PCM30C
  - **PRBS Pattern**
  - **Invert**

Press Apply once all the parameters are set.

Status

Status



Indicator Symbols

- Master Mode

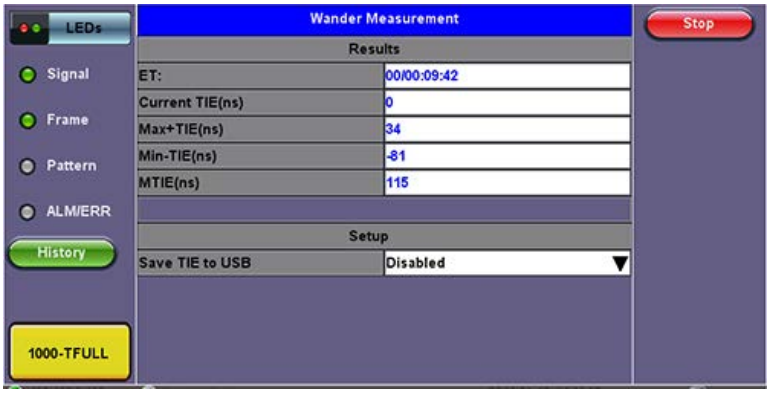
- Slave Mode

An M or S indicates that the test set is in Master or Slave Mode. A green SyncE icon indicates that the SyncE test is running and a green 1588 icon indicates that the 1588 test is running. If the icon is flashing or solid red, there may be an issue with setup and the test will not work.

Go back to top Go back to TOC

15.10.2 SyncE Wander Measurements (only in Slave Mode)

SyncE Wander Measurements Setup and Results



15.10.2.1 Setup

Save TIE to USB: OFF/ ON
OFF presents the current real time TIE measurements on screen only.
ON sends real time TIE measurements to an attached USB memory, for further post analysis (refer to the MTIE and TDEV Analysis section). This feature requires the MTIE and TDEV Post Analysis option.

Sampling Rate: When Save TIE to USB is ON, this selection indicates how many samples per second are recorded and stored in the USB memory stick.

Press the Start button to run the test. If Save TIE to USB is set to ON, the test set asks for a file name (keep this into account when running time-sensitive tests).

Note: *Do not remove the USB memory stick while the wander test is running.*

Go back to top Go back to TOC

15.10.2.2 Results

Current TIE: Shows the last Time Interval Error (relative phase error) measured between the reference clock and the test signal.

Max TIE: Records the maximum TIE value measured since the test was started.

Min TIE: Records the minimum TIE value measured since the test was started.

MTIE: Shows the maximum difference between TIE values measured since the test started (Max - Min)

Note: *The wander tests will automatically stop if either of the signals used as reference clock or recovered clock (test signal) have significant levels of impairments, are lost, or disconnected.*

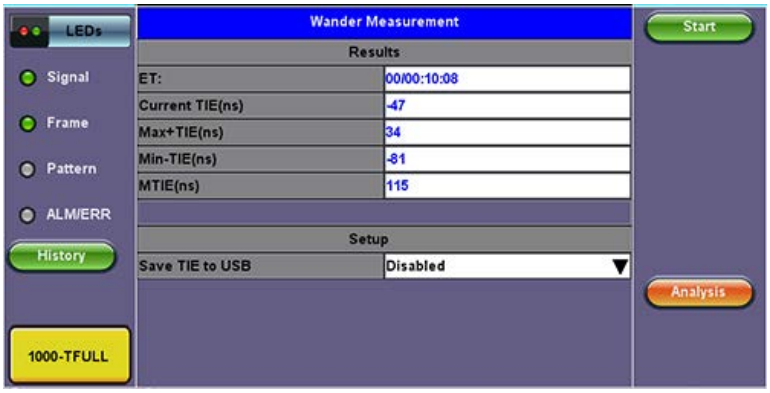
Press the Stop button to terminate the test. If Save TIE to USB is set to ON, then remove the USB memory stick from the test set, bring it to a computer, and open it with the VeEX Wander Analysis PC software, for further MTIE, TDEV, and masks analysis (refer to the MTIE and TDEV Analysis section).

Both, Wander Analysis and MTIE / TDEV Post Analysis are optional features.

Go back to top Go back to TOC

15.10.2.3 Built-in TIE, MTIE & TDEV Analysis (Optional)

SyncE Wander Measurements with Analysis



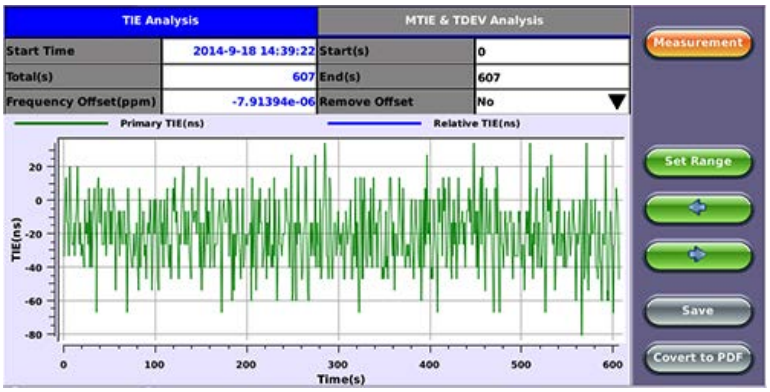
This option enables the test set to analyze up to 72 hours' worth of wander measurement data and compare it against standard masks for a PASS/FAIL assessment, without the need for a PC. The analysis can be performed while the test is still running for run-time verification. Longer test take a lot longer to be analyzed, so the VeEX Wander Analysis PC Software is still recommended for tests longer than 24 hours.

Features:

- Provides further post-processing of clock stability data, such as MTIE and TDEV
- Frequency offset calculation and removal for relative TIE analysis
- Standard MTIE and TDEV masks can be selected
- MTIE and TDEV results and mask export to CSV for further report generation using spreadsheets
- Direct PDF report generation to USB

TIE Analysis Results

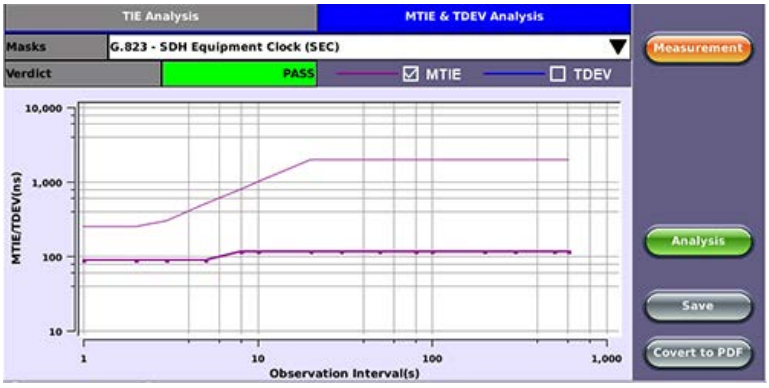
TIE Analysis



- Date and Time stamp indicating when the test was started
- Total of seconds recorded during the test
- Beginning and end of the data set to be analyzed and displayed in the graph (5) below. Tap in the Start and/or End field and enter the desired time limits, then press the Set Range button to apply these changes.
- Based on all the TIE measurements captured, the test set automatically calculates any small difference in frequency between the signal under test and the reference clock. Once the frequency difference is known, users can remove it to perform Relative TIE measurements. The offset removal tool is important for field tests when the local reference clock used is highly accurate and stable but not traceable to the PRC in the network core (e.g. a portable frequency reference). Even if the frequency of the local reference is a few ppb (parts per billion) different than the PRC, it can still be used for wander measurements, as long as it is highly stable, because the Offset Removal feature can mathematically remove the know difference and make it as if a traceable reference had been used. Once removed, user can perform relative MTIE (or MRTIE) and TDEV analysis.
- Auto-scale TIE graph, based on the limits set.
- Press the Measurement button to return to the current wander measurements
- Fine cursor controls. User can use the stylus to tap on the screen to position the cursor and then use these arrow buttons to position the cursor and read specific TIE values. The rubber cursor keys can also be used to move the cursor.

MTIE & TDEV Pass/Fail Analysis

MTIE and TDEV Analysis



- Standard MTIE & TDEV masks selection
- Pass or Fail indicator, evaluated depending on selected masks
- MTIE line color indicator and Enable/Disable check box
- TDEV line color indicator and Enable/Disable check box
- MTIE & TDEV logarithmic graphs and standard masks
- Press this button to return to the wander measurements screen
- Once the mask has been selected, press Analysis to run the MTIE and/or TDEV calculations. Depending on the number of samples collected, this calculation could take a few minutes.
- Save the MTIE, TDEV and mask calculations in CSV format to a USB Memory stick. The graph can be recreated using a spreadsheet program like Microsoft Excel, printed as a report or shared via email or other electronic media
- Generates a MTIE and TDEV report in PDF format to a USB Memory stick.

Go back to top Go back to TOC

15.10.3 ESMC SSM

Overview

Ethernet Synchronization Message Channel (ESMC) Synchronization Status Messages (SSM) are supported by both SDH and Ethernet networks. SDH is supported by the transport overhead channel and is unidirectional, Ethernet is defined as Organization Specific Slow Protocol (OSSP).

SSM represents the quality level of the system clocks located in the network. Background (or heartbeat) is sent once per second as keep alive. (ESMC information PDU) Event message is sent immediately in case the clock quality level has changed. (ESMC event PDU) Failure condition is declared if no message is received in 5 seconds.

ESMC PDU Format

Octet number	Size	Field
1-6	6 octets	Destination address =01-80-C2-00-00-02
7-12	6 octets	Source address
13-14	2 octets	Slow protocol Ethertype = 88-09
15	1 octet	Slow protocol subtype = 0x0A
16-18	3 octets	ITU-OUI = 00-19-A7
19-20	2 octets	ITU-T subtype
21	4 bits	Version
	1 bit	Event flag
	3 bits	Reserved
22-24	3 octets	Reserved
25-1514	36-1490 octets	Data and padding (see point j)
Last 4	4 octets	Frame check sequence

Event flag: This bit distinguishes the critical time-sensitive behavior of the ESMC event PDU from the ESMC information PDU. A value of 1 indicates an event PDU and a value of 0 indicates an information PDU.

IEEE Assigned OUI and slow protocol subtype

Organizationally specific identifier	00-19-A7
Slow protocol subtype	0x0A

QL TLV Format

8 bits	Type: 0x01
16 bits	Length: 00-04
4 bits	0x0 (unused)
4 bits	SSM code

TLV: Type Length Field

QL: Quality Level

Heirarchy of Quality Levels in Option I of Synchronization Networks

Quality level	Order
QL-PRC	Highest
QL-SSU-A	|
QL-SSU-B	|
QL-SEC	|
QL-DNU	|
QL-INVx, QL-FAILED, QL-UNC, QL-NSUPP	Lowest

Heirarchy of Quality Levels in Option II Synchronization Networks

Quality level	Order
QL-PRS	Highest
QL-STU	|
QL-ST2	|
QL-TNC (Note)	|
QL-ST3E (Note)	|
QL-ST3	|
QL-SMC	|
QL-ST4	|
QL-PROV (default position)	|
QL-DUS	|
QL-INVx, QL-FAILED, QL-UNC, QL-NSUPP	Lowest
NOTE – QL-TNC and QL-ST3E are not defined for first generation synchronization networking (refer to clause 5.4.1.2) and QL-PROV was identified as QL-RES.	

The SyncE ESMC SSM option has the following features:

- Generates “information” at a programmable interval, IPG, (default 1 sec)
- Generates “event” upon changing the QL-TLV followed by “information”
- Count message types
- Monitor and decode messages on screen
- Capture ESMC/SSM messages and output in pcap file for further off-line protocol analysis

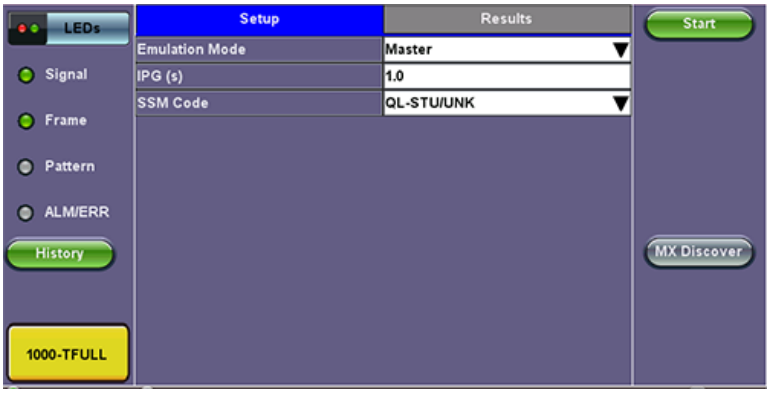
Go back to top Go back to TOC

Setup

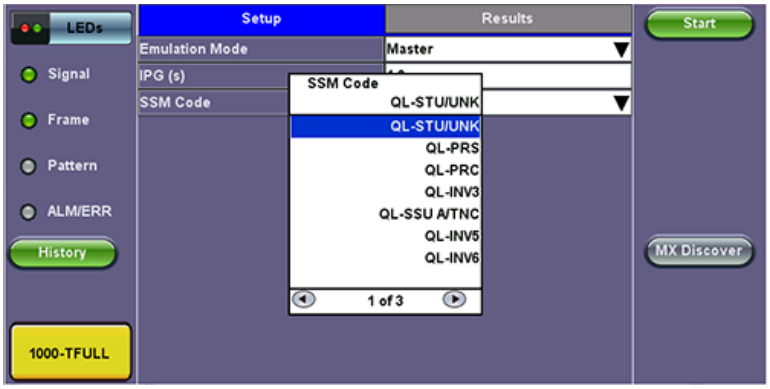
- **Emulation Mode:** The unit can be set as Master or Slave.
- **IPG(s):** Value can be entered by clicking in the box next to it.
- **SSM Code:** Quality Levels

Once the parameters are set, press Start to start the test.

ESMC SSM



SSM Codes



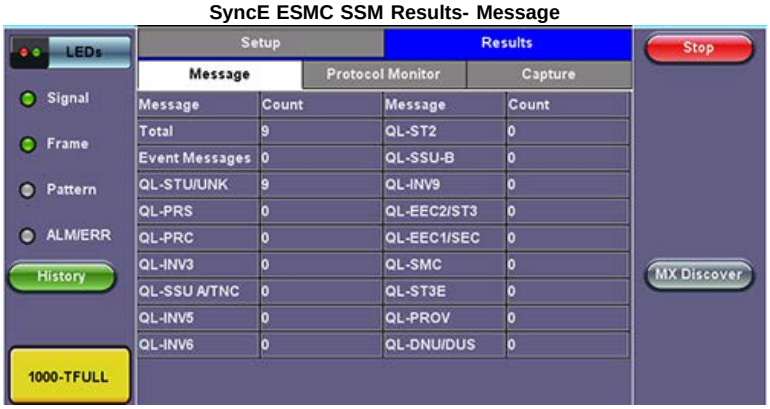
Go back to top Go back to TOC

Results

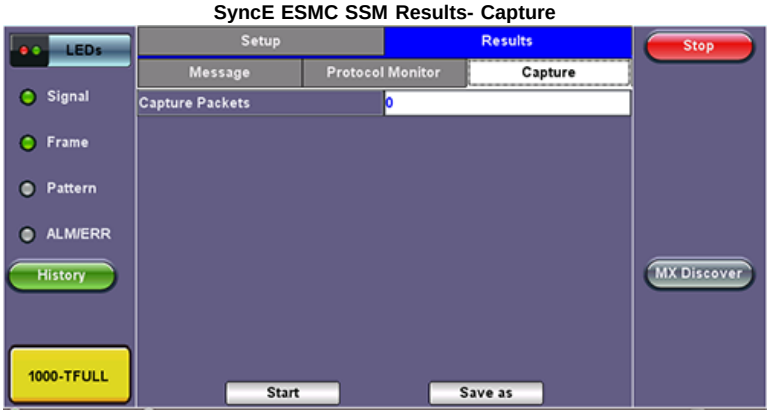
The Results screen shows Messages, Protocol Monitor, and Capture.

Message: A list of all the SSM quality levels with the results of the QL selected in Setup next to it.

SyncE ESMC SSM Results- Message



SyncE ESMC SSM Results- Capture

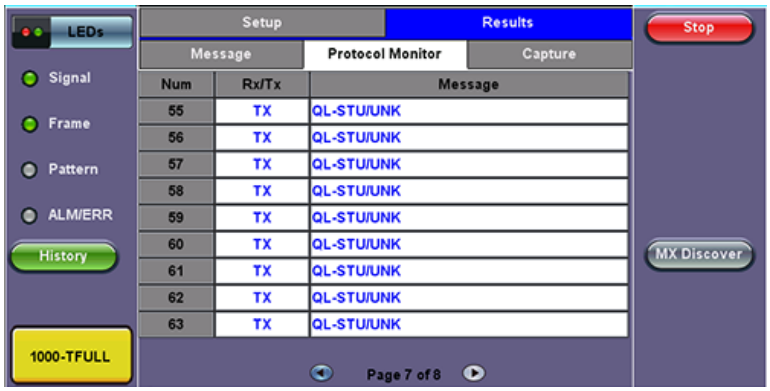


Go back to top Go back to TOC

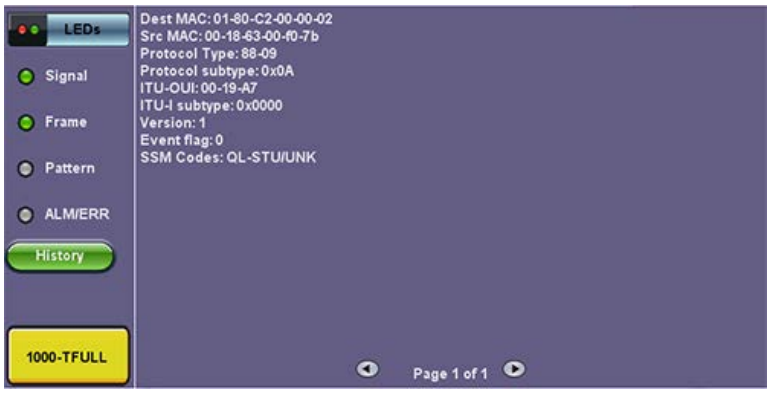
Monitor

The Tracer shows the messages as they are sent or received. The test set stores up to 2000 messages. Tap on the desired message to view decoded message details.

SyncE ESMC SSM Results- Protocol Monitor



Message Details



Go back to top Go back to TOC

Capture

Press Start to Capture Packets. The number of captured packet results is displayed.

To store these results packets, press stop, then press Save as. Enter a name for the results file. Press Apply to save the file. The file is saved under the Files folder on the unit in pcap format. The file can be later exported to a PC and analyzed using Wireshark.

SyncE ESMC SSM Capture

SyncE ESMC SSM Capture Save

Go back to top Go back to TOC

15.11 1588v2/PTP

- **Setup**
  - IP Configuration
  - Port
- **Mode Setup**
  - Master Emulation Mode Setup
  - Master Clock Settings
  - Slave Emulation Mode Setup
  - Slave Clock Settings
- **Test Results**
  - PTP Messages Overview
- **Protocol Monitor**
- **1588v2 Wander Measurement**
  - Setup
  - Results

1588v2/PTP Under Advanced Tools

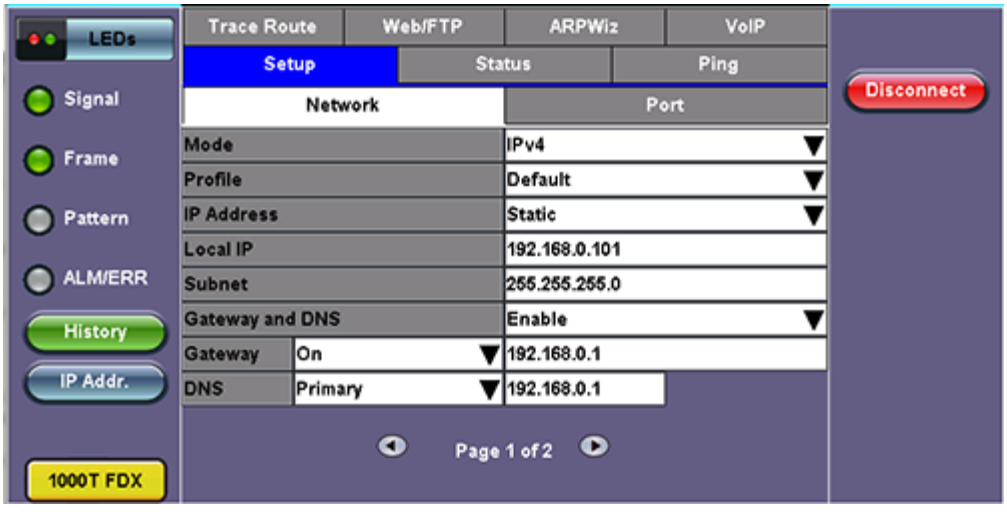
Go back to top Go back to TOC

15.11.1 IP and Port Setup

Before proceeding with any tests, configure the Port and IP connection.

IP configuration setup

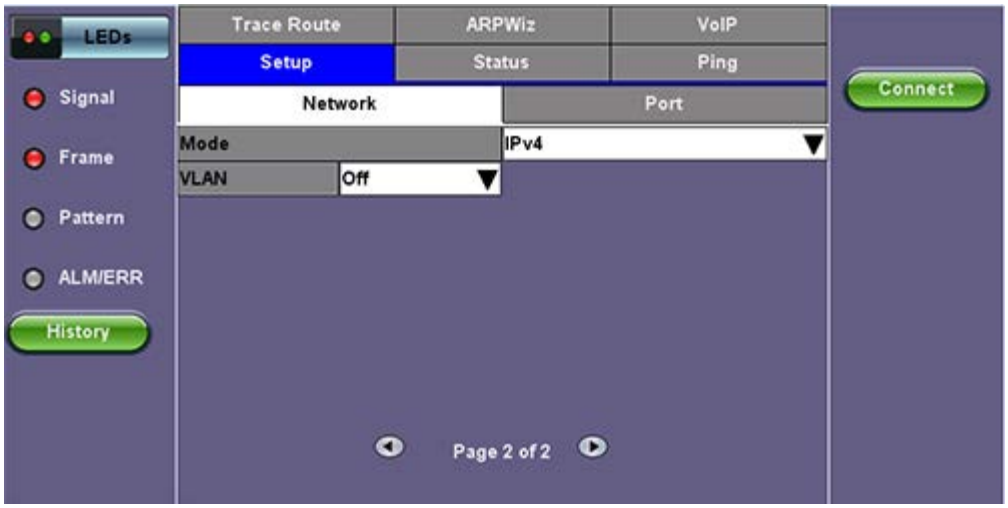
IP Setup (Page 1)



(Page 1)

- **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.

IP Setup (Page 2)



(Page 2)

- **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.

Port Setup

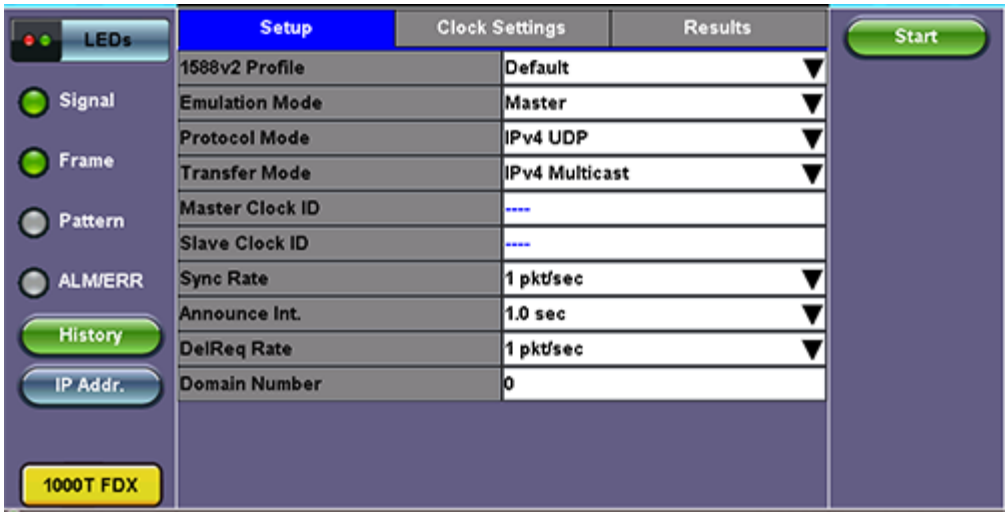
Refer to 15.1.2 Port Setup section for further configuration instructions, then continue to Mode Setup. Prior to starting the 1588v2 operation, the selected test port must be connected to the network.

Go back to top Go back to TOC

15.11.2 Mode Setup

15.11.2.1 Master Emulation Mode Setup

Setup Home Master



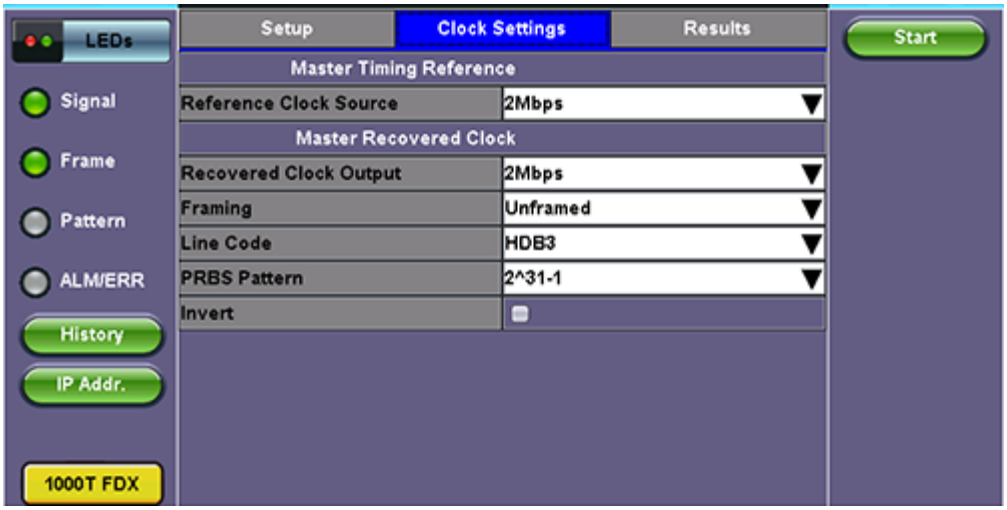
Master mode emulates a 1588v2 PTP Master clock device out of the Ethernet test port (10/100/1000BaseT or 100/1000BaseX). It uses an internal or external reference clock.

- **Emulation Mode:** Select Master
- **Protocol Mode:** IPv4 UDP, IPv6 UDP or Layer 2
  - **IPv4 UDP:** The PTP messages are transmitted with an IPv4 and UDP encapsulation.
  - **IPv6 UDP:** The PTP messages are transmitted with an IPv6 and UDP encapsulation.
  - **Layer2:** The PTP messages are encapsulated directly in an Ethernet frame without IP or UDP header.
- **Transfer Mode:** Select between Unicast or Multicast mode.
  In multicast mode, the Master Clock will send multicast PTP messages.
  In unicast mode, the Master and Slave clocks will exchange unicast PTP messages. If Unicast is selected, Master Clock's IP address needs to be entered.
- **Master and Slave Clock ID:** This field is not configurable; it will be populated with the clock ID of the 1588 Master and Slave once the 1588 protocol exchange is established. This will be indicated by the 1588 top icon becoming green.
  The Clock ID is formatted as the MAC address of the device first 3 byte -- FF -- FE -- last 3 byte of MAC address.
  The MAC address of the device can be manually changed in Tool > IP menu.
- **Sync Rate:** Sets the rate of the multicast Sync messages sent by the master, values from 0.625 packets/second to 64.
- **Announce Int:** Interval of the announcement message to be sent by the master clock. Options are 1, 2, 4, 8, and 16 seconds.
- **DelayReq Rate:** Defines the DelayReq/DelayResp messages rate, values from 0.625 packets per second to 64.
- **Domain Number:** Enable/Disable. Enabling this feature allows the user to assign a domain number to a slave-master network. The domain number limit is 255.
- **Clock Class:** Select Value from drop down menu. Defines the Grand Master Clock Class value set in the Master's Announce Messages.

Go back to top Go back to TOC

15.11.2.2 Master Clock Settings

Clock Settings - Master



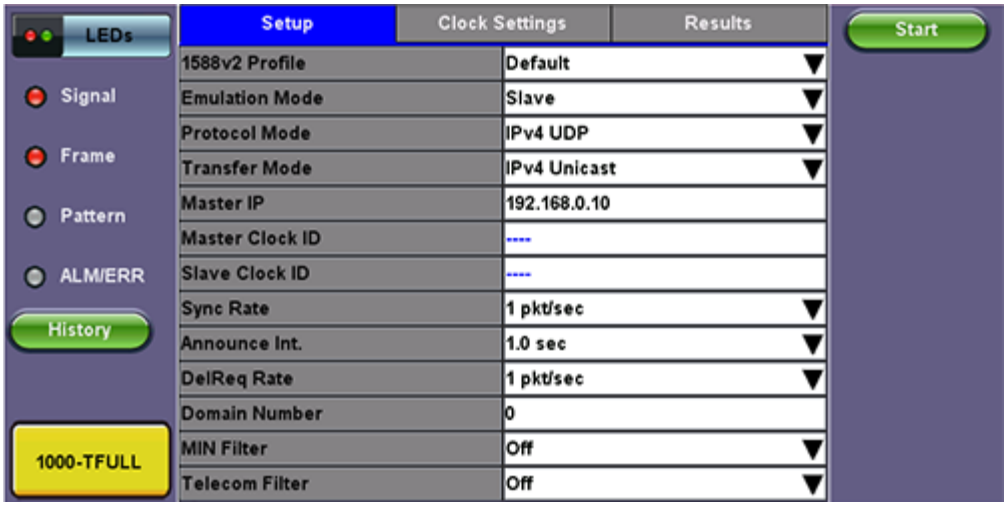
- **Reference Clock Source:** Select between an internal or external clock source. This setting defines the reference clock used by the 1588 Master Clock. Possible external clock sources: 1.5444MHz,1.544Mbps, 2 MHz, 2Mbps (E1 signal), 10MHz, 25MHz, 125MHz or External1 pps. The external clock source is connected to the SMA port on each Test Module, this port is marked CLK on the connector panel.
  Possible Internal Clock sources: Internal Clock (+/-3.5ppm accuracy), Internal GPS 1 PPS (Requires GPS option and Antenna), Internal Atomic 1 PPS (Requires High Precision Atomic Clock option)
- **Reference Clock Output:** The reference clock used by the 1588v2 Master can be regenerated out of the PDH Tx1 port (marked Tx1 on the connector panel) with a different clock format in order to synchronize other network elements.
  The clock can be formatted to: 2Mbps (E1 signal), 2.048MHz, 1.544MHz,10MHz, 25MHz, and 125MHz or none.
  - If 2Mbps clock is selected then the following parameters need to be set:
    - **Line Code:** HDB3 or AMI
    - **Framing:** Unframed, PCM31, PCM31C, PCM30, or PCM30C
    - **PRBS Pattern**
    - **Invert**

Press Start to Start the test.

Go back to top Go back to TOC

15.11.2.3 Slave Emulation Mode Setup

Setup Home Slave



Slave mode emulates a 1588v2 PTP Slave clock device from the Ethernet test port (10/100/1000BaseT or 100/1000BaseX).

- **Emulation Mode:** Select Slave
- **Protocol Mode:** IPv4 UDP, IPv6 UDP or Layer 2
  - **IPv4 UDP:** The PTP messages are transmitted with an IPv4 and UDP encapsulation.
  - **IPv6 UDP:** The PTP messages are transmitted with an IPv6 and UDP encapsulation.

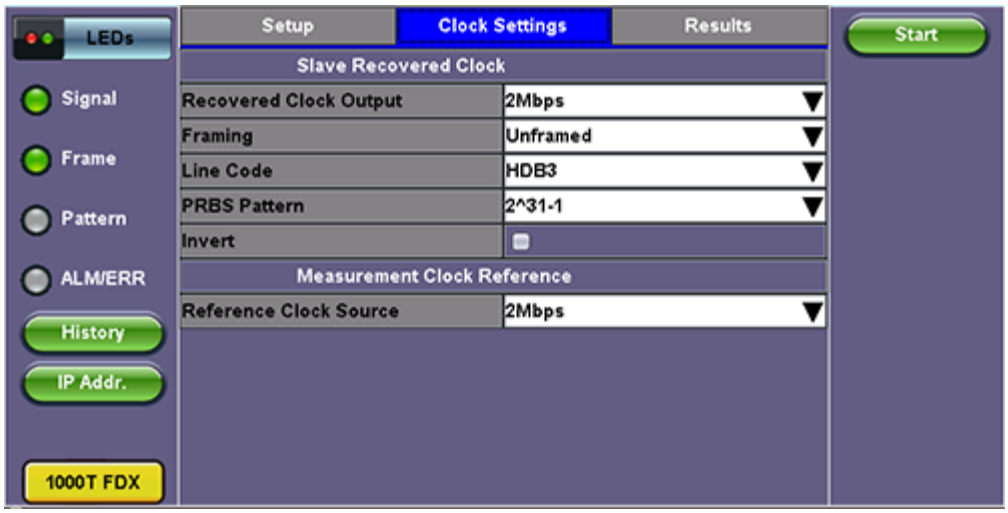
Layer2: The PTP messages are encapsulated directly in an Ethernet frame without IP or UDP header.

- **Transfer Mode:** Select between Unicast or Multicast mode.
  In multicast mode, the Master Clock will send multicast PTP messages.
  In unicast mode, the Master and Slave clocks will exchange unicast PTP messages. If Unicast is selected, Master Clock's IP address needs to be entered.
- **Master and Slave Clock ID:** This field is not configurable; it will be populated with the clock ID of the 1588 Master and Slave once the 1588 protocol exchange is established. This will be indicated by the 1588 top icon becoming green.
  The Clock ID is formatted as the MAC address of the device first 3 byte -- FF -- FE -- last 3 byte of MAC address.
  The MAC address of the device can be manually changed in Tool > IP menu.
- **Sync Rate (Unicast Slave only):** Sets the Sync messages rate requested by the slave to the master, values from 0.625 packets/second to 64.
- **Announce Int:** Interval of the announcement message to be sent by the master clock. Options are 1, 2, 4, 8, and 16 seconds.
- **DelayReq Rate:** Defines the DelayReq/DelayResp messages rate, values from 0.625 packets per second to 64.
- **Domain Number:** Enable/Disable. Enabling this feature allows the user to assign a domain number to a slave-master network. The domain number limit is 255.
- **MIN Filter:** Select between Off or enter the length of the filter (2,4,6,8,12).
  The filter is designed to compensate for network jitter by averaging the PTP messages timing values before updating the slave recovered clock. The length of the filter determines the number of samples averaged. Larger filter size will slow down the convergence speed of the slave. In condition of no or low network jitter it is recommended to disable the Filter.
- **Telecom Filter:** Off / On
  The setup of the PDV filter requires two parameters to be set. The 1st parameter is the filter time period (Filter Length in seconds). The 2nd parameter is the worst-case accuracy which the filter needs to meet in nanoseconds (Worst case accuracy in nsec). The filter time period is the period in which the clock runs linearly without adjusting the clock drift or the absolute time. In this period, the filter collects measurements. After this period, the filter estimates the offset on the basis of all collected measurements.
  The recommended settings are 5 second filter and 1 µsec worst case accuracy.
  After enabling the telecom filter the initial convergence time will be increased high jitter in some networks.
- **Master Address (Unicast Slave only):** Tap on the field and use the soft-keyboard to enter the master IP address.

Go back to top Go back to TOC

15.11.2.4 Slave Clock Settings

Clcok Settings - Slave



- **Reference Clock Output:** The reference clock used by the recovered clock from the 1588v2 Slave can be regenerated out of the PDH Tx1 port (marked Tx1 on the connector panel) with a different clock format in order to synchronize other network elements.
  The clock can be formatted to: 2Mbps (E1 signal), 2.048MHz, 1.544MHz,10MHz, 25MHz, and 125MHz or none.
  - If 2Mbps clock is selected then the following parameters need to be set:
    - **Line Code:** HDB3 or AMI
    - **Framing:** Unframed, PCM31, PCM31C, PCM30, or PCM30C
    - **PRBS Pattern**
    - **Invert**
- **Measurement Clock Reference:** Select between an internal or external clock source. This setting defines the reference

clock used for 1588 Slave clock wander measurement. Possible external clock sources: 1.5444MHz,1.544Mbps, 2 MHz, 2Mbps (E1 signal), 10MHz, 25MHz, 125MHz or External1 pps. The external clock source is connected to the SMA port on each Test Module, this port is marked CLK on the connector panel.
Possible Internal Clock sources: Internal Clock (+/-3.5ppm accuracy), Internal GPS 1 PPS (Requires GPS option and Antenna), Internal Atomic 1 PPS (Requires High Precision Atomic Clock option)

Press Start to Start the test.

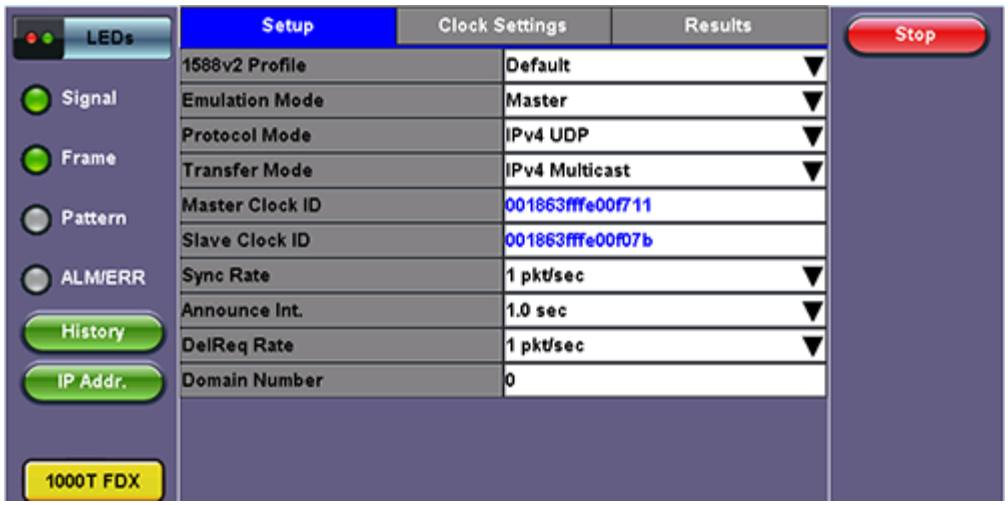
Go back to top Go back to TOC

Indicator Symbols

An M or S indicates that the test set is in Master or Slave Mode. A green 1588 icon indicates that the 1588 test is running. If the icon is flashing or solid red, there may be an issue with setup and the test will not work.

Master and Slave Clock IDs get populated once the test is started.

Master and Slave Clock ID



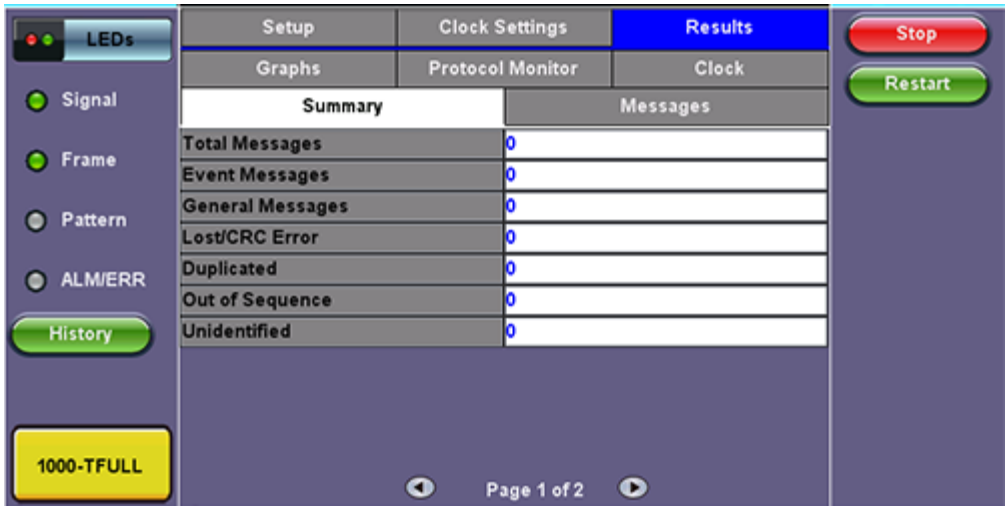
Go back to top Go back to TOC

15.11.3 Test Results

The Summary, Messages and Protocol Monitor results are available both in Master and Slave mode. The Graphs and Clock sections are available only in Slave mode.

Summary

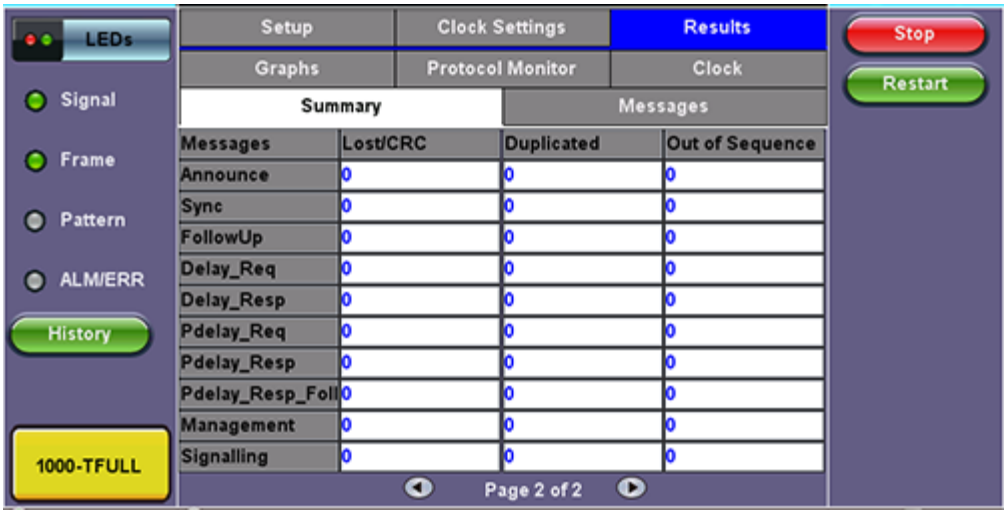
Summary



The **Summary** screen displays the 1588v2 message statistics including the number of **Total messages**, **Event messages,** and

General messages along with information on **Lost**, **Duplicated, Out of Sequence** and **Unidentified** messages. Tap on Page 2 to see more detailed message error information.

Summary Page 2

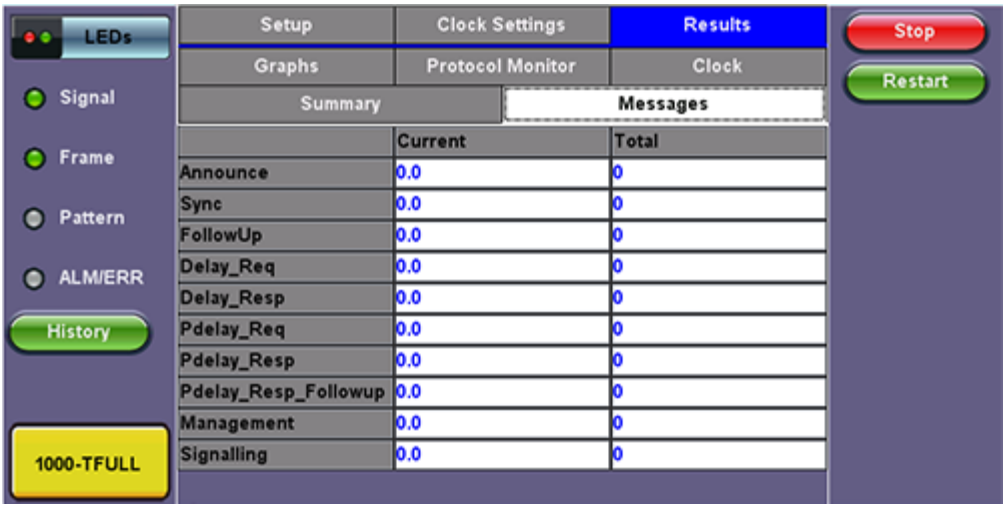


Additional message information is displayed on the Messages screen.

Messages

The Messages screen gives a further breakdown by message type. The total and per second average message rates are displayed.

Messages



Restart clears the counter and restarts the test.

Graphs (Slave Only)

Tap on the **Graphs** tab to access graphical statistics.

PDV: Delay Request, Asymmetry, and Sync PDV min and max information.

- Delay Request: The Delay_Req PDV measures t4-t3 (delay message jitter)
- Asymmetry: The Asymmetry PDV measures (t4-t3)+(t2-t1) (this measures the Delay)
- Sync PDV: The Sync PDV measures t2-t1 (sync messages jitter)
- RoundTrip PDV: The RoundTrip PDV measures (t4-t3)+(t2-t1), which is the Delay measurement packet delay variation

Note: *Refer to PTP Messages timing overview graph for t1, t2, t3, t4 definitions.*

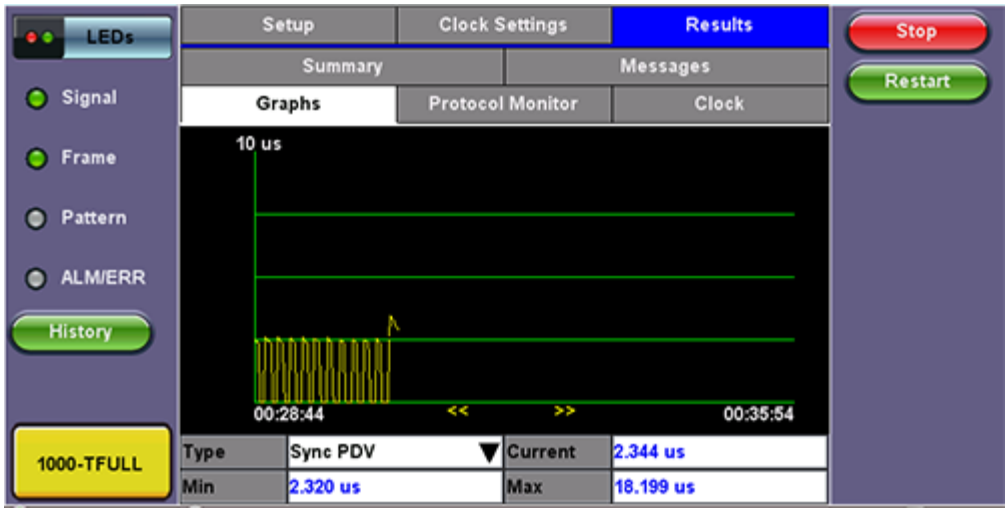
RTD: RTD and Delay Response RTD min and max information.

The RTD graph measures the time between when the delay_req leaves the slave and the delay_resp is received by the slave.

IPG: Sync and Delay Response IPG min and max information.

The IPG graphs give information about the Sync and Delay_resp arrival rate. This will depend on the setting 16 vs 32 vs 64. It can be used as a confirmation that the rates are as expected. This can be also verified with the packet counters.

Graphs

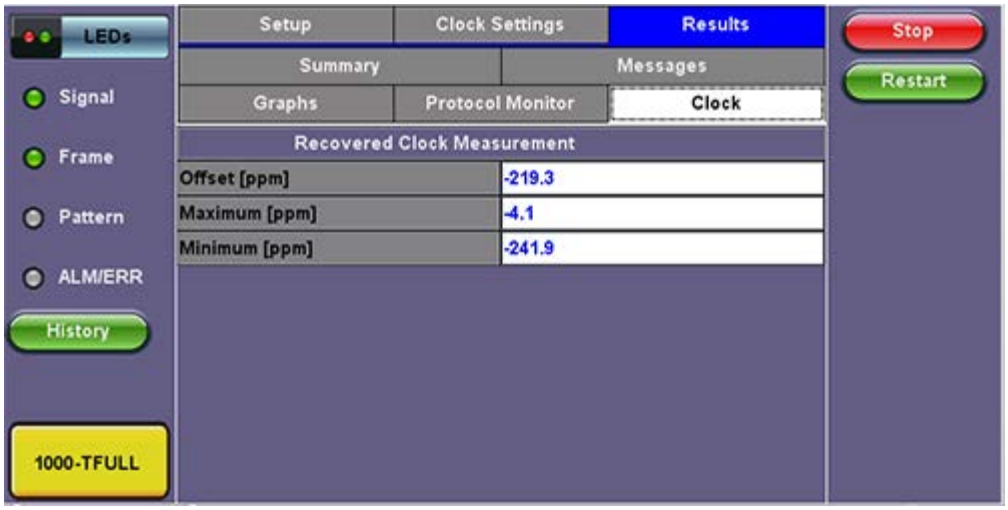


Clock Measurement (Slave only)

The Clock measurement function is used for frequency comparison between the 1588 slave recovered clock to a reference source. The results are measured in ppm (parts per million). This function can be used as a quick check prior to running a longer duration wander measurement.

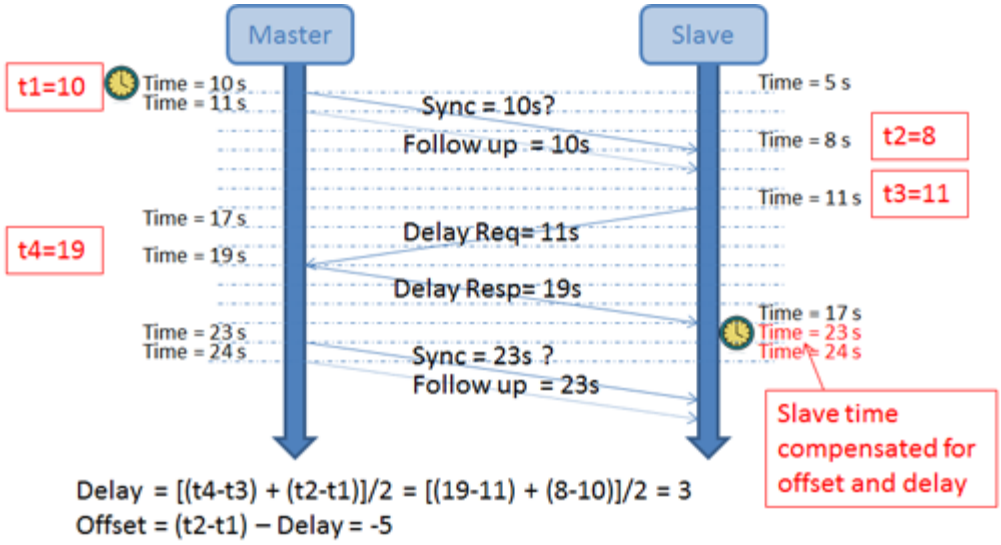
Offset, **Min**, and **Max** clock measurement offset results are displayed in ppm.

Clock



Go back to top Go back to TOC

Overview of timing - PTP Messages



1. The master starts the exchange by sending a Sync message to the slave. The message contains the time t1 at which the packet was sent. The slave notes the time t2 at which this message was received. Depending on the master hardware capabilities, the sending time may not be accurate enough in the original Sync message; therefore it can be optionally followed by a Follow up message containing the accurate send time t1 of the Sync message. A clock supporting Sync and Follow up messages is referred to as a two-step clock, whereas a clock supporting only Sync messages is referred to as a one-step clock.
2. The Slave sends a Delay Request message to the master and notes the send time t3. Upon reception of the Delay Request the master notes the time t4 and embeds this information in the Delay Response message.
3. The slave is now armed with 4 timestamps. The network delay between master and slave is estimated by averaging the time between master and slave (t2-t1) and the time between slave and master (t4-t3). It is important to note that this calculation assumes that the network delays are symmetrical.
4. The timing offset between slave and master is then determined by subtracting the delay from the difference between t1 and t2.
5. With the Delay and Offset information, the slave is able to align its clock to the master.
6. Sync, optional Follow up, Delay_Req and Delay_Resp are exchanged repeatedly throughout the duration of the 1588v2 session to compensate for clock drift.

Go back to top Go back to TOC

15.11.4 Protocol Monitor

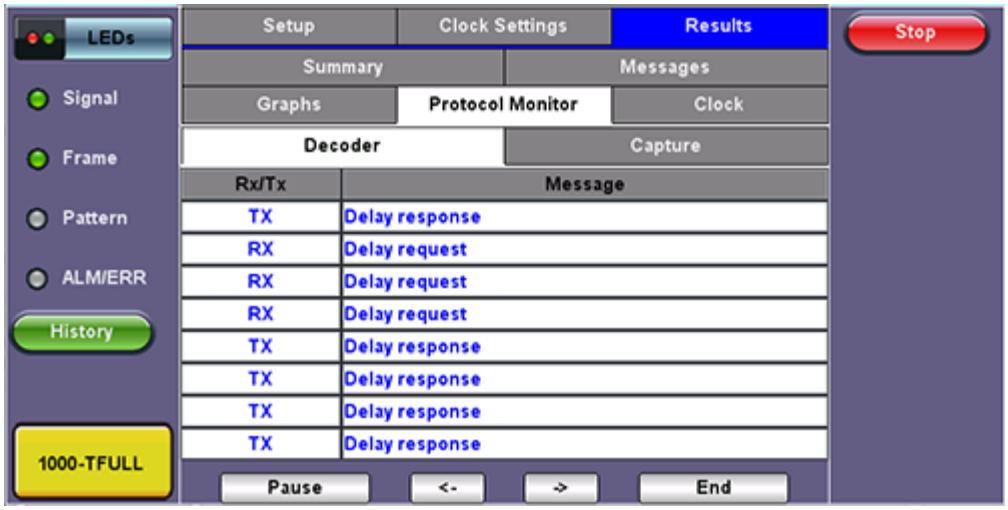
The Tracer shows the 1588v2 messages from both Master and Slave clock devices.

There are four function keys:

- **Pause**/**Continue** - to pause or continue the tracer.
- **->** & **<-** - in Pause mode, use the key to page up or page down.
- **End** - in Pause mode, use End key to jump to the end of the trace.

To view decoded messages, press **Pause** to pause the protocol tracer and tap on the desired message to view decoded message details.
Tap on the Capture tab then hit **Start** to capture packets. The Capture function can store up to 20,000 messages. The messages are saved in pcap format and can be viewed on wire shark for future analysis.

Master Protocol Monitor Decoder



Decoded Message

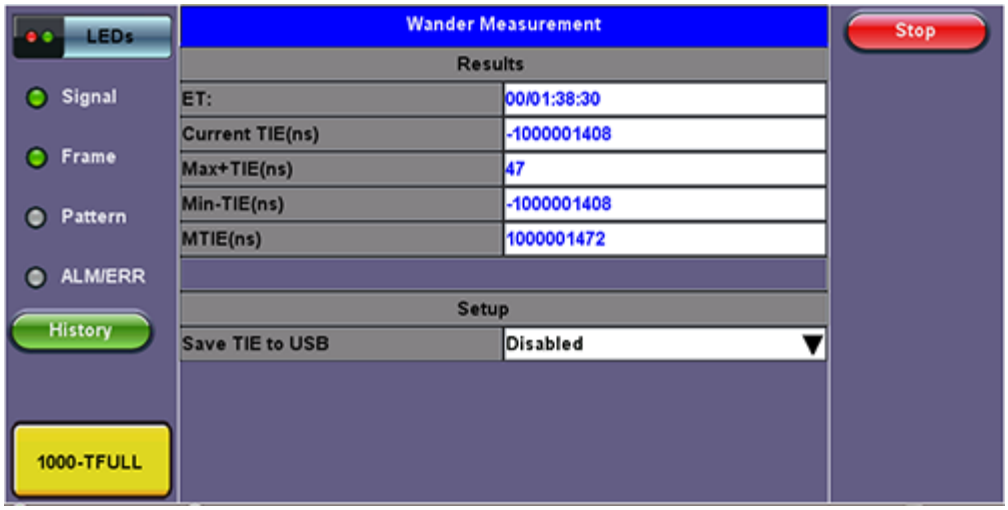
Capture

Go back to top Go back to TOC

15.11.4 1588v2 Wander Measurements

The wander measurements in the IEEE 1588v2 section are specific to 1588v2 Slave modes. Make sure that a PTP sync has been established and enough "warm up" time is given to the protocol to provide an accurate and stable recovered clock (test signal). The Sync PDV graph could be used to establish the level of readiness required for a wander test (when the graph has converged to a low and stable PDV value).

Wander Measurements



Setup

Save TIE to USB: OFF presents the current real time TIE measurements on screen only. ON sends real time TIE measurements to an attached USB memory, for further post analysis (refer to the MTIE and TDEV Analysis section). This feature requires the MTIE and TDEV Post Analysis option.

Press the Start button to run the test. If Save TIE to USB is set to ON, the test set asks for a file name (keep this into account when running time-sensitive tests). Do not remove the USB memory stick while the wander test is running.

Results

- **ET**
- **Current TIE:** Shows the last Time Interval Error (relative phase error) measured between the reference clock and the test signal.
- **Max TIE:** Records the maximum TIE value measured since the test was started.
- **Min TIE:** Records the minimum TIE value measured since the test was started.
- **MTIE:** Shows the maximum difference between TIE values measured since the test started (Max - Min)

Note: *The wander tests will automatically stop if either of the signals used as reference clock or recovered clock (test signal) have significant levels of impairments, are lost, or disconnected.*

Press the Stop button to terminate the test. If Save TIE to USB is set to ON, then remove the USB memory stick from the test set, bring it to a computer, and open it with the VeEX Wander Analysis PC software, for further MTIE, TDEV, and masks analysis (refer to the MTIE and TDEV Analysis section).

Both, Wander Analysis and MTIE / TDEV Post Analysis are optional features.

Go back to top Go back to TOC

16.0 Fiber Channel

Fiber Channel Applications

Introduction

Enterprises worldwide rely on complex IT infrastructures to store and maintain critical data and applications. Storage Area Networks (SANs) have evolved to improve availability, resiliency, performance, modularity and geographical distribution of data storage systems and Fiber Channel is an important technology for linking SANs together.

Fiber Channel over IP

Often, IP-centric networks are used to connect SAN islands over Local Area Networks (LAN), Metropolitan Area Networks (MAN), or Wide Area Networks (WAN). An operational IP backbone (Layer 2 or Layer 3 topology) capable of delivering the required bandwidth for Fiber Channel applications is an absolute prerequisite. The test set equipped with Ethernet and Fiber Channel features is able to verify FCIP connections in a variety of network configurations.

Fiber Channel over SDH/SONET

Service providers have made huge investments in SDH/SONET infrastructure over many decades, hence storage over SONET/SDH networks are considered an essential part of any operator's SAN extension solution. DWDM networks are perfect for transporting high-density, high-bandwidth SAN applications over short distances while SDH/SONET/OTN networks are often used for longer distance applications. The test set is equipped with a strong set of features needed to verify the strategic components and network interconnects.

Key Test Applications

Transport layer - Most customers or providers transporting Fibre Channel are not necessarily trained or concerned with testing the higher protocol layers -- instead the transport groups tasked with transporting this data across a point-to-point or ring type DWDM network are more likely to ask: Did data arrive error free or were any bit errors encountered? Was the CRC corrupted or were any code violations experienced? Testing the transport layer is crucial and normally includes the FC-0 Layer, FC-1 Layer, and parts of the FC-2 Layer where:

- FC-0 addresses the physical layer: the optical fiber, connectors, and associated optical signal parameters.
- FC-1 addresses the transmission protocol encoding/decoding, and special characters used for protocol management.
- FC-2 addresses the signaling protocol layer, which comprises the framing protocol and the flow control process.

The Fibre Channel option addresses all the transport layers by measuring the optical power level and supporting the generation/analysis of bit errors, order sets, frame delimiters, frame transmission, and the generation of primitive sequences. User defined bytes, fixed test patterns or industry-standard PRBS patterns can be selected and inserted into the payload field depending on the test layer. Bit error, CRC error and Code violation insertion are useful features to verify Mux/Demux equipment for error monitoring and detection.

Buffer-to-Buffer Credit Estimation - To avoid loss of frames during transmission, the Fibre Channel protocol uses a buffer-to-buffer flow control mechanism between link partners. During the login process, the remote node informs the local nodes as to the number of receive buffers it has available. For each frame received, the remote port returns a R_RDY frame to indicate that one of the receive buffers is now free - the local port in turn increments its available credit counter by one for each R_RDY acknowledgement frame it receives. However, as the distance between nodes or link partners increases, so does the time it takes for the transmitting node to receive the R_RDY frame because of signal propagation delay. The standard practice for a 1Gbps Fibre Channel link is to allow 1 buffer credit for each 2km of distance.

Go back to top Go back to TOC

16.1 Setup

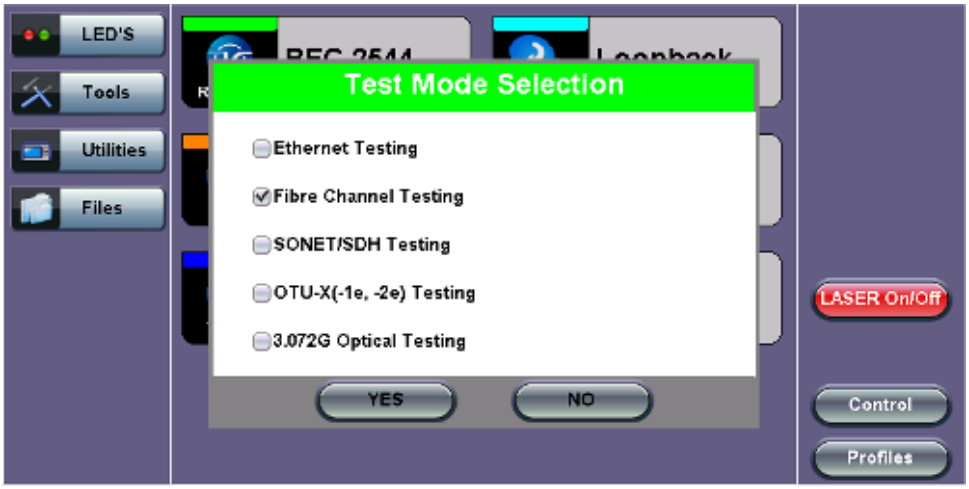
“Fibre Channel ” versus “Fiber Channel”

Confusing naming and spelling conventions have stuck with Fibre Channel during its development. The word “channel” in no way indicates a preference for channel protocols or environments. Even though “fibre” and “fiber” are semantically equivalent (“fibre” is the international English spelling), “Fibre Channel” is the official spelling for the technology.
“Fiber” has come to mean more specifically the optical (glass) media used for long-distance (up to 10 km) connections.

Go back to top Go back to TOC

16.1.1 Test Applications

The Fiber Channel test mode is accessed by clicking the Test Mode button at the bottom right hand side of the screen.



The Fiber Channel Home screen or Main Menu is shown below.

Fiber Channel Main Menu

The Fiber Channel Main Menu provides shortcut application buttons for FC BERT, FC RFC 2544, FC Throughput, FC Loopback, and IP testing.

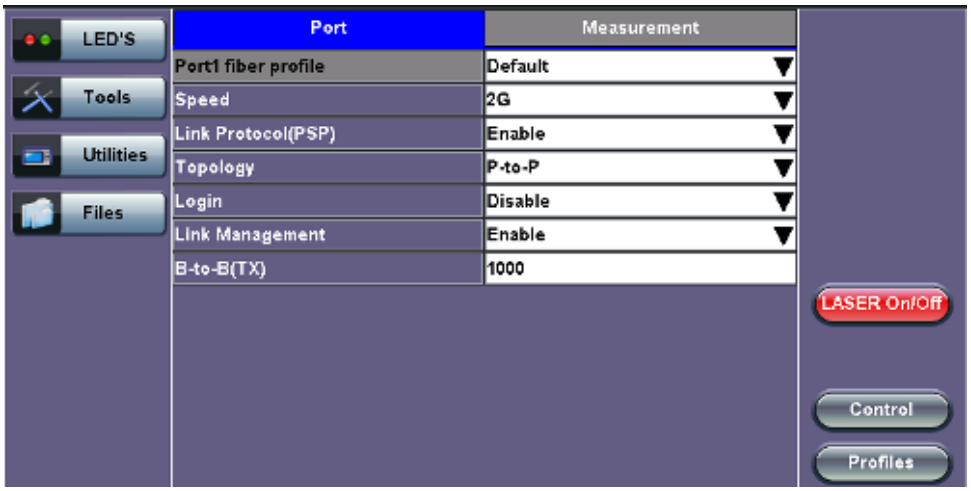
Some test capabilities or test rates may be specific to the product configuration or may require the purchase of a software option in order to be displayed or be enabled.

Note: The IP function is not supported in the V300 series.

Go back to top Go back to TOC

16.1.2 Port Configuration

Fiber Channel - Port Setup



- **Fiber Profile:** Predefined Fiber Channel test profiles or Default setting
- **Speed:** Selectable test rates via drop-down menu:
  - 1G (1.0625 Gbps)
  - 2G (2.125 Gbps)
  - 4G (4.25 Gbps)
  - 8G (8.50 Gbps)
  - 10G (10.52 Gbps)
- **Link Protocol:** Enables or Disables the PSP
  - Enabling the Primitive Sequence Protocol (PSP) allows link management
  - Disabling the Primitive Sequence Protocol (PSP) forces the port into an Active state with no link management
    - PSP is an Ordered Set transmitted repeatedly which is used to establish and maintain a link.
    - PSP also when this setting is enabled
    - When a Primitive Sequence is received and recognized, a corresponding Primitive Sequence or Idle is transmitted in response. Recognition of a Primitive Sequence requires consecutive detection of 3 instances of the same Ordered Set.
    - The Primitive Sequences supported by the standard are:

    - Offline (OLS)
    - Not Operational (NOS)
    - Link Reset (LR)
    - Link Reset Response (LRR)

- **Topology:** Point-to-Point (P-to-P) mode is supported.
    - Fibre Channel defines three topologies, namely, Point-to-Point, Arbitrated Loop, and Fabric however Point-to-Point topology is the simplest one.
    - In Point-to-Point mode, only two ports are used, connected by a fiber optic link. The transmitter of each port is connected directly to the receiver of the opposite port. There is no ambiguity in addressing, and there is no question of availability.

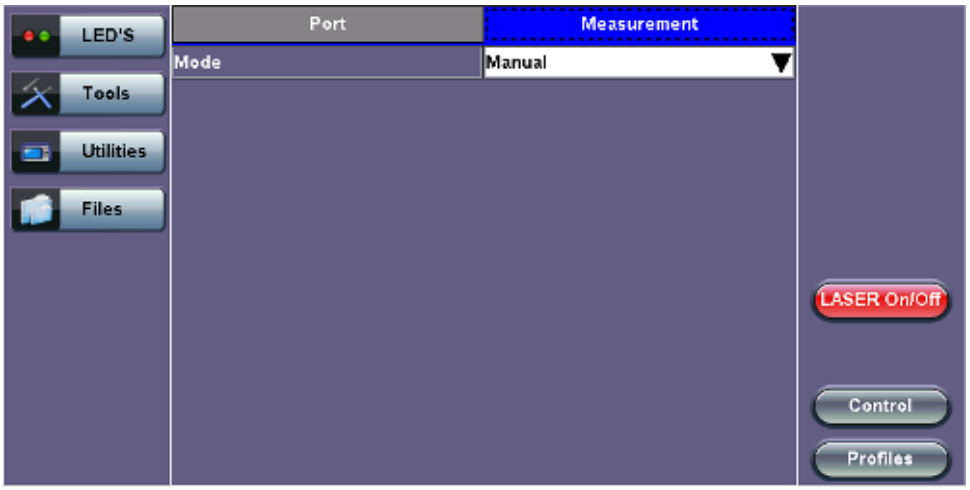
- **Login:** Disable only. Port login will be a future option.
    - Fibre Channel defines several types of ports. First of all, any port on a node device, (e.g., a PC, is an N_Port as compared with a port on a Fabric, which is an F_Port).
    - Ports that connect switches together are called E_Ports. They generally do not need to follow Fibre Channel rules and protocols.

- **Link Management:** Enable or Disable
    - Only available when PSP is enabled
    - Initializes the Fibre Channel link and manages various states, including link failure, loss of synchronization, loss of signal, or protocol violations

- **B-to-B (Tx): Buffer to Buffer:** Valid settings are in the range from 1 to 65535.
    - Number of local port frame buffers are available to receive frames from another port
    - Determines how many frames can be sent before receiving R_RDY acknowledgements.
    - “Credits”, or the number of frames, are negotiated between the n_ports and f_ports at the time of login
    - Both ports on the link exchange values of how many frames they are willing to receive at a time from the other port. This value becomes the other port's BB_Credit value and remains constant as long as the ports are logged in.
    - Each port also keeps track of BB_Credit_CNT.
        - Transmitter: For each frame transmitted, BB_Credit_CNT is incremented by 1.
        - Receiver: The value is decremented by 1 for each R_RDY Primitive Signal received from the other port.

Go back to top Go back to TOC

Fiber Channel - Measurement Setup



- **Mode**: Manual or Timed
    - **Manual:** Measurement is started (by the User) by pressing the **Start** button and ended when pressing the **Stop** button
    - **Timed:** Measurement duration can be programmed in seconds, minutes, hours or days

Go back to top Go back to TOC

16.2 BERT/Throughput

16.2.1 Overview

The test set complies with ANSI NCITS FC-FS recommendations and has the ability to test 1, 2, 4, 8 and 10 Gigabit Fibre Channel.

- 1/2/4/8G Fiber Channel: The unit verifies the 8B/10B PCS Layer with a basic primitive set at FC-1 or FC-2 lower layers.

10G Fiber Channel: The unit verifies the 64B/66B PCS Layer with a basic primitive set at FC-1 or FC-2 lower layers.
- FC-1 Layer addresses the transmission protocol encoding, decoding, and special characters used for protocol management
- FC-2 is the signaling protocol layer, which is made up of a framing protocol and a flow control process

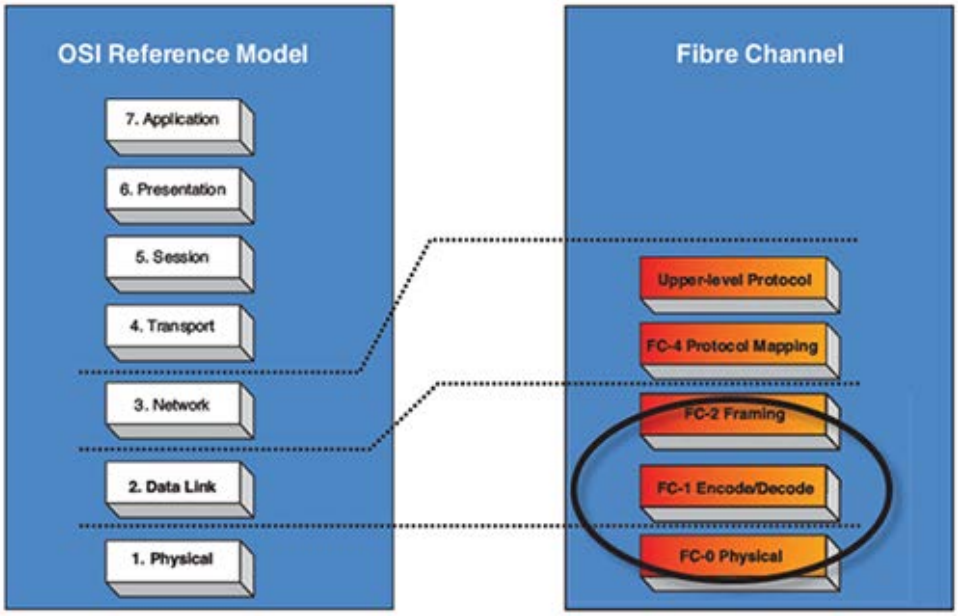
The unit supports the generation and monitoring of: bit errors, order sets, frame delimiters, frame transmission, and generation of primitive sequences. BERT diagnostics perform a bit-by-bit comparison to find bit errors in the received data pattern. Error Count and Error Rate for the latest sample are displayed and maintained, as well as totals for all samples from the test start.

The user can use a default frame header or define a custom frame header - the unit takes care of the frame/header setup, creates the user defined SOF and EOF delimiters and calculates the CRC error checking bytes, which are placed within the frame. User defined bytes, fixed patterns or industry standard PRBS patterns can be selected from drop-down menus and radio buttons and inserted into the payload field.

Testing is supplemented with the capability to perform Bit and CRC error insertion. These tests allow users to test their own Mux demux equipment for error monitoring and detection. The test set displays the BERT test results continuously and any anomaly is recorded in an event log which is date and time stamped. All results can be saved and exported into ReVeal MX for analysis or customer test report generation.

Fiber Channel Layers

The Open Systems Interconnect (OSI) model breaks communications into seven layers namely, Physical, Data Link, Network, Transport, Session, Presentation, and Application. Fibre Channel does not follow the ISO model - instead, the protocol has been broken into five layers: FC-0, FC-1, FC-2, FC-3, and FC-4.



OSI layers versus FC layers

- **FC-0** defines the physical portions of Fibre Channel, including the media types, connectors, and the electrical and optical characteristics needed to connect ports. This level is in the FC-PH standard.
  - Signaling
  - Media specifications
  - Receiver/Transmitter specifications

- **FC-1** defines the transmission protocol, encoding, order of word transmission, and error detection. This level is in the FC-PH standard.
  - 8B/10B character encoding (1/2/4/8G FC) or 64/66B character encoding (10G FC)
  - Link maintenance

- **FC-2** defines the signaling and framing protocol, including frame layout, frame header content, and rules for use. It also contains independent protocols such as login. This is the bulk of the FC-PH standard.
  - Frame format
  - Sequence management
  - Exchange management
  - Flow Control
  - Classes of Service

- Login/Logout
- Topologies
- Segmentation and Reassembly

OSI Model	Fiber Channel	Description
Layer 2: Data link	FC-2	Similar to the MAC functionality – Fiber Channel frames are defined, addressed and CRC are added
Layer 1: Physical	FC-1	Similar to the physical layer of the OSI model – Fiber Channel adds basic flow control functionality and ordered sets
	FC-0	

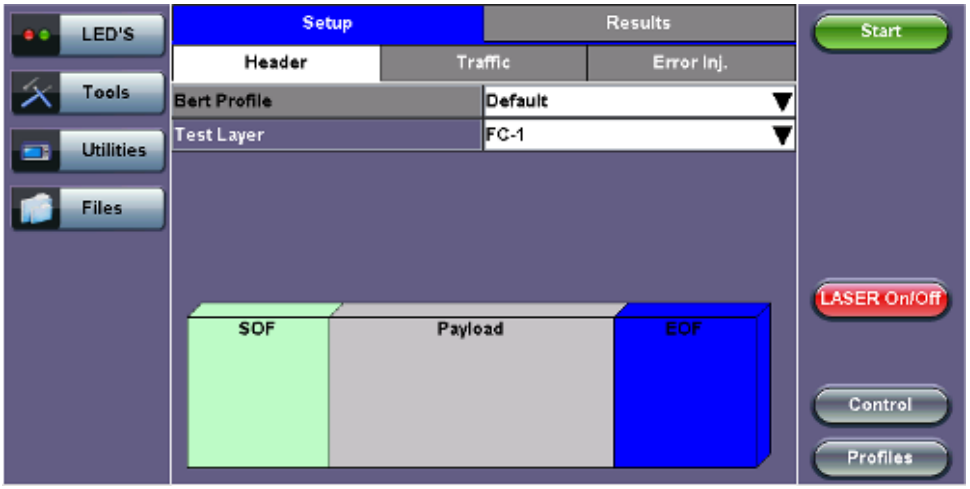
Fiber Channel layers and functionality

- **FC-3** defines common services that may be available across multiple ports in a node. This level has no standard now.
  - Services for multiple ports on one node
- **FC-4** defines the mapping between the lower levels of Fibre Channel, and the command sets that use Fibre Channel.
  - Upper Layer Protocol (ULP) mapping
    - Small Computer System Interface (SCSI)
    - Internet Protocol (IP)
    - High Performance Parallel Interface (HIPPI)
    - Asynchronous Transfer Mode - Adaption Layer 5 (ATM-AAL5)
    - Intelligent Peripheral Interface - 3 (IPI-3) (disk and tape)
    - Single Byte Command Code Sets (SBCCS)

Go back to top Go back to TOC

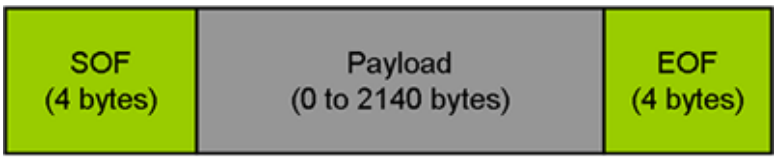
16.2.2 Setup

FC-1 BERT - Test Frame Setup



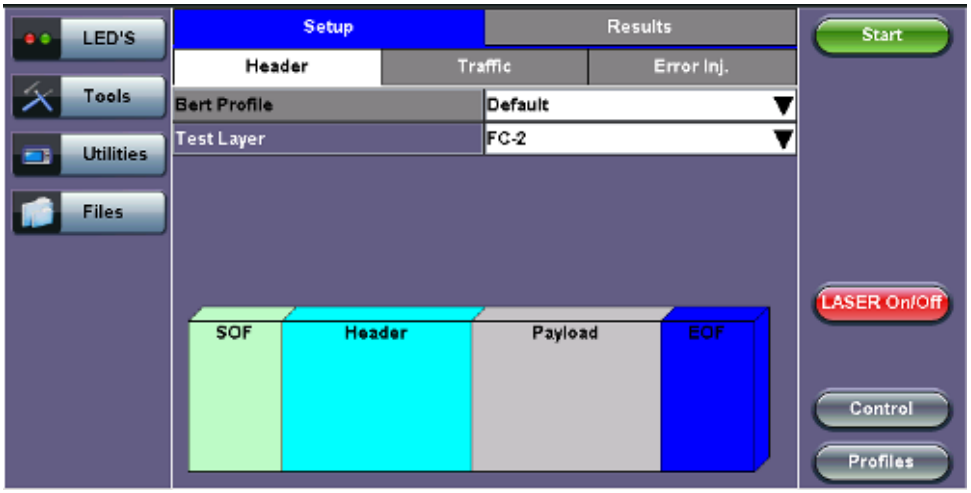
Profile: User Defined Profile or Default setting can be used for testing.
Test layer: FC-1 or FC-2 only. Testing at other layers is not supported.

- **FC-1:** Information is transmitted using an adaptive code (8B/10B or 64/66B) depending on test rate and the encoding process results in the generation of transmission characters.
  - The two types of Transmission Characters defined are data and special. Certain combinations of Transmission Characters, referred to as Ordered Sets, are designated by this standard to have special meaning.
  - Ordered Sets are used to identify frame boundaries, transmit primitive function requests, and maintain proper link transmission characteristics during periods of inactivity.

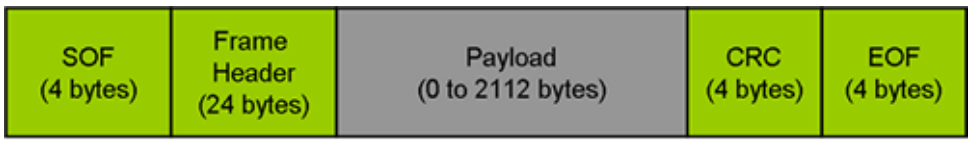


FC-1 Frame Structure

FC-2 BERT - Header Setup



- **FC-2:** Only FC-2 frames have a header, so these fields are not available for FC-1 frames.
  - Defines the framing rules and mechanisms for controlling the different service classes. The following building blocks are defined by the standard:
    - Ordered Set
    - Frame
    - Sequence
    - Exchange
    - Protocol



FC-2 Frame Structure

FC-2 Header

The FC-2 header is only 24 bytes long. Header settings do not affect the transmission or reception of the FC-2 frame.

Go back to top Go back to TOC

Understanding the Basic Test Channel Frame Structure

The Fibre Channel standard defines a variable frame length consisting of 36 bytes of overhead and up to 2112 bytes of payload for a total maximum size of 2148 bytes.

- **SOF and EOF**
  - A Start of Frame (SOF) delimiter and End of Frame (EOF) delimiter mark the beginning and end of each Fibre Channel frame
  - Available for both FC-1 and FC-2 frame formats
- **Frame Header**
  - Is the first field of the frame content and immediately follows the SOF delimiter and is transmitted on a word boundary
  - Is used to control link operations and device protocol transfers as well as detect missing or out of order frames
  - Available in FC-2 frame format only

CRC - The Cyclic Redundancy Check (CRC)
- Is a four byte field that follows the Data Field and is used to verify the data integrity of the Frame Header and Data Field.
- SOF and EOF delimiters are not included in the CRC verification
- The CRC field is calculated on the Frame Header and Data Field prior to encoding for transmission and after decoding upon reception

Frame Delimiters

A frame delimiter is an **Ordered Set** that immediately precedes or follows the contents of a frame. Separate and distinct delimiters shall identify the start of a frame and the end of a frame and shall be recognized when a single Ordered Set is detected. An Ordered set is described below.

Ordered Set

An Ordered Set is a four-character combination of data and special Transmission Characters. Ordered Sets provide the ability to obtain bit and word synchronization that also establishes word boundary alignment. The three types of Ordered Sets are:

- **Frame Delimiters**
  - **(SOF)** Start-of-Frame
  - **(EOF)** End-of-Frame

- **Primitive Signals**
  A Primitive Signal is an Ordered Set designated to have special meaning. All FC_Ports shall at a minimum recognize R_RDY and IDLE Primitive Signals. All Primitive Signals not recognized by the FC_Port shall be treated as an IDLE.
  - **Idle:** Idle is a Primitive Signal transmitted on the link to indicate that link initialization is complete and to maintain link synchronization
  - **(R_RDY)** Receiver Ready

- **Primitive Sequence**
  - **(OLS)** Off-line
  - **(NOS)** Not Operational
  - **(LR)** Link Reset
  - **(LRR)** Link Reset Response

Start of Frame (SOF) and End of Frame (EOF) Delimiter setup

The Start-of-Frame (SOF) delimiter is an Ordered Set that immediately precedes the frame content. There are multiple SOF delimiters defined for Sequence control. SOF indicates that a Frame will immediately follow and indicates which class of service the Frame will use.

The value of the SOF field determines the class of service associated with the FC frame. Several Classes of service are specified in Fiber Channel but only Classes 1,2,3 & 4 are described below. Classes 1, 2, and 3 are topology independent, however, Classes 4 and 6 require a Fabric. If the Fabric is not present, the service is provided as a special case of point-to-point. FC_Ports are not required to support all classes of service.

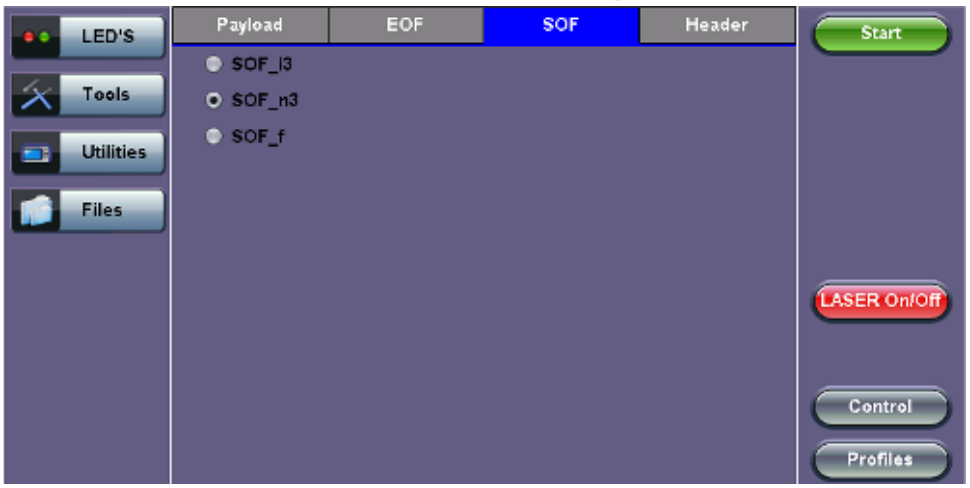
- **Class 1:** Dedicated physical connection with delivery confirmation. This class of service has three phases:
  - Setting up the connection
  - Transferring the information
  - Closing down the connection
- **Class 2:** Frame multiplexed service with delivery confirmation. No dedicated connection between the two communication parties is established. This class of service allows a stream of frames to be sent to different destinations quickly. Class 2 also requires frame confirmations by the recipient.
- **Class 3:** Is sometimes called "datagram". It is "connectionless" service with the Fabric multiplexing frames at frame boundaries, if a Fabric is present. If a Fabric is not present, this service becomes a special case of point-to point.
- **Class 4:** Is a service that uses a virtual circuit established within a Fabric and between two communicating Nx_Ports to transmit frames to each other using a fabric-managed fractional bandwidth allocation protocol. This service requires a Fabric.

The following SOF Service Class selections are available:

- **SOF Initiate** (SOFix)
  A Sequence shall be initiated and identified by using SOFi1, SOFi2, SOFi3, or SOFi4 in the first frame. SOFix is used to represent these four SOF delimiters.
  - **SOF_i3:** Contains a code value of 0x2E indicating SOF Initiate Class 3. A SOFi3 should be used on the first frame of a Sequence for Class 3 Service.

- **SOF Normal** (SOFnx)
  The following delimiters identify the start of all frames other than the first frame of a Sequence based on class of service. SOFnx is used to indicate SOFn1, SOFn2, SOFn3 and SOFn4.
  - **SOF_n3:** Contains a code value of 0x36 indicating SOF Normal Class 3. The SOFn3 shall be used for all frames except the first frame of a Sequence for Class 3 Service.
- **SOF Fabric (SOFf)**
  - **SOF_f:** Contains a code value of 0x28 indicating SOF Fabric. If an Nx_Port or Fx_Port receives a Class F frame, indicated by an SOFf delimiter, it shall be discarded by the Nx_Port or Fx_Port. The receiving Nx_Port or Fx_Port may send an R_RDY

FC-2 BERT - SOF Setup



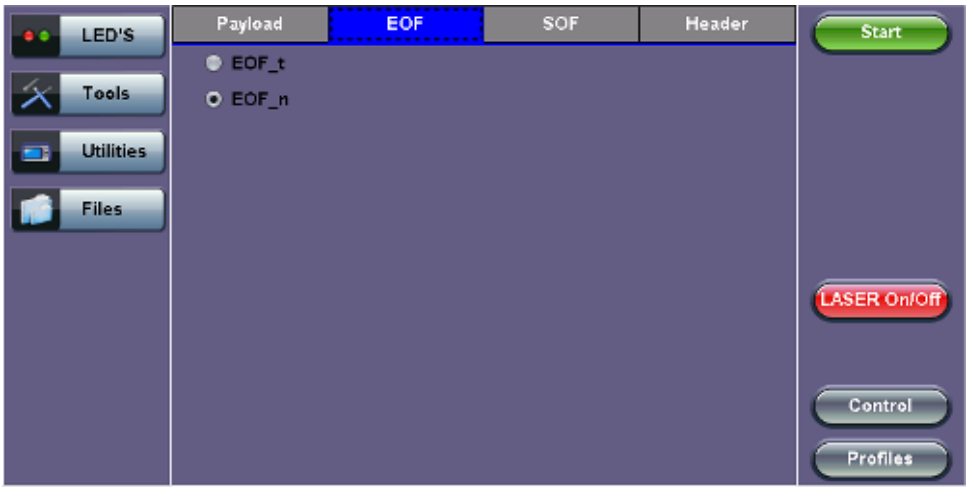
End of Frame (EOF)

The End-of-Frame (EOF) delimiter is an Ordered Set that immediately follows the CRC and is transmitted on a word boundary. The EOF delimiter designates the end of the frame content and is followed by Idles. There are three categories of EOF delimiters found in the Fiber Channel standard, however the test set only supports the first category that indicates that the frame is valid from the sender's perspective and potentially valid from the receiver's perspective.

The following selections are available:

- **EOF_t:** Contains a code value of 0x42 indicating EOF Terminate. The EOFt indicates that the Sequence associated with this SEQ_ID is complete. EOFt is used to properly close a Sequence without error.
- **EOF_n:** Contains a code value of 0x41 indicating EOF Normal. The EOFn identifies the end of frame when one of the other EOF delimiters indicating valid frame content is not required.

FC-2 BERT - EOF Setup



Go back to top Go back to TOC

Payload

The test set implements and observes "Methodologies for Jitter and Signal Quality Specification (MJSQ)". A major goal of MJSQ is to

improve the relationship between measurements on signals and receiver performance in terms of bit errors. The unit transmits a "compliant pattern" which consists of a valid Fiber Channel protocol frame (SOF, payload, CRC, EOF) containing a test pattern as the payload. Different payload selections are available depending on the Fiber Channel layer to be tested. The payload consists of 0 to 2112 bytes, and is sent in 4 byte increments, otherwise it is considered to be a misaligned frame.

FC-1 Payload (test pattern)
Layer 1 test patterns are formatted using the 8B/10B symbol format and include the PCS layer as part of the BER pattern.

CRPAT, CSPAT, and CJTPAT test patterns according to NCITS-TR-25-1999 and MJSQ, are designed to evaluate frequency fluctuations, transceiver noise and phase jumps caused by jitter and other anomalies. These test patterns are described briefly as follows:

- **CSPAT:** Compliant Supply Noise Pattern
  - Represents worst case power supply noise
- **CRPAT:** Compliant Random Pattern
  - Provides broad spectral content and minimal peaking for the measurement of jitter at component or system level
- **CJTPAT:** Compliant Jitter Test Pattern
  - Jitter Tolerance Pattern that stresses a receiver by exposing it to extreme phase jumps thereby stressing the clock data recovery (CDR) circuitry
  - The pattern alternates between repeating low transition density patterns and repeating high transition density patterns

FC-1 BERT - Payload Setup

FC-1 Test Patterns

CRPAT sequence is offered for TX jitter measurements.

CRPAT and CJTPAT are available for RX jitter tolerance measurements - use these test patterns to test the resilience of the receiver (Clock Data Recovery - CDR) and its tolerance to signals with jitter.

Go back to top Go back to TOC

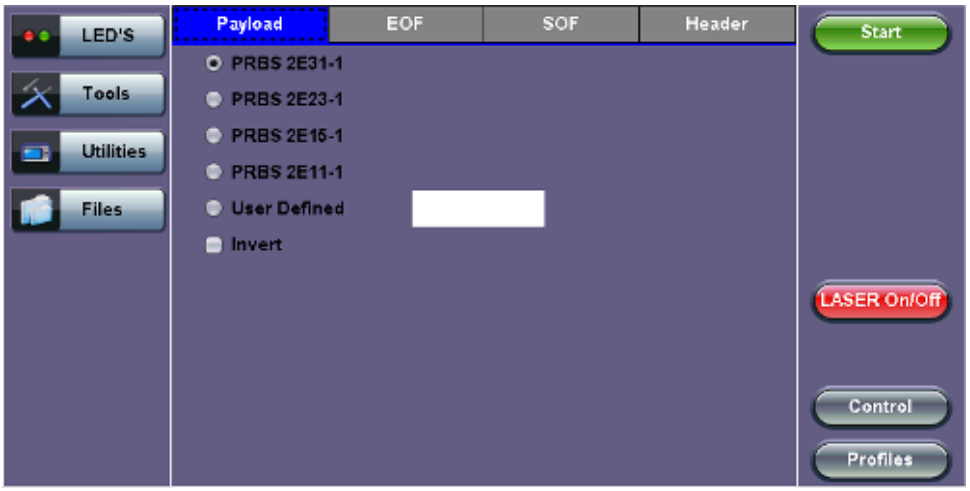
FC-2 Payload (test patterns)
Layer 2 "Compliant" test patterns are modified to resemble a true Fiber Channel frame - the pattern's format is similar to a basic frame which includes a Start of Frame Delimiter (SFD), End of Frame Delimiter (EFD), and Cyclic Redundancy Check (CRC).

Pseudo Random Bit Sequences (PRBS) are commonly used to test the signal integrity of high-speed links and are defined in ITU-T 0.150 & 0.151 Recommendations – These legacy SONET/SDH/PDH test sequences may appear random but they have specific properties that can be used to measure the quality of a link. PRBS patterns can be normal or can be inverted.

- **2E31-1:** 147 483 647-bit pattern used for special measurement tasks, (e.g., delay measurements at higher bit rates)
- **2E23-1:** 8 388 607 bit pattern primarily intended for error and jitter measurements at bit rates of 34 368 and 139 264 kbps
- **2E15-1:** 32 767 bit pattern primarily intended for error and jitter measurements at bit rates of 1544, 2048, 6312, 8448, 32 064 and 44 736 kbps

- **2E11-1:** 2047 bit pattern primarily intended for error and jitter measurements on circuits operating at bit rates of 64 kbps and N x 64 kbps

FC-2 BERT - Payload Setup



BERT Testing Tips

A BERT samples every incoming bit and looks for something that doesn't occur often. This traditional method typically used in SONET/SDH measurements, can however take a very long time. For example, in a 1Gbps Fiber Channel system, errors occur on average once every 1000 s (about 17 Min) for $1x10^{-12}$ BER, so you would need to detect at least 10 to 100 errors before you can have confidence in your measurement. Bear in mind that for a quick measurement, you need a test pattern that repeats frequently. A PRBS-11 sequence (2047 bits) repeats many times a second at a 1-Gbps rate, however a PRBS-31 pattern, with 2 billion bits, repeats only every 2 s at 1 Gbps.

A general rule of thumb is to choose a PRBS that is closest to the nature of the data you will be passing through your network. Patterns between $2^{11}–1$ and $2^{31}–1$ (such as $2^{15}–1$ and $2^{23}–1$) offer good gradual steps in difficulty that allow you to see where networks fail, or how much margin you have beyond pass/fail thresholds.

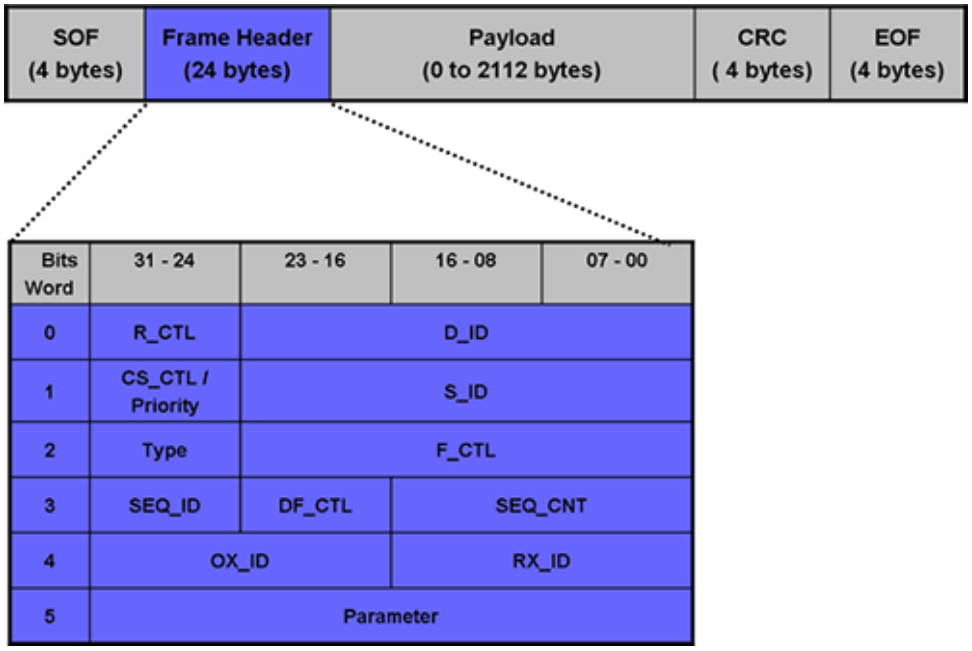
Bit errors can affect the data frames - these frames will be re-transmitted at the request of the upper-layer protocols. If the FC link suffers a lot of bit errors, you may experience a slight performance loss. These bit errors can also affect the Receiver Ready (R_RDY) messages. A R_RDY is never repeated, so the buffer credit is one BB_Credit short until the link is reset.

The Fiber Channel standard allows a 1 x 10E-12 maximum error rate.

Go back to top Go back to TOC

Header Setup (FC-2 only)

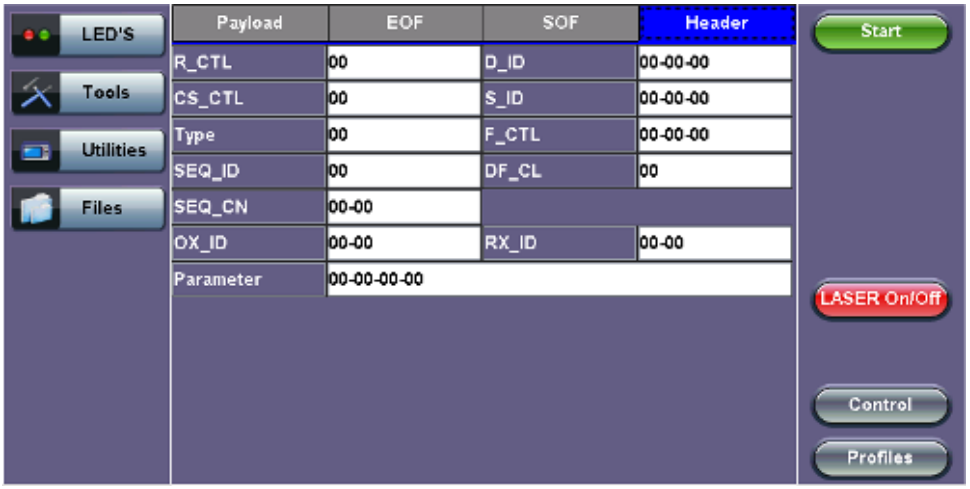
The FC-2 Frame Header is subdivided into the fields as shown in the diagram below.



FC-2 Header Format

The Frame Header is the first field of the frame content and immediately follows the SOF delimiter. The Frame Header is used to control link operations and device protocol transfers as well as detect missing or out of order frames. The values of each field can be edited depending on network setup and test scenario. A brief description of each parameters is provided below.

FC-2 Header Setup



- **Routing Control (R_CTL):**
  - The R_CTL field is a one-byte field in Word 0 Bits 31-24 that contains routing bits and information bits to categorize the frame function.
  - When used in combination with the TYPE field (Word 2, bits 31-24), it provides an FC_Port with assistance in frame routing, data routing, or addressing.
  - The R_CTL field is further subdivided into the ROUTING field (bits 31-28) and the INFORMATION field (bits 27-24).

- **D_ID Address Identifier:**
  - Destination Identifier is a three-byte field (Word 0, Bits 23-0) that contains the address identifier of the destination Nx_Port.
  - Each Nx_Port has a native N_Port_ID that is unique within the address domain of a Fabric. It may also represent hunt groups, domain controllers, and other servers.

- **Class Specific Control (CS_CTL)/Priority:**
  - When bit 17 of F_CTL is set to zero, Word 1, bits 31-24 of the Frame_Header is defined as the CS_CTL field.
  - Contains management information for the class of service identified by the SOF. The meaning of the CS_CTL field is dependent on the class of service.
  - When supported by FC_Ports, the Priority field shall be used to resolve resource contention or to determine the order to deliver frames. The definition and use of the Priority field is class dependent.

- **S_ID Address Identifier:**
  - The S_ID is a three-byte field (Word 1, Bits 23-0) that contains the address identifier of the source Nx_Port.

- **Type (Data Structure Type):**
  - The data structure type (TYPE) is a one-byte field (Word 2, Bits 31-24) that identifies the protocol of the frame content for Data frames.

- **Frame Control (F_CTL):**
  - The Frame Control (F_CTL) field (Word 2, Bits 23-0) is a three-byte field that contains control information relating to the frame content such as exchange, retransmission, or sequence control. It is also used to identify the function of the CS_CTL/P field.

- **Sequence Identifier (SEQ_ID):**
  - The SEQ_ID is a one-byte field (Word 3, Bits 31-24) assigned by the Sequence Initiator that is unique for a specific D_ID and S_ID pair while the Sequence is open.
  - Both the Sequence Initiator and the Sequence Recipient track the status of frames within the Sequence using fields within the Sequence_Qualifier.

- **Data Field Control (DF_CTL):**
  - Data Field Control (DF_CTL) is a one-byte field (Word 3, Bits 23-16) that specifies the presence of optional headers at the beginning of the Data_Field for Device_Data or Video_Data frames.
  - DF_CTL bits are not meaningful on Link_Control or Basic Link Service frames.

- **Sequence count (SEQ_CNT):**
  - The sequence count (SEQ_CNT) is a two-byte field (Word 3, Bits 15-0) that indicates the sequential order of Data frame transmission within a single Sequence or multiple consecutive Sequences for the same Exchange.

- **Originator Exchange_ID (OX_ID):**
  - The Originator Exchange_ID is a two-byte field (Word 4, Bits 31-16) that identifies the Exchange_ID assigned by the Originator of the Exchange.
  - Each Exchange is assigned an identifier unique to the Originator or Originator - Responder pair.

- **Responder Exchange_ID (RX_ID):**
  - The Responder Exchange_ID is a two byte field (Word 4, Bits 15-0) assigned by the Responder that provides a unique, locally meaningful identifier at the Responder for an Exchange established by an Originator and identified by an OX_ID.

- **Parameter:**
  - The Parameter field (Word 5, Bits 31-0) has meanings based on frame type.
  - For Link_Control frames, the Parameter field is used to carry information specific to the individual Link_Control frame.
  - For Data frames with the relative offset present bit set to 1, the Parameter field specifies relative offset, a four-byte field that contains the relative displacement of the first byte of the Payload of the frame from the base address as specified by the ULP.

For detailed information, please visit http://www.incits.org/ and download the Fiber Channel FRAMING AND SIGNALING-2 (FC-FS-2) standard.

Go back to top Go back to TOC

16.2.3 Traffic Generation and Error Injection

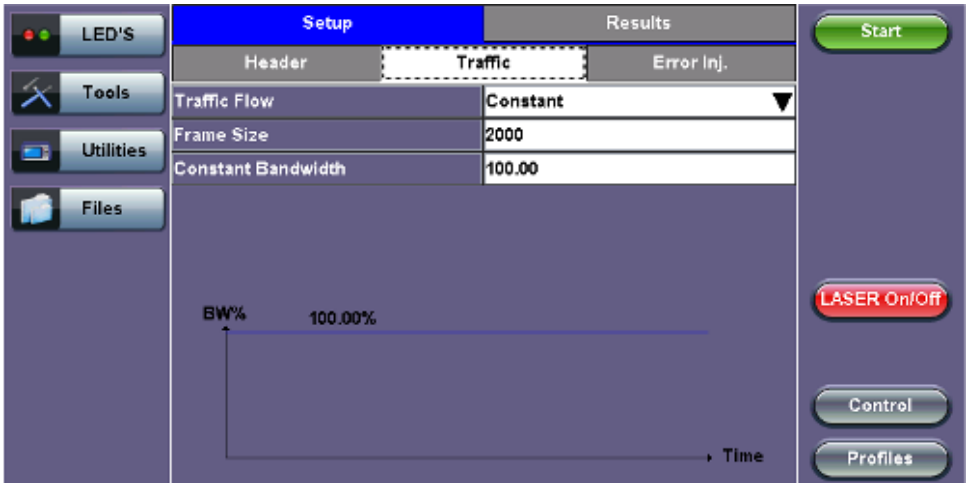
Traffic Setup

- **Traffic Flow:** Select from Constant, Ramp, or Burst traffic flow - available selections depend on FC-1 or FC-2
  - **Constant:** Continuous traffic (no traffic shaping)
  - **Burst:** Two burst bandwidths are configured with variable burst time in seconds
  - **Ramp:** Start and stop bandwidths are configured along with the bandwidth step size and duration

- **Frame Size:** Set the frame size in bytes.
  - Available in FC-2 mode only
  - Valid settings are 56 bytes to 2148 bytes.
  - The frame length includes the SOF and EOF overhead bytes.

- **Constant Bandwidth:** Configure the transmit rate or bandwidth in %
  - Valid settings are 1% to 100% in 0.01% increments

Traffic Setup



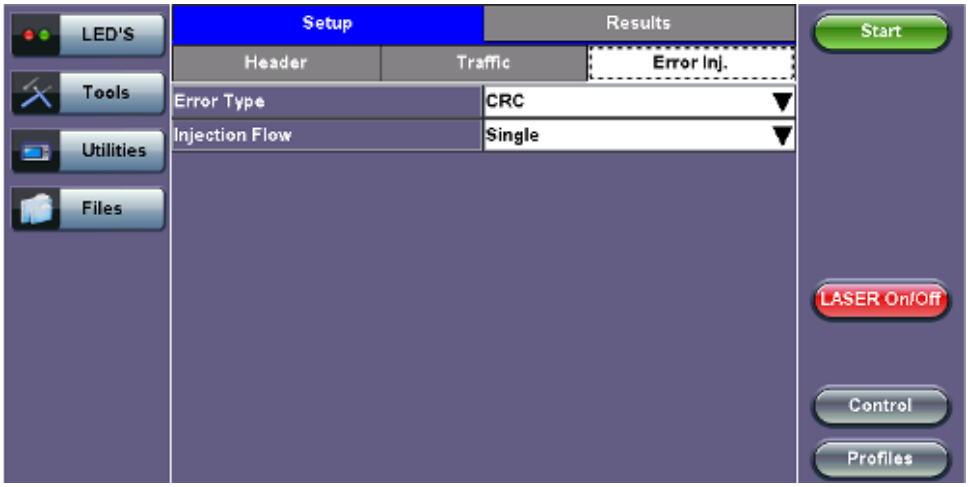
Go back to top Go back to TOC

Error Injection Setup

Error injection can be performed during a test. The type of errors and error injection rate or flow are configured in the Error Injection tab.

- **Error type:** Select from Bit and CRC.
- **Injection Flow:** Determines how the selected errors will be injected. The user can select a single error injection, a specific count, or error rate.
- **Rate and Count:** The user is able to configure the error rate (when rate is selected) and error count via the numeric pop-up keypad.

Error Injection Setup



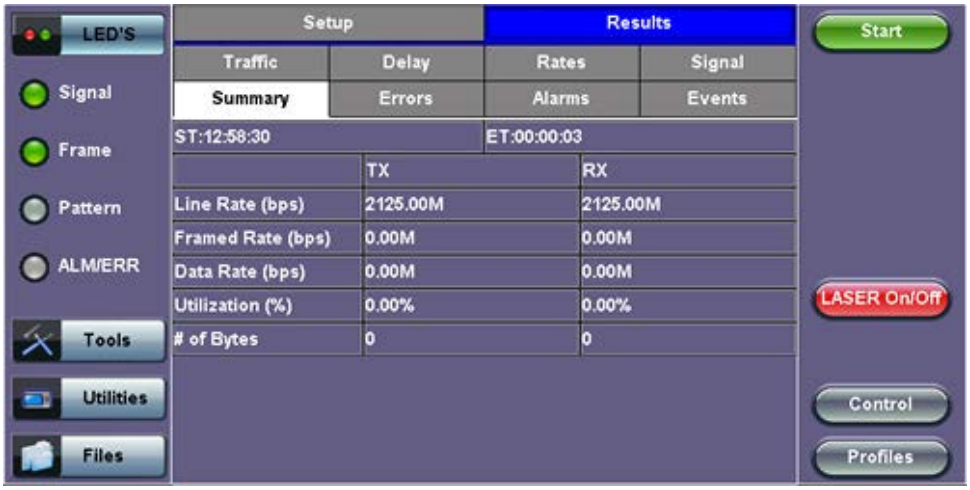
Once the test is running, error injection can be enabled by selecting the **Error Injection** icon from the action drop-down menu at the top of the screen. Press the **Error Inject** button to start injecting errors.

Go back to top Go back to TOC

16.2.4 Starting Measurements

- **Start** button: Click to start the measurement.
- **Laser** button: Can be turned On or Off to make adjustments to the fiber patch cord, etc.
- **TX Start** button: Activate the Transmitter to initiate the BER measurement.

FC-1/2 BERT - Prior to Starting



Go back to top Go back to TOC

16.2.5 Results

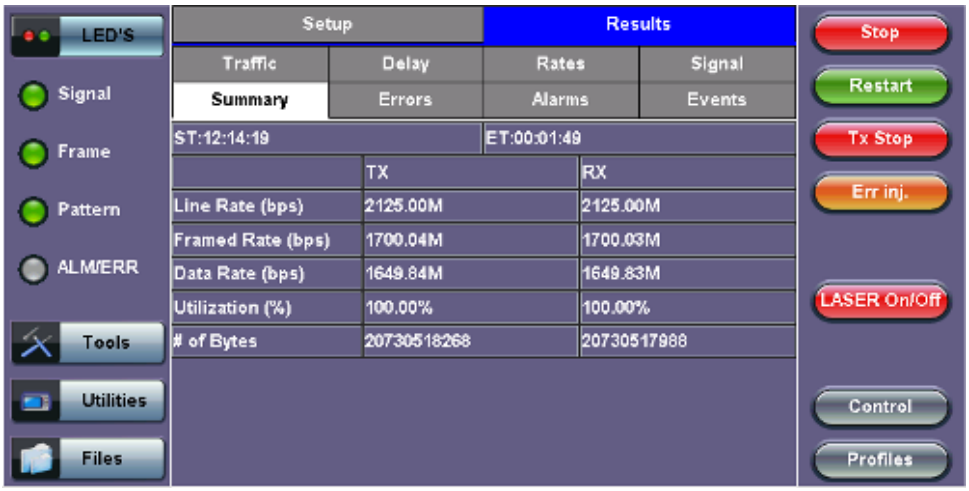
Summary

- **Line Rate:** Indicates the transmitted and received bit rate
  - 1.0625 Gbps, 2.125 Gbps, 4.25 Gbps, 8.50Gbps, or 10.52 Gbps displayed in Mbps
- **Framed Rate:** Total number of frames including overhead of any type per second (Mbytes)
- **Data rate:** Total count of frames with payload data per second (Mbytes)
- **Utilization:** Bandwidth utilization in %
- **# of Bytes:** Number of bytes transmitted versus bytes received

Throughput only

- **Total Frames**: Total number of frames transmitted versus frames received

BERT - Summary



Go back to top Go back to TOC

Errors

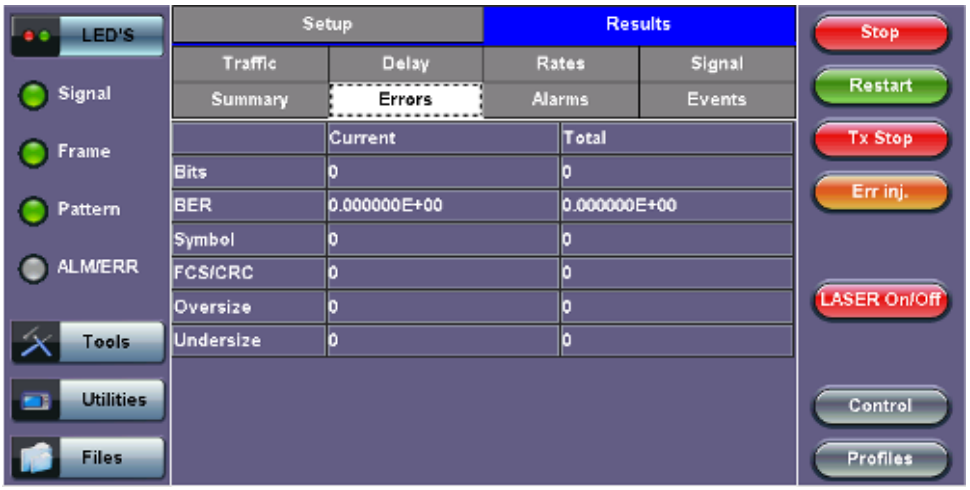
Current and Total values for:

- **Bits:** Number of bits received
- **BER:** Bit error ratio based on PRBS received or ratio of payload bit errors to total received payload bits
- **Symbol:** Symbol error or Code Violation is a bit error or disparity error occurring in a primitive sequence or Ordered Set
- **FCS/CRC:** Number of frames with either a bad or missing CRC or Frame Check Sequence
- **Oversize:** Number of Oversize frames received (> 2112 bytes)
- **Undersize:** Number of Undersize frames received (< 28 bytes)

Throughput only

- **Frame Loss:** Number of frames lost
- **Frame Loss (%):** Percentage of frames lost
- **OOS:** Number of out-of-sequence frames received

BERT - Errors



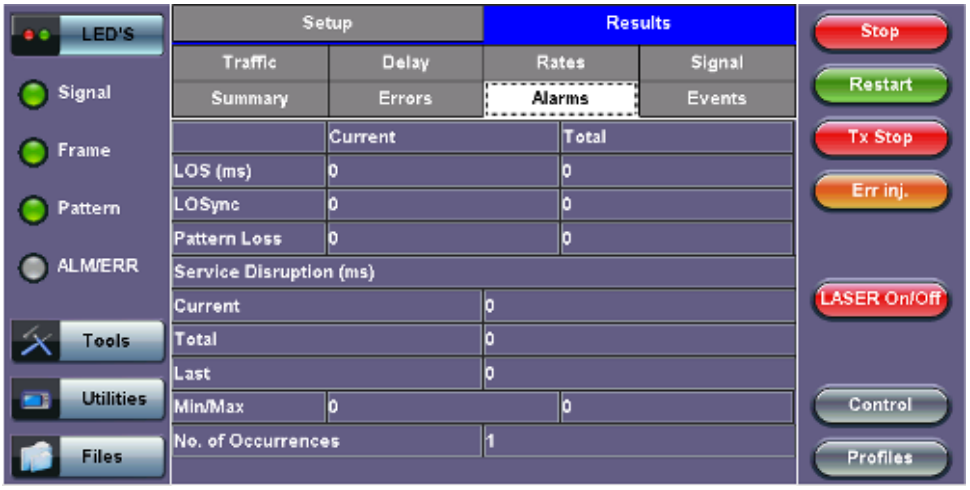
Go back to top Go back to TOC

Alarms

Current and Total values for:

- **LOS:** Number of times the Link has transitioned to a Loss of Signal state in the measurement interval. Generally loss of optical signal.
- **LOSync:** Number of times the Link has transitioned to a Loss of Sync state in the measurement period
- **Pattern Loss:** Number of times test pattern or test sequence was lost
- **Service Disruption**
  - **Current:** Current disruption in ms
  - **Total:** Total measurement period
  - **Last:** Last disruption measurement time
  - **Min/Max:** Minimum and Maximum disruption time
  - **No. of Occurrences:** A count of the disruption events over the measurement period

BERT - Alarms



Go back to top Go back to TOC

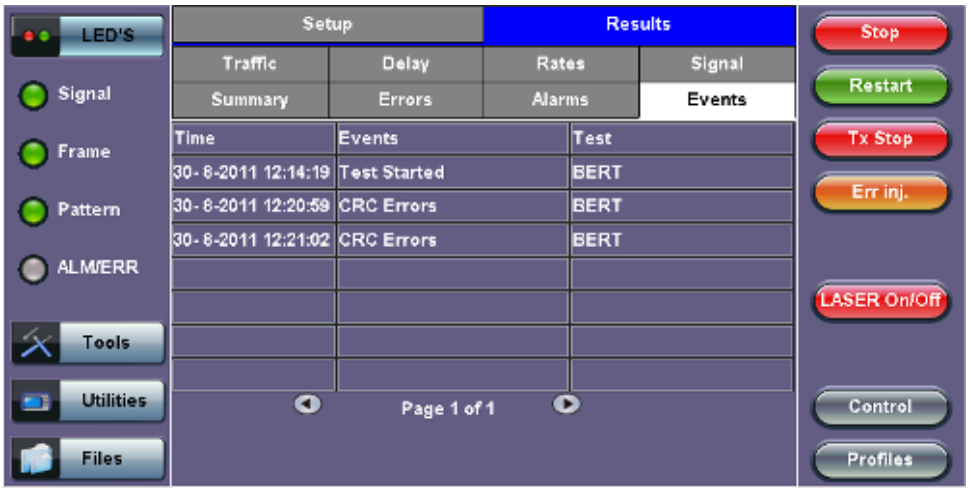
Events

Time stamped event table:

- **Time:** Indicates when the test was started, an anomaly occurred or a test was stopped

- **Events:** Indicates type of anomaly
- **Test:** Indicates the test mode

BERT - Events



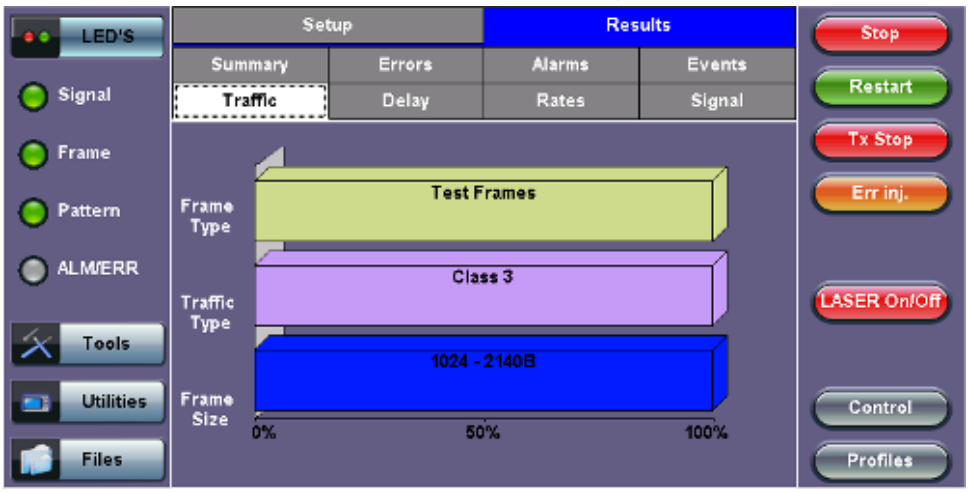
Go back to top Go back to TOC

Traffic Distribution Overview

Graphical representation of:

- **Frame type:** Test frames in BER mode
- **Traffic type:** Class of service set by the SOF delimiter
- **Frame size:**
  - FC-1 mode - the frame size is determined by the test sequence being used
  - FC-2 mode - the frame size corresponds to the frame size configured in the traffic menu

BERT - Traffic Summary



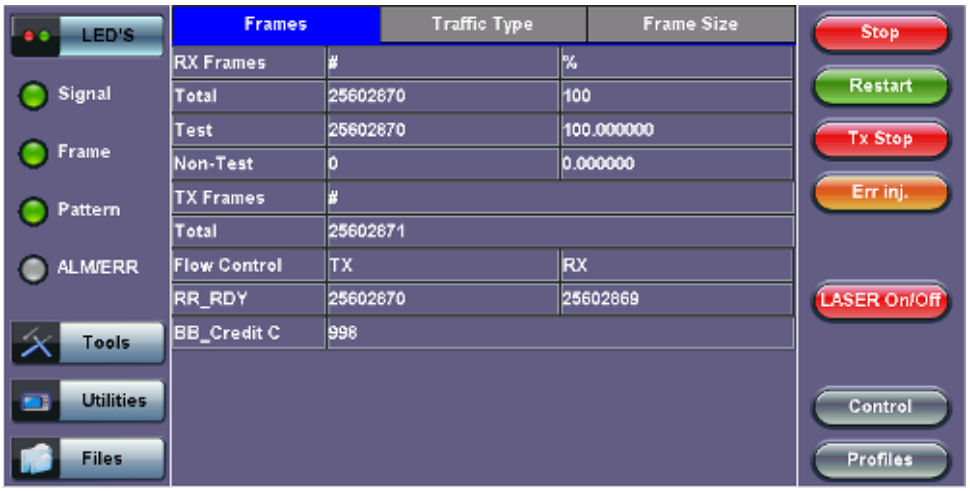
Go back to top Go back to TOC

Traffic Distribution Details - Frames

- **Received Frames (RX)**
  - **Total**: Total number of frames received
  - **Test**: Number of test frames received
  - **Non-Test:** Number of non-test frames received
- **Transmitted Frames (TX)**
  - Total: Number of test frames transmitted
- **Flow Control:** Flow control is the FC-2 control process to pace the flow of frames between Nx_Ports, an Nx_Port and the Fabric and within the Fabric to prevent overrun at the receiver.
  - Flow control is managed between Nx_Ports (end-to-end) and between FC_Ports (buffer-to-buffer). Flow control management has variations dependent upon the service class, however Class 3 uses only buffer-to-buffer flow control.

- **RR-RDY:** For Class 3 frames transmitted and received, a R_RDY is issued when a receive buffer is available.
- **BB Credit Count:** Memory or “buffers” to temporarily store frames as they arrive and until they are assembled in sequence, and delivered to the upper layer protocol.
  - The number of buffers (the number of frames a port can store) is called “Buffer Credit”. Also defined as the number of unacknowledged or outstanding frames awaiting R_RDY responses from the directly attached FC_Port.
  - To track the number of frames transmitted for which R_RDY responses are outstanding, the transmitting FC_Port uses the BB_Credit_CNT.

BERT - Frame Distribution



Go back to top Go back to TOC

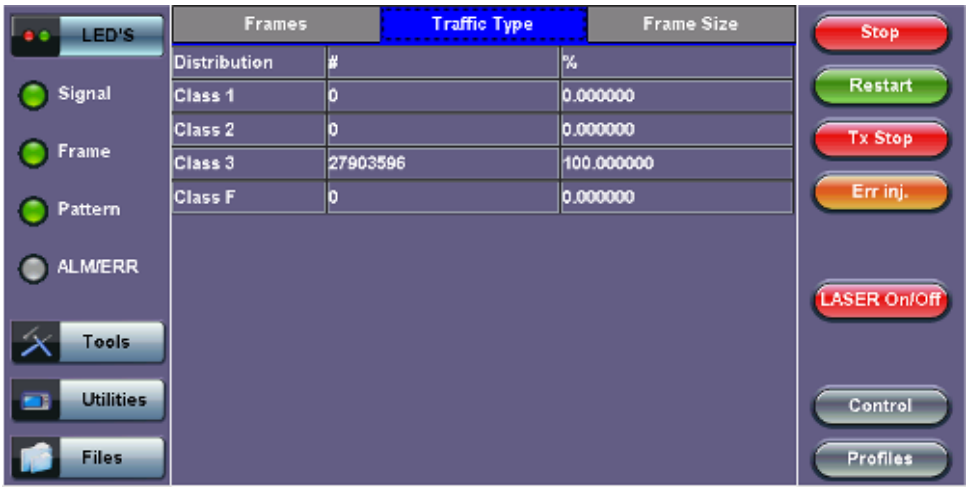
Traffic Distribution - Traffic Type

Fibre Channel supports three classes of services, and a fourth which is a combination of classes 1 and 2.

Similar to ATM, different classes allow Fibre Channel to support a variety of communication needs.

- **Class 1:** Provides a circuit-emulation service for time-sensitive applications such as video teleconferencing.
  - Designed for dedicated, non-bursty links between supercomputers. Class 1 traffic is circuit-switched.
- **Class 2**: Provides guaranteed delivery for connectionless traffic.
  - Class 2 traffic is switched on each frame rather than on a connection. An acknowledgment from the destination provides an end-to-end guarantee of delivery.
- **Class 3:** Offers a best-effort connectionless service.
  - Class 3 is similar to Class 2, except that no guarantee is given for delivery.

BERT - Traffic Type Distribution

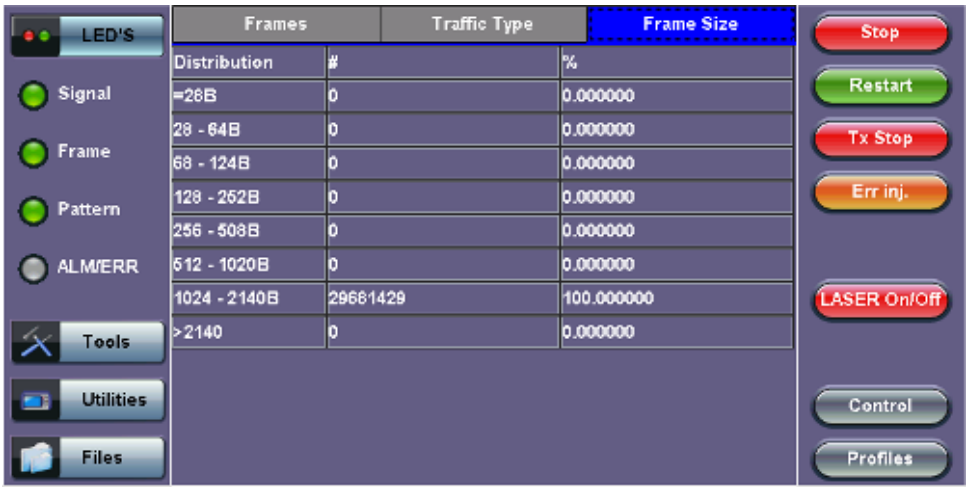


Go back to top Go back to TOC

Frame Size Distribution

Indicates the number and percentage of different frame sizes received during the test period.

BERT - Frame Size Distribution



Go back to top Go back to TOC

Delay

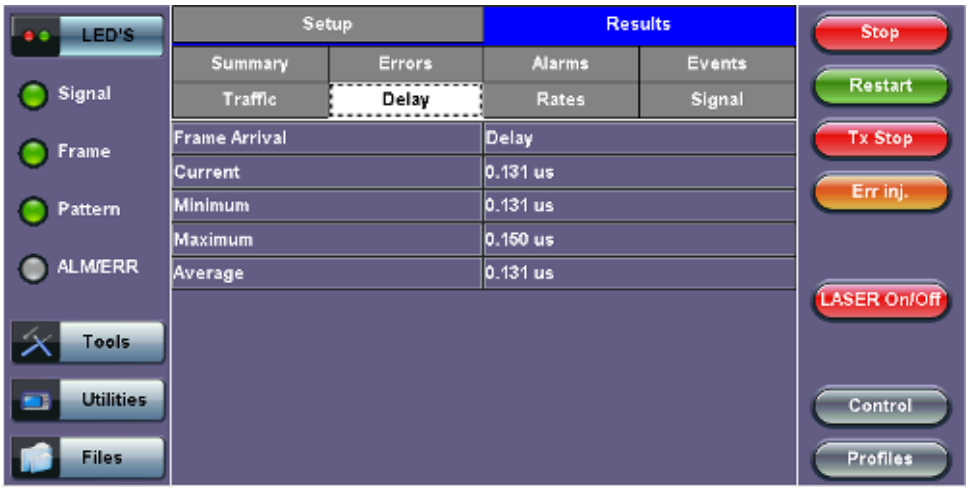
Frame Arrival Delay or Latency is the round-trip delay experienced by a frame as it traverses the fiber link or network. The difference between the transmitted time and received time is the measured delay.

Indicates the Current, Minimum, Maximum, and Average frame arrival delay during the test period.

Throughput only

Current, Minimum, Maximum, and Average round-trip delay during the test period is also displayed.

BERT - Delay

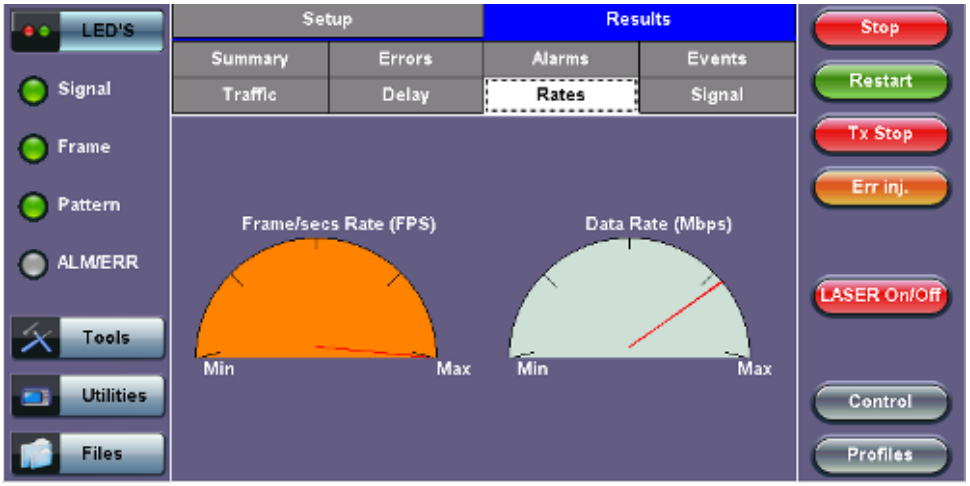


Go back to top Go back to TOC

Frame Rate Summary

Graphical representation of the Frame rates and Data rates.

BERT - Frame Rate Summary

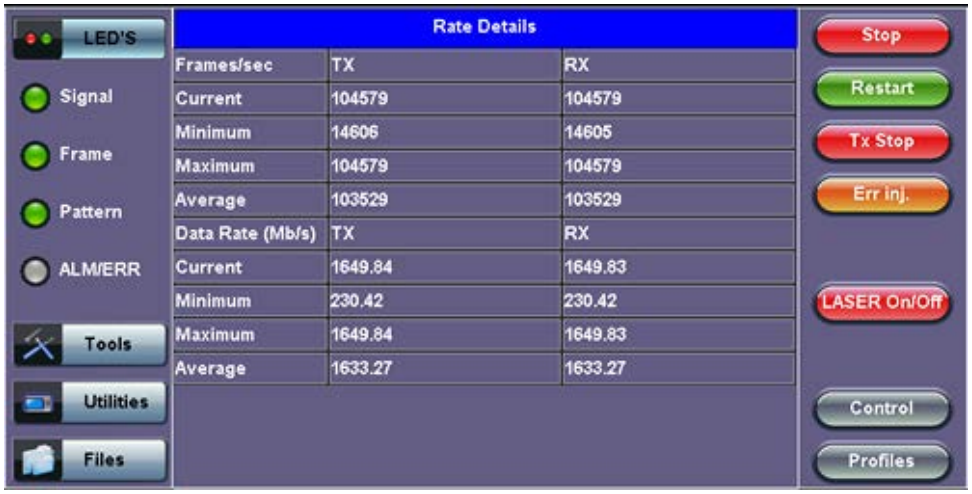


Go back to top Go back to TOC

Frame Rate Details

Tabular representation of the Transmitted and Received frames and the corresponding Data Rates in Mbps.

BERT - Frame Rate Details



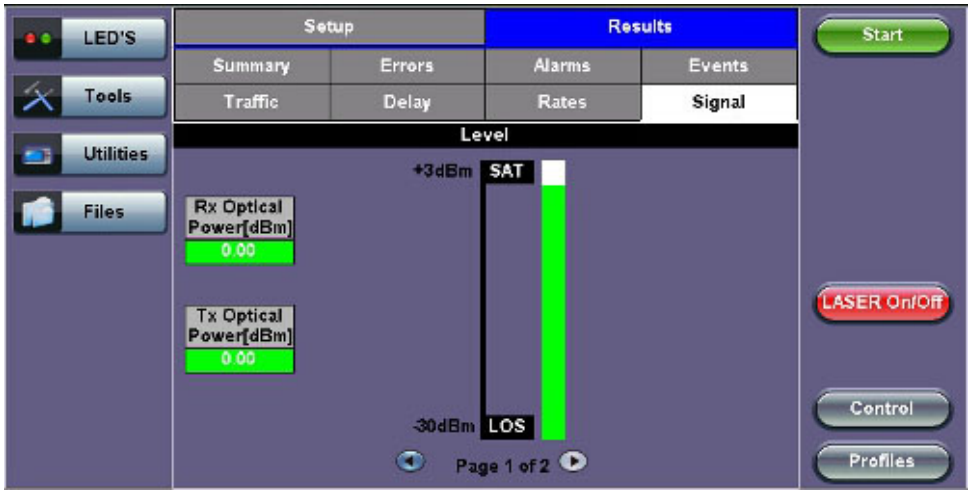
Go back to top Go back to TOC

Signal

Level (Page 1)

The Signal tab displays the Level and Frequency screen. Page 1 displays the level measurement Loss of Signal (LOS), and the Saturation level for optical signals is shown graphically, including the level measurement in dBm.

Signal - Level (Page 1)



Optical Information (Page 2)

Page 2 displays the Optical module XFP information which includes Vendor name, Part number, and Optical Wavelength.

Signal - Optical Information (Page 2)

Go back to top Go back to TOC

16.3 RFC 2544

The RFC 2544 Ethernet test suite is adapted to Fiber Channel circuits to verify 1Gbps, 2Gbps, 4Gbps, 8Gbps and 10Gbps SAN networks. The automated RFC 2544 test routine/analysis ensures repeatable installations:

- Check buffer parameters needed to achieve desired Service Level Agreement (SLA)
- Determine optimum buffer size - Capacity versus link speed
- Determine minimum buffer credits for selected throughput for each frame length
- Measuring throughput at various buffer credit sizes to check link quality

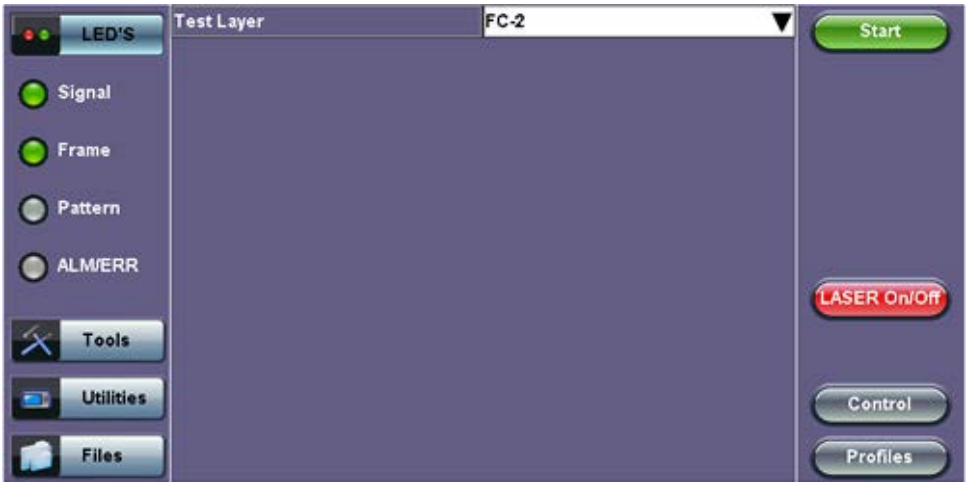
The test methodology is the same as for Ethernet testing. Please refer to the RFC 2544 section for details.

Go back to top Go back to TOC

16.4 Loopback

The Loopback function can be found on the Fiber Channel Home menu.

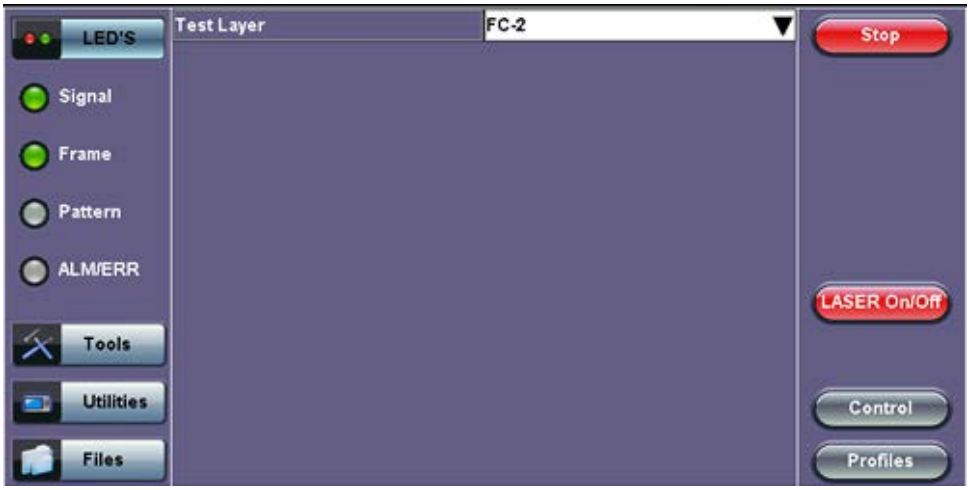
FC-1/2 Manual Loopback Setup



Modes of operation: Manual and Responder (future)

Mode (FC layer): FC-1 or FC-2 Layer loopbacks are supported. In FC-2 mode, the destination and source IDs (D_ID and S_ID) are swapped including any other relevant Header fields (e.g., OX_ID, RX_ID, etc.).

FC-1/2 Manual Loopback Active



To enable the loopback, press **Start** from the drop-down menu. Once the loopback is enabled, a message appears indicating that the loopback is active.

Go back to top Go back to TOC

17.0 CPRI Testing

- **Overview**
- **Interface Specifications**
- **CPRI Testing**
  - Test Areas
  - Test Ports
  - Test Modes
- **CPRI Unframed Setup**
  - Test Pattern
  - Traffic Pattern
  - Error Injection
- **CPRI Unframed Results**
  - Summary
  - Signal
  - Errors
  - Alarms
  - Events
- **CPRI Layer 1 Framed Testing**
  - Setup
  - Results
- **CPRI Layer 2 Framed Testing**
  - Setup
  - Results
  - CPRI Round Trip Delay
  - SDT
  - Control Words
  - Frame Capture
- **Saving and Retrieving Files**
- **File Management in ReVeal**

CPRI Overview

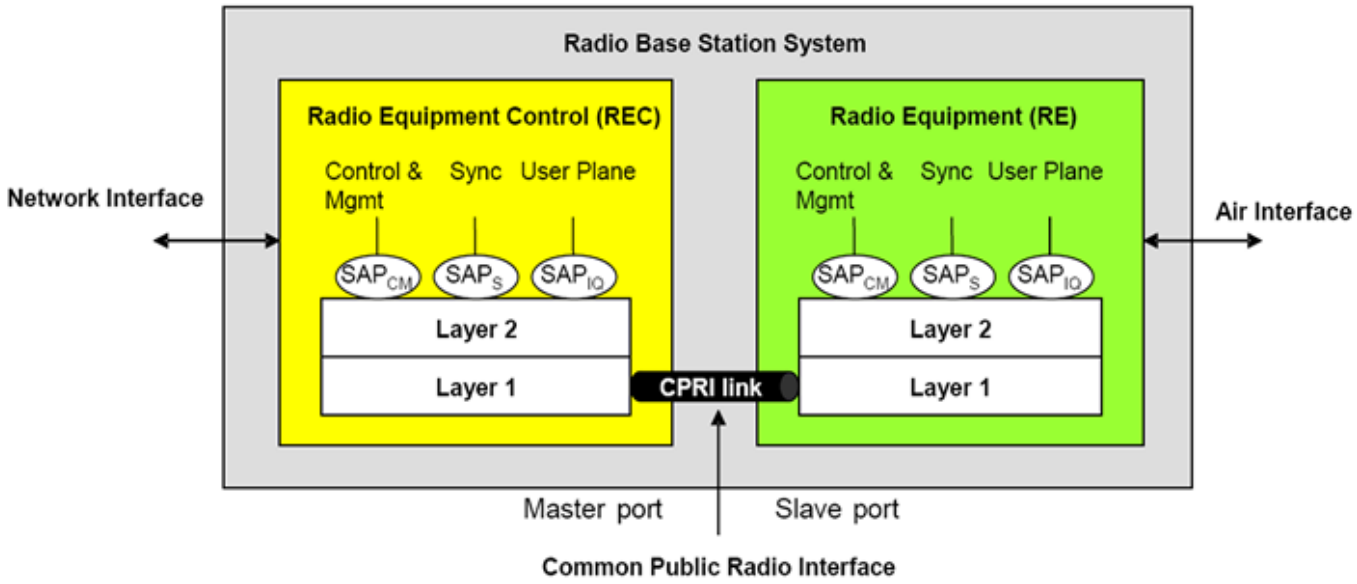
- CPRI stands for **Common Public Radio Interface**
- This protocol has been developed by Ericsson AB, Huawei Technologies Co. Ltd, NEC Corporation, Alcatel Lucent and Nokia Siemens
- It is an industry cooperation aimed at defining a publicly available specification for the key internal interface of radio base stations between the Radio Equipment Control (REC) and the Radio Equipment (RE)
- The standard is public and can be downloaded from http://www.cpri.info

OBSAI:

- OBSAI stands for **Open Base Station Architecture Initiative**
- This protocol has been developed by Hyundai, LGE, Nokia, Samsung and ZTE
- OBSAI Rates range from 728 Mbps to 6.8 Gbps

Go back to top Go back to TOC

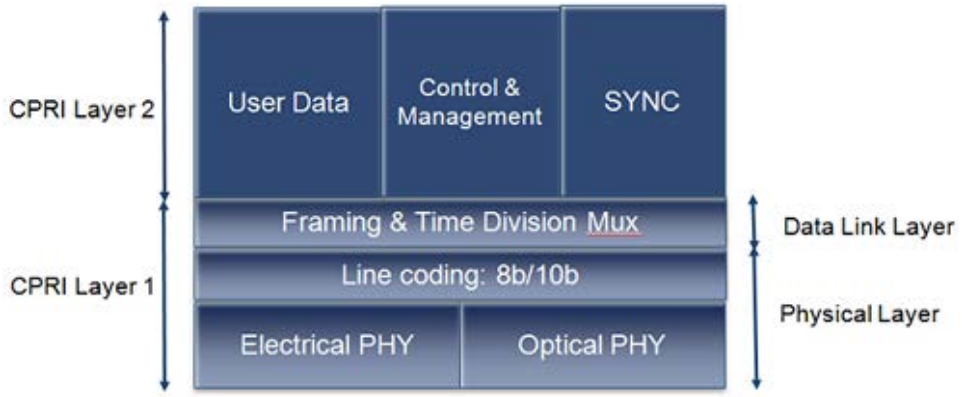
17.1 Interface Specifications



- CPRI specification defines only Layer 1 and Layer 2
- Specification written with the goal to be generic enough to support scalable rates, physical access medium type, and air interface technologies

Go back to top Go back to TOC

Protocol Stack



Go back to top Go back to TOC

Physical Layer

The following Line bit rates are defined from the standard:

- **Line Coding:**
  - 8B/10B line coding shall be used for serial transmission according to IEEE 802.3-2005, clause 36. (Same encoding as used for Gigabit Ethernet and Fibre Channel)
- **Bit Error Correction/Detection:**
  - The physical layer is designed in such a way that a very low bit error ratio can be achieved without expensive forward error correction schemes. Therefore, no general bit error correction is applied at Layer 1.
  - The RE and the REC shall support detection of 8b/10b code violations. Link failures shall be detected by means of 8b/10b code violations.

	8B/10B Encoding - What is it and Why is it Used? • 8b/10b is the line code used for Gigabit Ethernet and Fibre Channel. • It maps 8 bits of data into a 10 bits symbol, each 8 bits can map into 2 possible 10 bit

symbols. The symbols are chosen so that there is a limit of 5 consecutive equal bits and the difference of the count of 0s and 1s is no more than 2.

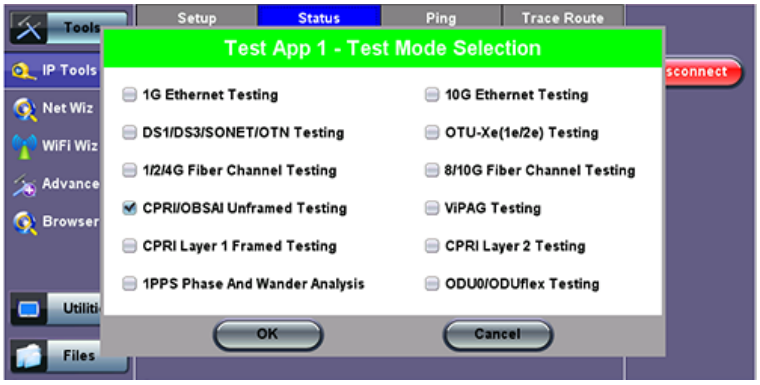
- The goal is to achieve DC balance by having a running disparity of 1s and 0s and to provide enough state changes to allow clock recovery.
- Clock recovery is particularly important because in the CPRI implementation, the RE must recover timing from the 8B/10Bencoded line rate and regenerate the original reference frequency to the required UMTS accuracy.
- In addition the 8b/10b has several error detection mechanisms: Validation of correct codes (only 268 of the possible 1024 10-bit codes are used)
    - Validation of correct running disparity
    - Validation that running number of 1s or 0s does not exceed 5

Go back to top Go back to TOC

17.2.1 CPRI Unframed Setup

Tap on **Test Mode** and select **CPRI / OBSAI Unframed Testing** from the menu to access this feature. The test set also offers CPRI Layer 1 Framed Testing and CPRI Layer 2 Testing.

Test Mode Selection

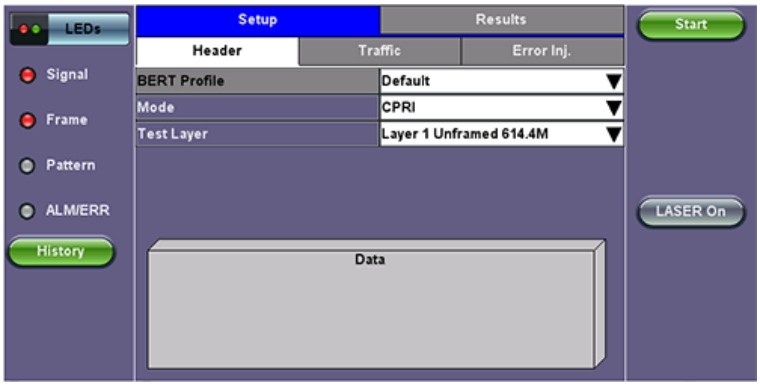


CPRI/ OBSAI Home

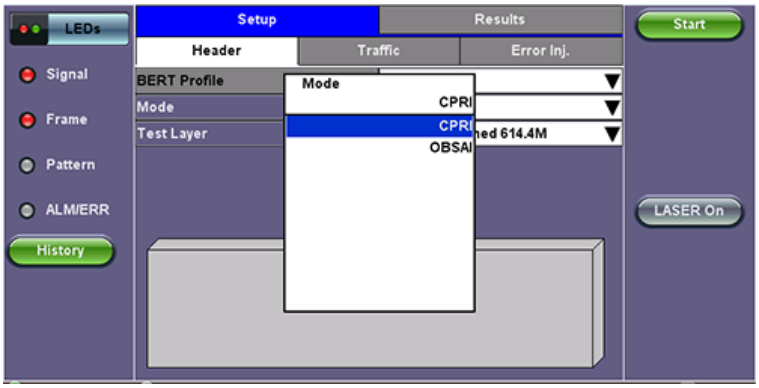
Before proceeding with BER testing, configure the Header, Traffic, and Error Injection tabs under **Setup** (BERT icon > **Setup**). When finished configuring BERT settings, press the **Start** button

to run the tests. This will automatically bring up the **Results** screen.

BERT Setup

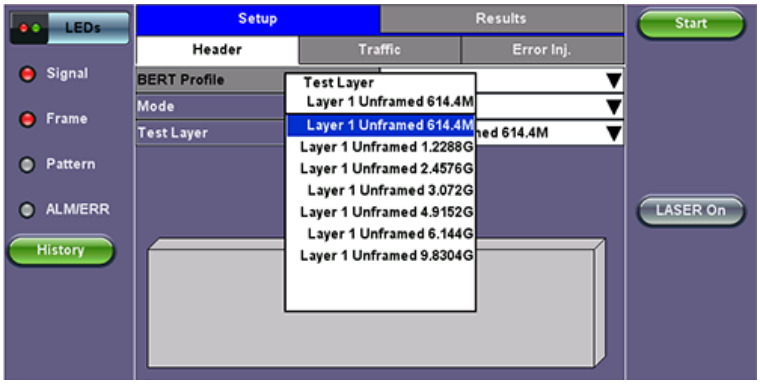


Mode Setup

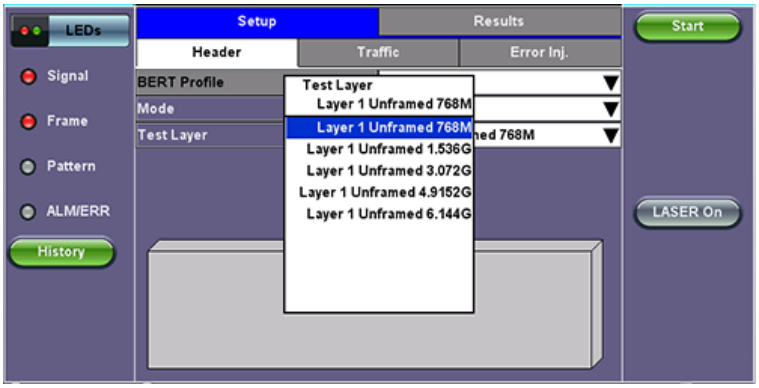


From the Header tab, select a **BERT Profile** from the drop-down menu.

CPRI Test Layer Setup



OBSAI Test Layer Setup



Select a **Test Layer**:

CPRI:

- Layer 1 Unframed 614.4M
- Layer 1 Unframed 1.2288G
- Layer 1 Unframed 2.4576G
- Layer 1 Unframed 3.072G
- Layer 1 Unframed 4.9152G
- Layer 1 Unframed 6.144G
- Layer 1 Unframed 9.8304G

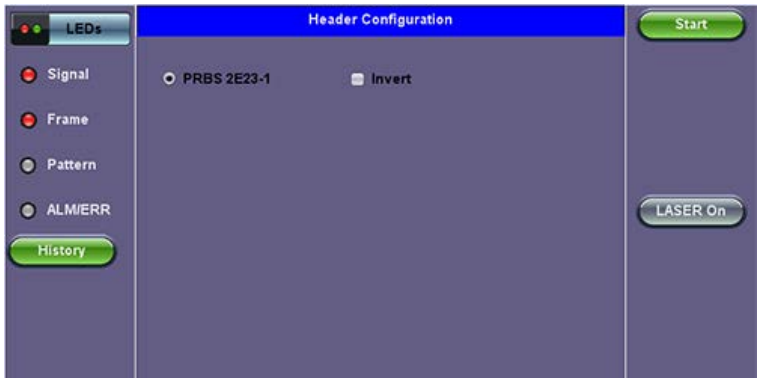
OBSAI:

- Layer 1 Unframed 768M
- Layer 1 Unframed 1.536G
- Layer 1 Unframed 3.072G
- Layer 1 Unframed 4.9152G
- Layer 1 Unframed 6.144G

Go back to top Go back to TOC

17.2.1.1 Test Pattern

Header Configuration



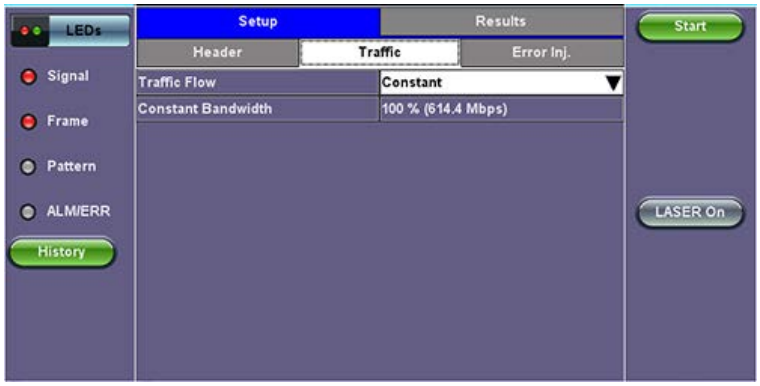
Tap on the Data icon to reach the Header Configuration and select a test pattern.

Tap the close button , located at the top right corner of the screen to apply configurations and return to the previous screen.

Go back to top Go back to TOC

17.2.1.2 Traffic Pattern

BERT Traffic Setup

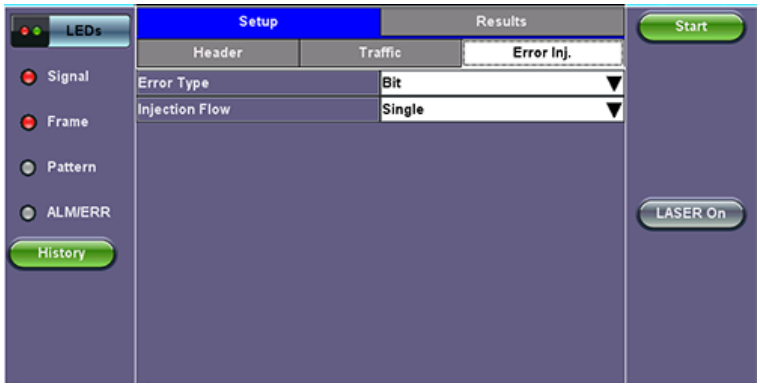


Constant traffic flow at 100% constant bandwidth is fixed for this release.

Go back to top Go back to TOC

17.2.1.3 Error Injection

Error Injection



In this release, the error type is fixed as Bit at Single error injection. An error injects each time the **Error Injection** button is pressed.

Go back to top Go back to TOC

17.2.2 CPRI Unframed Results

Results

Pressing the **Start** button

brings up the **Results** screen.

Go back to top Go back to TOC

17.2.2.1 Summary

The following screen displays a **Summary** of the test results:

Summary tab

- **Line Rate** (bps)**:** Negotiated rate of the interface. 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. Unframed traffic is transmitted at 100% line rate.
- **TX Pattern:** The test pattern being transmitted.
- **RTD:** If Round Trip Delay measurements are enabled, RTD will be indicated as On and results (Current/Average/Min/Max) will be displayed. To enable or disable Round Trip Delay measurement, tap on the **RTD On/Off** button

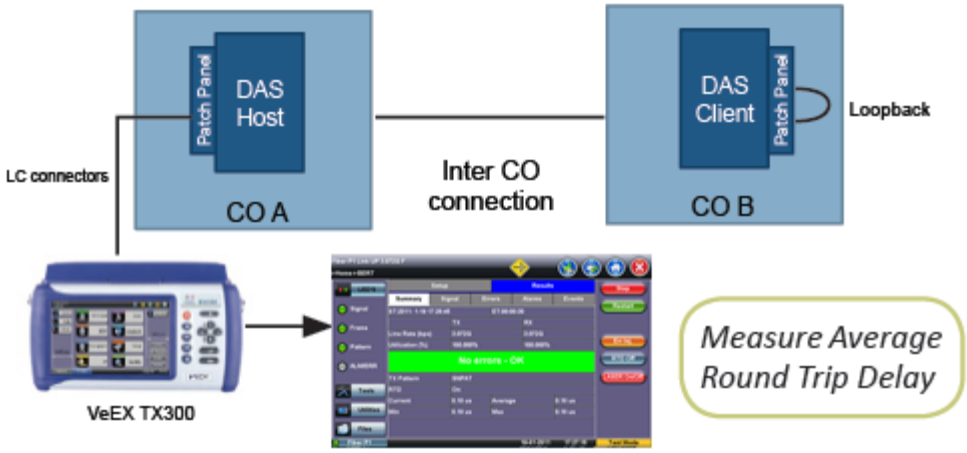
, located in the right side column.

Note: Round Trip Delay measurements require a physical Loopback at the far-end.

Verify that no errors are present and the TX and RX Utilization (%) is at 100%. Press the **Restart** button

if errors are present.

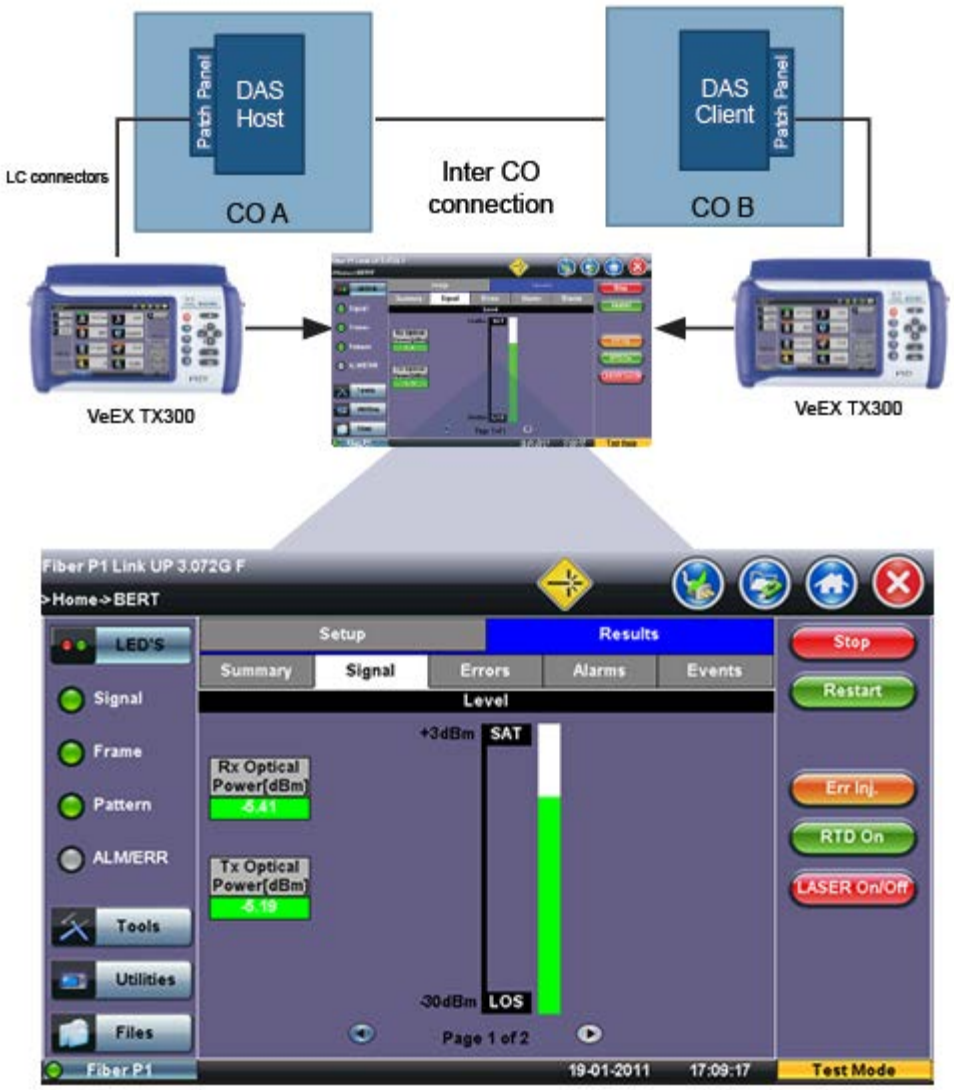
Round Trip Delay Diagram



Go back to top Go back to TOC

17.2.2.2 Signal

Signal Diagram



The Signal tab shows Receiver Saturation and Loss of Signal thresholds. Tx and Rx optical power levels are measured by the transceiver.

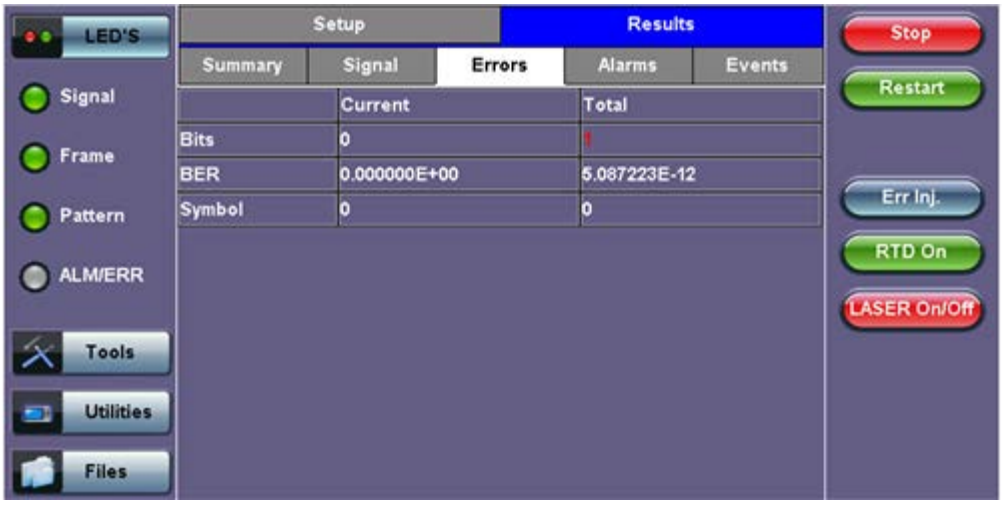
Go back to top Go back to TOC

17.2.2.3 Errors

Tap on the Errors tab to view test measurements.

- **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

Errors tab



Go back to top Go back to TOC

17.2.2.4 Alarms

Tap on the Alarms tab to view the Loss of Signal (duration) and Pattern Loss (events).

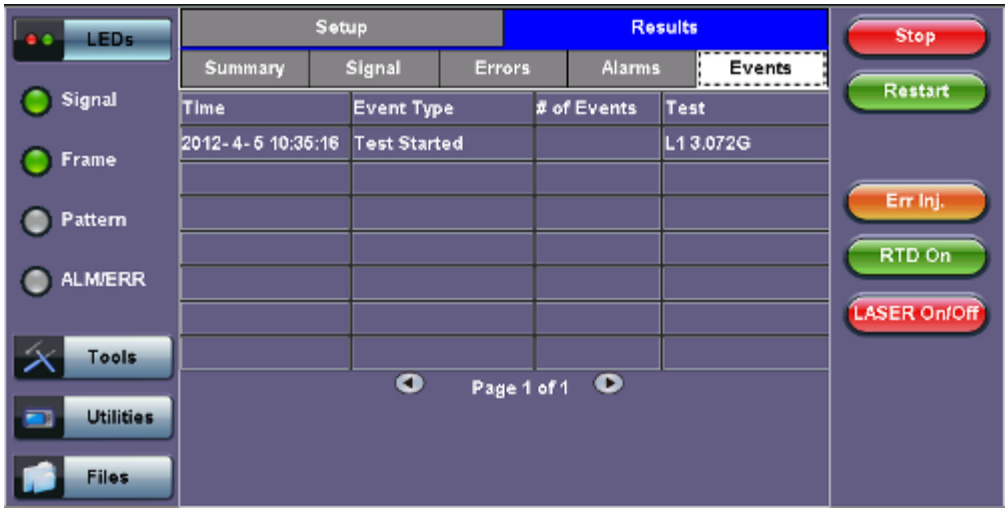
Alarms tab

Go back to top Go back to TOC

17.2.2.5 Events

This Events tab displays a list of events for the test in progress.

Events tab



Go back to top Go back to TOC

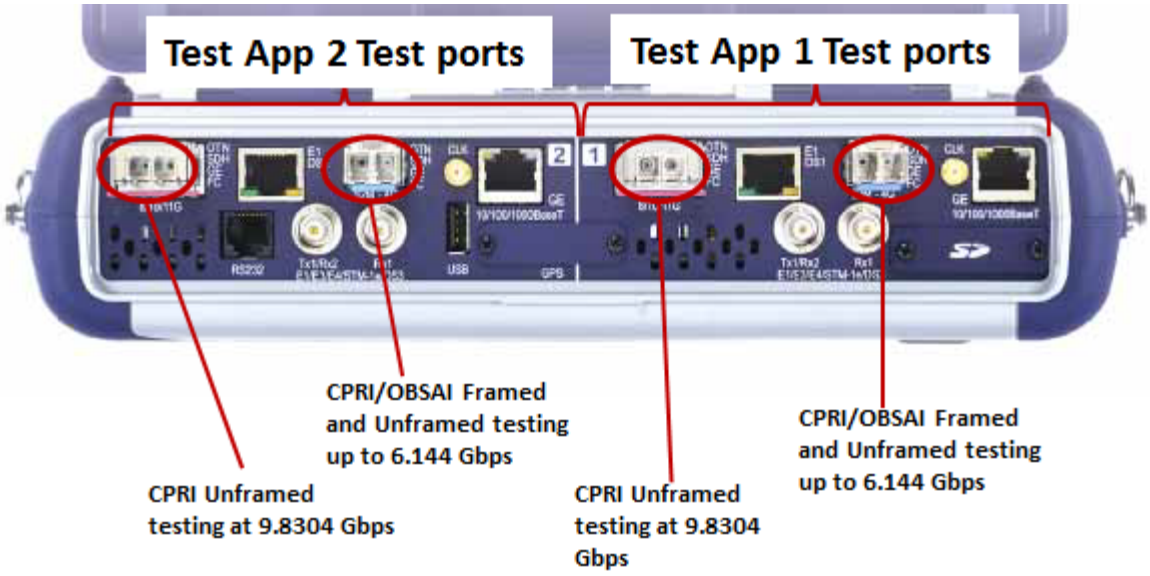
17.2 CPRI Testing

Test Areas

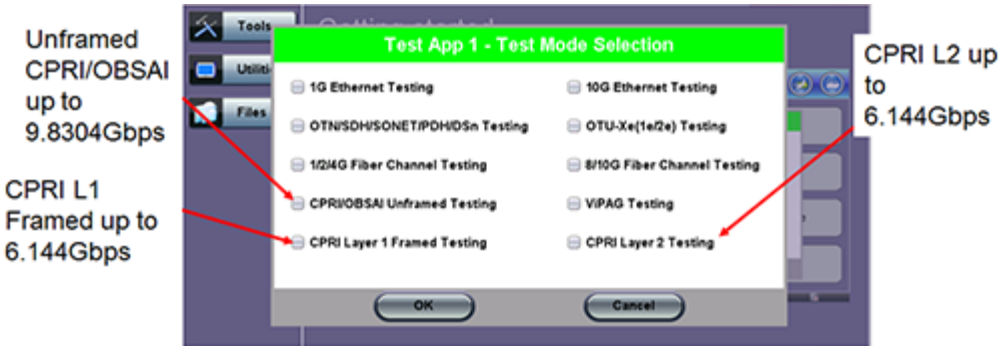
Tests for CPRI Transport link should focus on verifying that BER requirements are met by performing the following tests:

- Test in Layer 1 unframed mode to verify CPRI physical layer with 8b/10b line coding (see CPRI protocol stack)
- Test at full line rate

Test Ports



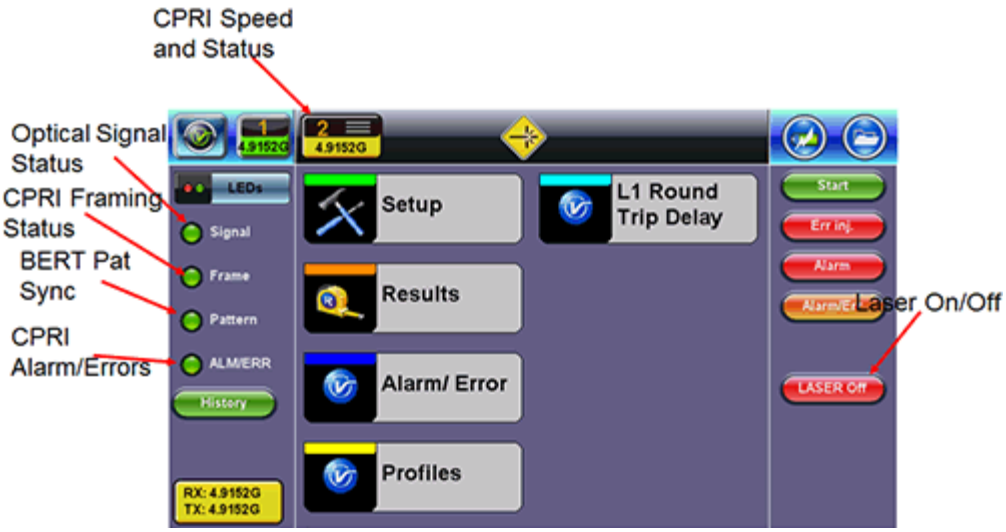
Test Modes



Go back to top Go back to TOC

17.3 CPRI Layer 1 Framed Testing

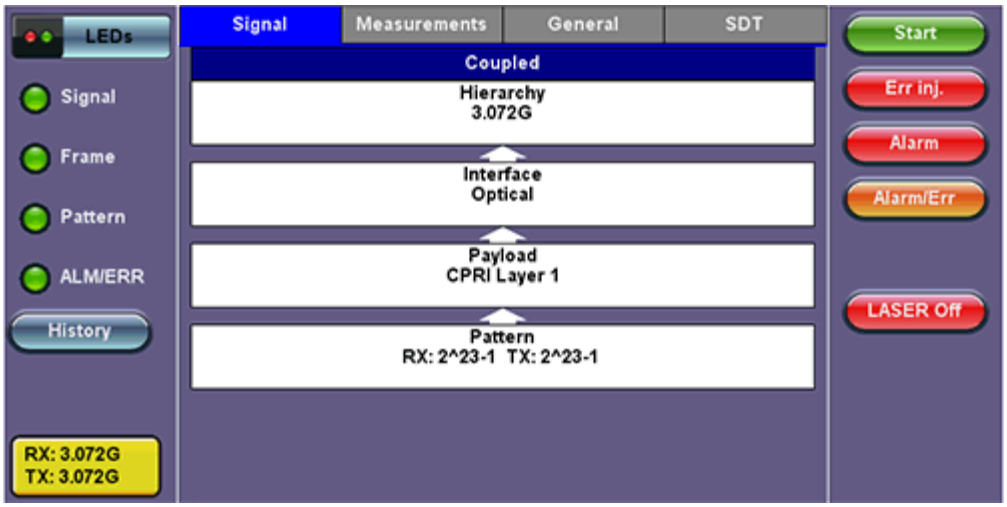
CPRI Layer 1 Main Menu



Go back to top Go back to TOC

17.3.1 Setup

Setup Menu

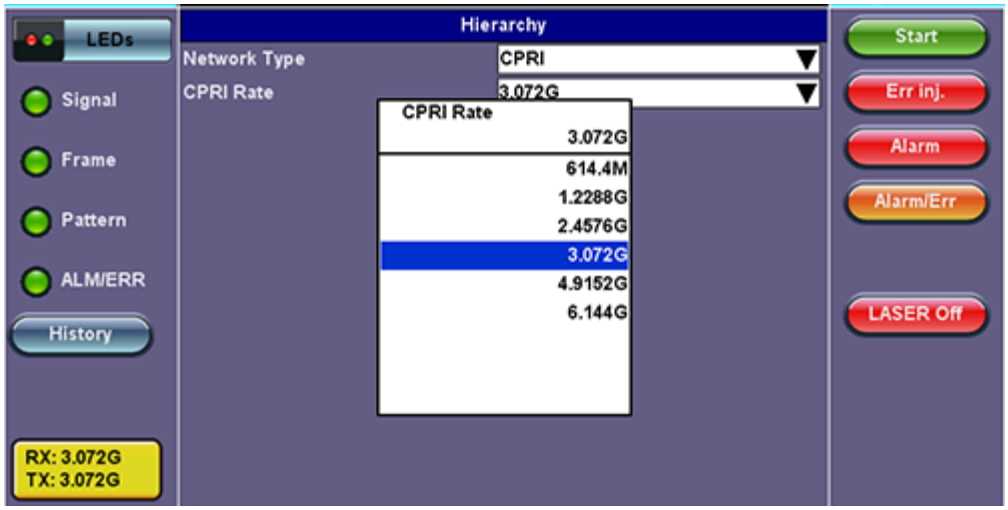


Configure the following:

Signal:

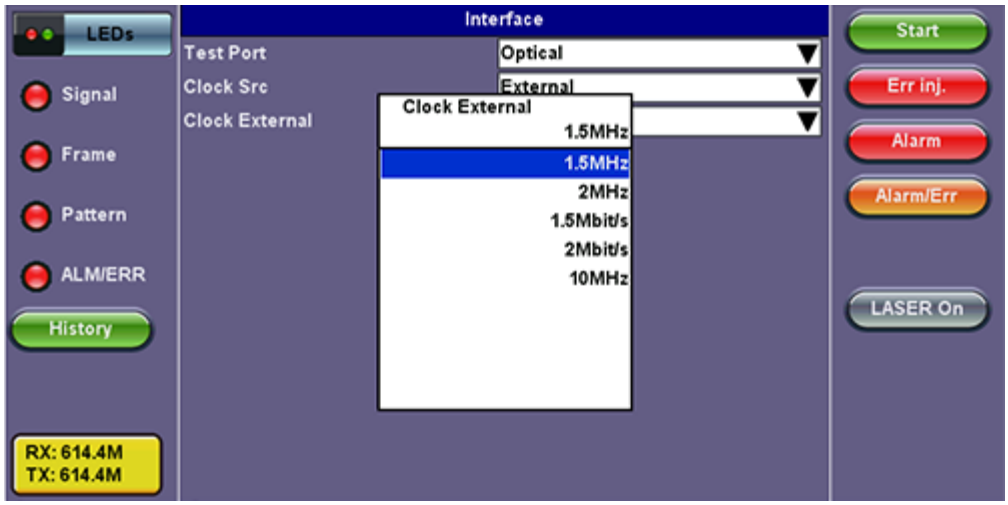
- **Hierarchy:** CPRI Speed Selection from 614.4Mbps to 6.144Gbps. 4.9 and 6.1 Gbps rate requires compatible SFP+.

Hierarchy Setup



- **Interface:** CPRI Clock Selection Internal/External
  - External Clock Sources: 1.5MHz, 2MHz, 1.5Mbit/s, 2Mbit/s, 10MHz

Clock Source Setup

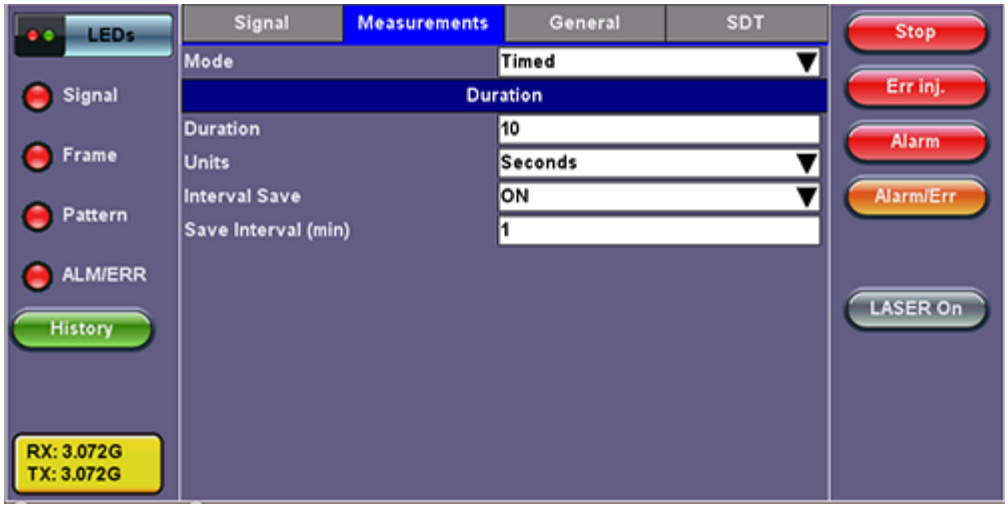


- **Payload: #Z.0.1 Byte:** Sync Control Word Z.0.1 set to D16.2 or D5.6
- **Pattern**: Independent TX/RX test Pattern selection. PRBS 2^23-1 (normal or inverted) or PRBS 2^31-1 (normal or inverted)

Go back to top Go back to TOC

Measurements:

Measurements Setup

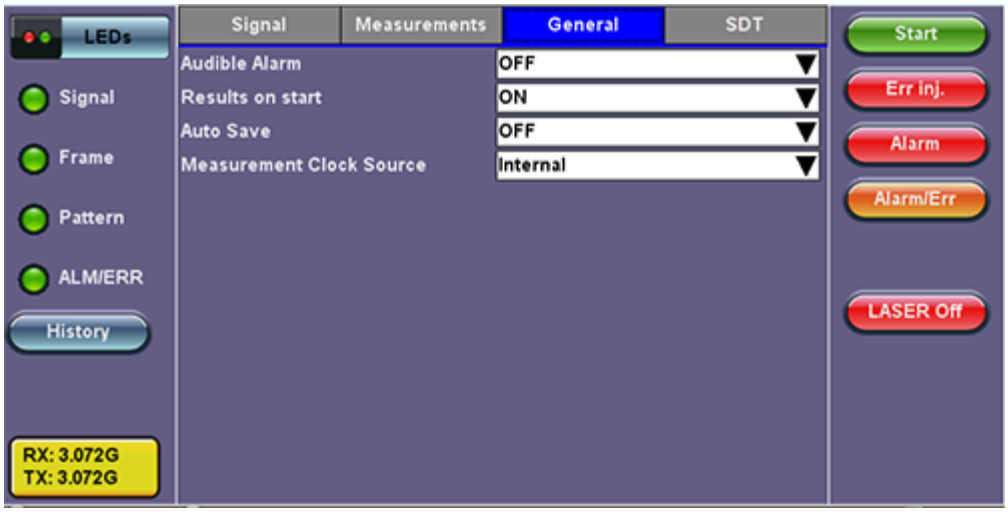


- **Mode:** Manual, Timed, Auto
  - **Timed:**
    - Duration: Enter the time
    - Units: Select seconds, minutes, hours, days
  - **Auto:** Start time, and Duration
- **Interval Save:** Test result automatically saved at configurable interval
  - **ON:** Set the Save Interval (in minutes). Tap the box to enter the value.
  - **OFF:** To opt to not save

Go back to top Go back to TOC

General:

General Setup



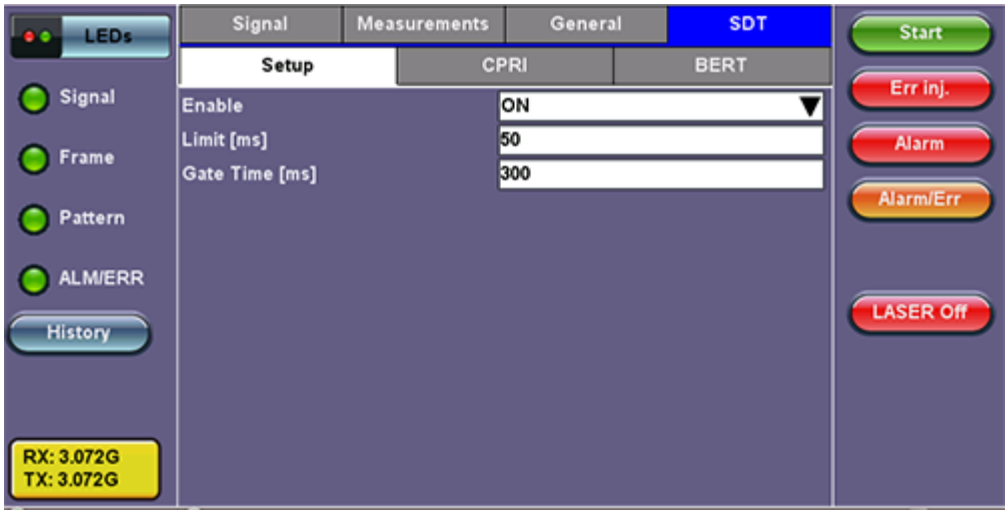
- **Audible Alarm:** OFF / ON. A sound will be generated every time there is an alarm.
- **Results on start:** OFF / ON. Shows the results screen on pressing Start.
- **Auto Save:** OFF / ON. Automatically Save the test results.
- **Measurement Clock Source:** Select the Measurement clock source used for Frequency measurement.
  For Master: Internal or TX clock source (if external clock source is used)
  For Slave: Internal

SDT: The Service Disruption Test can be disabled or enabled. If enabled the SDT Test is triggered by a qualifying error or alarm.

If enabled, select:

- **Limit Time:** Limit time determines qualifying events total time pass/fail criteria. Configurable from 20 to 1000 ms.
- **Gate Time:** Gate time setting determines the duration of the measurement. Configurable from 20 to 10000 ms.

SDT Setup



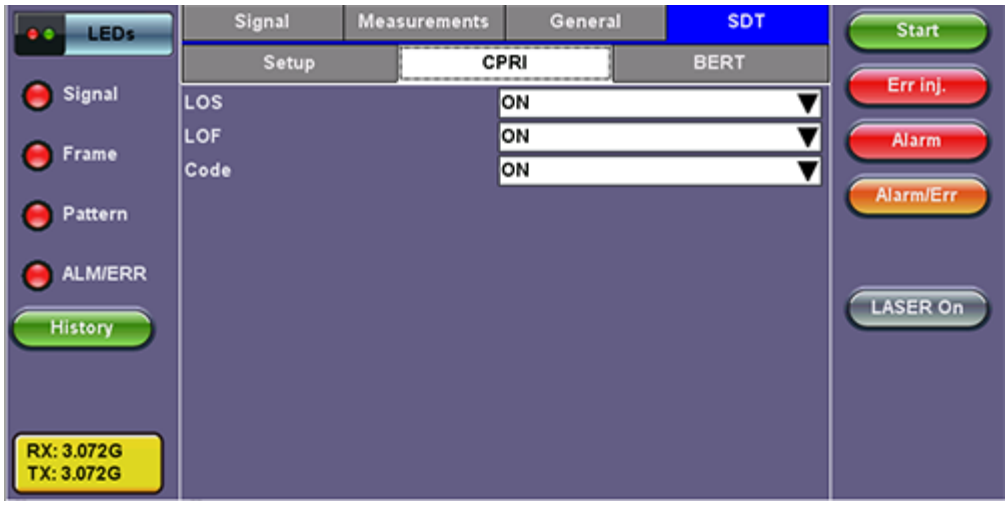
Enable the CPRI and/or BERT Trigger Events

In the CPRI and BERT Tab enable (ON) or disable (OFF) the Alarms and Errors used to determine Service Disruption events. At least one error or alarm must be enabled for SDT to trigger.

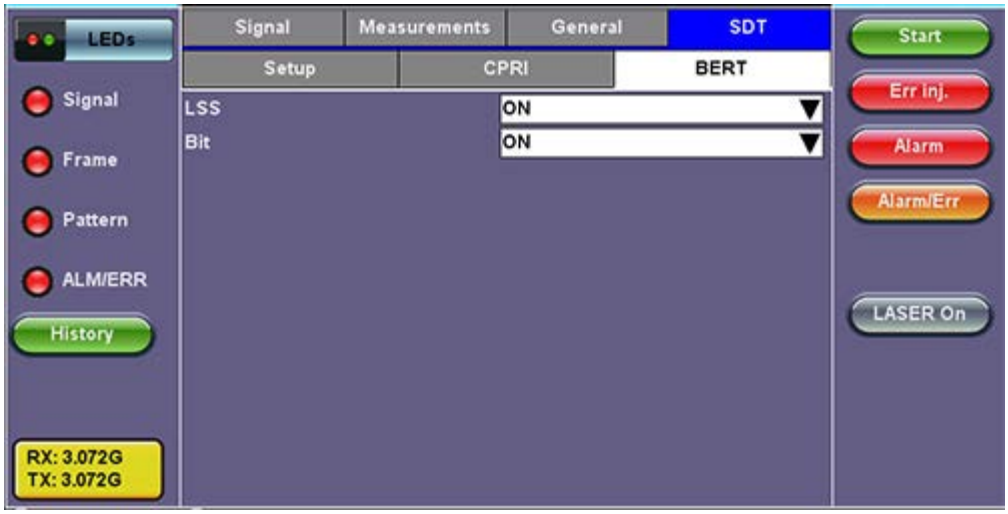
CPRI: LOS, LOF, Code

BERT: LSS, Bit

SDT CPRI Setup



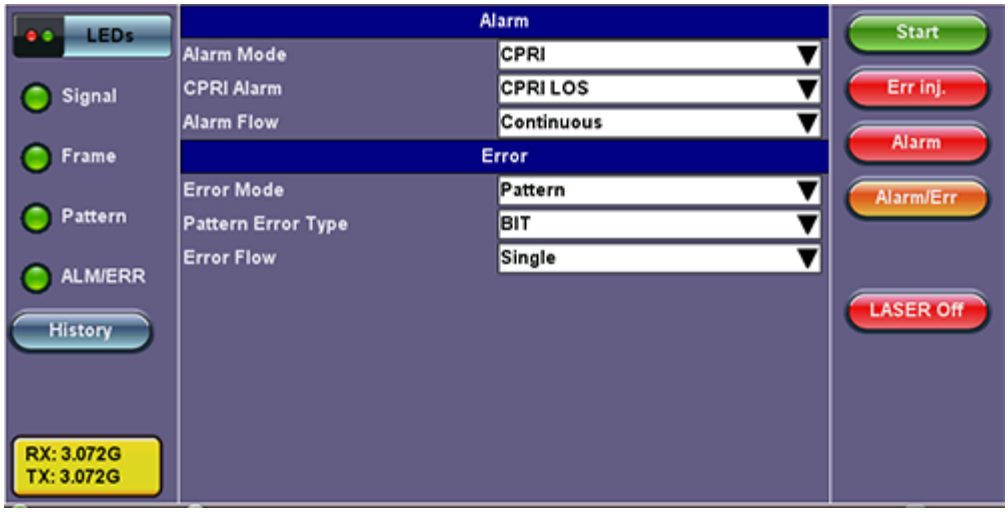
SDT BERT Setup



Go back to top Go back to TOC

Alarm and Error Injection

Alarm and Error Injection



- **Alarm Injection:**
  - CPRI LOS = Loss of Signal
  - CPRI LOF = Loss of Framing
  - **Alarm Flow:**
    - Continuous
    - Count: 0.1s, 1s, 10s, 100s
- **Error Injection:**
  - **Error Mode:**
    - **Pattern:** BIT - Bit error injection in test pattern
    - **CPRI:** Code: Code violation error injection
  - **Error Flow:**
    - **Single**
    - **Count:** Enter the value
    - **Rate:** 1E-3, 5E-4, 2E-4, 1E-4, 5E-5, 2E-5, 1E-5, 5E-6, 2E-6, 1E-6, 5E-7, 2E-7, 1E-7, 5E-8, 2E-8, 1E-8, 5E-9, 2E-9, 1E-9

Press Start to start the test.

Go back to top Go back to TOC

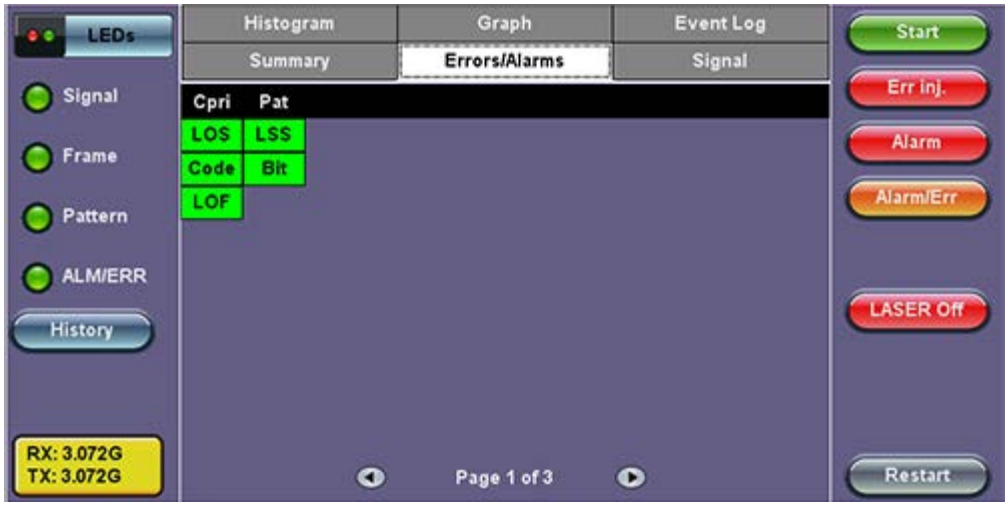
17.3.2 Results

Results Summary

Alarms and Errors

- Green indicates no alarm
- Red indicates current alarm
- Grayed out indicates that the measurements are masked by an higher layer alarm or error

Alarms and Errors Page 1

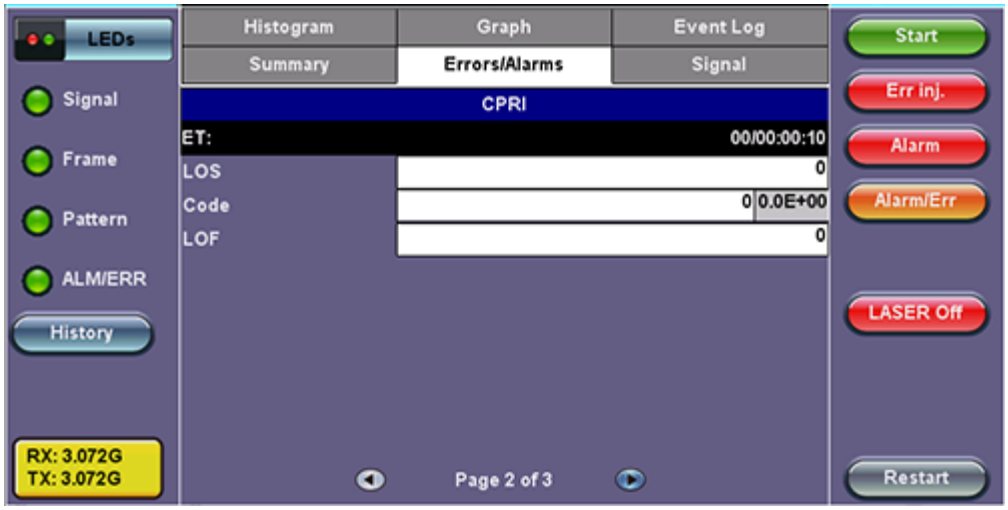


Go back to top Go back to TOC

CPRI:

- **LOS:** Loss of Signal detection in seconds
- **Code:** 8b/10b code violation detected count and rate
- **LOF:** Loss of framing seconds detected if invalid Z.0.0 sync byte is received

Alarms and Errors Page 2

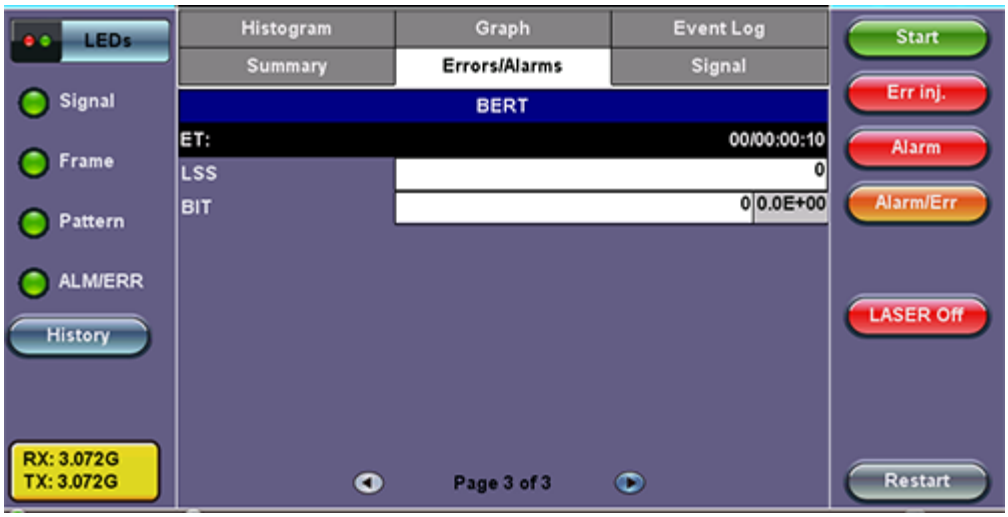


Go back to top Go back to TOC

BERT:

- **LSS:** Loss of test pattern seconds
- **Bit:** Number of test pattern bit errors detected count and rate

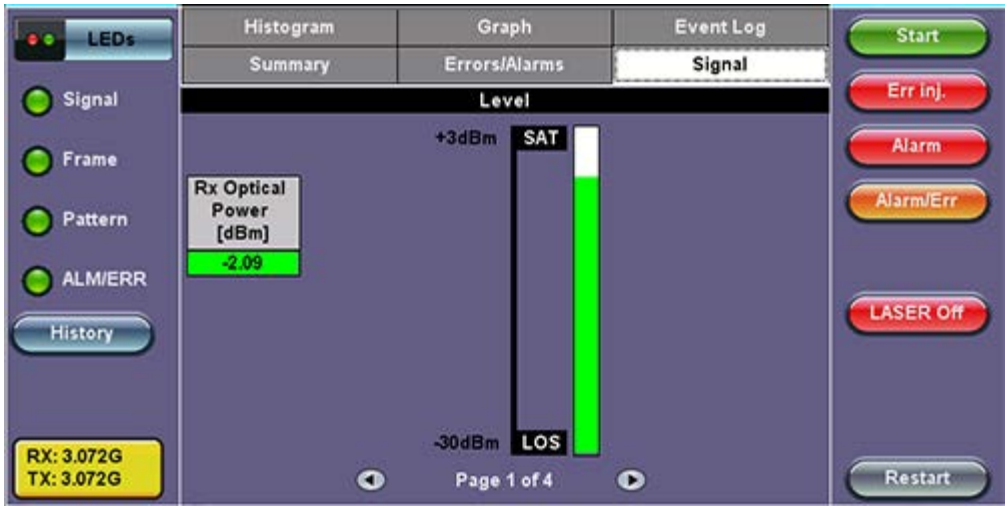
Alarms and Errors Page 3



Go back to top Go back to TOC

Signal:

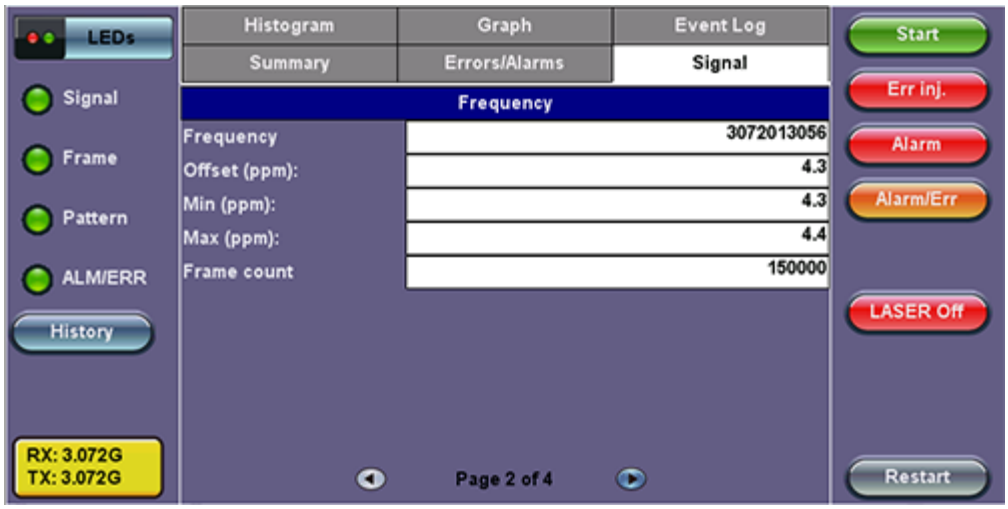
Signal



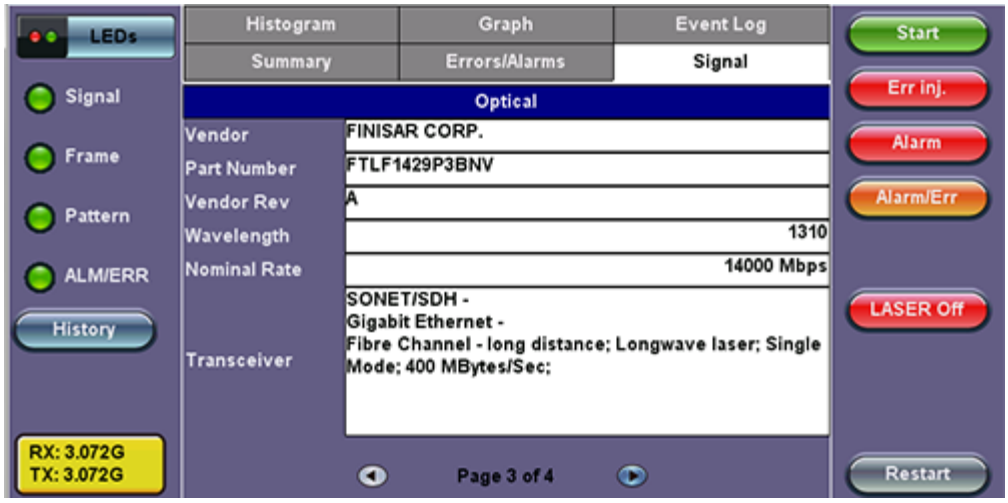
Page 2 includes:

- **Frequency:** Measured RX signal frequency
  - **Offset:** current frequency offset from the frequency measurement clock (internal or external)
  - **Min:** minimum frequency offset
  - **Max:** maximum frequency offset
- **Frame Count**

Signal Page 2

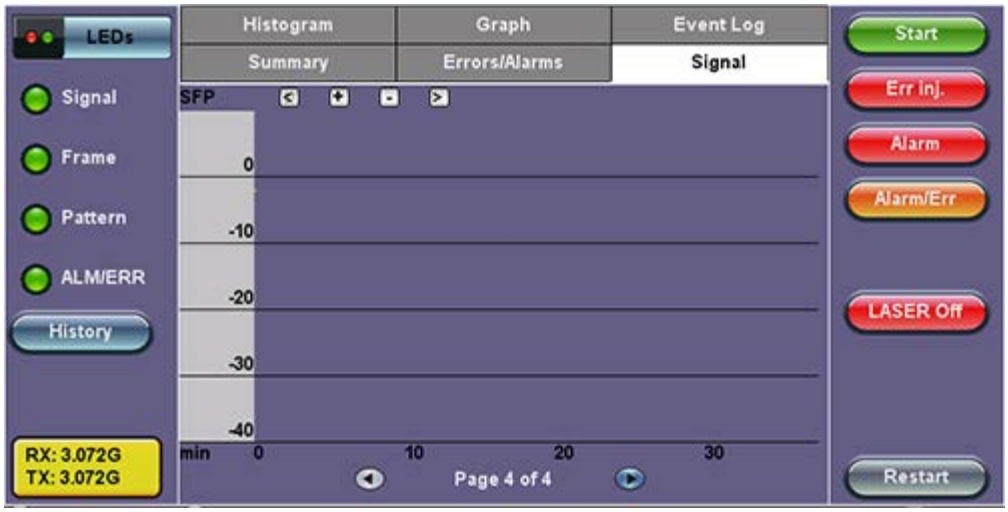


Signal Page 3



Histogram showing the fluctuation in RX optical signal level

Signal Page 4

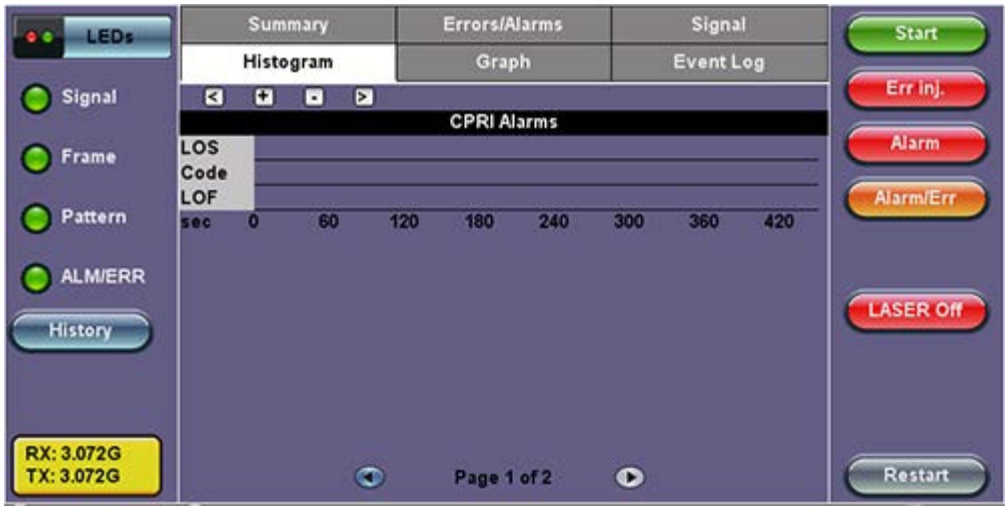


Go back to top Go back to TOC

Histogram:

Histogram showing CPRI alarms and errors events.

Histogram

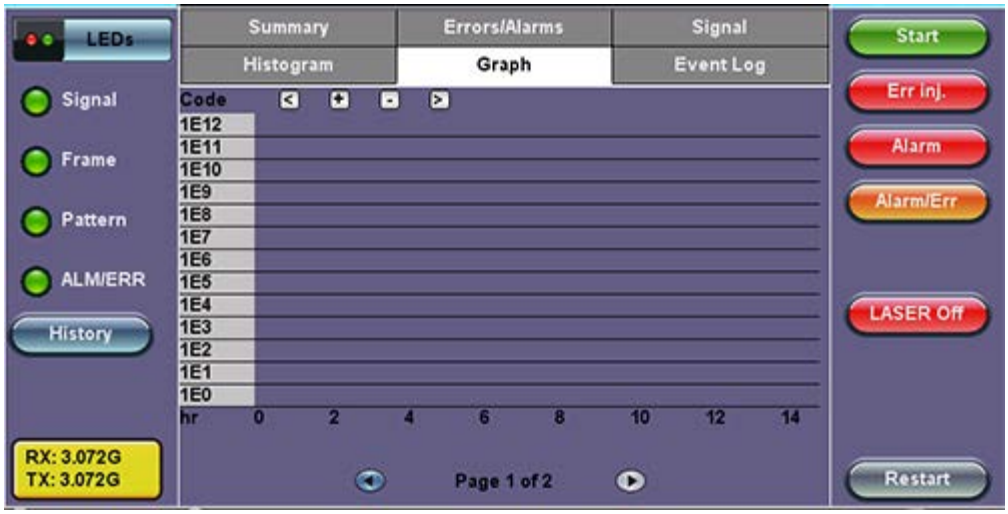


Go back to top Go back to TOC

Graph:

Graph showing CPRI Code and Bit error rate over time

Graph

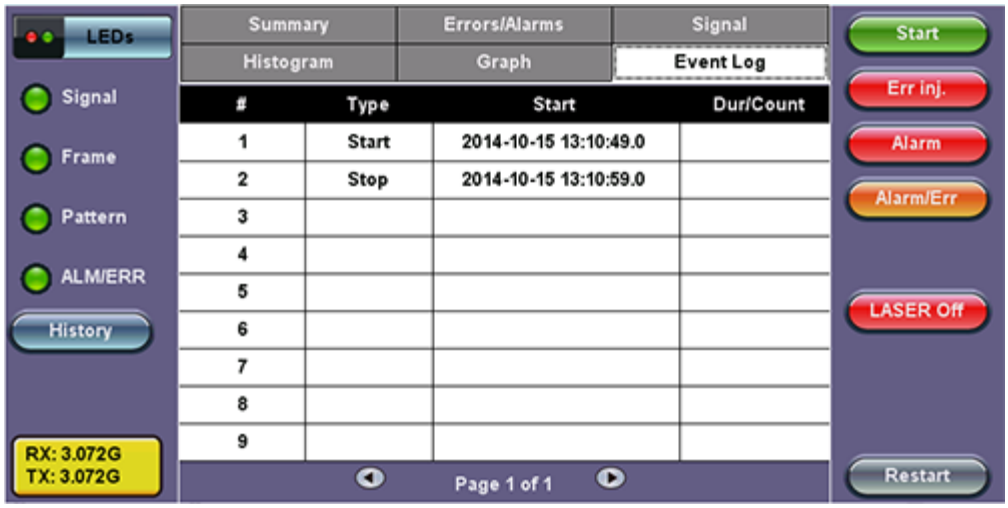


Go back to top Go back to TOC

Event Log:

Logs CPRI Alarms and Errors events along with corresponding count and duration for each event.

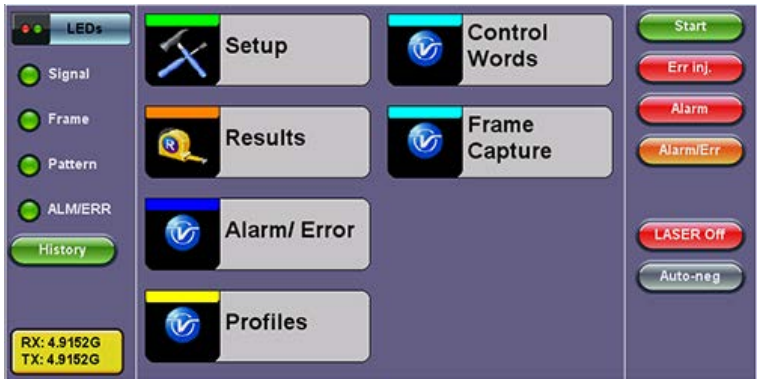
Event Log



Go back to top Go back to TOC

17.4 CPRI Layer 2 Framed Testing

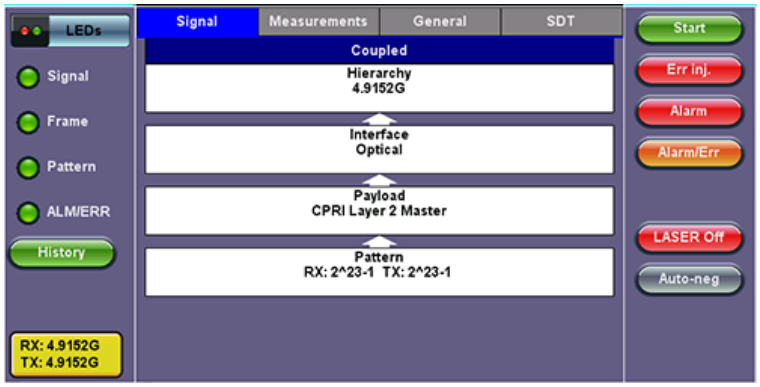
CPRI Layer 2 Main Menu



Go back to top Go back to TOC

17.4.1 Setup

Setup Menu



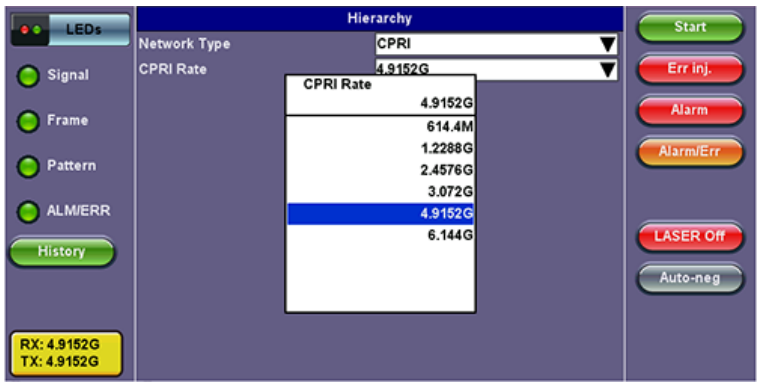
Go back to top Go back to TOC

Configure the following:

Signal:

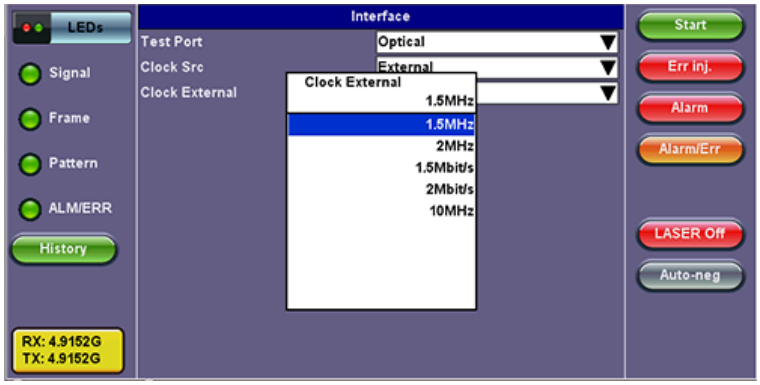
- **Hierarchy:** CPRI Rate selection from 614.4Mbps to 6.144Gbps. 4.9 and 6.1 Gbps rate requires compatible SFP+.

Hierarchy



- **Interface:** CPRI Clock Selection Internal/External (Master mode only). Slave uses RX signal recovered clock.
  - **Master:** Internal, External (1.5MHz, 2MHz, 1.5 Mbps, 2Mbps, 10MHz), Or Atomic 10MHz (Atomic clock option required) For External clock connection use the unit's SMA CLK port.

Interface



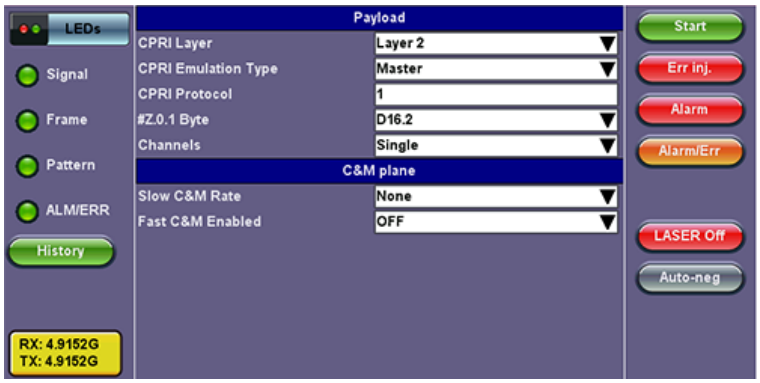
- **Payload:** CPRI Layer 2 configuration
  - **CPRI Emulation Type:** CPRI Master emulation (Radio Equipment Controller Emulation)
    CPRI Slave emulation (Remote Radio Unit). Slave = RE. Master is responsible for CPRI Start up sequence and Synchronization
  - **CPRI Protocol:** Version 1 supported
  - **#Z.0.1 Byte:** Sync Control Word Z.0.1 set to D16.2 or D5.6
  - **Channels:**
    - **Single:** PRBS test pattern transmitted on one AxC
    - **All:** PRBS test pattern transmitted on all AxC

Control and Management (C&M) channel configuration:

- **Slow C&M Rate:**
  - **None:** HDLC channel disabled
  - **Configurable rate:** 240kb/s to 2400 kb/s HDLC channel data rate depending on CPRI Link speed
- **Fast C&M Enabled:** Ethernet channel, configurable start of Ethernet channel pointer in Control word or channel disabled.
  - **OFF:** Ethernet Channel disabled
  - **ON:** Ethernet Channel enabled, configure Ethernet pointer location from 20 to 63

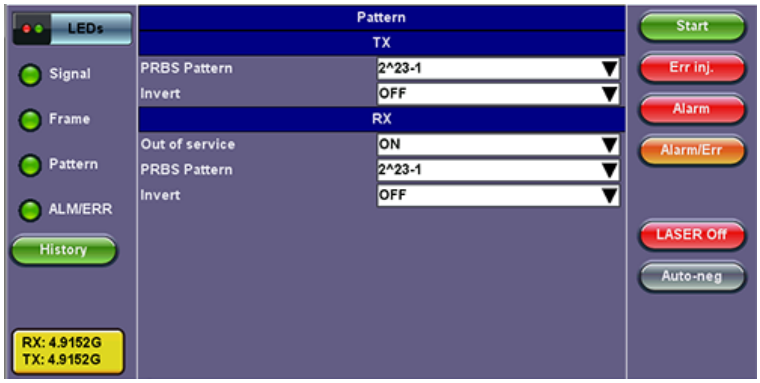
Note: Auto-negotiation can be used for Master/Slave to negotiate their maximum C&M channels capabilities

Payload



- **Pattern**: Independent TX/RX test Pattern selection. PRBS 2^23-1 (normal or inverted) or PRBS 2^31-1 (normal or inverted)

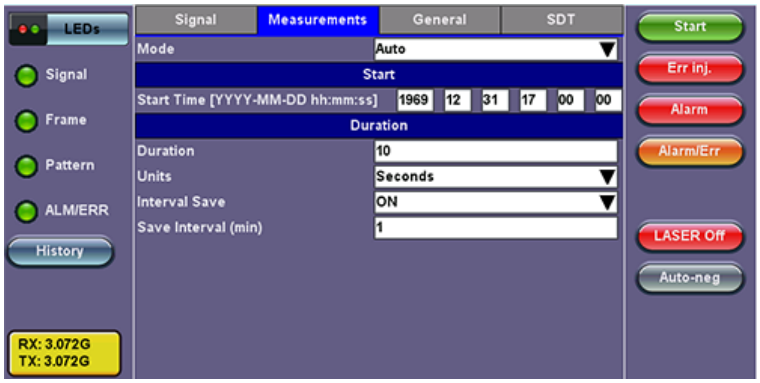
Pattern



Go back to top Go back to TOC

Measurements:

Measurements Setup

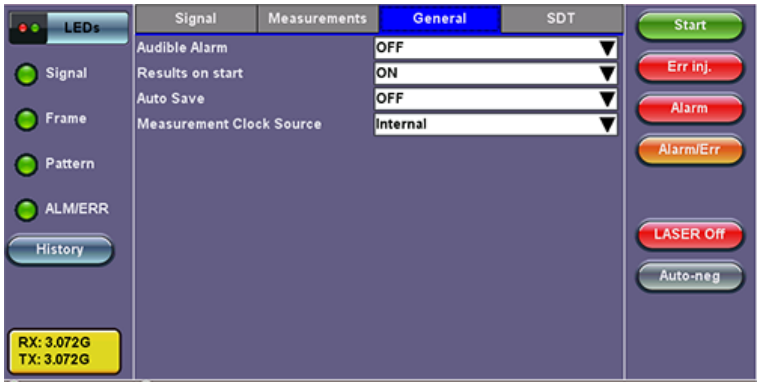


- **Mode:** Manual, Timed, Auto
  - **Timed:**
    - Duration: Enter the time
    - Units: Select seconds, minutes, hours, days
  - **Auto:** Start time, and Duration
- **Interval Save:** Test result automatically saved at configurable interval
  - **ON:** Set the Save Interval (in minutes). Tap the box to enter the value.
  - **OFF:** To opt to not save

Go back to top Go back to TOC

General:

General Setup



- **Audible Alarm:** OFF / ON. A sound will be generated every time there is an alarm.
- **Results on start:** OFF / ON. Shows the results screen on pressing Start.
- **Auto Save:** OFF / ON. Automatically Save the test results.
- **Measurement Clock Source:** Select the Measurement clock source used for Frequency measurement.
  For Master: Internal or TX clock source (if external clock source is used)
  For Slave: Internal

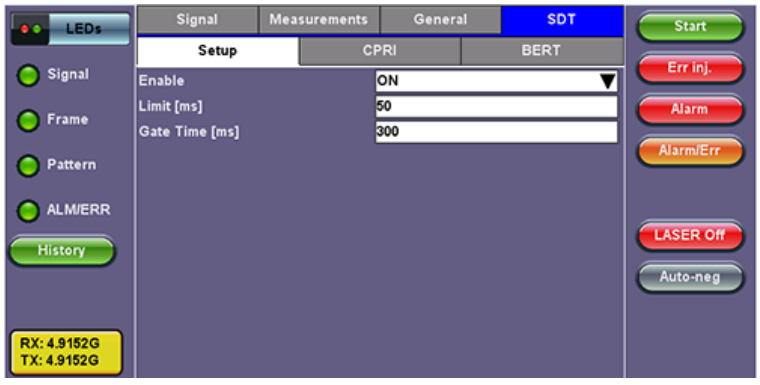
Go back to top Go back to TOC

SDT: The Service Disruption Test can be disabled or enabled. If enabled the SDT Test is triggered by a qualifying error or alarm.

If enabled, select:

- **Limit Time:** Limit time determines qualifying events total time pass/fail criteria. Configurable from 20 to 1000 ms.
- **Gate Time:** Gate time setting determines the duration of the measurement. Configurable from 20 to 10000 ms.

SDT Setup



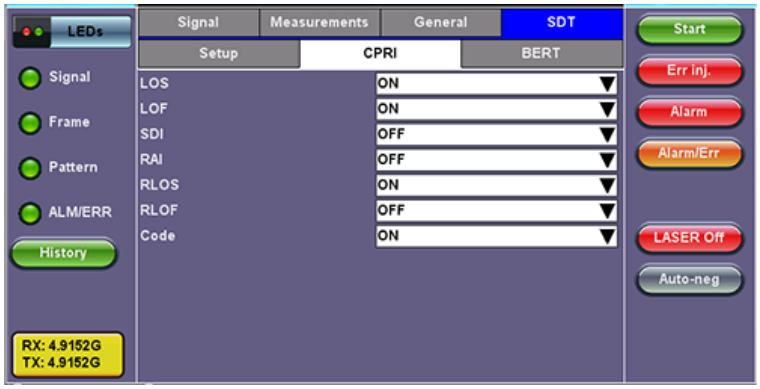
Enable CPRI and/or BERT trigger events

In the CPRI and BERT Tab enable (ON) or disable (OFF) the Alarms and Errors used to determine Service Disruption events. At least one error or alarm must be enabled for SDT to trigger.

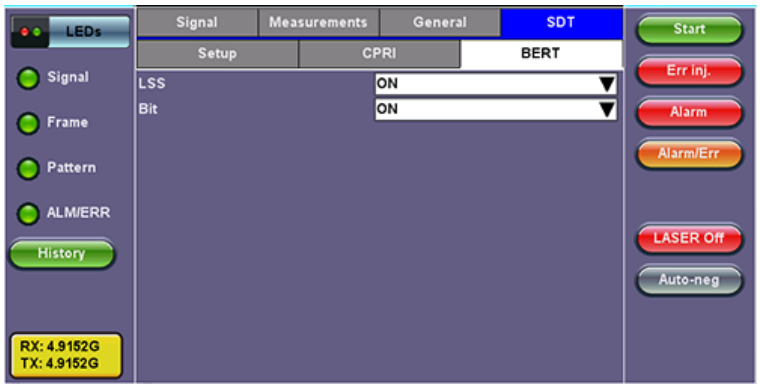
CPRI: LOS, LOF, SDI, RAI, RLOS, RLOF, Code

BERT: LSS, Bit

CPRI Event Setup



BERT Event Setup



Go back to top Go back to TOC

Alarm and Error Injection

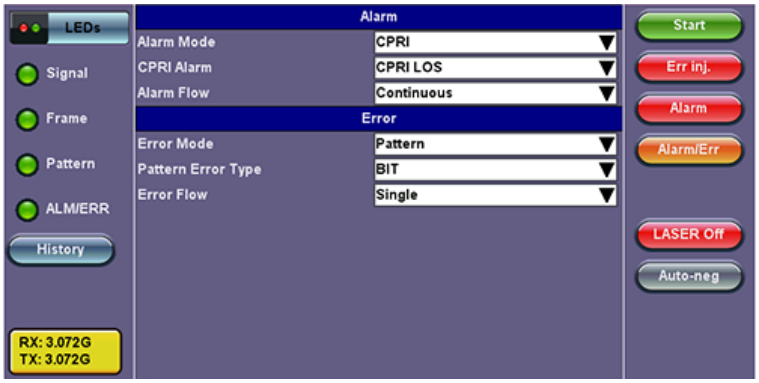
Alarm Injection: Each alarm can be set to Continuous or Count

- **CPRI Alarms:**
  - **LOS:** Trigger a Loss of Signal event (Laser OFF)
  - **LOF:** Trigger a Loss of Framing event. The Z.0.0 control byte is modified to send an invalid byte of value 0xff
  - **SDI:** Service Defect Indication is transmitted in the Control bytes for L1 inband protocol
  - **RAI:** Remote Alarm Indication is transmitted in the Control bytes for L1 inband protocol
  - **RLOS:** Remote Loss of Signal is transmitted in the Control bytes for L1 inband protocol
  - **RLOF:** Remote Loss of Framing is transmitted in the Control bytes for L1 inband protocol
- **Alarm Flow:**
  - **Continuous**
  - **Count:** 0.1s, 1s, 10s, 100s

Error Injection:

- **Error Mode:**
  - **Pattern:** BIT - Bit error injection in test pattern
  - **CPRI:** Code: 8B/10B Code violation error injection
- **Error Flow:**
  - **Single**
  - **Count:** Enter the value
  - **Rate:** 1E-3, 5E-4, 2E-4, 1E-4, 5E-5, 2E-5, 1E-5, 5E-6, 2E-6, 1E-6, 5E-7, 2E-7, 1E-7, 5E-8, 2E-8, 1E-8, 5E-9, 2E-9, 1E-9

Alarm and Error Injection

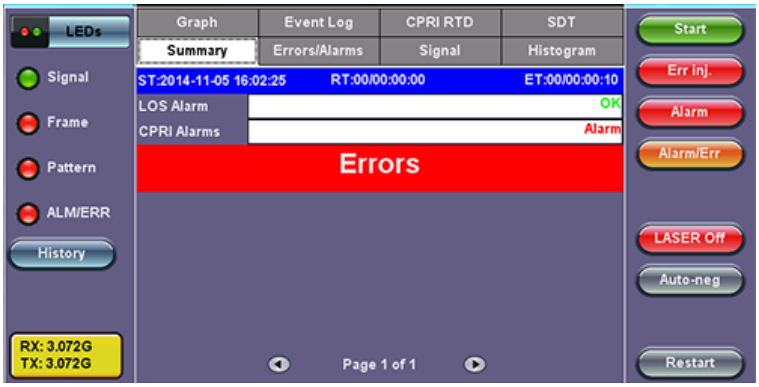


Press Start to start the test.

Go back to top Go back to TOC

17.4.2 Results

Results Summary



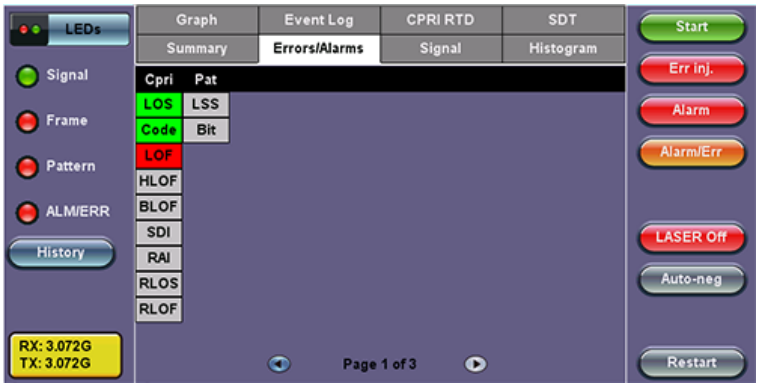
Go back to top Go back to TOC

Alarms and Errors

These include Hyperframe Synchronization indication and BFN (NodeB Radio Frame) Synchronization indication.

- Green indicates no alarm
- Red indicates current alarm
- Grayed out indicates that the measurements are masked by an higher layer alarm or error

Alarms and Errors Page 1



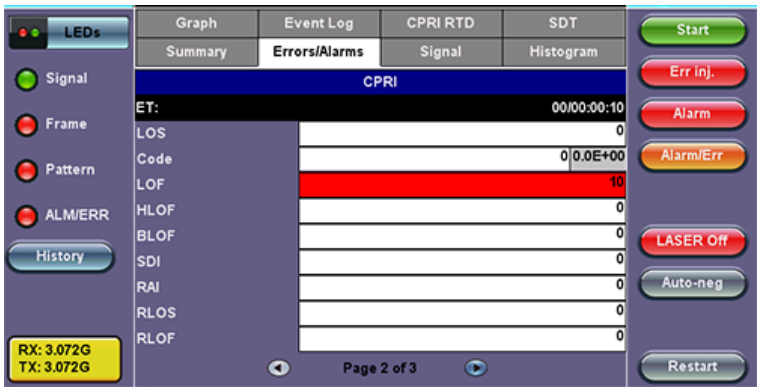
Go back to top Go back to TOC

CPRI:

- **LOS:** Loss of Signal detection in seconds
- **Code:** 8b/10b code violation detected count and rate
- **LOF:** Loss of framing seconds detected if invalid Z.0.0 sync byte is received
- **HLOF:** Loss of Hyperframe synchronization seconds
- **BLOF:** Loss for Basic Frame (NodeB) frame synchronization seconds
- **SDI:** Service Defect Indication is detected in the Control bytes for L1 inband protocol
- **RAI:** Remote Alarm Indication is detected in the Control bytes for L1 inband protocol
- **RLOS:** Remote Loss of Signal is detected in the Control bytes for L1 inband protocol

- **RLOF:** Remote Loss of Framing is detected in the Control bytes for L1 inband protocol

Alarms and Errors Page 2

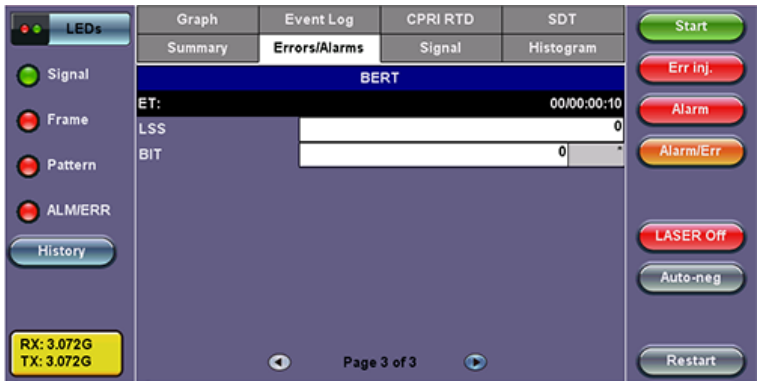


Go back to top Go back to TOC

BERT:

- **LSS:** Loss of test pattern seconds
- **Bit:** Number of test pattern bit errors detected count and rate

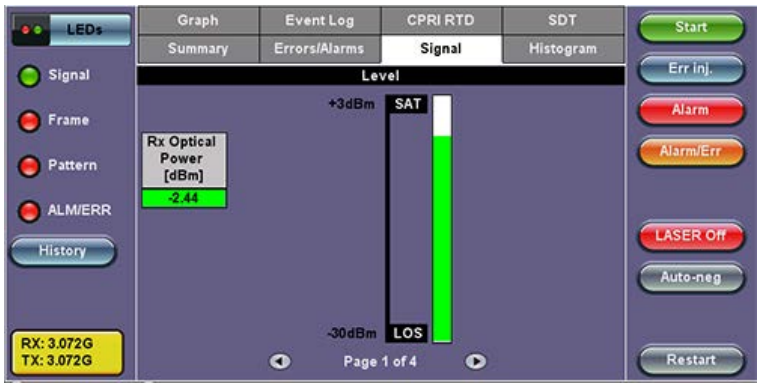
Alarms and Errors Page 3



Go back to top Go back to TOC

Signal

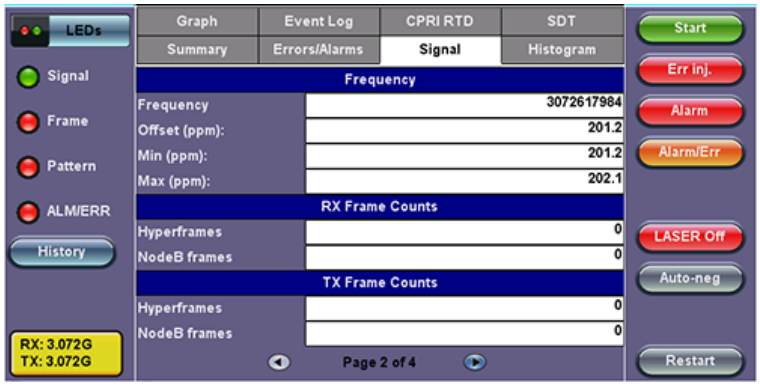
Signal Page 1



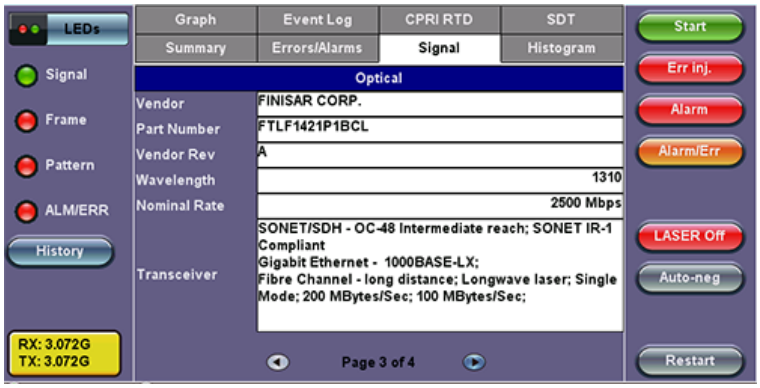
Page 2 includes:

- **Frequency:** Measured RX signal frequency
  - **Offset:** current frequency offset from the frequency measurement clock (internal or external)
  - **Min:** minimum frequency offset
  - **Max:** maximum frequency offset
- **Hyperframes TX/RX:** counters of Transmitted/Received Hyperframes
- **NodeB frames TX/RX:** counters of Transmitted/Received NodeB (Radio) framed

Signal Page 2

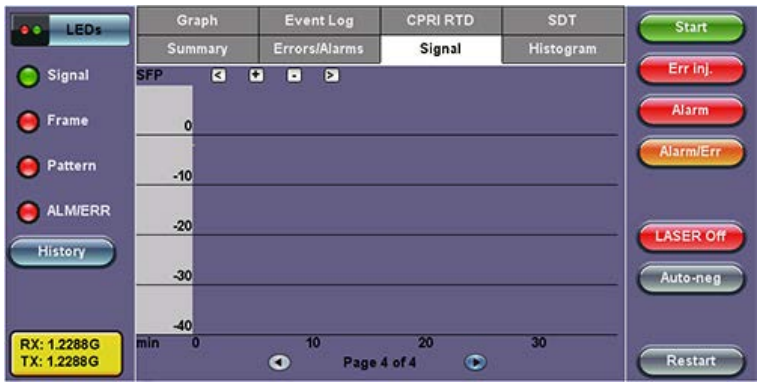


Signal Page 3



Histogram showing the fluctuation in RX optical signal level.

Signal Page 4

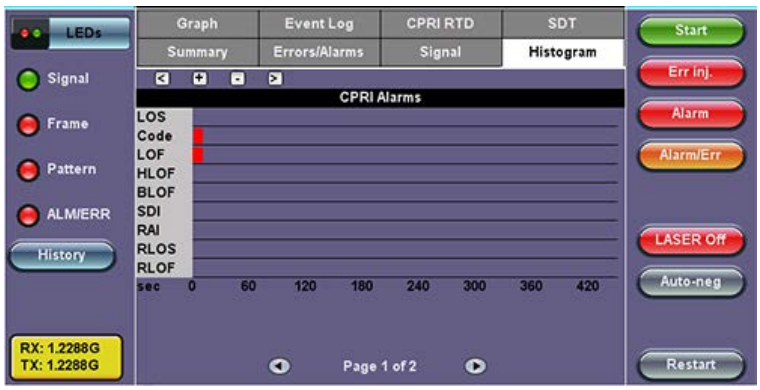


Go back to top Go back to TOC

Histogram

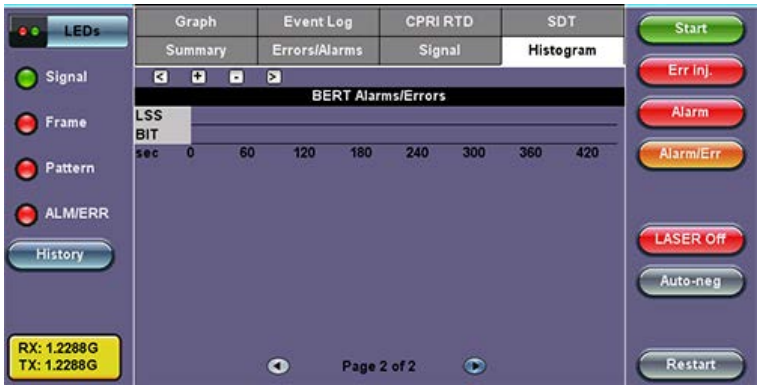
Histogram showing CPRI alarms and errors events.

Histogram



Histogram showing BERT alarms and errors events.

Histogram Page 2

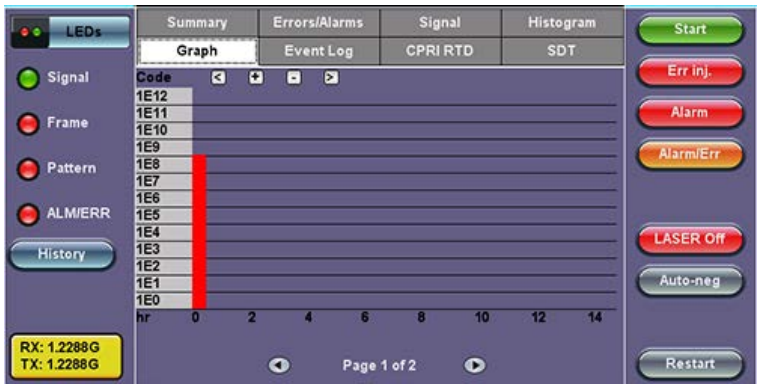


Go back to top Go back to TOC

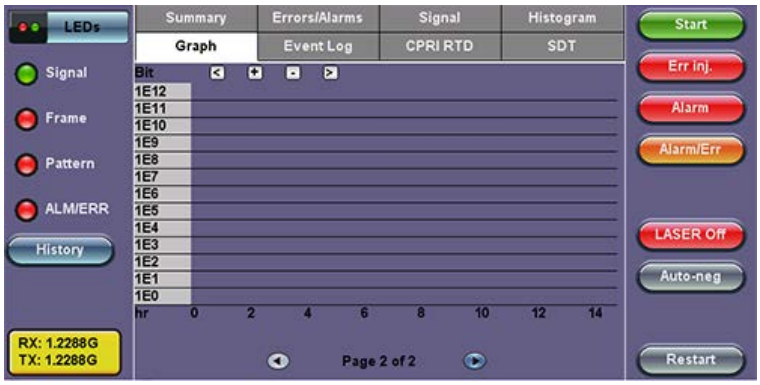
Graph

Graph showing CPRI Code and Bit error rate over time.

Graph



Graph Page 2

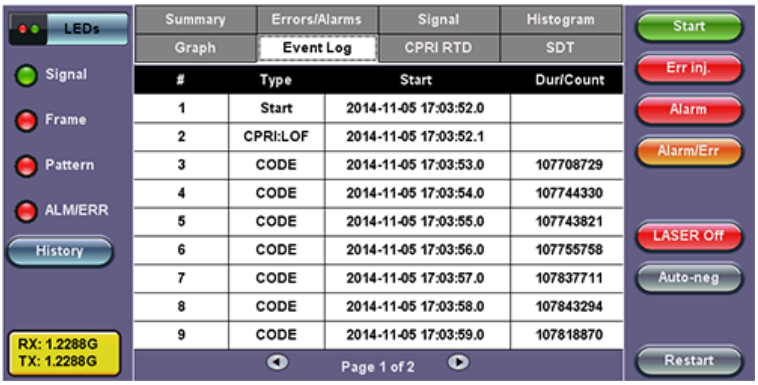


Go back to top Go back to TOC

Event Log

Logs CPRI Alarms and Errors events along with corresponding count and duration for each event.

Event Log



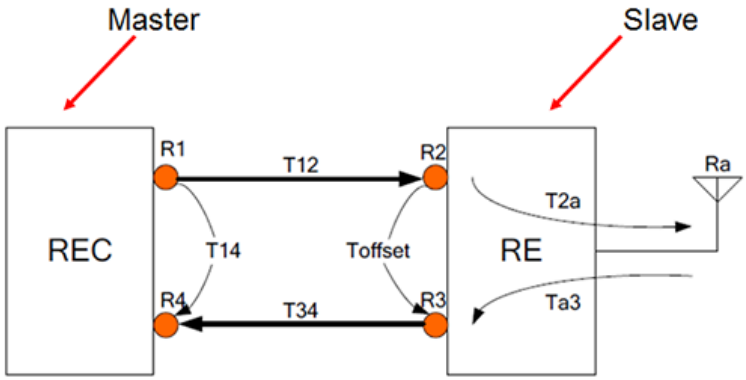
Go back to top Go back to TOC

17.4.3 CPRI Round Trip Delay

CPRI Standard Cable Delay Measurement reference points:

- Toffset = Frame offset delay between Slave RX and Slave TX
- T 1,4 = Frame delay between Master TX and Master RX
- Cable Delay (round trip) = T 1,4 – Toffset

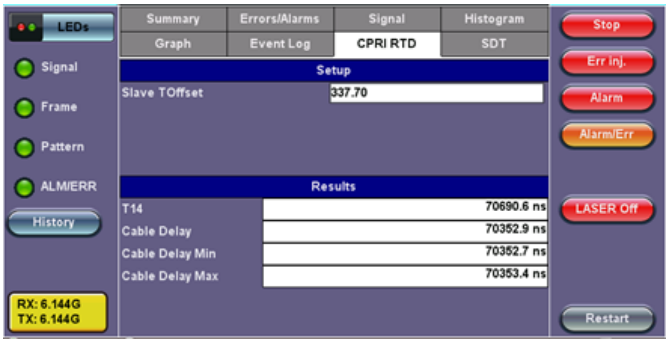
The figure below shows the definition of reference points for delay calibration (single-hop configuration):



Round trip delay Measurement procedure:

1. Slave Side: Start the test and note Toffset value
2. Master Side: Enter the Slave Toffset value using keypad
3. Master Side: Start the Test
4. Master Side: Note Cable Delay measurement min, max and current values

CPRI RTD



Go back to top Go back to TOC

17.4.4 SDT

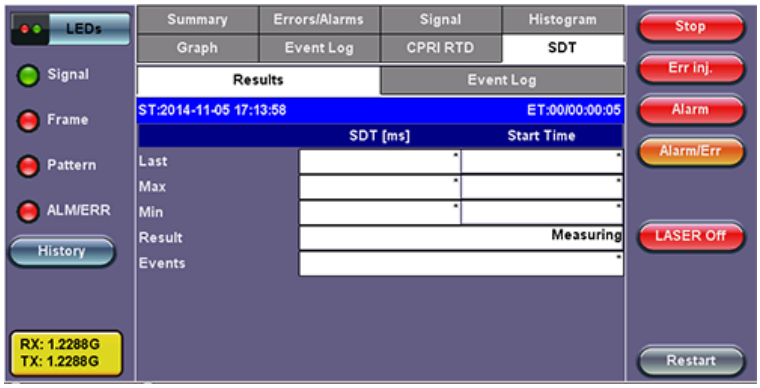
Limit and Gate Time counters begin at the onset of the first valid event.

SDT Measurement ends after the Gate time is elapsed, to allow the capture of multiple smaller events.

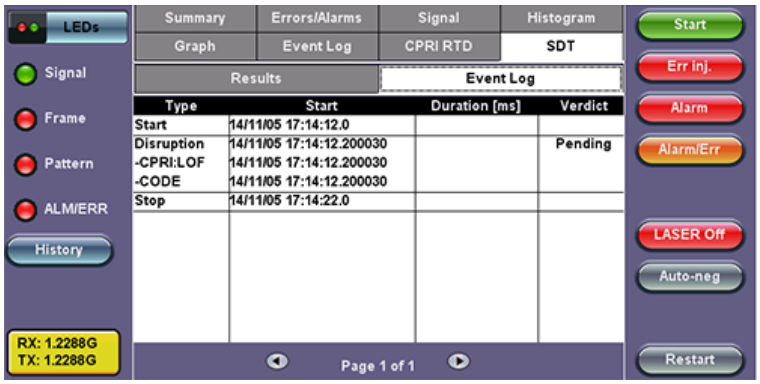
The total time from the beginning of the first event to the end of the last event (within the Gate Time) is the reported SD time.

The measurement process is immediately restarted in search for the next trigger. Results are presented in tabular form (Events table) indicating SD start time (1 ms resolution or better), disruption time, and Pass/Fail evaluation. This table gets populated as new disruptions are detected and measured.

SDT Results



SDT Event Log



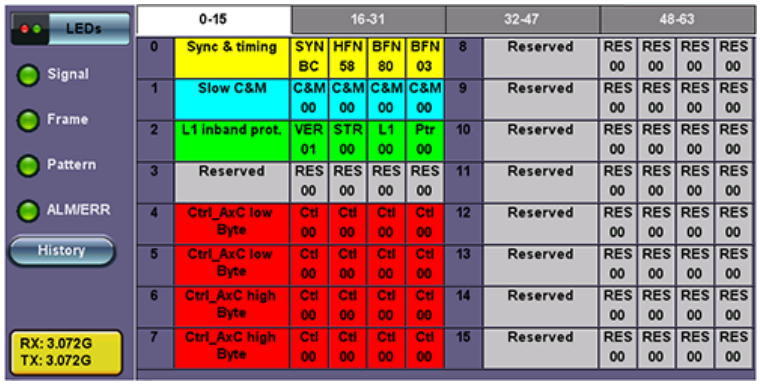
Go back to top Go back to TOC

17.4.5 Control Words

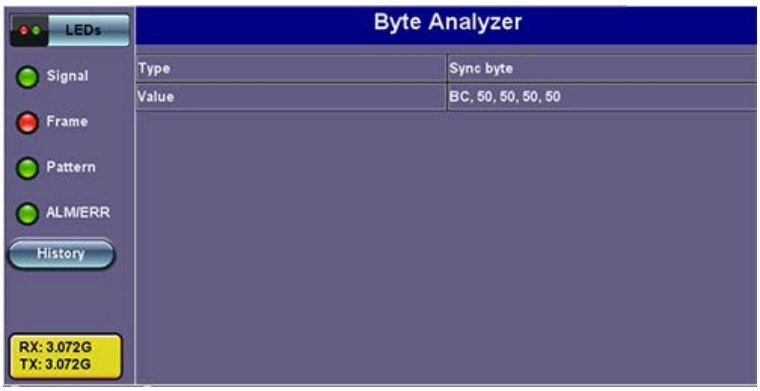
Display of Control words content in the 64 Subchannels.

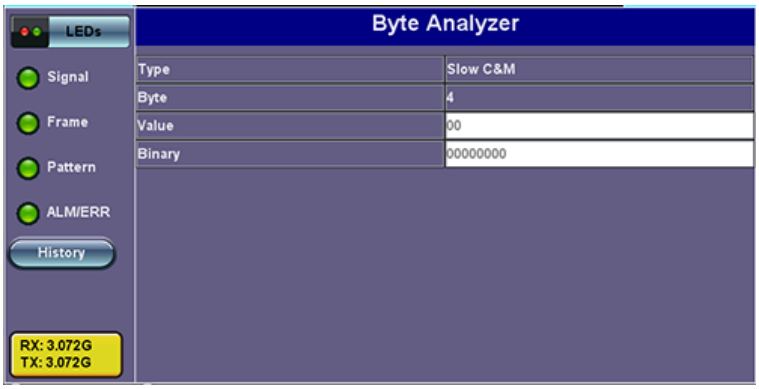
Tap on any subchannel to display Hex and Binary value of the contents.

Control Words Display



Control Words Byte Analyzer

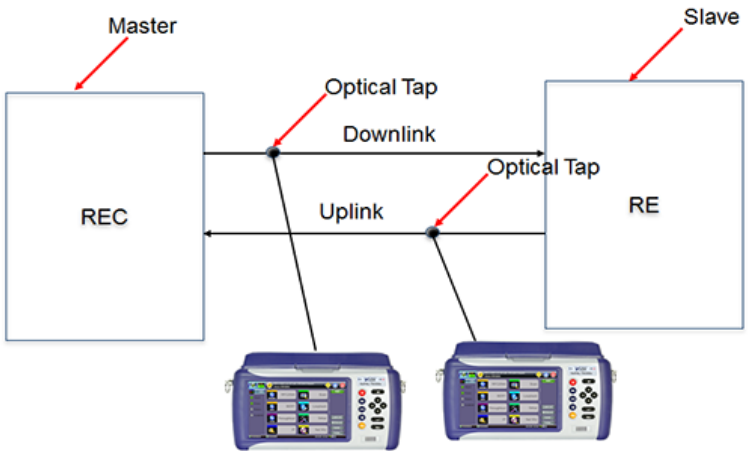




Go back to top Go back to TOC

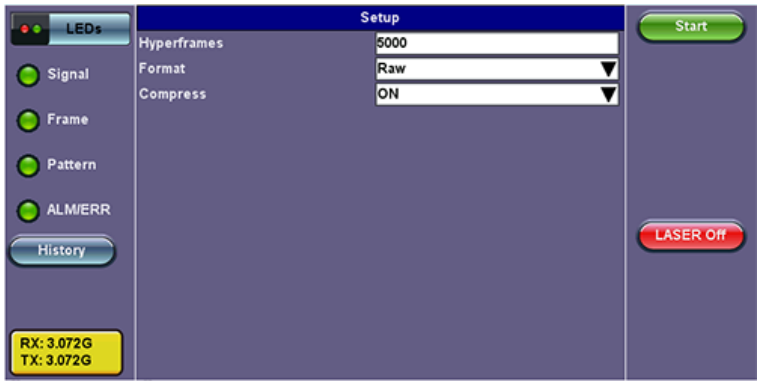
Frame Capture

The test set must be set to Slave mode or use the Master's ref. Clock.



- Capture up to 5000 Hyperframes
- CSV or raw frame format
- Compression (gzip format)
- Capture file written directly to USB drive

Frame Capture Setup



Go back to top Go back to TOC

18.0 IEEE C37.94™ Testing (TX320s only)

Optical Interface between Teleprotection & Multiplexer Equipment

18.1 Introduction

The IEEE C37.94™-2002 standard (reaffirmed in 2008) defined a multi-vendor optical transmission interface to be used by power utility companies to replace existing electrical supervisory control and data acquisition links. Low level electrical links were considered unreliable for use in the power industry as they are prone to interference and damages due to intra-substation electromagnetic interference (EMI), signal ground loops, and ground potential rise. Optical links and fiber optics don't have such problems.

C37.94 was originally defined as an 850 nm MMF interface with ST (BFOC/2.5) connectors, but 1310 nm MMF and SMF variants with other connector types could be found today. It is capable of transmitting a single data stream at Nx64 kbit/s, with N being 1 to 12 (64 to 768 kbit/s). It uses a simple faming structure and a line rate of 2048 kbit/s. Every bit in the data channel is encoded as a two bit symbol consisting of the original data bit and its complement (01 or 10) to assure enough transitions to help with clock recovery.

The frame alignment signal is carried in the header, as a 16-bit pattern that alternated with every other frame:

- Framing pattern 1: 1001 1011 0000 1111
- Framing pattern 2: 11y1 1111 0000 1111 (y = yellow alarm indication bit. 1 indicates alarmed condition)

The framing pattern is followed by a 48-bit p -p q -q r -r s -s 1 0 1 0 1 0 1 0…1 0 overhead pattern, where the pqrs bits represent the N value or data rate multiplier. The alternate trailing 1010 pattern is most likely to seed the clock recovery circuitry and serve as a preamble to client data.

Loss of Signal (LOS) and Loss of Frame Alignment (LOF)

Although the standard recognizes the ITU-T G.706 LOF definition as the event that starts after the detection of three consecutive incorrect frame alignment signals, IEEE considers loss of framing a link LOS condition. LOS is declared when the optical signal is too low or frame alignment is lost.

Per IEEE, the LOS condition is declared upon receiving two or more errors in eight consecutive framing patterns, and cleared upon receiving eight consecutive correct framing patterns.

VeEX test sets repot Frame (induced) LOS and Signal (induced) LOS separately to provide extra information to users for better problem isolation and troubleshooting purposes.

Remote Defect Indication (RDI) and Yellow Alarm

Although the IEEE C37.97 refers to RDI path defects (as defined by ITU-T G.755), their official name for this far-end alarm status is Yellow alarm. RDI has become a more common term, but some users may use RDI and others Yellow, to refer to the alarm sent by the far end to indicate that there is a problem with the received signal. The yellow alarm indicator is carried by the third bit (y) in the second fame alignment signal.

Alarm Indication Signal (AIS)

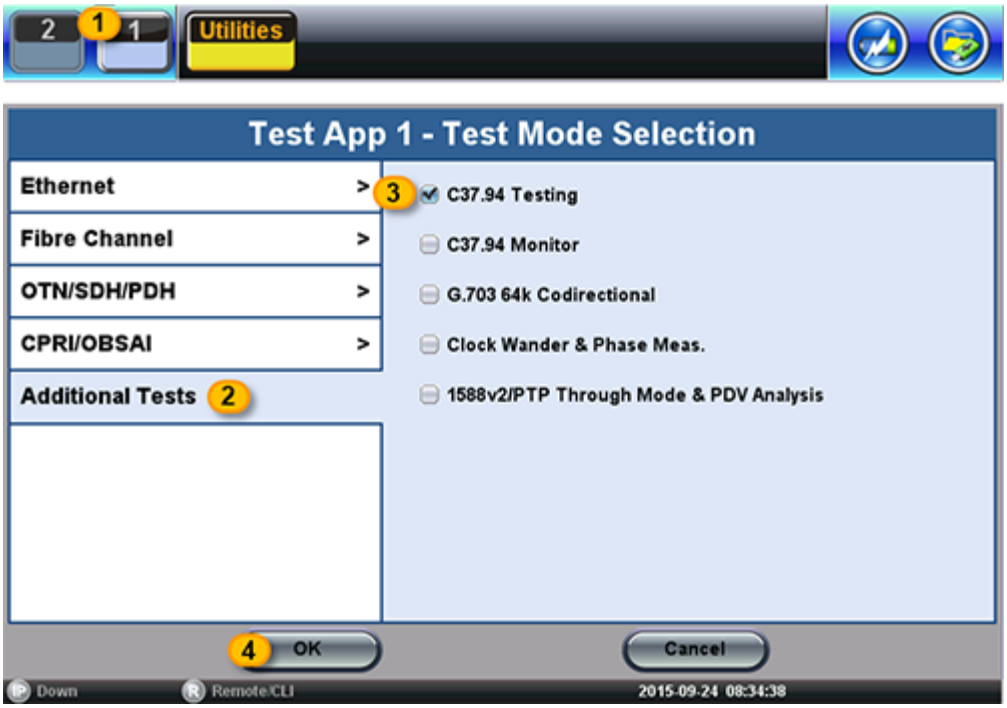
When a network element declared loss of signal at its receiver, it send a yellow (RDI) alarm back to the originating equipment and an AIS alarm to all the other equipment located upstream (in the direction of the original transmission). The AIS consist in replacing all channel data with an All Ones pattern.

Go back to top Go back to TOC

18.2 Getting Started

Starting the C37.94 Test Application:

Turn the test set ON.



1. From the welcome screen, select the Test Application button 1.
2. Select Additional Tests from the technologies section.
3. Check the C37.94 Testing test mode (or C37.94 Monitor for dual-port pass-through).
4. Press OK to start the C37.94 application.

After a few seconds the C37.94 Menu is displayed and the application button turns yellow (active), displaying C37.94 as the application running.

User Interface Elements

a. **Utilities button:** Provides access to the test platform setting and global functions.
b. **Test Application button:** Indicate the current active test application. Tap on this button to release or change the test mode.
c. **Testing:** Indicates that a test is currently running.
d. **Laser Status:** Indicates if the laser is currently ON or OFF.
e. **Alarm Generation:** Indicates that an alarm is being inserted to the TX test signal.
f. **Error Generation:** Indicates that error are being injected into the TX test signal.
g. **Home:** Goes back to the Main Menu.
h. **Exit:** Goes back to the previous screen or menu level.

i. **Soft LED indicators:** Show the main test signal health status. Green = good, Red = bad, Blinking = historical event reminder (e.g. some events that happened while the user was away).
j. **History:** Acknowledges and resets the blinking historical reminder. The LED goes back to display its current status. No events or counters are deleted from the test.
k. **Interface Status:** Show that the test set is transmitting and receiving C34.97 signals.
l. **Start/Stop button:** Initiates and terminates a BER test. Test can also be timed so they stop after a set amount of time.
m. **Error Injection button:** Activates and deactivates the error injection function. The type of error and behavior can be programmed using the Alarm/Err button.
n. **Alarm Generation button:** Activates and deactivates the alarm generation function. The type of alarm and behavior can be programmed using the Alarm/Err button.
o. **Alarms/Error Settings button:** Provides access to the Alarm Generation and Error Injection configuration menu at any time, from any screen.
p. **Laser ON/OFF button:** Use this button to turn the laser ON and OFF.
q. **Restart button:** Restarts the test, clearing all records and counter, without saving.
r. The C37.94 Main Menu items are shown in the center of the screen example. Results and Configurations are also shown in this main area.

Physical Buttons

- **Save:** Use the or button on the test set to save the current test results.
- **History:** The button has the same effect as the History function. Clears the LED reminders (blinking).
- **Lock:** Use the button to temporarily disable the touch screen and prevent accidental changes during unattended or long-term tests. An icon on the top-right corner of the screen will indicate whether the screen lock is enabled or disabled.
- **Capture:** The button can also be temporarily programmed to capture and store screen shots (PNG format). To enable this alternate function go to >Utilities >Settings >Global >Save Settings, select Save Screen, set desired quality (compression) level and the maximum number of images to store in Files.

Go back to top Go back to TOC

18.3 Testing C37.94

Fiber optics links or network elements using this simple transmission technology can be verified like regular PDH signals, performing bit error rate tests (BERT), monitoring signal levels, errors and alarms.

Notes:

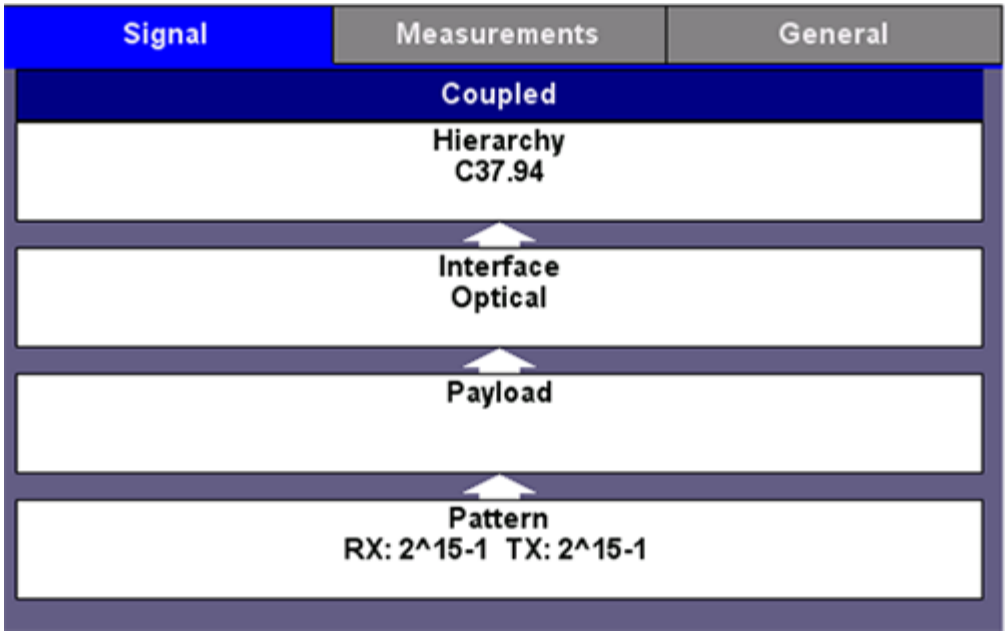
- C37.97 Testing is an optional feature and it must be activated in order to have access to its functions.
- The optical data rate is very low and not all SFPs are compatible with it. Only use SFPs recommended by VeEX.
- The output signal of the SFP could be stronger than the actual teleprotection equipment output. In order to avoid saturation at the far end, or invalid measurements due to the extra reach, use a loopback to confirm the SFP output power and add the appropriate in-line attenuator to match network elements output, if necessary.

Go back to top Go back to TOC

18.3.1 Test Setup

18.3.1.1 Signal

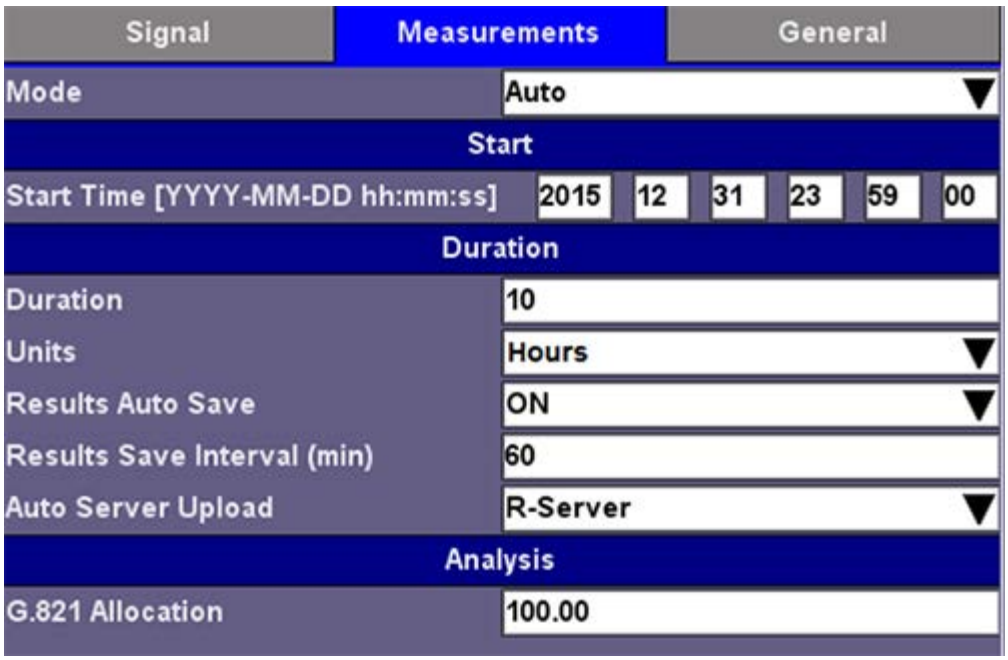
The C37.94 Test Application uses VeEX's signature layered test signal configuration user interface, allowing users to build the desired test signal using an intuitive flow chart structure. Tap on each box to have access to all applicable parameters that can be configured.



- **Hierarchy:** No selection. Fixed to C37.94.
- **Interface:** Let users select the Clock Source to be used to drive the optical interface.
  - **Internal:** Uses the test set's oscillator to generate the TX test signal.
  - **External:** Uses an external reference clock source applied to the CLK input in the connector panel.
  - **From RX:** Uses the clock recovered from the received signal to time the TX test signal.
  - **Offset:** Adds frequency offset to the internal oscillator to stress the far end receiver clock recovery circuits and verify it complied with the minimum ±100 ppm deviation tolerance required by the standard.
- **Payload:** Allow users to configure the TX data rate by entering the number of Nx64 kbit/s data Channels to be used for the test. N can be any number between 1 and 12.
  If the RX is already connected to the far-end signal, this screen will also show the N value sent by the far end and auto configure the test set's receiver to match. The Received Channels information can also be used to confirm the N value to be configured in test set's TX channels.
- **Pattern:** C37.94 is a datacom interface and it is always tested with a bulk constant bit rate (CBR) payload carrying a pseudo random bit sequence (PRBS) or test pattern, to identify any data errors.

18.3.1.2 Measurement Setup

Select this tab to configure how the BER test behaves. The menu fields will change depending on the selections made.

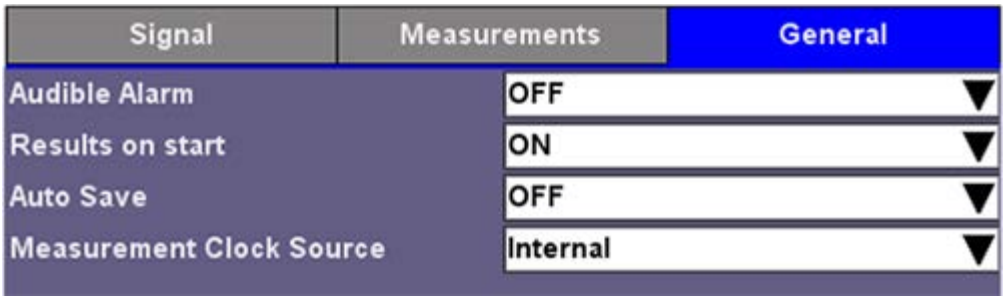


- **Mode:**

  - **Manual:** User starts and stops the test.
  - **Timed:** Allows user to program the duration of the test. When the set time has elapsed, the test set automatically stops the test.
  - **Auto:** Programmable start time. Users can enter the exact date and time when they want the test to start and its duration. Press the Start button to trigger the function and leave the test set on. Note that no measurements are made until the test starts.
- **Auto Save:** The test set can also be programed to automatically save results at specific intervals. When enabled, users can also select to automatically upload these results to a centralized R300-Server (requires Advanced Management option and R-Server account) or to an FTP server. Requires server login.
- **Analysis:** User can program the hypothetical reference configuration (HRX) allocation to be used for the ITU-T G.821 Pass/Fail performance evaluation.
  Three distinct quality levels are defined for an end-to-end path (link); two access links (one at each end) with Local and Medium grade and one long-haul link in the middle with High grade. Local links are allowed 15%, Medium grade are allowed 15% and High grade are allowed 40%, for a total of 100% (Local+Mediun+High+Medium+Local). Enter the appropriate allocation depending on the section of the end-to-end path being tested. In practice, users testing complete links leave this at 100% block error allocation.

18.3.1.3 General Setup

Provides extra configuration parameters applicable to the test.



- **Audible Alarm:** Enables or disables the audible alarm. When enabled the test set buzzer emits a warning tone. This function is test application dependent and may not be available in all test modes.
- **Results on start:** When turned ON, the test set automatically jumps to the Results screen when the Start button is pressed. If set to OFF, user has to manually navigate to the test Results section.
- **Auto Save:** When turned ON, the test set automatically saves the test results when the Stop button is pressed. The file is saved with a temporary name based on the yyyymmdd-hhmmss time stamp format.
- **Meas. Clock Source:** This is a selection of the reference clock that will be used to perform frequency-related measurement on the received signal. Internal mode uses the test set's crystal oscillator, while TX Clock Source uses the clock selection used by the transmitter, as configured in >Setup >Signal >Interface.

Go back to top Go back to TOC

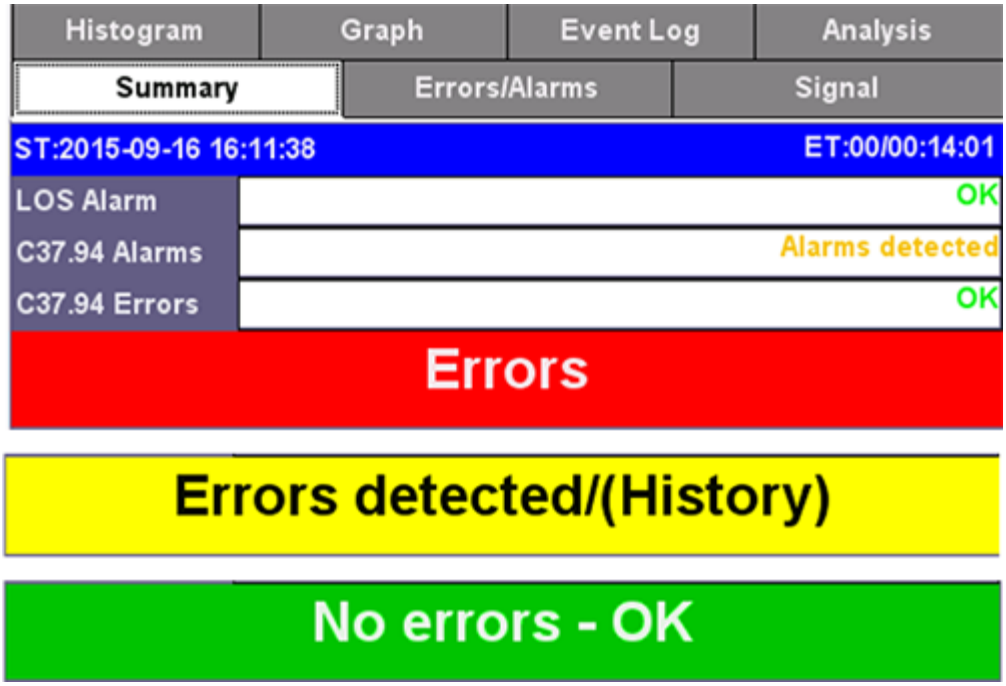
18.3.2 Test Results

In general, the following color coding is used to identify the status.

- **Red:** Errors or alarms are present.
- **Yellow:** Errors or alarms have been detected but no longer present.
- **Green:** Good! No errors or alarms have been detected.

18.3.2.1 Summary

Shows the overall status of the current test.

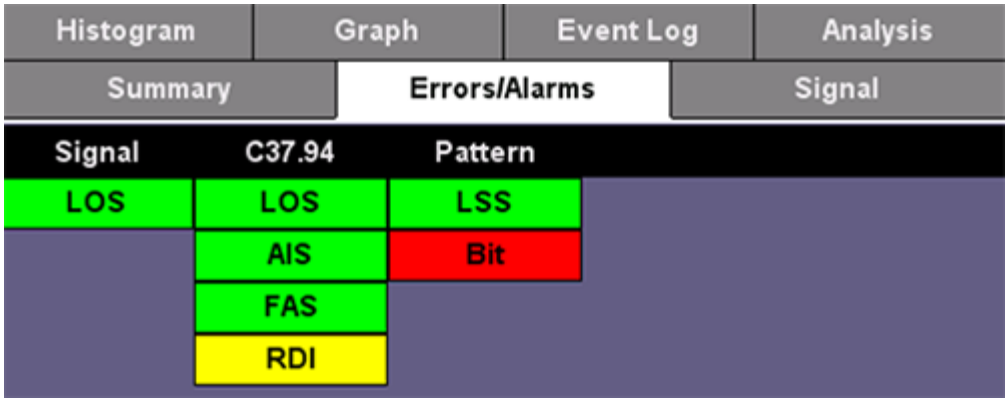


- **ST:** Start Time. Date and time when the test started.
- **ET:** Elapsed Time. Total time that the current test has been running.
- **RT:** Remaining Time. During timed tests it indicates how much time is still left before the test stops.

The bottom banner shows the overall status, while the individual fields at the top provide more information about which layers may have been affected.

18.3.2.2 Errors/Alarms

The first page of this detailed test results report shows a layer-by-layer summary of all Alarms and Errors being monitored. Tap on the individual indicators to quickly access detailed count and rate measurements. The arrow buttons at the bottom can also be used to navigate the results page by page.

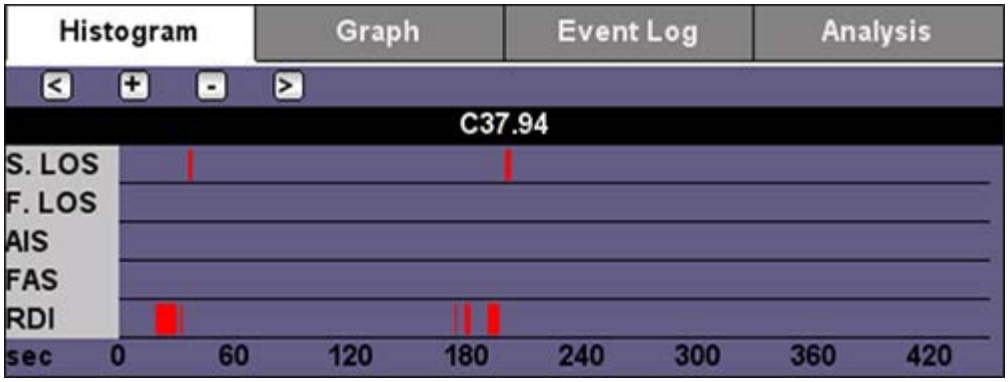


18.3.2.3 Signal

All physical layer information can be found in this tab.

- **Level:** Received optical power readings as reported by the transceiver. Presented in numerical and graphical format.
- **Frequency:** Received clock measurement and clock offset calculation in parts per million (ppm).
- **Optical:** Displays transceiver related information.
- **SFP:** Graphical display of received power level fluctuations over time.

18.3.2.4 Histogram



Shows the correlation of errors and alarms over time. It can be used to correlate intermittent problems to other events (e.g. power loss, storms, etc.) or identify if the problem is cyclic or random in nature. User can zoom in and zoom out using the [+] and [-] buttons to view the results in hours, minutes or seconds. In zoom mode, use the [<] and [>] icons to navigate the different data windows.

18.3.2.5 Graph

Displays the behavior of individual error or alarm in a bar graph format over time. It is used to identify the severity of each event over time to understand the behavior. User can zoom in and zoom out using the [+] and [-] buttons to view the results in hours, minutes or seconds. In zoom mode, use the [<] and [>] icons to navigate the different data windows.

18.3.2.6 Event Log

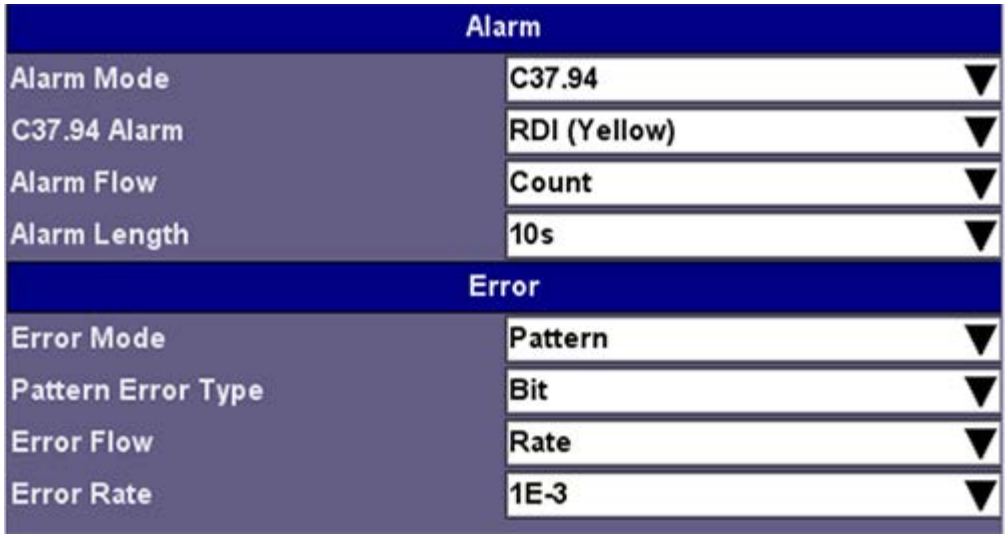
Shows a time-stamped sequence of all events detected during the test, including the length or error count for each of the events.

18.3.2.7 Analysis

Shows G.821 out-of-service BER performance analysis with Pass/Fail evaluation. Errored Second (ES), Severely Errored Seconds (SES), Available Seconds (AS), Unavailable Seconds (UAS), Error Free Seconds (EFS).

18.3.2.8 Alarm / Error

Configures the behavior of the Alarm Generation and Error injection soft buttons.



- **Alarms:** The test set can generate Signal LOS, Frame LOS, AIS and RDI (Yellow), in Continuous or Count (timed) modes. In timed mode the alarms can be set to last 0.1, 1, 10 or 100 seconds.
- **Errors:**
  - **Error Mode:** The test set can inject errors to the C37.94 structure or to the test Pattern.
  - **Error Type:** FAS, Bit
  - **Error Flow:** Determines the behavior of the error injection. It can be set to inject a Single error, a Count or specific number of errors from 1 to 1000, or a continuous error Rate from as low as 1E-9 (1x10-9) to as high as 1E-3

(1x10-3).

Go back to top Go back to TOC

18.3.3 Test Profiles

Test configurations can be saved and later retrieved using the Test Profiles function.

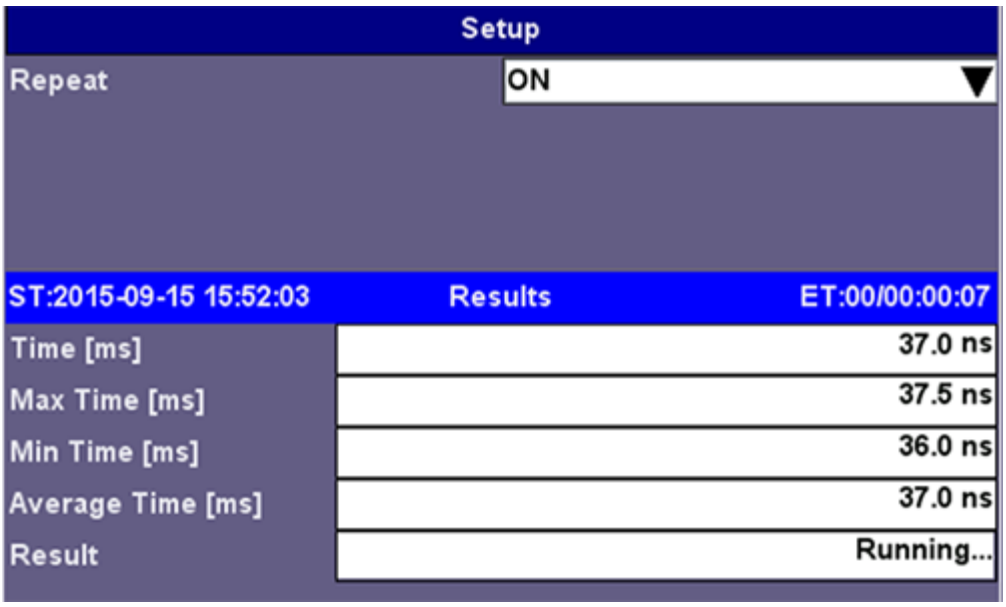
- To save the current test configuration, select the Save As function and use the keypad to give it a name that represents the use case or test scenario for that specific configuration (site, network element, type of link, etc.). Press Apply to save.
- To update a test profile with the current test setup, open the profile pull-down menu and select Save.
- To retrieve a saved test profile, open the profile pull-down menu and select the desired profile from the list. The setting are immediately copied to the test set.
- To delete a test profile, open the profile pull-down menu and select the desired profile from the list to activate it, open the pull-down menu again and select Delete.

Test profiles can also be managed using the test platform File Manager. Go to >Utilities >Files >Saved.

Go back to top Go back to TOC

18.3.4 Round Trip Delay (RTD)

With a loopback at the far-end, the test set can measure the time it takes for test bits to make the round trip. This measures the total fiber length and equipment delay combined. The loopback can be fiber optics, electrical (in case it terminates in other Datacom interface) or logical (triggered inside network elements).

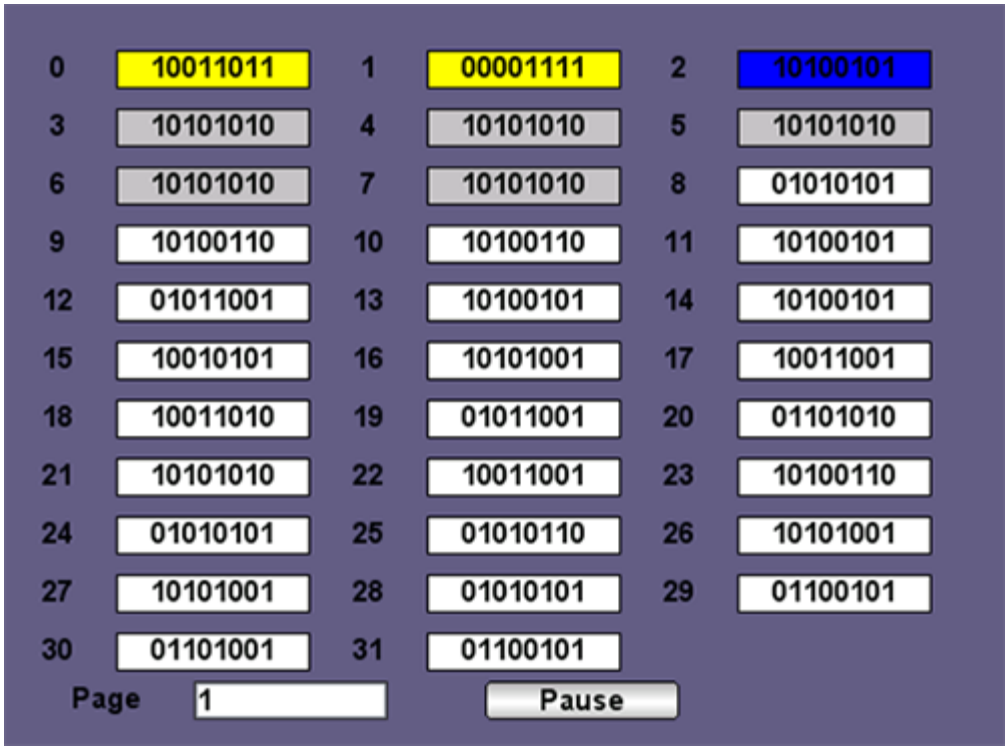


The test can be configured to run a single measurement, Repeat = OFF, if the total delay is not expected to change over time, or Repeat = ON to run it continuously. When Repeat is enabled, the test set will keep track of the Current (last), Maximum, Minimum and Average times measured.

Go back to top Go back to TOC

18.3.5 C37.94 Data (Received)

Displays a sampling of the C37.94 raw data being received, including framing bits (yellow), Overhead N bits and its complements (blue) and the overhead preamble bits (light gray), followed by data bits and their respective complements (white). Note that only the active pairs of bytes (depending on the N value) will be updating. Unused channels (two bytes) will display the idle code 10101010 10101010 .



The Page field at the button is to view up to 16 captured frames. Odd frames show Framing Pattern 1 and even frames show Framing Pattern 2, including the RDI (Yellow) alarm bit.

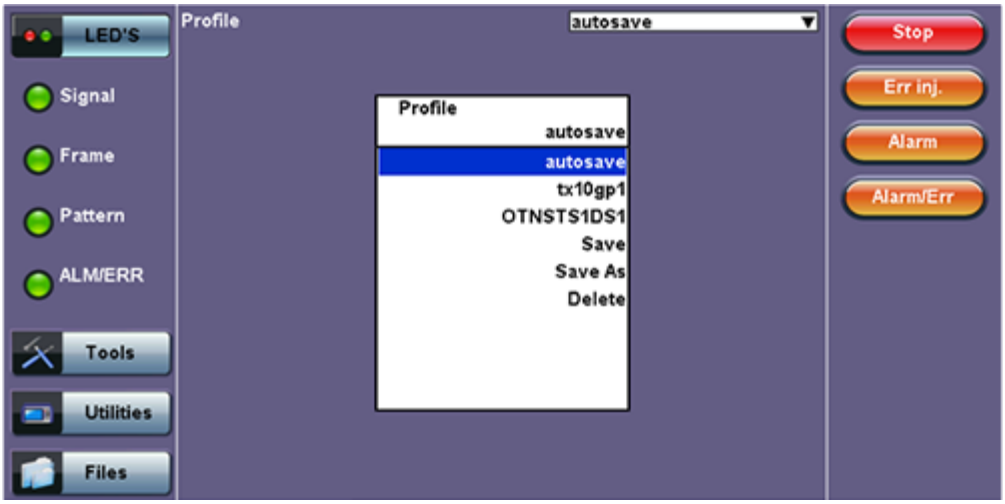
Use the Pause button to freeze the 16 frames.

Go back to top Go back to TOC

19.0 Profiles

Profiles can be created in any application that has a "Profiles" drop-down menu available. The PDH, SDH, OTN, Ethernet and Fiber Channel applications all have the ability to save profiles.

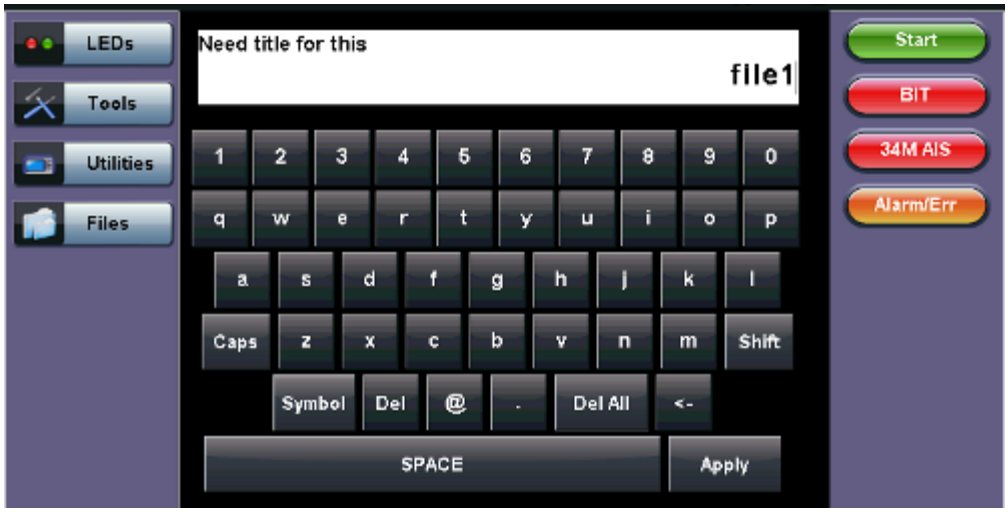
Profiles can be viewed and loaded in the Profiles folder located in the Files folder structure.



Accessing and Configuring Profiles

To access the Profiles menu from the **OTN/SDH/SONET** Testing main menu, tap on the following icons: **Advanced Mode** > **Profiles**. To save a new profile from the PDH or SDH applications mentioned above, select the **Save as** drop-down option. This will bring up an alphanumeric keypad to name the profile. When the profile is saved, all of the test configurations that apply to the particular application are saved. This allows for fast access to preconfigured test configurations.

Alphanumeric keypad



Go back to top Go back to TOC

20.0 Common Functions

Please refer to the TX300S Platform manual for the following functions:

- IP Tools: Ping, Trace Route
- Net Wiz
- WiFi Wiz
- Advanced Tools
- Utilities
- Files
- R-Server
- Backlight
- VeExpress
- M.Upgrade

Go back to TOC

21.0 Warranty and Software

Warranty Period: The warranty period for hardware, software and firmware is stated in the Warranty Card that came with the product (identified by the affixed serial number label). Coverage starts on 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

Go back to top Go back to TOC

22.0 Product Specifications

The 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.

Go back to TOC

23.0 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

Go back to top Go back to TOC

24.0 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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Go back to top Go back to TOC