JDSU ONT-503/506/512 Optical Network Tester

August 2009

40/100 GE
see separate datasheet!

JDSU

40/100 GE see separate datasheet!

ONT-503

- 3 slots to take any combination of modules up to 43G
- Portable
- Early deployment, LAB, SVT
- 15"TFT display

ONT-506

- 6 slots to take any combination of modules up to 43G
- Desktop
- Early deployment, LAB, SVT
- 15"TFT display

ONT-512

- 12 slots to take any combination of modules up to 43G
- Rack mount
- Multi-port load testing with high port count

Key Features

- **Multi-Application**
  Ethernet, OTN, Jitter/Wander, SDH/SONET, VCAT, GFP, Fibre Channel, DSn/PDH
- **Multi-Port testing**
  All interfaces run simultaneously and independently
- **Multi-User** to share modules with log-in control
- **Multi-Channel test** checks SDH/SONET channels simultaneously
- Industry-leading **40/43G SDH/SONET/OTN and unframed BERT** testing with jitter/wander capability
- **Highly accurate Jitter/Wander test** according to ITU-T O.172 Appendices VII (incl. Accuracy Map) + VIII and according to ITU-T O.173
- **Module-E 10G**: all rates covered from 9.95 to 11.32 G
- **Automation made easy** via Linux OS, Tcl/Tk, C- and LabWindows driver libraries with Ethernet and GPIB connectivity
- Various mainframes **ONT-503/506/512 with 3/6/12 slots**

Testing design and conformance of 40/43G networks and line cards

The JDSU Optical Network Tester (ONT) platform is a multi-functional, multi-port and multi-user solution for fast and flexible testing of optical network environments. The ONT is available in three models: the ONT-503, a three-slot tester with an intuitive 15-inch touch screen that combines lab testing needs with a portable form factor weighing less than 15 kg (33 lbs.) when fully equipped for 40/43G; the ONT-506, a 6-slot test solution that also has the 15-inch touch screen and is engineered for local and remote controlled applications; and the ONT-512, a 12-slot, rack-mounted mainframe test solution. All ONT testers support testing up to 40/43 G, and the ONT-506 and ONT-512 provide physical layer jitter/wander testing from 155 Megabits per second (Mb/s) up to 43 Gigabits per second (Gb/s) to address the bandwidth demands being placed on metro and long haul networks and network elements by the deployment of triple-play services.

All ONT models are designed to address the optical and digital testing needs in research and development (R&D), service verification testing (SVT), production and troubleshooting. JDSU offers a range of plug-in instrument modules for packet based services like Ethernet and Fibre Channel as well as for frame based services like OTN and SDH/SONET and legacy services DSn/PDH and most services also in combination with Jitter/Wander. Designed to keep pace with the high-speed evolution of today's communications technology, the ONT is the essential test tool for manufacturers, early technology installers, network operator verification labs and tier-3 support of optical networks. EoS, 10 Gigabit Ethernet (GigE) with native and OTN overclocked and forward error correction (FEC) and 40/43 G test functionality are the newest additions.

This catalog provides a detailed overview of the ONT product family and its modules, software and technology variations. For more information please contact your JDSU sales representative.

Design and conformance testing of NextGeneration transport networks

Multi-application and multi-port configuration

40/43G Solution
- SDH/SONET, OTN (optional)
- Unframed testing
- 40/43G NRZ and 43G DPSK

40/43G jitter/Wander Solution
- SDH/SONET, OTN (optional)
- Highly accurate jitter evaluation according to new O.172 Appendices VII + VIII
- Wander (optional)

Module-E 10G
- 9.9 to 11.3 Gb/s unframed
- 10G LAN/WAN/FC/SDH/SONET, OTN and overclocked (optional)
- Electrical interfaces 10G (optional)

10G-D Jitter Module
- High-accurate jitter evaluation according to O.172 Appendices VII + VIII
- Adds jitter to module-E 10G
- Adds jitter at 9.9G, 10.3G (optional) and 10.7G (optional)
- Adds wander (optional)

DSn/PDH Modules
- Unframed, framed and muxed DSn and PDH signals
- Single and dual ports

Ethernet Modules up to 1 Gb/s
- Optical and/or electrical interfaces
- Ethernet MAC
- Ethernet link

OTN 2.5/2.7G-B Module
- OTN/SDH/SONET (PoS optional)
- Multi-Channel SDH/SONET (optional)
- Jitter/wander version -C (optional)

OTN 10/10.7G (-B) Module
- OTN/SDH/SONET (PoS optional)
- Multi-Channel SDH/SONET (optional)

Multi-Channel Extension Module
- Adds Multi-Channel SDH/SONET to 2.5/10G, OTN and NewGen modules

2.5G-B/10G (-B) Modules
- SDH/SONET (PoS optional)
- Multi-Channel SDH/SONET (optional)

2.5G-C, 2.5/2.7G-C Jitter Module (155 Mb/s to 2.7 Gb/s)
- Highly accurate jitter evaluation according to O.172 Appendices VII + VIII
- Adds jitter to 2.5G-B module
- Adds jitter to NewGen module 2.5G-B
- Adds jitter to OTN module 2.5/2.7G-B
- Wander (optional)

NewGen Solution 2.5G-B/10G
- Ethernet over SDH/SONET (EoS)
- Ethernet MAC
- LCAS, GFP, differential delay
- SDH/SONET (PoS optional)
- Multi-Channel SDH/SONET (optional)
- GFP-T (optional)
- Jitter/wander for version 2.5G-B (optional)

4

Mainframes

ONT-503 mainframe, 3 slots, 15" TFT display		**BN 3075/01**	
ONT-506 mainframe, 6 slots, 15" TFT display		**BN 3062/01**	
ONT-512 mainframe, 12 slots, rack mount		**BN 3061/01**	
Modules and options	**Slots required**		**Page**
Module-E 10G LAN/WAN/FC/SDH/SONET/OTN			
Module-E 10G XFP slot	2	BN 3061/92.10	7
Module-E 10G XFP slot (ONT-503)	1	BN 3075/92.10	7
Module-E 10G 1310 nm	2	BN 3061/92.11	7
Module-E 10G 1310 nm (ONT-503)	1	BN 3075/92.11	7
Module-E 10G 850/1310 nm	2	BN 3061/92.12	7
Module-E 10G 850/1310 nm (ONT-503)	1	BN 3075/92.12	7
Module-E 10G 1310/1550 nm	2	BN 3061/92.13	7
Module-E 10G 1310/1550 nm (ONT-503)	1	BN 3075/92.13	7
Module-E 10G 850/1310/1550 nm	2	BN 3061/92.14	7
Module-E 10G 850/1310/1550 nm (ONT-503)	1	BN 3075/92.14	7
Electrical interfaces 10G	–	BN 3061/92.19	7
OC-192c/STM-64c BERT	–	BN 3061/93.35	24
SDH/SONET Single Channel	–	BN 3061/93.36	24
Multi-Channel 10G High Order	–	BN 3061/93.37	27
10G VCAT High Order	–	BN 3061/93.39	20
10G GFP-F	–	BN 3061/93.45	18
10G Fibre Channel	–	BN 3061/93.46	22
10GigE LAN	–	BN 3061/93.47	12
10GigE WAN	–	BN 3061/93.48	17
OTN 10.7 G	–	BN 3061/93.49	29
OTN 11.05/11.1 G	–	BN 3061/93.50	29
OTN 11.27/11.32 G	–	BN 3061/93.51	29
OTN Data (11.05/11.1/11.27/11.32 G)	–	BN 3061/93.52	29
OTN 10.7 to 11.32 G	–	BN 3061/93.53	29
OTN Multiplexing OTU2	–	BN 3061/93.54	32
MAC-in-MAC 802.1 ah	–	BN 3061/93.60	13
IPv6	–	BN 3061/93.62	13
Capture MAC/IP	–	BN 3061/93.65	17
10G Transport Solution	–	BN 3061/93.75	78
10G VCAT High Order Solution	–	BN 3061/93.76	78
10G Ethernet Solution	–	BN 3061/93.77	78
10G OTN Multiplexing Solution	–	BN 3061/93.78	78
10G Multi-Channel High Order Upgrade	–	BN 3061/93.79	78
Jitter module 10G-D 1310 nm	+ 1	BN 3061/90.86	8
Jitter module 10G-D 1550 nm	+ 1	BN 3061/90.88	8
Jitter 10.3G	–	BN 3061/93.70	8
Jitter 10.7G	–	BN 3061/93.71	8
Wander 10/11G	–	BN 3061/93.95	10
Wander DS1/E1 + BITS	–	BN 3061/93.96	10
Wander 10/11G Expert	–	BN 3061/93.97	10

5

ONT-5xx Mainframes

Key features

- Interchangeable plug-in modules for most flexible use
- Linux operating system
- Easy test automation with full featured driver support

ONT-503

- 3 slots to cover multiple ports/applications
- Portable
- Large 15″ TFT touchscreen

ONT-506

- 6 slots to cover multiple ports/applications
- Desktop
- Large 15″ TFT touchscreen

ONT-512

- 12 slots to cover multiple ports/applications
- Rack-mount chassis

'Plug-in' modules allow for easy upgrade in the field and exchange of interfaces among ONT-503 mainframes as well as between ONT-506 and ONT-512 mainframes.

All modules use the same software concept. Therefore, developed scripts can be used and training times for users are minimized.

General specifications

Power supply (nominal range of use)

AC line voltage	100 to 240 V
AC line frequency	50/60 Hz, ± 5%
Power consumption (fully equipped)	
ONT-503	max. 350 VA
ONT-506	max. 650 VA
ONT-512	max. 1000 VA
Safety class to IEC 61010-1	Class I

Ambient temperature

Nominal range of use	+5 to +40 °C/41 to 104 °F
Storage	–25 to +45 °C/–13 to +113 °F
Transport	–40 to +70 °C/–40 to 158 °F

Weight and dimensions

Dimensions, including handle/bumpers (w × h × d)

ONT-503	360 × 392 × 185 mm, 14.1 × 15.4 × 7.3 in
ONT-506	450 × 335 × 435 mm, 17.7 × 13.2 × 17.1 in
ONT-512	464 × 327 × 523 mm, 18.2 × 12.9 × 20.6 in 7.5 rack unit height is required in a 19″ rack for stacking

Weight, without modules

ONT-503	approx. 10 kg/ 21.5 lb
ONT-506/512	approx. 17 kg/ 37.5 lb

Clock and synchronization

Internal master clock accuracy	± 2.0 ppm (Exceeds T1.101 stratum 3/3E accuracy)

External synchronization

Connector, unbalanced	75 Ω, BNC jack
Clock source	DS1, E1, 1544 kHz, 2048 kHz, 8 kHz, 1 MHz, 5 MHz, 10 MHz
Connector, balanced	110 Ω, Bantam jack
Clock source	DS1, E1, 1544 kHz, 2048 kHz

From RX

Each module may use its received signal clock information as reference for its transmitter.

Clock output

Connector, unbalanced	75 Ω, BNC jack
Connector, balanced	110 Ω, Bantam jack (ONT-506/512)

Instrument operation

The ONT-5xx, which uses the Linux operating system, supports three types of operation:

- Local GUI via built-in touchscreen (ONT-503, ONT-506)
- Local by connecting screen/ mouse/ keyboard (ONT-512)
- Customer script controlled for test automation
- Remote control for test automation via LAN and GPIB
- Remote operation via LAN

Touchscreen display (ONT-503 and ONT-506)

Large color TFT	15″
Resolution	1024 × 768 (XGA)

Interfaces, storage, data transfer

The ONT-5xx use a Pentium PC as internal controller allowing to run Linux applications as well.

Interfaces	Ethernet (RJ45), 4 x USB, External keyboard, mouse, VGA, DVI
PC Pentium M, 1.8 GHz, 1 GB RAM	
Hard drive for data/setup storage	≥ 40 GB

Remote control for test automation

The ONT-503/506/512 is controlled remotely via SCPI commands sent by the customer's program using an Ethernet TCP/IP or a GPIB connection. The GPIB connection is possible via USB-GPIB cable, provided by National Instruments.
Modules are addressed independently and in parallel and may be shared among multiple users. In case of GPIB one module can be addressed.
Universal driver libraries facilitate automation with specific support for individual applications.
Scripting support via Tcl/Tk and C libraries and LabWindows drivers.
The interactive GUI also works in parallel to remote control, so that it is very easy to develop automated scripts.

Modules and Options

JDSU offers a complete line of optical connectors for all optical interfaces. A list of available connectors is shown in the ordering information section of this data sheet. All modules include the required number of connectors.

Module-E 10G

Highlights

- Switchable **built-in optics** and/or configurable **XFP slot**
- 10 unframed bit rates from 9.95 up to 11.31 Gb/s
- Wide offset range generation **± 500 ppm**
- Differential **electrical interfaces** (optional) with adjustable output voltages
- Jitter and Wander capable optical and electrical interfaces (optional)

Module-E 10G XFP slot Optics via XFP slot	BN 3061/92.10
Module-E 10G XFP slot (ONT-503) Optics via XFP slot	BN 3075/92.10
Module-E 10G 1310 nm Optics built-in 1310 nm	BN 3061/92.11
Module-E 10G 1310 nm (ONT-503) Optics built-in 1310 nm	BN 3075/92.11
Module-E 10G 850/1310 nm Optics XFP 850 nm, built-in 1310 nm	BN 3061/92.12
Module-E 10G 850/1310 nm (ONT-503) Optics XFP 850 nm, built-in 1310 nm	BN 3075/92.12
Module-E 10G 1310/1550 nm Optics built-in 1310/1550 nm switchable	BN 3061/92.13
Module-E 10G 1310/1550 nm (ONT-503) Optics built-in 1310/1550 nm switchable	BN 3075/92.13
Module-E 10G 850/1310/1550 nm Optics XFP 850 nm, built-in 1310/1550 nm switchable	BN 3061/92.14
Module-E 10G 850/1310/1550 nm (ONT-503) Optics XFP 850 nm, built-in 1310/1550 nm switchable	BN 3075/92.14

For XFP optics and software options see "Ordering Information".
The modules support unframed signals for all rates. With additional software options it provides a broad application range of LAN, WAN, FC, SDH, SONET, OTN.

Interface specifications

Optical interfaces

Module-E supports a combination of built-in and pluggable XFP optics. Wavelengths 1310 and 1550 nm are built-in and switchable, 850 nm is always a pluggable XFP.

Supported rates		9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 11.049, 11.095, 11.270, 11.318 Gb/s
Wavelengths (depend on option)		850, 1310, 1550 nm
Output level	850 nm	-7 to -1 dBm
	1310 nm	-6 to -1 dBm
	1550 nm	-2 to +2 dBm
Receiver wavelength 1310/1550 nm		1260 to 1580 nm
Sensitivity	850 nm	-7.5 to -1 dBm
	1310 nm	-11 to -1 dBm
	1550 nm	-14 to -1 dBm
Max. input power (destructive)		+ 2dBm
Connector types built-in optics		Exchangeable adaptors
Connector types XFP optics (850 nm)		Twin LC

Clock output

Source	Internal reference, from RX, clock module inputs
Output frequency	All rates f/16, f/64 switchable
Output level (AC coupled)	Single 400 mVpp Differential 800 mVpp
Connector	Two SMAs / 50 Ω

Electrical interfaces

Electrical interfaces 10G *3061/92.19*

The hardware option provides differential electrical interfaces for all rates and signals 9.95 up to 11.32 Gb/s available with Module-E. The additional High-Speed-Trigger allows particular applications during the hardware design of 10G boards. It is realized with a special XFP plug-in. The electrical interfaces are integrated in the 2nd slot of Module-E and can be ordered with the 2-slot Module-Es BN 3061/92.10 ....14.

Supported rates	9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 11.049, 11.095, 11.270, 11.318 Gb/s

TX NRZ data out

Output rates	9.953 to 11.32 Gb/s
TX offset	± 500 ppm
Output level (AC coupled) adjustable	Single 50 to 1100 mVpp Differential 100 to 2200 mVpp
Step size	1 mVpp
Connector	Two SMAs / 50 Ω

High-speed TX clock out

Clock is not phase aligned with RX Data out

Source	Internal reference, from RX, Clock module inputs, sync clock in
Output frequencies	9.95 to 11.32 GHz
TX offset	± 500 ppm
Output level (AC coupled) selectable	Off, low, normal, high Single 200, 300, 400 mVpp Differential 400, 600, 800 mVpp
Variation in 1% steps	± 50%
Max. output level	1000 mVpp
Connector	Two SMAs / 50 Ω

RX NRZ data in

Built-in clock recovery

Input rates	9.95 to 11.32 Gb/s
Input offset	± 200 ppm
Input level (AC coupled)	Single 100 to 1100 mVpp
	Differential 50 to 2200 mVpp
LOS detection diff.	Off, 120 mVpp typ.
Connector	Two SMAs / 50 Ω

Sync clock in

Input clock is jitter filtered (~10Hz)

Input rates	f/16 and f/64 switchable
Input offset	± 80 ppm
Input level (AC coupled)	Single 100 to 1000 mVpp
	Differential 50 to 2000 mVpp
LOS detection diff. (LTI)	40 mVpp typ.
Connector	Two SMAs / 50 Ω

High-speed trigger out

For trigger signals with high timing accuracy requirements.
The trigger period corresponds with frame, block or pattern period.
The trigger signal can be used to trigger an oscilloscope or other test equipment.
The trigger pulse length is fixed, the trigger phase is adjustable.
This trigger output is realized by placing a special XFP inside the XFP slot, so that it can be used in conjunction with the built-in optics or the electrical interface.

Trigger events	Frame trigger SDH/SONET/WAN/OTN, Pattern trigger PRBS/DW/A-/B-seed/Square wave/66B block
Trigger every pattern interval	SDH/SONET/WAN/OTN A-/B-seed, PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1
Trigger every 2nd pattern interval	PRBS 2^{7}-1
Trigger every 4th pattern interval	DW32
Trigger every 16th pattern interval	Square wave
Trigger every 64th pattern interval	66B block
Trigger delay to data out	0 to ± t.b.d. ns
Trigger pulse duration	4 bits
Trigger frequency	Depend on pattern
Trigger phase	Adjustable positive and negative
Trigger phase step	1 bit
Trigger phase adjustment	Depends on pattern
Output level (AC coupled)	Single-ended 400 mVpp
Connector	SMA / 50 Ω

Jitter Module 10G-D with 10/10.3/10.7G

Jitter Module 10G-D 1310 nm *BN 3061/90.86*

Together with the Module-E in the different versions, the jitter module provides jitter function at 9.95 Gb/s. The optical interface is 1310 nm.

Jitter Module 10G-D 1550 nm *BN 3061/90.88*

Together with the Module-E in the different versions, the jitter module provides jitter function at 9.95 Gb/s. The optical interface is 1550 nm.

Software Option Jitter 10.3G *BN 3061/93.70*

Enables Jitter at the service bit rate of 10.3 Gb/s to measure Synch Ethernet .

Software Option Jitter 10.7G *BN 3061/93.71*

Enables Jitter at the service bit rate of 10.7 G b/s for OTN

Standards

Jitter and wander are generated and analyzed in accordance with the following standards:

- ITU-T Recommendation O.172 including Appendices VII + VIII with Accuracy Map support at 10 Gb/s
- ITU-T Recommendation O.173
- ITU-T Recommendations G.825, G.8251, G.8261, G.8262
- Telcordia GR-253 (September 2000)
- ANSI standards T1.101, T1.105, T1.105.03

Supported rates for digital measurements	
	9.953, 10.00, 10.313, 10.519, 10.709 Gb/s
Wavelengths (depend on option)	1310, 1550 nm
Output level	1310 nm -3 to +2 dBm
	1550 nm -3 to +2 dBm
Receiver wavelength	1310/1550 nm 1260 to 1580 nm
Sensitivity	-14 to -3 dBm
Max. input power (destructive)	+ 2dBm
Measuring optical input power	-14 to 0 dBm
Connector types built-in optics	Exchangeable adapters

Electrical interfaces

Impedance	AC coupled 50 Ω
Connector type	SMA
Generator data signal	
Code	Scrambled NRZ
Output level	> 200 mVpp
Generator clock signal	
Output level	> 200 mVpp
Receiver data signal	
Code	Scrambled NRZ
Input level	100 to 600 mVpp

Clock output

Source	Internal reference, from RX, clock module inputs
Output frequency	All rates f/16, f/64 switchable
Output level (AC coupled)	Single 400 mVpp
Differential	800 mVpp
Connector	Two SMAs / 50 Ω

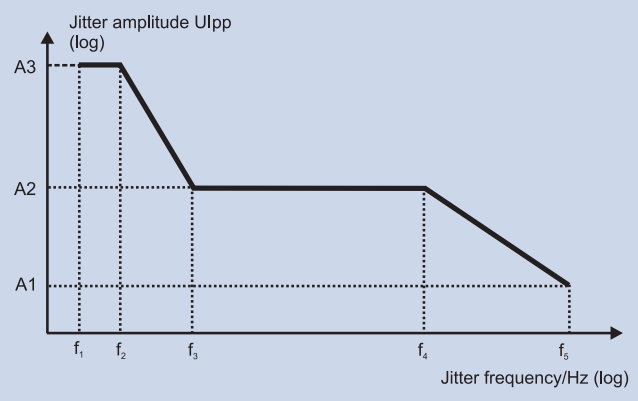
Jitter generator

Meets or exceeds the requirements of ITU-T Recommendations O.172 and O.173.

Bit rate	9.953, 10.313 and 10.709 Gb/s
Offset	± 150 ppm
Modulation	Internal or external
Jitter modulation signal	Sine wave

Built-in modulation generator

Jitter amplitude	up to 3200 UIpp
Step width	0.001 UI



Amplitude in [UIpp]			Frequency in [Hz]				
A_1	A_2	A_3	f_1	f_2	f_3	f_4	f_5
0.5	6	3200	10	100	50 k	6.67 M	80 M

Generation accuracy conforming to ITU-T O.172 and O.173

External modulation input

BNC, 75 Ω

Modulation frequency	0.1 to 80 MHz
Input voltage range	0 to 2 Vpp

Jitter analyzer

Meets or exceeds the requirements of ITU-T Recommendations O.172 and O.173.

Bit rate	9.953 and 10.709 Gb/s
Offset permitted	± 20 ppm
Bit rate	10.313 Gb/s
Offset permitted	± 100 ppm
Electrical data input	SMA, 50 Ω,
Input level	100 to 600 mVpp

Measuring ranges/resolution

Standard Range

Peak-Peak	0 to 50 UIpp / 1 mUIpp
RMS	0 to 25 UIpp / 0.1 mUIpp

Extended Range

Peak-Peak	0 to 3200 UIpp / 0.1UIpp
RMS	0 to 1600 UI / 0.01UI

Built-in filters

High pass filters cutoff frequency	20 kHz, 50 kHz, 4 MHz
Low pass filter cutoff frequency	8 MHz, 80 MHz

Accuracy of the measurement

Peak-Peak I	Fixed error 15 mUIpp*

* Optical input power level -10 dBm to -12 dBm, mapping SDH VC-4/ SONET STS-1, payload pattern PRBS 2^{31}-1, environmental temperature +20 °C to +30°C.

Demodulator output

BNC, 75 Ω

Jitter testing 10 Gb/s, 10.3 Gb/s and 10.7 Gb/s

Supports all manual and automatic measurements for jitter evaluations.

Jitter measuring modes

Current values (continuous measurement): Peak-Peak, positive peak, negative peak, RMS

Maximum values (gated measurement): Peak-Peak, positive peak, negative peak

Logged values (repetitive measurements): Peak-Peak, positive peak, negative peak

Phase hits

The instrument detects when the programmable threshold for positive and negative jitter values is exceeded and the result indicates how often the threshold was exceeded.

Jitter versus time

This function is used to record variations of jitter with time and allows the positive and negative peak values, peak-to-peak values, and RMS values to be displayed versus time. Duration is up to 99 days.

Automatic jitter measurements

Selective jitter transfer function (JTF)

The JTF shows the ratio of the jitter amplitude at the output of the device under test (DUT) and at the input at various frequencies. Standard tolerance masks are available and can be edited.

Maximum tolerable jitter (MTJ)

The jitter module automatically determines the maximum jitter amplitude tolerated by the DUT at selected jitter frequencies. The maximum permissible jitter amplitude can be precisely determined using a successive method. The module determines the exact limit value. Several error sources are selectable. Standard tolerance masks are available and can be edited.

Fast maximum tolerable jitter (Fast-MTJ)

This extremely fast measurement tests the device under test for conformance to the standard tolerance mask limits for maximum tolerable jitter. The editable frequency/amplitude values are set sequentially and the test pattern is monitored for the permitted threshold by the receiver. The result of each measurement is shown in a table as a status message.

Wander testing 10 Gb/s, 10.3 Gb/s and 10.7 Gb/s

Software Option Wander 10/11G *BN 3061/93.95*

This software option is only available in conjunction with jitter modules (BN 3061/90.86 or /90.88) and **enables wander generation** (sine wave) and analysis at 10 Gb/s, 10.3 Gb/s (if available) and 10.7 Gb/s (if available).
Fully complies with or exceeds the requirements of ITU-T O.172.

Software Option Wander DS1/E1 + BITS *BN 3061/93.96*

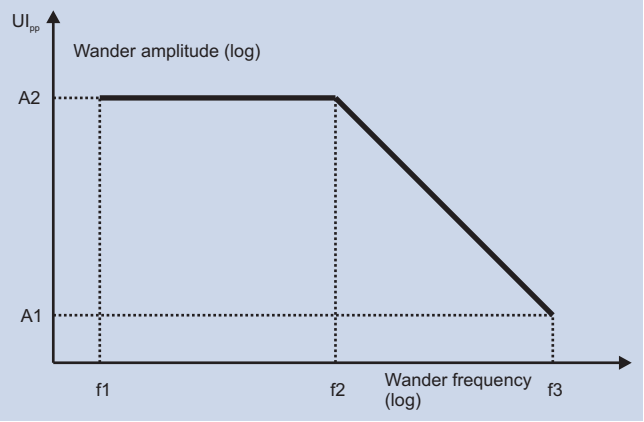
This software option is only available in conjunction with Wander 10/11G (BN 3061/93.95) and enables wander generation (sine wave) at DS1/E1 and BITS, and supports wander analysis at DS1/E1.

Wander 10/11G Expert *BN 3061/93.97*

This software option adds White/TDEV noise to BN3061/93.95 and /93.96, and enables the Wander Transfer Function. White/TDEV noise according Telcordia GR-253, ANSI T1.101 and ITU-T G.812/13, G.8261/G.8262

Wander generator and analyzer 10/11 Gb/s (BN 3061/93.95)

Modulation signal	Sine wave, White/TDEV noise (BN 3061/93.97)
Amplitude range	0.1 to 320 000 UI
Amplitude step width	0.1 UI
Frequency range	10 µHz to 10 Hz
Frequency step width	1 µHz
Generator accuracy	Conforms to ITU-T O.172



Clock offset	A1 in UI	A2 in UI	f1 in µHz	f2 in Hz	f3 in Hz
0 ppm	16 000	320 000	10	0.5	10

Four different sampling rates are available for detailed analysis versus time:
Sampling rate – Low-pass filter
1/s – 0.1 Hz, 30/s – 10 Hz (O.172), 60/s – 20 Hz, 1000/s – 100 Hz (O.172)

Measurement accuracy	Conforms to ITU-T O.172

Wander generator and analyzer DS1/E1 (BN 3061/93.96)

According to ITU-T G.703

Line rate	DS1 (ESF, AMI), E1 (PCM31 CRC, HDB3)
Connector Bantam	110 Ω, BNC 75 Ω
Modulation signal	Sine wave, White/TDEV noise (BN 3061/93.97)

Four different sampling rates are available for detailed analysis versus time:
Sampling rate – Low-pass filter
1/s – 0.1 Hz, 30/s – 10 Hz (O.172), 60/s – 20 Hz, 1000/s – 100 Hz (O.172)

Measurement accuracy	Conforms to ITU-T O.172

Wander generator BITS/SETS (BN 3061/93.96)

According to ITU-T G.703

Line rate	DS1 (ESF, AMI), E1 (PCM31 CRC, HDB3)
Clock	1544 kHz, 2048 kHz, 6312 kHz, 64 kHz (App. II)
Connector Bantam	110 Ω, BNC 75 Ω
Modulation signal	Sine wave, White/TDEV noise (BN 3061/93.97)

Wander reference signal input

Balanced	Bantam 110 Ω
Clock signals	1.544, 2.048 MHz
Data signals	1.544, 2.048 Mb/s
Unbalanced	BNC 75 Ω
Clock signals	1.544, 2.048, 5, 10 MHz
Data signals	1.544, 2.048 Mb/s

Wander measuring modes

Time interval error (TIE) numerical and graphical, peak-peak wander numerical. TIE values are recorded and available for MTIE/TDEV evaluations and frequency offset and drift rate measurements with graphs and built-in masks that comply with Telcordia GR-253, GR-1244, ANSI T1.101, ETSI ETS 300 462, EN 302 084, ITU-T O.172, G.810 to G.813 and G.8261/G.8262 recommendations.

Automatic wander measurements

Maximum tolerable wander (MTW)

ITU-T G.823, G.825

This application tests the DUT for conformance to the standard tolerance mask limits for wander tolerance and is available in connection with the wander generator. The device under test is subjected to wander at several amplitudes and frequencies and the output signal is monitored for different error sources. The measurement point is then marked as "Pass" (no alarms or errors detected) or "Fail" (alarms or errors detected).

Wander Transfer Function (WTF, option BN 2061/93.97)

This application tests the DUT for conformance to the standard tolerance mask limits for wander transfer function and is available in connection with the wander generator. The stimulus is a noise-modulated signal with defined TDEV. A TDEV evaluation derived from wander measurements taken at the output of the device under test (DUT) is compared against the TX TDEV characteristics. Standard tolerance masks are available and can be edited.

Interface and unframed testing

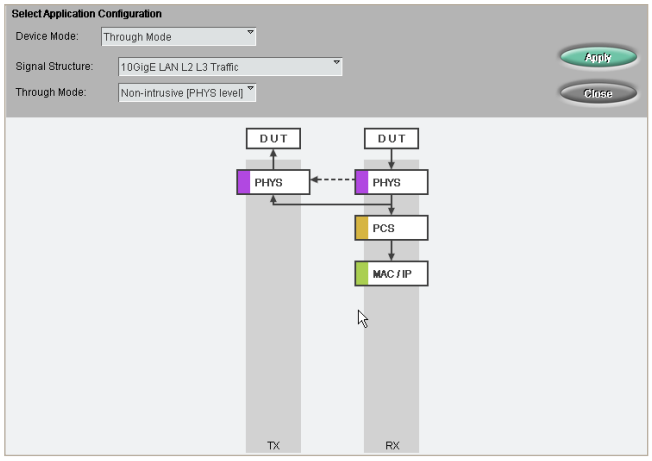
All available rates are offered with unframed pattern and BERT capabilities. These functions are useful especially to qualify XFPs components and DWDM links

Mode

The physical layer supports the following two modes, also when additional layers are attached.

Mode	Terminate, Non-intrusive through-mode

The non-intrusive through-mode implies that no errors/alarms or other modifications can be inserted. For higher layer features the analyzer parts are fully supported. The generator parts are unavailable.



Interface

Transmitter

Frequency offset generation	± 500 ppm
Step size	0.1 ppm
Offset change mode	Step, transition ramp
Transition ramp	5 ppm step in 25 ms

Receiver

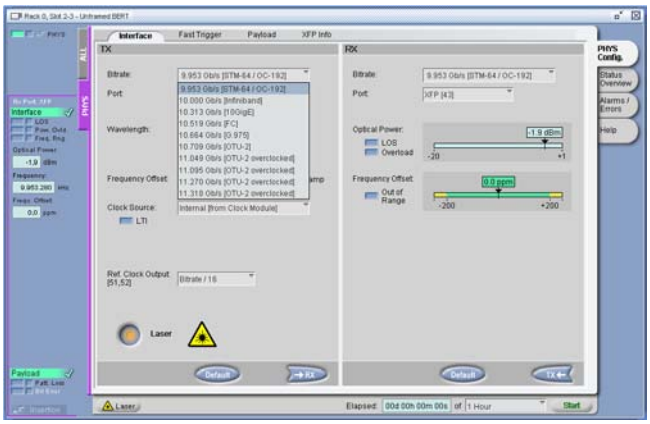
Level measurement resolution	0.1 dBm

Displays the current optical input level and the min/max values with time stamp.

Frequency measurement range	± 200 ppm
Frequency measurement resolution	0.1 ppm

Displays the current signal frequency and the offset in ppm and the min/max offset values in ppm with time stamp.

Bit rates	9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 11.049, 11.095, 11.270, 11.318 Gb/s
Pattern	Unframed pattern Or client signal from higher layer application
Unframed pattern	PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}-1 and inverted, PRBS 2^{31}-1 IEEE, DW 32 bits, square wave (Tx only), repeating ones/zeros editable 4 to 11 bits



Generator

Error insertion

Type	Bit errors (only applicable for unframed pattern)
Trigger	Once, rate
Rate	1×10^{-2} to 1×10^{-12}

Alarm insertion

Type	LOS
Trigger	Continuous

Analyzer

Errors

Type	Bit errors (only applicable for unframed pattern)

Alarms

Type	LOS, power overload, frequency range no XFP available, pattern loss (only applicable for unframed pattern)

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error. Duration in seconds is displayed for each alarm.

Tabular display

Display of all events with time stamps

Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis resolution	Second, minute, hour

Intermediate bit error (only applicable to unframed pattern)

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, count and ratio

10GigE LAN

Highlights

- 10GigE LAN Layer 1 BERT and Layer 2/3 traffic
- **Sophisticated PCS** layer testing with dynamic block errors, coding statistics and block capture
- Additional **VPLS and MAC-in-MAC** Ethernet frame formats
- Up to **256 traffic flows** and **independent receiver filters**
- Up to **10 mixed VLAN/MPLS** tags
- Online **hitless traffic** control
- Real-time QoS, service disruption and packet jitter **analysis per flow**
- **IPv4/v6** and **packet capture**

Software option	*10GigE LAN*	*BN 3061/93.47*
	MAC-in-MAC 802.1 ah	*BN 3061/93.60*
	IPv6	*BN 3061/93.62*
	Capture MAC/IP	*BN 3061/93.65*

Interfaces

See "Interface specification" page 7

Physical layer testing

See "Interface and unframed testing" page 11

PCS testing

Pattern	PCS pattern or client signal from higher layer application
PCS pattern	A seed, B seed
Scrambler	TX/RX on/off independent (only available for higher layer testing)
Minimum inter-packet gap control	Editable 8 to 127 bytes (only available for higher layer testing)

Error insertion

Simultaneous error and alarm insertion is supported

Type	Sync header error, Invalid block type, User defined control block, Line errored frame Pseudo random block error (only available if PCS pattern)
Trigger	Once, continuous, rate, burst once/cont., rate burst once/cont.
Rate	9.9×10^{-3} to 1×10^{-10}
Burst	N = off, M = on
N, M	1 up to 4 294 967 295 events

Alarm insertion

Simultaneous error and alarm insertion is supported

Type	LOBL (loss of block lock), HI BER (high bit error rate), Local and remote fault
Trigger	Continuous, burst once/cont.
Burst	N = off, M = on
N, M	1 up to 4 294 967 295 events (LOBL)
N, M	1 up to 219902 x 125 µs (HI BER)
N, M	1 up to 4 294 967 294 events (Local and remote fault)

Error evaluation

Type	Invalid sync header errors, errored block, invalid block, Invalid block type, LOBL (loss of block lock event), HI BER event, Error propagation, line error frame, Local and remote fault event, IPG violation event (if higher layer traffic), Pseudo random block error (only available for PCS pattern)
Minimum IPG threshold	Editable 5 to 255 bytes
Evaluation (depends on type)	Count, ratio, rate, seconds

Alarm evaluation

Type	LOBL (loss of block lock), HI BER (high bit error rate), Local and remote fault, Link down (only available for higher layer testing), IPG violation evaluation seconds (only available for higher layer testing), Pattern loss (only available if PCS pattern)

Block statistics 64B/66B

Transmit block types	Total, data, control
Transmit control block types	Block format and type
Receive block types	Total, data, control, good, errored, invalid
Receive control block types	Block format and type
Evaluation (depends on type)	Count, ratio, rate

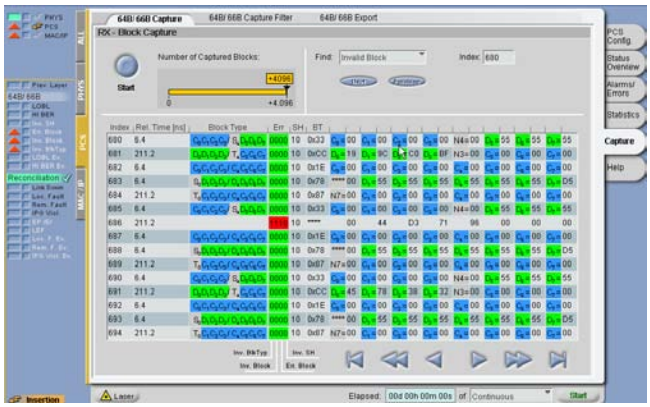
Reconciliation sublayer statistics

Transmit sequence ordered sets	Total, local fault, remote fault
Receive sequence ordered sets	Total, local fault, remote fault
Evaluation	Count, rate

Link bandwidth

Link bandwidth and utilization can be measured with/without minimum IPG.

TX/RX total link bandwidth	Rate in Mb/s
TX/RX link utilization	Ratio in %



Block capture 64B/66B

To analyze detailed behavior of the 64B/66B coding the capture functionality allows a detailed view on particular coding blocks. The numerical evaluation shows content and timestamp of individual blocks, a graphical evaluation gives a characterization of data, control and errored blocks.

Various filters are provided to control the kind of blocks captured.

Captured data	66B blocks, relative time, block number
Number of captured blocks	≤ 4.096
Time stamp resolution	6.4 ns at 10.315 Gb/s
Filter types	Block errors, block types
Error filters	Invalid sync header, invalid block type, Invalid block, errored block
Block type filters	Data block, 16 different control blocks

Error and block type filters can be combined.

Layer 2/3 Ethernet/IP testing

Generator Ethernet/IP

MAC frame generation

Frame type	IEEE 802.3, Ethernet II, IEEE 802.2 LLC, SNAP, VPLS with inner and outer MAC MAC-in-MAC 802.1ah (optional)
IPv4	Is supported for all frame types except VPLS and MAC-in-MAC
IPv6 (optional)	Is supported for all frame types except VPLS and MAC-in-MAC

VLAN tagging

Type	Available for all frame types Single IEEE 802.1q, double (Q-in-Q) IEEE 802.1ad Multiple tags up to 10
Editable parameters	TPI, Priority, CFI/DEI, VID

MPLS labeling

Type	Available for Ethernet II and SNAP frames, Multiple labels up to 10
Editable parameters	Label, CoS (class of service/exp), TTL

MAC addresses

Destination address	User defined, multicast, broadcast
Source address	User defined, factory default

MAC frame size	User defined, Jumbo
Predefined values	64, 128, 256, 512, 1024, 1280, 1518, 2000, 9000, 9600, 10000
User defined	64 to 64k
Dynamic frame size	Incr./decr., random, Max/min user defined
Selectable increment step size	1 to 64k bytes

VPLS framing

Inner frame structure

As per standard Ethernet frame including MAC addresses, VLAN tags (6), Frame Type, Ethertype and payload

Outer frame structure

Parameters	MAC addresses, frame type, Ethertype
Tunnel and VC label	Label, CoS, TTL
Control Word	Reserved bits, sequence number

MAC-in-MAC 802.1ah framing (optional)

Inner frame structure

As per standard Ethernet frame including MAC addresses, VLAN tags and MPLS labels (5), Frame Type, Ethertype and payload

Outer frame structure (PBB/PBT)

Parameters	MAC addresses
B-Tag (up to 2 tags)	TPI, VID, Priority, DEI
I-Tag	TPI, SID, Priority, DEI, NCA, Res1, Res2

IPv4/IPv6/UDP/TCP settings

IP types	IPv4 standard, IPv6 optional
IPv4 basic settings	Port address, default gateway, subnet mask
IPv4 header	ToS, DSCP, Flags, Protocol, TTL Source and destination address
IPv6 header	Traffic class, flow label, next header, hop limit, Source and destination address
UDP, TCP header	Source and destination ports

IPv4 configuration services

To test more than just a point-to-point connection, the complexity of the setup is increasing. Two protocols (DHCP & ARP) help to simplify this task. ARP may be enabled. In addition, DHCP may be enabled.

Payload of MAC or IP frames Test frame or test pattern

Test frame	Time stamp and sequence number
Test pattern	PRBS 2^{31}-1, 2^{23}-1 and inverted All 1s, all 0s, user defined 32 bits
Filling pattern	Editable digital word, PRBS 2^{31}-1

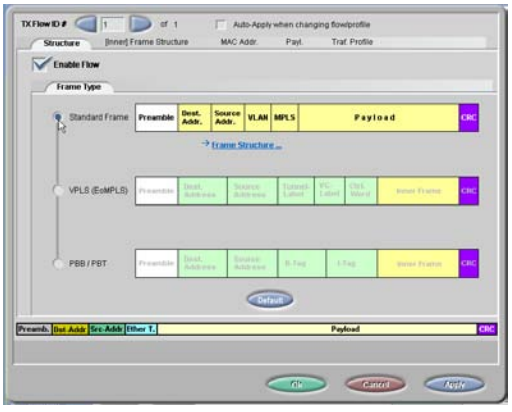
Flow control

Modes	Generation, emulation, analysis
Generation of PAUSE frames	Off, once, continuous
Once	Number of frames per shot 1 to 2^{16}
Pause frame interval	Editable 60 ns to 42 s
Pause quanta	Editable 0 to 64k / 0 to 3.35 ms
Emulation of flow control	Throttling on/off
Analysis of PAUSE frames	See analyzer

Traffic generation

Traffic control

Mode	Bandwidth controlled, Gap controlled
Trigger	Once, continuous
Continuous	Ongoing traffic as defined
Once	Triggers generation of programmed number of frames/bursts per flow (see traffic profiles – burst) All flows are started synchronously



Bandwidth controlled traffic

16 independent user programmable traffic profiles are provided. Every flow is associated with a traffic profile.

Flow bandwidth	Absolute, scaled, limited
Absolute	If the 10GB bandwidth is crossed, flow is scaled accordingly
Scaled	If the scaled bandwidth is crossed, each flow is scaled accordingly
	below the limited bandwidth, all flows are sent unchanged,
	above the limited bandwidth, all flows are scaled accordingly
Flow bandwidth adjustment	in %, Mb/s, fixed values, slide bar

Gap controlled traffic

Gives the user precise and direct control over the IPG sequence generated. Resolution of 1 byte. Can be used in combination with multiple flows.

Traffic flows	up to 256
Parameters independent per flow	Frame type, header
Traffic profiles (frame size)	16 independent

Adding and removing flows does not impact the running flows .

Traffic profiles for bandwidth controlled traffic

Each flow has to be associated with one of 16 independent traffic profiles. Online update of traffic parameters is supported.

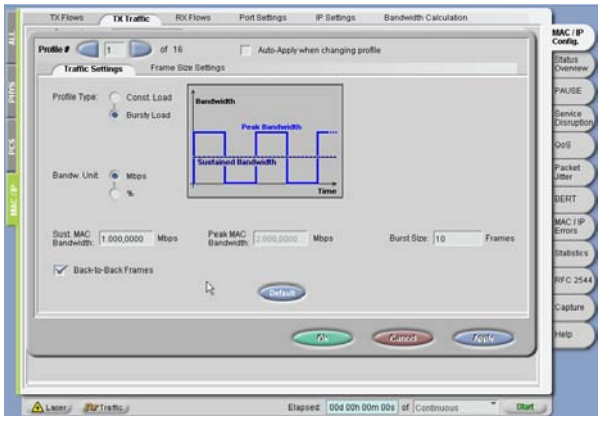
Traffic type	Constant, burst, back to back
Frame size	Editable, fixed values, Dynamic incr./decr., random
Back to back (enables max. bandwidth by forcing the traffic to min IPG)	On/off

Constant mode

Bandwidth	Adjustable utilization in Mb/s and %
Utilization accuracy	0.1%

Burst mode

Peak, sustained bandwidth	Adjustable utilization in Mb/s and %
Burst size	1 to 64k frames
Utilization accuracy	0.1%



Traffic profiles for gap controlled traffic

Each flow has to be associated with one of 16 independent traffic profiles. Online update of traffic parameters is supported

Traffic type	Constant IPG, incr./decr. IPG, random IPG
Frame size	Editable, fixed values, Dynamic incr./decr and random
IPG constant	1 to 2^{24} bytes
IPG incr./decr. start/stop	min to 2^{24} bytes
IPG step size	1 to 64k bytes
IPG random min/max values	min to 2^{24} bytes

MAC/IP error insertion

(all flows and per flow)

Error type	Jabber, Runt, Oversized, FCS errored
MAC error type	Header error
IP error type	Header error
Triggering	Once, continuous, burst once/cont. rate, Rate burst once/cont.
Rate	9.9×10^{-3} to 1×10^{-9}
Burst	M errored, N non errored frames
M, N	1 to 2^{24} frames

Error insertion (per flow only)

Error type (test frame)	Loss, misinsertion, duplication, swapping
Error type (test pattern)	Bit error
Triggering	Once

Generator statistics

Bandwidth	Current and average, Mb/s or %, plus graphics
Bytes total	Count
Frames total	Count and rate
Pause frames	Count, rate, ratio
Bandwidth per flow	Current and average, Mb/s or %
Bytes per flow	Count
Frames per flow	Count, rate, ratio

Analyzer Ethernet/IP

Total link analysis (non flow selective)

Error counts

MAC types	Errored , FCS errored, jabber, runt, oversized
IP types	Header error
Evaluation	Count, rate, ratio, seconds

MAC frame/Byte counts

Bytes	Total
Frames	Total, good, errored, Broadcast, Multicast, Pause, PBB/PBT VLAN: total, single, double, triple, four or more MPLS: total, single, double, triple, four or more Total flow, total non flow
Evaluation (type dependent)	Count, rate, %, and graphics
Pause quanta and time	Last, min, max , count, rate, ratio

IPv4/v6/UDP/TCP Frame/Byte counts

IPv4 frames	Total, total valid, optional header, fragments
ICMPv4 messages	Total, error
IPv6 frames	Total, extension header
ICMPv6 messages	Total, error
UDP/TCP frames	Total
Evaluation	Count, rate, % and graphics

Bandwidth

Total used bandwidth and utilization	
(utilization = used bandwidth/link bandwidth)	
MAC bandwidth types	Port addressed, VLAN/MPLS tagged, PBB/PBT
IP bandwidth types	IPv4/IPv6
Bandwidth results	Current, average in Mb/s, Utilization, share in %

Frame size

Results	Min., max., average
Frame size distribution	Count, rate, ratio Graphical display of results
Distribution classes	64, 65 to 127, 128 to 255, 256 to 511, 512 to 1023, 1025 to 2000, >2000, 1024 to 1518+VLAN, >1518+VLAN

Analysis per flow

MAC/IP flow filtering

The flow filter defines the parameters particular flows have to fulfil to pass the filter and to be analyzed in detail. Others are not looped through to the per flow analysis. Besides definable values, don't cares are also offered

Frame structure	Number of VLANs, MPLSs
Frame type	Ethernet II, 802.3, LLC, SNAP, VPLS with inner and outer MAC, MAC-in-MAC 802.1 ah
Ethertype	Editable value
MAC addresses	Editable source and destination
VLANs	Priority, VID, TPI, CFI/DEI
MPLSs	Label, CoS, TTL
IPv4 header	ToS, DSCP, Protocol
	Source and destination address, number of mask bits
IPv6 header	Traffic class, flow label, next header Source address, destination address

Evaluation of the traffic flows

Filter bandwidth

Bandwidth of all filtered flows	
"Utilization" is filter BW / link BW, "share" is filter BW / used BW	
Bandwidth	Current, average
Bandwidth results	Mb/s, utilization (link), share (flows)

Flow bandwidth

Bandwidth of single filtered flows	
"Utilization" is flow BW / link BW, "share" is flow BW / used BW	
Bandwidth types	Current, current payload, average, Average payload
Bandwidth results	Mb/s, utilization (link), share (flows)

Frame counts per flow

Types	Bytes, frames
Evaluation	Count, rate, ratio

QoS measurements per flow

Graphical error/alarm matrix for all active flows with current and history results. Results of particular flows are selectable .

QoS alarms	LPAC (Loss of Performance Assessment Capability) Corresponds to "no sync of test frame possible"
	NFTF (No Flow Test Frame)
QoS errors	Lost, duplicated, misinserted, out of order frames
Evaluation (type dependent)	Count, rate, ratio, seconds
Throughput MAC/IP	Bandwidth, utilization in B/s and %
Transfer delay	Min., max., average, variation (packet jitter)

Service disruption measurements per flow

Graphical SD matrix for all active flows with "Threshold exceeded" and "Disruption" results. Results of particular flows are selectable

Disruption results are given for any disruption occurring which is above the disruption time threshold

Port disruption (non flow selective)

Disruption result	Longest

Flow selective

Disruption result	Shortest, longest, last
Parameters	Duration, size, type
Size	1 to 2^{32} frames
Type	Lost, duplication, out of order, Misinsertion, time-out, link alarm

Disruption counters

Results	Total disruptions, disruptions exceeding threshold
Evaluation	Count, rate, seconds

Packet jitter analysis per flow (3 types)

Packet jitter is usually caused by queuing and routing across or buffering in a switched transport networks. The final effect of high packet jitter is the number of rejected packets.

Three types of packet jitter are analyzed:
Instantaneous, RFC 3550 and absolute jitter.

Instantaneous Jitter is defined as the difference between packet spacing of the transmitter compared to packet spacing of the receiver. Instantaneous jitter is a measure of jitter dynamics.

RFC 3550 Jitter is defined as low pass filtered instantaneous jitter. A low pass filter of first degree with a time constant of 16 frames is used.

Absolute jitter is defined as the maximum difference of the plus and minus peak of the transfer delay. Absolute jitter is a measure of the required buffer sizes.

The Module-E analyzes all three kinds of jitter simultaneously and per flow.
For instantaneous jitter a hit counter is implemented counting the number of jitter hits above a user defined threshold. A graphical pointer shows how close the current jitter is to the defined threshold.

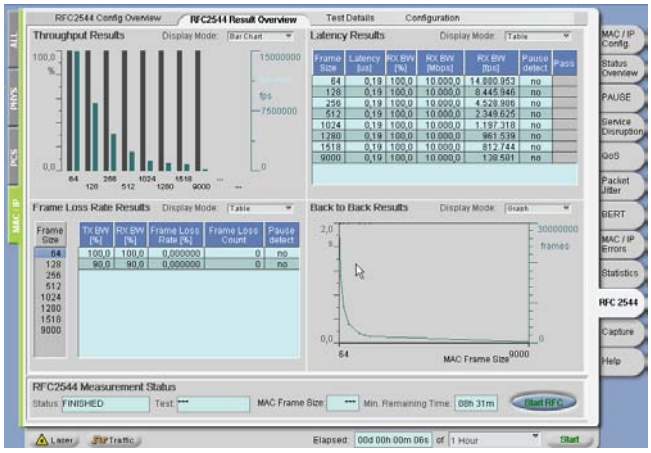
Instantaneous jitter	Current, Peak, Average, Minimum in ns
	Hits in count values
Hit threshold editable	10 ns to 42 s
RFC 3550 jitter	Current, Peak, Average in ns
Absolute jitter	Current, peak early and late in ns

BERT per flow

Graphical error/alarm chart for all active flows with current and history results. Results of particular flows are selectable

Alarms	Pattern sync loss, pattern loss, LPAC
Errors	Bit errors
Evaluation	Count, rate, ratio, seconds

RFC 2544 Conformance Testing



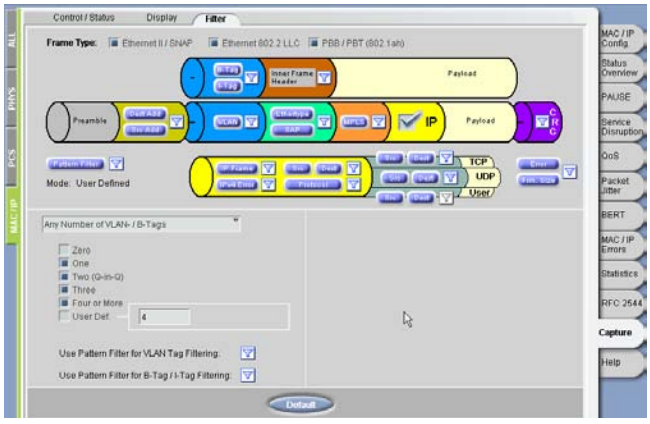
RFC 2544 addresses the need of Service Providers to perform the QoS measurements in Ethernet and IP networks. Vendors are forced to qualify the correct behavior of their Ethernet/IP equipment towards their customers.
The Module-E enables users to perform automated RFC 2544 testing. In detail it performs: Throughput, Frame Loss, Round Trip Delay and Back to Back (burstability) tests. The RFC 2544 is suited for LAN and WAN as well as OTN-mapped applications.
All setup parameters for the 4 tests are editable on one page.

In addition, packet jitter measurement can be included in the RFC.

Results of all tests are shown on one page.

Results Throughput	Table, Graph, Bar Graph
Results Frame Loss	Table, Graph
Results Latency, Back to Back	Table
During the measurement, online parameters are shown:	Test, Status, Current Frame length, Remaining minimum time

Capture MAC/IP (optional)



Software option *Capture MAC/IP* *BN 3061/93.65*

This software option allows capturing Ethernet traffic with/without IP payloads.

Capture modes can be selected as well as buffer sizes. MAC frames are captured with or without preambles.

The captured data is filtered and shown with Ethernet frame details of all captured flows and detailed Hex values for selected frames. The captured data can be viewed within the ONT GUI with focus on overhead information.
The result can be saved in a *.cap format which is compatible to the "Ethereal/Wireshark" analysis tool. Ethereal is by default installed on the ONT mainframe and can be used native with focus on payload analysis.

Buffer size selectable	1, 4, 16, 64, 256 Mbyte
Capture modes	Direct (all), filtered
Direct mode (all)	All RX flows are captured
Filter mode flow based:	Enabled or disabled flows are captured, The RX filter parameters are used (See chapter "Analyzer Ethernet")
Filter mode general purpose:	Flows with user editable Parameters are captured SA, DA, VLAN, B-/I-tag (802.1ah), Ethertype, MPLS Frame size, CRC errored/error free, oversized

10 GigE WAN Testing

Highlights

- 10GigE WAN layer 1 and layer 2/3 traffic
- Full SDH/SONET testing also for WAN
- PCS features see under "LAN testing"
- Additional **VPLS and MAC-in-MAC** Ethernet frame formats
- Real-time QoS, service disruption and packet jitter **analysis per flow**
- **IPv4/v6** and **packet capture**

Software option	*10GigE WAN*	*BN 3061/93.48*
	MAC-in-MAC 802.1ah	*BN 3061/93.47*
	IPv6	*BN 3061/93.62*
	Capture MAC/IP	*BN 3061/93.65*

Interfaces

See "Interface specification" page 7

Physical testing

See "Interface and unframed testing" page 11

WIS testing

WIS testing is mostly similar to SDH/SONET testing. Major differences are the following two items.

Pattern	Mixed frequency pattern or Client signal from higher layer application
Framed signal structure only	STS-192c-SPE, VC-4-64c

See "SDH/SONET testing"' page 24

PCS testing

See "PCS testing" page 12

Layer 2/3 Ethernet/IP testing

See "Layer 2/3 Ethernet/IP testing" page 13

RFC 2544

See "RFC 2544" page 16

Capture MAC/IP

See "Capture MAC/IP" page 17

10GigE via GFP and OTU2

Highlights

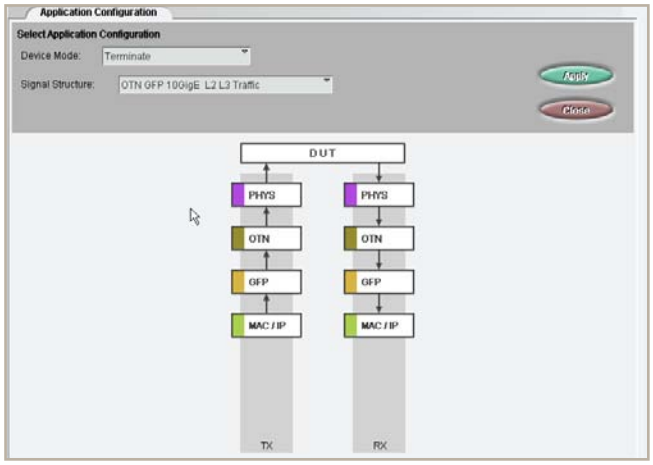
- 10GigE LAN layer 2/3 traffic
- Real-time QoS, service disruption and packet jitter **analysis per flow**
- GFP-F with extension header and full OAM support
- In-depth OTU2 testing
- Standard compliant

Software option	*OTN 10.7G*	*BN 3061/93.49*
	10G GFP-F	*BN 3061/93.45*
	10GigE LAN	*BN 3061/93.47*

This structure is defined in ITU-T G.709 Chapter 17.3 version 2003.

Interfaces

See "Interface specification" page 7



Physical testing

See "Interface and unframed testing" page 11

OTU2 testing

See "OTU2 testing" page 29

GFP testing

GFP-F – Generic Frame Procedure (framed) Application

The GFP functionality provides Ethernet MAC encapsulation and mapping/de-mapping of GFP to SONET/SDH Virtual Concatenation or OTN.

Implementation is in accordance with ITU-T G.7041, G.707, and ANSI T1.105.02 GFP-F (frame mapped Ethernet).
The functionality encompasses:

- Generation and analysis of GFP frame types
- Core header processing
- Payload type header processing
- Frame-based Ethernet MAC frame encapsulation
- Error and alarm processing

GFP generation

Frame size	up to 65516 bytes
TX payload scrambler	Enable/disable

Client data frame

Payload type header settings	Null extension header or Extension header
PFI (client data frame)	FCS off/on
UPI (client data frame)	Clear text selection Acc. to ITU-T G.7041 or numerical value

Linear extension header settings

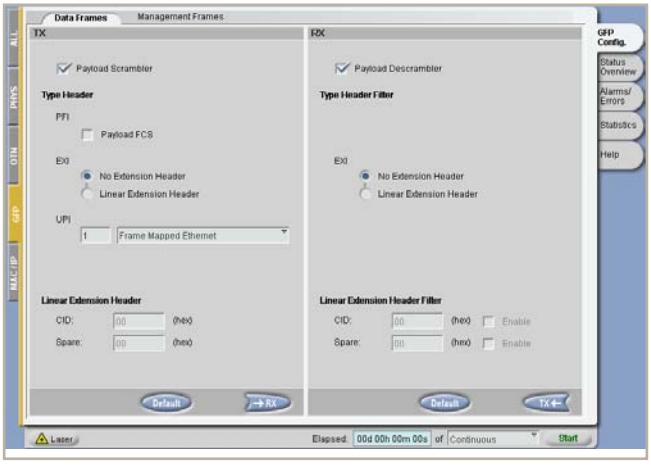
CID and Spare editable	00 to FF

Client management frame

Management type header settings	Null extension header or Extension header
PFI (client management frame)	FCS off/on
UPI (client management)	Loss of client signal (LCS), Loss of client character synchronization (LCCS), Forward defect indication (FDI) Reverse defect indication (RDI),

Linear extension header settings

CID and Spare editable	00 to FF



Error insertion

Type

Core header	Single/multiple bit error
Payload type header	Single/multiple bit error
Linear frame header	Single/multiple bit error
Payload FCS	Single bit error
Trigger	Single, rate
Rate	1×10^{-9}, 1×10^{-8}, 1×10^{-7}, 1×10^{-6}, 1×10^{-5}, 1×10^{-4}, 1×10^{-3}, 1×10^{-2}, 1×10^{-1}

Alarm insertion

Type	Loss of frame delineation (LFD), CSF-loss of client signal (CSF-LCS), CSF-loss of client character synchronization (CSF-LCCS), Forward defect indication (FDI) Reverse defect indication (RDI),
Frame period (CSF-LCS, CSF-LCCS, FDI, RDI)	100 to 1000 ms
Trigger	Continuous

GFP transmit statistics

Frame counts	Total frames, total data frames, Idle frames, total management frames
Evaluation	Count, rate
Total GFP bandwidth	Current, average
Total GFP utilization	Current, average

GFP Analysis

RX payload scrambler	Enable/disable

Client data frame

Payload type header settings	Null extension header or linear extension header
PFI (client data frame)	Automatic evaluation

Linear extension header filter

CID filter	Enable/disable
Spare filter	Enable/disable
CID and spare user defined	00 to FF

Client management frame filter

Management type header filter settings	Null extension header or linear extension header

Linear extension header filter

CID filter	Enable /disable
Spare filter	Enable/disable
CID and spare user defined	00 to FF

Error detection

Error types	Core header single, payload type header single & multiple, extension header single & multiple, payload FCS
Evaluation	Count, ratio

Alarm detection

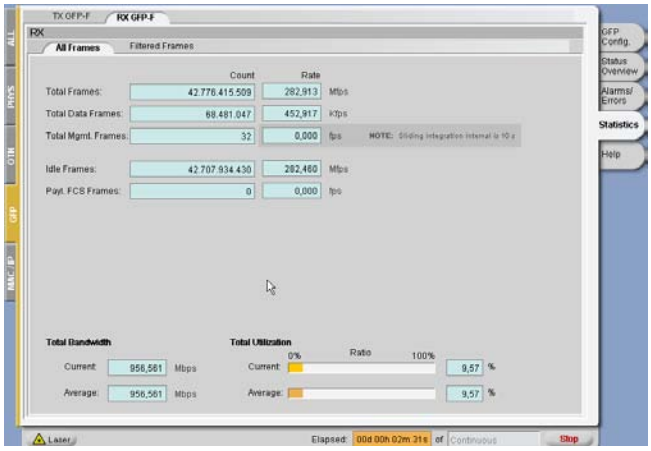
Alarm types	LFD, CSF-LCS, CSF-LCCS, FDI,RDI
Evaluation	Duration

GFP receive statistics

Frame type	Total frames, total data frames, total management frames, idle frames Payload FCS frames
Evaluation	Count, rate
Total GFP bandwidth	Current, average
Total GFP utilization	Current, average

GFP receive filter statistics

Frame type	Total frames, total data frames, total management frames, CSF-LCS frames, CSD-LCCS frames, DCI frames, FDI frames, RDI frames
Evaluation	Count, rate



Layer 2/3 Ethernet/IP testing

See "Layer 2/3 Ethernet/IP testing" page 13

RFC 2544

See "RFC 2544" page 16

Capture MAC/IP

See "Capture MAC/IP" page 17

10GigE via GFP in VCAT

Highlights

- 10GigE layer 2/3 traffic
- Real-time QoS, service disruption and packet jitter analysis per flow
- GFP-F with extension header and full OAM support
- Full aggregation bandwidth up to 10G
- In-depth SDH/SONET analysis

Software options	*10GigE LAN*	*BN 3061/93.47*
	10G GFP-F	*BN 3061/93.45*
	10G VCAT high order	*BN 3061/93.39*

Interfaces

See "Interface specification" page 7

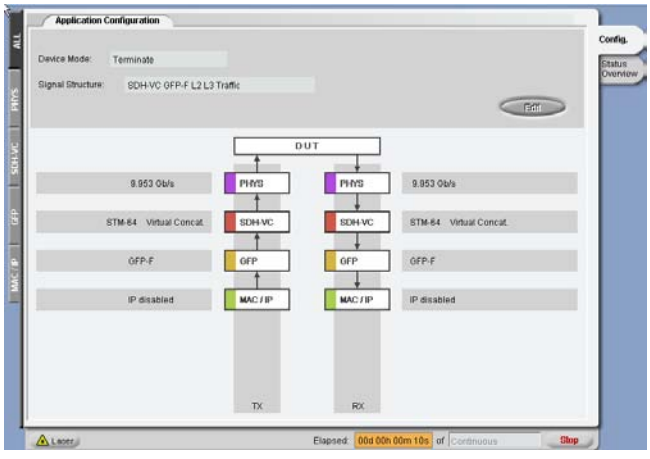
Physical testing

See "Interface and unframed testing" page 11

VCAT testing

VCat – Virtual Concatenation

Virtual concatenation implementation is in accordance with ITU-T G.707, G.783, and ANSI T1.105. One virtual concatenation group (VCG) is supported. Selectable mappings and group sizes are as follows:



High-Order VCat

Mapping

SDH	VC-4-Nv (N= 1, ... 64), AU3/VC-3-Nv (N= 1, ...192)
SONET	STS-1-Nv (N= 1, ... 192)

All members can be distributed in all channels of the SDH/SONET signal.

Group size is selectable from 1 to the maximum.

All path layer parameters including SQ number, overhead, errors, and alarms are supported for every member of the VCG individually.

Background channels

SDH	AU4 unequipped, AU3 unequipped
SONET	STS-1 unequipped

Sequence numbers generation

User programmable, per member.

Sequence numbers evaluation

Expected sequence numbers are user programmable, per member. If expected (ExSQ) and accepted (AcSQ) SQ numbers are not equal, a mismatch alarm is generated.

Sequence number mismatch defect	SQM

Error/alarm insertion

Error types

SDH/SONET	Random, FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P
Triggering	Single error, rate
Path Insertion	Single or multiple members

Error rate for

Random	1×10^{-3} to 1×10^{-12}
FAS	1×10^{-3} to 1×10^{-10}
B1	6.4×10^{-6} to 1×10^{-10}
B2	1×10^{-3} to 1×10^{-10}
MS-REI/REI-L	1×10^{-3} to 1×10^{-10}
B3	1×10^{-3} / 4.2×10^{-4} to 1×10^{-10}
HP-REI/REI-P	1×10^{-3} / 4.2×10^{-4} to 1×10^{-10}
Step size for mantissa	0.1

The maximum value ensures that all parity bits in all frames are affected.

Alarm types

SDH/SONET	LOS, LOF,MS-AIS/AIS-L, MS-RDI/RDI-L, AU-AIS/AIS-P, MS-TIM/TIM-S, HP-RDI/RDI-P, HP-RDI-C/RDI-P-C, AU-AIS/AIS-P, HP-RDI-S/RDI-P-S, HP-RDI-P/RDI-P-P, AU-LOP/LOP-P, HP-UNEQ/UNEQ-P, OOM2, OOM1
Path insertions	Single or multiple members
Triggering	Continuous, single burst Continuous burst

Burst Triggering not available for TIM

Error/alarm analysis

Error types

SDH/SONET	Random, FAS, B1, B2, REI-L/MS-REI B3, REI-P/HP-REI

Alarm types

SDH/SONET	LOS, LOF, OOF/SEF, MS-AIS/AIS-L, MS-RDI/RDI-L, MS-TIM/TIM-S, AU-AIS/AIS-P, HP-RDI/RDI-P,HP-RDI-C/RDI-P-C, HP-RDI-S/RDI-P-S, HP-RDI-P/RDI-P-P, HP-TIM/TIM-P AU-LOP/LOP-P, HP-UNEQ/UNEQ-P Loss of alignment (LOA) Loss of multi frame (LOM) Out of multi frame 1 (OOM1) Out of multi frame 2 (OOM2)

Errors/alarms are analyzed simultaneously for all members and displayed in an event list.

Event list	Event type, channel, start-time, end-time, duration
Resolution	100 ms for alarm, 1 s for errors

TOH/SOH and POH

Manipulation and analysis is provided for:

- All accessible TOH/SOH bytes
- POH bytes of all members independent
- Traces J0, J1 in clear text
- J1 of all members independently
- Sync status (S1) in clear text
- The signal label C2 of all members are shown independently in clear text.

Background channels

Background channels are unequipped.

Differential delay analysis

Parallel measurement, of differential delay, provided for each group member. Calculation of differential delay provided for entire group.

Results provided for all members and groups, differential delay in ms

Measurement range HO- VCat	256 ms
Reassembly range HO-VCat	80 ms

Pointer analysis

- STS/AU pointer values of all members
- Counts of increment, decrement and NDFs

Payload

The following payloads can be transported with VCat:

Test pattern: PRBS pattern, higher layer
PRBS pattern:
Higher layer: GFP-F with PRBS 2^{31}-1, 2^{31}-1 inv. or GFP-F with the Ethernet / IP Service

GFP testing

See “GFP testing” page 18

Layer 2/3 Ethernet/IP testing

See “Layer 2/3 Ethernet/IP testing” page 13

RFC 2544

See “RFC 2544” page 16

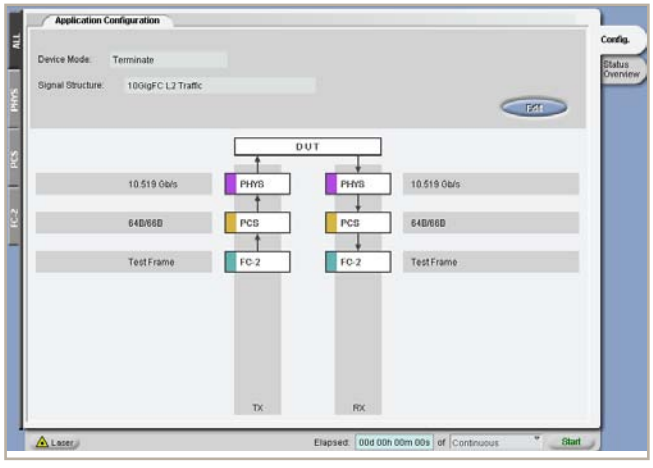
Remark:
The MAC/IP capture option is not available in combination with 10G VCAT.

10G Fibre Channel Testing

Highlights

- **Completes** the service variety at 10G
- Features at the PCS layer same as 10G Ethernet LAN
- **Single stream** with constant traffic, bursty traffic and full bandwidth support
- **Implicit flow control login**
- Credit buffer support
- Optionally usable as an OTN client

Software option 10G Fiber Channel *BN 3061/93.46*



Interfaces

See “Interface specification“ page 7

Physical testing

See “Interface and unframed testing” page 11

PCS testing

See “PCS testing” page 12

FC2 testing

FC2 generator

Frame type	Standard FC2 frame
Editable Parameter	Destination ID, source ID, sequence ID, Originator exchange ID, responder exchange ID

Frame payload

Payload type	Test frame, PRBS pattern
PRBS pattern	PRBS 2^{23}-1, 2^{31}-1, 2^{23}-1 inv., 2^{31}-1 inv., All 0s, All 1s, Digital Word 32 bit

Traffic Generation

Mode	Constant, burst, back to back
Trigger	Once, continuous
Once	User defined number of frames, count of bursts
Load	Adjustable in % or Mb/s
Frame size	User defined from 76 up to 2140

Flow control

Transmit R_RDY	Enable/disable

Transmitter results

Total bytes	Count
Total frames	Count, current rate
Total bandwidth	Current, average
Total utilization	Current, average
Total payload bandwidth	Current
Transmitted R_RDY	Count

Login

Type	Implicit
Mode	Enable/disable
TX buffer credits	0 up to 4095 Frames

Status information

Current buffer-to-buffer credits	Count

Login alarm

Type	Credit zero
Result	Count, status

Error insertion

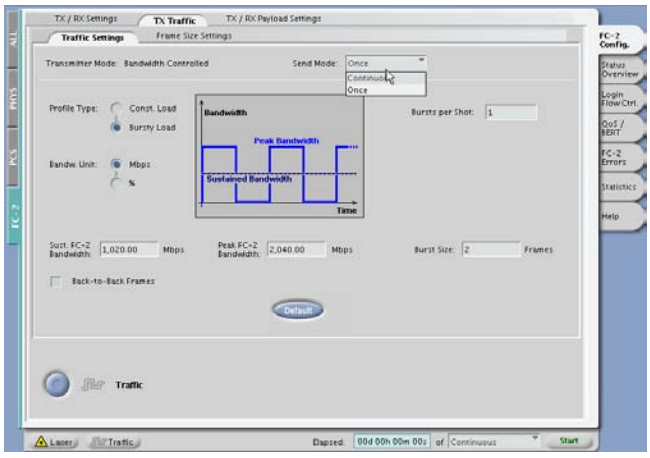
Type	CRC,
Trigger	Single, burst
Burst	1 up to 32767 frames
Type	Bit error
Trigger	Single, rate
Rate	10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8} 10^{-9}

FC 2 analyses

Frame type	Standard FC2 frame
Filter	Enable/disable
Filter criteria	Destination ID, source ID, sequence count, Routing control, data structure type

Frame payload

Payload type	Test frame, PRBS pattern
PRBS pattern	PRBS 2^{23}-1, 2^{31}-1, 2^{23}-1 inv., 2^{31}-1 inv., All 0s, all 1s, digital word 32 bit



Traffic evaluation

Unfiltered Traffic

Total bytes	Count
Total frames	Count, current rate
Total bandwidth	Current, average
Total utilizations	Current, average
Total payload	Bandwidth current
Total errored frames	Count, current rate
Total class 1 frames	Count, current rate, ratio
Total class 2 frames	Count, current rate, ratio
Total class 3 frames	Count, current rate, ratio
Total class F frames	Count, current rate, ratio

Frame size evaluation

Evaluation	Min, may, average, classes
Classes	28-64 bytes, …. , >2140 bytes
Results	Values, graphs

Filtered Traffic

Total bytes	Count
Total frames	Count, current rate
Total bandwidth	Current, average
Total utilizations	Current, average
Total payload	Bandwidth current
Total errored frames	count, current rate
Total class 1 frames	Count, current rate, ratio
Total class 2 frames	Count, current rate, ratio
Total class 3 frames	count, current rate, ratio
Total class F frames	Count, current rate, ratio

Frame size evaluation

Evaluation	Min, max, average, classes
Classes	28-64 bytes, …. , >2140 bytes
Results	Values, graph

Flow control results

Received R_RDY primitives	Count
Test frames	Count

Error evaluation

Type	Runt frames, Jabber frames, CRC errored frames, Undersized frames, oversized frames, Errored frames (any error), lost frames, Out of order frames, bit errors
Results	Count, current rate, ratio, seconds

Alarm evaluation

Type	NFTF, LPAC, pattern Loss
Results	Seconds

Delay measurement

In payload mode test frame the round trip delay is evaluated.

Result	Min., average, max.

10G SDH/SONET Testing

Highlights

- Full SDH/SONET testing also for WAN
- **Dynamic error/alarm** insertion including bursts
- **Best-in-class service disruption** with high level of details and user-accessible settings – no blind spots
- Full access to overhead bytes
- **All pointer** sequences
- Performance monitoring G.826/828/829
- **Byte capture** all SOH//TOH bytes

Software option OC-192c/STM-64c BERT *BN 3061/93.35*

The functionality consists of OC-192c/STM-64c BERT

Software option SDH/SONET Single Channel *BN 3061/93.36*

The functionality includes all mappings down to AU3/VC3, STS-1 SPE. This option can also be used as the client signal for ODU1 in an OTU2.

Both options provide detailed SDH/SONET testing with all errors, alarms, traces, pointers, OH bytes as per standard SDH/SONET testing.

These applications are preferred for Jitter and wander measurments.

Interfaces

See "Interface specifications" page 7

Physical testing

See "Interface and unframed testing" page 11

SDH/SONET testing

Generation/evaluation of STM-64 signal according to ITU-T G.707

Generation/evaluation of OC-192 signal according to ANSIT1.105

Generator SDH/SONET

Mapping

SDH	VC-4-64c, VC-4-16c, VC-4-4c, VC-4, AU-3/VC-3
SONET	STS-192c SPE, STS-48c SPE, STS-12c SPE, STS-3c SPE, STS-1 SPE

In some applications only VC-4-64c or STS-192c is available.

Generator modes

- Free definable foreground
- All channels identical
- Background selectable mapping, depending on foreground channel with definable path overhead and Null pattern as payload.

Generator

Test pattern	SDH/SONET test pattern or higher layer application test pattern
SDH/SONET test pattern	PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{31}-1 inv., 2^{23}-1 inv. , 2^{15}-1 inv., 2^{11}-1 inv. (conforming to ITU-T O.150), programmable word
Programmable word	Length 32 bits

Error insertion

Types

SDH	Random, FAS, B1, B2, B3, MS-REI, HP-REI, Bit errors (if SDH/SONET test pattern)
SONET	Random, FAS, B1, B2, B3, REI-L, REI-P, Bit errors (if SDH/SONET test pattern)
Trigger	Single, rates

For all errors except random/bit errors: single, continuous burst

Burst with M frames active and N frames inactive

N, M = 1 to 800000 or 125 µs to 1000 s

Error	Min rate	Max rate	Stepping	Mapping
Random	1×10^{-10}	1×10^{-3}	Exponential	
FAS	1×10^{-12}	1×10^{-3}	0.1	
B1	1×10^{-12}	6.4×10^{-6}	0.1	
B2	1×10^{-12}	1×10^{-3}	0.1	
MS-REI, REI-L	1×10^{-12}	1×10^{-3}	0.1	
B3	1×10^{-12}	6.6×10^{-6}	0.1	VC-4-64c STS-192c
B3	1×10^{-12}	1×10^{-3}	0.1	VC-3 STS-1
HP-REI, REI-P	1×10^{-12}	6.6×10^{-6}	0.1	VC-4-64c STS-192c
HP-REI, REI-P	1×10^{-12}	1×10^{-3}	0.1	VC-3 STS-1
Bit error	1×10^{-12}	1×10^{-3}	Exponential	

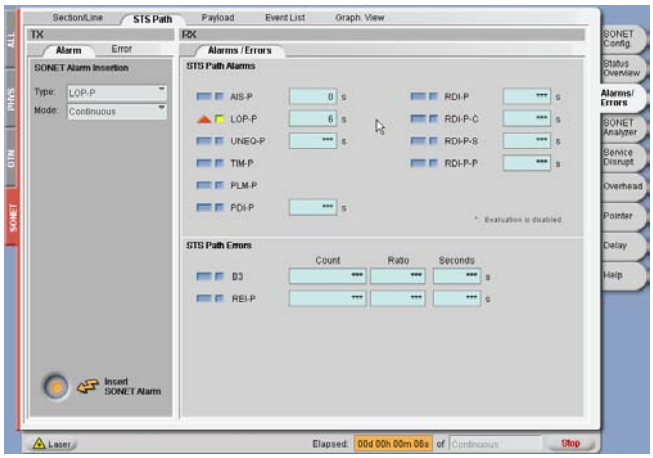
Alarm generation

Type

SDH	LOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-RDI, RS-TIM, HP-TIM, HP-RDI-C, HP-RDI-S, HP-RDI-P
SONET	LOF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, RDI-P, PDI-P, TIM-S, TIM-P, RDI-P-C, RDI-P-S, RDI-P-P
Trigger	Continuous, single burst, continuous burst

Burst with M frames active and N frames inactive

N, M = 1 to 800000 or 125 µs to 1000 s



Overhead generator

The stimulus of different overhead byte patterns is an important part of verification and interoperability testing. Network elements (NE) should respond in the defined manner and any responses then conveyed by a different overhead byte.

Statically programmable bytes

- A1-A2 unscrambled
- RSOH/SOH all bytes except B1
- MSOH/LOH all bytes except B2, H1...H3
- POH all bytes except B3

Display of overhead on the GUI.

Trace identifier

J0, J1 programmable 1 byte, 16 bytes with CRC or 64 byte sequence

Generation of pointer actions

Generation of pointer actions at the AU/STS level

- New pointer value setting with or without NDF
- Offset simulation in ppms
- Single, periodical and alternating pointer increment/decrement
- Pointer sequences with different types
- SS-bits definable

Analyzer SDH/SONET

Mapping

SDH	VC-4-64c, VC-4-16c, VC-4-4c, VC-4, AU-3/VC-3
SONET	STS-192c SPE, STS-48c SPE, STS-12c SPE, STS-3c SPE, STS-1 SPE

In some applications only VC-4-64c or STS-192c is available.

Auto signal structure

Receiver analyses the signal structure (mapping, payload, traces) automatically for easy configuration of the test channel.

Analyzer

Test pattern	SDH/SONET test pattern or higher layer application test pattern
SDH/SONET test pattern	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{31}-1 inv., 2^{23}-1 inv. , 2^{15}-1 inv., 2^{11}-1 inv. (conforming to ITU-T O.150)
Programmable word	Length 32 bits

"Live traffic" mode ignores pattern loss and bit error that allows analysis of live traffic without trouble indication.

Error measurements

SDH	FAS, B1, B2, B3, MS-REI, HP-REI, Bit errors (if SDH/SONET test pattern)
SONET	FAS, B1, B2, B3, REI-L, REI-P, Bit errors (if SDH/SONET test pattern)

Alarm detections

SDH	OOF, LOF, MS-AIS, MS-RDI, RS-TIM, AU-AIS, AU-LOP, HP-TIM, HP-UNEQ, HP-PLM, HP-RDI, HP-RDI-C, HP-RDI-S, HP-RDI-P, pattern loss
SONET	OOF, LOF, AIS-L, RDI-L, TIM-L, AIS-P, LOP-P, TIM-P, UNEQ-P, PLM-P, PDI-P, RDI-P-C, RDI-P-S, RDI-P-P, pattern loss
Resolution	100 ms

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error.
Duration in seconds is displayed for each alarm.

Tabular display

Display of all events with time stamps

Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis resolution	Second, minute, hour

Intermediate bit error (if SDH/SONET test pattern)

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, Count and ratio

Overhead analyzer

Display of Overhead on the GUI.

Message evaluation (TIM/PLM)

- J0, J1 1 byte, 16 bytes with CRC or 64 byte sequence
- J0, J1 clear text display
- TIM evaluation: expectation value editable as criterion for TIM
- C2 signal label clear text selection
- PLM Evaluation: Expectation value editable as criterion for PLM

Service disruption test SDH/SONET

To analyze service disruption times, the ONT-5xx generates a high-speed event list as a result of all detected events.

Sensor to trigger service disruption test, selectable

SDH	
Alarms	LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP , HP-UNEQ, HP-PLM, HP-RDI,
Errors	FAS, B1, B2, MS-REI, B3, HP-REI, Payload errors (if SDH/SONET test pattern)
SONET	
Alarms	LOS, LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, PDI-P, RDI-P
Errors	FAS, B1, B2, REI-L, B3, REI-P, Payload errors (if SDH/SONET test pattern)
Event sample resolution	100 µs
Separation time	0.1 ms to 100000 ms

Separation time starts at the end of the last event. Separation time is used to determine if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

Result display of disruptions

Numerical display

Total number of disruptions, begin timestamp of first disruption, end timestamp of last disruption,
Shortest disruption time (with timestamp)
Longest disruption time (with timestamp)

Average disruption time

The threshold to identify a violation of allowed service disruption time can be set in the range of 0 ms to 100000 ms

Tabular display

Service disruption events with start/stop times and duration.
Three logging modes available (no logging; disruption events only; disruption and causing sensor events)

Transfer delay analysis

Transfer delay measurements by special payload pattern in the range of 0 to 40 s.
Transfer delay can be measured even between different ports within the same mainframe.

Numerical display

Current transfer delay with	Accuracy of 1 µs and resolution 100 ns
Minimum transfer delay (with timestamp)	
Maximum transfer delay (with timestamp)	

Pointer analysis

AU/STS Pointer

Numerical display

Value, count of increments, decrements, NDF.

Tabular display

Display of all events with time stamps

Criteria	Start, stop, duration, count

Performance monitoring (SONET)

Evaluation of ES, EFS, SES, UAS and SEFS (GR 253, T1.231) ESA, ESB

Performance monitoring G.826 (SDH)

EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments based on line length allocation of 0.1 to 100%.

The SES and UAS thresholds are user-programmable. In-service measurement (ISM) of the near end and the far end of a selected path, as well as out-of-service (OOS) measurements, are supported.

Performance monitoring G.828 and G.829 (SDH)

The G.828 defines error performance parameters for international synchronous paths.

EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments are based on a line length allocation of 0.1 to 100%.The SES and UAS thresholds are user-programmable. The SEP can be switched off for assessment. G.829 defines error performance events and block structures for SDH multiplex and regenerator sections.

Byte capture SOH/TOH

To analyze the SOH/TOH functions, it is necessary to capture individual bytes vs. time, allowing detection of errors or short term changes with frame level resolution. The capture function is started by a selectable trigger.

Values for one/two selected bytes are stored and can be accessed subsequently in a table of values.

Particularly in capturing the APS sequences, bytes K1 and K2 are displayed in clear text.

Selectable bytes for SOH/TOH	All bytes
Captured parameters	Byte value, number of frames and Correspondent time

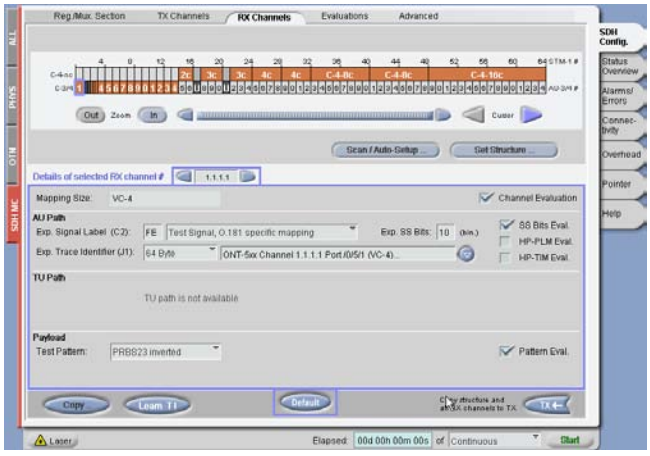
Storage depth of one byte or K1/K2 combination

Post trigger	up to 256 value changes
Pre trigger	up to 256 value changes
Trigger conditions	Pre, post, center
Trigger events	User defined byte value, bit mask (Compare, not compare, don't care)

Multi-Channel 10G High Order

Highlights

- Full coverage of an OC-192 or STM-64 signal with parallel generation/analysis of up to **192 x STS-1 SPE/64 x VC-4** for BER, service disruption, errors, and alarms
- Real life load generation and load analysis with **mixed mappings:** STS-1/3c/6c/9c/12c/24c/48c/192c or AU3/VC-3, VC-4, VC-4-2c/3c/4c/8c/16c/64c
- No blind spots in the structure
- **Dynamic error/alarm insertion** into multiple channels including bursts to simulate flooding of events for stress test



Software option Multi-Channel 10G High Order *BN 3061/93.37*

Interfaces

See "Interface specification" page 7

Physical testing

See "Interface and unframed testing" page 11

Multi-Channel testing

Generation

Signal structure and mixed payloads

The Multi-Channel extension module fills up an OC-192 or STM-64 signal completely with any combination of valid mappings. Granularity for mixing of mapping structures is STS-1/AU-3 level.

SONET mappings for mixed payloads

STS-1/3c/6c/9c/12c/24c/48c/192c, STS-1 unequipped

SDH mappings for mixed payloads

AU3/VC-3, VC-4, VC-4-2c/3c/4c/8c/16c/64c, AU-3/AU-4 unequipped

Patterns

PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv.
User defined 32-bit word

Patterns may be set individually per each test channel. This is as well applicable for path labels and traces.

Alarm and error messaging test

Alarm insertion

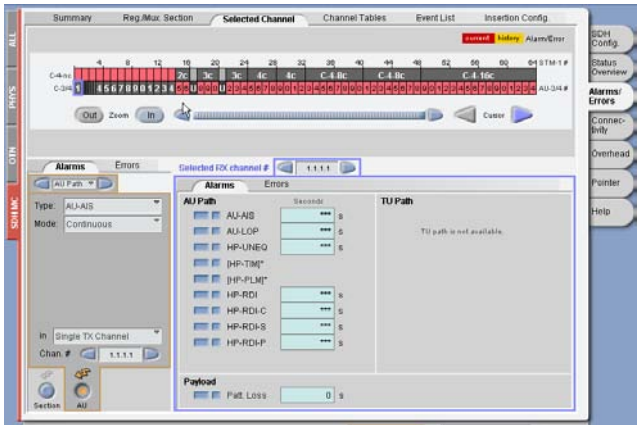
SONET	LOS, LOF, TIM-S, AIS-L, RDI-L, LOP-P, AIS-P, UNEQ-P, PLM-P, RDI-P, RDI-P-C, RDI-P-P, RDI-P-S
SDH	LOS, LOF, TIM-S, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, P-RDI, P-PLM, HP-RDI, HP-RDI-C, HP-RDI-S, HP-RDI-P

Triggering

LOS	On/off
All others	On/off or bursts
Burst	Once and continuous
M frames with alarm ON, N frames with alarm OFF	M, N = 1 to 8 000 000 or 125 µs to 1 000 s

Alarms are inserted into all or selected channels .

Alarm detection



Error insertion

Error types	Bit errors, random errors (after scrambling), FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P

Triggering

Once	All errors
Error rate for FAS	1×10^{-3} to 1×10^{-12}
Bit errors	1×10^{-3} to 1×10^{-12}
Random	1×10^{-3} to 1×10^{-12}
All others minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
	Random and bit error step size exponential.
Burst error	Once and continuous

M errored frames followed by N error-free frames

All errors except	
Random and bit error	M, N = 1 to 8 000 000 or 125 µs to 1 000 s

Rate burst error

Defined error rate with additional burst time window.
All errors except random and bit error.
Parameters see under "error rate" and "burst".
Errors are inserted into all or selected channels .

Analysis

Complete analysis of all channels set within an OC-192 or STM-64 signal.

Auto signal structure detection

Receiver detects the signal structure (mappings, payload, traces) automatically for easy configuration of the test set.

Bit error testing

Bit error testing is performed on all payloads simultaneously with error count, error ratio and errored seconds per channel. Summary results provide overview of all channels on one page.

Service disruption test

The Multi-Channel extension module measures service disruption time on all test channels simultaneously up to 192 × STS-1, 192 × AU3/VC-3 or 64 x VC-4.
Each disruption in every channel is stored with time stamp and duration.

A setup page allows to enable/disable each channel individually.

Result presentation

- Summary results for all channels
- Channel table: contains shortest/longest/average/# of disruptions for each channel and the total duration, easy table sorting
- Disruption list: contains each disruption with start time and duration for all channels. Resolution: 1 ms. Storage capacity: 100000 events per measurement.

Separation time setting: 1 ms to 100 000 ms.

Separation time starts with the end on an event and determines if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

The criteria to trigger the service disruption test is selectable (any combination of criteria allowed):

SONET	
Alarms	LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, RDI-P
Errors	B1, B2, REI-L, B3, RDI-P, REI-P, bit errors
SDH	
Alarms	LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-RDI
Errors	B1, B2, MS-REI, B3, HP-REI, payload error

The threshold to identify a violation of the allowed service disruption time (for all channels) is 1 ms to 1000 ms.
Violation is shown in summary results and channel table.

Error measurement

Same error types as insertion. Error count, error ratio and errored seconds per channel. Summary results provide overview of all channels on one page. Count results for all channels simultaneously.

Error/alarm logging with time stamps

The ONT stores errors/alarms in all channels with time stamps. This allows to identify when events did occur in any of the channels.

Errors	Count with 1 s resolution
Alarms	Start/stop/duration with 0.1 ms resolution

Error and alarm event list

Including filter capabilities.

Storage capacity	300000 events per measurement

The event list contains following information

- Event type
- Channel ID
- Start/end time
- Duration
- Error count

Message evaluation/overhead access

Trace identifier setting, display and evaluation (TIM)

J0: 1/16/64 byte
J1: 1/16auto16/64auto/64 byte
Manual setting or Auto mode (sets unique values to each channel for easy source identification).
TIM evaluation per channel: expected value learnable from received signal.
J0/J1 view accessible for each channel.

Path label setting, display and evaluation (PLM)

C2 manual setting and view for each channel.
PLM evaluation per channel: expected value editable.

TOH/SOH and POH setting and display

Access to TOH/SOH bytes for edit and display
K1, K2 and S1 are shown and may be edited using clear text messages
Display of POH for each channel

Byte capture SOH/TOH

To analyze the SOH/TOH functions, it is necessary to capture individual bytes vs. time, allowing detection of errors or short term changes with frame level resolution. The capture function is started by a selectable trigger.
Values for one/two selected bytes are stored and can be accessed subsequently in a table of values.

Particularly in capturing the APS sequences, bytes K1 and K2 are displayed in clear text.

Selectable bytes for SOH/TOH	All bytes
Captured parameters	Byte value, number of frames and Correspondent time

Storage depth of one byte or K1/K2 combination

Post trigger	up to 256 value changes
Pre trigger	up to 256 value changes
Trigger conditions	Pre, post, center
Trigger events	User defined byte value, Bit mask (compare, not compare, don't care)

Pointer evaluation

Pointer actions are counted for all channels in parallel: Increment, decrement, NDF

Display modes

Summary for all channels
Per channel view
Paths table with sorting criteria

Connectivity check

The Connectivity feature verifies that all channels are routed through a switching matrix as expected, e.g. after reloading the matrix. The path trace information is used to perform the Connectivity.
Unique values are set for all J1 path traces in parallel for path identification.
The 'trace learning mode' stores the path trace values provided by the device under test to be used as reference to check connectivity. Any mismatch is indicated graphically in the signal structure overview.

Multi-Channel mapped into OTN 10.7G

The SDH/SONET Multi-Channel signal can be mapped into OTN 10.7G at ODU2 (optional) and ODU1 (optional).

OTN OTU2 10/11G Testing

Highlights

- Standard and overclocked OTU2 rates
- **OTN wrapper/de-wrapper testing** (RX<>TX client/line rates)
- Support of all TCM layers
- **Transfer delay** and **service disruption**
- Unique **FEC stress testing** with walking pattern
- Overhead byte capture

The functionality includes OTN framing as per G.709 with standard and/or overclocked rates.

The OTN applications support generation and analysis of OH bytes, errors, alarms and FEC. Parameters and measurement results at the OTN and Client layer are processed simultaneously

Software options	Clients
OTN 10.7G	Bulk, OC-192,/STM-64c BERT (optional), SDH/SONET Single channel (optional), Multi-Channel 10G High Order (optional), OTN Multiplexing OTU2 (optional), 10GigE WAN (optional), 10GigE LAN via GFP-F (optional), 10GVCAT High Order (optional)
OTN 11.05/11.1G	Bulk, 10GigE LAN (optional)
OTN 11.27/11.32G	Bulk, 10G Fibre Channel (optional)

All Clients can be mapped synchronously and asynchronously

Interfaces

See "Interface specification" page 7

Physical testing

See "Interface and unframed testing" page 11

OTU2 testing

Modes

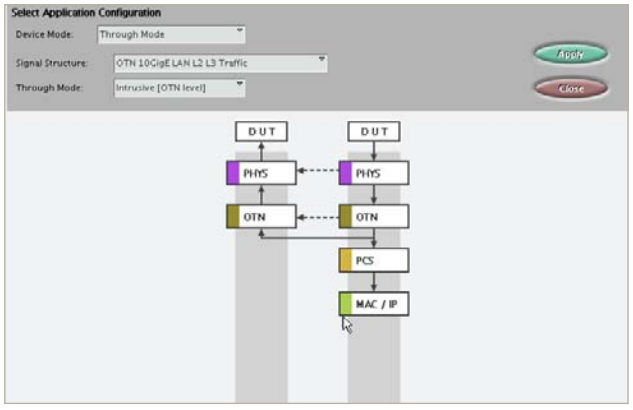
Multiple testing modes are available with OTN.

Terminate

Generator and analyzer are running at the same OTN rate.

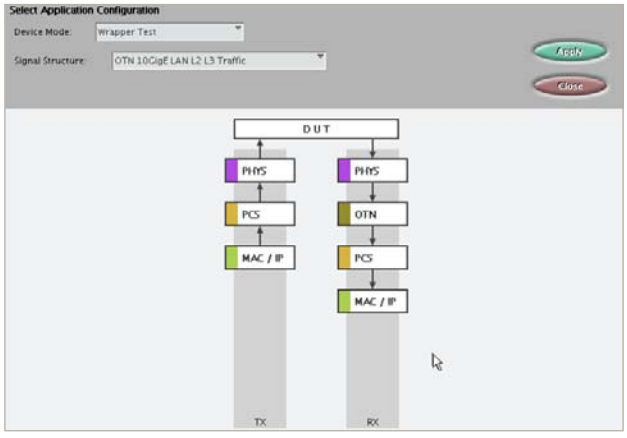
Intrusive through mode

Generator and analyzer are running at the same OTN rate. The received traffic is terminated at the OTN layer and retransmitted with the transmitter. All OTN layer information can be unchanged transmitted or overwritten with the capabilities available in the OTN generator part. The client signal is unchanged retransmitted and analyzed by the higher layer if support is available.



Wrapper/de-wrapper test

Transmitter and receiver interface are running at different rates. The wrapper test is used to test the wrapper function of a DUT (Device Under Test). The ONT generates a client signal and analyzes an OTN signal with wrapped client. The OTN generator features are not available.



The dewrapper test is used to test the de-wrapper function of a DUT. The ONT generates an OTN signal with wrapped client and analyzes a dewrapped client signal. The OTN analyzer features are not available.

OTN generator

Pattern	OTN test pattern, higher layer test pattern live traffic
OTN test pattern	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv. (conforming to ITU-T O.150), and digital word 32 bit
"Live traffic" mode ignores pattern loss and bit error that allows analysis of live traffic without trouble indication	

Client offset – stuffing

The asynchronous client offset can be adjusted within the ± 65 ppm range and the stuffing rate of the client can thus be manipulated.

Overhead (frame alignment/OTU/ODU/OPU)

- All bytes statically programmable except MFAS, SM BIP, PM BIP, TCM1...6 BIP
- Additional possibilities for SM TTI, PM TTI, TCM1...6 TTI (Trail Trace Identifier):
  Sequence consisting of the SAPI (16 bytes) and DAPI (16 bytes) and the operator specified (32 bytes)
- User designed payload structure identifier (PSI), payload type identifier clear text and support of MSI
- One OH byte can be selected for a freely defined sequence of 16/32/64/128/256 bytes
- FTFL free definable forward/backward (FW/BW) fault indication and operator identifier

Error insertion

Type	Random, FAS, MFAS, SM BIP-8, SM BEI, PM BIP-8, PM BEI, TCMi BIP-8, TCMi BEI (i = 1 to 6), Bit errors (only available with OTN test pattern)
Trigger	Single , rate, burst , burst continuous
Burst error	M frames errors, N frames error free, M and N = 0 to 2^{31}

Rate

Error name	Min rate	Max rate	Stepping
Random	1×10^{-10}	1×10^{-3}	Exponential
Bit	1×10^{-12}	1×10^{-3}	Exponential
FAS	4.9×10^{-12}	1×10^{-3}	0.1
MFAS	3.0×10^{-11}	1×10^{-3}	0.1
SM BIP	1×10^{-12}	6.6×10^{-5}	0.1
SM BEI	1×10^{-12}	6.6×10^{-5}	0.1
PM BIP	1×10^{-12}	6.6×10^{-5}	0.1
PM BEI	1×10^{-12}	6.6×10^{-5}	0.1
TCMi BIP	1×10^{-12}	6.6×10^{-5}	0.1
TCMi BEI	1×10^{-12}	6.6×10^{-5}	0.1

BIP masks

The position and number of bit errors in the bytes can be selected.

Valid for SM BIP, PM BIP, TCMi BIP (i = 1 to 6)

BEI value

To stress the BEI evaluation of the DUT receiver the BEIs can be set to values 0 to 15

Valid for SM BEI, PM BEI, TCMi BEI (i = 1 to 6)

Alarm generation

Type	LOF, OOF, LOM, OOM
	OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK, SM BDI, SM IAE,
	SM BIAE, PM-BDI, FW-SD, FW-SF, BW-SD, BW-SF
	TCMi-LTC, TCMi-IAE, TCMi-BDI, TCMi-BIAE (i = 1 to 6)
	SM-TIM, PM-TIM, TCMi-TIM

Trigger

Continuous	All alarms
Burst once/burst continuous	All alarms except LOS, LOF, TIMS, OOF, OOM, SD, SF
Burst alarms	M frames with alarm, N frames no alarm, M and N = 0 to 2^{31}

OTU FEC

The FEC generation can be switched on and off. Using the OTU FEC field, FEC according to the Reed-Solomon (255,239) algorithm is performed on the generated frame. With data blocks consisting of 239 data bytes and 16 FEC field bytes, up to 16 byte errors can be detected or 8 byte errors be corrected.

FEC error insertion modes

- FECcorrectable, FECuncorrectable
- FECstress: This extremely helpful function allows maximum stress tests within a short time frame.
  The maximum possible number of errors that the device under test (DUT) should still be able to correct is inserted into the OTU frame by a walking pattern. All bits are affected in less than 2 seconds.

FECadvanced

FECadvanced allows the user to define a detailed position for error insertion in the OTU frame. Correction capability testing below and above the correction limit can be performed.

Selectable parameters:	Row, subrow, errored bytes per subrow,
	Start position in subrow, byte error mask

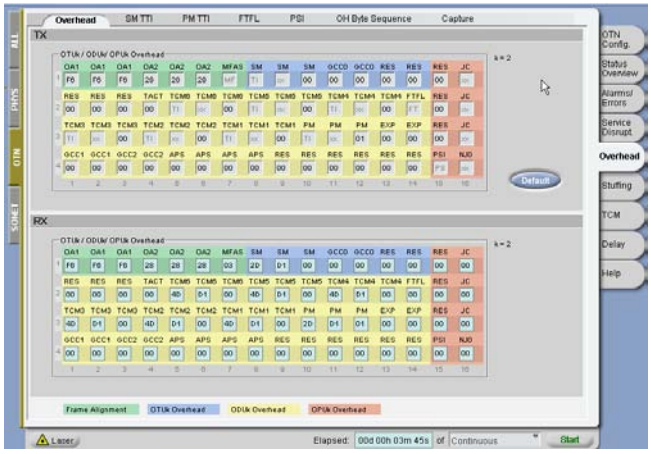
Analyzer OTN

Stuffing of the client

Display of payload offset in ppm

Stuffing counts

Positive, negative, sum count, duration of affected seconds



Overhead evaluation (frame alignment/OTU/ODU/OPU)

- Display of the complete overhead
- SM TTI, PM TTI, TCM1…6 TTI display of the 64 byte ASCII sequence of SAPI, DAPI and Operator field
- One sequence of up to 256 bytes can be captured and displayed for a selectable OH byte
- Display payload structure identifier (PSI) bytes, payload type identifier (PT) clear text and support of MSI
- Editable PT expectation value as mismatch criterion
- FTFL forward/backward (FW/BW) fault indication and operator identifier fields

Trace references

- Set of SAPI and DAPI expectation values in traces SM TTI, PM TTI, TCM1…6 TTI
- Select evaluation type of the received signal: SAPI or DAPI or SAPI/DAPI

General Communication Channel Capture (GCC)

The management information between network element and termination equipment is transported in the GCCs in the OTN overhead. With this feature, the transmitted information can be captured in real-time.

Captured fields	GCC0, GCC1, GCC2, GCC1+2
Captured format	Raw
Capture size	up to 500 MB
Trigger	Manual

Error measurement

Validation of data for error measurement occurs after frame alignment, descrambling, and FEC computation and correction.

Error detection

Types	FAS, MFAS, SM BIP, SM BEI, PM BIP, PM BEI,
	TCMi BIP, TCMi BEI (i = 1 to 6)
	Bit error (only available for OTN test pattern)
	FECcorr. bit, FECcorr. code word , FECuncorr. code word

Alarm detection

Type	LOF, OOF, LOM, OOM, OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK, SM BDI, SM IAE, SM, BIAE, SM TIM PM-BDI, PM TIM, FW-SD, FW-SF, BW-SD, BW-SF TCMi-LTC, TCMi-BDI, TCMi-IAE, TCMi-BIAE, TCMi-TIM (i = 1 to 6) CL-LOSS (Client signal Loss of synchronization) PT-MISM, pattern loss (only available for OTN test pattern)
Resolution	100 ms

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error
Duration is displayed for each alarm

Tabular display

Display of all results with time stamps	
Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis	second, minute, hour

Service disruption test

To analyze service disruption times, the ONT-5xx generates a high-speed event list as a result of all detected events.

Sensor to trigger service disruption test, selectable:

Alarms	LOS, LOM, OOM, SM-IAE, SM-BDI, SM-BIAE, ODU-AIS, ODU-OCI, ODU-LCK, PM-BDI
Errors	MFAS, SM-BEI, PM-BIP, PM-BEI, bit errors
Event sample resolution	100 µs
Separation time	0.1 ms to 100000 ms

Separation time starts at the end of the last event. Separation time is used to determine if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

Result display of disruptions

Numerical display

Total Number of disruptions, begin timestamp of first disruption, end timestamp of last disruption,

Shortest disruption time (with timestamp)	
Longest disruption time (with timestamp)	

Average disruption time

The threshold to identify a violation of allowed service disruption time can be set in the range of 0 ms to 100000 ms

Tabular display

Service disruption events with start/stop times and duration.

Three logging modes available (no logging; disruption events only; disruption and causing sensor events)

Intermediate bit error

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, Count and ratio

Transfer delay analysis

Transfer delay measurements by special payload pattern in the range of 0 to 40 s.
Transfer delay can be measured even between different ports within the same mainframe.

Numerical display

Current transfer delay with accuracy of 1 µs and resolution 100 ns

Minimum transfer delay (with timestamp)	
Maximum transfer delay (with timestamp	

OTN Multiplexing

As OTN is moving forward from a point to point technology to a network technology additional features getting implemented. Especially, OTN multiplexing is to mention as such a feature. The ONT-503/-506/-512 will support ODU1 multiplexing in ODU2.

Software option OTN multiplexing OTU2 *BN 3061/93.54*

OTU2

Generator

Signal structure

Foreground	Fully structured ODU1
With one of the following clients	Bulk client, SDH/SONET Single Channel client (optional) SDH/SONET Multi-Channel HO client (optional) SDH/SONET VCat client (optional,
Bulk client	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv., and digital word 32 bit
User background with user defined	Structured ODU1 PM-TTI and a NULL client payload Generation enable/disable
Background	The remaining time slots are filled ODU1
With user defined	PM-TTI identical all channels and a NULL client payload
User background and background can be overwritten by	ODU-OCI, ODU-AIS and ODU-LCK
Time slot allocation	Foreground and user background can be allocated freely, background channels are automatically allocated.

Client offset stuffing

Following modes a supported	Negative, positive, Double positive
Foreground	Default 0 ppm to client bit rate
Offset range	± 65 ppm
User Background	Enabled, default 0ppm to client bit rate
Offset range	± 65 ppm
Background	No stuffing support

Other generator capabilities are identical to OTU2 for the Foreground with following restrictions:

No SM support, because only at OTU available.

No FEC support, because only at OTU available.

Analyzer

Signal structure

Foreground	Fully structured ODU1
With one of the following clients	Bulk client, SDH/SONET Single Channel client (optional) SDH/SONET Multi-Channel HO client (optional) SDH/SONET VCat client (optional)
Bulk client	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv., and digital word 32 bit
Time slot allocation	Foreground can be allocated freely

Client offset stuffing

Following modes a supported	Negative, positive, Double positive
Displays of client offset	in ppm

Stuffing counts

Positive, double positive, negative, sum count, duration of affected seconds

Other analyzer capabilities are identical to OTU2 for the foreground with following restrictions:

No SM support, because only at OTU layer available

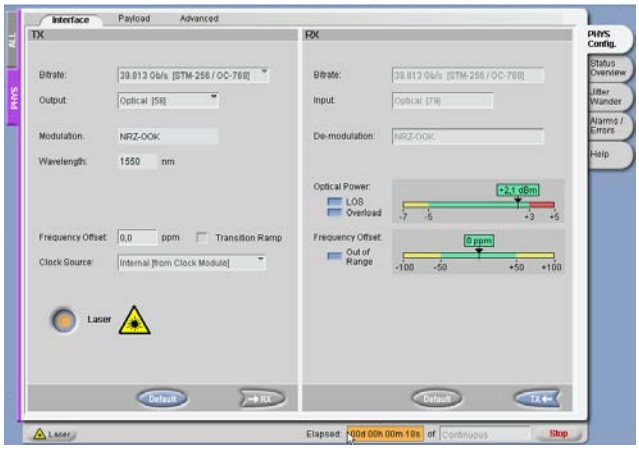
No FEC support, because only at OTU layer available

No GCC capture

Further supported feature see “OTU2 testing” page 29

40/43G Solutions

Physical layer



40G General

Interface

Line rate	39.813 Gb/s
Line code	Scrambled NRZ

Clock generator

Internal accuracy	± 2 ppm
Offset range	± 50 ppm
Offset step size	0.1 ppm
Offset change mode	Step, transition ramp
Transition ramp	1 ppm step in 25 ms

Synchronization to external reference signals:

- From received signal
- From mainframe see clock and synchronization of the ONT-503/506/512 mainframe

40G standard optical

Optical interface

The interface is in accordance with ITU-T G.693, more specificly VSR2000-3R3 and VSR2000-3R5

Transmitter

Wavelength	1530 to 1565 nm
Output level	0 dBm to +3 dBm

Receiver

Wavelength	1530 to 1565 nm
Sensitivity	–6 dBm to +3 dBm
Offset pulling range	± 50 ppm

40G standard electrical

Electrical interface

Impedance	AC coupled 50 Ω
Connector type	PC 2.92 mm (SMA compatible)

Transmitter

Line code	Scrambled NRZ
Output level	>200 mVpp

Receiver

Line code	Scrambled NRZ
Input level	200 to 600 mVpp

40G Jitter

Optical interface

The interface is in accordance with ITU-T G.693

Transmitter

Wavelength	1530 to 1565 nm
Output level	0 dBm to +3 dBm

Receiver

Wavelength	1530 - 1565 nm
Sensitivity	–5 dBm to +3 dBm
Sensitivity for jitter measurement	–2 dBm to +2 dBm
Offset pulling range	± 50 ppm
Offset permitted for jitter measurement	± 20 ppm

Eye clock interface

Clock	9.953 GHz
Connector type	SMA

Electrical interfaces

Impedance	AC coupled 50 Ω
Connector type	PC 2.92 mm (SMA compatible)

Generator data signal

Line code	Scrambled NRZ
Output level	>200 mVpp

Generator clock signal

Output level	>200 mVpp

Receiver data signal for digital measurement

Line code	Scrambled NRZ
Input level	200 to 600 mVpp

43G General

Interface

Line Rate	43.018 Gb/s
Line code	Scrambled NRZ

Clock generator

Internal accuracy	± 2 ppm
Offset range	± 50 ppm
Offset step size	0.1 ppm

Offset change mode	Step, transition ramp
Transition ramp	1 ppm step in 25 ms

Synchronization to external reference signals

- From received signal
- From mainframe, see clock and synchronization of the ONT-503/506/512 mainframe

43G Standard optical

Optical interface

The interface is in accordance with ITU-T G.693, more specificly VSR2000-3R3F and VSR2000-3R5F

Transmitter

Wavelength	1530 to 1565 nm
Output level	0 dBm to +3 dBm

Reference clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Receiver

Wavelength	1530 to 1565 nm
Sensitivity	–6 dBm to +3 dBm
Offset pulling range	± 50 ppm

Recovered clock output

Via 50 Ω SMA connector, with clocking at line rate/64

43G Standard electrical

Electrical interfaces

Impedance	AC coupled 50 Ω
Connector type	PC 2.92 mm (SMA compatible)

Transmitter

Line code	Scrambled NRZ
Output level	>200 mVpp

Generator reference clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Receiver

Line code	Scrambled NRZ
Input level	200 to 600 mVpp

Recovered clock output

Via 50 Ω SMA connector, with clocking at line rate/64

43G OTN DPSK

Interface

Line rate	43.018 Gb/s
Line code	NRZ-DPSK

Optical interface

Transmitter

Wavelength adjustable	λ min. 1528.773 nm
	λ max. 1563.863nm
	Frequency grid 50 GHz conforming to ITU-T G.694.1
Output level adjustable	-1 up to +3 dBm
Step size	0.1

Reference clock

Via 50 Ω SMA connector, with clocking at line rate/64

Receiver

Wavelength	wide range C-Band compatible
Sensitivity	+5 dBm to +10 dBm
Offset pulling range	± 50 ppm
Free spectral range switchable	50 GHz, 66 GHz

Recovered clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Remark:

40G line rate is not available with this coding.

Service disruption with LOS sensor is only supported with a lower performance, due to transponder restrictions.

43G Jitter

Optical interface

The interface is in accordance with ITU-T G.693

Transmitter

Wavelength	1530 to 1565 nm
Output level	0 dBm to +3 dBm

Reference clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Receiver

Wavelength	1530 to 1565 nm
Sensitivity	–5 dBm to +3 dBm
Sensitivity for jitter measurement	–2 dBm to +2 dBm
Offset pulling range	± 50 ppm
Offset permitted for jitter measurement	± 20 ppm

Recovered clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Eye clock interface

Clock	10.75 GHz
Connector type	SMA

Electrical interfaces

Impedance	AC coupled 50 Ω
Connector type	PC 2.92 mm (SMA compatible)

Generator data signal

Line code	Scrambled NRZ
Output level	>200 mVpp

Generator clock signal

Output level	>200 mVpp

Receiver data signal for digital measurement

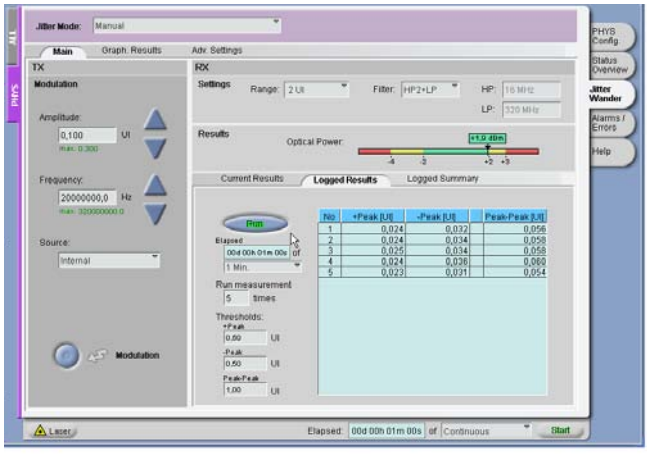
Line code	Scrambled NRZ
Input level	200 to 600 mVpp

40/43G Jitter

Standards

Jitter is generated and analyzed in accordance with the following standards:

- ITU-T Recommendation O.172
- Receiver verification and characterization using ITU-T Rec. O.172 Appendices VII + VIII with Accuracy Map support
- ITU-T Recommendation O.173
- ITU-T Recommendation G.825
- ITU-T Recommendation G.8251



Jitter generator

Built-in modulation generator

Jitter modulation signal	Sine wave, 10 Hz to 320 MHz
Jitter amplitude	up to 12800 UIpp
Step width	0.001 UI
Generation accuracy (16 MHz to 320 MHz)	40 mUIpp

External modulation input

Connector type	BNC, 50 Ω
Modulation frequency	0.1 Hz to 320 MHz
Input voltage range	0 to 632 mVpp (0 dBm)

Jitter analyzer

Measuring ranges/resolution

Peak-Peak I	0 to 2 UIpp/1 mUIpp
Peak-Peak II	1 to 8 UIpp/1 mUIpp
Peak-Peak III	4 to 40 UIpp/10 mUIpp
Peak-Peak IV	20 to 800 UIpp/100 mUIpp
Peak-Peak V	400 to 14000 UIpp/1 UIpp
RMS I	0 to 1 UI/0.1 mUI
RMS II	0.5 to 4 UI/0.1 mUI
RMS III	2 to 20 UI/1 mUI
RMS IV	10 to 400 UI/10 mUI
RMS V	200 to 7000 UI/100 mUI

Measurement accuracy (fixed error in 2 UI range)

20/80 kHz to 320 MHz	150 mUIpp
16 MHz to 320 MHz	50 mUIpp

Built-in filters

High-pass filters	20 kHz, 80 kHz, 16 MHz
Low-pass filter	320 MHz

Demodulator output

Connector type	BNC, 50 Ω

Jitter application

Supports all manual and automatic measurements for jitter evaluations.

Jitter measuring modes

Current values (continuous measurement): Peak-Peak, positive peak, negative peak, RMS

Maximum values (gated measurement): Peak-Peak, positive peak, negative peak

Logged values (repetitive measurements): Peak-Peak, positive peak, negative peak

Phase hits

The instrument detects when the programmable threshold for positive and negative jitter values is exceeded and the result indicates how often the threshold was exceeded.

Jitter versus time

This function is used to record variations of jitter with time and allows the positive and negative peak values, peak-to-peak values, and RMS values to be displayed versus time. Duration is up to 99 days.

Automatic jitter measurements

Maximum tolerable jitter (MTJ)

The jitter module automatically determines the maximum jitter amplitude tolerated by the DUT at selected jitter frequencies. The maximum permissible jitter amplitude can be precisely determined using a successive method. The module determines the exact limit value. Several error sources are selectable. Standard tolerance masks are available and can be edited.

Fast maximum tolerable jitter (Fast-MTJ)

This extremely fast measurement tests the device under test for conformance to the standard tolerance mask limits for maximum tolerable jitter. The editable frequency/amplitude values are set sequentially and the test pattern is monitored for the permitted threshold by the receiver. The result of each measurement is shown in a table as a status message.

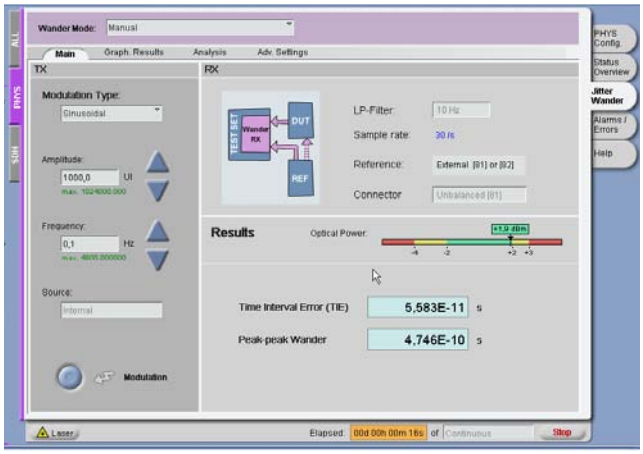
Selective jitter transfer function (JTF)

The JTF shows the ratio of the jitter amplitude at the output of the device under test (DUT) and at the input at various frequencies. Standard tolerance masks are available and can be edited.

40/43G Wander

Fully complies with or exceeds the requirements of ITU-T O.172.

This software option is only available in conjunction with 40G SDH/SONET jitter and the 43G jitter option which enables wander generation and analysis at the different bit rates.



Wander generator

Modulation signal	Sine wave
Amplitude range	0.1 to 1024000 UI
Amplitude step width	0.1 UI
Frequency range	10 µHz to 10 Hz
Frequency step width	1 µHz

Wander analyzer

Four different sampling rates are available for detailed analysis versus time:
Sampling rate – Low-pass filter

1/s – 0.1 Hz, 30/s – 10 Hz (O.172), 60/s – 20 Hz, 1000/s – 100 Hz (O.172)

Wander reference signal input

Balanced	Bantam 110 Ω
Clock signal	1.544, 2.048 MHz
Data signal	1.544, 2.048 Mb/s
Unbalanced	BNC 75 Ω
Clock signal	1.544, 2.048, 5, 10 MHz
Data signal	1.544, 2.048 Mb/s

Wander measuring modes

Time interval error (TIE) numerical and graphical, peak-peak wander numerical.
TIE values are recorded and available for MTIE/TDEV evaluations and frequency offset and drift rate measurements with graphs and built-in masks that comply with Telcordia GR-253, GR-1244, ANSI T1.101, ETSI ETS 300 462, EN 302 084, ITU-T O.172, and G.810 to G.813 recommendations.

Automatic wander measurements

Maximum tolerable wander (MTW)

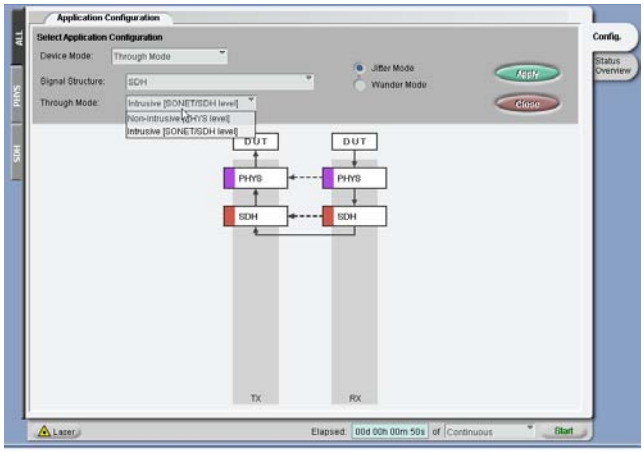
This application tests the DUT for conformance to the standard tolerance mask limits for wander tolerance and is available in connection with the wander generator.

The device under test is subjected to wander at several amplitudes and frequencies and the output signal is monitored for different error sources. The measurement point is then marked as "Pass" (no alarms or errors detected) or "Fail" (alarms or errors detected).

Unframed Testing

Unframed testing

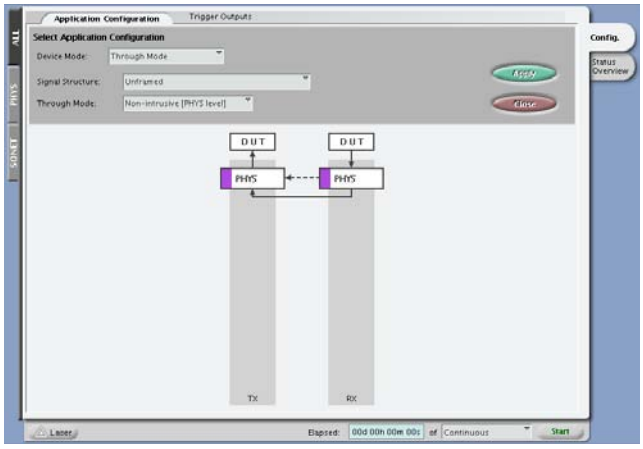
With the possibility to generate and analyze unframed test signals the application space for testing with ONT family can be extended to earlier testing phases in the optical component area but also for verification of real transparent signals.



The unframed physical layer supports the following two modes:

Mode	Terminate
	Non-intrusive through mode

The non-intrusive through mode implies that no errors/alarms or other modification can be inserted.



Transmitter

Generator reference clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Receiver

Recovered clock output

Via 50 Ω SMA connector, with clocking at line rate/64

Displays the current optical input level and the min/max values with timestamp.
Displays the current signal frequency and offset and the min/max values with timestamp.

Generator

Test pattern: PRBS

PRBS:	2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}-1,
	2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv.
	(Conforming to ITU-T O.150)

Error insertion

Type	Bit errors
Trigger	Single, rates from 1 x 10^{-3} to 1 x 10^{-12}
	With mantissa equal 1

Alarm insertion

Type	LOS
Trigger	Continuous

Trigger output

Type	Off, Laser on
Pulse output	Event present, logical high
Level	TTL compatible, high >2.4 V, low <0.8 V
Connector	BNC, 75 Ω

Analyzer

Analysis of test pattern	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}-1,
	2^{31} -1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7} -1 inv.
	(Conforming to ITU-T O.150)

Error measurement

Type	Bit errors

Alarm detection

Type	LOS, Pattern Loss
Resolution	100 ms

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error
Duration is displayed for each alarm

Tabular display

Display of all results with time stamps

Criteria	Start, stop, duration, count

Intermediate bit error

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, Count and ratio

Trigger output

Type	Off, LOS alarm
Pulse output	Event present, logical high
Level	TTL compatible, high >2.4 V, low <0.8 V
Connector	BNC, 75 Ω

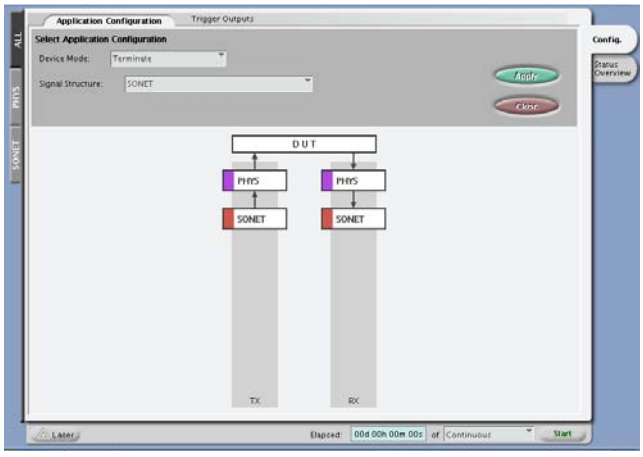
40G SDH/SONET

SDH/SONET application

The SDH/SONET application supports three modes of testing.

Terminate

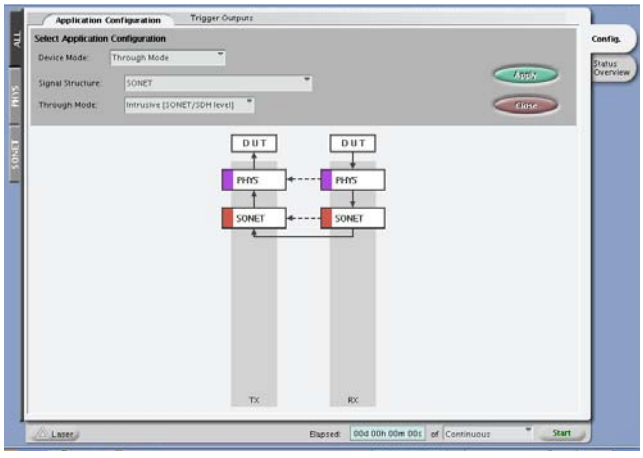
Generator and Analyzer generate independent at the same line rate



Intrusive Through mode

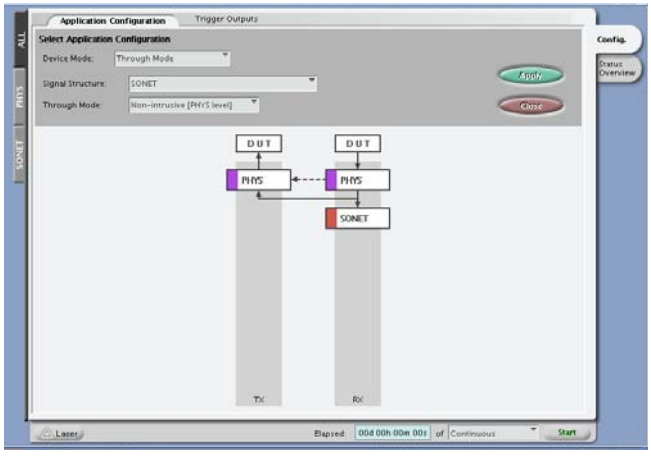
The generator and the analyzer are running at the same SDH/SONET line rate.

The received traffic is terminated an the SDH layer and retransmitted with the transmitter. All SDH/SONET layer can be unchanged transmitted or overwritten with the capabilities available in the SDH/SONET generator. The payload signal is unchanged retransmitted.



Non-intrusive Through mode

This mode is derived from the intrusive through, but with the assurance that the signal is retransmitted without any modification.



SDH/SONET testing

Generation/evaluation of STM-256 signal according to ITU-T G.707
Generation/evaluation of OC-768 signal according to ANSI T1.105

Mapping

SDH	VC-4-256c, VC-4-64c, VC-4-16c, VC-4-4c, VC-4, AU-3/VC-3
SONET	STS-768c SPE, STS-192c SPE, STS-48c SPE, STS-12c SPE, STS-3c SPE, STS-1 SPE

Generator

Generator modes

- Free definable foreground
- All channels identical
- Background selectable mapping, depending on foreground channel with definable path overhead and Null pattern as payload

Test pattern PRBS, programmable word

PRBS:	2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv. (Conforming to ITU-T O.150)
Programmable word	Length 32 bits

Error insertion

Types

SDH	Random, FAS, B1, B2, B3, MS-REI, HP-REI, bit errors
SONET	Random, FAS, B1, B2, B3, REI-L, REI-P, bit errors
Trigger	Single, rates

Error	Min rate	Max rate	Stepping	Mapping
Random	1×10^{-10}	1×10^{-3}	Exponential	–
FAS	1×10^{-12}	1×10^{-3}	0.1	–
B1	1×10^{-12}	1.61×10^{-6}	0.1	–
B2	1×10^{-12}	1×10^{-3}	0.1	–
MS-REI, REI-L	1×10^{-12}	1×10^{-3}	0.1	–
B3	1×10^{-12}	1.61×10^{-6}	0.1	STM-VC-4-256c, STS-1-768cSPE
B3	1×10^{-12}	1×10^{-3}	0.1	STM-VC-3, STS-1-SPE
HP-REI, REI-P	1×10^{-12}	1.61×10^{-6}	0.1	STM-VC-4-256c, STS-1-768cSPE
HP-REI, REI-P	1×10^{-12}	1×10^{-3}	0.1	STM-AU-3/VC-3, STS-1-SPE
Bit error	1×10^{-12}	1×10^{-3}	Exponential	–

Burst error once and continuous M errored frames followed by N error-free frames. All errors except random and bit errors
N, M = 1 to 8000000 or 125 µs to 1000 s

Alarm generation

Type:

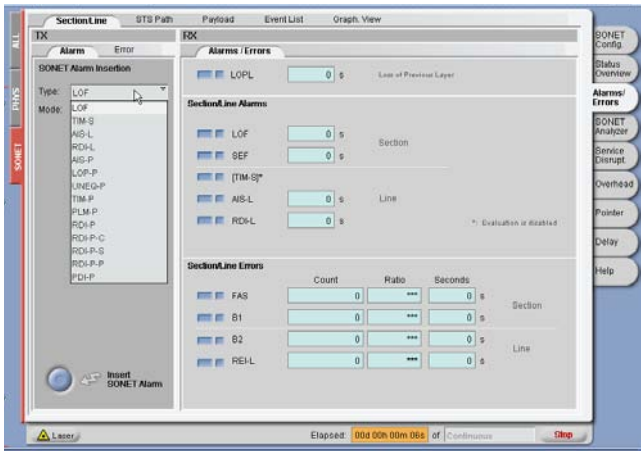
SDH	LOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-TIM, HP-PLM, HP-RDI, HP-RDI-C, HP-RDI-S, HP-RDI-P
SONET	LOF, AIS-L, RDI-L, TIM-L, AIS-P, LOP-P, UNEQ-P, TIM-P, PLM-P, RDI-P, RDI-P-C, RDI-P-S, RDI-P-P, PDI-P
Trigger	LOS, TIMs on/off
	All others on/off or burst
	Burst once and continuous
	M frames with alarm ON, N frames with alarm OFF
	N, M = 1 to 800000 or 125 µs to 1000 s

Trigger output

Generates an external trigger signal at generation of the internal event.

Types

SDH	Off, frame trigger, MS-AIS, AU-AIS, B1, B2, B3, Bit errors
SONET	Off, frame t rigger, AIS-L, AIS-P, B1, B2, B3, Bit errors
Pulse output	Event present, logical high
Level	TTL compatible, high >2.4 V, low <0.8 V
Connector	BNC, 75 Ω



Overhead generator

The stimulus of different overhead byte pattern is an important part of verification and interoperability testing. Network elements (NE) should respond in the defined manner and any responses then conveyed by a different overhead byte.

Statically programmable bytes

- A1-A2 unscrambled
- RSOH/SOH all bytes except B1
- MSOH/LOH all bytes except B2, H1...H3
- POH all bytes except B3

Display of overhead on the GUI.

Trace identifier

J0, J1 programmable 1 byte, 16 bytes with CRC or 64 byte sequence

Generation of pointer actions

Generation of pointer actions at the AU/STS level

- New pointer value setting with or without NDF
- Offset simulation in ppms
- Single, periodical and alternating pointer increment/decrement
- Pointer sequences with different types
- SS-bits definable

Analyzer

Auto signal structure

Receiver analyses the signal structure (mapping, payload, traces) automatically for easy configuration of the test channel.

Test pattern: PRBS, programmable word, live traffic

PRBS:	2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{31}-1 inv., 2^{23}-1 inv. , 2^{15}-1 inv., 2^{11}-1 inv. (conforming to ITU-T O.150)
Programmable word	Length 32 bits

"Live traffic" mode ignores pattern loss and bit error that allows analysis of live traffic without trouble indication

Error measurements

SDH	FAS, B1, B2, B3, MS-REI, HP-REI, Bit errors
SONET	FAS, B1, B2, B3, REI-L, REI-P, Bit errors

Alarm detections

SDH	OOF, LOF, MS-AIS, MS-RDI, RS-TIM, AU-AIS, AU-LOP, HP-TIM, HP-UNEQ, HP-PLM, HP-RDI, Pattern Loss
SONET	OOF, LOF, AIS-L, RDI-L, TIM-L, AIS-P, LOP-P, TIM-P, UNEQ-P, PLM-P, RDI-P, PDI-P, PLM-P, ERDI-P-Payload, ERDI-P-Server, ERDI-P-Connect, Pattern Loss
Resolution	100 ms

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error
Duration is displayed for each alarm

Tabular display

Display of all results with time stamps

Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis	Second, minute, hour

Intermediate bit error

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, Count and ratio

Trigger output

Generates an external trigger signal at the detection of the received event.

Types

SDH	Off, frame trigger, LOF alarm, OOF alarm, MS-AIS alarm, AU-AIS alarm, B1, B2, B3, Bit errors
SONET	Off, frame trigger, LOF alarm, SEF alarm, AIS-L alarm, AIS-P alarm, B1, B2, B3, Bit errors
Pulse output	Event present, logical high
Level	TTL compatible, high >2.4 V, low <0.8 V
Connector	BNC, 75 Ω

Overhead analyzer

Display of Overhead on the GUI.

Message evaluation (TIM/PLM)

- J0, J1 1 byte, 16 bytes with CRC or 64 byte sequence
- J0, J1 clear text display
- TIM evaluation: exception value editable as criterion for TIM
- C2 signal label clear text selection
- PLM Evaluation: exception value editable as criterion for PLM

Service disruption test

To analyze service disruption times, the ONT-5xx generates a high-speed event list as a result of all detected events.

Sensor to trigger service disruption test, selectable

Errors

SDH	FAS, B1, B2, MS-REI, B3, HP-REI, bit errors/pattern loss
SONET	FAS, B1, B2, REI-L, B3, REI-P, bit errors/patt. loss

Alarms

SDH	LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP , HP-UNEQ, HP-PLM, HP-RDI,
SONET	LOS, LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, PDI-P, RDI-P
Event sample resolution	100 µs
Separation time	0.1 ms to 100000 ms

Separation time starts at the end of the last event. Separation time is used to determine if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

Result display of disruptions

Numerical display

Total Number of disruptions, begin timestamp of first
Disruption, end timestamp of last disruption,
Shortest disruption time (with timestamp)
Longest disruption time (with timestamp)

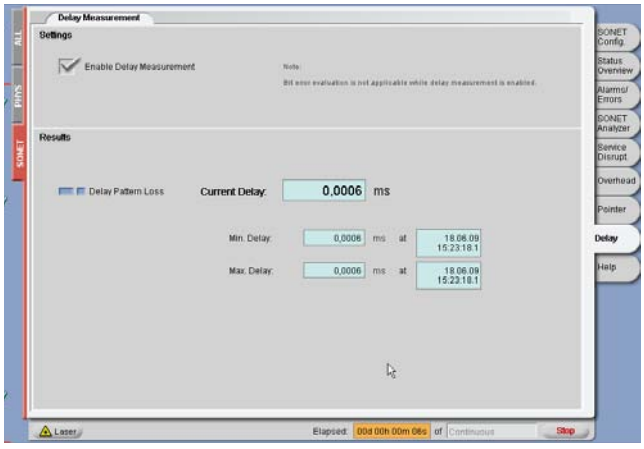
Average disruption time

The threshold to identify a violation of allowed service
Disruption time can be set in the range of 0 ms to 100000 ms

Tabular display

Service disruption events with start/stop times and duration.
Three logging modes available (no logging; disruption events only; disruption and causing sensor events)

Transfer delay analysis



Transfer delay measurements by special payload pattern in the	
Range of 0 to 40 s.	

Transfer delay can be measured even between different ports within the same mainframe.

Numerical display

Current transfer delay with accuracy of 1 µs and	
Resolution 100 ns	
Minimum transfer delay (with timestamp)	
Maximum transfer delay (with timestamp)	

Pointer analysis

AU/STS Pointer

Numerical display

Value, count of increments, decrements, NDF.

Tabular display

Display of all events with time stamps

Criteria	Start, stop, duration, count

Performance monitoring

For SDH

Performance monitoring G.826

EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments based on line length allocation of 0.1 to 100%.
The SES and UAS thresholds are user-programmable. In-service measurement (ISM) of the near end and the far end of a selected path, as well as out-of-service (OOS) measurements, are supported.

Performance monitoring G.828 and G.829

The G.828 defines error performance parameters for international synchronous paths.
EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments are based on a line length allocation of 0.1 to 100%.The SES and UAS thresholds are user-programmable. The SEP can be switched off for assessment. G.829 defines error performance events and block structures for SDH multiplex and regenerator sections.

For SONET

Evaluation of ES, EFS, SES, UAS and SEFS (GR 253, T1.231) ESA, ESB

Byte capture SOH/TOH

To analyze the SOH/TOH functions, it is necessary to capture individual bytes vs. time, allowing detection of errors or short term changes with frame level resolution. The capture function is started by a selectable trigger.
Values for one/two selected bytes are stored and can be accessed subsequently in a table of values.
Particularly in capturing the APS sequences, bytes K1 and K2 are displayed in clear text.

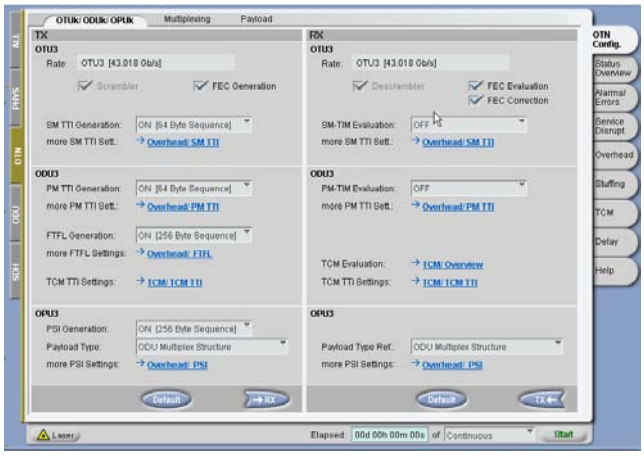
Selectable bytes for SOH/TOH	All bytes
Captured parameters	Byte value, number of frames and Correspondent time

Storage depth of one byte or K1/K2 combination

Post trigger	up to 256 value changes
Pre trigger	up to 256 value changes
Trigger conditions	Pre, post, center
Trigger events	User defined byte value, bit mask (compare, not compare, don't care)

43G OTN

OTN application



OTU2 testing

Modes

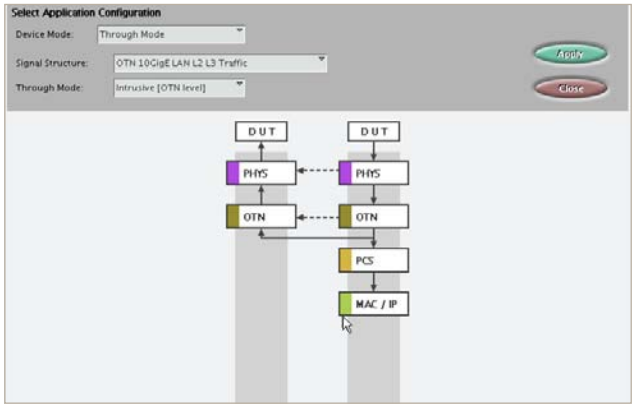
Multiple testing modes are available with OTN.

Terminate

Generator and analyzer are running at the same OTN rate.

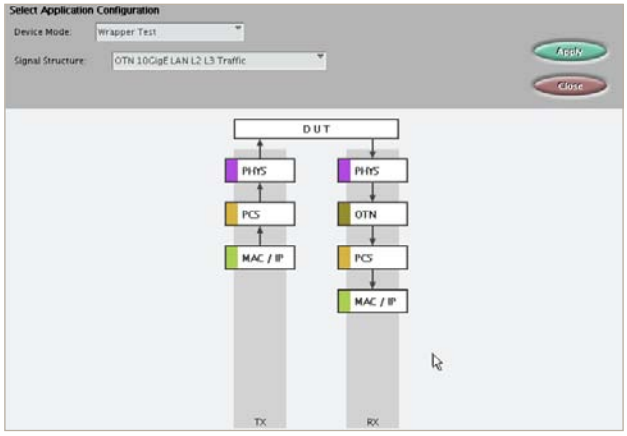
Intrusive through mode

Generator and analyzer are running at the same OTN rate. The received traffic is terminated at the OTN layer and retransmitted with the transmitter. All OTN layer information can be unchanged transmitted or overwritten with the capabilities available in the OTN generator part. The client signal is unchanged retransmitted and analyzed by the higher layer if support is available.



Wrapper/de-wrapper test

Transmitter and receiver interface are running at different rates.
The wrapper test is used to test the wrapper function of a DUT (Device Under Test). The ONT generates a client signal and analyzes an OTN signal with wrapped client. The OTN generator features are not available.



The dewrapper test is used to test the de-wrapper function of a DUT. The ONT generates an OTN signal with wrapped client and analyzes a dewrapped client signal. The OTN analyzer features are not available.

OTN testing

The OTN application runs on the interface modules and allows the generation and analysis of an OTM-0.3 signal using NRZ or NRZ-DPSK modulation.

Detailed parameters can be manipulated and evaluated in different OTN levels. Its payload supports both framed SDH/SONET and unframed clients.

The test set provides signal analysis and manipulation (alarm, error, overhead), Forward Error Correction (FEC) generation and analysis as well as FEC error testing. In addition to this, the full analysis capabilities of SDH and SONET are available for OTN client analysis.

Generator

OPU3 mapping of client signals:

CBR40G with SDH/SONET client (for BN 3061/91.81 included, optional with BN 3061/91.85)
STM-256/STS-768 signal internally generated.
Generation see "40G SDH/SONET application" page 38.

PRBS test signal 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{7}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{7}-1 inv. (conforming to ITU-T O.150)
Digital word 32 bit free programmable

Null client

OTN multiplexing (optional, see page 46)

All clients can be mapped bit-synchronous or asynchronous.

Client offset – stuffing

The asynchronous SONET and SDH client offset can be adjusted within the ± 65 ppm range and the stuffing rate of the client can thus be manipulated.

Overhead

Overhead bytes (frame alignment/OTU/ODU/OPU)

- All bytes statically programmable except MFAS, SM BIP, PM BIP, TCM1...6 BIP
- Additional possibilities for SM TTI, PM TTI, TCM1...6 TTI (Trail Trace Identifier):
  Sequence consisting of the SAPI (16 bytes) and DAPI (16 bytes) and the operator specified (32 bytes).
- User designed payload structure identifier (PSI), payload type identifier clear text and support of MSI
- One OH byte can be selected for a freely defined sequence of 16/32/64/128/256 bytes
- FTFL free definable forward/backward (FW/BW) fault indication and operator identifier

Error insertion

Type: Random, FAS, MFAS
SM BIP-8, SM BEI, PM BIP-8, PM BEI
TCMi BIP-8, TCMi BEI (i = 1 to 6)
Bit errors (only available with PRBS test signal)

Trigger: Single , rate, burst , burst continuous

Burst error: M frames errors, N frames error free,
M and N = 0 to 2^{31}

Rate

Error name	Min rate	Max rate	Stepping
Random	1×10^{-10}	1×10^{-3}	Exponential
Bit	1×10^{-12}	1×10^{-3}	Exponential
FAS	4.9×10^{-12}	1×10^{-3}	0.1
MFAS	3.0×10^{-11}	1×10^{-3}	0.1
SM BIP	1×10^{-12}	6.6×10^{-5}	0.1
SM BEI	1×10^{-12}	6.6×10^{-5}	0.1
PM BIP	1×10^{-12}	6.6×10^{-5}	0.1
PM BEI	1×10^{-12}	6.6×10^{-5}	0.1
TCMi BIP	1×10^{-12}	6.6×10^{-5}	0.1
TCMi BEI	1×10^{-12}	6.6×10^{-5}	0.1

BIP masks

The position and number of bit errors in the bytes can be selected.
Valid for SM BIP, PM BIP, TCMi BIP (i = 1 to 6)

BEI value

To stress the BEI evaluation of the DUT receiver the BEIs can be set to values 0 to 15
Valid for SM BEI, PM BEI, TCMi BEI (i = 1 to 6)

Alarm generation

Type	LOF, OOF, LOM, OOM
	OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK, SM BDI,
	SM IAE, SM BIAE, PM-BDI, PM-TM
	FW-SD, FW-SF, BW-SD, BW-SF
	TCMi-LTC, TCMi-BDI, TCMi-BIAE, TCMi-TIM (i = 1 to 6)

Trigger

Continuously	All alarms
Burst once/ Burst continuous	all errors except LOF, OOF, OOM, SD, SF, TIMs
Burst alarms	M frames with alarm, N frames no alarm,
	M = 1 to 2^{31}
	N = 0 to 2^{31}

OTU FEC

The FEC generation can be switched on and off. Using the OTU FEC field, FEC according to the Reed-Solomon (255,239) algorithm is performed on the generated frame. With data blocks consisting of 239 data bytes and 16 FEC field bytes, up to 16 byte errors can be detected or 8 byte errors be corrected.

FEC error insertion modes

- FECcorrectable, FECuncorrectable
- FECstress: This extremely helpful function allows maximum stress tests within a short time frame.
  The maximum possible number of errors that the device under test (DUT) should still be able to correct is inserted into the OTU frame.

FECadvanced

FECadvanced allows the user to define a detailed position for error insertion in the OTU frame. Correction capability testing below and above the correction limit can be performed.

Selectable parameters:	row, subrow, errored bytes per subrow,
	Start position in subrow, byte error mask

Analyzer

OPU3 mapping of client signals:

CBR40G with SDH/SONET client (for BN 3061/91.81 included, optional with BN 3061/91.85)	
	STM-256/STS-768 signal.
	Analysis see 40G SDH/SONET applications" page 38.
PRBS test signal	2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{7}-1, 2^{31}-1 inv., 2^{23}-1 inv.
	2^{15}-1 inv., 2^{7}-1 inv., (conforming to ITU-T O.150)
	Digital word 32 bit free programmable
Null client	
OTN multiplexing	(optional, see page 46)

All clients can be de-mapped bit-synchronous and asynchronous

Stuffing of the client

Display of client offset in ppm

Stuffing counts

Positive, negative, sum count, duration of affected seconds

Overhead

Overhead evaluation (frame alignment/OTU/ODU/OPU)

- Display of the complete overhead
- SM TTI, PM TTI, TCM1…6 TTI display of the 64 byte ASCII sequence of SAPI, DAPI and Operator field
- One sequence of up to 256 bytes can be captured and displayed for a selectable OH byte
- Display payload structure identifier (PSI) bytes, payload type identifier (PT) clear text and support of MSI
- Editable PT expectation value as mismatch criterion
- FTFL forward/backward (FW/BW) fault indication and operator identifier fields

Trace references

- Set of SAPI and DAPI expectation values in traces SM TTI, PM TTI, TCM1…6 TTI
- Select evaluation type of the received signal: SAPI or DAPI or SAPI/DAPI

General Communication Channel Capture (GCC)

The management information between network element and termination equipment is transported in the GCCs in the OTN overhead. With this feature, the transmitted information can be captured in real-time.

Captured fields	GCC0, GCC1, GCC2, GCC1+2
Captured format	Raw
Capture size	up to 500 MB
Trigger	Manual

Error measurement

Validation of data for error measurement occurs after frame alignment, descrambling, and FEC computation and correction (if enabled).

Alarm detection

Types	LOF, OOF, LOM, OOM
	OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK, SM BDI, SM IAE, SM
	BIAE, SM TIM, PM-BDI, PM TIM
	FW-SD, FW-SF, BW-SD, BW-SF
	TCMi-LTC, TCMi-BDI, TCMi-IAE, TCMi-BIAE, TCMi-TIM (i = 1 to 6)
	CL-LOSS (Client signal loss of synchronization)
	PT-MISM

Error detection

Types	FAS, MFAS, SM BIP, SM BEI, PM BIP, PM BEI
	TCMi BIP, TCMi BEI (i = 1 to 6)
	Bit error (only available for PRBS/digital word testing signal)
Resolution	100 ms

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error

Duration is displayed for each alarm

Tabular display

Display of all results with time stamps	
Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis	Second, minute, hour

Intermediate bit error

In addition to the long term bit error measurement, intermediate results are available.

Interval	1 s up to 3600 s,
Results	Current/previous interval, Count and ratio

OTU FEC

The FEC analysis and correction can be switched on and off. Using the OTU FEC field, FEC according to the Reed-Solomon (255,239) algorithm is performed on the received frame. With data blocks consisting of 239 data bytes and 16 FEC field bytes, up to 16 byte errors can be detected or 8 byte errors be corrected.

Error detection

Type	FECcorrectable bit, FECcorrectable code word, FECuncorrectable code word

Result display of errors

Numerical display

Count, ratio and duration are displayed for each error

Tabular display

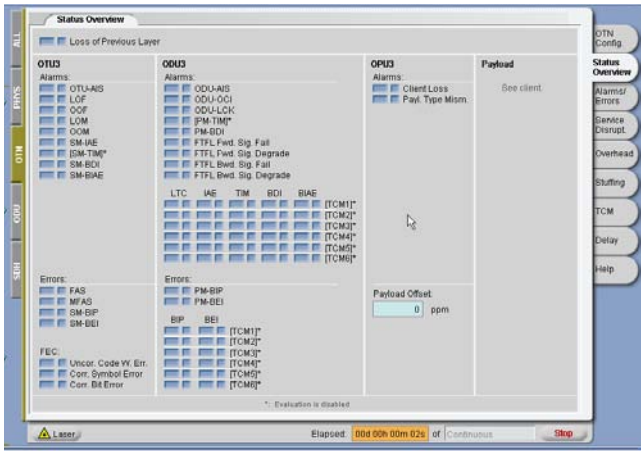
Display of all results with time stamps

Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis	Second, minute, hour



Service disruption test

To analyze service disruption times, the ONT-5xx generates a high-speed event list as a result of all detected events.

Sensor to trigger service disruption test, selectable:

Errors

Types	MFAS, SM-BEI, PM-BIP, PM-BEI, payload errors
Event sample resolution	100 µs

Alarms

Types	LOS, LOM, OOM, SM-IAE, SM-BDI, SM-BIAE, ODU-AIS, ODU-OCI, ODU-LCK, PM-BDI
Separation time	0.1 ms to 100000 ms

Separation time starts at the end of the last event. Separation time is used to determine if the following event is a continuation of the

same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

Result display of disruptions

Numerical display

Total Number of disruptions, begin timestamp of first disruption, end timestamp of last disruption,

Shortest disruption time (with timestamp)

Longest disruption time (with timestamp)

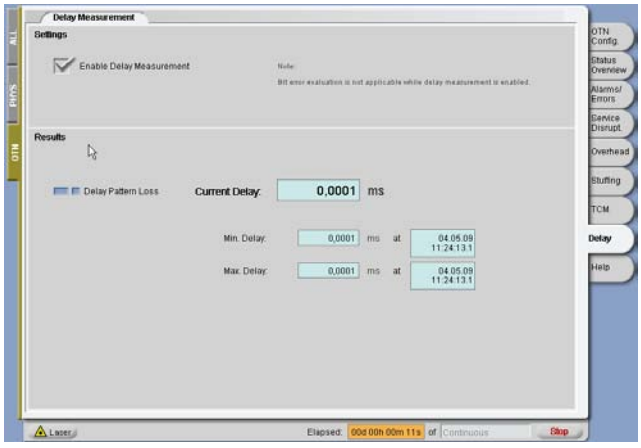
Average disruption time

The threshold to identify a violation of allowed service disruption time can be set in the range of 0 ms to 100000 ms

Tabular display:

Service disruption events with start/stop times and duration.

Three logging modes available (no logging; disruption events only; disruption and causing sensor events)



Transfer delay analysis

Transfer delay measurements by special payload pattern in the range of 0 to 40 s.

Transfer delay can be measured even between different ports within the same mainframe.

Numerical display

Current transfer delay with accuracy of 1 µs and resolution 100 ns

Minimum transfer delay (with timestamp)

Maximum transfer delay (with timestamp)

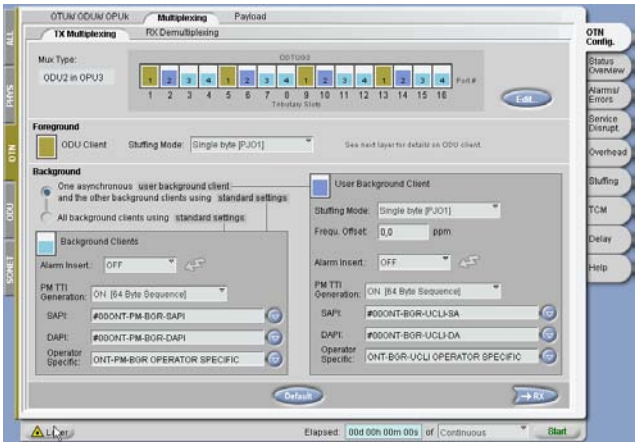
OTN Multiplexing

As OTN moving forward from a point to point technology to a network technology additional features getting implemented. In special OTN-Multiplexing is to mention as such a feature. The ONT-503/-506/-512 will support ODU2/1 multiplexing in ODU3.

Software option 43G OTN Mulitplexing *BN 3061/93.14*

OTU3

Generator



Signal structure

Foreground	Full structured ODU1/ODU2
With one of the following clients	Bulk client, SDH/SONET (optional)
Bulk client	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv. and digital word 32 bit
User Background	Structured ODU1/ODU2
With user defined	PM-TTI and a NULL client payload Generation enable/disable
Background	The remaining time slots are filled ODU1/ODU2
With a user defined	PM-TTI, identical all channels and a NULL client payload

User background and background can be overwritten by ODU-OCI, ODU-AIS, and ODU-LCK

Only one multiplex type is supported at a time ODU1 or ODU2. TX and RX not coupled.

Time slot allocation	Foreground and user background can be Free allocated, background channels Are automatically allocated.

Client offset stuffing

Following modes a supported	Negative, positive, Double positive
Foreground	Default 0 ppm to client bit rate
Offset range	± 65 ppm
User Background	Enabled, default 0 ppm to client bit rate
Offset range	± 65 ppm
Background	No stuffing support

Other generator capabilities are identical to OTU3 for the Foreground with following restrictions:

No SM support, because only on OTU available.

No FEC support, because only on OTU available.

Analyzer

Signal structure

Foreground	Full structured ODU1/ODU2
With one of the following clients	Bulk client, SDH/SONET client (optional)
Bulk client	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv. and digital word 32 bit
Time slot allocation	Foreground can be free allocated

Client offset stuffing

Following modes a supported	Negative, positive, Double positive
Displays of client offset	in ppm

Stuffing counts

Positive, double positive, negative, sum count, duration of affected seconds

Other analyzer capabilities are identical to OTU3 for the foreground with following restrictions:

No SM support, because only at OTU layer available
No FEC support, because only at OTU layer available
No GCC capture

For more features see "OTN application" page 46

SDH/SONET applications

Highlights SDH/SONET

- **Dynamic error/alarm** insertion including bursts
- **Best-in-class service disruption** test with high level of details and user-accessible settings – no blind spots

Hardware modules

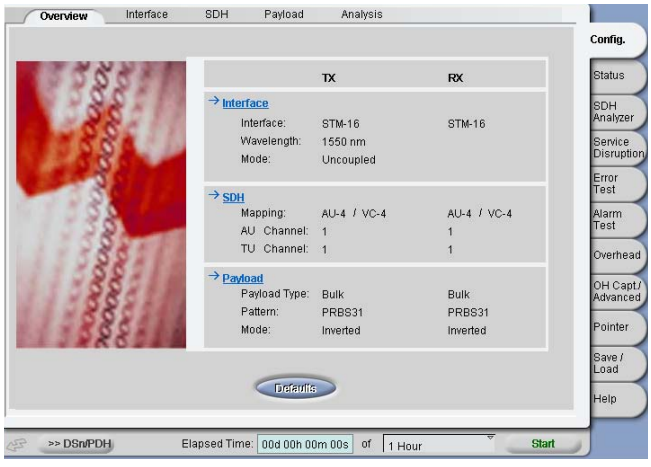
Module 2.5G-B, 1310/1550 nm
NewGen Solution 2.5G-B, 1310/1550 nm
OTN Module 2.5/2.7G-B, 1310/1550 nm

Hardware options – 1 slot each

Module 2.5G-B, 1310/1550 nm/electrical interfaces	*BN 3061/90.26*
NewGen Solution 2.5G-B, 1310/1550 nm/el. interfaces	*BN 3061/90.43*
OTN Module 2.5/2.7G-B, 1310/1550 nm/el. interfaces	*BN 3061/90.27*

Tests supported

- SDH/SONET from 52 Mb/s to 2.5 Gb/s (page 49)
- Multi-Channel SDH/SONET (optional, page 52)
- EoS (NewGen solutions only, page 58)
- OTU1 testing (OTN modules only, page 56)
- PoS (optional, page 52)
- Jitter/wander for versions **–C** (optional, page 71)



General/interfaces

Line rates	2.488 Gb/s, 622/155/52 Mb/s
	2.666 Gb/s (OTN modules only)
Line code	Scrambled NRZ

Clock generator

Clock accuracy and synchronization from external signal: see clock specifications of ONT-503/506/512 mainframe

Selectable clock offset	± 50 ppm
Step size	0.1 ppm

Optical interface

The interface meets the specification of ITU-T G.957 / GR.253

Generator

Wavelength	1310/1550 nm
Wavelength	1310 nm
Output level	–2 to +3 dBm

Receiver

Wavelength range	1260 to 1360 nm, 1430 to 1580 nm
Rx offset acceptance	± 100 ppm
Sensitivity all rates	–8 to –28 dBm
Additionally at 155M, 52M	–8 to –34 dBm
Maximum input power (destructive)	+3 dBm
Optical power measurement	–8 to –34 dBm

Electrical interfaces (except BN 3061/90.80)

Impedance	50 Ω, AC coupled
Connector type	SMA

Generator data signal

Bit rates	52 Mb/s to 2.488 Gb/s, 2.666 Gb/s (OTN modules only)
Line code	Scrambled NRZ
Output level	>200 mVpp

Generator clock signal

Bit rates	52 Mb/s to 2.488 GHz, 2.666 GHz (OTN modules only)
Eye clock	$f_{clock}/4$
Output level	>200 mVpp

Receiver data signal

Bit rates	52 Mb/s to 2.488 Gb/s, 2.666 Gb/s (OTN modules only)
Line code	Scrambled NRZ
Input level	200 to 1000 mVpp

Receiver clock signal

Recovered clock	$f_{clock}/4$
Input level	>200 mVpp

Module 10G (-B), 1310 nm
Module 10G (-B), 1550 nm
NewGen Solution 10G, 1550 nm
OTN module 10/10.7G – 1550 nm
OTN module 10/10.7G-B – 1550 nm
OTN module 10/10.7G-B – 1310 nm

Hardware options 90.15 and 90.16 – 1 slot each
Hardware options others – 2 slots each

Module 10G, 1310 nm	*BN 3061/90.15*
Module 10G-B, 1310 nm/electrical interfaces	*BN 3061/90.21*
Module 10G, 1550 nm	*BN 3061/90.16*
Module 10G-B, 1550 nm/electrical interfaces	*BN 3061/90.19*
NewGen Solution 10G, 1550 nm/electrical interfaces	*BN 3061/90.45*
OTN module 10/10.7G, 1550 nm	*BN 3061/90.30*
OTN module 10/10.7G-B, 1550 nm/ electrical interfaces	*BN 3061/90.32*
OTN module 10/10.7G-B, 1310 nm/ electrical interfaces	*BN 3061/90.33*

Tests supported

- SDH/SONET 10 Gb/s (page 49)
- Multi-Channel SDH/SONET (hardware option, page 52)
- EoS (NewGen solution only, page 52)
- PoS (optional, page 52)
- OTU2 testing at 10.7 Gb/s (OTN modules only, page 56)

General/interfaces

Line rate	9.953 Gb/s, 10.709 Gb/s (only OTN module)
Line code	Scrambled NRZ

Clock generator

Clock accuracy and synchronization from external signal: see clock specifications of ONT-503/506/512 mainframe

Selectable clock offset	± 50 ppm
Step size	0.1 ppm

Optical interfaces

The interface meets the requirements of ITU-T G.691/GR.253

Generator

Wavelength /90.15	1310 nm
Output level	–6 to –1 dBm
Wavelength /90.21, /90.33	1310 nm
Output level	–3 to +2 dBm
Wavelength /90.16, /90.30	1550 nm
Output level	–3 to +2 dBm
Wavelength /90.19, /90.32, /90.45	1550 nm
Output level	–3 to +2 dBm

Receiver

Wavelength range /90.15	1290 to 1330 nm

Sensitivity	–11 to –1 dBm
Max. input power (destructive power)	0 dBm
Measuring optical input power	–14 to 0 dBm
Wavelength range /90.16, /90.30	1530 to 1565 nm
Sensitivity	–17 to –3 dBm
Max. input power (destructive power)	+2 dBm
Measuring optical input power	–14 to 0 dBm
Wavelength range /90.19, /90.21, /90.32, /90.33, /90.45	1260 to 1620 nm
Sensitivity	–14 to –3 dBm
Max. input power (destructive power)	+2 dBm
Measuring optical input power	–14 to 0 dBm

Generator eye clock signal

Bit rate	622 MHz, 669 MHz (only OTN module)
Output level sinusoidal	>200 mVpp

Electrical interfaces (except BN 3061/90.15, /90.16, /90.30)

Impedance	AC coupled 50 Ω
Connector type	SMA

Generator data signal

Bit rate, code	9.953 Gb/s, 10.709 Gb/s (only OTN module), Scrambled NRZ
Output level	> 200 mVpp

Generator clock signal

Bit rate	9.953 GHz, 10.709 Gb/s (only OTN module)
Output level	> 200 mVpp

Receiver data signal

Bit rate , code	9.953 Gb/s, 10.709 Gb/s (only OTN module) Scrambled NRZ
Input level	100 to 600 mVpp

SDH/SONET testing

Signal structure

SONET mappings	VT 1.5/ 2/ 6, STS-1/ 3c/ 12c/ 48c-SPE
For 10G modules inclusive	STS-192c-SPE
SDH mappings	AU-4: VC-12, VC-11, VC-2, VC-3, VC-4, VC-4-4c/16c
	AU-3: VC-12, VC-11, VC-2, VC-3
For 10G modules inclusive	VC-4-64c

Payload

- Test pattern without stuffing bits (Bulk O.181)
- Unframed DSn/PDH test pattern
- Framed and muxed DSn/PDH signals (refer to page 74)

Fill patterns

- 2^{15}-1/ 2^{23}-1/ 2^{31}-1 (ITU and inverted),
- 16 bit user selectable word
- "Traffic" mode: the content of the containers is ignored thus allowing analysis of live traffic.

Background channels

Identically structured
Fill pattern independent from test pattern

- 2^{15}–1/ 2^{23}–1/ 2^{31}–1 (ITU and inverted),
- 16 bit user selectable word

Measurements

Error measurement

Bit errors, FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P, LP-BIP/BIP-V, LP-REI/REI-V
All errors, count, ratio, seconds

Alarm detection

SDH	LOS, OOF, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-RDI, HP-UNEQ, LP-TIM, LP-PLM, RS-TIM, HP-PLM, HP-TIM TU-LOM, TU-AIS, LP-RDI, LP-RFI, TU-LOP, LP-UNEQ, Pattern loss
SONET	LOS, SEF, LOF, AIS-L, RDI-L, LOP-P, AIS-P, RDI-P, TIM-S, TIM-P, PLM-P, UNEQ-P, TIM-V, PLM-V, LOM-V, AIS-V, RDI-V, RFI, LOP-V, UNEQ-V, Pattern loss
Resolution	100 ms

Error and alarm measurement DSn/PDH

Please refer to page 74, DSn/PDH testing.

Result display of errors and alarms

Numerical display

Count, ratio and seconds are displayed for each error, seconds are displayed for each alarm.

Tabular display

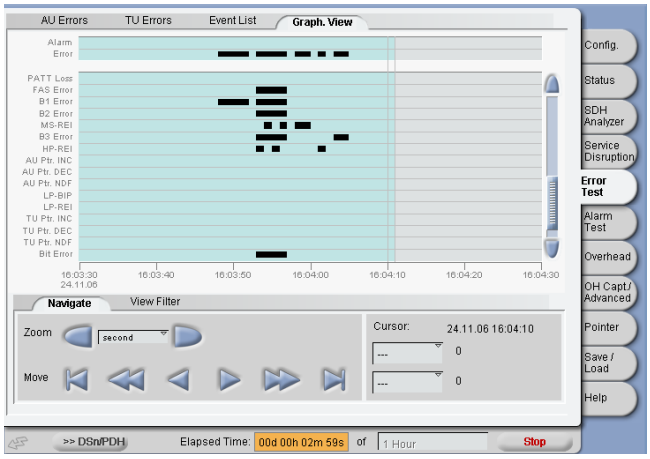
Display of all results with time stamps: start, stop, duration/count

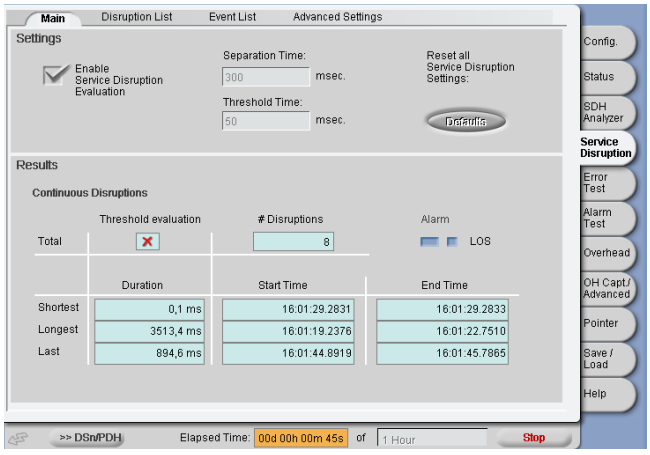
Graphical display

Events are displayed as bar graphs versus time. Cursors allow for easy identification and zooming-in on the results. Filters enable event selection.
Time axis: second, minute, hour

Measurement interval

The application can be started and stopped manually or automatically with the use of a timer.
Measurement stop intervals are 1 min, 15 min, 1 h, 24 h, 72 h, 96 h or user definable.





Service disruption test

The ONT-503/506/512 provides one of the most comprehensive service disruption tests available.
In synchronous networks, automatic protection switching (APS) is used to switch traffic to backup links if faults occur. During the switch event the service will be disrupted. Limits are defined and need to be checked for this service disruption time.
To analyze service disruption times, the ONT-503/506/512 generates a high-speed event list as a result of all detected events.

Criteria to trigger service disruption test, selectable

Errors

SDH	FAS, B1, B2, MS-REI, B3, HP-REI, bit errors/pattern loss
SONET	FAS, B1, B2, REI-L, B3, REI-P, bit errors/patt.loss

Alarms

SDH	OOF, LOF, MS-AIS, MS-RDI, AU-AIS, HP-RDI, AU-LOP
SONET	SEF, LOF, AIS-L, RDI-L, AIS-P, RDI-P, LOP-P
Event resolution	frame based 125 µs

For troubleshooting, two independent sets of criteria may be defined for two disruption results and high speed event lists.

Separation time	1 ms to 60000 ms

Separation time starts at the end of the last event. Separation time is used to determine if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

Service disruption results are stored in a list with start/stop times and duration.

The shortest, longest, and last disruptions are displayed as summary result.

The threshold to identify a violation of allowed service disruption time is 1 ms to 60000 ms

In addition to the service disruption list, all events are stored in a high-speed event list with time stamps. This allows for the tracking of individual events caused by service disruptions.

Pointer analysis

- STS/AU and VT/TU pointer
- New value
- Count of increments, decrements, NDF

Message generation and evaluation (TIM, PLM)

- J0, J1, J2:
  programmable 1, 16 and 64 byte ASCII sequence
  TIM evaluation: expectation value editable as criterion for TIM
- C2, V5:
  signal label clear text selection PLM
  evaluation: expectation value editable as criterion for PLM
- J0, J1, J2, C2, V5:
  clear text display

TOH/SOH and POH evaluation

- Manipulation and analysis of all accessible TOH/SOH and POH overhead bytes (including K1/K2, C2, V5, J0/J1/J2)
- TOH/SOH and POH display
- K1, K2 and S1 are shown and may be set using clear text messages

Byte capture SOH/TOH

To analyze the SOH/TOH functions, it is necessary to capture individual bytes vs. time, allowing detection of errors or short term changes with frame level resolution. The capture function is started by a selectable trigger.
Values for one/two selected bytes are stored and can be accessed subsequently in a table of values.
Particularly in capturing the APS sequences, bytes K1 and K2 are displayed in clear text.

Selectable bytes for SOH/TOH	All bytes
Captured parameters	Byte value, number of frames and Correspondent time
Storage depth of one byte or K1/K2 combination	
Post trigger	up to 256 value changes
Pre trigger	up to 256 value changes
Trigger conditions	Pre, post, center
Trigger events	User defined byte value, bit mask (Compare, not compare, don't care)

Performance monitoring

For SONET

Evaluation of ES, EFS, SES, UAS and SEFS (GR 253, T1.231) ESA, ESB

For SDH

Performance monitoring G.826

EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments based on line length allocation of 0.1 to 100%.
The SES and UAS thresholds are user-programmable. In-service measurement (ISM) of the near end and the far end of a selected path, as well as out-of-service (OOS) measurements, are supported.

Performance monitoring G.828 and G.829

The G.828 defines error performance parameters for international synchronous paths.
EB, BBE, ES, EFS, SES, and UAS are evaluated. Pass/fail assessments are based on a line length allocation of 0.1 to 100%.The SES and UAS thresholds are user-programmable. The SEP can be switched off for assessment. G.829 defines error performance events and block structures for SDH multiplex and regenerator sections.

Event generation

Event generation DSn/PDH

Please refer to page 74, DSn/PDH testing.

Error insertion

Error types	bit errors, random errors (after scrambling), FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P, LP-BIP/BIP-V, LP-REI/REI-V

Triggering

Once	All errors
Error rate for	
FAS	1×10^{-2} to 1×10^{-10}
Bit errors	1×10^{-2} to 1×10^{-10}
Random	1×10^{-2} to 1×10^{-10}
All others minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
Burst error	Once and continuous
	M errored frames followed by N error-free frames
	All errors except random and bit error
Section and high order path	M, N = 1 to 65535 or 125 µs to 8 s
Low order path	M, N = 1 to 65535 or 500 µs to 32 s

Rate burst error

Defined error rate with additional burst time window
All errors except random and bit error
Parameters see under "error rate" and "burst".

Alarm insertion

SDH	LOS, LOF, RS-TIM, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, HP-TIM, HP-RDI, TU-LOM, TU-LOP, TU-AIS, LP-UNEQ, LP-PLM, LP-TIM, LP-RDI, LP-RFI
SONET	LOS, LOF, TIM-S, AIS-L, RDI-L, LOP-P, AIS-P, UNEQ-P, PLM-P, TIM-P, PDI-P, RDI-P, LOM-V, LOP-V, AIS-V, UNEQ-V, PLM-V, TIM-V, RDI-V, RFI-V

Triggering

LOS	On/off
All others	On/off or bursts
Burst	Once and continuous
	M frames with alarm ON, N frames with alarm OFF
Section and high order path	M, N = 1 to 65535 or 125 µs to 8 s
Low order path	M, N = 1 to 65535 or 500 µs to 32 s

Pointer generation

- STS/AU and VT/TU pointer:
  Increment, decrement, new value
- Pointer sequences G.783 with programmable spacing
- Set new value and correspondent container offset
- Trigger: inc/dec single, periodical, alternating

SS bits definable

Through mode

The received signal is looped through the module and re-transmitted. The receiver signal may be monitored (as per 'Measurements') and events may be included in the transmitted signal.

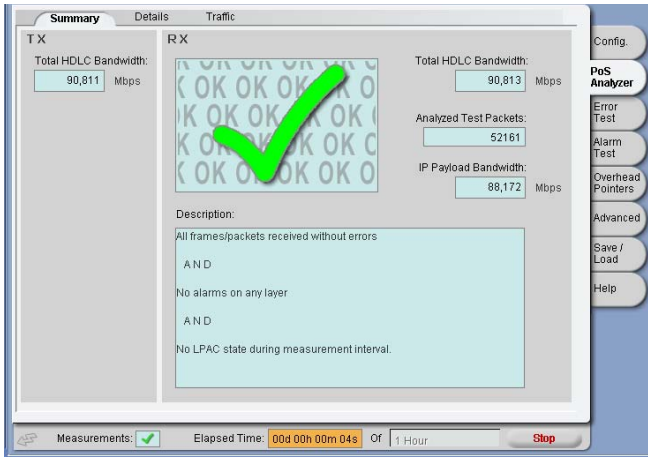
Event injection

Errors	B1, B2, FAS, REI-L/MS-REI, Random

Triggering: ones, rate, burst, rate burst as per error insertion in termination module

Alarms	LOS, LOF, AIS-L/MS-AIS, RDI-L/MS-RDI, AIS-P/AU-AIS, LOP-P/AU-LOP

Triggering: On/off, burst as per alarm insertion in termination mode.



PoS/IP processing

Software option *BN 3061/93.03.*

One option belongs to one module. Several PoS applications require several PoS options.

The combined IP/PoSDH and IP/PoSONET application allows the user to check the physical layer (SDH/SONET) as well as traffic in IP networks with HDLC/PPP framing.

Signal structure

SONET mappings with PoS

STS-1/3c/12c/48c/(192c – 10G modules)

SDH mappings with PoS

AU-4: VC-4, VC-4-4c/16c/(64c– 10G modules)
AU-3: VC-3

Fill patterns

- HDLC/PPP like framing (RFC 1662)
- CISCO HDLC

PoS measurements

Traffic parameters on transmit side

- Frame size, frame rate
- Sustained bandwidth
- Utilization

Traffic analysis on receive side

- Frame rate, total frames received, analyzed test frames
- Link bandwidth, link utilization
- Average delay, delay variation

Error insertion

Error types	FCS error, invalid frame, lost packets
Triggering	Single

Error measurement

All errors count, ratio, duration

Alarm detection

Red, Yellow, LPAC duration

Resolution	100 ms

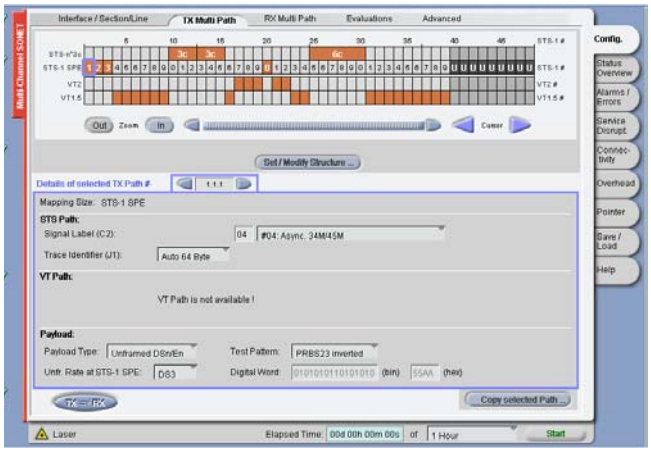
Results

Results are displayed in count and ratio and the summary result provides clear GO/NOGO indication.

Multi-Channel SDH/SONET Application

Highlights Multi-Channel SDH/SONET

- Full coverage of an OC-1/3/12/48 or STM-0/1/4/16 signal with parallel generation/analysis of up to **1344 VT1.5/1008 VC-12** for BER, service disruption, errors, and alarms
- Real life load generation and load analysis with **mixed mappings:** VT 1.5/2, STS-1/3c/6c/9c/12c/24c/48c or VC-12/11/3/4, VC-4-2c/3c/4c/8c/16c
- **Best-in-class service disruption** test, no blind spots
- **Dynamic error/alarm insertion** into multiple channels including bursts to simulate flooding of events for stress test
- **Enhanced Through Mode** with error and alarm insertion into multiple channels at STS/AU and VT/TU layer



Hardware modules

Multi-Channel extension module

BN 3061/90.82 – 1 slot

The Multi-Channel extension module can be added to a variety of modules. Its SDH/SONET Multi-Channel test provides parallel generation and analysis of up to 2.5G bandwidth. It supports OC1-/3/12/48/192 and STM-0/1/4/16/64 interfaces.

This option can be added to the following modules:

- Modules 2.5G-B/10G(-B)
- NewGen solution 2.5G-B and 10G
- OTN modules 2.5/2.7 -B and 10/10.7G (-B)

Multi-Channel SDH/SONET testing

Generation

Signal structure and mixed payloads

The Multi-Channel extension module fills up an OC-1/3/12/48 or STM-0/1/4/16 signal completely with any combination of valid mappings.
Connected to a 10G interface, one selectable OC-48/STM-16 subset is used for mixed payload generation.
This subset can be copied three times to fill up a 10G stream completely. Inserted errors/alarms are copied as well, resulting in full 10G bandwidth alarm flooding. Alternatively, the remaining three OC-48/STM-16 are filled with background traffic.

SONET mappings for mixed payloads

VT 1.5/2, STS-1/3c/6c/9c/12c/24c/48c, STS-1 unequipped

SDH mappings for mixed payloads (via AU-4 or AU-3)

VC-12, VC-11, VC-3, VC-4, VC-4-2c/3c/4c/8c/16c, AU-3/AU-4 unequipped

Connected to a 10G interface, a selectable OC-48/STM-16 subset is analyzed completely .

Granularity for mixing of mapping structures is STS-1/AU-3 level.

Fill patterns

PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv.
User defined 16-bit word

Patterns may be set individually per each test channel.

Analysis

Complete analysis of all channels within an OC-1/3/12/48 or STM-0/1/4/16 signal.

Connected to a 10G interface, a selectable OC-48/STM-16 subset is analyzed completely .

Auto signal structure detection

Receiver detects the signal structure (mappings, payload, traces) automatically for easy configuration of the test set.

Bit error testing

Bit error testing is performed on all payloads simultaneously with error count, error ratio and errored seconds per channel. Summary results provide overview of all channels on one page.

Service disruption test

The Multi-Channel extension module measures service disruption time on all test channels simultaneously up to 1344 × VT 1.5/ 1008 × VC-12.
Each disruption in every channel is stored with time stamp and duration.

A setup page allows to enable/disable each channel individually.

Result presentation

- Summary results for all channels
- Channel table: contains shortest/longest/# of disruptions for each channel, easy table sorting
- Disruption list: contains each disruption with start time and duration for all channels. Resolution: 1 ms. Storage capacity: 100000 events per measurement.

Separation time setting: 1 ms to 10000 ms.

Separation time starts with the last event and is used to determine if the following event is a continuation of the same disruption (event occurs within separation time) or the start of the next disruption (event occurs after separation time has elapsed).

The criteria to trigger the service disruption test is selectable (any combination of criteria allowed):

Errors

SDH	B1, B2, MS-REI, B3, HP-REI, LP-BIP, LP-REI, Bit error/pattern loss
SONET	B1, B2, REI-L, B3, REI-P, BIP-V, REI-V, bit errors

Alarms

SDH	LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-RDI, TU-LOM, TU-AIS, TU-LOP, LP-UNEQ, LP-PLM, LP-RDI
SONET	LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, PDI-P, RDI-P, LOM, AIS-V, LOP-V, UNEQ-V, PLM-V, RDI-V

The threshold to identify a violation of the allowed service disruption time (for all channels) is 1 ms to 1000 ms.

Violation is shown in summary results and channel table.

Alarm and error messaging test

Alarm insertion

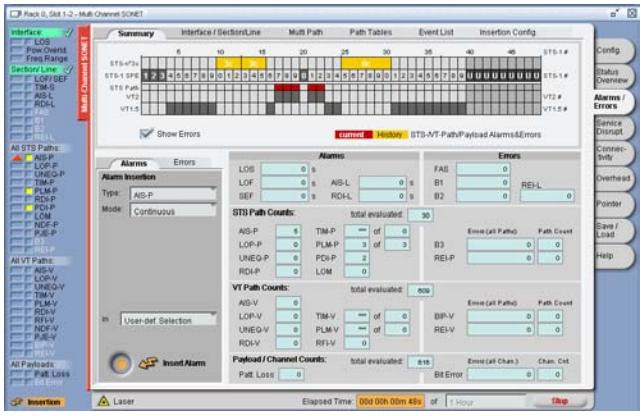
SDH	LOS, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, P-RDI, P-PLM, HP-RDI, TU-LOM, TU-LOP, TU-AIS, LP-UNEQ, LP-PLM, LP-RDI, LP-RFI
SONET	LOS, LOF, AIS-L, RDI-L, LOP-P, AIS-P, UNEQ-P, PLM-P, RDI-P, LOM-V, AIS-V, LOP-V, UNEQ-V, PLM-V, RDI-V, RFI-V

Triggering

LOS	On/off
All others	On/off or bursts
Burst	Once and continuous
M frames with alarm ON, N frames with alarm OFF	M, N = 1 to 2^{24} or 125 µs to 2097 s

Alarms are inserted into all or selected channels .

Alarm detection



Same alarm types as generation plus OOF, PDI-P and pattern loss.

Error insertion

Error types	Bit errors, random errors (after scrambling), FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P, LP-BIP/BIP-V, LP-REI/REI-V

Triggering

Once	All errors
Error rate for FAS	1×10^{-2} to 1×10^{-10}
Bit errors	1×10^{-2} to 1×10^{-10}
Random	1×10^{-2} to 1×10^{-10}
All others minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
Burst error	once and continuous

M errored frames followed by N error-free frames

All errors except random and bit error	M, N = 1 to 65535 or 125 µs to 8 s

Rate burst error

Defined error rate with additional burst time window.
All errors except random and bit error.
Parameters see under "error rate" and "burst".
Errors are inserted into all or selected channels .

Error measurement

Same error types as insertion. Error count, error ratio and errored seconds per channel. Summary results provide overview of all channels on one page. Count results for all channels simultaneously.

Error/alarm logging with time stamps

The ONT stores errors/alarms in all channels with time stamps. This allows to identify when events did occur in any of the channels.
Errors: Count with 1 s resolution
Alarms: Start/stop/duration with 0.1 ms resolution

Error and alarm event list

Including filter capabilities.

Storage capacity	300000 events per measurement

The event list contains following information

- Event type
- Channel ID
- Start/end time
- Duration
- Error count

Message evaluation/overhead access

Trace identifier setting, display and evaluation (TIM)

J0: 1/16/64 byte
J1: 1/16auto16/64auto/64 byte
J2: 1/16auto/16 byte
Manual setting or Auto mode (sets unique values to each channel for easy source identification).
TIM evaluation per channel: expected value learnable from received signal.
J0/J1/J2 view accessible for each channel.

Path label setting, display and evaluation (PLM)

C2, V5 manual setting and view for each channel.
PLM evaluation per channel: expected value editable.

TOH/SOH and POH setting and display

Access to TOH/SOH bytes for edit and display
K1, K2 and S1 are shown and may be edited using clear text messages
Display of POH for each channel

Byte capture SOH/TOH

To analyze the SOH/TOH functions, it is necessary to capture individual bytes vs. time, allowing detection of errors or short term changes with frame level resolution. The capture function is started by a selectable trigger.
Values for one/two selected bytes are stored and can be accessed subsequently in a table of values.
Particularly in capturing the APS sequences, bytes K1 and K2 are displayed in clear text.

Selectable bytes for SOH/TOH	All bytes
Captured parameters	Byte value, number of frames and Correspondent time

Storage depth of one byte or K1/K2 combination

Post trigger	up to 256 value changes
Pre trigger	up to 256 value changes
Trigger conditions	Pre, post, center
Trigger events	User defined byte value, Bit mask (compare, not compare, don't care)

Pointer evaluation

Pointer actions are counted for all channels in parallel: Increment, decrement, NDF

Display modes

Summary for all channels
Per channel view
Paths table with sorting criteria

Connectivity check

The Connectivity feature verifies that all channels are routed through a switching matrix as expected, e.g. after reloading the matrix. The path trace information is used to perform the Connectivity.
Unique values are set for all J1/J2 path traces in parallel for path identification.
The 'trace learning mode' stores the path trace values provided by the device under test to be used as reference to check connectivity. Any mismatch is indicated graphically in the signal structure overview.

Intrusive through mode

The Multi-Channel extension module offers the unique feature to modify error/alarm information at all layers (STS/AU to VT/TU). Errors/alarms might be added to all or selected channels.

Error/alarm insertion

Types of errors/alarms and triggering as described in section 'Alarm and error messaging test' (terminate mode, excluding bit errors).

Intrusive Through mode at 10 Gb/s: one selectable STS-48/STM-16 can be modified as described above. The other 3 STS-48/STM-16 are looped Through transparently.

Measurements in through mode

All error/alarm/service disruption measurements are supported as in terminate mode.

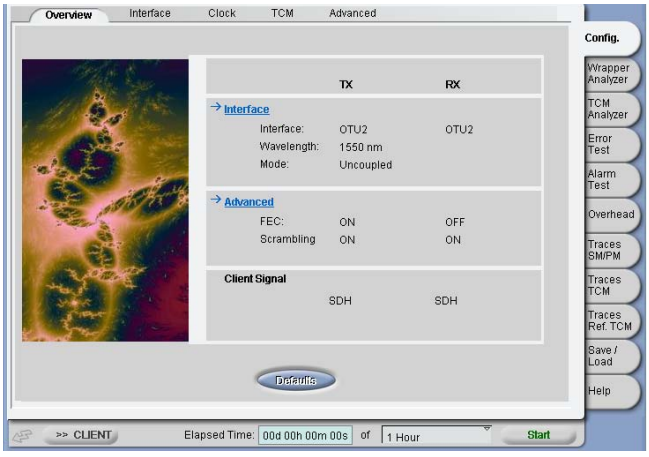
Through & replace

All or selected channels may be replaced by a test pattern generated internally (Through & Replace mode). This can be combined with the error/alarm insertion features.

OTN applications

Highlights OTN

- **Advanced FEC generation**
- **FEC** stress testing
- Support of all **6 TCM layers**
- Error stress testing with **BIP masks** and editable BEI values
- **OH byte sequencer and capture**



Hardware modules

OTN module 2.5/2.7G-B

BN 3061/90.27

Tests supported

- OTN testing at 2.7 Gb/s, OTU1 (page 56)
- SDH/SONET (page 49)
- Multi-Channel SDH/SONET testing (optional, page 52)
- PoS (optional, page 52)
- Jitter/wander for versions **–C** (optional, page 71)

General/interfaces

Please refer to hardware modules 2.5/2.7G (page 47)

OTN module 10/10.7G – 1550 nm
OTN module 10/10.7G-B – 1550 nm
OTN module 10/10.7G-B – 1310 nm

BN 3070/90.30, BN 3070/90.32, BN 3070/90.33 – 2 slots each

Tests supported

- OTN testing at 10.7 Gb/s/OTU2 (page 56)
- SDH/SONET (page 49)
- Multi-Channel SDH/SONET testing (optional, page 52)
- PoS (optional, page 52)

General/interfaces

Please refer to hardware modules 10/10.7G (page 48)

OTN testing

The OTN application runs on the OTN modules 2.5/2.7G (OTU1) and 10/10.7G (OTU2) and allows generation and analysis of OTN signals. Detailed parameters can be manipulated and evaluated in different OTN levels. Its payload supports both framed SDH/SONET and unframed clients. The test set provides signal analysis and manipulation (alarm, error, overhead), forward error correction (FEC) generation and analysis as well as in depth FEC error testing. In addition to this, the full analysis capabilities of SDH and SONET are available for OTN client analysis.

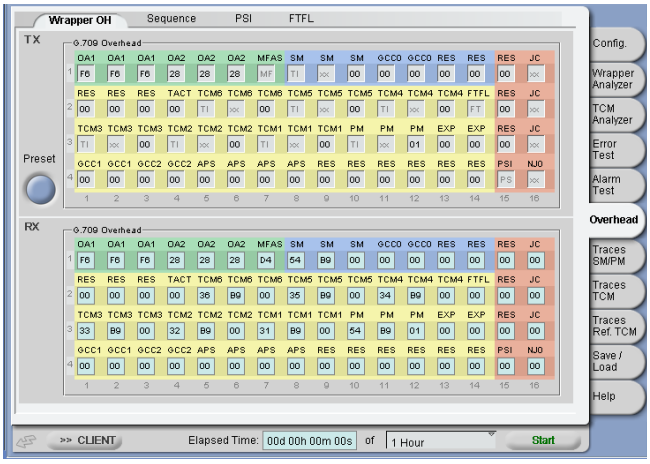
OTU1 and OTU2 generation

Content of overhead bytes (frame alignment/OTU/ODU/OPU)

- All bytes statically programmable except MFAS, SM BIP-8, PM BIP-8, TCM1...6 BIP-8
- Additional possibilities for SM TTI, PM TTI, TCM1...6 TTI (trail trace identifier):
  – Sequence consisting of the SAPI (16 bytes)
  – DAPI (16 bytes) and
  – The operator specific field (32 bytes)
- User designed payload structure identifier (PSI) and payload type identifier clear text
- One OH byte can be selected for a freely defined sequence of 16/32/64/128/256 bytes
- FTFL free definable forward/backward (FW/BW) fault indication and operator identifier

OPU client signals

- OTU1: OC-48/STM-16 signal internally generated
  Generation see chapter SDH and SONET testing.
- OTU2: OC-192/STM-64 signal internally generated
  Generation see chapter SDH and SONET testing.
- PRBS 231–1 inv./non-inv., PRBS 223–1 inv./non-inv.
- Digital word 16 bit free programmable
- Null client



Client offset – stuffing

The asynchronous SONET and SDH and PRBS client offset can be adjusted within the ± 65 ppm range and the stuffing rate of the client can thus be manipulated.

The OTU FEC field

This field contains the FEC values calculated according to the Reed-Solomon (255,239) algorithm.

Error insertion

Error types

Random, FAS, MFAS
SM BIP-8, SM BEI, PM BIP-8, PM BEI

FECuncorrectable, FEC correctable, FECstress, FECadv.

TCMi BIP-8, TCMi BEI (i = 1 to 6)

Triggering

Single	All errors except FEC
Ratio	Only random, 1×10^{-3} to 1×10^{-10}
Burst once	All errors except random, FECstress
Burst continuous	All errors except random
Burst error	M frames errors, N frames error-free
	M and N = 0 to 2^{31}

BIP masks

The position and number of bit errors in the bytes can be selected.
Valid for SM BIP-8, PM BIP-8, TCMi BIP-8 (i = 1 to 6)

BEI value

To stress the BEI evaluation of the DUT receiver the BEIs can be set to values 0 to 15
Valid for SM BEI, PM BEI, TCMi BEI (i = 1 to 6)

FEC error insertion modes

- FECcorrectable, FECuncorrectable
- FECstress: This extremely helpful function allows maximum stress tests within a short time frame.
  The maximum possible number of errors that the device under test (DUT) should still be able to correct is inserted into the OTU frame.

FECadvanced

FECadvanced allows the user to define a detailed position for error insertion in the OTU frame. Correction capability testing below and above the correction limit can be performed.

Selectable parameters:	Row, subrow, errored bytes per subrow, Start position in subrow, byte error mask

Alarm generation

LOS, LOF, LOM, OOF, OOM, OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK, SM BDI, SM IAE, SM BIAE, PM-BDI, FW-SD, FW-SF, BW-SD, BW-SF, TCMi-TIM, TCMi-BDI, TCMi-BIAE (i = 1 to 6), SM-TIM, PM-TIM,

Triggering

Continuous	All alarms
Burst once/ Burst continuous	All errors except LOS, LOF, OOF, OOM, SD, SF
Burst alarms	M frames with alarm, N frames no alarm, M and N = 0 to 2^{31}

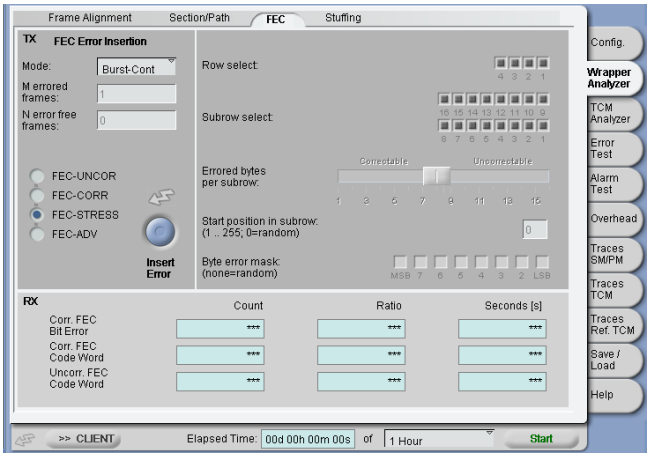
Through mode

The received signal is looped through the ONT-506 and retransmitted without termination of alarms and errors. All alarms, errors and traces of the received signal can be monitored on the client signal and on the wrapper level.

OTU1 and OTU2 analyzer

Overhead evaluation (frame alignment/OTU/ODU/OPU)

- Display of the complete overhead
- SM TTI, PM TTI, TCM(1-6) TTI display of the 64 byte ASCII sequence of SAPI, DAPI and operator field
- One sequence up to 256 bytes can be displayed for a selectable OH byte
- Display payload structure identifier (PSI) bytes and payload type identifier (PT) clear text
- Editable PT expectation value as mismatch criterion
- FTFL forward/backward (FW/BW) fault indication and operator identifier fields



Trace references

- Set of SAPI and DAPI expectation values in traces SM TTI, PM TTI, TCM(1-6) TTI
- Select evaluation type of the received signal: SAPI or DAPI or SAPI/DAPI

OPU client signals

- OTU1: OC-48/STM-16 signal internally generated
  Analysis see chapter SDH/SONET testing.
- OTU2: OC-192/STM-64 signal internally generated
  Analysis see chapter SDH/SONET testing.
- Validation for payload bit error measurement at:
  – PRBS 2^{31}–1 inv./non-inv., PRBS 2^{23}–1 inv./non-inv.
  – Digital word 16 bit free programmable
  – Null client

The OTU FEC

The FEC procedure can be switched on and off. Using the OTU FEC field, FEC according to the Reed-Solomon (255,239) algorithm is performed on the received frame. With data blocks consisting of 239 data bytes and 16 FEC field bytes, up to 16 byte errors can be detected or 8 byte errors be corrected.

Error measurement

Validation of data for error measurement occurs after frame alignment, descrambling, and FEC computation and correction.

Error types
FAS, MFAS, SM BIP-8, SM BEI, PM BIP-8, PM BEI
FECcorrectable, FECuncorrectable,
TCMi BIP-8, TCMi BEI (i = 1 to 6)
Alarm detection
LOS, LOF, OOF, LOM, OOM
OTU-AIS, ODU-AIS, ODU-OCI, ODU-LCK,
SM BDI, SM IAE, SM BIAE, SM TIM
PM-BDI, PM TIM
FW-SD, FW-SF, BW-SD, BW-SF
TCMi-BDI, TCMi-BIAE, TCMi-TIM (i = 1 to 6)
CL-LOSS (client signal loss of synchronization); PT-MISM

Result display of errors and alarms

Numerical display

Count, ratio and duration are displayed for each error.

From each alarm the duration will be displayed.

Tabular display

Display of all results with time stamps

Criteria	Start, stop, duration, count

Graphical display

Display of all events as bar graphs versus time. Cursors allow easy identification and zooming (in and out) on results. Filters enable event selection.

Time axis	Second, minute, hour

Stuffing of the payload

Display of payload offset	ppm

Stuffing counts

Positive, negative, sum	Count, duration

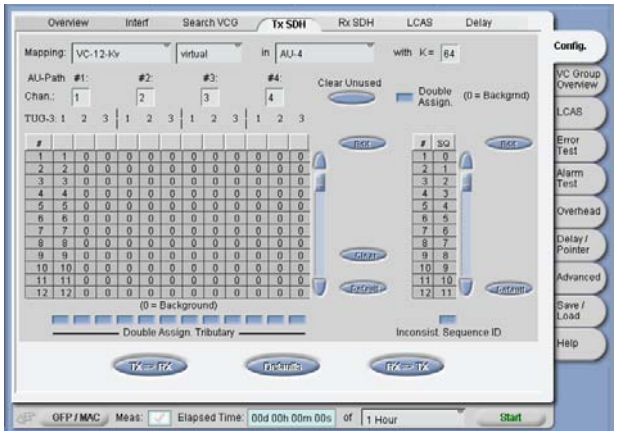
SDH/SONET/PoS testing

These tests are also running on the OTN modules. Please refer to this section on page 52

Data over SDH/SONET Applications

Highlights EoS

- **High and Low order** virtual concatenation up to 1 Gb/s service
- **VCG search** for simple configuration
- **Enhanced Differential Delay** generation
- Worldwide first tester with full LCAS emulation
- **LCAS protocol tracer** for trouble finding
- **GFP framing** and manipulation of GFP header
- SDH/SONET Interfaces for virtual concatenation from 155 Mb/s to 2.5 Gb/s optical and electrical IFs
- **MAC framing** of different types, Ethernet link layer and MAC layer analysis
- **Complete interworking** test solution NewSDH/SONET with Ethernet in one unit



Hardware modules

NewGen solution 2.5G-B
NewGen solution 10G

BN 3061/90.43 – 1 slot each
BN 3061/90.45 – 2 slots

Tests supported

- Ethernet over SONET (EoS, page 59)
- Ethernet MAC (page 62)
- GFP-T processing (optional, page 64)
- SDH/SONET (page 49)
- Multi-Channel SDH/SONET (optional, page 52)
- PoS (optional, page 52)
- Jitter/wander (optional for 2.5G, page 71)

General/interfaces

Please refer to hardware modules 2.5G and 10G (page 47/48)

EoS (SDH/SONET) testing

Ethernet over SDH/SONET testing up to 2.5 Gb/s is supported by NewGen solution 2.5G-B, BN 3061/90.43

EoS at 10 Gb/s is supported by NewGen solution 10G, BN 3061/90.45

EoS testing includes all the associated topics addressed by the New SDH/SONET technology including virtual concatenation (VCat), link capacity adjustment scheme (LCAS), generic frame procedure (GFP), and the generation and analysis of Ethernet frames.

VCat – Virtual concatenation

Virtual concatenation implementation is in accordance with ITU-T G.707, G.783, and ANSI T1.105-2001. One virtual concatenation group (VCG) is supported, and the selectable mappings and group sizes are as follows:

High order VCat

VC-4-7v, VC-3-21v (AU-3), VC-4, VC-3 (AU-3)
STS-3c-7v, STS-1-21v, STS-3c, STS-1
All members can be distributed in all channels of the SDH/SONET signal.

Low order VCat

VC-11-64v, VC-12-64v, VC-3-12v (AU-4), VC-3 (AU-4), VC-12, VC-11
VT-1.5-64v, VT-2-64v, VT-1.5, VT-2
All members can be distributed in up to 4× VC-4/STS-3c or up to 12×VC-3/STS-1 of the SDH/SONET signal.

Group size is selectable from 1 to the maximum.

All path layer parameters including SQ number, overhead, errors, and alarms are supported for every member of the VCG individually.
In the case of a group with one member standard VC and VCat can be mixed for RX and TX.

VCG search utility

For the low order mappings, a search VCG utility lets you scan the selected physical signal structure to find a dedicated virtual concatenated group. Filters help to determine the right group. The detected group can be used for setting either the Rx, or the Rx & Tx signal structure, for further testing.

Sequence numbers generation

User programmable, per member, with LCAS disabled.
Sequence numbers are automatically assigned with LCAS enabled.

Sequence numbers evaluation

LCAS disabled

Expected sequence numbers are user programmable, per member. If expected (ExSQ) and accepted (AcSQ) SQ numbers are not equal, a mismatch alarm is generated.

Sequence number mismatch defect	SQM

LCAS enabled

Sequence number acceptance is in accordance with LCAS protocol rules

Error insertion

Error types	Random, FAS, B1, B2, REI-L/MS-REI

Triggering

Once	all errors
Error rate for	
FAS	1×10^{-2} to 1×10^{-10}
Bit errors	1×10^{-3} to 1×10^{-10}
Random	1×10^{-4} to 1×10^{-10}
All others minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
Burst error	Once and continuous M errored frames Followed by N error-free frames
All errors except random and bit error	M, N = 1 to 65535 or 125 µs to 8 s

Error insertion path

Error types	B3, REI-P/HP-REI, BIP-V/LP-BIP, REI-V/LP-REI
Insertion	Single or multiple member
Minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
Burst error	Once and continuous M errored frames followed by N error-free frames
High order path	M, N = 1 to 65535 or 125 µs to 8 s
Low order path	M, N = 1 to 65535 or 500 µs to 32 s

Error analysis

All errors count, ratio and seconds

Errors are analyzed for all members and are shown both independently and as group errors (e.g. GP-B3).

Alarm insertion

Alarm types	LOS, LOF, AIS-L/MS-AIS, RDI-L/MS-RDI

Triggering

LOS	on/off
All others	on/off or bursts
Burst	once and continuous M frames with alarm ON, N frames with alarm OFF M, N = 1 to 65535 or 125 µs to 8 s

Alarm insertion path

SONET:	AIS-P, RDI-P, LOP-P, UNEQ-P, OOM2, OOM1, AIS-V, RDI-V, LOP-V, UNEQ-V, PLM-P
SDH:	AU-AIS, HP-RDI, AU-LOP, HP-UNEQ, OOM2, OOM1,TU-AIS, LP-RDI, TU-LOP, LP-UNEQ, LP-PLM
Insertion	Single or multiple members

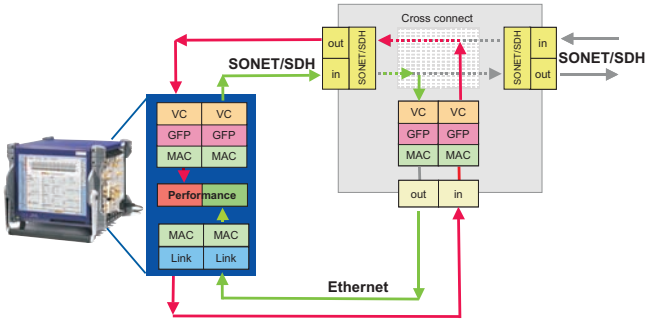
Triggering

All	On/off or bursts
Burst	Once and continuous M frames with alarm ON, N frames with alarm OFF
High order path	M, N = 1 to 65535 or 125 µs to 8 s
Low order path	M, N = 1 to 65535 or 500 µs to 32 s

Alarm analysis

All alarms are shown in seconds

Alarms are analyzed for all members and are shown independently and as group alarms (e.g. GP-OOM1)



Ethernet over SDH/SONET interworking

Alarms	As inserted above
Additional detected alarms	SEF (SONET), OOF (SDH), Loss of alignment (LOA) Loss of multi frame (per member) (LOM) Out of multi frame 1 (per member) (OOM1) Out of multi frame 2 (per member) (OOM2)

TOH/SOH and POH

Manipulation and analysis is provided for:

- All accessible TOH/SOH bytes
- POH bytes of all members independent
- Traces J0, J1, J2 in clear text
  J1, J2 of all members independently
- Sync status (S1) in clear text
- The signal label (C2, V5) and the extended signal label (K4, Z7) of all members are independently in clear text.

Background channels

All background channels have the same pattern.

Fill patterns

$2^{31}-1$, $2^{23}-1$, $2^{31}-1$ inv., $2^{23}-1$ inv., 16 bit user selectable word

Enhanced differential delay generation

Delay value, of every member, can be set independently

High order VCat

Range, programmable	0 to 100 ms
Granularity	N × 125 µs (MFI) + M × 0.16 µs (Ptr)
Pointer rate	8 to 2000 1/s

Low order VCat

VC-3	0 to 100 ms
Granularity	N × 125 µs (MFI) + M × 0.16 µs (Ptr)
Pointer rate (VC-3)	8 to 2000 1/s
VC-11/-12, VT-1.5 /-2	0 to 256 ms
Granularity	N × 500 µs + M × 4.8 µs (Ptr)
Pointer rate	2 to 500 1/s

Three modes are available to set the delays.

Direct mode

Delay values are set manually on a per member basis. At the click of a button, delays are applied instantly for all group members in parallel. Service is disrupted temporarily.

This mode is useful to simulate the effect of APS actions.

Pointer mode

Delay values are set manually on a per member basis. At the click of a button, instrument starts to perform pointer movements until programmed delay is set for each group member. Pointer movements for all group members are executed in parallel. Pointer rate is user programmable. No service disruption occurs.

This mode is useful to simulate the effects of delay wander.

Stress mode

This is an automatic stress test mode. In an endless loop, sets of automatically generated delay values are generated and auto-applied using pointer mode. A programmable waiting time is inserted between sets of delay values. Pointer rate is user programmable. Delay value sets are generated by a random number generator. User programmable random number generator speed allows true random, as well as reproducible pseudo random operation. This mode requires no user interaction.

This mode is useful for automatic reassembler test.

Differential delay analysis

Parallel measurement, of differential delay, provided for each group member. Calculation of differential delay provided for entire group.

Results provided for all members and groups, differential delay in ms

Measurement range (HO- and LO-VCat)	256 ms
Reassembly range (HO-VCat and VC-3-Nv (AU-4))	128 ms
Reassembly range (LO-VCat)	256 ms

Pointer analysis

- STS/AU pointer values of all members
- Counts of increment, decrement and NDFs
- VT/TU pointer analysis functionality is to be determined

Link capacity adjustment scheme (LCAS)

LCAS implementation is in accordance with ITU-T G.7042, G.707, and ANSI T1.105.02-2001

The functionality encompasses:

- Emulation of state machines for source and sink
- Monitoring of LCAS control packets (H4, K4/Z7)
- Generation and evaluation of control packets
- Generation and evaluation of member status information
- Source reacts automatically to received member status
- Full manual control of state machines supported
- Full trace of all changes in the protocol communication

LCAS protocol emulation

An LCAS source state machine is implemented for every member of the Tx VCG. An LCAS sink state machine is implemented for every member of the Rx VCG. The ONT-503/506/512 provides state machine control as well as state machine monitoring capabilities. LCAS protocol emulation can be disabled. With LCAS disabled, FIXED control packets are generated (all H4/K4/Z7 byte information is zero except sequence number and multiframe indicators).

Source state machine control (per member)

Direct command	Add, remove, add all, remove all
Overwrite received member status	Ok, fail, auto
Force re-sequence acknowledge	Rx RS-Ack
MSU timer supported	

Sink state machine control (per member)

Direct command	Add, remove, add all, remove all
Overwrite generated member status	Fail, auto
Force re-sequence acknowledge	Tx RS-Ack
Force member status alarm	MSU

Source state machine monitoring (per member)

Transmitted sequence number

Received re-sequence acknowledge	Count
Following commands are shown in clear text:	
Machine state	Idle, add, norm, DNU, remove
Transmitted control word	Add, norm, EoS, idle, DNU
Received member status	Ok, fail

Sink state machine monitoring (per member)

Sink monitoring information is analyzed after differential delay compensation.

Received sequence number

Transmitted re-sequence acknowledge	Count
Following commands are shown in clear text:	
Machine state	Idle, fail, ok
Received control word	Add, norm, EoS, idle, dnu, fixed
Received alarms	LOC, MSU, FOP CRC, non-LCAS

LCAS defects and alarms

Source

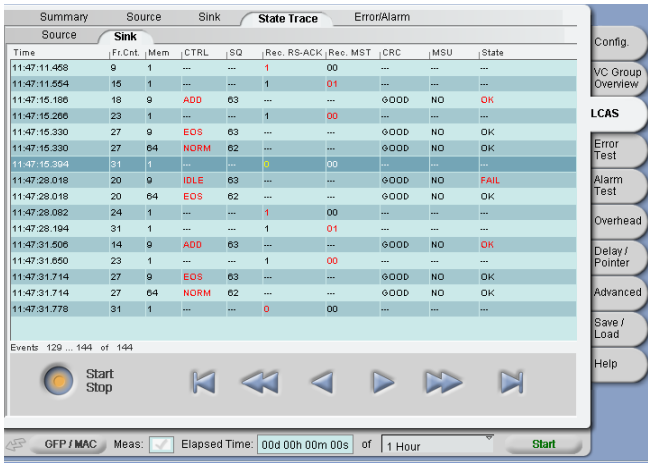
Loss of transport capacity	TxLOC
Loss of partial transport capacity	TxLOPC
Loss of total transport capacity	TxLOTC

Sink

Loss of transport capacity	RxLOC
Loss of partial transport capacity	RxLOPC
Loss of total transport capacity	RxLOTC
Failure of protocol excessive CRC errors	FOP_CRC

LCAS state tracer

In the emulation mode and in the monitoring mode the LCAS State Tracer traces each change in the LCAS control packet for all members independent if sent or received. This allows e.g. to verify the response time to an add command.
The trace can be started manually.



All changes are displayed separate for source or sink in a dedicated view.
All changes are traced with event and accurate timestamp

Event accuracy	1 ms and frame based

GFP-F – Generic Frame Procedure (framed)

The GFP functionality provides Ethernet MAC encapsulation and mapping/de-mapping of GFP to SDH/SONET virtual concatenation. Implementation is in accordance with ITU-T G.7041, G.707, and ANSI T1.105.02-2001 GFP-F (frame mapped Ethernet).

The functionality encompasses:

- Generation and analysis of GFP frame types
- GFP traffic generation and analysis
- Core header processing
- Payload type header processing
- Frame based Ethernet MAC frame encapsulation
- Error and alarm processing

GFP traffic generation

Traffic profile

Frame size	72 to 65539 bytes
Bandwidth dependent on VCat	0 to max. 1 Gb/s

Details see chapter Ethernet MAC layer.

Payload type header settings

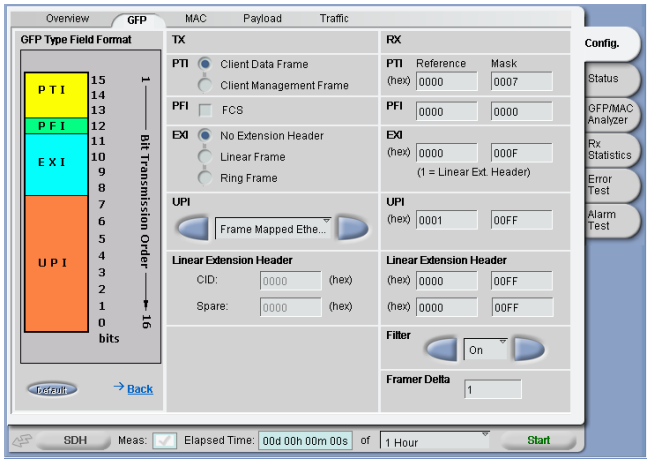
PTI	Client data or client management frame
PFI	FCS off/on
EXI	Null extension header or linear frame or ring frame
UPI (client data)	Clear text selection acc. to ITU-T G.7041
UPI (client management)	Loss of client signal (LOCS) and
	Loss of client character synchronization (LOCCS)

Linear extension header settings

CID and Spare editable	00 to FF

Error insertion

Core header	Single and multiple bit error
Payload type header	Single and multiple bit error
Linear frame header	Single and multiple bit error
Payload FCS	Single bit error



Alarm insertion

Loss of frame delineation	LFD
Client signal fail type	CSF (LOCS, LOCCS) selectable with PTI/UPI
CSF frame period	500 ms

Receiver GFP frame filter

On Rx, filtering based on type header fields, is performed.
The filter criteria are reference values and bit masks. Only error free frames, matching the reference value and bit masks, are forwarded to MAC layer processing.
Core, payload, and extension header error detection as well as error correction are supported.
Reference values of parameters payload type and extension header settings are programmable.

Error detection

Error types	Core header single,
	Payload type header single & multiple,
	Linear frame single & multiple and payload FCS
Evaluation	Count, ratio, duration

Alarm detection

Alarm types	LFD, CSF
Evaluation	Duration

GFP frame detection

Frame types	Idle, client data with/without linear frame,
	Client data with/without FCS, CSF
Evaluation	Count, ratio

Online view of payload type and extension header values.

GFP traffic analysis

Tx total bandwidth dependent on VCat	0 Mb/s to max. 1 Gb/s
Tx total utilization	0 to 100%
Rx total bandwidth dependent on VCat	0 Mb/s to max. 1 Gb/s
Rx total utilization	0 to 100%

Ethernet MAC layer testing

The EoS and Ethernet book support the following Ethernet frame formats:

- Ethernet II frames (ISO/IEC 8802-3)
- IEEE 802.3 frames
- IEEE 802.2 (LLC) frames
- SNAP frames
- VLAN tagged frames
- Double tagged VLAN frames + variations

Measurement overview

- Throughput/lost packets
- Transfer delay/latency
- Connectivity
- Flow control
- Traffic analysis/utilization
- Error and alarm analysis

MAC traffic generation

Traffic profiles	Constant, burst
Generator modes	Once, continuous
Frame size	64 to 1518/1522 bytes
Oversized (jumbo)	Max. 65 kB optical
	Max. 10 kB twisted pair
Bandwidth	0 to max. 1 Gb/s
Preamble size half-duplex	8
full-duplex 10/100/1000/1G	5/2/3/2 to 32
Inter frame gap threshold (IFG) minimum, half-duplex	TX 8 to 32
	RX 6 to 12
full-duplex	TX 6 to 126
	RX 6 to 12

Back-to-back frames	On/off Enables maximum bandwidth By forcing the traffic to minimum IFG

Constant mode

Bandwidth	0.1 Mb/s to max. 1 Gb/s

Burst mode

Peak bandwidth	0.1 Mb/s to max. 1 Gb/s
Sustained bandwidth	0.1 to 100%
Burst size	1 to 65 k frames
Frames per shot (once)	1 to 65 k

Note: Actual maximum bandwidth can be below the stated value depending on port type, mapping, and group size. The ONT-503/506/512 is capable of generating 100 % load for every combination of port type, mapping, and group size.

MAC frame settings

MAC frame parameters can be set to specific values depending on the selected Ethernet frame type

Header types	Value
VLAN types	Tag protocol identifier (TPI), Tag control information priority, TCI-VLAN identifier
LLC header	Destination service access point DSAP, Source service access point SSAP
LLC/SNAP header	Protocol type, Organizational unique identifier

Error insertion

Error type	Oversized, Runt, Jabber, FCS, alignment (For 1 G optical Ethernet: Alignment only valid, runt not valid)
Triggering	Once, continuous, burst once, burst cont., Rate, rate burst once, rate burst cont.
Rate	1×10^{-4} to 1×10^{-8}
Bursts	N for units ON, M for units OFF
N and M	1 to 262143

Receiver MAC frame filter

Filtering, based on source and destination address information, is performed.

The filter criteria are reference values and bit masks. Only error free frames matching the reference value and bit masks are forwarded to network performance evaluation. Reference values for parameters as per "MAC frame settings" are programmable.

Error detection

Error type	In range, runt, oversized, FCS, jabber, Errored, lost packets
Evaluation	Count, ratio, duration

MAC payload modes

- JDSU test frame. The content is necessary for evaluation of lost packets and transfer delay
- BER with 2^{31-1}, 2^{23-1}, 32 bit user selectable word
- Live traffic for Rx, suppressing evaluation of the MAC payload content.

Payload error insertion

Error type	Lost frame or bit error
Trigger	Once

Network performance

Error type	Lost packets or bit error
Evaluation	Count, ratio, duration
Alarm type	LPAC (loss of performance assessment capability) (Active if higher layer alarm or no valid traffic for 10 s)
Evaluation	Duration
Transfer delay integrated, current	0 to 42.9 s
Transfer delay variation integrated, current	0 to 42.9 s

MAC frame statistics

Total MAC traffic

Total, good, broadcast, multicast, VLAN tagged, VLAN double tagged, paused

Analysis	Count, rate

Filtered MAC traffic

MAC bandwidth	Mb/s
Frame rate	kb/s
Frames	Count

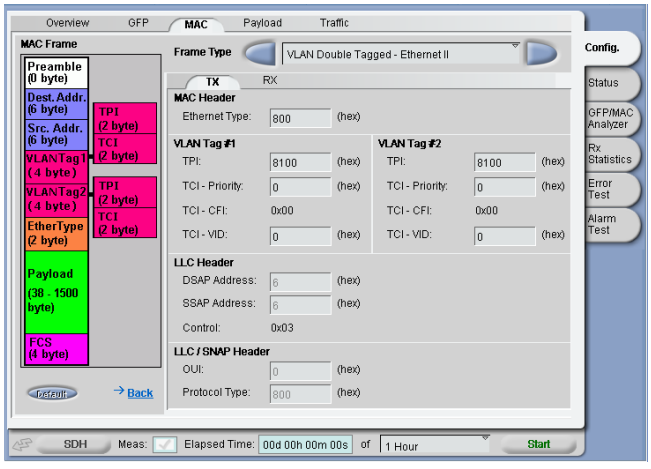
MAC layer flow control (PAUSE)

Instrument responses to received PAUSE frames as specified by IEEE 802.3 (2002).

Supported duplex mode	Full duplex

Receiver

PAUSE frame evaluation	Count, rate, current PAUSE quanta



Generator

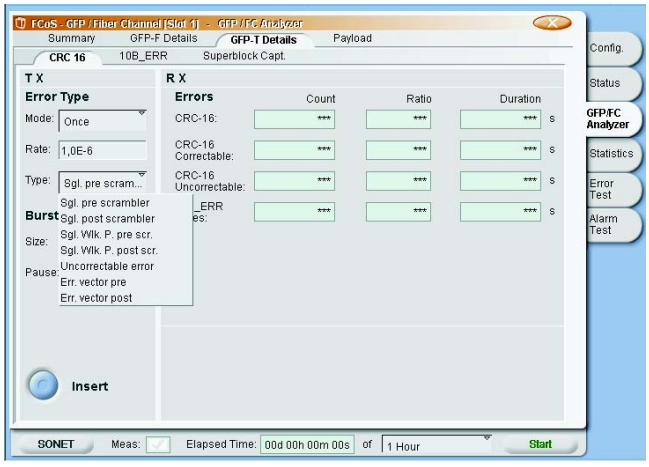
Generator reaction to received

PAUSE frames	switch on/off
Generated Alarm	PAUSED
In case of Ethernet over SDH/SONET	
The quanta time value is selected related	
To these values	10 Mb/s, 100 Mb/s, 1000 Mb/s

GFP-T processing

Highlights GFP-T processing

- Extensive **CRC-16 error insertion** capability
- **Capture of superblock**
- **Programmable** service **sequences**



Software option GFP-T processing BN 3061/93.08, one option relates to one module. Several GFP-T applications require several GFP-T options.

FCoS testing is supported by the NewGen solution 2.5G-B, BN 3061/90.43, NewGen solution 10G, BN 3061/90.45.

FCoS testing contains all topics related to test Fibre Channel services over SDH/SONET. The following technologies are addressed: Virtual concatenation (VCAT), generic framing procedure (GFP), GFP-T and the handling of the PRBS and Fibre Channel (FC) service simulation.

VCat – Virtual concatenation

Virtual concatenation implementation is in accordance with ITU-T G.707, G.783, and ANSI T1.105-2001. One virtual concatenation group (VCG) is supported, and the selectable mappings and group sizes are as follows:

High order VCat

VC-4-7v, VC-3-21v (AU-3)
STS-3c-7v-SPE, STS-1-21v-SPE

Group size is selectable from 1 to the maximum.

All path layer parameters including SQ number, overhead, errors, and alarms are supported for every member of the VCG individually.

Sequence numbers generation

User programmable, per member.

Sequence numbers evaluation

Expected sequence numbers are user programmable, per member. If expected (ExSQ) and accepted (AcSQ) SQ numbers are not equal, a mismatch alarm is generated.

Sequence number mismatch defect	SQM

Error insertion

Error types	Random, FAS, B1, B2, REI-L/MS-REI

Triggering

Once	All errors
Error rate for FAS	1×10^{-2} to 1×10^{-10}
Bit errors	1×10^{-3} to 1×10^{-10}
Random	1×10^{-4} to 1×10^{-10}
All others minimum values	1×10^{-10}

The maximum value ensures that all parity bits in all frames are affected.

Step size for mantissa	0.1
Burst error	Once and continuous M errored frames followed by N error-free frames
All errors except random	
And bit error	M, N = 1 to 65535 or 125 µs to 8 s

Error insertion path

Error types	B3, REI-P/HP-REI, BIP-V/LP-BIP, REI-V/LP-REI
Insertion	Single member or multiple members
Triggering all errors	Single

Error analysis

All errors count, ratio and seconds

Errors are analyzed for all members and are shown both independently and as group errors (e.g. GP-B3)

Alarm insertion

Alarm types	LOS, LOF, AIS-L/MS-AIS, RDI-L/MS-RDI
Triggering	On/off

Alarm insertion path

SDH	AU-AIS, HP-RDI, AU-LOP, HP-UNEQ, OOM2, OOM1, TU-AIS, LP-RDI, TU-LOP, LP-UNEQ, LP-PLM
SONET	AIS-P, RDI-P, LOP-P, UNEQ-P, OOM2, OOM1, AIS-V, RDI-V, LOP-V, UNEQ-V, PLM-P
Insertion	Single member or multiple members
Triggering	On/off

Alarm analysis

All alarms are shown in seconds

Alarms are analyzed for all members and are shown independently and as group alarms (e.g. GP-OOM1)

Alarms	As inserted above
Additional detected alarms	SEF (SONET), OOF (SDH),
Loss of alignment	LOA
Loss of multi frame (per member)	LOM
Out of multi frame 1 (per member)	OOM1
Out of multi frame 2 (per member)	OOM2

TOH/SOH and POH

Manipulation and analysis is provided for:

- All accessible TOH/SOH bytes
- POH bytes of all members independent
- Traces J0, J1, J2 in clear text
  J1, J2 of all members independently
- Sync status (S1) in clear text
- The signal label (C2) of all members is independently in clear text.

Background channels

All background channels have the same pattern.

Fill patterns

$2^{31}-1$, $2^{23}-1$, $2^{31}-1$ inv., $2^{23}-1$ inv., 16 bit user selectable word

Enhanced differential delay generation

Delay value, of every member, can be set independently

High order VCat

Range, programmable	0 to 100 ms
Granularity	N × 125 µs (MFI) + M × 0.16 µs (Ptr)
Pointer rate	8 to 2000 1/s

Three modes are available to set the delays.

Direct mode

Delay values are set manually on a per member basis. At the click of a button, delays are applied instantly for all group members in parallel. Service is disrupted temporarily.
This mode is useful to simulate the effect of APS actions.

Pointer mode

Delay values are set manually on a per member basis. At the click of a button, instrument starts to perform pointer movements until programmed delay is set for each group member. Pointer movements for all group members are executed in parallel. Pointer rate is user programmable. No service disruption occurs.
This mode is useful to simulate the effects of delay wander.

Stress mode

This is an automatic stress test mode. In an endless loop, sets of automatically generated delay values are generated and auto-applied using pointer mode. A programmable waiting time is inserted between sets of delay values. Pointer rate is user programmable. Delay value sets are generated by a random number generator. User programmable random number generator speed allows true random, as well as reproducible pseudo random operation. This mode requires no user interaction.

This mode is useful for automatic reassembler test.

Differential delay analysis

Parallel measurement, of differential delay, provided for each group member. Calculation of differential delay provided for entire group.

Results provided for all members and groups, diff. delay in ms

Measurement range	256 ms
Reassembly range	128 ms

Pointer analysis

- STS/AU pointer values of all members
- Counts of increment, decrement and NDFs

GFP-T Generic Framing Procedure

GFP-T is used to transport time sensitive services over the SDH/SONET network. The main service is Fibre Channel. The option provides the GFP-T mapper and demapper as well as the encapsulation of PRBS pattern and Fibre Channel service simulation. The implementation is according G.7041-Y.1303.

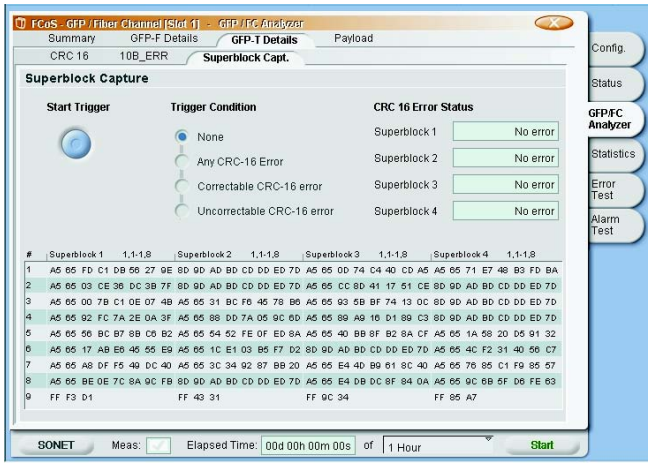
- Error detection and correction of single and double errors
- Service jitter
- Adjustable service offset
- Superblock programming with adaptation to the service bandwidth
- Insertion of client management frames
- Mapping/demapping of PRBS payload
- Mapping/demapping of some service structures

GFP traffic generation

Traffic profile with a bandwidth from 200 Baud up to 1062 Baud

Payload type header settings

PTI	Client data or client management frame
PFI FCS	Off/on
EXI	Null extension header or linear frame or ring frame
UPI (client data)	Clear text selection acc. to ITU-T G.7041
UPI (client management)	Loss of client signal (LOCS) and Loss of client character synchronization (LOCCS)



Linear extension header settings

CID and Spare editable	00 to FF

Error insertion

Core header	Single and multiple bit error
Payload type header	Single and multiple bit error
Linear frame header	Single and multiple bit error
FCS	Single-bit error

Alarm insertion

Loss of Frame Delineation LFD

Client signal fail	CSF type (LOCS, LOCCS) selectable with PTI/UPI
CSF	Frame period 500 ms

Transparent specific

Superblock generation

Programmable amount of superblocks per Frame	up to 977
Transmitted superblock	Count

CRC16 generation

Generation of CRC-16 error

Insertion point	Pre and post scrambler
Insertion mode	Single fixed, walking pattern, Uncorrectable and error vector
Repetition rate	Once, rate, continuous, burst once, Burst continuous

Service rate

Generation of service bit rate	FC full pipe, FC full speed, FC half speed, FC quarter speed, ESCON and DVB-ASI
Generation service offset	± 250 ppm
Transmitted spare bandwidth	Absolute (Mb/s), relative (ppm)
Transmitted count	All codes, D-codes and K-codes

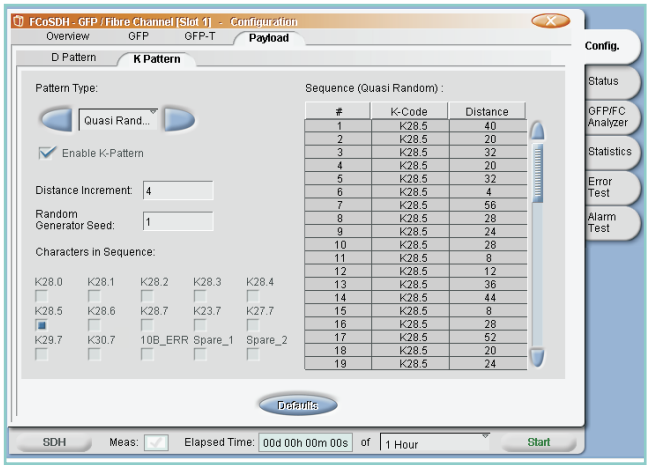
10B_ERR generation

Insertion rate	Once, rate, continuous, burst once, Burst continuous

PRBS service generation (D & K-pattern)

D-pattern

PRBS pattern	$2^{31}-1$, $2^{23}-1$, $2^{31}-1$ inv., $2^{23}-1$ inv., digital word
Error insertion	Single



K-pattern

Transmission	Enable/disable
Pattern mode	Repeated code, user-defined sequence, Pseudo random, pseudo fibre channel frame structure

Receiver GFP frame filter

On Rx, filtering based on type header fields is performed. The filter criteria are reference values and bit masks. Core, payload, and extension header error detection as well as error correction are supported. Frame delta is programmable.

Reference values of parameters payload type and extension header settings are programmable.

Error detection

Error types	Core header single, payload type header Single & multiple, Linear frame single & multiple, Payload FCS
Evaluation	Count, ratio, duration

Alarm detection

Alarm types	LFD, CSF
Evaluation	Duration

GFP frame detection

Frame types	Idle, client data with/without linear frame, Client data with/without FCS, CSF
Evaluation	Count, ratio

Online view of payload type and extension header values.

Superblock analysis

Self adapting and verification superblocks per frame

Measure number of superblock per frame	Count
Total superblock received	Count, ratio
Good superblock received	Count, ratio, rate
Bad superblock received	Count, ratio, rate
Superblock capture	4 blocks

Trigger condition	Any, any CRC-16-error, Correctable CRC-16 , uncorrectable CRC-16
Display	In hexadecimal

CRC16 analysis

Error correction	Enable, disable
Correction mode	Auto mode, single, double error with 43 spacing
Evaluation of correctable, uncorrectable, total errors	Count, ratio

Service bandwidth measurement

Client bandwidth	Absolute and relative
Spare bandwidth	Absolute and relative
Total codes received	Count, ratio
D-codes received	Count, ratio
K-codes received	Count ratio
65B_Pad codes received	Count, ratio
10B_ERR codes received	Count, ratio
K28.5 codes received	Count, ratio

10B_ERR evaluation

Evaluation	Count, rate

PRBS service evaluation (D & K-pattern)

D-codes

PRBS evaluation	$2^{31}-1$, $2^{23}-1$, $2^{31}-1$ inv., $2^{23}-1$ inv., digital word

Error detection

Bit error	Count, ratio, duration

Alarm detection

Loss of D-code synch. evaluation	Duration

K-codes

Evaluation of the transmitted sequence	

Alarm detection

Loss of K-code synch. evaluation	Duration

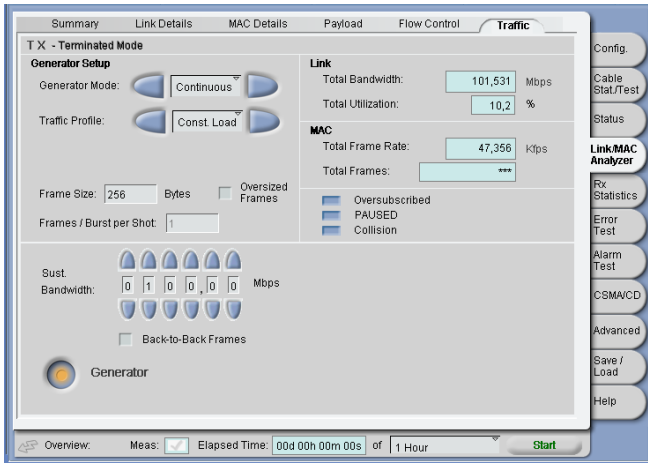
SDH/SONET/PoS testing

These tests are also running on the NewGen module. Please refer to this section on page 52.

Ethernet applications up to 1 Gb/s

Highlights Ethernet

- Ethernet interfaces for 1 Gb/s **optical** and 10/100/1000 Mb/s **twisted pair**
- **Flexible error insertion** on physical and MAC layer
- **TDR** for the copper interfaces
- **Programmable auto-negotiation**
- Complete **interworking** test solution NewSDH/SONET with Ethernet in one unit



Hardware modules

Ethernet module 10/100/1000M

BN 3061/90.71 – 1 slot

Together with the NewGen Solution 2.5G, the Ethernet Module 10/100/1000M provides efficient interworking test of NewSDH/SONET network elements. The Ethernet Module 10/100/1000M provides independent traffic load at 4 twisted pair ports up to 1 Gb/s. In addition, the module can be used for end to end testing for connectivity and Ethernet transparency.

Interface specifications

Compliant	IEEE 802.3 (2002)
Number of ports	4
Interfaces – independently settable per port	10BASE-T, 100BASE-TX, 1000BASE-T

Duplex modes

1000BASE-T	Full duplex
10BASE-T, 100BASE-TX	Full duplex, half duplex
Auto polarity correction	All pairs, all interface types

Data rates	10, 100, 1000 Mb/s
Connectors	RJ-45

Port wiring

Manual setting	MDI, MDIX
Auto	Auto-MDIX, all interface types

Clocks

Clock accuracy and synchronization from external signal: See clock specifications of ONT-506 mainframe

Tx offset	± 120 ppm
Tx offset resolution	0.1 ppm
1000BASE-T Slave mode	Tx is locked to Rx, no Tx offset possible.
Rx offset acceptance	± 200 ppm

Tx reference clock output

Nominal frequencies

10BASE-T	2.5 MHz
100BASE-TX	25 MHz
1000BASE-T	125 MHz
Pulling range	± 120 ppm
Signal level	≥ 300 mVpp
Impedance	AC coupled 50 Ω
Connector type	SMA

Rx recovered clock output

Nominal frequency

10BASE-T	2,5 MHz
100BASE-TX	25 MHz
1000BASE-T	125 MHz
Pulling range	± 200 ppm
Signal level	≥ 300 mVpp
Impedance	AC coupled 50 Ω
Connector type	SMA

Cable status/test

The status of the connected cable is shown in service.

Estimated cable length	for 1000 only
Port wiring, polarity, skew	all rates

Time Domain Reflectometer

It is an accurate cable length measurement for fault location to determine where it runs out of service.

For Link and MAC measurement details see Ethernet testing section (page 62).

Mixed Ethernet module

BN 3061/90.72 – 1 slot

The Mixed Ethernet Module provides two optical ports for 1G and two electrical ports for 10/100/1000M. For detailed specifications please refer to the "Ethernet Module 1G" and "Ethernet Module 10/100/1000M" sections.

Ethernet module 1G

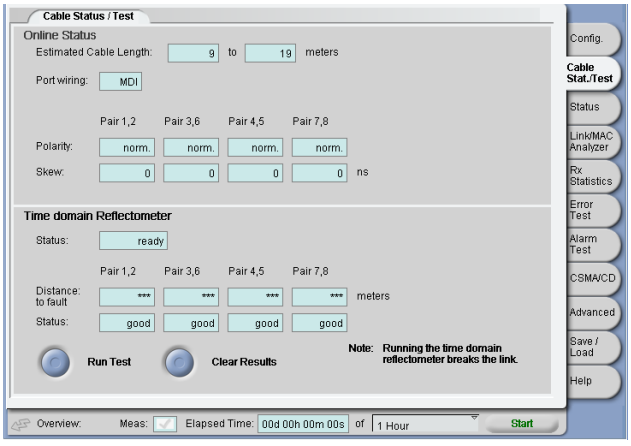
BN 3061/90.73 – 1 slot

Together with the NewGen Solution 2.5G, the Ethernet Module 1G provides efficient interworking test of NewSDH/SONET network elements. The Ethernet Module 1G provides independent traffic load at 4 ports, up to 1 Gb/s. In addition, the module can be used for end to end testing for connectivity and Ethernet transparency.

Interface specifications

Compliant	IEEE 802.3 (2002)
Number of ports	4
Interfaces – can be mixed	1000BASE-SX (850 nm)
	1000BASE-LX (1310 nm)
	Other interfaces on request
Duplex mode	Full duplex
Data rate	1000 Mb/s
Coding scheme	8B/10B
Plugables	SFPs

Module accepts SFPs compliant to the "Small Form Factor Plugable Transceiver Multi-Source Agreement (SFP)" – Sept. 14th, 2000



Operating Modes Terminate and Through (two operating modes)

Minimal intrusive through mode is useful for monitoring. Data is looped through at the 8B/10B code word level. Tx clock is locked to Rx.

Optical SFP transceiver plug-in modules

The Ethernet interface uses SFP plug-in modules. Therefore, optical parameters and connector types depend on the SFPs. JDSU supplied SFPs have LC connectors. Optical parameters given in the ONT-5xx data sheet are valid for JDSU supplied SFPs only.

Generator

Wavelength SX	850 nm
Output level	–9.5 to –4.0 dBm
Fiber SX	multi mode 50/62.5 µm
Wavelength LX	1310 nm
Output level	–9 to –3 dBm
Fiber LX	Single mode

Receiver

Wavelength range SX	770 to 860 nm
Sensitivity	–3 to –17 dBm
Wavelength range LX	1100 to 1600 nm
Sensitivity	–3 to –20 dBm

Optical power measurement

The optical power measurement is supported for SFPs compliant to SFF-8472 Rev. 9.3 "Specification for Diagnostics Monitoring Interface for Optical Xcvrs", August, 1 2002. The measurement range and accuracy depends on the SFP used.

Clocks

Clock accuracy and synchronization from external signal: See clock specifications of ONT-506 mainframe

Tx clock mode	Internal, recovered
Tx offset	± 120 ppm
Tx offset resolution	0.1 ppm
Rx offset acceptance	± 200 ppm
Rx offset measurement	± 200 ppm
Rx offset measurement resolution	1 ppm

Tx reference clock output

Nominal frequency	125 MHz
Pulling range	± 120 ppm
Signal level	≥ 300 mVpp
Impedance	AC coupled 50 Ω
Connector type	SMA

Rx recovered clock output

Nominal frequency	62,5 MHz
Pulling range	± 200 ppm
Signal level	≥ 300 mVpp
Impedance	AC coupled 50 Ω
Connector type	SMA

Ethernet testing

Supported by Ethernet Module 1G	*BN 3061/90.73*
Ethernet Module 10/100/1000M	*BN 3061/90.71*
and Mixed Ethernet Module	*BN 3061/90.72*

Link layer testing (physical)

Auto-negotiation and link control

The instrument supports auto-negotiation for all types of Ethernet interfaces. Implementation is conforming to IEEE 802.3 (2002).

Link control:

Tx ignore link status	On/off
(Forces transmitter to ignore link status).	
Auto-negotiation control:	On/off
Manual restart (forces re-negotiation)	

Auto-negotiation advertised capabilities (1000BASE-X)

Advertised capabilities are user settable

Flow control	None, asymmetric, symmetric, both
Remote fault encoding	No error, offline, link failure, Auto-negotiation error

Auto-negotiation advertised capabilities (twisted pair interface)

Advertised capabilities are user settable:

Speed and duplex mode	1000BASE-T FDX, 100BASE-TX FDX, 100BASE-TX HDX, 10BASE-T FDX, 10BASE-T HDX
Flow control	None, asymmetric, symmetric, both
Remote fault	No error, error

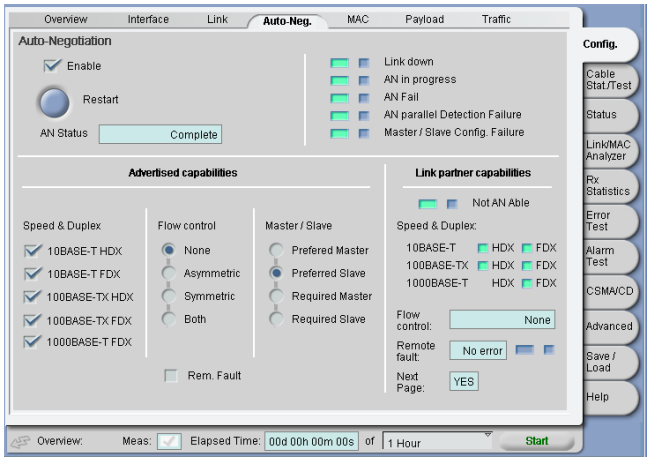
Auto-negotiation status

Status	Auto-negotiation in progress, auto-negotiation fail,
Evaluation	Duration
State machine status	Current state

Auto-negotiation link partner advertised capabilities (1000BASE-X)

The following link partner advertised capabilities are indicated:

Flow control	None, asymmetric, symmetric, both
Remote fault encoding	No error, offline, link failure, Auto-negotiation error
Duplex mode	Full-duplex, half-duplex
Next page capability	Yes/no



Auto-negotiation link partner advertised capabilities (twisted pair interface)

The following link partner advertised capabilities are indicated:

Speed and duplex mode	1000BASE-T FDX, 100BASE-TX FDX, 100BASE-TX HDX, 10BASE-T FDX, 10BASE-T HDX
Flow control	None, asymmetric, symmetric, both
Remote fault	No error, error

Link error and alarm generation (1000BASE-X)

Error types	Invalid code group, running disparity, bit errors, Line errored frame, false carrier
Triggering	Once, rate, continuous, random, burst once, Burst continuous, rate burst once, Rate burst continuous (running disparity only single)
Rates	9.9^{-3} to 10^{-10}
Bursts	N for units ON, M for units OFF N and M depending on error bits or frames Lower limit and upper limit depending on error
Alarm types	Loss of signal, loss of synchronization

Link error monitoring (1000BASE-X)

Error types	Invalid code group, running disparity error, Error propagation (/V/), Link down, line error frame, loss of synchronization event, False carrier
Evaluation	Count, ratio, duration

Link alarm generation (1000BASE-X)

Alarm types	Loss of signal, loss of synchronization
Triggering	Continuous, burst once, burst continuous
Bursts	N for ON in time M for OFF in time N and M: 1 to 10000 ms

Link status monitoring (1000BASE-X)

Alarm types	Loss of signal, loss of synchronization, Link down, Rx clock out of range
Evaluation	Duration

Transceiver related

Alarms	No SFP, Tx fault, Tx loss of timing information

Link error generation (twisted pair interface)

Error types	Dribble, line errored frame
Trigger	Once, rate, continuous, burst once, Burst continuous, rate burst once, rate burst continuous
Rate	10^{-4} to 10^{-8}
Burst	N for ON, M for OFF in frames N and M: 1 to 262143

Link error monitoring (twisted pair interface)

Error types	Rx line error, link down event, false carrier, Line errored frames, dribble frames
Evaluation	Count, rate, duration (link down event no ratio), False carrier rate

Link alarm generation (twisted pair)

Alarm type	Link down
Trigger	Continuous, burst once, burst continuous
Burst	N for ON, M for OFF N and M: 10 to 10000 ms

Link status monitoring

Alarm type	Link down, remote fault, Local Rx bad, remote Rx bad, mode change
Evaluation	Duration

Link bandwidth and utilization measurement

Rx total link bandwidth	0 to maximum
Rx total link utilization	0 to 100%
Tx total link bandwidth	0 to maximum
Tx total link utilization	0 to 100%

MAC layer testing

For Ethernet MAC layer generation and analysis see the Ethernet MAC layer chapter in the EoS testing section (page 62).

Jitter/Wander applications

Highlights Jitter

- Optical and electrical jitter testing at 155 Mb/s, 622 Mb/s, 2.5 Gb/s, 2.7 Gb/s, 10 Gb/s, 10.7 Gb/s, 40 Gb/s and 43 Gb/s
- Receiver-only jitter accuracy of 15 mUIpp (10/10.7G), 25 mUIpp (2.5/2.7G), 50 mUIpp at 16M – 320M (40G)
- Receiver verification and characterization using ITU-T Rec. O.172 Appendices VII + VIII with Accuracy Map support
- OTN mapping jitter

Highlights Wander

- Optical and electrical wander testing at 155 Mb/s, 622 Mb/s, 2.5 Gb/s, 2.7 Gb/s, 10 Gb/s, 10.7 Gb/s, 40 Gb/s, 43 Gb/s
- Graphical TIE, MTIE/TDEV (online)
- Four sample rates for long-term up to transients
- Separate reference clock input for clock and data
- TDEV noise generation and BITS/SETS output

Jitter module 2.5G-C
Jitter module 2.5/2.7G-C

Jitter module 2.5G-C *BN 3061/90.90 – 1 slot*

Together with modules 2.5G-B (BN 3061/90.26 or /90.43), the jitter module (BN 3061/90.90) provides jitter functions at 155 Mb/s, 622 Mb/s and 2.5 Gb/s.

Jitter module 2.5/2.7G-C *BN 3061/90.89 – 1 slot*

Together with module 2.5/2.7G-B (BN 3061/90.27), the jitter module (BN 3061/90.89) provides jitter functions at 155 Mb/s, 622 Mb/s, 2.5 Gb/s and 2.7 Gb/s.

Wander option BN 3061/93.92 supports wander generation and analysis on both jitter options.

Standards

Jitter and wander are generated and analyzed in accordance with the following standards:

- ITU-T Recommendation O.172 including Appendices VII and VIII with Accuracy Map support at 2.5Gb/s
- ITU-T Recommendation O.173
- ITU-T Recommendations G.825, G.8251
- Telcordia GR-253 (September 2000)
- ANSI standards T1.101, T1.105, T1.105.03

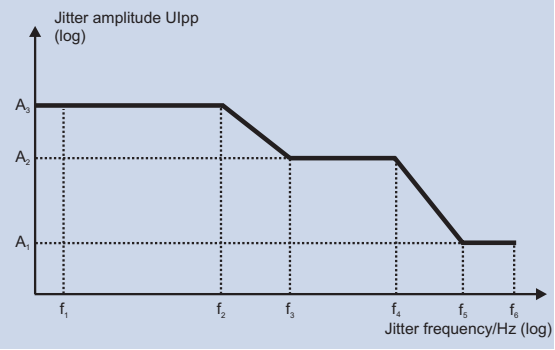
Jitter generator 2.5/2.7 Gb/s

Meets or exceeds the requirements of ITU-T Recommendations O.172 and O.173.

Bit rate	155.520 Mb/s, 622.080 Mb/s, 2.488320 Gb/s and 2.666057 Gb/s
Offset	± 50 ppm
Modulation	Internal or external
Jitter modulation signal	Sine wave
Error limits	Max. deviation: ± Q% of setting, ± 0.02 UIpp

Built-in modulation generator

Jitter amplitude	up to 800 UIpp



Step width 0.001 UI

	Amplitude in [UIpp]			Frequency in [Hz]					
	A_1	A_2	A_3	f_1*	f_2	f_3	f_4	f_5	f_6
155M	0.2	2	50	0.1	19	500	6.5k	65k	1.3M
622M	0.2	2	200	0.1	10	1k	25k	250k	5M
2.5/2.7G	0.2	2	800	0.1	12	5k	100k	1M	20M

* with wander option

Generation accuracy conforming to ITU-T O.172/O.173.

External modulation input

BNC, 75 Ω

Modulation frequency	0.1 Hz to 20 MHz
Input voltage range	0 to 2 Vpp

Jitter analyzer 2.5/2.7 Gb/s

Meets or exceeds the requirements of ITU-T Recommendations O.172 and O.173.

Bit rate	155.520 Mb/s, 622.080 Mb/s, 2.488320 Gb/s and 2.666057 Gb/s
Offset permitted	± 20 ppm
Electrical data input	SMA, 50 Ω
Input level	200 to 1000 mVpp

Measuring ranges/resolution

Standard range	
Peak-Peak	0 to 50 UIpp/1 mUIpp
RMS	0 to 25 UI/0.1 mUI
Extended range	
Peak-Peak	0 to 800 UIpp/0.1 UIpp
RMS	0 to 400 UI/10 mUI

Accuracy of the measurement

Standard range all bit rates	Fixed error 25 mUIpp*

* Optical input power level -10 dBm to -12 dBm, mapping SDH VC-4/ SONET STS-1, payload pattern PRBS 2^{31}-1, environmental temperature +20 °C to +30°C.

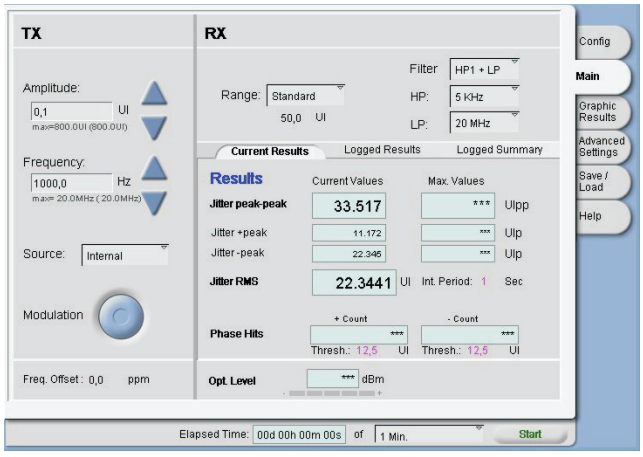
Built-in filters

High-pass filters	500 Hz, 1 kHz, 5 kHz, 12 kHz, 65 kHz, 250 kHz, 1 MHz
Low-pass filter range	1.3 MHz, 5 MHz, 20 MHz

Demodulator output

BNC, 75 Ω

Jitter testing 155 Mb/s to 2.7 Gb/s



Supports all manual and automatic measurements for jitter evaluations.

Jitter measuring modes

Current values (continuous measurement): Peak-Peak, positive peak, negative peak, RMS

Maximum values (gated measurement): Peak-Peak, positive peak, negative peak

Logged values (repetitive measurements): Peak-Peak, positive peak, negative peak

Phase hits

The instrument detects when the programmable threshold for positive and negative jitter values is exceeded and the result indicates how often the threshold was exceeded.

Jitter versus time

This function is used to record variations of jitter with time and allows the positive and negative peak values, peak-to-peak values, and RMS values to be displayed versus time. Duration is up to 99 days.

Automatic jitter measurements

Selective jitter transfer function (JTF)

The JTF shows the ratio of the jitter amplitude at the output vs. input of the device under test (DUT) at various frequencies. Standard tolerance masks are available and can be edited.

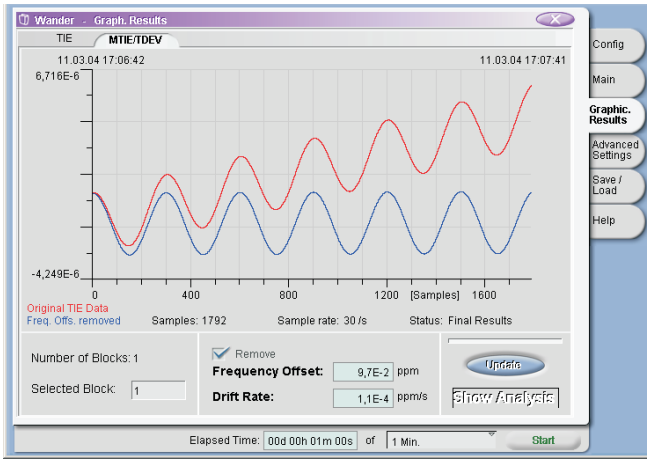
Maximum tolerable jitter (MTJ)

The jitter module automatically determines the maximum jitter amplitude tolerated by the DUT at selected jitter frequencies. The maximum permissible jitter amplitude can be precisely determined using a repetitive method. The module determines the exact limit value. Several error sources are selectable. Standard tolerance masks are available and can be edited.

Fast maximum tolerable jitter (Fast-MTJ)

This extremely fast measurement tests the device under test for conformance to the standard tolerance mask limits for maximum tolerable jitter. The editable frequency/amplitude values are set sequentially and the test pattern is monitored for the permitted threshold by the receiver. The result of each measurement is shown in a table as a status message.

Wander testing 155 Mb/s to 2.7 Gb/s



Software option *BN 3061/93.92*

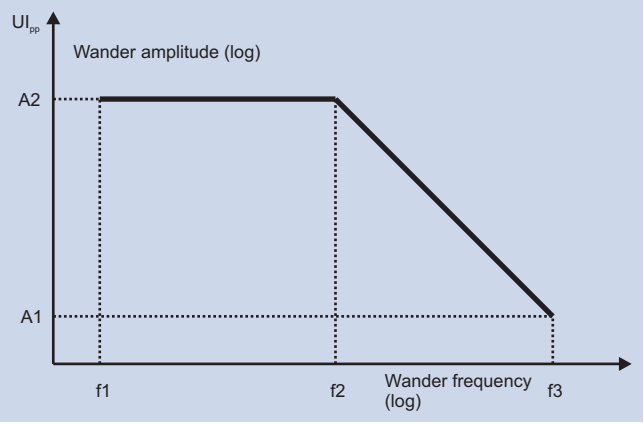
This software option is only available in conjunction with jitter modules (BN 3061/90.89 or /90.90) and enables wander generation and analysis at 155 Mb/s, 622 Mb/s, 2.5 Gb/s and 2.7 Gb/s including wander generation for BITS/SETS.

Fully complies with or exceeds the requirements of ITU-T O.172.

Wander generator 2.5/2.7 Gb/s

Modulation signal	Sine wave, white noise, TDEV noise
Amplitude range	0.1 to 100000 UI
Amplitude step width	0.1 UI
Frequency range	10 µHz to 10 Hz
Frequency step width	1 µHz
Generator accuracy	Conforms to ITU-T O.172

White/TDEV noise according Telcordia GR-253, ANSI T1.101 and ITU-T G.812/13



Clock offset	A1 in UI	A2 in UI	f1 in µHz	f2 in Hz	f3 in Hz
0 ppm	4000	100 000	10	0.4	10
50 ppm	400	100 000	10	0.04	10

BITS/SETS output

According to ITU-T G.703

Line rate	DS1 (ESF, AMI), E1 (PCM31 CRC, HDB3)
Clock	1544 kHz, 2048 kHz, 6312 kHz, 64 kHz (App. II)
Connector	Bantam 110 Ω, BNC 75 Ω
Modulation signal	sine wave, white noise, TDEV noise

Wander analyzer 2.5/2.7 Gb/s

Four different sampling rates are available for detailed analysis versus time:

Sampling rate – Low-pass filter
1/s – 0.1 Hz, 30/s – 10 Hz (O.172), 60/s – 20 Hz, 1000/s – 100 Hz (O.172)

Measurement accuracy	Conforms to ITU-T O.172

Wander reference signal input

Balanced	Bantam 110 Ω
Clock signal	1.544, 2.048 MHz
Data signal	1.544, 2.048 Mb/s
Unbalanced	BNC 75 Ω
Clock signal	1.544, 2.048, 5, 10 MHz
Data signal	1.544, 2.048 Mb/s

Wander measuring modes

Time interval error (TIE) numerical and graphical, peak-peak wander numerical.

TIE values are recorded and available for MTIE/TDEV evaluations and frequency offset and drift rate measurements with graphs and built-in masks that comply with Telcordia GR-253, GR-1244, ANSI T1.101, ETSI ETS 300 462, EN 302 084, ITU-T O.172, and G.810 to G.813 recommendations.

Automatic wander measurements

Maximum tolerable wander (MTW)

ITU-T G.823, G.825

This application tests the DUT for conformance to the standard tolerance mask limits for wander tolerance and is available in connection with the wander generator.

The device under test is subjected to wander at several amplitudes and frequencies and the output signal is monitored for different error sources. The measurement point is then marked as "Pass" (no alarms or errors detected) or "Fail" (alarms or errors detected).

DSn/PDH applications

Highlights DSn/PDH

- Two independent ports
- Multiplex chains DS1/DS3, E1/E4 and mixed mux DS1/E1 in DS3

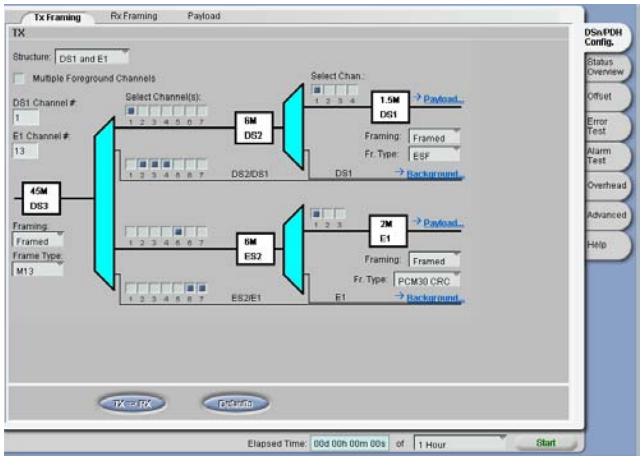
DSn/PDH modules single port and dual port

Hardware option *BN 3070/90.61, BN 3070/90.62*

1 slot each

The module supports all DSn/PDH rates on each port independently.

It provides unframed and framed signals with overhead access and error and alarm insertion and analysis



Clocking all rates

Clock sources	Internal, recovered from RX
Internal clock accuracy	As per mainframe clock
Internal clock pulling range	± 500 ppm
Pulling step	0.1 ppm

Interface measurements

Frequency measurement	± 500 ppm
Level measurement	mVpp
Alarms	LOS, Overload, Frequency out of range
	TX LTI (TX Loss of timing information)
Alarm insertion	LOS
Triggering	Continuous, burst once, burst continuous
Burst	M bits/ms alarm on, N bits/ms alarm off
M, N	1 to 16 777 215 bits

DS1 interface

Recommendations	T1.102-1993, G.703
Line rate, codes	1.544 kb/s, B8ZS, AMI
Connectors, balanced	Bantam/100 Ω, RJ-48c/120 Ω
unbalanced	BNC/75 Ω

Transmitter DS1

Output level balanced	0 dBdsx/6 Vpp
unbalanced	4.74 Vpp
Output waveform	Pre equalized 0.6, 1.2, 1.8, 2.4, 3.0 dBdsx
	ft: 0 to 133, 133 to 266, 266 to 399, 399 to 533, 533 to 655

Receiver DS1

Modes	Terminate, monitor, bridge
Sensitivity Terminate	≤ 6 dB cable
Monitor	-30 dB/0 dB cable, -26 and -23 dB/≤ 6 dB cable
Bridge balanced input (> 1 kΩ)	≤ 6 dB cable
Offset acceptance	± 180 ppm

E1 Interface

Recommendation	G.703
Line rate, codes	2.048 kb/s, HDB3, AMI
Connectors, balanced	RJ-48c/120 Ω, Bantam/100 Ω
unbalanced	BNC/75 Ω

Transmitter E1

Output level balanced	6 Vpp
unbalanced	4.74 Vpp

Receiver E1

Modes	Terminate, monitor, bridge
Sensitivity Terminate	≤ 6 dB cable
Monitor	-30 dB/0 dB cable, -26 and -23 dB/≤ 6 dB cable
Bridge balanced input (> 1 kΩ)	≤ 6 dB cable
Offset acceptance	± 80 ppm

E3 Interface

Recommendation	G.703
Line rate, codes	34.368 kb/s, HDB3, AMI (TX only)
Connector, unbalanced	BNC, 75 Ω

Transmitter E3

Output level	2 Vpp

Receiver E3

Modes	Terminate, monitor
Sensitivity Terminate	≤ 12 dB cable
Monitor	-20 dB/≤ 12 dB cable, -26 dB/≤ 6 dB cable
Offset acceptance	± 100 ppm

DS3 Interface

Recommendations	T1.102-1993, G.703
Line rate, codes	44.736 kb/s, B3ZS, AMI (TX only)
Connector, unbalanced	BNC, 75 Ω

Transmitter DS3

Output level HIGH	0 ft cable/2.0 Vpp
DSX	450 ft cable/1.0 Vpp
LOW	900 ft cable/0.5 Vpp

Receiver DS3

Modes	Terminate, monitor
Sensitivity Terminate	≤ 12 dB cable
Monitor	-20 dB/≤ 12 dB cable, -26 dB/≤ 6 dB cable
Offset acceptance	± 100 ppm

E4 Interface

Recommendation	G.703
Line rate, code	139.264 kb/s, CMI
Connector, unbalanced	BNC, 75 Ω

Transmitter E4

Output level	1 Vpp

Receiver E4

Modes	Terminate, monitor
Sensitivity Terminate	≤ 12 dB cable
Monitor	-20 dB/≤ 6 dB cable, -26 dB/0 dB cable
Offset acceptance	± 100 ppm

DSn/PDH testing

Standard test pattern

Pattern	PRBS 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv.
	16 bit user selectable, all 0 s, all 1 s
	Bit pattern with programmable length 3 to 32 bit

E1, E3, E4 (PDH) unframed

Pattern	Standard test pattern
Alarms	Pattern loss, LOS, AIS
Alarms E1 only	Excess. zeros
Errors	Bit error
Errors E1& E3 only	Code

DS1, DS3 unframed

Pattern	Standard test pattern
Special pattern DS1 only	QRSS20, 1 in 8, 2 in 8, 3 in 24
Alarms	LOS
Alarms DS1 only	AIS, Excess. zeros
Errors	BPV, Bit error

E1, E3, E4 (PDH) framed

Frame types E1 (E1 is not channelized)	PCM30, PCM30 CRC, PCM31, PCM31 CRC
Frame types E3, E4	G.751
Pattern	Standard test pattern
Alarms	Pattern loss, LOS, AIS, LOF, RDI
Alarms E1 only	Excess. zeros
Errors	FAS word/bit, bit error
Errors E1 only	CRC, REBE
Errors E1& E3 only	Code

Overhead bits E1

Si, Sa4 to Sa8	Programmable and displayed online
CAS TS16 (PCM30 only)	Programmable 16 byte sequence
SSM (PCM30/31 CRC only)	Clear text edit and display

Overhead bits E3, E4

E3 Bit12	Programmable and displayed online
E4 Bit14 to 16	Programmable and displayed online

DS1, DS3 framed

Frame types DS1	SF, ESF
Frame types DS3	C-Parity, M13
Pattern	Standard test pattern
Special pattern DS1	QRSS20, 1 in 8, 2 in 8, 3 in 24
Special pattern DS3	100
Alarms	LOS, AIS, frame loss, RAI, Idle
Alarms DS1 only	Excess. zeros
Alarms DS3 only	FTM (frame type mismatch), RX only
Errors	BPV, frame errors, bit error
Errors DS1 only	CRC
Errors DS3 only	P-bit, CP-bit, FEBE

Data link DS1 ESF

Format	16 bits programmable and displayed online
	Includes synchronization message

Overhead bits DS3

X1, X2 bits	Displayed online
C11-/ AIC-bit	Displayed online

Multiplex chains

E-carrier mux

E3 structured	E1 in E3 via E2
E4 structured	E1 in E4 via E2/E3

E1 is unframed or framed, not channelized.
One selected channel is generated and one is measured.
Background channels are fully structured

T-carrier mux

DS3 structured	DS1 in DS3 via DS2
DS3 structured	E1 in DS3 via ES2

DS1 is unframed or framed, not channelized.
One selected channel is generated and one is measured.
Background channels are fully structured

Mixed mux

DS3 mixed	DS1 via DS2 and E1 via ES2

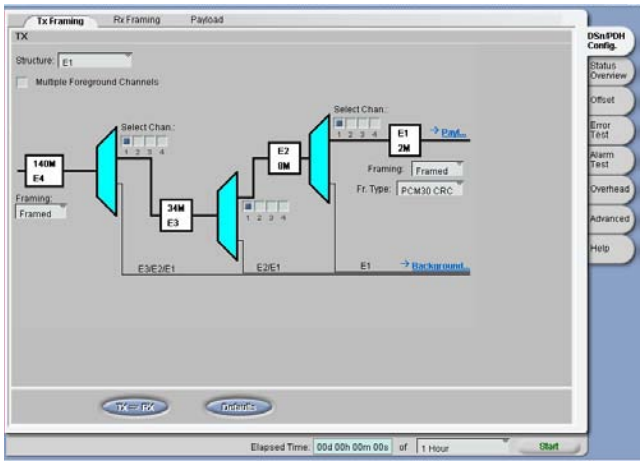
DS1 and E1 are unframed or framed, not channelized.
One selected channel DS1 and one E1 are generated and one of each is measured (dual channel measurement).
Background channels are fully structured

ES2 framing testing

Frame type	E1 in DS3 comply G.747
Alarms	AIS, LOF, RDI
Errors	FAS word/bit
OH Reserved bit S	Programmable and displayed online

Bit rate offsets

Measurement	Offsets of all mux levels



DSn/PDH error/alarm insertion and measurement

Simultaneous generation of errors and alarms is supported

Alarm insertion	Alarms see correspondent signal
Triggering	Continuous, burst once, burst continuous
Burst	M bits/ms alarm on, N bits/ms alarm off
M, N	Depend on signal type

Error insertion	Errors see correspondent signal
Triggering	Single, rate, burst once, burst continuous Rate burst once, rate burst continuous
Rates	9.9×10^{-3} to 1×10^{-10}
Burst	M errored frames followed by N error free frames
M, N	In frames/µs

Alarm detection	Alarms see correspondent signals

All alarms are measured with duration

Error detection	Errors see correspondent signals

All errors are measured with count, ratio and duration

Mainframes

BN 3075/01 ONT-503 Optical Network Tester

3-slot mainframe with 15" TFT display to take any combination of modules.

Please check number of slots required per module.

BN 3075/92.45	Carrying case
BN 3075/94.01	Calibration report

BN 3062/01 ONT-506 Optical Network Tester

6-slot mainframe with 15" TFT display to take any combination of modules.

Please check number of slots required per module.

BN 3062/92.45	Carrying case
BN 3062/94.01	Calibration report

BN 3061/01 ONT-512 Optical Network Tester

12-slot rack mount mainframe to take any combination of modules.

Please check number of slots required per module.

BN 3061/94.01	Calibration Report
BN 3061/92.01	**Rack mount kit** It is required to install a support bar in the rack when mounting the ONT-512 by using the rack mount kit.

Some modules are only available for the ONT-503. The BN starts in this case with BN 3075/...

Module 40/43G solution

SDH/SONET Application

BN 3061/91.81	**40G SDH/SONET NRZ V2** STM-256, OC-768, unframed 40G 3 slots
BN 3061/91.84	**40G SDH/SONET electrical V2** STM-256, OC-768, unframed 40G 3 slots

OTN Application

BN 3061/93.29	**43G OTN V2** OTM-0.3, unframed 43G, SDH/SONET and bulk-client Requires one of the following: 40G SDH/SONET NRZ V2 BN 3061/91.81 or 43G Jitter V2 BN 3061/91.92
BN 3061/93.14	**43G OTN Multiplexing** ODU2 and ODU1 in ODU3 with bulk client or SDH/SONET client (optional) Requires BN 3061/93.29 or /91.85

OTN Application with DPSK

BN 3061/91.85	**43G OTN with bulk client DPSK V2** OTM-0.3 with NRZ-DPSK Unframed 43G OTU3 with bulk client 3 slots
BN 3061/93.28	**43G OTN with SDH/SONET client V2** Adds to OTU3 the capability to have a SDH/SONET client Requires BN 3061/91.85

Jitter/Wander Application

BN 3061/91.91	**40G SDH/SONET Jitter V2** STM-256, OC-768, unframed 40G 5 slots
BN 3061/91.92	**43G Jitter** Unframed jitter at 43G No additional slot required Requires the following: 40G SDH/SONET Jitter V2 BN 3061/91.91 OTN framed signals require: 43G OTN V2 BN 3061/93.29
BN 3061/93.93	**Wander 40/43G** Software option Requires the following: 40G SDH/SONET Jitter V2 BN 3061/91.91 and 43G Jitter V2 BN 3061/91.92 (optional)

Module-E 10G Solution

LAN/WAN/FC/SDH/SONET/OTN

Module-E Hardware

Module-E supports a combination of built-in optics and pluggable XFPs.

The wavelength combinations 1310 and 1550 nm are built-in and switchable, 850 nm is always a pluggable XFP.

Modules for ONT-503/506/512 (BN 3061/92.xx) are 2-slot and modules for ONT-503 (BN 3075/92.xx) are 1-slot versions.

BN 3061/92.10	**Module-E 10G XFP slot** Optics via XFP slot
BN 3075/92.10	**Module-E 10G XFP slot** Optics via XFP slot
BN 3061/92.11	**Module-E 10G 1310 nm)** Optics built-in 1310 nm
BN 3075/92.11	**Module-E 10G 1310 nm** Optics built-in 1310 nm

Ordering Information

BN 3061/92.12	**Module-E 10G 850/1310 nm** Optics XFP 850 nm, built-in 1310 nm
BN 3075/92.12	**Module-E 10G 850/1310 nm** Optics XFP 850 nm, built-in 1310 nm
BN 3061/92.13	**Module-E 10G 1310/1550 nm** Optics built-in 1310/1550 nm switchable
BN 3075/92.13	**Module-E 10G 1310/1550 nm** Optics built-in 1310/1550 nm switchable
BN 3061/92.14	**Module-E 10G 850/1310/1550 nm** Optics XFP 850 nm, built-in 1310/1550 nm switchable
BN 3075/92.14	**Module-E 10G 850/1310/1550 nm** Optics XFP 850 nm, built-in 1310/1550 nm switchable
BN 3061/92.19	**Electrical interfaces 10G** Differential interfaces to be combined with Module-E (2 slots)

The offered XFPs optics are qualified for all bit rates and applications

BN 3061/92.20	XFP Optics 850 nm
BN 3061/92.21	XFP Optics 1310 nm
BN 3061/92.22	XFP Optics 1550 nm
BN 3061/92.23	XFP Fast Trigger (spare for BN 3061/92.19)

Module-E Hardware/Software Packages

BN 3061/92.30	**Module-E 10GE LAN XFP slot** Optics via XFP slot Includes BN 3061/93.47
BN 3061/92.31	**Module-E 10GE LAN 1310 nm** Optics built-in 1310 nm Includes BN 3061/93.47
BN 3061/92.32	**Module-E 10GE LAN 850/1310 nm** Optics XFP 850 nm, built-in 1310 nm Includes BN 3061/93.47
BN 3061/92.33	**Module-E 10GE LAN 1310/1550 nm** Optics built-in 1310/1550 nm switchable Includes BN 3061/93.47
BN 3061/92.34	**Module-E 10GE LAN 850/1310/1550 nm** Optics XFP 850 nm, built-in 1310/1550 nm switchable Includes BN 3061/93.47

Module-E Software – Option valid for one module

BN 3061/93.35	**OC-192c/STM-64c BERT**
BN 3061/93.36	**SDH/SONET Single Channel** Includes BN 3061/93.35
BN 3061/93.37	**Multi-Channel 10G High Order**
BN 3061/93.39	**10G VCAT High Order**
BN 3061/93.45	**10G GFP** Requires OTN 10.7G BN 3061/93.48 or 10G VCAT High Order BN 3061/93.39) as transport technique and 10GigE LAN BN 3061/93.47 as service
BN 3061/93.46	**10G Fibre Channel**
BN 3061/93.47	**10GigE LAN** Included in BN 3061/92.30 to BN 3061/92.34
BN 3061/93.48	**10GigE WAN** Requires BN 3061/93.47
BN 3061/93.49	OTN 10.7G
BN 3061/93.50	**OTN 11.05/11.1G** Overclocked OTN for 10G LAN (optional)
BN 3061/93.51	**OTN 11.27/11.32G** Overclocked OTN for 10GFC (optional)
BN 3061/93.52	**OTN Data 11.05/11.1/11.27/11.32G** Consists of BN 361/93.50 and BN 3061/93.51. See there for more information.
BN 3061/93.53	**OTN 10.7 to 11.32G** Consists of BN 3061/93.49 and BN 3061/93.50 and BN 3061/93.51. See there for more information.
BN 3061/93.54	**OTN Multiplexing OTU2** Requires BN 3061/93.49 as base option, SDH/SONET client is optional (BN 3061/93.36 or BN 3061/93.37)
BN 3061/93.60	**MAC-in-MAC 802.1ah** Requires BN 3061/93.47
BN 3061/93.62	**IPv6** Requires BN 3061/93.47
BN 3061/93.65	**Capture MAC/IP** Requires BN 3061/93.47

Module-E Software Packages

BN 3061/93.75	**10G Transport Solution** Consists of SDH/SONET Single Channel BN 3061/93.36 10G VCAT High Order BN 3061/93.39 10G GFP-F BN 3061/93.45 10GigE LAN BN 3061/93.47 10GigE WAN BN 3061/93.48 OTN 10.7G BN 3061/93.49 OTN Multiplexing OTU2 BN 3061/93.54
BN 3061/93.76	**10G VCAT High Order Solution** Consists of 10GigE LAN BN 3061/93.47 10G VCAT High Order BN 3061/93.39 10G GFP-F BN 3061/93.45
BN 3061/93.77	**10G Ethernet Solution** Consists of 10GigE LAN BN 3061/93.47 10GigE WAN BN 3061/93.48 10G GFP-F BN 3061/93.45
BN 3061/93.78	**10G OTN Multiplexing Solution** Consists of SDH/SONET Single Channel BN 3061/93.36 OTN 10.7G BN 3061/93.49 OTN Multiplexing OTU2 BN 3061/93.54
BN 3061/93.79	**10G Multi-Channel High Order Upgrade** Requires BN 3061/93.36

Jitter

BN 3061/90.86	**Jitter Module 10G-D 1310 nm** 1310 nm, high-accurate jitter 9.9G unframed Evaluated with O.172 Appendices VII + VIII Requires a Module-E BN 3061/92.10.../92.14 Requires SDH/SONET option for service measurements preferred BN 3061/93.35 or 93.63 Adds 1 slot
BN 3061/90.88	**Jitter Module 10G-D 1550 nm** 1550 nm, high-accurate jitter 9.9G unframed Evaluated with O.172 Appendices VII + VIII Requires a Module-E BN 3061/92.10.../92.14 Requires SDH/SONET option for service measurements preferred BN 3061/93.35 or 93.63 Adds 1 slot
BN 3061/93.70	**Jitter 10.3G** Enables jitter at 10.36G Requires BN 3061/90.86 or /90.88 Requires 10G LAN option for service-based measurements BN 3061/93.47
BN 3061/93.71	**Jitter 10.7G** Enables jitter at 10.7G Requires BN 3061/90.86 or /90.88 Requires OTN 10.7G option for service-based measurements BN 3061/93.49
BN 3061/93.95	**Wander 10/11G** Software option TIE, MTIE, TDEV Requires BN 3061/90.86 or /90.88 Requires optional BN 3061/93.70 and /93.71
BN 3061/93.96	**Wander DS1/E1 + BITS** Software option DS1/E1 + BITS Requires BN 3061/93.95
BN 3061/93.97	**Wander 10/11G Expert** Software option TDEV noise Requires BN 3061/93.95

Modules and Options

SDH/SONET Applications

BN 3061/90.26	**Module 2.5G-B, 1310/1550 nm** Electrical interfaces OC-1/3/12/48, STM-0/1/4/16 Prepared for jitter 1 slot
BN 3061/90.15	**Module 10G, 1310 nm** OC-192, STM-64 1 slot
BN 3061/90.21	**Module 10G-B, 1310 nm** Electrical interfaces OC-192, STM-64 Prepared for jitter 2 slots
BN 3061/90.16	**Module 10G, 1550 nm** OC-192, STM-64 1 slot
BN 3061/90.19	**Module 10G-B, 1550 nm** Electrical interfaces OC-192, STM-64 Prepared for jitter 2 slots
BN 3061/93.03	**IP/PoS processing** Runs on all classical SDH/SONET capable modules. One option relates to one module. This option is not available for 10G Module-E and for the 40/43G solutions.

Multi-Channel SDH/SONET Application

BN 3061/90.82	**Multi-Channel extension module** Parallel generation/analysis of up to 1344 VT1.5/1008 VC-12 channels with mixed signal structure 1 slot Requires one of the following modules: Modules 2.5G/10G: BN 3061/90.26, /90.16, /90.15, /90.21, /90.19 NewGen solution 2.5G/10G: BN 3061/90.43, /90.45 OTN modules 2.5/2.7 and 10/10.7G: BN 3061/90.27, /90.30, /90.32, /90.33

Data over SDH/SONET Applications

BN 3061/90.43	**NewGen solution 2.5G-B** 1310/1550 nm, electrical interfaces SDH/SONET/EoS: OC-3/12/48, STM-1/4/16 SDH/SONET additionally: OC-1/STM-0 VCat LO/HO, Differential Delay, GFP, LCAS, MAC Prepared for jitter 1 slot
BN 3061/90.45	**NewGen solution 10G** 1550 nm, electrical interfaces OC-192, STM-64 SDH/SONET/EoS VCat LO&HO, Differential Delay, GFP, LCAS, MAC 2 slots
BN 3061/93.08	**GFP-T processing** Software option Requires one of BN 3061/90.41, /90.43, /90.45 one option relates to one module.
BN 3061/90.71	**Ethernet module 10/100/1000M** 4 ports 10/100/1000Base-T 1 slot
BN 3061/90.72	**Mixed Ethernet module** 2 ports 1000Base-SX/LX and 2 ports 10/100/1000Base-T 1 slot Please select number of SFPs (2 free of charge) SFP 1000Base-SX BN 3070/90.78 SFP 1000Base-LX BN 3070/90.79

BN 3061/90.73 **Ethernet module 1G**
4 ports 1000Base-SX/LX
1 slot
Please select number of SFPs (4 free of charge)
SFP 1000Base-SX BN 3070/90.78
SFP 1000Base-LX BN 3070/90.79

OTN Applications

BN 3061/90.27 **OTN module 2.5/2.7G-B**
1310/1550 nm, electrical interfaces
OC-1/3/12/48, STM-0/1/4/16, OTU1
Prepared for jitter
1 slot

BN 3061/90.32 **OTN module 10/10.7G-B**
1550 nm, electrical interfaces
OC-192, STM-64, OTU2
Prepared for jitter
2 slots

BN 3061/90.33 **OTN module 10/10.7G-B**
1310 nm, electrical interfaces
OC-192, STM-64, OTU2
Prepared for jitter
2 slots

Jitter/Wander Applications

BN 3061/90.90 **Jitter module 2.5G-C**
High-accurate jitter 155M, 622M, 2.5G
Evaluated with O.172 Appendices VII + VIII
Requires BN 3061/90.26, /90.43
1 slot

BN 3061/90.89 **Jitter module 2.5/2.7G-C**
High-accurate jitter 155, 622M, 2.5G, 2.7G
Evaluated with O.172 Appendices VII + VIII
Requires BN 3061/90.27
1 slot

BN 3061/93.92 **Wander 2.5/2.7G**
Software option, TIE, MTIE, TDEV
Requires BN 3061/90.89, /90.90
1 slot

DSn/PDH Applications

BN 3061/90.61 **DSn/PDH module single port**
DS1, DS3, E1, E3, E4
1 slot

BN 3061/90.62 **DSn/PDH module dual port**
Two times: DS1, DS3, E1, E3, E4
1 slot

Optical Connectors

For built-in optics, the following adapter types are available. One adapter per interface is included in the initial order and is user selectable.

Measuring adapter

BN 2060/00.51	FC, FC-PC, FC-APC
BN 2060/00.58	SC, SC-PC, SC-APC
BN 2060/00.32	ST type (AT&T)
BN 2060/00.51	DIN 47256
BN 2060/00.53	E 2000 (Diamond)
BN 2060/00.59	LC, F-3000 (PC-APC)

Optical attenuators

BN 2239/90.30	FC-PC, 10 dB, 1310/1550 nm
BN 2239/90.38	SC, 10 dB, 1310/1550 nm

JDSU offers a wide range of optical power meters, sources and attenuators. Contact your local sales representative for details.

Notes

Related products

TestPoint Family

TestPoint offers a flexible and cost effective telecom and datacom test solution for Production and Service Verification Testing (SVT). It consists of a modular platform that provides versatility in configuring interface types, transmission rates, protocols, and port density. One of the TestPoint's key attributes is support for multiple rates on single modules.

It is available in three chassis formats: a lightweight, fixed interface TS-10, a 3-slot TS-30, and a 17-slot TS-170. TestPoint provides 1G/2G/4G/10G Fibre Channel support and Ethernet features from 10 Mb/s up to 10 Gigabit Ethernet.

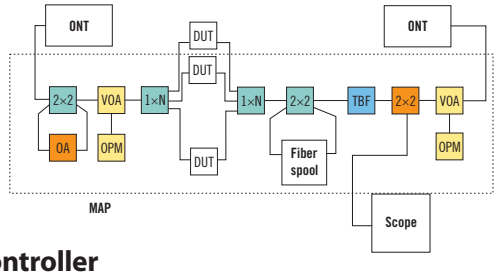
Transport protocol coverage includes SDH/SONET up to 40G, and Optical Transport Network (G.709) including overclocked rates.

Multiple Application Platform (MAP)

With over 20 unique modules, MAP enables users to manipulate and control optical transmission signals (independent of rate or format) and enables testing of transmission quality as a function of parameters such as Average Power, OSNR and Polarization state. Optical switches and optical splitter modules may be added to enable automation interfaces for multiple devices and/or multiple signal sources.

The modular platform is available in 3 or 8 slot chassis with GPIB or RS-232 interfaces. ActiveX and LabView drivers are also provided. Rack mount kits and a reverse mount system enable clean factory test integration and rear fiber exit when needed.

2×2: optical switch (cross)
OA: optical amplifier
OPM: optical power meter
VOA: variable optical attenuator
1×N: 1:N switch
TBF: tunable bandpass filter



OLA-55M Optical Level Controller

The OLA-55M contains both attenuator and power level function making test set-up simple and eliminating the need to connect several instruments, cables and couplers.

See OLA-55M data sheet for details.

Handheld Fiber Inspection Microscope

Many light transmission problems occur as a result of improper fiber connectors. The Fiber Microscope reflects details of scratches and any contamination of connector end surfaces. The light weight microscope is equipped with universal push-pull adapter.

Test & Measurement Regional Sales

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