JDSU

COMMUNICATIONS TEST & MEASUREMENT SOLUTIONS

ONT-503/506/512

Module-E 10/11G LAN/WAN/FC/SONET/SDH/OTN

March 2009

Key features

- Unframed BERT for 9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 11.049, 11.095, 11.270, 11.318 Gb/s
- Electrical Interfaces all rates 10G
- 10GigE LAN/WAN L1 BERT and L2/L3 traffic
- 10G Fibre Channel (FC) L1 BERT
- SONET/SDH (OC-192c/STM-64c)
- Multi-Channel 10G (64x AU-3/-4, 192x STS-1)
- OTN 10.709, 11.049, 11.095, 11.270, 11.318 Gb/s
- OTN wrapper/de-wrapper testing
- FEC stress test
- Multiple MAC/IP flows and independent filters (up to 256)
- JDSU's first MAC-in-MAC framing (802.1 ah)
- VPLS frames and multiple mixed VLAN/MPLS tags (up to 10)
- QoS, service disruption and packet jitter per flow

Today's market is facing tremendous growth of new packet-based services, such as VoIP and IPTV. This level of growth, combined with an increase in end-user demand for direct Ethernet access, has caused an urgent need for cost-effective high-speed Ethernet transmission systems.

All major operators view 10 Gigabit Ethernet (10 GigE) as the key enabling technology in today's market and are implementing it in their networks as LAN, WAN, or in combination with OTN.

The major challenge of manufacturers is to provide interface cards with capabilities for multiple technologies. They need to verify the ports against various standards, such as IEEE and ITU-T, to ensure that all of the network layers are interacting properly. As Ethernet behavior changed from "best effort" to "carrier grade", comprehensive testing is required.

The Module-E for JDSU's ONT-503/506/512 address the needs of R&D and SVT labs by providing all of the necessary functionality for testing OTN/SONET/SDH/LAN/WAN networks at different wavelengths. With its MAC-in-MAC option the Module-E supports JDSU's first approach of PBB/PBT implementation.

With its broad range of modules, the ONT-503/506/512 is the ideal tool for testing both current and emerging technologies.

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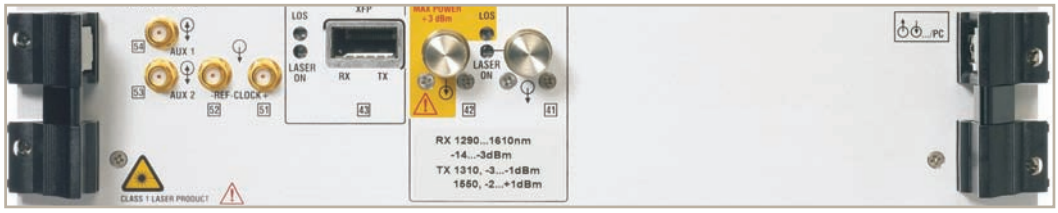
Design and conformance testing of NextGeneration transport networks

Multi-application and multi-port configuration

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 with Module-E (in preparation)

- 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)

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Mainframe

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**	
Module-E 10G LAN/WAN/FC/SDH/SONET/OTN		
Module-E 10G XFP slot	2	BN 3061/92.10
Module-E 10G XFP slot (ONT-503)	1	BN 3075/92.10
Module-E 10G 1310 nm	2	BN 3061/92.11
Module-E 10G 1310 nm (ONT-503)	1	BN 3075/92.11
Module-E 10G 850/1310 nm	2	BN 3061/92.12
Module-E 10G 850/1310 nm (ONT-503)	1	BN 3075/92.12
Module-E 10G 1310/1550 nm	2	BN 3061/92.13
Module-E 10G 1310/1550 nm (ONT-503)	1	BN 3075/92.13
Module-E 10G 850/1310/1550 nm	2	BN 3061/92.14
Module-E 10G 850/1310/1550 nm (ONT-503)	1	BN 3075/92.14
Electrical interfaces 10G	–	BN 3061/92.19
OC-192c/STM-64c BERT	–	BN 3061/93.35
SDH/SONET Single Channel	–	BN 3061/93.36
Multi-Channel 10G High Order	–	BN 3061/93.37
10G VCAT High Order (in preparation)	–	BN 3061/93.39
10G GFP-F (in preparation)	–	BN 3061/93.45
10G Fibre Channel	–	BN 3061/93.46
10GigE LAN	–	BN 3061/93.47
10GigE WAN	–	BN 3061/93.48
OTN 10.7 G	–	BN 3061/93.49
OTN 11.05/11.1 G	–	BN 3061/93.50
OTN 11.27/11.32 G	–	BN 3061/93.51
OTN Data (11.05/11.1/11.27/11.32 G)	–	BN 3061/93.52
OTN 10.7 to 11.32 G	–	BN 3061/93.53
OTN Multiplexing OTU2	–	BN 3061/93.54
MAC-in-MAC 802.1 ah	–	BN 3061/93.60
IPv6	–	BN 3061/93.62
Capture MAC/IP	–	BN 3061/93.65
10G Transport Solution (in preparation)	–	BN 3061/93.75
10G VCAT High Order Solution (in preparation)	–	BN 3061/93.76
10G Ethernet Solution (in preparation)	–	BN 3061/93.77
10G OTN Multiplexing Solution	–	BN 3061/93.78
10G Multi-Channel High Order Upgrade	–	BN 3061/93.79
Jitter module 10G-D 1310 nm (in preparation)	+ 1	BN 3061/90.86
Jitter module 10G-D 1550 nm (in preparation)	+ 1	BN 3061/90.88
Jitter 10.3G (in preparation)	–	BN 3061/93.70
Jitter 10.7G (in preparation)	–	BN 3061/93.71
Wander 10/10.3/10.7G (in preparation)	–	BN 3061/93.95
Wander DS1/E1 + BITS (in preparation)	–	BN 3061/93.96

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

CD R/W/DVD-ROM drive for data transfer and software update.
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 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 only 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.

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

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		9.95, 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

TX sync 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	9.953 to 11.32Gb/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 400mVpp
Connector	SMA / 50 Ω

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

Jitter Module 10G-D 1310 nm *BN 3061/90.86 (in preparation)*

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 (in preparation)*

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 (in preparation)*

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 (in preparation)*

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
- 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 adaptors

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

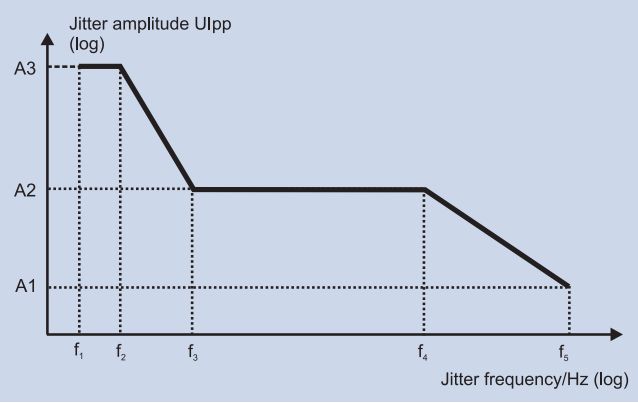
Clock output

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 10/10.3/10.7 Gb/s

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	± 200 ppm
Modulation	Internal or external
Jitter modulation signal	Sine wave
Jitter value of transmitter	Verified with appendix VIII
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 10/10.3/10.7 Gb/s

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	80 MHz
Bandpass filter XFI	50 kHz….8 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 (in preparation) *BN 3061/93.95*

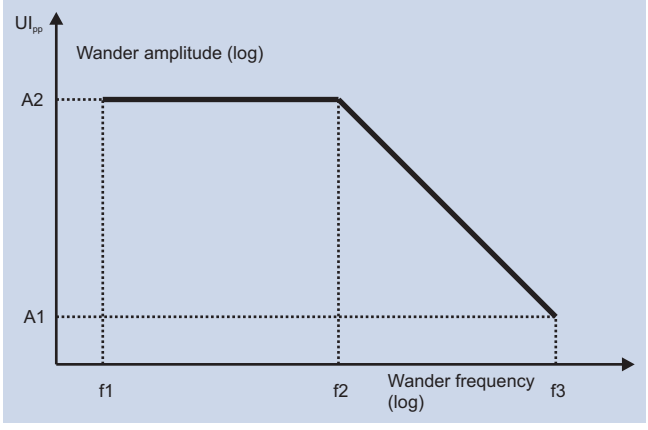
This software option is only available in conjunction with jitter modules (BN 3061/90.86 or /90.88) and enables wander generation and analysis at 10 Gb/s, 10.3 Gb/s (if available) and 10.7 Gb/s (if available) including wander generation for BITS/SETS.
Fully complies with or exceeds the requirements of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

Software Option Wander DS1/E1 + BITS (in preparation) *BN 3061/93.96*

Wander generator 10/10.3/10.7 Gb/s

Modulation signal	Sine wave, white noise, TDEV noise
Amplitude range	0.1 to 320000 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	16 000	320 000	10	0.5	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 10/10.7 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 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, 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).

Wander Transfer Function (WTF)

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

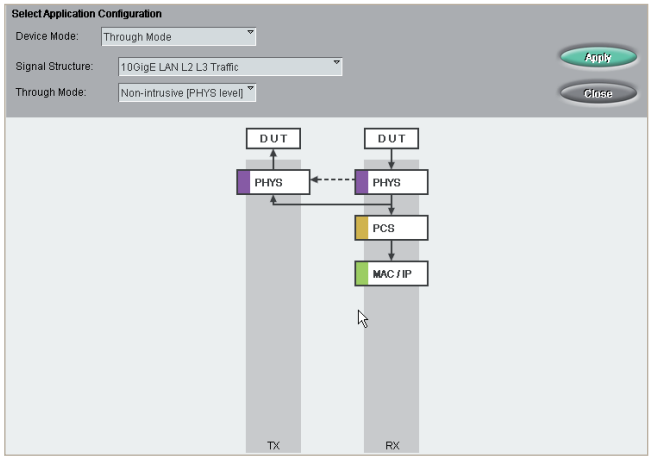
All available rates are offered with unframed pattern and BERT capabilities. These functions are useful especially to qualify XFPs components and DWDM links

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

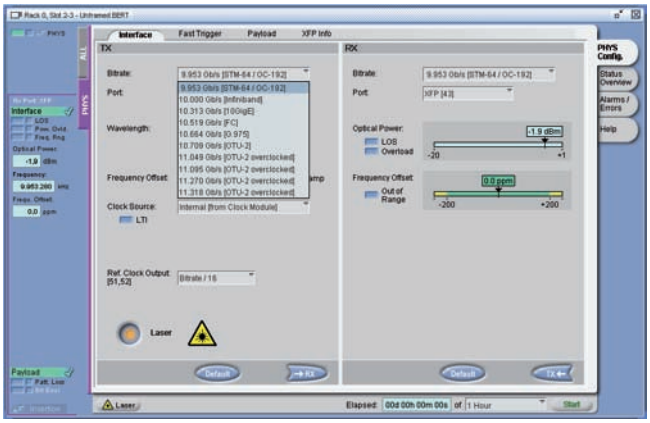
Level measurement resolution	0.1 dBm

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*

Interfaces

See "Interface specification" page 5

Physical layer testing

See "Interface and unframed testing" page 8

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

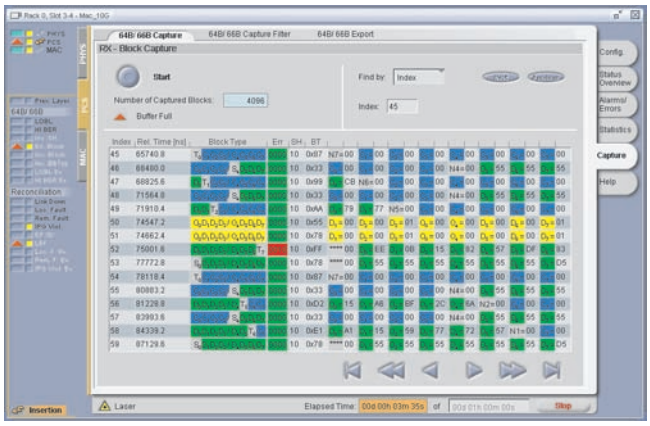
Reconciliation sublayer statistics

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

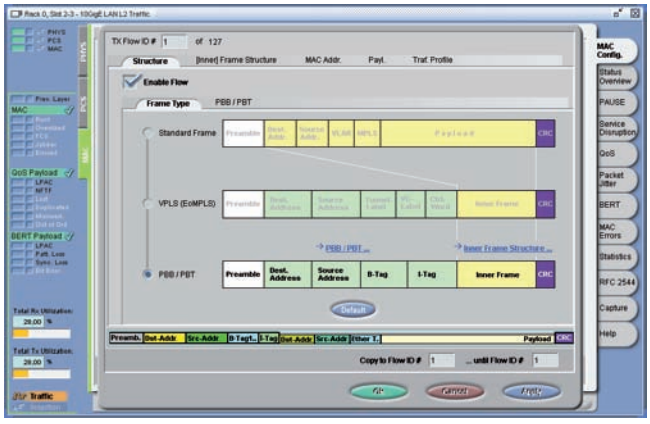
Flow control

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

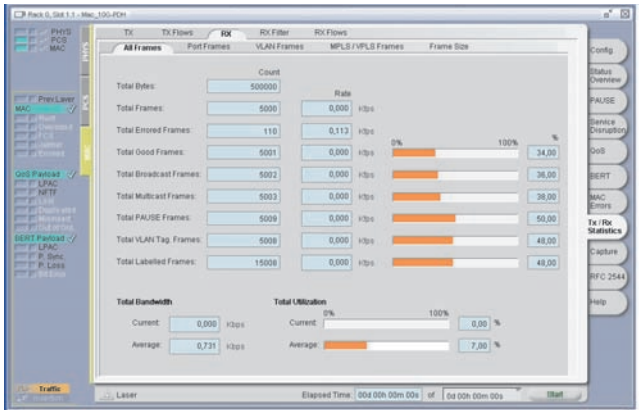
Bandwidth of single filtered flows "Utilization" is flow BW / link BW, "share" is flow BW / used BW	
Bandwidth types	Current, current payload, average, Average payload
Bandwidth results	Mb/s, utilization (link), share (flows)

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

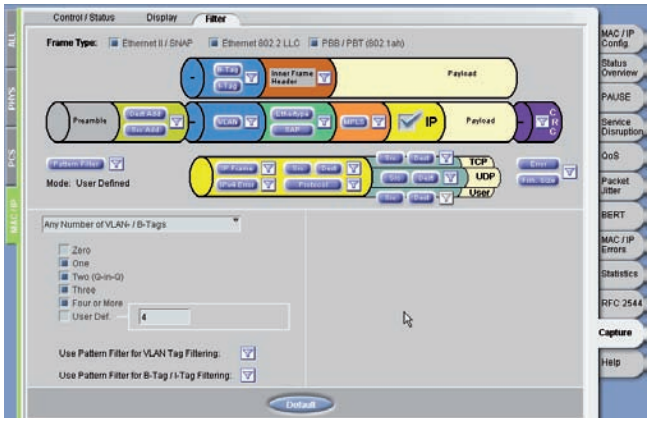
RFC 2544 addresses the need of Service Providers to perform the QoS measurements in Ethernet and IP networks. Vendors are forced to qualify the correct behavior of their Ethernet/IP equipment towards their customers.
The Module-E enables users to perform automated RFC 2544 testing. In detail it performs: 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*

Interfaces

See "Interface specification" page 5

Physical testing

See "Interface and unframed testing" page 8

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 20

PCS testing

See "PCS testing" page 10

Layer 2/3 Ethernet/IP testing

See "Layer 2/3 Ethernet/IP testing" page 11

Capture MAC/IP

See "Capture MAC/IP" page 15

10GigE via GFP and OTU2
(in preparation)

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*

Interfaces

See "Interface specification" page 5

Physical testing

See "Interface and unframed testing" page 8

OTU2 testing

See "OTU2 testing" page 26

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

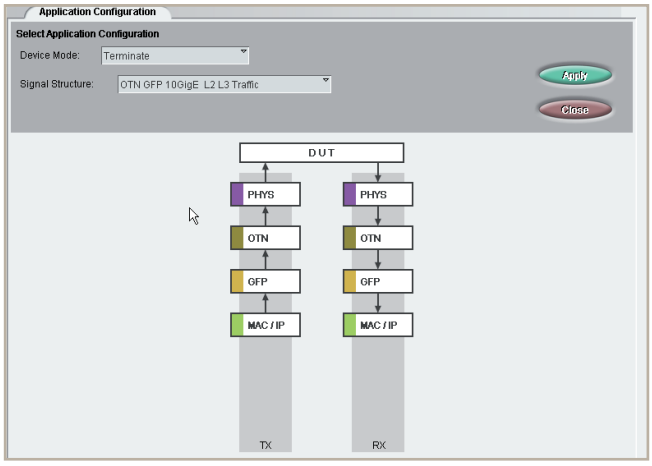
CID and Spare editable	00 to FF

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), Reverse defect indication (RDI), Forward defect indication (FDI)

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

Alarm insertion

Type	Loss of Frame delineation (LFD), Loss of client signal (LCS), Loss of client character synchronization (LCCS), Reverse defect indication (RDI), Forward defect indication (FDI)
CSF frame period	500 ms
Trigger	Continuous

GFP transmit statistics

Frame counts	Total frames, total data frames, Idle frames, total management frames
Evaluation	Count, rate, ratio
Bandwidth	Total GFP bandwidth
Utilization	Total GFP utilization

GFP Analysis

RX payload scrambler	enable/disable

Client data frame

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

Linear extension header filter

CID and spare user defined	00 to FF

Client management frame

Management type header settings	Null extension header or Extension header
PFI (client management frame)	Automatic evaluation
UPI (client management)	CSF-Loss of client signal (LCS),
	CSF-Loss of client character synchronization (LCCS),
	Reverse defect indication (RDI),
	Forward defect indication (FDI)

Linear extension header filter

CID and Spare user defined	00 to FF

Error detection

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

Alarm detection

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

GFP receive statistics

Frame counts	Total frames, total data frames,
	Idle frames, total management frames
	CSF-LCS frames, CSF-LCCS frames
Evaluation	Count, rate, ratio
Bandwidth	Total GFP bandwidth
Utilization	Total GFP utilization

Layer 2/3 Ethernet/IP testing

See "Layer 2/3 Ethernet/IP testing" page 11

Capture MAC/IP

See "Capture MAC/IP" page 15

Remark:
This structure is defined in ITU-T G.709 version 2003.

10GigE via GFP in VCAT

(in preparation)

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 5

Physical testing

See "Interface and unframed testing" page 8

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

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

All members can be distributed in all channels of the SONET/SDH 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	AU4 unequipped,
	AU3 unequipped, 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	Random, FAS, B1, B2, REI-L/MS-REI, B3, REI-P/HP-REI
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}
REI-L/MS-REI	1×10^{-3} to 1×10^{-10}
B3	1×10^{-3} / 4.2×10^{-4} to 1×10^{-10}
REI-P/HP-REI	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	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	Random, FAS, B1, B2, REI-L/MS-REI B3, REI-P/HP-REI
Alarm types	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 filled with a fixed pattern. All background channels have the same pattern.

Differential delay injection

Not covered in this plan

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:

PRBS 2^{31}-1, 2^{31}-1 inv.
or GFP-F with the Ethernet / IP Service

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

GFP testing

See "GFP testing" page 16

Layer 2/3 Ethernet/IP testing

See "Layer 2/3 Ethernet/IP testing" page 11

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 5

Physical testing

See "Interface and unframed testing" page 8

PCS testing

See "PCS testing" page 10

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 (in preparation)

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

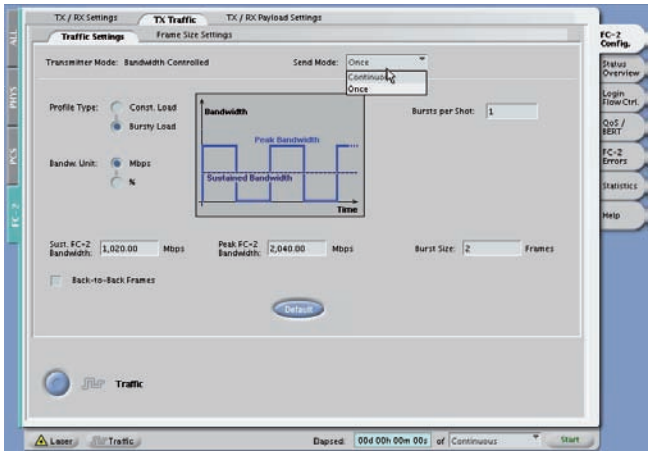
Type	Bit error
Trigger	Single, rate
Rate	10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8} 10^{-9}

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, may, 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 pulse 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

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

Interfaces

See “Interface specifications” page 5

Physical testing

See “Interface and unframed testing” page 8

SDH/SONET testing

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

Generation/evaluation of OC-192 signal according to ANSI T1.105

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 are 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	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

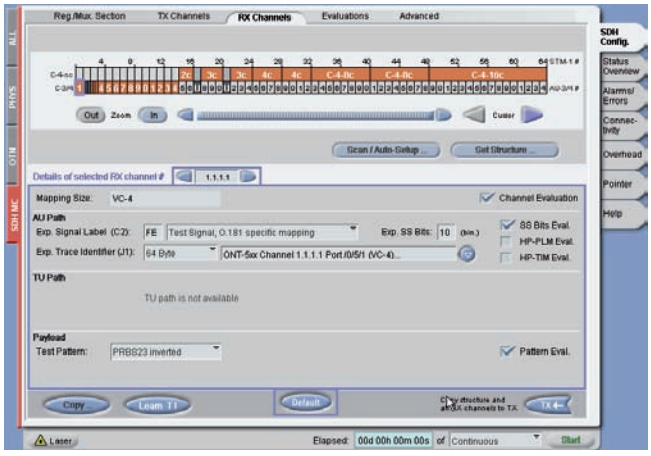
Storage depth of one byte or K1/K2 combination

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 pulse 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 5

Physical testing

See "Interface and unframed testing" page 8

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^{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.

Alarm and error messaging test

Alarm insertion

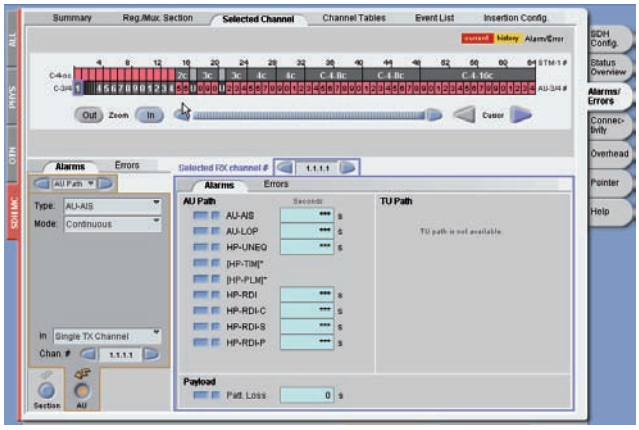
SONET	LOS, LOF, AIS-L, RDI-L, LOP-P, AIS-P, UNEQ-P, PLM-P, RDI-P
SDH	LOS, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, P-RDI, P-PLM, HP-RDI

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 2^{24} or 125 µs to 2097 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^{-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 .

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 (in preparation)

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/# 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):

SONET	
Alarms	LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P
Errors	B1, B2, REI-L, B3, 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 and in preparation).

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, in preparation), 10GVCAT High Order (optional, in preparation)
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 5

Physical testing

See “Interface and unframed testing” page 8

OTU2 testing

Modes

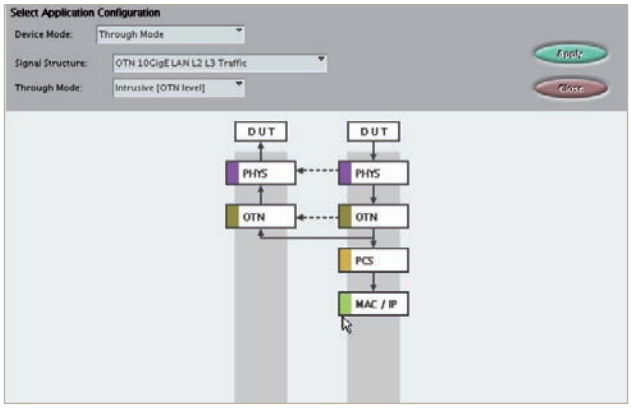
Multiple testing modes are available with OTN.

Terminate

Generator and analyzer are running at the same OTN rate.

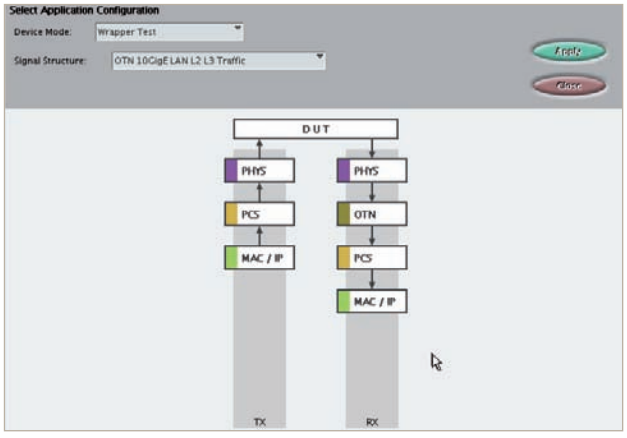
Intrusive through mode

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 or higher layer test pattern
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)

"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, in preparation)

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

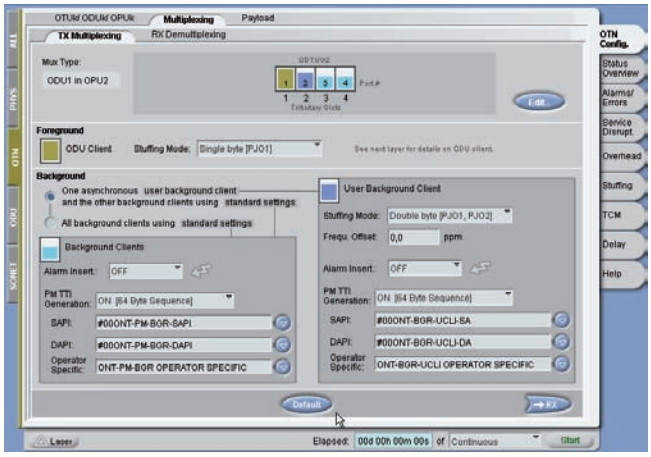
Foreground	Fully structured ODU1
With one of the following clients	Bulk client, SDH/SONET Single Channel client (optional) SDH/SONET Multi-Channel HO client (Optional, in preparation) SDH/SONET VCat client (optional, in preparation)
Bulk client	PRBS: 2^{31}-1, 2^{23}-1, 2^{15}-1, 2^{11}-1, 2^{7}, 2^{31}-1 inv., 2^{23}-1 inv., 2^{15}-1 inv., 2^{11}-1 inv., 2^{7}-1 inv.
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	Full structured ODU1
With one of the following clients	Bulk client, SDH/SONET Single Channel client (optional) SDH/SONET Multi-Channel HO client (Optional, in preparation) SDH/SONET VCat client (optional, in preparation)
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.
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

See “OTU2 testing” page 26

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
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 (for BN 3061/92.19)

Module-E Hardware/Software Packages

BN 3061/92.30	**Module-E 10GE LAN XFP slot** Optics via XFP slot
BN 3061/92.31	**Module-E 10GE LAN 1310 nm** Optics built-in 1310 nm
BN 3061/92.32	**Module-E 10GE LAN 850/1310 nm** Optics XFP 850 nm, built-in 1310 nm
BN 3061/92.33	**Module-E 10GE LAN 1310/1550 nm** Optics built-in 1310/1550 nm switchable
BN 3061/92.34	**Module-E 10GE LAN 850/1310/1550 nm** Optics XFP 850 nm, built-in 1310/1550 nm switchable

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 (in preparation)**
BN 3061/93.45	**10G GFP-F (in preparation)**
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
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
BN 3061/93.54	**OTN Multiplexing OTU2** Requires BN 3061/93.49 as base option, DH/SONET client is optional
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
BN 3061/93.75	**10G Transport Solution (in preparation)** 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 (in preparation)** Consists of 10GigE LAN BN 3061/93.47 10GigE VCAT High Order BN 3061/93.39 10.7G GFP-F BN 3061/93.45

Ordering Information

BN 3061/93.77	**10G Ethernet Solution (in preparation)** 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
BN 3061/90.86	**Jitter Module 10G-D 1310 nm (in preparation)** 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 options for service measurements Adds 1 slot
BN 3061/90.88	**Jitter Module 10G-D 1550 nm (in preparation)** 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 options for service measurements Adds 1 slot
BN 3061/93.70	**Jitter 10.3G (in preparation)** 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 (in preparation)** 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 10/10.3/10.7G (in preparation)** Software option TIE, MTIE, TDEV Requires BN 3061/90.86 or /90.80 Requires optional BN 3061/93.70 and /93.71
BN 3061/93.96	**Wander DS1/E1 + BITS (in preparation)** Software option DS1/E1 + BITS Requires BN 3061/93.95

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.

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.

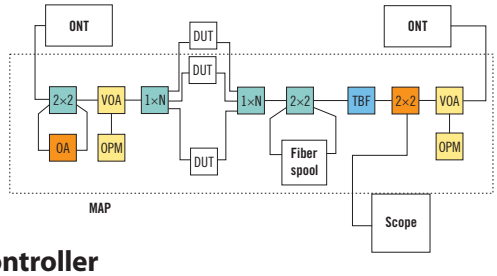
Transport protocol coverage includes SDH/SONET up to 40G, and Optical Transport Network (G.709) including overclocked rates.

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

NORTH AMERICA	LATIN AMERICA	ASIA PACIFIC	EMEA	
TEL: 866 228 3762	TEL: +1 954 688-5660	TEL: +852 2892 0990	TEL: +49 7121 86 2222	www.jdsu.com/ont
FAX: 301 353 9216	FAX: +1 954 3454668	FAX: +852 2892 0770	FAX: +49 7121 86 1222	