JDSU Optical Network Tester ONT

Module-E, Jitter Module Specifications

Module-E 10G

Module-E 10G/2.5G

Jitter Module 10G–E

Jitter Module 2.5G–D

Specifications

Interface Specifications

Optical Interfaces

For high rates, interface options exist for XFP pluggable or built-in fixed optics at 1310 and 1550 nm. Tunable XFP optics are supported. For low rates, the interface is SFP pluggable optics.

XFP or Built-in Optics

Supported high rates	9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 10.755, 11.049, 11.095, 11.181, 11.270, and 11.318 G

Built-in Optics Specifications

Output level	1310 nm : –6 to –1 dBm 1550 nm: –2 to +2 dBm
Receiver wavelength	1310 or 1550 nm 1260 to 1580 nm
Sensitivity	1310 nm : –11 to –1 dBm 1550 nm: –14 to –1 dBm
Max. input power (destructive)	+2 dBm
Connector types	Exchangeable adaptors
Tunable XFP wavelength	User selectable

SFP Optics

Supported low rates	155.52, 622.08 Mbps, 1.063, 1.25, 2.125, 2.488, and 2.666 G

For Jitter Module interface specifications please see 10/11 Jitter and Wander Testing and 155M/2.5G Jitter and Wander Testing sections.

Electrical Interfaces

Reference Clock Output

Output frequency	All rates f/16, f/64 switchable
Output level (AC coupled)	Single 400 mVpp differential 800 mVpp
Connector	Two SMAs/50 Ω

Unframed Testing

All available rates are offered with unframed pattern and BERT capabilities.

Mode

Terminate, non-intrusive Through mode

Bit rates

155.52, 622.08 Mbps, 1.063, 1.25, 2.125, 2.488, 2.666 G, 9.953, 10.000, 10.313, 10.519, 10.664, 10.709, 10.755, 11.049, 11.095, 11.181, 11.270, and 11.318 G

Test pattern

PRBS 2^{31}–1, 2^{23}–1, 2^{15}–1, 2^{11}–1, 2^{7}–1 and inverted, PRBS 2^{31}–1 IEEE, Digital Word 32 bits, Square Wave (Tx only); repeating 1s/0s editable 1 to 16 bits

Generator

Frequency offset generation	±500.0 ppm
Step size	0.1 ppm
Offset change mode	Step, Transition Ramp
Transition Ramp	5 ppm in 25 ms

Alarm Insertion

Type	LOS
Trigger	Continuous

Error Insertion

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

Analyzer

Optical Level measurement resolution	0.1 dBm

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

Frequency offset 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.

Alarms

Type	LOS, power overload, frequency range, no XFP/SFP available, pattern loss

Errors

Type	Bit errors (only applicable for unframed pattern), errored zero/one (only applicable for PRBS pattern)

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/last interval, count and ratio

Result Display of Errors and Alarms

Numerical Display

Errors	Count, ratio, duration (errored zeros/ones)
Alarms	Duration in seconds

Event List

Display of all results with time stamps

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time-axis scale	Second, minute, hour

Specifications *cont'd.*

OTN OTU2/OTU1 Testing

OTN Testing Modes

Terminate Mode

Generators and analyzers run at the same OTN rate.

Through Mode

Both intrusive and non-intrusive through mode are offered. The generator and analyzer run at the same OTN rate and the received traffic is terminated at the OTN layer and retransmitted with the transmitter. In non-intrusive through mode, all OTN layer information is unchanged, whereas for intrusive through mode, it can be selectively overwritten with the capabilities available in the OTN generator. The client signal is unchanged, retransmitted, and analyzed by the higher layer if support is available.

Wrapper/De-wrapper Test

Transmitter and receiver interfaces run at different rates. The Wrapper test is used to test the wrapper function for the device under test (DUT). The client signal is generated and the OTN signal with wrapped client is analyzed:

TX signal structure	*RX signal structure*
SONET/SDH	OTU2-ODU2-SONET/SDH OTU1-ODU1-SONET/SDH
PCS-MAC/IP	OTU2-ODU2-GFP-F-MAC/IP
PCS-MAC/IP	OTU2e-ODU2e-PCS-MAC/IP
PCS-FC2	OTU2e-ODU2e-PCS-FC2

The dewrapper test is used to test the de-wrapper function of a DUT. An OTN signal with wrapped client is generated and the dewrapped client signal is analyzed.

OTN Generator

Multiplexing mappings	ODU0, ODU1, ODU2, ODUflex
Mapping types	AMP, BMP, or GMP
Stuffing simulation	Independent at each layer
Timeslot base	1.25/2.5 G
Pattern	OTN bulk client, higher layer test pattern
OTN 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. (conforming to ITU-T O.150), and digital word 32-bit free programmable, null client
Scrambler	On/off
FEC generation	On/off

OTN Multiplexing Mappings

OTN multiplexing provides a technology to multiplex/demultiplex lower bit rate clients into/from a higher bit rate OTN signal according to ITU-T G.709. The multiplexing functionality depends on the available software options:

- Freely definable foreground channel with client generated by the subsequent ODU layer
- Null client background channels with PM-TTI generation and OCI, LCK, AIS generation
- One optional stuffing adjustable null client user background channel

Stuffing Simulation

AMP, GMP, and ODUflex-mapped payloads allow client offset stimulation. At each layer of multiplexing, the stuffing can be independently adjusted. The offset stuffing range depends on multiplexing type and stuffing scheme.

AMP Stuffing

Payload offset	–65.0ppm to +65.0ppm
Stuffing Schemes	+1/0/–1 or +2/0/–1

GMP Stuffing

Payload offset	-1.000×10^{6} ppm to 0.000ppm
Nominal Cm value of the GMP mapper	0.000 to 15232.000

ODUflex in OPU2 Stuffing

Nominal payload rate of the GMP mapper	656 bps to 9.99 G
Nominal Cm value of the GMP mapper	0.001 to 15232

Alarm Insertion

Type	OTU-AIS, OOF, LOM, OOM,SM-IAE, SM-TIM, LOF, SM-BDI, SM-BIAE,ODU-AIS, ODU-OCI, ODU-LCK, PM-TIM, PM-BDI, FTFL-FWSD, FTFL-FWSF, FTFL-BWSD, FTLFL-BWSF, TCMi-LTC, TCMi- IAE, TCMi-TIM, TCMi-BDI, TCMi-BIAE (i = 1 to 6), client signal fail
Mode	
Continuous	All alarms
Burst once/burst continuous	All alarms except LOF, TIMS, OOF, OOM, SD, SF
Burst alarms	M frames with alarm, N frames no alarm, M and N = 1 to 2^{31}

Error Insertion

Type	Random, FAS, MFAS, SM-BIP, SM-BEI, FEC uncorrectable, FEC correctable, FEC stress, FEC advanced, PM-BIP, PM- BEI, TCMi-BIP, TCMi-BEI (i = 1 to 6), CRC-5, CRC-8, bit error
Mode	single error, rate, single burst, continuous burst
Burst error	M frames errors, N frames error free, M and N = 1 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^{-2}	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
CRC-5	1×10^{-9}	1×10^{-2}	0.1
CRC-8	1×10^{-9}	1×10^{-2}	0.1

Error Insertion Configuration

BIP masks	Valid for SM BIP, PM BIP, TCMi BIP (i = 1 to 6)
GMP CRC masks	Valid for GMP-CRC-5, GMP-CRC-8
BEI value	Values from 0 to 15. Valid for SM BEI, PM BEI, TCMi BEI (i = 1 to 6)

FEC Insertion Configuration

FECstress	Inserts the maximum number of errors possible into the OTU frame that the DUT can correct by a walking pattern that affects all bits in less than 2 seconds.
FECadvanced	Custom define the position for error insertion in the OTU frame, enabling correction capability testing below and above the correction limit.
Selectable parameters	Row, sub row, errored bytes per sub row, start position in sub row, byte error mask

Overhead Generation

Byte Diagram	All bytes are statically programmable except MFAS, SM BIP, PM BIP, and TCM1...6 BIP
Message sequences	SM TTI, PM TTI, and TCM1...6 TTI: consisting of the SAPI (16 bytes), DAPI (16 bytes) and the operator specified (32 bytes)
TTI (SM/PM) Generation	64 byte sequence
TCM1..6 TTI Generation	64 byte sequence, 6 simultaneous channels

FTFL free definable forward/backward (FW/BW) fault indication, operator identifier (9 bytes) and operator specific field (118 bytes)

FTFL Generation	256 byte sequence
Payload structure identifier (PSI) with MSI	User defined, payload type identifier in clear text
PSI Generation	256 byte sequence
OH byte sequence	Freely defined single byte sequence of 16/32/64/128/256 frames

OTN Analyzer

Demultiplexing mappings	ODU0, ODU1, ODU2, ODUflex
De-mapping types	AMP, BMP, or GMP
Stuffing analysis	Independent at each layer
Timeslot base	1.25 G, 2.5 G
Analysis pattern	OTN bulk client, higher layer test pattern
OTN bulk client	See OTN Generator
Pattern evaluation	On/off
Descrambler	On/off
FEC evaluation	On/off
FEC correction	On/off

OTN Demultiplexing Mappings

Freely definable tributary timeslots

Payload type 20 (2.5 G time slots) and payload type 21 (1.25 G time slots)

AMP Stuffing

Receive offset	In ppm
Stuffing counts	Positive, double positive, negative, summary Counts and duration in sec

Specifications *cont'd.*

GMP Stuffing

Nominal payload rate	In bit/s
Effective payload rate	In bit/s
Payload offset	In ppm
Cm value	Nominal, effective, Cm min, Cm max
Stuffing counts	Positive, double positive, negative, double negative, unchanged, new value

Alarm Detection

Type	OTU-AIS, LOF, OOF, LOM, OOM, SM-IAE, SM-TIM, SM-BDI, SM-BIAE,ODU-AIS, ODU-OCI, ODU-LCK, PM-TIM, PM-BDI, FTFL-FWSD, FTFL-FWSF, FTFL-BWSD, FTLFL-BWSF, TCMi-AIS, TCMi-OCI, TCMi-LCK, TCMi-LTC, TCMi- IAE, TCMi-TIM, TCMi-BDI, TCMi-BIAE (i = 1 to 6), payload type Mismatch, client signal fail, GMP loss of sync, GMP Cm =0, pattern loss, delay pattern loss

Error Detection

Type	FAS, MFAS, SM-BIP, SM-BEI, FEC Uncorrectable word, FEC correctable word, FEC correctable symbol, FEC correctable bit, PM-BIP, PM- BEI, TCMi-BIP, TCMi-BEI (i = 1 to 6), GMP CRC-5, GMP CRC-8, Bit error with configurable intermediate interval duration

Intermediate Bit error

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

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

Error Detection Measurement

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

Resolution	100 ms

Overhead Evaluation

Byte diagram display of the complete overhead

Message sequences SM TTI, PM TTI, TCM1..6 TTI display of the 64 byte ASCII sequence of SAPI, DAPI, and Operator field

TIM evaluation on/off; evaluation on can be SAPI or DAPI or SAPI+DAPI

Set SAPI and DAPI expectation values in traces SM TTI, PM TTI, TCM1…6 TTI

TCM1..6 evaluation on/off; simultaneous evaluation of all 6 TCM channels

FTFL forward/backward (FW/BW) fault indication, operator identifier and operator-specific fields

Display payload structure identifier (PSI) bytes, payload type identifier (PT) clear text and multiplex structure identifier (MSI) bytes clear text

PT expectation value editable as mismatch criterion

Capture and display selectable single byte sequence of up to 256 frames

Result Display of Alarms and Errors

Numerical Display

Errors	Count, ratio, duration (errored zeros/ones)
Alarms	Duration in seconds

Event List

Display of all results with time stamps

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

General Communication Channel (GCC) Capture

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. The capture file is stored locally and can be exported.

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

Performance Analysis

ITU-T G.8201 and M.2401 performance analysis and G.798 signal quality supervision (SQS) are optionally performed.

G.8201/M.2401 Performance Analysis Results Display

Path and Tandem Connection Monitoring Analysis

Near-end performance results	EFS, ES, SES, UAS, BBE, EB
Far-end performance results	EFS, ES, SES, UAS, BBE, EB, Path UAS (G.8201 only)

A pass/rejected verdict is given for each analysis.

Results are displayed in seconds and ratio.

G.8201 Configuration

HRP allocation	0.10000 to 100.00000%
UAS limit	0 to 100,000 secs
UAS mode	
Individual/global	
SESR APO, BBER APO	Displayed

M.2401 Configuration

HRP allocation	0.10000 to 100.00000%
APO multiplier	0.10000 to 10.00000%
UAS limit	0 to 100,000 secs
SESR APO, BBER APO	Displayed
SES BISPO, BBE BISPO	Displayed

G.798 Signal Quality Supervision Results Display

Section, Path, and Tandem Connection Monitoring Analysis

Near-end analysis [SM/PM/TCMi-BIP]	Good seconds, bad seconds, degraded seconds, alarm seconds, dDEG count
Far-end analysis [SM/PM/TCMi-BIP]	Good seconds, bad seconds, degraded seconds, alarm seconds, dDEG count

SQS configuration

DEG threshold	Absolute/relative
Absolute range	1 to 82,026
DEGM threshold	2 to 10

Service Disruption Test

To analyze service disruption times, a high-speed event list as a result of all detected events is generated. Disruption events at all layers of the OTN hierarchy are monitored simultaneously.

Result Display of Disruptions

Numerical Display

Total number of disruptions, begins with timestamp of first disruption and ends with a timestamp of last disruption.

Statistics

Shortest disruption time (with timestamp) in msec

Longest disruption time (with timestamp) in msec

Average disruption time in msec

Event List

Display of all results with time stamps and duration

Logging modes	No logging, disruption events only, distribution, and sensor Events
Viewing filters	Events, durations

Sensor to Trigger Service Disruption test, Selectable

Alarms	LOS, OTU-IAS, LOF, OOF, LOM, OOM, SM-IAE, SM-BDI, SM-BIAE, ODU-AIS, ODU-OCI, ODU-LCK, PM-BDI
Errors	FAS, MFAS, SM-BEI, SM-BIP, PM-BIP, PM-BEI, bit error/pattern loss
Event sample resolution	100 µs 0.1 to 100,000 ms

Disruption Measurement Configuration

Separation time	0.1 to 100,000.0 ms
Threshold time	0.0 to 100,000.0 ms

Separation time starts at the end of 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 one (event occurs after separation time has elapsed).

Transfer Delay Measurement

A proprietary payload pattern with measurement range of 0s to 40s is used. Transfer delay is measured between ports within the same mainframe.

Numerical Display

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

Specifications *cont'd.*

OTN-ODU MultiChannel

The OTN-ODU MultiChannel optional capability enables the parallel generation and analysis of multiple ODU tributaries. The following tests for an in-depth ODU analysis can be performed:

- Stuffing analysis
- Alarm and error test
- Overhead analysis
- TCM analysis
- Service-disruption analysis

OTN layer functionality is as described in OTU2/OTU1 Testing. The ODU layer MultiChannel capabilities and differences with the single channel OTN application are described below:

Tributary Channel Configuration

Signal structure	Tributary channels can be freely assigned as ODU0, ODU1, ODU1mux with ODU0, and ODUflex
LO ODTUG	Payload type 20 or 21
Tributary allocation	Channels can be freely assigned to tributary slots
ODTU mapping	AMP, GMP
Payload mapping	BMP, GMP
Payload test pattern	PRBS: $2^{31}-1$, $2^{23}-1$, $2^{31}-1$ inv., $2^{23}-1$ inv.

ODU MultiChannel Stuffing Simulation

AMP, GMP and ODUflex mapped payloads allow client offset simulation. At each layer of multiplexing the stuffing can be independently adjusted. The offset stuffing range is dependent on multiplexing type and stuffing scheme.

AMP Stuffing

ODTU offset	−48.0 ppm to +83.0 ppm
Payload offset	−65.0 ppm to +65.0 ppm
Stuffing Schemes	+1/0/−1 or +2/0/−1

GMP Stuffing

ODTU offset	-1.000×10^6 ppm to 4219.410 ppm
Payload offset	-1.000×10^6 ppm to 0.000 ppm
Nominal Cm value of the GMP mapper	0.000 to 15232.000

ODUflex in OPU2 Stuffing

Payload mapping	BMP

ODU MultiChannel Alarm and Error Insertion

Alarms and errors can be configured for insertion on select channels, multiple channels simultaneously, or multiple insertion types triggered concurrently.

Error name	*Min rate*	*Max rate*	*Stepping*
FAS	4.9×10^{-12}	1×10^{-3}	0.1
MFAS	3.0×10^{-11}	1×10^{-3}	0.1
PM BIP	1×10^{-12}	6.5×10^{-5}	0.1
PM BEI	1×10^{-12}	6.5×10^{-5}	0.1
TCMi BIP	1×10^{-12}	6.5×10^{-5}	0.1
TCMi BEI	1×10^{-12}	6.5×10^{-5}	0.1

ODU Error Insertion Configuration

BIP masks	Valid for PM BIP, TCMi BIP (i = 1 to 6)
BEI value	Values from 0 to 15. Valid for PM BEI, TCMi BEI (i = 1 to 6)

ODU MultiChannel Overhead Generation

All defined channels have the following capability:

Byte diagram	All bytes are statically programmable except MFAS, PM BIP, and TCM1...6 BIP
Message sequences	PM TTI, and TCM1...6 TTI: consisting of the SAPI (16 bytes), DAPI (16 bytes) and the operator specified (32 bytes)
PM TTI generation	Auto or User 64 byte sequence
TCM1..6 TTI generation	Auto or User 64 byte sequence, 6 simultaneous channels

FTFL free definable forward/backward (FW/BW) fault indication, operator identifier (9 bytes) and operator-specific field (118 bytes)

FTFL generation	256 byte sequence
Payload structure identifier (PSI) with MSI	User defined, payload type identifier in clear text
PSI Generation	256 byte sequence

ODU MultiChannel Evaluation Configuration

Channels	Enable/disable evaluated channels
Payloads	Enable/disable evaluated payloads

ODU MultiChannel Stuffing Analysis

AMP Stuffing

Receive offset	In ppm
Stuffing counts	Positive, double positive, negative, summary Counts and duration in sec

GMP Stuffing

Nominal payload rate	In bit/s
Effective payload rate	In bit/s
Payload offset	In ppm
Cm value	Nominal, effective, Cm min, Cm max

ODU Multichannel Result Display of Alarms and Errors

Numerical Display

Duration in seconds is displayed for each alarm.

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

Event List

Display of all results with time stamps

Criteria	Start, stop, duration, count
Viewing filters	Events, channels, durations, count

Tabular View

Display of all alarm durations and error counts across all channels.

ODU MultiChannel Alarm and Error Detection

Alarms and errors are simultaneously monitored across all channels.

ODU MultiChannel Overhead Evaluation

Byte diagram display of the complete overhead per channel

Message sequences per channel; PM TTI, TCM1..6 TTI display of the 64 byte ASCII sequence of SAPI, DAPI, and Operator field

TIM evaluation on/off; Evaluation On can be SAPI or DAPI or SAPI+DAPI

Set SAPI and DAPI expectation values in traces SM TTI, PM TTI, TCM1…6 TTI

TCM1..6 evaluation on/off; simultaneous evaluation of all TCM channels. TCM Channels are assigned one per tributary channel

FTFL forward/backward (FW/BW) fault indication, operator identifier and operator-specific fields

Display payload structure identifier (PSI) bytes, payload type identifier (PT) clear text and multiplex structure identifier (MSI) bytes clear text

PT expectation value editable as mismatch criterion

ODU MultiChannel Service Disruption Test

Disruption events on all channels of the ODU hierarchy are monitored simultaneously. Channels can be selectively enabled or disabled for Service disruption evaluation.

ODU MultiChannel Result Display of Disruptions

Summary Numerical Display

Total disruptions (timestamps for begins of first disruption, end of last disruption), channel with max disruptions, and count of max disruptions, total channels with disruption, total channels above threshold, total channels evaluated

Statistics

Shortest disruption time (with timestamp) in msec, and related channel

Longest disruption time (with timestamp) in msec, and related channel

Average disruption time in msec

Per Channel Numerical Display

Total disruptions (timestamps for begins of first disruption, end f last disruption

Statistics

Shortest disruption time (with timestamp) in msec, and related channel

Longest disruption time (with timestamp) in msec, and related channel

Average disruption time in msec

Event List

Display of all results with Channel, timestamps, and duration

Logging modes	No logging, disruption events Only, sensor events only, Disruption and sensor events
Viewing filters	Events, channels, durations

Tabular View

Display of all disruptions across all channels.

Statistics count, shorted, longest, average, total duration, threshold

Sensor to Trigger Service Disruption test, Selectable

Alarms	LOS, LOF, OOF, LOM, OOM, ODU-AIS, ODU-OCI, ODU-LCK, PM-BDI FAS, MFAS, PM-BIP, PM-BEI, Bit error/pattern loss
Errors	
Event sample resolution	100 µs 0.1 to 100,000 ms

GFP Testing

GFP-F – Generic Frame Procedure (Framed) Application

The GFP functionality provides Ethernet MAC encapsulation and mapping/de-mapping of GFP to SDH/SONET Virtual Concatenation or ODU0, ODUflex, or OTU2.

Specifications *cont'd.*

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

Generator

Tx payload scrambler	On/off
Data frame	
PFI	Payload FCS on/off
EXI	No extension header, linear extension header
UPI	User-editable with clear text decode as per G.7041

Data Frame Linear Extension Header

CID	00 to FF
Spare	00 to FF
Management frame	
PFI	Payload FCS on/off
EXI	No extension header, linear extension header

Management Frame Linear Extension Header

CID	00 to FF
Spare	00 to FF

Alarm Insertion

Type	LFD, CSF-LCS, CSF-LCCS, FDI, RDI continuous
Trigger	1 frame every 100 to 1,000 ms
Management frame rate	On/off
Terminate with DCI	

Error Insertion

Type

Core header	Single, multiple
Type header	Single, multiple
Extension header	Single, multiple
Payload FCS	Single
Trigger	Single, rate
Rate	1.0E-9 to 0.1E0

Transmit Statistics

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

Analyzer

Rx payload scrambler	On/off

Data Frame

EXI	No extension header, linear Extension header
UPI reference	User editable
Data frame linear extension header filter	
CID filter	On/off
Spare filter	On/off
CID	00 to FF
Spare	00 to FF

Client Frame

EXI	No extension header, linear extension header

Client Frame Linear Extension Header Filter

CID filter	On/off
Spare filter	On/off
CID	00 to FF
Spare	00 to FF

Alarm Detection

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

Error Detection

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

Receive Statistics All Frames

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

Receive Statistics Filtered Frames

Frame type	Total frames, total data frames, Total management frames, CSF-LCS frames, CSF-LCCS frames, Client DCI frames, client fdi frames, client RDI frames
Evaluation	Count, rate

Result Display of Alarms and Errors

Numerical Display

Duration in seconds is displayed for each alarm

Count and ratio is displayed for each error

Event List

Display of all results with time stamps

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

GFP-T – Generic Frame Procedure Transparent

The GFP-T functionality provides timing transparent transcoding (TTT) of Gigabit Ethernet into OPU0 according to ITU-T G.709/Y.1331.
The functionality encompasses:

- Generation and analysis of superblocks
- Transparent Gigabit Ethernet mapping
- Error and alarm processing

The functionality is as described in GFP-F with additional specifications below.

Generator

Superblocks per frame	1 to 10
Error insertion	
Type	Correctable CRC, uncorrectable CRC
Trigger	Single error, rate
Rate	1.0E-9 to 0.1E0

Transmit Superblock Statistics

Total superblocks	Count, rate

Analyzer

Error Detection

Type	CRC-16 correctable, CRC-16 uncorrectable, 10B_ERR
Evaluation	Count, ratio

Receive Superblock Statistics

Type	Total superblocks, 65B_PAD codes, 10B_ERR codes
Evaluation	Count, rate

10GigE LAN Testing

PCS 64B/66B Testing

PCS Configuration

Pattern	PCS pattern or client signal from higher layer application
PCS pattern	A-seed, B-seed
Scrambler	On/off
Descrambler	On/off
Disable Hi BER detection	On/off
TX Ignore link faults	On/off
Minimum inter-packet gap control	8 to 127 bytes (only available for higher layer testing)
Minimum inter-packet gap threshold	5 to 255 bytes
Testing modes	Terminate, through

Terminate Mode

Generators and analyzers run at the same PCS rate.

Through Mode

Non-intrusive through mode is offered. The generator and analyzer run at the same PCS rate and the received traffic is terminated at the PHYS layer and retransmitted with the transmitter. In non-intrusive through mode all PCS layer information is unchanged. The client signal is unchanged, retransmitted, and analyzed by the higher layer if support is available.

PCS Generator

Simultaneous alarms and error alarm insertion is supported

Alarm Insertion

Type	LOBL (loss of block lock), high BER (high bit error rate), LF/RF (local and remote fault)
Mode	Continuous, single burst, continuous burst
Burst alarms	M = on, N = off
LOBL N, M	1 to 4,294,967,295 blocks
HI BER N, M	1 to 219,902 x 125 µs
LF/RF N, M	2 to 4,294,967,294 events

Error Insertion

Specifications *cont'd.*

Type	Invalid sync header, invalid block type, user control block, line errored frame, payload block error (only available if PCS pattern) invalid sync header, invalid block
User defined inserted values	type, user control block
Trigger (all errors)	Single error, rate
Trigger (except payload block error)	Continuous, single burst, continuous burst, single burst rate, continuous burst rate
Rate alarms	1 x 10^{-10} to 9.9 × 10^{-3}
Burst alarms	M = on, N = off
N, M	1 up to 4,294,967,295 events

PCS Analyzer

Alarm Detection

Type	LOBL, high BER , LF/RF, link down (only available for higher layer testing), IPG violation (only available for higher layer testing), pattern loss (only available if PCS pattern)
Evaluation	Duration in seconds

Error Detection

Type	Invalid sync header, errored block, invalid block, invalid block type, LOBL event, high BER event, error propagation, line error frame, LF/RF fault event, IPG violation event (if higher layer traffic), payload block error (only available for PCS pattern)
Evaluation (depends on type)	Count, rate, ratio, seconds

Result Display of Alarms and Errors

Numerical Display

Duration in seconds is displayed for each alarm
Count, rate, ratio and duration in seconds are displayed depending on error type

Event List

Display of all results with time stamps

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

PCS Statistics

Link

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

Tx/Rx total link bandwidth	Rate in Kbps, Mbps
Tx/Rx link utilization	ratio in %

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, rate, ratio

Reconciliation

Transmit Ordered Sets	Total, LF, RF
Receive Ordered sets	Total, LF, RF
Evaluation	Count, rate

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, which can be combined, are provided to control the kind of blocks captured. The captured data can be exported to a CSV format file.

Captured data	Index, Relative time, block type, error type, Sync header, 66B Block payload bytes
Number of captured blocks	≤ 4,096
Time stamp resolution	6.4 ns at 10.315 G
Filter types	Block errors, block types
Block error filters	Errored blocks, invalid blocks, blocks with invalid block type, blocks with invalid sync header
Data block filter	All, none
Control block filter	All, none, Selected (16 different control blocks)

MAC/IP Testing

MAC/IP Testing includes the ability to generate/analyze up to 256 independent traffic flows, and apply up to 16 unique traffic profiles to those flows. Flows and traffic parameters can be modified on the fly.

MAC/IP Configuration

Port Settings

MAC port address	Factory default, user defined
Max Accepted frame size	128 to 65,500 bytes
Start of frame detection	Byte count mode, SFG Detect mode
MAC Speed TX/RX	10.0 G, 10.0 G stretched
Bandwidth Calculation	
MAC bandwidth Calculation	Without Preamble, without Min IPG; With Preamble, without Min IPG, With Preamble, with Min IPG

Generator

MAC Frame Generation

Structure types	Standard frame, VPLS (EoMPLS), PBB/PBT

Standard frame

Frame type	IEEE 802.3, Ethernet II, IEEE 802.2 LLC, SNAP
Frame structure	VLAN/Q-in-Q, MPLS

VPLS (EoMPLS) frame

Outer frame type	Ethernet II, SNAP
Inner frame type	IEEE 802.3, Ethernet II, IEEE 802.2 LLC, SNAP
Inner frame structure	VLAN/Q-in-Q

PBB/PBT frame

Outer frame type	PBB/PBT
Inner frame type	IEEE 802.3, Ethernet II, IEEE 802.2 LLC, SNAP
Inner frame structure	VLAN/Q-in-Q, MPLS

VLAN/Q-in-Q Settings

Tags	Multiple up to 10
Editable parameters	TPI, priority, CFI/DEI, VID, Ethertype

MPLS Settings

Type	Available for Ethernet II and SNAP frames
Labels	Multiple up to 10
Editable parameters	Label, CoS, TTL, Ethertype (unicast/multicast)
MAC address settings	
Source address	User defined, factory default, type (port, any, unicast)
Destination address	User defined, type (unicast/multicast, broadcast)

VPLS (EoMPLS) Settings

Inner frame structure

As per Standard frame including up to 6 VLAN Tags

Outer frame structure

Tunnel label	Label, CoS, TTL
Control word	Reserved Bits, sequence number label, CoS, TTL
VC-label Parameters	Ethertype, MAC addresses, Frame type

PBB/PBT Settings

Inner Frame Structure

As per standard frame including up to 5 VLAN tags and MPLS labels

Outer Frame Structure

B-Tag (up to 2 tags)	TPI, VID, priority, DEI
I-Tag	TPI, SID, priority, DEI, NCA, Res1, Res2
Parameter	MAC addresses
IPv4/IPv6/UDP/TCP settings	

Supported for All Standard Frame Types

IP types	IPv4, IPv6
IPv4 basic settings	Destination address, default gateway, subnet mask
IPv4 header	ToS, DSCP, ECN, identification, flags, protocol, TTL, IP source and destination address
IPv6 header	Traffic class, flow label, next header, hop limit, IP source and destination address
UDP, TCP header	Source and destination ports

IPv4 Configuration Services

To test more than just a IPv4 point-to-point connection increases the complexity of the flow setup. Two protocols assist in simplifying resolving the IPv4 destination address; ARP, and DHCP including ARP may be enabled.

Retries	0 to 100
Timeout	100 to 60,000 ms

Payload of MAC or IP Frames

The payload can be configured as a Test frame or a BERT pattern

Test frame	Time stamp, sequence number with filling pattern

Specifications *cont'd.*

Test frame filling pattern	Digital byte, PRBS 2^{31}–1
BERT pattern	PRBS 2^{31}–1, 2^{23}–1 and inverted, all 1s, all 0s, digital word 32 bits

TX Traffic Generator

Transmitter mode	Bandwidth controlled, gap controlled
Send mode	Once, continuous
Continuous	Ongoing traffic as defined
Once	triggers generation of programmed number of frames/bursts per flow as per traffic profiles, all flows are started synchronously

Bandwidth Controlled Traffic

Flow Bandwidth Modes

Absolute	Speed of all flows is cut proportionally, if sustained bandwidth exceeds 100%.
Scaled	All flows are transmitted with their relative proportion as per traffic profile and can be adapted from 0 to 100% utilization.
Limited	Same as scaled except with an upper limit that does not exceed traffic profile.

Traffic Profiles for Bandwidth Controlled Traffic

Profile type	Constant load , bursty load
Back-to-back frames (enables max. bandwidth by forcing the traffic to min IPG)	On/off

Constant Load

Bandwidth	Adjustable utilization in Mbps and %
Utilization accuracy	0.1%
Frames/bursts per shot	1 to 16,777,215

Bursty Load

Sustained, peak MAC bandwidth	Adjustable utilization in Mbps and %
Frames/bursts per shot	1 to 65,535
Burst size	1 to 16,777,215
Utilization accuracy	0.1%

Frame Size Settings

Mode	Fixed, increment/decrement, random
Fixed	64 to 64k bytes
Increment/decrement	Min, max, step
Random	Min, max

Gap Controlled Traffic

IPG mode	Fixed, increment/decrement, random
Fixed IPG	8 to16,777,215 bytes
Increment/decrement IPG	Min, max, step
IPG step size	1 to 156 bytes
Random IPG	Min, max

Traffic Profiles for Gap Controlled Traffic

Frame Size Settings

Mode	Fixed, increment/decrement, random
Fixed	64 to 64k bytes
Increment/decrement	Min, max, step
Random	Min, max

PAUSE Flow Control

Mode	Generation, emulation
Flow control emulation	On/off
Pause generator	Off, once, continuous
Once	1 to 65,535 frames
Continuous quanta	2 to 820,312,500
Continuous time	102.4 to 42.0E9 ns
PAUSE frame settings	Destination address, source address, Ethertype, opcode, PAUSE quanta

Service Disruption Measurements per Flow

Graphical and tabular results 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.

Configuration

Threshold time	100 to 100,000 ms
Impairment separation	2 to 65,535 frames

Summary Statistics

Total flows evaluated, total flows with disruption, total flows above threshold time, total disruptions, max count of disruptions

Port disruption results

Disruption result type	Longest

Flow disruption results

Disruption result type	Shortest, longest, Last
Parameters	Duration, size, type, flow
Size	1 to 232 frames
Type	Lost, duplication, out of order, misinsertion, time-out, link alarm

Disruption Counters

Results	Disruptions, exceeding threshold
Evaluation	Count, rate, seconds

QoS Measurements per Flow

Graphical and tabular results for all active flows with current and historical results. results of particular flows are selectable .

QoS alarms	LPAC (loss of performance assessment capability), NFTF (no flow test frame)
QoS errors	Lost, duplicated, misinserted, out of order
Error evaluation (type dependent)	Count, rate, ratio, seconds
IP throughput	IP bandwidth, MAC utilization in bps and %
IP evaluation	Current, average
Frame statistics	Frame count, frame rate, Analyzed frame count, analyzed frame rate
Transfer delay	Min, max, average, variation
Transfer delay resolution	1 ns
QoS error insertion	Lost, duplicated, misinserted, out of order

Packet Jitter Analysis per Flow

Packet jitter is usually caused by queuing and routing across or buffering in a switched transport network. The final effect of high packet *jitter* is the number of rejected packets. All three types of jitter are analyzed simultaneously and per flow.

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

Instantaneous jitter	Current, peak, average, minimum in ns, hits in count values
Hit threshold editable	0.10 to 42.00E6 us
RFC 3550 jitter	Current, peak, average in ns
Absolute jitter	Current, peak Early, peak Late in ns
Jitter measurement resolution	10 ns

BERT per Flow

Graphical and tabular results for all active flows with current and history results. Results of particular flows are selectable.

Alarms	LPAC, pattern loss, pattern Sync Loss
Errors	Bit errors
Evaluation	Count, rate, ratio, seconds

MAC/IP Error Insertion (Any Flows and Selected Flow)

MAC error type	Runt, oversized, FCS, jabber
IP error type	Header error
Oversized frame	1,519 to 65,500 bytes
Triggering	Single, rate, continuous, single burst, continuous burst, single burst rate, continuous burst rate
Rate	1.0E-9 to 9.9E-3
Burst	M active, N inactive errored frames M, N = 1 to 16,777,215 frames

Generator Statistics

Total bandwidth	Current/average in bps and %
Total bytes	Count
Total frames	Count and rate
PAUSE frames	Count, rate, ratio
MAC bandwidth per flow	Current/average in bps and %, Current/average share
IP bandwidth per flow	Current/average in bps
Bytes per flow	Count
Frames per flow	Count, rate, ratio

Analyzer Total Link Analysis

Error counts

MAC errors	Runt, oversized, FCS, jabber, errored
IP errors	Header error
Evaluation	Count, rate, ratio, seconds
MAC counters	
Bytes	Total
Frames	Total, errored, good, broadcast, multicast, PAUSE, PBB/PBT: total, single, double, triple, four or more VLAN: total, single, double, triple, four or more MPLS/VPLS: total, single, double, triple, four or more, total labeled total flow, total non-flow
Evaluation (type dependent)	Count, rate, %
PAUSE quanta	Last, min, max
PAUSE frames	Count, rate, ratio
IP counters	

Specifications *cont'd.*

IPv4 frames	Total, total valid, optional Header, fragments
ICMPv4 messages	Total, error
IPv6 frames	Total, extension reader
ICMPv6 messages	Total, error
UDP/TCP frames	Total
Evaluation	Count, rate, %
Bandwidth results	
Total bandwidth and utilization	
MAC bandwidth types	Port, MPLS/VPLS labeled
IP bandwidth types	IPv4/IPv6
Bandwidth results	Current, average bps
Utilization results	Ratio in %
Frame size results	
Results	Min, max, average
Frame size distribution	Count, rate, ratio
Distribution classes	64, 65 to 127, 128 to 255, 256 to 511, 512 to 1023, 1024 to 2,000, >2,000, 1024 to 1518+VLAN, >1518+VLAN

Analysis per Flow

MAC/IP Flow Filtering

The flow filter defines the parameters particular flows have to fulfill to pass the filter and to be analyzed in detail. Besides definable values, don't cares are also offered.

Frame structure	VLAN/Q-in-Q, MPLSs
Frame type	Ethernet II, 802.3, 802.2 LLC, SNAP
Ethertype	Editable value
MAC addresses	Editable source and destination
VLANs	Priority, VID, TPI, CFI/DEI
MPLSs	Label, CoS, TTL
IPv4 header	ToS, DSCP, ECN, protocol, source and destination address, Number of address mask bits
IPv6 header	traffic class, flow label, next header, source and destination address, number of address
TCP/UDP	Mask bits Source and destination port
Payload type	Test frame, BERT pattern, live traffic

Evaluation of the Traffic Flows

Filter bandwidth	
Total frames	Filtered In, not filtered In
Total frames results	Count, rate in fps, %
Bandwidth	Current and average for filtered In, not filtered In
Bandwidth results	Rate in bps, utilization (link), share (flows)

Flow Bandwidth

Bandwidth of each single filtered flows	
Bandwidth types	MAC, IP, payload
Bandwidth measurements	Current, average
Bandwidth results	Rate in bps, utilization %, share %

Flow Frame Counts

Types	Bytes, frames
Evaluation	Count, rate, ratio

SyncE G.8264 ESMC Testing

Synchronous Ethernet (SyncE) equipment requires clock-quality reporting capabilities, and as specified in recommendation ITU-T G.8264 the Ethernet synchronization messaging channel (ESMC) provides these reporting capabilities by means of the synchronization status message (SSM) protocol.

SSM Generator

All static settings of the transmitted SSM frames are displayed. The source address used for the SSM frame is equal to the MAC port address.

SSM insertion	On/off
Send mode	Single frame, continuous
Message rate	0.1 to 20.0 fps
QL mode	Static, alternating
QL code	0 to 15
QL duration	1.0 to 3,600.0 s
SSM asynchronous event	On/off

SSM Analyzer

SSM timeout threshold	1 to 60 s
Sliding window size	1 to 10 s
SSM status display	SSM timeout, SSM rate, last QL code
SSM statistics	Average/peak rate, min/max inter-frame gap

SSM Delay Measurement

Switching delays of synchronous Ethernet equipment can be measured by triggering a change of the reported clock quality of an incoming link and simultaneously monitoring the change of reported clock quality of an outgoing link. Through a flexible trigger mechanism, a delay measurement is started when a user-defined TX trigger match is detected and stopped when the corresponding RX trigger match is detected.

Delay measurement	On/off
TX/RX trigger conditions	Any QL change, Rising QL, falling QL, change to QL
Delay measurement	in ms

Results Display of SSM Events

Event List

Display of all results with time stamps

Criteria	Start, end, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

RFC 2544 Conformance Testing

Automated and advanced RFC 2544 conformance testing is provided. Throughput, frame loss, latency and back to back tests can be setup as per RFC and also fully customized to user needs. Packet jitter testing can also be added to the RFC 2544 standard tests.

RFC 2544 Configuration

Test type	*Configurable parameters:*
Throughput	Trial duration, initial bandwidth, search mode, repetition, accuracy
Frame loss rate	Trial duration, max bandwidth, step size
Latency	Trial duration, repetition, bandwidth
Back to Back	Max duration, repetition, search mode, accuracy
Packet jitter	Trial duration, repetition, bandwidth, jitter mode

Frame settings

Numbers of frame sizes	1 up to 10
Frame size	64 to 10,000 bytes
Frame structure	Selectable from defined flows

RFC 2544 Results

Results are updated as the test runs

Measurement status	MAC frame size, remaining time
Results display	Table, graph, bar graph
Test report	Exportable

Capture MAC/IP

This software option enables capturing Ethernet traffic with/without IP payloads. Frames are captured with selectable buffer size, optionally truncated and with or without preamble data. A powerful user configurable General Purpose filter can be used to capture select data of interest. Captured data is displayed as both a decoded frame and in raw Hex. The result can be saved in a *.cap format compatible with the open source Wireshark packet analysis tool.

Capture Configuration

Buffer size	1, 4, 16, 64, 256 Mbyte
Truncate frames	64 to 65,535 bytes
Capture with preamble	On/off
Capture mode	Direct or filter
Direct mode	All Rx captured
Filter mode flow based	Enabled flows or disabled and Unknown flows captured
Filter mode general purpose	Flows with user-editable parameters are captured
General purpose filter editable parameters	frame type, destination and source address, VLAN Tags, B-tags, I-tags, Ethertype, SAP, MPLS labels, IP frame type, IPv4 error, IP destination and source address, IP protocol, TCP/UDP destination and source address, MAC frame error, MAC frame Size, user-pattern filter Decoded frame, raw bytes

Capture Display

Viewing format	Decoded Frame, Raw Bytes

GigE LAN Testing

PCS 8B/10B Testing

PCS Configuration

Auto-negotiation	On/off
Auto-negotiation start	Automatic/manual
Advertised capabilities	Flow control, remote fault encoding
Flow control	
Remote fault encoding	None, asymmetric, symmetric, both no error, offline, link failure, auto-negotiation error

Specifications *cont'd.*

Minimum inter-packet gap control	6 to 24 bytes
Minimum inter-packet gap threshold	5 to 255 bytes
Testing modes	Terminate, through

Terminate Mode

Generators and analyzers run at the same PCS rate.

Through Mode

Non-intrusive through mode is offered. The generator and analyzer run at the same PCS rate and the received traffic is terminated at the PHYS layer and retransmitted with the transmitter. In non-intrusive through mode all PCS layer information is unchanged. The client signal is unchanged, retransmitted, and analyzed by the higher layer if support is available.

PCS Generator

Alarm Insertion

Type	Loss of synch
Trigger	Continuous

Error Insertion

Type	Invalid code group, running Disparity, bit error

PCS Analyzer

Auto-Negotiation Status

Trigger	Single error, rate, single burst (invalid code group only)
Rate	1.0E-9 to 0.1E0
Burst size	1 to 255
Status	Auto-negotiation in progress, Auto-negotiation Fail
State machine status	Current state

Auto-Negotiation Link Partner Capabilities

Flow control	None, asymmetric, symmetric, Both
Remote fault encoding	No error, offline, link failure, Auto-negotiation error
Mode	Full duplex, half duplex
Next-page capability	Yes/no

Alarm Detection

Type	Loss of synch, link down, IPG violation

Error Detection

Type	Invalid code group, running disparity, error propagation /V/, IPG violation events
Evaluation (depends on type)	Count, rate, ratio, seconds

Result Display of Alarms and Errors

Numerical Display

Duration in seconds is displayed for each alarm.

Count, rate, ratio and duration in seconds are displayed depending on error type.

Event List

Display of all results with time stamps.

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

MAC/IP Testing

Feature is identical to MAC/IP Testing specified under 10GE LAN Testing

10 G WAN Testing

WIS Testing

WIS testing is similar to SDH/SONET testing, except for two differences:

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

10 G Fibre Channel Testing

10 G FC Testing

Testing modes	Terminate, non-intrusive Through, wrapper/de-wrapper

Generator Configuration

Frame type	FC-2 frame
Frame header settings	Destination ID, source ID, sequence ID, Originator exchange ID, Responder exchange ID

Traffic Generation

Transmitter mode	Bandwidth controlled
Send mode	Once, continuous
Continuous	Ongoing traffic as defined
Once	User defined number of frames, count of bursts

Traffic Profiles

Profile type	Constant load , bursty load
Back-to-Back frames	On/off

Constant Load

Bandwidth	Adjustable utilization in Mbps and %
Frames/bursts per shot	1 to 65,535

Bursty Load

Sustained, peak FC-2 bandwidth	Adjustable utilization in Mbps and %
Frames/bursts per shot	1 to 65,535
Burst size	2 to 268,435,455

Frame Size Settings

Fixed	76 to 2,140 bytes

Payload Settings

Payload type	Test frame, BERT pattern
BERT pattern	PRBS 2^{23}–1, 2^{31}–1, 2^{23}–1 inv., 2^{31}–1 inv., All 0s, All 1s, digital word 32 Bit

Flow control

Transmit R_RDY	Enable/disable
Received R_RDY	Count

Login

Enable login	On/off
Type	Implicit
Tx buffer credits	1 up to 4096
Current credits	Count

Login Alarm

Type	Zero credits
Result	Count, status

Error Insertion

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

Transmitter Statistics

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

Analyzer Configuration

Frame type	FC-2 frame
Filter	On/off
Filter criteria	Destination ID, source ID, sequence count, routing control, data structure type

Traffic Evaluation

QoS Evaluation

QoS alarms	LPAC,NFTF
Alarm evaluation	Seconds
QoS errors	Lost, out of order
Error evaluation	Count, current rate, ratio, seconds
FC-2 throughput	Bandwidth, utilization
Throughput evaluation	Current, average
Transfer delay	Min, max, average
Tested frame count	Count of frames

BERT Evaluation

BERT alarms	LPAC, pattern loss
Alarm evaluation	Seconds
BERT errors	Bit error
Error evaluation	Count, current rate, ratio, seconds

FC-2 Error Evaluation

Type	Runt, jabber, CRC error, undersized, oversized, errored
Results	Count, current rate, ratio, seconds

Statistics All Traffic

Total bytes	Count
Total frames	Count, current rate
Total errored frames	Count, current rate
Total good frames	Count, current rate
Total CL1 frames	Count, current rate, ratio
Total CL2 frames	Count, current rate, ratio
Total CL3 frames	Count, current rate, ratio
Total CLF frames	Count, current rate, ratio

Specifications *cont'd.*

Total bandwidth	Current, average
Total utilization	Current, average
Total payload bandwidth	Current
Port Service disruption	Maximum

Frame Size Statistics

Available for All frames and filtered frames

Frame size distribution Classes	28-64, 68-124, 128-252, 256-508, 512-1020, 1024-2140, >2140
Evaluation	Count, current rate, ratio
Results	Numerical and Graphical View
Frame size	Min, average, Max.

Statistics Filtered Traffic

Filtered In

Total bytes	Count
Total frames	Count, current rate, ratio
Bandwidth	Current, average
Utilizations	Current, average
Share	Current, average
Payload bandwidth	Current, average

Not Filtered In

Total frames	Count, current rate, ratio
Bandwidth	Current, average
Utilizations	Current, average
Share	Current, average

SDH/SONET Testing

Generator

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

Signal Structure Configuration

Free definable Foreground Channel

Optionally definable Background Channel

Background Channel with selectable mapping (dependent on Foreground Channel) with definable HO Path Overhead, payload pattern, J1 trace and SS bits.

Payload	Test pattern or higher layer application test pattern
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 0.150), Digital Word 32 bits

Alarm Insertion

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	M frames active and N frames inactive N, M = 1 to 8,000,000 or 125 µs to 1,000 s

Error Insertion

Type

SDH	Random, FAS, B1, B2, B3, MS-REI, HP-REI, Bit error
SONET	Random, FAS, B1, B2, B3, REI-L, REI-P, Bit error
Mode	Single error, rate, single burst, continuous burst
Burst	M frames active and N frames inactive N, M = 1 to 8,000,000 or 125 µs to 1,000 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	

Intrusive Through Mode

Through mode manipulation and error/alarm insertion is available when set to intrusive through mode.

All individual SOH/TOH bytes except B1, B2, B3, H1, H2, H3 can be replaced by a fixed value or passed through.

J0 byte can be replaced by a fixed byte value or 16/64 bytes J0 sequence

B1, B2 parity bytes are regenerated at all times.

B3 parity bytes are passed through but additional error insertion is possible.

H1, H2, H3 pointer bytes are passed through at all times.

Supported alarm insertion	SDH: LOF, RS-TIM, MS-AIAS, MS-RDI SONET: LOF, TIM-S, AIS-L, RDI-L
Supported error insertion	SDH: random, FAS, B1, B2, B3, MS-REI, HP-REI All 0s, All 1s, digital word 32 Bit SONET: random, FAS, B1, B2, B3, REI-L, REI-P

Overhead Generator

Visual display of overhead bytes.

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

Trace Identifier

J0, J1	User definable
Mode	1 byte, 16 bytes, 64 byte, auto 16-byte, auto 64-byte
K1,K2	User definable with clear text decode
Architecture	Ring, linear

Pointer Insertion

Generation of pointer actions at the AU/STS level with definable SS Bits

Pointer action type	New pointer value, offset Simulation, pointer increments/decrements, pointer sequence
New pointer value	New value, with/without NDF
Offset simulation	–320 ppm to +320 ppm
Pointer increments/decrements	Single, periodical, alternating
Pointer action period (T1)	2 to 4,800,000 frames, or 250 us to 600s
Pointer sequence	Sequence type, direction, pointer action period, basic period, add/cancel period
Sequence type	87/3, 87/3 Cancel, 87/3 Add
Direction	Increment, decrement
Basic period (T2)	T1 x 90
Add/cancel period (T3)	T2 x (2 to 65,535)

Analyzer

Auto Signal Structure

The receiver automatically analyzes the incoming signal structure (mapping, payload, traces) for easy configuration of the test channel.

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

Alarm Detection

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	LOF,SEF, TIM-S, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, TIM-P, PLM-P, PDI-P, RDI-P-C, RDI-P-S, RDI-P-P, pattern loss
Resolution	100 ms

Error Detection

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

Intermediate bit error (if SDH/SONET test pattern)

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

Interval duration	1 to 3600 s
Results	Current and previous Interval, count, and ratio

Result Display of Alarms and Errors

Numerical Display

Duration in seconds is displayed for each alarm.

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

Event List

Display of all results with time stamps.

Criteria	Start, stop, duration, count
Viewing filters	Events, durations, count

Graphical View

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

Viewing filters	Events
Time axis scale	Second, minute, hour

Specifications *cont'd.*

Performance Monitoring

SONET Evaluation of GR-253, T1.231

Results	EFS, ES, SES, UAS-L, UAS, AUS,ESA, ESB
Evaluation duration and percentage	

SDH Evaluation of ITU-T G.826, G.828, G.829

Results	EFS, ES, SES, UAS, BBE, EB
Evaluation duration, percentage, pass/fail verdict	
Configuration	HRP Allocation, SES thresholds, UAS Limit, UAS, UAS mode
HRP allocation	0.10000 to 100.00000%
SES thresholds	1 to 8,000 blocks; 1 to 64,000 (G.829 Reg. Section); 1 to 49,152,000 (G.829 Mux. section)
UAS limit on/off, 0 to 100,000 secs	
UAS mode individual, global	

Service Disruption Test

To analyze service disruption times, a high-speed event list as a result of all detected events is generated.

Result Display of Disruptions

Numerical Display

Total number of disruptions, begins with timestamp of first disruption, and ends with a timestamp of last disruption.

Statistics

Shortest disruption time (with timestamp) in msec

Longest disruption time (with timestamp) in msec

Average disruption time in msec

Event List

Display of all results with time stamps, and duration

Logging modes	No logging, disruption events only, distribution and sensor events
Viewing filters	Events, durations

Sensor to Trigger Service Disruption test, Selectable

SDH

Errors	FAS, B1, B2, MS-REI, B3, HP-REI, bit error/pattern loss
Alarms	LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP , HP-UNEQ, HP-PLM, HP-RDI

SONET

Errors	FAS, B1, B2, REI-L, B3, REI-P, bit error/pattern loss
Alarms	LOS, LOF, SEF, AIS-L, RDI-L, AIS-P, L OP-P, UNEQ-P, PLM-P, PDI-P, RDI-P
Event sample resolution	100 µs
Separation time	0.1 to 100,000 ms

Disruption Measurement Configuration

Separation time	0.1 to 100,000.0 ms
Threshold time	0.0 to 100,000.0 ms

Separation time starts at the end of 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 one (event occurs after separation time has elapsed).

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

Byte Capture SOH/TOH

Analyzing SOH/TOH functions requires capturing 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 can be stored and 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 Analysis

AU/STS pointer	
Numerical display	
Value	Increments, decrements, and NDF

Tabular Display

All events with time stamps	
Criteria	Start, stop, duration, count

Transfer Delay Analysis

Measure by special payload pattern ranging from 0 to 40 s	
Measure between ports within the same mainframe	
Numerical display	
Current transfer delay	Accuracy of 1 µs and resolution 100 ns

Minimum and maximum transfer delay (with timestamp)

SDH/SONET VCAT Testing

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

VCAT Testing

Virtual Concatenation (VCAT)

Virtual concatenation implementation is in accordance with ITU-T G.707, G.783, and ANSI T1.105. One virtual concatenation group (VCG) is supported.

Mode	Terminate, through mode at PHYS layer

Signal structures/mappings

SDH	STM-64-Vc4-nv (n = 1...64), STM-64-AU3/Vc3-xv (x = 1...192), STM-16-Vc4 (n = 1...16), STM-16-AU3/Vc3-xv (x = 1...48), STM-4-Vc4-nv (n = 1...4), STM-4-AU3/Vc3-xv (x = 1...12)
SONET	OC192-STS-1--xv (x = 1...192), OC48-STS-1--xv (x = 1...48), OC12-STS-1--xv (x = 1...12)

Generator

Mapping

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

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

Group size is selectable from 1 to the maximum.

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

Background Channels

SDH	AU4 unequipped, AU3 unequipped
SONET	STS-1 unequipped

Sequence Number Generation

User programmable, per member

Payload

The following payloads can be transported with VCAT:

Test pattern	PRBS pattern, higher layer
PRBS pattern	PRBS $2^{31}-1$, $2^{31}-1$ inv.

Error insertion

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

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

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

Alarm Insertion

Type	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
Trigger	Continuous, single burst, continuous burst
Burst	Triggering not available for TIM

SOH/TOH and POH

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

Analyzer

Error Detection

Specifications *cont'd.*

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

Alarm Detection

Type	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

Sequence Number 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

SOH/TOH and POH Analysis

All accessible TOH/SOH bytes

POH bytes of all members independent

Traces J0, J1 in clear text

J1 of all members independently

Sync status (S1) in clear text

The signal label C2 of all members are shown independently in clear text.

Background Channels

Background channels are unequipped.

Pointer Analysis

STS/AU pointer values of all members

Counts of increment, decrement and NDFs

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	125 ms

10G High Order MultiChannel

MultiChannel Testing

The SDH/SONET MultiChannel option adds parallel generation and analysis of mixed mapping signal structures up to 64 x VC-4/192 x STS 1. The MultiChannel signal can be mapped into OTN.

Generator

The MultiChannel option fills up a STM-N/OC-N signal completely with mixed or homogeneous mappings. Granularity for mixing of mapping structures is AU-3/STS-1 level.

SDH mappings for mixed payloads	AU3/VC-3, VC-4, VC-4-2c/3c/4c/8c/16c/64c, AU-3/AU-4 unequipped
SONET mappings for mixed payloads	STS-1/3c/6c/9c/12c/24c/48c/192c, STS-1 unequipped
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., user-defined 32-bit word

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

Alarm Insertion

SDH	LOS, LOF, TIM-S, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-UNEQ, HP-PLM, P-RDI, P-PLM, HP-RDI, HP-RDI-C, HP-RDI-S, HP-RDI-P
SONET	LOS, LOF, TIM-S, AIS-L, RDI-L, LOP-P, AIS-P, UNEQ-P, PLM-P, RDI-P, RDI-P-C, RDI-P-P, RDI-P-S
Trigger	Continuous, single burst, continuous burst
Continuous burst	M frames with alarm on, N frames with alarm off
M, N	1 to 80,000,000 or 125 µs to 1,000 s

Error Insertion

Type	Random, FAS, B1, B2, MS-REI/REI-L, B3, HP-REI/REI-P, bit error
Trigger	Single, rate, single burst, continuous burst, single burst with rate, continuous burst with rate

Rate

FAS, B2, MS-REI/REI-L, bit error	1×10^{-3} to 1×10^{-12}
Random error	1×10^{-3} to 1×10^{-10}
B1	6.4×10^{-6}*) to 1×10^{-12}
B3, HP-REI/REI-P	1×10^{-3} (1×10^{-6})*) to 1×10^{-12}

*) depends on bit rate and mapping

Continuous burst	M frames with alarm on, N frames with alarm off
M, N	1 to 80,000,000 or 125 µs to 1,000 s

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

Burst with Rate

Defined error rate with additional burst time window.

All errors except random and bit error.

Errors are inserted into all or selected channels.

SOH/TOH and POH Overhead

Access to all SOH/TOH/POH bytes except Bx and Hx. New values can be set to all bytes in parallel.

K1/K2	With interpretation acc. to ANSI T1.105.01 for ring or linear protection
S1	Setting with text interpretation
C2, J1	Can be set individually per each test channel
J0, J1	1/16/64 byte, auto 16/64 byte

Auto modes for J0, J1 set unique values to all channels containing a channel identification.

Analyzer

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

Auto Signal Structure Detection

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

Error/Alarm Detection

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

Error/Alarm Logging with Time Stamps

The ONT stores errors/alarms in all channels with time stamps, enabling identification of events occuring in any of the channels.

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

Error and Alarm Event List

Includes filter capabilities

Storage capacity	300,000 events per measurement

The event list contains the following:

- Event type
- Channel ID
- Start/end time
- Duration
- Error count
- Message evaluation/ overhead access

SOH/TOH and POH Overhead

Display of all SOH/TOH/POH bytes.

J0, J1, C2	View accessible for each channel

PLM evaluation per channel, expected value editable.

TIM evaluation per channel, determines expected value from received signal.

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. Start the capture function using a selectable trigger.

Store values for one/two selected bytes for subsequent access 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)

Connectivity Check

The connectivity feature verifies that all channels are routed through a switching matrix as expected, for example 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.

Specifications *cont'd.*

The Trace Learning mode stores the path trace values provided by the device under test to be used as reference to check connectivity.

Mismatches are indicated graphically in the signal structure overview.

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

Service Disruption Test

The MultiChannel 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 on every channel is stored with time stamp and duration.

A setup page allows enabling/disabling of each channel individually.

Result Presentation

Summary results for all channels

Channel table	Contains shortest/longest/average/# of disruptions for each channel and the total duration with 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	100 000 ms

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

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

SDH

Errors	B1, B2, MS-REI, B3, HP-REI, payload error
Alarms	LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-UNEQ, HP-PLM, HP-RDI

SONET

Errors	B1, B2, REI-L, B3, RDI-P, REI-P, bit errors
Alarms	LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, UNEQ-P, PLM-P, RDI-P

The threshold to identify a violation of the allowed service disruption time (for all channels) is 1 to 1,000 ms.

Violation is shown in summary results and channel table.

10/11 G Jitter and Wander Testing

Jitter Module 10G-E 1550 nm (BN 3076/90.75)

Combines with Module-E and includes jitter function at 9.953 G. The optical interface is 1550 nm.

Jitter Module 10G-E 1310/1550 nm (BN 3076/90.76)

Combines with Module-E and includes jitter function at 9.953 G. The optical interface is 1310/1550 nm.

Option Electrical Interfaces (BN 3076/90.77)

This option for the Jitter Module 10G-E enables differential electrical Jitter functions.

Option Jitter 10.3G -E (BN 3076/90.70)

Enables jitter at the service bit rate of 10.313 G to measure synchronous Ethernet.

Option Jitter 10.5G-E (BN 3076/90.63)

Enables jitter at the service bit rate of 10.519 G for 10G Fibre Channel

Option Jitter 10.7G-E (BN 3076/90.78)

Enables jitter at the service bit rate of 10.709 G for OTN.

Option Jitter 10.75G-E (BN 3076/90.81)

Enables jitter at the service bit rate of 10.755 G to measure unframed OTL3.4.

Option Jitter 11.05/11.1G-E (BN 3076/90.79)

Enables jitter at the service bit rate of 11.049/11.095 G for OTN overclocked (OTU1e/OTU2e).

Option Jitter 11.18G-E (BN 3076/90.99)

Enables jitter at the service bit rate of 11.181 G to measure unframed OTL4.10.

Option Jitter DS1/E1+BITS (BN 3076/90.74)

Enables DS1/E1 and BITS jitter measurement capability to Jitter 10G or Jitter 2.5G module.

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 G
- ITU-T Recommendations O.173 and O.174
- ITU-T Recommendations G.825, G.8251, G.8261, G.8262
- Telcordia GR-253
- ANSI standards T1.101, T1.105, T1.105.03

Optical Interfaces

Supported bit rates for jitter/wander and BER testing	9.953, 10.313, 10.519, 10.709,10.755, 11.049, 11.095, 11.181 G
Wavelengths	1550 or 1310/1550 nm
Output level	typical 0 dBm
Max. TX bit rate offset	± 150 ppm
Receiver wavelength	1260 to 1580 nm
Sensitivity	–14 to –8 dBm
Max. input power (destructive)	+ 2 dBm
Max. RX bit rate offset	± 150 ppm (jitter) ± 100 ppm (wander)
Connector types built-in optics	Exchangeable adapters

Electrical Interfaces

Reference Clock Output

Output frequency	All rates f/16, f/64 switchable
Output level (AC coupled)	Single 400 mVpp differential 800 mVpp
Connector	Two SMAs/50 Ω

Differential Electrical Interfaces (BN 3076/90.77)

A hardware option add-on to the Jitter 10G card provides differential electrical interfaces for all rates and signals from 9.95 up to 11.32 G.

Supported rates

Same as high-rate optical interfaces

Tx NRZ Data Out

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

High-Speed Tx Clock Out

Clock is not phase aligned with Rx data out

Source	Internal reference, from Rx, clock module inputs, sync clock in
Output frequencies	9.95 to 11.32 GHz
Tx offset	±500 ppm
Output level (AC coupled) selectable	Off, low, normal, high single 200, 300, 400 mVpp; differential 400, 600, 800 mVpp
Variation in 1% steps	±50%
Max. output level	1,000 mVpp
Connector	Two SMAs/50 Ω

Rx NRZ Data In

Built-in clock recovery.

Input rates	9.95 to 11.32 G
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 (~10 Hz).

Input rates	f/16 and f/64 switchable
Input offset	±80 ppm
Input level (AC coupled)	Single 100 to 1,000 mVpp; differential 50 to 2,000 mVpp
LOS detection diff. (LTI)	40 mVpp typ.
Connector	Two SMAs/50 Ω

Recovered clock (RX, BN 3076/90.77)

Output frequency	Bit rate clock
Output level	typ. 500 mVpp (AC coupled)
Connector type	SMA 50 Ω

Eye clock output (TX)

Output frequency	1/16 of bit rate
Output level	Typ. 500 mVpp (AC coupled)
Connector type	SMA 50 Ω

Reference clock input (TX)

Input frequency	1/16 or 1/64 of bit rate
Input level	Typ. 50 to 2,000 mVp
Impedance	2 × 50 Ω, AC coupled, differential
Connector type	SMA

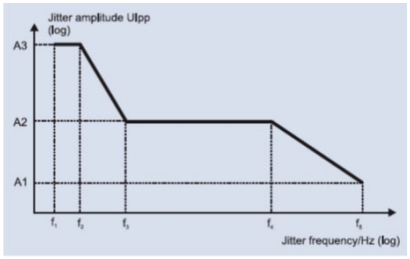
Specifications *cont'd.*

Jitter Testing

Jitter Generator

Meets or exceeds the requirements of ITU T Recommendations 0.172, 0.173, and 0.174.

Jitter modulation signal	Sine wave
Jitter amplitude	up to 3200 UIpp
Amplitude resolution	0.001 UI
Frequency range	1 Hz to 80 MHz
Frequency resolution	0.1 Hz



Amplitude in [UIpp]			*Frequency in [Hz]*				
A1	***A2***	***A3***	***f1***	***f2***	***f3***	***f4***	***f5***
0.5	6	3200	10	100	50 k	6.67 M	80 M

Jitter Analyzer

Meets or exceeds the requirements of ITU T Recommendations 0.172, 0.173 and 0.174.

Measuring Range/Resolution (Standard)

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

Measuring Range/Resolution (Extended)

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

Measurement Filters

High pass filter	20 kHz (HP 1), 50 kHz (RMS), 4 MHz (HP 2)
Low pass filter	8 MHz (XFI), 80 MHz (LP)

Measurement Accuracy

Fixed error	15 mUIpp*, 20 mUIpp (<11 G), 25 mUIpp (>11 G)

* Optical input power level −10 dBm to −12 dBm, mapping SDH VC-4/ SONET STS-1, payload pattern PRBS 2^{23}–1, environmental temperature +20°C to +30°C.

Demodulator Output

Connector/impedance	BNC/75 Ω
Output voltage	3 V/64 UI (standard range) 3 V/4096 UI (extended range)

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 measurement)	Peak-peak, positive peak, negative peak

Parallel Measurement Filters

Results for all measurement bandwidth ranges are calculated simultaneously, e.g. HP1+LP, HP2+LP and RMS+LP. Ideal for reducing measurement time of jitter generation.

Phase Hits

The instrument detects when the programmable threshold for positive and negative jitter values is exceeded as well as how often it was exceeded. Max. count frequency is approx. 80 MHz (sine wave).

Jitter Versus Time

This function is used to record variations of jitter with time and allows the display of the positive and negative peak values, peak-peak values, and RMS values versus time. Duration is up to 99 days. Time resolution is 1 s.

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 (max. 60). 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 (max. 60). Precisely determine the maximum permissible jitter amplitude 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

Wander 10/11G (BN 3061/93.95)

This software option is only available in conjunction with Jitter modules (BN 3076/90.75 or /90.76) and enables wander generation (sine wave) and analysis at 9.953 G, 10.313/ 10.519/10.709/10.755/11.049/ 11.095/11.181 G (optional). Fully complies with or exceeds the requirements of ITU-T 0.172, 0.174.

Wander 10/11G Expert (BN 3061/93.97)

This software option adds white/TDEV noise and MTIE transient to BN 3061/93.95 and /93.96, and enables the wander transfer function, phase transient, phase build-out, offset in ppb. White/TDEV noise and MTIE transient are according to Telcordia GR-253, ANSI T1.101, and ITU-T G.812/13, G.8261/G.8262 (SyncE).

Wander DS1/E1+ BITS (BN 3061/93.96)

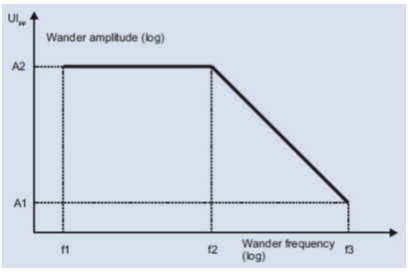
This software option is only available in conjunction with Wander 10/11G (BN 3061/93.95) and enables wander generation (sine wave) at DS1/E1 and BITS/SETS, and supports wander analysis at DS1/E1.

Wander BITS Expert (BN 3061/90.74)

This hardware option is only available in conjunction with Wander DS1/E1 + BITS (BN 3061/93.96). It supports 1 pps signal generation and analysis, enables injection of signal interruptions and wander measurements on clock signals. It complements the reference input signals with 64/6312 kHz.

Wander 10/11G (BN 3061/93.95)

Modulation signal	Sine wave
Amplitude range	0.1 to 320 000 UI
Amplitude resolution	0.1 UI
Frequency range	10 µHz to 10 Hz
Frequency resolution	1 µHz
Generator accuracy	Conforms to ITU-T 0.172, 0.174



Amplitude in [UIpp]		*Frequency in [Hz]*		
A1	***A2***	***f1***	***f2***	***f3***
16 000 UI	320 000 UI	10 µHz	0.5 Hz	10 Hz

Wander 10/11G Expert (BN 3061/93.97)

Additional Modulation Signals

White noise	10 to 150 Hz
TDEV noise	Conforms to ITU-T, Telcordia, ANSI
MTIE transient	Conforms to ITU-T, Telcordia
Phase transient	Linear, exponential, cosine
Phase build out	Linear
ppb-offset generation	−100,000 to +100,000 ppb

Wander DS1/E1+ BITS (BN 3061/93.96)

According to ITU-T G.703

Data signal	DS1 (ESF, AMI), E1 (PCM31 CRC, HDB3)
Clock signal	1544, 2048, 6312, CC64 kHz (G.703 App. II)
Connector	Bantam 110 Ω, BNC 75 Ω
Clock signal	10 MHz
Connector	BNC 75 Ω
Modulation signal	Sine wave

Additional modulation signals see BN 3061/93.97

Wander BITS Expert (BN 3076/90.74)

Signals	1 pps, CC64 kHz, 1.5/2/6.3/10 MHz
Connector	BNC 75 Ω
Output level	0 to 3900 mV
Pulse width	0.5 to 500 µs
Modulation	Sine wave Offset in ppb (BN 3061/93.89) Signal interruptions on BITS
Measurement	Wander 1 pps pulse width and delay

BN 3076/90.74 includes an external converter for 1 pps balanced signals.

Wander Measurements

Wander Reference Signal Input

Data signal	DS1, E1
Clock signal	CC64/64/6312 kHz (BN 3061/90.74), 1544/2048 kHz
Connector	Bantam 110 Ω, BNC 75 Ω
Clock signal	1, 5, 10 MHz
Connector	BNC 75 Ω

Specifications *cont'd.*

Measurement Filters

Sampling rate – Low-pass filter	1/s – 0.1 Hz, 30/s – 10 Hz (0.172), 60/s – 20 Hz, 1,000/s – 100 Hz (0.172)

Result Display

Time interval error (TIE)	Numerically, graphically
Peak-peak TIE	Numerically
Frequency offset	Numerically
Frequency drift rate	Numerically
Measurement accuracy	Conforms to ITU-T 0.172, 0.174

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 0.172/0.174 G.810 to G.813, and G.8261/G.8262 (SyncE) recommendations.

Automatic Wander Measurements

Maximum Tolerable Wander (MTW)

This application tests the DUT for conformance to the standard tolerance mask limits for wander tolerance and is available in connection with the wander generator. The DUT 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, BN 3061/93.97)

Automatic measurement of the wander transfer function (WTF) is provided by the combination of a wander generator and wander measurement. The wander generator applies a TDEV shaped noise signal to the input of the device under test (DUT). The transferred wander output signal of hte DUT is measured and a TDEV analysis of the measurement is performed repeatedly. The TDEV result curve is compared to the user selectable TDEV mask and each point of the TDEV result is marked as "Pass" or "Fail".

External Wander Analysis SW (BN 3061/95.98)

PC software for wander evaluation, Import of TIE data from ONT/ANT-20, Analysis of TIE/MTIE/TDEV/FFO/FFD

155M/2.7G Jitter and Wander Testing

Jitter Module 2.5G-D 1550 nm (BN 3076/90.66)

Combines with Module-E and includes jitter function at 155/622 Mbps, 2.5 G. The optical interface is 1550 nm.

Jitter Module 2.5G-D 1310/1550 nm (BN 3076/90.67)

Combines with Module-E and includes jitter function at 155/622 Mbps, 2.5 G. The optical interface is 1310/1550 nm.

Option Jitter 1.25G -D (BN 3076/90.69)

Enables jitter at the service bit rate of 1.25 G to measure synchronous Ethernet.

Option Jitter 2.7G-D (BN 3076/90.68)

Enables jitter at the service bit rate of 2.7 G for OTU1.

Option Jitter DS1/E1+BITS (BN 3076/90.74)

Enables DS1/E1 and BITS jitter measurement capability to Jitter 10G or Jitter 2.5G module.

Standards

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

- ITU-T Recommendation 0.172 including Appendices VII + VIII with Accuracy Map support at 2.5 G
- ITU-T Recommendations 0.173 and 0.174
- ITU-T Recommendations G.825, G.8251, G.8261, G.8262
- Telcordia GR-253
- ANSI standards T1.101, T1.105, T1.105.03

Optical Interfaces

Supported bit rates for Jitter/wander and BER testing	155/622 Mbps, 1.25/2.5/2.7 G
Wavelengths	1550 or 1310/1550 nm
Output level	typical 0 dBm
Max. TX bit rate offset	± 50 ppm
Receiver wavelength	1260 to 1580 nm
Sensitivity for BER testing	–28 to –8 dBm
Max. input power (destructive)	+ 3 dBm
Max. RX bit rate offset	± 20 ppm
Connector types built-in optics	Exchangeable adapters

Electrical Interfaces (155/622 Mbps, 1.25/2.5/2.7 G)

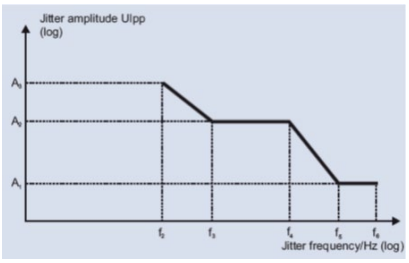
TX signals	Data output (Eye) clock output
RX signals	Data input Recovered clock output
Impedance	50 Ω single-ended, AC coupled
Connector type	SMA
Output level	>200 mVpp
Input level	200 to 1,000 mVpp

Jitter Testing

Jitter Generator

Meets or exceeds the requirements of ITU T Recommendations 0.172, 0.173, and 0.174.

Jitter modulation signal	Sine wave
Jitter amplitude	up to 800 UIpp
Amplitude resolution	0.001 UI
Frequency range	10 Hz to 20 MHz
Frequency resolution	0.1 Hz



Bit rate	Amplitude in [UIpp]			Frequency in [Hz]				
	A1	A2	A3	f1	f2	f3	f4	f5
155 M	0.2	2	50	20	500	6.5k	65k	1.3M
622 M	0.2	2	200	10	1k	25k	250k	5M
1.25 G	0.2	2	400	12.5	2.5k	50k	500k	10M
2.5/2.7 G	0.2	2	800	12.5	5k	100k	1M	20M

Jitter Analyzer

Meets or exceeds the requirements of ITU T Recommendations 0.172, 0.173 and 0.174.

Measuring Range/Resolution (Standard)

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

Measuring Range/Resolution (Extended)

Peak-peak	0 to 800 UIpp/0.1UIpp
RMS	0 to 400 UI/0.01UI

Accuracy Of The Measurement

Standard range (2.5 G) Fixed error 25 mUIpp*

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

Built-In Filters

High-pass filters	500 Hz, 1 kHz, 2.5 kHz, 5 kHz, 12 kHz, 65 kHz, 250 kHz, 500 kHz 1 MHz
Low-pass filter range	1.3, 5, 10, and 20 MHz
Extended range	25 Hz to 400 kHz

Demodulator Output

Connector/impedance	BNC/75 Ω
Output voltage	3 V/64 UI

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 measurement)	Peak-peak, positive peak, negative peak

Parallel Measurement Filters

Results for all measurement bandwidth ranges are calculated simultaneously, e.g. HP1+LP, HP2+LP and HP12+LP. Ideal for reducing measurement time of jitter generation.

Phase Hits

The instrument detects when the programmable threshold for positive and negative jitter values is exceeded as well as how often it was exceeded.

Jitter Versus Time

This function is used to record variations of jitter with time and allows the display of the positive and negative peak values, peak-peak values, and RMS values versus time. Duration is up to 99 days. Time resolution is 1 s.

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 (max. 60). Standard tolerance masks are available and can be edited.

Specifications *cont'd.*

Maximum Tolerable Jitter (MTJ)

The jitter module automatically determines the maximum jitter amplitude tolerated by the DUT at selected jitter frequencies (max. 60). Precisely determine the maximum permissible jitter amplitude 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

Wander 2.5/2.7G (BN 3061/93.92)

This software option is only available in conjunction with jitter modules (BN 3061/90.66 or /90.67) and enables wander generation (sine wave) and analysis at 155/622 Mbps, 2.5 Gpbs, 1.25 G (optional), 2.7 G (optional). Fully complies with or exceeds the requirements of ITU-T O.172, O.174.

Wander 2.5/2.7G Expert (BN 3061/93.89)

This software option adds white/TDEV noise and MTIE transient to BN 3061/93.92 and /93.96, and enables the wander transfer function, phase transient, phase build-out, offset in ppb. White/TDEV noise and MTIE transient are according to Telcordia GR-253, ANSI T1.101, and ITU-T G.812/13, G.8261/G.8262 (SyncE).

Wander DS1/E1 + BITS (BN 3061/93.96)

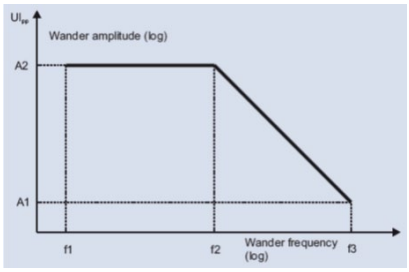
This software option is only available in conjunction with Wander 2.5/2.7G (BN 3061/93.92) and enables wander generation (sine wave) at DS1/E1 and BITS/SETS, and supports wander analysis at DS1/E1.

Wander BITS Expert (BN 3061/90.74)

This hardware option is only available in conjuction with Wander DS1/E1 + BITS (BN 3061/93.96). It supports 1 pps signal generation and analysis, enables injection of signal interruptions and wander measurements on clock signals. It complements the reference input signals with 64/6312 kHz.

Wander 2.5/2.7 G (BN 3061/93.92)

Modulation signal	Sine wave
Amplitude range	0.1 to 100,000 UI
Amplitude resolution	0.1 UI
Frequency range	10 µHz to 10 Hz
Frequency resolution	1 µHz
Generator accuracy	Conforms to ITU-T O.172, O.174



Offset	*A1*	*A2*	*f1*	*f2*	*f3*
0 ppm	4,000 UI	100,000 UI	10 µHz	0.5 Hz	10 Hz

Wander 2.5/2.7 G Expert (BN 3061/93.89)

Additional modulation signals	
White noise	10 to 150 Hz
TDEV noise	Conforms to ITU-T, Telcordia, ANSI
MTIE transient	Conforms to ITU-T, Telcordia
Phase transient	Linear, exponential, cosine
Phase build out	Linear
ppb-offset generation	–100,000 to +100,000 ppb

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According to ITU-T G.703	
Data signal	DS1 (ESF, AMI), E1 (PCM31 CRC, HDB3)
Clock signal	1544, 2048, 6312, CC64 kHz (G.703 App. II)
Connector	Bantam 110 Ω, BNC 75 Ω
Clock signal	10 MHz
Connector	BNC 75 Ω
Modulation signal	Sine wave
For additional modulation signals, see BN 3061/93.89.	

Wander BITS Expert (BN 3061/90.74)

Signals	1 pps, CC64 kHz, 1.5/2/6.3/10 MHz
Connector	BNC 75 Ω
Output level	0 to 3900 mV
Pulse width	0.5 to 500 µs
Modulation	Sine wave Offset in ppb (BN 3061/93.89) Signal interruptions on BITS
Measurement	Wander 1 pps pulse width and delay

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Wander Measurements

Measurement Filters

Sampling rate – Low-pass filter	1/s – 0.1 Hz, 30/s – 10 Hz (0.172), 60/s – 20 Hz, 1,000/s – 100 Hz (0.172)

Result Display

Time interval error (TIE)	Numerically, graphically
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External Wander Analysis SW (BN 3061/95.98)

PC software for wander evaluation, Import of TIE data from ONT/ANT-20, Analysis of TIE/MTIE/TDEV/FFO/FFD

Test & Measurement Regional Sales

NORTH AMERICA
TOLL FREE: 1 855 ASK-JDSU
(1 855 275-5378)

LATIN AMERICA
TEL: +1 954 688 5660
FAX: +1 954 345 4668

ASIA PACIFIC
TEL: +852 2892 0990
FAX: +852 2892 0770

EMEA
TEL: +49 7121 86 2222
FAX: +49 7121 86 1222

WEBSITE: www.jdsu.com/test

