Agilent Technologies

OmniBER OTN Communications Performance Analyzers

Technical Data Sheet

Powerful Next Generation SONET/SDH testers with accurate, repeatable jitter measurements - reducing the time to insight.

Agilent Technologies

Key Features

- **Supports all telecomms transmission rates from 1.5Mb/s to 10Gb/s**
- **Fully standards compliant next generation SONET/SDH and OTN (ITU-T G.709) testing**
- **ITU-T G.7041 (GFP Framed and Transparent) compliance test**
- **ITU-T G.7042 (LCAS) compliance test**
- **ITU-T G.707 (virtual concatenation -high and low order) compliance test with full 256ms delay generation**
- **Internally generated Ethernet signals and measurements**
- **Encapsulation analyzer captures, displays and decodes entire GFP frames**
- **Industry leading jitter measurement accuracy through ITU-T O.172 Appendix VII calibration and characterization**
- **Optical power, frequency and service disruption times**

Product Overview

Introduction

Whether you are testing compliance to new next generation SONET/SDH (NGS) standards or tight jitter standards, time to insight is a key requirement for faster problem identification and resolution. The new OmniBER not only provides the abilities to identify problematic areas of design and performance, it enables the user to delve deeper to understand the reason behind the failure. Thus, speeding up the time to resolution and improving time to market.

The Industry Standard for Next Generation SONET/SDH

Being first to market, the OmniBER is the industry's standard for verifying compliance to the stringent new NGS standards. Transparent and Framed GFP (GFP-T and GFP-F) to ITU-T G.7041, LCAS to ITU-T G.7042 plus high and low order virtual concatenation test to ITU-T G.707, with 256ms of delay generation, are all supported. These design areas must all be verified for compliance to avoid interoperability issues on deployment.

Insight into device behaviour

The OmniBER's industry leadership position has been consolidated through the provision of tools to give advanced analysis and deep insight into device behaviour providing the following key benefits:

- Deep insight into device behaviour with capture and analysis of signal structures down to byte level using Encapsulation Analyzer, enabling complete capture, decode, and display of GFP frames. Clear indication of errors and alarms and quick access to the GFP payload information. Identify and decode the Ethernet overhead and payloads for GFP framed (GFP-F) signals.
- Transparent and Framed GFP (GFP-T and GFP-F) to ITU-T G.7041 with GFP encapsulation analysis, provides selective capture and full byte decode of GFP-F and GFP-T frames within high order and low order SONET containers, allowing designers to find and fix non-conformant designs.
- Ethernet payload analysis enabling frame sequence and "packet BER" of Ethernet traffic transported over SONET/SDH. Using an Agilent-proprietary Ethernet Test Payload, users can find QoS problems not visible with existing test equipment.
- New Vcat test to ITU-T G.707 provides VCat delay analysis using up to 256ms of thru-mode differential delay generation to test the effect of virtual container delay (both high and low order) on the QoS of Ethernet, fiber channel or other data client payloads.
- LCAS to ITU-T G.7042 provides protocol analysis that provides time stamping and decoding of both high order and low order LCAS messages for debugging control protocol errors.

Industry leading jitter accuracy

The OmniBER is the most accurate and repeatable solution available for measuring 10Gb/s SONET/SDH and G.709 OTN jitter.

Reduced time to insight equally applies to jitter compliance testing. Increased use of modular optical transceivers (i.e. XFP/SFP) has increased the need to be able to verify the performance of individual modules independently before integration into a larger system. The need to control the jitter contribution of each component so that the entire system jitter generation is below Telcordia GR-253-CORE's 100 mUI limit is a challenge requiring extremely accurate and repeatable jitter measurement at these low levels. Without accurate and repeatable measurements designers, suppliers and end users are unable to resolve jitter compliance issues.

Upgraded design of critical components coupled with ITU-T O.172 Appendix VII calibration techniques ensures reduced variability and improved absolute accuracy. The resulting OmniBER solution provides the industry's most accurate jitter generation and measurements for SONET/SDH and G.709 OTN with a guaranteed fixed error intrinsic of 15mUI at OC-192/STM-64, which is one third of the limit specified in ITU-T O172 plus a guaranteed ITU-T O.172 Appendix VII accuracy map is supplied with each instrument.

Whether you are testing SONET, SDH, or OTN (ITU-T G.709) network equipment this tester has everything you need to ensure all your designs meet the relevant Telcordia and ITU-T jitter recommendations.

Key jitter benefits

- Fully standards compliant SONET/SDH jitter testing to ITU-T O.172
- Industry leading jitter measurement accuracy through O.172 Appendix VII calibration and characterization
- Receiver-only, fixed jitter accuracy specification of 15 mUI reduces jitter measurement uncertainty by more than 50 percent.
- Guaranteed ITU-T O.172 Appendix VII "accuracy maps" (for both 2.5 and 10 Gb/s rates)
- Unique parallel jitter measurements across multiple bandwidths not only deliver results 5 times faster, they also provide unique insight into your device's jitter behaviour across different bandwidths This added insight allows jitter performance to be more fully understood and issues resolved more quickly.
- Programmable jitter tolerance and jitter transfer masks provide an easy to use graphical display of compliance to standards.
- Wander test from 52Mb/s to 10Gb/s, MTIE/TDEV analysis
- 2 year calibration cycle ensures that the tester's performance is guaranteed and directly contributes to a reduced cost of ownership.

Comprehensive on-line help

A comprehensive on-line help system is accessible at the touch of a button, while context sensitive help is provided automatically as you navigate through the user interface. You can also extend the help available by adding you own documentation.

Contents

Overview

Signal Wizard

Signal Wizard is a unique test tool that has been specifically designed to meet the challenges associated with testing the new generation of SONET/SDH transmission systems - systems that combine grooming, switching and multiplexing in a single unit. With one key press, Signal Wizard automatically:

- Simultaneously monitors the line signal and all STS/AU channels (up to 192) for errors, alarms and pointer activity.
- Shows which channels are unequipped and the type of service being carried by equipped channels.
- Provides Path Trace message listing and search tools (including sub-string searches) to assist in identifying path routing errors within the network

GFP Testing (ITU-T G.7041)

The OmniBER OTN allows structured test signals to be generated in order to fully test Ethernet over SONET/SDH encapsulation to ITU-T G.7041. This verifies that designs are compliant to standards and ensures multi-vendor interoperability.

- Generate and receive Framed (GFP-F) and Transparent (GFP-T) payloads
- Generate and detect correctable and uncorrectable Header Error Control (HEC) errors
- Generate and detect Loss of Client Signal (LOCS) and Loss of Client Character Synchronization (LOCCS)
- Access to GFP overhead including extended header for linear (CID) and null topologies
- Ethernet MAC Payload mapping with adjustable data rate from 1Mb/s to 1Gb/s (GbE)
- User specified number of superblocks for GFP-T

LCAS Testing (ITU-T G.7042)

- Full emulation of ITU-T G.7042 protocol
- Manual control of protocol for stress testing
- Hitless addition and removal of containers
- LCAS protocol trace enables faster debug

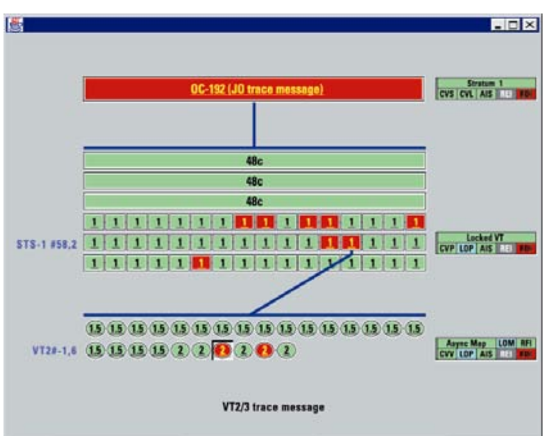


Figure 1: Error and alarm status clearly presented for each detected STS/AU channel, and for all VT/TU channels in a selected STS/AU.

Channel	Size	Trace Message	Signal Label
1,1	STS-48c	San Francisco - NewYork #3	ATM
17,1	STS-12c	San Francisco - Washington #17	HDLC/PPP
21,1	STS-3c	San Francisco - Los Angeles #10	ATM
22,2	STS-1	San Francisco - Phoenix #4	VT
23,1	STS-3c	San Francisco - San Jose #8	ATM
24,1	STS-12c	San Francisco - Chicago #6	HDLC/PPP
28,2	STS-1	San Francisco - Little Rock #1	VT
29,3	STS-1	San Francisco - Minnesota #2	VT
30,1	STS-1	San Francisco - San Jose #2	DS3
32,2	STS-1	San Francisco - LasVegas #4	VT
34,1	STS-1	San Francisco - Seattle #10	VT
50,3	STS-1	San Francisco - NewYork #20	VT
55,2	STS-1	San Francisco - Denver #5	DS3
63,1	STS-1	San Francisco - Boston #9	DS3

San Francisco - San Jose # 8

Figure 2: Clear tabular display of J1 or J2 path trace messages, or those identified based on a sub-string search.

LAPS Testing (ITU-T X.86)

Prove standards compliance and ensure interoperability with OmniBER OTN's ability to generate and analyze Ethernet mapped into SONET/SDH via LAPS encapsulation as defined in ITU-T X.86.

- Generate and receive LAPS encapsulated Ethernet
- Error generation includes the ability to inject undersized frames and invalid control sequence errors
- Ability to inject and detect erroneous frame alarms and link loss
- User programmable header fields allows other HDLC-based encapsulations such as Cisco HDLC to be generated and received

Ethernet MAC Testing

OmniBER OTN provides the capability to test Ethernet MAC payloads, which have been encapsulated using GFP or LAPS.

- User definable Ethernet overhead
- Adjustable data rate from 1Mb/s to 1Gb/s with burst control
- Ethernet MAC Error generation and detection
- PRBS generation within Ethernet MAC payload

SONET/SDH Virtual Concatenation

Verify virtual concatenation of high and low order payloads with delay generation across the full ITU-T G.707 256ms range. Realistic traffic with full Ethernet payload mapped via GFP or LAPS.

- High order concatenation of STS-3c/STS-1/AU-4/AU-3
- Low order concatenation of VT2/VT1.5/ TU-3/TU-12/TU-11
- Flexibility to specify which members form the group and add delay to each member
- Group overview simultaneously monitors all group members
- Discovery function automatically detects virtual concatenation members
- Fine delay adjustment to see exactly when input buffers fail
- Coarse delay adjustment allows performance under transients to be verified, e.g. an APS event
- Delay stress test simulates the effect of network wander

SONET/SDH testing

SONET/SDH capability allows comprehensive testing of synchronous networks with the following interface rates: 2.5 G/s, 622 Mb/s, 155 Mb/s and 52 Mb/s. Supported functionality includes:

- Framed/unframed testing at all rates
- SONET/SDH error and alarm generation and detection
- Setup and monitor all overhead bytes
- Alarm stress testing with 'p', 'n', and 'm' sequences
- Overhead sequence generation and capture
- Entire overhead capture
- Transmit and receive error and alarm event trigger outputs
- Through mode test capability
  - Transparent through mode
  - Overhead overwrite - add errors/alarms
- Service disruption test
- Setup and monitoring for linear and ring APS/MSP messages
- Active APS test
- Setup and monitoring for J0, J1 and J2 trace messages
- Tandem connection monitoring testing to the SDH standards (both N1 and N2)
- Burst and periodic sequence pointer adjustment control
- Drop-Insert of DCC channels
- External drop-Insert of asynchronous mapped payloads
- Performance analysis G.826, G.828, G.821, M.2101, M.2101.1, M.2110, M.2120

Contiguous Concatenations enhancement

Enhancement of contiguous concatenations allows you to test the breadth of GR-253/ G.707.

- STS-3c, 6c, 9c, 12c, 24c and 48c
- AU-3, AU-4, AU-4-2c, AU-4-3c, AU-4-4c, AU-4-8c, AU-4-16c

Mixed mappings

Support for mixed mappings now allows convenient setup of complex structures resulting in reduced test times

- Two convenient configuration modes
  - Preset (simple background selection)
  - Mixed mappings (mixed background selection)
- Configure any combination of valid positions
- Any channel can be set as Foreground
- Foreground channel can be virtually concatenated
- Background channels can be either
  - Equipped
  - Unequipped
  - AIS

Encapsulation Analyzer

- Full capture and decode of GFP frames including payload data
- Frame byte values are interpreted and displayed in numerical and textual form. Errors and alarms are clearly highlighted.
- GFP and Ethernet (for GFP-F) frames and payload data are interpreted and displayed.
- Enables fast analysis of why failures have been detected - not just an indication of their occurrence.

Jitter

Jitter capabilities include:

- jitter generation
- output jitter measurements
- jitter tolerance
- wander tolerance
- jitter transfer measurements
- standard and user defined jitter masks
- rapid jitter measurements,
- a bank of up to five digital filters each with their own peak detector
- parallel measurement processing
- Industry leading 15mUI fixed intrinsic with full ITU-T O.172 Appendix VII calibration and accuracy map plotted for each individual instrument. See a typical example in Figure 3.

User definable masks are more flexible than ever, and are ideal for design applications through to production where tailor made masks can be applied. For example, you can select specific frequency ranges and zoom in for closer scrutiny. And for margin testing, you can adjust the masks up or down by up to 100% to make device-testing more stressful.

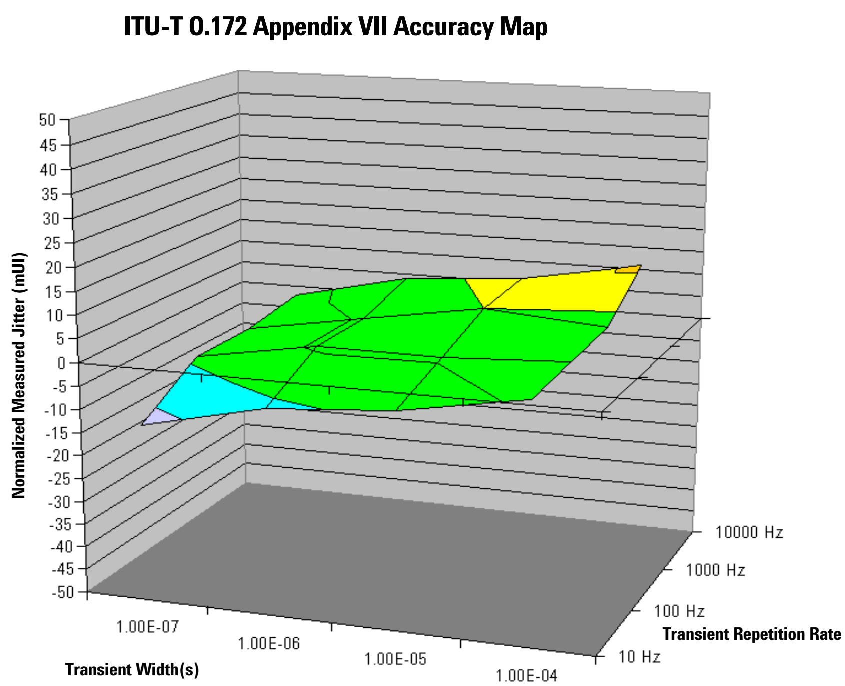


Figure 3: A typical accuracy map as a result of ITU-T O.172 Appendix VII calibration

DSn/PDH testing

The DSn/PDH test capability allows comprehensive testing of DSn/PDH signals and networks with the following interfaces: DS1 (1.5 Mb/s), DS3 (45 Mb/s), 2 Mb/s, 8 Mb/s, 34 Mb/s and 140 Mb/s. Supported functionality includes:

- Unframed, framed, and structured (mux/demux) testing
- Error and alarm generation and detection
- 56 kb/s, n x 56 kb/s, 64 kb/s and n x 64 kb/s testing
- Drop-Insert DSn/PDH to/from SONET/SDH
- Drop-Insert DS1/2Mb/s to/from DSn/PDH
- DS1 loop codes and DS3 FEAC messages
- PDH spare-bits control and monitoring
- Performance analysis G.826, G.828, G.821, M.2101, M.2101.1, M.2110, M.2120

POS (optional)

Packet over SONET/SDH (POS) maps IP packets into the SONET/SDH frame payload using Point-to-Point (PPP) encapsulation and High Level Data Link Control (HDLC) framing.

- Supported functionality includes:
- "POS payloads at all synchronous rates to 10.7 Gb/s.
- "Channelized testing.
- "PPP/HDLC and Cisco HDLC coverage.
- "Verify HDLC stuffing.
- "Continuity and throughput testing.
- "Stress testing using traffic profiles - IP datagram size and inter-packet gap size fully configurable.
- "Comprehensive jitter test with POS payloads.
- "Service disruption measurement with POS payloads.

Additional measurements

- Optical power
- Line frequency
- Pointer measurements
- Service disruption
- Virtual concatenation differential delay measurement

Instrument Tour

Figure 4: Instrument Front Panel

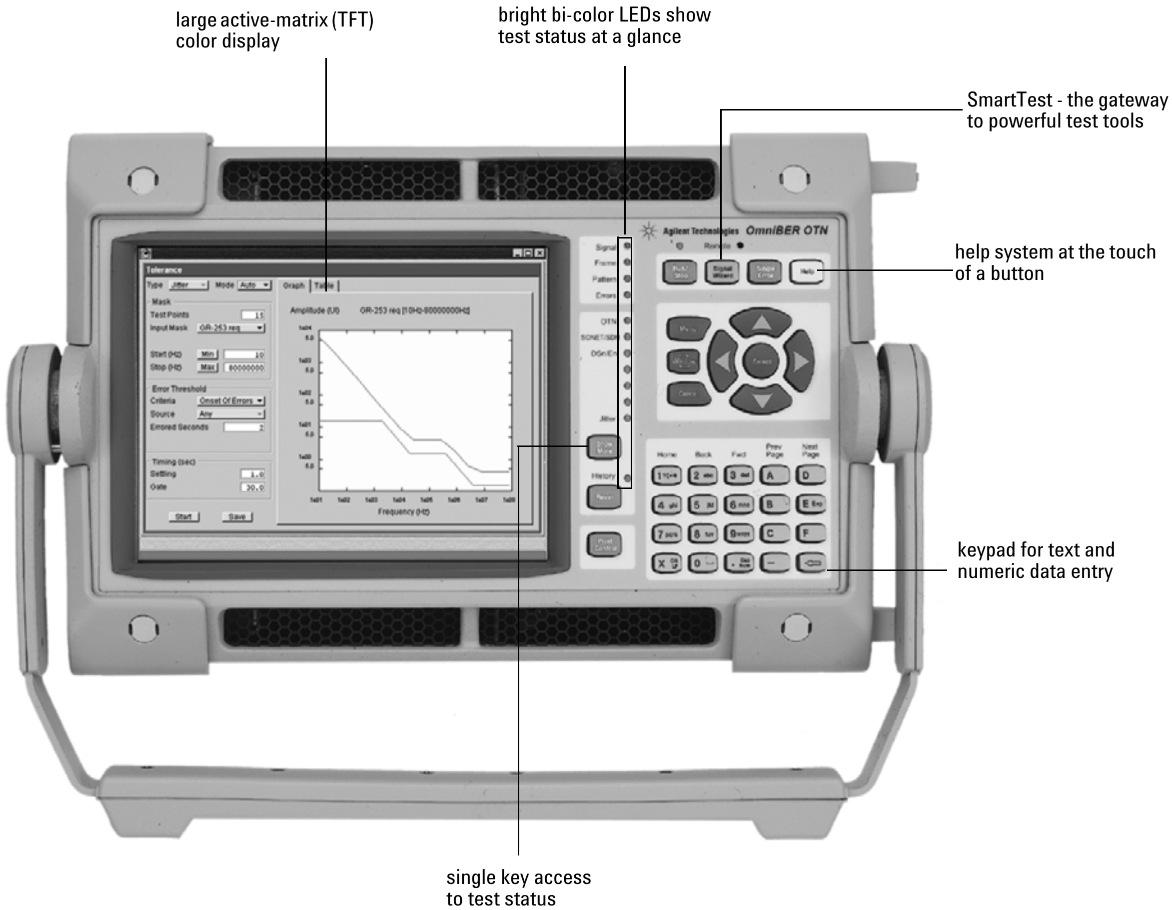
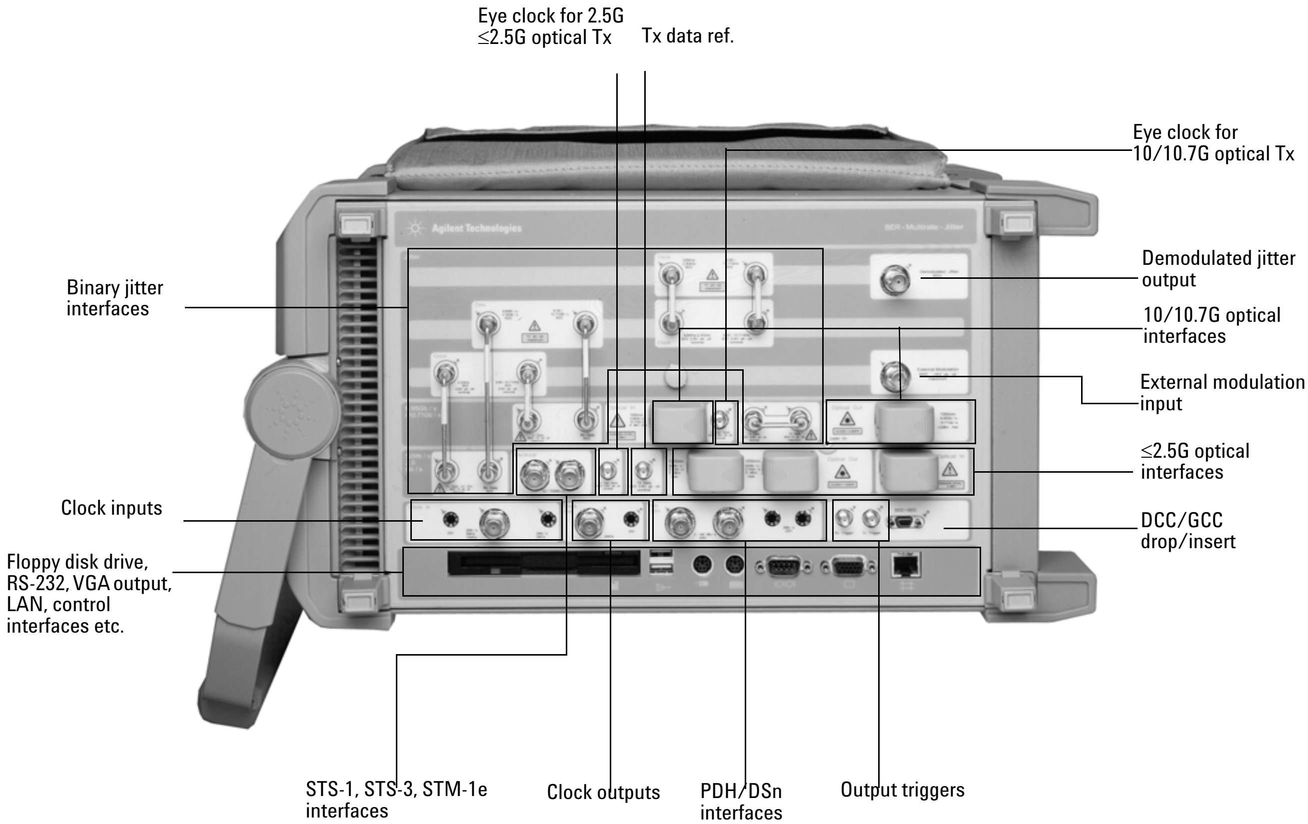


Figure 5: Instrument Rear Panel

Instrument Tour (continued)

Figure 6: Instrument Side Panel



Technical specifications

OmniBER OTN

The following specification provides the details on the OmniBER OTN transmission test set, including all options. Where required contact your Agilent sales representative for information regarding availability of these enhanced testing products.

There are 4 main products. Each product can be upgraded to the equivalent functionality of any other product. There is therefore no limit to the upgrade possibilities of each product.

OmniBER OTN	Functional Testing	Jitter & Functional Testing
OC-48/STM-16 (2.5Gb/s)	J7232A	J7233A
OC-192/STM-64 (10Gb/s)	J7230B	J7231B

The 10Gb/s specifications in this document therefore refer to the J7230B and J7231B. The jitter specifications refer to the J7233A and J7231B. It is however possible to upgrade to jitter and/or 10Gb/s optical interfaces if these were not initially ordered.

Test interfaces (rates, wavelengths, connectors, line codes)

Optical	**Line Rates** Framed: OTU2 OC-1/3/12/48/192 STM-0/1/4/16/64 Unframed: 10.71/9.95/2.48 Gb/s 622/155/52 Mb/s
	Wavelength (≤ 2.5 Gb/s) Option 104 - 1310 nm Option 106 - 1310/1550 nm
	Wavelength (10 Gb/s) Option 108 - 1550 nm **Wavelength (10/10.71 Gb/s)** Option 112 - 1550 nm
	Connectors Option 609 - FC/ PC Option 610 - SC Option 611 - ST
SONET/SDH Electrical	**Line Rates** STS-1/3 (STM-0/1e)
	Connectors STS-1/3 (STM-0/1e) - BNC (75 Ω, unbalanced)
	Line Code STS-3/STM-1e - CMI STS-1/STM-0e - B3ZS
PDH/DSn Electrical	**Line Rates** DS1, DS3; 2/8/34/140 Mb/s
	Connectors DS1- Bantam (100 Ω, balanced) DS3 - BNC (75 Ω, unbalanced) 2 Mb/s - BNC (75 Ω, unbalanced); 3-pin Siemens (120 Ω, balanced) 8/34/140 Mb/s - BNC (75 Ω, unbalanced)
	Line Code DS1 - B8ZS, AMI DS3 - B3ZS 2/8/34 Mb/s - HDB3 140 Mb/s - CMI

Optical transmitters

	52Mb/s - 2.5Gb/s	10Gb/s | 10.71Gb/s
Line Code	NRZ	NRZ
Wavelength		
1310nm	1280-1335nm	-
1550nm	11500-1580nm	1530-1565nm
Output Power		
1310nm	-2.5 to +2.0dBm	-
1550nm	-2.5 to +2.0dBm	-1.0 to +2.0dBm
Spectral Width (-20dB)	<1.0nm	<1.0nm
Extinction Ratio	>8.2dB	>8.2dB
Pulse Mask	Meets ITU-T G.957 (6/1999) and Telcordia GR-253-CORE issue 3 (9/2000)	
Fiber Type	Single mode	Single mode
Laser Safety	See "Regulatory Standards" section for details	

Optical receivers

	52Mb/s - 2.5Gb/s	10Gb/s & 10.71Gb/s
Line Code	NRZ	NRZ
Wavelength (1)	1310nm/1550nm	1310nm/1550nm
Fiber Type	Single mode	Single mode
Damage Input Power	>0dBm	>+2dBm
Operating Range (2)	-28dBm to -9dBm	-16dBm to -8dBm

Notes:

1. Specification nominal however the receiver is a broadband device and operates over the 1290 - 1565nm range.

2. Typical specification.

Minimum sensitivity measured using:

52-2488 Mb/s: For BER = 1 x 10 -10 (input signal ER >= 8.2 dB). 10.71 Gb/s: For BER = 1 x 10 -12 (input signal ER >= 8.2 dB).

Optical transmitters

	52Mb/s - 2.5Gb/s	10Gb/s | 10.71Gb/s

Notes:

1. 52-2488 Mb/s: For BER = 1 x 10^{-10} (input signal extinction ratio >= 8.2 dB).
10.71 Gb/s: For BER = 1 x 10^{-12} (input signal extinction ratio >= 8.2 dB).

2. Specification nominal however the receiver is a broadband device and operates over the 1290 - 1565nm range.

3. Typical specification.

SONET/SDH Electrical interfaces (supplied with options 104 and 106)

STS-1/3 and STM-0/1e

Transmitter	Meets Telcordia GR-253-CORE Issue 3 and ITU-T G.703 for level and pulse shape. **Level:** STS-1: STS-1 (HI), STSX-1 (450 ft), STS-1 (900 ft). STM-0e: ± 1.1 Vpk, ± 10%.STS-3/STM-1e: ± 0.5 Vpk, ± 10%.
Receiver	**Input mode:** terminated or monitor. **Monitor gain:** 20 dB or 26 dB. **Equalization:** STS-1/STM-0e: Selectable off/on. When enabled, automatic equalization provided for 450 to 900 ft of cable loss. STS-3/STM-1e: Automatic for cable loss to 12 dB at half the bit rate. **Jitter tolerance:** Meets Telcordia GR-253-CORE Issue 3 and ITU-T G.825.

DSn/PDH Electrical interfaces (requires option 012)

DS1/3

Transmitter	Meets ANSI T1.102-1993. **Level:** DS1: DSX-1, DS1-LO. DS3: DS3-HI, DSX-3, DS3-900'.
Receiver	Meets ANSI T1.102-1993. **Input mode:** terminated or monitor. **Monitor gain:** DS1: 20 dB, 26 dB, 30 dB. DS3: 20 dB, 26 dB. **Equalization:** DS1: Automatic equalizes for DS1-HI, DSX-1, and DS1-LO levels in both terminated and monitor modes. DS3: Selectable off/on. When enabled, automatically equalizes for DS3-HI, DSX-3, and DS3-900' levels in both terminated and monitor modes. **Jitter tolerance:** Meets Telcordia GR-499 Category II and ITU-T G.824.

2/8/34/140 Mb/s

Transmitter	Meets ITU-T G.703. **Level:** Meets ITU-T G.703 for all rates.
Receiver	Meets ITU-T G.703 and G.772. **Input mode:** terminated or monitor. **Monitor gain:** 2/8 Mb/s: 20 dB, 26 dB, 30 dB. 34/140 Mb/s: 20 dB, 26 dB. **Equalization:** Meets ITU-T G.703. **Jitter tolerance:** Meets ITU-T G.823.

Clock synchronization (inputs, outputs, line frequency offset)

Clock references	**Internal:** ± 4.5 ppm Includes setting accuracy, stability over temperature and aging. **External Clock Inputs:** BITS (1.5 Mb/s): Bantam (100Ω balanced). MTS (2 MHz and 2 Mb/s): BNC (75Ω unbalanced) and Bantam (120Ω balanced) **Loop-timed:** Transmitter timed by a clock recovered from the receiver.
Frequency offset	Offsets the transmitted line signal relative to the selected clock reference. **Offset:** ± 100 ppm in 0.1 ppm step. **Offset accuracy:** 0.02 ppm Note: For 10Gb/s and 10.71Gb/s operation the total of external clock reference offset and transmitter line rate offset must not exceed ± 90 ppm. For all other rates the combined offsets must not exceed ±120 ppm.
Clock outputs	Output clocks generated relative to the selected transmit reference clock. BITS (1.5Mb/s): Bantam (100Ω balanced). MTS (2 MHz): BNC (75Ω unbalanced).
Eye clock outputs	Clock outputs that are frequency locked to the transmitted optical line signal. **Rate:** 52/155/622 Mb/s and 2.5 Gb/s: Output line rate divided by four. 10 Gb/s: Output line rate divided by sixteen (622 MHz nominal). 10.71 Gb/s: Output line rate divided by sixteen (669 MHz nominal) **Level:** Nominal ECL, ac coupled. **Impedance:** Drives nominal 50Ω inputs. **Connector:** SMA.

Signal Structures, Mappings and Payloads

OTN mappings

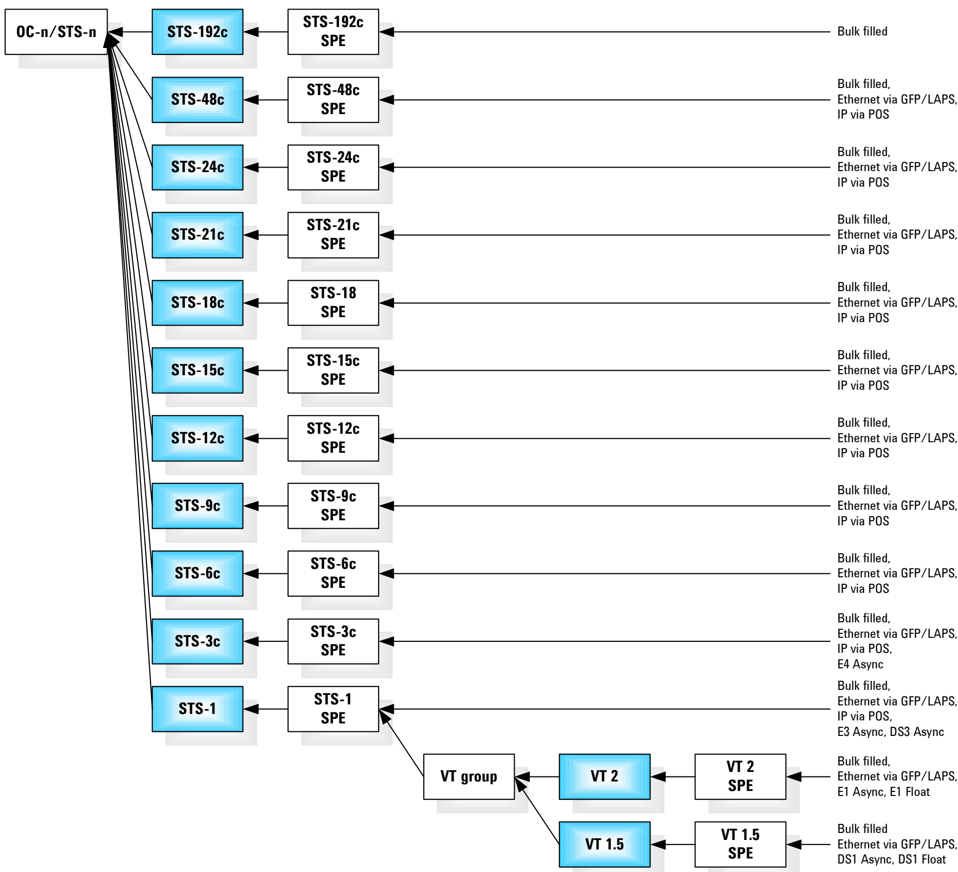
Synchronous and asynchronous mapping of full SONET/SDH structured payloads, including virtually concatenated payloads, is supported plus test signal and null client mappings as per ITU-T G.709.

SONET mappings

Figure 7 shows the SONET mapping structure supported. Test payloads include Bulk filled with PRBS test patterns, Ethernet mapped via GFP (Framed and Transparent), Ethernet mapped via LAPS, fully structured DS1/DS3 and fully structured E1/E3/E4.

The table below shows the virtual concatenation mappings possible.

Figure 7: SONET Mappings Supported



Virtual Concatenation mappings

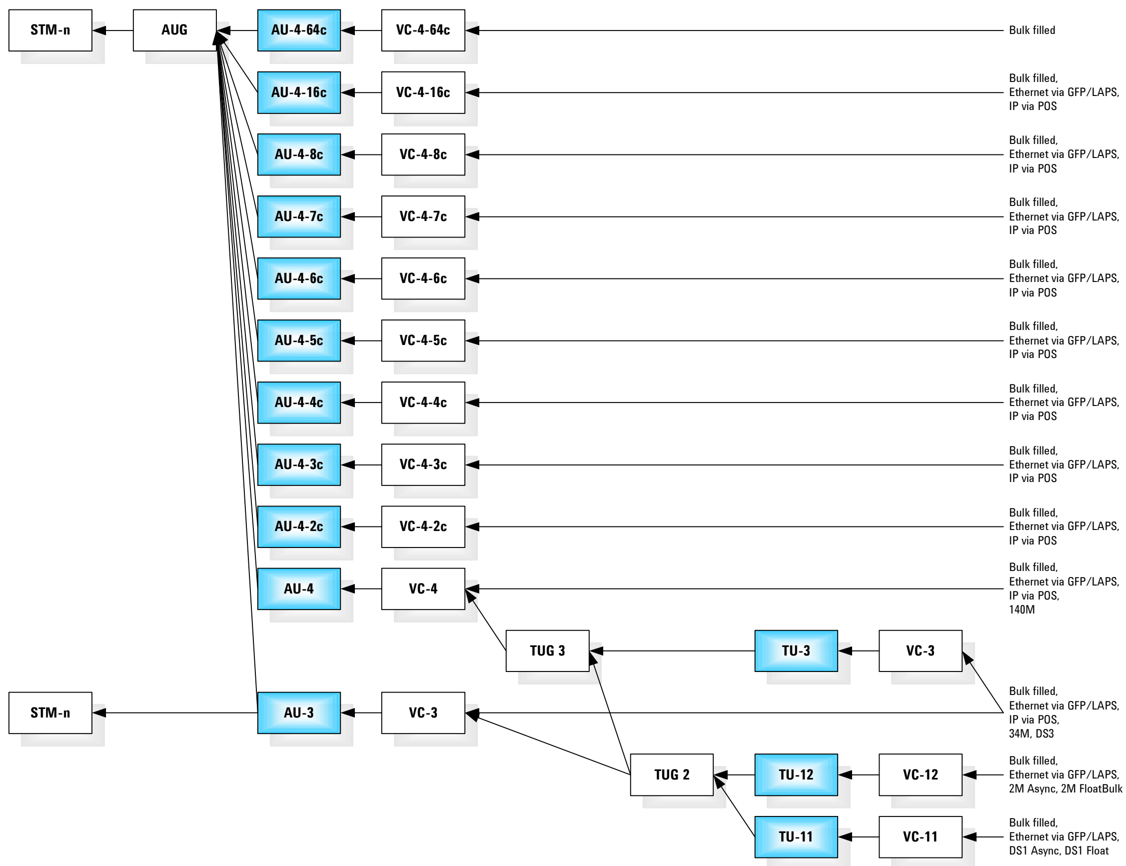
Mapping	No. of Members	Payloads
STS-3c-Xv	X=1 to 16	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
STS-1-Xv	X=1 to 48	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VT2-Xv into any 6 STS-1s	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VT1.5-Xv into any 4 STS-1s	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS

SDH mappings

Figure 8 shows the SDH mapping structure supported. Test payloads include Bulk filled with PRBS test patterns, Ethernet mapped via GFP (Framed and Transparent), Ethernet mapped via LAPS, fully structured DS1/DS3 and fully structured 2/34/140 Mb/s.

The table below shows the virtual concatenation mappings possible.

Figure 8: SDH Mappings Supported



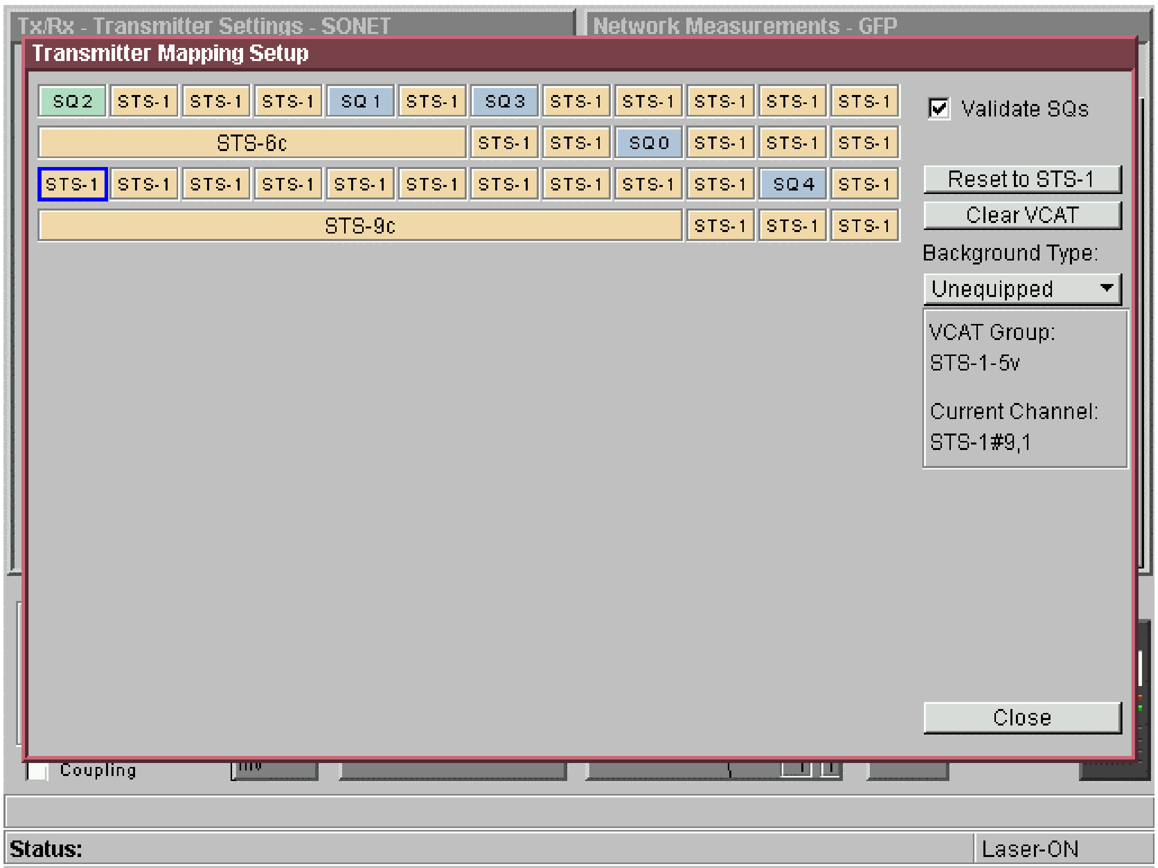
Virtual Concatenation mappings		
Mapping	**No. of Members**	**Payloads**
AU-4-Xv	X=1 to 16	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
AU-3-Xv	X=1 to 48	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
TU-3-Xv via TUG-3	X=1 to 48	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VC-12-Xv into any 2 AU-4s	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VC-12-Xv into any 6 AU-3s	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VC-11-Xv into any AU-4	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS
VC-11-Xv into any 4 AU-3s	X=1 to 64	Bulk Filled, Ethernet via GFP/LAPS, IP via POS

Mixed mappings generation (supplied with options 325/328/510)

The OmniBER OTN can easily generate a SONET/SDH test signal containing any valid combination of supported STS/AU containers. An example is shown in Figure 9 below:

With a mixed mapping configuration, one channel is selected as the foreground/test channel on the instrument transmitter. This test channel can be a virtually concatenated signal. The background channels can be defined as equipped, unequipped or AIS-P/AU-AIS.

Figure 9: Example Setup of SONET Mixed Mapping



DSn/PDH frame formats and channel structures

Supports generation and analysis of framed, channel structured (mux/demux) and unframed test signals.

Signal	Framing	Channel structures
DS1	SF (D4), ESF, SLC-96, no frame, bit	56 kb/s, 64 kb/s, n x 56 kb/s, n x 64 kb/s
DS3	M13, C-bit	DS1, 2 Mb/s, 56 kb/s, 64 kb/s, n x 56 kb/s, n x 64 kb/s
2 Mb/s	PCM30, PCM30CRC, PCM31, PCM31CRC	64 kb/s, n x 64 kb/s
8 Mb/s	ITU-T G.742	2 Mb/s, 64 kb/s, n x 64 kb/s
34 Mb/s	ITU-T G.751	8 Mb/s, 2 Mb/s, 64 kb/s, n x 64 kb/s
140 Mb/s	ITU-T G.751	34 Mb/s, 8 Mb/s, 2 Mb/s, 64 kb/s, n x 64 kb/s

Test patterns

PRBS	2^{9}-1, 2^{11}-1(1), 2^{15}-1, 2^{20}-1(1), QRSS (2), 2^{23}-1. **Polarity control:** Inverted, non-inverted.
Word	All 1s, All 0s, 1010, 1000, 16-bit word, Incremental Byte(3). Note: Word not available in unframed mode
Agilent Instrumented Payload	An instrumented payload transmitted within the Ethernet frame enabling interworking N2X, RT900 and J2127A fitted with Ethernet test interfaces. CRC and sequence error measurements are provided.
Additional DS1 patterns	3-in-24, 1-in-8, 2-in-8, 55-octet (Daly).

Notes:

1. Not provided for GFP payloads.
2. Non-inverted only. Provided for DSn signals (including 56/64 kb/s channel testing) and VT1.5 bulk payloads.

Measurements

Error measurements

Measurement control	Manual, single, timed start.
Basic results	Error count, error ratio. Provided for the total measurement period and the most recent (last) measurement second.
SONET	**Transport O/H:** Frame (A1,A2), CV-S (B1), CV-L (B2), REI-L (CV-LFE) **Path O/H:** CV-P (B3), REI-P (CV-PFE) **VT:** CV-V(V5), CV-VFE(REI-V). **Bulk payload:** Bit. **Signal:** BPV (STS-1 and STS-3 interfaces).
SDH	**Section O/H:** Frame (A1A2), B1 BIP, B2 BIP, MS-REI **Path O/H:** B3 BIP, HP-REI **LO-path:** B3 (VC-3), BIP-2; LP-REI **Tandem path:** (VC-3/4 and VC-4-Nc): IEC, TC-REI, OEI, TC-ERR (VC-11/12): TC-REI,OEI,N2-BIP, TC-ERR **Bulk payload:** Bit. **Signal:** Code (STM-0e and STM-1e interfaces).
LCAS	CRC-8
GFP - Framed	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS, header mismatch.
GFP - Transparent	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, uncorrectable superblock errors, correctable superblock errors, 10B_ERR errors, payload FCS, header mismatch.
LAPS	Invalid control sequence, undersize frames, FCS, header mismatch.
Ethernet MAC	FCS, length/type mismatch, runt frames, jumbo frames, header mismatch.
DSn	**DS1:** BPV, frame, CRC6, bit. **DS3:** BPV, frame, P-bit, CP-bit, FEBE, bit.
PDH (En)	**2 Mb/s:** Code, frame, CRC4, E-bit, bit. **8Mb/s and 34 Mb/s:** Code, frame, bit. **140 Mb/s:** Frame, bit.
Performance analysis SONET, SDH, DSn and PDH	G.826, G.828, G.821, M.2100, M.2101, M2101.1, M.2110, M.2120.

Alarm detection and measurement

Results	Alarm seconds provided for all supported alarms.
Alarm LEDs	**Front panel LEDs:** **Red/green:** Signal, frame (all levels of framing), errors (any error type), pattern. **Red:** SONET/SDH (any SONET/SDH alarm), DSn/PDH (any DSn or PDH alarm), history (any error/alarm event earlier in measurement period). **Virtual LEDs** (accesses via front panel 'Show More' key): Graphical alarm display showing status information (including history) for all supported alarm types.
SONET	**Physical:** LOS **Transport O/H:** LOF, SEF, AIS-L, RDI-L, K1/K2 change. **Path O/H:** AIS-P, AIS-C, LOP-P, LOP-C, RDI-P, RDI-P-P, RDI-P-C, RDI-P-S, PDI-P, UNEQ-P, STS pointer change **VT path:** H4-LOM, P1P2 Loss, LOP-V, AIS-V, UNEQ-V, RDI-V, RDI-V-P, RDI-V-S, RDI-V-C, RFI-V, VT pointer adjustment. **Virtual Concatenation:** OOM1, OOM2, LOM, SQM **Payload:** Pattern loss. **Other:** Clock loss, power loss.
SDH	**Physical:** LOS. **Section O/H:** LOF, OOF, MS-AIS, MS-RDI, K1/K2 change. **Path O/H:** AU-AIS, AU-AIS-C, AU-LOP, AU-LOP-C, HP-RDI, HP-RDI-P, HP-RDI-C, HP-RDI-S, HP-UNEQ, AU pointer change **LO-path:** H4-LOM, TU-AIS, TU-LOP, LP-UNEQ, LP-RDI, LP-RFI, TU pointer change **Tandem path:** (VC-3/4 & VC-4-Nc): TC-OOM, VC-AIS, TC-IAIS, TC-RDI, ODI, TC-UNEQ (VC-11/12): TC-RDI, ODI, TC-IAIS, TC-OOM, TC-UNEQ. **Virtual Concatenation:** OOM1, OOM2, LOM, SQM **Payload:** Pattern loss **Other:** Clock loss, power loss
LCAS	GID Mismatch
GFP	Loss of Client Signal (LOCS), Loss of Client Character Synchronization (LOCCS), GFP link loss (no valid GFP frames)
LAPS	Erroneous Frame Alarm and Link Loss Alarm
DSn	**DS1:** LOS, LOF, AIS, RAI, excess zeros, pattern loss. **DS3:** LOS, LOF, LOMF, AIS, RAI, idle, DS3 framing mismatch, DS2 LOF, excess zeros, pattern loss.
PDH (En)	**2 Mb/s:** LOS, LOF, LOMF, AIS, RDI, RDI (MF), minor alarm, pattern loss. **8 /34/140 Mb/s:** LOS, LOF, AIS, RDI, minor alarm, pattern loss.

Additional measurements

Optical power	Supported for all optical receive rates. **Ranges:** 10/10.71 Gb/s: -3dBm to -25 dBm. 52Mb/s, 155Mb/s, 622Mb/s, 2.5 Gb/s: -3 dBm to -28 dBm. **Accuracy:** 10/10.71 Gb/s: ± 1.5 dB. 2.5 Gb/s: ± 2 dB. 622 Mb/s and below: ± 1 dB. **Resolution:** 0.1 dB.
Line frequency	Supported for all optical and electrical receive rates. **Results:** Frequency (Hz), Offset (Hz and ppm). **Accuracy:** ± 4.5 ppm **Resolution:** Frequency: 1 Hz (up to 622 Mb/s), 0.1 kHz (2.5 Gb/s and 10 Gb/s). Offset: 0.1 ppm.
Pointer measurements	Supported for both STS/AU and VT/TU pointers **Results:** Pointer value, increment count, decrement count, increment seconds, decrement seconds, NDF seconds, missing NDF seconds, SPE/VC offset (in ppm).
Virtual Concatenation	Measurement of differential delay with reference to earliest arriving member to a maximum of 256ms. VCAT Measurement Overview - a group alarm indication graphically displays active errors and alarms and in which member of the group the condition is present.
GFP	Data rate, bandwidth utilization, valid frames, invalid frames, valid idles frames, total frames, payload bytes, non idle bytes, all bytes, total superblocks, valid superblocks, invalid superblocks.
LAPS	Data rate, bandwidth utilization, valid frames, invalid frames, total frames, rate adaptation octets, payload bytes, all bytes, flag bytes.
Ethernet MAC	Data rate, frame size, valid frames, invalid frames, total frames, runt frames, jumbo frames, MAC bytes.
Service disruption	Measures the duration of an error burst detected in the received test pattern (not available for word patterns). Supported for all SONET/SDH mappings (including concatenated) and DSn/PDH signals. **Results:** Longest burst, shortest burst, last burst. **Range:** 50 µs to 2 s. **Accuracy:** ± 100 µs plus the sum of the applicable re-framing times. **Resolution:** 50 µs. **Re-framing time (maximum):** SONET/SDH: 250 µs STS/AU Pointer: 500 µs H4 multiframe (VT/TU): 1000 µs VT/TU Pointer: 2000 µs

Signal Wizard (all-channel testing)

Line rates

OTN: OTU2
SONET: OC-1/3/12/48/192, STS-1/3
SDH: STM-0/1/4/16/64o, STM-0/1e

Channel sizes

Supports detection and simultaneous monitoring of any 'mix' of the following channel types:
OTN: OPU2
SONET: STS-1, STS-Nc (where N = 3, 12, 48, 192).
SDH: AU-3, AU-4, AU-4-Nc (where N = 4, 16, 64).

Note: SignalWizard will identify STS/AU channels of any size (for example STS-24c, AU-4-8c). However, error and alarm results will only be provided for the channel types identified above.

Signal monitoring

Monitors the line signal for:

- CV-S (B1), CV-L (B2), CV-LFE (MS-REI) errors.
- LOS, LOF, OOF, AIS-L (MS-AIS), RDI-L (MS-RDI).
- Signal power/level.
- Synchronization status (S1) message.
- J0 section trace message.

Simultaneously monitors each STS/AU channel for:

- CV-P (B3), CV-PFE (HP-REI) errors.
- AIS-P (AU-AIS), LOP-P (AU-LOP), RDI-P (HP-RDI) alarms.
- Payload mapping type (C2 signal label).
- Pointer activity.
- J1 path trace message.

Simultaneous monitor of all VT/TU channels in selected STS/AU for:

- CV-V (BIP-2), CV-VFE (LP-REI) errors.
- AIS-V (TU-AIS), LOP-V (TU-LOP), RFI-V (LP-RFI), RDI-V (LP-RDI) alarms.
- Payload mapping type (V5 signal label).
- Pointer activity.
- J2 path trace message.

STS/AU channel viewer display

Results clearly presented on a colour-coded graphical display showing:

- Line rate and power/level of the received signal.
- Status (including history) for each line/section error and alarm.
- Text decode of synchronization status (S1) and J0 section trace.
- For each STS/AU channels:
  - Channel size and channel traffic information (equipped/unequipped and channels carrying VT/TU payloads).
  - Aggregated error/alarm status (including history) and pointer activity.
- For a selected STS/AU channel:
  - Status indicators (including history) for each channel error/alarm.
  - Pointer activity.
  - The payload mapping being carried (C2 signal label decode).
  - J1 path trace message.
- For each VT/TU channel in a selected STS/AU:
  - Channel size and traffic information (equipped/unequipped).
  - Aggregated error/alarm status (including history) and pointer activity.
- For a selected VT/TU channel:
  - Status (including history) for each channel error and alarm.
  - The payload mapping being carried (V5 signal label decode).
  - Pointer activity.
  - J2 path trace message.

Path routing test facilities

Overview of received path trace messages:

- Tabular display showing the J1 path trace message associated with each STS/AU channel in the received line signal.
- Tabular display showing the J2 path trace message associated with each VT/TU channel in a selected STS/AU.

Search for specified path trace message:

- Identifies channel that is carrying a user-specified path trace message.
- For J1 messages, the search is performed on all STS/AU channels in received signal.
- The J2 message search is performed on:
  - All VT/TU channels in a selected STS/AU channel.
  - All VT/TU channels in all STS/AU channels.
- Search can be performed using any sub-string contained in the target path trace message. Search results report up to 25 matches.

Channel traffic overview

Tabular display that lists for each STS/AU channel in the received signal:

- Channel number.
- Channel size/type.
- The payload mapping being carried.
- J1 path trace message.

Tabular display that lists for each VT/TU channel in a selected STS/AU:

- Channel number.
- Channel size/type.
- The payload mapping being carried.
- J2 path trace message.

Error and alarm generation

Error generation

OTN	**Physical:** Entire frame (1) **OTU2:** Frame (OA1,OA2), MFAS, BIP-8, BEI, correctable FEC errors, uncorrectable FEC blocks **ODU2:** BIP-8, BEI **Payload:** Bit **Error control:** Single, error all (3), M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps; n = 3 to 9)(4),
SONET	**Physical:** Entire frame (1) **Transport O/H:** Frame (A1A2), CV-S (B1), CV-L (B2), REI-L (CV-LFE) (2) **Path O/H:** CV-P (B3), REI-P (CV-PFE) **Bulk payload:** Bit. Additional error add capability provided by: **Signal:** BPV (STS-1). **VT path:** CV-V (V5), CV-VFE (REI-V). **DSn/En payload:** See DSn and PDH (En) error add for details. **Error Control:** Single, error all(3), M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps; n = 3 to 9)(4), N-in-4(5), N-in-T(6).
SDH	**Physical:** Entire frame (1) **Section O/H:** Frame (A1A2), B1 BIP, B2 BIP , MS-REI.(2) **Path O/H:** B3 BIP, HP-REI **Tandem path** (VC-3/4 and VC-4-Nc): IEC, TC-REI, OEI. **Bulk payload:** Bit. Additional error add capability provided by: **Signal:** Code (STM-0e). **LO-path:** B3 (VC-3), BIP-2 (VC-1/2); LP-REI. **Tandem path** (VC-11/12): TC-REI, TC-OEI, N2-BIP. **PDH/DSn payload:** See PDH and DSn error add for details. **Error Control:** Single, Error All (3), M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps; n = 3 to 9) (4), N-in-4 (5), N-in-T (6)(7)
Virtual Concatenation	B3 errors can be added to any or all members of the virtual concatenation group.
LCAS	CRC-8 errors can be added to any or all members of the virtual concatenation group.
GFP - Framed	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS.
GFP - Transparent	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, uncorrectable superblock errors, correctable superblock errors (pre scrambler), superblock errors (post scrambler), 10B_ERR errors, payload FCS.
LAPS	Undersize Frames <=7bytes, undersize frames <=5bytes, FCS, Invalid Control Sequence
Ethernet MAC	Jumbo Frame, Runt Frame, FCS
DSn	**DS1:** BPV(8), excess zeros(9), frame, CRC6, bit. **DS3:** BPV (8), excess zeros(9), frame, MFAS, P-bit, CP-bit, FEBE, bit. **Error Control:** Single, M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps, and n = 3 to 9)(4), N-in-4(10) , N-in-6(11)
PDH (En))	**2 Mb/s:** Code(8), frame, CRC4, E-bit, bit. **8 Mb/s and 34 Mb/s:** Code(8), frame, bit. **140 Mb/s:** frame, bit. **Error Control:** Single, M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps, and n = 3 to 9)(4), N-in-4(10).

Notes:

1. Errors added after scrambling (and also after FEC calculation for OTN) to simulate transmission errors.

2. For OC-192/STM-64, supports both the 'M1 only' and 'M0+M1' options of the standards.
3. Not supported for data, frame, MFAS BPV/code, FEC block or bit.
4. The maximum error rate for any error type is 1 x 10^{-3} or the maximum error rate supported by the error type (its saturation value), whichever is the lower.
5. Supported for frame (A1A2) errors. N = 1 to 4.
6. SONET: B2 errors only. N errors transmitted during time T (T = 10 ms to 1000 s in decade steps; N = 0 to 640 x n errors, where n is the hierarchical level of the STS-n/OC-n signal).
7. SDH: B2 errors only. N errors transmitted during time T (T = 10 ms to 1000 s in decade steps; N = 0 to 640 errors for STM-0, and 0 to 1920 x n errors for all other line rates, where n is the hierarchical level of the STM-n signal).
8. Not available when signal is a mapped payload in SONET/SDH or a channel within a higher rate DSn/PDH signal.
9. Single burst of 3 to 16 zeros (user selectable) transmitted without line coding.
10. Supported for DS3 frame, DS3 MFAS and PDH frame errors. N = 1 to 4.
11. Supported for DS1 frame errors. N = 1 to 6.

Alarm generation

Alarm control	On/Off/Single/Stress **On/Off:** The alarm is turned on or off **Single:** A single instance of the selected alarm is generated as per ITU-T /Telcordia recommendations **Stress test:** Performed using a 'p', 'n' and ' m' sequence. With alarm initial condition ON (OFF), the alarm is toggled OFF (ON) for 'p' frames followed by a continuous repeat of 'n' frames ON (OFF) then 'm' frames OFF (ON). The values of p, n and m can be changed hitlessly during testing. Note: Single and stress test only available for SONET and SDH alarm testing, excluding VT/TU alarms
OTN	**Physical:** LOS **OTU2:** LOF, OOF, OOM, AIS, IAE, BDI **ODU2:** AIS, OCI, LCK, BDI
SONET	**Physical:** LOS. **Transport O/H:** LOF, SEF, AIS-L, RDI-L. **Path O/H:** AIS-P, LOP-P, RDI-P, RDI-P-P, RDI-P-S, RDI-P-C, UNEQ-P. **VT path:** H4-LOM, AIS-V, LOP-V, RDI-V, RDI-V-P, RDI-V-S, RDI-V-C, RFI-V, UNEQ-V.
SDH	**Physical:** LOS. **Section O/H:** LOF, OOF, MS-AIS, MS-RDI. **Path O/H:** AU-AIS, AU-LOP, HP-RDI, HP-RDI-P, HP-RDI-C, HP,RDI-S, HP-UNEQ. **Tandem path:** (VC-3/4 and VC-4-Nc): TC-OOM, VC-AIS, TC-IAIS, TC-RDI, ODI, TC-UNEQ. **LO-path:** H4-LOM, TU-AIS, TU-LOP, LP-RDI, LP-RFI, LP-UNEQ. **Tandem path** (VC-11/12): TC-RDI, TC-ODI, VC-AIS, TC-UNEQ.
Virtual Concatenation	OOM1, OOM2, LOM, SQM - applied to selected member of group AIS-P, RDI-P, LOP-P, UNEQ-P, AIS-V, RDI-V, LOP-V, UNEQ -V applied to all SONET members. HP-AIS, HP-RDI, AU-LOP, HP-UNEQ, TU-AIS, LP-RDI, TU-LOP, LP-UNEQ - applied to all SDH members.
GFP - Framed and Transparent	Loss of Client Signal (LOCS), Loss of Client Character Synchronization (LOCCS) with configurable time interval between 100 and 1000ms.

LAPS	Erroneous frame - abort, - inverted FCS, link loss.
DSn	**DS1:** LOS, LOF, AIS, RAI. **DS3:** LOS, LOF, AIS, RAI, idle.
PDH (En)	**2 Mb/s:** LOS, LOF, LOMF, AIS, RDI, RDI (MF), minor alarm. **8 /34/140 Mb/s:** LOS, LOF, AIS, RDI, minor alarm.

Overhead testing

OTN overhead testing

Overhead Setup	Overhead bytes are user programmable in hexadecimal. Trace identifier messages are settable in ASCII. Restrictions: SM BIP-8 and PM BIP-8 are calculated values. Control of these bytes is achieved using the instrument error generation feature. No access to JC, NJO or PJO.
Overhead Monitor	Displays all received OTU, ODU and OPU overhead bytes in hexadecimal format. Values are updated approximately every second.
Overhead Sequence Generation	A single overhead channel can be chosen to have a sequence of hexadecimal values inserted. 256 different elements for the sequence can be defined, each element being the appropriate number of bytes for the selected overhead channel. Each element can be transmitted for a variable number of frames (1-65535). This sequence can be transmitted as a single run or repeated indefinitely. **Sequence Channels:** 6 Bytes: FAS 4 Bytes: APS/PCC 2 Bytes: GCC0-2, EXP 1 Byte: MFAS, TCM ACT, FTFL, RES, PM bytes 1 and 3, SM bytes 1 and 3, TCM 1-6 bytes 1 and 3, OPU2 bytes (excluding JC, NJO and PJO when in async mode) For TCM1-6, bytes 1 and 3 can be sequenced, the BIP-8 is calculated. Overhead sequences will be automatically synchronized to the MFAS if the number of frames in the sequence is a multiple or sub-multiple of 256 (e.g. 64, 128 or 512 frames).
Overhead Sequence Capture	A single overhead channel can be selected for capture. 256 unique values of the selected channel are displayed along with the number of frames (1-65535) for which each value has persisted. **Sequence Channels:** 6 Bytes: FAS (OA1, OA2) 4 Bytes: APC/PCC 2 Bytes: GCC0, TCM TOS, EXP, GCC1, GCC2 1 Byte: MFAS, TCM ACT, FTFL, RES, PM bytes 1 and 3, SM bytes 1 and 3, TCM 1-6 bytes 1 and 3, OPU2 bytes (not JC, NJO , PJO in async mode) **Trigger value:** User definable Capture is triggered when user defined value is • Equal to the received value in the selected channel or • NOT equal to the received value in the selected channel **Trigger Mask:** Trigger mask value settable by user. Only bits corresponding to a '1' in the mask value are used to detect trigger. **Trigger Selection:** • Manual. 256 values following the manual capture are displayed. • Pre trigger capture. Up to 256 values up to and including the trigger point are displayed. Capture is triggered as soon as possible after the capture is started, even if 256 values have not been captured. • Post trigger capture. Up to 256 values including and following the trigger point are displayed. The captured data is updated every second after the capture has triggered. • Centred capture. Up to 128 values before the trigger point and up to 128 values including and following the trigger point are displayed.
Frame Capture	Four complete optical channel frames including overhead, payload and FEC blocks can be captured for display and analysis. **Frame Capture Triggers:** Trigger Selection: • Manual - Four frames after the manual trigger are captured. • Pre-trigger - Four frames up to and including the trigger frame are captured. • Post-trigger - The trigger frame plus three following frames are captured. • Centered - Two frames before the trigger frame, the trigger frame and the next frame are captured. **Capture Triggers:** Frame capture can be triggered on receive triggers as detailed in "Event Trigger Outputs".
Trail Trace Identifiers	Text based set-up and monitoring of the SM and PM TTI message

SONET/SDH overhead testing

Overhead setup	All TOH/SOH, STS-path/HO-path, and VT-path/LO-path overhead bytes user programmable in hexadecimal. **Restrictions:** B1, B2, B3, H1 (SS-bits programmable), H2, H3, V1 to V4, V5 (bits 5-7 programmable).
Overhead monitor	Displays all TOH/SOH overhead bytes in a selected STS-3/STM-1group, plus all STS-path/HO-path and VT path/LO-path overhead bytes. Byte values are presented in hexadecimal.
Overhead Sequence Generation	A single overhead channel can be chosen to have a sequence of hexadecimal values inserted. 256 different elements for the sequence can be defined, each element being the appropriate number of bytes for the selected overhead channel. Each element can be transmitted for a variable number of frames (1-65535). Sequence transmitted as a single run or repeated indefinitely. **Sequence Channels:** 9 Bytes: D4-D12 6 Bytes: A1,A2 for STM-1 to 64 and STS-3 to 192 3 Bytes: D1-D3 2 Bytes: A1,A2 for STM-0 or STS-1, M0-M1 (STM-64 only), K1-K2, H1-H2 1 Byte: J0, E1, F1, Z0, J1, C2, G1, F2, H4, F3, K3, N1, H3
Overhead Sequence Capture	A single overhead channel can be selected for capture. 256 unique values of the selected channel are displayed along with the number of frames (1-65535) for which each value has persisted. **Sequence Channels:** 9 Bytes: D4-D12 6 Bytes: A1,A2 for STM-1 to 64 and STS-3 to 192 3 Bytes: D1-D3 2 Bytes: A1,A2 for STM-0 or STS-1, M0-M1 (STM-64 only), K1-K2, H1-H2 1 Byte: J0, E1, F1, S1, M1, Z0, J1, C2, G1, F2, H4, F3, K3, N1, H3 **Trigger value:** User definable Capture is triggered when user defined value is • Equal to the received value in the selected channel or • NOT equal to the received value in the selected channel **Trigger Mask:** Trigger mask value settable by user. Only bits corresponding to a '1' in the mask value are used to detect trigger. **Trigger Selection:** • Manual. 256 values following the manual capture displayed. • Pre trigger capture. Up to 256 values up to and including the trigger point are displayed. Capture is triggered as soon as possible after the capture is started, even if 256 values have not been captured. • Post trigger capture. Up to 256 values including and following the trigger point are displayed. The captured data is updated every second after the capture has triggered. • Centred capture. Up to 128 values before, the trigger point and up to 128 values including and following the trigger point are displayed.
Entire Overhead Capture	6 complete frames of overhead are captured. **Overhead selection:** • SOH+LOH / RSOH+MSOH or • STS/POH **Trigger selection:** • Manual - 6 frames after the manual trigger are captured • Pre-trigger - 6 frames up to and including trigger captured • Post-trigger - Trigger plus 5 following frames captured • Centred - 3 frames before the trigger frame, the trigger frame and the next 2 frames are captured **Capture Triggers:** Entire overhead capture can be triggered on receive triggers as detailed in "Event Trigger Outputs"
APS/MSP messages (K1K2)	Text-based setup and monitoring of APS/MSP messages. **Linear:** Messages comply with Telcordia GR-253-CORE Issue 3 and ITU-T G.783. **Ring:** Messages comply with Telcordia GR-1230 and ITU-T G.841
Active APS Test	NOTE: Only available for linear architecture. The ACTIVE APS message test gives real-time K1/K2 response to provide switching keep-alive capability. The instrument will not initiate any K1/K2 changes, but will respond to change requests that appear on the input K1/K2 byte values. K1/K2 response is sent (response time:10ms) if received value persists for 3 frames. **Operating Modes:** • Unidirectional • Bidirectional Emulation response time:10ms
Trace messages(J0, J1, J2, TC-APId)	Text-based setup and monitoring of all trace messages (J0, J1, J2, TC-APId (VC-3/4, VC-4-Nc), TC-APId (VC-11/12). **Message formats:** J0/J1/J2: Selectable as 16-byte or 64-byte format. TC-APId (SDH only): 16-byte format.
Synchronization status message (S1)	Text-based setup and monitoring of Synchronization Status messages. Messages comply with Telcordia GR-253-CORE Issue 3 and ITU-T G.707 (04/00 draft).
Signal labels (C2, V5)	Text-based setup and monitoring of payload signal labels (both STS path/HO-path and VT path/LO-path). Labels comply with Telcordia GR-253-CORE Issue 3 and ITU-T G.707 (04/00 draft).

LCAS overhead testing

LCAS Action	Source and/or sink can be selected in passive or active mode. **Active mode:** automatically interprets received LCAS messages and responds according to the state machine defined in ITU-T G.7042. **Passive mode:** provides full control of the LCAS messages being generated and can therefore verify device operation when LCAS messages are not generated according to ITU-T G.7042
Passive Source Mode	**Source Messages:** FIXED, ADD, NORM, EOS, IDLE, DNU, User Defined. There is no hit to the payload when bandwidth is increased or decreased. The generated Ethernet frame rate is automatically reduced to meet the configured bandwidth.

Passive Sink Mode	The RS-ACK bit for each member can be set manually to 0 or 1. All MST bits can be set manually.
Active Source Mode	The source state machine defined in ITU-T G.7042 is automatically executed. The state of the LCAS source state machine is displayed to the user. There is a separate state machine for each member set up. The SQI for each member is allocated by the source state machine and displayed to the user. The user can perform the following for any number of members. Increase bandwidth (add member), Decrease bandwidth (remove member). There is no hit to the payload when the bandwidth is increased or decreased. If the bandwidth is not sufficient to carry the configured Ethernet frame rate then it is automatically reduced.
Active Sink Mode	The sink state machine defined in ITU-T G.7042 is executed. The state of the LCAS sink state machine is displayed to the user. There is a separate state machine for each member. The possible states of the sink state machine are: OK, OK-WTR, FAIL, FAIL-WTR, IDLE. Settable Wait To Restore and Hold off timer. The RS-ACK and MST bits being transmitted for each member are displayed to the user. The instrument responds to commands to increase or decrease bandwidth on the receiver. The user can also request to add or remove members. There is no hit to the payload when the bandwidth is increased or decreased.
LCAS Protocol trace	LCAS protocol trace captures the sink and source message history in both normal receive and thru mode. All messages are time stamped to allow the events leading up to and after non-conformity to be traced.

GFP overhead testing

Overhead setup	User programmable PTI, PFI, EXI (linear, NULL, user definable), CID (Linear), UPI. User definable extension overhead can be configured to be between 0 and 60 bytes, each user byte programmable, eHEC automatically calculated.

LAPS overhead testing

Overhead setup	User programmable SAPI, Address, Control, FCS length (16/32 bit), scrambler (ON/OFF), Rate adaptation octet (Enable/Disable). Custom mode allows other HDLC encapsulations such as HDLC/PPP to be simulated using an Ethernet payload.

Ethernet overhead testing

Overhead setup	User programmable destination address, source address, VLAN (tagged/untagged), User priority (VLAN tagged), VLAN No. (VLAN tagged), Length/Type field, requested data rate.

SONET/SDH pointer adjustment control

The following pointer adjustment controls are provided as standard for STS-Nc/AU-4-Nc and STS/AU payload pointers.

New pointer	Transmits a new pointer address with or without a new data flag (NDF). Supports setting of any valid pointer value.
Burst	Single burst of adjustments transmitted in a selected pointer. **Adjustment polarity:** Incrementing, decrementing, alternating. **Burst size:** STS/AU and STS-Nc/AU-4-Nc: 1 to 10. VT/TU: 1 to 5. S**eparation of adjustments in burst:** STS/AU and STS-Nc/AU-4-Nc: 4 frames (500µs). VT/TU: 4 multiframes (2 ms).
Periodic sequence	Periodic sequence of pointer adjustments created by generating a frequency offset between the line and SPE/VC clocks. **Clock control:** User selectable as either: 1. SPE/VC clock offset, line clock locked to reference. 2. Line clock offset, SPE/VC clock locked to reference. **Offset:** User selectable in the range ± 100 ppm. **Setting resolution:** 0.1 ppm. **Accuracy:** 0.02 ppm.

Virtual Concatenation Delay Generation

Delay Generation	Full 256ms delay generation to ITU-T G.707 can be added to any or all members of the virtually concatenated group. Full delay applies to both high order and low order containers.
Delay Control	Delay can be entered in microseconds to 2 decimal places. ON/OFF control provides the ability to simulate APS events by instantly adding delay. In addition hitlessly pointer increment/decrement functions can be made to any or all members. This enables the compensation threshold of the device under test to be accurately determined. An automatic dynamic delay function continuously cycles between a settable maximum and minimum level from a settable initial delay position. This stress test simulates the effects of delay wander.

Encapsulation Analyzer (option 400)

Capture Buffer	GFP overhead and payload data is captured, interpreted, and displayed to the user. Clear textual decode allows frame characteristics to be quickly and easily identified. Errors and alarms are highlighted. **Buffer Size:** 512k bytes **Filtering:** Pre and post-capture filtering available. When field value triggering is selected, 2 pre-capture modes are available: All frames or Filtered frames (only frames meeting the filter criteria are captured). **Scrambling:** Data captured after de-scrambling. No GFP header error correction is performed prior to capture.
Capture Triggers	**Position:** Pre, Post and Center trigger available **High Order Path Overhead Triggers:** CV-P/B3 BIP, REI-P/HP-REI, IEC, TC-REI, OEI, RDI-P/HP-RDI, UNEQ-P/HP-UNEQ, PDI-P, VC-AIS, TC-RDI, TC-ODI, TC-UNEQ, TC-OOM, TC-AIS. **Payload Capture Triggers:** Uncorrectable and correctable Header Mismatch, Core Header Error, Type Header Error, Extension Header Error and Superblock Error. pFCS, 10B_ERR, Invalid GFP frame, Loss of Client Signal alarm, Loss of Client character Synchronisation alarm. **Field Value Triggers:** GFP- PLI, Type field, CID (Linear frame only), Spare (Linear frame), entire extension header field (1 to 60 bytes). If GFP with frame-mapped Ethernet payload is selected, the following addition Ethernet level triggers are available: Destination address, source address, Qtag Length/Type (VLAN tagged frames), User priority (VLAN tagged frames), CFI (VLAN tagged frames), MAC length/type.
Capture Display	**Numbering:** Captured frames are numbered 0 to N for post-trigger, -M to N for centred triggered and -N to 0. N and M depend on the number of frames captured. **Timestamp:** The time at which the capture is triggered is recorded. **Filter:** Captured data may be filtered to sort for display purposes. The following filters may be applied: Frame Type - Idle, Client Data, Client Management. Errored Frame - with highest priority error indicated. CID value, UPI value and Frame length value filters can all be applied **Error Decoding:** Errors present in the capture are highlighted to the user. The following error conditions are highlighted: Uncorrectable/Correctable Core Header Error, Type Header Error, Extension Header Error, Superblock Error. Also pFCS error and Ethernet FCS Error (GFP-Framed only) **Byte Interpretation:** The GFP header labels are displayed alongside the captured bytes. In addition, interpretation of field values is performed and displayed to the user in textual form. If GFP-Frame -Mapped Ethernet is selected Ethernet header labels are displayed alongside the captured bytes and field interpretation is performed. For GFP-T capture the superblocks are clearly identified.
Capture Data File	Captured data may be stored in.csv format. Three types of data storage may be selected: Raw data (ASCII form), Frame list (a one line summary for each frame captured displaying important information) and Frame data (entire captured data including interpretation fields).

Jitter/Wander generation

Jitter generation rates/interfaces	**SDH/SONET:** 10Gb/s, 2.5Gb/s, 622Mb/s, 155Mb/s, 52Mb/s **OTN:** 10.71 Gb/s
Wander generation rates/interfaces	**SDH/SONET:** 10Gb/s, 2.5Gb/s, 622Mb/s, 155Mb/s, 52Mb/s
Modulation source	**Internal Modulation:** Sinusoidal. **External modulation:** Frequency Range:

Data rate	Modulation frequency
52M	10Hz-400kHz
155M	10Hz-1.3MHz
622M	10Hz-5MHz
2.5G	10Hz-20MHz
10G	10Hz-80MHz
10.71G	10Hz-80MHz

Signal format: Sinusoidal but can be used with other signal formats.

Signal amplitude: 3v pk-pk, typical.

Maximum input level: ±5v peak.

Connector: BNC, 50Ω nominal unbalanced.

Jitter/Wander generation capability	The minimum requirements for jitter/wander amplitude/frequency generation function as defined by the standards are; 1. For SDH rates, ITU-T O.172 is used 2. For SONET, GR-253 is used 3. For OTN rates, ITU-T O.173 (draft) is used The OmniBER jitter/wander generation exceeds these requirements

Jitter/Wander generation (continued)

Frequency resolution	Wander Frequency Range (µHz)		Resolution (µHz)
	10	99.9	0.1
	100	999	1
	1,000	9,990	10
	10,000	99,900	100
	100,000	999,000	1,000
	1,000,000	10,000,000	10,000
	Jitter Frequency Range (Hz)		Resolution (Hz)
	1	999.9	0.1
	1,000	99,999	1
	100,000	999,990	10
	1,000,000	9,999,900	100
	10,000,000	80,000,000	1,000
Jitter/Wander Amplitude	Amplitude Range (UI)		Resolution (UI)
	0.001	99.999	0.001
	100	999.99	0.01
	1,000	9,999.9	0.1
	10,000	1,000,000	1
Jitter/Wander generation accuracy	**Frequency:** ±0.1% at all frequencies **Amplitude:** ±Q% of setting ± 0.02 UIpp		
	Variable error (Q)		
	Data Rate	Error, Q (%)	Frequency Range (Hz)
	52M	± 7% ± 8%	10µ to 300 300 - 400k
	155M	± 7% ± 8% ± 12%	10µ to 500 500 to 500k 500k to 1.3M
	622M	± 7% ± 8% ± 12% ± 15%	10µ to 1k 1k to 500k 500k to 2M 2M to 5M
	2.5G	± 7% ± 8% ± 12% ± 15%	10µ to 5k 5k to 500k 500k to 2M 2M to 20M
	10G	± 7% ± 8% ± 12% ± 15%	10µ to 20k 20k to 500k 500k to 2M 2M to 80M
	10.71G	± 8% ± 12% ± 15%	500 to 500k >500k to 1M >1M to 20M
Intrinsic jitter/wander	Intrinsic jitter/wander (measured in bandwidth f_1-f_4)		
		J7231B J7233A	J7232A J7230B
Data: PRBS23 bulk filled	52/155/622M	0.06UI pp	0.1UI pp
	2.5/10G	0.08UI pp	0.3UI pp
Data: PRBS31 bulk filled	10.7G	0.08UI pp	0.3UI pp

Jitter measurement

Jitter measurement rates/interfaces

SDH/SONET: 10 Gb/s, 2.5 Gb/s, 622Mb/s, 155Mb/s, 52 Mb/s.
OTN: 10.71 Gb/s

Optimum input power for jitter measurement

	52Mb/s - 2.5Gb/s	10Gb/s & 10.71Gb/s
Nominal input power	-15 dBm	- 8 dBm

Jitter measurement bandwidth

		Filters (2,3)		
Measurement Range	**Demodulation Bandwidth (1)**	**HP**	**LP**	**Measurement Bandwidth (4,5)**
52M Line Rate				
'Super-Fine'	10 Hz - 1.6 MHz	100Hz, 12kHz, 20kHz	400kHz	100 Hz - 400 kHz
'Fine'	10 Hz - 1.6 MHz	100Hz, 12kHz, 20kHz	400kHz	100 Hz - 400 kHz
'Medium'	10 Hz - 130 kHz	100Hz, 12kHz, 20kHz	400kHz	100 Hz - 80 kHz
155M Line Rate				
'Super-Fine'	10 Hz - 6.5 MHz	500Hz, 12kHz, 65kHz	1.3MHz	500 Hz - 1300 kHz
'Fine'	10 Hz - 6.5 MHz	500Hz, 12kHz, 65kHz	1.3MHz	500 Hz - 1300 kHz
'Medium'	10 Hz - 400 kHz	500Hz, 12kHz, 65kHz	1.3MHz	500 Hz - 230 kHz
622M Line Rate				
'Super-Fine'	10 Hz - 16.5MHz	1kHz, 12kHz, 250kHz	5MHz	1 kHz - 5000 kHz
'Fine'	10 Hz - 16.5MHz	1kHz, 12kHz, 250kHz	5MHz	1 kHz - 5000 kHz
'Medium'	10 Hz - 1.6 MHz	1kHz, 12kHz, 250kHz	5MHz	1 kHz - 1040 kHz
2.5G Line Rate				
'Super-Fine'	10 Hz - 28 MHz	5kHz, 12kHz, 1MHz	20MHz	5 kHz - 20 MHz
'Fine'	10 Hz - 28 MHz	5kHz, 12kHz, 1MHz	20MHz	5 kHz - 20 MHz
'Medium'	10 Hz - 13 MHz	5kHz, 12kHz, 1MHz	20MHz	5 kHz - 11 MHz

		Filters [2,3]		
Measurement Range	**Demodulation Bandwidth** [1]	**HP**	**LP**	**Measurement Bandwidth** [4,5]
10G Line Rate				
'Super-Fine'	10 Hz - 95 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	20 kHz - 80 MHz
'Fine'	10 Hz - 95 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	20 kHz - 80 MHz
'Medium'	10 Hz - 13 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	20 kHz - 11 MHz
10.7GLine Rate				
'Super-Fine'	10 Hz - 95 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	10 kHz - 80 MHz
'Fine'	10 Hz - 95 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	10 kHz - 80 MHz
'Medium'	10 Hz - 13 MHz	10kHz, 12kHz, 20kHz, 50kHz, 4MHz	80MHz	20 kHz - 11 MHz

Notes:
1. This represents the unfiltered frequency range of the receiver.
2. Independent simultaneous selection of high pass (HP) and low pass (LP) filters [Hz].
3. Filter transition band responses: HP -20 dB / decade, LP -60 dB / decade.
4. The total jitter receiver accuracy is specified over this -3 dB measurement bandwidth.
5. Measurement bandwidth taken from G.825 Table 1 for 155M to 10G, G.8251 Table 1 for 10.7G

Measurement filters

Rate	**HP1**		**HP2**	**HP**		**LP**
		f_1	f_3	**HP**		f_4
52 M		100 Hz	20 kHz		12 kHz	400 kHz
155 M		500 Hz	65 kHz		12 kHz	1.3 MHz
622 M		1 kHz	250 kHz		12 kHz	5 MHz
2.5 G		5 kHz	1 MHz		12 kHz	20 MHz
10 G /10.71G	10 kHz	20 kHz	4 MHz	12 kHz	50 kHz	80 MHz

Parallel Measurement Filters

This feature provides the ability to measure jitter measurement bandwidth ranges in parallel.

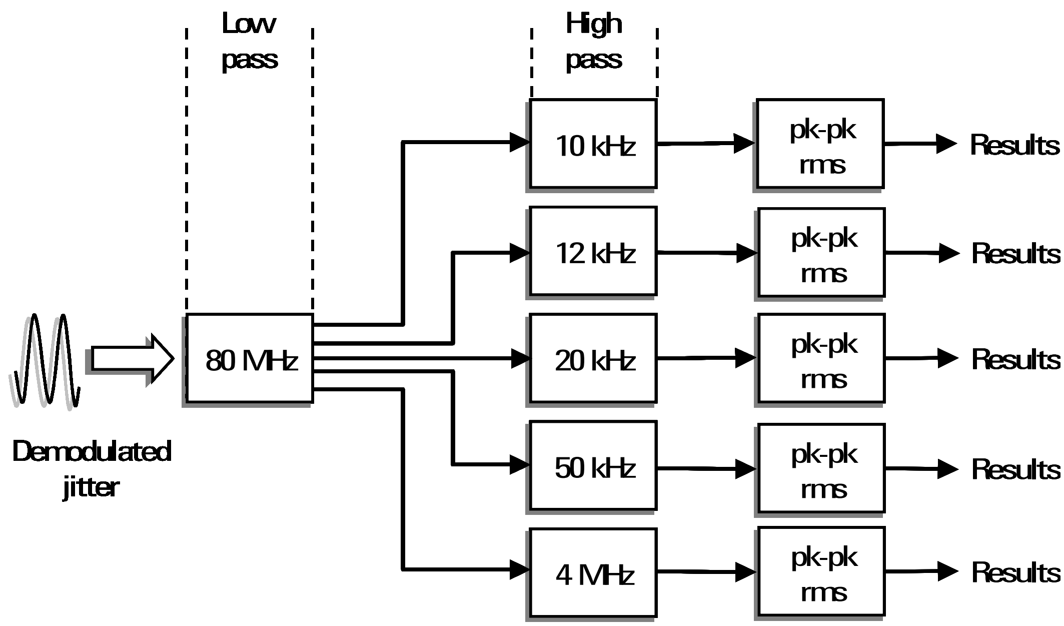


Figure 10: Parallel Measurement Filters

Results for all measurement bandwidth ranges are calculated simultaneously. This means that up to 5 sets (dependent on line rate) of measurement results are available simultaneously, dependent on the measurement configuration.

Possible measurement configurations are:

- Filters Off
- LP filter on, HP filters off.
- LP filter off, HP filters on (up to 5).
- LP filter on, HP filters on (up to 5).

Jitter measurement accuracy

Receiver accuracy

The measurement accuracy is specified as:

$$UI_{pp} \pm \left(R\% \text{ of reading} + W + \text{Resolution} \right)$$

$$UI_{rms} \pm \left(\sqrt{(R\% \text{of reading})^2 + (W)^2} + \text{Resolution} \right)$$

(Spec for UI_{RMS} is typical)

where W represents the intrinsic jitter for a given data pattern and receiver range, R represents the frequency response term of the receiver, and Resolution represents the receiver range resolution.

Intrinsic Term W

Data Rate	Maximum peak-to-peak jitter error (UIpp) for given digital signals								
	Super-Fine, Fine, Medium range								
	(f_1-f_4)			(f_3-f_4)			(HP-f_4)[(4)]		
	O.172/3 (Rx)	Receiver	System	O.172/3 (Rx)	Receiver	System	GR-253	Receiver	System
52M [(1)]	0.070	0.035	0.070	0.050	0.035	0.070	0.100	0.035	0.070
155M [(1)]	0.070	0.035	0.070	0.050	0.035	0.070	0.100	0.035	0.070
622M [(1)]	0.100	0.035	0.070	0.050	0.035	0.070	0.100	0.035	0.070
2.5G [(1)]	0.100	0.035	0.070	0.050	0.035 [(5)]	0.070	0.100	0.035 [(5)]	0.070
10G [(2)] (option 200)	0.150	0.050 (typical)	0.080	0.050	0.035 (typical)	0.070	0.100	0.035 (typical)	0.070
10G [(2)] (option 205)	0.150	0.035	0.080	0.050	0.025 [(5)]	0.070	0.100	0.025 [(5)]	0.070
10G [(2)] (option 210)	0.150	0.035	0.080	0.050	0.015 [(5)]	0.050	0.100	0.015 [(5)]	0.060
10.7G [(3)] (option 200)	0.150	0.050 (typical)	0.080	0.050	0.035 (typical)	0.070	0.100	0.035 (typical)	0.070
10G [(2)] (option 205)	0.150	0.035	0.080	0.050	0.025 [(5)]	0.070	0.100	0.025 [(5)]	0.070
10G [(2)] (option 210)	0.150	0.035	0.080	0.050	0.015 [(5)]	0.050	0.100	0.015 [(5)]	0.060

Notes:

1. 52M -2.5G measured with an STM-Nc signal with a 2^{23}-1 inverted PRBS, as specified in O.172
2. 10G measured with an STM-Nc signal with a 2^{31}-1 inverted PRBS, as this is the most stringent pattern.
3. 10.7G measured with a OTUk signal (FEC on) with a frame structure and payload mapping of a 231-1 inverted PRBS test signal into a OPUk, as specified in O.173.
4. Accuracy specified in 3 frequency ranges: f1-f4, f3-f4, HP-f4. Where HP is 12kHz for rates up to 2.5G, and 50kHz at 10 and 10.7G.
5. Receiver intrinsic values guaranteed using ITU-T O.172 Appendix VII calibration. Option 210 must be ordered. Instrument supplied with 2.5G and 10G accuracy maps individual to instrument. Specified for optical power range -6dBm to -10dBm, temperature range 20oC to 30oC. non-option 210 instruments

Data Rate	Maximum rms jitter error (UIrms) for given digital signals								
	Super-Fine, Fine, Medium range								
	$(f_1\text{-}f_4)$			$(f_3\text{-}f_4)$			$(HP\text{-}f_4)$ (4)		
	O.172/3	Receiver	System	O.172/3	Receiver	System	GR-253	Receiver	System
52M (1)	N/A	0.004	0.005	N/A	0.003	0.004	0.01	0.004	0.005
155M (1)	N/A	0.004	0.005	N/A	0.003	0.004	0.01	0.004	0.005
622M (1)	N/A	0.004	0.005	N/A	0.003	0.004	0.01	0.004	0.005
2.5G (1)	N/A	0.004	0.007	N/A	0.003	0.005	0.01	0.004	0.006
10G (2)	N/A	0.004 (5)	0.007	N/A	0.003 (5)	0.005	0.01	0.004 (5)	0.006
10.7G (3)	N/A	0.004 (5)	0.008	N/A	0.003 (5)	0.006	0.01	0.004 (5)	0.007

Notes:
1. 52M -2.5G measured with an STM-Nc signal with a 2^{23}-1 inverted PRBS, as specified in O.172
2. 10G measured with an STM-Nc signal with a 2^{31}-1 inverted PRBS, as this is the most stringent pattern.
3. 10.7G measured with a OTUk signal (FEC on) with a frame structure and payload mapping of a 231-1 inverted PRBS test signal into a OPUk, as specified in O.173.
4. Accuracy specified in 3 frequency ranges: f1-f4 , f3-f4, , HP-f4. Where HP is 12kHz for rates up to 2.5G, and 50kHz at 10 and 10.7G.
5. 10 and 10.7G receiver intrinsic values are nominal.

Accuracy Resolution

Range	Rate	Peak-Peak Resolution (UIpp)	RMS Resolution (UIrms)
'Super-Fine'		±0.001	±0.0005
'Fine'		±0.01	±0.002
'Medium'		±0.040	±0.020
'Extended'	52M	±0.025	±0.012
	155M	±0.075	±0.037
	622M	±0.3	±0.15
	2.5G	±1.2	±0.6
	10G	±5	±2.5
	10.7G	±5	±2.5

Receiver Frequency Inaccuracy Term R

Data Rate	Additional frequency response error		Frequency Range
	R term		
	0.172/3	J7231B	
52M	For Further Study	±5% ±6%	100 Hz to 300 kHz 300 kHz to 400 kHz
155M	±7% ±8% ±10%	±5% ±6% ±7%	500 Hz to 300 kHz 300 kHz to 1 MHz 1 MHz to 1.3 MHz
622M	±7% ±8% ±10% ±15%	±5% ±6% ±7% ±10%	1 kHz to 300 kHz 300 kHz to 1 MHz 1 MHz to 3 MHz 3 MHz to 5 MHz
2.5G	±7% ±8% ±10% ±15% ±20%	±5% ±6% ±7% ±10% ±15%	5 kHz to 300 kHz 300 kHz to 1 MHz 1 MHz to 3 MHz 3 MHz to 10 MHz 10 MHz to 20 MHz
10G	±7% ±8% ±10% ±15% ±20%	±5% ±6% ±7% ±10% ±15%	20 kHz to 300 kHz 300 kHz to 1 MHz 1 MHz to 3 MHz 3 MHz to 10 MHz 10 MHz to 80 MHz
10.7G	±7% ±8% ±10% ±15% ±20%	±5% ±6% ±7% ±10% ±15%	20 kHz to 300 kHz 300 kHz to 1 MHz 1 MHz to 3 MHz 3 MHz to 10 MHz 10 MHz to 80 MHz

Note:
The OmniBER OTN jitter models (J7231B and J7233A) exceed the requirements in ITU-T O.172. The 'R term' values shown are with respect to a calibrated value at 100kHz. At 100kHz, R=0. The frequency response term will only apply over the instrument measurement bandwidth.

Jitter measurement results

Jitter Hits

Jitter hits detected when the programmable thresholds for positive or negative jitter values are exceeded.

Hit threshold

+ve peak
-ve peak
(+ve and -ve peaks are independently settable)

Both are specified in UI, as below:

Range	Rate	Minimum value (UI)	Maximum value (UI)	Resolution (UI)
'Super-Fine'		0.025	0.4	0.005
'Fine'		0.025	1.5	0.005
'Medium'		0.25	15	0.05
'Extended'	52M	0.5	32	0.1
	155M	0.5	32	0.1
	622M	0.5	128	0.1
	2.5G	5.0	1,250	1.0
	10G	5.0	5,000	1.0
	10.7G	5.0	5,000	1.0

Total results

+ve hit count
-ve hit count
hit seconds
hit free seconds

Amplitude	
Total & last second results	A display of the 'total' and 'last second' jitter amplitude results for each of the active receiver measurement bandwidths (each filter bandwidth is selected individually). +ve peak -ve peak peak-to-peak RMS
Parallel filters	A display of the 'peak-to-peak' & RMS jitter amplitude results for ALL of the active receiver measurement bandwidths.

Demodulated jitter out

Range	Gain (UIpp/V) (1)	
Super-Fine		1 mUI/mV
Fine		5 mUI/mV
Medium		50 mUI/mV
Extended	52M / 155M	50 mUI/mV
	622M	0.1 UI/mV
	2.5G	1 UI/mV
	10/10.7G	10 UI/mV

Notes:
1. Nominal

Format: Reconstructed analogue output, 50Ω single ended DC coupled to ground. The filter bandwidth of the demodulated output can be selected when more than one filter is active.

Jitter tolerance

Jitter tolerance modes

Auto tolerance, Fast auto tolerance, Sweep, Spot

Auto tolerance	Automatic jitter generation/measurement mode. Determines the maximum jitter amplitude tolerated by the DUT, and compares it against the selected tolerance mask. The result of this measurement shows the margin to which the device passes or fails against the selected tolerance mask.
Fast auto tolerance	Automatic jitter generation/measurement mode. Tests DUT for conformance to the tolerance mask. The frequency/amplitude values are set precisely to the values defined by the tolerance mask. At each frequency point, the receiver is checked against the desired performance criteria. The result of this measurement is shown as a PASS or FAIL.
Sweep	Automatic jitter generation mode. Equivalent to fast auto tolerance without measurement i.e. generation only.
Spot	Manual jitter generation mode. Jitter is generated at selected spot frequencies at amplitude defined by the selected tolerance mask.

Jitter tolerance test methods

Both 'Onset of errors' and 'BER penalty' methods are supported:

Onset of errors	The jitter amplitude is increased until the number of errors crosses a certain threshold. All (non-FEBE) error sources will be tested against a threshold of 0 at each amplitude point as per `Supplement No. 3.8 of the O-Series Recommendations'.
BER penalty	Only bit errors are tested against a selected error threshold at each amplitude point as per `Supplement No. 3.8 of the O-Series Recommendations'. In either case, any active alarm will result in the test recording a failure.

Test configuration

Number of points	1 to 100
Input Mask	Select from Fixed masks or User programmable masks.
Frequency range	The selected tolerance mask defines the default frequency range for the measurement. To enable the user to 'zoom-in' to a particular frequency range of interest, the frequency range for the measurement can be changed. • 10Hz to 80MHz (dependent on rate)
Settling time	Time taken for DUT to settle, before measurement, 0.1 to 99.9s in 0.1s steps
Gate time	Time spent measuring, 0.1 to 99.9s in 0.1s steps.

Error criteria	Onset of errors: Errored seconds = 2. All errors. Gate time = 30s. BER penalty: 100 or more BIT errors, observed during 1s. User defined criteria can also be applied to the above.

Error Criteria (1)	BER Penalty	Onset of Errors	Error Count
	Point where 100 or more Bit errors occur in 1s.	Point where 2 errored seconds occur in 30s.	Point where errors (equal to or more than the set Count) occur during the set Gate Time.
Error Source	Bit	All	Select from: OTN: OTU BIP,ODU BIP, Bit, All (2) SONET: B1,B2,B3,Bit, All (2) SDH: B1,B2,B3,IEC,OEI,Bit, All (2)
Error Count	100	Not Valid	n where 1≤n≤1,000,000
Error Rate	Calculated (3,4)	Not Valid	Calculated (3) (no Error Rate field when Error Source is 'All')
Errored Seconds	Not Valid	2	Not Valid
Gate Time	0.1 to 99.9 sec, 0.1sec steps. Default - 1s	0.1 to 99.9 sec, 0.1 sec steps. Default - 30s	0.1 to 99.9 sec, 0.1 sec steps.
Settling Time	0.1 to 99.9 sec, 0.1 sec steps.	0.1 to 99.9 sec, 0.1 sec steps.	0.1 to 99.9 sec, 0.1 sec steps.

Notes:
1. Criteria selection affects the availability of Error Source/Count/Rate and Errored seconds fields.
2. The selection, Error Source = 'All', sets a criteria of 'any errors'.
3. Error Rate calculated is affected by the Gate Time configured.
4. When the Rx input to OmniBER is OTN, BER is measured by leaving the FEC enabled and counting the number of corrected bit errors per unit time.

Jitter tolerance results

The frequency/amplitude result pairs results can be displayed in tabular or graphical form.

Graph

The graphical display shows the measurement results plotted against the selected tolerance mask.
A failure is indicated if the measured point is below the mask.

Text

The tabular results show the following information displayed for each point:

- Point Number
- Frequency
- Mask Value
- Result
- Pass / Fail Margin
- Pass / Fail Indication

Jitter Tolerance Masks

The following fixed Jitter Tolerance masks are provided:

Data Rate	OTN Masks [1]	SDH Masks [1]		SONET Masks [1]
	G.8251	G.825	G.783	GR-253
52 Mb/s				•
155 Mb/s		•	•	•
622 Mb/s		•	•	•
2.5 Gb/s		•	•	•
10 Gb/s		•	•	•
10.7 Gb/s	•			

Notes:
1. The list of masks available for selection is dependent on the input data rate of the network element under test only, i.e. it is not restricted by the selected instrument mode (OTN, SDH, or SONET).

G.8251 Masks

Rate	Mask	G.825 Mask
10.7[1] Gb/s	G.8251	Table 3, Figure 2

G.825 Masks

Both variants of the G.825 mask are supported:

1. G.825 1.5M: networks based on the 1.5 Mb/s hierarchy
2. G.825 2M: networks based on the 2 Mb/s hierarchy

Rate	Mask	G.825 Mask
155 Mb/s	G.825 (1.5Mb/s networks)	Table 3, Figure 1
	G.825, (2Mb/s networks)	
622 Mb/s	G.825 (1.5Mb/s networks)	Table 5, Figure 3
	G.825, (2Mb/s networks)	
2.5 Gb/s	G.825 (1.5Mb/s networks)	Table 6, Figure 4
	G.825, (2Mb/s networks)	
10 Gb/s	G.825 (1.5Mb/s networks)	Table 7, Figure 5
	G.825, (2Mb/s networks)	

G.783 Masks

Both variants of the G.783 mask are supported:

1. G.783 Type A: Type A regenerators require to tolerate input jitter as per G.825. The high-band portion of the G.825 jitter tolerance masks is given in G.783.
2. G.783 Type B: Type B regenerators have reduced jitter tolerance.

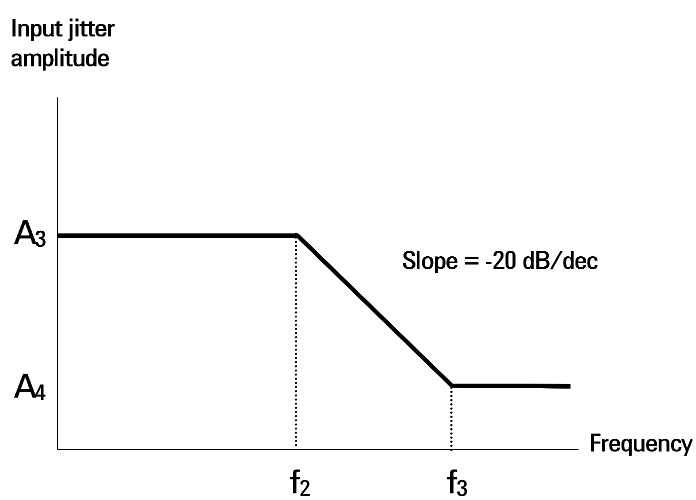


Figure 11: G. 783 Input Jitter Tolerance Mask

Rate	G.783 Mask	f_1	f_2	f_3	f_4	A_3	A_4
155 Mb/s	Type A (Table 15-1)	500	6.5k	65k	1.3M	1.5	0.15
622 Mb/s	Type A (Table 15-1)	1k	25k	250k	5M	1.5	0.15
2.5 Gb/s	Type A (Table 15-1)	5k	100k	1M	20M	1.5	0.15
10 Gb/s	Type A (Table 15-1)	10k	400k	4M	80M	1.5	0.15

Rate	G.783 Mask	f_1	f_2	f_3	f_4	A_3	A_4
155 Mb/s	Type B (Table 15-1a)	10	1.2k	12k	1.3M	1.5	0.15
622 Mb/s	Type B (Table 15-1a)	10	1.2k	12k	5M	1.5	0.15
2.5 Gb/s	Type B (Table 15-1a)	10	1.2k	12k	20M	1.5	0.15
10 Gb/s3	Type B (Table 15-1a)	10	1.2k	12k	80M	1.5	0.15

GR-253 Masks

Two variants of the GR-253 mask are supported:

1. GR-253 Requirement Mask
2. GR-253 Objective Mask

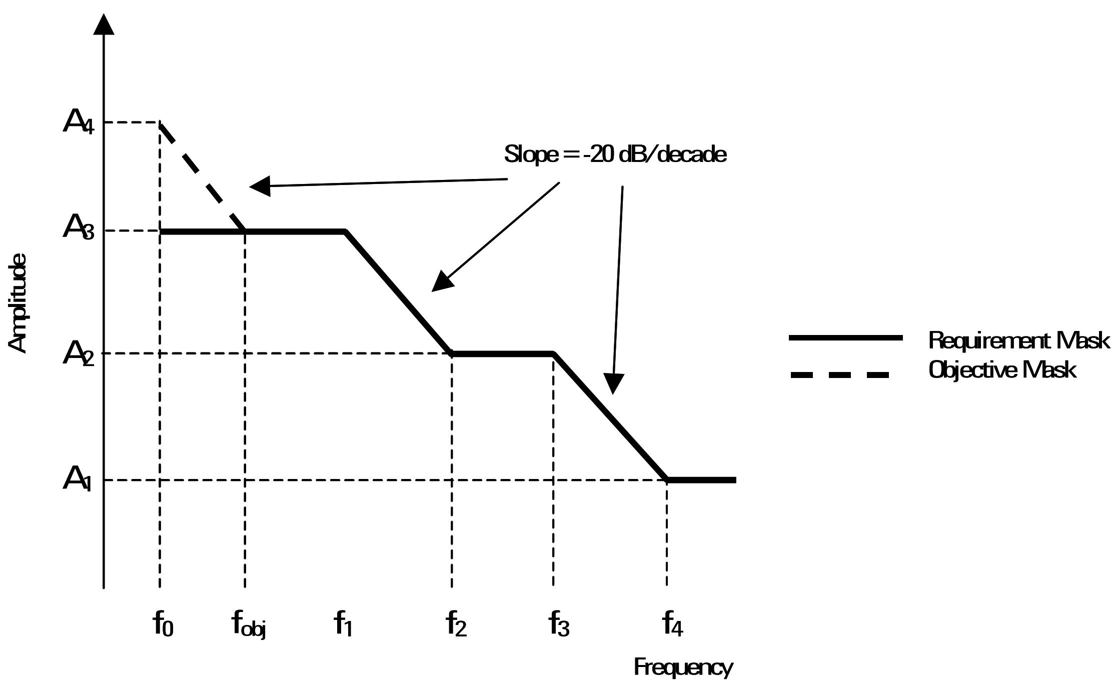


Figure 12: GR-253 Input Jitter Tolerance Masks

Rate	Mask	F0	Fobj	F1	F2	F3	F4	F5	A1	A2	A3	A4
		(Hz)	(Hz)	(Hz)	(Hz)	(kHz)	(kHz)	(kHz)	(UI)			
52 Mb/s	GR-253[1]	10	-	30	300	2	20	400	0.15	1.5	15	-
155 Mb/s	GR-253[1]	10	-	30	300	6.5	65	1300	0.15	1.5	15	-
622 Mb/s	GR-253[1]	10	18.5	30	300	25	250	5000	0.15	1.5	15	27.8
2.5 Gb/s	GR-253[1]	10	70.9	600	6000	100	1000	20000	0.15	1.5	15	106.4
10 Gb/s	GR-253[1]	10	296	2000	20000	400	4000	80000	0.15	1.5	15	444.6

Note - Values taken from GR-253, Figure 5-28.

User-programmable masks

Ability to create, edit and title user defined masks.

No of masks	Up to 10 user masks
Mask title	15 character string
Mask create/delete	A flexible mask creation scheme is provided, offering the following features: New: Create user mask. Copy: From 'preset' or 'user'. Allows a mask to be copied from one of the preset masks defined by the standards, or another mask. Delete: Delete user mask.
Mask edit	Scale factor: Allows all points on the mask to be shifted by 0 to +/- 100%, with single percent resolution. Useful for margin testing. Delete: single point Add/Edit: single point.
Display	The user mask is displayed in both tabular and graphical form.

Jitter transfer

Jitter transfer function

An automatic jitter transfer function is available when both transmitter and receiver are configured to the same rate.

Test configuration

Number of points	1 to 100
Input mask	Fixed masks: as per Jitter Tolerance User Programmable masks: up to 10
Frequency range	10Hz to 80MHz (dependent on rate)
Offset	An offset in the range -2.00 dB to +2.00 dB in steps of 0.01 dB can be added to the selected Pass Mask.
Settling time	5 to 30s, in 1s steps
Gate time	5 to 30s, in 1s steps

Jitter transfer receiver

A narrowband filtering technique is used when performing a jitter transfer measurement.

Dynamic range	+5 dB to -40 dB.
Recommended settling time	10s
Recommended gating time:	20s

Jitter transfer accuracy

The specification of SDH equipment jitter transfer characteristics in G.783 [5] uses a gain-versus-frequency mask to limit the maximum transfer gain (P) and the maximum transfer bandwidth (f_C). This mask is specified in between the frequency range f_L to f_H. The accuracy of the jitter transfer measurement depends on several factors: the repeatability of the jitter generator's performance, the linearity and repeatability of the jitter measurement equipment's performance, and the noise floor of the measurement. Where the jitter frequency f_m is less than f_C, the measurement accuracy affects the determination of whether the gain limit P has been met. Where the jitter frequency f_m is greater than f_C, the measurement accuracy affects the determination of whether the bandwidth limitation mask above f_C is not exceeded.

The total measurement error in the jitter frequency range $f_L = 0.01 \cdot f_C$ and $f_H = 100 \cdot f_C$ or f_4, if f_4 is lower than $100 \cdot f_C$ and for input jitter amplitudes $\geq 0.15\ UI_{pp}$ shall be less than:

$$\pm 0.05\ \text{dB} \pm 0.12 \cdot g$$

where *g* is the measured jitter transfer gain at the jitter frequency f_m in dB.

Jitter transfer results

The jitter transfer results can be displayed in tabular or graphical form.

Graph	The result is plotted on a graph of gain versus frequency. The pass mask is `displayed on the graph as well as the results.
Text	Point number, frequency, mask value, result, pass/fail indication.

Jitter Transfer pass masks

Data Rate	OTN Masks (1)	SDH Masks (1)				SONET Masks (1)	
Input Mask	G.8251 ODCr	G.825		G.783	G.783	GR-253	
		1.5M	2M	A	B	Req	Obj
Pass Mask		G.783			G.783	GR-253	
		A			B		
52 Mb/s						•	
155 Mb/s		•				•	
622 Mb/s		•				•	
2.5 Gb/s		•				•	
10 Gb/s		•				•	
10.7 Gb/s	•						

Notes:
1. The list of masks available for selection is dependent on the data rate only (Tx - Input Mask, Rx - Pass Mask) only, i.e. it is not dependent on the selected instrument mode (OTN, SDH, or SONET).

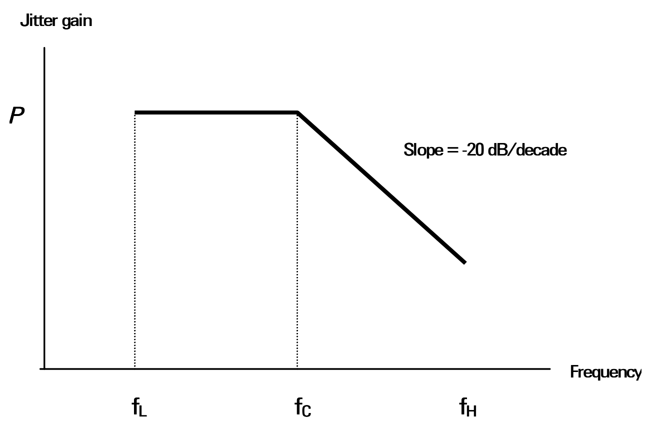


Figure 13: Jitter Transfer Pass Mask

fL and fH define the start and stop frequency respectively for the jitter transfer measurement.

G.8251 Masks

Rate	Mask	f_L (Hz)	f_C (Hz)	f_H (Hz)	P (dB)	Input Mask
10.7 Gb/s	G.8251, ODCr	10k	1000k	80M	0.1	G.8251

G.783 Jitter Transfer Pass Mask

Two variants of the G.783 pass mask are supported:

- G.783 Type A
- G.783 Type B

Rate	Mask	f_L (Hz)	f_C (Hz)	f_H (Hz)	P (dB)
155Mb/s	G.783, Type A	1.3k	130k	1.3M	0.1
622Mb/s	G.783, Type A	5k	500k	5M	0.1
2.5 Gb/s	G.783, Type A	20k	2000k	20M	0.1
10 Gb/s	G.783, Type A	10k	1000k	80M	0.1

Rate	Mask	f_L (Hz)	f_C (Hz)	f_H (Hz)	P (dB)
155Mb/s	G.783, Type B	0.3k	30k	1.3M	0.1
622Mb/s	G.783, Type B	0.3k	30k	3M	0.1
2.5 Gb/s	G.783, Type B	0.3k	30k	3M	0.1
10 Gb/s	G.783, Type B	0.3k	30k	3M	0.1

GR-253 Jitter Transfer Pass Mask

Rate	Mask	f_L (Hz)	f_C (Hz)	f_H (Hz)	P (dB)
52Mb/s	GR-253-CORE	0.4k	40k	400k	0.1
155Mb/s	GR-253-CORE	1.3k	130k	1.3M	0.1
622Mb/s	GR-253-CORE	5k	500k	5M	0.1
2.5 Gb/s	GR-253-CORE	20k	2000k	20M	0.1
10 Gb/s	GR-253-CORE	1.2k	120k	12M	0.1

Calibration

Before a test cycle can be performed, the instrument must be connected back-to-back in order to perform a calibration cycle. This will need to be redone after a configuration change is performed or when any of the parameters associated with the test are changed.

Note: To meet the quoted accuracy, the instrument MUST have been switched on in stable climatic conditions for at least 1 hour before starting a calibration cycle. Also, from start of calibration until end of measurement, the climatic conditions MUST remain stable.

Wander measurement

Wander measurement rates	**SDH/SONET:** 10Gb/s, 2.5 Gb/s, 622 Mb/s, 155 Mb/s, 52 Mb/s.
Wander timing reference	Wander measurement can only be performed on a locked synchronous system where one clock reference is used.
Wander measurement bandwidth	All rates: 10µHz to10Hz.
Wander measurement range	The dynamic range of the TIE measurement is a minimum of $\pm 1 \times 10^9$ns.
Wander sampling rate	Sampling rate is 50/s.
Wander measurement accuracy	For each measurement of TIE, over an observation interval of length t (i.e. current test time), the total TIE measurement error shall be less than:

	Measurement accuracy
O.172	±5% of the measured TIE value $\pm Z_o(\tau)$
	Z_o(ns) = 2.5+0.0275τ, 0.05 ≤ τ ≤ 1000 Z_o(ns) = 29+0.001τ, τ> 1000
J7231B	±3% of the measured TIE value ±2.5ns

Frequency accuracy	10Hz ± 5%
Wander measurement results	Text • Time Interval Error (ns or UI) • +ve Peak: (ns or UI) • -ve Peak (ns or UI) • Peak-Peak (ns or UI) • Frequency offset (ppm) • Frequency drift (ppm/sec)

Wander analysis software (E4547A)

The Wander analyzer software provides the *real-time* calculation of the MTIE, TDEV and MRTIE wander performance indices. The software is Windows compatible.

Measurement rates	**SONET:** OC-192, OC-48, OC-12, OC-3, OC-1 **SDH:** STM-64, STM-16, STM-4, STM-1, STM-0
Wander analysis results	TIE, MTIE, MRTIE, TDEV, frequency offset and frequency drift
Standards compliance	Complies with all relevant ITU-T, Telcordia, ETSI, ANSI standards. **ITU-T:** G.783, G.811, G.812, G.813, G.823, G.824. **Telcordia:** GR-253-CORE, GR-1244-CORE. **ANSI:** T1.101. **ETSI:** ETS 300 462, ETS TM 3067.
User defined pass mask	In addition to providing all relevant masks from the standards bodies, the software provides the ability to quickly and easily generate additional user defined pass masks.
Software controls	Software provides user control of Cursor, Markers, Zoom In/Out, TIE Value and Transient search.
Minimum PC requirements	**Processor:** 166 MHz Pentium MMX (Windows 2000, NT 4.0, 98, 95) 300 MHz Pentium MMX (Windows XP) **Memory:** 64M (Windows 2000, NT 4.0, 98, 95) 128M (Windows XP) **Comm Port:** RS-232 connection to OmniBER

Wander tolerance

Wander tolerance mode	**Spot:** Manual wander generation mode. Wander is generated at selected spot frequencies at amplitudes defined by the selected tolerance mask.
Wander tolerance masks	• G.812 (sinusoidal) • G.813 (sinusoidal) • G.825

Binary Interfaces

Binary Interface Transmitter

Clock

Clock Waveform	Square wave	
Clock Duty Cycle	40:60 worst case	
Level	Min: 600 mV, Max: 1.0 V	
Overshoot	10 %	
Output Impedance	50Ω ac	
Return Loss	>10 dB at clock frequency	
Rise time, fall time	10 / 10.7G	<30 ps
	2.5G	<120 ps
	622M	<480 ps
	155M	<1920 ps
	52M	<2000 ps
Maximum Power	15 dBm	
Reverse damage voltage	±5 V dc	
Connector	SMA	

Note - All specifications are nominal.

Data

Data Format	NRZ	
Level	Min: 600 mV, Max: 1.0 V	
Overshoot	10 %	
Output Impedance	50Ω ac	
Return Loss	>10 dB at ½ bit rate	
Rise time, fall time	10 / 10.7G	<30 ps
	2.5G	<120 ps
	622M	<480 ps
	155M	<1920 ps
	52M	<2000 ps
Maximum Input Power	15 dBm	
Reverse damage voltage	±5 V dc	
Connector	SMA	

Note - All specifications are nominal.

Binary Interface Receiver

Clock

Clock Waveform	Square wave
Clock Duty Cycle	40:60 worst case
Level sensitivity	200 mV p-p
Level (maximum)	1.2 V
Termination	50Ω ac
Return Loss	>15 dB at clock frequency

Rise time, fall time

	10 / 10.7G	2.5G	622M	155M	52M
(200 mV)	<30 ps	<120 ps	<480 ps	<1920 ps	<2000 ps
(400 mV)	<45 ps	<180 ps	<720 ps	<2880 ps	<2880 ps

Maximum Input Power	15 dBm
Damage voltage	±5 V dc
Connector	SMA

Note - All specifications are nominal.

Data	
Data Format	NRZ
Level	Min: 200 mV, Max: 1.2 V
Return Loss	>15 dB at ½ bit rate

Rise time, fall time

	10 / 10.7G	2.5G	622M	155M	52M
(200 mV)	<30 ps	<120 ps	<480 ps	<1920 ps	<2000 ps
(400 mV)	<45 ps	<180 ps	<720 ps	<2880 ps	<2880 ps

Maximum Input Power	15 dBm
Damage voltage	±5 V dc
Connector	SMA

Note - All specifications are nominal.

Event triggers outputs - OTN/SONET/SDH

OTN transmit triggers	**Source:** **OTU2:** LOF, OOF, LOM, OOM, AIS, IAE, BDI **ODU2:** AIS, OCI, LCK, BDI, **Format:** Level **Source:** Start of frame, entire frame error add, frame error (OA1,OA2), MFAS **OTU2:** BIP8, BEI **ODU2:** SM BIP8, SM BEI, FEC Block error, bit **Format:** Pulse
OTN receive triggers	**Source:** **OTU2:** LOF, OOF, AIS, IAE, BDIO **DU2:** AIS, OCI, LCK, BDI **Format:** Level **Source:** Start of frame, frame error (OA1,OA2), MFAS **OTU2:** BIP8, BEI **ODU2:** BIP8, BEIFEC Block error **Format:** Pulse **Note:** All of the above triggers are selectable for frame capture
SONET transmit triggers	**<u>Alarms</u>** **Physical:** LOS **Transport O/H:** LOF, SEF, AIS-L, RDI-L **Path O/H:** AIS-P, AIS-C, LOP-P, LOP-C, RDI-P, UNEQ-P **Virtual Concatenation:** OOM1, OOM2, LOM, SQM **Format:** Level **<u>Errors/Events</u>** **Transport O/H:** Start of frame, entire frame error add, frame error (A1,A2), CV-S(B1), CV-L(B2), REI-L (CV-LFE) **Path O/H:** CV-P(B3), REI-P (CV-PFE) LCAS: CRC-8 error add, new value transmitted **Payload:** Bit **Format:** Pulse
SONET receive triggers	**<u>Alarms</u>** **Physical:** LOS **Transport O/H:** LOF, SEF, AIS-L, RDI-L, K1/K2 change **Path O/H:** LOP-P*, LOP-C*, AIS-P*, AIS-C*, RDI-P, UNEQ-P **Virtual Concatenation:** OOM1, OOM2, LOM, LOA, SQM **Format:** Level **<u>Errors/Events</u>** **Transport O/H:** Start of frame, frame error, CV-S(B1), CV-L(B2), REI-L(CV-LFE), STS pointer change **Path O/H:** CV-P(B3), REI-P (CV-PFE) **LCAS:** CRC-8, MST change, RS-Ack change, CTRL change **Format:** Pulse **Note:** TOH event triggers are selectable for TOH frame capture. STS event triggers are selectable for STS-Path capture. * Trigger not available for Entire Overhead Capture

SDH transmit triggers	**Alarms** **Section O/H:** LOF, OOF, MS-AIS, MS-RDI, **Path O/H:** AU-AIS, AU-AIS-C, AU-LOP, AU-LOP-C, HP-RDI, HP-UNEQ **Tandem path:** TC-OOM, VC-AIS, TC-IAIS, TC-RDI, ODI, TC-UNEQ **Virtual Concatenation:** OOM1, OOM2, LOM, SQM **Format:** Level **Errors/Events** **Section O/H:** Start of frame, entire frame error add, frame error (A1,A2), B1 BIP, B2 BIP, MS-REI **Path O/H:** B3 BIP, HP-REI **Tandem Path:** IEC, TC-REI, OEI **LCAS:** CRC-8 error add, new value transmitted **Payload:** bit **Format:** Pulse **Format:** Pulse
SDH receive triggers	**Alarms** **Physical:** LOS **Section O/H:** LOF, OOF, MS-AIS, MS-RDI, K1/K2 change **Path O/H:** AU-AIS*, AU-AIS-C*, AU-LOP*, AU-LOP-C*, HP-RDI, HP-UNEQ **Tandem Path:** TC-OOM, VC-AIS, TC-IAIS, TC-RDI, ODI, TC-UNEQ **Virtual Concatenation:** OOM1, OOM2, LOM, LOA, SQM **Format:** Level **Errors/Events** **Section O/H:** Start of frame, frame error (A1,A2), B1 BIP, B2 BIP, MS-REI, AU-3/4 pointer change **Path O/H:** B3 BIP, HP-REI **Tandem Path:** IEC, TC-REI, OEI, TC-ERR **LCAS:** CRC-8, MST change, RS-Ack change, CTRL change **Format:** Pulse **Note:** RSOH and MSOH event triggers are selectable for RSOH+MSOH frame capture.POH event triggers are selectable for POH capture. * Trigger not available for Entire Overhead Capture

Trigger output port for OTN/SONET/SDH

Connectors	SMA, TTL, 50ohm
Output level	Logic '1' = 4V typical Logic '0' = 0V typical
Pulse Width	100ns Nominal

GCC/DCC drop/insert

Supports the drop and insert of DCC channels from SONET/SDH or GCC channels from OTN signals

Connector	9-pin miniature D-type.
Rates	**D1-D3 DCC channel:** 192 kb/s. **D4-D12 DCC channel:** 576 kb/s. **GCC0, 1, 2 channels:** 1.3124 Mb/s
Signal type	Unipolar differential type designed to be similar to TIA/EIA-422-B and ITU Recommendation V.11 with reduced common-mode voltage range due to reduced supply voltage of 3.3V.
Input termination	100Ω differential.
Input sensitivity	200mV over a common-mode input voltage range from -0.3V to 5.5V.
Output voltage swing	>0.95V (1.5V typical)
DC Levels	Logic '1' = 2.3V typical, 1.85V min Logic '0' = 0.8V typical, 1.05V max
Order of transmission	Most significant bit (MSB) transmitted first (for both data input and data output).

GCC/DCC drop/insert connector pin-out

Pin number	**RS-449/422 signal**
1	Rx data output (+)
2	Rx clock output (+)
3	Signal ground
4	Tx clock output (+)
5	Tx data input (+)
6	Rx data output (-)
7	Rx clock output (-)
8	Tx clock output (-)
9	Tx data input (-)

Payload drop/insert capabilities

DSn/PDH to/from SONET	Supports the external drop/insert of asynchronous mapped DSn/PDH payloads. Drop/insert is performed via the instrument's DSn/PDH electrical test ports. **Supported rates:** DS1, E1 (2Mb/s), DS3.
DSn/PDH to/from SDH	Supports the external drop/insert of asynchronous mapped DSn/PDH payloads. Drop/insert performed via the instrument's DSn/PDH electrical test ports. **Supported rates:** DS1, 2 Mb/s, 34 Mb/s, DS3, 140 Mb/s.
DSn/PDH to/from DSn/PDH	Supports the external drop/insert of a DS1 or 2 Mb/s channel to/from a higher-rate DSn/PDH signal. Drop-insert performed via the instrument's DSn/PDH electrical test ports. **Supported rates:** DS1 to/from DS3; 2 Mb/s(1) to/from 8/34/140 Mb/s or DS3.
Voice drop	Allows the traffic in a selected 56 kb/s or 64 kb/s timeslot carried within a DS1 or 2 Mb/s signal to be dropped to an internal speaker. The DS1 or 2 Mb/s signal can be at the primary signal rate or carried within a higher-rate line signal (SONET/SDH or DS3/PDH). **Coding:** A-law (2 Mb/s), μ-law (DS1).

Note: 2 Mb/s drop/insert to/from an 8/34/140 Mb/s signal is performed via the 120Ω balanced test ports (3-pin Siemens connectors)

Thru-mode testing

OTN	**Rate:** OTU2 **Transparent:** Receive signal passes unaltered through test set. All receiver test facilities are available.
SONET/SDH	**Rates:** **SONET:** OC-1, OC-12, OC-48, STS-1, STS-3. **SDH:** STM-0o, STM-4o, STM-16o, STM-0e, STM-1e. **Transparent:** Receive signal passes unaltered through test set. All receiver test facilities are available. **Overhead Overwrite:** Error and alarm events down to high order path level as detailed in sections "Error Generation" and "Alarm Generation" DCC drop/insert Trace messages (J0, J1) Labels (S1, C2) APS Messages (K1,K2) Entire frame error add A1/A2 error add
Virtual Concatenation	Receive signal can pass unaltered or have errors, alarms and delay added. The errors and alarms are as per those specified in the Error and Alarm generation section. Any or all members can have up to 256ms of delay added irrespective of the payload type. This effectively simulates the delay likely to be experienced by different paths in the network without the need for additional equipment.
GFP	Receive signal can pass unaltered or have all the GFP errors and alarms defined in the Error and Alarm generation section added.
Ethernet	Receive signal passes unaltered through the test set. All receiver test functions are available.
DSn	Receive signal passes unaltered through test set. All receiver test facilities are available. **Rates:** DS1, DS3.

DSn/PDH testing

DS1 loopcodes and DS3 FEAC messages

DS1 loopcodes	Transmits and monitors in-band and out-of-band DS1 loopcodes. **In-band:** Line, payload, network, user (selectable from 3 to 8 bits). Transmit: Selected code transmitted for 8 seconds (nominal). Monitor: Indicates the detection of a selected loop-up and loop-down code. Displays the last valid loopcode received. **Out-of-band:** Line, payload, network, universal, user (11111111 0xxxxxx0). Transmit: Selected code transmitted either continuously or in a burst of n-messages (where n is selectable in the range 1 to 15). Monitor: Displays in decode form the two most recently received loopcodes (current and previous).
DS3 FEAC messages	Applies to DS3 C-bit framed signals. Transmits and monitors loopback and alarm/status codes as per ANSI T1.107-1995. **Loopback code transmit:** Transmits any user selected loopback code as a single burst of 'N loopback codes' and 'M messages' (where N and M are selectable in the range 1 to 15). **Alarm/status code transmit:** Transmits any ANSI T1.107-1995 message or any user specified code (0xxxxxx0 11111111), either continuously or in a single burst (selectable in the range 1 to 15). **Monitor:** Displays in decoded form the two most recently received FEAC messages (current and previous).

PDH spare-bits testing

Supports user-programming and monitoring of PDH frame spare-bits.

2 Mb/s (non-CRC framing)	Si-bit (timeslot 0, bit 1); Sa4 to Sa8 (NFAS timeslot); timeslot 16 (MFAS) bits 5, 7 and 8 (PCM30 framing).
2 Mb/s (CRC framing)	E-bits (Si-bit in frames 13 and 15); 8-bit pattern in each NFAS Sa-bit (Sa4 to Sa8); timeslot 16 (MFAS) bits 5, 7 and 8 (PCM30CRC framing).
8/34/140 Mb/s	**8 Mb/s and 34 Mb/s:** FAS bit 12. **140 Mb/s:** FAS bits 14 to 16.

Signaling-bits testing

2 Mb/s	**Framing formats:** PCM30, PCM30CRC (CAS). **Transmit:** User-programmed value transmitted in ABCD signaling-bits associated with all 30-channels. **Monitor:** Displays ABCD signaling-bits associated with all 30-channels.
DS1	**Frame formats:** SF (D4), ESF, SLC-96 **Channel type:** 56 kb/s structured timeslots. **Transmit:** User-programmed value transmitted in AB or ABCD signaling-bits associated with all 24-channels. **Monitor:** Displays AB or ABCD signaling-bits associated with all 24-channels.

Additional features

Help facilities	**On-line user documentation:** Accessed via front panel key. **Context-sensitive help:** Provided for each control-field on a dedicated line of the instrument's display. The displayed help information automatically tracks the cursor. **User-help documentation:** Supports the installation (from floppy disk) of up to 1.44 Mbytes of user-authored help files in the instrument's non-volatile memory. This help information is available in addition to that provided as standard.
Stored configurations	Provides storage for five instrument configurations (one factory-default configuration plus four user configurations) in non-volatile memory. Additional instrument configurations can be saved to and recalled from the floppy disk.
Graphical results	The following graphical results are available for display during a measurement: **STS/AU pointer:** Line graph of STS/AU pointer address versus time. Additional graphical result capability provided by **Errors:** Bar graph for each supported error types versus time. **Alarms:** Line graph for each supported alarm type versus time. **VT/TU pointer:** Line graph of VT/TU pointer address versus time. **Time resolution:** 1-second. **Storage:** Up to 10 sets (or 10 Mbytes in total) of graphical results can be saved in the instrument's non-volatile memory.
Result logging	Supports logging of results during a measurement to a printer, to a file in the instrument's non-volatile memory or to floppy disk. **Logged information:** Instrument settings, time and date, period-results, end-of-measurement results (the results logged are user selectable). **Logging period:** 10-minutes, 1-hour, 24-hours, user-defined (in ranges 10 to 99-minutes; 1 to 99-hours).
Printing	Supports printing of logged results and screen dumps via USB port.
Beep-on-error	Audible beep emitted on detection of any valid error-type. **Control:** Off/on (with user controlled volume).

General specifications

Display	8.4" VGA display (TFT active matrix).
File Save Facilities	Results and configuration files can either be saved to floppy disk or file transferred directly to a PC/Workstation over LAN using TFTP. Supported facilities include: **Stored configurations:** Save and recall of instrument configurations. **Logged results:** Saving the results generated during measurement logging. Results saved in Windows®-compatible 'plain text' format. **Screen dumps:** Saving the current instrument display in Windows-compatible.BMP format. **User-help files:** Downloading user-help files to the instrument. **Graphical results.** Save and recall of the instrument's graphical results. Results saved in Windows-compatible CSV (comma separated variable) format for importing in to spreadsheets and other PC applications.
Remote control interfaces	LAN (10/100BaseT), RS-232, GP-IB.
Peripheral interfaces	PS/2 keyboard; PS/2 mouse 2 x USB (for printer).
Remote graphical user interface	A JavaTM application connected remotely via LAN or modem. Compatible with PC-based Windows® operating systems.
Firmware upgrades	Downloaded to the test set from a PC via LAN or RS-232 interface.
AC power	**Voltage range:** 90 to 260 Vac nominal (auto-ranging). **Frequency range:** 47 to 63 Hz. **Power:** 250 VA.
Environmental	**Operating temperature:** 10oC to 40oC (50oF to 104oF) BER products 20oC to 30oC (59oF to 104oF) Jitter products **Storage temperature:** -20oC to 70oC (-4oF to 158oF). **Humidity:** 15% to 90% relative humidity at 40oC (104°F).
Dimensions (height x width x depth)	Maximum dimensions including handle: 300 mm x 365 mm x 450 mm (11.75" x 14.5" x 17.75").
Weight	18 kg (39.7 lbs) up to 2.5 Gb/s 19.5 kg (43 lbs) up to 10.71 Gb/s
Warranty	1-year as standard. Extended warranty period to 3-years available. Extended warranty period to 5-years available.
Calibration cycle	2-years.

Regulatory standards	
EMC	Complies with: • EMC Directive 89/336/EEC. • Australian EMC Framework Act 1992. • ICES/NMB-001. Meets: • EN 55011:1991 Group 1, Class A. • EN 50082-1:1992.
Electrical safety	Complies with: • Low Voltage Directive 73/23/EEC. Meets: • EN 61010-1:1993. • IEC 61010-1 (2001 - 02). • CSA C22.2 No. 1010.1-92.
Laser safety	Meets: • EN 60825-1:1994 Class I. • IEC 60825-1 (1993) Class I. • 21 CFR Chapter 1 1040-2 Class 1.

The OmniBER OTN is

Class 1 laser product

EN60825-1: (1994)

IEC60825-1: (1993)

Class 1 laser product

FDA 23 CER CH.1 1040.10: (1994)

UNIVERSAL INSTRUMENT DRIVERS

Windows® is a U.S. registered trademark of Microsoft Corporation.

JavaTM is a U.S. trademark of Sun Microsystems, Inc.

Agilent Technologies manufactures the OmniBER OTN family under a quality system approved to the international standard ISO 9001 plus TickIT (BSI Registration Certificate No FM 10987).

Product literature

You'll find ordering details for the OmniBER OTN J7232A and J7230B in the product configuration guides at www.agilent.com/comms/otn

Related products

Agilent N2X

The Agilent N2X Multi-Services test application offers fast and thorough system verification test (SVT) to accelerate the time to market of next-generation SONET/SDH network equipment. With multi-channel, multi-port, multi-rate and multi-user capability, the N2X XM cards can generate (in terminate or intrusive-thru mode) realistic network signals using mixed payloads, with errors and alarms, on up to 192 STS-1/AU-3 channels or up to 1344 VT1,5/TU-11 channels simultaneously. This replicates real network conditions to truly stress-test network elements, and increases the effectiveness of verification test. The N2X XM cards also simultaneously measure each channel for errors, alarms, APS switching durations, and correct connectivity, reducing test times and uncovering all performance issues. For more information, refer to www.agilent.com/comms/n2x

The N2X E7880A Traffic Generation and Analysis application excels for testing layer 2 and 3 devices that are used in enterprise, metro/edge and core networks. Combined with the new 10/100 Ethernet and GbE XP Test Cards, this flexible traffic generation offers a cost-effective solution for performing Ethernet traffic testing on switches, routers, next generation SONET/SDH Multi-Service Provisioning Platforms and many other devices.

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