OmniBER 719 communications performance analyzer

Specification

SONET:
OC-48, OC-12, OC-3, OC-1, STS-3, STS-1

T-carrier/PDH:
DS3, DS1, E1, E2, E3 (full mux/demux to DS0)

ATM:
DS1 to OC-48c

Jitter:
DS1 to OC-48c

POS:
STS-1 to OC-48

Agilent Technologies

Contents

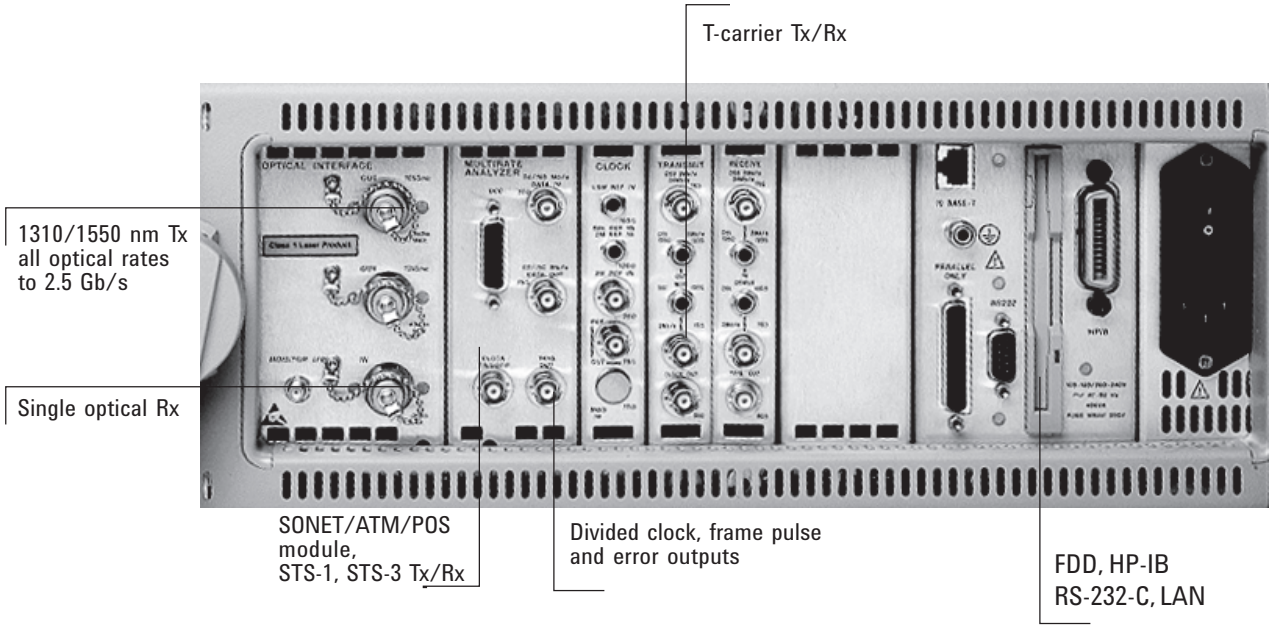
OmniBER 719

communications performance analyzer

The Agilent Technologies OmniBER 719 communications performance analyzer offers a single box field portable multi-rate SONET tester up to 2.5 Gb/s (OC-48). The analyzer is ideally suited to installation, maintenance, commissioning, system verification and manufacture of SONET transport networks and network equipment.

POS and ATM devices can also be tested up to 2.5 Gb/s. The latest enhancements to the OmniBER 719 analyzer include a choice of instrument variants for multi rate testing. This new choice allows you to buy the SONET test configuration you need today and upgrade in the future as your testing needs move to higher SONET rates.

Side view



Summary of capability

Model	SONET rates	Optional T-carrier/PDH
37719A	OC-48, OC-12, OC3, OC-1 STS-3, STS-1	DS1, DS3, E1, E2, E3
37719B	OC-12, OC3, OC-1 STS-3, STS-1	DS1, DS3, E1, E2, E3
37719C	OC-3, OC-1 STS-3, STS-1	DS1, DS3, E1, E2, E3
37719C	STS-3, STS-1	DS1, DS3, E1, E2, E3

Other enhancements added to the latest OmniBER 719 include:

- Smartsetup autodiscover wizard simultaneously displays all J1 trace identifiers.
- Smartsetup lets you quickly and easily explore right down into the payload of selected SONET tributaries.
- A telephone jack socket enables talk/listen on DS0 channels carried in higher rate signals.
- SONET-only configurations available.
- Real-time analysis of key performance indices MTIE, TDEV/MRTIE.
- Electrical-only configuration available for STS-3/STS-1 testing.
- E1 mapped into DS3.
- DS1 floating byte sync mapping.
- DS1 in-band and out-of-band loop code generation and monitor.
- New test patterns:
  Daly (55 octet), 1-in-8, 2-in-8.
- ATM payloads available.
- POS payloads available.

Smartsetup

Not only is the OmniBER 719 analyzer rugged and portable, its easy-to-use **Smartsetup** and **Smart Tests** simplify and speed up the installation and maintenance of SONET networks.

The OmniBER 719 analyzer lets you start testing with just ***two key presses!*** With the analyzer connected to any signal, simply press the **Smart Test** key on the front panel, select **Smartsetup** and the instrument's autodiscover wizard automatically identifies the line rate and payload structure of the unknown input signal. For SONET signals the analyzer also automatically displays all of the J1 trace identifiers, that is 48 J1 identifiers in an OC-48 signal. With the signal structure now identified it's a simple process, using the cursor control keys, to select a channel of interest and to explore right down into the payload.

Smart Tests

The front panel Smart Test key offers a simple shortcut to the extensive capabilities of the OmniBER 719 analyzer. The Smart Tests are grouped together in functional blocks so you don't need to be an instrument 'expert' to get tests up and running quickly. Test capability that is accessed with only a couple of key presses include:

- Protection switch time measurement
- Optical power measurement
- Line frequency measurement
- Error and alarm summary results.

Large color display

The color VGA display on the OmniBER 719 analyzer operates in single- or multi-window mode. In multi-window mode, four windows are diplayed allowing simultaneous viewing of transmitter settings, receiver settings, graphical results and text results summary.

A VGA output is provided on the analyzer's front panel for connection to VGA projector for training purposes.

Protection switch time measurement

Service disruption measurement couldn't be simpler than with the OmniBER 719 analyzer. Using dedicated hardware, the analyzer measures the length of the error burst associated with a protection switch. Unlike the old method of correlating bit errors with time, the unique implementation in the analyzer (patent pending for DSn) is accurate to 50 µs with a resolution of 1 µs.

SONET ring testing

Configuring SONET rings and verifying their functionality is a complex and time-consuming process. Using the comprehensive thru mode capability of the OmniBER 719 analyzer can help to speed up the task and ensure that the advantages of the SONET ring configuration will be delivered when problems arise on the live network.

The three different thru modes of operation available are:

- **Transparent:** The SONET signal is monitored and normal measurements made. The line signal is passed through unaltered without recalculation of BIPs.
- **STS Payload overwrite:** Select an STS SPE channel and overwrite with an internally generated payload. BIPs are recalculated and all other SPEs are retransmitted unaltered. Standard transmit test functions are enabled so that it is possible to add errors, alarms, pointer adjustments etc.
- **VT payload overwrite:** Select a VT channel and overwrite with an internally generated payload. All other VTs are retransmitted unaltered. Standard transmit test functions are enabled so that it is possible to add errors, alarms and pointer adjustments.

Concatenated payloads

Concatenated payloads are vital for the rapid and accurate testing of high bandwidth paths before they are brought into service. The OmniBER 719 analyzer provides concatenated payload testing at all levels of a SONET signal. As well as providing concatenated payloads at the line rate e.g. OC-48c, the analyzer lets you test SONET structures containing concatenated payloads from lower levels of the SONET hierarchy e.g. STS-12c carried in OC-48. See Figure 1 for the full range of possibilities.

Remote control for manufacturing

Every OmniBER 719 analyzer is shipped with a set of Universal Instrument Drivers (UIDs) on CD-ROM. UIDs provide a suite of graphical function panels which make programming the analyzer easy and fast! There is no need to know about SCPI commands – the SCPI commands are generated automatically by setting switches on a graphical function panel.

UIDs are supported in the following environments:

- HP VEE
- Labview
- LabWindows/CVI
- Visual Basic
- C++

and on the following operating systems:

- Windows 95
- Windows NT
- HP-UX
- Sun Solaris.

Remote control for remote in-service monitoring

The Distributed Network Analyzer (DNA) software (HP E4540A) allows control of an OmniBER 719 analyzer from a remote PC via modem or LAN. Changes made on the virtual front panel on the PC are seen in real time at the remote site. Key presses made on the instrument at the remote site are seen in real time on the PC – ideal for remote troubleshooting by a centralized expert!

For long-term monitoring applications it is also possible to dial in to a remote OmniBER 719 analyzer, download/update results and disconnect. Disconnect and re-connect at any time without interrupting test progress.

T-carrier and En testing

The T-carrier test module provides comprehensive test capability for DS1, DS3, E1, E2 and E3 interfaces. For DS3 testing FEAC code generation and monitor capability is included. At DS1 both in-band and out-of-band loop code generation and monitor is also available.

The T-carrier test module also provides mapped payload testing capability for SONET testing

Other supported functionality includes:

- Unframed, framed and structured (mux/demux) testing
- Error and alarm generation and measurement
- 56 kb/s, n × 56 kb/s, 64 kb/s and n × 64 kb/s testing
- DS1 add/drop from DS3
- E1 add/drop from E2/E3
- DS1/DS3 and E1/E3 add/drop from SONET
- Telephone handset connector for talk/listen capability.

Testing of E1 mapped into DS3 is also available if required.

Jitter Testing

The OmniBER 719 can optionally perform jitter generation and measurement at all installed interface rates from 2.5 Gb/s to 1.5 Mb/s. The jitter capability in the OmniBER 719 lets you ensure that your network equipment complies with all relevant Bellcore jitter recommendations. Jitter test applications covered by the OmniBER 719 are:

- Output Jitter Measurement
- Auto Jitter Tolerance
- Auto Jitter Transfer
- Pointer Jitter Measurement
- Mapping Jitter Measurement

As well as the standard Bellcore masks, user definable jitter masks are included to let you specify the exact points you need to test your network equipment.

What's more, the OmniBER 719 meets the latest ITU-T 0.172 recommendation for test equipment.

Wander Testing

Wander measurements are used to verify the synchronization quality in digital networks. Using the OmniBER 719 it is possible to measure wander at all installed interface rates from 2.5 Gb/s to 1.5 Mb/s.

To check network equipment wander tolerance meets Bellcore recommendations, wander generation can be performed at 1.5 Mb/s, 2 Mb/s and also at all synchronous rates from 52 Mb/s to 2.5 Gb/s. Wander frequencies down to 10μHz and amplitudes up to 57,600UI can be generated.

Wander analysis software

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

What's more, the OmniBER 719 meets the latest ITU-T O.172 recommendation for test equipment.

SONET

- Troublescan automatically scans for all possible error and alarm conditions
- Payload offset test
- SONET error and alarm generation/detection
- SONET tributary scan
- SONET pointer adjustments to GR-253
- Graphical pointer location graph
- Access to SONET overhead
- Overhead sequence generation and capture
- Text decode of APS messages for transmit and receive
- Optical stress test
- Drop/insert of DCC channels
- Optical power measurement
- Line frequency measurement
- Line frequency offset
- Choice of clock reference: Internal, recovered, external 64 kb/s, 1.5 Mb/s (BITS), 10 MHz
- Performance analysis to ITU-T G.821, G.826, M.2101, M.2110, M.2120
- Graphical results storage.

ATM (optional)

- ATM payloads up to 2.5 Gb/s.
- Comprehensive jitter test with ATM payloads.
- Fast, accurate measurements of protection switch times of ATM circuits.

T-Carrier/PDH

- Troublescan automatically scans for all possible error and alarm conditions
- Alarm scan
- Error and alarm generation/detection
- DS1/DS3 thru mode
- Choice of clock reference: Internal, recovered, external 64 kb/s, 1.5 Mb/s (BITS), 10 MHz
- Line frequency offset
- Signaling bits generation/detection
- Performance analysis to ITU-T G.821, G.826, M.2100, M.2110, M.2120
- Graphical results storage.

POS (optional)

- POS payloads at all synchronous rates to 2.5 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.

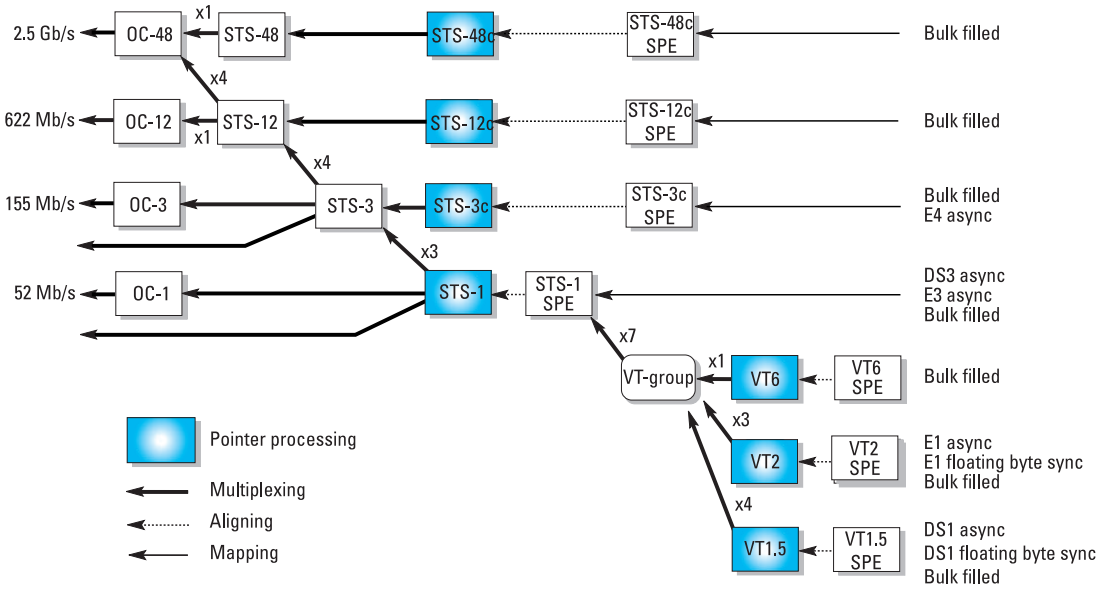


Figure 1: Bellcore GR-253 mapping structure (SONET payload mapping)

Optical interfaces

	37719A	37719B	37719C
Wavelength Option 104 Option 105 Option 106	 1310 nm 1550 nm 1310/1550 nm	 1310 nm 1550 nm 1310/1550 nm	 1310 nm 1550 nm 1310/1550 nm
Rates	OC-48/12/3/1	OC-12/3/1	OC-3/1
Connectors	FC/PC (standard) SC (option 610) ST (option 611) ***Notes:*** *Optical interfaces on the 37719A use a customer exchangeable connector system. On 37719B and 37719C models, a fixed optical connector system is used (supports removal for cleaning).*		

Optical transmitters

The following specifications cover both 1310 and 1550 nm transmitters unless otherwise stated.

	37719A	37719B and 37719C
Line code	NRZ	NRZ
Wavelength 1310 nm 1550 nm	 1280 to 1330 nm Typical: 1310 nm 1530 to 1570 nm Typical: 1550 nm	 1280 to 1335 nm Typical: 1310 nm 1480 to 1580 nm Typical: 1550 nm
Power	1 dBm ± 2 dB	–3 to +2 dBm
Spectral width	≤ 0.3 nm at –3 dB ≤ 1.0 nm at –20 dB	≤ 1.0 nm at –20 dB
Extinction ratio	> 10 dB	> 10 dB
Pulse mask	Meets Bellcore GR-253-CORE and ITU-T G.957	
Fiber pigtail	Single mode	Single mode
Laser safety	Class 1 as defined by IEC825-1 and FDA 21 CFR, chapter 1, subchapter J.	

Optical receiver

	37719A	37719B and 37719C
Line code	NRZ	NRZ
Wavelength	1280 to 1335 nm and 1500 to 1580 nm	1200 to 1600 nm
Sensitivity	OC-48: –28 dBm OC-12/3/1: –28 dBm, typically –34 dBm	OC-12: –28 dBm OC-3/1: –28 dBm, typically –34 dBm
Max input power	–8 dBm	–3 dBm
Fiber pigtail	Multi-mode	Multi-mode

Notes:

1. *Sensitivity and maximum input power specifications are valid in the 0 to +40 °C temperature range.*
2. *Sensitivity and maximum input power specifications are measured at 10^{-10} error rate using a $2^{23} – 1$ test pattern.*
3. *37719A: The optical receiver operates over the range 1200 to 1600 nm. Sensitivity and maximum input power specifications are valid in defined wavelength ranges.*

Protected monitor point input

52 Mb/s, 155 Mb/s and 622 Mb/s (not available on 37719C).
Line code: NRZ.
Level: Nominal 1 V peak-to-peak into 50 ohms.
Connector: SMA female.

Electrical line rates/interfaces

STS-3 (CMI), STS-1 (B3ZS)
Input mode: Terminate or monitor mode.
Monitor gain: 20 dB or 26 dB
Equalization:
STS-3: Automatic for cable loss up to 12 dB at half the bit rate.
STS-1: Automatic covering range LO, x-connect and HI.
STS-1 operating level:
STS-1 HI: 1.1V peak nominal with cable equalization up to 450 ft.
STS-1 900ft: As STS-1 HI with added cable equalization for 450ft to 900 ft.
Connector: BNC, 75 ohm unbalanced.
Option 620: WECO 560 connector replaces BNC.

Clock reference

Internal: ± 0.5 ppm; stability: ± 3 ppm; Ageing: ± 1 ppm.
Loop-timed: Clock recovered from receiver's SONET input.
External reference: BITS (1.5 Mb/s), 64 kb/s, 10 MHz.
Connector: Bantam, 100 ohm balanced (BITS, 64 kb/s);
BNC, 75 ohm unbalanced (10 MHz).

Clock trigger

Divided clock output:
51.840 MHz for OC-48/OC-12/OC-3/STS-3/OC-1/STS-1.
Connector: BNC, ECL to –2 V, ac coupled, 50 ohm.

Trigger/error output

60 µsec (nominal) pulse on B1, B2, B3 error, Tx/Rx frame (TTL level, termination can be 75 ohm or 10 kohm).
Connector: BNC, 75 ohm unbalanced.

Clock offset

± 999 ppm in 0.1 ppm steps; offset accuracy ± 0.02 ppm
Offsets the transmitted OC/STS-n line frequency relative to the selected clock reference.

SONET payload structure

See Figure 1 for details of SONET payload mapping.

The foreground STS-n test signal can be mapped into any select channel in the SONET line signal. Background channels can be set to the same as to the foreground or filled with an unequipped signal structure.

Notes:

1. *Option 013 (T-carrier testing) is required for DS1/DS3/E1/E3/E4 mappings.*
2. *OC-48 mappings only available on 37719A fitted with optical interface option (option 104, 105 or 106).*
3. *OC-12 mappings only available on 37719A or 37719B fitted with optical interface option (option 104, 105 or 106).*

Payload offset

± 100 ppm in 1 ppm steps, linearity 0.5 ppm.
The mapped DSn/En signal is offset with respect to the SPE in which it is carried.

Payload test pattern

2^9–1, 2^{11}–1, 2^{15}–1, 2^{23}–1 (inverted or non-inverted), all ones, all zeros, 1010, 1000, 16 bit user word.
DS1 only: QRSS (2^{20}–1; 14 zero limited), Daly (55-octet) 1-in-8, 2-in-8.

PDH/DSn drop/insert

Requires option 013 (T -carrier testing).
DS3, DS1, E3, E1 dropped from and/or inserted into OC-N/STS-N line signal (supported for asynchronous mappings only).

SONET tributary scan

Automatically test BER on each SONET tributary for error free operation. Rx setup is used to determine tributary structure and test pattern. (At OC-48/OC-12 the foreground STS-3 will be scanned).
Alarms: Pattern loss.
User selectable BER threshold: Off, >0, $\geq 10^{-3}$,$\geq 10^{-6}$.

SONET error add

Data (whole frame)[1], frame (A1,A2)[1], CV-S (B1), CV-L (B2), REI-L (M0), REI-L (M1), CV-P (B3), REI-P (G1), STS IEC, CV-V (V5), REI-V (V5), bit[1].

Control: Single, error all, M.P x 10^{-n} (where M.P = 0.1 to 9.9 in 0.1 steps and n = 3 to 9)[2].
N-in-T[3], where N is the number of errors transmitted in time T,
T = 10 ms to 10000s in decade steps.
N = 0 to 640 (STS-1), 1920 (STS-3), 7680 (STS-12), 30720 (STS-48).

1. *No "error all" selection available.*
2. *Max error rate depends on the error type.*
3. *CV-L (B2) errors only.*

SONET alarm generation

LOS, LOF, OOF, AIS-L, RDI-L, AIS-P, RDI-P, LOP-P, UNEQ-P, AIS-V, LOP-V, RDI-V, UNEQ-V, H4 LOM.
Control: On/off.

SONET pointer adjustments

Frequency offset: Offset the SPE/VT relative to the line rate. In the SPE/VT pointer mode the 87:3 sequence is generated. Frequency offset control (±100 ppm in 0.1 ppm steps).
Bellcore GR-253,ANSI T1.105.03 sequences: Initialisation sequence and cool down period

1. Periodic single,
2. Periodic burst,
3. Periodic phase transient burst,
4. Alternating single,
5. Alternating double,
6. Periodic with added,
7. Periodic with cancelled.

Programmable interval between regular adjustments.
Regular: Interval between regular adjustments can be programmed as follows:
10 ms < T < 100 ms in 10 ms steps
100 ms < T < 1 s in 100 ms steps
1 s, 2 s, 5 s or 10 s
Single burst: Incrementing burst, decrementing burst, alternating.
Burst size: 1 to 10 adjustments (SPE). 1 to 5 adjustments (VT).
Adjustments within the burst are separated by the minimum legal limit (4 frames/multiframes).
New pointer: New pointer address transmitted with or without a NDF. SPE/VT payload moves to the user programmed address immediately.

SONET overhead setup

TOH: All bytes user settable except B1 B2, H1, H2 and H3. The size bits in H1 are settable.
J0: User byte; 16 byte section trace message.
S1: Clear text setup of synchronization status message.
STS POH: All bytes user settable except B3.
J1: 64 or 16 byte path trace message.
C2: Clear text setup of signal label.
VT POH: V5, J2, Z6, Z7 user settable.
J2: User byte; 16 byte VT path trace message..
V5 (VT signal label): Clear text setup of VT path signal label.

SONET overhead monitor

SOH, LOH, STS POH, VT POH all bytes (hex/binary)
Text decodes provided for section trace (J0), synchronization status (S1), ASP/MSP messages (K1K2), STS and VT path trace messages (J1, J2), STS and VT signal labels (C2, V5).

APS messages

Clear text setup and decode of protection switching messages. Supports both linear (Bellcore GR-253) and ring (Bellcore GR-1230) messages.

For linear topologies APS messages can be active or passive. In passive, static messages can be generated and received. The active APS selection gives relative response to provide switch keep-alive capability by responding to change requests that appear on the K1/K2 byte values.

SONET overhead sequence generation

Sequence of up to 5 values transmitted in a selected overhead channel. The transmit duration for each value is user programmable in range 0 to 64000 frames.
Overhead channel:
SOH: A1-A2 (6 bytes), D1-D3 (3 bytes), J0, Z0 ,E1, F1,
media dependent bytes (row 2 col 2; row 2, col 3; row 3 col 2; row 3, col 3).
LOH: D4-D12 (9 bytes), K1K2 (2 bytes), S1, M0, M1, Z1, Z2, E2.
POH: J1, C2, G1, F2, H4, Z3, Z4, N1.

SONET overhead sequence capture

A selected overhead channel can be selected for capture. The capture can be triggered manually or on a user-defined receive value. The first 16 different receive values including the trigger are displayed along with the number of frames for which the value has persisted.
Overhead channel:
SOH: A1-A2 (6 bytes), D1-D3 (3 bytes), J0, Z0 , E1, F1,
media dependent bytes (row 2 col 2; row 2, col 3; row 3 col 2; row 3, col 3).
LOH: H1H2 (2bytes), D4-D12 (9 bytes), K1K2 (2 bytes), S1, M0, M1, Z1, Z2 E2
POH: J1, C2, G1, F2, H4, Z3, Z4, N1.

SONET overhead BER

2^9–1 PRBS transmitted and analyzed in a single 64 kb/s overhead channel. Single bit errors can be inserted in the transmitted test pattern.
Overhead channel:
SOH: D1-D3 (single byte), J0, Z0, E1, F1,
media dependent bytes (row 2 col 2; row 2, col 3; row 3 col 2; row 3, col 3).
LOH: D4-D12 (single byte), K1, K2, S1, M1, M0, E2.
POH: J1, C2, G1, F2, H4, Z3, Z4, N1.
Results: Error count, error ratio, error free seconds, % error free seconds, pattern loss seconds.

Optical stress test

Payload is overwritten with a block of zeros or ones after scrambling to stress timing recovery circuits.
Range:
2 to 85 bytes – OC-1.
2 to 259 bytes – OC-3.
2 to 1042 bytes – OC-12.
2 to 4174 bytes – OC-48.

DCC add-drop

D1-D3 (192 kb/s), D4-D12 (576 kb/s)
Serial add-drop of DCC channels via RS-449 (15-pin D-type connector).

SONET thru mode

OC-48, OC-12, OC-3, OC-1, STS-3, STS-1 through mode:
Transparent mode: Signal passes through unaltered. BIPs are not recalculated.

Overhead overwrite: The test features associated with the TOH/POH can be enabled to alter one single or multi-byte overhead channel (ie, errors and alarms, overhead sequences, stress test, APS/MSP messages, DCC insert, overhead BER) In this mode the parity bytes are recalculated.

STS payload overwrite: Overwrite a selected STS SPE channel with an internally generated payload. All other SPEs are retransmitted unaltered. All standard transmit test functions are enabled (errors and alarms, pointer adjustments, overhead sequences, stress test, overhead BER).

VT payload overwrite: Overwrite a selected VT with an internally generated payload. All other VT s and SPEs are retransmitted unaltered. All standard transmit test functions are enabled (errors and alarms; pointer adjustments).

SONET alarm detection

LOS, OOF, LOF, AIS-L, RDI-L, LOP-P, AIS-P, RDI-P, H4-LOM, LOP-V, AIS-V, RDI-V, pattern loss, clock loss, K1/K2 change, power loss, pointer adjust.

SONET error measurements

Measurement control: Manual, single, timed start.
Error: Frame (A1,A2), CV-S(B1), CV-L(B2), CV-LFE(REI-L), CV-P(B3), CV-PFE(REI-P), CV IEC (STS path IEC), CV-V(V5), CV-VFE(REI-V), bit.
Basic results: Error count, error ratio, alarm seconds.
Performance analysis: G.826, G.821, M.2100. M2101, M.2110, M.2120.

Service Disruption test
Note: *Requires Option 013*

Measures error burst length for measurement of service disruption during protection switching times to ITU-T G.783 (linear architecture)/G.841 (ring network topology).
Accuracy: 50 µs. for unframed signals
NOTE: It is recommended that unframed signals are used to measure service disruption as frame sync times will affect the measurement.
Results: longest burst length, shortest burst length, last burst length.
Resolution: 1 µs.

Start Condition: An error burst of greater than 50 µs.

Stop Condition: Error burst assumed complete when greater than 200ms have elapsed witout any errors being received.

Measurement Period: Elapsed time between the first bit error received and the last error received when the Start and Stop Conditions have been met.

NOTE: Option 350 is required for the following service disruption and AIS functionality.
OmniBER now provides timestamping of the first 10 service disruption events and the first 10 AIS duration measurements.

Service disruption has been extended to cover the following SDH and SONET tributaries.

- ❑ AU-4-16c/STS-48c
- ❑ AU-4-4c/STS-12c
- ❑ AU-4/STS-3c
- ❑ AU-3/STS-1

Service disruption measurement parameters

Display resolution: 1 µs

Measurement accuracy: 50 µs or better (for unframed signals)

Pattern: All current supported PRBS patterns (2^9–1, 2^{11}–1, 2^{15}–1, 2^{20}–1, 2^{23}–1) normal or inverted.
Bulk fitted.
POS
ATM (Using ITU-T 0.191 test cell)

Start condition: Single PRBS bit error.

Stop condition: Error burst assumed complete when >200ms has elapsed without any errors being received.

Measurement period: The elapsed time between the first bit error received and the last error received once the start and stop conditions have been met.

AIS duration measurement parameters

Display resolution: 1 µs

Measurement accuracy: 125 µs (1 frame)

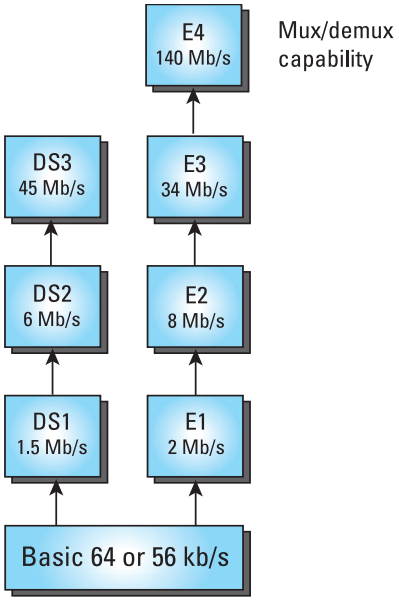
Start condition: Detection of an all ones pattern in the H1 and H2 bytes, present for three consecutive super-frames (i.e. detection of AIS-P/AU-AIS).

Stop condition: The absence of all ones in the H1 and H2 bytes.

AlarmScan	Automatically identifies the payload structure then scans each STS/VT channel for alarms and BIP errors. Graphically displays the status of each STS/VT channel. **Alarms:** **STS-SPE:** LOP-P, AIS-P, RDI-P. **VT :** AIS-P, RDI-P, H4 LOM, LOP-V, AIS-V, RDI-V. **BIP errors:** B3 or V5 BIP-2 associated with each STS/VT channel.
TroubleScan	Scans all possible error and alarm sources simultaneously. Non-zero error counts are displayed in large characters, up to a maximum of four different error counts.
Pointer location graph	**Graphical display:** Shows the variation with time of the STS SPE and VT pointer location. Up to four days of pointer location activity can be monitored. **Implied SPE/VT offset:** Calculated from the total +ve and –ve pointer movements since start of the measurement period.
Pointer results	SPE and VT Justifications (pointer value, positive count, positive seconds, negative count, negative seconds, NDF seconds, missing NDF seconds, implied SPE/VT offset).
Optical power measurement	**Accuracy:** ± 2 dB; Range: –10 dBm to –30 dBm. **Wavelength:** 1310 nm or 1550 nm. **Resolution:** 0.1 dBm.
Frequency measurement	**OC-48:** Frequency displayed in kHz with a 0.1 kHz resolution. Offset in ppm/kHz ≤ **OC-12:** Frequency displayed in Hz with a 1 Hz resolution. Offset in ppm/Hz. **Accuracy:** ± 1 Hz ± (internal clock error[1]) × frequency. [1] *See 'clock reference' for details on internal clock error.*
Stored measurement graphics	10 internal SMG stores (increases with floppy disc drive - number of stores limited only by free disc space). **Bar chart:** Results versus time periods with up to 1 second resolution. **Alarm chart:** Alarms versus time periods with up to 1 second resolution. **Resolution:** 1sec, 1min, 15min, 60min **SONET bar graphs:** Frame (A1A2), CV-S (B1), CV-L (B2), CV-LFE (REI-L), CV-P (B3), CV-LFE (REI-P), CV-IEC (STS path IEC), CV-V (V5), CV-VFE (REI-V), bit. **SONET alarms:** LOS, LOF, OOF, LOP-P, NDF, missing NDF, AIS-L, RDI-L, K1K2 change, AIS-P, RDI-P, H4 LOM, LOP-V, VT NDF, VT missing NDF,AIS-V, RDI-V, pattern sync loss, power loss. Adds T-carrier and En test capability. Testing can be performed directly at DSn/En physical interfaces or on SONET mapped payload signals.

DS1/PDH/ T-carrier testing

(Option 013)



Line rates

DS1, DS3, E1, E2, E3
Interfaces DS1: B8ZS/AMI; 100 ohm balanced (WECO Bantam).
DS3: B3ZS; 75 ohm unbalanced (BNC[1]).
E1: HDB3/AMI; 75 ohm unbalanced (BNC[1]), 120 ohm balanced (WECO Bantam).
E2: HDB3; 75 ohm unbalanced (BNC[1])
E3: HDB3; 75 ohm unbalanced (BNC[1]).
Input mode: Terminate or monitor mode.
Monitor gain:
DS1, E1/E2: 20, 26 dB or 30 dB.
DS3, E3: 20 or 26 dB.
Equalization:
DS1: DSX-1,DS1-LO 0-655ft (ANSI T1.102-1993).
DS3: DSX3, DS3-HI, DS3-900': 0-900ft (ANSI T1.102-1993).
E1/E2: 6 dB at f/2.
E3: 12 dB at f/2.
DS1 operating level: DSX-1, DS1-LO.
DS3 operating level: DS3-HI, DSX-3, DS3-900.
E1 output level: ITU-T G.703.
E2 output level: ITU-T G.703.
E3 output level: ITU-T G.703.

[1] Option 620 replaces BNC with WECO 560 connector.

Clock references

Internal: ± 0.5ppm @ 25C [± 4.5 ppm (includes ageing, stability, setting accuracy)].
DS1 only: ± 0.7ppm @ 25C [± 4.7 ppm (includes ageing, stability setting accuracy)].
Loop-timed: Clock recovered from receiver.
External reference: BITS (1.5 Mb/s), 64 kb/s, 10 MHz.
Connector: Bantam, 100 ohm balanced (BITS, 64 kb/s);
BNC, 75 ohm unbalanced (10 MHz).

Line rate offset

± 100 ppm in 1ppm steps.
Offsets the transmitted DSn/En line frequency relative to the selected clock reference.

Frame format

Framed, structured (mux/demux), unframed

	Framing	Channel structure
DS1	SF (D4), ESF, SLC-96 (ANSI T1-403-1989, TR-TSY-000499, ITU-T G.704)	56/64 kb/s, n × 56/64 kb/s
DS3	M13 (ANSI T1-107-1995), C-bit (ANSI T1-107a-1990)	DS1, 56/64 kb/s, n × 64 kb/s Option 014: E1 (ITU-T G.747)
E1	PCM30, PCM30CRC, PCM31, PCM31CRC (ITU-T G.703, G.732, G.706)	64 kb/s, n × 64 kb/s
E2	ITU-T G.742	2 Mb/s 64 kb/s, n × 64 kb/s
E3	ITU-T G.751	2/8 Mb/s, 64 kb/s, n × 64 kb/s
E4[1]	ITU-T G.751	2/8/34 Mb/s, 64 kb/s, n × 64 kb/s

[1] Supported as a mapped SONET payload (ie no physical E4 interfaces)

Test pattern

PRBS: 2^9–1, 2^{11}–1, 2^{15}–1, QRSS (14 zero limit – DS1 only), 2^{20}–1, 2^{23}–1.
Word: All 1s, all 0s, 1010, 1000, 16-bit word (frame aligned).
DS1 only: 3-in-24, 1-in 8, 2-in-8, Daly (55 octet).
Live traffic: Externally generated.
The test pattern can be inserted/measured at the line rate or at any level within the multiplexing structure, inlcuding in a selected 64/56 kb/s or n × 64/56 kb/s timeslot.

Error add

DS1: Bit, FAS (frame alignment signal), BPV/Code, CRC6, EXZ (excess zeros).
DS3: Bit, FAS, MFAS (multi-frame alignment signal), FAS+MFAS, BPV/Code, C-bit, P-bit, FEBE, EXZ.
E1: Bit, FAS, code, CRC4, REBE
E2/E3: Bit, FAS, code.
E4: Bit, FAS *(SONET payload – no interface provided)*.

Control:

Single	Selected error type transmitted when "single error" key is pressed.
Rate	1.0×10^{-3}, 1.1×10^{-3}, $M.P \times 10^{-n}$ n = 4 to 9; M.P = 1.0 to 9.9 in 0.1 steps)[1]
Burst	Single burst of n-errors. EXZ: n = 3 to 16. DS1 FAS: n = 1 to 6 DS3 FAS and MFAS: n = 1 to 4 En FAS: n = 1 to 4

[1] *Maximum error rate is 2.1×10^{-4} for:*
- *DS1 CRC6 errors*
- *DS3 FEBE, P-bit and C-bit errors*

Alarm generation

DS1: LOS, OOF, AIS, RAI (yellow).
DS3: LOS, OOF, AIS, Idle, RAI (X-bit), FEAC codes (Loopback and alarm/status codes).
E1: LOS, LOF, AIS, RAI, RAI (MF), CASMFL,minor alarm (via spare bits).
E2/E3: LOS, LOF, AIS, RAI.
E4: LOF, AIS, RAI *(SONET payload – no interface)*.
Control: On/off.

Spare bits generation

User-selected value transmitted in spare bits of En frame.
E4: FAS bits 14 to 16.
E3: FAS bit 12.
E2: FAS bit 12.
E1: Si bits (international bits): Timeslot 0 bit1 in both FAS and NFAS frames.
E1: E bits: CRC4 frames 13 and 15: timeslot bit 1.
E1: Sa bit (national bits): NFAS timeslot bits 4 to 8.
E1: Sa bit sequences: 8 bit sequence transmitted in any selected NFAS Sa bit.
E1: CAS multiframe: MFAS timeslot bits 5,7 and 8.

Signaling bits generation/monitor	**DS1:** Monitoring only. Displays signaling bits associated with all DS0 channels (ABCD format for ESF; AB format for SF (D4) and SLC-96). SLC-96 can display one of three states; 0,1 or alternating. **E1:** PCM30 and PCM30CRC frame formats. Transmit: User selected value transmitted in ABCD signal bits associated with all channels. Monitor: Simultaneously displays received ABCD signaling associated with all 30 channels.
FEAC codes	DS3 C-bit frame format. Transmits and monitors loopback and alarm/status codes as per ANSI T1.107-1995. **Transmit:** Use-selected loopback or alarm/status code tranmitted for controlled duration. Loopback codes: A single burst of N loopback codes and M messages transmitted (where N and M are selectable in the range 1 to 15). Alarm/status codes: Any ANSI T1.107-1995 message or any 0xxxxxx0 11111111 message may be transmitted, either in a single burst (selectable in the range 1 to 15) or continuously. **Monitor:** Displays in decoded form the two most recently received FEAC messages (current and previous messages.)
DS1 loopcodes	Transmits and monitors both in-band and out-of-band DS1 loopcodes. **In-band:** Line, payload, network, user (selectable in range 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 range 1 to15). Monitor: Displays in decode form the two most recently received loopcodes (current and previous).
TroubleScan	Scans all possible error and alarm sources simultaneously. Non-zero error counts are displayed in large characters, up to a maximum of 4 different error counts.
PDH alarm scan	Continuously scans a received signal for alarms at the interface rate or within any sub-channel. Results presented graphically.
Error and alarm measurements	**Measurement control:** Manual, single, timed start. **Errors:** **DS1:** Bit, BPV/code, frame error, CRC6. **DS3:** Bit, BPV/code, frame error, P-bit, C-bit, FEBE. **E1:** Bit, code, frame error, CRC, REBE. **E2/E3:** Bit, code, frame error. **E4:** Bit, frame error *(SONET payload – no interface).*

	Alarms: **DS1:** LOS, pattern loss, AIS, OOF, multiframe loss, RAI (yellow), EXZ, idle. **DS3:** LOS, pattern loss, AIS, OOF, multiframe loss, RAI (x-bit), EXZ, idle. **E1:** LOS, pattern loss, AIS, LOF, RAI, RAI(MF), CASMFL. **E2/E3:** LOS, pattern loss, AIS, LOF, RAI. **E4:** LOS, pattern loss, AIS, LOF, RAI *(SONET payload – no interface)*. **Basic results:** Error count, error ratio, alarm seconds.
Performance analysis	ITU-T G.821 (bit), G.826, M.2100, M.2101, M.2110, M.2120.
Additional measurements	Line frequency (Hz and ppm offset), delay (En signals only).
Thru mode	DS1 and DS3 only. Received signal is retransmitted either unchanged or with a selected error rate injected across the entire DSn frame. All standard DSn received functions are available. **Error rate:** 1.1×10^{-3} to 1.0×10^{-9} (in 0.1 steps).
DS1/E1 add-drop	DS1 inserted and extracted from a DS3 signal. 100 ohm balanced (WECO Bantam). E1 inserted and extracted from a E2/E3/E4 signal. 75 ohm unbalanced (BNC). DS1, DS3, E1, E3 dropped from and/or inserted into an OC-N, STS-N line signal.
Handset connector	Supports adding and dropping of a selected DS0 voice channel (carried in a DSn or En signal) to an external handset. **Connector:** RJ411. **Coding:** μ-law (DSn), A-law (En).

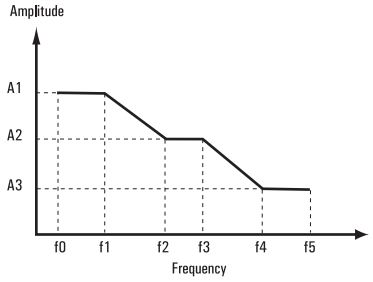
Jitter (Option 200)

1. Jitter generation

Jitter generation rates/interfaces	**SONET:** OC-48, OC-12, OC-3, OC-1, STS-3, STS-1. **T-carrier/PDH:** DS3 (45 Mb/s), DS1 (1.5 Mb/s), E3 (34 Mb/s), E2 (8 Mb/s), E1 (2 Mb/s).
Wander generation rates/interfaces	**SONET:** OC-48, OC-12, OC-3, OC-1, STS-3, STS-1. **T-carrier/PDH:** DS1 (1.5 Mb/s), E1 (2 Mb/s).
External jitter modulation input	Used for external modulation. **Input range:** 10 UI: E3, E2, E1. 20 UI: SONET rates, DS1, DS3. Jitter Tx display provides a numerical indication of the level of externally applied modulation. **Signal:** Sinusoidal but can be used with other signal formats. **Max Input Level:** ± 5 V peak. **Connector:** BNC, 75 ohm nominal unbalanced.
Bellcore GR-253/ITU-T jitter generation specification	Exceeds the network equipment requirements of Bellcore GR-253 for SONET jitter generation. Exceeds the network equipment requirements of Bellcore GR-499 for DSn jitter generation. Exceeds the network equipment requirements of ITU-T G.823 for PDH jitter generation and ITU-T G.825/ITU-T G.958 for synchronous jitter generation. Meets the test equipment requirements of ITU-T O.171 for T-carrier/PDH jitter generation and ITU-T 0.172 for synchronous jitter generation.
Fixed jitter tolerance masks	**Spot mode, swept mode or auto jitter tolerance** Bellcore GR-253, Bellcore GR-499-CORE, ITU-T G.825, ITU-T G.958 type A and type B and ITU-T G.823 low Q and high Q.
Automatic jitter tolerance	**Onset of errors and BER penalty methods** **User defined:** No of frequency points (3 to 55), delay time (0.1 to 99.9s), dwell time (0.1 to 99.9s), bit error threshold (1 to 10^6). **Masks:** Bellcore GR-253 and GR-499, ITU-T G.825, G.958 (type A and type B), G.823 (low Q and high Q).
User-programmable masks	Provides the ability to create, edit and title up to 5 user input jitter masks. Each mask can be defined with up to 55 frequency and amplitude points.

Bellcore GR-253-CORE SONET jitter tolerance

Bellcore GR-253 jitter amplitude versus modulation frequency:

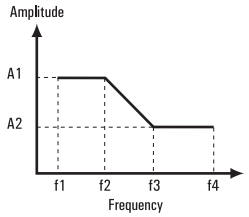


Bellcore GR-253 jitter amplitude versus modulation frequency table

Bit Rate (kb/s)	A1 (UI)	A2 (UI)	A3 (UI)	f0 (Hz)	f1 (Hz)	f2 (Hz)	f3 (kHz)	f4 (kHz)	f5[1] (kHz)
51840	15	1.5	0.15	10	30	300	2	20	400
155520	15	1.5	0.15	10	30	300	6.5	65	1300
622080	15	1.5	0.15	10	30	300	25	250	5000
2488320	15	1.5	0.15	10	600	6000	100	1000	20000

Bellcore GR-499-CORE T-carrier jitter tolerance

Bellcore GR-499 jitter amplitude versus modulation frequency:

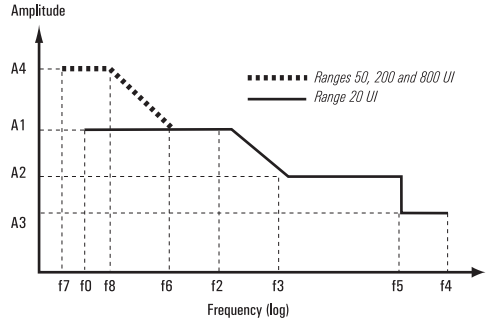


Bellcore GR-499 jitter amplitude versus modulation frequency:

Bit Rate (kb/s)	A4 (UI)	A2 (UI)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (kHz)
1544, Cat 1	5	0.1	10	500	8k	40
1544, Cat 2	10	0.3	10	192.9	6.43 k	40
44736, Cat 1	5	0.1	10	2.3 k	60 k	300
44736, Cat 2	10	0.3	10	669	22.3	300

SONET generated jitter amplitude versus modulation frequency

SONET generated jitter amplitude versus modulation frequency:

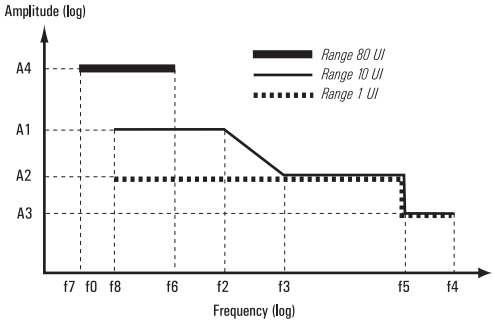


SONET generated jitter amplitude versus modulation frequency:

Bit Rate (kb/s)	A4 (UI)	A1 (UI)	A2 (UI)	A3 (UI)	f7 (Hz)	f0 (Hz)	f8 (Hz)	f6 (Hz)	f2 (kHz)	f3 (kHz)	f5 (kHz)	f4 (kHz)
51840	20	20	1.0	0.6	0.1	2	–	200	2	10	100	400
155520	50	20	1.0	0.6	0.1	2	30	500	5	50	1000	1300
622080	200	20	1.0	0.6	0.1	2	30	1000	25	250	1000	5000
2488320	800	20	1.0	0.6	0.1	2	30	5000	100	1000	5000	20000

T-carrier/PDH generated jitter amplitude versus modulation frequency

T-carrier/PDH generated jitter amplitude versus modulation frequency:



T-carrier/PDH generated jitter amplitude versus frequency:

Bit Rate (kb/s)	A4 (UI)	A1 (UI)	A2 (UI)	A3 (UI)	f7 (Hz)	f0 (Hz)	f6 (Hz)	f2 (kHz)	f3 (kHz)	f5 (kHz)	f4 (kHz)
1544	80	20	1.0	0.6	0.1	2	100	1.0	10	30	42
2048	80	10	1.0	0.6	0.1	2	100	13	25	50	102
8448	80	10	1.0	0.6	0.1	2	100	50	100	200	430
34368	80	10	1.0	0.6	0.1	2	100	100	200	400	840
44736	80	20	1.0	0.6	0.1	2	100	10	200	300	430

Jitter generation modulation range

Range (UI)	Line Rate (Mb/s)	Min (UI)	Max (UI)	Amplitude Resolution (UI)	Modulation Frequency Range
20	52, 155, 622, 2488	0.01	20.0	0.01	2 Hz to f4[1]
20 *(low freq)*	52	0.5	20.0	0.5	0.1 to 200
50	155	0.5	50.0	0.5	0.1 to 500 Hz
200	622	0.5	200.0	0.5	0.1 to 1000 Hz
800	2488	0.5	800.0	0.5	0.1 to 5000 Hz
10	2, 8, 34	0.01	10.0	0.01	2 Hz to f4[1]
20	1.5, 45	0.01	20.0	0.01	2 Hz to f4[1]
80	1.5, 2, 8, 34, 45	0.5	80.0	0.5	0.1 to 100 Hz

[1] Refer to f4 in SONET and T-carrier/PDH jitter generation vs frequency amplitude table.

Jitter modulation frequency resolution

Modulation Frequency	Mimimum Resolution
< 10 kHz	1 Hz
10 to 99.99 kHz	10 Hz
100 to 999.99 kHz	100 Hz
1 to 20 MHz	1000 Hz

Jitter modulation accuracy

Jitter frequency:
± 1% above 3 Hz.
± 3% between 3 Hz and 1 Hz.
± 10% below 1 Hz.

Jitter amplitude:
± 5% ± X ± Y ± Z
where X is given by the following table:

Amplitude accuracy:

Range	X (UI)
10	0.01
20	0.01
50	0.5
80	1.0
200	1.0
800	2.0

and where Y is given by the following tables:

T-carrier/PDH generator intrinsic jitter:

Bit Rate (kb/s)	Y (UI) All 1s Data Pattern	Y (UI) PRBS[1] Data Pattern
1544	0.02	0.02
2048	0.02	0.02
8448	0.02	0.02
34368	0.03	0.03
44736	0.03	0.03

SONET generator intrinsic jitter:

Bit Rate (kb/s)	Y (UI) 1010 Data Pattern	Y (UI) PRBS Data Pattern[1] (payload)
51840 electrical	0.02	0.03 (STM-0/STS-1)
155520 electrical	0.02	0.03 (STM-1/STS-3c)
155520 optical	0.02	0.03 (STM-1/OC-3c)
622280	0.02	0.03 (STM-4c/OC-12c)
2488320	0.02	0.04(STM-16c/OC-48c)

[1] The payload is PRBS length (2^{23}–1) scrambled.

[2] SONET intrinsic jitter generation is specified over the HP1-LP filter bandwidth.

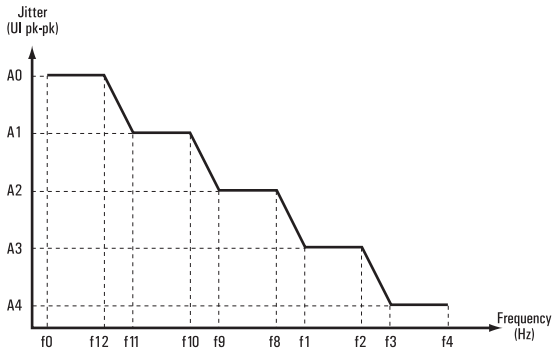
and where Z is given by the following table:

Additional frequency response term Z[1]	
1 to 5 MHz	±2%
5 to 10 MHz	±3%
10 to 20 MHz	±5%

[1] Applies to SONET generation only.

ITU-T O.171/0.172 PDH/T-carrier/synchronous jitter generation requirements

ITU-T O.171/0.172 jitter amplitude versus modulation frequency:



ITU-T O.171 PDH jitter amplitude versus modulation frequency:

Bit Rate (kb/s)	A0 (UI)	A1 (UI)	A2 (UI)	A3 (UI)	A4 (UI)	f0 (μHz)	f12 (Hz)	f11 (Hz)	f10 (Hz)	f9 (Hz)	f8 (Hz)	f1 (Hz)	f2 (Hz)	f3 (kHz)	f4 (kHz)
1544	–	–	–	10	0.5	–	–	–	–	–	–	2	400	8	40
2048	40	–	20	10	0.5	12	–	–	–	–	5	10	900	18	100
8448	200	–	20	10	0.5	12	–	–	–	–	10	20	400	8.5	400
34368	1000	–	20	10	0.5	–	–	–	–	–	50	100	1.0k	20	800
44736	–	–	–	10	0.5	–	–	–	–	–	–	2	5.0k	100	400

ITU-T O.172 SDH jitter amplitude versus modulation frequency:

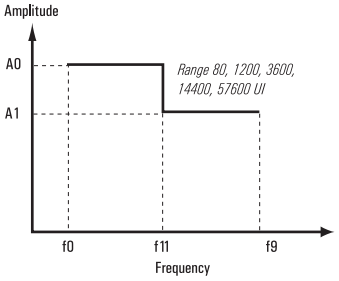
Bit Rate (kb/s)	A0 (UI)	A1 (UI)	A2 (UI)	A3 (UI)	A4 (UI)	f0 (μHz)	f12 (μHz)	f11 (mHz)	f10 (mHz)	f9 (Hz)	f8 (Hz)	f1 (Hz)	f2 (kHz)	f3 (kHz)	f4 (kHz)
51840	–	–	20	2	0.2	–	–	–	–	10	30	300	2.0	20	400
155520e	3600	400	50	2	0.1	12	178	1.6	15.6	0.125	19.3	500	3.25	65	1300
155520	3600	400	50	2	0.2	12	178	1.6	15.6	0.125	19.3	500	6.5	65	1300
622080	14400	1600	200	2	0.2	12	178	1.6	15.6	0.125	9.65	1k	25	250	5000
2488320	57600	6400	800	2	0.2	12	178	1.6	15.6	0.125	12.1	5k	100	1000	20000

Note: *OmniBER 719 exceeds above requirements of ITU-T O.171/O.172*

2. Wander generation

Generated wander amplitude versus modulation frequency

Generated wander amplitude versus modulation frequency:



Generated wander amplitude versus modulation frequency

Bit Rate (kb/s)	A0 (UI)	A1 (UI)	f0 (µHz)	f11 (mHz)	f9 (Hz)
1544	80	80	10	0.125	–
2048	80	80	10	0.125	–
51840	1200	140	10	1.6	0.125
155520	3600	400	10	1.6	0.125
622080	14400	1600	10	1.6	0.125
2488320	57600	6400	10	1.6	0.125

Wander generation modulation range

Range	Min (UI)	Max (UI)	Amplitude Resolution (UI)	Modulation Frequency Min	Modulation Frequency Max
80	0.5	80	0.5		
1200	0.5	1200	0.5		
3600	0.5	3600	0.5	10 µHz	0.125 Hz
14400	0.5	14400	0.5		
57600	2	57600	2		

Wander modulation accuracy

Wander frequency:
±1%.
Wander amplitude:
±5% ± X ± Y
where X is amplitude accuracy and Y the generator intrinsic jitter as give in the table below:

Range	X (UI)	Y (UI)
80	1.0	0.1
1200	0.5	0.1
3600	0.5	0.1
14400	0.5	0.1
57600	1.0	0.1

Fixed wander tolerance masks

Spot mode: ITU-T G.825.

3. Jitter measurement

Jitter measurement rates/interfaces

SONET: OC-48, OC-12, OC-3, OC-1, STS-3, STS-1.
T-carrier/PDH: DS3 (45 Mb/s), DS1 (1.5 Mb/s), E3 (34 Mb/s), E2 (8 Mb/s), E1 (2 Mb/s).

Wander measurement rates/interfaces

SONET: OC-48, OC-12, OC-3, OC-1, STS-3, STS-1.
T-carrier/PDH: 34/8/2 Mb/s, DS1 (1.5 Mb/s), DS3 (45 Mb/s).

Optical sensitivity

–12 to –20 dBm for OC-48, –10 to –22 dBm for OC-1, OC-3, OC-12.

Jitter measurement ranges

These ranges cover the measurements required in ITU-T O.171 Table 3 and ITU-T O.172 Table 5.

Range (UI)	Rate	Max UI_{p-p}	Max UI_{rms}[1]
1.6	All rates	1.6	0.8
16	All rates to 622 Mb/s	16	8
64	2.5 Gb/s	64	32

Extended jitter measurement peak-peak ranges

Range (UI)	Rate	Max UI_{p-p}	Max UI_{rms}[1]
256	All rates to 45 Mb/s	256	128
64	155/52 Mb/s	64	32
256	622 Mb/s	256	128
1024	2.5 Gb/s	1024	512

[1]The rms range is linked to the selection for peak-peak jitter measurement.

Jitter receiver results resolution

Range (UI)	Resolution UI_{p-p}	Resolution UI_{rms}
1.6	1 m	1 m
16	5 m	1 m
64	10 m	1 m
256	50 m	5 m
1024	200 m	20 m

Jitter hit threshold

Range (UI)	Min UI_{p-p}	Max UI_{p-p}	Resolution UI_{p-p}
1.6	50 m	1.6	10 m
16	500m	16.0	100 m
64	1.0	64.0	200 m
256	5.0	256.0	1.0
1024	10.0	1024.0	5.0

Jitter measurement bandwidth

		Jitter measurement bandwidth			
Rate	**Range (UI)**	**F_L (Hz)**	**F_{min} (Hz)**	**F_{max}**	**F_U**
1.5 Mb/s	1.6	2	10	40 kHz	80 kHz
1.5 Mb/s	16	2	10	7.0 kHz	8.27 kHz
2 Mb/s	1.6	2	20	100 kHz	150 kHz
2 Mb/s	16	2	20	10 kHz	12.5 kHz
8 Mb/s	1.6	2	20	400 kHz	500 kHz
8 Mb/s	16	2	20	20 kHz	25 kHz
34 Mb/s	1.6	2	100	800 kHz	1300 kHz
34 Mb/s	16	2	100	64 kHz	80 kHz
45 Mb/s	1.6	2	10	400 kHz	800 kHz
45 Mb/s	16	2	10	80 kHz	100 kHz
52 Mb/s	1.6	10	100	400 kHz	800 kHz
52 Mb/s	16	10	100	80 kHz	100 kHz
155 Mb/s	1.6	10	500	1.3 MHz	2.6 MHz
155 Mb/s	16	10	200	100 kHz	150 kHz
622 Mb/s	1.6	10	1000	5 MHz	5 MHz
622 Mb/s	16	10	500	1040 kHz	1.3 MHz
2.5 Gb/s	1.6	10	5000	20 MHz	20 MHz
2.5 Gb/s	64	10	2000	2.8 MHz	3.5 MHz

[1] Measurement accuracy is specified between F_{min} and F_{max} bandwidth.
F_L = lower3 dB point. F_U = upper 3 dB point.

Measurement filters

LP, HP1 and HP2 filters to Bellcore GR-499 and GR-253, ITU-T O.171 (T-carrier/PDH)/ O.172 (synchronous); 12 kHz HP filter.

	HP1 (Hz)	**HP2 (kHz)**	**LP (kHz)**	**HP rms (kHz)**
1.5 Mb/s	10	8	40	12
2 Mb/s	20	18	100	12
8 Mb/s	20	80	400	12
34 Mb/s	100	10	800	12
45 Mb/s	10	30	400	12
52 Mb/s	100	20	400	12
155 Mb/s	500	65	1300	12
622 Mb/s	1000	250	5000	12
2.5 Gb/s	5000	1000	20000	12

Extended range jitter measurement bandwidth

		Jitter measurement bandwidth[1]			
Rate	**Range (UI)**	**F_L (Hz)**	**F_{min} (Hz)**	**F_{max}**	**F_U**
1.5 Mb/s	256	0.15	1	200 Hz	250 Hz
2 Mb/s	256	0.15	1	200 Hz	250 Hz
8 Mb/s	256	0.15	1	200 Hz	625 Hz
34 Mb/s	256	0.15	1	2 kHz	2.5 kHz
45 Mb/s	256	0.15	1	5 kHz	6.25 kHz
52 Mb/s	64	0.15	1	20 kHz	25 kHz
155 Mb/s	64	0.15	1	20 kHz	25 kHz
622 Mb/s	256	0.15	1	20 kHz	25 kHz
2.5 Gb/s	1024	0.15	1	20 kHz	25 kHz

[1] Measurement accuracy is specified between F_{min} and F_{max}
F_L = lower 3 dB point. F_U = upper 3 dB point.

Note: *No selectable filters are provided for extended jitter measurement operation.*

SONET jitter measurement accuracy (as per ITU-T O.171/O.172)

The peak-to-peak accuracy for SONET rates is specified as ± 5% of reading ± W ± Z as is the convention in ITU-T recommendation O.172 where W represents the intrinsic jitter for a given data pattern and receiver range, and where Z represents the frequency response term of the receiver. The typical rms accuracy for SONET rates is specified as ± 5% of reading ± W ± Z.

SONET system intrinsic term W:

		Data Pattern			
		System		Receiver only[1]	
Bit rate (kb/s)	**Range**	**OC/STS-n[2]c with PRBS[3] scrambled payload**		**OC/STS-nc with PRBS scrambled payload**	
		W[4,5]		**W[4,5]**	
		UI p-p	**UI rms[1]**	**UI p-p**	**UI rms**
51840	1.6 16 64	0.07 0.1 3	0.005 0.03 1	0.035 0.07 2	0.004 0.015 0.7
155520	1.6 16 64	0.05 0.1 3	0.005 0.03 1	0.035 0.07 2	0.004 0.015 0.4
622080	1.6 16 256	0.07 0.1 12	0.005 0.03 4	0.05 0.07 8	0.004 0.015 1.6
2488320	1.6 64 1024	0.07 0.15 50	0.005 0.06 15	0.05 0.1 24	0.004 0.03 8

[1] Typical specification only.
[2] Variable n corresponds to the line bit rate, OC-3, OC-12 or OC-48.
[3] The PRBS used will be of length (2^{23}–1).
[4] W is specified for the supplementary filter HP1 inserted in peak-peak measurements and filter rms in rms measurements. For extended range operation W is specified with no filtering.
[5] Intrinsic limits for a calibrated OmniBER 719 transmitter and receiver pair.

SONET receiver frequency inaccuracy term Z:

Bit Rate (kb/s)	Additional frequency response error[1,2]
51840	± 2% of reading from 100 Hz to 300 kHz ± 3% of reading from 300 kHz to 400 kHz
155520	± 2% of reading from 500 Hz to 300 kHz ± 3% of reading from 300 kHz to 1 MHz ± 5% of reading from 1 MHz to 1.3 MHz
622080	± 2% of reading from 1000 Hz to 300 kHz ± 3% of reading from 300 kHz to 1 MHz ± 5% of reading from 1 MHz to 3 MHz ± 10% of reading from 3 MHz to 5 MHz
248830	± 2% of reading from 5000 Hz to 300 kHz ± 3% of reading from 300 kHz to 1 MHz ± 5% of reading from 1 MHz to 3 MHz ± 10% of reading from 3 MHz to 10 MHz ± 15% of reading from 10 MHz to 20 MHz

1 This is with respect to calibrated value at 100 kHz. At 100 kHz Z = 0.
2 The frequency response term will only apply over the bandwidth F_{min} to F_{max} in an associated receiver range.

T-carrier/PDH jitter measurement accuracy

The peak-to-peak accuracy for T-carrier/PDH rates is specified as ± 5% of reading ± W ± Z where W represents the intrinsic jitter for a given data pattern and receiver range, and where Z represents the frequency response term of the receiver. The typical rms accuracy for PDH/T-carrier rates is specified as ± 5% of reading ± W ± Z.

T-carrier/PDH system intrinsic term W

Bit Rate (kb/s)	Range	Data Pattern							
		System				Receiver only[1]			
		PRBS[2] W[3,4]		All 1s input W[3,4]		PRBS W[3,4]		All 1s input W[3,4]	
		UI p-p	UI rms[1]	UI p-p	UI rms[1]	UI p-p	UI rms	UI p-p	UI rms
1544	1.6 16 256	0.02 0.1 10	0.004 0.045 3	0.02 0.07 10	0.002 0.045 3	0.01 0.07 4	0.002 0.015 1.4	0.005 0.05 4	0.002 0.015 1.4
2048[5]	1.6 16 256	0.02 0.1 10	0.004 0.045 3	0.02 0.07 10	0.002 0.045 3	0.01 0.07 4	0.002 0.015 1.4	0.005 0.05 4	0.002 0.015 1.4
8448[5]	1.6 16 256	0.02 0.1 10	0.004 0.045 3	0.02 0.07 10	0.002 0.045 3	0.02 0.07 4	0.004 0.015 1.4	0.01 0.05 4	0.002 0.015 1.4
34368	1.6 16 256	0.03 0.1 10	0.004 0.045 3	0.03 0.07 10	0.003 0.045 3	0.02 0.07 4	0.004 0.015 1.4	0.01 0.05 4	0.002 0.015 1.4
44736	1.6 16 256	0.03 0.1 10	0.004 0.045 3	0.03 0.07 10	0.003 0.045 3	0.02 0.07 4	0.004 0.015 1.4	0.01 0.05 4	0.002 0.015 1.4

1 Typical specification only
2 The PRBS pattern type 2^{15}–1 for 2048 and 8448 kbit/s, and 2^{23}–1 for 34368 kbit/s as given in ITU-T recommendation O.171.
3 W is specified for the supplementary filter HP1 inserted in peak-peak measurements and filter rms in rms measurements. For extended range operation W is specified with no filtering.
4 Intrinsic limits for a calibrated OmniBER 719 transmitter and receiver pair.
5 Specified only for HDB3 encoding, the performance is not specified for AMI encoding.

T-carrier/PDH receiver frequency inaccuracy term Z

Bit Rate (kb/s)	Additional frequency response error[1,2]
1544	± 4% of reading from 10 Hz to 1 kHz ± 2% of reading from 1 kHz to 40 kHz
2048	± 2% of reading from 20 Hz to 100 kHz
8448	± 2% of reading from 20 Hz to 300 kHz ± 3% of reading from 300 kHz to 400 kHz
34368	± 2% of reading from 100 Hz to 300 kHz ± 3% of reading from 300 kHz to 800 kHz
44736	± 4% of reading from 10 Hz to 200 kHz ± 2% of reading from 200 kHz to 300 kHz ± 3% of reading from 300 kHz to 400 kHz

1 With respect to calibrated value at 1 kHz. At 1 kHz Z = 0.
2 The frequency response term will only apply over the bandwidth F_{min} to F_{max} in an associated receiver range.

Demodulated jitter output

The output has gain dependent on range and is after the supplementary filter selection.

Demodulated output gain:

Range (UI p-p)	Gain (mV/UI p-p)
1.6	1000
16	100
64	25
256	6
1024	1.5

Connector: BNC, 75 ohm nominal unbalanced.

Jitter measurement results

Amplitude: +ve peak, –ve peak, peak-peak, rms, filters (indicates filters in use), elapsed time
Hits: Jitter hit count, jitter hit seconds, jitter hit free seconds, elapsed time.

Jitter stored measurement graphs

Bar graph: Hit count.
Alarms: Unlock, out-of-range, LOS (STS-3 only), LOL (OC-N optical only).

4. Jitter transfer

Jitter transfer rates

SONET: OC-48, OC-12, OC-3, OC-1, STS-3, STS-1.
T-carrier/PDH: DS3 (45 Mb/s), DS1 (1.5 Mb/s), E3 (34 Mb/s), E2 (8 Mb/s), E1 (2 Mb/s).

Jitter transfer function

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

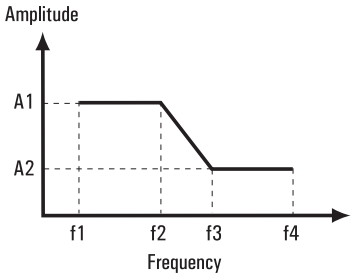
Automatic jitter transfer function

Masks: Bellcore GR-253 and GR-499 Cat 1 and Cat2, ITU-T G.825, G.958: type A and type B, ITU-T G.823 low Q and high Q.
User defined: No of frequency points (1 to 55), delay time (5 to 30 s), dwell time (5 to 30 s).

Fixed jitter transfer input masks

Bellcore GR-253, ITU-T G.958: type A and type B.
ITU-T G.823 low Q and high Q.

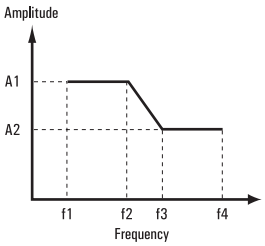
Generated jitter amplitude versus modulation frequency:



SONET jitter transfer input masks:

Rate (Mb/s)	Mask	F1 (Hz)	F2 (Hz)	F3 (Hz)	F4 (Hz)	A1 (UI)	A2 (UI)
52	GR-253-CORE(1) GR-253-CORE(2)	10 500	30 2k	300 20k	500 400k	15 1.5	1.5 0.15
155	GR-253-CORE(1) GR-253-CORE(2)	10 500	30 6.5k	300 65k	500 1300k	15 1.5	1.5 0.15
622	GR-253-CORE(1) GR-253-CORE(2)	10 1k	30 25k	300 250k	1k 5000k	15 1.5	1.5 0.15
2488	GR-253-CORE(1) GR-253-CORE(2)	10 10k	600 100k	6k 1000k	10k 20000k	15 1.5	1.5 0.15

Generated jitter amplitude versus modulation frequency:

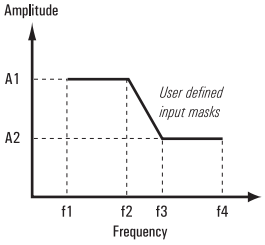


T-carrier/PDH and ITU-T synchronous jitter transfer input masks:

Rate (Mb/s)	Mask	F1 (Hz)	F2 (Hz)	F3 (kHz)	F4 (kHz)	A1 (UI)	A2 (UI)
1.5	GR-499, Cat 1 GR-499, Cat 2 G.824	10 10 10	500 192.9 120	8 6.43 6	40 40 40	5 10 5	0.1 0.3 0.1
2	G.823, High Q G.823, Low Q	20 20	93 2.4 k	0.700 18	100 100	1.5 1.5	0.2 0.2
8	G.823, High Q G.823, Low Q	20 20	400 10.7	3 80	400 400	1.5 1.5	0.2 0.2
34	G.823	100	1 k	10	800	1.5	0.15
45	GR-499, Cat 1 GR-499, Cat 2 G.824	10 10 10	2.3k 669 600	60 22.3 30	300 300 400	5 10 5	0.1 0.3 0.1
155	G.958, Type A G.958, Type B	500 500	6.5 k 1.2 k	65 12	1300 1300	1.5 1.5	0.15 0.15
622	G.958, Type A G.958, Type B	1 k 500	25 k 1.2 k	250 12	5000 5000	1.5 1.5	0.15 0.15
2488	G.958, Type A G.958, Type B	5 k 500	100 k 1.2 k	1000 12	20000 20000	1.5 1.5	0.15 0.15

User selectable jitter transfer input masks

User defined:
f1, f2, f3, f4 (Note f1<f2<f3<f4); $f1_{min}$=10 Hz;
$f4_{max}$ rate dependent, see table below:



Rate	f4 max
2.5 Gb/s	20 MHz
622 Mb/s	5 MHz
155 Mb/s	1.3 MHz
52 Mb/s	400 kHz
45 Mb/s	400 kHz
34 Mb/s	800 kHz
8 Mb/s	400 kHz
2 Mb/s	100 kHz
1.5 Mb/s	40 kHz

A1,A2 ($A1_{max}$ = max value instrument can generate at f2;
$A2_{max}$ = max value instrument can generate at f4)

Jitter transfer receiver

A narrowband filtering technique will be used when performing a jitter transfer measurement.
Measurement bandwidth: 10 Hz.
Dynamic range: +5 dB to –40 dB.
Stability: 0.02 dB.
Calibration: 0.01 dB.

Jitter transfer accuracy

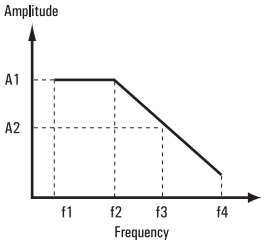
Rx Jitter (UI)	Accuracy (dB)
> 0.3	0.04
0.3 to 0.1	0.15
0.1 to 0.03	0.25
0.03 to 0.01	0.5
0.01 to 0.003	1
0.003 to 0.001	3

[1] *Specified for a minimum dwell time of 20 s and a minimum delay time of 10 s.*

Jitter transfer results

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

Jitter transfer pass masks



Bellcore GR-253, GY-499 Cat 1 and 2 ITU-T G.958: type A and type B . ITU-T G.823 low Q and high Q.

Rate (Mb/s)	Mask	F1 (Hz)	F2 (Hz)	F3 (Hz)	F4 (kHz)	A1 (UI)	A2 (UI)
1.5	G.824 GR-499, Cat 1 GR-499, Cat 2 GR-253-CORE	10 10 10 10	350 350 9.65 40	2.5 k 2.5 k – –	15 k 15 k 40 k 15 k	0.5 0.1 0.1 0.1	– – – –
2	G.823[1], High Q G.8231, Low Q	20 20	40 70	400 700	100 100	0.5 0.5	–19.5 –19.5
8	G.823[2], High Q G.823[2], Low Q	20 20	100 8 k	1 k 80 k	400 400	0.5 0.5	–19.5 –19.5
34	G.823[2]	100	300	3 k	800	0.5	–19.5
45	G.824 GR-499, Cat 1 GR-499, Cat 2 GR-253-CORE	10 10 10 10	500 10 k 59.6 k 40	2.5 k – – –	15 k 15 k 300 k 15 k	0.1 0.1 0.1 0.1	– – – –
52	GR-253-CORE	10	40 k	–	400 k	0.1	–
155	G.958, Type A GR-253-CORE	500	130 k	Note 2	–	0.1	–
	G.958, Type B	500	30 k	Note 2	–	0.1	–
622	G.958, Type A GR-253-CORE	1 k	500 k	Note 2	–	0.1	–
	G.958, Type B	1 k	30 k	Note 2	–	0.1	–
2488	G.958, Type A GR-253-CORE	5 k	2000 k	Note 2	–	0.1	–
	G.958, Type B	5 k	30 k	Note 2	–	0.1	–

[1] Actual values from ITU-T G.742.
[2] Actual values from ITU-T G.751.

Note 1: *The mask shows threshold falling off by 20 dB per decade after F2.*

An offset in the range –2 dB to +2 dB in steps of 0.01 dB can be added to the selected pass mask.

Jitter transfer graph results

The result is plotted on a graph of gain versus frequency. The pass mask is displayed on the graph as well as the results.

Jitter transfer text results

Point number, frequency, mask value, result, pass/fail indication.

5. Wander measurement

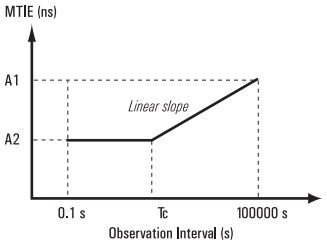
Wander measurement rates

SONET: OC-48, OC-12, OC-3, OC-1, STS-3, STS-1.
T-carrier/PDH: DS3 (45 Mb/s), DS1 (1.5 Mb/s), E3 (45 Mb/s), E2 (8 Mb/s), E1 (2 Mb/s).

Wander timing reference

Wander measurement can only be performed on a locked synchronous system where one clock reference is used. For wander measurement on a T-carrier/PDH tributary, the T-carrier/PDH source must be locked to a clock reference which is available to the instrument.

Sinusoidal wander receive range MTIE:



Sinusoidal wander receive range MTIE:

A1 ns)	A2 (ns)	Tc	Resolution (ns)
10^{10}	10^{5}	3.14	0.1

Wander measurement bandwidth

All rates: 10 µHz to 10 Hz.

Wander sampling rate

Maximum sampling rate is 50 Hz.

Wander measurement accuracy

3% max ± 2.5 ns.

Wander results

Amplitude: +ve Peak, –ve peak, peak-peak, peak-peak (15 mins), peak-peak (24 hours), estimated bit slips (E1 and DS1 only), estimated frame slips (E1and DS1) , time interval error, implied frequency offset.

Graphical wander

Sliding bar graph presenting wander results in a graphical format (E1 and DS1 only).

Wander stored measurement graphs

Bar graph: +ve bit slips, –ve bit slips, frame slips.

Wander slew rate limit

Should not exceed 100000 ns/s. The slew rate limit is equivalent to a maximum fixed frequency offset of ± 100 ppm.

6. Wander Analysis Software (E4547A)

Description	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-48, OC-12, OC-3, OC-1. **T-Carrier/PDH:** 45 Mb/s (DS3), 34 Mb/s, 8 Mb/s, 2 Mb/s, 1.5 Mb/s (DS1).
Results	TIE, MTIE, MRTIE, TDEV, frequency offset and drift.
Standards Compliance	Complies with all relevant ITU-T, Bellcore, ETSI, ANSI standards. **ITU-T:** G.811, G.812, G.813, G.823, G.824. **Bellcore:** GR-253-CORE, GR-1244-CORE. **ANSI:** T1.101. **ETSI:** ETS 300 462, ETS 302 084.
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. **Memory:** 64M (Windows NT). **Comm Port:** RS-232 connection to OmniBER.

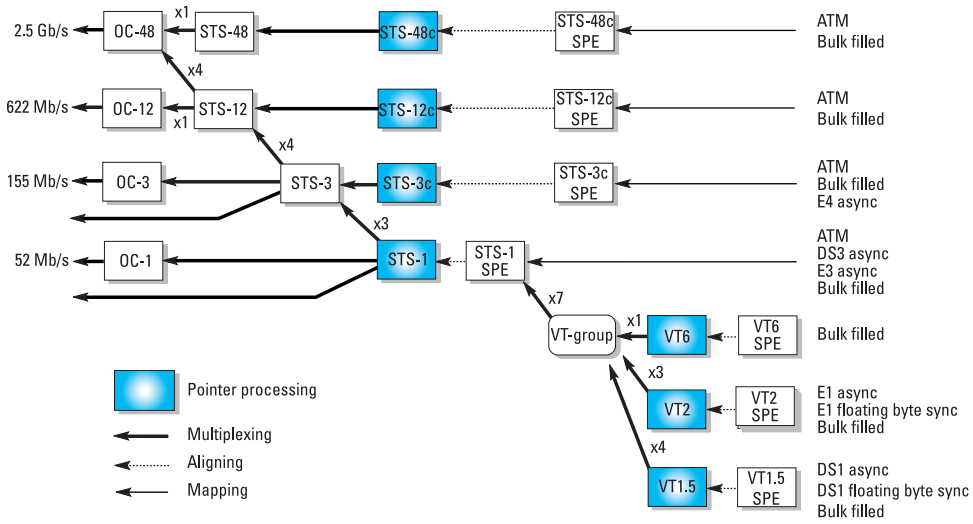


Figure 1: Bellcore GR-253 mapping structure (SONET payload mapping)

Physical interfaces

Specifications for the PDH and SONET interfaces can be found in the SONET and PDH/T-carrier specifications.

ATM physical layer structure

An ATM signal can be mapped into the following physical layers;

SONET (bulk filled):
STS-1 full SPE;
STS-3c full SPE;
STS-12c full SPE;
STS-48c full SPE.

PDH/T-Carrier:
2M (AMI,HDB3);
34 M (HDB3);
DS1 (AMI,B8ZS);
DS3 direct mapping (B3ZS);
DS3 PLCP mapping (B3ZS).

Note: *For PDH/T-carrier ATM test, option 013 must be ordered.*

SONET mappings:
All ATM mappings can be multiplexed into the selected line-rate as defined in Figures 1.

ATM framing structure

STS-1, STS-3c, STS-12c and STS-48c: As per Bellcore GR-253.
34 Mb/s: As per ITU-T G.832.
2 Mb/s: PCM30, PCM30CRC.
DS3 (45 Mb/s): C-bit parity framing.
DS1 (1.5 Mb/s): ESF.

Cell scrambling

On/off, conforms to ITU-T I.432.

DS3 PLCP mappings

Direct/PLCP. PLCP per Annex A of T1E1.2/95-003 and ITU-T Rec. G.804

Error add

SONET physical layers: See SONET specifications.
2 Mb/s: See PDH/T-carrier specifications.
34 Mb/s Code, EM-BIP.
DS1: See PDH/T-carrier specifications.
DS3: See PDH/T-carrier specifications.
DS3 PLCP: BIP.

Error add ratios

Single	Selected error type transmitted when "single error" key is pressed.
Rate	1.0×10^{-3}, 1.1×10^{-3}, M.P $\times 10^{-n}$ (n = 4 to 9; M.P = 1.0 to 9.9 in 0.1 steps)[1]
[1] Maximum error rate is 2.1×10^{-4} for: *– 34 M EM-BIP*	

For other error ratios refer to PDH and SONET specifications.

Alarm generation

SONET physical layers: See SONET spec.
2 Mb/s: See PDH/T-carrier specifications.
34 Mb/s: LOS, LOF, AIS, RDI.
DS1: See PDH/T-carrier specifications.
DS3: See PDH/T-carrier specifications.
DS3 PLCP: RAI.

Thru mode

SONET only: Thru mode passes the received signal unchanged to the transmit port. Payload overwrite and overhead channel overwrite operate with ATM payload in the same manner as PRBS.

ATM transmitter

ATM cell stream	Physical layer as per ITU-T I.432, ATM layer as per ITU-T I.361.
Cell streams	1 foreground, 7 background, fill cells. A single ATM cell stream is set up as the foreground test signal. The remaining bandwidth is then filled with background cells and idle or unassigned cells.
Cell stream header	The following are settable for the foreground and all background cell streams: UNI/NNI, GFC, VPI, VCI, PTI, CLP.
Foreground cell distribution	**Service type:** Constant bit rate (CBR) with settable peak cell rate (PCR) and cell delay variation tolerance (CDVT). Variable bit rate (VBR) with settable PCR, CDVT sustained cell rate (SCR) and maximum burst size (MBS). Single cell or burst of cells. SCR: Sustainable cell rate (VBR only) 0 to maximum value (step size 1 cell/s). PCR: Peak cell rate 0 to maximum value (step size 1 cell/s). CDVT: Cell delay variation tolerance 10 µs to 100 ms, step size 10 µs. MBS: Maximum burst size, 1 to 2047 (VBR and single only). Traffic is generated according to ITU-T O.191 enhanced traffic generator.
Rate synchronization	The transmit cell rates for both foreground and background traffic are synchronized to the selected timing source. Adding jitter, wander or line frequency offset does not affect the transmitted cell rate.
Foreground cell payload	Test cell as per ITU-T O.191. Cross cell PRBS (2^{15} –1 and 2^{23} –1). User byte.
Background cell distribution	CBR with settable PCR.
Background cell payload	User byte.
Fill cell payload	Idle, unassigned.
Error Add	**Type:** Single HEC, double HEC, bit, lost cell, misinserted cell, errored cell. **Stream:** For foreground cells or all cells (HEC only). **Rate :** Off, 1^{-n} where n is 3 to 9, user programmable 1.1E–3 to 1.0E–9. **Burst size:** HEC errors, all cells: Selectable between 1 and 8. Lost, misinserted, errored: Selectable between 1 and 999. Single error add: A single error (or burst) of selected type is added when single key is pressed. Only when rate is off.

Fault management

OAM alarm type : VP-RDI, VP-AIS, VC-RDI, VC-AIS, (all end-to-end).

Continuity check: VP-CC, VC-CC

ATM receiver

ATM Physical layer structure

An ATM signal can be demapped from the following physical layers :

SONET(bulk filled):
STS-1 full SPE;
STS-3c full SPE;
STS-12c full SPE;
STS-48c full SPE.

PDH/T-Carrier:
2 M (AMI, HDB3);
34 M (HDB3);
DS1 (AMI, B8ZS);
DS3 direct mapping (B3ZS);
DS3 PLCP mapping (B3ZS).

Framing

As for transmitter.

Cell descrambling

On/Off (conforms to ITU-T I.432).

Header error correction

On/off.

Interface

UNI/NNI.

Cell selected for test

All user cells, VP, VC, expert mode (all bits selectable).

Cell stream filter

Selectable GFC, VPI, VCI, user data cells (ITU-T I.610).

Cell payload

Test cell, cross cell PRBS $2^{15}-1$ and $2^{23}-1$, user byte, live traffic.

Policing

Policing algorithm as defined in ITU-T I.371 is applied to measure cells that do not conform to tariffed parameters. Parameters are set up on receiver page.

Service type :
CBR (policing via PCR & CDVT);
VBR (policing via PCR, CDVT, SCR and MBS);
OFF;

PCR: 1 cell/s up to max value. Format of PCR is cells/s. *PCR > SCR*;
CDVT: Cell delay variation tolerance. 10 µs to 100 ms, step size 10 µs;
SCR: 1 cell/s up to max. value. Format of SCR is cells/s *VBR only*;
MBS: Maximum burst size 1-2047 cells *VBR only*.

Measurements

Physical layer alarms

Signal loss, power.

SONET: See SONET specifications.
2 Mb/s: See PDH/T-carrier specifications.
34 Mb/s: AIS, LOF, RDI.
DS1: See PDH/T-carrier specifications.
DS3: See PDH/T-carrier specifications.
PLCP alarms: OOF, RAI.

Physical layer errors/events

SONET: See SONET specs.
2 Mb/s errors: See PDH/T-carrier specifications.
34 Mb/s errors: Code, EM BIP, REI, trail trace.
DS1 errors: See PDH/T-carrier specifications.
DS3 errors: See PDH/T-carrier specifications.
PLCP errors: BIP.

ATM alarms

Alarm seconds are calculated for each of the following alarms:
LCD (loss of cell delineation as defined in ITU-T I.432);
SCNR (selected cell not received; no cells of selected type received for 1s);
VP AIS (alarm indication signal as defined in ITU-T I.610);
VP RDI (remote defect indication as defined in ITU-T I.610);
VP LOC (loss of continuity as defined in ITU-T I.610);
Congestion experienced (as defined in ITU-T I.361);
VC AIS (alarm indication signal as defined in ITU-T I.610);
VC RDI (remote defect indication as defined in ITU-T I.610);
VC LOC (loss of continuity as defined in ITU-T I.610);
Test cell sync loss (LPAC as defined in ITU-T O.191);
Pattern loss.

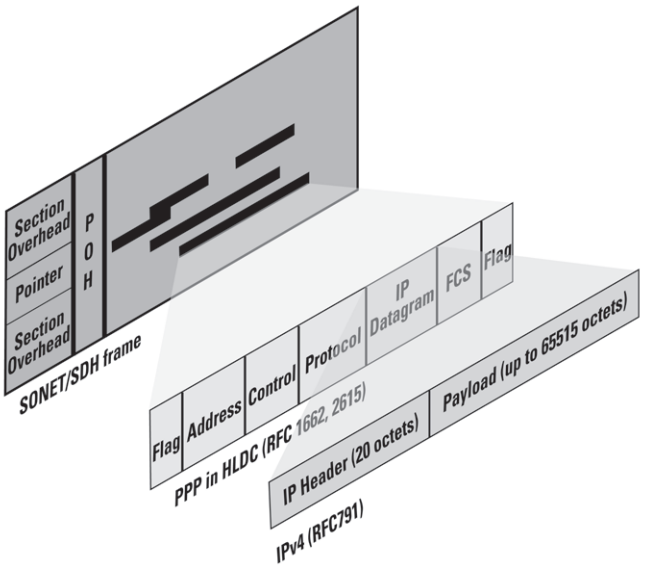
ATM errors/events

Corrected HEC errors;
Non corrected HEC errors;
Received cells CLP0 (high priority);
Received cells CLP1 (low priority);
Received cells CLP0+1;
Errored cells;
Lost cells;
Misinserted cells;
Mean cell transfer delay;
Peak-to-peak 2-point CDV;
Bit error;
Non-conforming cells.

ATM LEDs	VP alarm (VP AIS, VP RDI or VC LOC); VC alarm (VP AIS, VP RDI or VC LOC); LCD; Selected cell not Rx; Pattern loss (pattern loss or test cell sync loss); Error.
ATM service disruption measurement	Service disruption can be measured on an ATM signal using ITU-T O.191 test cell. The disruption period is the time from a received error free test cell to the occurrence of the next error-free test cell after an impairment has been detected. The measurement is recorded only if 200 ms of no errors occur after the disruption period. *Technique awaiting patent approval.*
ATM jitter measurement	Comprehensive jitter capability is available with ATM payloads. Please see the Jitter specifications for full details of the OmniBER's jitter capability.

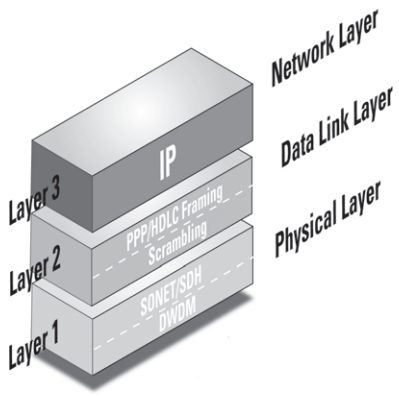
POS (Option 310)

"Packet over SONET"



POS protocol stack

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



POS transmitter

Physical Layer

Interface Rates

SONET	Rate
OC-48	2.5 Gb/s
OC-12	622 Mb/s
OC-3	155 Mb/s
OC-1/STS-1	52 Mb/s

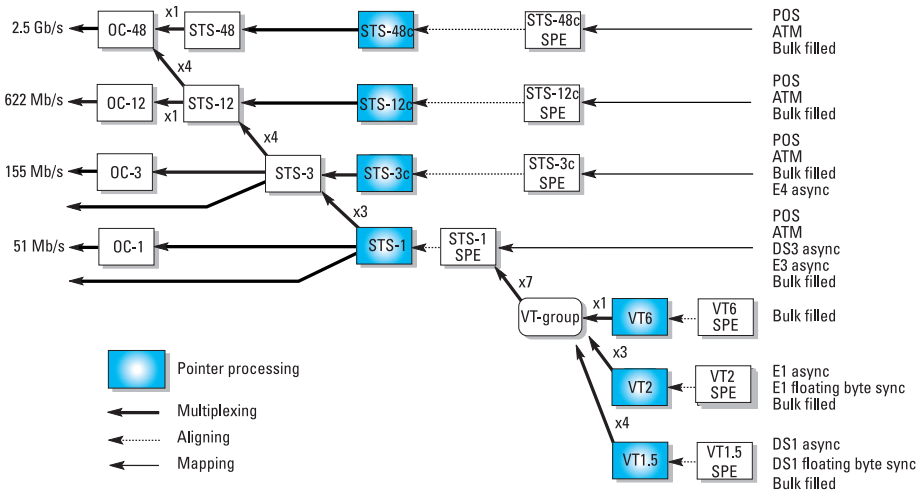


Figure 1: Bellcore GR-253 mapping structure (SONET payload mapping)

POS payload mappings

All POS mappings can be multiplexed into the selected line rate as defined in figure 1.

Overhead

Path signal label (C2):
Set to 0x16 to indicate PPP with x^{43}+1 scrambling
Set to 0xCF to indicate PPP without x^{43}+1 scrambling.
Multiframe indicator (H4): Set to 0.

Data Link Layer

PPP encapsulation

As per RFC1661

Protocol	Information	Padding
16 bits	Variable	Not supported

Framing

PPP encapsulated packets are mapped to frames. Two framing formats are supported:

PPP in HDLC framing (as per RFC 1662);
Cisco HDLC.

The frame structure is common to both formats as shown below:

	Flag	Address	Control	Protocol	IP Datagram	Padding	FCS	Flag
	8 bits	8 bits	8 bits	16 bits	variable		16/32 bits	8 bits
PPP in HDLC	7E	FF	03	0021				7E
Cisco HDLC	7E	0F	00	0800				7E

Flag Inter-frame gap is configurable (1 to 2^{30}–1 octets, step size 1 octet).

Frame check sequence (FCS) Calculated over all bits of the address, control, protocol and information fields (FCS, flags and stuffing octets not included). As defined by RFC 1662.
CRC-16 (not available at 2.5 Gb/s);
CRC-32 (all rates).

Scrambling **off:** (provided for backwards compatibility with RFC 1619).
on: scrambling is performed during insertion into SONET/SDH using an $x^{43}+1$ polynominal.

IP Layer

IP packet stream Both the IP datagram size and the inter-packet gap are settable.

IP datagram size

User selectable: User, random or 7,4,1 distribution
User: settable between 20 and 65535 octets, step size 1 octect. This is the size of the entire datagram, including the 20 octet header, before any HDLC octect stuffing. When the size is set to 20, only a header is transmitted.
Random: The IP datagram size is varied randomly between minimum and maximum limits. The minimum datagram size is settable between 20 and 63 octets. The maximum datagram size can be set to one of the following values: 127, 511, 1023, 8191, 65535. There is an approximately equal probability of finding datagram sizes between min. and max. values.
7,4,1 distribution: Emulates traffic patterns by sending a repeating sequence of 12 packets in which 7 have size 40 octets, 4 have size 552 octets, and 1 has size 1500 octets.

Inter-packet gap size

User selectable: User or random.
User: Settable between 1 to 2^{30} –1 octets. Step size 1 octet.
Random: The inter packet gap is varied randomly between minimum and maximum limits. The minimum gap size is 1 octet. The maximum gap size can be set to one of the following values: 4, 32, 1024, 2^{20}, 2^{30} –1. There is an equal probability of finding inter-packet gap sizes between min and maxvalues.

Hitless re-configuration

Changing packet size or inter-packet gap size will not affect the contents of the POS frames.
If a long packet is in progress, it will complete before the new size takes effect.
If a long inter-packet gap is in progress it will be terminated when the gap size is changed, and the new packet will begin immediately.

Note: At very low packet rates there may be a noticeable delay between changing a packet size, and the first occurrence of the new packet size. This is due to buffering of packet data (approximately 50 bytes) within the transmitter.

IP header	**Version:** 0100 (version 4). **Header length** (specified in 32 bit words): 5 (fixed) i.e. no header options. **Type of service:** User definable, 0 → 0xFF. **Total length:** User definable (see IP datagram size above). **Identification:** 0 (fixed). **Flags:** User definable. **Fragment offset:** 0 (fixed). **Time to live:** User definable, 0 → 255 (default 64). **Protocol:** User definable, 0 → 255 (default 6 – TCP). **Header checksum:** automatically calculated. **Source address:** settable in dotted decimal notation. **Destination address:** settable in dotted decimal notation. **Options:** Not supported.
IP payload data	2^{23}–1 PRBS (inverted/normal), all ones, all zeros, 0xAA55 pattern, 16 and 32 bit user defined word (Hex or Binary).

Test Functions

Alarm generation	HDLC frame loss: Asserted by transmitting a value 0x81, the logical inverse of 0x7E flag in all octets.
Error add	HDLC FCS (CRC-16 or CRC-32) errors: single, 10^{-3}. IP header checksum errors: single, 10^{-3}. IP payload bit errors: single, 10^{-3} to 10^{-9}.

POS receiver

Physical Layer

Interface rates	As for transmitter.
POS payload mappings	As for transmitter.

Data Link Layer

PPP encapsulation	As per RFC1661
Framing	User selectable between: PPP in HDLC framing (as per RFC 1662); Cisco HDLC.
Flag	Minimum inter-frame gap is one flag sequence.

Frame check sequence (FCS) User selectable between:
CRC-16 (not available at 2.5 Gb/s);
CRC-32 (all rates).

Descrambling off, on (default).

MPLS The receiver automatically handles any number (from 0 upwards) of 4-octet MPLS Shim headers. MPLS shims are silently removed and the IP datagram is processed as usual. MPLS unicast and multicast protocol fields (0x281, 0x283, 0x8847, 0x8848) handled by receiver.

IP Layer

IP header The receiver can support variable length IP header options.

IP payload data 2^{23}–1 PRBS (inverted/normal), all ones, all zeros, 0xAA55 pattern,
16 and 32 bit user word (Hex or Binary), live traffic.

Measurements

Physical layer alarms Power loss.
SONET : See SONET specifications.

Physical layer errors/events SONET : See SONET specifications.

POS alarms/LEDs HDLC link loss
IP not Rx
Pattern loss.

POS errors **HDLC FCS errors** (count and ratio): The number of HDLC frames received with the FCS in error.
IP header errors (count and ratio): The number of IP datagrams received with an error in the header, where any of the following will be counted as an IP header error:
– header length shorter than 20 octets
– header checksum error
– error in MPLS formatting
IP payload bit errors (count and ratio): The number of errors in the IP payload.

Any of above will cause the red 'error' LED to light.

POS events Transmit packet rate (packets/s).
HDLC Frame (count, frames/s).
IP datagrams (count and rate).

Service disruption Service disruption can be measured with POS payloads.
The disruption period is the time from the end of a received error-free packet to the occurence of the next error-free word. The measurement is recorded only if 200 ms of no bit errors occur after the disruption period.

General

Thru mode

The transmitter can be configured to retransmit the signal being input to the receiver. The following modes are available with POS payloads:
Transparent mode: signal unaltered.
Overhead overwrite: The test features associated with the TOH/POH can be enabled to overwrite one single or multi-byte overhead channel.
STS overwrite: Overwrites the complete SPE with internal payload. This enables the TOH to be looped while a new payload is inserted.
AU-4/AU-3 overwrite : Overwrites the complete AU-4/AU-3 with internal payload. This enables the TOH and background AU-4/AU-3's to be looped while a new payload is inserted.

Jitter

Comprehensive jitter capability is available with POS payloads. Please see the Jitter specifications for full details of the OmniBER's jitter capability.

Disk drive

Configurations	Save/recall of instrument configurations to/from floppy disk drive (in addition to the 5 internal stored settings).
Graphics	Save/recall of stored measurements graphics (SMG) to/from floppy disk drive. Extends internal event based storage from 10,000 events to 310,000 events.
Logging	Direction of logging output to floppy disk drive.
PC results format	Save SMG (stored measurement graphics) results in a CSV (comma separated variable) PC compatible format for importing to PC spreadsheets etc.
Screen dumps	Save screen dumps to disk in Windows-compatible .BMP format.
Disk management	Instrument provides the following disk drive features: Copying of instrument measurement graphics files to/from internal instrument storage to/from floppy disk drive. Copying of stored measurement graphics files from internal instrument storage to floppy disk drive. Deleting files or directories from floppy disk drive. Renaming of files. Labeling of floppy disks. Formatting of floppy disks.
Firmware upgrades	Allows the upgrading of instrument firmware from the floppy disk drive.

Graphics/logging

Max test result stores	10 internal SMG stores (stored graphics and data) (increases with floppy disk drive – number of stores limited only by free disk space).
Graphic display or printout	Bar chart (results versus time periods with up to 1 second resolution) for current or stored measurement period.
Storage capacity	10,000 events (increases to 310,000 events with floppy disk drive).
Bar resolution	1 second or 1, 15, 60 minutes.
DSn/En bar graphs	**En:** Bit, code, frame, CRC, REBE plus all En alarms. **DS1/DS3:** Bit, BPV, frame, CRC6, P-bit, C-bit, FEBE plus all DSn alarms.
SONET bar graphs	Frame errors (A1A2), CV-S (B1), CV-L (B2), CV-LFE (REI-L), CV-P (B3), CV-PFE (REI-P), CV-IEC (STS path IEC), CV-V (V5), CV-VFE (REI-V), bit plus all SONET alarms.
Printing/logging	Results, time, date and instrument control settings to internal/external printer or floppy disk drive. **Print/logging period:** 10 minutes, 1 hour, 24 hours, user-defined (10 to 99 minutes, or 1 to 99 hours).

Printers

		OmniBER 719 Option 602	External Printer
In-lid	80-column full-width graphics printer.	•	–
Results logging	Logging of instrument results to printer.	•	•
Graphics logging	Logging of instrument graphics results to printer.	•	•
Screen dump	Full-width printing of instrument screen to printer at press of a key.	•	–
Environmental	Printer operating temperature:	5 to 35°C	n/a
	Printer storage temperature:	–15 to +50°C	n/a
	Printer humidity range:	30% to 85% RH	n/a

Remote control/printer interface options

		601
Capability	RS-232-C printer/remote-control interface.	•
	HP-IB printer/remote-control interface.	•
	Parallel printer interface.	•
	LAN remote control interface.	•

General

Preset facility	Complete instrument configurations can be saved in non-volatile memory. Four independent configurations plus one factory default can be saved. Each store has a user-programmable name (disk drive increases storage – number of stores only limited by free disk space).
Supply	90 to 260 Vac nominal; 47 to 63 Hz, 450 VA nominal.
Dimensions	7.5 (H) × 13.40 (W) × 18.5 in (D) (× 20.10 in (D) with lid fitted). 190 (H) × 340 (W) × 470 mm (D) (× 510 mm (D) with lid fitted)
Weight	16 kg (typical); 35 lb.
Internal clock error	**Basic accuracy:** < 0.5 ppm at 77 °F (25 °C). **Temperature stability:** < 3 ppm over operating temperature range. **Ageing rate:** < 1 ppm per year.
Environmental	**Operating temperature:** 32 to 113°F (0 to 45 °C). **Storage temperature:** 68 to 168 °F (–20 to + 70 °C). **Humidity range:** 15% to 95% RH.
CE mark	ESD/Electrical fast transients/radiated susceptibility: Meets EN50082-1 (1992). Radiation emissions/conducted emissions: Meets EN55011 (1991).

Regulatory standards

Product safety	EN 61010-1 (1993); IEC 1010-1 (1990) +A1 (1992) +A2 (1995); CSA C-22.2 No 1010.1-92.
EMC compatibility	**Immunity:** EN 50082-1 (1992); **Emmissions:** EN 55011 (1991), Group 1 Class A.
Laser safety standards	21 CFR CH.1 1040; EN 60825-1 (1994).

Accessories

Optical accessories	**E4545A:** 3 m fiber optic cable (FC/PC connectors) **E4546A:** FC/PC 15 dB attenuator.
Optical coupler	**15744B:** In-lid optical coupler. **15744C:** In-pouch optical coupler.
Carrying cases	**15910B:** Soft, vinyl carrying case. **15772C:** Hard, robust transit case.
Rack mount kit	**15989A:** Rack mount kit. **15990A:** Connector access panel (see publication number 5968-2793E).
Warranty	3-year warranty as standard.
Calibration certificate	**Option UK6:** Commercial calibration certificate with test data.
Graphics printer paper	**9270-1360:** Printer paper.
Telephone handset	**15722A:** Telephone handset for option 013.

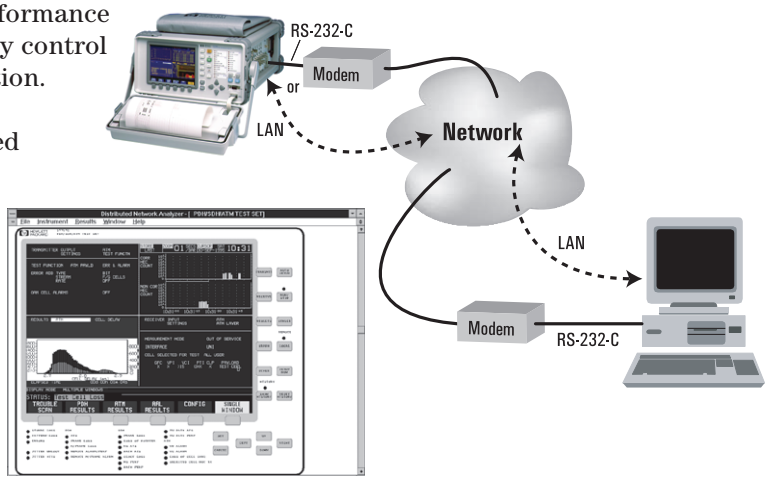
Distributed network analyzer (DNA) features

Use E4540A DNA software to pin-point elusive network faults and identify links with poor performance. The DNA software's long-term testing and automatic results logging capability let you easily monitor the quality of service you provide to key customers.

Monitor the network to identify performance and signal degradation. Interactively control analyzers for faster problem resolution.

Create and run your own customized test sequences effectively.

Transfer results to other Windows®- based applications and provide detailed quality-of-service information for managers and customers.



Distributed/remote testing

E4540A distributed network

PC/laptop/MS Windows® software (Windows 3.1, Windows NT or Windows 95) that allows control of the 377xx family of analyzers via a virtual instrument display. Allows remote user to store and recall instrument configurations, create and run test sequences, transfer test results to other Windows-based applications and provide quality-of-service information for managers and customers.

Option 0A9: License to use up to 10 copies.
Option UAT: License to use unlimited copies.

For full details of centralized testing using the OmniBER 719 analyzer and other telecom testers from Agilent Technologies, please ask your local Agilent representative for brochure 5964-2240E (distributed network analyzer software).

Also order an RS-232-C or LAN remote control interface (option 601).

UNIVERSAL INSTRUMENT DRIVERS

OmniBER 719 is a
Class 1 laser product
EN60825-1: 1994

Class I laser product
FDA 23 CER CH.1 1040.10 (1994)

Agilent Technologies manufactures the OmniBER 719 analyzer under a quality system approved to the international standard ISO 9001 plus TickIT (BSI Registration Certificate No FM 10987).

Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

By internet, phone, or fax, get assistance with all your test & measurement needs

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(fax) (905) 206 4120

Europe:
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(fax) (31 20) 547 2390

Japan:
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(fax) (81) 426 56 7840

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(tel) (305) 267 4245
(fax) (305) 267 4286

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(tel) 1 800 629 485
(fax) (61 3) 9272 0749

New Zealand:
(tel) 0 800 738 378
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