OmniBER OTN
10 Gb/s communications performance analyzer

Product note

The key to (10G) line card testing

Agilent Technologies

The growing demand for bandwidth in the network has encouraged service providers to install even more 10G systems. Consequently, this places acute demands on manufacturers to increase 10G line card production. To ensure throughput is increased without compromising test coverage (and hence quality), it is essential to invest time selecting the appropriate test equipment and processes.

So what should you look for in a SONET/SDH test set?

Firstly, it must be able to carry out tests simultaneously to increase throughput. Tests such as error and alarm monitoring, frequency, optical power or jitter measurement should all be carried out at the same time.

Secondly, when using external equipment such as an oscilloscope for eye diagram tests, the test set should provide the necessary trigger outputs. This simplifies the set up as additional equipment or connections to provide the requisite triggers are unnecessary.

Thirdly, as test equipment is normally integrated into a production test stand, it is important that the test set is easy to program. Programming tools such as Universal Instrument Drivers (UIDs) speed up test set up and aid production capacity ramp-up. In addition, rackmounting for manufacturing test is critical for easy installation and maintenance.

Finally, for tests to be carried out as quickly as possible, a SONET/SDH test set with one multi-rate optical output minimizes the number of switches and time required to characterize the losses involved in each connection path.

The Agilent OmniBER OTN 10G communications performance analyzer provides all the answers in one test set. What's more, test time can be further reduced with the instrument's SignalWizard facility. This industry – first ITU-T G.709 optical channel test set allows detection of the signal structure and performance monitoring of all 192 STS-1/STM-0 channels in a 10Gb/s signal simultaneously.

So what about the tests themselves? To ensure line cards are produced to a sufficiently high standard, a combination of physical and functional tests are required, as outlined below.

Testing overview

At the basic level, line cards transmit and receive optical data. To process the data, however, requires convertion to the electrical domain. Testing is typically carried out back-to-back, which means that the test signal supplied to the line card's receiver is looped back to the test set. This can be achieved either by looping the signal back at the backplane interconnect, or by looping back the line side signal, that is, a signal composed of all the tributary line signals multiplexed together.

Figure 1 shows a typical test set-up.

The performance of a line card is highly dependent on the performance of its individual components. Any test regime must be designed to adequately stress these elements.

Receiver testing

Line card receivers must be able to process low power signals, without producing a bit error ratio (BER) of greater than 1 x10^{-10} for compliance to Telcordia GR-253 and ITU-T G.957. The loop-back connection feeds attenuated signals back to the line card transmitter and ultimately the test set. Tables 1 and 2 detail the minimum sensitivity a receiver must have for the appropriate interface rates and the gating time for the 95% confidence of 10^{-10} and 10^{-12} BER for 2.5 Gb/s and 10 Gb/s respectively.

To avoid corruption of incoming data, the receiver's clock recovery circuit must cope with frequency offsets. To test the ability of a clock recovery circuit to 'pull-in' and retime the data to the ideal line rate frequency, frequency offsets are applied to the line rate of a signal. When these applied offsets are greater than the clock recovery circuits 'pull-in' range, errors are introduced into the data stream. Telcordia/ITU-T specify that a receiver must remain in lock, that is, pull-in and retime a signal with an offset dependent on data rate. The OmniBER OTN can apply different offsets, are again dependent on data rate. These offsets are specified in Table 3.

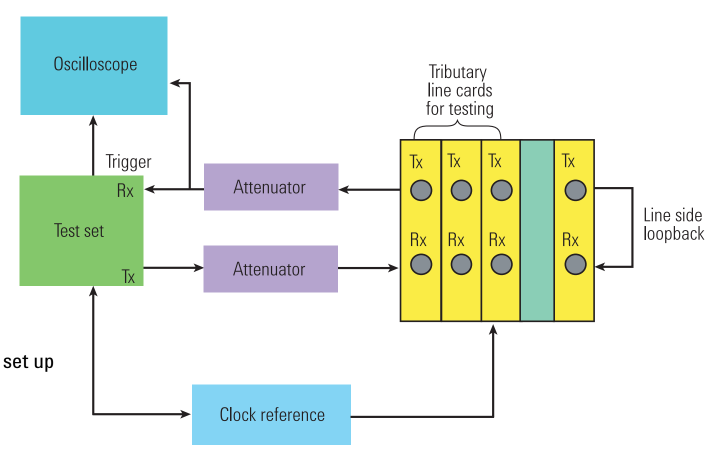


Figure 1. Typical line card test set up

Interface rate	Minimum sensitivity	Gating time for 10^{-10} BER 95% confidence
OC-3/STM-1	Short haul -28 dBm Long haul -34 dBm	3.2 minutes
OC-12/STM-4	Short haul –28 dBm Long haul –28 dBm	48 seconds
OC-48/STM-16	Short haul –18 dBm Long haul – 28 dBm	12 seconds

Table 1. GR-253 and ITU-T G.957 optical receiver specifications

Note: There is no sensitivity value specified in ITU-T G.957 for STM-64.

Interface rate	Minimum sensitivity	Gating time for 10^{-10} BER 95% confidence
OC-192	Short haul -12 dBm Long haul -13 to - 26 dBm (Depending on attenuation and launch power)	5 minutes

Table 2. Telcordia GR-1377 optical receiver specifications

Data rate	OmniBER OTN offset	Device receiver offset	Recommendation
DS1	+/- 100 ppm	+/- 50 ppm	GR-499
DS3	+/- 100 ppm	+/- 20 ppm	GR-499
E1	+/- 100 ppm	+/- 50 ppm	G.703
E2	+/- 100 ppm	+/- 30 ppm	G.703
E3	+/- 100 ppm	+/- 20 ppm	G.703
E4	+/- 100 ppm	+/- 15 ppm	G.703
OC-1/STM-0	+/- 999 ppm	+/- 20 ppm	G.783/GR-253
OC-3/STM-1	+/- 999 ppm	+/- 20 ppm	G.783/GR-253
OC-12/STM-4	+/- 999 ppm	+/- 20 ppm	G.783/GR-253
OC-48/STM-16	+/- 999 ppm	+/- 20 ppm	G.783/GR-253
OC-192/STM-64	+/- 100 ppm	+/- 20 ppm	G.783/GR-253

Table 3. Frequency offsets: OmniBER OTN capability and device receiver recommended values

Incorrect sampling is another potential source of errors. To avoid such errors, sampling needs to take place at the center of the data pulse. This sampling point is determined by a system clock, recovered from transitions in the incoming data stream. Long stream of 1s and 0s, known as Consecutive Identical Digits (CIDs) do not have any transitions making clock recovery more difficult. Line cards must handle certain levels of CIDs to be compliant with ITU-T G.783 and avoid incorrect sampling and errors. To test your line cards ability to cope with a range of CIDs, OmniBER OTN provides the following tests patterns

- PRBS 29 -1 to 231-1
- QRSS (220-1 PRBS as per ITU-T O.151)
- 1010
- 1000
- 16-bit user word
- all 1s
- all 0s

Finally, reporting and responding to errors and alarms is also critical. To ensure the line card has detected the correct errors, a known error rate is applied and the network element interrogated to ensure detection. Alarms can also be simulated, test sets will detect if a line card has registered and reported these alarms.

Transmitter testing

Although line cards process data electrically, the data must be converted to the optical domain for transmission. To ensure successful transmission, Telcordia GR-253 and ITU-T G.957 recommend minimum output power levels for each line rate as shown in tables 4 and 5. To verify whether the output power is in the correct range the signals must be attenuated before being applied to a test set. For more accurate measurements, dedicated optical power meters are required.

Rate	Short range	Long range
OC-1	-14 to –23 dBm	-5 to 0 dBm
OC-3	-8 to –15 dBm	-5 to 0 dBm
OC-12	-8 to –15 dBm	-3 to +2 dBm
OC-48	-3 to –10dBm	-2 to +3 dBm
OC-192	-1 to –5 dBm	-2 to +13dBm

Table 4. Launch power as specified in Telcordia GR-253

Rate	Short range	Long range
STM-1	-8 to –15 dBm	-5 to +10 dBm
STM-4	-8 to –15 dBm	-3 to + 2 dBm
STM-16	-5 to +8.2 dBm	-2 to + 8.2 dBm

Table 5. Launch power as specified in ITU-T G.957

Optical power affects the signal-to-noise ratio. Viewing the signal-to-noise ratio as an eye diagram allows you to easily compare your results with Telcordia GR-253 or ITU-T G.957 recommendations. To create an eye diagram, apply a PRBS signal to the line card receiver, looped back to the test set and oscilloscope. By triggering the oscilloscope sweep with the test set's divided clock, each successive sweep builds up the eye diagram on the oscilloscope display. Figure 2 shows a typical eye diagram.

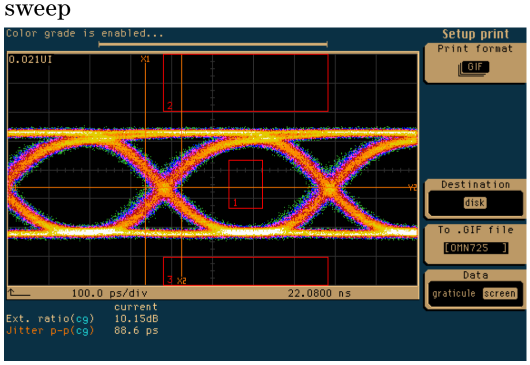


Figure 2. Typical eye diagram

As previously described under receiver testing, frequency offsets can cause data corruption. To ensure transmitted signals do not cause problems elsewhere in the network, ITU-T G.783 recommends signal frequencies with reference to the nominal rate. Most devices maintain a signal within 5 ppm.

Ideally these signals are transmitted without introducing errors or alarms. To ensure zero errors, test sets typically verify that the SONET/SDH overhead has been correctly generated, testing A1, A2 framing bytes, C2 path label and J0, J1 path trace messages.

Multiplexing

Line cards receive data at all line rates. However, they often process data at lower rates. For example, a line card operating at OC-192/STM-64 may manipulate data in chunks of STS-1/STM-0. In other words, the STS-1/STM-0s must be de-multiplexed from the OC-192/STM-64 line rate.

To verify that the line card's multiplexing and de-multiplexing functions are operating correctly, the test set must produce OC-192/STM-64s made up of STS-1/STM-0s. The line card will then be able to resolve STS-1/STM-0s and process them. As the signal is looped back to the receiver, the test set can verify the integrity of all STS-1/STM-0s and ensure they have been processed without errors being introduced. Typically, each STS-1/STM-0 (192 in an OC-192/STM-64) is tested for zero errors in five seconds.

The OmniBER OTN's SignalWizard can test up to 192 channels at the same time. With traditional test sets, each channel must be tested individually. In practise, only a sample of channels are usually tested to save time. By testing a limited number of channels the hidden danger is that errors may be missed, appearing later in the product's lifetime.

Using the OmniBER OTN software facility provides the solution. 192 channels can be tested simultaneously, in exactly the same time as a traditional tester can test just one channel.

SignalWizard provides the following advantages:

- Test all the STS/STM channels in your payload simultaneously – saving considerable test time
- Test all channels at the same time – Increasing confidence in your test result
- Test all the channels instead of a sample
- Find faults earlier
- Detect all faults including intermittent faults

Table 6 shows the time savings that can be made by testing all channels simultaneously rather than individually.

Signal	Traditional test time	SignalWizard OmniBER OTN
OC-192/STM-64	16 minutes	5 seconds
OC-48/STM-16	4 minutes	5 seconds
OC-12/STM-4	60 seconds	5 seconds
OC-3/STM-1	15 seconds	5 seconds

Table 6. Test time is based on 5 seconds gating per STS-1/AU channel

Using SignalWizard

Just two key presses on the OmniBER OTN are required to access the test set’s all-channel monitoring function. Once the OC-n signal of interest is connected to the appropriate receiver port on the test set, simply press the ‘SmartTest’ button on the front panel of the instrument.

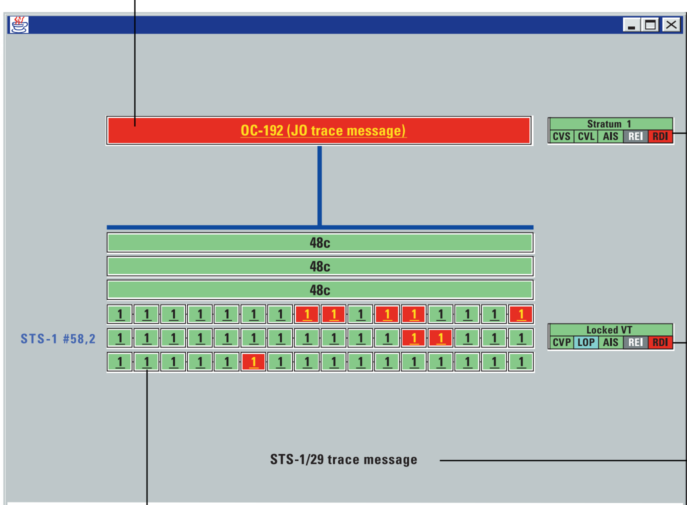
SignalWizard is now initiated and scans all the input ports to determine those receiving signals. (If more than one signal is detected, these will be displayed together with their associated line rates.)

The instrument displays the signal overview page allowing you to monitor the signal of interest, including error and alarm status, in its entirety.

In figure 3, it is evident that some of the STS channel mappings contain a sub-VT signal structure. By highlighting the signal of interest and pressing the ‘Select’ button, in-depth analysis can take place, as shown in figure 4.

Line signal viewer

Displays the detected SONET/SDH signal. If a J0 trace message is detected this is also displayed (both 16 and 64 byte message formats are supported).



Section/line viewer

Displays results information associated with the section and line levels of the signal, including

- synchronization status message (decoded S1 byte)
- CV-S (B1)/B1, CV-L (B2)/B2 and REI-L/MS-REI error status
- AIS-L/MS-AIS and RDI-L/MS-RDI alarm status

(LOS, LOF, OOF alarms are displayed on the instrument’s front-panel LEDs.)

Selected STS/AU channel viewer

Displays result information associated with the selected STS/AU channel, including

- type of payload (traffic) being carried in the channel (decoded C2 byte)
- CV-P/B3 and REI-P/HP-REI error status
- AIS-P/AU-AIS, LOP-P/AU-LOP and RDI-P/HP-RDI alarm status
- indicator for detected pointer adjustments

STS/AU channel viewer

Each STS/AU channel detected in the signal is provided with a dedicated box that summaries the channels status. An STS/AU channel carrying a VT/VC mapping is highlighted by its size designator being underlined. Broadband mappings are not underlined.

The size designator displayed within each box is the channel size identifier, where 1 indicates STS-1(3c indicates STS-3c, 12c indicates STS-12c, 48c indicates STS-48c and 192c indicates STS-192c). For SDH 3 indicates AU-3 (4 indicates AU-4, 4c indicates AU-4-4c, 16c indicates AU-4-16c and 64c indicates AU-4-64c). While any non-standard concatenated channel will be detected and displayed, no errors or alarms are reported. Unequipped channels are grayed out.

Pointer activity within the channel structure is indicated by the STS/AU background flashing blue.

J1 trace mesage

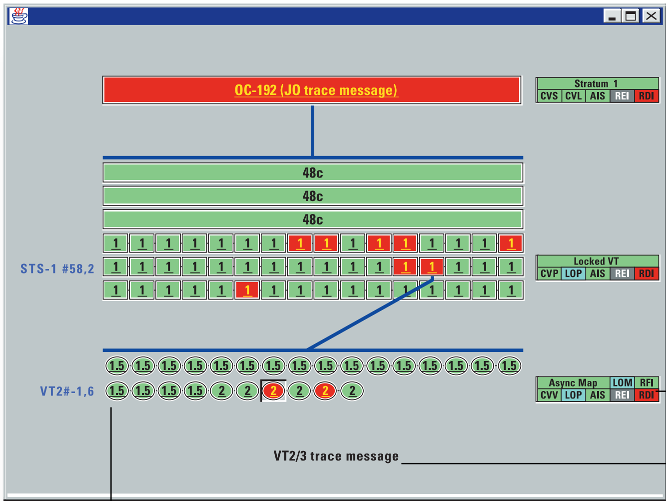
Displays the decode path trace message associated with the selected channel. Both 16 and 64 byte message formats are supported.

Figure 3. SignalWizard STS/AU-level monitoring

Color-coded results key

green	No errors/alarms detected since test started
red	Errors/alarms currently detected
yellow	Currently no alarms detected and error-free, however, errors/alarms detected earlier in measurement
grey	Unequipped channel
blue	Pointer adjustment detected
black	Illegal pointer value
red/black	AIS alarm

Figure 4. SignalWizard STS and VT monitoring



Selected VT/TU channel viewer

Displays result information associated with the selected VT/TU channel, including

- type of service mapping being carried in the channel (decoded V5 byte)
- BIP-2 and REI-V/LP-REI error status
- AIS-V/TU-AIS, LOP-V/TU-LOP, RFI-V/LP-RFI, RDI-V/LP-RDI and TU-LOM alarm status
- indicator for detected pointer adjustments

VT/TU channel viewer

Each VT/TU channel detected is provided with a dedicated display area identifying traffic status. For SONET the VT channel's size designator identifies the tributary rate, where 1.5 indicates VT1.5 and 2 indicates VT2. For SDH the TU size designator identifies the tributary rate, where 11 indicates TU-11 and 12 indicates TU-12. Channels underlined indicate the channel is carrying a mapped service. Unequipped channels are grayed out.

Pointer activity within the channel structure is indicated by the VT background flashing blue.

J2 trace message

Displays the selected VT channel. Both 16 and 64 byte message formats are supported.

Programming

Test automation speeds up test set-up and aids production ramp-up. The Agilent OmniBER OTN enables Universal Instrument Drivers (UIDs) programs to be constructed quickly and easily. Using the UIDs, writing test programs is reduced to a series of mouse clicks–generating complete test programs in a couple of hours. Figure 5 shows an example of the templates that can take hours out of your test programming.

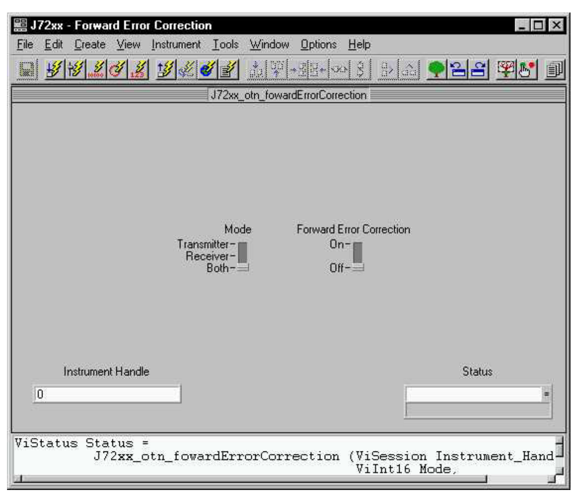


Figure 5. UID display and generated code

Summary of key tests

Table 6 below shows a summary of the tests necessary to ensure that the line card receiver and transmitter are configured correctly and functioning to the desired specification.

Function area	Test	Purpose	Parameters
Receiver	Optical sensitivity	Prove line card can effectively receive low power signals	Telcordia GR-253/ ITU-T G.783 compliant
	Error and alarm reporting	Prove signal is not degraded by receiver and that on-board error and alarm reporting and responding functions are working correctly	Zero errors and correct alarn reporting
	Frequency offset	Prove that the receiver can correctly receive a signal with up to 20 ppm offset	Telcordia GR-253/ ITU-T G.783
	CID immunity	Proves clock recovery can maintain lock in the presence of data containing long runs of '1's and '0's	ITU-T G.783
Transmitter	Optical power	Proves launch power is within specification	Telcordia GR-253/ ITU-T G.957
	Eye diagram	Gives an indication of the signal-to-noise ratio of the receiver	Telcordia GR-253/ ITU-T G.783
	Frequency measurement	Ensures transmit signal is at exactly the correct frequency	Telcordia GR-253/ ITU-T G.783
	Error and alarm	Proves the transmitter can transmit a signal without introducing error or alarms	Zero errors and correct alarm reporting
Multiplexing	Integrity of all STS-1/STM-0s	Ensure they have been processed without errors being introduced	Zero errors

Table 6. Summary of key line card tests

Product literature

You'll find further details of the OmniBER OTN's capability in the product specification publications no. 5988-3653EN and configuration guide publication no. 5988-3654EN or at www.agilent.com/comms/otn

Related products

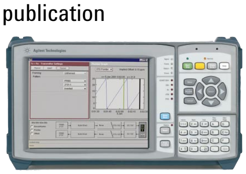
The Agilent Technologies OnmiBER 718 communications performance analyzer is the proven SONET/SDH one-box test solution. It provides full T-carrier/PDH and SONET/SDH up to 2.5 Gb/s, including concatenated payloads, ATM, Jitter and POS. For further information, refer to publication no. 5968-8740E

OmniBER 718

The OnmiBER 725 combines best in class SDH and SONET jitter capability at all rates up to 2.5 Gb/s, with differential electrical interfaces. Offering unframed PRBS signals it's the ideal choice for testing optical components and modules. For further information, refer to publication no. 5988-0327EN.

OmniBER 725

Focused on field applications, the J2127A transmission test sets cover all rates from 64 kb/s up to 10 Gb/s. Supporting SONET/SDH and T-carrier/PDH configurations, the test set offers simultaneous monitoring technology for faster turn-up and troubleshooting. For further information, refer to publication no. 5988-2569EN.



Transmission test set

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

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