Accelerate OTN Switch Validation with Multichannel Testing

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In today's high-speed core network market, more and more network operators are deploying high-speed optical transport network (OTN) links in response to increased demand for higher bandwidth. OTN technology offers a multitude of benefits, particularly its forward error correction (FEC) mechanisms as well as the efficient traffic grooming and optimal granularity through virtual containers or mapping structures. One of the important types of use of OTN is to transport TDM traffic, for example synchronous digital hierarchy (SDH) or synchronous optical network (SONET). OTN also provides ideal support for packet-based services such as Ethernet and Fibre Channel with its flexible approach of mapping structures via ODU0 and ODUflex as OTN payload. High-speed OTN signals are therefore built upon many smaller bandwidth signal channels as illustrated in Figure 1.

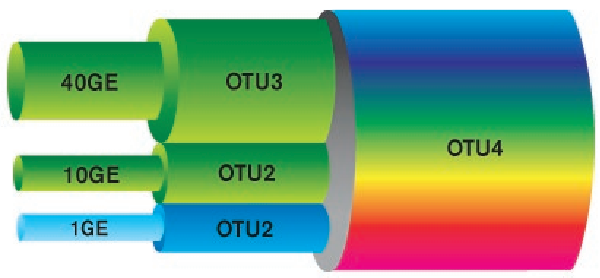


Figure 1: High-speed OTN signals built on smaller bandwidth signals

CHALLENGES

Network equipment manufacturers (NEMs) design multiple types of network equipment that reach higher rates of up to 100G. These devices must correctly handle all the signals that make up the overall link. They face a significant challenge of making sure that the interaction of all composing signals is seamless and that each and every channel is transmitted error-free from end to end (Figure 2). The validation of the entire 100G channel is fundamental at design and validation labs where first class NEMs develop their high speed network elements, ensuring that they deliver high performance equipment that are trustworthy and reliable.

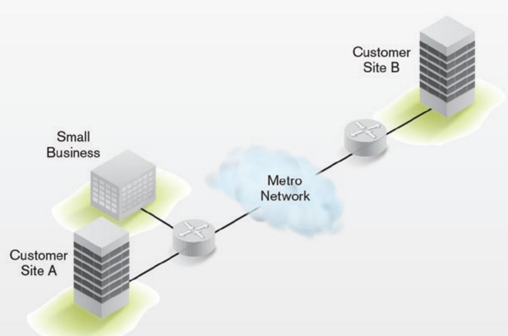


Figure 2: End-to-end metro network

The OTN also offers a protection-switching mechanism that switches traffic from the working path to the protection path in the event of failures. OTN networks typically use a mesh topology and require accurate service disruption time measurements for each and every individual channel that composes the overall high rate signal. As a result, the channels must be simultaneously monitored. Testing tools must be able to use advanced triggers and measure the transition time from the working path to the protection one. The switching time must comply with the ITU G.841 standard, which is 50 ms. In today's metro networks, the mesh (Figure 3) configuration is heavily used where OTN core network switches can cause delays, resulting in channels not switching within the recommended time. It is essential for NEMs to ensure that all channels can be viewed at the same time, and that the service disruption time (SDT) of each channel complies with the specified switching time.

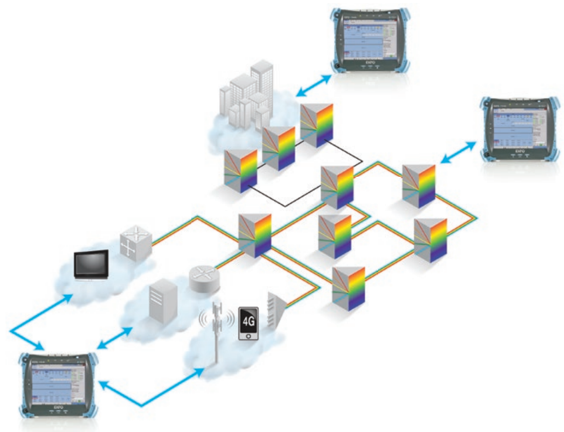


Figure 3: Mesh configuration

Another key element for NEMs is the capability to demonstrate that the bit error rate (BER) of each channel that makes up the high rate pipe complies with the network specifications and therefore meets the expected quality of services. Again, all the channels must be individually monitored and the BER performance evaluated separately. It is paramount to have a testing tool that can perform this evaluation of all the independent channels simultaneously without wasting time. Tools that do not offer the complete high-rate performance evaluation are not worth being used for two reasons. First, all composing channels must be monitored simultaneously to validate any cross channel interference. Second, the time to validate each and every channel individually would be very costly and represent a major burden for NEMs.

Most large carrier networks have aggregation switches deployed at major gateway locations. This architecture is very beneficial and offers the following advantages:

- OTN switches operating at the OTU layer. These switches are independent of the traffic type carried within the payload. This means that the network becomes transparent to any underlying services and protocols: Ethernet, Fibre Channel, SONET, SDH, etc.
- Switching at the ODU layer, which allows alarm monitoring and end-to-end performance evaluation.
- Switching scalability, which provides all the necessary resources needed for current traffic and protects the investment of network operators and services providers when additional services and traffic must be added.
- OTN switching utilizing standard OTN mapping structures. The diversified OTN mapping structures enable efficient grooming of traffic as well as high utilization of the ultra-long-haul wavelengths.
- Guaranteed switching time within standard values and ODU0, ODU1, ODU2, ODU3 and ODUflex granularity.

This application note introduces the Multichannel OTN Test Application, which is now available on EXFO's popular and industry-leading FTBx-88200NGE PowerBlazer and FTB-85100G PacketBlazer. The following sections outline the multichannel generation and monitoring features and capabilities of the application, particularly:

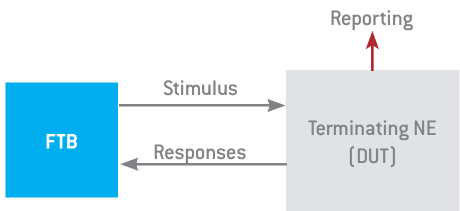
- Validation of individual channel connectivity with a device under test (DUT) connected to the network
- Basic interoperability
- Support of ODU0, ODU1, ODU2, ODU3 channels
- Alarm/Error monitoring
- Single Alarm/Error injection on one single channel or on all channels at a time
- Concurrent OTN BERT analysis
- Concurrent SDT measurement
- Configurable Channels/Tributary slots

Figure 4: FTBx-88200NGE and FTB-85100G

When deploying a new network element on an OTN network, the operation team must make sure that this new element operates according to the standards and fulfills the performance expectations previously specified by the network planning group. The team must also validate that all alarms and errors are correctly and timely reported so that both deployment and troubleshooting tasks are performed at an optimum pace, allowing the fastest possible introduction of a new piece of equipment and a reduced failure time. Hence, NEMs must be able to validate that all these tasks are optimally performed in their laboratories prior to the installation of the network element.

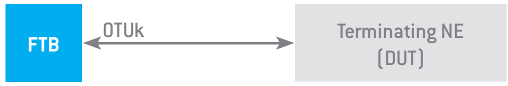
CONNECTIVITY VALIDATION – BASIC INTEROPERABILITY – SUPPORT OF ODU0, ODU1, ODU2 AND ODU3 CHANNELS

Once the physical installation of the new network element is completed, the next task is to validate the logical connectivity of the device. To accomplish this job, the technician must generate a test signal to this device, which is configured as a terminating network equipment (NE) under test (DUT). The technician may use the Multichannel OTN Application to both generate the stimulus and analyze the responses from the DUT.



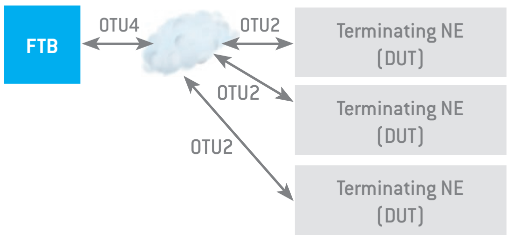
From a physical configuration point of view, this interoperability test may be set in three different ways:

- Scenario 1: The test equipment (FTBx-88200NGE) directly connected to the Terminating NE (DUT)



- Scenario 2: Both the test equipment and the DUT connected to the network

- Scenario 3: Multiple DUTs connected to the network with a single test equipment that generates the stimulus. In the following example, the test equipment is connected to the network via an OTU4 link. The interoperability monitoring of multiple DUTs is done via OTU2 links.



The Multichannel OTN Test Application supports single stage multiplexing (Figure 5): ODU0 > ODU4, ODU1 > ODU4, ODU2 > ODU4, ODU3 > ODU4 channels. The technician can specifically select the mapping to be exercised among the following multiplexing options:

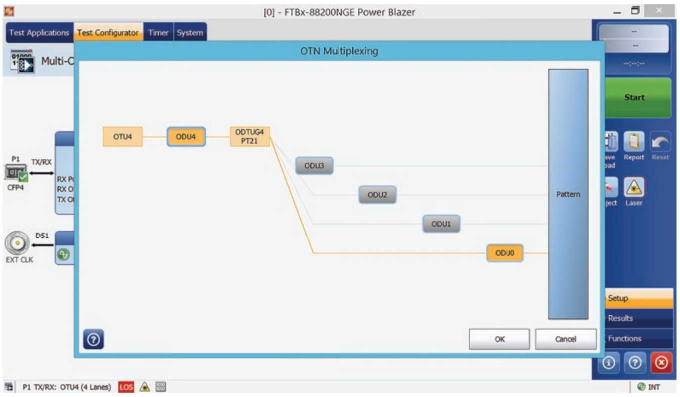


Figure 5: FTBx-88200NGE - OTN mapping capabilities

The following table shows the maximum number of channels to fulfill the OTU4 signal.

Multiplexing	Number of Channels
OTU4/ODU4/ODU0	80
OTU4/ODU4/ODU1	40
OTU4/ODU4/ODU2	10
OTU4/ODU4/ODU3	2

One alternative to verify the interoperability between the test equipment and the DUT is by the injection of a stimulus (alarms or errors). Once the test is mounted on the test equipment, for example OTU4/ODU4/ODU0 (Figure 6), the technician starts the test and the test equipment automatically goes to the Results > Summary page (Figure 7). The user must then select in which channel to inject an alarm or an error. The final step is to select the stimulus among multiple options (Figure 8); in the example, ODU0-AIS is selected in channel 56 (Figure 9).

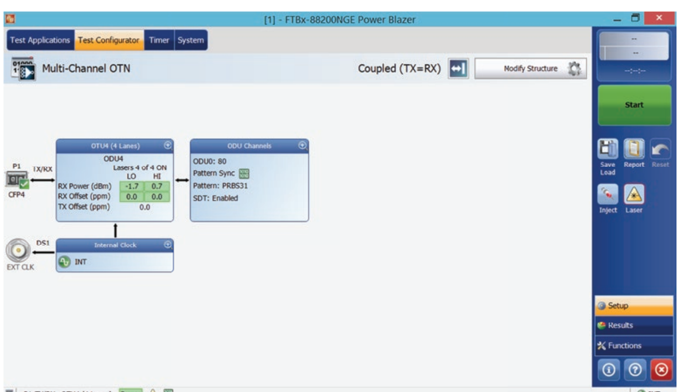


Figure 6: FTBx-88200NGE - Test Configurator

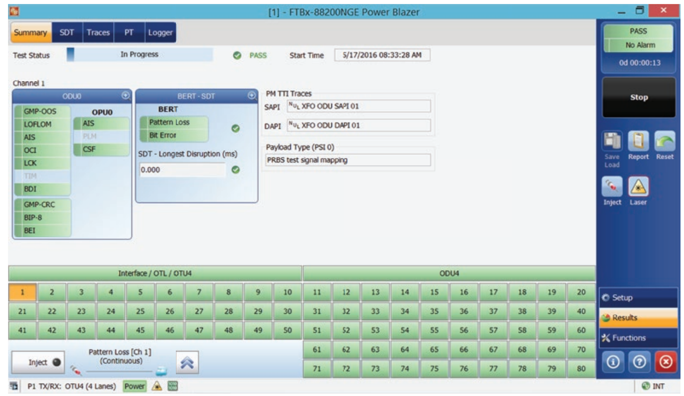


Figure 7: FTBx-88200NGE - Summary page

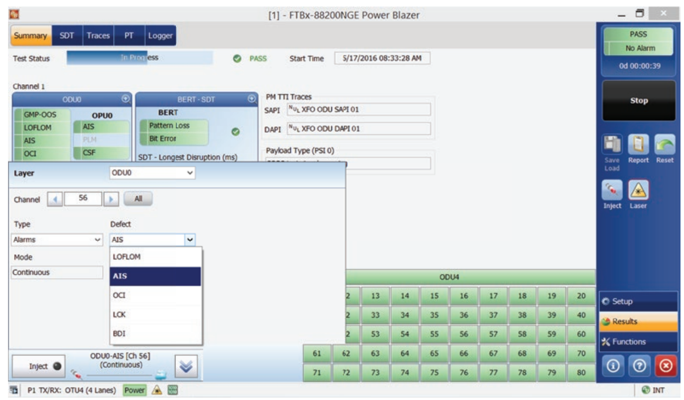


Figure 8: FTBx-88200NGE - Alarm/Error options

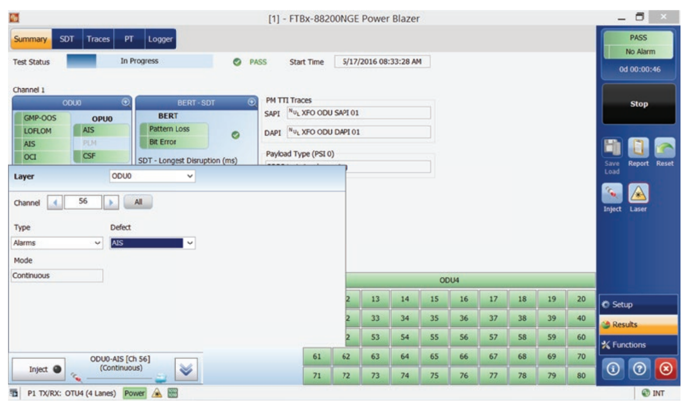


Figure 9: FTBx-88200NGE - Selected channel and alarm

The Multichannel OTN Application displays the responses coming from the DUT upon the introduction of the stimulus, as displayed in Figures 10 and 11. The technician can easily validate the connectivity between the DUT and the test equipment. This will ensure that the newly introduced network equipment is correctly configured and operating as expected. Another way to validate the connectivity is by using the traces features also available in the Multichannel OTN Test Application.

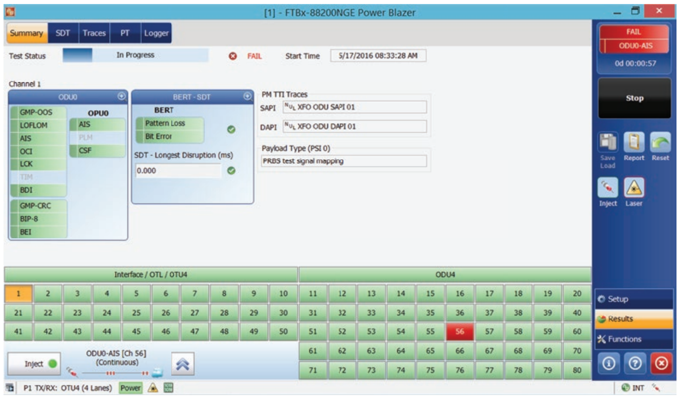


Figure 10: FTBx-88200NGE - Summary alarm indication

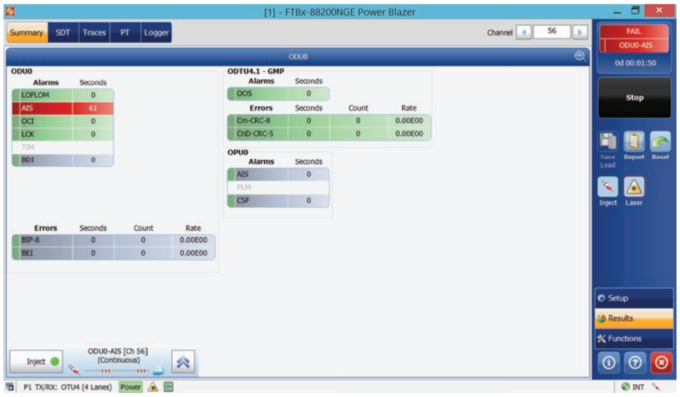


Figure 11: FTBx-88200NGE - Detailed alarms and errors - channel 56

EXFO is recognized for the quality of the graphical user interfaces of its testers. For the Multichannel OTN Test Application, the user interface strategy has been to establish a simple configuration of all the channels and grant access to the results through an optimized Summary page that allows a global view of all channels and layers on one single page.

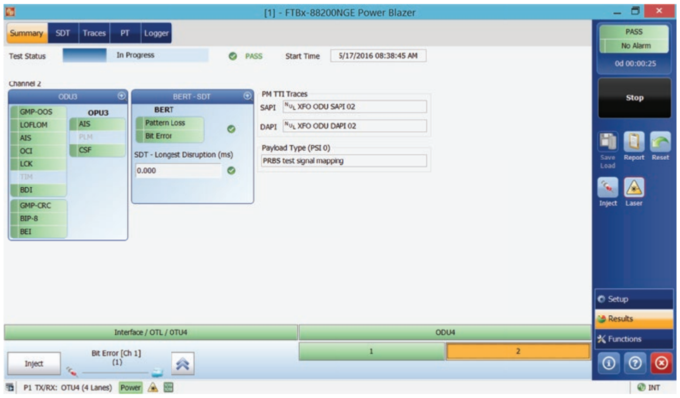


Figure 12: FTBx-88200NGE - Summary view of all channels: OTU4/ODU4/ODU3 mapping

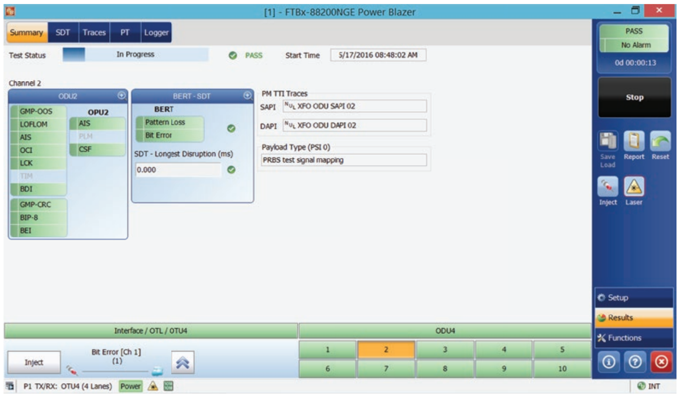


Figure 13: FTBx-88200NGE - Summary view of all channels: OTU4/ODU4/ODU2 mapping

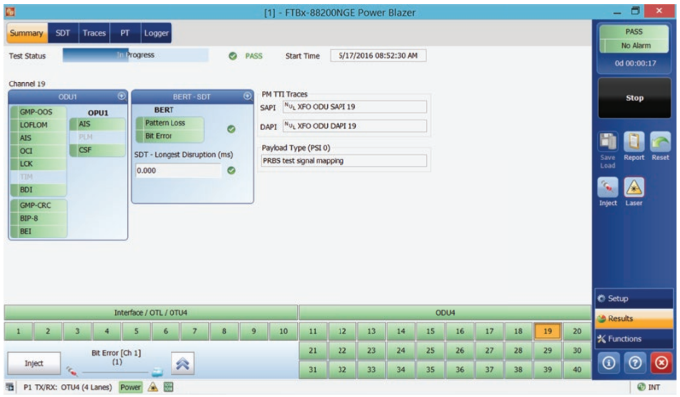


Figure 14: FTBx-88200NGE - Summary view of all channels: OTU4/ODU4/ODU1 mapping

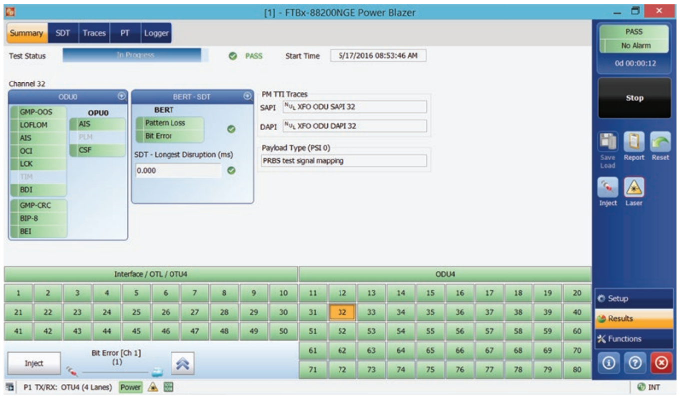


Figure 15: FTBx-88200NGE - Summary view of all channels: OTU4/ODU4/ODU0 mapping

The FTBx-88200NGE PowerBlazer and the FTB-85100G PacketBlazer offer a simple and complete user interface that enables the visualization of OTN alarms and errors. The interface also offers a simple and unique monitoring system that detects any alarms and errors on all the channels in real time as indicated in Figure 16:

Channels 1 and 75 have a yellow indication meaning that some alarms or errors have been observed since the test has started.

Channel 53 in red indicates that currently there is an active error or alarm observed on this channel.

The orange color in Channel 33 indicates that this is the currently selected channel and the summary alarms refer to it.

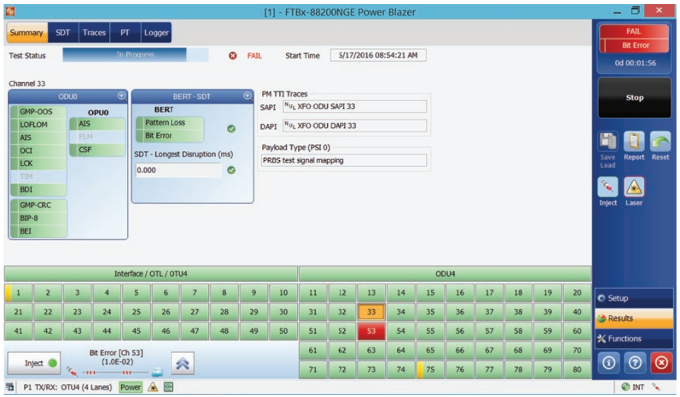


Figure 16: FTBx-88200NGE - Summarized alarm and error indication for all 80 ODU0 channels composing an OTU4 signal

CONCURRENT BERT ANALYSIS

Once the connectivity between the DUT and the test equipment (FTBx-88200NGE) has been verified, the next step is to validate if the overall link meets the performance specifications. The test equipment therefore provides the necessary tools to support concurrent BER testing. The user defines the pattern to be used, for instance PRBS31 (Figure 17), and starts the BER evaluation over a predetermined amount of time. The application tool constantly monitors the traffic and, in case of errors, compare the results with the threshold. Moreover, the performance evaluation is done in all composing channels simultaneously (Figure 18). The Multichannel OTN Test Application provides all the necessary features to accomplish this task, offering also a very easy interface to configure the test as well as an optimum view of the passing/failing status of the test.

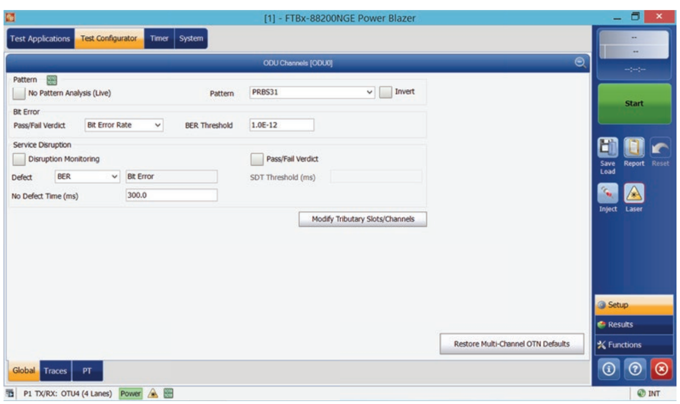


Figure 17: FTBx-88200NGE - BER test configuration

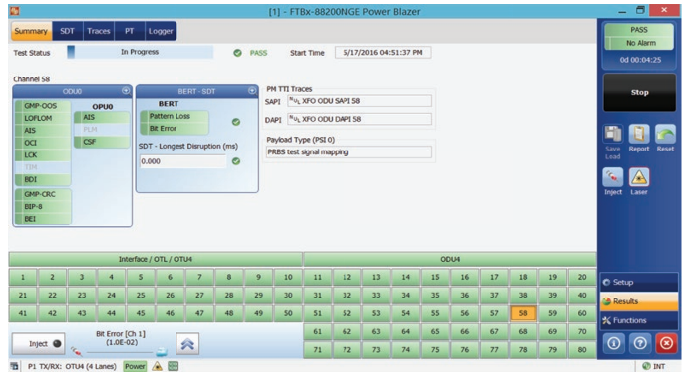


Figure 18: FTBx-88200NGE - Simultaneous monitoring of all channels

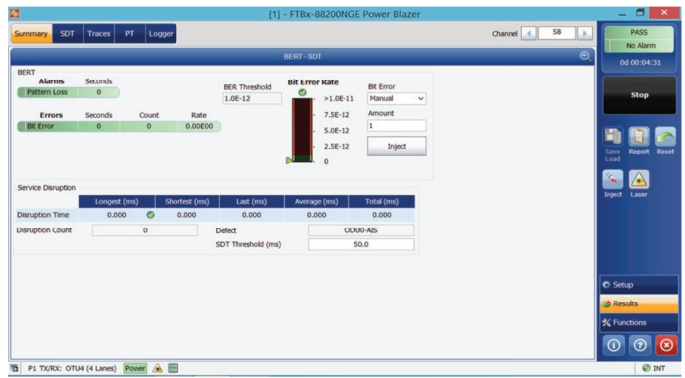


Figure 19: FTBx-88200NGE - Detailed BER results per channel

SERVICE DISRUPTION TIME MEASUREMENTS

As previously mentioned, one of the key features that NEMs have to verify is the amount of time required for network elements to switch to the protection path. This is validated with the SDT measurement. Once the SDT function is enabled and the selected defect is detected (Figures 20 and 21), the test period begins and the SDT starts measuring the disruption time. If there is an absence of defects for a period exceeding the No Defect Time (which is also user-configurable), the SDT measurement duration will be calculated as the time between the detection of the first defect to the end of the last defect, excluding the No Defect Time. The SDT feature will be automatically ready for another measurement as soon as the next defect is detected.

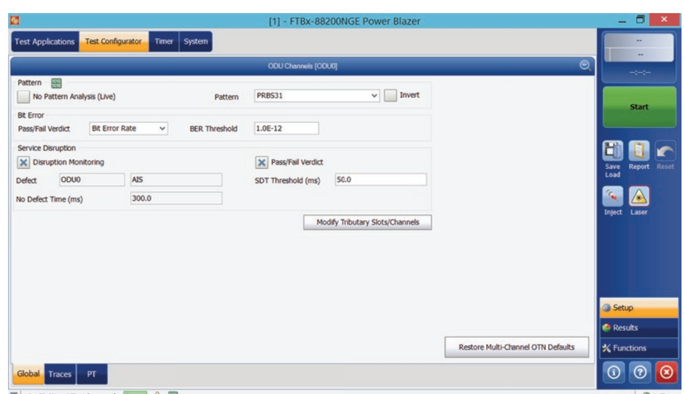


Figure 20: FTBx-88200NGE - SDT configuration

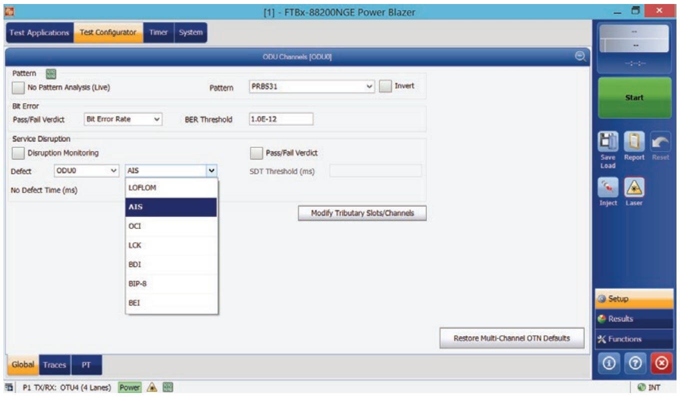


Figure 21: FTBx-88200NGE - Defect selection for SDT measurement

Figure 22 below shows two scenarios of SDT measurements.

a. Supposing the defect type set to AIS with the No Defect Time configured to 300 ms.

The first AIS event lasts 20 ms, followed by an absence of the alarm for 150 ms and another AIS event lasting 45 ms. No other alarm is observed afterwards. Since the No Defect Time is set to 300 ms, the 150 ms interval is not enough for the system to clear the service disruption. Therefore the total SDT is 215 ms (20 + 150 + 45 ms) with one single disruption event being counted.

b. Supposing now a different No Defect Time configuration set to 20 ms. The interval between the two AIS situations is enough to clear the first disruption and trigger a second event when the second occurrence of AIS is detected. In this case, there is a total of two disruptions, the first one with a 20 ms duration and the second once with a 45 ms duration.

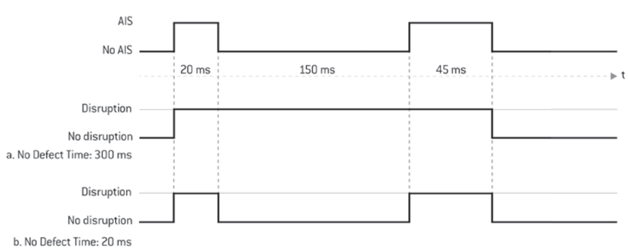


Figure 22: Service disruption scenarios based on different No Defect Time configurations

If the user selected the Pass/Fail verdict for the SDT measurement and defined the SDT threshold to 50 ms, the first scenario would result in a failing verdict with an SDT measurement of 215 ms. The second scenario would present a passing verdict with two SDT measurements that are below 50 ms.

The simplicity offered by the FTBx-88200NGE graphical user interface allows the user to select the Defect type and define the No Defect Time. The per-channel testing and validation makes it possible to easily detect defective channels for advanced troubleshooting. Because each channel does not need to be re-measured, the overall test time is reduced.

CONFIGURABLE CHANNELS/TRIBUTARY SLOTS

Another important feature available with the Multichannel OTN Test Application is the possibility of decoupling Tx tributary slot/channel assignment from the Rx tributary slot/channel assignment. This offers greater flexibility for network equipment manufacturers to validate different channel to tributary slot assignments.

The graphical user interface (Figure 23) is adjusted to give the optimum approach to configure the test and to allow the user to visualize the results/status.

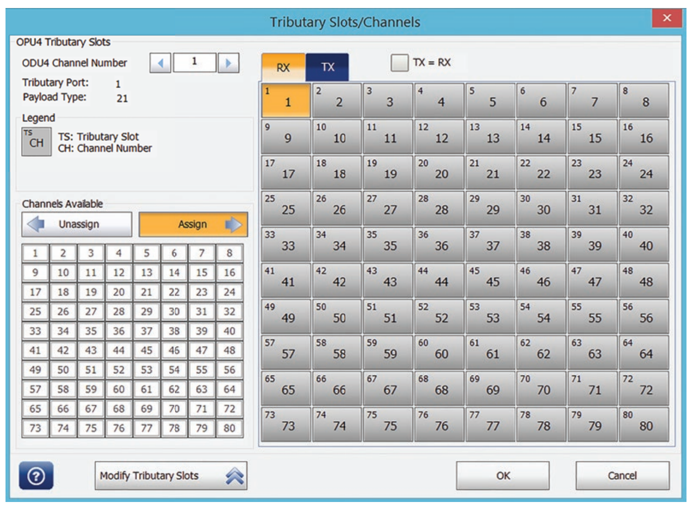


Figure 23: FTBx-88200NGE - Tributary Slots/Channels assignment

CONCLUSION

In conclusion, NEMs have access to a new tool that addresses the challenges related to their OTN deployments, namely: testing of all channels that make up their overall link up to 100G with one single test equipment, simultaneous BERT measurement for all channels, concurrent SDT measurements, and channel/tributary assignment. This can be accomplished for all 80 ODU0 channels that make up an OTU4 link. The tool provides multiple features:

- Detailed per channel information, such as the number of defects, the errored seconds as well as the rate
- Injection of a single alarm or error on one channel or on all channels at the time
- Concurrent BERT analysis over each and every channel
- Concurrent SDT measurement on every channel

With this new Multichannel OTN Test Application, NEMs can thoroughly test the network elements that they design, expediting their verification and troubleshooting operations, and ultimately provide first-in-class devices to be deployed in high speed OTN networks.

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