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APPLICATION NOTE

TDM CIRCUIT TURN-UP MADE EASY WITH THE COMPACT SONET/SDH ANALYZER

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In recent years, there have been many technological advances that have changed the work environment of transport engineers and technicians. Over the last decade, SONET/SDH networks have primarily been used to transport telephony and private line services; however these networks have now evolved to support the transport of Ethernet-based broadband services, including VoIP and video. This evolution has resulted in the performance requirements of the underlying transport network becoming more stringent, making the testing and qualification of these transport networks more important and more challenging.

This application note outlines various tests that should be performed during the installation and commissioning of network elements and the services/circuits they provide. This document is intended as a baseline test plan only, therefore is not exhaustive in nature. Other advanced testing scenarios may be required for troubleshooting or more complex scenarios.

In general, the basic tests required for every optical circuit installation are the following:

1) Fiber-path identification
2) Connector inspection and cleaning
3) Power-level verification
4) Frequency-offset testing
5) Continuity testing
6) Stress testing/margin verification
7) Automatic-protection-switch (APS) testing (for APS enabled systems)
8) Round-trip delay measurement
9) System stability or long-term bit-error-rate (BER) testing

To perform these tests, technicians are usually required to carry multiple test units. This application note will highlight how EXFO's FTB-8120 and FTB-8130 Transport Blazer modules—when combined with the FTB-200's optional integrated high-precision power meter, visual fault locator and fiber scope—provide field technicians with all the critical test tools they need to conduct these test activities, thus eliminating the necessity to carry and manage multiple test sets.

Fiber-Path Identification

The environment in which today's telecom technicians work is a product of many years of circuit turn-ups, tear downs and relocations. The networks they build and maintain are complex and span a larger number of elements than they did in the past, making it more difficult to find exactly the right set of fiber paths needed to inter-connect sites. To avoid the aggravation of using the wrong path or the costly mistake of taking down existing traffic, great care should be taken to properly identify the correct fiber path before any other work is attempted.

Inside Plant Identification – Tracing fibers inside the central office is usually best accomplished with a visual fault locator (VFL), which emits a red light that is visible through the fiber cladding. To locate the fiber, simply use the VFL to send the signal through one end of the fiber. The VFL will then help to highlight the other end of the fiber.

Inter-Office Facility Identification – Unfortunately, VFLs only work on links up to 5 km and are therefore not effective to trace down fibers traveling from office to office. For these scenarios, a light source and power meter can be used; these units provide a modulated "tone" that can be injected and detected along the fiber. This can be done by using any EXFO light source (OTDR, OLTS, etc) at one end of the fiber, setting the output wavelength to 1550 nm, and modulating the source at 2 kHz. Once completed, the optional integrated power meter on the FTB-200 is used to detect this tone by either directly connecting a fiber jumper to the fiber distribution panel (FDP) or by using EXFO's 2 kHz tone detector cap for non-intrusive identification. The 2 kHz tone cap provides an easy method of checking cross-connect fibers without disconnecting them, thus preventing the possibility of inadvertently disconnecting the wrong jumper; critical assurance when circuit bit rates exceed 1 Gb/s.

Figure 1a. *VFL connector on the FTB-200*

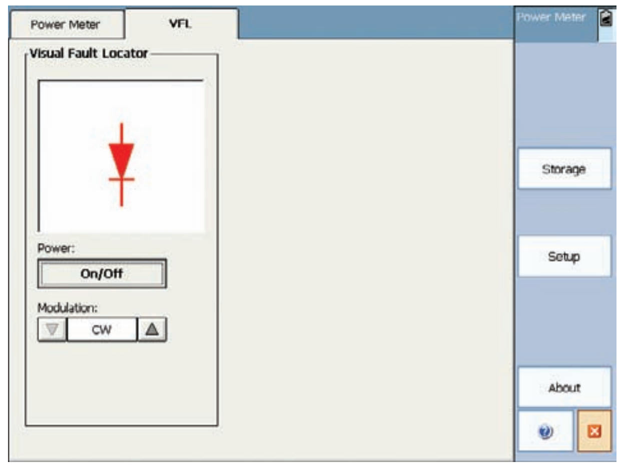

Figure 1b. *VFL screen*

Connector Inspection and Cleaning

Before connecting the test equipment to any fiber jumpers, you should inspect and clean the connectors thoroughly. Dirty connectors can cause significant power loss and reflection, thus inducing errors during network testing; so it is absolutely crucial that both the patchcords and the patch panel are clean prior to testing.

The FTB-200 can be equipped with a fiber-optic inspection probe to facilitate safe and thorough inspection of patchcords and panels.

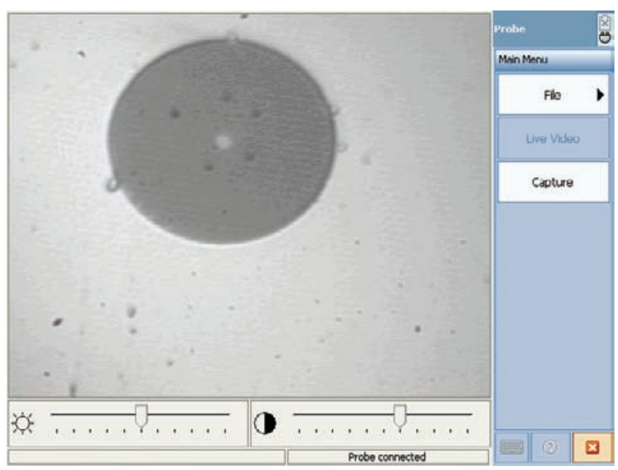

Figure 2. *Probe screen*

Power-Level Verification

Verifying the power level may seem obvious, but it is a vital step often omitted due to lack of convenience or test equipment. With the FTB-200 Compact Platform's built-in, high-performance power meter, you can accurately test ingress and egress levels without risking damage to expensive circuit packs or SONET/SDH test equipment. Checking ingress and egress levels at all interfaces is necessary to ensure that operating specifications are met.

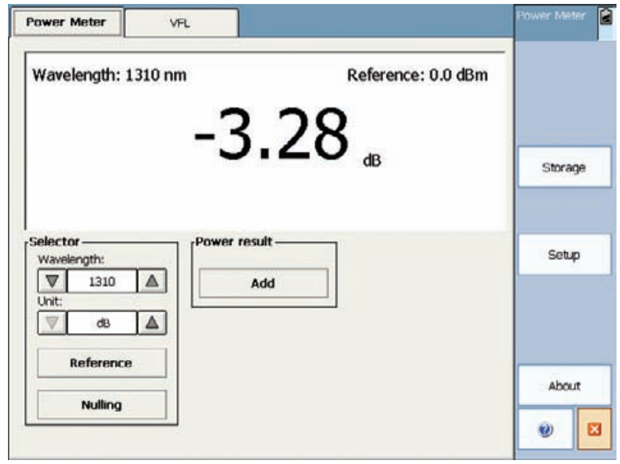

Figure 3. Power Meter screen

Frequency-Offset Testing

According to ANSI T1.105 and Bellcore GR-1244 standards, all SONET/SDH Network Elements must be externally synchronized by a Stratum 3 or better clock signal. The first choice for this signal is an external central office (CO) or building-integrated timing system (BITS) clock. If the SONET/SDH network element (NE) does not have an internal Stratum 3 or better clock, then it must be equipped with an internal locking oscillator with minimum accuracy of ± 20 ppm. In this scenario, the NE would derive synchronization from the incoming OC-n/STM-n signal (i.e., line-timed mode).

Along with optical power measurements, frequency accuracy verification of the SONET/SDH line rate is a good sanity check to determine network health prior to BER testing during SONET/SDH network commissioning.

To verify the synchronization health of the network element under test, set up the FTB-8120/8130 to the proper signal structure and test configuration. Once completed, connect the FTB-8120/8130 OC-N/STM-N transmit port to the westbound fiber and the receiver port to the eastbound fiber. Verify that the incoming signal is within the ± 20 ppm of the OC-N/STM-N line rate using the appropriate frequency measurement window of the FTB-8120/8130 user interface.

Using the frequency transmission (Tx) offset feature, increase the setting to positive and then negative, verifying that the incoming signal frequency readings remain stable within 20 ppm. This verifies the pull-in range of the NE oscillator. Each NE manufacturer specifies the offset value that the OC-n clock recovery circuitry operates accurately.

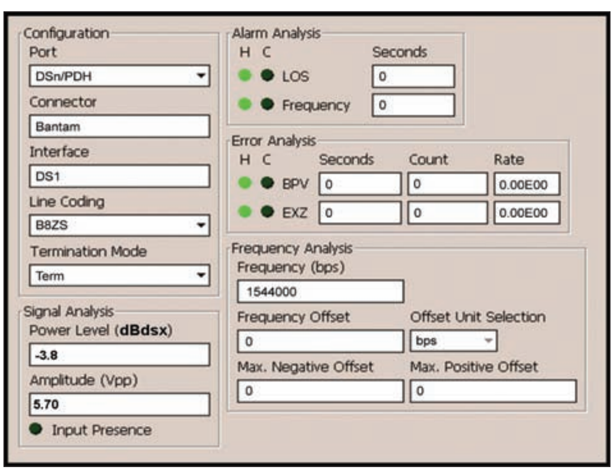

Figure 4. Frequency Measurement screen

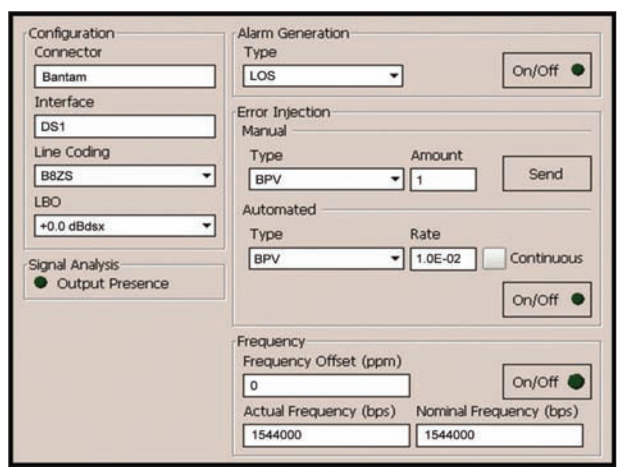

Figure 5. Frequency Offset screen

Continuity Testing

Before beginning any complex testing procedure, it is important to take a moment to make sure that end-to-end connectivity is established and that the logical setup is correct. A convenient and thorough way of accomplishing this task is to set up a path trace using the J1 byte. The proper reception of the transmitted path trace will verify that the configurations for framing, coding and synchronization are basically compatible throughout the network under test.

To verify continuity, connect the FTB-8120/8130 Transport Blazer to the interface under test, and mount the proper test case signal structure. Check if any alarms are present on the FTB-8120/8130 user interface (using the Alarm Summary tab) or on the network elements. If alarms are present, troubleshoot and eliminate them before proceeding.

Once all alarms are cleared, verify continuity throughout the network by updating and transmitting the path trace, as illustrated. Verify that the received path trace is updated correctly. Once successfully completed, continuity has properly been established.

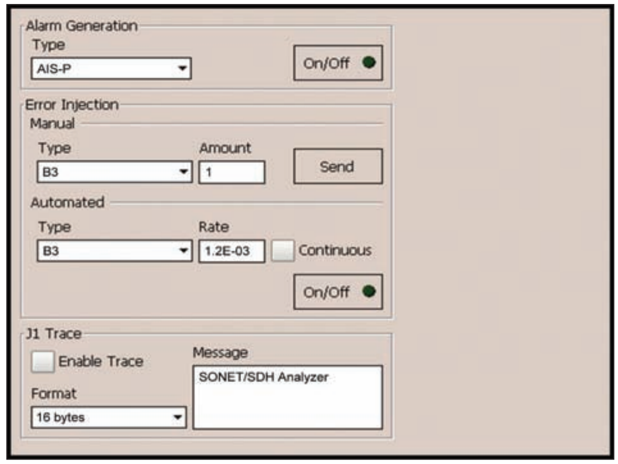

Figure 6. *J1 Path Trace screen*

Stress Testing or Margin Verification

Once continuity and physical-layer testing is complete, it is important to verify that the engineered loss margin is as expected. Transport systems are designed with a built-in overhead that provides insurance to help avoid non-catastrophic loss induced outages. This loss budget is usually at least 3 dB and is typically closer to 5 dB. This margin allows technicians to manipulate fibers for fiber identification purposes without inadvertently dropping the service.

To perform this test, set up the FTB-8120/8130 Transport Blazer to run a bit-error–rate (BER) test from the client-side interface while providing a traffic loop on the far side. Install a variable optical attenuator (VOA) on the near in-line side (Tx or Rx) to adjust the line side power, then slowly adjust the VOA to induce attenuation in steps of 0.1 dB, 5 seconds per step, until errors are detected on the test equipment. It may be necessary to disable automatic protection switching during this test. Once errors are detected, reduce attenuation by 0.1 dB steps, 5 seconds per step, until errors cease. At this level, clear all errors on the test set and let it run for 15 minutes. If error-free after 15 minutes, record the attenuation level set on the VOA as the available overhead. This test should be repeated in the opposite direction (Tx or Rx).

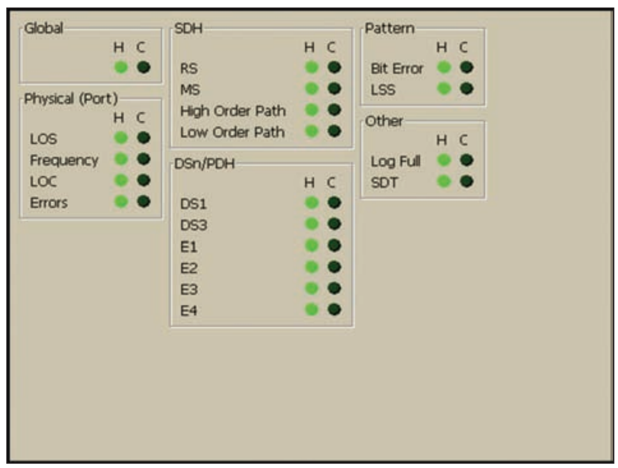

Figure 7. *Alarm Summary screen*

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Round-Trip Delay

Many of the services being transported by today's SONET/SDH networks are sensitive to a problem known as excess latency or delay. Latency is simply the time it takes for a piece of information to be transported from point A to B. Although simple, this issue can cause huge problems in these complex networks, as they are getting increasingly larger and contain more and more network elements. A customer's end-to-end circuit may travel considerable distances and go through a very large number of network elements before being delivered.

This great distance and the numerous optical/electrical conversions have a direct effect on the signal delay and may, in turn, affect proper signal transmission. Cellular and IP traffic (i.e., video and voice) are especially sensitive to delay and will experience unacceptable degradation if delay requirements are not met.

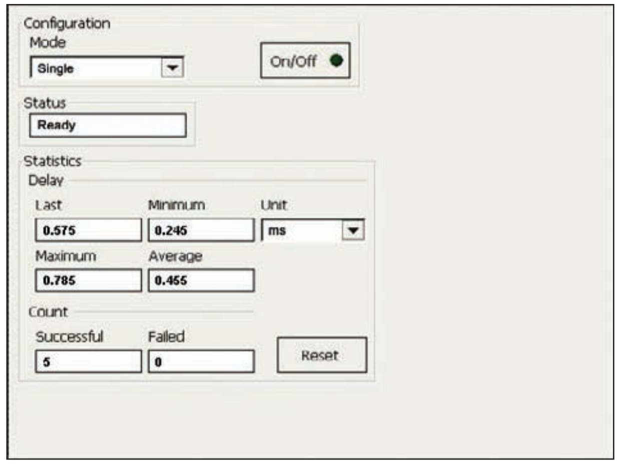


Figure 8. RTD measurement screen

The goal of the round-trip delay test is to send a signal through the network and test the time it takes for the signal to return to the test equipment. This test is most often performed when a new service is turned up, and usually from the customer premises.

To test round-trip delay, connect the FTB-8120/8130 Transport Blazer to a client interface and set up the appropriate test configuration. Create a loop at the far end of the network and ensure that the circuit is properly mapped. Enable the round-trip delay (RTD) measurement option from the FTB-8120/8130's user interface. The unit will automatically test and display the round-trip delay measurements. Measurements displayed include minimum, maximum and average round-trip delay recorded.

Automatic-Protection-Switch (APS) Testing

If automatic protection switching is enabled, it is necessary to verify that this feature is working within the 50 ms window specified by the ITU G.841 standards. The FTB-8120/8130 Transport Blazer's service disruption time (SDT) feature makes it simple to perform this test in any environment. Simply connect the FTB-8120/8130 Transport Blazer to a client interface and enable the SDT feature (choosing the appropriate disruption event trigger) and induce a switch. A switch may be induced by removing a fiber, pulling a circuit pack or using the network elements management software. The FTB-8120/8130 Transport Blazer's intuitive interface will automatically calculate and display the total switch time based on the trigger selected.

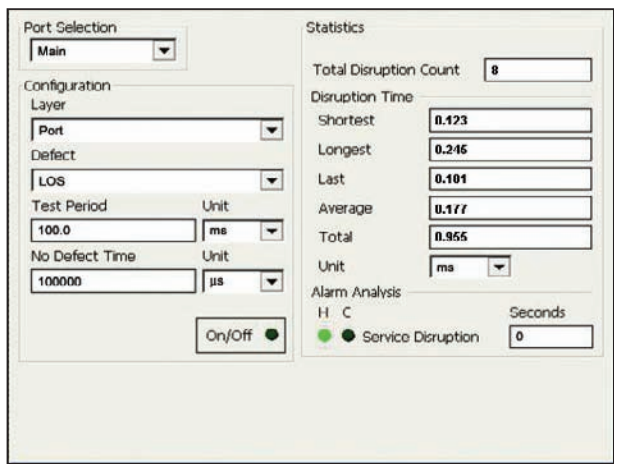
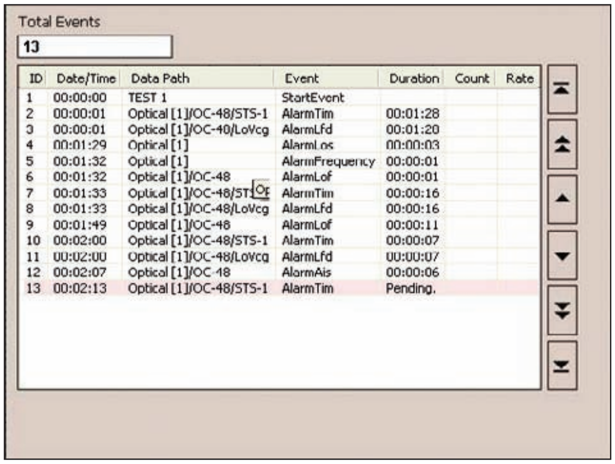


Figure 9. Cropped view of SDT measurement screen

Stability / Long-Term BER Testing

The final test that should be performed prior to circuit turn-up is usually a stability test that verifies the ability of the system to operate error-free for an extended period of time. The bit-error-rate (BER) test provides a complete qualification of the payload-carrying ability of the SONET/SDH circuit. As this is always an out-of-service type test, it is vital that a complete BER test be conducted prior to user traffic being commissioned onto the system.

During the test, the FTB-8120/8130 records all events and timestamps them on its event logger window. In addition, at the end of the test, the user can generate a detailed test report to highlight the circuit quality and SLA compliance. The FTB-8120/8130 Transport Blazer also supports real-time performance monitoring standards described in ITU recommendations G.821, G.826, G.828, G.829, M.2100 and M.2101, which are also included in the final test report.



ID	Date/Time	Data Path	Event	Duration	Count	Rate
1	00:00:00	TEST 1	StartEvent			
2	00:00:01	Optical [1]/OC-48/STS-1	AlarmTim	00:01:28		
3	00:00:01	Optical [1]/OC-40/LoVcg	AlarmLfd	00:01:20		
4	00:01:29	Optical [1]	AlarmLos	00:00:03		
5	00:01:32	Optical [1]	AlarmFrequency	00:00:01		
6	00:01:32	Optical [1]/OC-48	AlarmLof	00:00:01		
7	00:01:33	Optical [1]/OC-48/ST	AlarmTim	00:00:16		
8	00:01:33	Optical [1]/OC-48/LoVcg	AlarmLfd	00:00:16		
9	00:01:49	Optical [1]/OC-48	AlarmLof	00:00:11		
10	00:02:00	Optical [1]/OC-48/STS-1	AlarmTim	00:00:07		
11	00:02:00	Optical [1]/OC-48/LoVcg	AlarmLfd	00:00:07		
12	00:02:07	Optical [1]/OC-48	AlarmAis	00:00:06		
13	00:02:13	Optical [1]/OC-48/STS-1	AlarmTim	Pending.		

Figure 10. *Alarm Summary and Logger screen*

BER testing is accomplished easily with the FTB-8120/8130 Transport Blazer. From the user interface, set up the appropriate test configuration and select the proper test pattern (usually 2E31-1 for 10 Gb/s services and 2E23-1 for all other lower-rate synchronous services). Allow the test to run for an extended period of time; typically 72 hours for 10 Gb/s services and 24 to 48 hours for all other synchronous services. During or at the end of the test, consult the logger for events, errors and/or alarms. If errors or alarms occur during the test, troubleshoot the problem and then repeat the BER test.

To simplify BER testing, the FTB-8120/8130 Transport Blazer allows users to configure the test start and end time, ensuring that BER tests can be initiated during proper test time windows. The user is no longer required to start and stop the test, making efficient use of their time.

Conclusion

SONET/SDH-based networks have proven to be the most robust data-transport technology available and will continue to be the transmission system of choice for carriers who demand a stable and resilient method of delivering broadband services.

With the tests described in this application, service providers can be sure that all new SONET/SDH circuits in service are proven capable of handling any of the demanding services that may be placed on them in the future. These test routines, when performed without the proper test equipment, can prove complex and cumbersome to perform. The FTB-8120 and FTB-8130 modules, when combined with the FTB-200 integrated optical test tools, offer field technicians all the critical test components to turn up, maintain, and troubleshoot SONET/SDH networks, setting a new standard for the test and measurement market.

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