

Mai Abou-Shaban, Application Engineer
Claudio Mazzuca, Product Manager

Although there are various predictions regarding future trends in the telecom market, one thing is clear: next-generation SONET/SDH technologies are key enablers in helping service providers deliver value-added end-to-end Ethernet transport services over their reliable SONET/SDH infrastructure. The combination of GFP¹ as a generic data-services framing mechanism, VCAT² for improved service bandwidth granularity and LCAS³ for dynamic bandwidth allocation is extending the transport network capabilities through improved provisioning flexibility and transport efficiency. Consequently, these new technologies have introduced new sets of requirements when it comes to testing and validating Ethernet-over-SONET/SDH (EoS) services.

Today, packet-aware SONET/SDH add/drop multiplexers (ADMs) supporting GFP, VCAT and LCAS are commonly known as multiservice provisioning platforms (MSPPs) or multiservice transport platforms (MSTPs). Clearly, MSSPs/MSTPs offer obvious advantages to service providers as they help maximize the usage of their current install base with minimal capital expenditure, while providing a new revenue stream to fuel growth for the coming years.

However, with these new technologies come new deployment challenges. GFP, VCAT and LCAS add another layer of complexity to accommodate the transport of different data services. In many cases, these next-generation functionalities are delivered as enhancements to existing SONET/SDH ADMs. Nevertheless, for service providers and carriers, whether it is delivered by new network elements or by existing ADMs that have been enhanced, this additional layer needs to be fully tested prior to wide-scale deployment in the network.

This application note discusses how EXFO's FTB-8120NG/8130NG Transport Blazer™ Next-Generation SONET/SDH Test Modules, with their add/drop Ethernet interface feature in particular, can help service providers and system vendors satisfy these new testing needs. This feature, unique to EXFO, has proven to be invaluable to its users as it allows them to cover a wide range of test applications, from lab-based network verification and interoperability, to field-level Ethernet-over-SONET/SDH circuit turn-up and troubleshooting. This paper outlines five major test applications for qualifying next-generation systems, as well as for activating and maintaining Ethernet-over-SONET/SDH circuits in the network.

Ethernet Add/Drop Interface Overview

As shown in Figure 1, each FTB-8120NG/8130NG module includes one 10/100/1000M Ethernet interface (RJ-45) and one optical Gigabit Ethernet interface (SFP). These test interfaces can be used to connect the FTB-8120NG/8130NG modules with either EXFO's FTB-8510 Packet Blazer™ Ethernet Test Module or any other third-party Ethernet device (e.g., Ethernet packet generator/analyzer, L2/L3 switch or router, etc.), giving users the ability to add and drop an Ethernet client signal to and from a SONET/SDH signal. In essence, this provides full emulation of the data-service-mapping/demapping functions of an MSSP/MSTP network element.

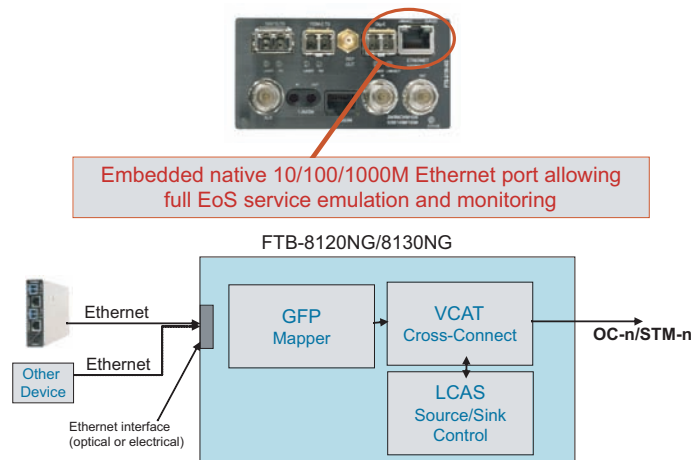


Figure 1. The FTB-8120NG/8130NG modules with embedded 10/100/1000M Ethernet and optical Gigabit Ethernet interfaces increase EoS test configuration options, allowing users to add or remove Ethernet payload to/from a GFP-mapped OC-n/STM-n line.

1. GFP: Generic Framing Procedure
2. VCAT: Virtual Concatenation
3. LCAS: Link-Capacity Adjustment Scheme

Through this unique feature, this is the industry's only test unit capable of offering full end-to-end Ethernet service emulation for next-generation networks, including, as we will demonstrate, multiservice transport validation of higher-layer applications (i.e., VoIP, IPTV, etc.). The resulting test configurations are ideal for Ethernet-over-SONET/SDH testing and troubleshooting applications, both in the lab and in the field.

Application 1: Ethernet-over-SONET/SDH Conformance Testing

EXFO's FTB-8120NG/8130NG modules give users the ability to conduct all required GFP, VCAT, and LCAS conformance tests for new MSPPs/MSTPs and/or new Ethernet mapper cards. These tests ensure that these devices comply with relevant ITU standards (G.7041, G.707 and G.7042, respectively). Some of the main test applications that ensure the devices' compliancy are the following:

- Manipulating and monitoring various bytes within the GFP overhead—validates the data-mapper cards' ability to configure proper settings, as well as its ability to detect and recover from erroneous conditions.
- VCAT differential delay injection—tests the ability of the MSPP/MSTP to compensate for the delay between arrival times of individual VCG members at their destination.
- Dynamic bandwidth adjustments using LCAS—validates the devices' resilient behavior to the removal and addition of VCAT members, while ensuring that these changes do not adversely affect the underlying Ethernet service.

In all these testing scenarios, users are ensuring that both errors and alarms are generated and reported correctly throughout the network on all three dimensions: GFP, VCAT, and LCAS. In addition, conformance testing would also include validation of the MSPP/MSTP's ability to allow service providers to provision SONET/SDH containers in increments that are more suited for Ethernet rates; i.e., 10/100/1000 Mb/s using low-order and high-order VCAT.

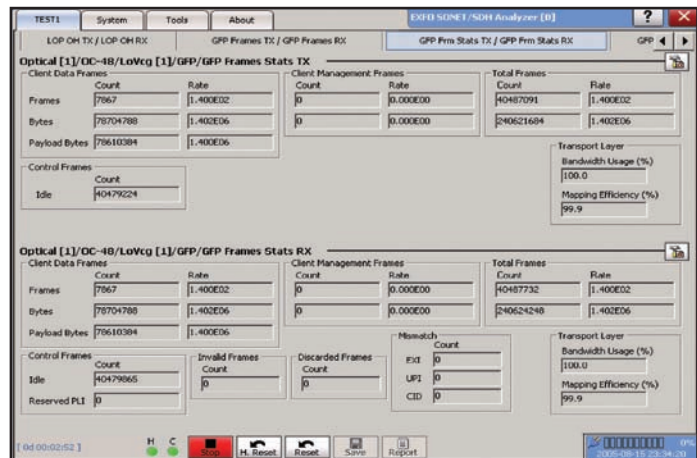


Figure 2. The 81x0 Next-Generation SONET/SDH module provides complete GFP frame analysis, including detailed statistics.



Figure 3. The 81x0 Next-Generation SONET/SDH module provides real-time GFP, VCAT and LCAS alarm and error analysis.

Figure 4 below shows a typical configuration used to perform these conformance and performance tests. In this configuration, the FTB-8510 module or other third-party Ethernet device is used to generate Ethernet traffic at any rate (10M, 100M or 1000M). Then, using the embedded Ethernet interface on the FTB-8120NG/8130NG module, the Ethernet traffic is mapped in the transmit direction of the OC-n/STM-n line into GFP using matched VCAT container sizes, generating an EoS signal for complete SONET/SDH and Ethernet analysis.

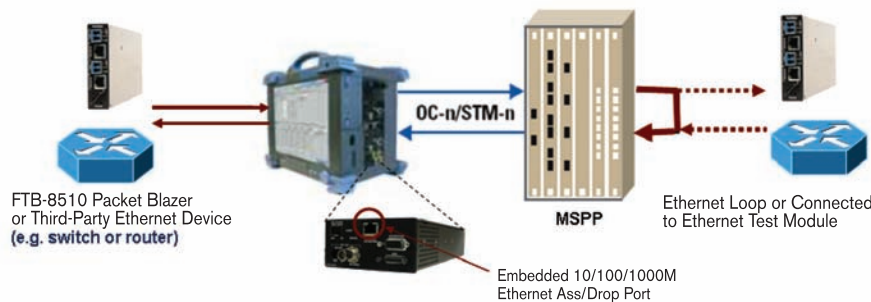


Figure 4. Next-generation technologies conformance-testing lab configuration used to verify the MSPP/MSTP compliance with the ITU standards.

The clear advantage of the add/drop port is that it allows for the decoupling of the Ethernet test signal from the SONET/SDH module. First, this allows users to generate anomalies or vary Ethernet frame sizes and type in real time, without interrupting the FTB-8120NG/8130NG GFP, VCAT, and LCAS functions. Second, the add/drop port supports any standard Ethernet signal, making this solution vendor-agnostic, meaning that if the user possesses alternate Ethernet generators, these units can be used with one of the FTB-8120NG/8130NG modules. This provides a powerful test configuration when verifying the next-generation functions of an MSPP/MSTP network element as the tests performed are no longer mandated, and consequently hindered, by the built-in Ethernet capabilities of the SONET/SDH tester.

Application 2: Multiservice Offering and QoS Testing

The previous application centers on basic point-to-point Ethernet over SONET/SDH service emulation and conformance testing. In reality, businesses worldwide are increasingly adopting advanced data applications such as VoIP, video-on-demand and videoconferencing over the same network. This shift has created the need for quality-of-service (QoS) assurance to validate the reliability and caliber of the services. Today, service providers are facing a growing customer demand to assign different QoS levels to each type of service they offer and guarantee that level of quality based on service-level agreements (SLAs). Failure to respect the QoS requirements often results in damage compensation by the service provider. For this reason it is vital to properly test QoS.

For Layer 2 services, service providers are required to validate the VLAN tag and priority configuration on the different switches across the network. This can be accomplished by using a test set that is capable of generating frames with different VLAN tags and their associated priorities. However, for Layer 3 (IP) services, there are currently two QoS standards available in the industry. The first standard is RFC-791, which defines the type of service (ToS). The second standard is RFC-2475, which defines the differentiated services code point (DSCP). Both of these standards use the same field in the IP packet header to identify the level of service for the packet.

Network equipment manufacturers have begun including QoS functionalities such as traffic policing and traffic classification on their MSPP/MSTP Ethernet mapper cards. Whether QoS is based on Layer 2 or 3 settings, it is important that service providers have the capability to replicate real traffic conditions when performing network equipment verification and Ethernet-over-SONET/SDH end-to-end service testing.

Sending different streams of traffic with varying levels of QoS across the simulated network environment is the ideal method for reproducing real network conditions. EXFO's FTB-8510 module offers the capability of generating/analyzing up to ten streams with different user-selectable QoS settings. Couple this with the FTB-8120NG/8130NG test functions, and the add/drop Ethernet interface creates the ideal configuration for multiservice Ethernet-over-SONET/SDH service testing and qualification.

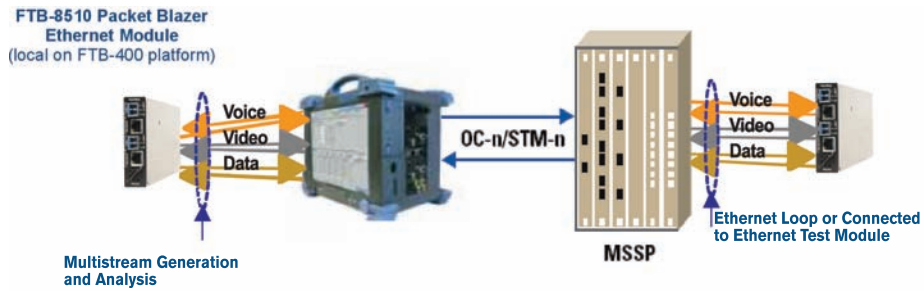


Figure 5. The FTB-8120NG/8130NG and FTB-8510 offering multiservice over SONET/SDH capabilities, for QoS testing of new data services over existing legacy SONET/SDH networks.

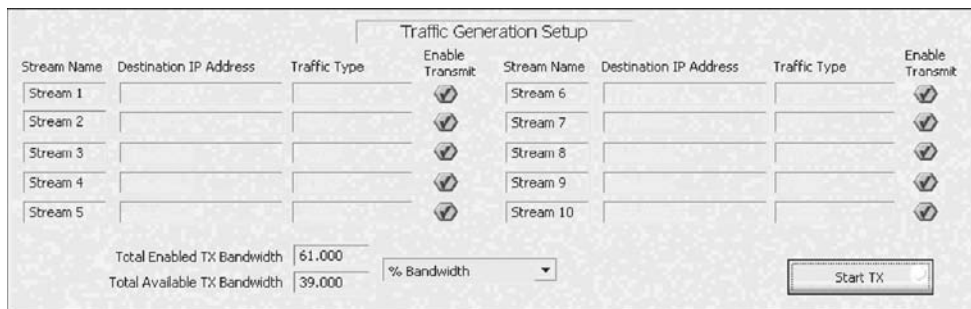


Figure 6. The FTB-8510, in conjunction with FTB-8120NG/8130NG, offers the capability of replicating real traffic conditions by sending different streams of traffic containing different levels of QoS (at Layer 2 or 3) across the network.

Application 3: Multivendor Interoperability

Multivendor networks are now commonplace in SONET/SDH networks. Given this, and the fact these next-generation technologies are largely in their early stages of deployment, it is important that proper vendor interoperability tests are performed in labs in order to detect and resolve any technical issues prior to actual deployment in the network.

Figure 7 below shows typical configurations used to perform these interoperability tests. In this configuration, the FTB-8510 module is used to generate Ethernet traffic at any rate (10M, 100M or 1000M GbE) at both ends of the Ethernet connection. With the capabilities of the FTB-8510, both single and multiservice end-to-end Ethernet test signals can be generated and analyzed as they flow through the next-generation SONET/SDH network configuration. If errors are encountered on the underlying Ethernet services, the test engineer will then locate the source of fault.

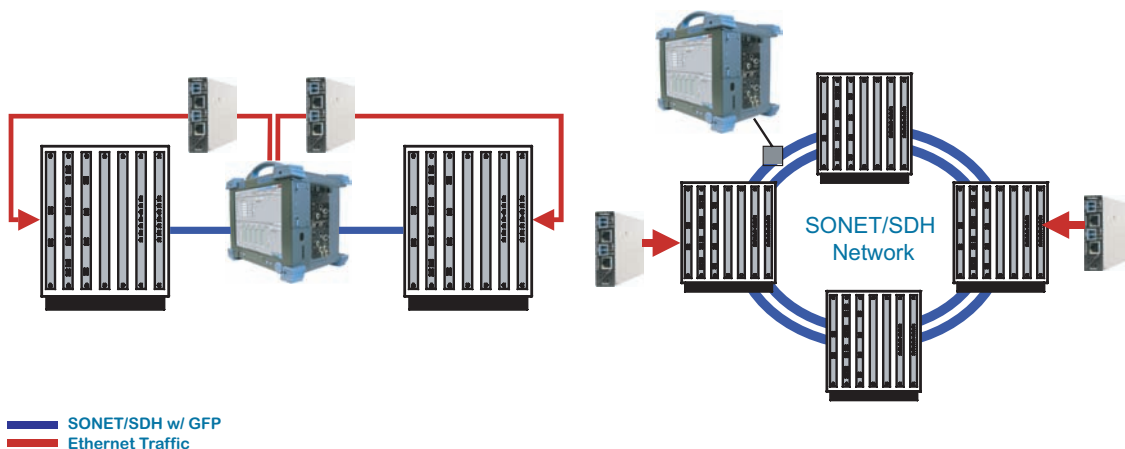


Figure 7. The FTB-8120NG/8130NG and FTB-8510 offer full interoperability testing, including a wide range of troubleshooting functions across Ethernet, SONET/SDH and next-generation SONET/SDH layers.

The FTB-8120NG/8130NG modules allow users to simultaneously monitor SONET/SDH and next-generation GFP, VCAT, and LCAS statistics and alarms, providing full visibility of all networking layers. In addition, only through the use of this add/drop Ethernet interface, can users also monitor all aspects of the Ethernet signal at any span in the simulated network. Ethernet analysis can be performed by an EXFO FTB-8510 module or, alternatively, by any Ethernet traffic analyzer connected to the add/drop port (e.g., higher-layer protocol analyzer). This flexibility offers users a wide range of troubleshooting scenarios.

Application 4: Ethernet Transport Service Qualification

The introduction of VCAT to SONET/SDH networks presents new revenue opportunities for service providers. VCAT was developed to allow individual SONET/SDH channels to be merged and thus create a customized SONET/SDH container size that can be any multiple of the basic rates (i.e., for high-order VCAT, this basic rate would be an STS-1/STS-3 or VC-3/VC-4, whereas for low-order VCAT, this basic rate could be VC-11/12 or VT-1.5/2). For example, two STS-1s can be combined to form one virtual concatenation group that comes close to supporting a 100 Mb/s Ethernet interface (an STS-1 payload envelope of approximately 49 Mb/s creates an almost exact match to the 100 Mb/s circuit).

In addition to providing a much more efficient use of the transport bandwidth for data service delivery over SONET/SDH networks, this technology also opens the door to delivering sub-rate Ethernet services over SONET/SDH networks (see Table 1). For instance, a service provider can now offer customers 6 Mb/s Ethernet service, via a 10 Mb/s Ethernet connection, using a VCAT group consisting of four VT-1.5s or three VC-12s. In addition, with LCAS delivering dynamic and non-service-affecting VCAT, group size increases and decreases as needed, allowing the service provider to offer this same customer an increase in service bandwidth at any time.

Service	Bit Rate (Mb/s)	Efficiency	
		Without VCAT	With VCAT
Ethernet	10	STS-1 (20%)/ VC-3 (20%)	VT1.5-7v (93%)/ VC12-5v (97%)
Fast Ethernet	100	STS-3c (47%)/VC-4 (67%)	STS-1-2v (99%)/ VC-3-2v (99%)
Gigabit Ethernet	1000	STS-48c (42%)/ VC-4-16c (42%)	STS-3c-7v (95%)/VC-4-7v (95%)
Fibre Channel (1x)	1062.5	STS-48c (43%)/ VC-4-16c (43%)	STS-3c-6v (98%)/ VC-4-7v (98%)

Table 1: Service Delivery Efficiency Using Virtual Concatenation

The key to making these service offerings a success requires extensive testing in the lab prior to deploying these sub-rate services for three main reasons:

- 1- to validate that the Ethernet mapper card on the MSPP/MSTP support these container sizes without any problems;
- 2- to validate that the Ethernet mapper card supports LCAS functionality that allows for dynamic adjustment of bandwidth with no underlying effect to this Ethernet connection, or any other Ethernet client signal serviced through the same network element; and
- 3- to monitor the resilient behavior of the MSPP/MSTP under test during defect conditions occurring on either the GFP, VCAT, or LCAS layers.

EXFO's FTB-8120NG/8130NG modules, used in conjunction with the FTB-8510 module, provide a complete and flexible solution to test all these scenarios.

In addition, if managed services are offered to customers, the add/drop Ethernet port (located on the FTB-8120NG/8130NG modules) allows service providers to mirror their network environment by using the specified customer premises equipment (CPE) device, connected directly to the FTB-8120NG/8130NG module and MSPP/MSTP. This ensures that the above tests can be performed in this environment, ensuring that any compatibility issues found during testing are resolved prior to deployment of this managed service.

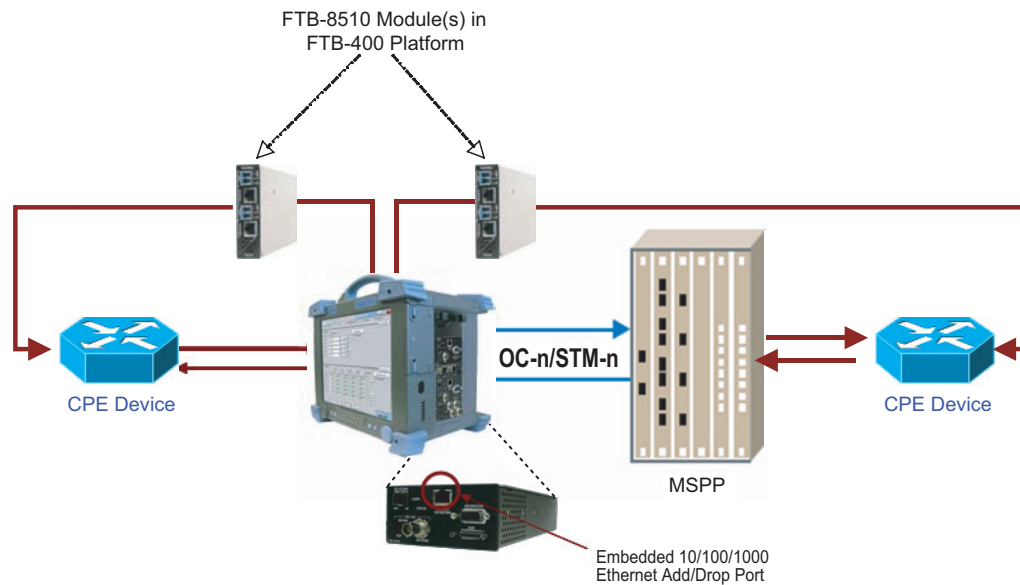


Figure 8. Ethernet-over-SONET/SDH service emulation using the FTB-8120NG/8130NG Ethernet add/drop electrical or optical interfaces.

Application 5: Ethernet-over-SONET/SDH Troubleshooting

Once next-generation services are deployed, service providers are left with the challenge of ensuring that their end-to-end data services perform according to signed service-level agreements. Post-deployment troubleshooting activities must now not only include legacy SONET/SDH-layer visibility, but also visibility at higher GFP, VCAT and LCAS layers as well as the data layer. Service providers require a test solution that can identify and correlate any potential problems that can normally occur throughout the network and, more importantly, across multiple layers.

EXFO's Next-Generation SONET/SDH Analyzer offers an ideal solution for Ethernet-over-SONET/SDH troubleshooting activities. Configured in through mode and tapped into any monitoring point in the network, the FTB-8120NG/8130NG modules can be used to monitor all relevant layers. Starting from the SONET/SDH layer, the FTB-8120NG/8130NG supports overhead monitoring, alarm and error analysis, and performance monitoring. If the source of error has not been identified at this layer, the next-generation layer must be monitored. The FTB-8120NG/8130NG supports a wide range of next-generation SONET/SDH monitoring functions, including in-depth GFP frame analysis, and GFP, VCAT or LCAS error or alarm monitoring. The last layer to troubleshoot, if the source of errors has not been discovered, is the Ethernet layer. The field personnel can use the FTB-8120NG/8130NG's Ethernet interface to drop the Ethernet traffic into the FTB-8510 or any other third-party Ethernet device for complete Ethernet frame and alarm/error analysis.

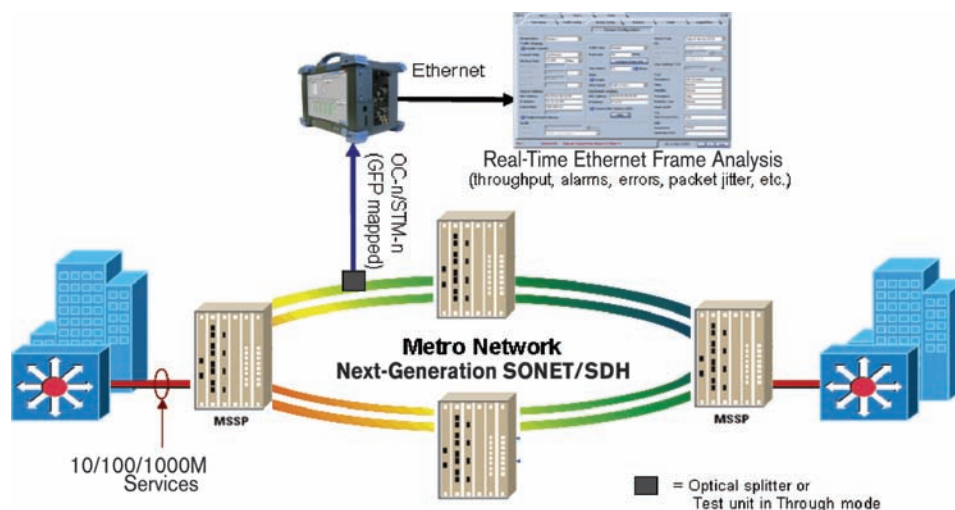


Figure 9. The FTB-8120NG/8130NG modules embedded 10/100/1000M Ethernet interface offers users an ideal Ethernet-over-SONET/SDH troubleshooting and monitoring tool in the field.

Conclusion

SONET and SDH have been commercial and technical successes. With these new next-generation enhancements, they will continue to endure and provide efficient, robust and reliable service well into the future. For service providers, the challenge will be to expand their networks to meet the growing demand for these Ethernet transport services and, once deployed, ensure that these services meet their service-level agreements. EXFO's FTB-8120NG/8130NG modules give service providers the industry's most flexible test platform to take on these challenges head-on.

Corporate Headquarters > 400 Godin Avenue, Quebec (Quebec) G1M 2K2 CANADA | Tel.: 1 418 683-0211 | Fax: 1 418 683-2170 | info@EXFO.com

Toll-free: 1 800 663-3936 (USA and Canada) | www.EXFO.com

EXFO America	3701 Plano Parkway, Suite 160	Plano, TX 75075 USA	Tel.: 1 800 663-3936	Fax: 1 972 836-0164
EXFO Europe	Le Dynasteur, 10/12 rue Andras Beck	92366 Meudon la Forêt Cedex FRANCE	Tel.: +33.1.40.83.85.85	Fax: +33.1.40.83.04.42
EXFO Asia-Pacific	151 Chin Swee Road, #03-29 Manhattan House	SINGAPORE 169876	Tel.: +65 6333 8241	Fax: +65 6333 8242
EXFO China	No.88 Fuhua, First Road Central Tower, Room 801, Futian District	Shenzhen 518048, CHINA	Tel.: +86 (755) 8203 2300	Fax: +86 (755) 8203 2306
	Beijing New Century Hotel Office Tower No.6 Southern Capital Gym Road, Room 1754-1755	Beijing 100044, P.R. CHINA	Tel.: 86.10.6849.2738	Fax.: 86.10.6849.2662