FTB-8130NGE Power Blazer

NEXT-GENERATION MULTISERVICE TEST MODULES

ExacTCP

EXFO Connect Compatible

EtherSAM

COMPLETE IPv6 TESTING

FROST & SULLIVAN 2011 BEST PRACTICES AWARD — GLOBAL SONET/SDH & OTN TEST EQUIPMENT GROWTH LEADERSHIP OF THE YEAR AWARD

FROST & SULLIVAN 2011 BEST PRACTICES AWARD — GLOBAL GIGABIT ETHERNET TEST EQUIPMENT GROWTH EXCELLENCE AWARD

Fully integrated multiservice test solution supporting next-generation SONET/SDH, OTN, Ethernet and Fibre Channel test functions

SPEC SHEET

KEY FEATURES

- The industry's smallest and most efficient module, ideal for mobile backhaul and packet transport network deployments
- Comprehensive Fibre Channel test capabilities (1x, 2x, 4x, 10x)
- OTN forward error correction (FEC) and optical channel data unit multiplex testing capabilities as per ITU-T G.709
- Complete bidirectional EtherSAM (ITU-T Y.1564) test suite
- ODU0 and ODUflex for optical transport network (OTN), the technology of choice for transporting Ethernet traffic over the core network; OAM&P for troubleshooting and maintenance
- Ability to test all channels simultaneously and real-time error/alarm monitoring to accelerate testing time and improve the efficiency of development environments
- Complete Carrier Ethernet services portfolio: PBB-TE, MPLS, IPv4/IPv6 and one-way delay
- True wire-speed, stateful TCP throughput based on RFC 6349 test for undisputable SLA reinforcement for Ethernet services
- EXFO Connect-compatible: automated asset management; data goes through the cloud and into a dynamic database

COMPLEMENTARY PRODUCTS

Platform
FTB-500

Compact Platform
FTB-200

EXFO

THE CHOICE FOR INTEGRATED MULTISERVICE TRANSPORT TESTING

The responsibilities of traditional SONET/SDH telecom field installation personnel have evolved over the last few years. With the advent of packet-aware SONET/SDH add-drop multiplexers—including multiservice transport platforms (MSTPs) and new reconfigurable add-drop multiplexers (ROADMs)—technicians must not only perform traditional SONET/SDH tests, but are now also responsible for verifying packet-based services such as Ethernet, 10 Gigabit Ethernet and Fibre Channel running over the same network elements.

This has resulted in a growing need for multitechnology test solutions to support the deployment, operation and maintenance of these multiservice platforms and the corresponding data-aware SONET/SDH networks.

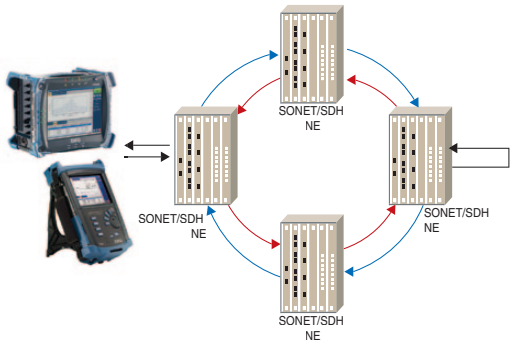
EXFO's FTB-8130NGE (10/11.3 Gbit/s) Power Blazer test module has been designed to specifically address such field commissioning and maintenance requirements, providing SONET/SDH, Ethernet and Fibre Channel test functions in the industry's smallest and most efficient module, and setting a new standard for multiservice field testing.

SCALABLE, HIGH-PERFORMANCE SONET/SDH TESTING

SONET/SDH Service Turn-Up and Troubleshooting

The FTB-8130NGE Power Blazer module offers a wide range of SONET/SDH test functions ranging from simple bit-error-rate (BER) testing to advanced characterization and troubleshooting procedures. These functions include:

- Mixed and bulk payload generation and analysis from 64 kbit/s to 10 Gbit/s
- High-order mappings: STS-1/3c/12c/48c/192c and AU-3/AU-4/AU-4-4c/16c/64c
- Low-order mappings: VT1.5/2/6, TU-11/12/2/3
- Unframed optical signal testing at 10 Gbit/s rate
- Section/RS, Line/MS, high-order (HO) and low-order (LO) path overhead manipulation and monitoring
- Section/RS, Line/MS, high-order and low-order path alarm/error generation and monitoring
- High-order and low-order pointer generation and monitoring
- K1/K2 OH byte capture
- Tandem connection monitoring
- Performance monitoring: G.821, G.826, G.828, G.829, M.2100, M.2101
- Frequency analysis and power measurement
- Payload block and replace
- Frequency offset generation
- DS1 loopcodes and NI/CSU loopback emulation
- Automatic protection switching (APS) and service disruption time (SDT) measurements
- Multichannel SDT measurements and real-time error/alarm monitoring for all STS-1/AU-4 channels
- Round-trip delay measurements
- DS1/DS3 auto detection of line-code framing and test pattern
- Dual DS1/DS3 receiver testing
- Independent transmitter and receiver testing
- Through mode analysis
- Intrusive Through mode
- Programmable error/alarm injection
- DS1 FDL
- Fractional T1/E1 testing
- DS3 FEAC



Housed in either the FTB-500 or FTB-200 platform, the 8130NGE module is the ideal solution for field circuit turn-up and troubleshooting.

Optical Transport Network Testing

OTN as per ITU-T G.709 has recently introduced two new concepts: ODU0 and ODUflex. ODU0 is a new virtual container of 1.25 Gbit/s bandwidth specifically defined for efficiently mapping Gigabit Ethernet services over OTN. As for ODUflex, it is the most efficient sub-wavelength bandwidth management capability for transport line rates of 10 Gbit/s, 40 Gbit/s and upcoming 100 Gbit/s. ODUflex allows providers to interconnect routers in ways that enable efficient bandwidth growth in steps of 1.25 Gbit/s, eliminating the need to allocate a full fixed-rate ODU container to each connection, and allowing service providers to transport efficiently and seamlessly across lower-cost optical infrastructures.

With OTN deployments rapidly increasing, so is the need for smaller, field-oriented OTN test equipment. The FTB-8130NGE Power Blazer module offers OTN test capabilities for verification of compliancy with ITU-T G.709 standards. The tests include:

- OTU1 (2.7 Gbit/s) and OTU2 (10.7 Gbit/s) bit rates
- ODU0 (1.25 Gbit/s) container with Gigabit Ethernet and SONET/SDH client signals mapping
- ODUflex with Ethernet client signal mapping
- Overclocked OTU2 rates: OTU1e (11.0491 Gbit/s), OTU2e (11.0957 Gbit/s), OTU1f (11.2701 Gbit/s) and OTU2f (11.3176 Gbit/s)
- Unframed optical signal testing at 10.7 Gbit/s, 11.0491 Gbit/s, 11.0957 Gbit/s, 11.2701 Gbit/s and 11.3176 Gbit/s rates
- Synchronous mapping of SONET/SDH signals within OTN as well as synchronous and asynchronous demapping
- Forward error correction (FEC) testing
- Service disruption time (SDT) measurements
- Multichannel SDT measurements and real-time error/alarm monitoring for all ODU0 channels
- Round-trip delay (RTD) measurements
- OTU, ODU, OPU overhead manipulation and monitoring
- OTU, ODU (including ODU TCM), OPU layer alarms/errors generation and analysis
- OTU, ODU (including ODU TCM) trace messages
- Mux/demux of ODU1/ODU2 testing; generation of four ODU1 into a single ODU2 structure and transporting it over a single wavelength
- ODU multiplexing alarm-generation and analysis
- Through mode analysis
- Intrusive Through mode
- EoOTN testing using internally generated 10 GigE LAN and mapping onto OTU1e and OTU2e rates
- 10 GigE LAN mapping into OTU2 using GFP-F

Power Blazer modules support G.709 testing in either the FTB-200 or FTB-500.

Next-Generation SONET/SDH Testing

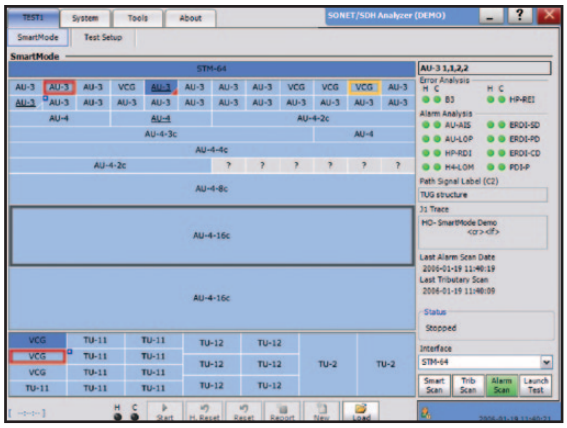
Available next-generation SONET/SDH test functionalities include generic framing procedure (GFP), virtual concatenation (VCAT) and link-capacity adjustment scheme (LCAS). These options are available when the FTB-8130NGE is housed in the FTB-500 platform.

GFP	VCAT	LCAS
› Generation and analysis of frame types (client management/client data)	› High-order and low-order VCAT support	› Emulation and analysis of LCAS protocol (Automatic and Manual modes)
› Alarm/error generation and monitoring	› Simultaneous manipulation and monitoring of each member	› Source and sink state machine control and monitoring
› Overhead manipulation and monitoring	› Alarm/error generation and monitoring	› Real-time generation and monitoring of LCAS control fields
› Transmission and reception statistics monitoring	› Sequence-indicator manipulation and processing	› Real-time insertion and monitoring of LCAS alarms/errors
› Supported over contiguous or VCAT containers	› Group-summary monitoring	
	› Differential delay analysis and insertion	

SmartMode: Real-Time Signal Structure Discovery and Monitoring

EXFO's FTB-8130NGE Power Blazer module supports a unique feature called SmartMode. This provides users with full visibility of all high-order (STS/AU) and low-order (VT/TU) mixed mappings within the incoming SONET/SDH and OTN test signal.

SmartMode automatically discovers the signal structure of the OC-n/STM-n line including mixed mappings and virtual concatenation (VCAT) members. In addition to this in-depth multichannel visibility, SmartMode performs real-time monitoring of all discovered high-order paths and user-selected low-order paths simultaneously, providing users with the industry's most powerful SONET/SDH multichannel monitoring and troubleshooting solution. Real-time monitoring allows users to easily isolate network faults, saving valuable time and minimizing service disruption. SmartMode also provides one-touch test case start, allowing users to quickly configure a desired test path and SmartMode specific reporting.



FTB-8130NGE SmartMode: multichannel signal discovery with real-time alarm scan (shown in the FTB-500 user interface).

ETHERNET PERFORMANCE VALIDATION AND RELIABILITY

EXFO's FTB-8130NGE offers a wide range of Ethernet test functions designed for performance validation and reliability testing.

Interfaces

These modules support multiple Ethernet interfaces, both electrical and optical.

ELECTRICAL	OPTICAL
10 Mbit/s	100 Mbit/s
100 Mbit/s	1000 Mbit/s (GigE)
1000 Mbit/s	10 Gbit/s (10 GigE)–FTB-8130NGE only

Applications

The FTB-8130NGE delivers the features required to perform Ethernet service acceptance testing, namely RFC 2544 and BER testing.

EtherSAM: The New Standard in Ethernet Testing

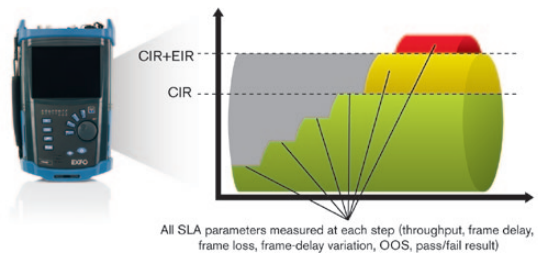
ITU-T Y.1564 is the new standard for turning up and troubleshooting Carrier Ethernet services. This methodology is completely adapted to today's Ethernet services, especially mobile backhaul and commercial services. Up to now, RFC 2544 has been the most widely used methodology. However, it was designed for network device testing in the lab, not for services testing in the field. ITU-T Y.1564 is the first testing standard developed for the field. It has a number of advantages over the RFC 2544 including validation of critical SLA criteria such as packet jitter and QoS measurements. This methodology is also significantly faster, thereby saving time and resources while optimizing QoS.

Contrary to other methodologies, EtherSAM supports new multiservice offerings. EtherSAM can simulate all types of services that will run on the network and simultaneously qualify all key SLA parameters for each of these services. Moreover, it validates the QoS mechanisms provisioned in the network to prioritize the different service types, resulting in more accurate validation and much faster deployment and troubleshooting. EtherSAM is comprised of two phases, the service configuration test and the service performance test.

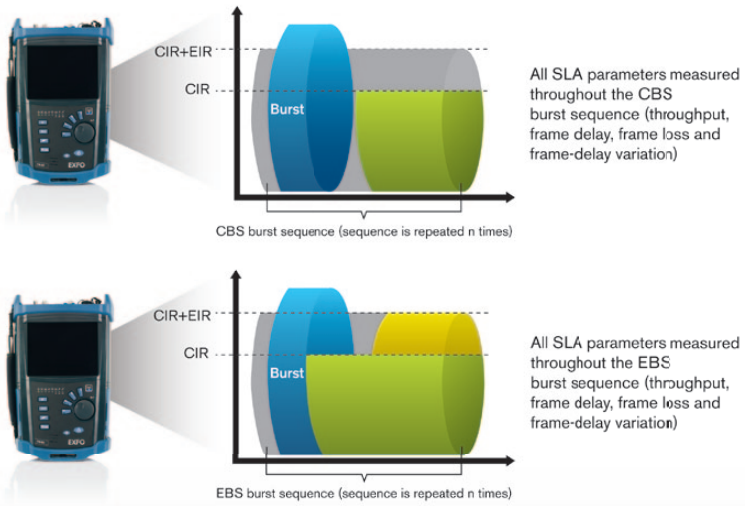
Service Configuration Test

The service configuration test consists of sequentially testing each service to validate that the service is properly provisioned and that all specific KPIs or SLA parameters are met. A ramp test and a burst test are performed to verify the committed information rate (CIR), excess information rate (EIR), committed burst size (CBS) and excess burst size (EBS).

Ramp Test

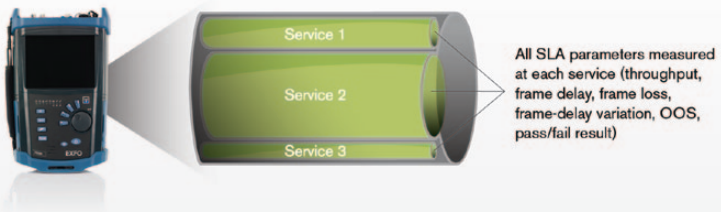


Burst Test



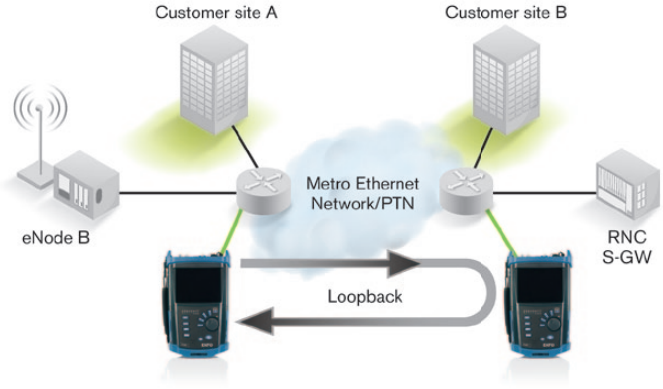
Service Performance Test

Once the configuration of each individual service is validated, the service performance test simultaneously validates the quality of all the services over time.

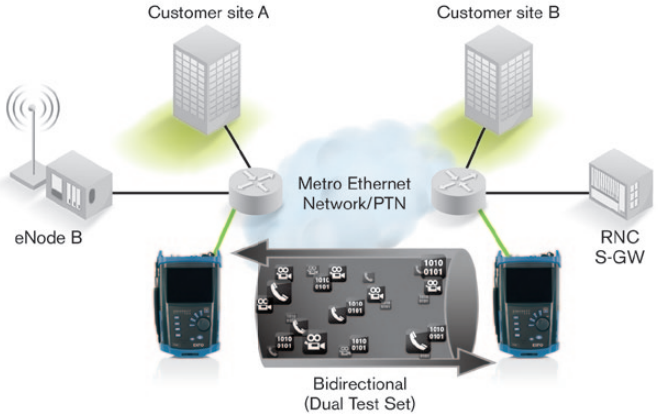


EtherSAM Bidirectional Results

EXFO's EtherSAM approach proves even more powerful as it executes the complete ITU-T Y.1564 test with bidirectional measurements. Key SLA parameters are measured independently in each test direction, thus providing 100 % first-time-right service activation—that is the highest level of confidence in service testing.



Round-trip results only



Simultaneous independant results for each test direction per individual service

RFC 2544 TESTING

In cases where the Ethernet service is delivered via switched transport, the RFC 2544 measurements provide a baseline for service providers to define SLAs with their customers. They enable service providers to validate the quality of service (QoS) delivered and can provide them with a tool to create value-added services that can be measured and demonstrated to customers. For example, these tests provide performance statistics and commissioning verification for virtual LANs (VLANs), virtual private networks (VPNs) and transparent LAN services (TLS), all of which use Ethernet as an access technology.

The FTB-8130NGE Power Blazer module comes with a complete set of RFC 2544 test capabilities, including:

- Throughput testing
- Burst (back-to-back) testing
- Frame loss analysis
- Latency measurement

BER TESTING

Since the transparent transport of Ethernet services over physical media is becoming more widespread, Ethernet is increasingly carried across a variety of layer 1 media over longer distances. This creates a growing need for the certification of Ethernet transport on a bit-per-bit basis, which can be done using bit-error-rate testing (BERT).

BERT uses a pseudo-random binary sequence (PRBS) encapsulated into an Ethernet frame, making it possible to go from a frame-based error measurement to a bit-error-rate measurement. This provides the bit-per-bit error count accuracy required for the acceptance testing of physical-medium transport systems.

In addition to BER testing, the FTB-8130NGE Power Blazer module provides service disruption time (SDT) measurements.

ETHERNET QUALITY OF SERVICE MEASUREMENTS

Data services are making a significant shift toward supporting a variety of applications on the same network. Multiservice offerings such as triple-play services have fuelled the need for QoS testing to ensure the condition and reliability of each service and fully qualify SLA parameters. The FTB-8130NGE allows service providers to simultaneously simulate and qualify different applications through their multiple stream application. The user has the capability to configure up to 10 streams with different Ethernet and IP QoS parameters such as VLAN ID (802.1Q), VLAN Priority (802.1p), VLAN stacking (802.1ad Q-in-Q), ToS and DSCP. Specific stream profiles to transmit Voice-over-IP (VoIP), video and data can be selected for each stream. For each stream, measurements for throughput, latency, frame loss and packet jitter (RFC 3393) are available simultaneously, allowing for fast and in-depth qualification of all SLA criteria.

PBB-TE AND MPLS: CARRIER ETHERNET TRANSPORT SOLUTION TESTING

As technologically-sophisticated commercial and residential consumers continue to drive demand for premium, high-bandwidth data services such as voice and video, service providers worldwide are evolving their transport infrastructures to support these bandwidth and quality intensive services. No longer is an all-IP core sufficient; providers must now expand their IP convergence to the edge/metro network, in a cost-effective, quality-assured manner.

Two Ethernet tunneling technologies address these requirements: Provider Backbone Bridge-Traffic Engineering or PBB-TE (also referred to as PBT) and transport MPLS. These two technologies enable connection-oriented Ethernet, providing carriers with a means of offering scalable, reliable and resilient Ethernet services. The PBB-TE and MPLS options on the FTB-8130NGE offer service providers a comprehensive field tool to efficiently qualify Ethernet services from end to end, validating metro and core tunneling technologies.

TCP THROUGHPUT

The Internet protocol (IP) and transmission control protocol (TCP) together form the essence of TCP/IP networking. While IP deals with the delivery of packets, TCP provides the integrity and assurance that the data packets transmitted by one host are reliably received at the destination. Applications such as hypertext transfer protocol (HTTP), e-mail or file transfer protocol (FTP) depend on TCP as their delivery assurance mechanism within networks. Customers deploying such applications expect not only physical and link level SLAs from their service providers, but assurance that their TCP traffic requirements will be supported across the network. The TCP throughput feature offers Ethernet service providers the capability of measuring and validating that the services offered to their customers support the TCP traffic performance they expect.

ETHERNET ADVANCED TROUBLESHOOTING

The FTB-8130NGE provides a number of advanced features essential for in-depth troubleshooting in the event of network failures or impairments. The advanced filtering option allows the user to configure up to ten filters each with up to four operands, which will be applied to the received Ethernet traffic. Detailed statistics are available for each configured filter providing the user with critical information required to pinpoint specific problems. Other advanced troubleshooting tools include advanced auto-negation and flow-control capabilities.

The FTB-8130NGE also supports full-line-rate data capture and decode. This key troubleshooting tool enables field technicians to easily identify complex network issues. The comprehensive capture feature includes the capability to configure capture filters and triggers to quickly zero in on network events.

FIBRE CHANNEL NETWORK INTEGRITY TESTING

EXFO's FTB-8130NGE Power Blazer module allows for comprehensive testing capabilities for Fibre Channel network deployment.

Interfaces

These modules support multiple Fibre Channel interfaces:

INTERFACE	RATE (GBIT/S)
1x	1.0625
2x	2.125
4x	4.25
10x	10.51875

Applications

Since most SANs cover large distances and Fibre Channel has stringent performance attributes that must be respected, it is imperative to test at each phase of network deployment to ensure appropriate service levels. EXFO's FTB-8130NGE Fibre Channel option provides full wire-speed traffic generation at FC-0, FC-1 and FC-2 logical layers, allowing BER testing for link integrity measurements. Latency, buffer-to-buffer credit measurements for optimization, and login capabilities that enable end-to-end Fibre Channel network testing features are also supported.

Latency

Transmission of frames in a network is not instantaneous and is subject to multiple delays caused by the propagation delay in the fiber and by processing time inside each piece of network equipment. Latency is the total accumulation of delays between two end points. Some applications such as VoIP, video and storage area networks are very sensitive to excess latency.

It is therefore critical for service providers to properly characterize network latency when offering Fibre Channel services. From the latency measurement it performs, the FTB-8130NGE module estimates buffer-to-buffer credit value requirements.

Buffer-to-Buffer Credit Estimation

The buffer credit mechanism is the flow-control engine for Fibre Channel. This is a crucial configuration parameter for optimal network performance. Usually, network administrators calculate the value by taking the distance traveled and the data rate into consideration; however, since latency issues are not considered, poor accuracy is to be expected. The FTB-8130NGE module is capable of estimating buffer credit values with respect to latency by calculating the distance according to the round-trip latency time.

Login Testing

Most new-generation transport devices (xWDM or SONET/SDH MUX) supporting Fibre Channel are no longer fully transparent; they also have increased built-in intelligence, acting more as Fibre-Channel switches. With switch fabric login ability, the FTB-8130NGE module supports connections to a remote location through a fabric or semi-transparent networks.

The login process not only permits the unit to connect through a fabric, but it also exchanges some of the basic port characteristics (such as buffer-to-buffer credit and class of service) in order to efficiently transport the traffic through the network.

The login feature allows automatic detection of port/fabric login, login status (successful login, in progress, failure and logout) and response to remote buffer-to-buffer advertised credit.

UNSURPASSED CONFIGURATION AND OPERATIONAL FLEXIBILITY

Multiplatform Support and Versatility

The FTB-8130NGE module shares a unique architecture that allows them to be supported and interchangeable on the FTB-500 and FTB-200 platforms. This cross-platform support provides users with added flexibility to select the platform that best suits their testing needs. EXFO is the first and only test solution provider to offer this versatility, delivering single to multi-application test solutions with the same hardware module, which in turn dramatically reduces capital expenditures.

Once inserted into the FTB-200 Compact Platform, the FTB-8130NGE module delivers the industry's most compact integrated SONET/SDH, Ethernet and Fibre Channel solution focused on field testing applications. Available with powerful options–high-precision power meter, visual fault locator and fiber inspection probe–the FTB-200 provides all the critical test tools required for day-to-day activities, eliminating the need to carry and manage multiple test sets.

Using the FTB-500 platform provides users with an all-in-one solution supporting a mix of SONET/SDH, OTN, Ethernet, Fibre Channel and optical-layer test modules, making it the industry's first truly integrated network testing platform. The resulting modularity enables users to upgrade their systems in the field according to their testing needs. This multitechnology test platform is the ideal solution for field, central office and lab applications.

Product Option Flexibility

With the FTB-8130NGE Power Blazer module, users can purchase one or more next-generation options (e.g., GFP, VCAT, LCAS) and/or OTN options (OTU1, OTU2) via field upgrades to customize their configuration as new needs arise. This eliminates the need to perform complete hardware and/or platform retrofits, therefore significantly decreasing capital and training expenses.

EXFO's FTB-8130NGE also supports 1x/2x/4x/10x Fibre Channel testing options.

EXFO Connect

EXFO Connect

AUTOMATED ASSET MANAGEMENT. PUSH TEST DATA IN THE CLOUD. GET CONNECTED.

EXFO Connect pushes and stores test equipment and test data content automatically in the cloud, allowing you to streamline test operation from build-out to maintenance.

EXPERT TEST TOOLS ON THE FTB-200 PLATFORM

EXpert Test Tools is a series of platform-based software testing tools that enhance the value of the FTB-200 platform, providing additional testing capabilities without the need for additional modules or units.

EXpert TEST TOOLS

EXpert VoIP TEST TOOLS

EXpert VoIP generates a voice-over-IP call directly from the test platform to validate performance during service turn-up and troubleshooting.

› Supports a wide range of signaling protocols, including SIP, SCCP, H.248/Megaco and H.323

› Supports MOS and R-factor quality metrics

› Simplifies testing with configurable pass/fail thresholds and RTP metrics

EXpert IP TEST TOOLS

EXpert IP integrates six commonly used datacom test tools into one platform-based application to ensure that field technicians are prepared for a wide range of testing needs.

› Rapidly performs debugging sequences with VLAN scan and LAN discovery

› Validates end-to-end ping and traceroute

› Verifies FTP performance and HTTP availability

EXpert IPTV TEST TOOLS

This powerful IPTV quality assessment solution enables set-top-box emulation and passive monitoring of IPTV streams, allowing quick and easy pass/fail verification of IPTV installations.

› Real-time video preview

› Analyzes up to 10 video streams

› Comprehensive QoS and QoE metrics including MOS score

ELECTRICAL INTERFACES

The following section provides detailed information on all supported electrical interfaces.

ELECTRICAL INTERFACES

		DS1	E1/2M		E2/8M	E3/34M	DS3/45M		STS-1e/ STM-0e/52M	E4/140M	STS-3e/ STM-1e/155M	
Tx pulse amplitude		2.4 to 3.6 V	3.0 V	2.37 V	2.37 V	1.0 ± 0.1 V	0.36 to 0.85 V			1.0 ± 0.1 Vpp	0.5 V	
Tx pulse mask		GR-499 Figure 9.5	G.703 Figure 15	G.703 Figure 15	G.703 Figure 16	G.703 Figure 17	DS-3 GR-499 Figure 9-8	45-M G.703 Figure 14	G.253 Figure 4-10/4-11	GR-703 Figure 18/19	STM-3e GR-253 Figure 4-12/ 4-13/4-14	STM-1e/155M G.703 Figure 22-23
Tx LBO preamplification		Power dBdsx +0.6 dBdsx (0-133 ft) +1.2 dBdsx (133-266 ft) +1.8 dBdsx (266-399 ft) +2.4 dBdsx (399-533 ft) +3.0 dBdsx (533-655 ft)					0 to 225 ft 255 to 450 ft		0 to 225 ft 255 to 450 ft		0 to 225 ft	
Cable simulation		Power dBdsx −22.5 dBdsx −15.0 dBdsx −7.5 dBdsx 0 dBdsx					450 to 900 (927) ft		450 to 900 (927) ft			
Rx level sensitivity (dynamic range)		For 772 kHz: TERM: ≤26 dB (cable loss only) at 0 dBdsx Tx DSX-MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only) Note: measurement units = dBdsx (Vref = 6 Vpp)	For 1024 kHz: TERM: ≤6 dB (cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only) Note: measurement units = dBm	For 1024 kHz: TERM: ≤6 dB (cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only) Note: measurement units = dBm	For 4224 kHz: TERM: ≤6 dB (cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Note: measurement units = dBm	For 17.184 MHz: TERM: ≤12 dB (coaxial cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Note: measurement units = dBm	For 22.368 MHz: TERM: ≤10 dB (cable loss only) DSX-MON: ≤26.5 dB (21.5 dB resistive loss + cable loss ≤ 5 dB) Note: measurement units = dBm (Vref = 1.21 Vpp)		For 25.92 MHz: TERM: ≤10 dB (cable loss only) MON: ≤25 dB (20 dB resistive loss + cable loss ≤ 5 dB) Note: measurement units = dBm	For 70 MHz: TERM: ≤12 dB (coaxial cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Note: measurement units = dBm	For 78 MHz: TERM: ≤12.7 dB (coaxial cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Note: measurement units = dBm	
Transmit bit rate		1.544 Mbit/s ± 4.6 ppm	2.048 Mbit/s ± 4.6 ppm	2.048 Mbit/s ± 4.6 ppm	8.448 Mbit/s ± 4.6 ppm	34.368 Mbit/s ± 4.6 ppm	44.736 Mbit/s ± 4.6 ppm		51.84 Mbit/s ± 4.6 ppm	139.264 Mbit/s ±4.6 ppm	155.52 Mbit/s ± 4.6 ppm	
Receive bit rate		1.544 Mbit/s ± 140 ppm	2.048 Mbit/s ± 100 ppm	2.048 Mbit/s ± 100 ppm	8.448 Mbit/s ± 100 ppm	34.368 Mbit/s ± 100 ppm	44.736 Mbit/s ± 100 ppm		51.84 Mbit/s ± 100 ppm	139.264 Mbit/s ± 100 ppm	155.52 Mbit/s ± 100 ppm	
Measurement accuracy (uncertainty)	Frequency	±4.6 ppm	±4.6 ppm	±4.6 ppm	±4.6 ppm	±4.6 ppm	±4.6 ppm		±4.6 ppm	±4.6 ppm	±4.6 ppm	
	Electrical power	Normal: ±1.0 dB Monitor: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	DSX range: ±1.0 dB DSX-MON range: ±2.0 dB		DSX range: ±1.0 dB DSX-MON range: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	Normal: ±1.0 dB Monitor: ±2.0 dB	
Peak-to-peak voltage		±10 % down to 500 mVpp	±10 % down to 500 mVpp	±10 % down to 500 mVpp	±10 % down to 400 mVpp	±10 % down to 200 mVpp	±10 % down to 200 mVpp		±10 % down to 200 mVpp	±10 % down to 200 mVpp	±10 % down to 200 mVpp	
Frequency offset generation		1.544 Mbit/s ± 140 ppm	2.048 Mbit/s ± 70 ppm	2.048 Mbit/s ± 70 ppm	8.448 Mbit/s ± 50 ppm	34.368 Mbit/s ± 50 ppm	44.736 Mbit/s ± 50 ppm		51.84 Mbit/s ± 50 ppm	139.264 Mbit/s ± 50 ppm	155.52 Mbit/s ± 50 ppm	
Intrinsic jitter (Tx)		ANSI T1.403 section 6.3 GR-499 section 7.3	G.823 section 5.1	G.823 section 5.1	G.823 section 5.1	G.823 section 5.1 G.751 section 2.3	GR-449 section 7.3 (categories I and II)		GR-253 section 5.6.2.2 (category II)	G.823 section 5.1	G.825 section 5.1 GR-253 section 5.6.2.2	
Input jitter tolerance		AT&T PUB 62411 GR-499 section 7.3	G.823 section 7.1	G.823 section 7.1	G.823 section 7.1	G.823 section 7.1	GR-449 section 7.3 (categories I and II)		GR-253 section 5.6.2.2 (category II)	G.823 section 7.1 G.751 section 3.3	G.825 section 5.2 GR-253 section 5.6.2.3	
Line coding		AMI and B8ZS	AMI and HDB3	AMI and HDB3	HDB3	HDB3	B3ZS		B3ZS	CMI	CMI	
Input impedance (resistive termination)		100 ohms ± 5 %, balanced	120 ohms ± 5 %, balanced	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced		75 ohms ± 5 %, unbalanced	75 ohms ± 10 %, unbalanced	75 ohms ± 5 %, unbalanced	
Connector type		BANTAM and RJ-48C	BANTAM and RJ-48C	BNC	BNC	BNC	BNC		BNC	BNC	BNC	

SYNCHRONISATION INTERFACES

	External Clock DS1/1.5M	External Clock E1/2M	External Clock E1/2M	Trigger 2 MHz
Tx pulse amplitude	2.4 to 3.6 V	3.0 V	2.37 V	0.75 to 1.5 V
Tx pulse mask	GR-499 figure 9.5	G.703 figure 15	G.703 figure 15	G.703 figure 20
Tx LBO preamplification	Typical power dBdsx +0.6 dBdsx (0-133 ft) +1.2 dBdsx (133-266 ft) +1.8 dBdsx (266-399 ft) +2.4 dBdsx (399-533 ft) +3.0 dBdsx (533-655 ft)			
Rx level sensivity (dynamic range)	TERM: ≤6 dB (cable loss only) (at 772 kHz for T1) DSX-MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only)	TERM: ≤6 dB (cable loss only) MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only)	TERM: ≤6 dB (cable loss only) MON: ≤26 dB (resistive loss + cable loss ≤ 6 dB) Bridge: ≤6 dB (cable loss only)	≤6 dB (cable loss only)
Transmission bit rate	1.544 Mbit/s ± 4.6 ppm	2.048 Mbit/s ± 4.6 ppm	2.048 Mbit/s ± 4.6 ppm	
Reception bit rate	1.544 Mbit/s ± 50 ppm	2.048 Mbit/s ± 50 ppm	2.048 Mbit/s ± 50 ppm	
Intrinsic jitter (Tx)	ANSI T1.403 section 6.3 GR-499 section 7.3	G.823 section 6.1	G.823 section 6.1	G.703 table 11
Input jitter tolerance	AT&T PUB 62411 GR-499 SECTION 7.3	G.823 section 7.2 G.813	G.823 section 7.2 G.813	
Line coding	AMI and B8ZS	AMI and HDB3	AMI and HDB3	
Input impedance (resistive termination)	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced	75 ohms ± 5 %, unbalanced
Connector type	BNC[a]	BNC[a]	BNC	BNC

Note

a. Adaptation cable required for BANTAM.

ELECTRICAL INTERFACES (CONT'D)

ETHERNET ADD/DROP INTERFACE

10/100/1000 Base-T (Add/Drop)	Compliance	10 Mbit/s: IEEE 802.3 section 14 100 Mbit/s: IEEE 802.3 section 25 1000 Mbit/s: IEEE 802.3 section 40
	Connector	RJ-45 Ethernet
Gigabit Ethernet (Add/Drop)	Interface/connector	SFP/Dual LC
	Compliance	1000 Mbit/s: IEEE 802.3 Section 40 [a]
	Wavelength/Max Tx level	850, 1310 nm/–3 dBm 1550 nm/+5 dBm

REF-OUT INTERFACE

Parameter	Value						
Tx pulse amplitude	600 ± 150 mVpp						
Transmission frequency	SONET/SDH/10 GigE WAN	10 GigE LAN	OTU2	OTU1e	OTU2e	OTU1f	OTU2f
Clock divider = 16	622.08 MHz	644.53 MHz	669.33 MHz	690.57 MHz	693.48 MHz	704.38 MHz	707.35 MHz
Clock divider = 32	311.04 MHz	322.266 MHz	334.66 MHz	345.29 MHz	346.74 MHz	352.19 MHz	353.68 MHz
Clock divider = 64	155.52 MHz	161.133 MHz	167.33 MHz	172.64 MHz	173.37 MHz	176.10 MHz	176.84 MHz
Output configuration	AC coupled						
Load impedance	50 ohms						
Maximum cable length	3 meters						
Connector Type	SMA						

SONET/SDH AND OTN OPTICAL INTERFACES

The following section provides detailed information on all supported SONET/SDH/OTN optical interfaces.

SONET/SDH AND OTN OPTICAL INTERFACES

		OC-3/STM-1				OC-12/STM-4				E2/8M				OC-192/STM-64/OTU2		
		15 km; 1310 nm	40 km; 1310 nm	40 km; 1550 nm	80 km; 1550 nm	15 km; 1310 nm	40 km; 1310 nm	40 km; 1550 nm	80 km; 1550 nm	15 km; 1310 nm	40 km; 1310 nm	40 km; 1550 nm	80 km; 1550 nm	10 km; 1310 nm	40 km; 1550 nm	80 km; 1550 nm
Tx level		–5 to 0 dBm	–2 to 3 dBm	–5 to 0 dBm	–2 to 3 dBm	–5 to 0 dBm	–2 to 3 dBm	–5 to 0 dBm	–2 to 3 dBm	–5 to 0 dBm	–2 to 3 dBm	–5 to 0 dBm	–2 to 3 dBm	–6 to –1 dBm	–1 to 2 dBm	0 to 4 dBm
Rx operating range		–23 to –10 dBm	–30 to –15 dBm	–23 to –10 dBm	–30 to –15 dBm	–22 to 0 dBm	–27 to –9 dBm	–22 to 0 dBm	–29 to –9 dBm	–18 to 0 dBm	–27 to –9 dBm	–18 to 0 dBm	–28 to –9 dBm	–11 to –1 dBm	–14 to –1 dBm	–24 to –9 dBm
Transmit bit rate		155.52 Mbit/s ± 4.6 ppm				622.08 Mbit/s ± 4.6 ppm				2.48832 Gbit/s ± 4.6 ppm 2.66606 Gbit/s ± 4.6 ppm (OTU1)				9.95328 Gbit/s ± 4.6 ppm (OC-192/STM-64) 10.70922 Gbit/s ± 4.6 ppm (OTU2) 11.0491 Gbit/s ± 4.6 ppm (OTU1e) 11.0957 Gbit/s ± 4.6 ppm (OTU2e) 11.2701 Gbit/s ± 4.6 ppm (OTU1f) 11.3176 Gbit/s ± 4.6 ppm (OTU2f)	9.95328 Gbit/s ± 4.6 ppm 10.70922 Gbit/s ± 4.6 ppm (OTU2)	
Receive bit rate		155.52 Mbit/s ± 100 ppm				622.08 Mbit/s ± 100 ppm				2.48832 Gbit/s ± 100 ppm 2.66606 Gbit/s ± 100 ppm (OTU1)				9.95328 Gbit/s ± 100 ppm (OC-192/STM-64) 10.70922 Gbit/s ± 100 ppm (OTU2) 11.0491 Gbit/s ± 120 ppm (OTU1e) 11.0957 Gbit/s ± 120 ppm (OTU2e) 11.2701 Gbit/s ± 120 ppm (OTU1f) 11.3176 Gbit/s ± 120 ppm (OTU2f)	9.95328 Gbit/s ± 100 ppm 10.70922 Gbit/s ± 100 ppm (OTU2)	
Operational wavelength range		1261 to 1360 nm	1263 to 1360 nm	1430 to 1580 nm	1480 to 1580 nm	1270 to 1360 nm	1280 to 1335 nm	1430 to 1580 nm	1480 to 1580 nm	1260 to 1360 nm	1280 to 1335 nm	1430 to 1580 nm	1500 to 1580 nm	1290 to 1330 nm	1530 to 1565 nm	1530 to 1565 nm
Spectral width		1 nm (–20 dB)				1 nm (–20 dB)				1 nm (–20 dB)				1 nm (–20 dB)		
Frequency offset generation		±50 ppm				±50 ppm				±50 ppm				±50 ppm [b]		
Measurement accuracy (uncertainty)	Frequency	±4.6 ppm				±4.6 ppm				±4.6 ppm				±4.6 ppm		
	Optical power	±2 dB				±2 dB				±2 dB				±2 dB		
Maximum Rx before damage [c]		3 dBm				3 dBm				3 dBm				3 dBm		
Jitter compliance		GR-253 (SONET) G.958 (SDH)				GR-253 (SONET) G.958 (SDH)				GR-253 (SONET) G.958 (SDH) G.8251 (OTN)				GR-253 (SONET) G.825 (SDH) G.8251 (OTN)		
Line coding		NRZ				NRZ				NRZ				NRZ		
Eye safety		SFP/XFP transceivers comply with IEC 60825 and 21 CFR 1040.10 (except for deviations pursuant to Laser Notice No. 50, dated July 2001), for Class 1 or 1M lasers.														
Connector [d]		Dual LC				Dual LC				Dual LC				Dual LC		
Transceiver type [e]		SFP				SFP				SFP				XFP		

Notes

a. SFP/XFP transceivers comply with IEC 60825 and 21 CFR 1040.10 (except for deviations pursuant to Laser Notice 50, dated July, 2001), for Class 1 or 1M lasers.

b. For OTU1e, OTU2e, OTU1f and OTU2f rates, the frequency offset generation is ±115 ppm.

c. In order not to exceed the maximum receiver power level before damage, an attenuator must be used.

d. External adaptors can be used for other types of connectors. For example FC/PC.

e. SFP/XFP compliance: The FTB-8130NGE selected SFP/XFP shall meet the requirements stated in the "Small Form-Factor Pluggable (SFP) Transceiver Multisource Agreement (MSA)". The FTB-8130NGE selected SFP/XFP shall meet the requirements stated in the "Specification for Diagnostic Monitoring Interface for Optical Xcvrs".

SONET/SDH FUNCTIONAL SPECIFICATIONS

SONET AND DSN		SDH AND PDH	
Optical interfaces	OC-3, OC-12, OC-48, OC-192	**Optical interfaces**	STM-1, STM-4, STM-16, STM-64
Available wavelengths (nm)	1310, 1550	Available wavelengths (nm)	1310, 1550
Electrical interfaces	DS1, DS3, STS-1e, STS-3e	Electrical interfaces [a]	1.5M (DS1), 2M (E1), 8M (E2), 34M (E3), 45M (DS3), 140M (E4), STM-0e, STM-1e
DS1 framing	Unframed, SF, ESF	2M framing	Unframed, PCM30, PCM31, PCM30 CRC-4, PCM31 CRC-4
DS3 framing	Unframed, M13, C-bit parity	8M, 34M, 140M framing	Unframed, framed
Clocking	Internal, loop-timed, external (BITS), intermodule	Clocking	Internal, loop-timed, external (MTS/SETS), 2 MHz, intermodule
Mappings [b]		**Mappings** [b]	
VT1.5	Bulk, DS1, GFP [c]	TU-11-AU-3, TU-11-AU-4	Bulk, 1.5M, GFP [c]
VT2	Bulk, E1, GFP [c]	TU-12-AU-3, TU-12-AU-4	Bulk, 1.5M, 2M, GFP [c]
VT6	Bulk, GFP [c]	TU-3-AU-4	Bulk, 34M, 45M, GFP [c]
STS-1 SPE	Bulk, DS3, GFP [c]	TU-2-AU-3, TU-2-AU-4	Bulk, GFP [c]
STS-3c	Bulk, E4, GFP [c]	AU-4	Bulk, 140M, GFP [c]
STS-12c/48c/192c, SPE	Bulk, GFP [c]	AU-4-4c/16c/64c	Bulk, GFP [c]
SONET overhead analysis and manipulation	A1, A2, J0, E1, F1, D1-D12, K1, K2, S1, M0, E2, J1, C2, G1, F2, H4, Z3, Z4, Z5, N1, N2, Z6, Z7	SDH overhead analysis and manipulation	A1, A2, J0, E1, F1, D1-D12, K1, K2, S1, M0, G1, F2, F3, K3, N1, N2, K4, E2, J1, C2, H4
Error insertion		**Error insertion**	
DS1	Framing bit, BPV, CRC-6, bit error	E1 (2M)	Bit error, FAS, CV, CRC-4, E-bit
DS3	BPV, C-bit, F-bit, P-bit, FEBE, bit error	E2 (8M), E3 (34M), E4 (140M)	Bit error, FAS, CV
STS-1e, STS-3e	Section BIP (B1), line BIP (B2), path BIP (B3), BIP-2, REI-L, REI-P, REI-V, BPV, FAS, bit error	STM-0e, STM-1e	RS-BIP (B1), MS-BIP (B2), HP-BIP (B3), MS-REI, HP-REI, LP-BIP-2, LP-REI, CV, FAS, bit error
OC-3, OC-12, OC-48, OC-192	Section BIP (B1), line BIP (B2), path BIP (B3), BIP-2, REI-L, REI-P, REI-V, FAS, bit error	STM-1, STM-4, STM-16, STM-64	RS-BIP (B1), MS-BIP (B2), HP-BIP (B3), MS-REI, HP-REI, LP-BIP-2, LP-REI, CV, FAS, bit error
Error measurement		**Error measurement**	
DS1	Framing bit, BPV, CRC-6, excess zeros, bit error	E1 (2M)	Bit error, FAS, CV, CRC-4, E-bit
DS3	BPV, C-bit, F-bit, P-bit, FEBE, bit error	E2 (8M), E3 (34M), E4 (140M)	Bit error, FAS, CV
STS-1e, STS-3e	Section BIP (B1), line BIP (B2), path BIP (B3), BIP-2, REI-L, REI-P, REI-V, BPV, FAS, bit error	STM-0e, STM-1e	RS-BIP (B1), MS-BIP (B2), HP-BIP (B3), MS-REI, HP-REI, LP-BIP-2, LP-REI, CV, FAS, bit error
OC-3, OC-12, OC-48, OC-192	Section BIP (B1), line BIP (B2), path BIP (B3), BIP-2, REI-L, REI-P, REI-V, FAS, bit error	STM-1, STM-4, STM-16, STM-64	RS-BIP (B1), MS-BIP (B2), HP-BIP (B3), MS-REI, HP-REI, LP-BIP-2, LP-REI, FAS, bit error
Alarm insertion		**Alarm insertion**	
DS1	LOS, RAI, AIS, OOF, pattern loss	E1 (2M)	LOS, LOS Mframe, LOS CRC Mframe, LOF, AIS, TS16 AIS, RAI, RAI Mframe, pattern loss
DS3	LOS, RDI, AIS, OOF, DS3 idle, pattern loss	E2 (8M), E3 (34M), E4 (140M)	LOS, LOF, RAI, AIS, pattern loss
STS-1e, STS-3e, OC-3, OC-12, OC-48, OC-192	LOS, LOF, SEF, AIS-L, RDI-L, AIS-P, LOP-P, LOM, PDI-P, RDI-P, ERDI-PCD, ERDI-PPD, ERDI-PSD, UNEQ-P, AIS-V, LOP-V, RDI-V, ERDI-VCD, ERDI-VPD, ERDI-VSD, RFI-V, UNEQ-V, pattern loss	STM-0e, STM-1e, STM-1, STM-4, STM-16, STM-64	LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, H4-LOM, HP-PDI, ERDI-PSD, ERDI-PCD, ERDI-PPD, HP-UNEQ, TU-AIS, LP-RFI, LP-RDI, ERDI-VCD, ERDI-VPD, ERDI-VSD, LP-RFI, LP-UNEQ, pattern loss
Alarm detection		**Alarm detection**	
DS1	LOS, loss of clock (LOC), RAI, AIS, OOF, pattern loss	E1 (2M)	LOS, LOS Mframe, LOS CRC Mframe, LOC, LOF, AIS, TS16 AIS, RAI, RAI Mframe, pattern loss
DS3	LOS, LOC, RDI, AIS, OOF, DS3 idle, pattern loss	E2 (8M), E3 (34M), E4 (140M)	LOS, LOC, LOF, RAI, AIS, pattern loss
STS-1e, STS-3e, OC-3, OC-12, OC-48, OC-192	LOS, LOC, LOF, SEF, TIM-S, AIS-L, RDI-L, AIS-P, LOP-P, LOM, PDI-P, RDI-P, ERDI-PCD, ERDI-PPD, ERDI-PSD, PLM/SLM-P, UNEQ-P, TIM-P, AIS-V, LOP-V, RDI-V, ERDI-VCD, ERDI-VCD, ERDI-VPD, ERDI-VSD, RFI-V, UNEQ-V, TIM-V, PLM/SLM-V, pattern loss	STM-0e, STM-1e, STM-1, STM-4, STM-16, STM-64	LOS, LOF, LOC, OOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, H4-LOM, HP-RDI, ERDI-PSD, ERDI-PCD, ERDI-PPD, HP-PLM/SLM, HP-UNEQ, HP-TIM, TU-AIS, LP-RFI, LP-RDI, ERDI-VPD, ERDI-VSD, LP-RFI, LP-UNEQ, LP-TIM, LP-PLM/SLM, pattern loss
Frequency alarm on all supported interfaces.			
Patterns		**Patterns**	
DS0	2E9-1, 2E11-1, 2E20-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 3-in-24, 32 bit programmable (inverted or non-inverted), bit errors	E0 (64K)	2E9-1, 2E11-1, 2E20-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 3-in-24, 32 bit programmable (inverted or non-inverted), bit error
DS1	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, QRSS, 1-in-8, 1-in-16, 3-in-24, 32 bit programmable (inverted or non-inverted), T1-DALY, 55-Octet, bit errors	E1 (2M)	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 3-in-24, 32 bit programmable (inverted or non-inverted), bit error
DS3	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 3-in-24 [d], 32 bit programmable (inverted or non-inverted), bit errors	E2 (8M), E3 (34M), E4 (140M)	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 3-in-24 d, 32 bit programmable (inverted or non-inverted), bit error
VT1.5/2/6	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, QRSS, 1-in-8, 1-in-16, 32 bit programmable (inverted or non-inverted), bit errors	TU-11/12/2/3	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 32 bit programmable (inverted or non-inverted), bit errors
STS-1, STS-3c/12c/48c/192c	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 32 bit programmable (inverted or non-inverted), bit errors	AU-3/AU-4/AU-4-4c/16c/64c	2E9-1, 2E11-1, 2E15-1, 2E20-1, 2E23-1, 2E31-1, 1100, 1010, 1111, 0000, 1-in-8, 1-in-16, 32 bit programmable (inverted or non-inverted), bit error
Pattern loss and bit-error generation and analysis supported on all patterns.			

Notes

a. 1.5M (DS1) and 45M (DS3) interfaces described under SONET and DSn column.
b. VCAT mappings are also available. Please refer to the VCAT section of this document for details.
c. GFP supported only with purchase of GFP-F option.
d. Not supported for E4 (140M).

SONET/SDH FUNCTIONAL SPECIFICATIONS (CONT'D)

NEXT-GENERATION SONET		NEXT-GENERATION SDH	
Generic framing procedure (GFP)		**Generic framing procedure (GFP)**	
Standards compliance	As per ITU-T G.7041, and ANSI T1.105.02	Standards compliance	As per ITU-T G.7041, G.707, and ANSI T1.105.02
Payload	PRBS pattern; Ethernet	Payload	PRBS pattern; Ethernet
Ethernet add/drop	Ability to add/drop Ethernet payload to/from GFP mapped OC-n/OTU signal	Ethernet add/drop	Ability to add/drop Ethernet payload to/from GFP mapped STM-n/OTU signal
Error insertion	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS	Error insertion	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS
Error monitoring	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS	Error monitoring	Correctable core HEC, uncorrectable core HEC, correctable type HEC, uncorrectable type HEC, correctable extension HEC, uncorrectable extension HEC, payload FCS
Alarm insertion	Loss of client signal (LOCS) and loss of client character synchronization (LOCCS) with configurable time interval between 10 and 1200 ms, and loss of frame delineation (LFD)	Alarm insertion	Loss of client signal (LOCS) and loss of client character synchronization (LOCCS) with configurable time interval between 10 and 1200 ms, and loss of frame delineation (LFD), client forward defect indication (FDI), client reverse defect indication (RDI) and client defect clear indication (DCI)
Alarm monitoring	Loss of client signal (LOCS), loss of client character synchronization (LOCCS) and loss of frame delineation (LFD)	Alarm monitoring	Loss of client signal (LOCS), loss of client character synchronization (LOCCS) and loss of frame delineation (LFD), client forward defect indication (FDI), client reverse defect indication (RDI) and client defect clear indication (DCI)
Statistics	Transmit: client data frames (including payload bytes), client management frames, total frames, idle frames, GFP bandwidth usage (%), GFP mapping efficiency (%) Receive: client data frames (including payload bytes), client management frames, total frames, idle (control) frames, reserved (control) frames, invalid frames, discarded frames, EXI mismatches, UPI mismatches, CID mismatches, GFP bandwidth usage (%), GFP mapping efficiency (%)	Statistics	Transmit: client data frames (including payload bytes), client management frames, total frames, idle frames, GFP bandwidth usage (%), GFP mapping efficiency (%) Receive: client data frames (including payload bytes), client management frames, total frames, idle (control) frames, reserved (control) frames, invalid frames, discarded frames, EXI mismatches, UPI mismatches, CID mismatches, GFP bandwidth usage (%), GFP mapping efficiency (%)
Header manipulation	PTI, PFI, EXI, UPI, CID and spare (extension header) fields	Header manipulation	PTI, PFI, EXI, UPI, CID and spare (extension header) fields
Header monitoring	PLI, PTI, PFI, EXI, UPI, CID, spare (extension header) fields, cHEC, tHEC, eHEC	Header monitoring	PLI, PTI, PFI, EXI, UPI, CID, spare (extension header) fields, cHEC, tHEC, eHEC
Virtual concatenation (VCAT)		**Virtual concatenation (VCAT)**	
Standards compliance	Supports high-order and low-order virtual concatenation as per ANSI T1.105	Standards compliance	Supports high-order and low-order virtual concatenation as per ITU G.707
Mappings	High-order STS-1-Xv (X = 1 to 21) STS-3-Xv (X = 1 to 7) Low-order VT1.5-Xv (X = 1 to 64) VT-2-Xv (X = 1 to 64)	Mappings	High-order VC-3-Xv (X = 1 to 21) VC-4-Xv (X = 1 to 7) Low-order VC-11-Xv (X = 1 to 64) VC-12-Xv (X = 1 to 64) VC-3-Xv in AU-4 (X = 1 to 21)
Alarm insertion	LOM, OOM1, OOM2, SQM VCAT and Path alarms can be generated independently on any member of a VCG	Alarm insertion	LOM, OOM1, OOM2, SQM VCAT and Path alarms can be generated independently on any member of a VCG
Alarm monitoring	LOM, OOM1, OOM2, SQM, LOA	Alarm monitoring	LOM, OOM1, OOM2, SQM, LOA
Differential delay	Analysis Range: 0 to 256 ms Display: numerical and graphical Insertion Range: 0 to 256 ms	Differential delay	Analysis Range: 0 to 256 ms Display: numerical and graphical Insertion Range: 0 to 256 ms
Sequence number manipulation and processing	Sequence range: 0 to 63 Sequence number monitoring: current AcSQ (accepted SQ) monitored against the ExSQ (expected SQ); SQM alarm raised on mismatch	Sequence number manipulation and processing	Sequence range: 0 to 63 Sequence number monitoring: current AcSQ (accepted SQ) monitored against the ExSQ (expected SQ); SQM alarm raised on mismatch

SONET/SDH FUNCTIONAL SPECIFICATIONS (CONT'D)

NEXT-GENERATION SONET/SDH (CONT'D)

Link capacity adjustment scheme (LCAS)

Standards compliance	As per ITU G.7042; supported for both low-order and high-order VCAT groups
Test functions	› Emulation of source and sink state machines › Automatic and manual control of source and sink state machines › Independent overwrite capability at the source and sink for each member › Automatic SQ management
Source state machine control	› Add/remove member(s) › Configure: RS-ACK timeout, remote DUT, PLCT threshold › Statistics count: received RS-ACK, unexpected RS-ACK › Error/alarm generation: CRC errors, group ID (GID) mismatch › Error/alarm monitoring: loss of partial transport capacity, loss of total transport capacity, failure of protocol transmission, CRC errors, unexpected member status
Sink state machine control	› Add/remove member(s) › Configure Hold-Off and Wait-to-Restore timers, PLCR threshold › Toggle RS-ACK › Statistics count: transmitted RS-ACK › Error/alarm generation: CRC errors, group ID (GID) mismatch › Error/alarm monitoring: loss of partial transport capacity, loss of total transport capacity, failure of protocol reception, CRC errors, unexpected member status

ADDITIONAL TEST AND MEASUREMENT FUNCTIONS

Power measurements	Supports power measurements, displayed in dBm (dBdsx for DS1), for optical and electrical interfaces.
Frequency measurements	Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency), displayed in ppm and Gbit/s, for optical and electrical interfaces.
Frequency offset generation	Supports offsetting the clock of the transmitted signal on a selected interface to exercise clock recovery circuitry on network elements.
Dual DSn receivers	Supports two DS1 or DS3 receivers, allowing users to simultaneously monitor two directions of a circuit under test in parallel, resulting in quick isolation of the source of errors.
Performance monitoring	The following ITU-T recommendations and corresponding performance monitoring parameters are supported on the FTB-8130NGE. **ITU-T recommendation** — **Performance monitoring statistics** G.821 — ES, EFS, EC, SES, UAS, ESR, SESR, DM G.826 — ES, EFS, EB, SES, BBE, UAS, ERS, SESR, BBER G.828 — ES, EFS, EB, SES, BBE, SEP, UAS, ESR, SESR, BBER, SEPI G.829 — ES, EFS, EB, SES, BBE, UAS, ESR, SESR, BBER M.2100 — ES, SES, UAS, ESR, SESR M.2101 — ES, SES, BBE, UAS, ESR, SESR, BBER
Pointer adjustment and analysis	Generation and analysis of HO/AU and LO/TU pointer adjustments as per GR-253, and ITU-T G.707 **Generation** › Pointer increment and decrement › Pointer jump with or without NDF › Pointer value **Analysis** › Pointer increments › Pointer decrements › Pointer jumps (NDF, no NDF) › Pointer value and cumulative offset
Programmable error/alarm injection	Ability to inject errors/alarms in the following modes: Manual, Constant Rate, Burst, Periodic Burst and Continuous.
Service disruption time (SDT) measurements	The service disruption time test tool measures the time during which there is a disruption of service due to the network switching from the active channels to the backup channels. User-selectable triggers: all supported alarms and errors. Measurements: last disruption, shortest disruption, longest disruption, average disruption, total disruption, and service disruption count.
Round-trip delay (RTD) measurements	The round-trip delay test tool measures the time required for a bit to travel from the FTB-8130NGE transmitter back to its receiver after crossing a far-end loopback. Measurements are supported on all supported FTB-8130NGE interfaces and mappings. Measurements: last RTD time, minimum, maximum, average, measurement count (no. of successful RTD tests), failed measurement count.
APS message control and monitoring	Ability to monitor and set up automatic protection switching messages (K1/K2 byte of SONET/SDH overhead).
Synchronization status	Ability to monitor and set up synchronization status messages (S1 byte of SONET/SDH overhead).
Signal label control and monitoring	Ability to monitor and set up payload signal labels (C2, V5 byte of SONET overhead).
Through mode	Ability to perform Through mode analysis of any incoming electrical (DSn, PDH) and optical line (OC-3/STM-1, OC-12/STM-4, OC-48/STM-16, OC-192/STM-64, OTU1, OTU2, OTU1e and OTU2e) either transparently or intrusively.
M13 mux/demux	Ability to multiplex/demultiplex a DS1 signal into/from a DS3 signal. (Note: E1 to DS3 mux/demux available with G.747 software option.)
DS1 FDL	Support for DS1 Facility Data Link testing.
DS1 loopcodes	Support for generation of DS1 in-band loopcodes with the availability of up to 10 pairs of user-defined loopcodes.
NI/CSU loopback emulation	Ability to respond to DS1 in-band/out-of-band loopcodes.
DS3 FEAC	Support for DS3 for-end alarms and loopback codewords.
DS1/DS3 auto detection	Ability to automatically detect DS1/DS3 line coding, framing and test pattern.
Tandem connection monitoring (TCM) [a]	Tandem connection monitoring (TCM), Option 2 [b], is used to monitor the performance of a subsection of a SONET/SDH path routed via different network providers. The FTB-8130NGE supports transmitting and receiving alarms and errors on a TCM link; also, transmission and monitoring of the tandem connection (TC) trace can be generated to verify the connection between TCM equipment. Error generation: TC-IEC, TC-BIP, TC-REI, OEI Error analysis: TC-IEC, TC-REI, OEI, TC-VIOL Alarm generation: TC-RDI, TC-UNEQ, ODI, TC-LTC, TC-IAIS Alarm analysis: TC-TIM, TC-RDI, TC-UNEQ, ODI, TC-LTC, TC-IAIS
Payload block and replace	Ability to terminate and analyze a specific high-order path element and replace it with a PRBS pattern on the TX side.
K1/K2 OH byte capture	Ability to capture K1/K2 OH byte value transitions.

Notes

a. HOP and LOP supported.

b. G.707 option 2.

SONET/SDH FUNCTIONAL SPECIFICATIONS (CONT'D)

ADDITIONAL FEATURES

Scripting	The built-in scripting engine and embedded macro-recorder provide a simple means of automating test cases and routines. Embedded scripting routines provide a powerful means of creating advanced test scripts. Available only on the FTB-500 platform.
Reports	Supports generation of test reports in .html, .csv, .txt, .pdf formats. Contents of reports are customizable by the user.
Power-up and restore	In the event of a power failure to the unit, the active test configuration and test logger are saved and restored upon bootup.
Store and load configurations	Ability to store and load test configurations to/from non-volatile memory.
Alarm hierarchy	Alarms are displayed according to a hierarchy based on root cause. Secondary effects are not displayed. This hierarchy serves to facilitate alarm analysis.
Configurable test views	This allows users to customize their test views; i.e., to dynamically insert or remove test tabs/windows, in addition to creating new test windows, so as to accurately match their testing needs. Available only on the FTB-500 user interface.
Configurable test timer	Provides the ability for a user to set predefined test start and stop times.
Remote control	Available with Windows-based remote management software known as Visual Guardian Lite (optional software package). This allows users to remotely monitor and control the FTB-8130NGE module via standard Ethernet connection.

OTN FUNCTIONAL SPECIFICATIONS

OTN FUNCTIONAL SPECIFICATIONS

OTN	Standards compliance	ITU-T G.709, ITU G.798, ITU G.872
	Interfaces	OTU1 (2.7 Gbit/s), OTU2 (10.7 Gbit/s), OTU1e (11.0491 Gbit/s), OTU2e (11.0957 Gbit/s), OTU1f (11.2701 Gbit/s), OTU2f (11.3176 Gbit/s)
	Client types [a]	All supported SONET/SDH mappings (including next-generation GFP, VCAT, LCAS), NULL, PRBS (2E31-1), ODU1 into OTU2 multiplexing.
OTU Layer	Errors	OTU-FAS, OTU-MFAS, OTU-BEI, OTU-BIP-8
	Alarms	LOF, OOF, LOM, OOM, OTU-AIS, OTU-TIM, OTU-BDI, OTU-IAE, OTU-BIAE
	Traces	64-bytes Trail Trace Identifier (TTI) as defined in ITU-T G.709
ODU TCM Layer	Errors	TCMi-BIP-8, TCMi-BEI (i = 1 to 6)
	Alarms	TCMi-LTC, TCMi-TIM, TCMi-BDI, TCMi-IAE, TCMi-BIAE
	Traces	64-bytes Trail Trace Identifier (TTI) as defined in ITU-T G.709
ODU Layer	Errors	ODU-BIP-8, ODU-BEI
	Alarms	ODU-AIS, ODU-OCI, ODU-LCK, ODU-TIM, ODU-BDI, ODU-FSF, ODU-BSF, ODU-FSD, ODU-BSD
	Traces	Generates 64-bytes Trail Trace Identifier (TTI) as defined in ITU-T G.709
	FTFL [b]	As defined in ITU-T G.709
ODU0	Muxing	ODU0 into ODU1, ODU0 into ODU2
	Client types	Pattern, OC-3/STM-1, OC-12/STM-4, GigE using GFP-T
	GFP-T errors	SB Correctable, SB Uncorrectable, 10B_ERR
ODU Multiplexing [c]	Alarms	OPU-MSIM, ODU-LOFLOM
ODUflex	Muxing	ODUflex into ODU2
	Client types	Ethernet using GFP-F or pattern for constant bit rate (CBR)
OPU Layer	Alarm	OPU-PLM, OPU-CSF, OPU-AIS
	Payload type (PT) label	Generates and displays received PT value
Forward Error Correction (FEC)	Errors	FEC-Correctable (Codeword), FEC-Uncorrectable (Codeword), FEC-Correctable (Symbol), FEC-Correctable (Bit), and FEC-Stress (Codeword)
Ethernet over OTN (EoOTN) [c]	Mapping	Direct mapping into OTU1e or OTU2e or using GFP-F into OTU2
	BERT	Framed layer 2 supported with or without VLAN
	Pattern	PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1 and up to 10 user patterns. Capability to invert patterns
	Error insertion	FCS, 64B/66B block, bit
	Error measurement	Jabber/giant, runt, undersize, oversize, FCS, 64B/66B block
	Error measurement (BERT)	Bit error, bit mismatch 0, bit mismatch 1
	Alarm insertion	Link down, local fault, remote fault, pattern loss
	Alarm detection	Link down, local fault, remote fault, pattern loss
	VLAN	Capability to generate one stream with one layer of VLAN
	Ethernet statistics	Multicast, broadcast, unicast, N-unicast, frame size distribution, bandwidth, utilization, frame rate

ADDITIONAL FUNCTION

Service disruption time (SDT) measurements	The service disruption time test tool measures the time during which there is a disruption of service due to the network switching from the active channels to the backup channels. User-selectable triggers: all supported alarms and errors. Measurements: last disruption, shortest disruption, longest disruption, average disruption, total disruption, and service disruption count.
Round-trip delay (RTD) measurements	The round-trip delay test tool measures the time required for a bit to travel from the FTB-8130NGE transmitter back to its receiver after crossing a far-end loopback. Measurements are supported on all supported FTB-8130NGE interfaces and mappings. Measurements: last RTD time, minimum, maximum, average, measurement count (no. of successful RTD tests), failed measurement count.
Multichannel testing	Ability to monitor in real-time errors and alarms, and to perform simultaneous SDT measurements for all ODU0 channels; a user-defined threshold can also be applied to the SDT measurements for simple pass/fail results for each channel.

Notes

a. Available with ODUMUX option.
b. Fault type and fault location.
c. Available on the FTB-8130NGE only.

ETHERNET INTERFACES

ELECTRICAL INTERFACES

	10Base-T	100Base-T	1000Base-T
Tx bit rate	10 Mbit/s	125 Mbit/s	1 Gbit/s
Tx uncertainty (accuracy) (ppm)	±100	±100	±100
Rx bit rate	10 Mbit/s	125 Mbit/s	1 Gbit/s
Rx measurement uncertainty (accuracy) (ppm)	±4.6	±4.6	±4.6
Duplex mode	Half and full duplex	Half and full duplex	Full duplex
Jitter compliance	IEEE 802.3	IEEE 802.3	IEEE 802.3
Connector	RJ-45	RJ-45	RJ-45
Maximum reach (m)	100	100	100

100 Mbit/s AND GigE OPTICAL INTERFACES

	100Base-FX	100Base-LX	1000Base-SX	1000Base-LX	1000Base-ZX
Wavelength (nm)	1310	1310	850	1310	1550
Tx level (dBm)	–20 to –15	–15 to –8	–9 to –3	–9.5 to –3	0 to 5
Rx level sensitivity (dBm)	–31	–28	–20	–22	–22
Maximum reach	2 km	15 km	550 m	10 km	80 km
Transmission bit rate (Gbit/s)	0.125	0.125	1.25	1.25	1.25
Reception bit rate (Gbit/s)	0.125	0.125	1.25	1.25	1.25
Tx operational wavelength range (nm)	1280 to 1380	1261 to 1360	830 to 860	1270 to 1360	1540 to 1570
Measurement uncertainty (accuracy) Frequency (ppm) Optical power (dB)	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2
Maximum Rx before damage (dBm)	3	3	6	6	6
Jitter compliance	ANSI X3.166	IEEE 802.3	IEEE 802.3	IEEE 802.3	IEEE 802.3
Ethernet classification	ANSI X3.166	IEEE 802.3	IEEE 802.3	IEEE 802.3	IEEE 802.3
Laser type	LED	FP	VCSEL	FP	DFB
Eye safety	Class 1	Class 1	Class 1	Class 1	Class 1
Connector	LC	LC	LC	LC	LC
Transceiver type	SFP	SFP	SFP	SFP	SFP

10 GigE OPTICAL INTERFACES

	10GBASE-SW	10GBASE-SR	10GBASE-LW	10GBASE-LR	10GBASE-EW	10GBASE-ER
Wavelength (nm)	850 Multimode	850 Multimode	1310 Singlemode	1310 Singlemode	1550 Singlemode	1550 Singlemode
Tx level (802.3ae-compliant) (dBm)	–7.3 to –1	–7.3 to –1	–8.2 to 0.5	–8.2 to 0.5	–4.7 to 4.0	–4.7 to 4.0
Rx operating range (dBm)	–9.9 to –1.0	–9.9 to –1.0	–14.4 to 0.5	–14.4 to 0.5	–15.8 to –1.0	–15.8 to –1.0
Transmission bit rate	9.95328 Gbit/s ± 4.6 ppm [a]	10.3125 Gbit/s ± 4.6 ppm [a]	9.95328 Gbit/s ± 4.6 ppm [a]	10.3125 Gbit/s ± 4.6 ppm [a]	9.95328 Gbit/s ± 4.6 ppm [a]	10.3125 Gbit/s ± 4.6 ppm [a]
Reception bit rate	9.95328 Gbit/s ± 135 ppm	10.3125 Gbit/s ± 135 ppm	9.95328 Gbit/s ± 135 ppm	10.3125 Gbit/s ± 135 ppm	9.95328 Gbit/s ± 135 ppm	10.3125 Gbit/s ± 135 ppm
Tx operational wavelength range (802.3ae-compliant) (nm)	840 to 860	840 to 860	1260 to 1355	1260 to 1355	1530 to 1565	1530 to 1565
Measurement uncertainty (accuracy) Frequency (ppm) Optical power (dB)	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2
Maximum Rx before damage (dBm)	0	0	1.5	1.5	4.0	4.0
Jitter compliance	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae
Ethernet classification	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae	IEEE 802.3ae
Laser type	VCSEL	VCSEL	DFB	DFB	EML	EML
Eye safety	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1	Class 1 laser; complies with 21 CFR 1040.10 and IEC 60825-1
Connector	Duplex LC	Duplex LC	Duplex LC	Duplex LC	Duplex LC	Duplex LC
Transceiver type (compliant with XFP MSA)	XFP	XFP	XFP	XFP	XFP	XFP

Note

a. When clocking is in internal mode.

ETHERNET FUNCTIONAL SPECIFICATIONS

TESTING (10 Mbit/s TO GigE)

EtherSAM (Y.1564)	Capability to perform the service configuration test, including the ramp and burst tests and service performance test as per ITU-T Y.1564. Tests can be performed to a loopback or dual test set mode for bidirectional results.
RFC 2544	Throughput, back-to-back, frame loss and latency measurements according to RFC 2544. Frame size: RFC-defined sizes, user-configurable.
BERT	Unframed, framed layer 1, framed layer 2 supported with or without VLAN Q-in-Q.
Patterns (BERT)	PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1, CRPAT, CSPAT, CJTPAT, Short CRTPAT, Long CRTPAT and up to 10 user patterns. Capability to invert patterns.
Error insertion (BERT)	FCS, bit and symbol.
Error measurement	Jabber/giant, runt, undersize, oversize, FCS, symbol, idle, carrier sense, alignment, collision, late collision, excessive collision, UDP and IP header checksum.
Error measurement (BERT)	Bit error, symbol error, idle error, bit mismatch 0, bit mismatch 1, performance monitoring (G.821 and G.826).
Alarm insertion (BERT)	LOS, pattern loss.
Alarm detection	LOS, link down, pattern loss, no traffic.
Service disruption time (SDT) measurement (BERT)	Defect or No Traffic mode. Disruption time statistics include shortest, longest, last, average, total and count.
VLAN stacking	Capability to generate one stream with up to three layers of VLAN (including IEEE 802.1ad Q-in-Q tagged VLAN).
Flow-control statistics	Pause time, last pause time, max. pause time, min. pause time, paused frames, abort frames, frames Tx, frames Rx.
Advanced autonegotiation	Capability to autonegotiate the rate, duplex and flow-control capabilities with another Ethernet port. Configurable autonegotiate parameters. Display of link partner capabilities. Fault injection: offline, link failure, autonegotiation error.
Multistream generation	Capability to transmit up to 10 streams. Configuration parameters are packet size, transmission mode (N-Frames, Burst, N-Burst, Ramp, N-Ramp and Continuous), MAC source/destination address, VLAN ID, VLAN priority, IP source/destination address, ToS field, DSCP field, TTL, UDP source/destination port and payload. (Available with Frame-Analyzer software option.) Selectable predefined stream profiles are also available for VoIP, video and data streams. VoIP codecs (G.711, G.723.1, G.729), video (MPEG-2 SDTV, MPEG-2 HDTV, MPEG-4 HDTV).
Traffic filtering	Capability to analyze the incoming traffic and provide statistics according to a set of up to 10 configurable filters. Filters can be configured for MAC source/destination address, VLAN ID, VLAN priority, IP source/destination address, ToS field, DSCP field, TCP source/destination port and UDP source/destination port. VLAN filtering can be applied to any of the stacked VLAN layers. (Available with Frame-Analyzer software option.)
Multistream analysis	Capability to analyze per stream statistics: packet jitter, latency, throughput, frame loss and out-of-sequence (available with Frame-Analyzer software option).
Ethernet statistics	Multicast, broadcast, unicast, N-unicast, pause frame, frame size distribution, bandwidth, utilization, frame rate, frame loss, out-of-sequence frames and in-sequence frames. (Available with Frame-Analyzer software option.)
Packet jitter statistics	Delay variation statistics (ms)—min., max., last, average and jitter measurement estimate (RFC 3393) (available with Frame Analyzer option).
PBB-TE [a]	Capability to generate and analyze streams with PBB-TE data traffic including configuration of B-MAC (source and destination), B-VLAN and I-tag (as per 802.1ah) and to filter received traffic by any of these fields.
MPLS [a]	Capability to generate and analyze streams with up to two layers of MPLS labels and to filter received traffic by MPLS label or COS.
IPv6 [a]	Capability to perform BERT, RFC 2544, traffic generation and analysis and Smart Loopback tests over IPv6; ping, traceroute, neighbor discovery and stateless auto-configuration.
Advanced filtering [a]	Capability to enhance the filters with up to four (4) fields each, which can be combined with AND/OR/NOT operations. A mask is also provided for each field value to allow for wildcards. Complete statistics are gathered for each defined filter.
Data capture [a]	Capability to perform 10/100/1000M full-line-rate data capture and decode. Capability to configure detailed capture filters and triggers as well as capture slicing parameters.
Traffic scan [a]	Capability to scan incoming live traffic and auto-discover all VLAN/VLAN Priority and MPLS ID/COS flows; capability to provide statistics for each flow including frame count and bandwidth.

ADDITIONAL TEST AND MEASUREMENT FUNCTIONS (10 Mbit/s TO GigE)

Power measurement	Supports optical power measurement, displayed in dBm.
Frequency measurement	Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency).
Frequency offset measurement	Range: ±120 ppm Resolution: 1 ppm Uncertainty (accuracy): ±4.6 ppm
Dual test set	Performs end-to-end, bidirectional performance testing (as required by leading standards bodies)—remote FTB-8130NGE controlled via the LAN connection under test.
DHCP client	Capability to connect to a DHCP server to obtain its IP address and subnet mask for connecting on to the network.
Smart Loopback	Capability to return traffic to the local unit by swapping packet overhead up to layer 4 of the OSI stack.
IP tools	Capability to perform ping and traceroute functions.
TCP throughput measurements [a]	Capability to evaluate TCP throughput and provide performance results and statistics: window size with corresponding throughput, number of transmitted and retransmitted segments, round-trip time.

Note

a. Available as a software option.

ETHERNET FUNCTIONAL SPECIFICATIONS (CONT'D)

TESTING (10 GigE)

EtherSAM (Y.1564)	Capability to perform the service configuration test, including the ramp and burst tests and service performance test as per ITU-T Y.1564. Tests can be performed to a loopback or dual test set mode for bidirectional results.
RFC 2544	Throughput, back-to-back, frame loss and latency measurements according to RFC 2544. Frame size: RFC-defined sizes, user-configurable.
BERT	Unframed, framed layer 1, framed layer 2 supported with or without VLAN Q-in-Q.
Patterns (BERT)	PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1, and up to 10 user patterns.
Error insertion (BERT)	FCS, bit, 64B/66B Block
Error measurement	LAN/WAN: jabber/giant, runt, undersize, oversize, FCS, 64B/66B Block WAN: B1, B2, B3, REI-L, REI-P UDP, TCP and IP header checksum
Error measurement (BERT)	Bit error, bit mismatch 0, bit mismatch 1, performance monitoring (G.821 and G.826)
Alarm insertion	LOS, link down, local fault, remote fault, pattern loss (BERT) WAN: SEF, LOF, AIS-L, RDI-L, AIS-P, RDI-P, LCD-P, LOP-P, ERDI-PSD, ERDI-PCD, ERDI-PPD, UNEQ-P
Alarm detection	LOS, link down, local fault, remote fault, frequency offset, pattern loss (BERT) WAN: SEF, LOF, AIS-L, RDI-L, AIS-P, RDI-P, LCD-P, LOP-P, ERDI-PSD, ERDI-PCD, ERDI-PPD, PLM-P, UNEQ-P, link (WIS)
Service disruption time (SDT) measurement (BERT)	Defect or No Traffic mode. Disruption time statistics include shortest, longest, last, average, total and count.
VLAN stacking	Capability to generate one stream with up to three layers of VLAN (including IEEE802.1ad Q-in-Q tagged VLAN).
Flow-control statistics	Pause time, last pause time, max. pause time, min. pause time, paused frames, abort frames, frames Tx, frames Rx.
Multistream generation	Capability to transmit up to 10 streams. Configuration parameters are packet size, transmission mode (N-Frames, Burst, N-Burst, Ramp, N-Ramp and Continuous), MAC source/destination address, VLAN ID, VLAN priority, IP source/destination address, ToS field, DSCP field, TTL, UDP source/destination port and payload. (Available with Frame-Analyzer software option.) Selectable predefined stream profiles are also available for VoIP, video and data streams. VoIP codecs (G.711, G.723.1, G.729), video (MPEG-2 SDTV, MPEG-2 HDTV, MPEG-4 HDTV).
Traffic filtering	Capability to analyze the incoming traffic and provide statistics according to a set of up to 10 configurable filters. Filters can be configured for MAC source/destination address, VLAN ID, VLAN priority, IP source/destination address, ToS field, DSCP field, TCP source/destination port and UDP source/destination port. VLAN filtering can be applied to any of the stacked VLAN layers. (Available with Frame-Analyzer software option.)
Multistream analysis	Capability to analyze per stream statistics: packet jitter, latency, throughput, frame loss and out-of-sequence (available with Frame-Analyzer software option)
Ethernet statistics	Multicast, broadcast, unicast, N-unicast, pause frame, frame size distribution, bandwidth, utilization, frame rate, frame loss, out-of-sequence frames and in-sequence frames. (Available with Frame-Analyzer software option.)
Packet jitter statistics	Delay variation statistics (ms)–min., max., last, average and jitter measurement estimate (RFC 3393) (available with Frame-Analyzer option).
PBB-TE [a]	Capability to generate and analyze streams with PBB-TE data traffic including configuration of B-MAC (source and destination), B-VLAN and I-tag (as per 802.1ah) and to filter received traffic by any of these fields.
MPLS [a]	Capability to generate and analyze streams with up to two layers of MPLS labels and to filter received traffic by MPLS label or COS.
IPv6 [a]	Capability to perform BERT, RFC 2544, traffic generation and analysis and Smart Loopback tests over IPv6; ping, traceroute, neighbor discovery and stateless auto-configuration.
Advanced filtering [a]	Capability to enhance the filters with up to four (4) fields each, which can be combined with AND/OR/NOT operations. A mask is also provided for each field value to allow for wildcards. Complete statistics are gathered for each defined filter.
Data capture [a]	Capability to perform 10/100/1000M full-line-rate data capture and decode. Capability to configure detailed capture filters and triggers as well as capture slicing parameters.
One-way delay	Capability to measure one-way frame delay as part of EtherSAM (Y.1564) and RFC 2544

ADDITIONAL TEST AND MESUREMENT FUNCTIONS (10 GigE)

Power measurement	Supports optical power measurement, displayed in dBm.
Frequency generation and measurement	Supports clock frequency generation and measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency). Frequency offset generation: Range: ±50 ppm Resolution: ±1 ppm Uncertainty (accuracy): ±4.6 ppm Frequency offset measurement: Range: ±135 ppm Resolution: ±1 ppm Uncertainty (accuracy): ±4.6 ppm
Signal label control and monitoring	Ability to configure and monitor J0 Trace, J1 Trace and payload signal label C2 (WAN).
Dual test set	Performs end-to-end, bidirectional performance testing (as required by leading standards bodies)–remote FTB-8130NGE controlled via the LAN connection under test.
DHCP client	Capability to connect to a DHCP server to obtain its IP address and subnet mask to connect to the network.
Smart Loopback	Capability to return traffic to the local unit by swapping packet overhead up to layer 4 of the OSI stack.
IP tools	Capability to perform ping and traceroute functions.

Note

a. Available as a software option.

ETHERNET FUNCTIONAL SPECIFICATIONS (CONT'D)

ADDITIONAL FEATURES

Expert mode	Ability to set thresholds in RFC 2544 and BERT mode to provide a pass/fail status.
Scripting	The built-in Visual Basic .NET scripting engine and embedded macrorecorder provide a simple means of automating test cases and routines. Embedded scripting routines provide a powerful means of creating advanced test scripts. [a]
Event logger	Supports logging of test results, and the ability to print, export (to a file), or export the information contained in the logging tool.
Power up and restore [a]	In the event of a power failure to the unit, the active test configuration and results are saved and restored upon bootup.
Save and load configuration	Ability to store and load test configurations to/from non-volatile memory.
Configurable test views	Allows users to customize their test views; i.e., to dynamically insert or remove test tabs/windows, in addition to creating new test windows, so as to accurately match their testing needs. [a]
Configurable test timer	Allows a user to set a specific start, stop and duration for tests.
Test favorites	Capability to select and load from predefined or user-modified test conditions.
Report generation	Ability to generate test reports in the following user-selectable formats: .pdf, .html, .txt and .csv.
Graph	Allows to graphically display the test statistics of the performance (RFC 2544).
Screen capturing [b]	Capability to gather a snap-shot of the screen for future use.
Logger printing [b]	Capability to send logger messages to a supported local printer.
Remote control	Remote control through Visual Guardian Lite software or VNC.

FIBRE CHANNEL INTERFACES

FC-1X/2X/4X

Wavelength (nm)	850	1310	1310	1550
Tx level (dBm)	−9 to −2.5	−8.4 to −3	0 to 5	1 to 5
Rx level sensitivity (dBm)	−15 at FC-4 −18 at FC-2 −20 at FC-1	−18 at FC-4 −21 at FC-2 −22 at FC-1	−18 at FC-4 −21 at FC-2 −22 at FC-1	−16.5 at FC-4 −20.5 at FC-2 −22 at FC-1
Maximum reach	500 m on 50/125 µm MMF [c] 300 m on 62.5/125 µm MMF [c]	4 km	30 km	40 km
Transmission bit rate (Gbit/s)	1.06/2.125/4.25	1.06/2.125/4.25	1.06/2.125/4.25	1.06/2.125/4.25
Reception bit rate (Gbit/s)	1.06/2.125/4.25	1.06/2.125/4.25	1.06/2.125/4.25	1.06/2.125/4.25
Tx operational wavelength range (nm)	830 to 860	1260 to 1350	1285 to 1345	1544.5 to 1557.5
Measurement uncertainty (accuracy) Frequency (ppm) Optical power (dB)	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2
Max Rx before damage (dBm)	3	3	3	3
Jitter compliance	ANSI FC-PI-2	ANSI FC-PI-2	ANSI FC-PI-2	ANSI FC-PI-2
FC classification	ANSI FC-PI-2	ANSI FC-PI-2	ANSI FC-PI-2	ANSI FC-PI-2
Laser type	VCSEL	Fabry-Perot	DFB	DFB
Eye safety	Class 1	Class 1	Class 1	Class 1
Connector	LC	LC	LC	LC
Transceiver type	SFP	SFP	SFP	SFP

FC-10X

Wavelength (nm)	850	1310	1310	1550	1550
Tx level (dBm)	−5 to −1	0.5 max	−6 to −1	−1 to 2	0 to 4
Rx level sensitivity (dBm)	−11.1	−12.6	−14.4	−16	−23
Maximum reach	300 m on 50/125 µm MMF 30 m on 62.5/125 µm MMF	10 km	10 km	40 km	80 km
Transmission bit rate (Gbit/s)	10.5	10.5	10.5	10.5	10.5
Reception bit rate (Gbit/s)	10.5	10.5	10.5	10.5	10.5
Tx operational wavelength range (nm)	840 to 860	1260 to 1355	1290 to 1330	1530 to 1565	1530 to 1565
Measurement uncertainty (accuracy) Frequency (ppm) Optical power (dB)	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2	 ±4.6 ±2
Max Rx before damage (dBm)	6	6	6	2	4
Jitter compliance	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3
FC classification	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3	ANSI FC-PI-3
Laser type	VCSEL	DFB	DFB	EML	EML
Eye safety	Class 1	Class 1	Class 1	Class 1	Class 1
Connector	LC	LC	LC	LC	LC
Transceiver type	XFP	XFP	XFP	XFP	XFP

Notes

a. Available on the FTB-500 platform only.

b. Available on the FTB-200 platform only.

c. Values in the table correspond to FC-1 rate. For FC-2, maximum reach is 300 m on 50/125 µm MMF and 150 m on 62.5/125 µm MMF. For FC-4, maximum reach is 150 m on 50/125 µm MMF and 70 m on 62.5/125 µm MMF.

FIBRE CHANNEL FUNCTIONAL SPECIFICATIONS

TESTING (1X, 2X, 4X AND 10X)

BERT	Unframed, framed FC-1, framed, FC-2
Patterns (BERT)	PRBS 2E31-1, 2E23-1, 2E20-1, 2E15-1, 2E11-1, 2E9-1 CSPAT, CRPAT, CJTPAT, and 10 user-defined 32 bits patterns
Error insertion	Bit error, symbol error, oversize error, CRC error, undersize error and block error
Error measurement	Bit error, symbol error, oversize error, CRC error, undersize error and block error
Alarm insertion	LOS, pattern loss
Alarm detection	LOS, pattern loss
Buffer-to-buffer credit testing	Buffer-to-buffer credit estimation based on latency
Latency	Round-trip latency measurement

ADDITIONNAL TEST AND MEASUREMENT FUNCTIONS (1X, 2X, 4X AND 10X)

Power measurement	Supports optical power measurement, displayed in dBm.
Frequency measurement	Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency).
Frequency offset measurement	Range: ±120 ppm Resolution: 1 ppm Uncertainty (accuracy): ±4.6 ppm

ADDITIONAL SPECIFICATIONS

FTB-8130NGE [a]

Next-generation SONET/SDH 10 Gbit/s and OTN 10.7 Gbit/s
Supports up to 10/10.7 Gbit/s optical rates, as well as electrical DSn/PDH interfaces
Test Interfaces
OTN: OTU1 (2.7 Gbit/s), OTU2 (10.7 Gbit/s) OTU1e (11.0491 Gbit/s), OTU2e (11.0957 Gbit/s) OTU1f (11.2701 Gbit/s), OTU2f (11.3176 Gbit/s)
SONET: STS-1e, STS-3e, OC-3, OC-12, OC-48, OC-192
SDH: STM-0e, STM-1e, STM-0, STM-4, STM-16, STM-64
DSn: DS1, DS3, Dual DS1 Rx, Dual DS3 Rx
PDH: E1, E2, E3, E4
Ethernet: 10/100/1000M electrical, 100/1000M optical and 10 GigE LAN/WAN
FC: 1x, 2x, 4x, 10x

GENERAL SPECIFICATIONS

	FTB-8130NGE
Weight (without transceiver)	0.9 kg (2.0 lb)
Size (H x W x D)	96 mm x 51 mm x 288 mm (3 3/8 in x 2 in x 11 3/8 in)
Temperature	
Operating	0 °C to 40 °C (32 °F to 104 °F)
Storage	–40 °C to 60 °C (–40 °F to 140 °F)

Note

a. Modules can also be purchased as FTB-8130NGE-FLEX, which provides maximum configuration flexibility, allowing all rates and options shown in “Ordering Information” to be ordered individually.

ORDERING INFORMATION

FTB-81XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX

Model
See models listed in previous page

SONET/SDH Rate Options
155 = 155 Mbit/s (OC-3/STM-1)
622 = 622 Mbit/s (OC-12/STM-4)
2.5G = 2.5 Gbit/s (OC-48/STM-16)
10G = 10G Gbit/s (OC-192/STM-64) [a]

OTN Rate Options
OTU1 = OTN optical rate 2.7 Gbit/s
OTU2 = OTN optical rate 10.7 Gbit/s [a]
OTU2-1e-2e = OTN optical rates 11.0491/ 11.0957 Gbit/s [a]
OTU2-1f-2f = OTN optical rates 11.2701 Gbit/s and 11.3176 Gbit/s [a]

Ethernet Rate Options
LAN/WAN 10GigE = 10 GigE LAN/WAN [b]
10M/100M/1000M = 10/100/1000Base and GigE optical
100M-O-AP = 100M optical

Fibre Channel Rate Options
FC1X = 1X Fibre Channel interface
FC2X = 2X Fibre Channel interface
FC4X = 4X Fibre Channel interface
FC10X = 10X Fibre Channel interface [a]

SONET/SDH Options
SONET = SONET-BASE-SW
SDH = SDH-BASE-SW
SONET-SDH = Software option for combined SONET/SDH functionality
G.747 = E1/2M in DS3/45M analysis, as per ITU-T G.747 recommendation
DS1-FDL = DS1 facility data-link generation/analysis
DS3-FEAC = DS3 far-end alarms and loopback code words
DUAL RX = Dual receiver testing mode for DS1 and DS3 interfaces
TCM = Tandem connection monitoring
INTR-THRU-MODE = SONET/SDH intrusive Through mode
SMARTMODE = Real-time signal discovery and alarm/error monitoring per channel

OTN Options
ODUMUX = ODU MUX functionality [a, c]
ODU0 = ODU0 mapping [d]
ODUflex = ODUflex functionality [e]
OTN-INTR-THRU = OTN intrusive Through mode [d]
EoOTN = Ethernet-over-OTN functionality [f]
OTU2-GFP-F = 10GigE LAN mapping into ODU2 using GFP-F
MULTI-CH-SDT = Multichannel SDT measurements

Next-Generation options
HO-VCAT = High-order virtual concatenation
LO-VCAT = Low-order virtual concatenation
LCAS = Link capacity adjustment scheme [g]
GFP-F = Generic framing procedure–framed
EoS = Ethernet-over-SONET/SDH [h]

Ethernet Options
100optical = 100 Mbit/s optical Ethernet
Frame-Analyzer = Multiple stream generation and analysis
PBB-TE = PBB-TE testing
MPLS = MPLS testing
Adv_filtering = Advanced filtering capabilities
IPv6 = IPv6 testing capabilities
TCP-THPUT= TCP throughput testing
EtherSAM = EtherSAM (Y.156sam) testing
Data_Capture = Data capture and decode capabilities
TRAFFIC-SCAN = VLAN/MPLS traffic scan

Transceivers XFP test port [a]
00 = Without XFP telecom
FTB-81900 = Multirate (10-11.3 Gbit/s) optical XFP transceiver module with LC connector; 1310 nm; 10 km reach
FTB-81901= Multirate (10/10.7 Gbit/s) optical XFP transceiver module with LC connector; 1550 nm; 40 km reach
FTB-81902 = Multirate (10/10.7 Gbit/s) optical XFP transceiver module with LC connector; 1550 nm; 80 km reach
FTB-85900 = 10GBase-SR/-SW (850 nm, LAN/WAN PHY) LC connectors; optical XFP transceiver module
FTB-85901 = 10GBase-LR/-LW (1310 nm, LAN/WAN PHY) LC connectors; optical XFP transceiver module
FTB-85902 = 10GBase-ER/-EW (1550 nm, LAN/WAN PHY) LC connectors; optical XFP transceiver module

Transceivers SFP Ethernet add/drop port [a, i]
00 = Without Ethernet add/drop
FTB-8190 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1310 nm; 15 km reach
FTB-8191 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1310 nm; 40 km reach
FTB-8192 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1550 nm; 80 km reach
FTB-8193 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1550 nm; 40 km reach
FTB-8590 = GigE/FC/2FC optical SFP transceiver module with LC connector; 850 nm; MMF, <500 m reach
FTB-8591 = GigE/FC/2FC optical SFP transceiver module with LC connector; 1310 nm; 10 km reach
FTB-8592 = GigE/FC/2FC optical SFP transceiver module with LC connector; 1550 nm; 90 km reach

Transceivers SFP test port [a]
00 = SFP test port
FTB-8190 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1310 nm; 15 km reach
FTB-8191 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1310 nm; 40 km reach
FTB-8192 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1550 nm; 80 km reach
FTB-8193 = Multirate (155/622 Mbit/s, 2.5/2.7 Gbit/s, GigE/FC/2FC) optical SFP transceiver module with LC connector; 1550 nm; 40 km reach
FTB-85910 [j] = 100Base-FX (1310 nm) MM, LC connectors; optical SFP transceiver module for FTB-8510B Packet Blazer
FTB-85911 [j] = 100Base-LX (1310 nm) SM, LC connectors; optical SFP transceiver module for FTB-8510B Packet Blazer
FTB-85912 [i] = SFP modules GigE/FC/2FC/4FC at 850 nm, MMF, <500 m
FTB-85913 [i] = SFP modules GigE/FC/2FC/4FC at 1310 nm, SMF, <4 km
FTB-85914 [i] = SFP modules GigE/FC/2FC/4FC at 1310 nm, SMF, <30 km
FTB-85915 [i] = SFP modules GigE/FC/2FC/4FC at 1550 nm, SMF, <40 km

Example: FTB-8130NGE-SONET-SDH-155-622-2.5G-OTU1-HO-VCAT-8190-8590

NOTES

a. Not applicable to the FTB-8130NGE-2.5G.
b. Applies to FTB-8130NGE and FTB-8130NGE-2.5G.
c. Must be combined with the OTU1 and OTU2 options.
d. Must be combined with the OTU1 or OTU2 option.
e. Not applicable to the FTB-8130NGE-2.5G) and must be combined with the OTU2 option.
f. Must be combined with the OTU2-1e-2e or OTU2-GFP-F or ODU0 option.
g. Must be combined with the HO-VCAT or LO-VCAT option.
h. Must be combined with the GFP-F option.
i. Available with 4x Fibre Channel interface only.
j. Multiple options can be purchased to suit the required test application.

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