# Multi-protocol transport and datacom solutions

## Smarter testing across your entire network up to 400G

EXFO leads the 5G revolution with the most complete testing portfolio in the industry, featuring automated, versatile and future-proof solutions. With support for multiple technologies—including Ethernet, Fibre Channel, Transport, CPRI, eCPRI, and more—EXFO solutions validate network performance from the lab to the field quickly, easily and with first-time-right results.

## BUSINESS ETHERNET AND TRANSPORT

**Activate services fast and intelligently**

- Multitechnology, multiport testing from 56K to 400G complete feature set: Ethernet, OTN, SONET, SDH, DSn, PDH, ISDN, synchronization
- Service activation using EXFO's unique iOptics and iSAM, making testing intelligent, simpler and faster
- Portable 4 x 100GE test set unique in the industry
- Full suite of Fibre Channel testing from 1X to 32X

## 5G, FRONTHAUL, MIDHAUL AND BACKHAUL

**Install, validate and troubleshoot your 5G and 4G networks**

- iORF: the only intelligent application for RF spectrum analysis over CPRI in the industry
- iOptics: intelligent pluggable optics test application
- eCPRI, CPRI up to option 10 (24.3G), OBSAI and up to 100G Ethernet testing
- Integrated and intelligent fiber testing

## DATA CENTER

**Speed up transceiver validation**

- iOptics: powerful and easy-to-use transceiver testing tool for AOC cables, QSFP28, SFP28, QSFP+, CFP4, SFP+, SFP, bidirectional SFP
- Portable QUAD PORT solution to test multiple circuits simultaneously: 4 x 100G, 4 x 25G, 4 x 10G
- Intelligent applications provide a complete test suite in a single-page configuration for quick test results
- Industry leader in high-accuracy latency measurements

## NEMS AND LABS

**Validate the design and the features of network elements**

- Optical transport system validation up to 100G: Ethernet, OTN, SONET/SDH, FC, CPRI/OBSAI, eCPRI
- Advanced OTN testing: single and multistage mappings, ODUflex multichannel with mixed mappings
- Full transceiver validation
- Wireless 5G transport validation

**EXFO**

# CHOOSE THE TESTING SOLUTION THAT MEETS YOUR REQUIREMENTS

| FEATURES | FTBx-8870 | FTBx-8880 | FTBx-88260 | FTBx-88200NGE |
|---|---|---|---|---|
| iOptics | • | • | • | • |
| iSAM | • | • | • | • |
| iORF | •[b] | •[b] | •[b] | |
| **Ethernet** | | | | |
| Dual-port Ethernet testing | • | • | • | • |
| BERT | • | • | • | • |
| Unframed BERT | • | • | • | • |
| RFC 2544 | • | • | • | • |
| Smart loopback | • | • | • | • |
| ITU-T Y.1564 testing (EtherSAM) | • | • | • | • |
| Traffic generation and monitoring | • | • | • | • |
| RFC 6349 (up to 10G) | • | • | • | • |
| RFC 6349 (40G and 100G) | | | • | • |
| Carrier Ethernet OAM (up to 10G) | • | • | • | • |
| Link OAM (up to 10G) | • | • | • | • |
| Dual test set (asymmetrical tests) | • | • | • | • |
| Layer 2 transparency | • | • | • | • |
| Tunable SFP+ | • | • | • | • |
| **Transport** | | | | |
| OTN OTU1/2 | • | • | • | • |
| OTN OTU3/4 | | | • | • |
| ODU Mux, EoOTN, ODU0, ODUflex | • | • | • | • |
| Multichannel OTN and mixed mapping testing | | | | •[a] |
| FlexE clients / FlexE 2.1 | | | • | |
| OTN GCC BERT (Power OTN OH analysis) | • | • | • | • |
| DSn/PDH (DS1/E1) | • | • | | |
| DSn/PDH (DS3, E3 and E4) | | • | | |
| ISDN PRI | •[b] | •[b] | | |
| SONET/SDH | • | • | • | • |
| **Synchronization** | | | | |
| 1588 PTP/SyncE | • | • | • | • |
| Wander and time error | | • | • | |
| Packet time error | | | • | |
| **Fibre Channel** | | | | |
| Fibre Channel (1X, 2X, 4X, 8X and 10X) | • | • | • | • |
| Fibre Channel 16X | | | • | • |
| Fibre Channel 32X | | | • | |
| **Wireless** | | | | |
| eCPRI 10G | • | • | • | • |
| eCPRI 25G | | | • | |
| eCPRI 100G | | | • | |
| Dual-port eCPRI | | | • | |
| CPRI 1.2 Gbit/s to 10.1 Gbit/s | • | • | • | • |
| CPRI 24.3 Gbit/s | | | • | |
| OBSAI 1.5 Gbit/s, 3.1 Gbit/s and 6.1 Gbit/s | • | • | • | • |
| Dual-port CPRI | • | • | • | |
| OpticalRF | •[b] | •[b] | •[b] | |
| BBU emulation | •[b] | •[b] | •[b] | |

a. Available on the FTB-2, FTB-4 Pro, LTB-2 and LTB-8 platforms.

b. Available on FTB-1 Pro platforms.

# FIELD TESTING: FTB-1 PRO
## Choose the portable platform that meets your field testing needs

FTB-1 Pro modular platforms are the most flexible solutions because they allow users to build a test set that includes the tools they really need. The unique advantage of this design is twofold. First, it allows engineers and field technicians to easily change the test module in the field so that the right test is performed during infrastructure deployment, service activation or troubleshooting. Second, it protects the investment in test instruments. This is particularly valuable in light of all the new testing needs coming with 5G.

5G standards are currently being developed. Only flexible, future-proof solutions will help MSOs, data centers, service providers and NEMs invest properly in their fleet of test instruments and minimize acquisition costs.

The modular FTB-1 Pro platform is available in three configurations.

## FTB-1 Pro single-carrier (SC)

This configuration offers engineers and field technicians the most compact and flexible one-slot test solution. The platform can host either an OTDR module or a 10G module for transport and Ethernet testing. It provides optical and electrical interfaces from 56K to 10G to easily turn-up, validate and troubleshoot OTN, SONET/SDH, DSn/PDH, ISDN/PRI, CPRI/OBSAI, Fibre Channel and Ethernet services, including dual port 10G multiservice testing.

## FTB-1 Pro dual-carrier (DC)



The dual-carrier configuration offers engineers and field technicians multiple configurations by hosting two modules allowing simultaneous optical, Ethernet and transport testing, depending on the modules used in the platform. It provides optical and electrical interfaces from 56K to 100G to easily turn-up, validate and troubleshoot transport technologies (OTN, SONET/SDH, DSn/PDH, ISDN), 5G and fronthaul (eCPRI, CPRI, OBSAI, OpticalRF), Fibre Channel and Ethernet services, including QUAD-port 10G multiservice testing. The dual-carrier platform can host an OTDR and a transport and datacom (T&D) module and, as a result, offers the most compact and flexible all-in-one solution on the market. Combined with EXFO's intelligent test applications such as iOLM, iSAM, iOptics and iORF, the FTB-1 Pro dual-carrier not only protects the investment on field test equipment but has a direct impact on reducing the operational costs of MSOs, service providers, wireless network operators and webscale companies.

The dual-carrier configuration supports concurrent dual-module operation when using OTDRs and 10G T&D modules. When equipped with a 100G module (FTBx-88260 or FTBx-88200NGE), the platform supports operation of one module at a time and 2 x 100G testing.

| Test module support | CONFIGURATIONS | | |
| --- | --- | --- | --- |
| | Single-carrier | Dual-carrier | High-power dual-carrier |
| FTBx-8880 (10G module) | • | •[a] | •[a] |
| FTBx-8870 (10G module) | • | •[a] | •[a] |
| FTBx-88200NGE (100G module) | | •[b] | •[c] |
| FTBx-88260 (25G & 100G module) | | •[b] | •[c] |

a. Platform with two modules enables QUAD 10GE testing.
b. Platform can host one 100G module at a time.
c. With two modules, it enables QUAD 100GE testing.

## FTB-1 Pro high-power dual-carrier (HPDC)

The high-power dual-carrier configuration features the FTB-1 Pro platform's most flexible solution, allowing simultaneous dual-module operation of all modules supported by the platform. The high-power version of the dual-carrier configuration offers simultaneous QUAD 100GE testing, which makes it the most compact 4 x 100GE field tester on the market when housing 2 x 100G test modules (FTBx-88200NGE or FTBx-88260).

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# LAB TESTING
## Select the most suitable platform for your lab or benchtop operation

### LTB-8 rackmount

The LTB-8 is 3U-high platform that offers rackmount or benchtop operation for both lab and production environments plus eight slots that can be accessed individually. It can host optical and T&D FTBx modules such as FTBx-8880, FTBx-8870, FTBx-88200NGE and FTBx-88260.

When equipped with 8 x FTBx-88260 or 8 x FTBx-88200NGE, this multiservice, multitechnology solution can test up to 16 x 100GE simultaneously.

### LTB-2 rackmount

The LTB-2 rackmount solution is a more compact version of the LTB-8 platform and occupies one rack unit. It can host two single-slot modules that run concurrently and independently. When equipped with 2 x FTBx-88260 or 2 x FTBx-88200NGE, this solution can test up to 4 x 100 GE simultaneously.

### FTB-4 Pro modular platform

The FTB-4 Pro offers four slots to house different optical and T&D modules: FTBx-8880, FTBx-8870, FTBx-88200NGE and FTBx-88260. This platform is the most suitable portable lab solution in a test scenario that requires optical spectrum analysis, OTDR validation and multiservice multitechnology service verification.

When equipped with 4 x FTBx-88260 or 4 x FTBx-88200NGE, the FTB-4 Pro can test up to 8 x 100GE circuits running simultaneously.

### FTB-2 Pro modular platform

EXFO's most compact modular lab-focused portable platform features two slots that can house optical and T&D modules.

When equipped with 2 x FTBx-88200NGE or 2 x FTBx-88260, the FTB-2 Pro enables 4 x 100GE testing.

### EXFO Multilink test environment

EXFO Multilink is a multi-user, multimodule and multiplatform software application that enables remote control access of each platform and module through a centralized dashboard featuring an easy-to-use, web-based graphical user interface. The multilink environment is controlled by a virtual server available on LTB-8 platforms and the environment can manage LTB-2, LTB-8, FTB-4 Pro and FTB-2 Pro platforms.

EXFO | MULTILINK

EXFO

# CHOOSE THE TRANSPORT AND DATACOM MODULE THAT MEETS YOUR TESTING REQUIREMENTS

## FTBx-88260: 10G, 25G, 40G, 50G and 100G testing with swappable transceiver interfaces

Today's wide variety of pluggable transceivers and the rapid rate at which new types of transceivers are being launched complicates telecom industry investment decisions. Whether we consider SFP and SFP+ (for rates up to 10G), look at QSFP28 and CFP4 (for 100G rates) or start adding SFP28 (for 25G rates) and PAM4 QSFP28 for 50GE transmissions, it becomes clear that integrating all these into the network is a challenge. With the imminent arrival of even more transceiver types (e.g., SFP56, SFP-DD, QSFP-56), NEMs will struggle to keep up while data centers and network operators will have difficulty integrating them in their networks.

With those challenges in mind, EXFO has introduced the FTBx-88260 T&D test module. This customizable unit is built with EXFO's Open Transceiver System (OTS), an innovative evolutionary design concept that enables users to match the module's interfaces with their specific testing needs. It's future-proof, so as new transceivers are developed and launched, testing them will be as simple as changing an OTS insert in the test module rather than having to purchase an entirely new test unit.

The FTBx-88260 offers two OTS slots (A and B) that can each house any of the options below:



FTBx-88260

| OPEN TRANSCEIVER SYSTEM | | SUPPORTED INTERFACES | FEATURES | NUMBER OF TEST PORTS |
|---|---|---|---|---|
| | SFP28 | SFP, SFP+, tunable SFP+, SFP28, copper SFP, SFP+ and bidirectional SFP | • 10M to 25G data rates<br>• FC 1X to FC 32X data rates<br>• Dual-port capability | 2 |
| | QSFP28 | QSFP+, QSFP28 | • 25G / 40G / 50G / 100G data rates<br>• Dual-port capability<br>• AOC cables | 2 |
| | CFP4 | CFP4, SMA (REF OUT) | • 100G data rate<br>• Ref out for eye diagram analysis<br>• Dual-port offered with extra OTS | 1 |
| | SYNC | SMA[a], SMB<br>(EXT CLK and 1PPS) | • Built-in GNSS/GPS [a]<br>• Ideal solution for one-way delay<br>• Ready for next-gen timing applications [a] | 1[b] |

a. For more information, please contact EXFO.
b. With 1 PPS as test port

## FTBx-8880/8870: comprehensive 10G testing

This series of modules provides a full suite of testing capabilities for multiple technologies from 56K to 10G, addressing different test applications both in field and lab scenarios: legacy testing (DSn/PDH), metro and longhaul Ethernet network, transport technology (OTN), fronthaul/backhaul, data centers, 5G deployment, etc.

## FTBx-88200NGE: the test solution for next-generation 40G-100G networks

Multiple 100G interfaces enable both data centers and carriers to deploy 100G circuits more cost effectively. It offers integrated CFP4 and QSFP28/QSFP+ interfaces, ready for 100G network diversity.

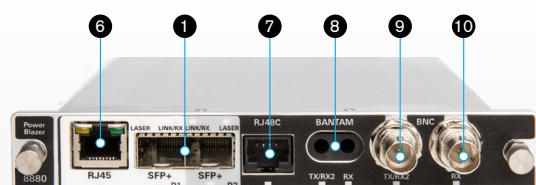| PHYSICAL INTERFACES | FTBx-8870 | FTBx-8880 | FTBx-88200NGE |
|---|---|---|---|
| RJ45 | • | • | •[a] |
| RJ48C | • | • | |
| BNC | •[b] | • | |
| Bantam | | • | |
| SFP/SFP+ | •[c] | •[c] | •[c] |
| QSFP+/QSFP28 | | | • |
| CFP4 | | | • |

a. With the use of a copper SFP.
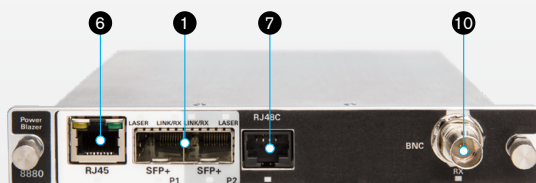b. BNC connector for input clock only.
c. Supports tunable SFP+ and copper SFP+.
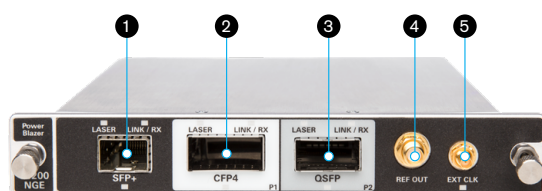
**FTBx-88200NGE**

**FTBx-8880**

**FTBx-8870**

**1  SFP+**
CPRI 1.2G to 10.1G
OBSAI 1.5G to 6.1G
10G eCPRI
SONET/SDH up to OC-192/STM-64
OTN up to OTU2 including overclock
Ethernet up to 10G
10/100/1000BASE-T with copper SFP
FC up to 10X
FC 16X (only on FTBx-88200NGE)
RF spectrum over CPRI (only on FTBx-8870/8880)

**2  CFP4**
OTN OTU4
Ethernet 100GE

**3  QSFP**
OTN OTU3/4 including overclock
Ethernet 40GE/100GE

**4  REF OUT**
SMA interface

**5  EXT CLK**
SMB interface

**6  RJ45**
Ethernet 10/100/1000BASE-T

**7  RJ48C**
DSn/PDH
EXT CLK
Wander

**8  BANTAM**
DSn/PDH
RX2: DS1
EXT CLK

**9  BNC**
Electrical
SONET/SDH
DSn/PDH
RX2: DS1/DS3
EXT CLK
Wander

**10  BNC**
DSn/PDH
RX: DS1
EXT CLK

# BUSINESS ETHERNET AND TRANSPORT

## Key benefits

EXFO's market-leading products are designed to make service turn-up and troubleshooting activities easy and fast. Service providers, system operators and contractors rank EXFO solutions number one in the market for both business Ethernet service and transport testing. EXFO's solutions once again lead the pack with our latest introduction of the FTBx-88260 module. EXFO's customers are no longer handcuffed by having to yet again purchase a new system to work with the latest optical transceiver. EXFO's OTS system guarantees the ability to interchange transceivers as tests become fully standardized.

EXFO's applications are also market leading. EXFO'S T&D test sets and modules cover all the typical Ethernet standard testing applications including BERT, RFC 2544, EtherSAM (ITU-T Y.1564) and RFC 6349 L4 TCP testing. EXFO also provides iSam, which combines all the cutting-edge standards tests into one EXFO-exclusive, user-friendly service turn-up and troubleshooting tool. From a transport perspective, EXFO's solutions cover legacy TDM DSn/PDH and ISDN PRI all the way to SONET/SDH and full-blown OTN testing up to OTU4.

Service providers and MSOs can expedite service activation by taking advantage of EXFO's unique QUAD port 100GE solution. Technicians can simultaneously validate 4 x 100G services using one portable tester: the QUAD port 100G kit. It enables faster deployment of multiple 100GE services and more productive use of test set fleets, which lowers both OPEX and CAPEX. The LTB-2 rackmount platform also features up to 4 x 100GE simultaneous testing. MSOs can have a universal test device located in central offices, promoting execution of standardized test procedures.
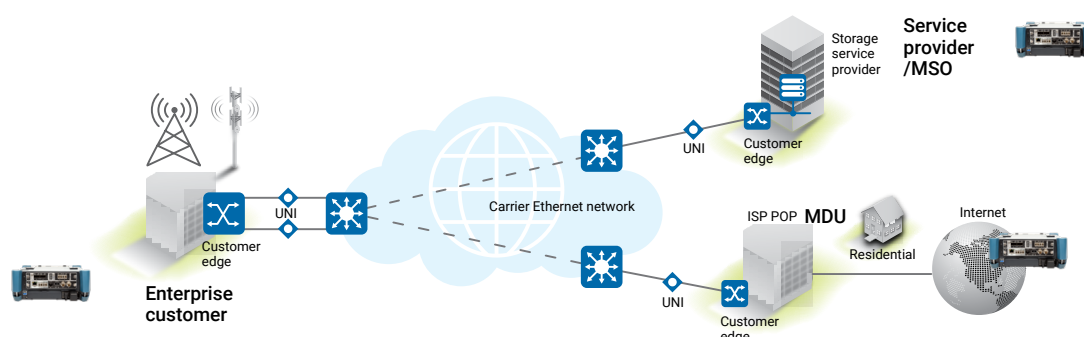


## ETHERNET BUSINESS SERVICES APPLICATIONS

| Physical interfaces | RFC 2544 | EtherSAM (Y.1564) | RFC 6349 | iSAM (Y.1564 & RFC 6349) |
|---|:---:|:---:|:---:|:---:|
| Single service: layer 2/3/4 SLA issues<br>Metrics: throughput, latency, frame loss | • | • | | • |
| Multiple services: layer 2/3 SLA issues<br>Metrics: throughput, latency, jitter, frame loss | | • | | • |
| Stateful layer 4 TCP troubleshooting<br>Metrics: BDP, window size, buffer delay, TCP efficiency | | | • | • |
| Layer 2, 3, 4 (Stateful) turn-up and troubleshooting<br>Metrics: all of the above including MEF pass/fail benchmarking | | | | • |

## Recommended test kits

### Service provider/MSO/Managed services kit

**FTB-1 Pro DC**
**FTBx-88260**
**FTBx-8880**

**Benefits:**
- EXFO's OTS system helps you protect your investment
- Complete Ethernet and transport feature set
  - Dual-port Ethernet up to 100G
  - DSn/PDH/ISDN/SONET/SDH
  - OTU1 to OTU4 and Fibre Channel 1X to 32X
  - Synchronization: 1588 PTP, SyncE, wander and time error

### Simultaneous QUAD port 100G kit

**FTB-1 Pro HPDC**
**2 x FTBx-88260**

**Benefits:**
- Unlimited dual-port capability
  - 2 x OTU4 multistage mapping and FEC
- 4 x 100G BERT tests
  - Minimizes testing time required, reducing OPEX and improving technician efficiency
- ZERO overheating issues

### 1G turn-up kit

**EX1**

**Benefits:**
- Turn-up via Ookla Speedtest™
- Business/Residential turn-up via
  - GPON emulation
  - LAN
  - Optical SFP
  - WiFi

# 5G, FRONTHAUL, MIDHAUL AND BACKHAUL

## Laying the foundation for 5G while strengthening your existing 4G network

As the industry migrates to LTE-Advanced Pro and 5G, latency, power loss and bit-error rate performance will become major concerns due to increasingly demanding fronthaul, midhaul and backhaul requirements. Fronthaul networks will be required to support speeds of up to 25 Gbit/s, 50 Gbit/s, even 100 Gbit/s with higher traffic loads and more demanding services. Deploying a rock-solid network that's massively scalable and able to support any new service demanded by customers can be challenging—unless you have the right test tools and procedures in place.

**Test smarter with the FTB 5GPro test solution**: Following standardized, field-proven procedures and using intelligent, flexible test solutions take the guesswork out of setup, execution and analysis—leading to high-quality networks, delivered on time and able to address any foreseeable service requirements.

| INSTALLATION | ACTIVATION | MAINTENANCE & TROUBLESHOOTING |
|---|---|---|

**Fiber connector inspection**
- Detect dirty or damaged connectors (at each connection point)
- Clean or replace damaged connectors, as required

**Fiber link characterization**
- Detect issues on the fiber span potentially impacting total budget loss (dB), such as macrobends, splices, bad connectors and fiber breaks

**Transport validation**
- CPRI link validation from 1.2 Gbit/s to 24.3 Gbit/s using BER and latency testing
- eCPRI 10G and 25G link validation using BER and QoS metrics like latency testing

**Site commissioning**
- Test RRH/RU functionality from the bottom of the tower or at the C-RAN hub by emulating the base station
- Verify if the 5G equipment located at the top of the tower is operational via eCPRI 10G/25G/100G link validation
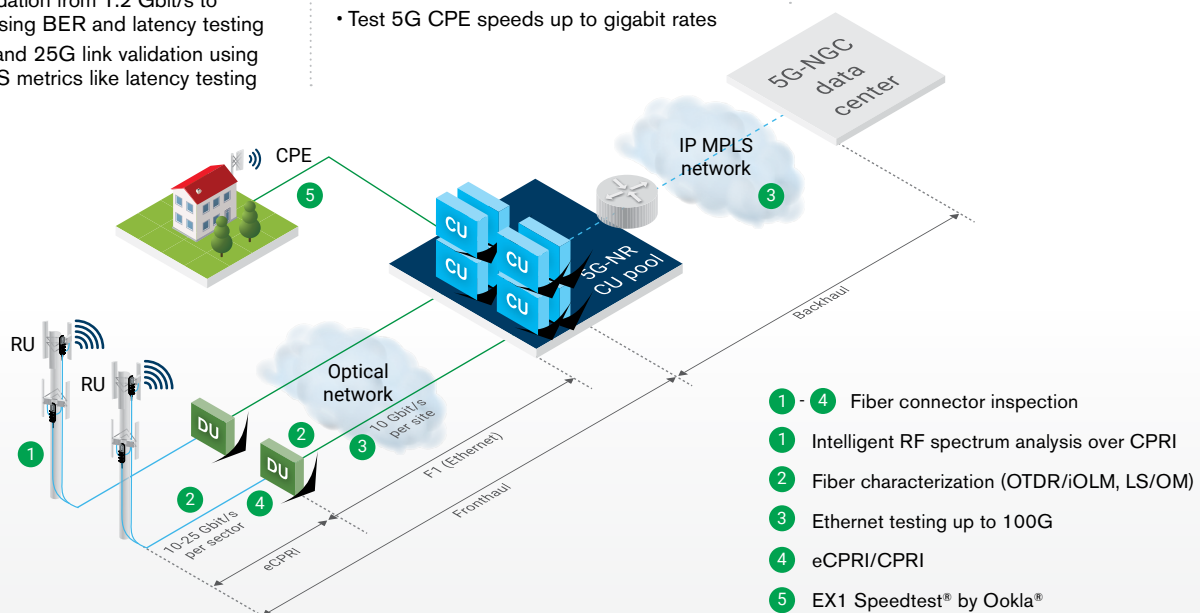- Validate proper installation of mobile network equipment before handover to MNO

**5G CPE commissioning**
- Verify 4G LTE and 5G coverage in residential areas
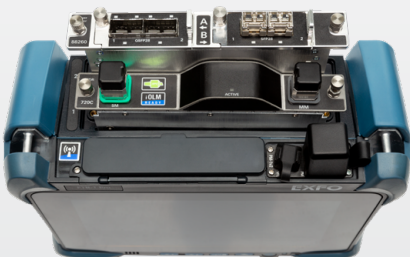- Test 5G CPE speeds up to gigabit rates

**Find and mitigate RF interference**
- Access the RF signal at the BBU location either at the bottom of the tower or at the C-RAN hub via CPRI link
- Track down and mitigate interference sources



1 - 4 Fiber connector inspection

1 Intelligent RF spectrum analysis over CPRI

2 Fiber characterization (OTDR/iOLM, LS/OM)

3 Ethernet testing up to 100G

4 eCPRI/CPRI

5 EX1 Speedtest® by Ookla®

## Recommended test kit: FTB 5GPro



FTB-1v2 DC
FTBx-88260
FTBx-720C

FIP-435B

EX1

Ookla® and Speedtest® are registered trademarks of Ookla.

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# DATA CENTER

Ever-increasing growth in bandwidth-hungry applications flooding data centers and the struggle to provide enhanced levels of performance inside cloud networks are driving migrations to higher data rates. Deploying fiber and network infrastructure inside data centers as quickly and efficiently as possible is the challenge. At the same time, new technologies are emerging, and data centers are struggling to keep pace. Hard choices must be made.

EXFO's unique data center portfolio helps data center managers and technicians keep up with both the explosion of data and the pace of technology change with its unique flexibility and powerful easy-to-use applications, allowing them to optimize deployment and troubleshooting times. (For 400G test solutions, please consult the 400G Power Blazer Series data sheet).

## Ultimate flexibility and interface support

**FTBx-88260**



CFP4
QSFP+
AOC cables
SFP/SFP+/SFP28
QSFP28 (CWDM4, LR4, SR4, PSM4, etc.)
Sync interface
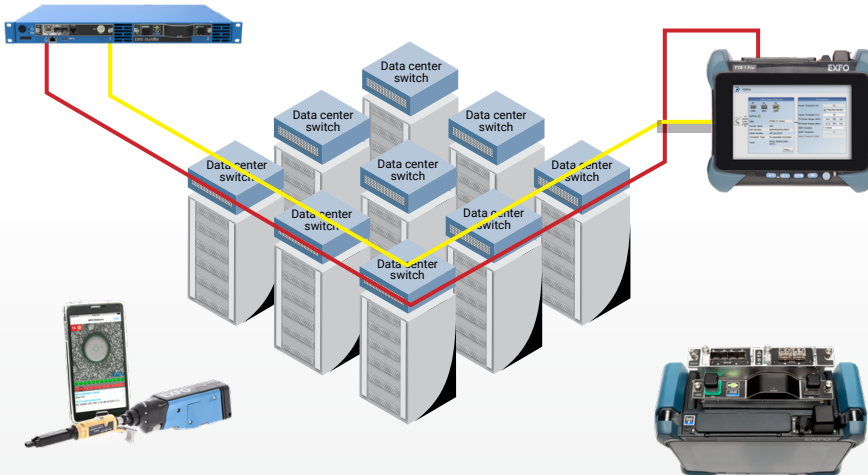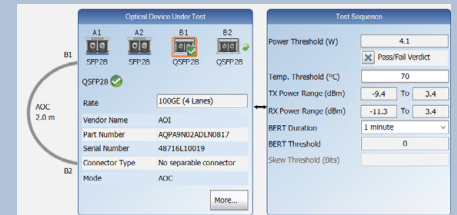
## Before deployment



**Optimize transceiver validation time up to 4 x QSFP28, 4 x SFP28 and 2 AOC cables**
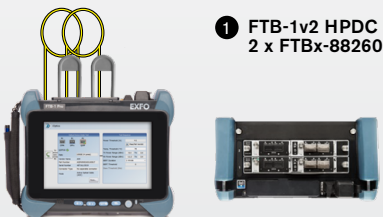
## iOptics



The iOptics intelligent pluggable optics test application offers a complete, powerful and easy-to-use tool for validating any type of 100M to 100G transceiver or AOC cable. It is a first-alert test that can be used in your data center to efficiently evaluate the proper operation of an optical transceiver device with minimal user configuration. The automated testing sequence includes:
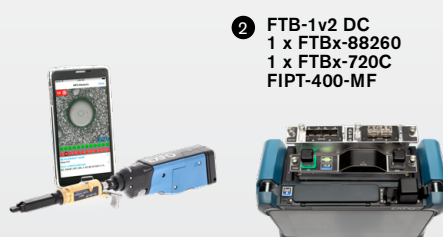
· Monitoring the pluggable's internal temperature

· Monitoring transceiver power consumption and current

· Validating the MDIO/I2C and hardware-pin operation from the transceiver or AOC cable tested

· Validating communication per channel

· Stress test: automated solution that validates the bit-error performance of the optical interface

· Skew test: measures the skew associated to each physical coding sublayer (PCS) lane

In the event of a fail verdict during the execution of any of the previous tests, the faulty area is highlighted and the associated errors/alarms are saved on a test report.

## After deployment

**Optimize deployment and troubleshooting times inside data centers with EXFO's all-in-one solutions**



## Recommended test kits



**❶ FTB-1v2 HPDC**
**2 x FTBx-88260**

**❷ FTB-1v2 DC**
**1 x FTBx-88260**
**1 x FTBx-720C**
**FIPT-400-MF**
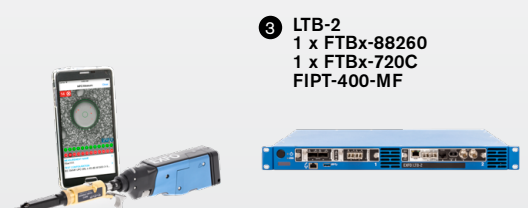
**❸ LTB-2**
**1 x FTBx-88260**
**1 x FTBx-720C**
**FIPT-400-MF**

## EXFO

# NETWORK EQUIPMENT MANUFACTURERS (NEMs) AND LABS

Network equipment manufacturers (NEMs) and high-speed labs are currently facing increasing pressure to ramp up and optimize their production lines to launch high-quality products as fast and efficiently as possible. Remote and synchronous access for different teams of developers around the world has become a must. Today's challenge is to acquire the right equipment while making the right long-term technology investment.

EXFO's NEMs portfolio is a powerful, versatile and scalable test and measurement solution that incorporates rackmount (LTB-8/LTB-2) and portable (FTB-4 Pro/FTB-2 Pro) platforms with a wide variety of modules, providing unique flexibility. The Open Transceiver System (OTS) enhances the portfolio by enabling interface mix-and-match, which allows users to maximize the life of the tester and, at the same time, be ready for future standards.

EXFO's Multilink provides easy-to-use remote access and automation tools for EXFO's rackmount and portable solutions. Taken together, they help NEMs to not only boost productivity and agility but also to accelerate their time to market while keeping CAPEX in check. (For 400G test solutions, please consult the 400G Power Blazer Series data sheet).

| | | |
|---|---|---|
| **Network system design and validation/verification** | • Standard-based testing<br>• Multirate testing from 10M to 400G<br>• Client testing: Ethernet, FC, OTN, SONET and SDH | |
| **Transceiver validation: optical and electrical test** | • iOptics<br>• Transceiver stress test<br>• Power and temperature monitoring | |
| **Transceiver validation spectral analysis** | • Optical spectrum analyzer for SMSR testing on transceiver production floor | |
| **5G wireless and core validation** | • eCPRI validation up to 25G<br>• eCPRI QoS measurement and dual-port<br>• CPRI/OBSAI link validation and BERT | |
| **Ethernet and FlexE testing** | • BERT<br>• Unframed BERT per lane<br>• Traffic generation<br>• Service validation<br>• Synchronization tools<br>• Service disruption time evaluation<br>• Support for FlexE 2.1 G.mtn path OAM including connectivity verification and bidirectional delay measurement | |
| **OTN advanced tools** | • OTN, multistage mapping<br>• Ethernet over OTN, ODU0 and ODUflex<br>• Multichannel OTN and mix mapping | |
| **Remote access and automation** | • Remote access<br>• Automation tools<br>• Inventory management | |

## Recommended test kit

FTB-4 Pro

FTBx-88260

TA-CFP4

TA-SFP28

TA-QSFP28

TA-SYNC/TA-SYNC Premium

FTBx-5243-HWA

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# SUMMARY OF KEY FEATURES

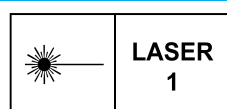| KEY FEATURES | |
|---|---|
| Detailed compliance testing | • IEEE 802.3 - 2018 standard<br>• CFP MSA CFP4 Hardware Specification Revision 1.1 18 Mar 2015<br>• CFP MSA Management Interface Specification Version 2.4 (R06b)<br>• ITU-T G.709, G.798 and G.872 |
| Multi-interface support | • Pluggable, MSA-compliant QSFP+ transceivers<br>• Pluggable, MSA-compliant CFP4 and QSFP28 transceivers<br>• Pluggable, MSA-compliant SFP28 optical transceiver<br>• Pluggable, MSA-compliant SFP/SFP+ electrical and optical transceivers<br>• External timing reference (DS1/E1/2 MHz/10 MHz)<br>• Low-speed and high-speed reference clock output for eye diagram measurements<br>• Active optical cable support<br>• Tunable SFP+ and complete ITU-T grid with 100 GHz and 50 GHz spacing |
| Robust physical-layer validation | • CAUI-4/XLAUI lane error generation and monitoring<br>• PCS lane mapping and monitoring capability<br>• Per-lane skew generation and measurement<br>• PCS error generation and monitoring per lane<br>• Full MDIO/I2C read/write access |
| PRBS patterns per lane | Allows users to configure different PRBS patterns on different CAUI-4/XLAUI lanes in 40G/100G, and on physical lanes in OTU3/OTU4 unframed configurations; typically used to identify crosstalk issues when looking at the eye diagram |
| Per-wavelength power measurement | Allows users to measure the received optical power per wavelength CFP4 and QSFP+/QSFP28 transceivers |
| iOptics | • Optical-device I/O interface quick check<br>• Optical TX power-level test<br>• Optical RX signal-presence and level test<br>• BERT and frequency offset standard<br>• Framed excessive skew test<br>• Temperature and power consumption monitoring |
| Layer 2/3/4 Ethernet testing | • Unframed BERT up to 100G<br>• EtherBERT at 10M, 1G, 10G, 25G, 40G, 50G and 100G using fixed frames (up to 16000 bytes) or EMIX<br>• Round-trip latency measurements with pass/fail verdict up to 100G<br>• Dual-port Ethernet testing capabilities from 10M to 100G, including 25G, 40G and 50G<br>• 100 GigE through mode testing<br>• RFC 2544, including throughput, back-to-back, latency and frame loss with dual test set for bidirectional measurements<br>• EtherSAM (ITU-T Y.1564) with dual test set for bidirectional measurements<br>• RFC 6349: Performs TCP testing with single or multiple TCP connections from 10BASE-T up to 100G; discovers the MTU, RTT, actual and ideal TCP throughput; user can apply suggested window size boost factor to optimize test results or perform multiple client iPerf tests against the RFC 6349 iPerf Server mode of operation<br>• Simplified ITU-T Y.1564 test that performs service configuration and service performance tests using remote loopback or dual test set mode for bidirectional results; an additional, completely automated RFC 6349 test can be run in conjunction with the EtherSAM (Y.1564) tests, or on its own to perform layer-4 TCP testing, with the inclusion of discovering the maximum transmission unit (MTU) and round-trip time (RTT), as well as the actual and ideal TCP throughput of the circuit under test<br>• Dual test set mode<br>• Layer-2 control protocol testing offers the most complete set of predefined L2 protocols in the industry (38 different protocols including all MEF 45 and CISCO L2CP frames) in addition to 8 user-defined protocols<br>• Intelligent autodiscovery of EXFO modules or third-party devices allowing single user to perform end-to-end testing by looping up and looping down remote devices (EXFO and 3rd party units) up to layer 4.<br>• Traffic generation and shaping of up to 16 streams of Ethernet and IP traffic, and monitoring of throughput, latency, packet jitter, frame loss and out-of-sequence<br>• Q-in-Q capability with the ability to go up to three layers of stacked VLANs<br>• VLAN CoS and ID preservation<br>• Discover up to three levels of VLAN tagged traffic (C-/S-/E-VLAN) including their ID and priority, as well as the total VLAN tagged frame count and associated bandwidth<br>• Ping and traceroute functions; user can configure up to 1000 ping messages<br>• Advanced filtering capability for in-depth network troubleshooting<br>• Smart loopback<br>• Flow control injects or monitors pause frames, including frame counts of pause, abort frames and total, last, maximum and minimum pause time<br>• IPv6 protocol generation and analysis<br>• Service disruption time (SDT)<br>• Ethernet MAC flooding<br>• Frame size sweep |
| Synchronization | • Validates 1588 PTP packet network synchronization services, emulates PTP clients, and generates and analyzes messages between master/clients, clock quality level and IPDV<br>• Validates SyncE frequency, ESMC messages and clock quality levels<br>• Ability to perform time error analysis and wander measurement; evaluation if the signal under test meets multiple standardized masks (MTIE, TDEV)<br>• Ability to perform packet-based time error analysis for 1G and 10G LAN optical ports |
| MPLS | Generates and analyzes streams with up to two layers of labels |
| Carrier Ethernet OAM | Fault-management and performance-monitoring Ethernet and MPLS-TP OAM protocols, including Y.1731, 802.1ag, MEF, Link OAM (802.3ah) and G.8113.1 OAMs |
| Advanced filtering | Ability to configure up to 10 filters, each with four fields that can be combined with AND/OR/NOT operations; a mask is also provided for each field value with IPv4 and IPv6 capabilities |
| Packet capture | • Ethernet packet capture up to 4 Mbit, depending on the rate<br>• Configurable triggers including errors and header fields<br>• Data capture in packet capture (PCAP) format; read through Wireshark |

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Specifications and descriptions are subject to change without prior notice. Spezifikationen und Beschreibungen können sich ohne Vorankündigung ändern.

Opternus

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## KEY FEATURES (CONT'D)

| | |
|---|---|
| OTN testing | • OTU4 (112 Gbit/s), OTU3 (43 Gbit/s), OTU3e1 (44.57 Gbit/s), OTU3e2 (44.58 Gbit/s), OTU2 (10.71 Gbit/s), OTU2e (11.10 Gbit/s), OTU2f (11.32 Gbit/s), OTU1 (2.67 Gbit/s),  OTU1e (11.05 Gbit/s) and OTU1f (11.27 Gbit/s) unframed and framed BER tests<br>• FEC testing: error insertion and monitoring<br>• OTL 3.4 and 4.4: alarm and error generation and monitoring<br>• OTL lane mapping, skew generation and measurement<br>• OTU, ODU, OPU overhead manipulation and monitoring<br>• OTU, ODU (including ODU TCM), OPU layer alarm/error generation and analysis<br>• OTU, ODU (including ODU TCM) trace messages<br>• Round-trip delay (RTD) measurement<br>• OTN SDT measurement<br>• OTN through and OTN intrusive through mode testing<br>• Multiplexing/demultiplexing of ODU13, ODU23, ODU123, ODU03, ODU013, ODU0123, ODU04, ODU014, ODU134, ODU24, ODU234, ODU34, ODU14, ODU01234, ODU0124, ODU12, ODU024, ODU034, ODU1e4, ODUflex24, ODU2e4 and ODU124, ODU1234 with PRBS pattern and GigE and 10 GigE client mappings into OPU payloads. ODUflex at ODU2, ODU3 and ODU4 rates with full flexibility to configure the required bandwidth based on n x 1.25 Gbit/s tributary time slots with a PRBS pattern into the ODUflex payload; 40 GigE client mapping into ODU3 into ODU4<br>• Performance monitoring: G.821, M.2100<br>• Frequency analysis and offset generation including frequency sweep<br>• Power OTN OH analysis for BERT and synchronization testing of multiple fields in the OTN OH, including GCC0/1/2 |
| Multichannel OTN and mixed mapping testing | • 100G OTN validation of individual channel connectivity<br>• Support for mixing and mapping of ODU0, ODU1, ODU2, or ODU3 data containers into an ODU4 container<br>• Alarm/error monitoring<br>• Single alarm/error injection on one single channel or on all channels at one time<br>• Concurrent OTN BERT analysis<br>• Simultaneous channelized SDT measurement<br>• Flexible channel/tributary slot selection |
| Ethernet mapping over OTN | • Ethernet mapping over OTN respectively, with GMP support<br>• 40G transcoding capability with alarms, errors and statistics<br>• GMP alarms, errors and statistics<br>• GigE mapping into ODU0 using GFP-T, 10 GigE mapping into ODU2 using GFP-F, direct 10 GigE mappings into ODU1e/2e in different ODU multiplexing structures, and 40 GigE client mapped into ODU3/ODU4<br>• Flexibility to map up to a 10G Ethernet client signal into ODUflex |
| SONET/SDH mapping over OTN | • OC-768/STM-256 mapping in ODU3<br>• OC-192/STM-64 mapping in ODU2<br>• OC-48/STM-16 mapping in ODU1<br>• OC-12/STM-4 and OC-3/STM1 mapping in ODU0 |
| SONET/SDH testing | • PRBS pattern payload generation and analysis down to STS-1/AU-3 granularity<br>• High-order mappings: STS-1/3c/12c/48c/192c and AU-3/AU-4/AU-4-4c/16c/64c<br>• Section/RS, Line/MS and high-order (STS/AU) path overhead manipulation and monitoring<br>• Section/RS, Line/MS and high-order (STS/AU) path alarm/error generation and monitoring<br>• Single, rate and burst error insertion modes<br>• High-order (STS/AU) pointer generation and monitoring<br>• Performance monitoring: G.821, G.828, G.829, M.2100, M.2101<br>• Frequency analysis and offset generation<br>• Automatic protection switching (APS) and SDT measurements<br>• Round-trip delay (RTD) measurements<br>• Tandem connection monitoring |
| Fronthaul | • CPRI layer-2 link validation for BBU or RRH from 1.2G to 24.3G. CPRI option 10 (24.3G) can be tested with either SFP28 or QSFP28 on the FTBx-88260.<br>• OBSAI layer-2 link validation for BBU or RRH from 1.5G to 6.1G<br>• BBU emulation allowing RF level validation of RRHs, RET status and control and remote SFP identification<br>• eCPRI BER testing: unframed and framed L2/3/4 BER measurement, bit error injection, one-way/round-trip delay measurement, QoS metrics and Pass/Fail verdict for 10G/25G rates. eCPRI 25G can be tested with either SFP28 or QSFP28 on the FTBx-88260.<br>• iORF: intelligent spectrum analysis over CPRI. Automated analysis and detection of interference and PIM issues at the push of one button |
| OpticalRF™ | The most powerful real-time high-resolution RF spectrum analysis over CPRI. Quickly identify issues such as RF interference and passive intermodulation (PIM) from the BBU site |
| Remote access | Supported via EXFO Remote ToolBox, EXFO Multilink, VNC or Web VNC |
| Report generation | Test reports generated in PDF and HTML formats. Reports are easily customizable and can be automatically generated at the conclusion of each test. |

## LASER SAFETY

LASER 1 — Complies with FDA 1040.10 and IEC 60825-1:2014

Laser Class 1 applies only to modules and their TAs and which may vary from that of platform

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# FUNCTIONAL SPECIFICATIONS

## 40G/100G PHYSICAL-LAYER FUNCTIONAL SPECIFICATIONS

| PHYSICAL LAYER | |
|---|---|
| **40GE/100GE** | |
| CAUI-4/XLAUI alarms | LOS, LOC lane, frequency |
| PCS lane alarms | LOBL, LOAML, excessive skew |
| PCS lane errors | Block error, invalid marker, PCS BIP-8 |
| Per-lane skew insertion | Range = 0 to 4095 for 40GE<br>Range = 0 to 2047 for 100GE |
| **OTU3/OTU3e1-e2/OTU4** | |
| Physical-lane alarms | LOS, LOC lane, frequency |
| Logical-lane alarms | LOF, OOF, LOL, LOR, OOR, excessive skew, LOL global alarm |
| Logical-lane errors | OTN BIP-8, PCS BIP-8, PCS BIP-8 error mask |
| Per-lane skew insertion | Range = 0 to 4095 for OTU3/OTU3e1/e2<br>Range = 0 to 2047 for OTU4 |
| **Additional functions** | |
| Power measurements | Allows users to measure the transmitted and received optical power per wavelength in the parallel optics being used |
| Frequency measurements | Allows users to measure the received frequency per wavelength in the parallel optics being used |
| Frequency offset (min./max.) | ±120 ppm for 40GE and 100GE<br>±50 ppm for OTU3, OTU3e1/e2 and OTU4<br>±115 ppm for Ethernet client mapping into ODU3 and ODU4 multiplexing schemes<br>Frequency offset sweep |
| PCS logical lane mapping | Manual and random |
| MDIO read/write | Full MDIO and I2C read/write access for CFP and QSFP |
| RS-FEC Support | Enable Ethernet FEC capabilities with alarms and error monitoring |

## ETHERNET FUNCTIONAL SPECIFICATIONS

| 40GE/100GE UNFRAMED BER TEST | |
|---|---|
| Line rates | 103.125 Gbit/s and 41.25 Gbit/s |
| Pattern configuration | 4 unframed physical lanes (CAUI-4), 10 unframed physical lanes (CAUI), 4 unframed physical lanes (XLAUI), and 20 unframed logical lanes (PCS) |
| Patterns | PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1, square waves |
| Error injection configuration | Single, rate and continuous |
| Error measurement | Mismatch 0, Mismatch 1, bit error count and rate |

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## 40G/100G ETHERNET (IEEE 802.3 - 2018)

| | |
|---|---|
| Standards compliance | IEEE 802.3 - 2018 |
| Line rates | 103.125 Gbit/s and 41.25 Gbit/s |
| Framing | Framed and unframed |
| Power measurement | Optical channel power measurement with color indicators |
| Frequency measurement | Clock frequency measurements displayed in Hz |
| EtherSAM (ITU-T Y.1564) | Performs service configuration and service performance tests as per ITU-T Y.1564, including excess burst size (EBS) and committed burst size (CBS), and can be performed using remote loopback or dual test set mode for bidirectional results, including VLAN preservation for monitoring and analysis of VLAN priority CoS and ID |
| Layer 2 transparency testing | Layer-2 control protocol testing offers the most complete set of predefined L2 protocols in the industry (38 different protocols including all MEF 45 and CISCO L2CP frames) in addition to 8 user-defined protocols. Users can define results per direction and obtain bidirectional independent test verdicts. |
| iSAM | Simplified ITU-T Y.1564 test that performs service configuration and service performance tests using remote loopback or dual test set mode for bidirectional results; an additional, completely automated RFC 6349 test can be run in conjunction with the EterSAM (Y.1564) tests, or on its own to perform layer 4 TCP testing, with the inclusion of discovering the maximum transmission unit (MTU) and round-trip time (RTT), as well as the actual and ideal TCP throughput of the circuit under test |
| RFC 2544 | Throughput, back-to-back, frame loss and latency measurements according to RFC 2544; frame size: RFC-defined or user-configurable |
| Dual test set | Complementing RFC 2544, RFC 6349 and EtherSAM (ITU-T Y.1564) for bidirectional measurements, including one-way latency |
| Intelligent auto-discovery | Offers intelligent auto-discovery of other EXFO modules or third-party devices, allowing single user to perform end-to-end testing by looping up and looping down remote devices (EXFO and third-party units) up to layer 4. |
| Smart loopback | Traffic return to the local unit by swapping packet overhead up to layer 4 of the OSI stack |
| BERT | Unframed and framed up to layer 4, with or without VLAN Q-in-Q, using fixed frames (up to 16000 bytes) or EMIX; round-trip latency measurement with pass/fail verdict |
| Dual port | Dual-port testing capabilities up to 100G |
| Layer 2/3/4 header | IP, MAC, UDP source/destination addresses |
| Patterns | PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1, Square Pattern and user-configurable pattern |
| Traffic generation and monitoring | Traffic generation and shaping of up to 16 streams of Ethernet and IP traffic, including the simultaneous monitoring of throughput, frame loss, packet jitter, latency and out-of-sequence frames, including MAC flooding for source and destination MAC addresses |
| Frame size | Fixed (from 64 to 16 000 bytes), Random and Sweep (from 64 to 16 000 bytes) |
| Framing | IEEE 802.3 SNAP and Ethernet II frame format testing |
| IFG | Tx minimum IFG value of 8, 9, 10, 11, 12 |
| Rx frame-size analysis | < 64, 64, 65-127, 128-255, 256-511, 512-1023, 1024-1518 and > 1518 |
| Rx rate | Line utilization (%), Ethernet BW (Mbit/s), frame rate (frame/s) and frame count |
| Traffic scan | Discover multiple levels of VLAN channels (C-/S-/E-VLAN) including their ID and priority, as well as the total VLAN tagged frame count and associated bandwidth |
| VLAN stacking | Capability to generate one stream with up to three layers of VLAN (including IEEE 802.1ad Q-in-Q tagged VLAN) |
| VLAN preservation | Monitoring and analysis of VLAN information presentation including VLAN priority CoS and ID |
| RFC 6349 | Performs TCP testing with single or multiple TCP connections from 10BASE-T up to 100G; discovers the MTU, RTT, actual and ideal TCP throughput; user can apply suggested window size boost factor to optimize test results |
| RFC 6349 Interop with iPerf client | RFC 6349 can be tested through the network using the transport and datacom module and multiple iPerf clients. |
| RFC 6349 Interop with BV-3100 | RFC 6349 can be tested through the network using the transport and datacom module and the BV-3100 Verifier, including the ability to use interop mode through NAT-enabled networks. |
| MPLS testing | Generates and analyzes streams with up to two layers of labels |
| 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 |
| Packet jitter statistics | Delay variation statistics (ms): minimum, maximum, current, average and jitter measurement estimate (RFC 3393) |
| Rx valid frame count | Multicast, broadcast, unicast, non-unicast and total valid count |
| IP error analysis | IP checksum |
| Ethernet alarms | Link down, local fault detected, local fault received, remote fault, LOA, Hi-BER, invalid mapping |
| Per-lane alarms | LOS, LOC-lane, frequency, excessive skew, LOBL, LOAML |
| Ethernet errors | FCS, jabber, runt, undersize, oversize |
| Per-lane errors | Block error, invalid marker, PCS BIP-8 |
| Higher-layer error analysis | UDP and TCP checksum |

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## 40G/100G ETHERNET (IEEE 802.3 - 2018) - (CONT'D)

| | |
|---|---|
| Error injection mode | Manual, rate and continuous (maximum rate) |
| Ethernet through mode | Sectionalizes traffic between a service provider's network and customer premises equipment up to 100G |
| Flow control | Injects or monitors pause frames, including frame counts of pause, abort frames and total, last, maximum and minimum pause time |
| Traffic filtering | Incoming traffic analysis and statistics can be enhanced with 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 |
| Advanced filtering | Includes: four fields that can be combined with logic operators AND/OR/NOT; a mask field that allows the use of wildcards; complete statistics gathered for each defined filter |
| Data capture | Full-line-rate data capture and decoding at up to 100G; configuration of detailed capture filters and triggers, as well as capture slicing parameters |
| IP tools | Ping and traceroute functions; user can configure up to 1000 ping messages |
| IPv6 testing | Performs the following tests up to 100G over IPv6: EtherSAM, RFC 2544, BERT, traffic generation and monitoring, intelligent autodiscovery, ping and traceroute |
| Service disruption time (SDT) | Service disruption time measurements based on no traffic mode, with statistics including longest disruption time, shortest, last, average, count, total, and pass/fail thresholds |
| FlexE G.mtn path OAM (pre-standard version) | Support of CC function status, connectivity verification, bidirectional delay measurement and CS type monitoring |

## ETHERNET TEST FEATURES AT 25G/50G

| | |
|---|---|
| Standards compliance | IEEE 802.3 - 2018 |
| Line rate | 25.78125 Gbit/s and 53.125 Gbit/s |
| Power measurement | Optical channel power measurement with color indication |
| Frequency measurement | Clock frequency measurements displayed in Hz |
| RFC 2544 (25 Gbit/s) | Throughput, back-to-back, frame loss and latency measurements according to RFC 2544; frame size: RFC-defined sizes, user can choose up to ten frame sizes |
| Dual test set (25 Gbit/s) | Complements RFC 2544 for bidirectional measurements |
| Intelligent autodiscovery | Offers intelligent autodiscovery of other EXFO modules or third-party devices, allowing single user to perform end-to-end testing by looping up and looping down remote devices (EXFO and 3rd party units) up to layer 4. |
| Smart loopback | Traffic return to the local until by swapping packet overhead up to layer 4 in OSI stack |
| BERT | Unframed and framed up to layer 4, with or without VLAN Q-in-Q, using fixed frames (up to 16000 bytes) or EMIX; round-trip latency measurement with pass/fail verdict |
| Unframed BERT | Support for unframed BERT testing including PRBS31 unscrambled |
| Dual port capabilities | Dual port testing capabilities |
| Layer 2/3/4 header | IP/MAC and UDP source and destination addresses |
| Patterns | PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1 and user pattern |
| Traffic generation and monitoring (25 Gbit/s) | Traffic generation and shaping of up to 16 streams of Ethernet and IP traffic at 25 Gbit/s, including the simultaneous monitoring of throughput, out-of-sequence frames, frame loss, packet jitter and latency, including MAC flooding for source and destination MAC addresses |
| Frame size | Fixed (from 64 to 16 000 bytes), random and sweep (from 64 to 16 000 bytes) |
| Framing | Ethernet II frame format testing |
| IFG | TX minimum IFG value of 8 |
| Rx frame-size analysis | < 64, 64, 65-127, 128-255,256-511, 512-1023, 1024-1518 and > 1518 |
| VLAN stacking | Capability to generate up to three layers of VLAN (including IEEE 802.1ad Q-in-Q tagged VLAN) per stream |
| MPLS testing (25 Gbit/s) | Generates and analyzes streams with up to two layers of labels |
| 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 |
| Packet jitter statistics (25 Gbit/s) | Delay variation statistics (ms):minimum, maxium, current, average and measurement estimate (RFC 3393) |
| Rx valid frame count | Multicast, broadcast, unicast, non-unicast and total valid count |
| IP error analysis | IP checksum |
| Ethernet alarms | Link down, local fault detected, local fault received, remote fault, LOA, Hi-BER |
| Ethernet errors | Block, FCS, jabber, runt, undersize, oversize |

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## ETHERNET TEST FEATURES AT 25G/50G - (CONT'D)

| | |
|---|---|
| Error injection mode | Manual, rate and continuous (maximum rate) |
| Flow control | Injects or monitors pause frames, including frame counts of pause, abort frames and total, last, maximum and minimum pause time |
| Traffic filtering | Incoming traffic analysis and statistics can be enhanced with 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 |
| Advanced filtering | Including four fields that can be combined with logic operators AND/OR/NOT; a mask field that allows the use of wildcards; complete statistics are gathered for each defined filter |
| Data capture | Full line-rate data capture and decoding up to 50G; configuration of detailed capture filters and triggers, as well as capture slicing parameters |
| IP tools | Ping and traceroute functions; user can configure up to 1000 ping messages |
| Service disruption time (SDT) | Service disruption time measurement based on no traffic mode, with statistics including disruption time, shortest, last, average, count, total and pass/fail thresholds |
| Pass/fail verdict | Provides a pass/fail outcome with user-adjustable thresholds, based on bit error rate and/or service disruption time |
| 50G FEC analysis | PAM4 RS-FEC generation and analysis with statistics and FEC distribution |

## ETHERNET TEST FEATURES UP TO 10G

| | |
|---|---|
| EtherSAM (ITU-T Y.1564) | Performs service configuration and service performance tests as per ITU-T Y.1564 including EBS, CBS, EMIX and VLAN preservation; use remote loopback or dual test set mode for bidirectional results |
| iSAM | Simplified ITU-T Y.1564 test that performs service configuration and service performance tests using remote loopback or dual test set mode for bidirectional results; an additional, completely automated RFC 6349 test can be run in conjunction with the EtherSAM (Y.1564) tests, or on its own to perform layer 4 TCP testing, with the inclusion of discovering the maximum transmission unit (MTU) and round-trip time (RTT), as well as the actual and ideal TCP throughput of the circuit under test |
| RFC 2544 | Throughput, back-to-back, frame loss and latency measurements according to RFC 2544; frame size: RFC-defined sizes, user can choose up to ten frame sizes |
| Dual test set mode | Complementing RFC 2544, RFC 6349 and EtherSAM (ITU-T Y.1564), for bidirectional measurements, including one-way latency |
| Intelligent autodiscovery | Offers intelligent autodiscovery of other EXFO modules or third-party devices, allowing single user to perform end-to-end testing by looping up and looping down remote devices (EXFO and 3rd-party units) up to layer 4. |
| Traffic generation and monitoring | Traffic generation and shaping of up to 16 streams of Ethernet and IP traffic, including the simultaneous monitoring of throughput, frame loss, packet jitter, latency and out-of-sequence frames, including MAC flooding for source and destination MAC addresses |
| BER testing | Up to layer 4 supported with or without VLAN Q-in-Q, using fixed frames (up to 16000 bytes) or EMIX; round-trip latency measurement with pass/fail verdict |
| Patterns (BERT) | PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1 and one user pattern; capability to invert patterns |
| Frame size | Fixed (from 64 to 16 000 bytes), random and sweep (from 64 to 16 000 bytes) |
| 10 GigE LAN patterns | Seed A, seed B, PRBS 31 unscrambled |
| Error measurement (BERT) | Bit error, bit mismatch 0, bit mismatch 1 |
| Traffic scan | Discover multiple levels of VLAN channels (C-/S-/E-VLAN) including their ID and priority, as well as the total VLAN tagged frame count and associated bandwidth |
| VLAN stacking | Generates up to three levels of VLAN (including IEEE 802.1ad and Q-in-Q tagged VLAN |
| VLAN preservation | Validates that the CE-VLAN tags and ID, which are part of classes of service (CoS), are passed transparently |
| Remote discovery tool | Allows you to discover source MAC addresses, VLAN IDs, source IPv6 and IPv4 addresses for single or cascaded 5G NR radios |
| MPLS | Generates and analyzes streams with up to two layers of MPLS labels |
| Service disruption time (SDT) | Service disruption time measurements based on no traffic mode, with statistics including longest disruption time, shortest, last, average, count, total, and pass/fail thresholds |
| IPv6 testing | Performs the following tests up to 10G over IPv6, EtherSAM, RFC 2544, BERT, traffic generation and monitoring, through mode, intelligent autodiscovery, ping and traceroute |
| 10 GigE WAN testing | Includes the WAN interface sublayer, J0/J1 trace and C2 label generation and monitoring |
| 10 GigE WAN alarm monitoring | Includes SEF, LOF, AIS-L, RDI-L, AIS-P, RDI-P, LCD-P, LOP-P, PLM-P, UNEQ-P, ERDI-P, WIS link down, B1, B2, B3, REI-L, REI-P |
| TCP throughput | True wire-speed, stateful TCP throughput test based on RFC 6349 for undisputable SLA enforcement of Ethernet services |
| RFC 6349 | Performs TCP testing with single or multiple TCP connections from 10BASE-T up to 100G; discovers the MTU, RTT, actual and ideal TCP throughput; user can apply suggested window size boost factor to optimize test results |
| Error measurement | Jabber/giant, runt, undersize, oversize, FCS, symbol, alignment, collision, late collision, excessive collision, IP checksum, UDP checksum, TCP checksum and 10G block error |
| Alarm detection | LOS, link down, pattern loss, frequency, LOC, 10G local/remote fault |
| Flow control statistics | Injects or monitors pause frames, including frame counts of pause, abort frames and total, last, maximum and minimum pause time |

**EXFO**

## ETHERNET TEST FEATURES UP TO 10G - (CONT'D)

| | |
|---|---|
| G.8265.1 1588 PTP | Validates 1588 PTP packet network synchronization services, emulates PTP clients, and generates and analyzes messages between master/clients, clock quality level and IPDV |
| G.8275.1 and G.8275.2 1588 PTP | Precision-time-protocol profile for phase and time synchronization with network full-timing support |
| SyncE | Validates SyncE frequency, ESMC messages and clock quality levels |
| Time Error/Wander | Ability to perform time error analysis and wander measurement; evaluation if the signal under test meets multiple standardized masks (MTIE, TDEV)<br>Ability to perform packet-based time error analysis for 1G and 10G LAN optical ports<br>Ability to perform Wander measurement at 10/100/1000BASE-T, 100M optical, 1GE optical and 10G optical<br>Ability to perform Time Error measurement at 1 PPS |
| Carrier Ethernet OAM | Fault-management and performance-monitoring Ethernet and MPLS-TP OAM protocols, including Y.1731, 802.1ag, MEF, Link OAM (802.3ah), and G.8113.1 OAMs; addresses metro Ethernet networks; supports continuity check, loopback, link trace, test, frame delay, frame loss and synthetic loss functions, and AIS, CSF, RDI, and LCK alarm generation and monitoring |
| Traffic filtering | Incoming traffic analysis and 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 |
| Advanced filtering | Ability to enhance the filters with up to four fields each, which can be combined with and/or/not operations; a mask is also provided for each field value to allow for wild cards; complete statistics are gathered for each defined filter |
| Data capture | Full line-rate data capture and decoding at up to 10G; configuration of detailed capture filters and triggers, as well as capture slicing parameters |
| IP tools | Performs ping and traceroute functions; user can configure up to 1000 ping messages |
| Smart loopback | Return Ethernet traffic to the local unit by swapping packet overhead up to layer 4 |
| Cable testing | Category 5 cable (or better), 100 UTP/STP cable, ≤120 meters |
| Pass/fail verdict | Provides a pass/fail outcome with user-adjustable thresholds, based on bit error rate and/or service disruption time |
| Dual port | Dual port testing with EtherSAM (ITU-T Y.1564), RFC 2544, EtherBERT and traffic generation and monitoring when using 10/100/1000BASE-T, 100BASE-X, GiGE and 10 GiGE |
| EoE/PBB-TE | Validates EoE and PBB-TE encapsulations |
| Tunable SFP+ | Support of tunable SFP+ transceivers offering ITU-T grid wavelength configuration and complete validation testing with iOptics. The wavelength configuration of these transceivers is available in all test applications. |

## Flex ETHERNET

| | |
|---|---|
| Compliance | Compliant with OIF, FlexE 2.0 |
| Interface support | Two QSFP28 ports to configure FlexE traffic up to 200GE |
| RS-FEC support | RS-FEC capabilities per port |
| Skew monitoring | Graphical skew monitoring per port |
| Skew insertion | Per-port skew generation and measurement range 0 to 10000 ns |
| PHY number | FlexE PHY number per port edition available |
| Group number | FlexE group number edition available |
| Client | Client ID and MAC address edition available per client |
| Calendar type | Calendar A/B configuration and monitoring |
| Calendar edition | Graphical calendar configuration per slot/client/clients for FlexE bonding, sub-rate and channelization |
| Clients available | Different client configuration included 5GE, 10GE, 25GE, 40GE, 50GE, 100GE |
| Ports capacity | Display the calendar used, unused and assigned capacity in Gbit/s |
| Client statistics | Size, TX and RX rate in Gbit/s, frame count |

**EXFO**

Specifications and descriptions are subject to change without prior notice. Spezifikationen und Beschreibungen können sich ohne Vorankündigung ändern.

Opternus

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## Flex ETHERNET - (CONT'D)

| | |
|---|---|
| BERT | Selectable FlexE client bit error rate analysis using a specific pattern |
| BER error injection | Manual, rate and continuous (maximum rate) |
| Error/alarms monitoring and injection | Per port FlexE PHY, per FlexE group and per client |
| FlexE overhead | Display a detail overview from block 1 to 8 per frame from the FlexE overhead for TX and RX |
| FlexE G.mtn path 0AM (pre-standard version) | Support of CC function status, connectivity verification, bidirectional delay measurement and CS type monitoring |

## FRONTHAUL

| | |
|---|---|
| iORF | Intelligent spectrum analysis over CPRI. Automated analysis and detection of interference and PIM issues at the push of one button |
| eCPRI BERT | Unframed and framed L2/3/4 BER measurement, bit error injection, one-way/round-trip delay measurement, QoS Metrics and Pass/Fail Verdict for 10G/25G/100G rates. The 25G eCPRI rate is available with the FTBx-88260, the user can select either SFP28 or QSFP28 interface. |
| CPRI BERT | Includes unframed and framed BER measurement, bit error injection, round-trip delay measurement, and pass/fail verdict for 1.2 to 24.3 Gbit/s rates. CPRI option 10 (24.3G) is available with the FTBx-88260, the user can select either SFP28 or QSFP28 interface. |
| CPRI/OBSAI layer 2 protocol testing | Supports BTS and RRH links validation by supporting start-up sequence states, autodetection of protocols, negotiated parameters for control and maintenance, Ethernet and HDLC channels, hyperframe and codeword counts, injection, and monitoring of layer-1 alarms and frequency |
| CPRI SDT | Measurements in milliseconds (ms) for the longest, shortest, last, average, total and count of disruptions |
| DP-CPRI | Enable dual-port CPRI testing capability |
| OBSAI BERT | Enable 1.5 Gbit/s, 3.1 Gbit/s and 6.1 Gbit/s |
| OpticalRF™ | The most powerful real-time high-resolution RF spectrum analysis over CPRI. Quickly identify issues such as RF interference and passive intermodulation (PIM) from the BBU site |

**EXFO**

# OTN FUNCTIONAL SPECIFICATIONS

## 40G/100G OTN UNFRAMED BER TEST

| | |
|---|---|
| Line rates | OTU4 (112 Gbit/s), OTU3 (43 Gbit/s), OTU3e1 (44.57 Gbit/s) and OTU3e2 (44.58 Gbit/s) |
| Pattern configuration | 10 unframed physical lanes, 4 unframed physical lanes, and 20 unframed logical lanes |
| Patterns | PRBS 2E9-1, PRBS 2E11-1, PRBS 2E15-1, PRBS 2E20-1, PRBS 2E23-1, PRBS 2E31-1, square waves |
| Error injection configuration | Single, rate and continuous |
| Error measurement | Mismatch 0, mismatch 1, bit error count and rate |

## 40G/100G OTN

| | | |
|---|---|---|
| **OTN interfaces** | Standards compliance | ITU-T G.709, G.798, G.872 and ITU-T G series Supplement 43 |
| | Line rates | OTU3 (43 Gbit/s), OTU3e1 (44.57 Gbit/s), OTU3e2 (44.58 Gbit/s), OTU4 (111.81 Gbit/s) |
| | Power measurement | Optical channel power measurement with color indicators |
| | Frequency measurement | Clock frequency measurements displayed in Hz |
| | Frequency offset | Offsetting of the transmitted signal's clock on a selected interface, and monitoring to exercise clock recovery circuitry on network elements |
| **OTL layer** | Errors per lane | Invalid marker, FAS |
| | Alarms per lane | OOF, LOF, LOR, OOR, excessive skew |
| | Global alarm | LOL |
| **OTU layer** | Errors | OTU-FAS, OTU-MFAS, OTU-BEI, OTU-BIP-8 |
| | Alarms | LOF, OOF, LOM, OOM, OTU-TIM, OTU-BDI, OTU-IAE, OTU-BIAE, OTU-AIS |
| | Traces | 64-byte 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, ODU-LOFLOM |
| | Traces | 64-byte trail trace identifier (TTI) as defined in ITU-T G.709 |
| | FTFL | Fault type and fault location byte; as defined in ITU-T G.709 standard |
| **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-byte trail trace identifier (TTI) as defined in ITU-T G.709 |
| **OPU layer** | Alarms | OPU-PLM, OPU-CSF, OPU-AIS, OPU-MSIM, OPU LOOMFI, OOMFI, OMFI [a] |
| | Payload type | Generates and displays received PT value |
| **Forward error correction (FEC)** | Errors | Generation and analysis of FEC correctable and uncorrectable errors |
| **Ethernet mapping over OTN** | | 40G and 100G Ethernet mapping over OTU3 and OTU4, respectively, using GMP |
| | | 40G transcoding capability with alarms, errors and statistics |
| | | GMP alarms, errors and statistics |
| | | GigE mapping into ODU0 using GFP-T, 10 GigE mapping into ODU2 using GFP-F, direct 10 GigE mappings into ODU1e and ODU2e in different ODU multiplexing structures |
| | | 40GE into OTU3 into OTU4 |
| | | Flexibility to map up to a 10G Ethernet client signal into ODUflex |
| **40GE transcoding** | Errors | Invalid flag, POS violation, MSEQ violation, PCS-BIP-8 mask per lane, PCS-BIP-8 per lane, OTN-BIP-8 per lane, SEQ violation |
| | Alarms | LOBL 1027B, Hi-BER 1027B, LOAML 1027B |
| **GMP** | Errors | Cm CRC-8, CnD CRC-5 |
| | Alarms | GMP OOS [a] |
| | Statistics | Cm minimum/maximum values and CnD minimum/maximum values for both GMP Tx and Rx |

a. Alarm analysis only.

**EXFO**

## 40G/100G OTN (CONT'D)

| | | |
|---|---|---|
| **ODU3/ODU4 multiplexing** | Mappings | ODU13, ODU23, ODU123, ODU03, ODU013, ODU0123, ODU04, ODU014, ODU134, ODU24, ODU234, ODU34, ODU14, ODU01234, ODU0124, ODU024, ODU034, ODU1e4, ODUflex24, ODU2e4 and ODU124, ODU1234 with PRBS pattern and GigE, 10 GigE, 40 GigE and 100 GigE client mappings into OPU payloads |
| | Alarms | ODU34, ODU14, ODU01234, ODU0124, ODU024, ODU034, ODU1e4, ODUflex24, ODU2e4 and ODU124, ODU1234 with PRBS pattern and GigE and 10 GigE client mappings into OPU payloads |
| | Clients | SONET/SDH, GigE, 10 GigE, 40 GigE and 100 GigE client mappings into OPU payloads |
| | ODU0 | ODU0 (1.25 Gbit/s) container with Gigabit Ethernet, SONET/SDH client signal mapping and PRBS pattern |
| | ODUflex | ODUflex at ODU3 and ODU4 rates with full flexibility to configure the required bandwidth based on n x 1.25 Gbit/s tributary time slots with a PRBS pattern into the ODUflex payload |
| **Multichannel OTN and mixed mapping testing** | | 100G OTN validation of individual channel connectivity |
| | | Support for mixing and mapping of ODU0, ODU1, ODU2, or ODU3 data containers into an ODU4 container |
| | | Alarm/error monitoring |
| | | Single alarm/error injection on one single channel or on all channels at one time |
| | | Concurrent OTN BERT analysis |
| | | Simultaneous channelized SDT measurement |
| | | Flexible channel/tributary slot selection |
| **GFP-F/T** | Errors | GFP-cHEC-CORR, GFP-cHEC-UNCORR, GFP-tHEC-CORR, GFP-tHEC-UNCORR, GFP-eHEC-CORR, GFP-eHEC-UNCORR, GFP-pFCS |
| | Alarms | GFP-LFD, GFP-EXM, GFP-UPM, GFP-DCI, GFP-FDI, GFP-RDI, GFP-LOCS, GFP-LOCCS, GFP-reserved CMF |
| | Frame type statistics | Client data, client management, idle, reserved PTI, reserved PLI, invalid, discarded |
| | Rx mismatch | PFI, EXI, UPI, CID |
| | GFP-T superblock statistics | Valid, invalid and total |

## OTN TEST FEATURES UP TO 10G

| | | |
|---|---|---|
| **OTN** | Standards compliance | ITU-T G.709, ITU G.798, ITU G.872 |
| | Interfaces | OTU1 (2.6660 Gbit/s), OTU2 (10.7092 Gbit/s), OTU1e (11.0491 Gbit/s), OTU2e (11.0957 Gbit/s), OTU1f (11.2701 Gbit/s), OTU2f (11.3176 Gbit/s) |
| **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-byte 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-byte 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, ODU-LOFLOM |
| | Traces | 64-byte trail trace identifier (TTI), as defined in ITU-T G.709 |
| | FTFL | As defined in ITU-T G.709 |
| **OPU layer** | Alarms | OPU-PLM, OPU-AIS, OPU-CSF, OPU-MSIM |
| | 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) |

**EXFO**

## OTN TEST FEATURES UP TO 10G - (CONT'D)

| | | |
|---|---|---|
| **Ethernet mapping over OTN** | 1G and 10G Ethernet mapping over ODU0 and OTU1/2, with alarms, errors and statistics | |
| | GigE mapping into ODU0 using GFP-T | |
| | 10 GigE mapping into ODU2 using GFP-F | |
| | Direct 10 GigE mappings into ODU1e and ODU2e | |
| | Flexibility to map up to a 10G Ethernet client signal into ODUflex | |
| **ODU multiplexing** | Single/multistage multiplexing | ODU0, ODU1, ODUflex |
| **Pattern** | Patterns | 2E-9, 2E-15, 2E-20, 2E-23, 2E-31, NULL, 32-bit programmable (inverted or noninverted) |
| | Error | Bit error |
| | Alarm | Pattern loss |

## ADDITIONAL OTN FUNCTION

| | |
|---|---|
| Frequency measurements | Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency), displayed in ppm; measurements are performed using an internal oscillator |
| Frequency offset generation | Supports offsetting the clock of the transmitted signal on a selected interface to exercise clock recovery circuitry on network elements |
| Performance monitoring | The following ITU-T recommendations and corresponding performance-monitoring parameters are supported:<br><br>**ITU-T recommendation**      **Performance-monitoring statistics**<br>G.821      ES, EFS, EC, SES, UAS, ESR, SESR, DM<br>M.2100      ES, SES, UAS |
| 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 active channels to backup channels<br><br>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 transmitter back to its receiver after crossing a far-end loopback; measurements are supported on all interfaces and mappings<br><br>Measurements: last RTD time, minimum, maximum, average, measurement count (no. of successful RTD tests) and failed measurement count |
| Through mode | Performs through mode analysis of any incoming OTN signal transparently |
| OTN GCC BERT (Power OTN OH analysis) | The Power OTN OH analysis functionality features 2 modes:<br>• BERT mode: performs bit error rate test of multiple OTN overhead fields such as GCC0/1/2, APS/PCC, PM&TCM, TCM ACT, FTFL, EXP, TCM 1 to 6 and many unused reserved bytes available in the overhead. The user can inject errors in each field, and the BERT is analyzed separately for each different field.<br>• SYNC mode: the user can validate whether the OTN frames arrive in the right order, facilitating troubleshooting activities, especially when these fields are used for passing encryption keys and encrypted data. |
| Overhead manipulation | Performs section/RS, line/MS, high-order (HO) and low-order (LO) path overhead manipulation and monitoring |
| Clocking | Clocking Internal, loop-timed, external (BITS), backplane |

**EXFO**

## SONET/SDH FUNCTIONAL SPECIFICATIONS

| SONET | | SDH | |
|---|---|---|---|
| Optical interfaces | OC-1, OC-3, OC-12, OC-48, OC-192 | Optical interfaces | STM-0, STM-1, STM-4, STM-16, STM-64 |
| Available wavelengths (nm) | **1310,** 0 | Available wavelengths (nm) | **1310,** 0 |
| Clocking | Internal, loop-timed, external building integrated timing supply (BITS) | Clocking | Internal, loop-timed, external (MTS/SETS) |
| **Mappings** | | | |
| VT1.5 | Bulk | AU-3-TU-11, AU-4-TU-11 | Bulk |
| VT2 | Bulk | AU-3 -TU-12, AU-4-TU-12 | Bulk |
| STS-1 SPE | Bulk | AU-3, AU-4-TU-3 | Bulk |
| STS-3c | Bulk | AU-4 | Bulk |
| STS-12c/48c/192c | Bulk | AU-4-4c/16c/64c | Bulk |
| SONET overhead analysis and manipulation | A1, A2, J0, E1, F1, D1-D12, K1, K2, S1, M0, M1, 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, M1, G1, F2, F3, K3, N1, N2, K4, E2, J1, C2, H4 |
| **Error insertion** | | | |
| OC-1, 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-0, 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 |
| **Error measurement** | | | |
| OC-1, 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-0, 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** | | | |
| OC-1, OC-3, OC-12, OC-48, OC-192 | LOS, LOF-S, 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-0, STM-1, STM-4, STM-16, STM-64 | LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, AU-LOP, H4-LOM, HP-ERDI-CD, HP-ERDI-PD, HP-ERDI-SD, LP-ERDI-CD, LP-ERDI-PD, LP-ERDI-SD, HP-UNEQ, TU-AIS, LP-RFI, LP-RDI, LP-RFI, LP-UNEQ, pattern loss |
| **Alarm detection** | | | |
| OC-1, OC-3, OC-12, OC-48, OC-192 | LOS, LOC, LOF-S, SEF, TIM-S, AIS-L, RDI-L, AIS-P, LOP-P, LOM, PDI-P, RDI-P, ERDI-PCD, ERDI-PPD, ERDI-PSD, PLM-P, UNEQ-P, TIM-P, AIS-V, LOP-V, RDI-V, ERDI-VCD, ERDI-VPD, ERDI-VSD, RFI-V, UNEQ-V, TIM-V, PLM-V, pattern loss | STM-0, STM-1, STM-4, STM-16, STM-64 | LOS, RS-LOF, LOC, RS-OOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, H4-LOM, HP-RDI, HP-ERDI-CD, HP-ERDI-PD, HP-ERDI-SD, LP-ERDI-CD, LP-ERDI-PD, LP-ERDI-SD, HP-PLM, HP-UNEQ, HP-TIM, TU-AIS, LP-RFI, LP-RDI, LP-RFI, LP-UNEQ, LP-TIM, LP-PLM, pattern loss |
| | | | *Frequency alarms on all supported interfaces* |
| **Patterns** | | | |
| VT1.5/2 | 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 non-inverted), bit errors | TU-11/12/3 | 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 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 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 non-inverted), bit errors |
| | | | *Pattern loss, and bit-error generation and analysis supported on all patterns* |

**EXFO**

## SONET/SDH TEST FEATURES

| | |
|---|---|
| Frequency measurements | Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency), displayed in ppm, for optical and electrical interfaces; measurements are performed using an internal oscillator |
| Frequency offset generation | Supports offsetting the clock of the transmitted signal on a selected interface to exercise clock recovery circuitry on network elements |

**Performance monitoring**

The following ITU-T recommendations, and corresponding performance-monitoring parameters, are supported:

| ITU-T recommendation | Performance-monitoring statistics |
|---|---|
| G.821 | ES, EFS, EC, SES, UAS, ESR, SESR, DM |
| G.826 | ES, EFS, EB, SES, BBE, UAS, ESR, 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 |
| M.2101 | ES, SES, BBE, UAS |

**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 | Analysis |
|---|---|
| • Pointer increment and decrement | • Pointer increments |
| • Pointer jump with or without NDF | • Pointer decrements |
| • Pointer value | • Pointer jumps (NDF, no NDF) |
| | • Pointer value and cumulative offset |

| | |
|---|---|
| Pointer sequence testing | Performs pointer sequence testing as per the G.783, GR253 and T1.105-3 standards |
| 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 active channels to backup channels<br><br>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 transmitter back to its receiver after crossing a far-end loopback<br><br>Measurements are provided on all supported interfaces and mappings<br>Measurements: last, minimum, maximum, average; measurement count: number of successful RTD tests and 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) |
| Tandem connection monitoring (TCM) [a, b] | TCM is used to monitor the performance of a subsection of a SONET/SDH path routed via different network providers; the T&D module 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<br><br>Error generation: TC-IEC, TC-BIP, TC-REI, TC-OEI<br>Error analysis: TC-IEC, TC-REI, TC-OEI, TC-VIOL (non-standardized alarm)<br>Alarm generation: TC-RDI, TC-UNEQ, TC-ODI, TC-LTC, TC-IAIS<br>Alarm analysis: TC-TIM, TC-RDI, TC-UNEQ, TC-ODI, TC-LTC, TC-IAIS |
| Through mode | Performs through mode analysis of any incoming optical line (OC-1/STM-0, OC-3/STM-1, OC-12/STM-4, OC-48/STM-16, OC-192/STM-64) transparently |

# FIBRE CHANNEL SPECIFICATIONS

## FIBRE CHANNEL FUNCTIONAL SPECIFICATIONS

**Testing 1X, 2X, 4X, 8X, 10X, 16X, 32X [a, b]**

| | |
|---|---|
| BERT | Framed Fibre Channel |
| Patterns (BERT) | PRBS 2E31-1, 2E23-1, 2E20-1, 2E15-1, 2E11-1, 2E9-1, one user-defined pattern and the capability to invert patterns |
| Error injection | Bit error and FCS |
| Error measurement | Bit error, symbol error, oversize error, CRC error, undersize error and block error (10x only) |
| Alarm detection | LOS, pattern loss, link down, local and remote fault |
| Buffer-to-buffer credit testing | Buffer-to-buffer credit estimation based on latency |
| Latency | Round-trip latency |

a. 16X supported on the FTBx-88200NGE and FTBx-88260.
b. 32X supported on the FTBx-88260.

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## DSN/PDH AND SONET/SDH TEST FEATURES

| | |
|---|---|
| Frequency measurement | Supports clock frequency measurements (i.e., received frequency and deviation of the input signal clock from nominal frequency), displayed in ppm, for optical and electrical interfaces. Measurements are performed using a local oscillator. |
| 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 |

The following ITU-T recommendations, and corresponding performance-monitoring parameters, are supported:

**Performance monitoring**

| ITU-T recommendation | Performance-monitoring statistics |
|---|---|
| G.821 | ES, EFS, EC, SES, UAS, ESR, SESR, DM |
| G.826 | ES, EFS, EB, SES, BBE, UAS, ESR, 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 |
| M.2101 | ES, SES, BBE, UAS |

**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 | Analysis |
|---|---|
| • Pointer increment and decrement | • Pointer increments |
| • Pointer jump with or without NDF | • Pointer decrements |
| • Pointer value | • Pointer jumps (NDF, no NDF) |
| | • Pointer value and cumulative offset |

| | |
|---|---|
| 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 active channels to backup channels<br><br>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 transport and datacom module transmitter back to its receiver after crossing a far-end loopback. Measurements are provided on all supported transport and datacom module interfaces and mappings.<br><br>Measurements: last, minimum, maximum, average; measurement count: number of successful RTD tests and 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) |
| Tandem connection monitoring (TCM) [a] | TCM is used to monitor the performance of a subsection of a SONET/SDH path routed via different network providers. The T&D module 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.<br><br>Error generation: TC-IEC, TC-BIP, TC-REI, TC-OEI<br>Error analysis: TC-IEC, TC-REI, TC-OEI, TC-VIOL (non-standardized alarm)<br>Alarm generation: TC-RDI, TC-UNEQ, TC-ODI, TC-LTC, TC-IAIS<br>Alarm analysis: TC-TIM, TC-RDI, TC-UNEQ, TC-ODI, TC-LTC, TC-IAIS |
| Pointer sequence testing | Perform pointer sequence testing as per G.783, GR253 and T1.105-3 standards |
| M13 mux/demux | Ability to multiplex/demultiplex a DS1 signal into/from a DS3 signal.<br>(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 far-end alarms and loopback code words |
| DS1/DS3 autodetection | Ability to automatically detect DS1/DS3 line coding, framing and test pattern |
| DS1 multipattern | BER test that includes five automated patterns: all ones, 1-in-8, 2-in-8, 3-in-2, QRSS |
| DS1 signaling bits | Ability to monitor the ABCD signaling bits for all 24 DS0 channels |
| Through mode | Perform Through mode analysis of any incoming electrical (DSn, PDH, SONET, SDH) and optical line (OC-1/STM-0, OC-3/STM-1, OC-12/STM-4, OC-48/STM-16, OC-192/STM-64) transparently |
| Wander | Ability to perform Wander measurements at DS1, E1, 2 MHz and 10 MHz interfaces |

a. HOP and LOP supported as per ITU-T G.707 option 2.

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## ISDN PRIMARY RATE INTERFACE TEST FEATURES

| | | | |
|---|---|---|---|
| Supported interfaces | • DS1: bantam or RJ48C (SF or ESF)<br>• E1: bantam, RJ48C or BNC (PCM31 with or without CRC-4) | Headset support | Talk/listen through a selectable connected voice or 3.1 kHz B-channel |
| Supported switch types | • DS1: national ISDN, Nortel DMS and AT&T 4/5ESS<br>• E1: Euro ISDN, Euro VN6 and Q.SIG | D-channel control | • D-channel timeslot configuration<br>• Rate (64K or 56K)<br>• HDLC mode (Normal or Inverted) |
| Emulation modes | • Terminal equipment (TE)<br>• Network termination (NT) | Statistics | • Call status, CRV, incoming or outgoing calls, call duration<br>• BERT (bit error count and rate) with graphical BERT meter on a per B-channel (data) basis<br>• Performance monitoring statistics: UAS, EFS, ES and SES<br>• Active calls (data, voice, 3.1 kHz)<br>• Total call count (connected, cleared, failed/rejected, placed)<br>• Frequency (Rx, offset, max +/max − offset) |
| Call types/rates | Data (56K or 64K), voice or 3.1 kHz (audio) | Alarms | • DS1: LOS, frequency, LOC, AIS, OOF, RAI, D-channel down<br>• E1: LOS, frequency, LOC, AIS, LOF, RAI, D-channel down<br>• Pattern loss (per B-channel injection) |
| BER test | • Configurable test pattern<br>• Provides simultaneous BER testing on multiple B-channels configured with data traffic | Errors | • DS1: BPV, EXZ, framing bit, CRC-6, D-channel FCS<br>• E1: CV, FAS, CRC-4, E-bit, D-channel FCS<br>• Bit error (per B-channel injection) |
| Call setting | • Calling party (numbering type, numbering plan and number up to 30 digits)<br>• Called party (numbering type, numbering plan and number up to 30 digits)<br>• Network (network transit selection code of up to four digits, and operator system access: none, principal or alternate)<br>• All parameters are configurable on a per-call basis<br>• Highlights missing calls or called party numbers | ISDN logger | • Logs layer-2 (Q.921) and layer-3 (Q.931) messages<br>• Filter: All, layer 2 or layer 3<br>• Information: ID, time, message type, direction, channel number, called number, call type, cause values/definition, status and progress |
| Call control | • Call origination<br>• Establishment of calls prior to starting the test<br>• Automatically initiate single, multiple or all configured calls upon starting a test<br>• Call reception<br>• Auto-answer mode, Auto-reject or prompt<br>• Call release<br>• Hang up individual or all channels | Pass/fail verdict | BERT, call establishment and termination |
| DTMF injection | • Generate DTMF tones for all standard digits, including 0-9, # and * as per Q.23/G.224<br>• Available for either 3.1 kHz B-channel or a connected voice call | Phone book | • Easy access to phone book to manage names and associated numbers<br>• Save/load functions to update the phone book and import/export to exchange the phone book with other datacom module |

EXFO

## EXFO OpticalRF™: RF SPECTRUM MEASUREMENTS OVER CPRI

| | |
|---|---|
| Application | Real-time RF spectrum analysis using digitized RF data (IQ data) in the CPRI link |
| CPRI rate support | • CPRI rate options from 2 to 8 (1.2 Gbit/s to 10.1 Gbit/s)<br>• Automatic CPRI rate scan<br>• Hardware-ready for CPRI rate option 9 (12.1 Gbit/s) |
| Air technology support | LTE, W-CDMA, CDMA, UMTS |
| Radio support | Ericsson, Alcatel-Lucent/Nokia, Huawei |
| Viewer options | • Power spectrum<br>• Waterfall<br>• Power spectrum persistence |
| RF spectrum settings | • Antenna carrier (AxC) selection<br>• Resolution bandwidth (59 Hz to 30 kHz)<br>• Video bandwidth (170 kHz to 8 MHz)<br>• Persistence delay<br>• Min./max./average hold<br>• Decay adjustments for all traces<br>• Zoom for all views<br>• Center frequency and frequency span adjustments<br>• Reference level adjustment<br>• Up to five markers, with table for power, frequency, delta power and delta frequency<br>• Snapshot and video recording capability<br>• dB, dBm, and dBFS adjustments |
| Graph settings | • Crosshair or normal cursor<br>• Channel bandwidth barriers<br>• Grid on/off |
| Interface support | Optical (CWDM, DWDM) SFP interface for both multimode and singlemode fibers |
| Protocol support | CPRI version 7.0 and lower |
| Recording | Up to 270 seconds of real-time RF recording available, depending upon channel bandwidth setting.<br>Saved file is playable on any EXFO OpticalRF-enabled test solution. |
| Remote control and collaboration | The unit can be remotely controlled via a wired or wireless internet connection. |
| Modules offering OpticalRF | FTBx-8870, FTBx-8880 and FTBx-88260 |

# ELECTRICAL INTERFACES

## SYNCHRONIZATION  INTERFACES

| | External clock DS1/1.5M | External clock E1/2M | External 2 MHz/10 MHz |
|---|---|---|---|
| Tx pulse amplitude (V) | 2.4 to 3.6 | 2.37 | 0.75 to 1.5 |
| Tx pulse mask | GR-499 figure 9.5 | G.703 figure 15 | G.703 figure 20 |
| Tx LBO pre-amplification (typical) (dBdsx) | 0.6 for 0 to 40.5 m (0 to 133 ft) 1.2 for 40.5 to 81.1 m (133 to 266 ft) 1.8 for 81.1 to 121.6 m (266 to 399 ft) 2.4 for 121.6 to 162.5 m (399 to 533 ft) 3 for 162.5 to 200 m (533 to 655 ft) | | |
| Rx-level sensitivity | TERM: ≤6 dB (cable loss only) at 772 kHz for T1 DSX-MON: ≤26 dB (20 dB resistive loss + cable loss ≤ 6 dB) | TERM: ≤6 dB (cable loss only) MON: ≤26 dB (resistive loss + cable loss ≤ 6 dB) | ≤6 dB (cable loss only) |
| Transmission bit rate | 1.544 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 | |
| Intrinsic jitter (Tx) | ANSI T1.403 section 6.3 GR-499 section 7.3 | G.823 section 6 | G.703 table 11 |
| Input jitter tolerance | AT&T PUB 62411 GR-499 SECTION 7.3 | G.823 section 7.2 G.8 | |
| Line coding | AMI and B8ZS | AMI and HDB3 | |
| Input impedance (resistive termination) | 75 Ω ± 5 %, unbalanced | 75 Ω ± 5 %, unbalanced | 75 Ω ± 5 %, unbalanced |
| Connector type [a] | SMB or BNC | SMB or BNC | SMB or BNC |

## WANDER REFERENCE INTERFACES

| | 1 PPS | 2 MHz | 10 MHz |
|---|---|---|---|
| Connector type | BNC, RJ48C | BNC, RJ48C | BNC, RJ48C |

## REF-OUT INTERFACE

| | |
|---|---|
| Tx pulse amplitude | Min: 200 mVpp Max: 1300 mVpp |
| Transmission frequency | 155 MHz to 3.5 GHz |
| Output configuration | AC-coupled |
| Load impedance | 50 Ω |
| Connector type | SMA |
| External cable | Maximum 1 meter cable length (RG178 cable with 3.1 dB/m attenuation at 3.5 GHz) |

a.  An SMB-to-BNC adapter is available.

## MECHANICAL AND ENVIRONMENTAL SPECIFICATIONS

| | | FTBx-8870 | FTBx-8880 | FTBx-88260 | FTBx-88200NGE |
|---|---|---|---|---|---|
| Size (H x W x D) | | 25 mm x 160 mm x 118 mm (1 in x 6 5/16 in x 4 5/8 in) | | 25 mm x 160 mm x 118 mm (1 in x 6 5/16 in x 4 5/8 in) | 25 mm x 160 mm x 118 mm (1 in x 6 5/16 in x 4 5/8 in) |
| Weight | | 0.35 kg (0.75 lb) | 0.41 kg (0.9 lb) | 0.9 kg (1.9 lb) | 0.5 kg (1.1 lb) |
| Temperature | Operating Storage | 0 °C to 40 °C (32 °F to 104 °F) −40 °C to 70 °C (−40 °F to 158 °F) | | 0 °C to 40 °C (32 °F to 104 °F)[a] −40 °C to 70 °C (−40 °F to 158 °F) | 0 °C to 40 °C (32 °F to 104 °F) −40 °C to 70 °C (−40 °F to 158 °F) |

a.  When testing 4 x 100GE EtherBERT Layer 2 using an FTB-1 Pro High Power Dual carrier platform, the maximum operation temperature is 35 °C or 95 °F

For a full list of all supported accessories, please contact EXFO.

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Specifications and descriptions are subject to change without prior notice. Spezifikationen und Beschreibungen können sich ohne Vorankündigung ändern.