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Fiber Optic Distributed Strain and Temperature Sensors (DSTS)

BOTDA+BOTDR Combo Module

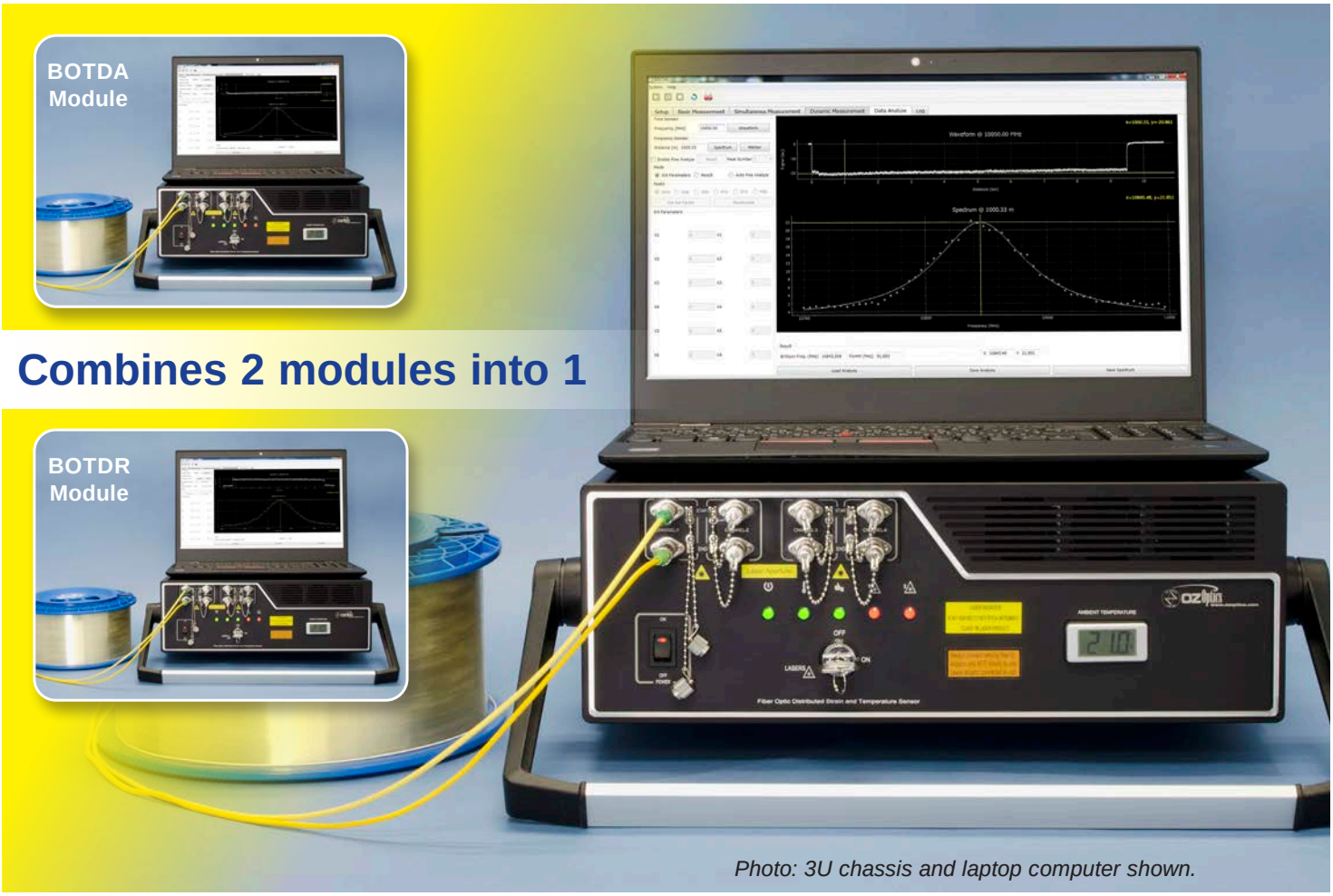


Photo: 3U chassis and laptop computer shown.

Features

- Loop or single end measurements
- Uses low-cost telecom single mode fiber
- High spatial resolution and long sensing range
- Multiple channel monitoring available

Performance at a glance

- 0.1 m (BOTDA) / 1 m (BOTDR) spatial resolution
- 160 km (BOTDA) / 70 km (BOTDR) maximum fiber length

Description

OZ Optics' ForeSight™ family of fiber optic Brillouin distributed strain and temperature sensors (DSTS) are sophisticated optical sensor systems employing Brillouin scattering. Distributed sensing provides a direct method of measuring the changes in strain and temperature along the entire length of an optical fiber. A new unit combining BOTDA (Brillouin Optical Time Domain Analyzer) and BOTDR (Brillouin Optical Time Domain Reflectometer) capabilities is now available. If there is a break somewhere along the fiber, this unit can be switched from BOTDA mode to BOTDR mode to continue measurements.

Oil and Gas applications

Oil and Gas Pipeline Monitoring

- Pipeline leakage monitoring
- Up to 100 km sensing range per channel
- High spatial resolution supports localized measurements over extended distances
- Short acquisition / response time

Oil and Gas Well Monitoring

- Well integrity management
- Temperature, strain and pressure monitoring with proper sensing cable and installation
- Not sensitive to hydrogen which may change the attenuation of the fiber

Refinery Efficiency Sensing

- Improve the efficiency of the refinery based on the distributed temperature profile
- Reduce downtime while ensuring safety levels
- Uses low cost telecom single mode fiber cable

Civil Engineering applications

Dam Monitoring

- Dam internal temperature monitoring
- Crack / sediment / deformation / seepage monitoring
- Up to 100 km sensing range per channel

Structural Health Monitoring (SHM)

- Sediment monitoring
- Strain and crack monitoring
- Up to 100 km sensing range per channel
- High spatial resolution supports localized measurement with long range object

Civil Engineering applications *continued*

Geohazard Monitoring

- Landslide, subsidence and deformation of levee / ground / highway monitoring
- Can monitor trends in ground movement
- Up to 100 km sensing range per channel

Highway Safety Monitoring

- Internal temperature / strain monitoring with proper sensing cable and installation
- Highway subsidence monitoring
- Up to 100 km sensing range per channel

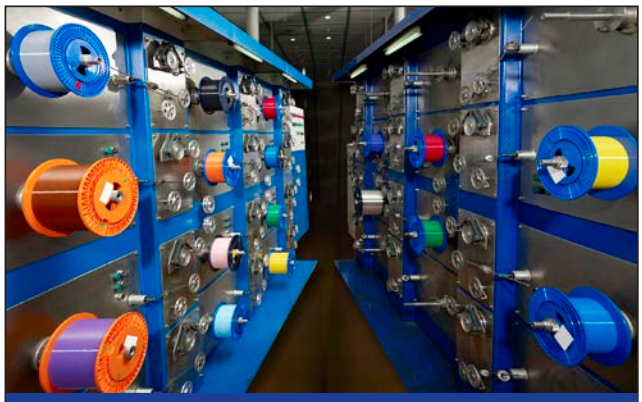
Utility and cable applications

Overhead Power Line Monitoring

- Lightning strikes, icing and broken wires can be detected
- Up to 100 km sensing range per channel
- No additional components required along power line route
- Easy deployment

Submarine Cable Monitoring

- Ongoing quality / status monitoring throughout the life of the cable
- May only require one fiber
- No additional components required along the route



Quality Inspection of Fiber Optic Cable

- More sensitive to strain than OTDR
- High level quality control based on high level technology
- Can monitor the quality of power cable / OPGW with optical fiber unit

Security, Cryostat, and Fire applications

Border Security Monitoring

- Fast, dynamic measurement
- High precision of event location
- Can work in conjunction with a video surveillance system

Cryostat Temperature Sensing

- Able to measure temperatures as low as 25 K
- May use low cost telecom single mode fiber
- Up to 100 km sensing range per channel
- High spatial resolution with good temperature resolution / precision

Building Fire Detection

- Fast, dynamic, and accurate temperature measurement
- Up to 100 km sensing range per channel
- May use low cost telecom single mode fiber cable

Specifications

	Model		BOTDA module	BOTDR module
Performance	Number of Channels		2 to 25[1]	
	Sensor Configuration		Loop fiber	Single end
	Maximum Fiber Length		160 km[2]	70 km
	Spatial Resolution		0.1 to 50 m | 0.5 to 50 m | 1 m to 50 m	1 to 80 m
	Spatial Step		as low as 5 cm	
	Dynamic Range		30 dB	>15 dB
	Temperature Sensing Range (depending on cable material)		-270°C to +2100°C	-100°C to +500°C[3]
	Temperature Resolution		0.005°C[4]	
	Temperature Accuracy (2σ)		± 0.1°C	± 0.8°C[5]
	Strain Range (depending on cable material)		-3% to +4%	-0.2% to +1%[3]
	Strain Resolution		0.1με[4]	
	Strain Accuracy (2σ)		± 2με	± 16με[5]
	Fault Point Detection	Acquisition Time	1 second per thousand scans	
		Sensing Range (round trip)	100 km	
	Simultaneous Measurement of Strain and Temperature (using patented cable design)	Temperature Resolution	0.005°C[4]	
		Temperature Accuracy (2σ)	± 0.1°C (whole sensing range for BOTDA)	
		Strain Resolution	0.1με[4]	
		Strain Accuracy (2σ)	± 2με (whole sensing range for BOTDA)	
		Sensing Range	50 km	
	Measured Variables		Strain, Temperature, Brillouin spectrum	
General	Communication & Connections		Ethernet port, USB	
	Output Signals		Software alarms via TCP/IP, SPST, SSR relays (optional)	
	Data Storage		Internal hard disc (128GB or more)	
	Data Format		Database, text files, MS Excel, bit map plot	
	Optical Connections		FC/APC[6]	
	Laser Wavelength		1550 nm band	
	Operating Temperature		0°C to 40°C, <85% RH, Non-condensing	
	Power Supply		115 or 230 VAC; 50–60Hz; max 300W	
	Dimensions (L x W x H)	3U Chassis	390 mm x 344 mm x 133 mm (not including computer)[7]	
	Weight	3U Chassis	<12 kg (not including computer)	
Features	Measurement Modes		Manual, remote or automatic unattended measurements	
	Data Analysis		Measurement analysis, multiple trace comparison with respect to selectable baseline, measurement trends, graphical zoom	
	Alarms & Warnings		Automatic alarm triggering, configurable alarm settings (gradient, threshold, etc.)	
	Remote Operation		Remote control, configuration and maintenance via TCP/IP	
	Watch Dog		Long term operation 24/7 guaranteed by automatic recovery and continuous self diagnostics	

1 2 channels or 4 channels are provided within the sensor unit. Additional channels can be added by using an external optical switch.

2 For fiber lengths longer than 100 km, only the first 100 km has a valid Brillouin spectrum.

3 -270°C to 1500°C and -3% to +3% is optional.

4 This value is estimated/calculated from the uncertainty of laser beat frequency (5 kHz), and temperature and strain coefficients of fibers.

5 Measurement condition: 1 km SM fibers with unstrained condition at pulse width of 10ns, average time of 60000, frequency sweep span of 300 MHz with frequency step of 5 MHz, standard deviation (2σ) of 100 consecutive data on temperature/strain distribution waveform.

6 Adaptors and patch cords are available for mating with other types of optical connectors.

7 Dimensions do not include carrying handle. Air vents on sides of unit must not be obstructed.

The ForeSight™ Brillouin based DSTS design enables focus on the variable of most concern. For instance, concrete fracture detection may require tight spatial resolution and high precision.

The measurement time of the DSTS BOTDA module can vary from **1 second** to **10 minutes** based on the requirements dictated by the application. The sample table below reflects some common requirements: better than ± 0.5°C and ± 10με precision. All table measurements were completed in less than 1 minute and 40 seconds.

The table is not a restriction of what can be achieved. Variations in the four areas of concern can be accommodated. For instance, the measurement of temperature/strain for 50 km sensing fiber, 2 m spatial resolution, with a precision of 0.2°C/4με is attainable, but will increase measuring time to 3 minutes and 45 seconds. Another comparison of the interaction of fiber length, spatial resolution, accuracy of temperature/strain, and measurement time: 100 km sensing fiber, 6 m spatial resolution can be 0.4°C/8με when measuring time is 4 minutes and 38 seconds, however the same 100 km can have a precision of 0.1°C/2με when spatial resolution is increased to 50 m with a measuring time of 3 minutes and 48 seconds.

		Spatial Resolution									
		10 cm	50 cm	1 m	2 m	3 m	4 m	5 m	10 m	20 m	50 m
Fiber Length	1 km	0.3°C/6με	0.2°C/4με								
	2 km		0.3°C/6με	0.1°C/2με							
	4 km		0.4°C/8με	0.3°C/6με							
	10 km			0.3°C/6με							
	20 km			0.4°C/8με	0.06°C/1.2με						
	30 km				0.2°C/4με						
	40 km				0.3°C/6με	0.1°C/2με	0.2°C/4με				
	50 km					0.2°C/4με	0.3°C/6με	0.2°C/4με	0.1°C/2με		
	60 km								0.2°C/4με		
	70 km								0.3°C/6με		
	80 km									0.2°C/4με	
	90 km									0.4°C/8με	
	100 km									0.4°C/8με	0.2°C/4με

Typical BOTDA module measurement precision table (acquisition time ≤ 100 seconds)

		Spatial Resolution						
		1 m	2.5 m	4 m	10 m	25 m	35 m	40 m
Fiber Length	1 km	± 0.8°C / ± 16με						
	2 km	± 1.2°C / ± 24με						
	5 km	± 1.5°C / ± 30με						
	10 km		± 1.5°C / ± 30με					
	20 km			± 1°C / ± 20με				
	30 km				± 1.5°C / ± 30με			
	40 km				± 1.5°C / ± 30με			
	50 km					± 1.75°C / ± 35με		
	60 km						± 1.25°C / ± 25με	
	70 km							± 2°C / ± 40με

Typical BOTDR module measurement precision table

Results listed above are based on 100 continuous measurement using a single mode sensing fiber with zero strain.
Averaging a greater number of scans can provide better precision but it will require longer measurement time.

Ordering Information

Part Number Description: DSTS-*CT* *CO* *I*-*SR*-*MSR*-*AS*-BOTDA/R-*X*-*CH*

CT = Chassis Type of DSTS opto-electronics box
3U = 3U chassis

CO = Computer Type
L = Laptop (requires 3U chassis)r
X = Customer supplier computer

I = Internal Interface between DAQ and computer
T = Thunderbolt (requires 3U chassis)
S = Standard

SR = Spatial Resolution (m)[1]
0.1/10
0.1/50
0.5/10
0.5/50
1/10
1/50

MSR = Maximum Sensing Range (km)[1,2]
60
1/60
5/60
100
1/100
5/100

AS = Acquisition Speed[3]
N = Normal
H = High Speed

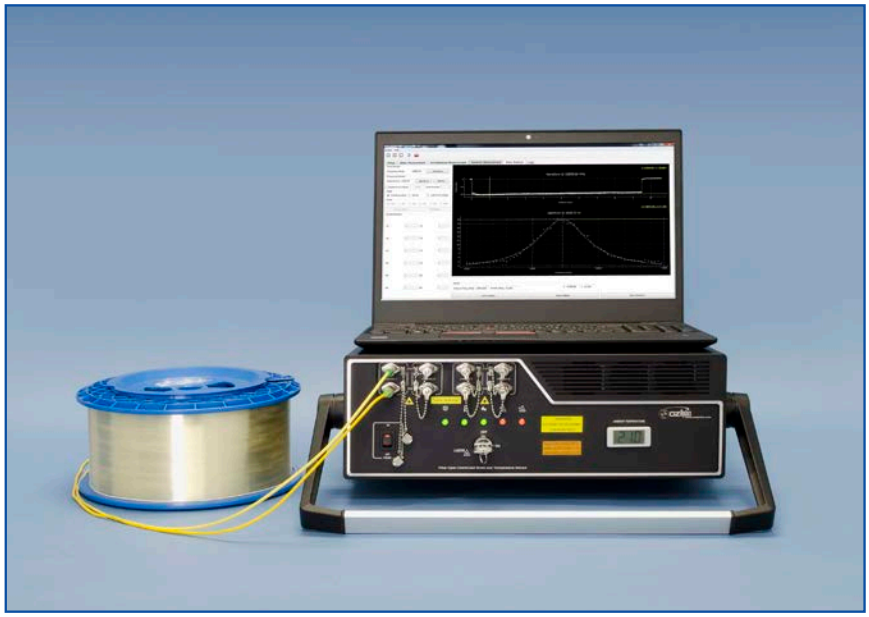
X = Connector Type
3A = FC/APC

CH = Number of channels
2CH = 2 built-in channels
4CH = 4 built-in channels

For a field-ready unit, replace the chassis type, computer type, and computer interface with a single letter "F." Field ready units include a built-in computer, monitor, keyboard and mouse.

Notes:

1. Each DSTS can be configured for short haul operation, long haul operation or both. The configuration must be specified at the time of purchase. The spatial resolution indicates the best resolution at the maximum sensing range. If the DSTS is configured for both short-haul and long-haul measurements then two numbers will be listed indicating the resolutions and maximum sensing range for each operating mode. For example, suppose the DSTS unit needs to achieve 0.1 meter resolution over a 1 km range for short-haul applications, and 50 meter resolution over a 100 km range for long-haul applications. The part number will specify the spatial resolution (SR) as 0.1/50, and maximum sensing range (MSR) as 1/100. The SR and MSR parameters refer to the BOTDA module only.
2. Maximum sensing range is 60 km or 100 km for long haul operation. Alternately, if the 0.1 m spatial resolution is chosen, a maximum sensing range of 1 km is displayed for that resolution (for short haul operation). Maximum sensing range is described as 60, 1/60, 5/60, 100, 1/100, or 5/100.
3. The acquisition speed is described as normal or high speed. N and H are used respectively. The high-speed version is typically at least a factor of two faster than the normal-speed version during the acquisition of data.



3U model with laptop computer

The 3U version of the DSTS comes with removable carrying handles. The user can easily replace the handles with tabs (sold separately) that will allow the unit to be installed in a standard 19-inch rack.

Optional Accessories

Fiber fusion splicer - FSP-100-S/M

Precision fiber cleaver - FSP-100-CLV

Optional Accessories

Bar Code	Part Number	Description
74023	DSTS-TRAVEL-CASE-3U	Plastic travel case for 2U or 3U DSTS unit, with extendable pull handle and wheels. Designed for checking on airplane. Approximate dimensions: 23.75 (H) x 22.5 (W) x 15 (D). {60.3 cm x 57.2 cm x 38.1 cm}.
65518	FIBERMICROSCOPEHANDHELD	Handheld Video Microscope kit for Fiber Optic Connector Inspection. The kit includes an LCD display with video probe. An AC power adapter with battery charger and a rechargeable battery pack is included. Several common adaptor types come with the unit, including an SC/FC PC female adaptor and an LC/PC female adaptor.
48980	CI-1100-A2-PT2-FS/APC/F	Tip for SC and FC APC type female (in receptacle) connector for CI-1100-A2 handheld microscope.
36939	HUXCLEANER-2.5	Receptacle fiber cleaner for FC, SC and ST types.
5336	Fiber-Connector-Cleaner-SA	Disposable Cletop reel type A optical fiber connector cleaner.
8122	SMJ-3A3A-1300/1550-9/125-3-1	1 meter long, 3 mm OD jacketed, 1300/1550 nm 9/125 µm Corning SMF 28e fiber patchcord, terminated with angled FC/APC connectors on both ends.
11	PMPC-03	Flanged sleeve thru connector for polarization maintaining FC/PC connectors. Keyway width is 2.03/2.07 mm wide for 2.00 mm wide (Type R) key connectors.
19711	AA-200-11-9/125-3A3A	Universal connector with a male angle FC/APC connector at the input and a female angle FC/APC receptacle at the output end for SM 9/125 applications.
58975	DSTS-3U-19IN-RACK-MOUNT-KIT	Brackets with handles & hardware to convert 3U DSTS to 19" rack mountable version.
77982	FSP-100-S/M	Fiber fusion splicer for singlemode and multimode fiber, featuring fiber core alignment and automatic fiber identification (singlemode vs multimode) for optimum splice loss. Suitable for bare fibers, patch cords, drop cables etc. A fiber cleaver and fiber stripper is included with the unit as a kit.
77984	FSP-100-CLV	Precision fiber cleaver for fusion splicing, with automatic blade rotation for maximum lifetime.

Related Products

Fiber Optic Sensor Probes, Components, Termination Kits, and Training

OZ Optics offers a full spectrum of fiber optic sensor probes, components, termination kits and training. OZ Optics' standard fiber optic products have been used worldwide in high performance sensor and telecommunications applications since 1985. OZ Optics also offers specialty fiber optic sensor probes and custom cabling for high temperature applications and other hostile and corrosive environments. System integrators with experience in structural and pipeline monitoring will find that OZ Optics offers a complete suite of enabling products and services for installing and maintaining fiber optic systems. If you are planning a pipeline or structural monitoring project, please contact OZ Optics to learn more about our fiber optic solutions.

Questionnaire

1. What is your application? Please describe briefly.
2. Are you looking for a BOTDA module (requires both ends of fiber to be connected to DSTS) or a BOTDR module (requires only one end of fiber to be connected to DSTS) or a COMBO unit with both BOTDA and BOTDR functions?
3. What are your resolution and precision requirements for temperature measurements?

   Resolution: _____

   Precision: _____
4. What are the highest and lowest temperatures you expect?
5. What are your resolution and precision requirements for strain measurements?

   Resolution: _____

   Precision: _____
6. What is the maximum strain to be measured?
7. What is the desired sensing range or fiber length in this application?
8. What spatial resolution do you desire?
9. Do you want to measure temperature, strain or both?
10. What is the desired data acquisition time?
11. Do you need fiber calibration / system design / project engineering service?
12. Where will the unit be housed?
13. Do you need a portable model with a laptop computer or a 19" rack-mounted model with a laptop computer?
14. Any additional information?

For more information about our strain and temperature sensor systems and related products, please visit www.ozoptics.com.