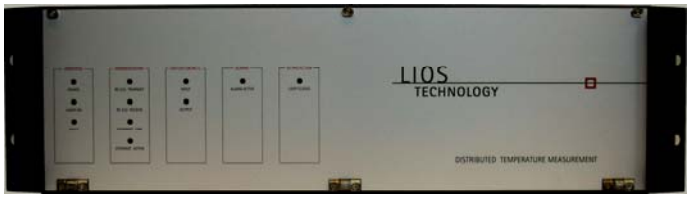
Distributed Temperature Sensing Systems
Controllers OTS60P to OTS160P



General

Controllers of the OTS product series are distributed temperature sensing (DTS) devices measuring temperature profiles along optical fibres. A single OTS device provides well-resolved spatial and temporal temperature profiles for up to 8 optical fibres with lengths of up to 16 km. Sensor fibres are immune to electrical interference and can be used in harsh environments. OTS controllers can be operated at remote locations without PC. They transfer data via standard network protocols to PC in control centres, SCADA or PLC systems.

Physical Background

LIOS OTS controllers use the effect of Raman scattering within optical fibres for temperature measurement. Laser radiation introduced in such a fibre is inelastically scattered transferring energy from or to vibrations of the glass molecular structure. Excitation of glass vibrations reduces the energy of the light photons and thus causes a signal at longer wavelength (Stokes signal). Annihilation of vibrations causes signals at shorter wavelength (anti-Stokes signal). The ratio of excitation and annihilation of vibrations depends on the portion of excited vibrations in the material and thus on the temperature. This effect allows for optical measurements of temperatures in fibres just by introducing laser light and by measuring the intensity ratio at the Stokes and anti-Stokes wavelengths. Spatial resolution is achieved by the optical frequency-domain reflectometry (OFDR) measuring technology.

Unique OFDR-DTS Measuring Technology

OFDR is a modulation technology to analyze the distance of signal sources. The light source is modulated at different frequencies and the amplitude and phase of signals coming back from the fibre are measured. The mathematical Fourier transformation of the amplitude and phase data provides the spatial distribution of the signal sources. This is an elegant method to gain high spatial resolution with a quasi-continuous light source. Distributed temperature sensing using OFDR is a proprietary technology of LIOS Technology that has been developed and optimized during the last 10 years. Essential benefits of the DTS based on OFDR are elimination of laser wear out by quasi-continuous operation of a semiconductor laser, clearly reduced requirements for costly fast detection electronics and signal-to-noise improvements achieved by the quasi-continuous excitation light and the narrowband detection scheme. In contrast to pulse techniques, OFDR does not suffer from pulse broadening, and it thus gives constantly high spatial resolutions over very long distances.

High Reliability and Industrial Strength

The semiconductor laser diode has been thoroughly type tested according the Telcordia GR-468 standard. It fulfils telecom standards with a medium lifetime of > 25 years. The entire system was comprehensively evaluated by various independent international bodies (e.g. the VdS, the association of German asset insurers) including EMC tests as well as endurance tests at accelerated aging environments.

Field data of the huge installed base prove the exceptional high reliability of the controllers.

System Design

The OTS controllers have a modular design consisting of the following sub-modules:

- Modulated eye-safe laser source
- Optical filter and receiver
- Digital signal processing
- Power supply
- Optional communication module

The controller is connected to up to 8 measuring fibres by standard telecommunication plugs. The back-scattered Raman light is spectrally filtered and converted into electrical signals by means of photo detectors and amplifiers. Signal mixing and frequency filtering serves for high signal-to-noise ratios. Fourier transformation of the digitized signals results in Stokes and anti-Stokes Raman backscatter profiles. The temperature along the fibre is calculated from the ratio of the two signals channels using patented calibration algorithms.

The OTS controller can be operated at 115/230 VAC or at 24 VDC power supplies (standard). A PC or Laptop is used for commissioning the OTS. Temperature measurements, further data and event processing as well as data logging are autonomously conducted by the OTS without need for a computer during operation. Temperature profiles, event and alarm messages can be transmitted via standard local and optional network interfaces from the controller to PC, SCADA or PLC systems.

Typical Performance

The OTS controllers of the latest generation provide accurate distributed temperature sensing even over very long distances enabled by the unique OFDR capabilities and sophisticated data processing including proprietary dynamic averaging algorithms. Typical temperature resolutions in dependence on distance (σ) are given in the table below. These measurements were conducted using a single-ended 16 km GI50/125 fibre at constant temperature. Significantly shorter cycle times are achieved for shorter fibres. Standard deviations are practically equal in space and time, i.e. for neighboured points at the fibre and for consecutive measurements of the same location.

Cycle time	30 sec	5 min	10 min
Spatial resolution	3 m	1 m	1 m
2 km	0.35 K	0.14 K	0.06 K
4 km	0.45 K	0.18 K	0.08 K
6 km	0.55 K	0.22 K	0.12 K
8 km	0.70 K	0.26 K	0.14 K
10 km	0.85 K	0.30 K	0.15 K
12 km	1.05 K	0.37 K	0.18 K
14 km	1.25 K	0.43 K	0.21 K
16 km	1.50 K	0.50 K	0.25 K

Software

CHARON_02 configuration and visualisation software provides comfortable access to the OTS system. CHARON_02 guides the user during system commissioning and maintenance phase. Several display languages and localisations are supported. The measurement and configuration data are stored in a database for convenient access. Data visualisation and configuration reports present desired information in a comprehensive shape. The enhanced visualisation options of CHARON_02 offer unlimited customisable views of data to the user. Data export, import and software interfaces (DDE, XML) support third party tools.

Rack mounting

The controllers are ready for 19" rack mounting. Rack mounted systems with controller and computer are available on request.

Optional Communication Protocols

The optional communication module provides an Ethernet interface enabling direct links of the controller to PC, SCADA and PLC systems via industry standard protocols like DNP3, IEC 60870-5, Modbus and XML based data interfaces such as LabView and Energistics WITSML.

Zone Processing and Alarm Actuation

Data points along the fibre can be split into up to 128 zones for separate evaluation of temperatures. Individual actuating parameters and outputs can be allocated for each zone. The OTS controllers can address a separate layer of up to 640 adjacent sub-zones using an extended alarm processing.

An alarm is actuated when one of the alarm criteria is exceeded in a zone:

- Maximum / minimum temperature
- Short and long-term temperature gradients (heating / cooling rates)
- Spatial temperature gradient (hot / cold spot)

Criteria can be set individually for each zone. To ensure a high degree of immunity to false alarm, the alarm notification can be delayed over multiple measuring cycles.

Fibre Break Detection

The OTS controllers indicate fibre breaks reliably and provide the exact meter location of these incidents. Fibre breaks are treated as OTS events and are further processed individually by zones according configuration.

Stand-Alone Operation

The OTS includes an embedded central processing unit (CPU) and can be operated stand-alone without external computer. The OTS can auto-start measurements after powering up. It stores all configuration parameters permanently and provides a battery-backed event log with all alarms, events, fault messages and measurement statistics.

The OTS system can operate as an autonomous data logger using the optional communication module. All measured data is stored on the built-in flash disk drive. Data can be downloaded using CHARON_02. The huge storage capacity enables at least 72 hours up to months of stand-alone operation in dependence on measuring cycle time and resolution.

Technical Data

Measurement Specifications	
Distance range (single end measurement)	OTS60P: 6 km OTS120P: 12 km OTS80P: 8 km OTS140P: 14 km OTS100P: 10 km OTS160P: 16 km
Spatial resolution	3m; 1.5m 1m; 0.5m (option)
Optical	
Connector position	Rear side
Fibre connector	E2000 APC 8° Laser safety: Enhanced connector with immediate laser shut-down if pigtail removed.
Laser classification	Class 1M laser product Eye-safe near-infrared wavelength
Measurement channels	1 channel (standard) 2, 4, 6 or 8 channels (option) Loop channels (option)
Fibre type	- Gradient index 50/125 µm multimode - Gradient index 62.5/125 µm multimode (on request)
Fibre bandwidth*distance	> 500 MHz*km @ 1300nm > 1000 MHz*km @ 1300nm for optional enhanced spatial resolution
Fibre attenuation	< 0.5 dB/km @ 1300 nm and 1383 nm (low water peak)
Optical cable	See LIOS fibres and cables datasheet
Power supply	
DC power supply	20 to 30 V; 1.8 to 1.2 A
DC power consumption	< 35 W
DC socket	SUB-D 3WK3, 3pin
Mains (option)	85 to 264 V ~; 47 to 63 Hz; 0.8 to 0.3 A
AC power consumption	< 70 VA
Socket	IEC 60320-C14 (inlet)
Software	
CHARON_02	PC software for configuration, data management and visualization
Computer requirements for configuration and visualization	Intel Pentium 4 (2 GHz), 512 MB RAM, minimum 250 MB free HD memory
Operation systems	Windows NT 4.0, SP 6 or higher Windows 2000, SP 2 or higher Windows XP, Windows VISTA
Detailed software features	See Charon_02 software datasheet
Communication	
Data transfer	Temperature profiles, backscattering curves, zone minimum, maximum and average values, zone alarms, alarm locations, error messages and notes are available by public protocols designed for communication with third party systems as well as with LIOS software CHARON_02. Frequency raw data graphical displays are provided by CHARON_02 only.
Interface RS232	Socket SUB-D 9 pin male
Interface Ethernet (option)	10Base-T, 8P8C socket (RJ45); TCP/IP
Communication protocols	MODBUS/TCP
(option)	DNP3 over TCP IEC 60870-5-104 LabView Energistics WITSML Further protocols are available on request.
Inputs	4 programmable logical inputs, Socket SUB-D 9 pin female, galv. isolated Input trigger logic configurable.
Outputs	10 or 19 programmable outputs, event notification, direct interface with third party supervisory systems, Socket SUB-D 25 pin female resp. SUB-HD 44, galvanically isolated Output trigger logic configurable.
Event memory	Battery-backed event log with all alarms, events, fault messages and measurement statistics, retrievable by CHARON_02.
Zone and event processing	
Number of zones	≤ 128
Number of sub zones (option)	≤ 640
Alarm actuation	Max. / min. temperature, 3 different temperature gradients, hot / cold spot and delay can be set individually for each zone
Operation conditions	
Operating temperature	0°C to 40°C
Storage temperature	-30°C to 70°C
Humidity	< 95% (non-condensing)
Maintenance	
Fan filters	Exchangeable
Fibre connector	To be cleaned before connecting pigtail
Compliance	
Protection class	IP30
EMC	EN 61000-6-2:2001 (Immunity for industrial environments) EN 61326:1997 +A1:1998 +A2:2001 EN 61000-3-2:2000
Laser safety	EN 60825-1:2007
Dimensions / Weight	
Dimensions (HxWxD)	13.5 cm x 44.9 cm x 31.5 cm
Weight	10.2 kg
Rack mounting	3 HU 19" rack; min. depth and width 60 cm Rear side accessible or 80 cm wide swing frame

LIOS Technology GmbH

LINEAR OPTICAL SENSORS

Schanzenstrasse 39, Building D9-D13

51063 Cologne, Germany

Phone: +49 221 99887-0

Fax: +49 221 99887-150

info@lios-tech.com

MEMBER OF THE NKT GROUP