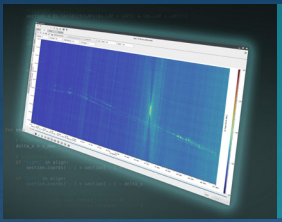
OptoDAS data sheets

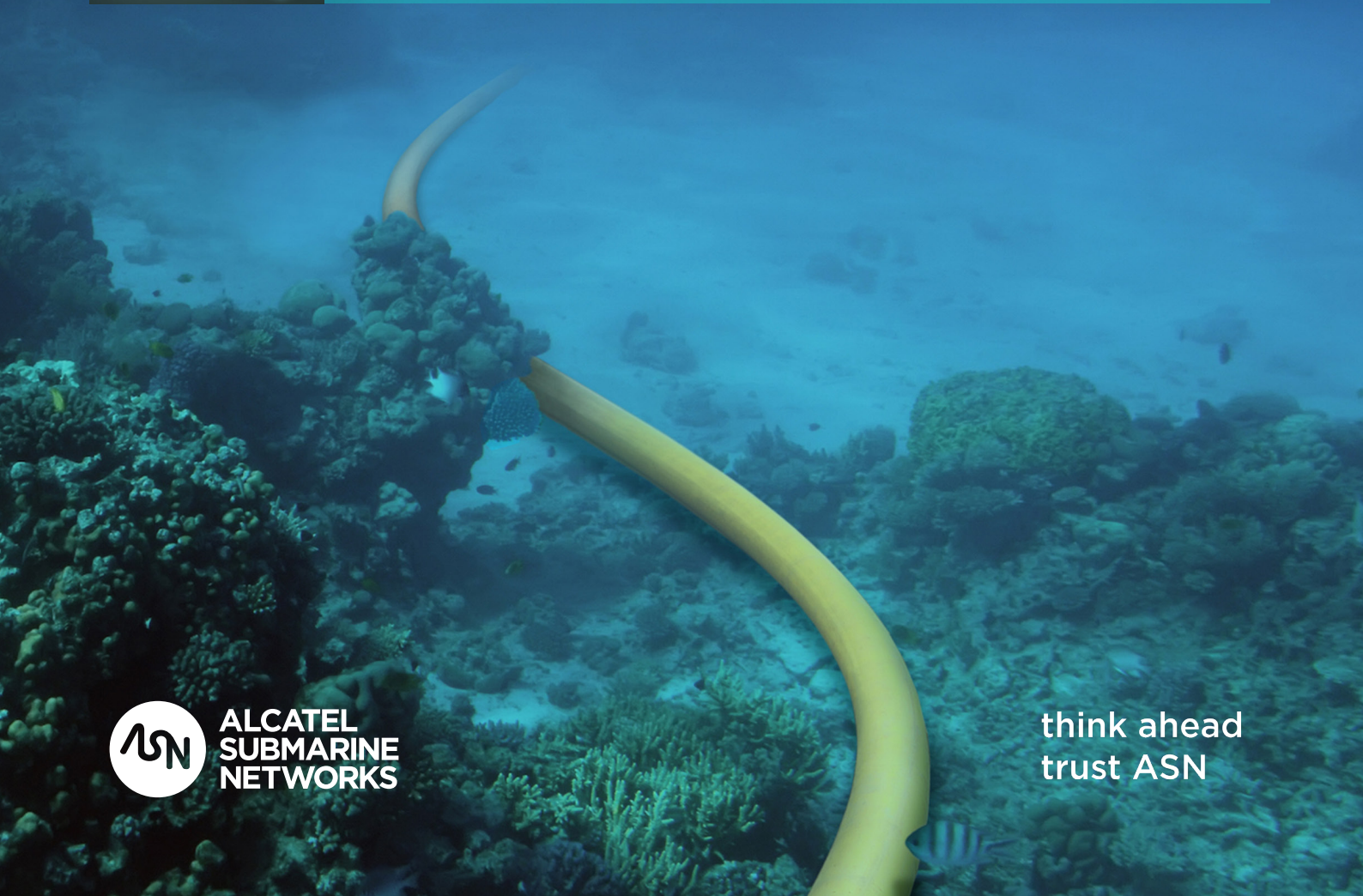
OptoDAS Interrogator

OptoDAS Recording Computer

OptoDAS Field Rack



OptoDAS Software Suite



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OptoDAS Interrogator
Distributed Acoustic Sensing

The OptoDAS C01-S interrogator provides long range and low noise performance with standard optical fibres. Real-time distortion free measurements of fibre strain modulation are achieved over distances up to 150 km.

The OptoDAS unit is based on a unique interrogation technique, named frequency swept interrogation, that allows long optical pulses to be launched into the fibre without impacting the spatial resolution. The spatial resolution – defined as the gauge length of the measurement – is configurable in steps of 1 m, from 2 m to 40 m. The large optical loss budget of > 28 dB one-way optical loss allows for distortion free measurements over distances up to 150 km in standard optical fibres, and with a noise level nearly independent of fibre lengths up to 80-90 km. OptoDAS is inherently tolerant to optical reflections in the fibre path.

An L-band version of OptoDAS is designed for coexistence with telecom traffic with no impact to the transmission line capacity and Q factor.

The OptoDAS unit is equipped with a built-in GPS module for precise time synchronization and is accompanied by a recording computer for storage, streaming and real-time processing of DAS data for generation of triggers and alarms. The system offers many flexible data acquisition features e.g. for integration with external optical switch, automation of reoccurring measurement sequences, configurable regions of interest and data storage options.

The performance characteristics have been measured according to the SEAFOM specification MSP-02 (measured with G652 fibre).

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OptoDAS Interrogator

Technical data

Back

Performance characteristics

Spatial sampling: 1 m.

Spatial resolution: Equal to the Gauge length (GL)

Gauge length (GL): Configurable from 2 – 40 m, in steps of 1 m.

Sampling frequency (f_S): 400 Hz – 100 kHz

Sensing frequency range: < 0.01 mHz to 50 kHz

Typical system self-noise:
(@ 10 Hz in standard single mode fibre, 0.2 dB/km)
- 3 pε/√Hz from start to end of a 10 km long fibre (GL = 10 m, f_S = 10 kHz)
- 7 pε/√Hz from start to end of a 50 km long fibre (GL = 10 m, f_S = 2 kHz)
- 20 pε/√Hz at the 80 km position of a 160 km long fibre (GL = 10 m, f_S = 625 Hz)
- 3 pε/√Hz at the 80 km position of a 160 km long fibre (GL = 40 m, f_S = 625 Hz)

Dynamic range:
(GL = 10 m, f_S = 10 kHz)
- 100 dB @ 10 Hz
- 85 dB @ 50 Hz
- 73 dB @ 250 Hz

Loss budget: > 28 dB one-way loss (GL = 10 m)

Harmonic distortion: < -40 dB (GL = 10 m)

Crosstalk: < -60 dB

Time stamp precision: ±250 ns (with internal GPS)

PPS tag precision: ±250ns (with internal GPS), PPS tags are recorded in the HDF5 output data file.

Optical characteristics

Laser Product Category: Class 1M

Wavelength: 1536.61 nm (standard version)
1577.86 nm (L-band version)
Other wavelengths available on request

Environmental characteristics

Storage Temperature: -20 °C to +60 °C

Operating Temperature: +0 °C to +35 °C

Operating Relative Humidity: 10% to 85% (non-condensing)

Output data

Output data file format: HDF5 (other formats available upon request)

Output data rate: Up to 1.6 Gbit/s (with spatial sampling 1 m)

Connection interfaces

Power: IEC 320 – C14

Network: 1 Gb/s RJ45, option for 10 Gb/s RJ45

Trig: BNC connector, TTL into 50 Ohm (bi-directional)

10MHz clock: BNC connector, 0.5 Vrms into 50 Ohm (bi-directional)

PPS: BNC connector, TTL into 50 Ω (bi-directional)

Internal GPS: Antenna and 20 m RG58 coaxial cable (50 Ω) included. Supports up to 300 m with RG58C, and up to 600 m with RG213.

External GPS or PTP: Connection through 10 MHz and PPS ports

Fibre: Diamond FC/APC or E2000/APC (single mode)

Interrogator Unit

Power consumption	Typical 135W, max 150W
AC power supply	100 V–240 V, 50 Hz–60 Hz
Height	3U – 133 mm
Width	483 mm (for 19" rack)
Depth	482 mm (526 mm incl. handles)
Mass	19 kg

Corresponding data for recording computer in separate datasheet.

Data acquisition features

Integration with **external optical switch**
Automation of **reoccurring measurement sequences**
Regions of interest (ROI), with customized spatial sampling in different regions.
Configurable **cyclic storage buffer** in RAID configuration
Configurable storage of raw data and processed data
Real-time data processing and display
Kafka-Avro streaming interface
Python library for reading, processing and saving HDF5 files
More details on the OptoDAS Software Suite in separate datasheet.

Modes of operation

DAS: For dynamic strain DAS measurements

OTDR: For optical loss measurements, with nearly 30 dB dynamics

Declaration of Conformity

Compliant with the Low Voltage Directive (LVD) 2014/35/EU, the Electromagnetic Compatibility Directive (EMC) 2014/30/EU and the ROHS directive 2011/65/EU with amendment 2015/863.

Rev. 04.09.2023

OptoDAS Recording Computer

The OptoDAS interrogator must be accompanied by a recording computer for storage and processing of DAS data.

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OptoDAS Recording Computer options

Technical data

Back

Server class computers enable remote operation and maintenance and can be equipped with a RAID storage system for reliable storage of large amounts of raw DAS data. The RAID storage size is configurable. The computers run the OpenSUSE Linux operating system and are configured with a processor enabling both real-time processing and display of DAS data.

Features

IPMI interface for remote service

Display ..... 2x Display port, 1x DVI port, 1x VGA port (for 3 independent monitors)
USB ..... 3x USB 3.1 Type A and 1x USB 3.1 Type C
Network ..... 1x 1 Gb/s RJ45 or 1x 10 Gb/s SFP+ (only when OptoNAS 2U-21 is selected)

OptoServer 2U-26

Form factor ..... 2U 19" rackmount
Dimensions (HxWxD) 89x482x646mm
Weight 24kg
Power consumption ..... Typical 200W, max 900W
Drive bay ..... 12x 3.5-inch, hot-swap drives

RAID storage options:

- OptoServer-2U-26-60TB, with 60TB storage
- OptoServer-2U-26-120TB, with 120TB storage
- OptoServer-2U-26-180TB, with 180TB storage

OptoServer 3U-20

Form factor ..... 3U 19" rackmount
Dimensions (HxWxD) 134x480x515mm
Weight 21kg
Power consumption ..... Typical 200W, max 900W
Drive bay ..... 8x 3.5-inch, hot-swap drives

RAID storage capacity options:

- OptoServer-3U-20-80TB, with 80TB storage
- OptoServer-3U-20-120TB, with 120TB storage

OptoServer 1U-15

Form factor ..... 1U 19" rackmount
Dimensions (HxWxD) 43x437x368mm
Weight 5kg
Power consumption ..... Typical 100W, max 350W

No data storage inside server. An external USB storage RAID with the same characteristics as the OptoNAS Desktop-08 will be provided.

Separate NAS server

When external transportable storage is desired, a NAS server rack can be supplied to accompany the recording computer.

OptoNAS 2U-21

Form factor ..... 2U 19" rackmount
Dimensions (HxWxD) ..... 89×482×534mm
Weight 15kg
Power consumption ..... Typical 60W, max 250W
Drive bay ..... 8x 3.5-inch, hot swap-drives
USB ..... 4x USB 3.2 Type A
Network ..... 2x 10Gb/s SFP+
2x 2.5GB/s RJ45

Storage capacity options:

- OptoNAS-2U-21-80TB, with 80TB storage
- OptoNAS-2U-21-120TB, with 120TB storage

OptoNAS Desktop-08

Form factor ..... Desktop
Dimensions (HxWxD) ..... Approx. 188×329x281mm
Weight 6kg
Power consumption ..... Typical 50W, max 250W
Drive bay 8x 3.5-inch
Data interface ..... 10Gb/s RJ45 Ethernet

Storage capacity options:

- OptoNAS Desktop-08-80TB, with 80TB storage
- OptoNAS Desktop-08-120TB, with 120TB storage

Storage capacity for OptoDAS recorded data

	Temporal sampling 1ms 10km fibre length			Max temporal sampling* Any fibre length		
Disc size	Spatial sampling 2m	Spatial sampling 4m	Spatial sampling 10m	Spatial sampling 2m	Spatial sampling 4m	Spatial sampling 10m
60TB	69 days	138 days	347 days	6 days	13 days	34 days
80TB	92 days	185 days	462 days	9 days	18 days	46 days
120TB	138 days	277 days	694 days	13 days	27 days	69 days
180TB	208 days	416 days	1041 days	20 days	41 days	104 days

* defined by length of fibre

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OptoDAS Field Rack

The OptoDAS interrogator can be delivered in a field rack for easy deployment and protection in field test environments. A server class computer, with extensive RAID disc storage, a network switch and a NAS server can also be included in the rack.

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OptoDAS Field Rack

Description

Back

Features

- All equipment available in one box, pre-configured and ready for use
- Interior 19” rack with built-in shock absorbers
- Lifting handles
- Stackable

OptoRack 8U-28

- 8U interior 19” rack height
- Space for optional auxiliary equipment, e.g. NAS server
- Supplied with SCHUKO socket strip, 8 sockets, with switch
- Castor kit included
- External dimensions: WxDxH: 673x1070x600mm
- Rackable depth: 736mm (28.9”)
- Depth from rail to back lid: 860mm
- Weight (empty): 41kg

OptoRack 6U-28

- 6U interior 19” rack height
- Castor kit included
- External dimensions: WxDxH: 673x1070x501mm
- Rackable depth: 736mm (28.9”)
- Depth from rail to back lid: 860mm
- Weight (empty): 38kg

OptoRack 6U-20

- 6U interior 19” rack height
- External dimensions: WxDxH: 692x711x486mm
- Rackable depth: 508mm (20”)
- Depth from rail to back lid: 581mm
- Weight (empty): 19kg

Other field rack size’s are available upon request.

OptoRack 6U-20

OptoRack 8U-28

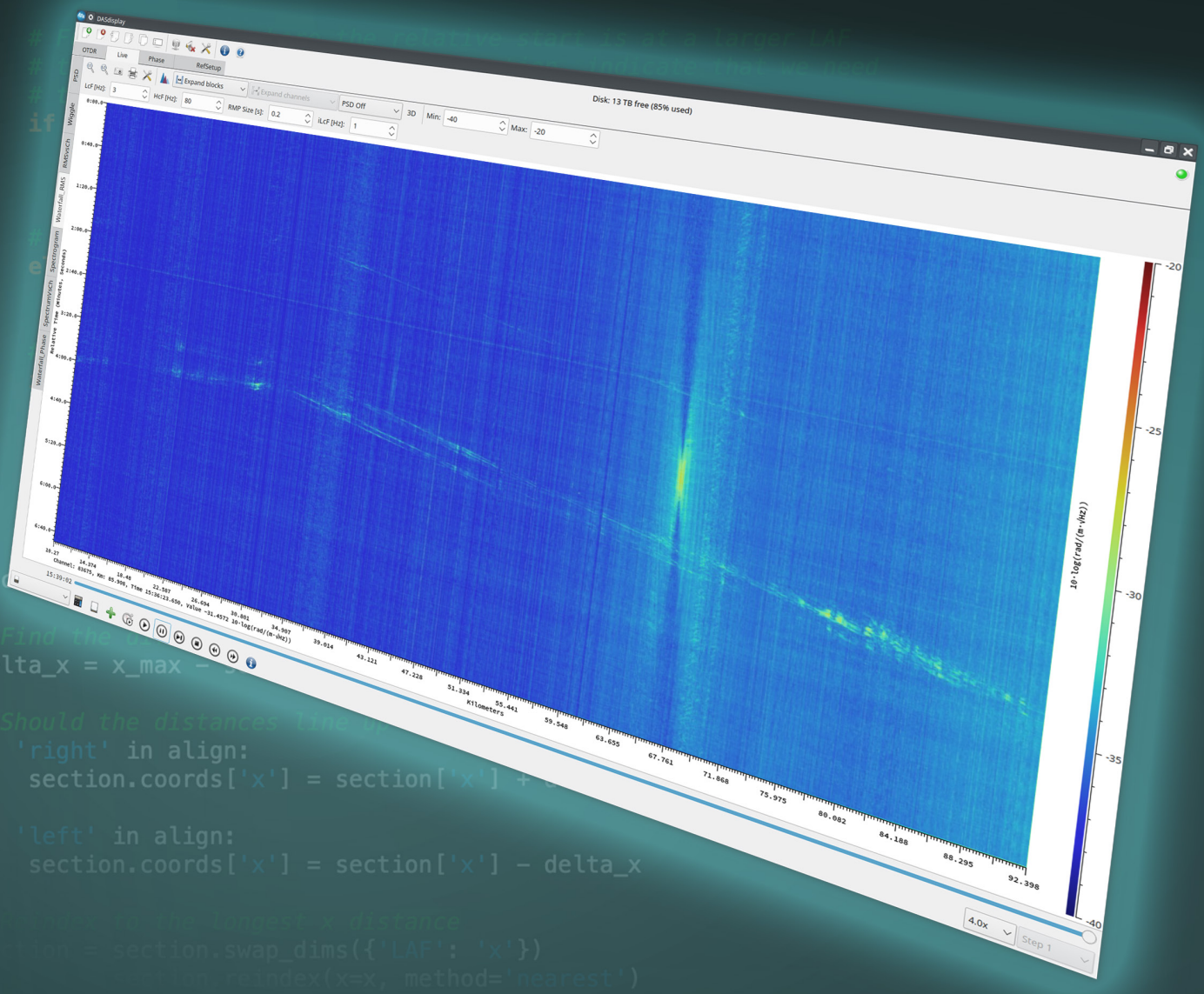
OptoRack 6U-28

OptoRack 6U-20

Rev. 04.09.2023

OptoDAS Software Suite

The OptoDAS software suite provides extensive functionality and flexibility for instrument control, data management, processing and display.



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OptoDAS Software Suite

Instrument software – DAScontrol

Back

Instrument control

The application *DAScontrol* offers a user-friendly graphical user interface (GUI) to monitor the acquisition status and modify the configuration of the OptoDAS interrogator without in-depth knowledge of DAS measurements. Flexible modules allow to customize the real-time data processing and storage on the instrument server.

Key features

Measurement configuration

- DAS-mode and OTDR-mode – *DAS mode can record both strain-rate and strain*
- Fibre length and temporal sampling frequency
- Gauge length
- Spatial sampling
- Region of interest (ROI) – multiple ROI's along the fibre can be defined with custom spatial sampling
- Measurement configurations can be stored for later use

Acquisition

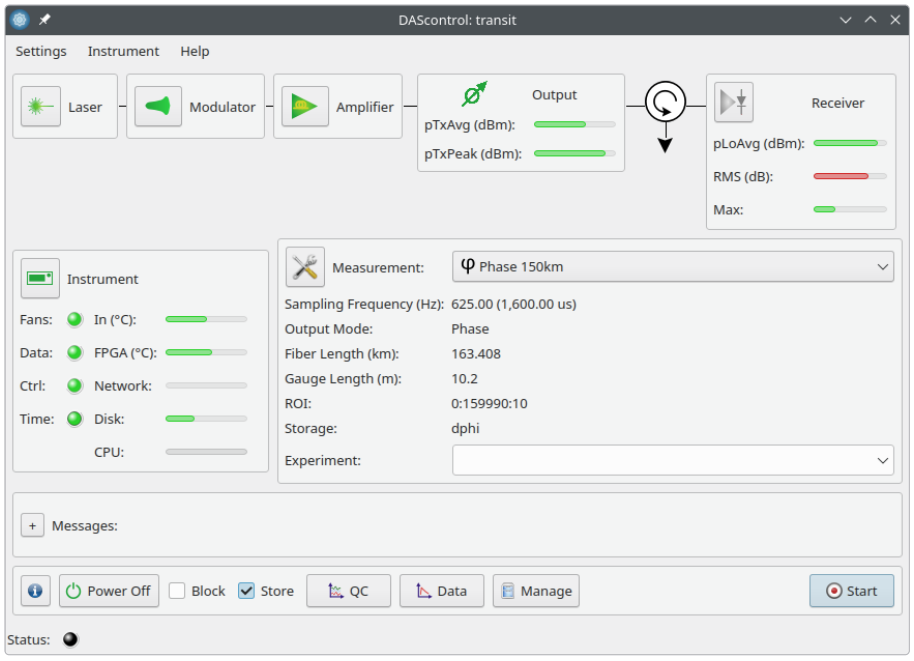
- Integration with **external optical** switch for periodic measurements on multiple fibres
- Automation of **reoccurring measurement sequences** for use with external optical switch and to define periodic measurement sequences with different recording parameters like ROI, gauge length, spatial sampling, temporal sampling and many more...
- **Regions of interes**t (ROI), with customized spatial sampling in different regions of the fibre
- **Real-time** data processing with versatile signal processing toolbox

Storage

- **HDF5** file format (other formats available upon request)
- **Configurable storage** of raw data and processed data
- Configurable **cyclic storage buffer**, with data management tools for definition of interesting data to keep for offline processing
- Storage to internal **RAID**, **NAS**, or both in parallel

Streaming

- Data may be streamed to multiple data display clients
- Streamed data can be raw or processed data
- Clients may be located locally or remotely
- Data streaming via Avro/Kafka



Instrument control and monitoring dialog

OptoDAS Software Suite

Plotting and visualization – DASdisplay

Back

The application DASdisplay offers a range of customizable plotting and visualizations for OptoDAS data. The processing and display are set up through a GUI interface to drag-and-drop modules. The input can be streamed in real-time from the interrogator or played back from file. Multiple plots can run in parallel to capture distinct signals in the fibre strain data, or to compare responses from different fibre channels or channel sections.

Key features

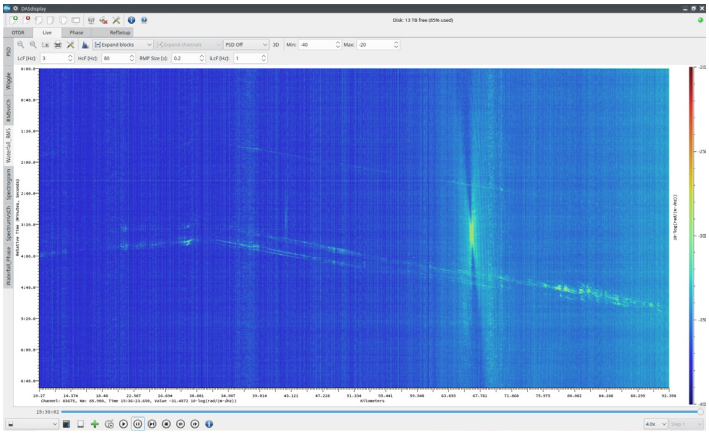
- Display of real-time data from OptoDAS interrogator or historic raw and processed data from file
- Multiple data displays can run in parallel, sharing common processing steps to reduce CPU load
- All data displays allow for zooming and customization of axis titles and legends and for on-demand or scheduled screenshots saved to image files.

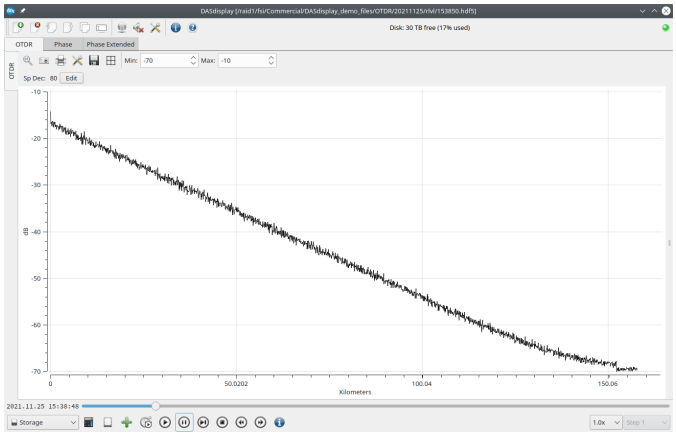
Example visualizations

- **Waterfall RMS plot**, with time on the vertical axis, fibre position on the horizontal axis and the fibre strain RMS values as a color map on the third color axis.
- **Waterfall phase plot**, with time on the vertical axis, fibre position on the horizontal axis and the fibre strain signal as a greyscale map on the third color axis.
- **Spectrogram plot**, with time on the vertical axis, frequency on the horizontal axis and the power spectral density (PSD) of the fibre strain signal on the third color axis. Multiple channels can be selected for plotting side by side in the same plot.
- **Spectrum vs. channel plot**, with frequency on the vertical axis, channel on the horizontal axis and the PSD of the fibre strain signal as a color map on the third color axis.
- **Power spectrum density plot**, with frequency on the horizontal axis and the PSD of the fibre strain signal on the vertical axis for the selected set of channels. Multiple channels can be selected for plotting in the same plot.
- **Wiggle plot**, time on the horizontal axis and fibre strain amplitude on the vertical axis for the selected set of channels. Multiple channels can be selected for plotting in the same plot.
- **Channel RMS plot**, with channel on the horizontal axis and fibre strain RMS values on the vertical axis.
- **OTDR plot**, with fibre position on the horizontal axis and back reflected optical power on the vertical axis.

Application specific displays

- Mapping application for co-visualization of DAS detections with other data sources and geodata





OptoDAS Software Suite

Data processing

Back

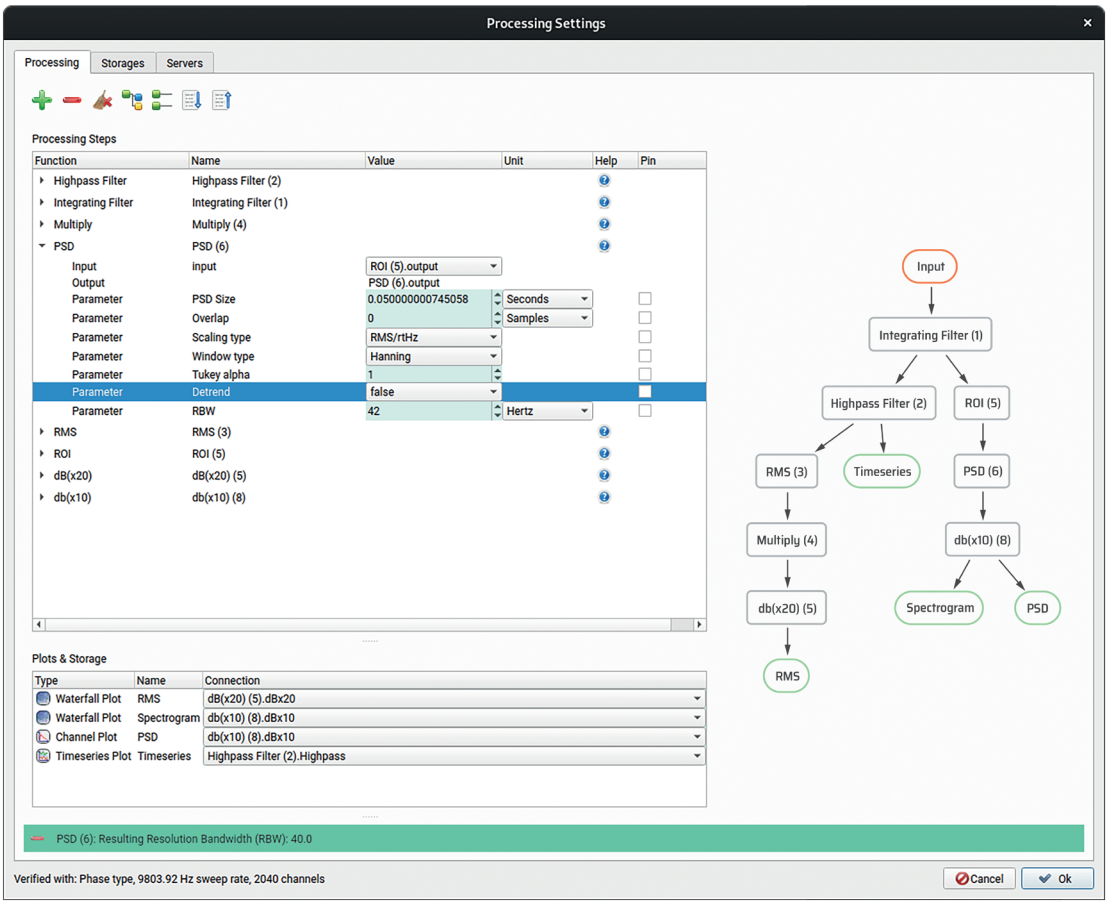
Processing of raw DAS data can be defined through the Processing Settings dialog available in both *DAScontrol* and *DASdisplay*.

Key features

- Powerful and flexible functionality for definition of processing flows producing either data displays, data files, notifications or alarms as results
- Network interface application for logging and exchange of detections and alerts
- Real-time analysis of data from OptoDAS interrogator as well historic data from file
- Graphical display of processing flow configuration with drag-and-drop functionality for re-arrangement of processing modules
- Multiple data displays and HDF5 file storage outputs can be defined within each processing flow
- Multiple processing flows can be defined and stored in configuration files for later use
- A versatile platform for filtering and decimation of large datasets prior to custom post-processing, e.g. in Python

Examples from the OptoDAS signal processing toolbox

- Time-integration of raw DAS data (fibre strain rate) to fibre strain
- Spatial averaging – increasing the gauge length post acquisition
- Region of interest (ROI)
- Temporal averaging
- Temporal band pass filtering
- RMS across a defined number of channels
- Power spectrum density
- Correlated noise filter – removal of noise components with strong temporal or spatial correlation
- Common noise subtraction – subtraction of common mode noise from all channels, defined by averaging on a selection of channels
- Event detector



Processing flow configuration dialog: A toolbox of processing filters and functions used to establish a data processing flow with desired data displays.

OptoDAS Software Suite

Audio output

Back

Key features

- Audio output to stereo headphones or loudspeakers for a chosen set of channels
- Channel axis reproduced as the stereo effect (from left to right) in the headphones or loudspeakers
- The audio output can be saved to audio files for replay

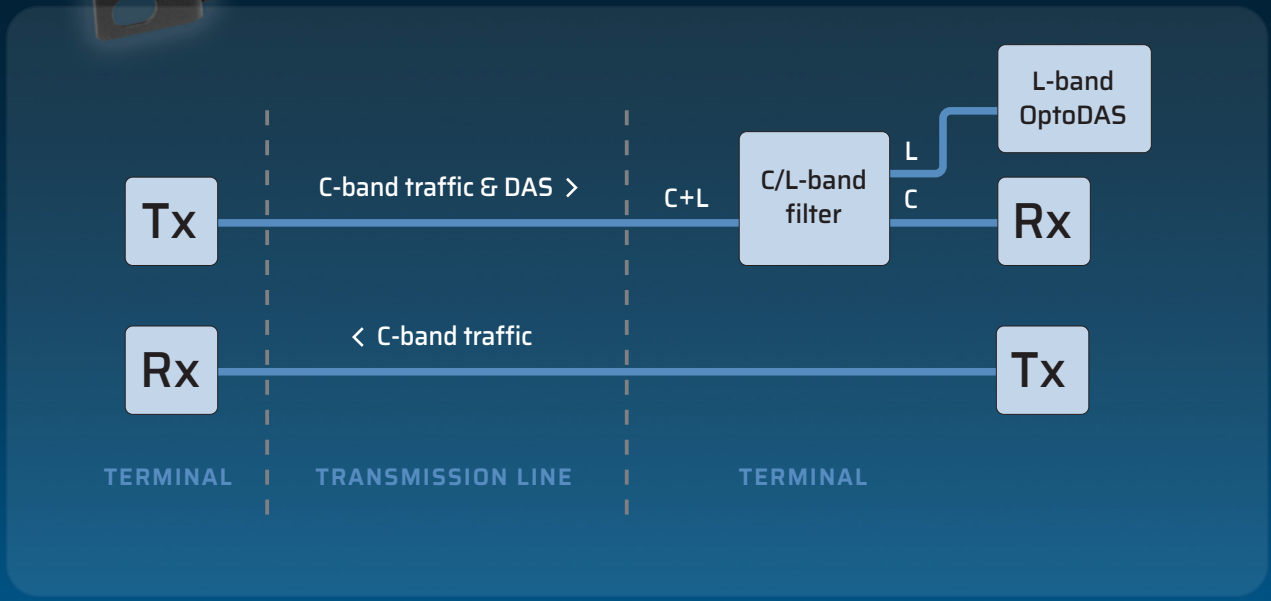
OptoDAS CL-band filter

For DAS interrogation on fibres carrying live telecom traffic

If a dark fibre is not available in the telecom system, DAS interrogation can be enabled by utilization of the L-band version of OptoDAS. The L-band version of OptoDAS is designed for coexistence with telecom traffic with no impact to the transmission line capacity and Q factor. The L-band OptoDAS, under co-existence with coherent telecom transmission channels, provides DAS data of the same quality and range as with standard OptoDAS interrogation on dark fibres.

The L-band OptoDAS, operating at the wavelength of 1577.86 nm, can be multiplexed into the telecom transmission line by use of a CL-band filter.

The CL-band filter is a passive three-port WDM that supports telecom transmission from the C+L-band port to the C-band port, and L-band OptoDAS interrogation thought the L-band port, see drawing below.



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OptoDAS CL-band filter

Technical data

Form factor

CL-band filter in 1U 19" rackmount shelf:

Form factor..... 1U 19" rackmount

Dimensions (HxWxD)..... 43×438×244mm (1U in height)

Weight..... 1.3 kg

CL-band filter module (when extracted from 1U shelf):

Dimensions (HxWxD)..... 34×129x235mm

Weight..... 0.3 kg

Optical characteristics

Insertion loss..... ≤ 1.0 dB

Isolation ..... ≥ 40 dB (L-band leakage to C-band)

Return loss ..... ≥ 45 dB

PDL ..... ≤ 0.2 dB

Power handling ..... ≥ 300 mW

Option	Supported C-band transmission spectrum	Recommended for connection to
Type A	1528.0 – 1567.5 nm	Terrestrial systems
Type B	1528.0 – 1569.0 nm	Submarine systems

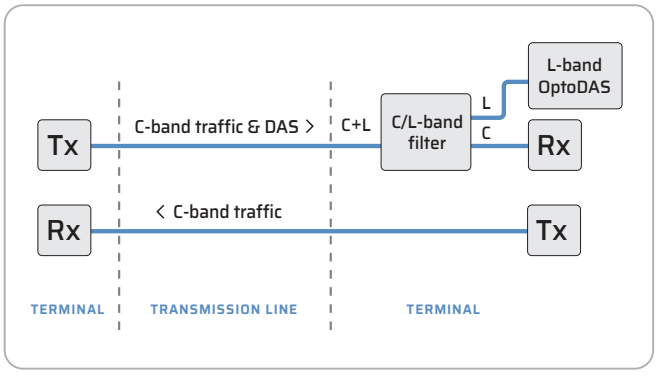
Environmental characteristics

Storage Temperature: -40 °C to +70 °C

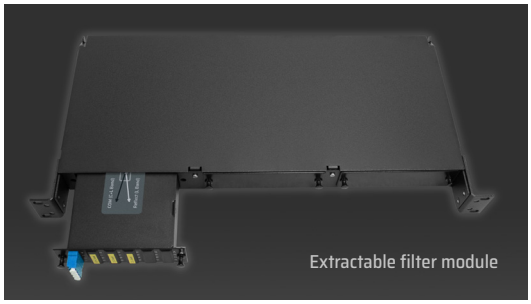
Operating Temperature: -5 °C to +70 °C

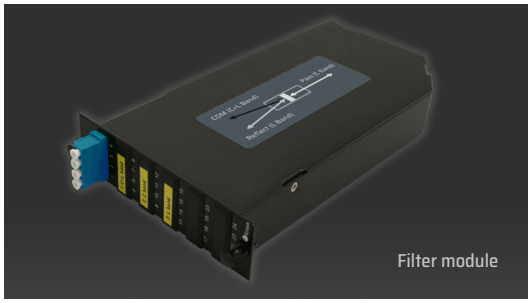
Operating Relative Humidity: 5% to 95% (non-condensing)

Connection diagram




1U 19" rackmount shelf


Extractable filter module


Filter module

Rev. 21.09.2023

OptoDAS MUX

For simultaneous interrogation on multiple fibres

The OptoDAS interrogator enables simultaneous interrogation of 2, 3 or 4 sensing fibres by use of the dual or quad fibre option. The dual and quad fibre option comprises a 1U rackmount unit installed together with the OptoDAS interrogator and enables both reduced cost, footprint, and power consumption, when simultaneous interrogation of multiple fibres is required.

The dual and quad fibre option supports simultaneous interrogation of multiple fibres without any degradation in the performance characteristics specified for the OptoDAS interrogator. Maximum total fibre length of the multiple fibres to be interrogated is limited to 250 km, and the sampling frequency is limited by the total fibre length.

[Preliminary front panel design]

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OptoDAS MUX

Technical data

Performance characteristics

No degradation compared to single channel operation.

Sensing range capacities

Maximum total length for all fibres is 250 km.

The sampling frequency is limited by the total fibre length interrogated.

Mechanical

Height: 1U – 44 mm

Width: 480 mm (for 19" rack)

Depth: 430 mm

Mass: 5 kg

Electrical

Power consumption: Typical 19W, max 25W

Supply voltage: 12V DC (AC-DC adapter included)

Optical

Insertion loss: < 1 dB, with OptoDAS MUX-200

< 2 dB, with OptoDAS MUX-400

Connection interfaces

Power: Jack 2.1/5.5mm

Control: Connection to OptoDAS interrogator

Optical: Diamond FC/APC or E2000/APC (single mode)

Options

OptoDAS MUX-200: Dual fibre option supporting simultaneous interrogation of two fibres.

OptoDAS MUX-400: Quad fibre option supporting simultaneous interrogation of two, three or four fibres.

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