

# HULLMOS<sup>®</sup>

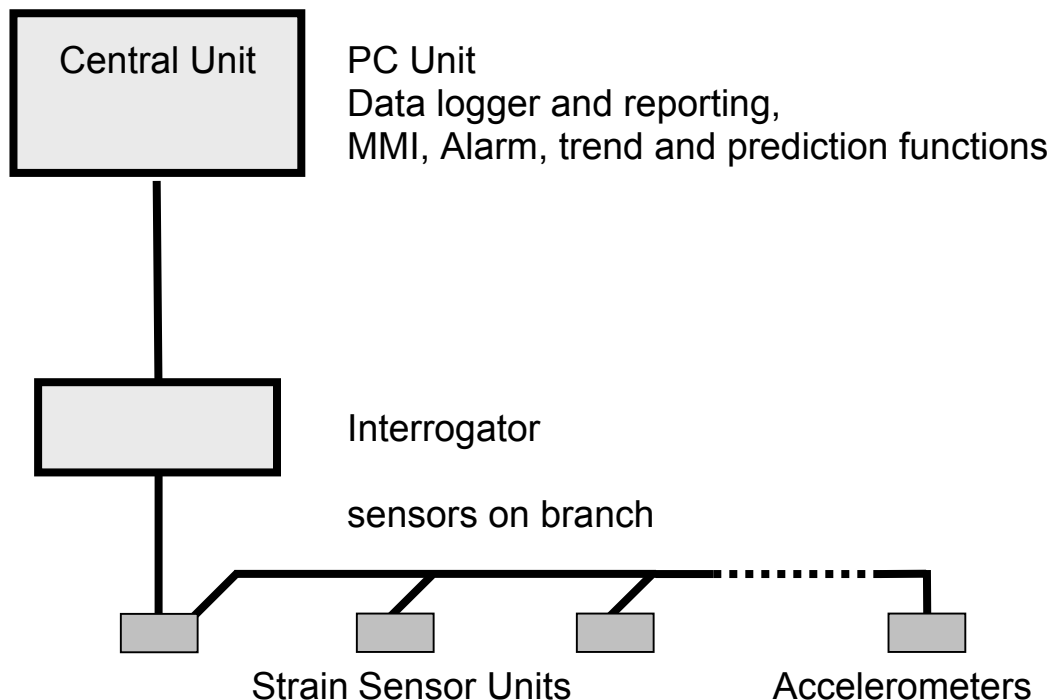
## FIBRE OPTIC STRESS MONITORING – TECHNICAL SYSTEM DESCRIPTION

The Hull Stress Monitoring System **HULLMOS** is to prevent design stresses being exceeded. This is achieved by measuring the relative deformation, strain (stress) in the hull due to loading (still water strain) and due to waves (dynamic strain). The measured stress is analysed in a distributed way inside the sensors. The analysis methods used identify the static, dynamic and slow changing temperature components from the signal and calculate different signal characteristics. The results are transmitted to the central unit, normally on the bridge, to be further analysed, datalogged and displayed to the bridge personnel to assist the navigation.

### **HULLMOS is an integrated platform for strain, fatigue and motion monitoring**

Sensors for strain and fatigue are SBSG(F) (Short Base Fibre Optic Strain Gauge). Off- the-shelf-type of sensors is used to measure motion and acceleration.

### **HULLMOS Monitoring System**



## Strain Sensor Usage and Installation

Typical installation places for the sensors are:

- onto the deck
- onto the bulkhead

The strain sensor is to be installed in such a way that it measures the deformation at the main hull girder.

In general, the installation is to exclude the effects of local stress concentrations caused e.g. by material discontinuities, welding and sandblasting. The sensor may be installed by using normal shipyard working standards for accurate installations.

The sensor is designed to be:

- easily tested
- easily calibrated and
- replaceable

## SBSG(F) Sensor Functional Description

The strain gauge is able to measure the strain with an accuracy of at least 5 micro strains. The linear range of the gauge is  $\pm 2000$  micro strains. Sampling rate with T4 interrogator is up to 1kHz

### System configuration:

The system functionality is realised in the Central Unit PC computer

#### *Signal characteristics:*

- signal mean value calculation
- signal standard deviation calculation
- signal peak value detection
- average zero (mean value)-crossing period detection
- rainflow analysis, cycle counting following standard

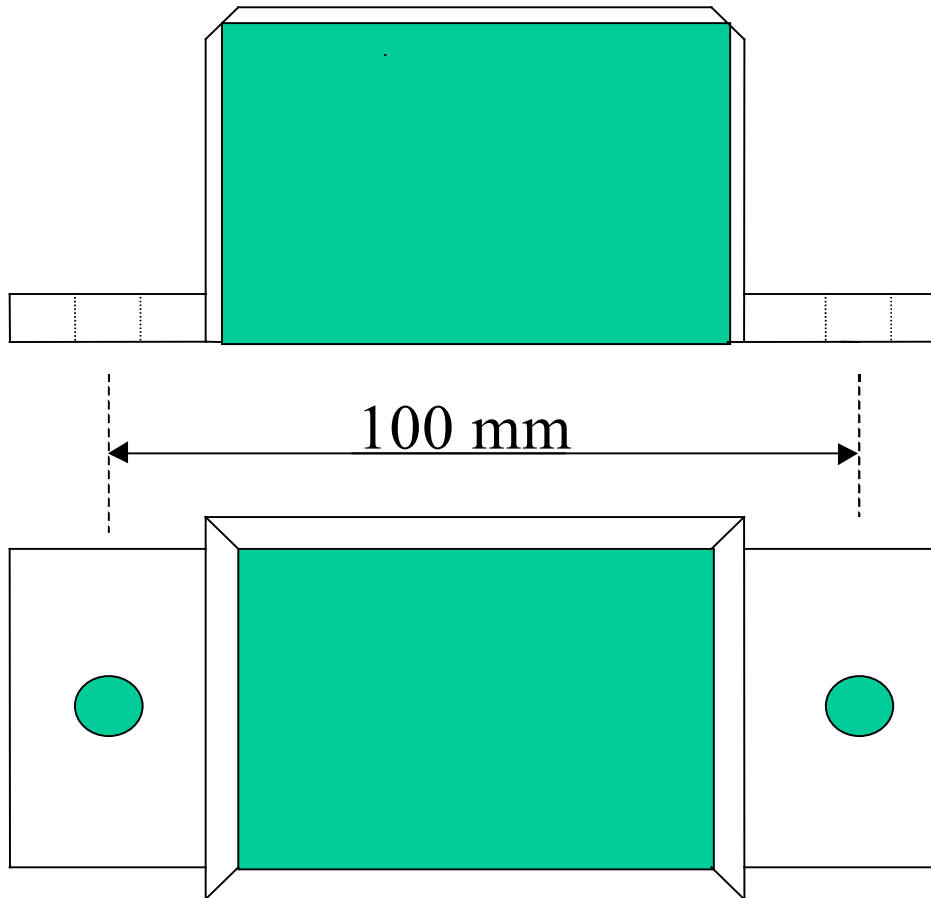
#### *Datalogging*

Datalogging has wide variety of options to fulfil different customer specifications.

#### *User interface (MMI)*

The analysis results are available on PC in well-specified format. Windows shared memory is used to integrate the strain analysis with the user interface (MMI) and other systems e.g. loading instrument.

## SBSG SENSOR(F) (Short Base Fibre Optic Strain Gauge)



### Sensor element characteristics (Smartfibres Ltd):

Strain Range $\mu$ strain	+/- 9,000 +/- 20,000
Strain sensitivity	pm/ $\mu$ strain - 1.20 -
Temp sensitivity	pm/ oC - 11 -
Strain Resolution	$\mu$ strain 0.2 1 -
Temperature Resolution	oC 0.02 0.1 -
FBG Measurement Drift	pm - - 0
Operating Temperature Range	-50 to +85 -100 to +300
FBG length mm	0.1 10 -
Typical FBG Type	CWL 1520 – 1570 nm FWHM $\leq$ 0.3 nm R>90% Apodised profile, SLSR >20dB Fibre Type Single Mode SMF-28, 9/125 $\mu$ m
250 $\mu$ m acrylate coat (150 $\mu$ m polyimide recoat for high temp range)	
Optical Fibre Cable 3 mm diameter PVC sheathed Kevlar armoured cable	

## Interrogator characteristics (Smartfibres Ltd):

Model	T4-01	T4-04	Wavelength
Range	1520 - 1570 nm		
No. of Channels	1	4	
Max No. of Sensors	Unlimited		
Min sensor spacing	3.5 m, shorter spacing on request		
Max Update Rate	500 KHz		
	± 17 pm at 10 kHz Wavelength		
	± 5 pm at 1 kHz		
	± 1.2 pm at 50 Hz		
	± 14 µstrain at 10 kHz		
Resolution	as T4-01, but 150µs delay in Strain †		
	± 5 µstrain at 1 kHz $\propto \sqrt{(1/Hz)}$ channel switching		
	± 1 µstrain at 50 Hz		
	± 1.5 °C at 10 kHz Temp ‡		
	± 0.5 °C at 1 kHz		
	± 0.1 °C at 50 Hz		
Processor	Micro controller		
Interface	Ethernet Base 10 (Base 100 as option)		
Optical connector	FC/APC		
	FC/APC Electrical Supply	5V	
DC	5V DC (adaptor supplied)	Max	
3A	Max 5A		
Output Power	Max 12 dBm	Max 12	
dBm Weight	~1 kg	~1 kg	
Operating Temp	0 °C to +50°		
Dimensions	17 x 28 x 5.5 cm		

## T4 FIBRE BRAGG GRATING INTERROGATORS



- Low cost
- Compact
- Robust

Using Smart Fibres' latest time domain multiplexed (TDM) technology, the T4 identifies individual FBG sensors by the timing of their returned signals, and since it does not contain any moving optical components enables a compact, thermally and mechanically stable unit. Unlike other TDM interrogators, the T4 offers a wide 50 nm waveband per channel, providing the flexibility of a broad sensing range using conventional, high reflectivity apodised sensors. An Ethernet interface to our SmartSoft suite of LabView applications allows for on-line calibration, data display and logging of the FBGs under test.

Model	T4-01	T4-04
Wavelength Range	1520 – 1570 nm	
Number of Optical Channels	1	4
Typical Number of Sensors/Channel	20	
Minimum Sensor Spacing	3.5 m ( $\geq 10$ m best performance)	
Sensor measurement data rate	Multi kHz (internal data logging) 50 Hz (real-time via Ethernet output)	
Repeatability* (50Hz data rate)	Wavelength	6 pm
	Strain <sup>†</sup>	5 $\mu$ strain
	Temp <sup>‡</sup>	0.5° C
Processor	Micro controller	
Interface**	Ethernet Base 10	
Optical connector	FC/APC	FC/APC
Electrical Supply (mains adaptor supplied)	5V DC Max 3A	5V DC Max 5A
Output Power	Max 12 dBm	Max 12 dBm
Weight	~1 kg	~1 kg
Operating Temperature**	0° C to +50° C	
Dimensions**	17 x 28 x 5.5 cm	

<sup>†</sup>at 1.2 pm /  $\mu$ strain

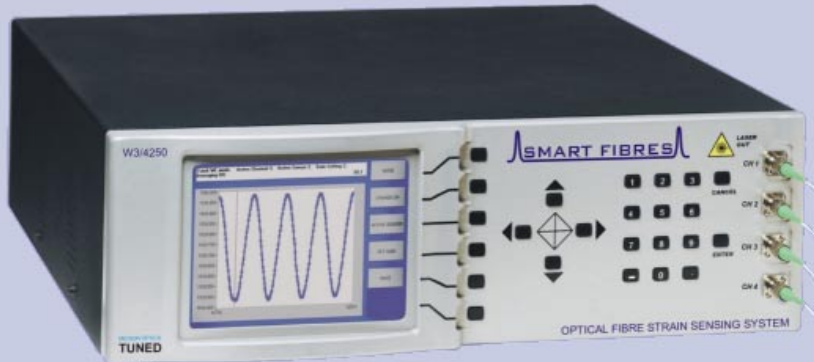
<sup>‡</sup>at 11 pm / °C

specifications may change without notice

\* Measured over several minutes, standard uncertainty (1  $\sigma$  distribution), sensor spacing of  $\geq 10$  m

\*\*For extended operating ranges, alternative interfaces and packaging options, please contact us

## W3 SERIES FIBRE BRAGG GRATING INTERROGATORS



- High Speed
- High Precision
- Easy to use
- Expandable System

The W3 Range of FBG interrogators contain the most mature and tested technology on the market today. Developed and manufactured by Micron Optics Inc., the W3 range provides high-resolution interrogation at speeds of up to 250 Hz on up to four optical channels, allowing up to 512 FBG sensors to be simultaneously monitored. An internal Linux PC provides deterministic data interrogation, and a convenient Ethernet interface to our SmartSoft suite of LabView applications allows for simple on-line calibration, data display and logging of the FBGs under test. Where required, an inbuilt LCD and front panel controls are also available.

Model	W3/1050	W3/2100	W3/4250
Wavelength Range	1520 - 1570 nm		
Number of Optical Channels*	1 *	2 *	4
Maximum Number of Sensors	32 *	128 *	512
Typical Sensor Spacing	> 2 x Sensor Bandwidth		
Scan Frequency	50 Hz*	100 Hz*	250 Hz**
Long-Term Stability	2 pm typ., 5 pm max		
Repeatability <sup>□</sup>	Wavelength	0.2 pm (25 averages)	
	Strain <sup>†</sup>	< 0.2 $\mu$ strain (25 averages)	
	Temp <sup>‡</sup>	0.02° C (25 averages)	
Processor	LINUX PC		
Interface	Ethernet	Ethernet & Colour LCD	
Optical Connector	FC/APC		
Electrical Supply	24 VDC or 100 to 240 VAC		
Power Consumption	75W Typical 150W Max		
Weight	~ 15 kg		
Operating Temperature	10° to 40° C		
Dimensions	133 x 432 x 451		

<sup>†</sup> at 1.2 pm /  $\mu$ strain

<sup>‡</sup> at 11 pm / °C

Specifications may change without notice

<sup>□</sup> 0.5 pm with no averaging

\*Denotes features that can be upgraded after or at time of sale

\*\*125 Hz for > 100 sensors

\*Number of optical channels may be increased using the ecm / esm series expansion modules