

ENGLISH

# **User Manual**





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# **1 TECHNICAL DETAILS**

### 1.1 General Information

The FS22 - Industrial BraggMETER SI with real time embedded Smart Peak Detection (SPD) is a continuous swept laser scanning interrogator specifically designed to interrogate Fiber Bragg Grating (FBG) based sensors in industrial environments.

BraggMETER interrogators include a NIST traceable wavelength reference that provides continuous calibration to ensure system accuracy over long term operation. The high dynamic range and high output power combined with the Smart Peak Detection (SPD) allow high resolution to be attained even for long fiber leads and lossy connections.

Multiple sensors can be connected in series in each optical fiber, in combination with one, four or eight optical connectors with parallel acquisition. The FS22 - Industrial BraggMETER SI is particularly suitable for large scale sensing networks acquiring a large number of sensors simultaneously and providing 1 S/s acquisition rates with sub picometer resolution.

The BraggMETER is available either in Standard and Rack-mountable formats. This manual applies to the following equipment:

- K-FS22 (1S/s option)
- 1-FS22SI-ST/4CH
- 1-FS22SI-ST/8CH

### 1.2 System Components

The FS22 - Industrial BraggMETER SI set includes:

Standard format	Rack-mountable format
- Interrogator	- Interrogator
- AC-DC power supply unit 24V	- Power cords (EU, US, UK, Aust/NZ)
- Power cords (EU, US, UK, Aust/NZ)	- Ethernet cable (L ~2 m)
- Ethernet cable (L ~2 m)	- Connector protection caps
<ul> <li>Mounting blocks with M6 screws</li> </ul>	- Quick start guide
- Connector protection caps	- Digital support material
- Mounting holes protection caps	- Calibration certificate
- Quick start guide	
- Digital support material	
- Calibration certificate	

### 1.3 Software

FS22SI Interrogators are delivered with BraggMONITOR SI software that enables easy device configuration, data viewing, saving and management, and can operate as a simple interface for command communication.

These interrogators can be integrated into any system through SCPI like commands (ASCII strings). LabView Drivers are also available for third party integration. Relevant software packages are available for dowload on our website <u>https://www.hbkworld.com/en/services-support/support/support-hbm/downloads/downloads-software/software-firmware-downloads-for-optical-interrogators</u>

The static industrial BraggMETER is compatible with the powerful professional catman Easy/AP software. Catman is available for purchase and download on our website <a href="https://www.hbkworld.com/en/services-support/support/support/support-hbm/downloads/downloads-software/support-downloads-catman">https://www.hbkworld.com/en/services-support/support/support/support/support/support/support-hbm/downloads/downloads-software/support-downloads-catman</a>

### 1.4 Synchronization

FS22 follows the NTP synchronization via Ethernet method, using an external NTP server.

# 2 REGULATORY AND CERTIFICATION CONSIDERATIONS

### 2.1 Environment Considerations

### 2.1.1 Disposal of your Old Appliance



When the attached symbol combination - crossed-out wheeled bin and solid bar symbol is attached to a product it means the product is covered by the European Directive 2002/96/EC and is applicable in the European Union and other countries with separate collection systems.

All electrical and electronic products should be disposed of separately from the municipal waste stream or household via designated collection facilities appointed by the government or the local authorities. The correct disposal of your old appliance will help prevent potential negative consequences for the environment and human health. For more detailed information about disposal of your old appliance, please contact your city office, waste disposal service or distributor that purchased the product.

HBK FiberSensing is a manufacturer registered in the ANREEE - "Associação Nacional para o Registo de Equipamentos Eléctricos e Electrónicos" under number PT001434. HBK FiberSensing celebrated a "Utente" type contract with Amb3E - "Associação Portuguesa de Gestão de Resíduos de Equipamentos Eléctricos e Electrónicos", which ensures the transfer of Electrical and Electronic appliance waste management, i.e. placing Electronic and Electrical appliances in the Portuguese market, from the manufacturer HBK FiberSensing to Amb3E.

### 2.1.2 Packaging Disposal

The packaging of this equipment is designed to protect it from damage during transportation and storage. It is also made of materials that can be recycled or reused, in accordance with the European Union's waste management regulations to minimize its environmental impact.

If you plan to move your equipment to different locations it is advisable that you keep the original package for reuse. This will not only grant proper protection for transportation, but also ensure the reduction of waste creation.

Packing boxes include a label with information on the materials used on that specific package.



Fig. 2.1 Packing label example

Please follow the instructions below to dispose of the packaging properly and responsibly and contribute to the preservation of our planet. Thank you!

To dispose of packaging, you should:

- Remove any labels, adhesives, nails, staplers or caps that are not part of the same material.
- Rinse the packaging with water to remove any residues or dirt.
- Flatten or fold the packaging to reduce its volume and save space (except for glass that should not be crushed).
- Separate the packaging by material and place it in the appropriate recycling bin or bag.

Most of our packing are made of paper and plastic and aimed to be reused or recycled, but they are not appropriate for food containing. Please consult the chapter "Packing Symbols" for more detailed information about the packing materials used by HBK FiberSensing, marked in the packing label of each product delivered to customers.

### Packaging Symbols

Packing materials are marked with the correspondent symbol for guidance.



Not appropriate for food

$\Box \Box$

Recyclable

The recycling symbols for the different materials include numbers and letters that identify the material type. For example, PET (polyethylene terephthalate) is marked also with the number 1, and PE-HD (high-density polyethylene) is marked with the number 2. For paper (PAP) 20 corresponds to corrugated cardboard and 22 to paper as seen in newspapers, books,...

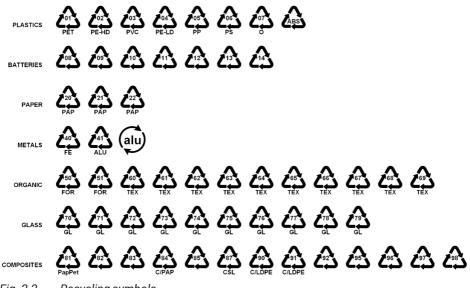


Fig. 2.2 Recycling symbols

### Plastics

Plastic packaging materials are commonly bags, films, trays, blisters or containers.

### **Batteries**

Batteries are not part of the packaging, but they may be included in the equipment or its accessories. *Please refer to section 2.1.1 "Disposal of your Old Appliance" for more information*.

### Paper

Paper packaging materials are commonly boxes, cartons, envelopes, or labels.

### Metals

Metal packaging materials are commonly cans, foils, caps, or wires.

### Organic

Organic packaging materials could be wood, cork, or cotton and are made of natural or biodegradable materials that can be composted or reused.

### Glass

Glass packaging materials are bottles, jars, or vials.

### Composites

Composite packaging materials are made of layers of different materials, such as paper, plastic, and aluminum. They are marked with a recycling symbol and a letter that indicates the composition of the packaging. For example, PAP is for paper and plastic, and ALU is for aluminum.

### 2.2 Laser Safety

The FS22 - Industrial BraggMETER SI interrogator contains a laser in its core. A laser is a light source that can be dangerous to people exposed to it. Even low power lasers can be hazardous to a person's eyesight. The coherence and low divergence of laser light means that it can be focused by the eye into an extremely small spot on the retina, resulting in localized burning and permanent damage.

The lasers are classified by wavelength and maximum output power into the several safety classes: Class 1, Class 1M, Class 2, Class 2M, Class 3R and Class 4.

# Warning symbol Class 1 Laser symbol CLASS 1 LASER PRODUCT

### 2.2.1 Symbols

### 2.2.2 Class 1 Laser

The FS22 - Industrial BraggMETER SI is a class 1 laser product:

«Any laser or laser system containing a laser that cannot emit laser radiation at levels that are known to cause eye or skin injury during normal operation.»

It is safe under all conditions of normal use. No safety requirements are needed to use Class 1 laser devices. This product contains a laser within an enclosure that prevents exposure to the radiation and that cannot be opened without shutting down the laser.

Laser Safety		
Laser Type	Fiber Laser	
Laser Class (IEC 60825-1)	1	

Laser Safety		
Typical Output Power per connector	≈ 0.3 mW (-5 dBm)	
Max Output Power per connector	≈ 0.5 mW (-3 dBm)	
Wavelength	1500-1600 nm	

### 2.2.3 General Precautions Considerations

Everyone who uses a laser equipment should be aware of the risks.

The laser radiation is not visible to the human eye but it can damage user's eyesight.

The laser is enabled when the interrogator is turned on.

Users should never put their eyes at the level of the horizontal plane of the optical adapters of the interrogator or uncovered optical connectors.

Adequate eye protection should always be required if there is a significant risk for eye injury.

When an optical connector is not in use (no optical cable plugged to the interrogator), a proper connector cap must be used.

The optical connectors are subjected to maintenance and/or inspection. *Please refer to section 3.3 "Maintenance", page 18 for maintenance procedure.* 

Do not attempt to open or repair a malfunction interrogator. It must be returned to HBK FiberSensing for repair and calibration.

### 2.3 Certification

### 2.3.1 CE marking



This product carries the CE marking and complies with the applicable international

requirements for product safety and electromagnetic compatibility, according to the following Directives:

- Low Voltage Directive (LVD) 2014/35/EU Electrical Safety
- Electromagnetic Compatibility (EMC) Directive 2014/30/EU

It is in compliance with the EN61326/EN55011 Emission Radiated Test Class A, under the Electromagnetic Compatibility Standard.

The corresponding Declaration of Conformity is available upon request.

### 2.3.2 UKCA Marking



This product carries the UKCA marking and complies with the applicable international requirements for product safety and electromagnetic compatibility, according to the following Directives:

EMC: Electromagnetic Compatibility Regulation 2016, No. 1091

• Safety: Electrical Equipment Regulations 2016, No. 1101

The corresponding Declaration of Conformity is available upon request.

### 2.3.3 Marking of pollutant emission limit values (for deliveries to China)



Statutory marking of compliance with emission limits in electronic equipment supplied to China.

### 2.3.4 Degree of protection

In compliance with the IEC/EN 60529 Degrees of protection provided by enclosures is:

- For the Standard format: IP40 certification (protection against the ingress of solids larger than 1 mm in diameter).
- For the Rack-mountable format: IP20 certification (protection against the ingress of solids larger than 12.5 mm in diameter).

### 2.4 The marking used in this document

Important instructions for your safety are specifically identified. It is essential to follow these instructions in order to prevent accidents and damage to property.

Symbol	Significance
	This marking warns of a <i>potentially</i> dangerous situation in which failure to comply with safety requirements <i>can</i> result in slight or moderate physical injury.
Notice	This marking draws your attention to a situation in which failure to comply with safety requirements <i>can</i> lead to damage to property.
Important	This marking draws your attention to <i>important</i> in- formation about the product or about handling the product.
<b>Г</b> р Тір	This marking indicates application tips or other information that is useful to you.

Symbol	Significance	
Information	This marking draws your attention to information about the product or about handling the product.	
Emphasis See	Italics are used to emphasize and highlight text and identify references to sections, diagrams, or external documents and files.	
	This marking indicates an action in a procedure	

# **3 OPERATION**

### 3.1 Connectors

### 3.1.1 Standard

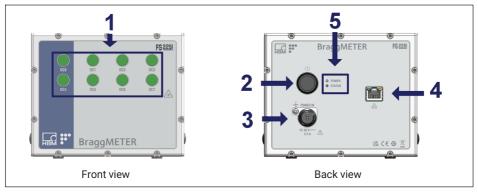


Fig. 3.1 Front and back views of FS22SI Standard

The connectors and buttons on Fig. 3.1 are:

- 1 Optical Output Connectors
- 2 ON/OFF Button
- 3 Power Connector
- 4 Ethernet Connector
- 5 POWER and STATUS LEDs

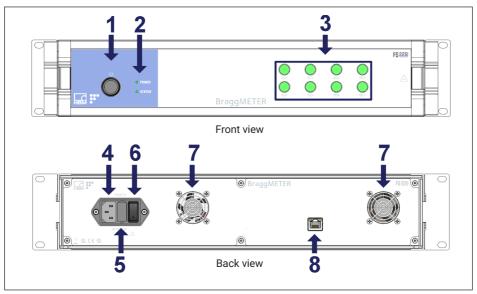


Fig. 3.2 Front and back views of FS22SI Rack-Mountable

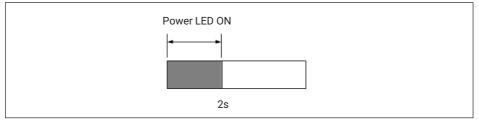
The connectors and buttons on Fig. 3.2 are:

- 1 ON/OFF Button
- 2 POWER and STATUS LEDs
- 3 Optical Output Connectors
- 4 Power Connector
- 5 Electric fuse
- 6 Safety Power Button
- 7 Fans
- 8 Ethernet Connector

### 3.2 Setting Up

### 3.2.1 Power Supply

To start the FS22 - Industrial BraggMETER SI interrogator connect the power cable to the interrogator Power Connector (number **3** on *Fig. 3.1* or number **4** on *Fig. 3.2*). To acknowledge proper power supply, the POWER LED will turn green during 2 seconds after connecting the power supply.



### Fig. 3.3

# Information

For the Standard version of the interrogator the power supply must have a minimum of 30 W, with an output voltage between 12-36 v and must withstand a peak of 4 A for at least 4 ms. For the Rack-Mountable version of the interrogator the power must be 100-240 V AC, 50-60 Hz, 1A.

### Notice

Powering above the specified limits will damage the equipment. For the Rack-mountable version there is a fuse protection that can be replaced. please see section 4.4.5 Fuse failure.



### Information

The interrogator must be powered using a power supply source not shared with other equipment's. A replacement AC-DC power supply unit 24 V (1-NTX001) for the Standard version or Power Cable (1-KAB274) available with different plug formats can be ordered from HBK.

### 3.2.2 Optical Connectors

The FS22 - Industrial BraggMETER SI can be purchased either with FC/APC, or SC/APC optical connectors. *number* **1** on *Fig.* 3.1 exemplifies FC/APC connectors.

Attention should be paid to the cleaning of the optical connectors. A dirty connector can compromise the measurement and will degrade the interrogator performance. It is advisable to frequently clean the connectors using appropriate tools.

FS22 - Industrial BraggMETER SI can have one, four or eight optical connectors in parallel.

### 3.2.3 Ethernet Connection

Connect the Ethernet RJ45 connector directly to a PC using a Ethernet cross-over cable, or to a network connector using a direct Ethernet cable (in this case, the FS22 - Industrial BraggMETER SI must be in the same subnet as your Local Network).

# Important

The interrogator default network configuration is "10.0.0.10:255.0.0.0:0.0.0.0".

### 3.2.4 Positioning

When installing the FS22 interrogator, please exercise caution regarding its placement.

The FS22 interrogator can be positioned in any orientation without impacting its functionality, providing that the remaining environmental conditions as specified on the data sheet are observed. However, it is essential to handle the fiber optic cables connected to the optical connectors with care to avoid strain or damage. Pay careful attention to rack doors or cabinet lids that may force, twist or pinch the cables (optical or electrical) compromising measured signals.

If you have questions or require assistance, please reach out to HBK FiberSensing for support.

### 3.3 Maintenance

### 3.3.1 Wear parts

HBK Optical Interrogators have wear parts (such as ventilation fans, optical connector adapters and batteries) that require minimum running conditions to ensure a correct operation of the equipment.

Wear parts are covered by a limited warranty as they are components that depend on the usage and on the environmental conditions the equipment operates in, such as humidity, temperature and dust.

A periodic maintenance should be planned and managed by the customer considering the actual operation conditions. Warranty will only be applied to wear parts if the cause of the defect can be clearly traced back to the material or manufacturing fault.

### 3.3.2 Ventilation

The FS22SI is an electronic equipment with active ventilation, meaning that it uses fans for thermal control of the device. Fine dust particles over time can reduce the life time of optical and electronic components leading to a general degradation of the equipment, so it is important to prevent dust from entering the device. For that reason the interrogators should be kept on a controlled environment, far or protected from major dust areas.

### 3.3.3 Optical connectors

Optical connectors of the interrogator are subject to degradation and can actually break upon misusage (see section 4.4.2. Broken Connector). If this happens, the interrogator must be sent back to HBK FiberSensing for repair.

### 3.3.4 Calibration

BraggMETER interrogators have a built-in NIST traceable gas cell that ensures calibrated measurements at all time. For this reason, a compulsory periodic calibration is not required. Nevertheless, for regulatory reasons or internal rules, a periodic certified calibration procedure is sometimes required. For those cases, the calibration service is available and can be requested to HBK FiberSensing.

### 3.4 Switching On

Pressing the ON/OFF button will start the interrogator. The STATUS LED will start blinking at 2 Hz. After approximately 30 seconds it will start blinking at 1 Hz. This means that the interrogator is already on and responsive, but the optoelectronic module is still warming up. After approximately 90 seconds it should stay on permanently. This means that the interrogator is able to measure.

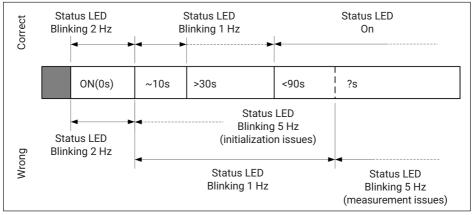


Fig. 3.4 Power ON/OFF button and status LED behavior



If the interrogator does not start correctly, the STATUS LED will blink faster. If this happens please contact HBK FiberSensing technical support.

### 3.5 Switching OFF

To avoid accidental shut-down of the interrogator, it is necessary to press the "ON/OFF" button between 2 and 6 seconds (*Fig. 3.5*).

If for some reason the 6 seconds are exceeded the user can release the button before 10 seconds are reached and the interrogator will remain ON (*Fig. 3.6*).

### Notice

If the ON/OFF button is pressed more than 10 seconds, changes in the interrogator configuration are performed and connection might be lost. See section 3.6.2, under Resetting IP to default, for further details.

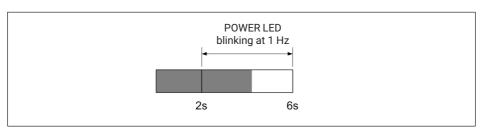


Fig. 3.5 Power LED while pressing Switching Off between 2 s and 6 s

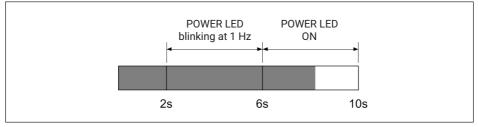


Fig. 3.6 Power LED while pressing Switching Off between 6 s and 10 s

### 3.6 Operating the Interrogator

### 3.6.1 Network Properties

To operate the FS22 - Industrial BraggMETER SI from a personal computer, the PC network properties should be set so that both elements are configured in the same subnet.

To configure your personal computer so that it is on the same subnet as the default for the interrogator, proceed as follows:

- > On the control panel choose **Network Connections**.
- Select the LAN connection. The window displayed in Fig. 3.7 will appear. Click on Properties.

General		
Connection -		
IPv4 Connec	tivity:	Internet
IPv6 Connec	tivity:	No Internet access
Media State:		Enabled
Duration:		06:54:52
Speed:		100.0 Mbps
D <u>e</u> tails		
D <u>e</u> tails	Sent —	— Received
D <u>e</u> tails		Received

Fig. 3.7 Local Area Connection Status

Select the Internet Protocol (TCP/IP) and click on the button **Properties** (*Fig. 3.8*).

	rking Sharing			
Conn	ect using:			. 11
2	Generic Marvell	Yukon 88E8057 PCI-	E Gigabit Ethernet C	
This	4:	the fellowine terror	Configure	
_	-	the following items:		- 11
	Client for Mic			
		Network Enhancer		
	QoS Packet			
	File and Print	er Sharing for Microsof	t Networks	
		ocol Version 4 (TCP/IF	2/4)	$\Box$
		opology Discovery Mar		-11
		opology Discovery Res		
	1	11.5	D III	÷IJ.
	Install	Uninstall	Properties	
	scription			
De				
Tr	de area network	ol Protocol/Internet Pro protocol that provides connected networks.		

Fig. 3.8 Local Area connection properties

Set the IP address and the subnet mask as in *Fig. 3.9*.

Internet Protocol Version 4 (TCP/IPv4) Properties						
General						
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.						
Obtain an IP address automatically						
• Use the following IP address:						
IP address:	10 . 0 . 0 . 66					
Subnet mask:	255.0.þ.0					
Default gateway:						
Obtain DNS server address au	tomatically					
• Use the following DNS server a	addresses:					
Preferred DNS server:						
Alternate DNS server:	· · ·					
Validate settings upon exit						
OK Cancel						

Fig. 3.9 Internet Protocol Version 4 Properties

Press OK.

### 3.6.2 Resetting the IP Address of the Interrogator

If for any chance there is the need to physically change the IP address of the interrogator, there is a reset procedure that consists on pressing the ON/OFF button for more than 10 seconds.

When the button is being pressed for 10 seconds the POWER LED blinks 3 times and goes OFF. At this moment the ON/OFF button can be released and the reset of IP address will happen.

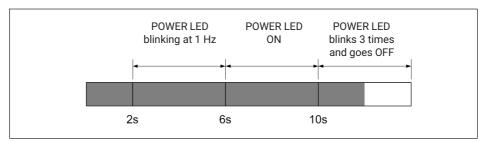


Fig. 3.10 Power LED while pressing Switching Off for more than 10 s

This procedure resets the interrogator changing its IP address to the default and its measuring settings to the last stored.

# Information

The interrogator default network properties are "10.0.0.10:255.0.0.0:0.0.0.0".

### 3.6.3 Synchronization

In order to achieve synchronous measurements between different devices the NTP (*Network Time Protocol*) synchronization via Ethernet must be used.

Each optical Interrogator can synchronize its internal clock with an NTP server. It is possible to achieve accuracies of 1ms or higher, depending on whether or not a dedicated NTP server is being used.

Further information about NTP can be found at http://www.ntp.org.

### Measuring Systems Typology

A measurement system can be as simple as a single interrogator or a bit more complex with combined interrogators with the same or different sampling rates, and interrogators combined with other equipment.

Single interrogator	For the usage of a single interrogator no special synchronization is needed.	
	BraggMONITOR SI software can only operate one interrogator at a time. If an NTP server is running on the same PC as the Brag- gMONITOR SI, the interrogator internal clock – hence Brag- gMONITOR SI – will sync.	
Multiple interrogators	If more than one interrogator is used, synchronization becomes important and if an NTP server is running the equipment will start synching as soon as a first communication from the server is received.	

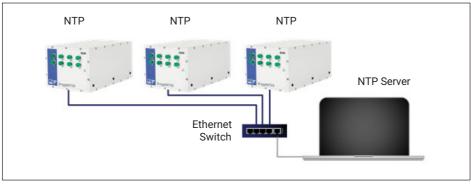


Fig. 3.11 Synchronizing multiple interrogators

# Important

The combination of FS22 interrogators and MXFS QuantumX Optical Interrogators is not possible in catman.

### Hybrid

A hybrid measurement system is a system composed by different equipment types and technologies that can be operated with different sampling rates. Taking the example of HBK families a hybrid system could be a combination of Interrogators with QuantumX.

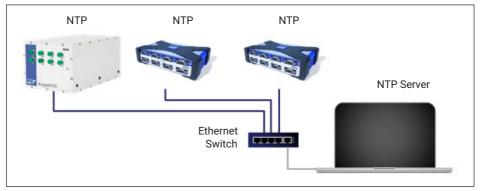


Fig. 3.12 Synchronizing interrogators with conventional technology

Synchronization is again of extreme importance in such systems. When an NTP server is running the Interrogator will start synching as soon as a first communication from the server is received.

For details on the other equipment please refer to their respective user manuals.

### Synchronization process

Each interrogator synchronizes its internal clock with the NTP server. Upon starting, all devices and the NTP server need some settling time to achieve the best synchronism possible.

The following features for NTP synchronization are available:

Number of devices to be synchronized	Unlimited
Synchronization accuracy	100 µs to 10 ms
Synchronization settling time	Up to 30 min during first start, up to 2 min during restart
Synchronization master	External SyncMaster, e.g. PC

For a good synchronization, the dedicated NTP server should run continuously. The accuracy is described by the two values:

- Offset: average deviation from time server
- Jitter: typical variation range of the offset value

The clock synchronization is classified using the following offset intervals:

- <500 µs: excellent</p>
- <1 ms: very good</li>
- <2 ms: good</li>
- <5 ms: acceptable</p>
- <10ms: poor
- >10ms: not acceptable

A successful NTP Sync is achieved if the offset between the internal clock of the device and the NTP server is below 5ms.

The quality of the NTP synchronization can be queried using the SCPI commands (please refer to section "Synchronization" on page 53 for further details).

### 3.6.4 Operation

The FS22 - Industrial BraggMETER SI interrogator can be fully controlled using standard SCPI syntax commands (for a complete command list, *please refer to section 5.1 "Communication Protocol Syntax" on page 43*).

### Using the available Drivers

LabVIEW<sup>™</sup> drivers can be downloaded from our webpage for operating with the FS22DI: Software & Firmware Downloads for Optical Interrogators - HBK (<u>www.hbkworld.com</u>) These drivers are to be used within the LabVIEW<sup>™</sup> environment. To develop custom applications using this language, copy the drivers' library. A set of ready to use examples to run on LabVIEW<sup>™</sup> is also provided.



Before using the provided LabVIEW<sup>™</sup> examples on a PC, make sure the Regional and Language options (in standards and formats) are defined as dot for decimal symbol, comma for digit grouping symbol and dash for date separation.

### **Operational States**

The FS22 - Industrial BraggMETER SI interrogator has six operational states:

0 Error	The error state corresponds to a malfunction of the optoelec- tronic module of the interrogator. The system can only recover from this state by resetting.
1 Ready	In the ready state, the FS22 - Industrial BraggMETER SI is ready to start acquisition.
2 Free acquisition	The free acquisition state enables the FS22 - Industrial BraggMETER SI interrogator to perform single measurements on a specified optical connector. The interrogator can be config- ured in terms of threshold and the corresponding configuration can be stored for further measurements.
3 Continuous acquisition	The continuous acquisition state allows continuous wavelength acquisition over all optical connectors and also performs continuous OSA trace acquisition at 1 S/s.
4 Scheduled acquisition	The scheduled acquisition state allows periodic data acquisition with a pre-defined period and number of samples while saving data to the internal interrogator memory. Whenever the acquisi- tion period minus the number of samples (at 1 S/s rate) is higher than 10 minutes, the interrogator will enter into sleep mode dur- ing inactive time intervals, to reduce power consumption. The minimum period is 5 s and the number of samples (at 1 S/s) cannot overcome the defined period.
5 Warming-up	The FS22 - Industrial BraggMETER SI interrogator starts on the warming-up state that enables the settling of the operation parameters and recall of the acquisition configuration.



### Information

The interrogator will only answer when the STATUS LED is already blinking at 1 Hz (see section 3.4 "Switching On" on page 19).

Mait	<b>5</b> Warming-up	IDEN? STAT?
Acaustop	4 5 Scheduled acquisition Warming-up	STAT?
Acaustop	3 Continuous acquisition	STAT?
ACQUISTOP	2 Free acquisition	IDEN? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? STAT? ACOU:CONF.THRE.CHAN:C? ACOU.ENGI:CHAN:C? ACOU.ENGI:CHAN:C? ACOU.ENGI:CHAN:C? ACOU.MAYE.CHAN:C? ACOU.MAYE.CHAN:C? ACOU.MAYE.CHAN:C? ACOU.POWE.CHAN:C? ACOU.POWE.CHAN:C? ACOU.ST.CHAN:C.CON.ST.CHAN:C? ACOU.ST.CHAN:C? ACOU.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:C? ACOU.ST.CHAN:CON.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:CNAN.ST.CHAN:C? ACOU.ST.CHAN:CAN.ST.CHAN:CAN.ST.CHAN.ST.CHAN.ST.CHAN.ST.CHAN.ST.CHAN.ST.CHAN.ST.CHAN.ST.CHAN.S
ACQU.SCHE.STAR ACQU.OSAT.CONT.STAR ACQU.OSAT.CONT.STAR ACQU.STAR ACQU.STAR ACQU.STAR ACQU.STAR ACQU.STAR ACQU.STAR	1 Ready	IDEN? SISAT7 SISAT7 SYST:TIME:HHMM:SS SYST:DATE? SYST:DATE? SYST:DATE? SYST:DATE? SYST:DATE? SYST:DATE? SYST:DATE? SYST:DATE? ACOU:SCHE:PER!? ACOU:SCHE:PER!? ACOU:SCHE:PER?? ACOU:SCHE:SAM??
Reset		STAT?
spuemmande status surge status commande surge su	STATUS sta	sbnsmmoo eldslisvA

Fig. 3.13 Operational States and commands

### **Power Shortage**

If a power shortage happens when the - FS22 Industrial BraggMETER SI interrogator is running in the ready, free acquisition or continuous acquisition states, the operational state is maintained once the power supply is reestablished with the stored acquisition settings.

If the power shortage occurs in the scheduled acquisition mode, the operational state is maintained once the power supply is reestablished except in the case the interrogator is in sleep mode for power saving.

### Notice

If the interrogator is in sleep mode when a power shortage occurs, scheduling will not resume upon power up.

### **Default Network Properties**

The default network properties are "10.0.0.10:255.0. 0.0:0.0.0". Whenever there is the need, the interrogator can be reset to this default address (see section 3.6.2 "Resetting the IP Address of the Interrogator" on page 23). The default address cannot be changed.

# 4 MEASURING

### 4.1 Typical Configuration

Typically, a fiber Bragg grating Sensing Network is divided into branches of several sensors connected in series. On *Fig. 4.1* there is a scheme of a usual fiber Bragg grating sensing branch.

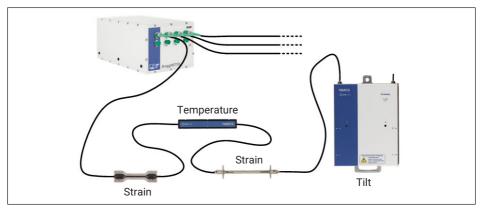


Fig. 4.1 Typical network configuration

A branch can accommodate sensors with wavelengths between 1500 nm to 1600 nm. The number of sensors in an optical connector can vary if there is previous knowledge about the spectral range the sensors will cover. The major concern is the overlap of adjacent sensors. The available optical connectors have simultaneous acquisition, meaning that the sensing network can have a large number of fiber Bragg grating sensors interrogated at the same time.

The employed technology allows multi-functionality meaning that on the same branch it is possible to measure Strain, Temperature, Displacement, Pressure, Acceleration, etc...

The sensing network can be placed several kilometers from the interrogator without significant losses on transmission over the optical fiber, operating under EM/RF interferences.

Each fiber Bragg grating sensor has a characteristic central wavelength ( $\lambda_0$ ) that depends only on the measurand. This means that with this technology there is no need for recalibrations every time the system is shut down. The FS22 - Industrial BraggMETER SI is a ruggedized interrogator designed for standalone operation.

### 4.2 Definitions

The following definitions are applicable to this equipment only.

### 4.2.1 Wavelength

The Wavelength value corresponds to the wavelength at the peak of the fiber Bragg grating reflection spectrum, commonly referred as Bragg wavelength (*Fig. 4.2*).

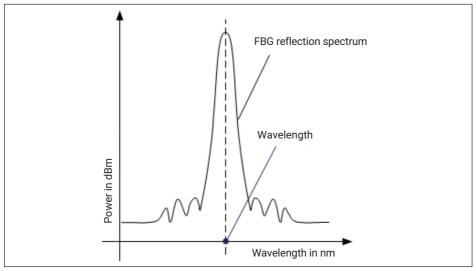


Fig. 4.2 Wavelength

### 4.2.2 Power

The Power value corresponds to the optical power reflected by the fiber Bragg grating at the peak wavelength (*Fig. 4.3*).

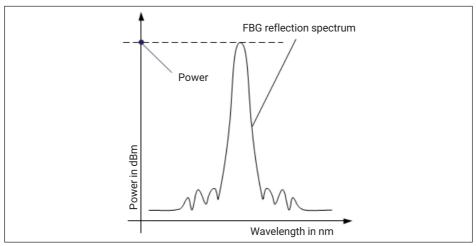


Fig. 4.3 Power

### 4.3 Measurement Methods

BraggMETER interrogators incorporate two distinct measurement methods. The Conventional in which a global threshold is considered for the detection and measurement of the fiber Bragg grating sensors and the Smart peak Detection (SPD), in which individual configurable sensor ranges are used combined with a defined threshold for the optical connector, referenced to the peak inside each range.

### 4.3.1 Conventional

In the conventional measuring approach, the threshold level is defined in dB for each optical connector individually and it is defined from the maximum peak power of the connector (*refer to Fig. 4.4*). The threshold value corresponds to the considered power level for the FBG peak computation, so that side lobes and ground noise are disregarded. Although it is considered an expedited way of performing measurements, the use of this method should be limited to laboratory applications with reduced power losses between sensors.



### Important

When measuring with the conventional method the configuration of all sensors can be affected by local insertion losses. If power losses are expected (field applications) the SPD method is recommended.

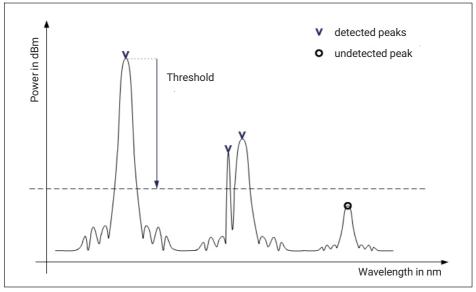


Fig. 4.4 Conventional detection method

### 4.3.2 Smart Peak Detection (SPD)

SPD allows the effective use of the high dynamic range offered by the interrogator through the introduction of individual and adaptive thresholds, referenced to the peak on each sensor's configurable range (*refer to Fig. 4.5*).

As in the conventional measuring method, the threshold value corresponds to the considered power level for the FBG peak computation and it is defined in dB for each optical connector individually. The difference on the SPD is that the threshold value is referenced to the highest peak of each range, operating individually in every range.

Within each sensor range, even though it happens, either permanently or occasionally, that multiple peaks overcome the threshold, only one FBG sensor will be computed, thus eliminating problems indexed to the measurements. Additionally, any influence these spurious peaks could exert on the measurements is canceled.

Summarily, the increased robustness provided is especially suited to overcome the limitations found in the conventional methods where low and high reflectivity FBGs coexist and signal losses are often a problem. SPD therefore improves the stability and accuracy of the measurements, contributing to the system's efficiency.

# i

### Information

When SPD is active, the total number of sensors that can be measured by the interrogator should not exceed 400.

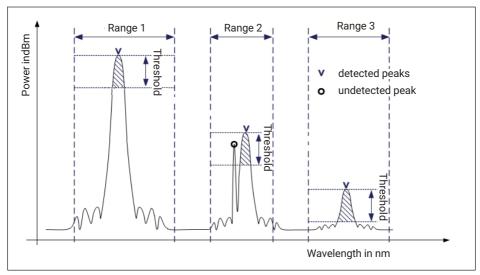


Fig. 4.5 Smart Peak Detection (SPD) detection method

## 4.4 Common Measuring Difficulties

There may be the possibility of having measuring malfunctions due to several problems in the sensing network or optical connections. A list of some of the usual problems is described below with the explanation for its occurrence and correction.

### 4.4.1 Dirty Connector

When an interrogator is repeatedly being plugged in and out with optical connectors, it is very important that the connectors are cleaned prior to any connection. If not, dust and moisture can be deposited in the interrogator adaptor and this will compromise measurements. On *Fig. 4.6* a picture of a magnified connector is presented. The dark gray circle corresponds to the fiber cladding and the small light gray circle is the core of the fiber. One picture for a clean connector and one picture for a dusty connector are presented.

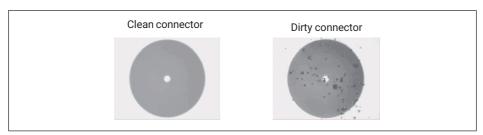


Fig. 4.6 Magnified Clean vs Dirty connector

The most common effect of dirt on the connections is that there is a large amount of broad band light being reflected at the connection, at both directions, meaning that the dynamic range for measuring becomes smaller.

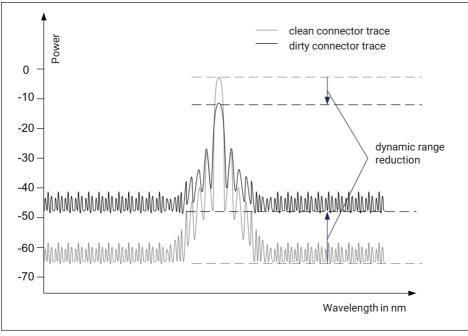


Fig. 4.7 Dirt impact on sensor signal

To clean an optical interrogator adapter, use an appropriate cleaner (1-FSCLEANER from HBK or similar). Insert it in the optical adapter, number 1 in *Fig. 4.8*, and press it against the inside of the connector to clean.

Alternatively, use an appropriate cotton swab (there are several cleaning swabs in the market frequently used for telecom) embedded in isopropyl alcohol. Insert it in the optical adapter, number **2** in *Fig. 4.8*, and rotate the swab always on the same direction.



Fig. 4.8 Cleaning connectors

### 4.4.2 Broken Connector

It may also occur that the interrogator adapter sleeve breaks. In this case, when an optical connector is inserted it does not get proper alignment and measurements are compromised. A broken sleeve will look as shown in *Fig. 4.9*.



Fig. 4.9 Broken connectors

To solve this problem you should contact HBK FiberSensing.

### 4.4.3 Reflective Fiber Ending

It may occur that the interrogator does not find any sensor on an array even if connections were performed correctly. One of the reasons may be the excess of reflected light saturating the detectors.

When a fiber is perfectly cut (Fig. 4.10 on the left) a large amount of light is reflected right back into the core of the fiber in such an angle that it gets guided back heading to the interrogator detectors. When this occurs, an index matching gel or an angled termination must be used. If these are unavailable, the tip of the fiber can be smashed with a metallic tool. This will destroy the perfect geometry (*Fig. 4.10 on the right*) and the light that is reflected at the surface will take random directions ending up outside the core.

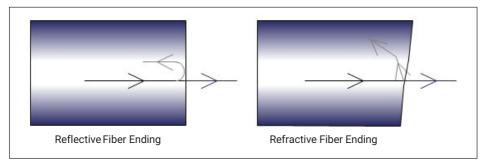


Fig. 4.10 Refraction and reflection at fiber end

### 4.4.4 Cut Fiber

When the fiber, for any reason, is broken between two sensors in a series, the sensors that are after the fault may disappear from the optical spectrum and may not be detected.

There may also be the case that the fiber is cut, but not completely spread apart (e.g. the fiber is damaged in an area covered with glue). This will cause a Fabry-Pérot effect – the light will suffer multiple reflections inside the cavity creating sinusoidal background reflection. *Fig. 4.11* shows a schematic representation of the reflected spectrum for these three presented cases.

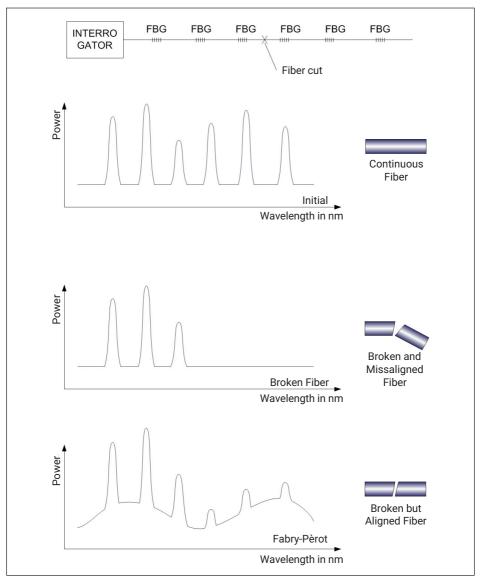


Fig. 4.11 Cut fiber effect

### 4.4.5 Fuse Failure

Electrical shorts on the power supply may cause problems to the interrogators. The Industrial BraggMETER SI on its Rack-Mountable format is directly connected to the

100-240 V power line meaning that it has no external protection. Replaceable fuses are available on the interrogator's back-side next to the power connector (*number* **5** *in Fig.* 3.2). To replace the fuses, release the top and bottom springs of the fuses' support (*Fig.* 4.12) and then remove the piece (*Fig.* 4.13).

Fuse characteristics:

- Rated voltage: 250 Volt AC
- Interrupting rate: 1 Ampere
- Number of fuses: 2



Fig. 4.12 Removing the fuse



Fig. 4.13 Fuse holder

FS22SI MEASURING The Standard format of the interrogator is powered at 11-36 VDC, which means that the electrical protection should be granted by the power source or the adapter. If, by any chance, the power supply is overcome, the interrogator might be damaged and need repair at HBK FiberSensing.

### 4.4.6 Distance effect

For sweeping laser based Optical Interrogators, such as the BraggMETER from HBK FiberSensing, there is an effect of the length of cabling between the interrogator and the sensor on the measured of the reflected measurement.

This effect is a constant shift in the wavelength measurement that depends on the actual sampling rate of the optical module. The shift on the measured wavelength is negligible for low acquisition rates or short distances but becomes important for high sampling rates or long distances.

### Sweeping laser measuring principle

This is so because of the increasing speeds of the sweeping laser needed for a faster acquisition. The sweeping laser emits a varying wavelength in time. The method for measuring the reflected wavelength from the fiber Bragg grating sensor identifies the wavelength that is being emitted at the time the reflected peak from the FBG is detected. As the acquisition rate grows, the effect of the delay caused by the distance the light needs to travel both ways gets higher and absolute wavelength gets less accurate. The same effect appears if the distances increase.

Absolute wavelength measurement error

Wavelength shift caused by acquisition rate and distance is:

### Wavelength shift due to sweeping laser speed

 $\Delta \lambda = \frac{d \cdot 2 \cdot n \cdot RepRate \cdot FullRange}{SweepDirection \cdot DutyCycle \cdot c}$ 

Where:

 $\Delta\lambda$  is the wavelength "error", in nm;

d is the distance (in m) between the sensor and the measurement unit;

n is the refraction index of the fiber (1.446 for standard SMF28 fiber);

*RepRate* is the optical module actual acquisition scan (for BraggMETER interrogators it it the selected acquisition rate, in S/s);

*FullRange* is the length of the range of measured wavelengths (102 nm for BraggMETER interrogators);

SweepDirection is the signal of the sweeping direction: 1 for sweeping from the lowest to highest wavelengths and -1 for sweeping from the highest to lowest wavelengths (1 for FS22SI);

*DutyCycle* is a constant for the acquisition period (0.9 for FS22SI interrogators); c is the speed of light  $(3.10^8 \text{ m/s})$ .

FS22SI MEASURING This means that for FS22SI, the shift in wavelength is given by a function of the distance and the acquisition rate defined on the interrogator:

 $\Delta \lambda = \frac{2 \cdot 1.446 \cdot 102}{1 \cdot 0.9 \cdot 3 \cdot 10^8} \cdot d \cdot RepRate = 1.0925 \cdot 10^{-6} \cdot d \cdot RepRate$ 

Next table aim to illustrate the difference in a sensor readout (wavelength shift in pm) caused by the distance between the Interrogator and the sensor for the different sampling rates.

Distance (m)	Acquisition rate (S/s)
	1
10	0.01
50	0.05
100	0.11
150	0.16
200	0.22
500	0.55
1000	1.09
1500	1.64
2000	2.19
5000	5.46

Tab. 4.1 Shift in wavelength (pm)

# Imp

### Important

When the distance effect is relevant enough to create an offset that takes the reflected FBG peak out of the 100nm wavelength range of the FS22SI interrogator, the interrogator will wrongly retrieve the wavelength peak considering the following sweep. This may cause the FBG to be detected on the other side of the spectrum, or not detected at all if falling on the fly-back area.

### Distance compensation

The distance compensation is advised for optical sensor measurements where the two below conditions are true:

- The pair distance/acquisition rate causes an error bigger that the interrogator's "accuracy";
- The measurement is based on an absolute wavelength measurement, which is true for the temperature, for example. Sensors to which measurements are based either on a

variation of wavelength to a reference value or on two FBG that are very close to each other do not require the compensation of the wavelength measurement error as it gets canceled by the deferential calculation.



In catman use a computational channel to get the distance correction.

# 5 **REMOTE COMMUNICATIONS**

### 5.1 Communication Protocol Syntax

The interrogator is controlled using standard SCPI syntax commands.

### 5.1.1 Command Syntax

Each command is an ASCII string with arguments separated by ":" and terminated with the "Line Feed" and "Carriage Return" characters ("End of Line").

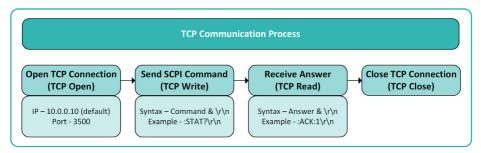


Fig. 5.1 TCP Communication Process

Commands for the Industrial BraggMETER SI are sent by port 3500. All commands, except for *Continuous Acquisition (see page 53)*, are received via the same port. Continuous Acquisition answers are retrieved via port 3365.

The commands for the FS22 - Industrial BraggMETER SI have the following correspondence:

С	Optical Connector	String.
		Integer
		FS22 Single Connector: 0
		FS22 Four Connectors: from 0 to 3.
		FS22 Eight Connectors: from 0 to 7.
		Character
		A for all connectors.
Т	Threshold	Floating point. From 0 to 60 (dB)
R	Sampling rate	Floating point.
		Valid Sampling Rates: 1 (S/s)
NR	Number of Ranges	Integer.

RN	Range Number	Integer. From 1 to NR
Min, Max	Range limits	Interval
		Min: Floating point. From 1500.00 to 1600.00.
		Max: Floating point. From 1500.00 to 1600.00.
		Ordered from the range with lowest wave- lengths to the range with higher wavelengths.
FML	Formula	Polynomial
		Considering "x" as the wavelength shift (in nm).
I	IP, subnet mask and gateway	Integer
S	Number of samples	Integer
YYYY:MM:DD	Date	Integer.
		YYYY – year.
		MM – month.
		DD – day.
HH:MM:SS	Time	Integer.
		HH – hours.
		MM – minutes.
		SS – seconds.
Q	NTP Quality	Integer.
		0 for "Not acceptable",
		1 for "Acceptable"

There are several possible answers with error messages:

:NACK:INVALID COMMAND

The command does not exist. Check if the spelling is correct.

:NACK:COMMAND NOT ACCEPTED AT CURRENT STATUS

It is not possible to execute the command sent at the current status. Ask the current status of the interrogator (:STAT?) and confer with scheme from *Fig. 3.13* to see how to change it.

:NACK: '?' MUST BE THE LAST CHARACTER

The sent command should have a '?' at the end of the command string.

:NACK:ARGUMENT OUT OF RANGE

The defined value for the parameter that is being configured with the command is outside the possible interval.

#### 5.1.2 Common Commands

#### :IDENtification?

Queries the FS22 - Industrial BraggMETER SI interrogator type and firmware revision. The return string is a list separated by ":" consisting of Manufacturer, Unit Name, Revision, Number of Connectors, Serial Number and Date.

Example:

Command :IDEN?

Answer :ACK:HBK FiberSensing:FS22SI v4.0:046 840 201 050:20231025

#### :STORe

Stores the current threshold values of all connectors to the configuration file. Once the interrogator is restarted, the last stored values will be configured.

Example:

Command :STOR Answer :ACK

#### :RECAII

Recalls previously saved instrument settings from the file. The command restores the state of the FS22 to a setup previously stored in the configuration file.

Example:

Command :RECA Answer :ACK

#### :STATus?

Queries the operation condition status of the interrogator. Returns the current status of the instrument:

0 Error;

1 Ready;

2 Free acquisition;

3 Continuous acquisition;

4 Scheduled acquisition;

5 Warming up.

Example:

Command Command :STAT?

Answer ACK:2

#### 5.1.3 System Commands

#### :SYSTem:DATE?

Queries the date of the real-time clock of the FS22. The answer is a string with date in the following format «YYYY:MM:DD»

Example:

Command :SYST:DATE?

Answer :ACK:2011:08:19

#### :SYSTem:DATE:YYYY:MM:DD

Sets the date of the real-time clock of the FS22. The date is defined as  $\$  (YYYY:MM:DD».

Example:

Command :SYST:DATE:2011:08:19

Answer :ACK

#### :SYSTem:TIME?

Queries the date of the real-time clock of the FS22. The answer is a string with time in the following format «HH:MM:SS»  $\,$ 

Example:

Command :SYST:TIME? Answer :ACK:12:27:34

#### :SYSTem:TIME:HH:MM:SS

Sets the date of the real-time clock of the FS22. The time is defined as «HH:MM:SS».

Example:

Command :SYST:TIME:12:28:00

Answer :ACK

#### Synchronization

#### NTP query

#### :SYSTem:NTPSync?

Queries for the NTP synchronization status. Retrieves information on three parameters separated by ":"

Q: NTP Quality:

0 = not acceptable if offset >= 10ms;

**1** = acceptable if offset <10ms.

Offset: time difference in milliseconds between the server clock and host clock.

Jitter: time difference in milliseconds between 2 samples.

Example:

Command :SYST:NTPS?

Answer :ACK:1:0.489:0.345

#### 

Sets the IP address, the subnet mask and the gateway of the FS22. The default IP address, subnet mask and gateway are "10.0.0.10:255.0.0.0:0.0.0.0". After this command is successfully executed, the FS22 will restart automatically. The gateway content is not optional.

Example:

 Command
 :SYST:IPAD:192.168.2.100:255.255.255.0:0.0.0.0

 Answer
 No reply

#### 5.1.4 Status Commands

#### :STATus?

Queries the operation condition status of the FS22. Returns the current status of the instrument: 0 error; 1 ready; 2 free acquisition; 3 continuous acquisition; 4 scheduled acquisition; 5 warming up.

Example:

Command :STAT? Answer :ACK:1

#### 5.1.5 Acquisition Commands

#### Free Acquisition

#### :ACQUisition:STARt

Starts the acquisition of the fiber Bragg grating sensors in all connectors of the FS22.

Example:

Command :ACQU:STAR

Answer :ACK

#### :ACQUisition:STOP

Stops the acquisition (free, continuous and scheduled) of the fiber Bragg grating sensors in all connectors of the FS22.

Example:

Command : ACQU:STOP

Answer :ACK

#### :ACQUisition:CONFiguration:THREshold:CHANnel:C:T

Sets the threshold value for the peak detection algorithm in the C connector of the FS22. The threshold is a value from 0 to 60 dB.

Note: The threshold value returns to the last stored threshold when the interrogator restarts. To change the current threshold to permanent run the :STORe command.

Example:

Command :ACQU:CONF:THRE:CHAN:2:20

Answer :ACK

#### :ACQUisition:CONFiguration:THREshold:CHANnel:C?

Queries the threshold value for the peak detection algorithm in the C connector of the FS22. The threshold is a value from 0 to 60 dB.

Note: The answer corresponds to the last used threshold value that may not be the stored value that will be active once the interrogator restarts.

Example:

Command :ACQU:CONF:THRE:CHAN:2?

Answer :ACK:20.0

#### :ACQUisition:CONFiguration:RATE?

Queries the actual sampling rate of the FS22.

Example:

**Command** :ACQU:CONF:RATE?

Answer :ACK:1

#### :ACQUisition:CONFiguration:RATE:R

Sets the FS22 sampling rate to R. The sampling rate for the static interrogator is currently limited to 1 (S/s).

Example:

Command :ACQU:CONF:RATE:1

Answer :ACK

#### :ACQUisition:CONFiguration:RANGe:WAVElength:C?

Queries the actual limits of defined ranges on connector C. The number of connectors can be set A to retrieve all ranges in all connectors simultaneously.

Example:

 Command
 :ACQU:CONF:RANG:WAVE:3?

 Answer
 :ACK:1534.13, 1536.13,1544.13, 1546.13

#### :ACQUisition:CONFiguration:RANGe:WAVElength:C:NR:MIN,MAX..,MIN,MAX

Defines NR number of ranges and their MIN and MAX limits on connector C. Note: The ranges should be sent with the wavelengths sorted in ascending order. Note: The minimum width accepted for the ranges defined via SCPI command is 1 nm. *Example:* 

Command	:ACQU:CONF:RANG:WAVE:3:2:1534.13, 1536.13,1544.13, 1546.13
Answer	:ACK

#### :ACQUisition:CONFiguration:RANGe:FORMula:C:NR:[CWL;FML],...,[CWL;FML]

Defines the formula(s) and central wavelength(s) for the range(s) on connector C. NR defines the number of ranges in connector C, CWL represents the central wavelength of the sensor in the specific range and FML represents the corresponding formula.

Note: This command shall be used after the ranges have been defined with the :ACQUisition:CONFiguration:RANGe:WAVElength:C:NR:MIN,MAX,...,MIN,MAX command.

Note: The central wavelengths and formulas shall be sorted by wavelength in ascending order.

Note: The variable "x" is used in the formulas to represent the wavelength variation of the sensor relatively to the central wavelength.

Example:

Command	:ACQU:CONF:RANG:FORM:1:2:[1512.1;-96.2*x^2+104.8*x+30],[15 20.5;x*0.78]
Answer	:ACK

#### :ACQUisition:CONFiguration:RANGe:FORMula:C:RN:FML

Defines the formula for the range number RN on the connector C. Range Number RN is an integer from 1 to the total number of ranges NR.

Example:

Command	:ACQU:CONF:RANG:FORM:3:2:-13.2*x^2+104.8*x+30
Answer	:ACK

#### :ACQUisition:CONFiguration:RANGe:DELEte:C

Allows the user to delete the configuration of a single connector (using an integer value to define the connector C) or of all the connectors at once (using "A" to define all the connectors).

Note: It is available only in state 2.

Example:

Command :ACQU:CONF:RANG:DELE:A

Answer :ACK

#### :ACQUisition:CONFiguration:RANGe:ENABle

Enables the use of Ranges. Measurement method changes from Conventional to Smart Peak Detection method (SPD).

Example:

Command :ACQU:CONF:RANG:ENAB

Answer :ACK

#### :ACQUisition:CONFiguration:RANGe:DISAble

Disables the use of Ranges. Measurement method changes from Smart Peak Detection method (SPD) to the Conventional.

Example:

Command :ACQU:CONF:RANG:DISA

Answer :ACK

#### :ACQUisition:CONFiguration:RANGe:STATus?

Queries the actual status of the ranges. There are two possible answers:

0 Disabled - Interrogator operating with Conventional Method

1 Enabled - Interrogator operating with Smart Peak Detection (SPD) Method

Example:

Command :ACQU:CONF:RANG:STAT?

Answer :ACK:1

#### :ACQUisition:ENGIneering:CHANnel:C?

When interrogator is operating with the Smart Peak Detection (SPD) Method acquires the engineering values, according to the range formula (FML), in the C connector of the FS22.

When the interrogator is operating with the Conventional Method acquires the peak wavelength of the fiber Bragg grating sensors in the C connector of the FS22.

Returned value is always in accordance to the defined threshold for the connector.

The number of connectors can be set to A to retrieve the data relative to all sensors in all connectors simultaneously.

#### Example:

Command :ACQU:ENGI:CHAN:1? Answer :ACK:30.4512,25.8503,0.2582,3.2154

#### :ACQUisition:OSATrace:CHANnel:C?

Acquires the optical spectrum trace of the fiber Bragg grating sensors in the C connector of the FS22. Returns the optical spectrum trace over the complete wavelength range. The number of connectors can be set A to retrieve the optical spectrum trace of all connectors simultaneously. The optical spectrum trace of each channel consists of 20001 points indicating the power of the wavelenghts in the [1500; 1600] nm range; equally spaced by 5 pm.

#### Example:

Command :ACQU:OSAT:CHAN:1?	
Answer :ACK:-41.064,-40.965,-40.719,-40.420,-40.116,-39.848,-39. 9.574,-39.624,-39.755,-39.919,-40.074,-40.176,-40.203,-40 ()	

#### :ACQUisition:POWEr:CHANnel:C?

Acquires the power of the fiber Bragg grating sensors in the C connector of the FS22. Returns the power value of the fiber Bragg grating sensors accordingly to the threshold settings and measurement method. The number of connectors can be set to A to retrieve the data relative to all sensors in all connectors simultaneously.

Example:

 Command
 :ACQU:POWE:CHAN:1?

 Answer
 :ACK:-41.064,-40.965

#### :ACQUisition:WAVElength:CHANnel:C?

Returns the peak wavelength of the fiber Bragg grating sensors in connector C of the FS22 according to the threshold settings. The number of connectors can be "A" to simultaneously retrieve the data relative to all sensors in all connectors.

Example:

Command :ACQU:WAVE:CHAN:1?

Answer :ACK:1523.6573, 1554.0709, 1566.7846

#### **Continuous Acquisition**

#### :ACQUisition:OSATrace:CONTinuous:STARt

Simultaneous continuous acquisition of optical spectrum traces of all connectors. This command is sent via port 3500 and corresponding data is received through port 3365 in binary format. The answer is a big endian binary stream representing a double precision (8 bytes) array with 20001 points times the number of optical connectors of the interrogator. The first 4 bytes of the binary stream indicate the number of channels and the last 4 bytes indicate the number of data bytes to be read. To be in agreement with the communication protocol syntax of the interrogator, Carriage Return/Line Feed (CR/LF) are also included in the stream and, therefore, "2" must be added to the value returned by the last 4 bytes of the stream.

The returned data represents the power values of the OSA traces for all optical connectors with points from 1500 nm to 1600 nm sampled every 5 pm.

#### Example:

Command	:ACQU:OSAT:CONT:STAR
Answer	Port 3500 » :ACK
	Port 3365 »
	$\begin{bmatrix} -68, 92 - 20, 46 & \cdots \\ & & & & & \\ & & & & \\ & & & & & \\ & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & &$

#### :ACQUisition:WAVElength:CONTinuous:STARt

Continuous acquisition of the peak wavelengths of the fiber Bragg grating sensors in all connectors of the FS22. This command is sent via port 3500 and corresponding data is received through port 3365. The answer is a string starting with the timestamp with the format «YYYY.MM.DD:hh:mm:ss» followed with the wavelengths in growing order of wavelength separated by "," from all connectors separated by ":".

Note: if there are connectors with no sensors, the answer will have no wavelength between ":".

Command	:ACQU:WAVE:CONT:STAR	
Answer	Port 3500 » :ACK	
	Port 3365 » 2011.10.07:16:04:52:	
	1523.6573, 1554.0709, 1566.7846:: 1567.6987, 1584.9825: 1534.9824	

#### :ACQUisition:ENGIneering:CONTinuous:STARt

When the Smart Peak Detection (SPD) is enabled, this command returns the engineering values according to the range formula (FML) in all defined ranges of all connectors.

When the Smart Peak Detection (SPD) is disabled, this command returns the peak wavelength of the fiber Bragg grating sensors in all connectors.

This command is sent via port 3500 and corresponding data is received through port 3365. The answer is a string starting with the timestamp with the format «YYYY.MM.DD:hh:mm:ss» followed with the values in growing order of wavelength separated by ",", from all connectors separated by ":".

Note: on the conventional measurement method if there are connectors with no sensors, the answer will have no wavelength between ":". On the SPD method if there are no sensors detected within a defined range the interrogator returns -998.

Command	:ACQU:ENGI:CONT:STAR
Answer	Port 3500 » :ACK
	Port 3365 » 2016.07.29:14.18.42:
	12.1254,23.4511::14.2301:25.6322

### :ACQUisition:WAVElength:CONTinuous:NTPSync:STARt

Continuous acquisition of wavelengths of all the connectors of the interrogator. This command is sent via port 3500 and corresponding data is received through port 3365. The received data is in binary format and contains information on Timestamp, Wavelength values of all sensors from all optical connectors with the following structure:

- 1) Fixed Header (30 bytes) [always sent independently of the payload content (even without sensors)]:
  - a) 2 bytes (sync "#0")
  - b) 4 bytes (remaining header length 24 bytes + payload length)
  - c) 8 bytes (timestamp):
    - i) LWORD1: seconds since 1.1.1970
    - ii) LWORD2: fraction of current second mapped to an integer range of 32 bit (i.e. 0.5 s would correspond to  $\frac{1}{2}$ \*2^32)
  - d) 2 bytes #sensors CH0 + 2 bytes #sensors CH1 + 2 bytes #sensors CH2 + 2 bytes #sensors CH3 + 2 bytes #sensors CH4 + 2 bytes #sensors CH5 + 2 bytes #sensors CH6 + 2 bytes #sensors CH7
- 2) Payload:
  - a) Payload on interrogator with 1 optical connector: 4 bytes CH0/wvl0 + 4 bytes CH0/wvl1 + (...)
  - b) Payload on interrogator with 4 optical connectors:
     4 bytes CH0/wvl0 + 4 bytes CH0/wvl1 + (...) + CH3/wvl0 + CH3/wvl1 + (...)
  - c) Payload on interrogator with 8 optical connectors:
     4 bytes CH0/wvl0 + 4 bytes CH0/wvl1 + (...) + CH7/wvl0 + CH7/wvl1 + (...)

with wavelengths in ascending order [wvl0 < wvl1 < (...)].

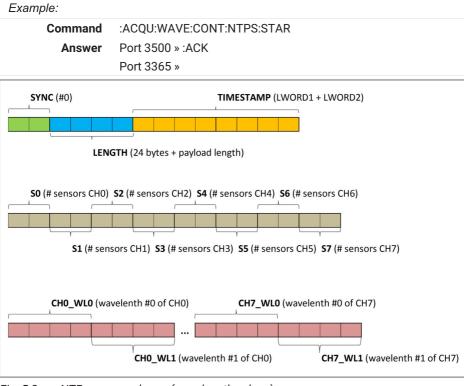


Fig. 5.2 NTP answer scheme (wavelength values)

### :ACQUisition:ENGIneering:CONTinuous:NTPSync:STARt

Continuous acquisition of engineering data of all the connectors of the interrogator. This command is sent via port 3500 and corresponding data is received through port 3365. The received data is in binary format and contains information on Timestamp, Engineering values of all sensors from all optical connectors with the following structure:

- 3) Fixed Header (30 bytes) [always sent independently of the payload content (even without sensors)]:
  - a) 2 bytes (sync "#0")
  - b) 4 bytes (remaining header length 24 bytes + payload length)
  - c) 8 bytes (timestamp):
    - i) LWORD1: seconds since 1.1.1970
    - ii) LWORD2: fraction of current second mapped to an integer range of 32 bit (i.e. 0.5 s would correspond to <sup>1</sup>/<sub>2</sub>\*2<sup>3</sup>2)
  - d) 2 bytes #sensors CH0 + 2 bytes #sensors CH1 + 2 bytes #sensors CH2 + 2 bytes #sensors CH3 + 2 bytes #sensors CH4 + 2 bytes #sensors CH5 + 2 bytes #sensors CH6 + 2 bytes #sensors CH7
- 4) Payload:
  - a) Payload on interrogator with 1 optical connector:
     4 bytes CH0/s0 + 4 bytes CH0/s1 + (...)
  - b) Payload on interrogator with 4 optical connectors:
     4 bytes CH0/s0 + 4 bytes CH0/s1 + (...) + CH3/s0 + CH3/s1 + (...)
  - c) Payload on interrogator with 8 optical connectors:
     4 bytes CH0/s0 + 4 bytes CH0/s1 + (...) + CH7/s0 + CH7/s1 + (...)

with sensors in reference wavelength ascending order  $[s0_{wvl} < s1_{wvl} < (...)]$ .

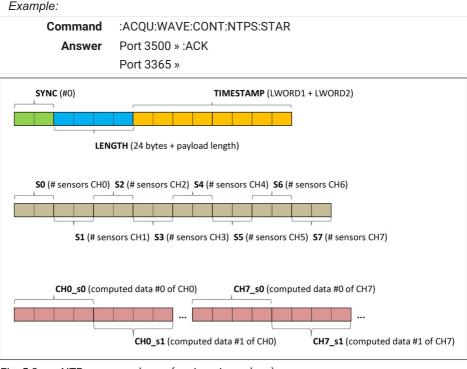


Fig. 5.3 NTP answer scheme (engineering values)

### :ACQUisition:SAVE:CONTinuous:STARt

Starts continuous absolute wavelength peak saving on the instrument internal memory. Saved data is stored on a separate directory for each day. The directory name is the date in the format «YYYYMMDD»

Note: Saving with different operating methods may be saved on the same data set, if these two types of data recording have been selected on the same day.

Note: Scheduled acquisition may be saved on the same data set as continuous acquisition if these two types of data recording have been selected on the same day (see section "Scheduled Acquisition" on page 59).

Example:

Command:ACQU:SAVE:CONT:STARAnswerPort 3500 » :ACK

#### **Scheduled Acquisition**

#### :ACQUisition:SCHEdule:STARt

Starts scheduled acquisition with the defined period and number of samples. Data is stored on the instrument internal memory on a separate directory for each day. The directory name is the date in the format «YYYYMMDD».

Note: Scheduled acquisition may be saved on the same data set as continuous acquisition if these two types of data recording have been selected on the same day (see section "Continuous Acquisition" on page 53).

The interrogator does not resume scheduled acquisition if power fails during sleep.

Example:

Command :ACQU:SCHE:STAR

Answer :ACK

#### :ACQUisition:SCHEdule:PERIod?

Queries the set period for scheduled acquisitions on the FS22. The answer is a string with time in the following format <code>«HH:MM:SS»</code>

Example:

Command :ACQU:SCHE:PERI? Answer :ACK: 01:00:00

#### :ACQUisition:SCHEdule:PERIod:HH:MM:SS

Sets the period for scheduled acquisitions on the FS22. The period is defined as a time interval with the format «HH:MM:SS». The minimum period is 5 seconds and maximum period is 23 hours, 59 minutes and 59 seconds.

Note: the defined period must never be smaller than the needed for the defined number of samples.

Example:

Command :ACQU:SCHE:PERI:01:00:00

Answer :ACK

#### :ACQUisition:SCHEdule:SAMPles?

Queries the set number of samples to collect on each scheduled acquisition on the FS22. The answer is an integer.

Example:

Command :ACQU:SCHE:SAMP?

Answer :ACK:300

#### :ACQUisition:SCHEdule:SAMPles:S

Sets the number of samples to collect on each scheduled acquisition on the FS22. It is an integer that will correspond to the number of seconds. The minimum definable number of samples is 1 and the maximum is 86399.

Note: the defined number of samples must never be higher than the number of seconds available with the defined schedule period.

Example:

Command :ACQU:SCHE:SAMP:300 Answer :ACK

#### 5.1.6 Memory Commands

#### :MEMOry:LIST:DIREctory?

Queries for directory list of previously saved data. Returns a list of directories separated with ";".

Example:

 Command
 :MEMO:LIST:DIRE?

 Answer
 :ACK:20150903;20151005;20151006;1051007

#### :MEMOry:RECA:DATA:YYYYMMDD?

Queries for data previously stored in the internal memory of the FS22 on the specified directory. Directories name have the following format «YYYYMMDD». Returns the data containing the timestamp and the absolute wavelength values of the fiber Bragg grating sensors in each connector. Timestamp is calculated using the number of seconds elapsed since 12:00 A.M. Friday, January 1st, 1904. The interrogator will not be responsive to other commands, while data file is being transferred. The command does not delete downloaded data. This command is sent via port 3500 and corresponding data is received through port 3365.

Files larger than 100 MB must be downloaded using BraggMONITOR.

#### Example:

Command	:MEMO:RECA:DATA:20111007?
Answer	Port 3500 » :ACK
	Port 3365 »
	:2011.10.07:00:00:00: 1523.6573, 1554.0713, 1566.7851:: 1567.6991, 1584.9830: 1534.9824
	:2011.10.07:00:00:01: 1523.6579, 1554.0709, 1566.7846:: 1567.6987, 1584.9825: 1534.9824
	:2011.10.07:00:00:02: 1523.6571, 1554.204, 1566.7849:: 1567.6985, 1584.9828: 1534.9844

#### :MEMOry:DELEte:YYYYMMDD

Deletes the YYYYMMDD data file previously stored in the internal memory of the FS22. The file name can be set to A to delete all stored files in the internal memory.

Example:

Command :MEMO:DELE:20140718

Answer :ACK

## 6 BRAGGMONITOR SI SOFTWARE DETAILS

### 6.1 Software Version

This document refers to BraggMONITOR SI Software version v2.6.

This application is compatible with all FS22 Series 1S/s acquisition rate interrogators.

### 6.2 Install and Uninstall Software

### 6.2.1 System Requirements

To operate the current version of BraggMONITOR, your PC must have the following requirements:

- Intel Pentium or equivalent processor upwards from 1 GHz
- Windows® XP (32 Bit and 64 Bit versions), Windows Vista® (32 Bit and 64 Bit versions), Windows® 7 (32 Bit and 64 Bit versions, Home, Professional or Ultimate editions) or Windows® 8/8.1 (32 Bit and 64 Bit versions) or Windows° 10 (32 Bit and 64 Bit versions)
- Main memory (RAM):
  - at least 512 Mbyte for Windows® XP
  - at least 1,024 Mbyte for Windows Vista®
  - at least 2,048 Mbyte for Windows®7 or higher
- Graphics card (and screen) with a resolution of 1,024 x 768 pixel or higher
- Approx. 1 Gbyte of free storage capacity for the program installation; at least a further 1 Gbyte is needed for the temporary storage of data; however you can also use a different drive for this.
- Ethernet interface (100/1000 MBit)

The above requirements are sufficient if you use low sample rates and some sensors. You must use a more powerful PC if you wish to use a large number of sensors with high sample rates.

Processor	
Pentium III / Celeron	
866 MHz	
Operating system	
Windows XP (with SP3) or higher	
Memory	
RAM	1 GB
available disk space	1.5 GB
Screen	
video adapter	Super VGA
resolution	1024x768

### 6.2.2 Software Installation

To install HBK FiberSensing BraggMONITOR SI Software on a PC, please follow the described steps:

- Insert the provided disk with software in the PC;
- Run Setup.exe inside BraggMONITOR folder;



### Information

When the operating system is Windows Vista or higher, open setup.exe as an Administrator with a right-click (see Fig. 6.1).

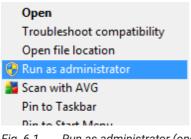


Fig. 6.1 Run as administrator (once)

Follow the described steps and press **finish**.

The installation is now completed. You will need to restart the computer before using the application.



Using windows display settings with the size of text not set to 100% might compromise the correct visualization of BraggMONITOR SI software.

### 6.2.3 Software Uninstall

To uninstall the application, use the Add/Remove programs tool in Windows

- Enter control panel
- Select programs and features
- Select BraggMONITOR SI Software
- Click uninstall/change option and follow the steps.

### 6.3 Running the Software

#### 6.3.1 Network Properties

To operate the interrogator, the PC network properties should be set so that both elements are configured in the same subnet.

To configure your personal computer so that it is on the same subnet as the default for the interrogator, *proceed as described on section 3.6.1 "Network Properties"*.

#### 6.3.2 Run as Administrator

The BraggMONITOR SI Software should run with full administrator privileges. To have these privileges when the operating system is Windows Vista or higher, the user shall right-click the BraggMONITOR SI Software icon and then select the "Run as administrator" option (see Fig. 6.1).

To configure the application to always open with Administrator privileges, right-click on the software icon and select "Properties > Compatibility". Check the box "Run this program as administrator" (see Fig. 6.2).

🛐 Bragg MONITOR	Properties	<b>— X</b> —						
Security	Details	Previous Versions						
General	Shortcut	Compatibility						
If you have problems with this program and it worked correctly on an earlier version of Windows, select the compatibility mode that matches that earlier version.								
Help me choose t	-							
Compatibility mode	•							
🔲 Run this prog	gram in compatibility m	ode for:						
Windows XP (S	ervice Pack 3)	-						
Settings Run in 256 colors Run in 640 x 480 screen resolution								
Disable visua	top composition							
Disable displ	ay scaling on high DP	settings						
Privilege Level								
Change settings for all users								
	ОК	Cancel <u>Apply</u>						

Fig. 6.2 Set Run as administrator automatically

# 7 BRAGGMONITOR SI USER INTERFACE

The BraggMONITOR SI Software graphical interface is divided into two different areas (*Fig. 7.1*):

- 1 General Bar
- 2 Graphical Area

Graphical View	Numerical View	Spectral View	Configuration	SCPI Interface	
40.0 30.0 20.0 10.0 0.0 4		5 20-03-2015 20-03-2015 20-03-2015	20-03-2015 144230 20-03-2015	Y       CH35001       w         Y       CH35002       w         Y       CH35003       w         Y       CH35004       w         Y       CH35005       w         Y       CH35005       w         Y       CH35005       w         Y       CH35007       w         Y       CH35007       w         Y       CH35008       w         Y       CH35008       w         Y       CH45002       w         Y       CH455003       w         Y       CH455004       w	
2015 14:43:15 (Using UTC Ti			S min.		

Fig. 7.1 BraggMONITOR SI User interface

### 7.1 General Bar

The General Bar (number **1** in *Fig.* 7.1) is where the main acquisition actions can be performed. This bar is always on, although its buttons may be disabled due to the interrogator status.

On the left, general information is presented (see Fig. 7.2):

- On the first line interrogator configured date and time is presented.
- The second line is destined for the connection status to the interrogator.
- The last and third line is destined to inform the user on the current status of the interrogator and error messages. For attention, error messages are shown in orange (see Fig. 7.3).

```
20-03-2015 14:43:15 (Using UTC Time)
Connected to 10.0.0.10
Measuring...
```

Fig. 7.2 Current status information



Fig. 7.3 Error message

### 7.1.1 Date and Time

The BraggMONITOR SI Software uses by default the UTC defined time on the PC that it is operating with. The BraggMONITOR updates the interrogator date and time settings when it connects to the device. Data, either by using the BraggMONITOR or the internal memory of the interrogator, will be saved with this time stamp.

It is possible to change the BraggMONITOR SI Software time reference from UTC to the defined Local Time on your device. To do so, you should change the "config.ini" file that is on the Application folder.

- Close the BraggMONITOR application;
- Open and edit the Config.ini file;
- Change the parameter «UseUTC = "1"» to «UseUTC = "0"» and save the file (Fig. 7.4);
- Run the BraggMONITOR application as an administrator.

```
Config.ini - Notepad

<u>File Edit Format View Help</u>

[TCP]

IPAddress = "10.0.0.10"

<u>[MISC]</u>

<u>UseUTC = "1"</u>

FileInterval = "3600"

DataFolder = ""

RangeWidth = "2.0"

TimeInterval = "300"

GLeg = "1@CH0S001|1@CH0S002|1@CH0S003|1@CH0S00

CfgNR = ""

LastDbBackup = ""
```

Fig. 7.4 Config.ini file

The Time definitions on the PC can be checked and/or configured on the Control Panel under the Date and Time (*Fig.* 7.5).

Pate and Time	×				
Date and Time Additional Close	ks				
	Date: Wednesday, July 23, 2014 Time: 17:05:46 @Change date and time				
Time zone					
(UTC) Dublin, Edinburgh,	Lisbon, London				
	Change time <u>z</u> one				
Daylight Saving Time ends on Sunday, October 26, 2014 at 02:00. The clock is set to go back 1 hour at that time.					
☑ Notify me when the clock changes					
Get more time zone information online How do I set the clock and time zone?					
	OK Cancel Apply				

Fig. 7.5 Date and time window

To adjust the time zone, chose the "Change time zone..." button (Fig. 7.5).

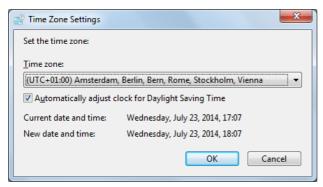


Fig. 7.6 Date and time settings - time zone

To adjust the Local Time, chose the "Change date and time..." button (Fig. 7.5).

Bate and Time	-	×
Date:		<u>T</u> ime:
	/e         Th         Fr         Sa           2         3         4         5           9         10         11         12           6         17         18         19           3         24         25         26           0         31         1         2	18:30:52
Change calendar	<u>settings</u>	OK Cancel

Fig. 7.7 Date and time settings - date and time

### 7.1.2 Connecting to the Interrogator

The first action to perform before starting an acquisition is to establish a connection between the interrogator and BraggMONITOR. For that, press the "Connect" button (number **1** in *Fig.* 7.8).

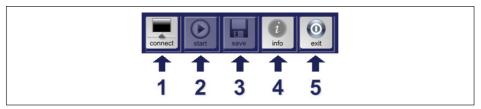


Fig. 7.8 Buttons on General Bar

A popup window will appear to indicate/select the IP Address of the interrogator to which the connection will be established (*see Fig. 7.9*). This popup window also allows one to search for FS22 interrogators in the network. To perform this search the "search" button shown with number **1** in *Fig. 7.9* should be pressed.

Define IP Addr	ess		<u>×</u>
IP Address			
10.0.0.10			
FS22SI In Netw	<b>2</b>	•	9
			*
Double+Click to Sel			+
Double-Click to Sel		→ s	arch

Fig. 7.9 Connecting via IP address

After successfully connecting to the IP indicated, the "connect" button (number **1** in *Fig.* 7.8) changes to "disconnect" (*Fig.* 7.10).



Fig. 7.10 Connect/Disconnect button status

### 7.1.3 Acquisition

### **Start Acquisition**

Whenever the software is connected to an interrogator and the software is on the Graphical View and Numerical View Tabs, the "start" button (number **2** in *Fig. 7.8*) becomes active, as shown in *Fig. 7.11*.



Fig. 7.11 Active Start Button

Press "start" button to start acquisition. This will start the acquisition and representation of the configured sensors.



### Information

It is necessary to configure sensors in order to start an acquisition.

Once the "start" button is pressed, it will change its appearance to "stop" button (*Fig. 7.12*).



Fig. 7.12 Start and Stop button status

Measured values are represented in wavelength shift (in nm) relative to the central wavelength or engineering values, according to the formula defined on the Configuration tab (see section "Add, Edit and Delete Sensor(s)" on page 85). It is possible to obtain absolute values of temperature, strain, acceleration, etc. However, a sensor configuration must be defined.

### Saving Data

To save data, press the "save" button (number **3** in *Fig.* 7.8). The data will be saved in the path specified in the field "Data Folder" on the Configuration tab (see section "Data File" on page 87).

The button will change its appearance stating the software status (see *Fig. 7.13*). It will also change its appearance whenever the mouse is on top of the button stating the action to perform.

To stop recording, uncheck the "saving" button.



Fig. 7.13 Data saving button status

### Saved Data Files

Saved data file collects the data between the instant the save button is pressed and the instant it is pressed back.

Data sets will be recorded in .txt files automatically named, as follows:

BraggMONITOR SI Data [YYYY.MM.DD.HH.MM.SS; YYYY.MM.DD.HH.MM.SS].txt.

The YYYY.MM.DD.HH.MM.SS parts of the filename represent the start and finish, respectively, of the period during which the data has been saved.

Data is organized in columns (see Fig. 7.15). The first row is a header indicating how many samples were acquired per second. The second row is a header containing the labels of each column:

Samples per S	econd 1					
UTC Date	UTC Time	Sample	CH1.S01 (152	2.122 ; x) CH1.S	02 (1528.579 ; x)	CH1.S03 (153
24-07-2014	09:50:47	10000	1522.1218	1528.5770	1534.8151	1541.2115
24-07-2014	09:56:48	00002	1522.1222	1528.5773	1534.8152	1541.2108
	00 FC 10	00000	4500 4000	4500 5777	4534 0446	45.44 34.94

Fig. 7.14 Data file header

- 1 1<sup>st</sup> column UTC or Local Date (according to what is configured) with format «DD-MM-YYYY»
- 2 2<sup>nd</sup> column UTC or Local Time with format «HH:MM:SS »
- **3** 3<sup>rd</sup> column Sample number
- 4 Following columns Sensor name (Central wavelength (nm); formula) ordered by optical connector and then by wavelength. The values along these columns represent either wavelengths (in nm) or engineering values (units in accordance with Formula from Configuration tab) of the corresponding sensors.

Samples per S	econd 1					
UTC Date	UTC Time	Sample		22.122 ; x) CH1.5	602 (1528.579 ; x)	CH1.S03 (153
24-07-2014	09:56:47	00001	1522.1218	1528.5776	1534.8151	1541.2113
24-07-2014	09:56:48	00002	1522.1222	1528.5773	1534.8152	1541.2108
24-07-2014	09:56:49	00003	1522.1220	1528.5777	1534.8146	1541.2106
24-07-2014	09:56:50	00004	1522.1218	1528.5773	1534.8148	1541.2110
24-07-2014	09:56:51	00005	1522.1219	1528.5773	1534.8153	1541.2109
24-07-2014	09:56:52	00006	1522.1221	1528.5774	1534.8148	1541.2109
24-07-2014	09:56:53	00007	1522.1220	1528.5773	1534.8147	1541.2108
24-07-2014	09:56:54	00008	1522.1219	1528.5769	1534.8149	1541.2111
24-07-2014	09:56:55	00009	1522.1214	1528.5770	1534.8148	1541.2108
24-07-2014	09:56:56	00010	1522.1219	1528.5774	1534.8147	1541.2107
24-07-2014	09:56:57	00011	1522.1215	1528.5770	1534.8143	1541.2106
24-07-2014	09:56:58	00012	1522.1218	1528.5770	1534.8146	1541.2112
24-07-2014	09:56:59	00013	1522.1219	1528.5769	1534.8148	1541.2108
24-07-2014	09:57:00	00014	1522.1220	1528.5775	1534.8144	1541.2105
24-07-2014	09:57:01	00015	1522.1215	1528.5771	1534.8146	1541.2107
				4		
1	2	2			7	
	4	3			-	

Fig. 7.15 Data in data file

#### Opening Data in Microsoft Excel

To import the data file to a Microsoft Office Excel Workbook proceed as follows:

Once Microsoft Excel is opened, press From Text  $\rightarrow$  Data  $\rightarrow$  Get External Data (see Fig. 7.16) and select the data file.

X 🖬	<u></u>	) •    •				_	_	_	Book1 - N	Aicrosoft Exe	cel		_	_			
File	Ho	me Insert Pi	ige Layout	Formulas	Data Re	view V	iew Ad	id-Ins									
From Access	From Web	From Other Text Sources *	Existing Connections	Refresh All *	Connections Properties Edit Links	2↓ 22 Z↓ Sort		Clear Reapply Advanced	Text to Columns	Remove Duplicates	Data Validation Data Too		What-If Analysis *	Group	Ungroup S	♥∃ Show ■∃ Hide D	
	A1	Get External Data Fr Import data from a			Sinceton	1	Jon an				butu 100						
1	A	Press F1 for mo	re help.	E	F	G	н	1	J	К	L	М	N	0	р	Q	R

Fig. 7.16 Import data in Excel

Then, it is necessary to complete text import wizard. All options must be set as shown in *Fig. 7.17, Fig. 7.18, Fig. 7.19, Fig. 7.20 and Fig. 7.21*.

😰 Import Text File					<b>X</b>
🚱 🔍 🛡 📕 🕨 braggmonitor			<b>▼</b> 49	Search braggmonitor	٩
Organize 🔻 New folder					
Pessoais	*	Name	Da	ite	Туре
New Library Oropbox		BM Data [2014.07.21.16.59.48 ; 2014.07.21.17.00.06].txt	20	14-07-24 10:41	Text Docum
<ul> <li>Proposx</li> <li>P0003-Tunel Rossio</li> <li>Downloads</li> </ul>					
Desktop					
Documents					
Recent Places New Library (2)	=				
<ul> <li>New Library (2)</li> <li>iCloud Photos</li> </ul>					
Eibraries					
J Music					F
File <u>n</u> ame: B	M Data [2014.07	7.21.16.59.48 ; 2014.07.21.17.00.06].txt	•	Text Files (*.prn;*.txt;*.cs	sv) 🔻
			Too <u>l</u> s 🔻	I <u>m</u> port 🔽	Cancel

Fig. 7.17 Select data file

Text Import Wizard - Step 1 of 3	?	X
The Text Wizard has determined that your data is Delimited.		
If this is correct, choose Next, or choose the data type that best describes your data.		
Original data type		
Choose the file type that best describes your data:      Opelimited - Characters such as commas or tabs separate each field.		
$\bigcirc$ Fixed width $-$ Fields are aligned in columns with spaces between each field.		
Start import at row: 1 File origin: MS-DOS (PC-8)		<b></b>
Preview of file C:\Users\cristina.barbo\BM Data [2014.07.21.16.59.48; 2014.07.21.17.00.06]	.txt.	
1 Samples per Second1		*
2 UTC DateUTC TimeSampleCH1.S01 (1522.106 ; 100*x)CH1.S02 (1528.562 3 21-07-201416:59:48000010.90250.00880.00610.00500.0120-0.0147-0.0	; х	
421-07-201416:59:49000020.91730.00900.00550.00500.0114-0.0154-0.0		
521-07-201416:59:50000030.84970.00760.00530.00450.0116-0.0152-0.0		
<		,
Cancel < Back <u>Next</u> >	Ei	nish

Fig. 7.18 Text Import Wizard 1/3

Text Import Wizard - Step 2	2 of 3	? X
This screen lets you set the d below.	delimiters your data contains. You can see how your text is affected in $\mathfrak{t}$	ne preview
Delimiters		
<mark>▼ <u>T</u>ab</mark>		
Semicolon	reat consecutive delimiters as one	
Comma	qualifier:	
Space Text	gualifier:	
Other:		
Data <u>p</u> review		
Samples per Second		<u>^</u>
UTC Date 21-07-2014	UTC Time Sample CH1.S01 (1522.106 ; 100*x) CH1.S0 16:59:48 00001 0.9025 0.0088	2 (1528
21-07-2014	16:59:49 00002 0.9173 0.0090	
21-07-2014	16:59:50 00003 0.8497 0.0076	-
		P.
	Cancel < <u>B</u> ack <u>Next</u> >	Einish

Fig. 7.19 Text Import Wizard 2/3

Text Import Wizard - Step 3 of	3	? ×
This screen lets you select each of Column data format General Text Data preview	lumn and set the Data Format. 'General' converts numeric values to numbers, date va remaining values to text. Advanced	alues to dates, and all
DMY Ger	eral GeneralGeneral	General
Samples per Second 1		A
	Time Sample CH1.S01 (1522.106 ; 100*x)	
	59:48 00001 0.9025	0.0088
	59:49 00002 0.9173	0.0090
	59:50 00003 0.8497	0.0076 👻
•		+
	Cancel < Back Nex	ct > <u>Fi</u> nish

Fig. 7.20 Text Import Wizard 3/3

Import Data
Where do you want to put the data? <ul> <li>Existing worksheet:</li> </ul>
=\$A\$1
◎ <u>N</u> ew worksheet
Properties OK Cancel

Fig. 7.21 Select data import location

#### **Stop Acquisition**

To stop the acquisition, press the "stop" button (*Fig.* 7.12), on position number **2** in *Fig.* 7.8. It will return to the state showed in *Fig.* 7.11.

#### 7.1.4 Software and Interrogator Information

General information about the software and the interrogator can be displayed by pressing the "info" button (number **4** in *Fig.* 7.8).

#### 7.1.5 Exit Application

To exit BraggMONITOR SI Software application, press the Exit button (number **5** in *Fig.* 7.8).

#### 7.2 Graphical Area

The graphical area is divided into five tabs:

- Graphical View
- Numerical View
- Spectral View
- Configuration
- SCPI Interface

#### 7.2.1 Graphical View

On the Graphical View, graphical representation of the measured values can be found over time (number **1** in *Fig.* 7.22).

It is possible to enable and disable the graphical representation of one or more sensors by checking and unchecking the check boxes (number **2** in *Fig. 7.22*). The displayed sensors can be changed by clicking on the scroll down menus along the right-hand side of the interface (number **2** in *Fig. 7.22*).

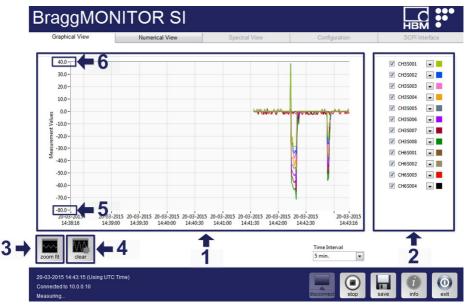


Fig. 7.22 Graphical View

#### Zooming

The graphical display automatically adjusts its vertical scale to fit all the measured values. Nevertheless, it is possible to manage the graphical representation using zoom in and zoom out functions.

The zoom in functionality is always on. To zoom in along the vertical axis drive the mouse arrow to the graphical area and press the left mouse button while moving the mouse up or down. This way a zoom in section will be defined. Once the desired Zoom In section is defined, release the left mouse button. The display will show the zoomed in section only.

In order to zoom back to full scale, press the zoom fit button (number 3 in Fig. 7.22).

It is also possible to modify vertical axis scale by clicking and inserting the axis numbers, identified with number **5** and **6** in *Fig.* 7.22.

The represented time interval (on the horizontal axis) can be selected from the Time Interval drop-down menu (number **7** in *Fig. 7.22*). The horizontal scale cannot be manually changed.

#### **Clear Representation**

Data represented on graphical display can be erased by pressing the clear button (number **4** in *Fig.* 7.22).

#### 7.2.2 Numerical View

The Numerical View tab shows the acquired measurements for each sensor, organized by optical connector as shown in *Fig.* 7.23. For each connector there are two columns, one with the name of the sensors and another with wavelength shift (in nm) relative to the central wavelength or engineering values (units defined by the sensor Formula in Configuration tab) (number **1** in *Fig.* 7.23). Next to the connector identifier, the number of sensors detected in that connector is stated (number **2** in *Fig.* 7.23).

CH0 (0 Sensors)	CH1 116 Se	ensors)	Ser ors)	CH2 (0	Sensors)	CH4 (D	Sensors)	C LI5 /0	Sensors)	CH6 /0	Sensors)	CH7 (0)	Sensors)	
Name Value	CH1S001 0 CH1S002 0 CH1S003 0	0.127 0.128 0.0089 0.0069 0.0135 0.1147 0.0061 0.0098 0.0164 0.0068 0.0119 0.0126 0.0065	ame value	Name	Value	Name	Value	Name	Value	Name	Value	Name	Value	
04-2016 09:31:34 nnected to 10.0.0. asuring		ime)							connect	stop	Save	info		

Fig. 7.23 Numerical View

#### 7.2.3 Spectral View

The Spectral View tab is only accessible when data acquisition is stopped.

This tab represents the spectral response of the sensors connected to the interrogator. The full spectrum contains 20001 data points corresponding to the reflected optical power in dBm from 1500 nm to 1600 nm with a 5 pm sampling resolution (number **1** in *Fig. 7.24*).



## Important

FS22SI displayed spectrum is a representation of the sensing network and is meant to be used as a diagnosis and configuration support tool. Small differences between the represented spectrum and actual measurements might be observable.

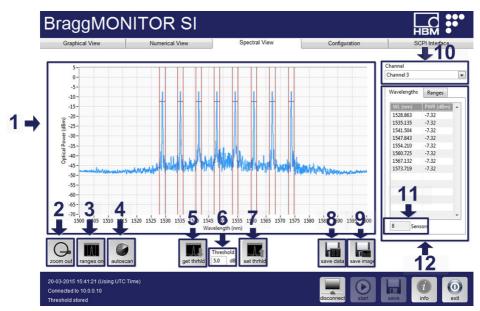


Fig. 7.24 Spectral View - Smart Peak Detection (SPD)

The spectral monitor can only represent one connector at a time. Connector selection can be done at the Connector scroll down box (number **10** in *Fig.* 7.24).

The BraggMONITOR can now be used to activate and configure two methods for FBG sensor detection. A conventional method (ranges OFF) that uses a global threshold and the Smart Peak Detection (ranges ON) that uses the threshold individually inside each sensor range.

#### Ranges

Using the "ranges on/off" button (number **3** in *Fig.* 7.24) the user may select which FBG sensor detection method will be used.

When ranges are ON (see Fig. 7.24), the spectral graph will display the range associated with each sensor that is listed in the Configuration tab and the respective threshold used for the FBG peak computation. Even when multiple peaks occur inside one range, only one FBG sensor will be detected.

When the ranges are OFF (see *Fig. 7.25*), the spectral graph will contain the optical spectrum of the selected connector and an horizontal line representing the threshold level considered for the detection of the FBG sensors.

On the right side of the spectral view tab, below the optical connector selector, one can find info regarding the detected sensors (number **12** in *Fig.* 7.24).

Conventional Measurement Method When the conventional method for FBG sensor detection is selected only the "Wavelengths" table is displayed (*see Fig. 7.25*). In that table it is possible to observe the wavelengths of the detected sensor peaks (WL (nm)) and the corresponding powers (PWR (dBm)). Below the "Wavelengths" table a numeric indicator shows the number of detected sensors on the selected connector (number **11** in *Fig. 7.24*).

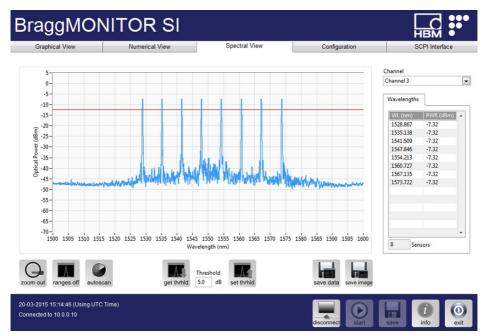


Fig. 7.25 Spectral View - Conventional detection method

SPD Measurement
 Method
 When the Smart Peak Detection method is selected, besides the "Wavelengths" table, the "Ranges" table is also presented (number 1 in *Fig. 7.26*), in which the lower (Min. (nm)) and upper (Max. (nm)) limits of each sensor range are displayed. These limits can be manually edited here by the user by clicking on each box to be edited.

The "Plot Ranges" checkbox (number **2** in *Fig.* 7.26) can be used to activate or deactivate the display of the ranges limits on the spectral graph.

Channel 1
Wavelengths       Ranges         Min. (nm)       Max. (nm)         1500.856       1523.356         1527.312       1529.812         1533.551       1553.051         1539.948       1542.448         1546.471       1548.971         Q       V         V       Plot Ranges

Fig. 7.26 Plot ranges

## Threshold

The threshold value is defined for each connector, independently of the FBG sensor detection method, through the "set thrhld" button (number **7** in *Fig.* 7.24). The "get thrhld" button (number **5** in *Fig.* 7.24) can be used to return the threshold value that is stored for the selected optical connector on the interrogator.

The threshold value can be defined from 0 to 60 dB and corresponds to the considered power level for the FBG peak computation, so that side lobes and ground noise are disregarded.

The threshold value is updated every time the "spectral view" tab is selected.

## Important

Measurement settings can influence sensor readings.

Conventional	When the ranges are OFF, the threshold is defined for each con-
Measurement	nector and is the same for all the sensors in that connector, see
Method	<i>Fig. 4.4 on page 33.</i>
SPD Measurement Method	When the ranges are ON, the Smart Peak Detection is active, allowing the effective use of the high dynamic range offered by the interrogator through the introduction of a threshold refer- enced to the peak on each sensor's configurable range ( <i>refer to</i> <i>Fig. 4.5 on page 34</i> ). As in the conventional measuring method, the threshold value corresponds to the considered power level for the FBG peak computation and it is defined in dB for each optical connector individually.

#### Autoscan

The autoscan functionality is used to detect the FBG sensors and to store the resulting configuration when its result is successful.

Upon an autoscan, Sensor Names are set by default as CHX.SABC, where X is the optical connector and ABC is the number of the sensor on that optical connector sorted by wavelength in ascending order.



#### Important

After an autoscan is successfully performed, the resulting configuration overwrites any previously existent one.

Conventional Measurement Method	In the case the ranges are OFF, the autoscan procedure will detect the sensors that are above the specified threshold. This threshold is referenced to the highest peak on the spectral trace.
SPD Measurement Method	For the case in which the ranges are ON, besides the threshold level, the autoscan procedure also takes into consideration the width of the ranges to detect the FBG sensors. When performing the autoscan with this method a pop up will appear for selecting the desired range width (see <i>Fig. 7.27</i> ). The FBG sensor peaks are automatically detected accordingly to the autoscan threshold value. The minimum autoscan threshold value is 1dB, being the maximum limited to 30dB. The minimum admissible range width is 0.5 nm while the maximum is 100 nm.

Message Box	х	>
Auto Pr	oscan will set ne Proceed with aut	ew ranges. itoscan?
Autoscan Thr 10.0		Ranges Width (nm) 3.0
		×

Fig. 7.27 Autoscan

Ranges maximum and minimum wavelengths will be set as the detected central wavelength of the FBG (displayed on the "Wavelengths" table as in number **12** in *Fig.* 7.24) plus/minus half the range width. Maximum and minimum range limits can then be changed on the "Ranges" table (number **1** in *Fig.* 7.26).



If the autoscan detects errors like overlapping ranges, it will show the error message and will not be considered valid. The latest successfully defined configuration will be active.

#### Zooming

The spectral graph can be zoomed in or out. The Zoom In tool is available every time the cursor is on the graph area. Zooming In is only possible over the horizontal axis. By pressing the left mouse while moving the mouse to the left or right, a Zoom In section will appear (*Fig. 7.28*). Once the desired zoom in section is defined, release the left mouse button and the display will show the Zoomed In section only (*Fig. 7.29*).

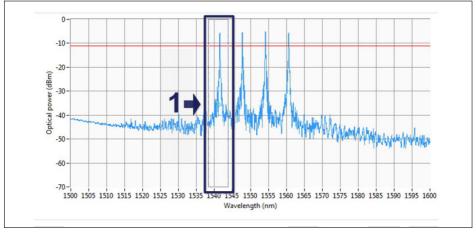


Fig. 7.28 Zoom section

In order to zoom back to full scale press the Zoom Out button (number 8 in Fig. 7.24).

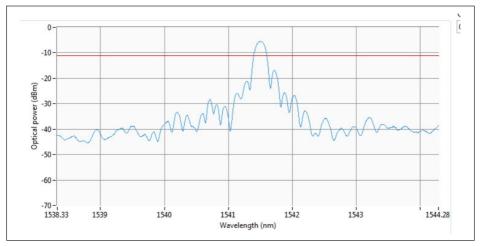


Fig. 7.29 Zoomed spectum

#### **Saving Spectral Data**

To save spectral data, press the "save data" button (number **8** in *Fig.* 7.24), then select the file path to define the folder where data is stored and define the file name. Data sets will be recorded in .txt format for a single sweep (*see Fig.* 7.30). The save button will automatically return to its default state.

Saved data file is organized in columns (see Fig. 7.30), meaning:

- 1 1<sup>st</sup> column wavelength values in nanometers
- 2 2<sup>nd</sup> column optical power values in dBm.

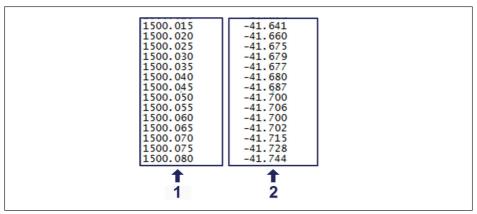


Fig. 7.30 Saved spectrum file

The "save image" button allows one to save a .bmp file containing an instant capture of the displayed spectral graph (number **9** in *Fig.* 7.24).

#### 7.2.4 Configuration

Acquisition configuration allows one to perform sensors configuration. To accomplish this step correctly, sensors' calibration sheets might be needed.

Graphical View	Num	erical View	Spectral View	Configuration		SCPI Interface	
Channels	Selected Channel Conf	iguration					
Channel 0 Channel 1	Name	CWL (nm)	Range Min. Value (nm)	Range Max. Value (nm)		Formula	^
Channel 2	1 CH35001	1528.867			x		
Channel 3	2 CH3S002 3 CH3S003	1535.140 1541.509			x		
Channel 4	3 CH35003 4 CH35004	1547.845			x		
Channel 5	5 CH35004	154,213			x		
Channel 6 Channel 7	6 CH35006	1560.727			x		
Chamiler/	7 CH35007	1567.137			x		1
	8 CH35008	1573.723			x		1
							н
							Ľ
							н
							1
							н
							1
							н
							н
		-					1
3 1	5	6		8	9	10 14	
3 4	0	<u>v</u>	_	0	3		
					_	_+_+	, r
	File Int	erval 1 hr.					
							k.
test change IP	memo data Data Fe	older		load	save	delete new	-
							_

Fig. 7.31 Configuration View

#### **Clear configuration**

If an old configuration is set, it is possible to clear it and start a new configuration pressing button "new" (number **11** in *Fig.* 7.31). Be aware this operation will discard all previous configurations of all connectors.

#### Add, Edit and Delete Sensor(s)

In order to Add a sensor to a configuration, the user is required to fill the fields (Name, Central wavelength (nm), Range Min. Value (nm), Range Max, Value (nm) and Formula) in the table (number **2** in *Fig. 7.31*). In the end, the new sensor is automatically sorted in the list by ascendant order using its central wavelength (nm). If any error is detected (for example, the Range Min. Value (nm) is higher than the central wavelength (nm) an auxiliary message is displayed in the "General Bar".

To Edit a sensor, the user can manually edit the fields corresponding to that particular sensor. The user can also delete a single sensor or all the sensors in an optical connector, either selecting a sensor or the connector, respectively, and then pressing the "delete" button.

	1		
Sensor Name	Sensor's identification field. It is not possible to have two sensors with the same name.		
Central Wavelength (CWL)	Reference wavelength from which wavelength shift ( $\Delta\lambda$ =x) is calculated.		
Range Min. Value	Safety ranges defined to avoid crosstalk between sensors.		
(nm)	Each sensor has its own operat	ion range.	
Range Max. Value (nm)	It is not possible to configure sensors with overlapping ranges. Sensor measured wavelength values out of the defined bands are returned as -998. Inside each band only one peak is con- sidered.		
	Note: Ranges are only used/accessible when the SPD method is active (ranges ON).		
Formula			
	Do	Do not	
	-11.3	-11,3	
	-11.3*x	-11.3x	
	-11.3*x^2+105.4*x+30	=-11.3*x^2+105.4*x+30	

Tab. 7.1

#### **Test configuration**

Test Configuration (number **3** in *Fig.* 7.31) allows the user to check the current values from each sensor according to its configuration. Measured values will be displayed on the central wavelength field, in accordance to the defined formula for the sensor.



#### Information

Error code -998 will be displayed when no sensor is found within a range.

#### Data File Definition: Path and Length

As referred on section "Saved Data Files" on page 71, data sets are named automatically.

The path for file saving and the maximum duration of each file can be defined under the Configuration Tab.

By opening the "Data Folder" box (number **7** in *Fig.* 7.31) the default files path can be searched and defined.

The "File Interval" (number **6** in *Fig. 7.31*) will define the maximum length of each saved file. Consecutive files will be created every time the defined time is achieved. The duration of the files can be set to: 1 min, 5 min, 10 min, 15 min, 30 min, 1 Hour, 2 Hours, 3 Hours or 6 Hours.

#### Save and Load configuration

The configuration is stored in the interrogator and updated while starting the BraggMONI-TOR SI.

Any defined configuration can be saved in .txt extension file by pressing the "Save" button (number **9** in *Fig.* 7.31) and choosing a save path.

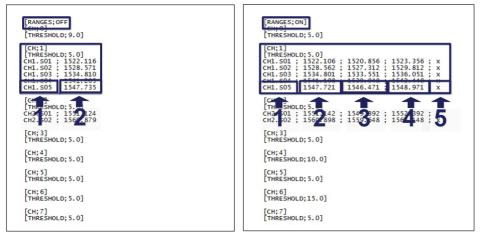


Fig. 7.32 Configuration file (ranges on)

Fig. 7.33 Configuration file (ranges off)

The header of the file indicates whether it contains information of a configuration with ranges OFF ([RANGES;OFF] - *Fig.* 7.32) or with ranges ON ([RANGES;ON] - *Fig.* 7.33).

Conventional Measurement Method For the case of a configuration without ranges, only the Name (number 1 in *Fig.* 7.33) and Central wavelength (nm) (number 2 in *Fig.* 7.33) are stored. This file might be edited in Notepad or Excel (see "Opening Data in Microsoft Excel" section on page 73) and saved as .txt extension file after editing.

#### SPD Measurement Method

In the case of a configuration with ranges ON, for each connector there are 5 columns: Name (number **1** in *Fig.* 7.33), Central wavelength(nm) (number **2** in *Fig.* 7.33), Range Min. Value (nm) (number **3** in *Fig.* 7.33), Range Max. Value (nm) (number **4** in *Fig.* 7.33), and Formula (number **5** in *Fig.* 7.33).

Configuration file can always be loaded by the user by pressing the Load button (number **8** in *Fig.* 7.31) and selecting the file containing the desired configuration (see Fig. 7.34).

Look in:	🌗 data	•	G 🤌 📂 🖽 -	
P.	Name	*	Date modified	Туре
-	BraggMO	NITOR_conf	23-05-2012 09:54	Text Docu
Recent Places	BraggMO	NITOR_OSA	23-05-2012 10:10	Text Docu
	BraggMO	NITOR_test_file	23-05-2012 09:18	Text Docu
	🚳 Ivanlys.dll		13-01-2012 08:36	Applicatio
Libraries Libraries Computer				
Network	•	m		+
Network	File name:	BraggMONITOR_conf	• (	ОК
	Files of type:	All Files (*.*)		Cancel

Fig. 7.34 Loading a configuration

#### **Change IP Address**

To change the IP address of the interrogator, you must be connected and access the Configuration tab. To check if the status is connected please refer to the connection status message displayed on the left of the General Bar. Press the change IP button to pop-up the change IP Address interface (see *Fig. 7.35*).

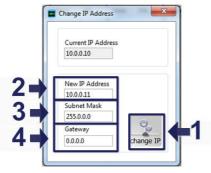


Fig. 7.35 Change IP address

Define the new IP Address (number **2** in *Fig.* 7.35). The Subnet Mask (number **3** in *Fig.* 7.35) will be automatically defined according to the IP Address. The Gateway is 0.0.0.0 by default and is user changeable (number **4** in *Fig.* 7.35). Then, press the Change IP button (number **1** in *Fig.* 7.35). The following procedure and status messages will be shown:

- 1. Interrogator is restarting. This can take more than a minute. Please wait.
- 2. Ping to interrogator is successful. Please wait.
- 3. Interrogator is ready.

After this process is complete, the connection will be established with the new IP.

#### **Internal Memory Management**

The data files created during scheduled acquisitions are saved into the internal memory of the interrogator (see "Scheduled Acquisition" section on page 59 for details).

To view the file list and download the data stored in the internal memory press the "memo data" button on the number **5** in *Fig.* 7.31. This button launches a pop up (*see Fig.* 7.36). Once a file is selected, on number **1** in *Fig.* 7.36, it is possible to download it by pressing the "download button" (number **2** in *Fig.* 7.36) or delete it using "delete" button (number **3** in *Fig.* 7.36). The files will be downloaded to the chosen directory on number **4** in *Fig.* 7.36.

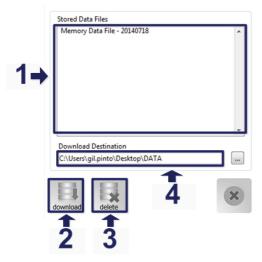


Fig. 7.36 Manage internal data memory

#### 7.2.5 SCPI Interface

This tab allows the user to send Standard Commands for Programmable Instruments (SCPI) to the equipment. *Please refer to the available command list in section 5* "*Remote Communications*" on page 43.

Commands are inserted on the command field (number **2** in *Fig.* 7.37) and sent by pressing Enter on the keyboard or the "send cmd" button (number **3** in *Fig.* 7.37). The interrogator's answers appear on the Reply field (number **1** in *Fig.* 7.37). Each time new answers are displayed, older ones are pushed down.

	BraggMON	NITOR SI			
	Graphical View	Numerical View	Spectral View	Configuration	SCPI Interface
2-	Command			V	send cmd
	Reply			^	<b>T</b> 3
				v	
4-	clear upload fw	5	1		
	21-04-2020 20:33:59 (Using UTC Connected to 172.23.42.104	Time)		disconnect Start	ve info exit

Fig. 7.37 SCPI Interface

Each time a new command is successfully executed, a shortcut at the scroll down box is created, as shown in *Fig. 7.38*.

STAT?	
:IDEN?	
:STAT?	
:ACQU:SCHE:SAMP?	
:ACQU:SCHE:PERI?	
:ACQU:STAR	
:ACQU:STOP	
:ACQU:SCHE:STAR	

Fig. 7.38 Recently used commands

# Important

When the user leaves SCPI Interface tab, interrogator status is changed and Scheduled and Continuous acquisitions are disabled. In order to keep the current interrogator status, the user shall not select other tab than the SCPI Interface one and the BraggMONITOR application shall be closed using the "exit" button.

The list of replies can be cleared by pressing the "clear" button (number 4 in Fig. 7.37).

#### **Firmware Update**

It is possible to upgrade/downgrade the firmware version of the FS22SI by pressing the upload firmware button (number **5** in *Fig. 7.37*).

- Download the new version of the firmware from the product page from HBK website (www.hbkworld.com).
- Select the file on the pop up of the Select Image File interface (see Fig. 7.39).

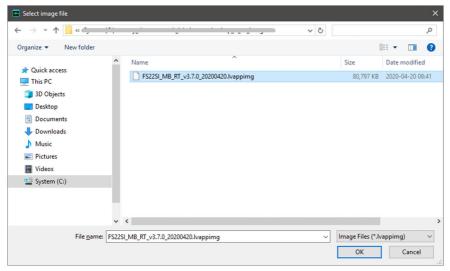


Fig. 7.39 Firmware update

The firmware upload process is performed automatically, being the FS22SI rebooted after completion and a successful update pop up message is depicted once the communication with the FS22SI is reestablished (*Fig. 7.40*).

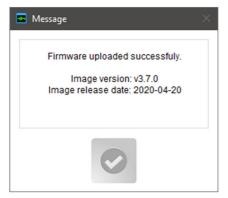


Fig. 7.40 Update info window

## 8 catman<sup>®</sup> SOFTWARE

The FS22SI interrogator is compatible with the powerful catman Easy and catman AP software (from version 4.2 with limitations and from version 5.2 with all specs) allowing the simple combination of optical and electrical signals on the same interface.

The following chapter aims to describe in a simplified manner the most common steps to configure and use the FS22SI interrogator with catman.



#### Information

Catman software has to be purchased separately. Please refer to our website (<u>www.hbkworld.com</u>) for further information and detailed documentation.

## Important

The combination of FS22 and MXFS optical interrogators is not available in catman.

#### 8.1 Connect to the device

Ensure that the system is correctly setup and the device is turned on and in communication with the PC.

- Open catman
- On the start menu, click to select the device types
- Select FS22 and search via Ethernet
- Fill in IP or IP range to scan

Search device types	Search ports	
QuantumX/SomatXR	HBM Device Manager	Scan range for TCP/IP device scan
MGCplus CP52/CP42		(e.g. 192.168.169.2,3,10-15;192.168.240.3,4)
PMX	Ethernet (TCP/IP, UDP)	172.23.42.40-50 🗸
FS22 MP41 Kistler KiRoad/RoaDyn	FireWire	Alternatively you may choose subnets of your comp the most recently used addresses from the list. Clear history More information on TCP/IP scan range
Help Options 💝		ОК

#### Fig. 8.1 Preparing a new DAQ project within catman

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For ensuring the use of Smart Peak Detection within catman it has to be defined before starting a project under **Advanced options** and select the usage of FS22SI with SPD.

> Open **Options** by clicking on the button.

General options CAN bus options Hardware time channels Advanced options	Additional devices
The following options apply only to specific device types.	1
QuantumX: Use On-Board math (MX878, MX879, MX410, MX460, MX403B)	
More about On Board functions	
None   Maximum number of QuantumX CX27C EtherCAT channel	els. The configuration must be done in MX Assistant.
8 x 16 • QuantumX MXFS channel layout (channel count > 16 for	MXFS8SI only)
Advanced configuration options for QuantumX MXFS (configuration of relative	threshold for peak detection)
Optical interrogators: use FS22 SI Smart Peak Detection	
What is Smart Peak Detection? More info ab	out advanced options
Help Hide A	OK Cancel

Fig. 8.2 Selecting SPD

#### 8.2 Device configuration

Start a new measurement.

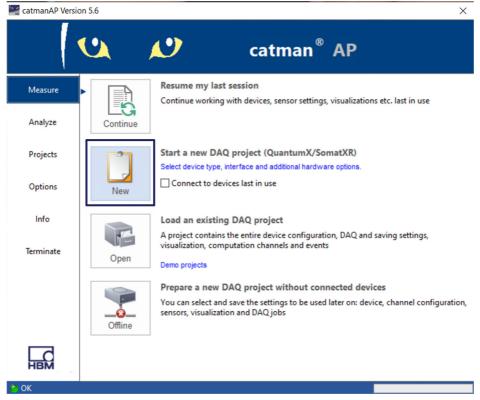


Fig. 8.3 Starting a new DAQ measurement project in catman

The channel list will be populated with the previously set definition for each device. A pop-up warning that spectrum should be checked and adapted appears. This verification is important as the previously set definitions might not be true for the current network setup.



Always check the optical spectrum signals of each connector through the **Optical func-***tions* interface.

Click Yes to open the optical functions. Alternatively, while on the channel list, open Optical functions" tab to correctly configure the sensors (channels) on each optical connector.



#### Check optical spectra?

It is recommended to check the position of the peaks in the optical spectra of the connected fibers before you continue with your DAQ project. Adapt the peak detection parameters like gain or threshold if necessary.

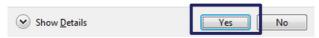


Fig. 8.4 Pop-up for Optical Spectrum visualization and optical channels definition

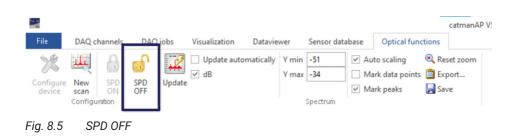


#### Important

Press SPD OFF

FS22SI displayed spectrum is a representation of the sensing network and is meant to be used as a diagnosis and configuration support tool. Small differences between the represented spectrum and actual measurements might be observable.

To configure the device settings, such as threshold or range width, the SPD lock should be off.



• Press Configure device.

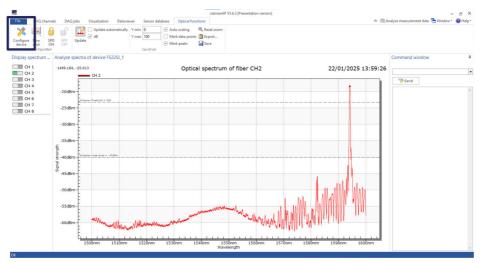


Fig. 8.6 Configure device button

Define parameters for peak detection:

Autoscan values are used for defining limits on the automatic detection of peaks for the band definition.

- Noise level (dBm) defines the limit line for considering the spectrum points as possible peaks or completely disregarding them because they are noise. It is defined as an absolute power value. Should be a value that draws the line slightly above the noise baseline.
- Threshold (dB) defines the limit line for considering the existence of a peaks. It is a relative power value measured from the maximum spectrum point down. Should be a high value that ensures the disregard for sidelobes.
- SPD Range width (nm) is also used on the definitions for the autoscan and sets the total wavelength width of each band to be created.

SPD Threshold values are used during the measurement.

 Threshold (dB) is the limit, per band, that defines the amount of peak area that is used on the peak center computation. It is a relative power value measured from the maximum peak, within a band, down. It does not need to be a very high level. 3~5dB are enough for an accurate peak calculation. Nevertheless, the highest the value is, the greater number of points of the spectrum are used for computing the peak center, which improves the result.

Peak parameters are defined individually per optical connector. For editing the parameters of the other connectors, change the connector/chain number. It is also possible to set the same parameters for all connectors by pressing **Apply to all**.

Device configuration FS22SI_1	-		×
Connector/Chain     Sensor       2 <ul> <li>Connector/Chain</li> <li>Connector/Ch</li></ul>	Appl	y to all	
Peak detection         SPD Threshold [dB]       5         SPD range width [nm]       6         Autoscan threshold [dB]       5         Autoscan noise level [dBm]       -40			
Load			~
Store permanently in device OK		Canc	el

Fig. 8.7 Device parameter configuration

Press OK to exit the Device Configuration menu.



#### Important

These defined settings are used on the running catman project. However, they are not stored on the device, which means that on the event of a power off, the settings get lost. It is then advisable to press Store permanently in device so that these settings maintain active on the next power on of the interrogator.

#### Press SPD ON.

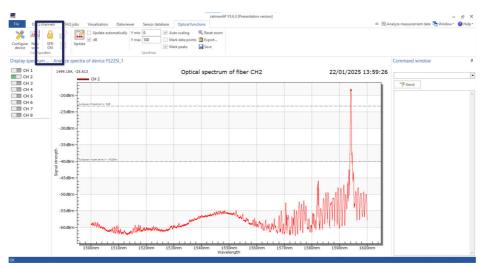


Fig. 8.8 SPD ON

A pop-up shows asking of the preconfigured bands should be kept, or if a new scan is to be performed.

Execute action.

Configu	jure optical instrument		
?	Activate Smart Peak Detection.		
	You can use the bands already preconfigured in the interrogator or configure the band want to proceed?	s based on the currently fou	und peaks. How do you
	O Use preconfigured bands		
	Configure bands (currently configured bands will be lost)		
Do	ion't show this message again	Execute action	Cancel Help

Fig. 8.9 Configure new bands



If the "use preconfigured bands" is selected, no auto scan is performed. To create new bands with the defined parameters press **new scan** button.

The optical spectrum shows:

- 1 Defined band limits
- 2 Reference wavelength

#### 3 Measured wavelength

#### 4 Threshold position

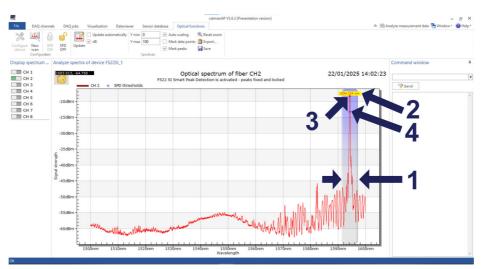


Fig. 8.10 OSA with SPD on

#### 8.3 Measurement configuration

On the channel list, configure sensors in accordance with the needs.

- Rename sensors.
- Assign sensors from the database.

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#### Information

HBK Optical Sensors Database is divided into interrogator categories as the sensor configuration communication with de device defers from model to model. For FS22SI open the optical sensors for FS22 section of the database.

- Adapt sensors.
- Create computation channels.
- Etc.



#### Important

For further details please refer to catman® software documentation available online and on the help interface of the software.

Sensor database	ųх
Sensordatabase.sdb	
🚨 🔷 нык 🎼 🚥 📭	
General sensors AC voltage/current Counters DC voltage/current Frequency IEPE Inductive transducers IRIG UVDT Optical sensors FS22 Pulse width modulation	^
FS22	~
Search       P       Advanced	d
	^
°C FS63DTP (FS22) g Optical acceleration sensor (FS22)	
e Optical strain sensor (FS22)	
°C Optical temperature sensor (FS22)	

Fig. 8.11 Optical sensors on the database

## 8.4 Acquisition and visualization

With the prepared channel list, you are ready to start an acquisition job. Remember that some sensors might require zeroing (for example strain sensors) and others must not be zeroed if an absolute measurement value is needed (for example temperature sensors).

Setting up visualization panels for real time data display is also very simple.



#### Important

For further details please refer to catman software documentation available online and on the help interface of the software.

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