BUS SYSTEM®

OPERATING MANUAL

MAN-00025 R3

EPROM version 3.42.x

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WARRANTY INFORMATION

Fiso Technologies warrants the ***Bus*** SYSTEM white-light fiber-optic signal conditioner sold has been made in good workmanlike and proper manner; that it will perform according to the specifications if used in compliance with the guidelines provided; that when shipped, it will be in proper working order, free from any defects in either workmanship or material; and that, for a period of one year from the date of delivery, we will repair or replace without cost any part that may prove to be defective. This warranty does not apply to the light sources of the ***Bus*** SYSTEM neither to the gages sold for use with the ***Bus*** SYSTEM.

WARNING

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DISCLAIMER

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1 GETTING STARTED

1.1 General Features

The ***Bus*** SYSTEM is a fiber-optic multi-channel signal conditioner that can conditions signal of Fiso Technologies' fiber-optic strain, temperature, linear position & displacement, force & load, and pressure sensors. This is the ideal instrument when multi-channel simultaneous recording is required. Each independent channel of the ***Bus*** SYSTEM has a 14-bit resolution (without averaging), with 15 000:1 dynamic range while the overall physical dynamic range and resolution will depend on the type and sensitivity of the fiber-optic sensor used with the instrument. Each channel can acquire at a *Sampling Rate* of 100, 500, or 1000 Hz (optional), and provides the user with full control over operating parameters. The following sections explain how to operate your ***Bus*** SYSTEM.

1.1.1 Front Panel

Each channel comes in plug-in module with a fiber-optic sensor input connector and an analog output connector. A status LED indicates that the light source of the module is working properly. The modules are assembled (maximum of eight modules) inside a rack mounting case with 19 inches mounting flanges. See the drawing below. RS-232 serial communication with each module is accessible through the DB-9 connector installed on the panel of the rack mount chassis.

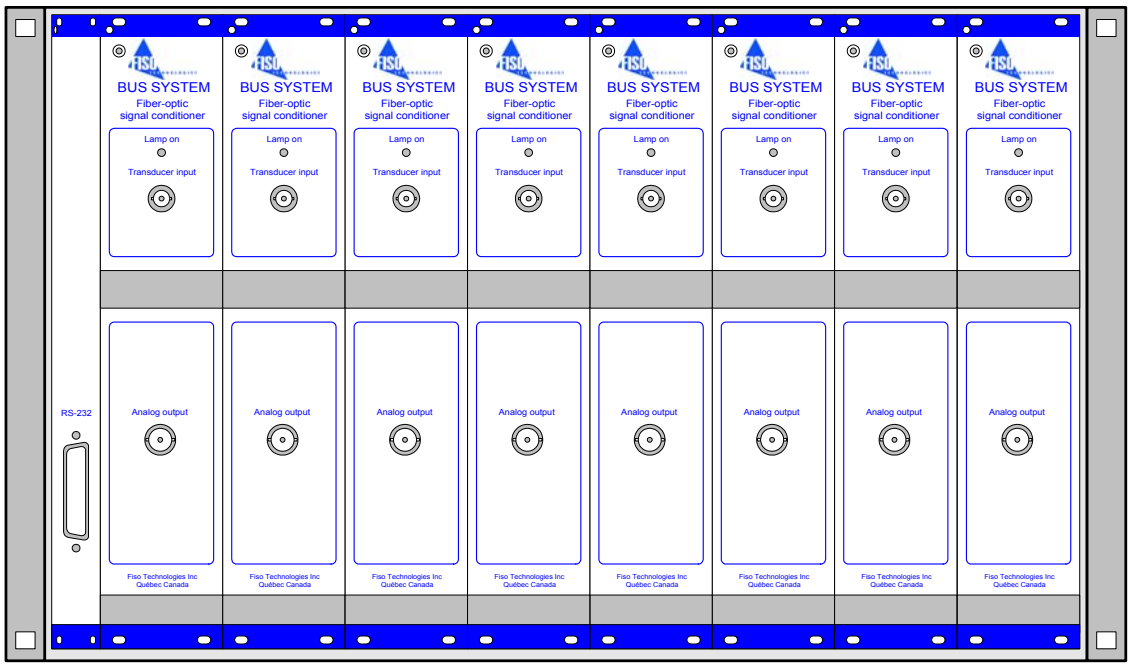


Figure 1: FRONT PANEL OVERVIEW OF *Bus* System
8-CHANNEL PLUG-IN MODULE VERSION

1.2 Installation

1.2.1 Line Power Connection

The model ***Bus*** SYSTEM is auto-configured for line voltages of 90 to 132 VAC_{RMS} or 187-264 VAC_{RMS} at line frequency of 47 Hz to 63 Hz. The power rating is 125 W. Follow the procedure below to connect the model ***Bus*** SYSTEM to a line power and to turn on the instrument:

1. Check to see that the line voltage is correct for the operating voltage in your area.

   CAUTION: Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.

2. Before plugging in the power cord, make sure that the power switch is in the off (0) position.

3. Connect the female end of the supplied power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

   WARNING: The power cord supplied with the model *Bus* SYSTEM contains a separate ground wire for use with grounded outlets. When proper connections are made, instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use grounded outlet may result in personal injury or death due to electrical shock.

4. Turn on the instrument by pressing the rear panel power switch to the on (1) position. At power on, the instrument turns on sequentially each lamp of the modules. A LED indicator shows that the lamps are working properly. If the LED indicator of a channel doesn't turn on, check if light is coming out of the fiber-optic input connector. If not, the lamp must be replaced. See section 1.3 for how to replace the lamp.

5. In order to minimize the current consumption (burst current), modules are supplied in a sequential order when conditioner chassis switch is power on. The front panel red LED indicates that the module is actually powered up. Make note that an additional preheating time of 1 second (100 Hz) to 5 seconds (500 to 1000 Hz) is required after module activation to perform a reading.

1.2.2 Replacing fuse

A rear panel fuse located next to the power receptacle protects the power line input of the instrument. If the line fuse needs to be replaced, performs the following steps:

WARNING: Make sure the instrument is disconnected from the AC line and other equipment before replacing the line fuse.

1. Pull out the fuse holder located next to the power receptacle.

2. Remove the fuse and replace it with the following type: 3 A (250V), slow blow, 5 x 20 mm.

CAUTION: For continued protection against fire or instrument damage, only replace fuse with the type and rating listed. If the instrument repeatedly blows fuses contact factory or your local distributor.

3. Install the fuse holder by pushing it until it locks in place.

1.2.3 Cooling and Installation

The ***Bus*** SYSTEM is cooled by forced convection. Two exhaust fans located on the rear allow ambient air to flow inside the casing of the instrument. The ambient air is draw inside the casing through the ventilation louvers located on the bottom cover (near the front).

CAUTION: The *Bus* SYSTEM casing must be installed in area where ambient temperature does not exceed 32°C. Enough space must be allowed for exhaust fans and ventilation louvers so they are not obstructed and sufficient ventilation is provided. Operating the instrument with improper cooling may cause damage to the instrument, possibly voiding the warranty

1.3 Maintenance

1.3.1 Replacing the lamp of the module

Each module has its own lamp with a lifetime rated at 1500 hours of continuous operation. The lifetime may vary with the operating condition such as frequent switching of the lamp, mechanical vibrations, ambient temperature, etc. If the LED indicator of the lamp, doesn't turn ON when the unit is powered on and if no light is coming out the fiber-optic input connector (make sure that the lamp has not been turn off with the Remote Control Command), then the lamp should be replaced.

When replacing the lamp pay attention do not touch the lamp with your fingers, use low lint tissue paper for manipulation. The lamp can be replaced without removing entirely the plug-in module. The lamp is located near the top front of the plug-in module. Performs the following steps:

WARNING: Make sure the instrument is disconnected from the AC line and other equipment before replacing the lamp.

Failure to disconnect AC line may result in personal injury or death due to electrical shock.

Unscrew the four fasteners located at each corner of the module's front-panel.

Pull the plug-in module out of the rack of about 15 cm (See figure 2).

CAUTION: Do not try to remove the plug-in module more than 15 cm out of the rack. The plug-in module is wire-connected at the back so it cannot be completely removed this way.

Locate the lamp assembly. The lamp is held in the metal holder behind the fan.

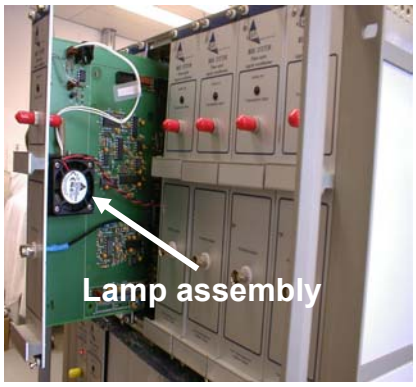


Figure 2

1. Disconnect the lamp connector **J7** (figure 3). Disconnect the fiber optic cable from the back side of front panel. Using small pliers, pull off the Hairpin Cotter that retains the lamp (figure 4). Then grab the two white wires connecting to the lamp and gently pull out the lamp of its holder (figure 5).

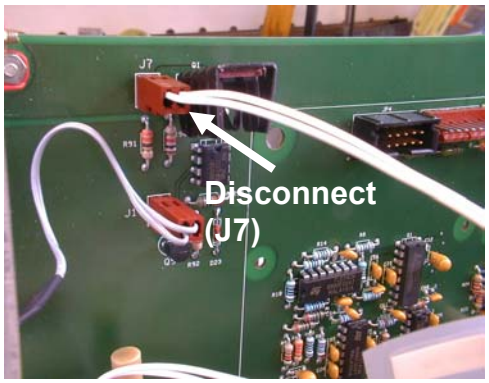


Figure 3

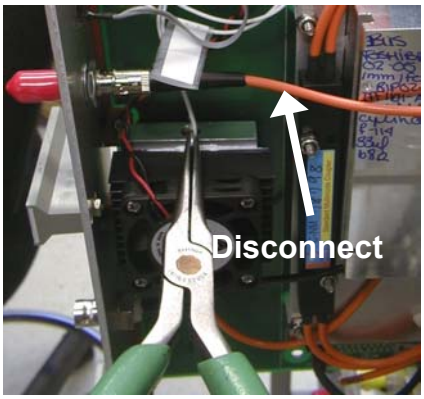


Figure 4

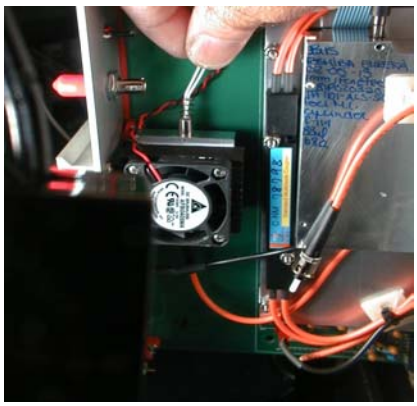


Figure 5

2. Install the new lamp in its holder. Pay attention to not touch the lamp bulb with your fingers. Use low lint tissue paper. Gently push the lamp down inside until it sets down to the bottom of the holder (Figure 6). The whole body of the lamp should not come out of the holder when properly set.

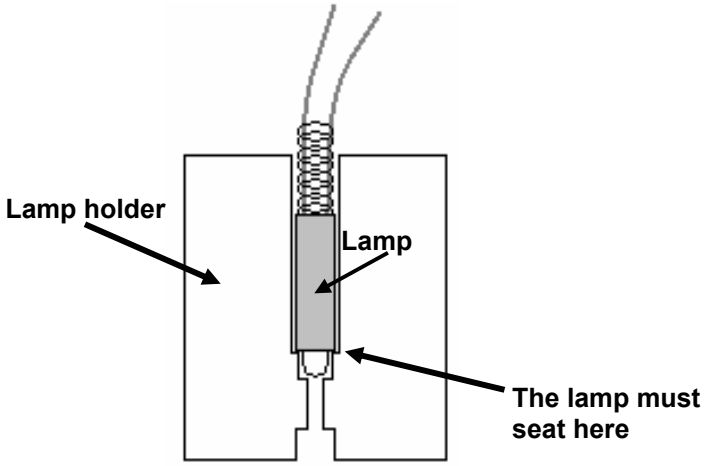


Figure 6

3. Using a small screwdriver, push down the lamp spring into the lamp support. Insert the Hairpin Cotter back in place to lock the lamp (figure 6 and 7). Make sure that the pin goes over both sides of the spring.

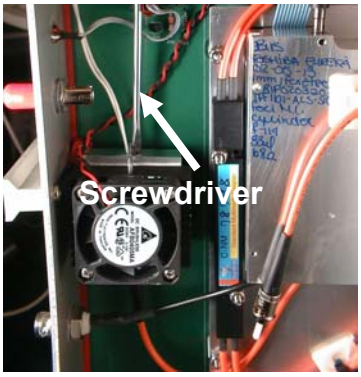


Figure 7

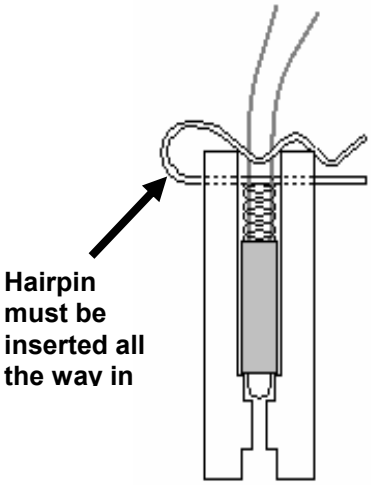


Figure 8

4. Connect the lamp connector to the electronic board (connector J7).

5. Reconnect the fiber optic cable. Before to do so, carefully clean the connector's ferrule.

6. Push the plug-in module in place.

7. Reconnect the AC line and turn the power on. Verify if the lamp is working properly. Then fasten the module in its rack.

8. Final check is made with a sensor connected to the module. Use the RS-232 Remote Control DIAGNOSTIC REPORT command and verify that the RAW signal shows correct level (see sections 2 and 4)

1.4 Mating the sensors to the *Bus* System conditioner

To connect the sensor to one of the ***Bus*** SYSTEM modules, simply mate the sensor fiber-optic connector with the input connector of the module. However and for proper use of the fiber-optic sensors, its connector must be kept clean and free of dust at all times. Any dust may obstruct the light transmitted from one connector to the other, and reduce the signal-to-noise ratio to an unusable level. Wiping the end with low lint tissue such as Kimwipes or lens cleaning tissues cleans sensor connector. By keeping your sensor connectors clean you will also prevent the contamination of the instrument input connectors. However, we recommend to clean the ***Bus*** SYSTEM input connectors once in a while. Use the specially designed 2.5 mm Mini Foam Swab provided with our cleaning kit (Part n° FTI-M) for cleaning the input connectors of ***Bus*** SYSTEM. It is a good practice to always clean the sensor connector before mating to the instrument.

In order to maximize the lamp lifetime, all unused channels should be deactivated (lamp turn off).

1.5 Using Fiber-Optic Extension Cable

All Fiso Technologies' fiber-optic sensors can be used with fiber-optic extension cables. The length of the extension cables can be up to 1 km long depending on the working *Sampling Rate*. It is recommended to use index-matching gel in between fiber-optic cable connections when working with more than one extension cables at *Sampling Rate* of 500 Hz or higher. The index matching gel is easily applied on the tip of the fiber-optic connectors of the extension cables and fiber-optic sensor cables. Unless absolutely required, it is not recommended to apply index matching gel to the fiber-optic connector that connects to the ***Bus*** SYSTEM modules. In any cases, only a very small drop of gel deposited in the center of the connector ferrule is needed. Index matching gel is available at Fiso Technologies. Contact us for more information.

2 Operating Basics

Each module of the ***Bus*** SYSTEM is controlled independently via the RS-232 serial link. The modules can be configured with the RS-232 Remote Control Commands described in the following sections and in Appendix A. The measurements output is provided by a ± 10V analog output with adjustable SCALE factor and ZERO offset. Note that the measurements can be obtained with RS-232 serial link as well but there are some limitations. See following sections.

2.1 RS-232 Serial Link

2.1.1 Hardware settings

The RS-232 serial connection to the ***Bus*** SYSTEM is made through a DB-9 connector located on the front of the rack mount chassis. The ***Bus*** SYSTEM is equipped with a RS-232 internal switch to give access to each module from one single RS-232 serial link (see section 2.2).

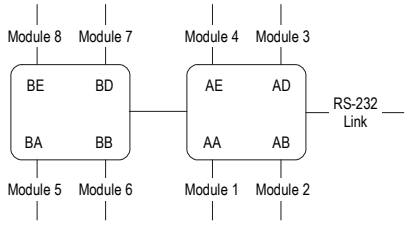
If your computer is equipped with a DB-9 serial port connector, then use a standard RS-232 extension cable (all wires straight through). If your computer is equipped with a DB-25 connector, use a DB-25 to DB-9 converter module with a standard RS-232 extension cable. NOTE: do not use a null modem cable or adapter. The serial link must be configured as follow:

BAUD RATE:	9600
PARITY:	NONE
DATA BITS:	8
STOP BIT:	1

2.1.2 Hardware flow control

The ***Bus*** SYSTEM instrument makes use of hardware flow control also called Handshaking based on DTR/DSR control. When activated, the Data Terminal Ready (DTR) line of the serial link informs the ***Bus*** SYSTEM that the UART of the host computer or controlling instrument is ready to exchange data. The Data Set Ready (DSR) line indicates, when activated, that the ***Bus*** SYSTEM is ready to exchange data.

2.1.3 RS-232 Switch



The ***Bus*** SYSTEM is equipped with two cascaded RS-232 switches to give easy access to any of the eight plug-in modules from one single RS-232 connector (Figure beside). It is required to first establish the link between the DB-9 connecting port and the module with which the communication needs to be established. Once the communication is established, then commands can be sent and received between the host computer and the selected module. The switch looks continuously for a four character code by monitoring the data that is being received from the host computer. The switch requires a four-character preamble code to turn on and off a port. The first character must be the ASCII escape character (decimal 27). The second character is the ASCII character STX (decimal 2). The third and fourth characters are used to select the port associated to the proper module.

The commands required to establish the connection to each module are given in the table below. Once the connection is established, the Remote Control Commands are sent to the selected module and data are received from as long as the switch doesn't catch a new command for establishing a new connection.

Selected Module n°	ASCII switching command	Keyboard switching command
1	ESC STX AA	Ctrl [Ctrl B AA
2	ESC STX AB	Ctrl [Ctrl B AB
3	ESC STX AD	Ctrl [Ctrl B AD
4	ESC STX AE	Ctrl [Ctrl B AE
5	ESC STX BA	Ctrl [Ctrl B BA
6	ESC STX BB	Ctrl [Ctrl B BB
7	ESC STX BD	Ctrl [Ctrl B BD
8	ESC STX BE	Ctrl [Ctrl B BE

2.2 Remote Control Commands

2.2.1 Principle of operation

All the Remote Control Commands can be sent to the ***Bus*** SYSTEM by using simple communication software (such as HyperTerminal® or MLINK®). These commands can also be used with programs made with BASIC, C/C++ compilers, or with third party software such as ASYST or LAB-VIEW.

All Remote Control Commands begin with a two letter (capital letter) identifier referred to as the prefix of that command. Commands without argument are composed solely of their prefix. All command must start with a left bracket ([ ) and end with a right bracket ( ]) to be interpreted correctly. These two characters are the delimiters of a command. Everything typed inside the bracket is considered to be part of the command. Whenever a command must be followed by an argument, the command prefix and the argument are strung together. The Bus SYSTEM does not interpret a command until the right delimiter is encountered in the incoming flow of characters. Everything between the brackets is sent back over the serial link as soon as the right delimiter is encountered. In other words, all command sent to the ***Bus*** SYSTEM is echoed back to the computer. The user will notify that the ***Bus*** SYSTEM modules take more time to respond (i.e. to sent the echo back) at 500 and 1000 Hz *Sampling Rate* than 100 Hz. This is not an abnormal situation so it is important to wait for the echo of the ***Bus*** SYSTEM before sending another command. Each line of characters returned to the computer by the ***Bus*** SYSTEM terminates with a line feed (\n) and carriage return (\r) character. Note also that each string of characters on same line are normally separated by one space character identified by the ∨ character in this manual.

Example: The command **[SN]** sends the unit serial number. Upon reception of the command, the ***Bus*** SYSTEM returns the following over the serial link: SN\n\r. The following table gives the list of remote control commands grouped by categories. For a complete description of each command see Appendix A.

REMOTE CONTROL COMMANDS			
COMMAND NAME	**SYNTAX**	**COMMAND NAME**	**SYNTAX**
DATA ACQUISITION		**GAGE**	
ACQUISITION AVERAGE	**[TC**X.XXX**]**	GAGE ADD	**[AS**XXXXXXX**]**
ACQUISITION MODE	**[TM**X**]**	GAGE ERASE	**[RS**XXXXXXX**]**
ACQUISITION RATE	**[SR**HHMMSS**]**	GAGE LIST	**[LG]**
STOP ACQUISITION	**[SAX]**	GAGE SELECT	**[GA**XXXXXXX**]**
DATA DOWNLOAD	**[DD]**	SYSTEM UNIT	**[SUX]**
SAMPLING RATE	**[SP**X**]**	ZERO DOWNLOAD	**[ZD]**
TRIGGER	**[TSX]**	ZERO INTERNAL	**[ZP**XXXXXXX**]**
ANALOG OUTPUT		ZERO PHYSICAL	**[ZO**XXXX.XX**]**
ANALOG SCALE	**[AV**XXXXX.X **]**	**MISCELLANEOUS**	
ANALOG ZERO	**[AZ**XXXXX.XXX**]**	VERSION BOARD	**[VB]**
MEMORY		AUTO-DIAGNOSIS	**[DNX]**
SYSTEM RESET	**[RW]**	LAMP OFF/ON	**[CS**X**]**
BUFFER LENGTH	**[TBXXXX]**	DIAGNOSTIC REPORT	**[DR]**
		FIRMWARE VERSION	**[VR]**
		SERIAL NUMBER	**[SN]**

2.3 Memory

Each module of the ***Bus*** SYSTEM has a non-volatile RAM type memory where all the module settings such as Gage Factors, acquisition process parameters, etc. are stored. When turned on, each module is initialized to its previous settings as the last time it was turned off. For any reason, if the RAM memory contents on a given module has been damaged or lost during operation, it will be reinitialized to its default factory settings. That means that all Gage Factors in the *Gage List* and associated zero will be lost. The user may also reset himself the RAM memory to its factory state by using the **SYSTEM RESET [RW]** command. Each module of the ***Bus*** SYSTEM has also a non-volatile ring memory buffer with a capacity of 4096 (4K) data points. See section 2.5 for more information.

2.4 Sampling Rate and Data Averaging

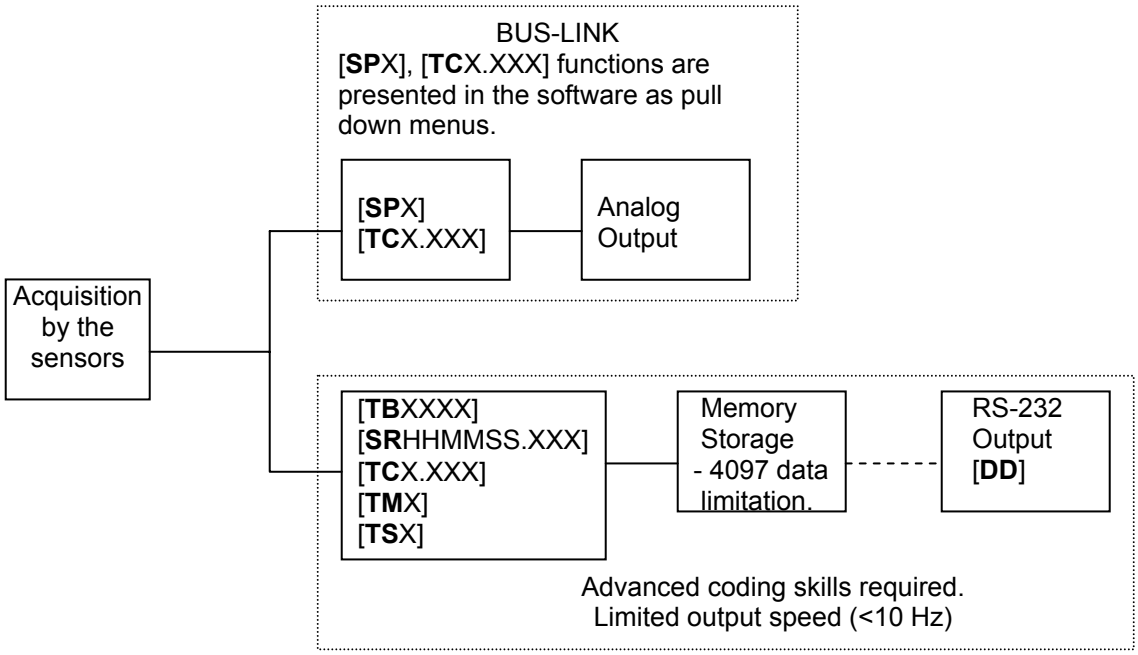
The *Sampling Rate* of the ***Bus*** SYSTEM modules can be separately set at 100 Hz, 500 Hz or 1000 Hz using the **SAMPLING RATE [SP**X**]** command. The user may thus select the proper sampling rate according to which type of measurements among static, quasi-static or dynamic are to be performed. Two important points must be reminded: 1) According to the Nyquist theorem, the sampling rate limits the bandwidth of the signal recorder by the ***Bus*** SYSTEM; 2) A higher sampling rate reduces the Signal-to-Noise ratio. The first point means that the modules of the ***Bus*** SYSTEM can not integrally record a dynamic physical phenomena (like with any recording instruments) up to frequency limit given by the Nyquist sampling theorem. The second point is due to the fact that the integration time of the light detector gets smaller at higher sampling rate thus reducing the amount of light measured by the detectors during one data measurement. This is why we recommend to **ALWAYS USE THE LOWEST SAMPLING RATE WHENEVER IT IS POSSIBLE** (See also Using Extension Cable at section 1.5).

The user can set for each module the averaging time. The data averaging is dependant on the 100 Hz, 500 Hz or 1000 Hz *Sampling Rate* setting. This averaging time is set with the **ACQUISITION AVERAGE [TC**X.XXX**]** command. For example and assuming that the module of the ***Bus*** SYSTEM is set with a *Sampling Rate* of 1000 Hz, an averaging time of 10 ms will result in averaging of 10 samples since the time interval between two consecutive samples is 1 ms (1/1000 Hz).

2.5 *Bus* System Acquisition Process with RS-232 Output

Acquisition Rate

The acquisition rate parameters set with **ACQUISITION RATE [SRhhmmss.xxx]** command is used to save a data in the conditioner memory. With the RS232 commands listed at the end of this manual the user may create its own program and download the memory using RS-232 serial port. In order to understand this advanced function, we sketched the two possible outputs, integrating the different commands involved.



Acquisition Modes

Three different *Acquisition Modes* are available with the **ACQUISITION MODE [TM**X**]** Remote Control Command. This command allows the user to perform data acquisition in different ways by selecting one of the following modes.

- *CONTINUOUS* mode (**[TM**0**]**): When operated in the *CONTINUOUS* acquisition mode (default state), the memory buffer is first filled with data and then wraps around to overwrite the previous values. The acquisition is done accordingly to the values set with **ACQUISITION AVERAGE** and **RATE** commands. Data is sent in standard ASCII characters with a line feed and carriage return character after each value. A header is included on the top line to indicate the Gage Factor for which the data was acquired. The data samples in the memory buffer can be downloaded to the computer with the **DATA DOWNLOAD** command. Downloading these data points resets the buffer and data sent is forever lost. Also remember that any command that affect the averaging time, the acquisition rate and the Gage Factor will also reset the buffer. The capacity of the buffer can be toggle between 4096 points and one single point (See **BUFFER LENGTH** command). The acquisition is started as soon as the command is received.
- *SINGLE* mode (**[TM**1**]**): When set in this mode, the ***Bus*** SYSTEM reads only on point (single shot acquisition). The single point acquisition, which depends only on the averaging value and SLOW or FAST acquisition, is performed as soon as the **TRIGGER** command is received by the ***Bus*** SYSTEM. However, the buffer length must be set to one data point to work properly (See **BUFFER LENGTH** command). The single data buffer can be used to acquire data with a period of time specified by the computer. For example, you can remotely trig the system, and then acquire the single data buffer. A header is included on the top line to indicate the Gage Factor for which the single data was acquired.
- VARIABLE mode (**[TM**X**]**; $6 \leq X \leq 4096$): This mode is used to perform acquisition of a given number of data samples according to a defined buffer length value. The buffer length value may be set in between 6 to 4096 data samples to be acquired. The BUFFER LENTGH is then automatically set according to the input parameter. The acquisition is started as soon as the command is received and stopped when the number of data samples given by the buffer length has been acquired. The module indicates it has reached the buffer length by sending the string "READY" through the RS-232 link. Next acquisitions can be started with the **[TS]** command. The acquisition is done accordingly to the values set with the **ACQUISITION AVERAGE** and **RATE** commands. Data is sent in standard ASCII characters with a line feed and carriage return character after each value. A header is included on the top line to indicate the Gage Factor for which the data was acquired. The data samples in the memory buffer can be downloaded to the computer with the **DATA DOWNLOAD** command. Downloading these data points resets the buffer and data sent is forever lost. Note that the buffer length will remains to the value set with this command until it is reset with the **[TB]** command.
- Special: [TM5] You will need to set manually the BUFFER LENTGH using the [TB] command. Also, the acquisition will start as soon as the TRIGGER command is received.

2.6 Analog Output

The BUS conditioner has a voltage analog output for each of its measuring channels. These outputs have a full scale range of ± 10 Volts with a resolution of approximately 1.22 mV. The analog outputs are updated at the same rate of the data measurements. For each of the outputs, the user has control of both the *Analog Scale Factor* (mV per Physical Unit) and the *Analog Offset* (the value of the data measurement M at which the analog output voltage is zero). The analog output voltage is proportional to the data measurement obtained from the sensor. It is given by the following equations:

$$V_{out} = SCALE \cdot (M - ZERO) \quad \text{(Volts)} \qquad (1)$$

where: *SCALE* is the *Analog Scale Factor* in mV/Physical Units
M is the data measurement displayed by the conditioner
ZERO is the *Analog Offset*

With the aid of the *FISOCommander BUS/Veloce Edition*, the user can adjust independently for each analog output, the values of the *SCALE* (*Analog Scale Factor*) and *ZERO* (*Analog Offset*) parameters so to cover the entire range of the instrument. However, for highest resolution, use the highest possible *Analog Scale Factor*. The voltage range of the output can be determined by using the above equation and substituting in the highest measured value of M, and lowest measured value of M. The analog output of the signal conditioner is adjusted at the factory with default setting values which depend on the type of the sensor. (The default value of the *Analog Offset* is always zero). The following table gives the analog output default setting values for different type of sensors along with the corresponding range and resolution.

DEFAULT SETTINGS OF THE ± 10 VOLTS ANALOG OUTPUT								
Sensor type	***Analog Scale Factor (SCALE)***		***Analog Offset (ZERO)***		Range		Resolution	
	SI	Imperial	SI	Imperial	SI	Imperial	SI	Imperial
Strain	2 mV/με	2 mV/με	0 με	0 με	± 5000 με	± 5000 με	0.6 με	0.6 με
Temperature	10 mV/°C	10 mV/°F	0 °C	0 °F	± 1000 °C	± 1000 °F	0.12 °C	0.12 °F
Pressure	75 mV/bar	5 mV/psi	0 bar	0 psi	± 133 bar	± 2000 psi	0.016 bar	0.24 psi
Load	2 mV/kg	1 mV/lb	0 kg	0 lb	± 5000 kg	± 10000 lb	0.6 kg	1.22 lb
Displacement	500 mV/mm	10000 mV/in	0 mm	0 in	± 20 mm	± 1 in	2.4 µm	0.12 µ-in
Internal unit (nm)	1 mV/nm		0 nm		± 10000 nm		1.22 nm	

- ✓ **To restore the *Analog Scale Factor* and the *Analog Offset* to their default value, set the *SCALE* parameter to zero.**
- ✓ **Assigning another *Gage Factor* from the *Gage List* (i.e. selecting another sensor) will restore the *Analog Scale Factor* and the *Analog Offset* to their default values only if this sensor is a different type than the previously assigned one. In other words, selecting another sensor but of same type, will not change the analog output settings.**

3 Sensors Operation

This section contains important information for the proper operation of your *Bus* SYSTEM instrument. It is recommended reading this section before using your *Bus* SYSTEM for the first time.

3.1 Gage Factor

Before a gage can be used with the ***Bus*** SYSTEM modules, its Gage Factor must first be stored in the module memory. Each ***Bus*** SYSTEM module can store up to 50 Gage Factors at the time, which is called the *Gage List*. The module uses the Gage Factor to identify the gage type and its factory calibration factor. The modules come with the default Gage Factors 0001000 (or 1000) and 0 already store in the memory. A gage is added to the *Gage List* by entering its Gage Factor in the module memory using the **GAGE ADD [AS**XXXXXXX**]** command. When a gage is no longer in use it can be removed from the *Gage List* with the **GAGE ERASE [RS**XXXXXXX**]** command.

3.1.1 Gage Factors

The Gage Factor is located on a label close to the gage fiber optic connector. The first digit of the Gage Factor corresponds to the type of gage used as indicated below, 0 is the default number and is not associated to any type of gage:

1: used for non-compensated strain gages
2: used for pressure gages type 1
3: used for force & load gages type 1
4: used for temperature gages type 1
5: used for compensated strain gages
6: used for pressure gages type 2
7: used for force & load gages type 2
8: used for linear position & displacement sensors
9: used for temperature gages type 2

The second digit is used to differentiate gages of same type and sensitivity. For strain, force & load and pressure gages: the third digit is used to increase the gage factor one decade per digit increase while the last four digits correspond to the gage scale factor. In the case of the linear position & displacement sensor, the last five digits correspond to its sensitivity. In the case of the temperature gage, the last six digits correspond to the factory calibration values.

3.1.2 Selecting a Gage

To use a gage with the ***Bus*** SYSTEM modules, you must select its Gage Factor in the *Gage List* with the **GAGE SELECT [GA**XXXXXXX**]** command. The Gage Factor 0001000 is default number selected by the module. Note that, whatever the gage type is connected to the module, if the Gage Factor 0001000 is selected, the module will read the gage cavity length in internal unit. The ***Bus*** SYSTEM internal unit of measure is the nanometer. The content of the *Gage List* may be downloaded using the **GAGE LIST [LG]** command.

3.2 Gage Calibration

Fiso Technologies' fiber optic gages come with their sensitivity or gage factor already calibrated at factory. For a complete calibration the user may just define a zero or an offset point using the **ZERO INTERNAL [ZP**XXXXXXX**]** or **ZERO PHYSICAL [ZO**XX.XX**]** command. ATTENTION: The temperature gage is a special case where both the gage factor and the zero point have been already calibrated at factory so the user should not have to make any calibration.

3.2.1 Nulling a gage

All type of gages can be nulled at any time and it is recommended that strain and pressure gages should be nulled at least once. **The temperature gage, which is fully calibrated at factory, must not be nulled for proper operation**. The linear position and displacement sensor should not be nulled as well for best precision. A gage can be nulled by sending the **ZERO PHYSICAL [ZO**XX.XX**]** command with 0 value for the parameter. After nulling, the module will indicate a gage reading of zero or very small value. Obviously, the gage should not be submitted to strain (for strain gages) or pressure (for pressure gage) if you want a true zero. Before the first nulling of a gage, we recommend to take note for your records of the actual zero value in internal unit of the selected gage (i.e. this number will correspond, after nulling, to the cavity length of the gage in nm at which the module indicates a zero value). This may be useful for long term measurements where you want to keep a record of your gage true zero. The actual zero value can be read with the **ZERO DOWNLOAD [ZD]** command.

3.2.2 Gage offset

Internal and Physical Offsets

The **ZERO PHYSICAL [ZO**XX.XX**]** or **ZERO INTERNAL [ZP**XXXXX**]** commands are used to null and/or add an offset value to the selected gage in physical (engineering) units or in internal units (nm), respectively. With the **ZERO PHYSICAL** command, the offset value entered is compatible with the physical units of the selected gage. With the **ZERO INTERNAL** command, the offset value is compatible with the internal unit that is nanometer. This last command can be useful to re-enter a zero value, which was lost from an instrument reset or a memory lost. (This is another reason to always keep a record of the gage zero value). Right after receiving the **ZERO PHYSICAL** or **ZERO INTERNAL** command, the module will indicate a gage reading corresponding to the physical or internal offset value.

4 Other System Functions

4.1 Diagnostic Function

The **DIAGNOSTIC REPORT [DR]** command provides important system performance information for diagnostic purposes. This function can be useful to evaluate the performances of both the instrument modules and the fiber optic gages. The system information are the GAIN and the RAW signal. The RAW signal and the GAIN signal provide the essential information on the module performance. The RAW signal measures the amplitude of the light power detected by the module so it does provide information on failure of the light source and improper connections. The GAIN provides information on the amplitude of the interferometric signal coming from the fiber-optic gage so it does provide information on the gage itself. The following table gives the numerical values of these signals depending on the system conditions. Note that these diagnostic results are significant only when the system *Sampling Rate* is set to 100 Hz.

Signal	***Sampling Rate***	**System condition**		
		Defective	**Poor**	**Good**
RAW	**100 Hz**	< 2.1 V	2.1 to 3.5 V	> 3.5 V
GAIN	**100 Hz**	> 80 %	60 - 80 %	< 60 %

Referring to the above table, the user can make a diagnosis on the performances of its instrument and gage set-up. Moreover, each module of the ***Bus*** SYSTEM is equipped with an auto-diagnosis feature that can detect a defective or noisy measurement condition. See the following section for more information.

4.2 Auto-Diagnosis and Error Messages

Each module of the ***Bus*** SYSTEM can make an auto-diagnosis of its own performances including the fiber-optic gage set-up. Using a check sum error values based on the amplitude of the RAW signal and the GAIN, the module can sent through the RS-232 link, in case of defective or noisy measurement conditions, different messages as described next. Note that the auto-diagnosis is only available when the module is run at *Sampling Rate* of 100 Hz. The auto-diagnosis feature can be enabled (default state) or disable using the **AUTO-DIAGNOSIS ON** and **OFF** commands.

LOW SIGNAL

The condition for this error message is: RAW (>2.1) and GAIN (60 - 80%).

When one of the modules of the ***Bus*** SYSTEM detects a noisy but still readable signal, it will send the LOW SIGNAL! error message over the serial link. This error message is a warning type error so it does not disable the acquisition process. The error message is sent just before the echo of any command received by the module. The following example shows a noisy condition after sending the [TM6] command and the following [DR] command effectively reports a noisy condition. The data acquisition made with [TM6] has worked as shown with by the READY string and confirmed with the [DD] command. The error message is sent just before the echo of each command.

[TM6]LOW^SIGNAL!\n\r
TM6\n\r
READY\n\r
[DR]LOW^SIGNAL!\n\r
DR\n\r
RAW:^4.8 \n\r
GAIN:^65%\n\r
[DD]LOW^SIGNAL!\n\r
DD\n\r
ser:^1001000\n\r
19339\n\r
22768\n\r
19324\n\r
19350\n\r
22784\n\r
19350\n\r

The possible cause and remedies for a NO SIGNAL error message are:

- Improper connection. Verify connections or clean the fiber-optic connector of the sensor, cable, and/or module of the ***Bus*** SYSTEM.
- Fiber optic cable is longer than the maximum length permitted or two many fiber-optic cable connections. Use cable with shorter length or use index matching gel in between cable connections (see section 1.5).
- Lamp is still working but its power is reduced (RAW is between 2.1 to 3.5 V). Replace the lamp.

- ***Bus*** SYSTEM module is defective. Contact factory.

CHECK GAGE

The condition for this error message is: RAW (>2.1) and GAIN (>80%).

When one of the modules detects a light but non-readable signal, it will send the CHECK GAGE! error message over the serial link. This error message is a fatal type error so it does disable the acquisition process. The error message is sent just before the echo of any command received by the module. The following example shows that effectively the acquisition has not worked because [TM6] did not return the READY string. This is also confirmed with [DD] command where no data points are returned.

[TM6]CHECK^GAGE!\n\r
TM6\n\r
[DR]CHECK^GAGE!\n\r
DR\n\r
RAW:^4.0 n\r
GAIN:^98%\n\r
[DD]CHECK^GAGE!\n\r
DD\n\r
ser:^1001000\n\r

The possible cause and remedies for a CHECK GAGE error message are:

- No gage connected to the module.
- Fiber optic cable or gage is damaged. Replace damaged part.
- ***Bus*** SYSTEM module is defective. Contact factory

LIGHT FAILED

The condition for this error message is: RAW (< 2.1) and GAIN (0 to 100%),

When one of the modules of the ***Bus*** SYSTEM detects no or very low light signal, it will send the LIGHT FAILED! error message over the serial link. This error message is a fatal type error so it does disable the acquisition process. The error message is sent just before the echo of any command received by the module.

The possible cause and remedies for a LIGHT FAILED! error message are:

- Lamp is turned OFF or defective. Turn the lamp ON, check the LED indicator or check if light is coming out of the input connector. If not, replace the lamp (see section 1.3).

APPENDIX A: Remote Control Commands

GAGE

[RS] Gage Erase

NAME:	**GAGE ERASE**
SYNTAX:	**[RSXXXXXXX]**
PARAMETERS:	XXXXXXX is the 7-digit *Gage Factor*
REMARKS:	This command erases a *Gage Factor* from the *Gage List*.
RETURN VALUE:	RSXXXXXXX\n\r
ERROR NUMBER:	**12** GAGE NOT FOUND

[LG] Gage List

NAME:	**GAGE LIST**
SYNTAX:	**[LG]**
PARAMETERS:	None, returns the content of the *Gage List*
REMARKS:	An "END" string is added at the end of the list.
RETURN VALUE:	LG\n\r *GAGE FACTOR*\n\r *GAGE FACTOR*\n\r *GAGE FACTOR*\n\r ---------- ---------- *GAGE FACTOR*\n\r END\n\r
ERROR NUMBER:	None

[AS] Gage Add

NAME:	**GAGE ADD**
SYNTAX:	**[ASXXXXXXX]**
PARAMETERS:	XXXXXXX is the 7-digit *Gage Factor*
REMARKS:	This command adds a *Gage Factor* to the *Gage List*.
RETURN VALUE:	ASXXXXXXX\n\r
ERROR NUMBER:	**1** MEMORY FULL (50), **10** ALREADY PRESENT, **11** INVALID NUMBER

[GA] Gage Select

NAME:	**GAGE SELECT**
SYNTAX:	**[GAXXXXXXX]**, **[GA], [GA0]**
PARAMETERS:	If none: Returns the *Gage Factor* XXXXXXX currently assigned to the system If = 0 : Turns the channel to OFF, therefore it deactivates the channel Otherwise : assigns the Gage Factor XXXXXXX to the channel
REMARKS:	
RETURN VALUE:	GAXXXXXXX\n\r (or) GA\n\r XXXXXXX (or) GA0\n\r
ERROR NUMBER:	**12** GAGE NOT FOUND

[ZO] Zero Physical

NAME:	**ZERO PHYSICAL**
SYNTAX:	**[ZOXX.XX]**
PARAMETERS:	XX.XX is the value (in physical units) that offsets (or zero adjust) the sensor currently assigned. Special : [ZO0]is used for *nulling* a gage
REMARKS:	This function is irrelevant for temperature sensor.
RETURN VALUE:	ZOXX.XX\n\r (or) ZO0\n\r
ERROR NUMBER:	**11** if used with a temperature sensor

[ZP] Zero Internal

NAME:	**ZERO INTERNAL**
SYNTAX:	**[ZPXXXXX]**
PARAMETERS:	XXXXX value expressed in nm
REMARKS:	This command is use to add an offset value, in internal units, to the selected gage.
RETURN VALUE:	ZPXXXXX\n\r
ERROR NUMBER:	**10** if X < -99999 or X > 99999 **11** if used with a temperature sensor

[ZD] Zero Download

NAME:	**ZERO DOWNLOAD**
SYNTAX:	**[ZD]**
PARAMETERS:	Returns the Gage Zero current value associated with the Gage Factor currently assigned
REMARKS:	This function is irrelevant for temperature sensor.
RETURN VALUE:	ZD\n\r XXXXX.XX\n\r (where XXXXX.XX is the *Zero* value of the selected gage in internal units)
ERROR NUMBER:	**11** if used with a temperature sensor

ANALOG OUTPUT

[AV] Analog Scale

NAME:	**ANALOG SCALE**
SYNTAX:	**[AVXXXXX.X], [AV], [AV0]**
PARAMETERS:	XXXXX.X represents the scale factor express in mV/physical units. Special: AV0 sets the current gage to it's default values
REMARKS:	This command returns the actual *analog scale (factor).*
RETURN VALUE:	AVXXXXX.X\n\r (or) AV\n\r XXXXX.X\n\r (XX.X is the current *SCALE* value of the analog output) (or) AV0\n\r
ERROR NUMBER:	**11**

Analog Scale Default value (Voltage output)

# of gage	Gage Type	Metric	Imperial
0	No type gage	1 mV/nanometer	1 mV/nanometer
1 et 5	Strain gage	2 mV/µstrain	2 mV/µstrain
2 et 6	Pressure gage	75 mV/Bar	5 mV/Psi
3 et 7	Force gage	2 mV/Kg	1 mV/lbs
4 et 9	Temperature gage	10 mV/°C	10 mV/°F
8	Displacement	500 mV/mm	10 000mV/inch

[AZ] Analog Zero

NAME:	**ANALOG ZERO**
SYNTAX:	**[AZXXXXX.XXX], [AZ]**
PARAMETERS:	If none: returns the current *ZERO* (*Analog Offset*) value from the analog output. Otherwise: XXXXX.XXXis a positive or negative number that sets the *ZERO* (*Analog Offset*) on the analog output.
REMARKS:	The value is in physical unit.
RETURN VALUE:	AZXXXXX.XXX\n\r (or) AZ\n\r XXXXX.XXX\n\r
ERROR NUMBER:	**10**

DATA ACQUISITION

[TM] Set Mode

NAME:	**ACQUISITION MODE**
SYNTAX:	**[TMX], [TM]**
PARAMETERS:	If none: returns the current *Acquisition Mode* (0, 1, or 5) If X = 0: sets acquisition in NORMAL mode (default state) if X = 1: sets acquisition in SINGLE mode if X ≥ 5: sets acquisition in VARIABLE mode (stop with READY string)
REMARKS:	This command sets the acquisition mode. Acquisition mode 2, 3 or 4 will lead to an error message.
RETURN VALUE:	TMX\n\r (or) TM\n\r X\n\r (where X is the current *Acquisition Mode*)
ERROR NUMBER:	10,11

[TS] Trigger

NAME:	**TRIGGER**
SYNTAX:	**[TSX], [TS]**
PARAMETERS:	If X=0: deactivates the *Acquisition Session* If X ≥ 1: activates the *Acquisition Session*
REMARKS:	
RETURN VALUE:	TSX\n\r (or) TSn\r X\n\r (where X is the current *Acquisition Session*)
ERROR NUMBER:	11

[DD] Data Download

NAME:	**DATA DOWNLOAD**
SYNTAX:	**[DD]**
PARAMETERS:	none
REMARKS:	This command is used to download the data points stored in the memory buffer. Data is sent in standard ACSII characters with a line feed and carriage return character after each value. A header is included on the top line to indicate the Gage Factor for which the data was acquired. Downloading these data points resets the buffer and data sent is forever lost.
RETURN VALUE:	
ERROR NUMBER:	none

[TC] Acquisition Average

NAME:	**ACQUISITION AVERAGE (AVERAGING TIME)**
SYNTAX:	**[TCX.XXX], [TC]**
PARAMETERS:	If none: returns the current value of the *Averaging Time* X.XXX is the Averaging Time express in seconds. The Averaging Time is dependant on the Acquisition Rate.
REMARKS:	This command is used to set the Averaging time.
RETURN VALUE:	TCX.XXXs\n\r (or) TC\n\r X.XXX\n\r (where X.XXX is the current *Averaging Time)*
ERROR NUMBER:	**10** if < 0 or >= 60s

[TB] Set Buffer Size

NAME:	**Set Buffer Size**
SYNTAX:	**[TBXXXX], [TB]**
PARAMETERS:	If none: returns the current value of the buffer size.
REMARKS:	This command is used to set the buffer length to 1 or 4096 data samples.
RETURN VALUE:	TBXXXX\n\r (or) TB\n\r XXXX\n\r (where XXXX is the current value of the buffer size*)*
ERROR NUMBER:	**10** if < 0001 or > 4096

[SA] Stop Acquisition

NAME:	**STOP ACQUISITION**
SYNTAX:	**[SAX], [SA]**
PARAMETERS:	If none: returns the current acquisition state If X = 0 the acquisition DISABLE If X ≥ 1 the acquisition ENABLE
REMARKS:	This command will enable and disable the reading of the sensor.
RETURN VALUE:	SAX\n\r (or) SA\n\r X\n\r (where X is the current acquisition state)
ERROR NUMBER:	none

[SR] Acquisition Rate

NAME:	**ACQUISITION RATE**
SYNTAX:	**[SRhhmmss.xxx], [SR]**
PARAMETERS:	If none: returns the current value of the *Acquisition Rate.* 0.000 < hhmmss.xxx < 24 hours is the rate at which one data is saved in the memory buffer.
REMARKS:	
RETURN VALUE:	SRhhmmss.xxx\n\r (or) SR\n\r Hhmmss.xxx\n\r (where X is the current *Acquisition Rate express in time*)
ERROR NUMBER:	**10** if 0.000 < hhmmss.xxx ≤ 240000.000

[SP] Sampling Rate

NAME:	**SAMPLING RATE**
SYNTAX:	**[SPX], [SP]**
PARAMETERS:	If none: returns the current value of the sampling rate If X = 0: sets the Sampling Rate to 100 Hz (default state) If X = 1: sets the Sampling Rate to 500 Hz If X = 2: sets the Sampling Rate to 1000 Hz If X > 2: maintains the current valid Sampling Rate
REMARKS:	This command is used to set the Sampling Rate.
RETURN VALUE:	SPX\n\r (or) SP\n\r X\n\r
ERROR NUMBER:	None

MISCELLANEOUS

[SU] System Unit

NAME:	**SYSTEM UNIT**
SYNTAX:	**[SUX], [SU]**
PARAMETERS:	If none: returns the current System of Units (0 or 1) If X = 0: sets the units to the International System of Units (default state) If X ≥ 1: sets the units to the Imperial System of Units
REMARKS:	When set to the International System of Units (SI), the conditioner uses the following units: **°C** for temperature, **bar** for the pressure, **kg** for the force or load, **mm** for the displacement. The equivalent Imperial Units are: **°F, psi, lb, in**. The strain unit is the micro-strain $\mu\varepsilon$, that is 10^{-6} meter/meter or 10^{-6} inch/inch
RETURN VALUE:	SUX\n\r (or) SU\n\r X\n\r (where X is the current System of Units)
ERROR NUMBER:	None

[DR] Diagnostic Report

NAME:	**DIAGNOSTIC REPORT**
SYNTAX:	**[DR]**
PARAMETERS:	None
REMARKS:	This command returns the diagnostic RAW and GAIN parameters.
RETURN VALUE:	DR\n\r RAW: XX\n\r Amplitude of the light power detected by the module. GAIN: YY\n\r (express in %) is a fraction of the maximum gain applied on the signal conditioner
ERROR NUMBER:	**11** the system is operating at 500Hz or 1Khz.

[VR] Firmware Version

NAME:	**FIRMWARE VERSION**
SYNTAX:	**[VR]**
PARAMETERS:	None
REMARKS:	This command is used to get the **BUS** system version number.
RETURN VALUE:	VR\n\r X.X.X\n\r (where X.X.X is the EPROM version)
ERROR NUMBER:	None

[SN] Serial Number

NAME:	**SERIAL NUMBER**
SYNTAX:	**[SN]**
PARAMETERS:	None
REMARKS:	This command is used to get the **BUS** system serial number.
RETURN VALUE:	SN\n\r XXXXXX\n\r (where XXXXXX is the serial number composed of 7 or 8 alphanumeric characters)
ERROR NUMBER:	None

[DN] Autodiagnosis

NAME:	**AUTODIAGNOSIS**
SYNTAX:	**[DNX], [DN]**
PARAMETERS:	If none: returns the current *value.* If X = 0 : the auto-diagnosis is deactivated If X ≥ 1: the auto-diagnosis is activated (default state)
REMARKS:	This command returns the auto-diagnostic status.
RETURN VALUE:	DNX\n\r (or) DN\n\r X\n\r (where X is the current value)
ERROR NUMBER:	None (only available with a sampling rate of 100Hz)

[CS] Lamp ON/OFF

NAME:	**LAMP ON/OFF**
SYNTAX:	**[CSX], [CS]**
PARAMETERS:	If none: returns the current *value.* If X = 0: turn the lamp ON (default state); If X = 8: turn the lamp OFF.
REMARKS:	This command is used to turn the lamp on and off.
RETURN VALUE:	CSX\n\r (or) CS\n\r X\n\r (where X is the current value)
ERROR NUMBER:	**10** LIGHT FAILED! (if lamp OFF)

[VB] Version Board

NAME:	**VERSION BOARD**
SYNTAX:	**[VB]**
PARAMETERS:	None
REMARKS:	This command is used to get the **BUS** system board version
RETURN VALUE:	VB\n\r 1KVy.xxxxx, y.xxxxx\n\r (y.xxxxx express the version board and compiler options)
ERROR NUMBER:	None

[RW] System Reset

NAME:	**SYSTEM RESET**
SYNTAX:	**[RW]**
PARAMETERS:	None
REMARKS:	This command is used to reset the memory content of the **BUS** system module to the default state values.
RETURN VALUE:	VB\n\r
ERROR NUMBER:	None

ERROR LISTING

ERROR #	MEANING	REMARK OR EXAMPLE
01	MEMORY FULL	No more memory space for adding a Gage Factor
02	SYSTEM STOPPED	Command cannot be executed because the conditioner is in Wait State, is making a diagnostic, etc.
03	NO SIGNAL	Command cannot be executed because of no signal condition
10	INVALID PARAMETER	Command is sent with an invalid parameter
11	COMMAND DENIED	Command is not available with that configuration
12	ITEM NOT FOUND	Trying to erase or select a non existing gage Factor or Gage Name.

Note: Those error number are used as a guideline, the program may also send an error message instead.