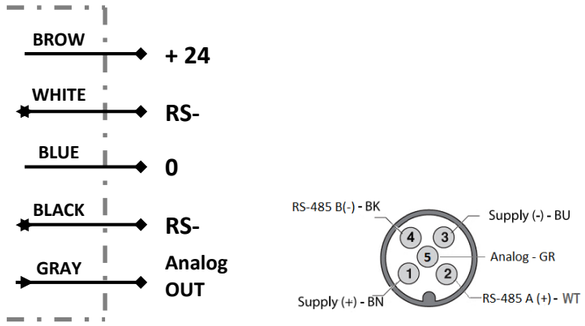
VBR

Shock and Vibrations Sensor
MEMS
826001780 Rev. A - *Created:* 15/11/2022

GENERAL DESCRIPTION

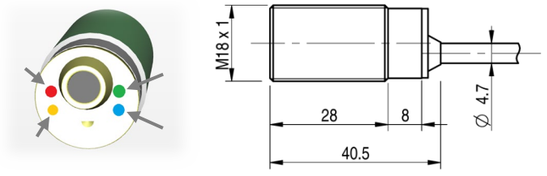
Sensor based on MEMS technology (*Micro Electro-Mechanical Systems*) to monitor shock, vibrations and tilt.

ELECTRICAL DIAGRAM OF THE CONNECTIONS



(The type of analogue output can be programmed through the RS-485 Bus)

USER INTERFACE



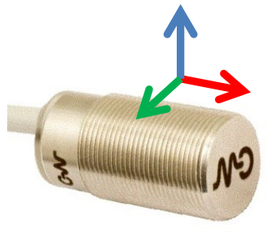
- ***"Green"*** LED indicates standard operation of the product (*RUN*)
- ***"Yellow"*** LED indicates the writing and programming of the memory
- ***"Blue"*** LED indicates the transit of packets on RS-485 bus (LED Toggle → a packet transit is detected)
- ***"Red"*** LED indicates the interrupt of the accelerometer (LED Toggle → shock over the set threshold)

If, at power up, during the system check, the sensor detects a fault, it emits 10 contemporary flashes of ***"Yellow, Red and Blue"*** LED.

TECHNICAL DATA

Supply Voltage	**24 Vdc +/- 20%**
Consumption	**< 1 W**
Operative Range	**+/- 16 g** *(MAX)*
Resolution	**15,62 mg** @ +/- 2 g **31,25 mg** @ +/- 4 g **62,50 mg** @ +/- 8 g **125 mg** @ +/- 16 g
Number of Measured Axes	**3 (X, Y, Z)**
Frequency Range	**400 Hz** *(VBR1)* **1250 Hz** *(VBR2)*
Technology	**MEMS** *(Micro Electro-Mechanical Systems)*
Digital output	**RS-485** *(to be addressed)* **57600** Baud rate - 1 bit stop - no parità *(VBR1)* **921600** Baud rate - 1 bit stop - no parità *(VBR2)*
Digital Resolution	**16 bit** @ RS-485 (complementary to 2) **12 bit** @ analogue output
Voltage Analogue Output	**0..5 V / 0..10 V** *(programmable)*
Current Analogue Output	**4..20 mA / 0..20 mA / 0..24 mA** *(programmable)*
Load Resistance (voltage)	**1k .. 1M Ohm**
Load Resistance (current)	**100 .. 500 Ohm**
Humidity	**< 80 %** without condensation
Temperature Range	**-25° C ... + 70°C** **(-25°...+50°C** ATEX models)
Storage Temperature	**-30° ... +90°C** without ice
Electrical Protections	**Polarity Reversal, overvoltage pulses**
Mechanical Protection Degree	**IP 67** *(EN60529)*
Housing Material	**GRILAMID + INOX AISI316-L**
Connections	**5 poles cable** **5 poles M12 Pig-Tail**
Housing Shape	**Cylindrical M18**
Weight	**100 gr.** *(cable version)*

AXES POSITION



The direction and the verse of the reference axes of the accelerometer are arranged as shown in the picture. Please take the MD logo on the front of the sensor as a reference.

ADJUSTMENT

FUNCTIONING

At the power on, after the system check, the device recalls from memory the last saved configuration and goes into normal operation (RUN) reported by the flashing of "Green" LED.

The analogue output, in standard configuration, shows the value of the acceleration detected on the X axis with a full scale of 4g through a voltage 0-10V.

NB. The resolution of the analogue output is 12 bit while the resolution of the data read directly on the RS-485 is 16 bits (complementary to 2).

NB. The 0g value corresponds to half scale of the analogue output (0..10V → 5V).

In this state it is always possible to send an RS-485 command.

(During sensor configuration, it is not possible to execute the monitoring of the vibrations).

FIRST POWER ON

Realize the first product configuration supplying one sensor at a time, in order to properly address the devices on the bus RS-485 and change its node address.

STANDARD CONFIGURATION

The default configuration of the sensor is the following *(Factory Setting)*:

- Node number (**0**)
- Analogue reference axis (**X** Axis)
- Analogue output (**VOLTAGE** with scale **0..10V**)
- Interrupt (**OFF** all disabled)
- Behaviour (**NORMAL**)
- Full scale (**1 → +/- 4g**)
- Shock threshold (**20 → 625 mg** *with a full scale 4g*)
- Shock duration (**1 → 2,5 msec**)

GENERAL WARNINGS

Make sure the power supply is properly stabilized.

The sensor must not be connected to the power supply line if it is powered: this can cause damage to the device.

If the interference induced from power lines is greater than that required by EC legislation (interference immunity), separate the sensor cables from the power lines and high voltage and insert the cable in a metal conduit connected to the ground.

Do not expose the sensor to water, steam, acids or solvents. To clean the sensor use a damp cloth and dry.

RS-485 SYNTAX

To avoid collisions and/or communication errors, all the commands are encapsulated in packages "on short syntax" and packages "extended syntax". Typically, "short" packages are used to send commands without parameters (Ex. Command ECHO) while "extended" packages contain parameters and they are also protected by a checksum control.

To discriminate the type of package, please refers to the eighth bit (MSB) of the byte "Node number". The packages in "short syntax" have this bit to "0" while the packages in "extended syntax" have the bit to "1".

Because it is possible to connect to the RS-485 bus more products, in order to identify them uniquely, it is always necessary to give them a unique value of the " Node number".

SHORT COMMAND SYNTAX

Byte 1	*Byte 2*	*Byte 3*	*Byte 4*	*Byte 5*
0x23 h	**0x74 h**	*node n°*	*command*	**0x65 h**

- *Byte 1* → Start (**0x23**)
- *Byte 2* → Start (**0x74**)
- *Byte 3* → Selection of command typology and node number
- *Byte 4* → Command
- *Byte 5* → End (**0x65**)

EXTENDED COMMAND SYNTAX

Byte 1	*Byte 2*	*Byte 3*	*Byte 4*	*Byte 5*	*Byte 6*	*Byte 7*	*Byte 8*
0x23 h	**0x74 h**	*node n°*	*command*	*data 1*	*data 0*	*Checksum*	**0x65 h**

- *Byte 1* → Start (**0x23**)
- *Byte 2* → Start (**0x74**)
- *Byte 3* → Selection of command typology and node number
- *Byte 4* → Command
- *Byte 5* → Byte 1 (MSB) of the data
- *Byte 6* → Byte 0 (LSB) of the data
- *Byte 7* → Checksum
- *Byte 8* → End (**0x65**)

CHECKSUM

To calculate the checksum it is necessary to add the first six bytes of the package and send only the less significant byte of the result:

Ex. *0x23 + 0x74 + 0x80 + 0x50 + 0x00 + 0x01 = 0x228* → ***0x28***

ACKNOWLEDGE

The sensor responds with an ACK to a command only if the command was successful. The ACK is composed of 2 bytes: the first byte is **0x40** and the second byte is the command sent.

Ex. Command (*ECHO*): *0x23 0x74 0x00 0x28 0x65* → ***0x40 0x28*** (*ACK*)

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Certificate number : 1603023X

WARNING These products are NOT safety sensors and are NOT suitable for use in personnel safety application

Declaration of conformity
Datasensing S.r.l. declares under its sole responsibility that these products are in conformity with the following EEC directive: 2004/108/EC and subsequent amendments.

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RS-485 COMMANDS LIST

During the standard operation of the product (*RUN*), it is always possible to send RS-485 command to the product if the RS-485 communication is available.

COMMANDS WITH EXTENDED SYNTAX (HEX)

- (**0x70**) SET of the value sent as "node number".

Ex. *0x23 0x74 0x80 0x70 0x00 0x01 0x88 0x65* → ***0x40 0x70*** (*ACK*)

NB. The node numbers may change in the range "**0..126**".

- (**0x36**) SET of the threshold value of the accelerometer (0..127)
- (**0x37**) SET of the minimum value of the recognized interrupt duration (0..127)
- (**0x38**) SET of the accelerometer full scale value (0..3)

NB. The possible full scale value of the accelerometer are:

- 0 → +/- **2** g
- 1 → +/- **4** g
- 2 → +/- **8** g
- 3 → +/- **16** g

Ex. *SET of the full scale value at +/- 2 g:*

0x23 0x74 0x80 0x38 0x00 0x00 0x4F 0x65 → ***0x40 0x38*** (*ACK*)

(To store the parameters, send always the save command)

COMMANDS WITH SHORT SYNTAX (HEX)

- (**0xAA**) Save the current configuration of the product
- (**0xBB**) Re-call last saved configuration
- (**0xBC**) Restore factory settings
- (**0x4D**) GET sensor model (*reserved*)
- (**0x4E**) GET sensor hardware revision (*reserved*)

NB. Restoring the factory settings brings the product to the default values and overwrites all saved configurations.

- (**0x80**) SET of the voltage analogue output with scale 0..10V
- (**0x81**) SET of the voltage analogue output with scale 0..5V
- (**0x82**) SET of the current analogue output with scale 4..20mA
- (**0x83**) SET of the analogue output in high impedance
- (**0x84**) SET of the current analogue output with scale 0..20 mA
- (**0x85**) SET of the current analogue output with scale 0..24 mA

- (**0x46**) SET of NORMAL behaviour
- (**0x47**) SET of TOGGLING behaviour
- (**0x48**) SET of IMPULSE behaviour

- (**0x28**) ECHO command

- (**0x34**) SET of the interrupt state on RS-485 ON
- (**0x44**) SET of the interrupt state on RS-485 and ANALOGUE ON
- (**0x45**) SET of the interrupt state on ANALOGUE ON
- (**0x35**) SET of the interrupt state OFF

- (**0x90**) SET analogue output on values of X axes acceleration
- (**0x91**) SET analogue output on values of Y axes acceleration
- (**0x92**) SET analogue output on values of Z axes acceleration

- (**0x30**) GET of the interrupt state:
  0x00 → OFF
  0x01 → ON RS-485
  0x02 → ON ANALOGUE OUT
  0x03 → ON ANALOGUE + RS-485

- (**0x4A**) GET of the reference axes for the analogue output:
  0x00 → X Axes
  0x01 → Y Axes
  0x02 → Z Axes

- (**0x4B**) GET of analogue output typology:
  0x00 → High impedance
  0x01 → Voltage with scale 0..5 V
  0x02 → Voltage with scale 0..10 V
  0x03 → Current with scale 4..20 mA
  0x04 → Current with scale 0..20 mA
  0x05 → Current with scale 4..24 mA

- (**0x4C**) GET behaviour typology:
  0x00 → NORMAL
  0x01 → TOGGLING
  0x02 → IMPULSE

- (**0x31**) GET of the threshold value of the accelerometer (0..127)
- (**0x32**) GET of the minimum value of the recognized interrupt duration (0..127)
- (**0x33**) GET of the accelerometer full scale value (0..3)

These GET commands respond with an ACK followed by 1 byte containing the requested value.

Ex. *GET THRESHOLD* → ***0x40 0x23*** *(= 35 decimal)*

- (**0x39**) GET of the positive peak values
- (**0x3A**) GET of the negative peak values
- (**0x3B**) GET of the average values (in a slot of 1024 samples)

The GET of the values responds with an ACK followed by 6 bytes containing the values of the recorded accelerations. The first 2 bytes of data (16 bits expressed in a complement of 2) are referred to the X axis, the following 2 bytes to the Y axis and the remaining 2, to the Z axis:

GET POSITIVE PEAK → ***0x40 0x00 0x01 0x00 0x02 0x00 0x03***

(X=1, Y=2, Z=3)

Each reading of the peak values (positive or negative) resets the value of the related variable in order to recalculate the data since the last query.

- (**0x50**) GET CONTINUOUS of the values of the 3 axis
- (**0x55**) GET BURST of 1000 data of the values of the 3 axis

NB. The "CONTINUOUS" command stops the bidirectional communication with the sensor and saturates the RS-485 bus with the data of acceleration at the maximum sampling rate of the sensor: 400Hz. To restore communication it is necessary to switch off and on the sensor.

- (**0x51**) GET of the current values of acceleration of the 3 axes
- (**0x52**) GET of the current values of acceleration of the X axis
- (**0x53**) GET of the current values of acceleration of the Y axis
- (**0x54**) GET of the current values of acceleration of the Z axis

The GET of these values are for polling management at a low frequency and when they are referred to the single axis (X or Y or Z), the command responds with an ACK followed by 2 bytes which contain the values of the recorded accelerations:

Ex. *GET VALUES X AXIS* → ***0x40 0x00 0x01*** *(X = 1)*

- (**0x59**) GET accelerometer temperature

The GET temperature value responds with an ACK followed by 1 byte that contains the required value in complement of 2 and 0x00 corresponding to 25 ° C. The boundary values are -40°C and + 85°C.

Ex. *GET TEMPERATURE* → ***0x40 0x0A*** *(= +35°C)*

INTERRUPT (Threshold and Duration)

The "interrupt" function works in an continuous basis and all the values within the sampling frequency (400 Hz) are compared with the "**threshold**" and "**duration**" parameters. If an acceleration exceeds the set "threshold" for a period longer than the "duration" an alarm is generated.

DURATION

The "duration" value is selectable on 128 levels (0..127) with a step of approximately **2,5**msec.

Ex. To get an alarm by an acceleration exceeding the "threshold" for a period longer than 30msec it is necessary to set the value of "duration" to 12:

30msec / 2,5msec = **12**

THRESHOLD

Since the accelerometer can be programmed with 4 different full scale values (2g, 4g, 8g and 16g) and the threshold value is 128-level, the step of resolution is calculated by dividing the full scale value for 128:

- *2g* → 2000mg / 128 = **15,625** mg
- *4g* → 4000mg / 128 = **31,25** mg
- *8g* → 8000mg / 128 = **62,5** mg
- *16g* → 16000mg / 128 = **125** mg

Ex. To get an alarm by an acceleration exceeding the "threshold" of 2g with a full scale of 4g:

2000 mg / (resolution of 4g) = level → 2000 mg / 31,25mg = **64** *(decimal)*

The *"Red"* LED of the transmitter is switched on at each "interrupt" event. This can be associated or not to the sending of an alarm packet on RS-485 bus.

INTERRUPT ON RS-485

NB. In order to have the alarms propagation on the bus, it is necessary to enable one of the following management interrupt:

- interrupt enabled only on RS-485
- interrupt enabled on RS-485 and ANALOGUE

(make reference to the RS-485 commands list)

NB. Take into account that, if the system was configured with too low alarm values, these values would be generated on a continuous basis up to saturate the RS-485 bus.

Ex. *Alarm packet on RS-485* → ***0x40 0x00 0x3C*** *(ACK + NODO + 0x3C)*

Each alarm on RS-485 bus generates a packet consisting of an **ACK** followed by the **NODE** number of the sensor and the byte **0x3C** (= alarm).

INTERRUPT WITH ANALOGUE OUTPUT

The analogue output of the sensor has 3 different functioning modalities:

- NORMAL
- TOGGLING
- IMPULSE

In the TOGGLING and IMPULSE mode, the analog output does not show the trend of vibration and it operates only with the minimum and maximum level of its configuration.

Ex. Output configured *in VOLTAGE 0..10 V:*

- minimum → 0 V
- maximum → 10 V

NB. In order to have the alarms propagation on the analogue output it is necessary, first of all, to choose the desired behaviour (TOGGLING or IMPULSE) and then enable one of the following interrupt management:

- interrupt enabled only on ANALOGUE
- interrupt enabled on RS-485 and ANALOGUE

(make reference to the RS-485 commands list)

NORMAL

The analog output does not propagate any alarm and it follows the standard trend of the acceleration both if the interrupt on analogue is enabled or not.

TOGGLING

Any acceleration that exceeds the value of "threshold" and "duration", causes the alarm condition and therefore, the output state is alternately switched between a "minimum" and a "maximum" value.

IMPULSE

In this behavior, the analog output is always on the "minimum" value. Each excess of the "threshold" and "duration" value, the output is switched to the "maximum" and maintained "high" for at least 5msec and then back to the "minimum".

NB. This behavior limits the frequency of alarm acknowledgment.

Ex. Two consecutive alarms with a time interval less than 5msec can't be both reported in the output.

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