

INC

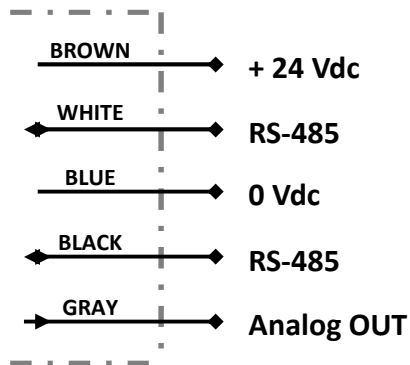
INCLINOMETER Sensor
MEMS

CAT8EIN1572901 - Created: 23/06/2016

GENERAL DESCRIPTION

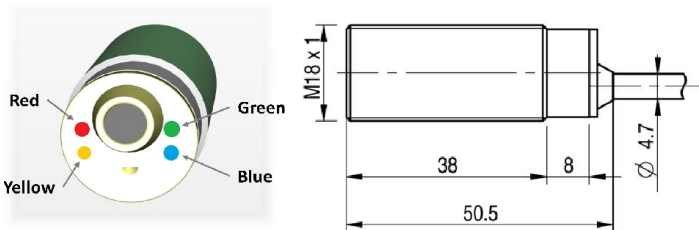
Sensor based on MEMS technology (*Micro Electro-Mechanical Systems*) to monitor tilt.

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
- “Red” LED indicates the state of the alarm condition:
 - LED ON → the angle is greater or less than the thresholds set for the analogue output
 - LED OFF → the angle is included in the thresholds set for the analogue output

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	360 °
Angular Resolution	0,025 ° @ RS-485
Number of Measured Axis	1
Response Time	< 3 msec
Technology	MEMS (<i>Micro Electro-Mechanical Systems</i>)
Digital output	RS-485 (to be addressed) 57600 Baud rate - 1 bit stop - no parity
Digital Resolution MEMS	14 bit
Digital Resolution Analogue Output	12 bit
Voltage Analogue Output	0..5 V / 0..10 V (<i>programmable</i>)
Current Analogue Output	4..20 mA / 0..20 mA / 0..24 mA (<i>programmable</i>)
Load Resistance (voltage)	1k .. 1M Ohm
Load Resistance (current)	100 .. 500 Ohm
Humidity	< 80 % without condensation
Temperature Range	-25° C ... + 70° C
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	Cavo 5 poli Pig Tail M12 5 poli
Housing Shape	M18
Weight	105 gr. (<i>cable version</i>)

AXES POSITION



The reference axis of the inclinometer is arranged along the axis of the arrow as shown in the picture.

ADJUSTMENT

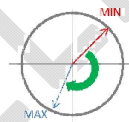
FUNCTIONING

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

The sensor has a digital resolution of 14 bit (available only on RS-485) and each DIGIT corresponds to an angular value of 0,025°. The minimum value is 0 and the maximum value is 14399 (decimal).

Ex. Angle: 0° a 359,975° → DIGIT: 0 a 14399 (decimal)

The analogue output is always referred to the angle subtended between the parameters of " Minimum Angle " and "Maximum Angle”:



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

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.

It is recommended to always make the offset calibration of the sensor to set the relative zero and standardize the measurements.

After configuration, to keep in memory the parameters, it is always needed to send the save command.

STANDARD CONFIGURATION

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

- Node number (0)
- Analogue Output (VOLTAGE with scale 0..10V)
- Behaviour (NORMAL)
- Minimum Angle (0 → 0 °)
- Maximum Angle (14399 → 359,975 °)
- Offset Angle (0 → 0 °)
- Analogue Output Direction (NORMAL)

GENERAL WARNINGS

Make sure the power supply is properly stabilized.

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	0x72 h	node n°	command	0x65 h

- Byte 1 → Start (0x23)
- Byte 2 → Start (0x72)
- 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	0x72 h	node n°	command	data 1	data 0	Checksum	0x65 h

- Byte 1 → Start (0x23)
- Byte 2 → Start (0x72)
- 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 + 0x72 + 0x80 + 0x50 + 0x00 + 0x01 = 0x166 → 0x66

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 0x72 0x00 0x28 0x65 → 0x40 0x28 (ACK)

CE




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

Declaration of conformity

M.D. Micro Detectors S.p.A. con Unico Socio declare under our 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 0x72 0x80 0x70 0x00 0x01 0x86 0x65 → **0x40 0x70** (ACK)

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

- **(0x36)** SET of the MINIMUM angle value (0..14399)
- **(0x37)** SET of the MAXIMUM angle value (0..14399)
- **(0x38)** SET of the OFFSET value (0..14399)

NB. The angular value may change only in the range “**0..14399**” (decimal). Otherwise, the command is not executed.

Both the minimum and the maximum angle refer to the angular value already compensated with the offset.

The offset value is referred to the absolute angle read by the sensor.

Ex. SET of the maximum angle to the value of 100,225°:

0x23 0x72 0x80 0x37 0x0F 0xA9 0x04 0x65 → **0x40 0x38** (ACK)

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

It is not allowed to assign the same angular value both at the minimum and the maximum. Otherwise, the command is not executed.

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*)
- **(0x4F)** GET MEMS (*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..10 V
- **(0x81)** SET of the voltage analogue output with scale 0..5 V
- **(0x82)** SET of the current analogue output with scale 4..20 mA
- **(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 ALARM behaviour

- **(0x28)** ECHO command

- **(0x90)** SET analogue output on angle +/- 30°
- **(0x91)** SET analogue output on angle +/- 45°
- **(0x92)** SET analogue output on angle +/- 90°
- **(0x93)** SET analogue output on angle +/- 120°
- **(0x97)** SET analogue output on angle 360°
- **(0x98)** SET MINIMUM angle analogue output
- **(0x99)** SET MAXIMUM angle analogue output
- **(0x9A)** SET OFFSET angle (compared to the absolute angle)

The SET commands act on the current angular value read by the sensor.

For commands referred to a fixed angular values: **30, 45, 90, 120 e 360**, the minimum angle and the maximum angle (necessary for the scaling of the analogue output), are automatically calculated by the sensor in the range of the read angle.

Ex. SET +/- 30° with a read angle from the sensor of **22,5 °**

Min → 22,5 ° - 30 ° = -7,5 ° = 360 ° - 7,5 ° = **352,5 °**
Max → 22,5 ° + 30 ° = **52,5 °**

- **(0x31)** GET MINIMUM angle value analogue output
- **(0x32)** GET MAXIMUM angle value analogue output
- **(0x33)** GET OFFSET angle value (compared to the absolute angle)
- **(0x57)** GET ABSOLUTE CURRENT angular value
- **(0x51)** GET CURRENT angular value (offset included)

The GET commands respond with an ACK followed by 2 bytes containing the angular value:

Ex. GET MINIMUM ANGLE → **0x40 0x00 0x00** (Min = 0°)
GET MAXIMUM ANGLE → **0x40 0x0E 0x10** (Max = 90°)
GET OFFSET ANGLE → **0x40 0x06 0xC1** (Offset = 43,225°)
GET CURRENT ANGLE → **0x40 0x2A 0x7D** (Angle = 271,925°)

- **(0x50)** GET CONTINUOUS of angular values (offset included)
- **(0x55)** GET BURST of 1000 data of angular values

NB. The "CONTINUOUS" command stops bidirectional communication with the sensor and it saturates the RS-485 bus with the angular data at the maximum response frequency of the sensor (about 330Hz). To restore communication it is needed to turn off and on the sensor.

- **(0x4B)** GET typology of the analogue output:

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

0x06 → Chip Assente

- **(0x4C)** GET typology of behaviour:

0x00 → NORMAL
0x00 → ALARM

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

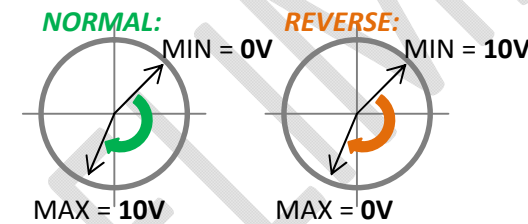
Ex. GET ANALOGUE TYPE → **0x40 0x02** (= Voltage with scale 0..10 V)

- **(0x52)** SET analogue output NORMAL
- **(0x53)** SET analogue output REVERSED
- **(0x54)** GET analogue output direction

When the sensor is configured with the direction of the analogue output in NORMAL mode, the minimum angular value is associated to the minimum of the analogue output and the maximum angular value is associated to the maximum of the analogue output.

In REVERSE mode, the sensor associates to the minimum angle the maximum value of the analogue output and viceversa.

Ex. Ramp direction with voltage output 0..10V:



The GET direction command (0x54) responds with an ACK followed by 1 byte containing the requested value:

0x00 → NORMAL Direction
0x01 → REVERSE Direction

- **(0x58)** GET angle value with AVERAGE
- **(0x60)** GET angle value with NODE NUMBER
- **(0x61)** GET angle value with AVERAGE and NODE NUMBER

The GET commands with NODE respond with an ACK followed by 3 byte containing the requested value and for the last, the node number:

Es. GET CURRENT ANGLE + NODE → **0x40 0x2A 0x7D 0x00** (Node 0)

The averages are implemented with an algorithm of “floating window average” on 512 samples.

ALARM WITH ANALOGUE OUTPUT

The analogue output of the sensor has two different functioning modalities (behaviour):

- NORMAL
- ALARM

In NORMAL behaviour, the analogue output shows, in a linear manner, the information related to the angular position included between "minimum angle" and "maximum angle".

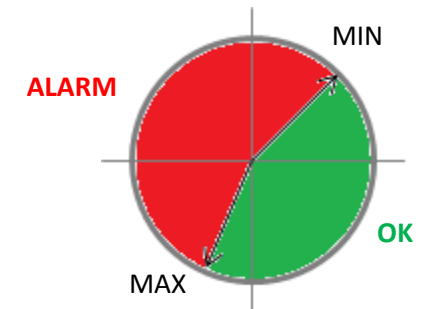
In ALARM behaviour, the analogue output operates only with the minimum and the maximum levels of its configuration.

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

- minimum → 0 V
- maximum → 10 V

When the angle read by the sensor is within the range "minimum angle" and "maximum angle", the state of the analogue output is low.

When the angle read by the sensor is above or below the range between "minimum angle" and "maximum angle", the state of the analogue output is high (= alarm condition).



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