OVERDIGIT

compact I/O modules

EX08AI

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- ☑ I/O interface - remotable on RS485 fieldbus
- ☑ 8 analog inputs, 16 bits, isolated and configurable
- ☑ Voltage reading from µV range up to ±50V
- ☑ Current reading from µA range up to ±24mA
- ☑ Direct resistance reading up to 130kΩ
- ☑ Thermocouples with internal / ext. compensation
- ☑ RTD thermal resistances, 2 / 3 wires connection
- ☑ No channels are lost in 3 wires connection
- ☑ Direct temperature reading with NTC sensors
- ☑ 12 bits channel with internal temperature sensor
- ☑ RS485 serial port with high speed (1Mb/s max)
- ☑ Modbus RTU protocol, configurable over RS485
- ☑ CoDeSys libraries for configuration and use
- ☑ PC tool for configuring and testing modules
- ☑ Compact dimension on 17.5mm of DIN rail

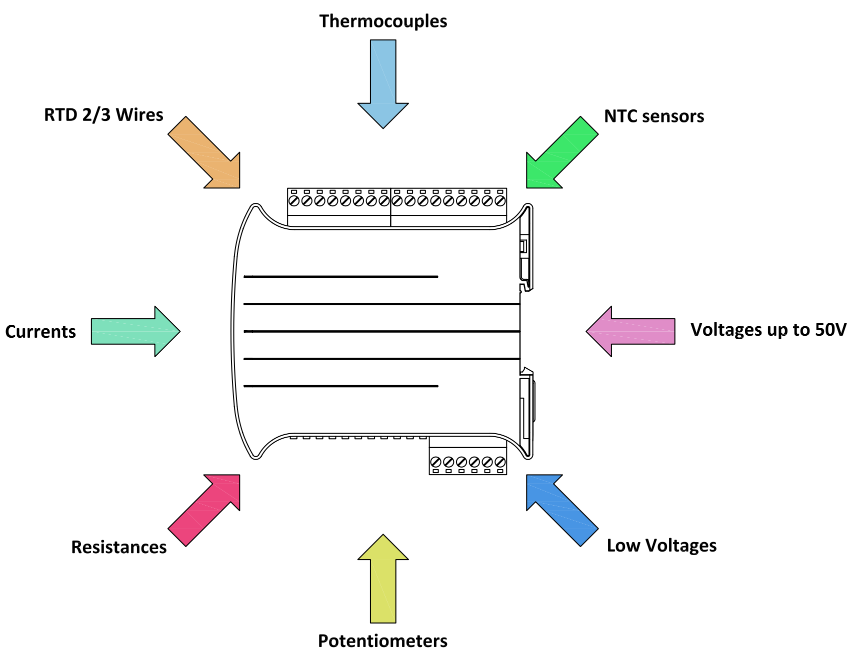
Compact module with 8 universal analog inputs, Modbus RTU protocol

The EX08AI module is an innovative product that can satisfy all the needs of the analog acquisition thanks to the 8 analog input channels arbitrarily configurable by the user on a wide overview of different measurement scales and sensors.

Finally, with a single module, all systems and plants can be realized in an optimized and flexible way, avoiding the purchase and management of many products different by type, number and performance of the input channels.

Remotable on RS485 fieldbus, the high-resolution EX08AI analog module is equivalent to 8 multimeters with 4½ digits that can measure voltage, current, resistance and temperature by sensors such as thermocouples, Pt100, Pt1000, Ni100, Ni1000 and NTC.

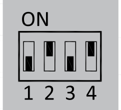
Configurable over fieldbus by IEC function block and easy integrable into "PLC Configuration" menu of CoDeSys using a configuration file. Extensions of the Modbus protocol for updating the I/O up to 1Mb/s in a single frames exchange.



CHANNELS CONFIGURATION
Single-ended voltage
±50V, ±20V, ±10V, ±5V, ±2V
Differential voltage
±1V, ±0.5V, ±0.2V, ±0.1V, ±0.05V, ±0.02V, ±0.01V
Differential current
±20mA, ±10mA, ±5mA, ±2mA, 4÷20mA, ±24mA
Differential thermocouple
E, J, K, N, R, T, S, B
RTD 2 / 3 wires thermal resistance
Pt100, Pt200, Pt500, Pt1000, Ni100, Ni1000
NTC thermal resistance
DKF103, 10K3435 (r.01.008)
Resistance
30kΩ, 3kΩ, 300Ω, 130kΩ (r.01.008)
Potentiometer
1÷100kΩ

Single-ended voltage

The single-ended voltage is the potential difference between AINx+ terminal of a channel and the common reference AGND.
In single-ended configuration AINx- terminal is internally connected to AGND terminal available as an additional connection to the reference. The potential difference between AINx+ terminal and the reference terminal can assume positive and negative values.

Single-ended voltage	Code	Dip-switch	Reading	Resolution	Precision	Note
±50V	5		±10000	0.01% fs	±0.05% fs	Input impedance > 100kΩ Input (-) connected to AGND common reference Maximum measurable voltage: ±55V (±20/50V scales) Maximum measurable value: ±32500 (all other scales) Maximum over-voltage referred to AGND: ±80V
±20V	6				±0.03% fs	
±10V	7				±0.03% fs	
±5V	8				±0.05% fs	
±2V	9				±0.08% fs	

Differential voltage

The small signals require a differential measurement with the two AINx+ and AINx- terminals connected to the signal source. In this way the measure is no longer referred to the AGND common, eliminating errors due to voltage drops on common cables. Using a shielded pair of twisted wires the interference of the noise signals on the connection is also suppressed.
Differential measurements require that each wires of the pair should not assume a voltage out of the specified range with refer to AGND. For sources not isolated from AGND is necessary to verify this specification while, for isolated sources, the inputs automatically settle within the allowed range. However, in some cases, it may be necessary to increase the internal polarization through the Dip-switch 2.

Differential voltage	Code	Dip-switch	Reading	Resolution	Precision	Note
±1V	10		±20000	0.005% fs	±0.01% fs	Input impedance > 5MΩ Maximum measurable voltage: ±1.25V (±1V scale) Maximum measurable value: ±32500 (all other scales) Inputs (+/-) voltage allowed from AGND: 0÷3V Maximum over-voltage referred to AGND: ±25V Maximum differential over-voltage: ±50V Dip-switch 2: input (+) is 1.2V polarized above AGND
±0.5V	11				±0.01% fs	
±0.2V	12				±0.01% fs	
±0.1V	13				±0.02% fs	
±0.05V	14				±0.01% fs	
±0.02V	15				±0.02% fs	
±0.01V	16				±0.04% fs	

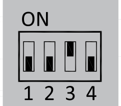
Differential current

The current is measured by the differential voltage on the shunt resistor connected internally using Dip-switch 1. While in a voltage measurement the high impedances reduce the currents flowing in the wires, in a current measurement the drop on the connections may be high, making indispensable the differential connection. However, it is also possible the single-ended configuration by connecting the AINx- terminal to the AGND common through the Dip-switch 4 (in this case only the positive currents are allowed).

Differential current	Code	Dip-switch	Reading	Resolution	Precision	Note
±20mA	20		±20000	0.005% fs	±0.01% fs	Shunt resistor: 50Ω (1.2V of maximum drop) Maximum measurable current: ±25mA (±20/24mA scales) Maximum measurable value: ±32500 (all other scales) Inputs (+/-) voltage allowed from AGND: 0÷3V Maximum over-voltage referred to AGND: ±25V Maximum differential over-current: ±80mA Dip-switch 4: optional connection of input (-) to AGND
±10mA	21				±0.01% fs	
±5mA	22				±0.01% fs	
±2mA	23				±0.02% fs	
4÷20mA	24				±0.01% fs	
±24mA	25				±0.01% fs	

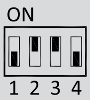
Differential thermocouple

The temperature reading on the thermocouple tip (hot junction) requires the measurement of the voltage generated by the junction and connected through the pair of wires to the module terminals. For this reason, all the considerations relating to the measurement of differential voltage must be applied. The module has an internal temperature sensor to compensate the cold junction created by the connection to its terminals while the software linearizes the measurement by calculation of polynomials with high degree.

Differential thermocouple	Code	Dip-switch	Reading	Resolution	Precision	Note
E (-200÷1000°C)	30		10 x °C	0.1°C	±0.025% fs	Input impedance > 5MΩ Inputs (+/-) voltage allowed from AGND: 0÷3V Maximum over-voltage referred to AGND: ±25V Maximum differential over-voltage: ±50V Dip-switch 2: input (+) is 1.2V polarized above AGND Cold junction compensation: internal / external / fixed Additional error with internal CJC: ±0.5°C Sensor fault signalling: short / open
J (-210÷1200°C)	31					
K (-200÷1372°C)	32					
N (-200÷1300°C)	33					
R (-50÷1768°C)	34				±0.05% fs	
T (-200÷400°C)	35					
S (-50÷1768°C)	36					
B (0÷1820°C)	37					

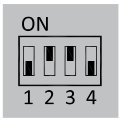
RTD 2 / 3 wires thermal resistance

The temperature of RTD sensor is obtained by the measure of its resistance and with the subsequent conversion into temperature calculating appropriate formulas and polynomials. During the resistance measurements, the module outputs a small current from AINx+ terminal and acquires the differential voltage across the two AINx+ and AINx- terminals.
RTDs with 3-wires can also be used. For this type of sensor the module eliminates the read error introduced by the connecting cables with the additional measure of their resistance. The third wire must be connected to the AGND common reference terminal. In case of more than 3-wire sensors, connect the third wire of each directly to the AGND terminal or use a common cable short and with high section.

RTD 2 wires thermal res.	Code	Dip-switch	Reading	Resolution	Precision	Note
Pt100 (-200÷850°C)	40		10 x °C	0.1°C	±0.05% fs	Input (-) connected to AGND common reference Measure current: ≈ 500µA (Pt100), ≈ 350µA (Pt1000)
Pt200 (-200÷850°C)	41				±0.04% fs	
Pt500 (-200÷850°C)	42				±0.03% fs	
Pt1000 (-200÷850°C)	43				±0.025% fs	
Ni100 (-60÷230°C)	44				±0.08% fs	
Ni1000 (-60÷230°C)	45				±0.04% fs	
RTD 3 wires thermal res.						
Pt100 (-200÷850°C)	50		10 x °C	0.1°C	±0.08% fs	Maximum line resistance for compensation: 100Ω Measure current: ≈ 500µA (Pt100), ≈ 350µA (Pt1000) Precision is measured with 10Ω line resistance
Pt200 (-200÷850°C)	51				±0.07% fs	
Pt500 (-200÷850°C)	52				±0.06% fs	
Pt1000 (-200÷850°C)	53				±0.05% fs	
Ni100 (-60÷230°C)	54				±0.16% fs	
Ni1000 (-60÷230°C)	55				±0.08% fs	

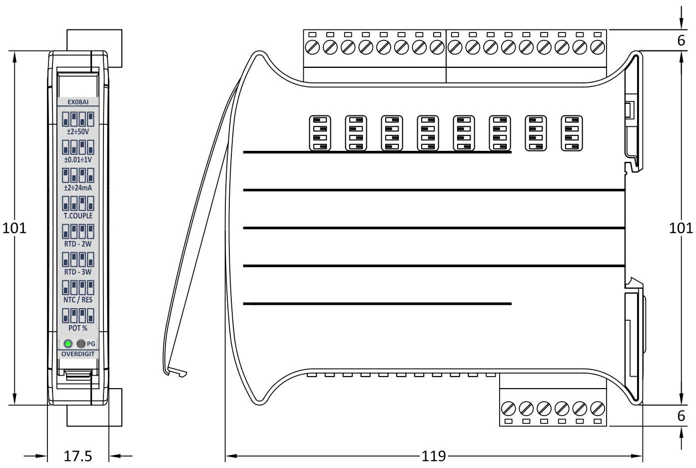
NTC thermal resistance, resistor and potentiometer

The module is able to directly measure the Ω value of resistance applied to the channel terminals. This function allows the interfacing with a wide variety of sensors where the magnitude to be measured is a function of the resistance. Knowing this relationship it's possible to implement a specific function, in the PLC software, suitable for any sensor. In particular, within the module, is already implemented the functions for the direct temperature reading of some commercial and low cost NTC sensors.
The module also allows to determine the cursor position of any potentiometer by measuring the voltage on the central terminal relative to the total voltage between extreme terminals.

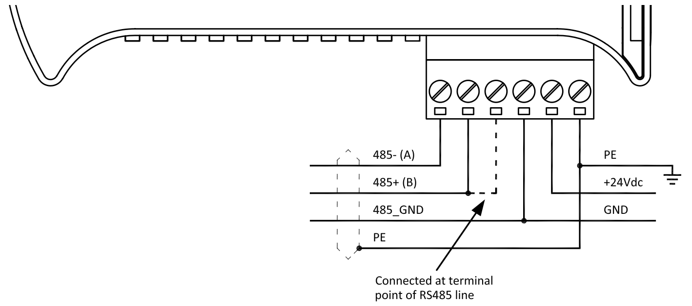
NTC thermal resistance	Code	Dip-switch	Reading	Resolution	Precision	Note
DKF103 (-10÷155°C)	60		10 x °C	0.1°C	±0.05% fs	Input (-) connected to AGND common reference 10K3435: 10kΩ at 25°C with B=3435 (requires r.01.008)
10K3435 (-25÷125°C)	61		10 x °C	0.1°C	±0.05% fs	
Resistor						
30kΩ	70		0÷30000	0.0033% fs	±0.03% fs	Input (-) connected to AGND common reference Measure current: 38÷520µA 130kΩ scale: R=2x(Reading+32500) (requires r.01.008)
3kΩ	71				±0.01% fs	
300Ω	72				±0.03% fs	
130kΩ	73		±32500	0.0016% fs	±0.05% fs	
Potentiometer						
1÷100kΩ (*)	80		0÷10000	0.01%	±0.05% fs	(*) potentiometer nominal value - max resistance Reading: percentage of cursor position

GENERAL SPECIFICATION			
Analog inputs	8 differential channels, 3V max from AGND	**Fieldbus**	RS485 with EMI filter, thermal prot. / ESD 15kV
Max over-voltage	±80V (single-ended V), ±25V (other scales)	Max nodes / Termin.	64 / insertable 120Ω load
Isolation	1500Vac max (from bus and power supply)	Baudrate	300b/s ÷ 1Mb/s (continuosly prog.)
Samples resolution	16 bits (from 2x Sigma-Delta 24 bits ADC)	Protocol	Modbus RTU, address 1 ÷ 247, parity N/O/E
Samples mean	62.5ms steps programmable (N = 1÷255)	Function codes	3, 4, 6, 16, 17, 23, 100, 101, 102, 109, 110
Acquisition time	62.5ms min (2 channels), 250ms (8 channels)	Max performance	Complete I/O update within 700µs (@ 1Mb/s)
Errors signalling	Underflow / Overflow / sensor fault	**Power supply**	24Vdc ±15% / 60mA max
Thermal drift	50 ppm/°C	Operative temp.	-20°C to 70°C
Temperature sensor	Internal NTC placed near input terminals	Connections	Plug-in screw terminals 28÷12AWG / 2.5mm^2
Conversion	12 bits ADC (indipendent from 8 channels)	Box	ABS with 35mm DIN rail mount / IP20
Temperature reading	-20°C to 80°C, 0.1°C resolution, ±0.5°C error	Max dimensions	113 x 17.5 x 119 mm (H x W x D)

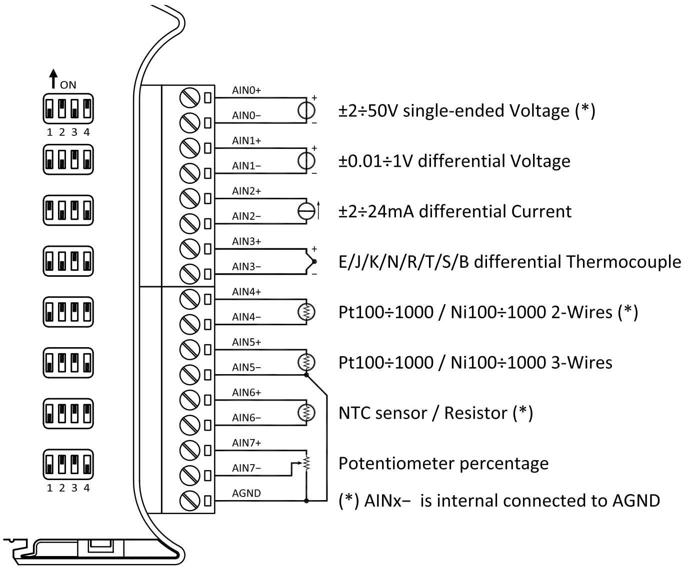
Dimensions



Power supply and RS485 fieldbus



Analog inputs



Module configuration

To configure the Modbus communication parameters, refer to the **"EX_Modules-Configuration_IT.pdf"** document containing general and common information on the EX series.

The configuration of the type and scale of each of the 8 analog channels requires the setting of the **4 Dip Switches** and the channel **numerical coding** on the relative Holding Register.
The code can be written (even once because the value is stored permanently in the module) with the **Modbus-Tool** software or by integrating in the PLC application the necessary calls to the Modbus functions. There is also a **CoDeSys program** for configuring and testing the module with graphical visualization interface (EX08AI_Configurator).

The DIP-switches position and the codes for all types of input and scale are shown in the tables above. The **code 0 disables** the channel in order to reduce the total time of acquisition.
The module is made by using two separate and parallel **24 bits Sigma-Delta** converters filtered and decimated to obtain 16 bits samples every 62.5ms. The input channels **0÷3** and channels **4÷7** form **two groups** managed separately by the respective converters thus reducing the total acquisition time.

The update of the value of each enabled channel occurs after a further filtering obtained by arithmetic average of **N samples** of the converter. For this reason, a new reading of a channel is available every:

Acquisition time = 62.5ms x N x (active channels of the group)

A specific number N of averages (in the range **1÷255**) can be set differently for each channel by adding the **256*N** value to the configuration Holding Register. If nothing is added (N = 0) it is considered the **default (N=4)** value.
With small values of N the reading is updated more frequently, but the value may be subject to fluctuations, while higher values will increase the stability and accuracy at the cost of speed.
To get the best speed performance it is recommended to split the signals appropriately on the two groups. For example, the signals for which the speed is not a strict requirement, like the temperatures, can be compacted in the same group, leaving in the other group, the minimum number of inputs that must be acquired in less time as the voltages.

The **code 190** disables the channel but inserts a dummy delay of 62.5ms (sampling time) to maintain a fixed time of acquisition in the case of dynamic modification of channels activation.

Modbus data model

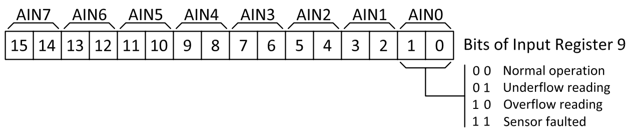
The resources available in the module are mapped to Modbus data areas using the following format:

Address	Fun. codes	Description
Input Registers		
0 ÷ 7	4	Input words AIN0 ÷ AIN7
8	4	Internal temperature on terminals (x 0.1°C)
9	4	Errors of input channels
Holding Registers		
0 ÷ 7	3, 6, 16, 23	AIN0 ÷ AIN7 configuration words
8	3, 6, 16, 23	Temp. for cold junction comp. (x 0.1°C)

To compensate the **cold-junction** of thermocouples it's necessary forcing the current value of the junction into the Holding Register with address 8. This can be either:

- Value of the sensor inside the module (copy of Input Register 8)
- Value of a remote sensor connected on other channel
- Known or fixed value (eg 0 with cold junction in ice)

The value of the Input Register with address 9 contains two flags for the **signaling error** of each of 8 input channels:



Order codes	
EX08AI	Modbus slave, 8 configurable 16 bits analog inputs

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