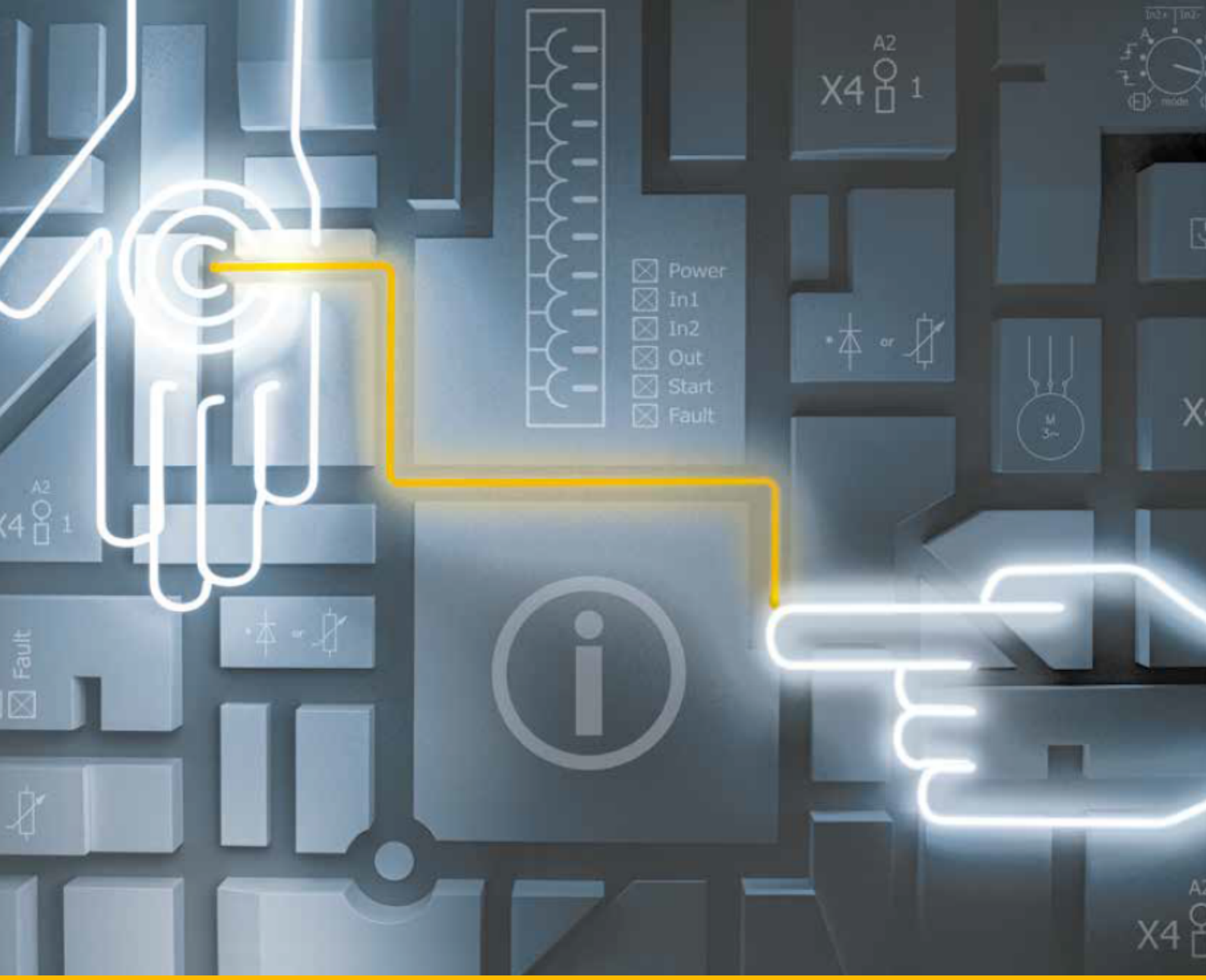


IndustrialPI AIO

PILZ
THE SPIRIT OF SAFETY

Operating Manual-1006974-EN-02
- IndustrialPI




This document is the original document.

Where unavoidable, for reasons of readability, the masculine form has been selected when formulating this document. We do assure you that all persons are regarded without discrimination and on an equal basis.

1 Introduction

1.1 Validity of documentation

This documentation is valid for the product IndustrialPI AIO. It is valid until new documentation is published.

This operating manual explains the function and operation, describes the installation and provides guidelines on how to connect the product.

1.2 Using the documentation

This document is intended for instruction. Only install and commission the product if you have read and understood this document. The document should be retained for future reference.

1.3 Definition of symbols

Information that is particularly important is identified as follows:

DANGER!

This warning must be heeded! It warns of a hazardous situation that poses an immediate threat of serious injury and death and indicates preventive measures that can be taken.

WARNING!

This warning must be heeded! It warns of a hazardous situation that could lead to serious injury and death and indicates preventive measures that can be taken.

CAUTION!

This refers to a hazard that can lead to a less serious or minor injury plus material damage, and also provides information on preventive measures that can be taken.

NOTICE

This describes a situation in which the product or devices could be damaged and also provides information on preventive measures that can be taken. It also highlights areas within the text that are of particular importance.

INFORMATION

This gives advice on applications and provides information on special features.

1.4 Symbols used on the product

	Functional earth (FE)

2 Overview

You can use this expansion module to connect analogue sensors, actuators and temperature sensors to your IndustrialPI system.

2.1 Product features

- Expansion module for the IndustrialPI 4
- 4 analogue inputs for current or voltage
- 2 analogue outputs for current or voltage
- 2 RTD channels for temperature sensors Pt100 or Pt1000
- Various output voltage ranges and output current ranges can be configured.

3 Safety

3.1 Intended use

IndustrialPI AIO is an analogue I/O module of the automation system IndustrialPI. IndustrialPI AIO is designed for use in non-safety-related applications.

Intended use includes making the electrical installation EMC-compliant. Please refer to the guidelines stated in the "PSSuniversal Installation Manual". The module is designed for use in an industrial environment. It is not suitable for use in a domestic environment, as this can lead to interference.

The following is deemed improper use in particular:

- Any component, technical or electrical modification to the module
- Use of the module outside the areas described in this manual
- Any use of the module that is not in accordance with the technical details.

Guidelines for UL approval

UL Markings

- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

3.1.1 Third-party manufacturer licence information

The product contains open source software, whose terms of use could further limit the product's application area. It is essential to refer to the third-party manufacturer licence information "IndustrialPI_Third-party_manufacturer_license_information_-_1007005-EN-01.txt" in the /boot directory on the IndustrialPI.

3.2 Safety regulations

3.2.1 Use of qualified personnel

The products may only be assembled, installed, programmed, commissioned, operated, decommissioned and maintained by persons who are competent to do so.

A competent person is a qualified and knowledgeable person who, because of their training, experience and current professional activity, has the specialist knowledge required. In order to inspect, assess and handle products, devices, systems, plant and machinery, this person must be familiar with the state of the art and the applicable national, European and international laws, directives and standards.

It is the company's responsibility only to employ personnel who

- Are familiar with the basic regulations concerning health and safety / accident prevention,
- Have read and understood the information provided in the section entitled Safety
- Have a good knowledge of the generic and specialist standards applicable to the specific application.

3.2.2 Warranty and liability

All claims to warranty and liability will be rendered invalid if

- The product was used contrary to the purpose for which it is intended,
- Damage can be attributed to not having followed the guidelines in the manual,
- Operating personnel are not suitably qualified,
- Any type of modification has been made (e.g. exchanging components on the PCB boards, soldering work etc.).

3.2.3 Disposal

- When decommissioning, please comply with local regulations regarding the disposal of electronic devices, such as the Electrical and Electronic Equipment Act.

4 Function description

4.1 Analogue inputs

The analogue inputs can be used either as current or voltage inputs. The input range for the current and voltage values is selectable. Scaling is possible for conversion into other units or for subsequent calibration. These and other settings are carried out using the browser-based application PiCtory (see Configuration [📖 16]).

4.2 Analogue outputs

The analogue outputs can output either current or voltage. The value ranges for current and voltage are selectable. Scaling is possible for conversion into other units or for subsequent calibration of an actuator. These and other settings are carried out using the browser-based application PiCtory (see Configuration [📖 16]).

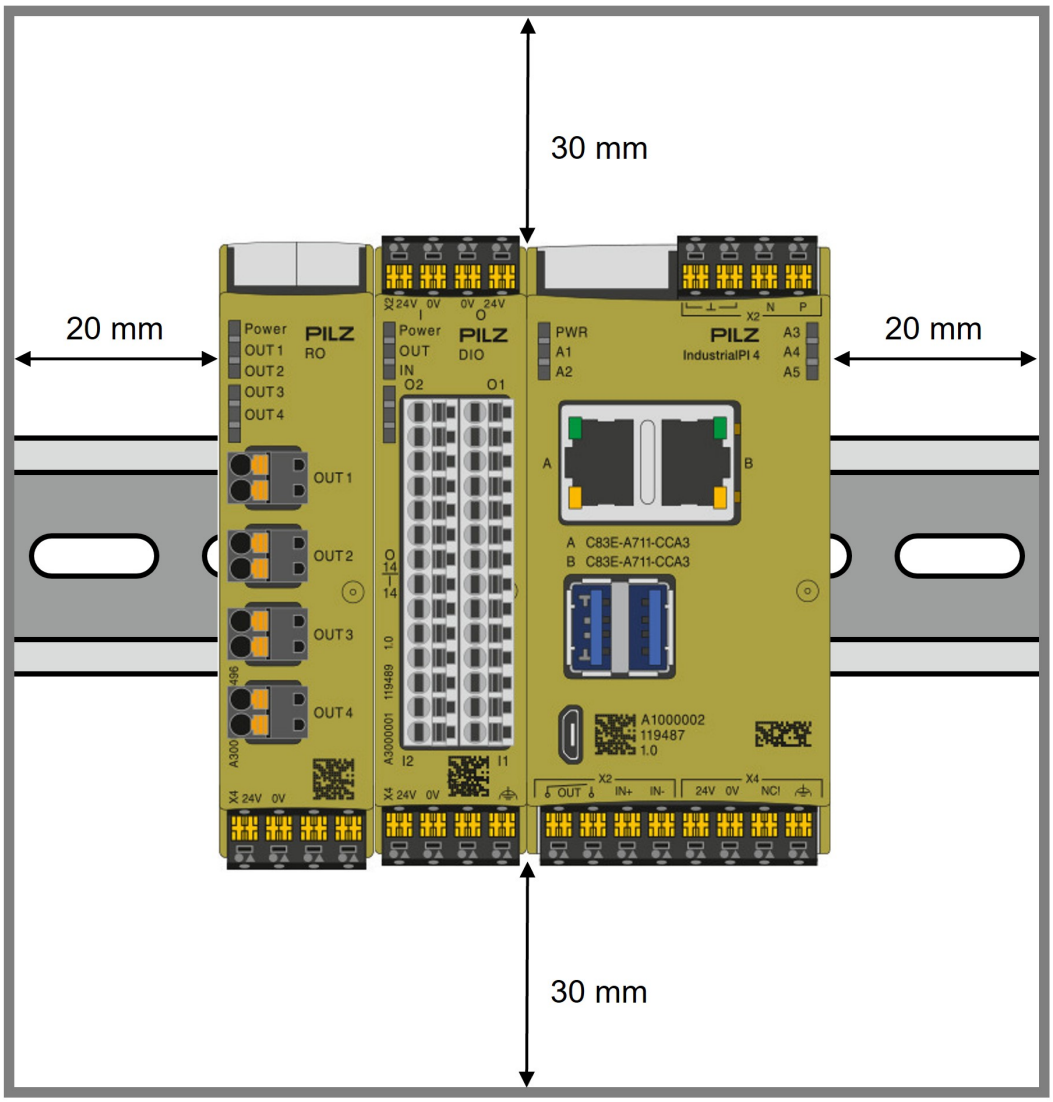
4.3 RTD channels

The RTD channels can be used for temperature measurements with Pt100 and Pt1000 sensors. The 2-wire, 3-wire or 4-wire measurement method is available. Scaling is possible for conversion into other units or for subsequent calibration of a temperature sensor. These and other settings are carried out using the browser-based application PiCtory (see Configuration [📖 16]).

5 Installation

IndustrialPI modules were developed for use in a control cabinet or housing. To operate them as intended in an industrial environment, you must observe the following:

- The protection type and protection class of the control cabinet or housing must comply with the standards provided for the intended use.
- For control cabinet installation you will need a mounting rail 35 x 7.5 mm (EN 50022).
- Install the mounting rail horizontally in the control cabinet, in accordance with the manufacturer's instructions. Only when installed horizontally is it guaranteed that air flows through the IndustrialPI modules from bottom to top, and can thereby cool the electronics (stack effect).
- Ensure that the IndustrialPI is at a sufficient distance from other products to guarantee sufficient airflow.



Procedure:

- Hold the latching element on the IndustrialPI module up to the mounting rail.
- Press the locking mechanisms towards the IndustrialPI module.

- Ensure that the IndustrialPI module is firmly connected to the mounting rail.

NOTICE

Excessive temperatures can damage the module!

Ensure that the ambient temperature in the control cabinet is less than 55 °C.

6 Wiring

The PiBridge is a backplane bus, which you can use to connect together all the modules from the IndustrialPI range.

The following expansion modules can be connected using the PiBridge:

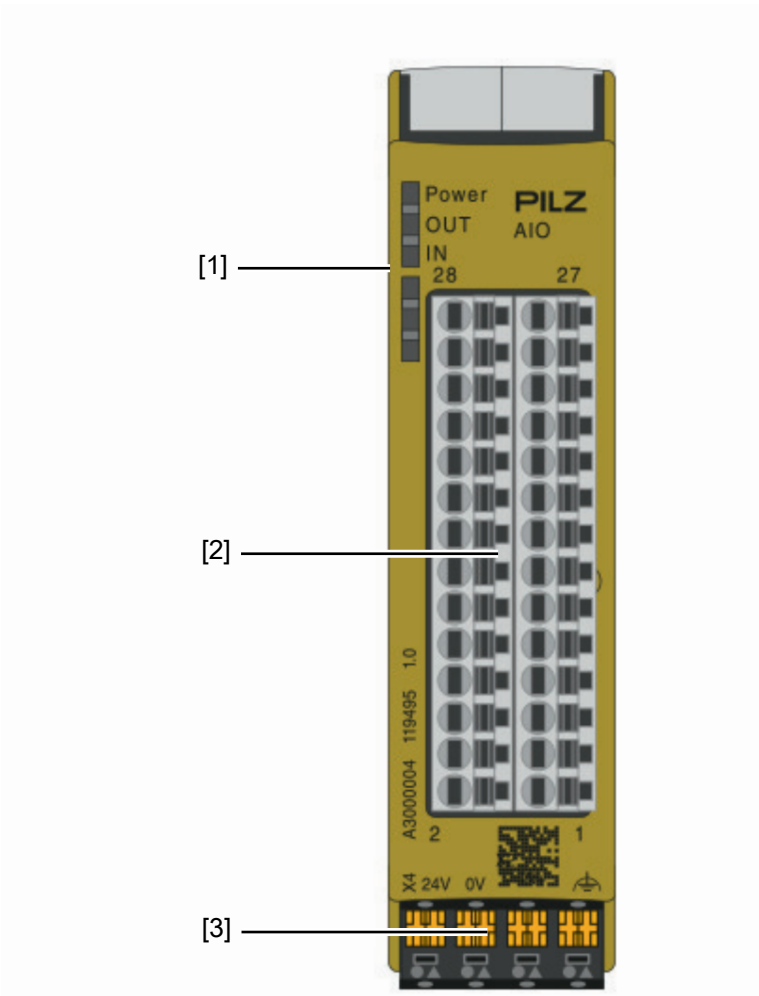
Up to ten expansion modules (e.g. our IO modules); five of these expansion modules on the left and five on the right.

Insert PiBridge, as shown [1], on to the PiBridge connections of the products you wish to connect.

Data is transmitted by signal lines from one module to the other via the PiBridge.

Use copper wiring with a temperature stability of 75 °C.

6.1 Terminal configuration



Position	Connection
1	Status LEDs The LEDs indicate whether the IndustrialPI AIO is working correctly or if a problem exists.
2	Connection for actuators and sensors Please note the pin assignment. It is very important because the connections change depending on the measurement method and signal type.
3	Mains connection

Pin assignment for connection of the actuators and sensors:

PIN	Assignment	Description	Application
1	Output 1	V+	Positive output for voltage ranges, channel 1
2	Output 2	V+	Positive output for voltage ranges, channel 2
3	Output 1	I+	Positive output for current ranges, channel 1
4	Output 2	I+	Positive output for current ranges, channel 2
5	Output 1	–	Common earth of both output channels 1 and 2 (current and voltage)
6	Output 2	–	Common earth of both output channels 1 and 2 (current and voltage)
7	Output 1	–	Common earth of both output channels 1 and 2 (current and voltage)
8	Output 2	–	Common earth of both output channels 1 and 2 (current and voltage)
9	RTD 2	White	Negative measuring current, 3 and 4-wire, with 2-wire bridge to Pin 18
10	RTD 1	White	Negative measuring current, 3 and 4-wire, with 2-wire bridge to Pin 12
11	Input4	–	Negative input for current or voltage measurement, channel 4
12	RTD 1	White	Negative measuring input, 2, 3 and 4-wire, channel 1
13	Input4	*	A jumper must be installed from here to Pin 15 for current measurements
14	RTD 1	Red	Positive measuring input, 2, 3 and 4-wire, channel 1
15	Input4	+	Positive input for current or voltage measurement, channel 4
16	RTD 1	Red	Positive measuring current, 4-wire only, channel 1
17	Input3	–	Negative input for current or voltage measurement, channel 3
18	RTD 2	White	Negative measuring input, 2, 3 and 4-wire, channel 2
19	Input3	*	A jumper must be installed from here to Pin 21 for current measurements
20	RTD 2	Red	Positive measuring input, 2, 3 and 4-wire, channel 2
21	Input3	+	Positive input for current or voltage measurement, channel 3
22	RTD 2	Red	Positive measuring current, 4-wire only, channel 2
23	Input2	–	Negative input for current or voltage measurement, channel 2

PIN	Assignment	Description	Application
24	Input1	–	Negative input for current or voltage measurement, channel 1
25	Input2	*	A jumper must be installed from here to Pin 27 for current measurements
26	Input1	*	A jumper must be installed from here to Pin 28 for current measurements
27	Input2	+	Positive input for current or voltage measurement, channel 2
28	Input1	+	Positive input for current or voltage measurement, channel 1

6.2 Supply voltage

Do not switch on the supply voltage until the modules are mounted on the top-hat rail and all the connectors are plugged in. Modules that are already connected via the PiBridge must always be supplied with voltage at the same time. Before switching on, check all the modules again to ensure the correct polarity of the power supply connections! You can operate IndustrialPI devices in a voltage range of 12 V to 24 V.

UL Markings

INFORMATION

The device may only be supplied by circuits that

comply with Class 2 or Safety Extra Low Voltage (SELV) in accordance with UL 61010-1.

7 Configuration

7.1 Configure analogue inputs

You can use PiCtory to configure your IndustrialPI AIO. This section describes the setting values of the “Value Editor” for the analogue inputs.

Prerequisites:

- You have a web browser installed on your PC (e.g. Chrome).
- IndustrialPI 4 is in your network.

Your AIO has 4 analogue inputs. These inputs can be set either as a voltage or current input. Here you can connect sensors such as proximity or level sensors with analogue outputs, for example (typically 4-24 mA or 0-10 V).

CAUTION!

The maximum common mode voltage for all 4 inputs must not exceed 45 V.

For your configuration to work, it is important that your products are connected to the correct input pins.

- Open your web browser.
- Enter the IP address of your IndustrialPI 4 in your browser's address bar.

  The login window opens.
- Log in with the user name “admin”.
- Enter your password. You'll find it on the sticker on the side of your IndustrialPI 4.
- Click on ***Login***

  You'll now see the current device status of your IndustrialPI 4.
- Click on the ***Apps*** tab.
- To open PiCtory, click on the ***Start*** button next to “PiCtory”.

  PiCtory opens.
- Open the ***I/O Devices*** folder in the Device Catalogue.
- Select the AIO.
- Drag & drop the AIO into the empty slot on the configuration board.
- Define the basic settings for your adapter under ***Device Data***.

  This entry is optional. If you are using many devices and wish to process the data later in another program, this entry may be very helpful.

You can configure the inputs in the Value Editor. You'll find the detailed setting values in the table below.

Description	Values	Comment
Input1Range, Input2Range, Input3Range, Input4Range	-10- 10 V 0 – 10 V 0 – 5 V -5 – 5 V 0 – 20 mA 0 – 24 mA 4 – 20 mA -25 – 25 mA	Set the input range for voltage or current measurement here. The measurement method (current or voltage) and range should match the output on the connected sensor. 0-10 V or 4-24 mA are typical on industrial sensors.
ADC_DataRate	5 Hz 10 Hz 20 Hz 40 Hz 80 Hz 160 Hz 320 Hz 640 Hz	Here you set the frequency that will then be used as the data rate on the analogue converter. The rate at which the values in the process image are updated is approximately 1/5 of this ADC data rate. This frequency applies to all 4 inputs.
Scaling input 1-4: Input1Multiplier Input1Divisor Input1Offset	16-bit signed multiplier 16-bit unsigned divisor 16-Bit signed offset	Here you can define a scaling for each input channel. It is determined by the three configuration values and calculated in accordance with the following formula from the original value (available in mV or µA respectively): Y = Multiplier/Divisor*X + Offset

INFORMATION

Please note that you can only ever measure either current or voltage on one channel.

When measuring current, a shunt resistor is connected between the inputs for voltage measurement via a jumper, which you must attach externally yourself. Modifying the ranges in PiCtory initially changes practically nothing in the measuring electronics, but is used only for the conversion to mV or µA and for monitoring the limit values. For the 0-5 V range only, the input sensitivity of the measuring amplifier is increased, whereby twice the accuracy is achieved in this range (maximum deviation in this range is 5 mV).

Scaling can be used for conversion into other units or for subsequent calibration of a sensor. 32-bit integer arithmetic is used for the calculation in the AIO module. However, the results are then stored again as 16-bit values in the process image. If the result Y exceeds the limits of a 16-bit signed value, the error is detected and the value is limited. The output values are always in the unit mV or µA.

Example:

A proximity sensor outputs a voltage of 0 to 10 V in the range between 30 and 300 mm. To have the distance in mm in the process image, you must select the parameters as follows:

Multiplier = 270, Divisor = 10000, Offset = 30

If the sensor works with 4-20 mA instead, you will need to set the values as follows:

Multiplier = 270, Divisor = 16000, Offset = -38

About ADC_DataRate:

The module uses a type ADS1248 delta-sigma converter. This converter has an adjustable data rate, which is closely related to the frequency curve of the digital filter contained in such a converter. Detailed diagrams for the frequency responses achieved for each setting can be found in the data sheet for the ADS1248 on pages 31 and 32. An important factor for your measurements here is that low-frequency interference signals, such as a 50 Hz mains hum for example, are only effectively suppressed at settings of 5 to 20 Hz. So you will get the greatest measurement accuracy with these settings. However, the update rate of the data values in the process image are reduced as a result. The relationship is as follows:

ADC_DataRate update rate in the PI:

5 Hz: 1 Hz

10 Hz: 2 Hz

20 Hz: 4 Hz

40 Hz: 8 Hz

80 Hz: 10 Hz

160 Hz: 25 Hz

320 Hz: max. 50 Hz

640 Hz: max. 125 Hz

Please note that the table values for the settings 320 Hz and 640 Hz represent maximum values only. The actual update rate achieved in this area can be significantly lower due to the load on the PiBridge. The load depends on your configuration and therefore the respective update rate for these ADC_DataRates can only be determined experimentally on your system and with your configuration. In general, therefore, these settings are not recommended.

▸ Click on ***File>Save***. This saves your file.

▸ Click on ***Tools>Reset Driver***. This activates the changes for the adapter.

Should an error occur, you will receive error messages in the input values of the process image named InputStatus_1-4. The values have the following meaning:

Bit position	Status message
Bit 0 (LSB)	0 = Value is higher than the lower limit of the configured range. 1 = Value is at least 20 mV or 20 µA lower than the lower limit of the configured range.
Bit 1	0 = Value is lower than the upper limit of the configured range. 1 = Value is at least 20 mV or 20 µA higher than the upper limit of the configured range.

You can now see the actual value of the input in the field InputValue_1-4. If you use the input as a voltage input, the value is stated in mV. If you use the input as a current input, the value is stated in µA.

You can define symbolic names for the 4 analogue input values in the fields Input Value 1-4. Under these names, you can then use PiTest, a self-written program or application software to read measured values for the connected sensors from the process image. The values are stated there in mV for the voltage ranges and in µA for the current ranges, if you have left the scaling at 1.

Do you want to continue using the settings in Python or C?

Then click on ***File>Export***.

A window is opened. Here you can define the file format and enter the file name.

Click ***OK***.

7.2 Configure analogue outputs

You can use PiCtory to configure your IndustrialPI AIO. This section describes in more detail the setting values of the “Value Editor” for the analogue outputs.

Prerequisites:

▸ You have a web browser installed on your PC (e.g. Chrome).

▸ IndustrialPI 4 is in your network.

Your IndustrialPI AIO has two analogue outputs. These outputs can emit either voltage or current. You can connect actuators such as frequency converters for speed control, for example.

For your configuration to work it is important that your products are connected to the correct output pins.

INFORMATION

Please note that you can only ever emit either current or voltage on one channel, although there are two separate connections.

▸ Open your web browser.

- Enter the IP address of your IndustrialPI 4 in your browser's address bar.
  The login window opens.
- Log in with the user name “admin”.
- Enter your password. You'll find it on the sticker on the side of your IndustrialPI 4.
- Click on ***Login***.
  You'll now see the current device status of your IndustrialPI 4.
- Click on the ***Apps*** tab.
- To open PiCtory, click on the ***Start*** button next to “PiCtory”.
  PiCtory opens.
- Open the ***I/O Devices*** folder in the Device Catalogue.
- Select the AIO.
- Drag and drop the AIO into the empty slot on the configuration board.
- Define the basic settings for your adapter under ***Device Data***. This entry is optional. If you are using many devices and wish to process the data later in another program, this entry may be very helpful.

You can configure the outputs in the Value Editor. You'll find the detailed setting values in the table below.

PiCtory setting	Values	Function
Output1Range, Output2Range	Off (output inactive) 0 – 5 V 0 – 10 V -5 – 5 V -10 – 10 V 0 – 5.5 V 0 – 11 V -5.5 – 5.5 V -11 – 11 V 4 – 20 mA 0 – 20 mA 0 – 24 mA	Set the value ranges for current or voltage that the outputs should emit.

PiCtory setting	Values	Function
Output1EnableSlew, Output2EnableSlew	On = Use slew rate Off = Do no use slew rate	Here you can specify whether you want to use a slew rate for the respective output. The slew rate controls the rate at which the output voltage or output current changes when you specify a new value for an output in the process image.
Output1SlewStepSize, Output1SlewStepSize	1 2 4 8 16 32 64 128	Here you can select the slew rate step size for the respective output. Step size 1 corresponds to the converter's least significant bit (LSB). Together with the step clock frequency, the step size determines the transition slew rate (of the pulse edge) between two analogue values.
Output1SlewUpdateFreq, Output1SlewUpdateFreq	258 kHz 200 kHz 154 kHz 131 kHz 116 kHz 70 kHz 38 kHz 26 kHz 20 kHz 16 kHz 10 kHz 8.3 kHz 6.9 kHz 5.5 kHz 4.2 kHz 3.3 kHz	Here you can select the step clock frequency for the slew rate of the respective output. Together with the step clock frequency, the step size determines the transition slew rate (of the pulse edge) between two analogue values.

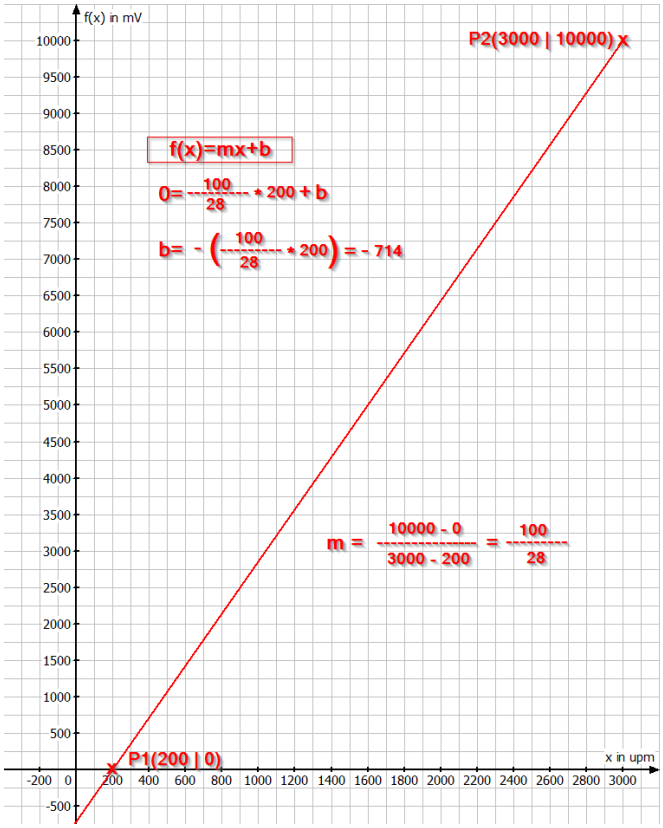
PiCtory setting	Values	Function
Scaling output 1: Output1Multiplier Output1Divisor Output1Offset **Scaling output 2:** Output2Multiplier Output2Divisor Output2Offset	16-bit signed multiplier 16-bit unsigned divisor 16-Bit signed offset	Here you can define a scaling for each output channel. It is determined by the three configuration values and calculated in accordance with the following formula from the original value (available in mV or µA respectively): Y = X*Multiplier/Divisor + Offset**X** is the value for the output. **Y** stands for the voltage supply used in millivolts.

Scaling can be used for conversion into other units or for subsequent calibration of an actuator. 32-bit integer arithmetic is used for the calculation in the AIO module. The results are then sent to the DAC as 16-bit values. If the result Y exceeds the limits of a 16-bit signed value, the error is detected and the value is limited. For a scaling factor of one, the output values must always be stored in the process image in the unit mV or µA.

Example:

A frequency converter activates an electric motor. It has an analogue input of 0 to 10 V, whereby 0 V corresponds to a motor speed of 200 rpm and 10 V to a speed of 3000 rpm. To store the speed in rpm in the process image, you must select the parameters for the output range 0-10 V as follows:

Multiplier = 100, Divisor = 28, Offset = -714



The slew rate settings mean the following:

Let's assume you have selected an output range from 0 to 10 V. The process image contains an output value of 3 V for channel 1. This value should now change to 8 V. Therefore, instead of 3000 mV, write the number 8000 at the corresponding offset in the process image. During the next PiBridge cycle, this number is then passed to the DAC (Digital to Analogue Converter), which uses it to generate the analogue voltage for the output. This takes place with a certain delay time of 10-40 ms, depending on the load on the PiBridge (which depends on the configuration). After this delay, the output voltage would jump very quickly from 3 V to 8 V. The voltage's slew rate depends only on the total capacitance at the output (which depends, among other things, on the connected devices). It should normally be a few µs. This slew rate is often undesirable because it has extremely high frequency ratios, which can lead to interference and other problems. For this reason you can artificially reduce the slew rate. To do this, switch “Output?EnableSlew” to “On”. Now, as soon as the DAC has the new data (8000), it will increase the output voltage in small steps until 8 V is reached. You can set the amplitude of the steps using “Output?SlewStepSize”. This step size is specified in the unit “LSB” (i.e. least significant bit). As our converter operates with 16-bit resolution in each output range, the step size of the least significant bit (LSB) is 10V/ 2^16 = 0.15 mV in the 0-10V range (or 0.30 µA in the 4-20 mA range). The number of steps the DAC needs depends on the voltage jump: our example has a step size of 1, so it is 5000 mV / 0.15 mV = 33,333 steps. The time in which these steps are performed is determined by the clock rate at which the steps are incorporated into the signal. You can set these using the parameter “Output?SlewClock”. With a set clock rate of 3.3 kHz, the edge needs from 5 V, i.e. 33,333* 1/3300 s = 10 s. With a setting of 258 kHz it would therefore be 130

ms. The slew rate is therefore 0.5 V/s at a clock rate of 3.3 kHz, or 38 V/s at a clock rate of 258 kHz. With larger step sizes you can drastically increase the slew rate. However, the signal will then “jump”, i.e. it will receive a much greater share of high frequency signals.

- Click on ***File>Save***. This saves the file.
- Click on ***Tools>Reset Driver.*** This activates the changes for the adapter.

Should an error occur, you will receive error messages in the input values of the process image named OutputStatus_1 and OutputStatus_2. The respective bits in the status bytes have the following meaning:

Bit position	Status message
0 (LSB)	Output module temperature error. The output module has overheated due to a prolonged overload (short circuit).
1	Current output open load error. In “Current output” mode, the connected circuit has too high impedance because the cable is disconnected, for example.
2	Output module internal CRC error. The error indicates a hardware defect or serious external interference signals.
3	Range error: the output value in the process image is outside the configured output range.
4	Reserved for internal purposes.
5	The supply voltage for the module is lower than 10.2 V.
	The outputs have been shut down.
6	The supply voltage for the module is greater than 28.8 V. The outputs have been shut down.
7 (MSB)	Timeout when connecting to the IndustrialPI 4 (e.g. due to a malfunction on the PiBridge or if the driver program PiControl is no longer running correctly on the IndustrialPI 4. The outputs have been shut down.

INFORMATION

Please note: In cases in which the outputs have been shut down for safety reasons, the outputs will not be available again until the device is restarted or the PiBridge is reset (e.g. piTest -x).

Do you want to continue using the settings in Python or C?

Then click on ***File>Export***.

A window is opened. Here you can define the file format and enter the file name.

Click ***OK***.

7.3 Configure RTD channels for temperature measurements

You can use PiCtory to configure your IndustrialPI AIO module. This section describes the setting values of the “Value Editor” for the RTD channels.

Prerequisites:

- You have a web browser installed on your PC (e.g. Chrome).
- IndustrialPI 4 is in your network.

Your AIO has 2 RTD channels. You can use these to determine the temperature of connected Pt100 and Pt1000 sensors.

For your configuration to work, it is important that your products are connected to the correct input pins.

INFORMATION

Please note that the AIO module uses the 3-wire measurement method for a 2-wire sensor. Simulate the missing 3rd wire by placing a jumper on the module between pins 10 and 12 or 9 and 18 respectively.

- Open your web browser.
- Enter the IP address of your IndustrialPI 4 in your browser's address bar.

  The login window opens.
- Log in with the user name “admin”.
- Enter your password. You'll find it on the sticker on the side of your IndustrialPI 4.
- Click on ***Login***.

  You'll now see the current device status of your IndustrialPI 4.
- Click on the ***Apps*** tab.
- To open PiCtory, click on the start button next to “PiCtory”.

  PiCtory opens.
- Open the ***I/O Devices*** folder in the Device Catalogue.
- Select the AIO module
- Drag and drop the AIO into the empty slot on the configuration board.
- Define the basic settings for your adapter under ***Device Data***. This entry is optional. If you are using many products and wish to process the data later in another program, this entry may be very helpful.

You can configure the RTD channels in the Value Editor. You'll find the detailed setting values in the table below:

Description	Values	Comment
RTD1Type, RTD2Type	Pt100 Pt1000	Set the sensor type you are using.
RTD1Wiring, RTD2Wiring	2-wire 3-wire 4-wire	Select the measurement method that's appropriate for your temperature sensor.
RTD 1 Scaling RTD1Multiplier RTD1Divisor RTD1Offset **RTD 2 Scaling** RTD2Multiplier RTD2Divisor RTD2Offset	16-bit signed multiplier 16-bit unsigned divisor 16-Bit signed offset	Here you can define a scaling for the RTD channels. It is determined by the three configuration values and calculated in accordance with the following formula from the original value (available in 1/10 °C): Y = Multiplier/Divisor*X + Offset

Scaling can be used for conversion into other units or for subsequent calibration of a temperature sensor. 32-bit integer arithmetic is used for the calculation in the AIO module. However, the results are then stored again as 16-bit values in the process image. If the result Y exceeds the limits of a 16-bit signed value, the error is detected and the value is limited.

Example:

To have the temperature in °C without decimal places in the process image, the setting must look like this:

Multiplier = 1, Divisor = 10, Offset = 0

To get the temperature in °F into the process image, the parameters must be set as follows:

Multiplier = 18, Divisor = 100, Offset = 32

For process data in °Kelvin you need these values:

Multiplier = 1, Divisor = 10, Offset = 273

- Click on ***File>Save***. This saves your file.
- Click on ***Tools>Reset Driver***. This activates the changes for the adapter.

Should an error occur, you will receive error messages in the input values of the process image named RTDStatus_1 and RTDStatus_2. The values have the following meaning:

Bit position	Meaning	Comment
Bit 0 (LSB)	0 = Temp. is higher than -200 °C, 1 = Recorded temp. is lower than -200 °C (e.g. short circuit in the sensor or cable).	If the recorded temperature is outside the range, the respective limit value is output (-200.0°C or 850.0°C) and the corresponding status bit is set.
Bit 1	0 = Temp. is lower than 850 °C, 1 = Recorded temp. is higher than 850 °C (e.g. no sensor connected or open circuit).	

You can define symbolic names for the two temperature values in the fields RTDValue_1 und RTDValue_2. Under these names, you can then use PiTest, a self-written program or application software to read measured values for the connected sensors from the process image. The values are stated there in 1/10 °C, if you have left the scaling at 1.

Do you want to continue using the settings in Python or C?

Then click on ***File>Export***.

A window is opened. Here you can define the file format and enter the file name.

Click ***OK***.

8 Operation

8.1 Display elements and messages

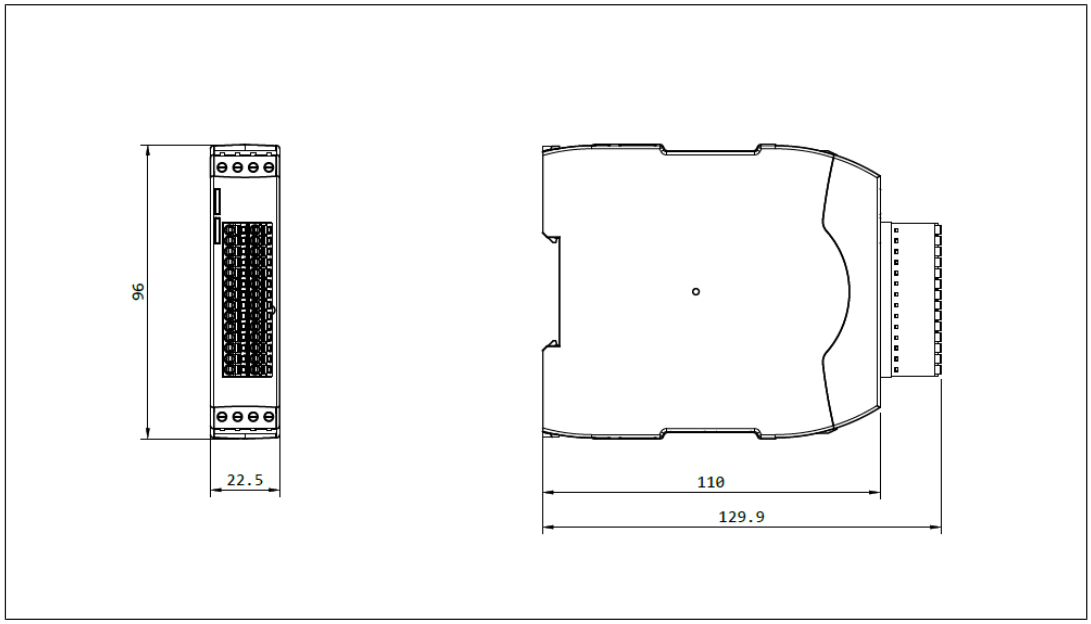
LED	Signal	Meaning
Power	On, green	The connection to IndustrialPI 4 has been established.
	Flashes, red	The connection to IndustrialPI 4 has not yet been established (initialisation phase).
	On, red	The connection to IndustrialPI 4 was interrupted. Please check that the PiBridge is inserted correctly.
Out	Off	The connection to IndustrialPI 4 has not yet been established (initialisation phase).
	On, green	Outputs are ready for operation
	Flashes, red	Range error. The values on IndustrialPI 4 are too high or too low.
	On, red	Other error. Check the output status in the process image.
In	Off	The connection to IndustrialPI 4 has not yet been established (initialisation phase).
	On, green	Inputs are ready for operation.
	Flashes, red	Range error. The voltage or current at one or more outputs is too high. Check the input status in the process image.

To accurately evaluate an error state of the IndustrialPI AIO module, your application software must evaluate the status entries in the process image. Status entries are stored there as input values by the PiControl driver. You can determine the position (offset) in the process image from the offset export in PiCtory for example, or you can query it using the symbolic names of the respective status values using the command line tool piTest. You'll find the meaning of the individual bits of the status bytes in the table below:

Bit	Cause	LED indicator	Reaction
Status messages: Analogue outputs			
Bit 0 (LSB)	Output module temperature error. The output module has overheated due to a prolonged overload (short circuit).	Red, on	–
Bit 1	Current output open load error. In “Current output” mode, the connected circuit has too high impedance because the cable is disconnected, for example.	Red, on	–

Bit	Cause	LED indicator	Reaction
Bit 2	Output module internal CRC error. The error indicates a hardware defect or serious external interference signals.	Red, on	–
Bit 3	Range error: the output value in the process image is outside the configured output range.	Red, flashes	The output is set to the maximum or minimum permitted value.
Bit 4	Reserved for internal purposes.		
Bit 5	Supply voltage of the AIO module is below 10.2 V.	Red, on	The outputs are set to 0 as safe operation cannot be guaranteed.
Bit 6	Supply voltage of the AIO module is above 28.8 V.	Red, on	The outputs are set to 0 as safe operation cannot be guaranteed.
Bit 7 (MSB)	Timeout when connecting to the IndustrialPI 4 (e.g. due to a malfunction on the PiBridge or if the driver program PiControl is no longer running correctly on the IndustrialPI 4.	Red, on	The outputs are set to 0. This is the assumed safe state, which is also present at the outputs when the AIO is started.
Status messages: Analogue inputs			
Bit 0 (MSB)	Input value is at least 24 mV or 20 µA below the configured input range	Red, flashes	–
Bit 1	Input value is at least 24 mV or 20 µA above the configured input range.	Red, flashes	–
Status messages: Temperature inputs			
Bit 0 (MSB)	Recorded temperature below -200 °C or sensor short circuit.	–	–
Bit 1	Recorded temperature above 850 °C, no sensor connected or open circuit.	–	–

9 Dimensions



10 Technical details

Standard	EN 61131-2
Housing dimensions (H x W x D)	96 x 22.5 x 110.5 mm
Housing type	Top-hat rail housing (EN 50022 for top-hat rail type)
Housing material	Plastic
Weight	Approx. 115 g
Protection type	IP20 Self Declared
Voltage supply	12 - 24 V (-15 %/+20 %)
Current consumption	Max. 200 mA at 24 V (full load) Max. 400 mA at 12 V (full load) Max. 500 mA during start-up
Permitted operating temperature	-30…+55 °C
Permitted storage temperature	-40…+85 °C
Max. relative humidity (at 40 °C)	93 % (non-condensing)
Plug-in connector	1 x 4-pin screw connector for supply voltage 24-12 AWG 1 x 8-pin spring-loaded plug-in connector (0.2 - 1.5 mm²) for IOs, 3.5 mm spacing 24-16 AWG
Voltage measuring ranges	±10 V | ±5 V | 0…10 V | 0…5 V
Current input ranges	0…20 mA | 0…24 mA | 4…20 mA | ±25 mA
Temperature input range	-200…+850 °C
Output voltage ranges	±10 V | ±11 V | ±5 V | ±5.5 V | 0…10 V | 0…11 V | 0…5 V | 0…5.5 V
Output current ranges	0…20 mA | 0…24 mA | 4…20 mA
Number of input channels	6
for voltage	Max. 4
for current	Max. 4
for RTDs (Pt100/Pt1000)	2
Number of output channels	2
for voltage	Max. 2
for current	Max. 2
Galvanic isolation	
between inputs	No
inputs towards outputs	Yes
between outputs	No
System bus towards inputs/outputs	Yes

Input type	
Voltage/current	Differential
Temperature sensor (RTD)	2, 3, 4-wire
Output type	Single-ended, common-ground, short circuit-proof
ADC type	24 Bit ΔΣ
DAC type	16 bit
Input resolution	
Process image	1 mV
Voltage / current	1 µA
Temperature	0.1 K
Output resolution process image	
Voltage	1 mV
Current	1 µA
Max. total input error (at 25 °C ambient temperature)	
Voltage (all input ranges)	±10 mV (±5 mV @ 0…5 V range)
Current (all input ranges)	±20 µA (±24 µA @ 0…24 µA range)
Temperature (full range)	±0.5 K
Max. total input error (at -30…+55 °C ambient temperature)	
Voltage (all input ranges)	±10 mV
Current (all input ranges)	±72 µA
Temperature (full range)	±1.5 K
Max. total output error (at 25 °C ambient temperature)	
Voltage (all input ranges)	±15 mV
Current (all input ranges)	±20 µA
Max. total output error (at -30…+55 °C ambient temperature)	
Voltage (all input ranges)	±15 mV
Current (all input ranges)	±72 µA
Input conversion time (data rate in the process image)	8…1000 ms (selectable)
Output data rate	1 PiBridge cycle
Output slew rate	
Selectable digital pulse edge	1 LSB@3.3 kHz to 128 LSB@258 kHz

Input impedance Voltage / current	 >900 kΩ <250 Ω
Output impedance Voltage Maximum capacitive load	 <16 Ω 5 nF @ 1 kΩ
Max. load resistance at current output	600 Ω
Min. load resistance at voltage output	1 KΩ
Further properties	All inputs and outputs can be scaled linearly Overtemperature monitoring Overcurrent monitoring Range monitoring
Optical display	3 status LEDs (2-colour)
Conformity	CE, RoHS
UL certification	UL Listed

11 Order reference

IndustrialPI AIO	Expansion module for the Industrial PI 4, 6 input channels, 2 output channels for current, voltage, RTDs, output voltage ranges: ±10 V, ±11 V, ±5 V, ± 5.5 V, 0…10 V, 0…11 V, 0…5 V, 0…5.5 V, Output current ranges: 0 … 20 mA, 0 … 24 mA, 4 … 20 mA,	A3000004

Support

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Environmental Management ISO 14001 REG. NO. 2462
Energy Management ISO 50001 REG. NO. 2462

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