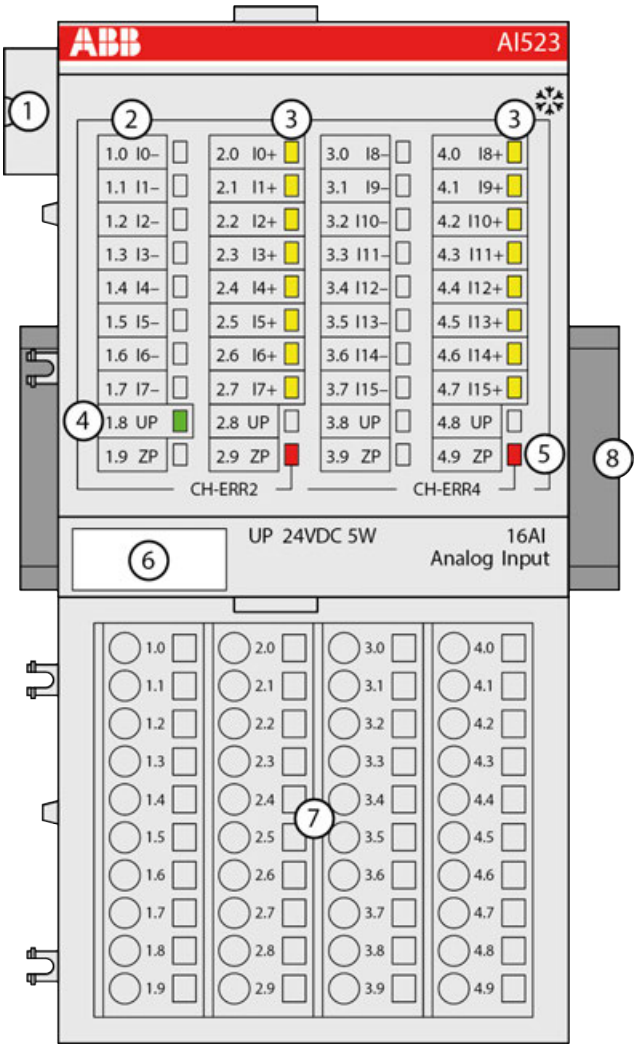
### 1.6.2.2.2 AI523 - Analog input module

- 16 configurable analog inputs (I0 ... I15) in 2 groups (1.0 ... 2.7 and 3.0 ... 4.7)
  Resolution 12 bits including sign
- Module-wise galvanically isolated
- XC version for use in extreme ambient conditions available




1 I/O bus
2 Allocation between terminal number and signal name
3 16 yellow LEDs to display the signal states at the analog inputs (I0 ... I15)
4 1 green LED to display the state of the process supply voltage UP
5 2 red LEDs to display errors
6 Label
7 Terminal unit
8 DIN rail
❄ Sign for XC version

#### Intended use

The module can be used both on an AC500 processor module and on a communication interface module.

Unless expressly intended for this purpose, the following applications are prohibited:

- Use in explosion-proof areas
- Use in environments with harmful oils, acids, gases, vapors, dusts and radiation

- Operation under water
- Not to be used as a safety module.

### Connections



*For a detailed description of the mounting, disassembly and connection of the module, please refer to the installation instructions.*

The modules are plugged on an I/O terminal unit.

↳ *TU515, TU516*

Properly position the modules and press until they lock in place. The terminal units are mounted on a DIN rail or with 2 screws plus the additional accessory for wall mounting.

↳ *Chapter 1.9.3.5 “TA526 - Wall mounting accessory” on page 1145*

The connection of the I/O channels is carried out using the 40 terminals of the I/O terminal unit. I/O modules can be replaced without re-wiring the terminal units.

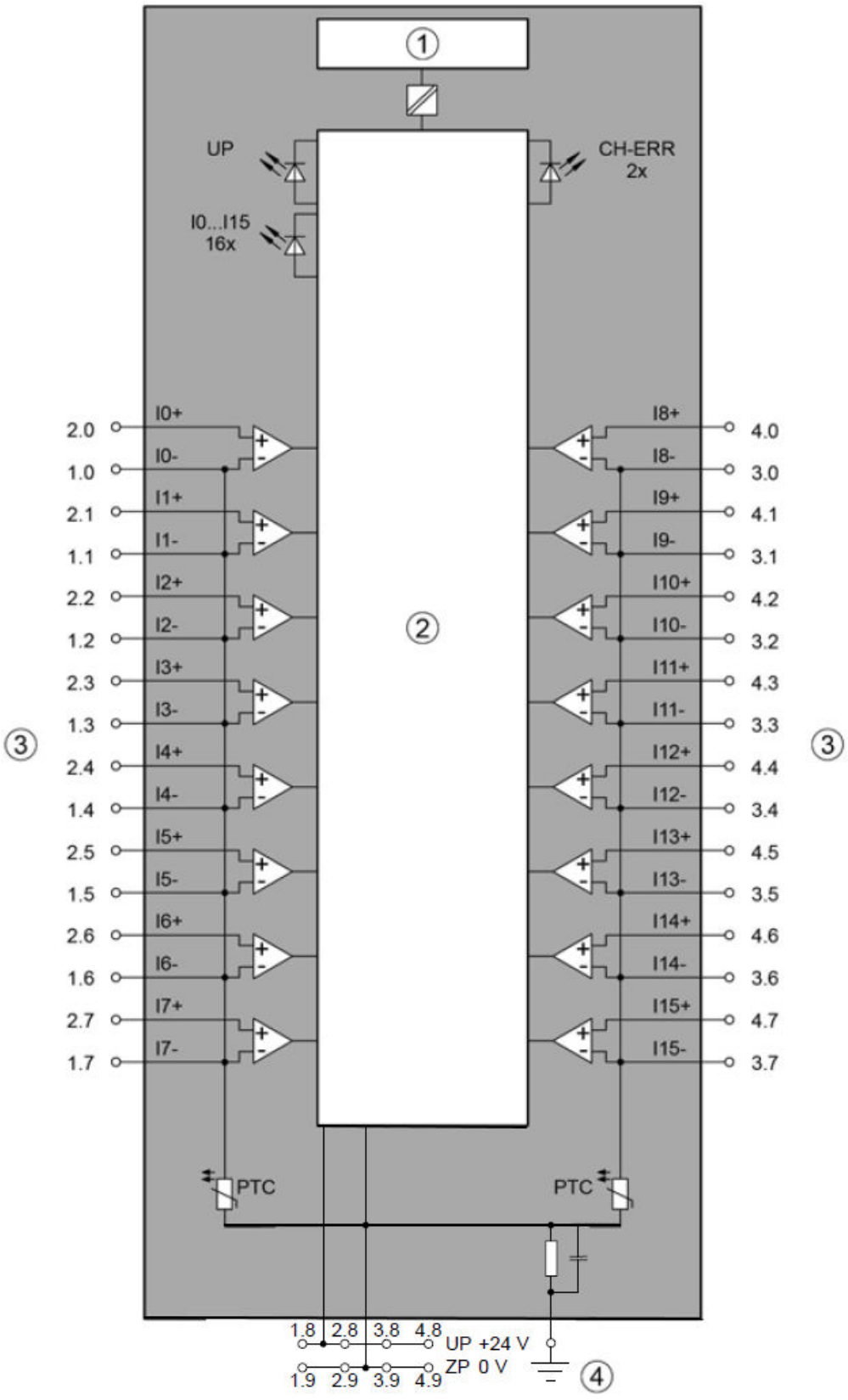
The terminals 1.8 ... 4.8 and 1.9 ... 4.9 are electrically interconnected within the I/O terminal units and have always the same assignment, independent of the inserted module:

Terminals 1.8 ... 4.8: process voltage UP = +24 V DC

Terminals 1.9 ... 4.9: process voltage ZP = 0 V



*The maximum current load capability of the terminals must be taken into account.*




1 I/O bus interface to the CPU or communication interface module
2 Internal logic and I/O circuits of the module
3 Analog outputs
4 Functional earth connection between terminal unit and DIN rail

**WARNING!**

**Removal/Insertion under power**

Removal or insertion under power is permissible only if all conditions for hot swapping are fullfilled.

*Conditions for hot swap*

*“Conditions for hot swap” on page 1152*

The devices are not designed for removal or insertion under power when the conditions for hot swap do not apply. Because of unforeseeable consequences, it is not allowed to plug in or unplug devices with the power being ON.

Make sure that all voltage sources (supply and process voltage) are switched off before doing any of the following actions:

– Connect or disconnect any signal or terminal block.
– Remove, mount or replace a module.

Disconnecting any powered devices while they are energized in a hazardous location could result in an electric arc, which could create an ignition source resulting in fire or explosion.

Prior to proceeding, make sure that power is disconnected and that the area has been thoroughly checked to ensure that flammable materials or ignitable concentrations are not present.

The devices must not be opened when in operation. The same applies to the network interfaces.

**CAUTION!**

By installing equipotential bonding conductors between the different parts of the system, it must be ensured that the potential difference between ZP and AGND never can exceed 1 V.

**CAUTION!**

The process supply voltage must be included in the grounding concept (e. g. grounding of the negative terminal).

**CAUTION!**

The potential difference between AGND and ZP at the module must not be greater than 1 V, not even in case of long lines.

**NOTICE!**

**Risk of damaging the PLC modules!**

Overvoltages and short circuits might damage the PLC modules.

– Make sure that all voltage sources (supply voltage and process supply voltage) are switched off before you begin with operations on the system.
– Never connect any voltages or signals to reserved terminals (marked with ---). Reserved terminals may carry internal voltages.

Generally, analog signals must be laid in shielded cables. The cable shields must be grounded at both sides of the cables. In order to avoid unacceptable potential differences between different parts of the installation, low resistance equipotential bonding conductors must be laid.

**NOTICE!**
All I/O channels (digital and analog) are protected against reverse polarity, reverse supply, short circuit and temporary overvoltage up to 30 V DC.

*By connecting the sensor's negative pole of the output voltage to AGND, the galvanically isolated voltage source of the sensor is referred to ZP.*

*If AGND does not get connected to ZP, the sensor current flows to ZP via the AGND line. The measuring signal is distorted, as a very small current flows through the voltage line. The total current through the PTC should not exceed 50 mA. This measuring method is therefore only suitable for short lines and small sensor currents. If there are bigger distances, the difference measuring method should be applied.*

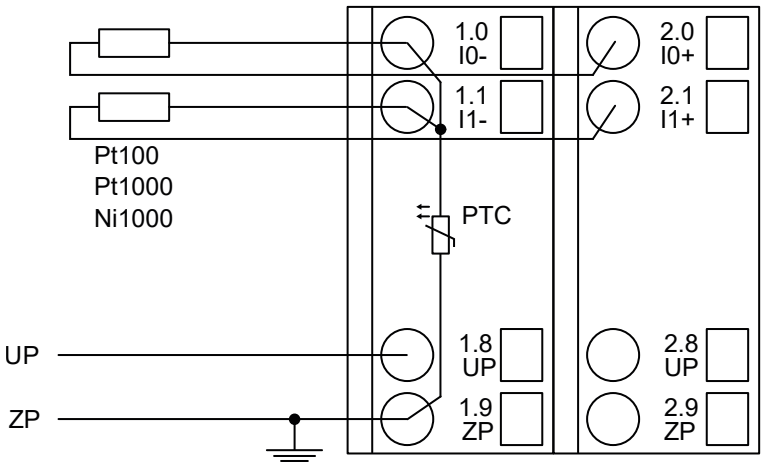
*The negative poles of the analog inputs are connected to each other to form an "Analog Ground" signal for the module.*

*Because of their common reference potential, analog current inputs cannot be circuited in series, neither within the module nor with channels of other modules.*

*For the open-circuit detection (wire break), each analog input channel is pulled up to "plus" by a high-resistance resistor. If nothing is connected, the maximum voltage will be read in then.*

**Connection of resistance thermometers in 2-wire configuration**

When resistance thermometers (Pt100, Pt1000, Ni1000) are used, a constant current must flow through them to build the necessary voltage drop for the evaluation. For this, the module AI523 provides a constant current source which is multiplexed over the 8 analog channels.

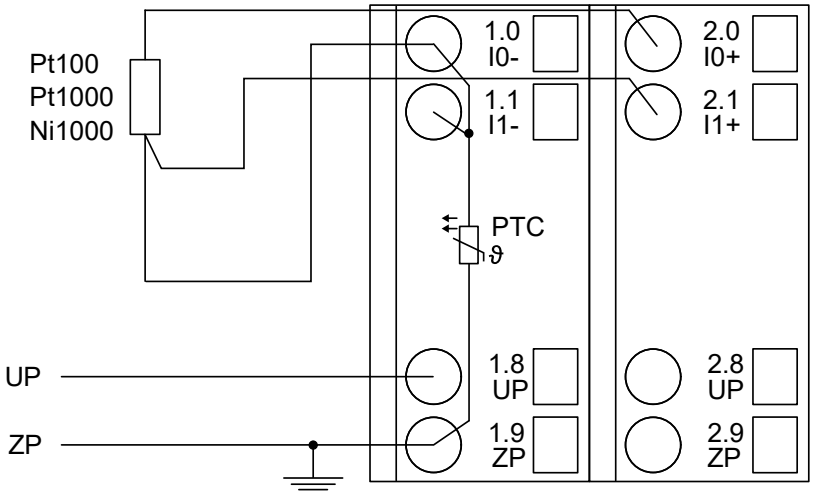



The module AI523 performs a linearization of the resistance characteristic.

In order to avoid error messages from unused analog input channels, it is useful to configure them as "unused".

### Connection of resistance thermometers in 3-wire configuration

When resistance thermometers (Pt100, Pt1000, Ni1000) are used, a constant current must flow through them to build the necessary voltage drop for the evaluation. For this, the module AI523 provides a constant current source which is multiplexed over the max. 8 (depending on the configuration) analog channels.




*If several measuring points are adjacent to each other, the return line is necessary only once. This saves wiring costs.*

With 3-wire configuration, two adjacent analog channels belong together (e.g. the channels 0 and 1). In this case, both channels are configured according to the desired operating mode. The lower address must be the even address (channel 0), the next higher address must be the odd address (channel 1).

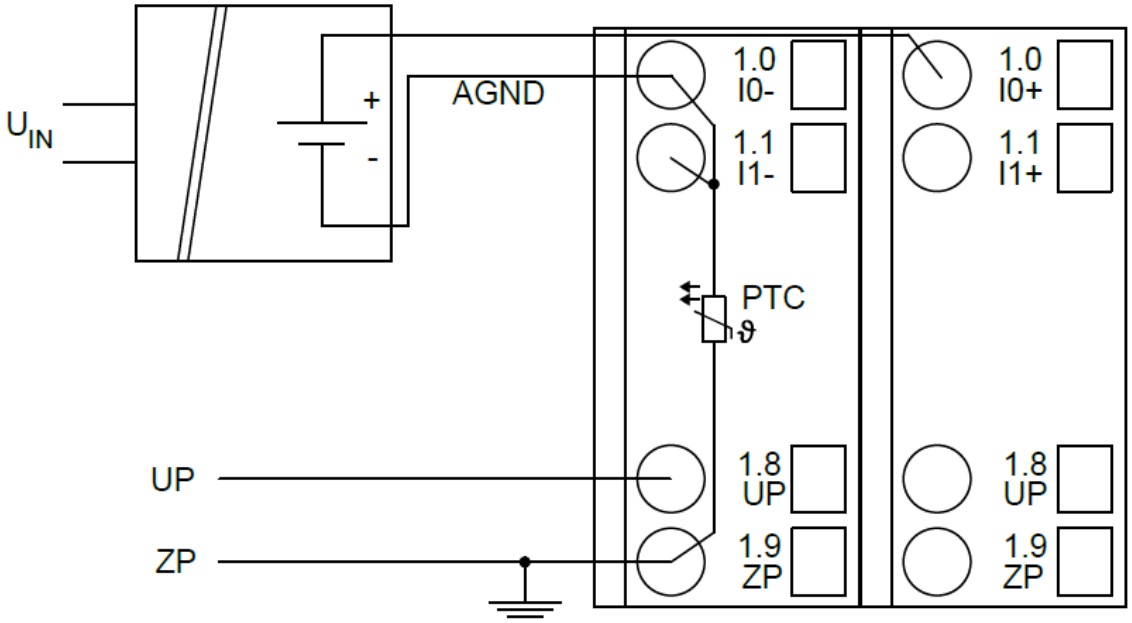
The constant current of one channel flows through the resistance thermometer. The constant current of the other channel flows through one of the cores. The module calculates the measured value from the two voltage drops and stores it under the input with the higher channel number (e.g. I1).

In order to keep measuring errors as small as possible, it is necessary to have all the involved conductors in the same cable. All the conductors must have the same cross section.

The module AI523 performs a linearization of the resistance characteristic.

In order to avoid error messages from unused analog input channels, it is useful to configure them as "unused".

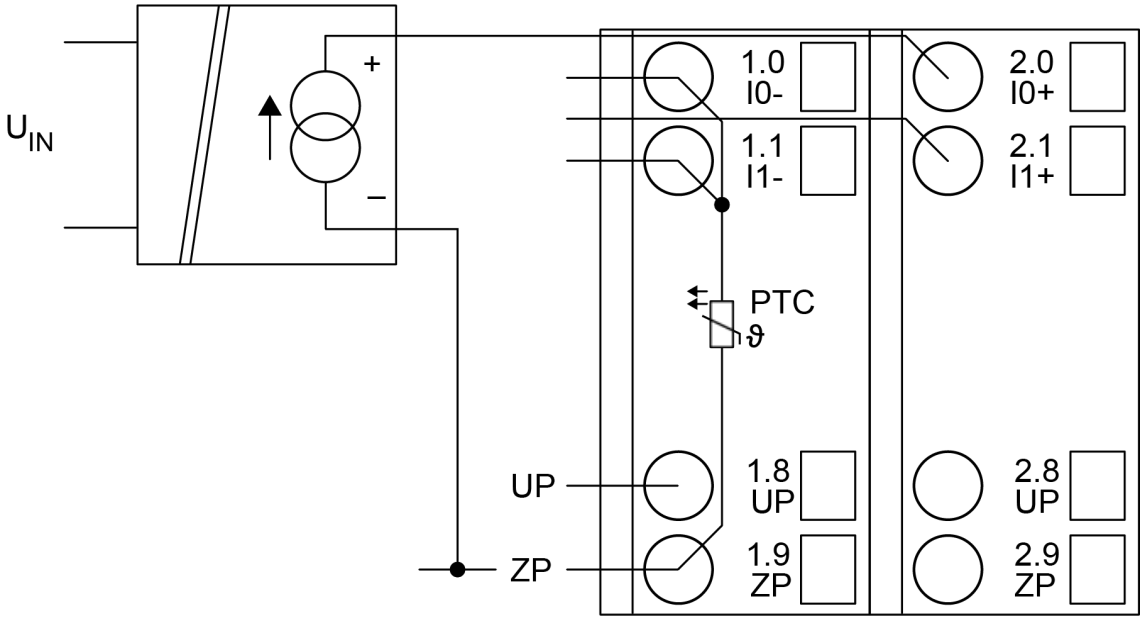
**Connection of active-type analog sensors (Voltage) with galvanically isolated power supply**




*By connecting the sensor's negative pole of the output voltage to AGND, the galvanically isolated voltage source of the sensor is referred to ZP.*

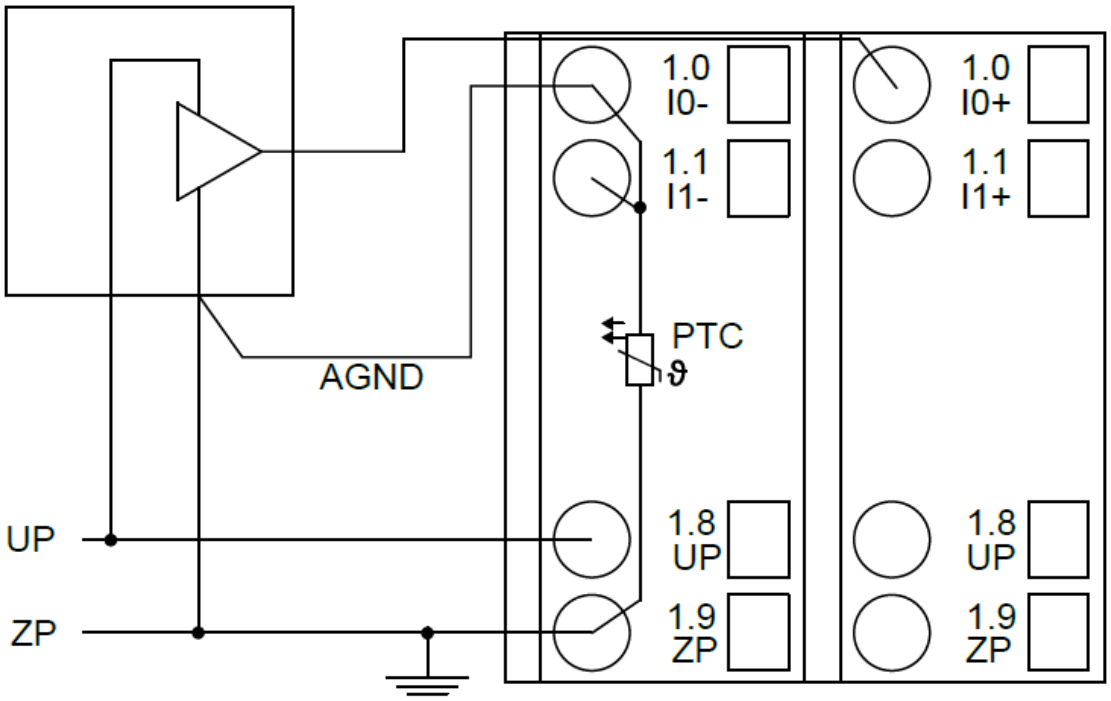
In order to avoid error messages or long processing times, it is useful to configure unused analog input channels as "unused".

**Connection of active-type analog sensors (Current) with galvanically isolated power supply**




Unused input channels can be left open-circuited, because they are of low resistance.

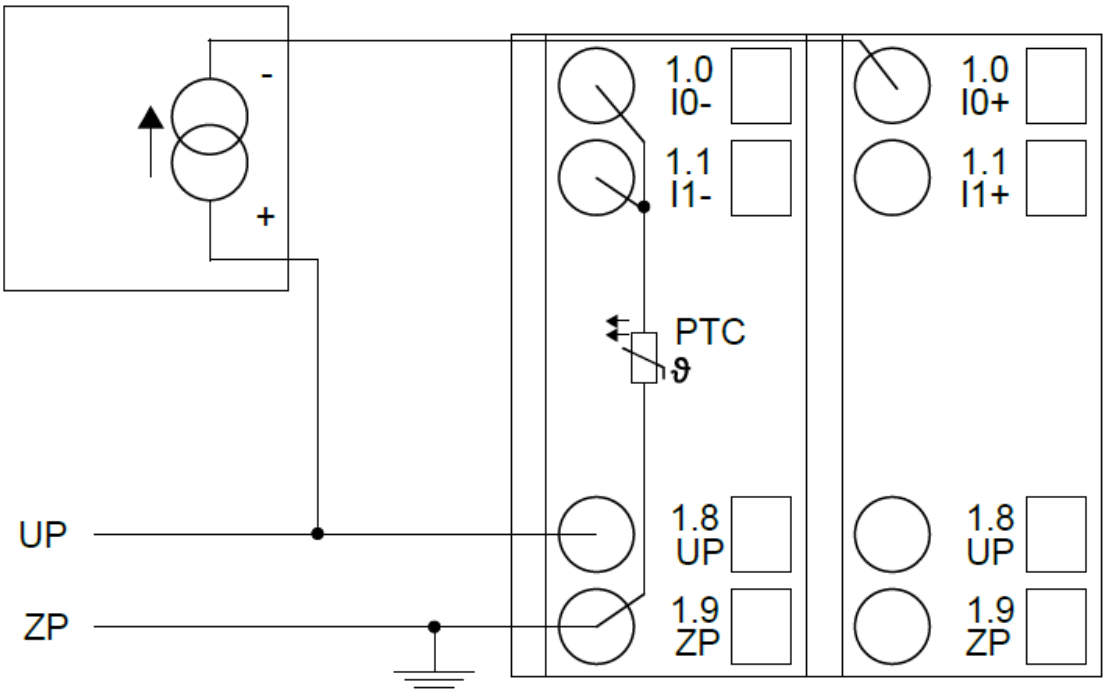
### Connection of active-type analog sensors (Voltage) with no galvanically isolated power supply




**CAUTION!**
The potential difference between AGND and ZP at the module must not be greater than 1 V, not even in case of long lines.

In order to avoid error messages or long processing times, it is useful to configure unused analog input channels as "unused".

### Connection of passive-type analog sensors (Current)



**CAUTION!**

**Risk of overloading the analog input!**

If an analog current sensor supplies more than 25 mA for more than 1 second during initialization, this input is switched off by the module (input protection).

Only use sensors with fast initialization or without current peaks higher than 25 mA. If not possible, connect a 10-volt Zener diode in parallel to I+ and ZP.

Unused input channels can be left open-circuited, because they are of low resistance.

### Connection of active-type analog sensors (Voltage) to differential inputs

Differential inputs are very useful if analog sensors which are remotely non-isolated (e.g. the negative terminal is remotely grounded) are used.

The evaluation using differential inputs helps to considerably increase the measuring accuracy and to avoid ground loops.

With differential input configurations, two adjacent analog channels belong together (e.g. the channels 0 and 1). In this case, both channels are configured according to the desired operating mode. The lower address must be the even address (channel 0), the next higher address must be the odd address (channel 1). The converted analog value is available at the higher address (channel 1).

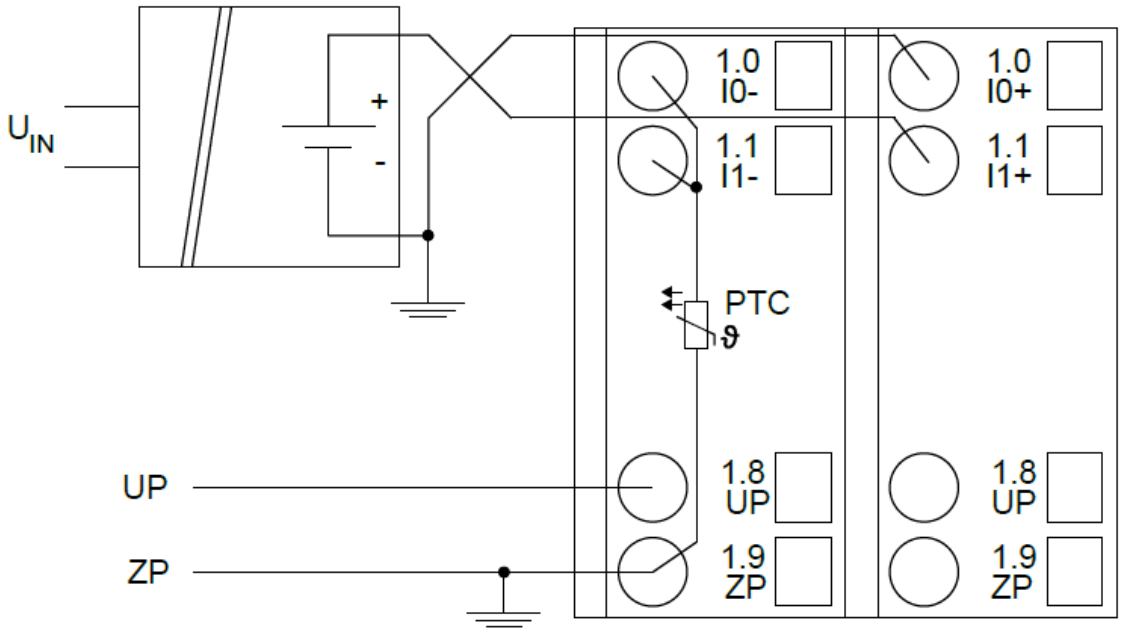
The analog value is calculated by subtraction of the input value with the higher address from the input value of the lower address.

The converted analog value is available at the odd channel (higher address).

**CAUTION!**

**Problems with the common-mode input voltages of the involved analog inputs**

The ground potential at the sensors must not have too large a potential difference with respect to ZP (max. ±1 V within the full signal range).

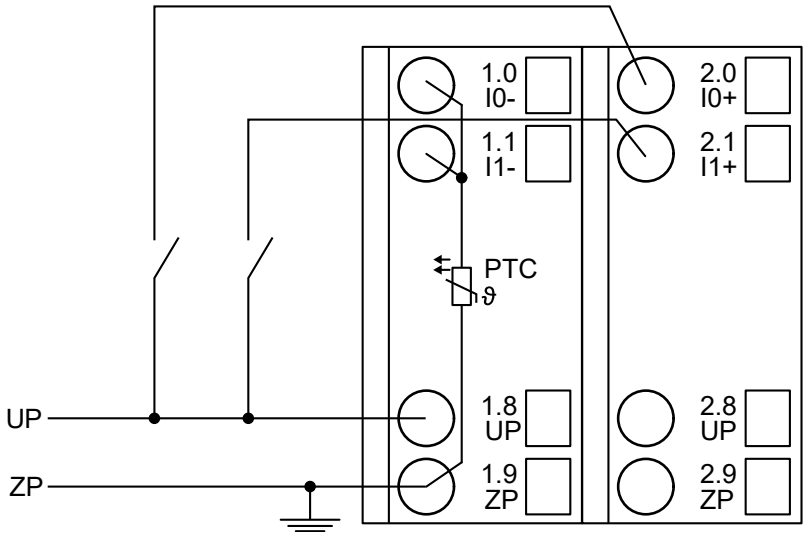


*The negative pole of the sensor must be grounded next to the sensor.*

In order to avoid error messages or long processing times, it is useful to configure unused analog input channels as "unused".

### Use of analog inputs as digital inputs

Several (or all) analog inputs can be configured as digital inputs. The inputs are not galvanically isolated against the other analog channels.




### Internal data exchange

| | |
|---|---|
| Digital inputs (bytes) | 0 |
| Digital outputs (bytes) | 0 |
| Counter input data (words) | 16 |
| Counter output data (words) | 0 |

### Parameterization

The module itself does not store configuration data. It receives its parameterization data from the master device of the I/O bus (CPU or communication interface module) during power-up of the system.

Hence, replacing I/O modules is possible without any re-parameterization via software.

*If the external power supply voltage via UP/ZP terminals fails, the I/O module loses its configuration data. The whole station has to be switched off and on again to re-configure the module.*

| Firmware version | Configuration |
|---|---|
| Firmware version > V2.0.0 | The arrangement of the parameter data is performed by Control Builder Plus/ Automation Builder software. |

The parameter data directly influences the functionality of modules.

For non-standard applications, it is necessary to adapt the parameters to your system configuration.

Module: Module slot address: Y = 1 ... 10

**Module parameters**

*Table 79: Module parameters*

| No. | Name | Default value | Internal value | Values in menu |
|---|---|---|---|---|
| 2 | Ignore module | Yes | 0 | Yes |
| | | | 1 | No |
| 4 | Check supply | On | 0 | On |
| | | | 1 | Off |

**Channel parameters**

*Table 80: Channel configuration*

| No. | Name | Default value | Internal value | Operating modes of the analog inputs, individually configurable |
|---|---|---|---|---|
| 1 | Channel configuration | Unused | 0 | Unused (default) |
| | | | 1 | Analog input 0 V ... 10 V |
| | | | 2 | Digital input |
| | | | 3 | Analog input 0 mA ... 20 mA |
| | | | 4 | Analog input 4 mA ... 20 mA |
| | | | 5 | Analog input -10 V ... +10 V |
| | | | 8 | Analog input Pt100, -50 °C ... +400 °C (2-wire) |
| | | | 9 | Analog input Pt100, -50 °C ... +400 °C (3-wire), requires 2 channels *) |
| | | | 10 | Analog input 0 ... 10 V via differential inputs, requires 2 channels *) |
| | | | 11 | Analog input -10 V ... +10 V via differential inputs, requires 2 channels *) |
| | | | 14 | Analog input Pt100, -50 °C ... +70 °C (2-wire) |
| | | | 15 | Analog input Pt100, -50 °C ... +70 °C (3-wire), requires 2 channels *) |
| | | | 16 | Analog input Pt1000, -50 °C ... +400 °C (2-wire) |
| | | | 17 | Analog input Pt1000, -50 °C ... +400 °C (3-wire), requires 2 channels *) |
| | | | 18 | Analog input Ni1000, -50 °C ... +150 °C (2-wire) |
| | | | 19 | Analog input Ni1000, -50 °C ... +150 °C (3-wire), requires 2 channels *) |

| No. | Name | Default value | Internal value | Operating modes of the analog inputs, individually configurable |
|---|---|---|---|---|
| 2 | Channel monitoring | Diagnosis | 0 | Diagnosis (Plausib, Cut wire, Short circuit) |
| | | | 3 | Not used |
| *) In the operating modes with 3-wire configuration or with differential inputs, two adjacent analog inputs belong together (e.g. the channels 0 and 1). In these cases, both channels are configured in the desired operating mode. The lower address must be the even address (channel 0). The next higher address must be the odd address (channel 1). The converted analog value is available at the higher address (channel 1). | | | | |

### Diagnosis

*Table 81: Possible diagnosis of I/O channels*

| Output range | Condition | |
|---|---|---|
| | Output value in the PLC underflow | Output value in the PLC overflow |
| 0 mA ... 20 mA | Error identifier = 7 | Error identifier = 4 |
| 4 mA ... 20 mA | | |
| -10 V ... +10 V | | |

*Table 82: Error severity E3: Warnings*

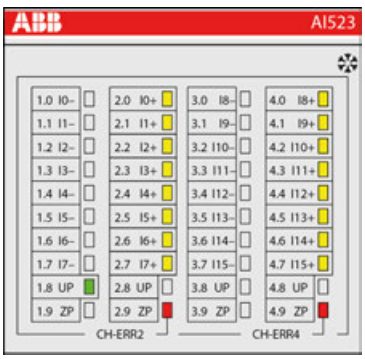
| Error severity | Location | Error code | d1 | d2 | d3 | d4 | Description | Remedy |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | | |
| E3 | iob (I/O bus) | 3 | 14 | 1 ... 10 | 31 | 31 | Timeout in the I/O module | Replace I/O module |
| E3 | iob (I/O bus) | 9 | 14 | 1 ... 10 | 31 | 31 | Overflow diagnosis buffer | New start |
| E3 | iob (I/O bus) | 11 | 14 | 1 ... 10 | 31 | 31 | Process voltage too low | Check process voltage |
| E3 | iob (I/O bus) | 19 | 14 | 1 ... 10 | 31 | 31 | Checksum error in the I/O module | Replace I/O module |
| E3 | iob (I/O bus) | 26 | 14 | 1 ... 10 | 31 | 31 | Parameter error | Check master |
| E3 | iob (I/O bus) | 36 | 14 | 1 ... 10 | 31 | 31 | Internal data exchange failure | Replace I/O module |
| E3 | iob (I/O bus) | 40 | 14 | 1 ... 10 | 31 | 31 | Different hard-/firmware versions in the module | Replace I/O module |
| E3 | iob (I/O bus) | 43 | 14 | 1 ... 10 | 31 | 31 | Internal error in the module | Replace I/O module |

*Table 83: Error severity E4: Warnings*

| Error severity | Location | Error code | d1 | d2 | d3 | d4 | Description | Remedy |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | | |
| E4 | iob (I/O bus) | 1 | 14 | 1 ... 10 | 1 | 0 ... 7 | Possibly wrong measured value caused by inadmissible temperature of the compensation channel | Check the temperature compensation channel |
| E4 | iob (I/O bus) | 2 | 14 | 1 ... 10 | 1 | 31 | Invalid measured value of the channel caused by overly high voltage difference | Check voltage difference; install equalizing conductors if necessary |
| E4 | iob (I/O bus) | 7 | 14 | 1 ... 10 | 1 | 0 ... 7 | Analog value underflow at an analog input | Check input value |
| E4 | iob (I/O bus) | 11 | 14 | 1 ... 10 | 1 | 0 ... 7 | Output voltage 10 V faulty | Check output load |
| E4 | iob (I/O bus) | 45 | 14 | 1 ... 10 | 31 | 31 | Process voltage is switched off (ON -> OFF) | Process voltage ON |
| E4 | iob (I/O bus) | 47 | 14 | 1 ... 10 | 1 | 0 ... 7 | Short circuit at an analog input | Check input value |
| E4 | iob (I/O bus) | 48 | 14 | 1 ... 10 | 1 | 0 ... 7 | Analog value overflow or broken wire at an analog input | Check input value or terminal |

### State LEDs

During the power ON procedure, the module initializes automatically. All LEDs (except the channel LEDs) are ON during this time.

| LED | | State | Color | LED = OFF | LED = ON | LED flashes |
|---|---|---|---|---|---|---|
|  | Inputs I0 ... I7 and I8 ... I15 | Analog input | Yellow | Input is OFF | Input is ON (brightness depends on the value of the analog signal) | -- |
| | UP | Process voltage 24 V DC via terminal | Green | Process voltage is missing | Process voltage OK | -- |
| | CH-ERR2 | Channel error, error messages in groups (analog inputs or | Red | No error or process voltage is missing | Severe error within the corresponding group | Error on one channel of the group |

| LED | | State | Color | LED = OFF | LED = ON | LED flashes |
|---|---|---|---|---|---|---|
| | CH-ERR4 | outputs combined into the groups 2 and 4) | Red | | | |
| | CH-ERR *) | Module error | Red | -- | Internal error | -- |
| | *) Both LEDs (CH-ERR2 and CH-ERR4) light up together | | | | | |

### Measuring ranges

#### Input ranges of voltage, current and digital input

The represented resolution corresponds to 16 bits.

| Range | 0 V ... 10 V | -10 V ... +10 V | 0 mA ... 20 mA | 4 mA ... 20 mA | Digital input | Digital value | |
|---|---|---|---|---|---|---|---|
| | | | | | | Decimal | Hex. |
| Overflow | >11.7589 | >11.7589 | >23.5178 | >22.8142 | | 32767 | 7FFF |
| Measured value too high | 11.7589<br>.<br>.<br>10.0004 | 11.7589<br>:<br>10.0004 | 23.5178<br>:<br>20.0007 | 22.8142<br>:<br>20.0006 | | 32511<br>:<br>27649 | 7EFF<br>:<br>6C01 |
| Normal range<br>Normal range or measured value too low | 10.0000<br>:<br>0.0004 | 10.0000<br>:<br>0.0004 | 20.0000<br>:<br>0.0007 | 20.0000<br>:<br>4.0006 | :<br>:<br>ON | 27648<br>:<br>1 | 6C00<br>:<br>0001 |
| | 0.0000 | 0.0000 | 0 | 4 | OFF | 0 | 0000 |
| | -0.0004<br>-1.7593 | -0.0004<br>:<br>:<br>-10.0000 | | 3.9994<br>1.1858 | | -1<br>-4864<br>:<br>-27648 | FFFF<br>ED00<br>:<br>9400 |
| Measured value too low | | -10.0004<br>:<br>-11.7589 | | | | -27649<br>:<br>-32512 | 93FF<br>:<br>8100 |
| Underflow | <-1.7593 | <-11.7589 | <0.0000 | <1.1858 | | -32768 | 8000 |

#### Input ranges resistance temperature detector

The resolution corresponds to 16 bits.

| Range | Pt100<br>-50 °C ... +70 °C | Pt100 / Pt1000<br>-50 °C ... +400 °C | Ni1000<br>-50 °C ... +150 °C | Digital value | |
|---|---|---|---|---|---|
| | | | | Decimal | Hex. |
| Overflow | > +80.0 °C | > +450.0 °C | > +160.0 °C | 32767 | 7FFF |
| Measured value too high | | +450.0 °C<br>:<br>+ 400.1 °C | | 4500<br>:<br>4001 | 1194<br>:<br>0FA1 |
| | | | +160.0 °C<br>:<br>+150.1 °C | 1600<br>:<br>1501 | 0640<br>:<br>05DD |
| | +80.0 °C<br>:<br>+70.1 °C | | | 800<br>:<br>701 | 0320<br>:<br>02BD |
| Normal range | :<br>:<br>+70.0 °C<br>:<br>+ 0.1 °C | +400.0 °C<br>:<br>:<br>+0.1 °C | :<br>+150.0 °C<br>:<br>:<br>+ 0.1 °C | 4000<br>1500<br>700<br>:<br>1 | 0FA0<br>05DC<br>02BC<br>:<br>0001 |
| | 0.0 °C | 0.0 °C | 0.0 °C | 0 | 0000 |
| | -0.1 °C<br>:<br>-50.0 °C | -0.1 °C<br>:<br>-50.0 °C | -0.1 °C<br>:<br>-50.0 °C | -1<br>:<br>-500 | FFFF<br>:<br>FE0C |
| Measured value too low | -50.1 °C<br>:<br>-60.0 °C | -50.1 °C<br>:<br>-60.0 °C | -50.1 °C<br>:<br>-60.0 °C | -501<br>:<br>-600 | FE0B<br>:<br>FDA8 |
| Underflow | < -60.0 °C | < -60.0 °C | < -60.0 °C | -32768 | 8000 |

## Technical data

### Technical data of the module

The AC500 and S500 system data is applicable to the standard version.

↳ *Chapter 2.6.1 “System data AC500” on page 1194*

The AC500-XC system data is applicable to the XC version.

↳ *Chapter 2.7.1 “System data AC500-XC” on page 1263*

Only deviating specifications are therefore described here.

The technical data is also applicable to the XC version.

| Parameter | | Value |
|---|---|---|
| Process voltage | | |
| | Rated value | 24 V DC |

| Parameter | | Value |
|---|---|---|
| | Max. ripple | 5 % |
| | Protection against reversed voltage | Yes |
| | Rated protection fuse on UP | 10 A fast |
| | Galvanic isolation | Yes, per module |
| Current consumption | | |
| | From 24 V DC power supply at the terminals UP/L+ and ZP/M of the CPU/communication interface module | Ca. 2 mA |
| | From UP at normal operation / with outputs | 0.15 A + output loads |
| Inrush current from UP (at power up) | | 0.050 $A^2s$ |
| Max. length of analog cables, conductor cross section > 0.14 $mm^2$ | | 100 m |
| Weight | | 300 g |
| Mounting position | | Horizontal mounting or<br>Vertical mounting with derating (output load reduced to 50 % at +40 °C per group) |
| Cooling | | The natural convection cooling must not be hindered by cable ducts or other parts in the control cabinet. |
| Internal power supply | | Via the I/O bus interface (I/O bus) |
| External power supply | | Via the terminals ZP and UP (process voltage 24 V DC) |
| Required terminal unit | | TU515 or TU516<br>*TU515, TU516* |

**NOTICE!**
All I/O channels (digital and analog) are protected against reverse polarity, reverse supply, short circuit and temporary overvoltage up to 30 V DC.

**Technical data of the analog inputs**

| Parameter | | Value |
|---|---|---|
| Number of channels per module | | 16 |
| Distribution of channels into groups | | 1 group of 16 channels |
| Input type | | Bipolar (not with current or Pt100/ Pt1000/ Ni1000) |
| Galvanic isolation | | |
| | Between the channels | No |
| | Between the channels and I/O bus | Yes |
| | Between the channels and process supply voltage (UP, ZP) | No |

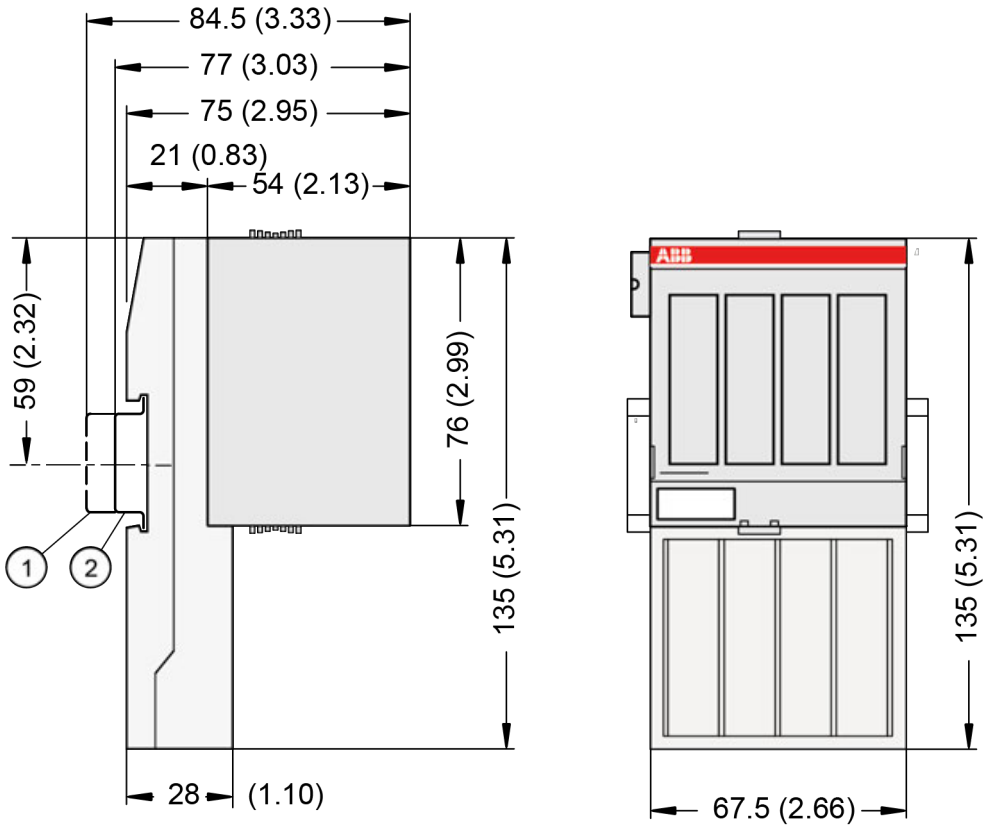
| Parameter | Value | |
|---|---|---|
| Configurability | 0 V ... 10 V, -10 V ... +10 V, 0/4 mA ... 20 mA, Pt100/1000, Ni1000 (each input can be configured individually) | |
| Channel input resistance | Voltage: > 100 kΩ<br>Current: ca. 330 Ω | |
| Time constant of the input filter | Voltage: 100 µs<br>Current: 100 µs | |
| Indication of the input signals | 1 LED per channel | |
| Conversion cycle | 2 ms (for 16 inputs), with Pt/Ni... 1 s | |
| Resolution | Range 0 V ... 10 V: 12 bits | |
| | Range -10 V ... +10 V: 12 bits including sign | |
| | Range 0 mA ... 20 mA: 12 bits | |
| | Range 4 mA ... 20 mA: 12 bits | |
| Conversion error of the analog values caused by non-linearity, adjustment error at factory and resolution within the normal range | Typ. | ±0.5 % of full scale<br>at +25 °C |
| | Max. | ±1 % of full scale (all ranges)<br>at 0 °C ... +60 °C or EMC disturbance |
| Effect of incorrect input terminal connection | Wrong or no signal detected, no damage up to 35 V | |
| Unused voltage inputs | Are configured as "unused" | |
| Unused current inputs | Have a low resistance, can be left open-circuited | |
| Overvoltage protection | Yes | |

**Technical data of the analog inputs, if used as digital inputs**

| Parameter | | Value |
|---|---|---|
| Number of channels per module | | Max. 16 |
| Input signal delay | | Typ. 8 ms, configurable from 0.1 ... 32 ms |
| Indication of the input signals | | 1 LED per channel |
| Input signal voltage | | 24 V DC |
| | Signal 0 | -30 V ... +5 V |
| | Undefined signal | +5 V ... +13 V |
| | Signal 1 | +13 V ... +30 V |
| Input current per channel | | |
| | Input voltage +24 V | Typ. 7 mA |
| | Input voltage +5 V | Typ. 1.4 mA |
| | Input voltage +15 V | Typ. 4.3 mA |

| Parameter | | Value |
|---|---|---|
| | Input voltage +30 V | < 9 mA |
| Input resistance | | Ca. 3.5 kΩ |

## Dimensions




1 Din rail 15 mm
2 Din rail 7.5 mm

*The dimensions are in mm and in brackets in inch.*

## Ordering data

| Part no. | Description | Product life cycle phase *) |
|---|---|---|
| 1SAP 250 300 R0001 | AI523, analog input module, 16 AI, U/I/Pt100, 12 bits including sign, 2-wires | Active |
| 1SAP 450 300 R0001 | AI523-XC, analog input module, 16 AI, U/I/Pt100, 12 bits including sign, 2-wires, XC version | Active |