

## S500 Analog I/O Modules, overview

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## Analog Input Module AI523

## Analog Output Module AO523

- AI523: 16 configurable analog inputs
- AO523: 16 configurable analog outputs
- resolution 12 bits plus sign
- module-wise electrically isolated

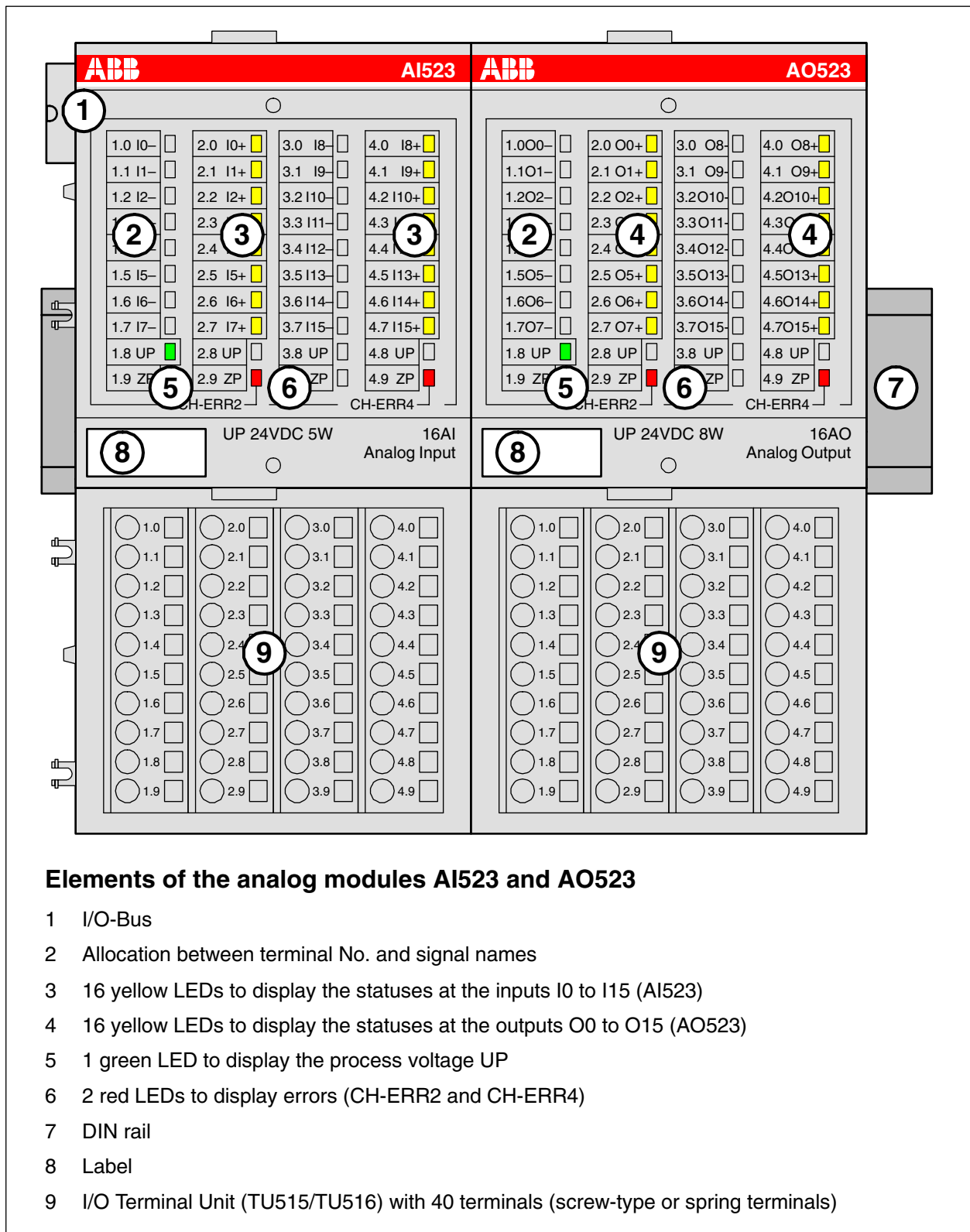


Figure: Analog input module AI523 and analog output module AO523, plugged on Terminal Units TU516

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## Intended purpose

The analog modules AI523 and AO523 can be used as remote expansion modules at the FBP Interface Module DC505-FBP, at the CS31 Bus Module DC551-CS31 or locally at an AC500 CPU. They contain 16 channels each with the following features:

Analog input module AI523:

- 16 configurable analog inputs in two groups (1.0...2.7 and 3.0...4.7)

Analog output module AO523:

- 8 configurable analog outputs in two groups (1.0...2.7 and 3.0...4.7)

The configuration is performed by software.

The modules are supplied with a process voltage of 24 V DC. The analog inputs and outputs are electrically isolated from the rest of the modules' electronics.

## Functionality

<b>AI523: 16 analog inputs, individually configurable for</b>	unused (default setting)
	0...10 V
	-10 V...+10 V
	0...20 mA
	4...20 mA
	Pt100, -50 °C...+400 °C (2-wire)
	Pt100, -50 °C...+400 °C (3-wire), requires 2 channels
	Pt100, -50 °C...+70 °C (2-wire)
	Pt100, -50 °C...+70 °C (3-wire), requires 2 channels
	Pt1000, -50 °C...+400 °C (2-wire)
	Pt1000, -50 °C...+400 °C (3-wire), requires 2 channels
	Ni1000, -50 °C...+150 °C (2-wire)
	Ni1000, -50 °C...+150 °C (3-wire), requires 2 channels
	0...10 V with differential inputs, requires 2 channels
	-10 V...+10 V with differential inputs, requires 2 channels
digital signals (digital input)	

<b>AO523: 8 analog outputs, individually configurable for</b>	unused (default setting)
	-10 V...+10 V
	0...20 mA
	4...20 mA
<b>AO523: 8 analog outputs, individually configurable for</b>	unused (default setting)
	-10 V...+10 V

Resolution of the analog channels	
- Voltage -10 V... +10 V	12 bits plus sign
- Voltage 0...10 V	12 bits
- Current 0...20 mA, 4...20 mA	12 bits
- Temperature	0.1 °C
LED displays	AI523: 19 LEDs for signals and error messages AO523: 19 LEDs for signals and error messages
Internal power supply	through the expansion bus interface (I/O-Bus)
External power supply	via the terminals ZP and UP (process voltage 24 V DC)

## Electrical connection

The analog modules are plugged on I/O Terminal Units TU515 or TU516. Properly seat 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 (TA526).

The electrical 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.



**Note:** Mounting, disassembling and electrical connection for the Terminal Units and the I/O modules are described in detail in the S500 system data chapters.

The terminals 1.8 to 4.8 and 1.9 to 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 to 4.8: Process voltage UP = +24 V DC

Terminals 1.9 to 4.9: Process voltage ZP = 0 V

The assignment of the other terminals:

### Analog input module AI523:

Terminals	Signal	Meaning
1.0 to 1.7	I0- to I7-	Minus poles of the first 8 analog inputs
2.0 to 2.7	I0+ to I7+	Plus poles of the first 8 analog inputs
3.0 to 3.7	I8- to I15-	Minus poles of the following 8 analog inputs
4.0 to 4.7	I8+ to I15+	Plus poles of the following 8 analog inputs

## Analog output module AO523:

Terminals	Signal	Meaning
1.0 to 1.7	O0- to O7-	Minus poles of the first 8 analog outputs
2.0 to 2.7	O0+ to O7+	Plus poles of the first 8 analog outputs
3.0 to 3.7	O8- to O15-	Minus poles of the following 8 analog outputs
4.0 to 4.7	O8+ to O15+	Plus poles of the following 8 analog outputs



**Caution:** The minus poles of the analog inputs are electrically connected to each other. They form an "Analog Ground" signal for the module. The minus poles of the analog outputs are also electrically connected to each other to form an "Analog Ground" signal.



**Caution:** There is no electrical isolation between the analog circuitry and ZP/UP. Therefore, the analog sensors must be electrically isolated in order to avoid loops via the earth potential or the supply voltage.



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



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

**The supply voltage 24 V DC for the modules' electronic circuitry comes from the I/O-Bus of the FieldBusPlug or the CPU.**



**Caution:** Removal of energized modules is not permitted. All power sources (supply and process voltages) must be switched off while working on any AC500 system.

**Analog signals are always laid in shielded cables. The cable shields are earthed at both ends of the cables. In order to avoid unacceptable potential differences between different parts of the installation, low resistance equipotential bonding conductors must be laid.**

For simple applications (low disturbances, no high requirement on precision), the shielding can also be omitted.

The following figures show the electrical connection of the analog modules AI523 and AO523.

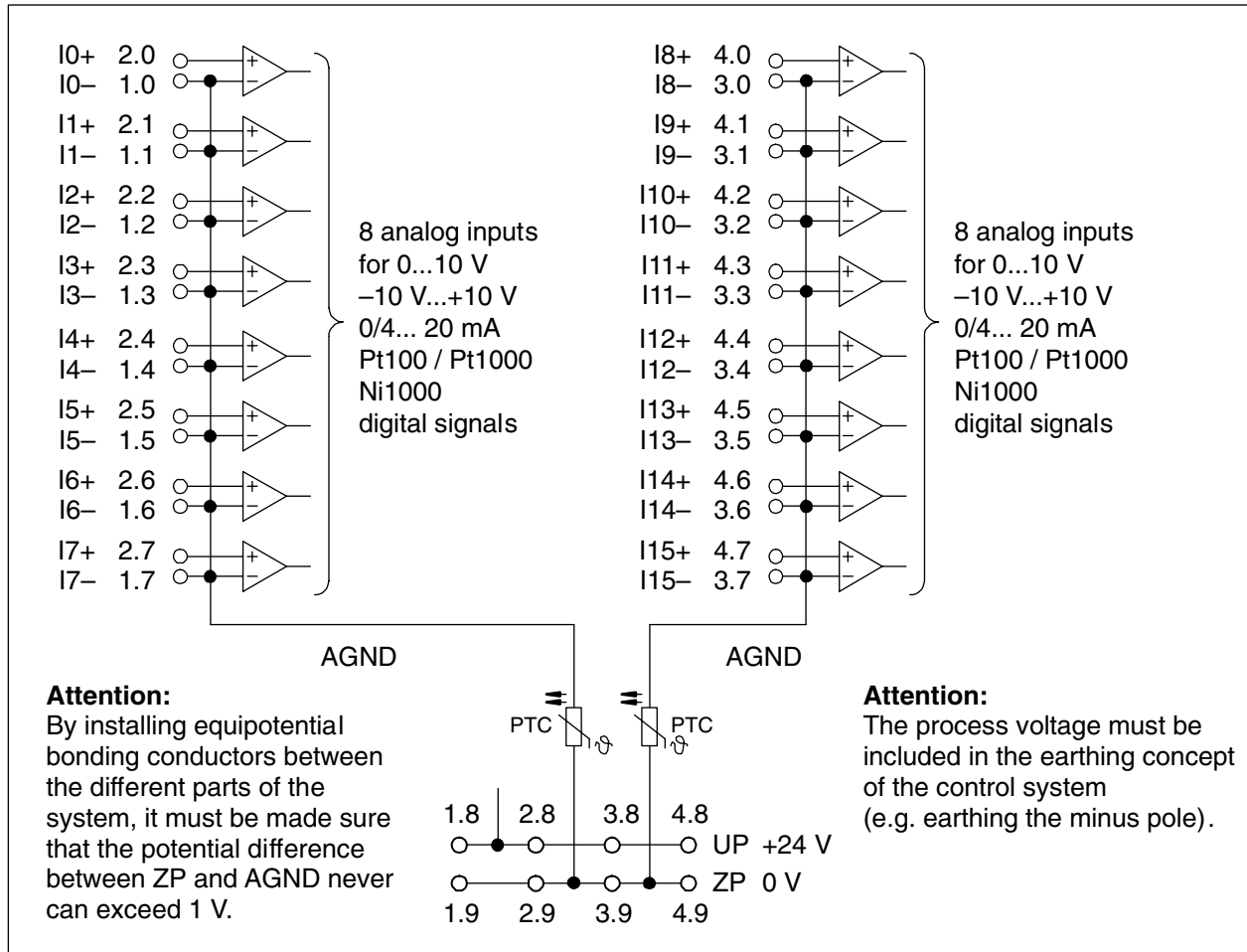


Figure: Terminal assignment of the analog input module AI523

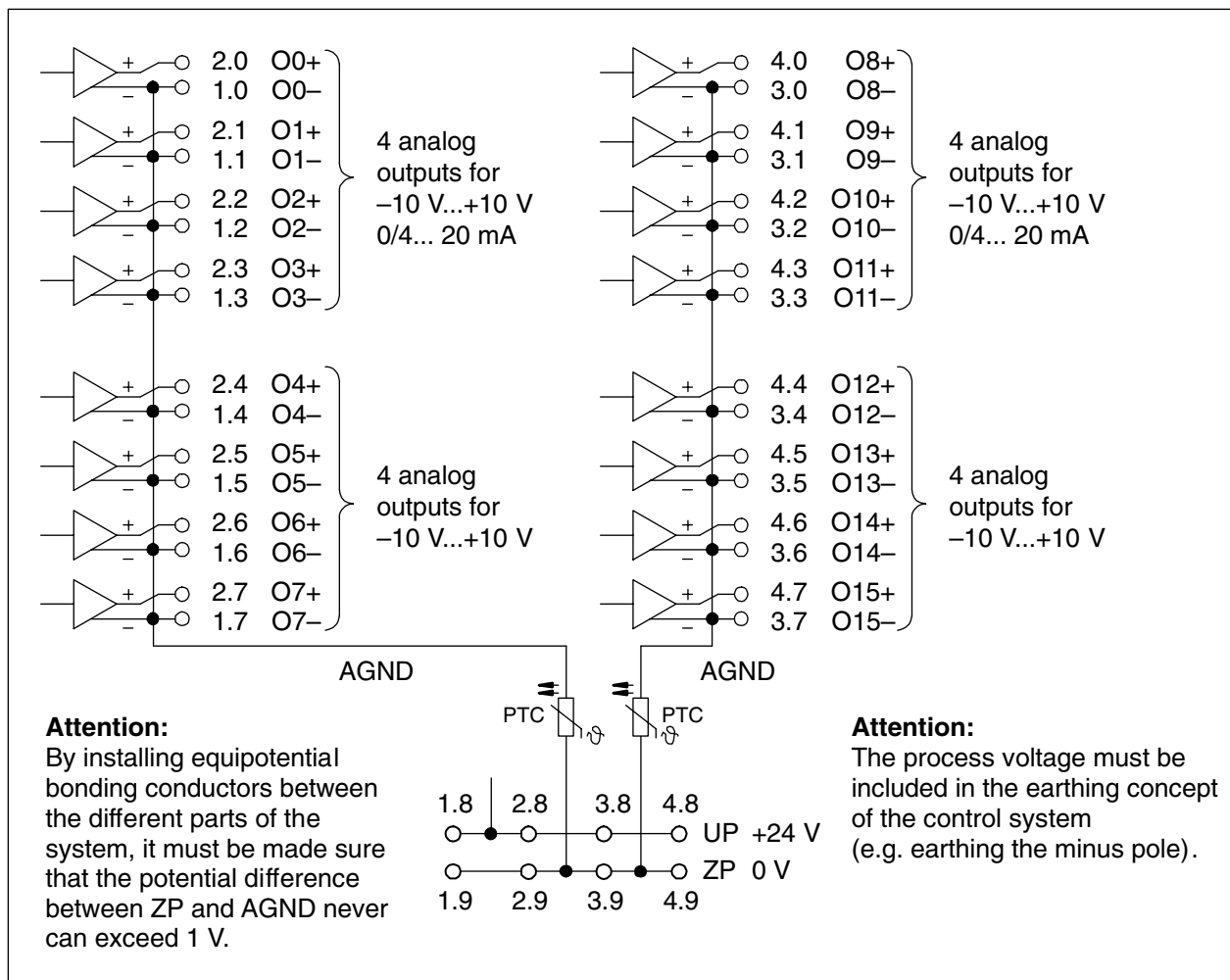


Figure: Terminal assignment of the analog output module AO523

The modules provide several diagnosis functions (see chapter "Diagnosis and display").



## AI523: 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 following figure shows the connection of resistance thermometers in **2-wire configuration**.

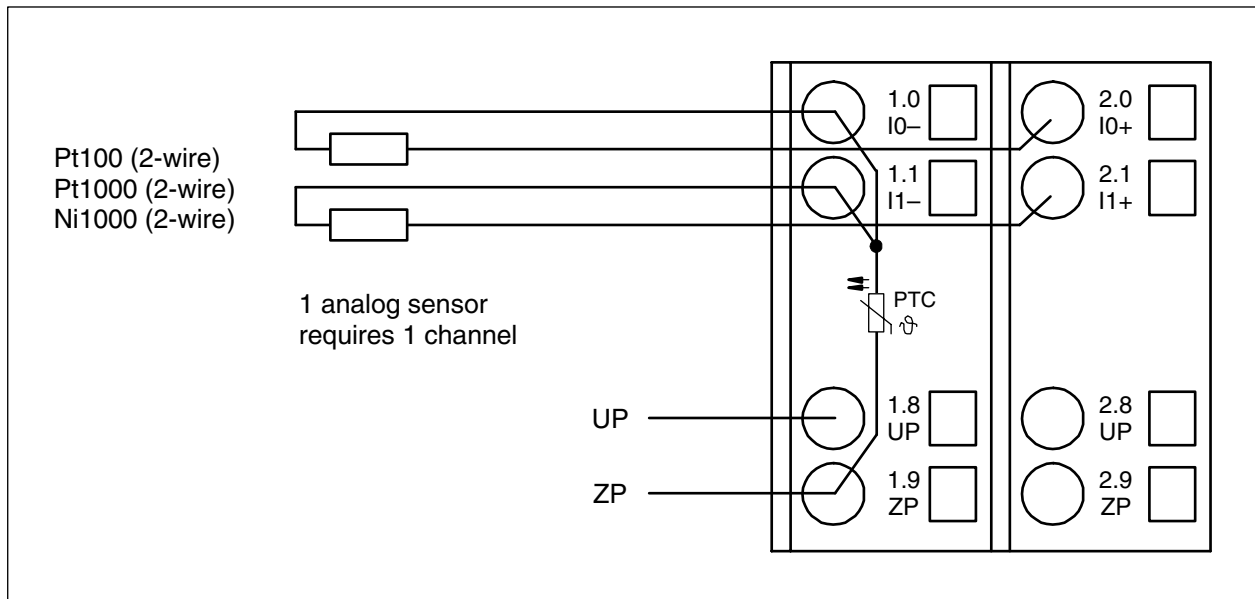


Figure: Connection of resistance thermometers in 2-wire configuration

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of resistances"):

Pt100	-50 °C...+70 °C	2-wire configuration, one channel used
Pt100	-50 °C...+400 °C	2-wire configuration, one channel used
Pt1000	-50 °C...+400 °C	2-wire configuration, one channel used
Ni1000	-50 °C...+150 °C	2-wire configuration, one channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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".

## AI523: 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.

The following figure shows the connection of resistance thermometers in **3-wire configuration**.

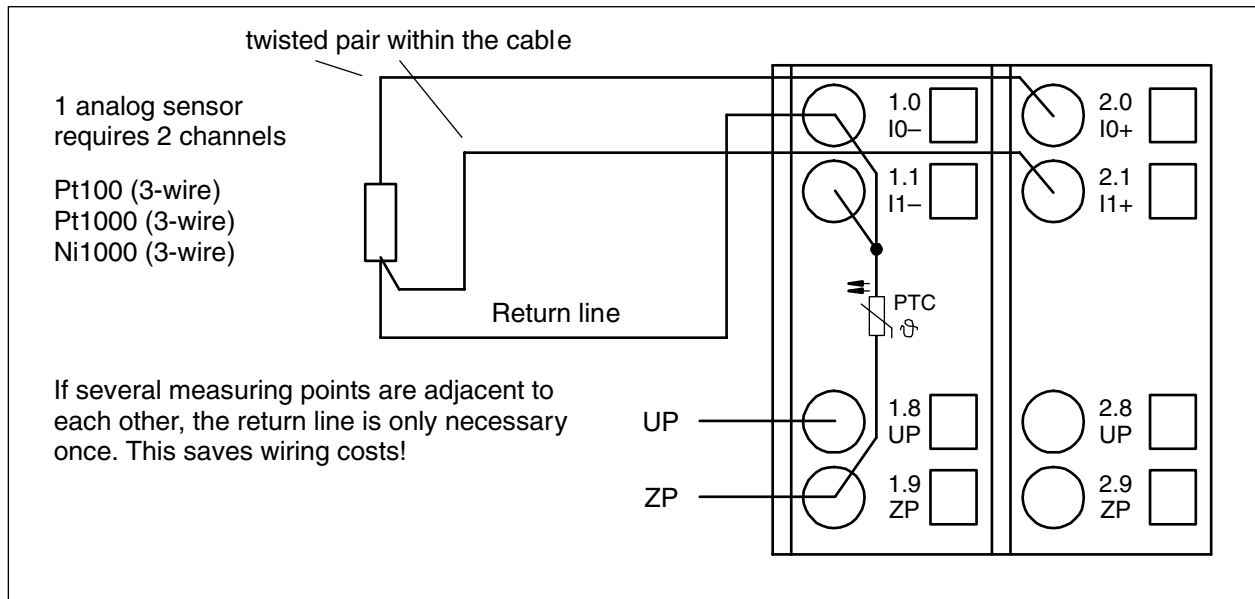


Figure: Connection of resistance thermometers in 3-wire configuration

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 following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of resistances"):

Pt100	-50 °C...+70 °C	3-wire configuration, two channels used
Pt100	-50 °C...+400 °C	3-wire configuration, two channels used
Pt1000	-50 °C...+400 °C	3-wire configuration, two channels used
Ni1000	-50 °C...+150 °C	3-wire configuration, two channels used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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".

## AI523: Connection of active-type analog sensors (voltage) with electrically isolated power supply

The following figure shows the connection of active-type analog sensors (voltage) with electrically isolated power supply.

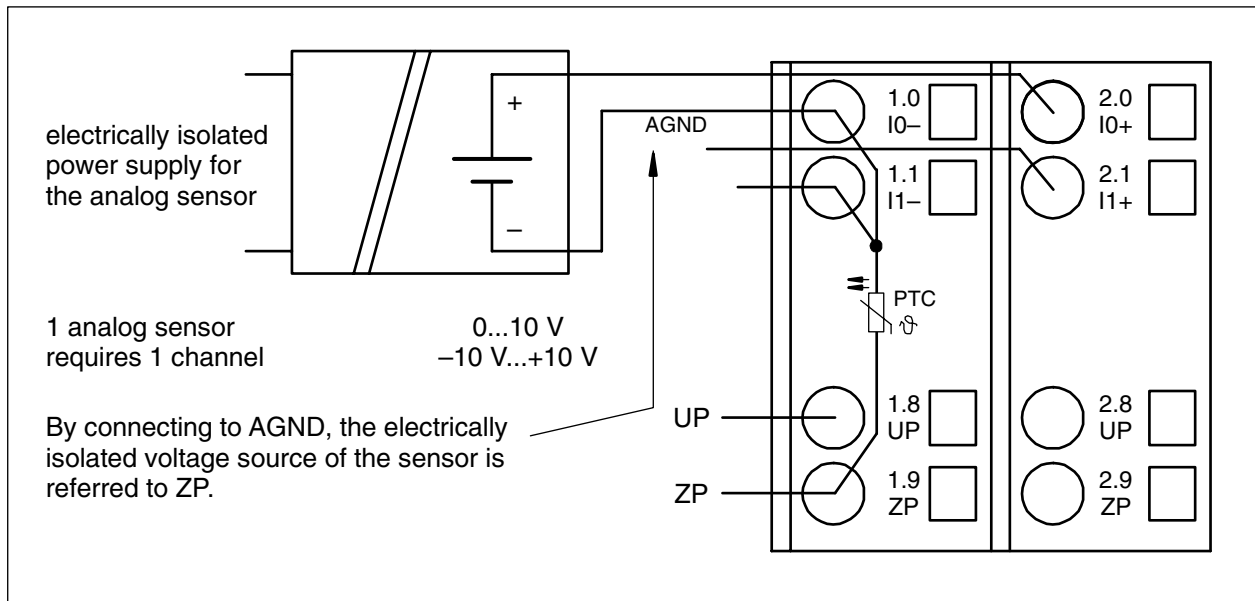


Figure: Connection of active-type analog sensors (voltage) with electrically isolated power supply

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	1 channel used
Voltage	-10 V...+10 V	1 channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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

## AI523: Connection of active-type analog sensors (current) with electrically isolated power supply

The following figure shows the connection of active-type analog sensors (current) with electrically isolated power supply.

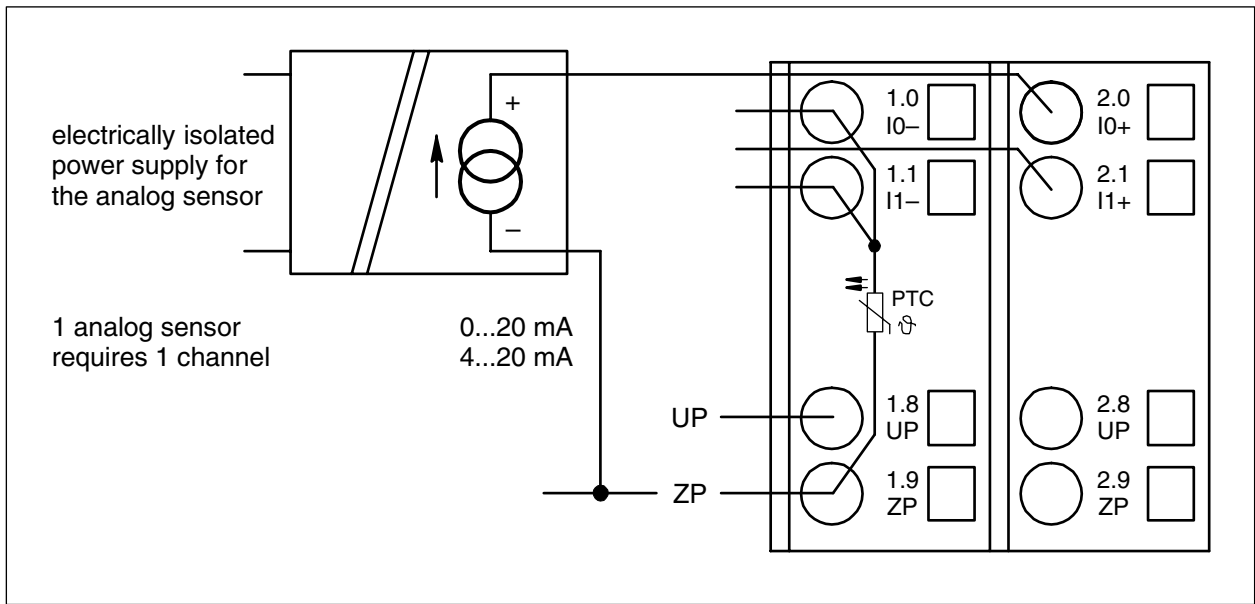


Figure: Connection of active-type analog sensors (current) with electrically isolated power supply

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Current	0...20 mA	1 channel used
Current	4...20 mA	1 channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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

## AI523: Connection of active-type analog sensors (voltage) with no electrically isolated power supply

The following figure shows the connection of active-type sensors (voltage) with no electrically isolated power supply.

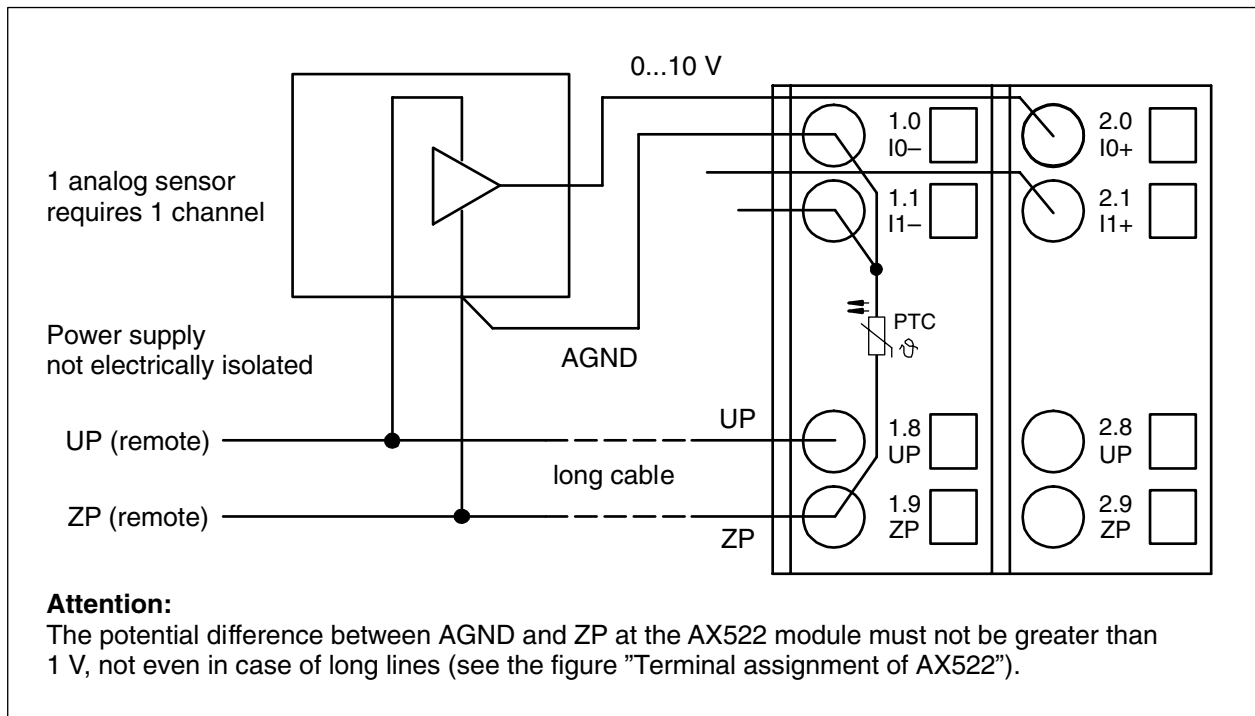


Figure: Connection of active-type sensors (voltage) with no electrically isolated power supply



**Note for the picture:** If AGND does not get connected to ZP, the sensor current flows to ZP via the AGND line. The measuring signal is distorted, since it flows a very little current over 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 has to be preferred.

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	1 channel used
Voltage	-10 V...+10 V *)	1 channel used

\*) if the sensor can provide this signal range

The function of the LEDs is described under "Diagnosis and displays / Displays".

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

## AI523: Connection of passive-type analog sensors (current)

The following figure shows the connection of passive-type analog sensors (current).

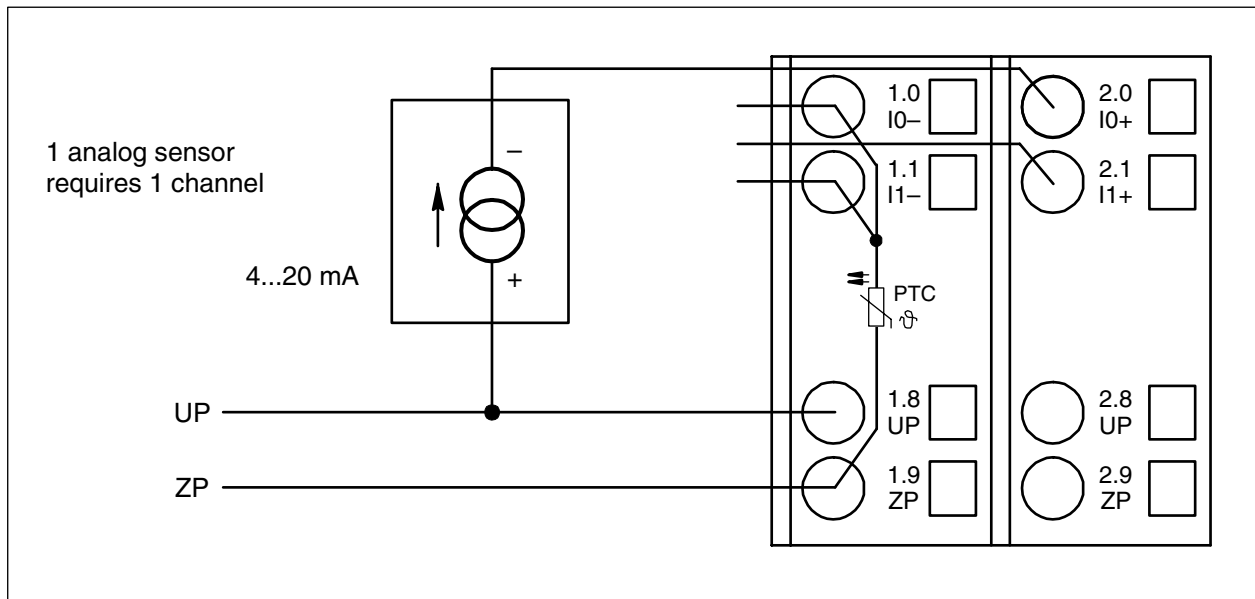


Figure: Connection of passive-type analog sensors (current)

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Current	4...20 mA	1 channel used
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The function of the LEDs is described under "Diagnosis and displays / Displays".

**⚠ Caution:** If, during initialization, an analog current sensor supplies more than 25 mA for more than 1 second into an analog input, this input is switched off by the module (input protection). In such cases, it is recommended, to protect the analog input by a 10-volt zener diode (in parallel to I+ and I-). But, in general, it is a better solution to prefer sensors with fast initialization or without current peaks higher than 25 mA.

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

## AI523: Connection of active-type analog sensors (voltage) to differential inputs

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

The evaluation using differential inputs helps to considerably increase the measuring accuracy and to avoid earthing 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).

**!** **Important:** The earthing potential at the sensors must not have a too big potential difference with respect to ZP (max.  $\pm 1$  V within the full signal range). Otherwise problems can occur concerning the common-mode input voltages of the involved analog inputs.

The following figure shows the connection of active-type analog sensors (voltage) to differential inputs.

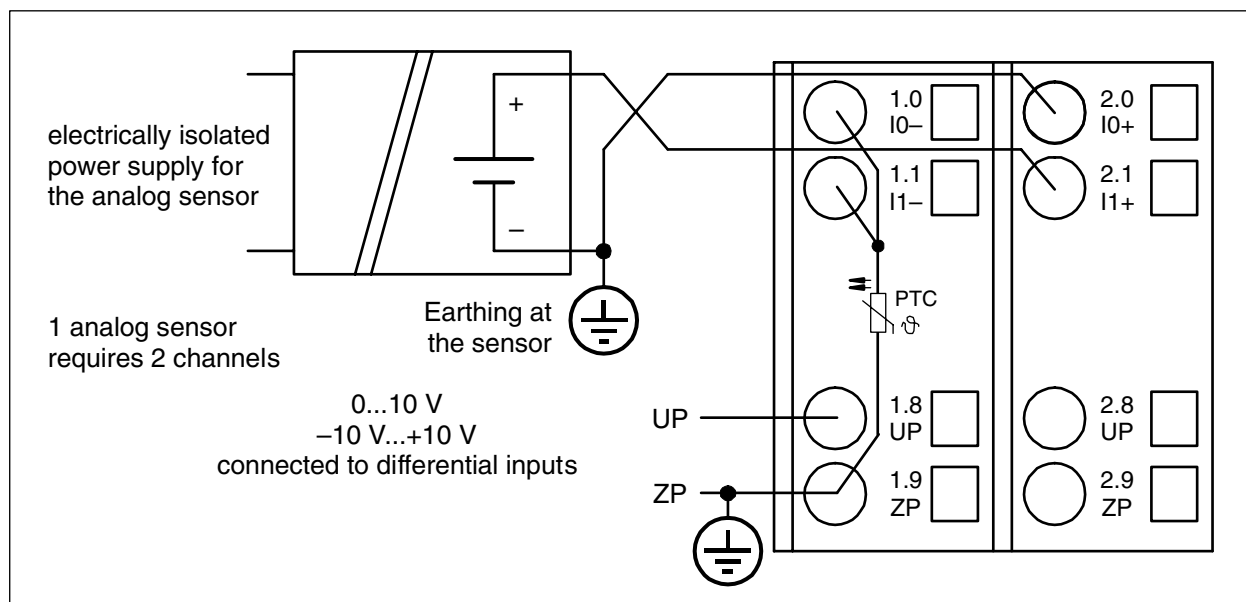


Figure: Connection of active-type analog sensors (voltage) to differential inputs

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	with differential inputs, 2 channels used
Voltage	-10 V...+10 V	with differential inputs, 2 channels used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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

### AI523: Use of analog inputs as digital inputs

Several (or all) analog inputs can be configured as digital inputs (see also "Technical Data / Technical data of the analog inputs, if they are used as digital inputs"). The inputs are not electrically isolated against the other analog channels.

The following figure shows the use of analog inputs as digital inputs.

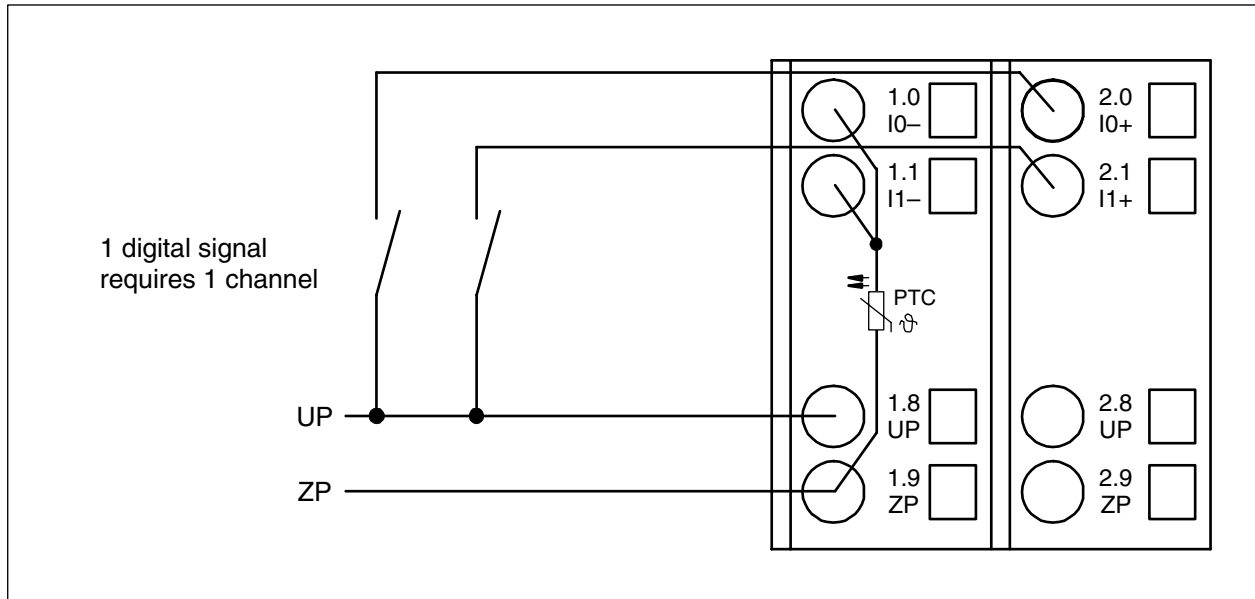


Figure: Use of analog inputs as digital inputs

The following operating mode can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Digital input	24 V	1 channel used
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The function of the LEDs is described under "Diagnosis and displays / Displays".

### AO523: Connection of analog output loads (voltage, current)

The following figure shows the connection of analog output loads (voltage, current).

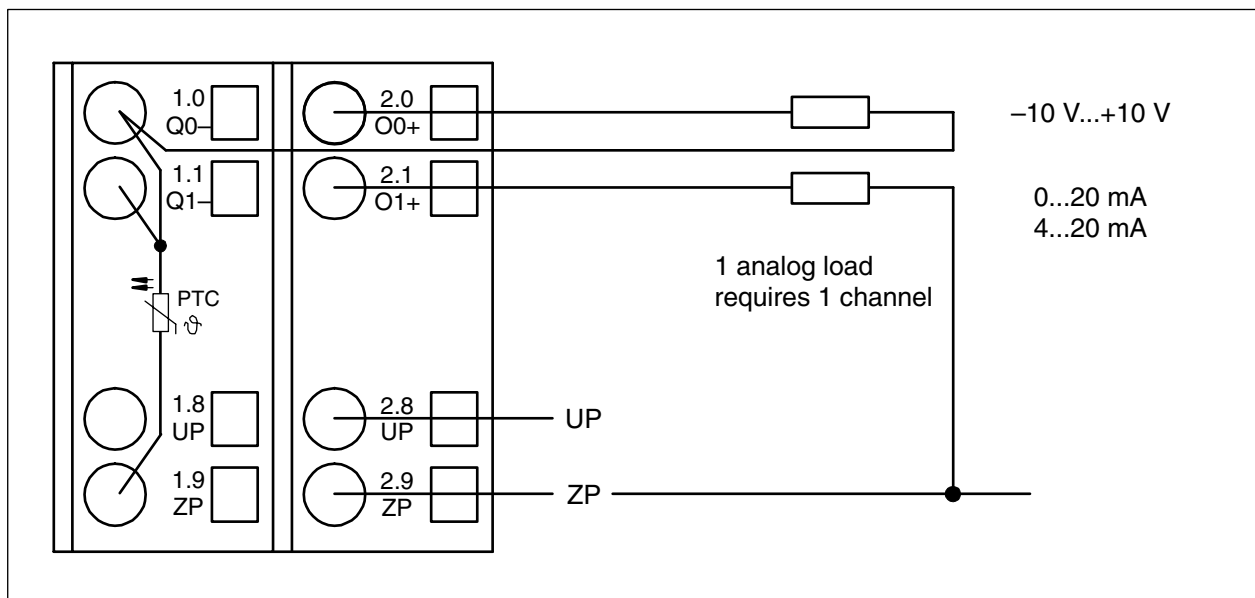


Figure: Connection of analog output loads (voltage, current)



The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Output ranges of voltage and current"):

Voltage	-10 V...+10 V	Load max. $\pm 10$ mA	1 channel used
Current	0...20 mA	Load 0...500 $\Omega$	1 channel used
Current	4...20 mA	Load 0...500 $\Omega$	1 channel used

Only the channels 0...3 and 8...11 can be configured as current output (0...20 mA or 4...20 mA).

The function of the LEDs is described under "Diagnosis and displays / Displays".

Unused analog outputs can be left open-circuited.

## Internal data exchange

	AI523	AO523
Digital inputs (bytes)	0	0
Digital outputs (bytes)	0	0
Counter input data (words)	16	0
Counter output data (words)	0	16

## I/O configuration

The analog modules AI523 and AO523 do not store configuration data themselves.

## Parameterization

The arrangement of the parameter data is performed by your master configuration software SYCON in connection with the S500 GSD files and in conjunction with the Control 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 AI523:

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Module ID	Internal	1515 *1)	Word	1515 0x05eb	0	65535
2 *2)	Ignore module	No Yes	0 1	Byte	No 0x00		
3	Parameter length in bytes	Internal	34	Byte	34-CPU 34-FBP	0	255
4	Check supply	Off On	0 1	Byte	On 0x01		
5	Analog data format	Default	0	Byte	Default 0x00		

\*1) With CS31 and addresses less than 70 and FBP, the value is increased by 1

\*2) Not with FBP

**Module AO523:**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Module ID	Internal	1510 *1)	Word	1510 0x05e6	0	65535
2 *2)	Ignore module	No Yes	0 1	Byte	No 0x00		
3	Parameter length in bytes	Internal	39	Byte	39-CPU 39-FBP	0	255
4	Check supply	Off On	0 1	Byte	On 0x01		
5	Analog data format	Default	0	Byte	Default 0x00		
6	Behaviour of outputs at communication errors	Off Last value	0 1	Byte	Off 0x00		

\*1) With CS31 and addresses less than 70 and FBP, the value is increased by 1

\*2) Not with FBP

**GSD file:**

<b>AI523</b>	Ext_User_Prm_Data_Len = Ext_User_Prm_Data_Const(0) =	37 0x05, 0xec, 0x22, \ 0x01, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00;
<b>AO523</b>	Ext_User_Prm_Data_Len = Ext_User_Prm_Data_Const(0) =	42 0x05, 0xe7, 0x27, \ 0x01, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00;

**Input channel (16 x with AI523):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *2)	see below *2)	Byte	0 0x00 see below *3)		
2	Channel monitoring	see below *4)	see below *4)	Byte	0 0x00 see below *5)		

**- Channel configuration**

*2)	Internal value	Operating modes of the analog inputs, individually configurable
*3)	0	Unused (default)
	1	Analog input 0...10 V
	2	Digital input
	3	Analog input 0...20 mA
	4	Analog input 4...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 *)
		*) 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).

**- Channel monitoring**

*4)	Internal value	Monitoring
*5)	0	Plausibility, open-circuit (broken wire) and short-circuit
	1	Open-circuit and short-circuit
	2	Plausibility
	3	No monitoring

**Output channels 0 and 8 (2 channels, AO523):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *6)	see below *6)	Byte	see below *7)		
2	Channel monitoring	see below *8)	see below *8)	Byte	see below *9)		
3	Substitute value *10)	0...65535	0...0xffff	Word	0		

**Output channels 1...7 and 9...15 (14 channels, AO523):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *6)	see below *6)	Byte	see below *7)		
2	Channel monitoring	see below *8)	see below *8)	Byte	see below *9)		

**- Channel configuration**

*6)	Internal value	Operating modes of the analog outputs, individually configurable
*7)	0	Unused (default)
	128	Analog output -10 V...+10 V
	129	Analog output 0...20 mA (not with the channels 4...7 and 12...15)
	130	Analog output 4...20 mA (not with the channels 4...7 and 12...15)

**- Channel monitoring**

*8)	Internal value	Monitoring
*9)	0	Plausibility, open-circuit (broken wire) and short-circuit (default)
	1	Open-circuit (broken wire) and short-circuit
	2	Plausibility
	3	No monitoring

**- Substitute value**

*10)	Intended behaviour of channel 0 when the control system stops:	Required setting of the module parameter "Behaviour of outputs in case of a communication error"	Required setting of the channel parameter "Substitute value"
	Output OFF	OFF	0
	Last value	Last value	0
	Substitute value	OFF or Last value	1...65535

## Diagnosis and display

### Diagnosis:

E1..E4	d1	d2	d3	d4	Identifier 000..063	AC500 display	<- Display in
Class	Comp	Dev	Mod	Ch	Err	PS501 PLC browser	
Byte 6 Bit 6..7	-	Byte 3	Byte 4	Byte 5	Byte 6 Bit 0..5	FBP diagnosis block	
Class	Inter- face	De- vice	Mod- ule	Chan- nel	Error identifier	Error message	Remedy
	1)	2)	3)	4)			
<b>Module error AI523 / AO523</b>							
3	14	1..7	31	31	19	Checksum error in the I/O module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	3	Timeout in the I/O module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	40	Different hard-/firmware versions in the module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	43	Internal error in the module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	36	Internal data exchange failure	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	9	Overflow diagnosis buffer	New start
	11 / 12	ADR	1..7				
3	14	1..7	31	31	26	Parameter error	Check master
	11 / 12	ADR	1..7				
3	14	1..7	31	31	11	Process voltage too low	Check process voltage
	11 / 12	ADR	1..7				
4	14	1..7	31	31	45	Process voltage is switched off (ON -> OFF)	Process voltage ON
	11 / 12	ADR	1..7				
<b>Channel error AI523</b>							
4	14	1..7	1	0...15	48	Analog value overflow or broken wire at an analog input	Check input value or terminal
	11 / 12	ADR	1..7				
4	14	1..7	1	0...15	7	Analog value underflow at an analog input	Check input value
	11 / 12	ADR	1..7				
4	14	1..7	1	0...15	47	Short-circuit at an analog input	Check terminal
	11 / 12	ADR	1..7				
<b>Channel error AO523</b>							
4	14	1..7	3	0...15	48	Analog value overflow at an analog output	Check output value
	11 / 12	ADR	1..7				
4	14	1..7	3	0...15	7	Analog value underflow at an analog output	Check output value
	11 / 12	ADR	1..7				

**Remarks:**

1)	In AC500 the following interface identifier applies: 14 = I/O-Bus, 11 = COM1 (e.g. CS31 bus), 12 = COM2. The FBP diagnosis block does not contain this identifier.
2)	With "Device" the following allocation applies: 31 = Module itself, 1..7 = Expansion module 1..7, ADR = Hardware address (e.g. of the DC551)
3)	With "Module" the following allocation applies dependent of the master: Module error: I/O-Bus or FBP: 31 = Module itself; COM1/COM2: 1..7 = Expansion 1..7 Channel error: I/O-Bus or FBP = Module type (2 = DO); COM1/COM2: 1..7 = Expansion 1..7
4)	In case of module errors, with channel "31 = Module itself" is output.

**Displays:**

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

**Status of the LEDs** (see also section "Diagnosis LEDs" in the S500 system data)

LED	Status	Color	LED = OFF	LED = ON	LED flashes
AI523: inputs 00...07 and 08...15	analog input	yellow	input is OFF	input is ON (brightness depends on the value of the analog signal)	--
AO523: outputs 00...07 and 08...15	analog output	yellow	output is OFF	output 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 and initialization successful	module is not initialized correctly
CH-ERR2 CH-ERR4	Channel Error, error messages in groups (analog inputs or outputs combined into the groups 2 and 4)	red red	no error or process voltage is missing	serious error within the corresponding group	error on one channel of the group
CH-ERR *)	Module Error	red	--	internal error	--
*) Both LEDs (CH-ERR2 and CH-ERR4) light up together					

## Measuring ranges

### AI523: Input ranges of voltage, current and digital input

Range	0...10 V	-10...+10 V	0...20 mA	4...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 : 10.0004	11.7589 : 10.0004	23.5178 : 20.0007	22.8142 : 20.0006		32511 : 27649	7EFF : 6C01
Normal range	10.0000 : 0.0004	10.0000 : 0.0004	20.0000 : 0.0007	20.0000 : 4.0006	ON	27648 : 1	6C00 : 0001
	0.0000	0.0000	0	4	OFF	0	0000
Normal range or measured value too low	-0.0004 -1.7593	-0.0004 : : : -10.0000		3.9994 : 0		-1 -4864 -6912 : -27648	FFFF ED00 E500 : 9400
Measured value too low		-10.0004 : -11.7589				-27649 : -32512	93FF : 8100
Underflow	<0,0000	<-11.7589	<0.0000	<0.0000		-32768	8000

The represented resolution corresponds to 16 bits.

### AI523: Input ranges resistance

Range	Pt100 / Pt 1000 -50...70 °C	Pt100 / Pt1000 -50...400 °C	Ni1000 -50...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 : 400.1 °C		4500 : 4001	1194 : 0FA1
			160.0 °C : 150.1 °C	1600 : 1501	0640 : 05DD
	80.0 °C : 70.1 °C			800 : 701	0320 : 02BD
Normal range	70.0 °C : 0.1 °C	400.0 °C : : : 0.1 °C	150.0 °C : : : 0.1 °C	4000 1500 700 : 1	0FA0 05DC 02BC : 0001
	0.0 °C	0.0 °C	0.0 °C	0	0000
	-0.1 °C : -50.0 °C	-0.1 °C : -50.0 °C	-0.1 °C : -50.0 °C	-1 : -500	FFFF : FE0C
	Measured value too low	-50.1 °C : -60.0 °C	-50.1 °C : -60.0 °C	-50.1 °C : -60.0 °C	-501 : -600
Underflow	< -60.0 °C	< -60.0 °C	< -60.0 °C	-32768	8000

## AO523: Output ranges voltage and current


Range	-10...+10 V	0...20 mA	4...20 mA	Digital value	
				decimal	hex.
Overflow	0 V	0 mA	0 mA	> 32511	> 7EFF
Measured value too high	11.7589 V	23.5178 mA	22.8142 mA	32511	7EFF
	: 10.0004 V	: 20.0007 mA	: 20.0006 mA	: 27649	: 6C01
Normal range	10.0000 V	20.0000 mA	20.0000 mA	27648	6C00
	: 0.0004 V	: 0.0007 mA	: 4.0006 mA	: 1	: 0001
	0.0000 V	0.0000 mA	4.0000 mA	0	0000
	-0.0004 V	0 mA	3.9994 mA	-1	FFFF
Measured value too low	: -10.0000 V	: 0 mA	: 0 mA	: -6912	: E500
	-11.7589 V	0 mA	0 mA	-27648	9400
Underflow	0 V	0 mA	0 mA	< -32512	< 8100

The represented resolution corresponds to 16 bits.

## Technical data

The system data of AC500 and S500 are valid here. Only additional details are therefore documented below.

Process voltage	
- Rated value	24 V DC
- max. ripple	5 %
- Protection against reversed voltage	yes
Rated protection fuse on UP	10 A fast
- Electrical isolation	yes, per module
- Current consumption from UP at normal operation	0.15 A + output loads (AO523)
- Inrush current from UP (at power up)	0.050 A <sup>2</sup> s
- Connections	Terminals 1.8 - 4.8 for +24 V (UP) and 1.9 - 4.9 for 0 V (ZP)
Max. length of analog cables, conductor cross section > 0.14 mm <sup>2</sup>	100 m
Conversion error of the analog values caused by non-linearity, adjustment error at factory and resolution within the normal range	typ. 0.5 %, max. 1 %
Weight	300 g
Mounting position	horizontal or vertical 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 switch-gear cabinet.

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



**AI523: Technical data of the analog inputs**

Number of channels per module	16
Distribution of channels into groups	2 groups of 8 channels each
Connections of the channels I0- to I7- Connections of the channels I0+ to I7+	Terminals 1.0 to 1.7 Terminals 2.0 to 2.7
Connections of the channels I8- to I15- Connections of the channels I8+ to I15+	Terminals 3.0 to 3.7 Terminals 4.0 to 4.7
Input type	bipolar (not with current or Pt100/Pt1000/Ni1000)
Electrical isolation	against internal supply and other modules
Configurability	0...10 V, -10...+10 V, 0/4...20 mA, Pt100/1000, Ni1000 (each input can be configured individually)
Channel input resistance	Voltage: > 100 k $\Omega$ , current: ca. 330 $\Omega$
Time constant of the input filter	Voltage: 100 $\mu$ s, current: 100 $\mu$ s
Indication of the input signals	one LED per channel
Conversion cycle	2 ms (for 8 inputs + 8 outputs), with Pt/Ni... 1 s
Resolution	Range 0...10 V: 12 bits
	Range -10...+10 V: 12 bits + sign
	Range 0...20 mA: 12 bits
	Range 4...20 mA: 12 bits
Relationship between input signal and hex code	see tables "Input ranges voltage, current and digital input" and "Input ranges resistance"
Unused voltage inputs	are configured as "unused"
Unused current inputs	have a low resistance, can be left open-circuited
Overvoltage protection	yes

**AI523: Technical data of the analog inputs, if they are used as digital inputs**

Number of channels per module	max. 16
Distribution of channels into groups	2 groups of 8 channels each
Connections of the channels I0+ to I7+ Connections of the channels I8+ to I15+	Terminals 2.0 to 2.7 Terminals 4.0 to 4.7
Reference potential for the inputs	Terminals 1.8 to 4.8 (ZP)
Input signal delay	typ. 8 ms, configurable from 0.1 to 32 ms
Indication of the input signals	one LED per channel
Input signal voltage	24 V DC
Signal 0	-30 V...+5 V
Signal 1	+13 V...+30 V

## AO523: Technical data of the analog outputs

Number of channels per module	16, of which channels O0...O3 and O8...O11 for voltage and current, and channels O4...7 and O12...15 only for voltage
Distribution of channels into groups	2 groups of 8 channels each
- Channels O0-...O7- - Channels O0+...O7+	Terminals 1.0...1.7 Terminals 2.0...2.7
- Channels O8-...O15- - Channels O8+...O15+	Terminals 3.0...3.7 Terminals 4.0...4.7
Output type	bipolar with voltage, unipolar with current
Electrical isolation	against internal supply and other modules
Configurability	-10...+10 V, 0...20 mA, 4...20 mA (each output can be configured individually), current outputs only channels 0...3
Output resistance (load), as current output	0...500 $\Omega$
Output loadability, as voltage output	max. $\pm 10$ mA
Indication of the output signals	one LED per channel
Resolution	12 bits (+ sign)
Relationship between output signal and hex code	see table "Output ranges voltage and current"
Unused outputs	can be left open-circuited

## Ordering data

Order No.	Scope of delivery
1SAP 250 300 R0001	AI523, Analog input module, 16 AI, U/I/Pt100, 12 Bit + sign, 2-wires
1SAP 250 200 R0001	AO523, Analog output module, 16 AO, U/I, 12 Bit + sign, 2-wires
1SAP 212 200 R0001	TU515, I/O Terminal Unit, 24 V DC, screw-type terminals
1SAP 212 000 R0001	TU516, I/O Terminal Unit, 24 V DC, spring terminals

## Analog Input/Output Modules AX521 and AX522

- AX521: 4 configurable analog inputs, 4 configurable analog outputs
- AX522: 8 configurable analog inputs, 8 configurable analog outputs
- resolution 12 bits plus sign
- module-wise electrically isolated

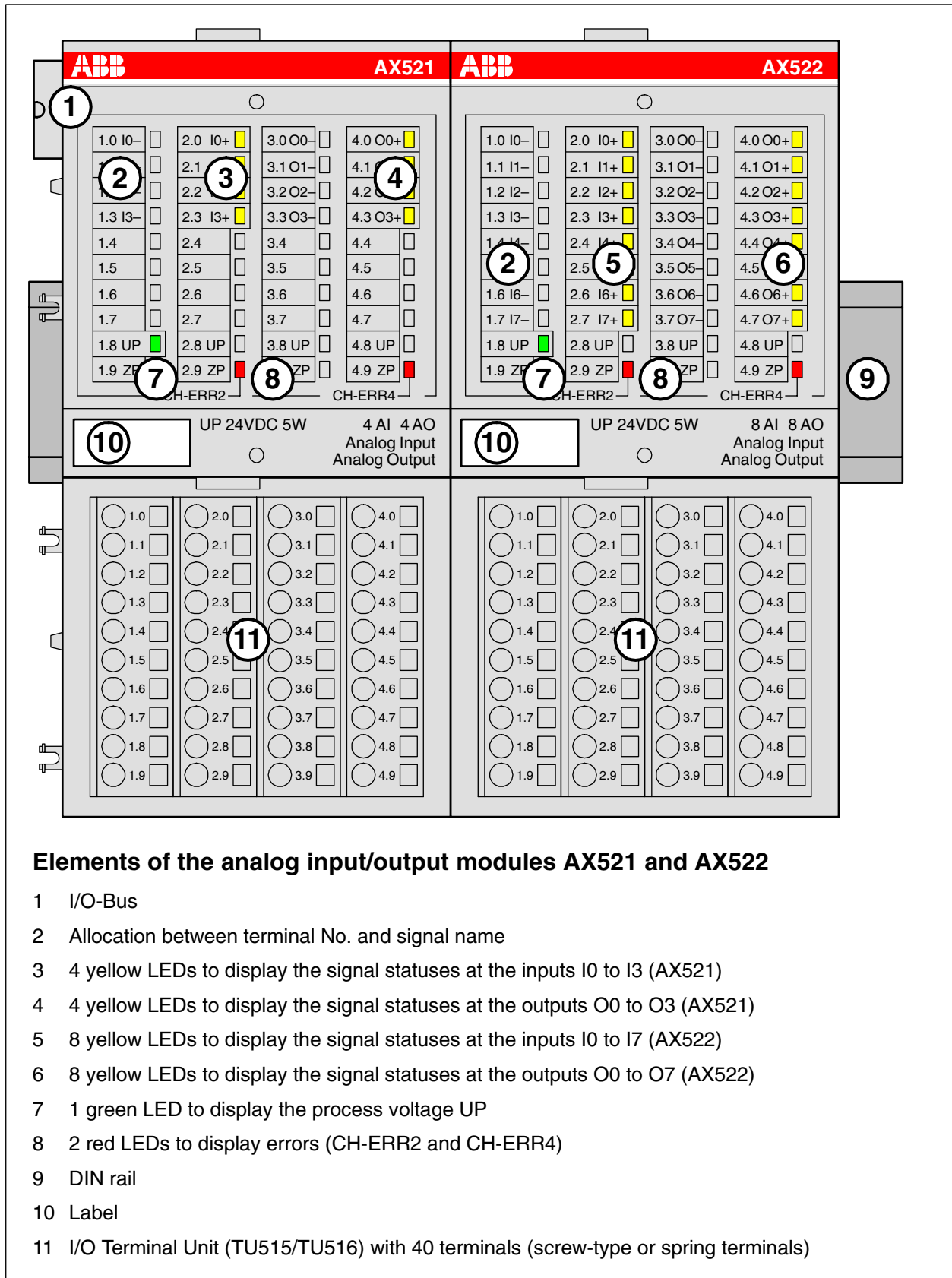


Figure: Analog input/output modules AX521 and AX522, plugged on Terminal Units TU516

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## Intended purpose

The analog input/output modules AX521 and AX522 can be used as remote expansion modules at the FBP Interface Module DC505-FBP, at the CS31 Bus Module DC551-CS31 or locally at an AC500 CPU. They contain 8 or 16 channels each with the following features:

AX521:

- 4 configurable analog inputs in one group (1.0...2.3)
- 4 configurable analog outputs in one group (3.0...4.3)

AX522:

- 8 configurable analog inputs in one group (1.0...2.7)
- 8 configurable analog outputs in one group (3.0...4.7)

The configuration is performed by software.

The modules are supplied with a process voltage of 24 V DC. The analog inputs and outputs are electrically isolated from the rest of the modules' electronics.

## Functionality

<b>AX521: 4 analog inputs, individually configurable for</b>	unused (default setting)
	0...10 V
	-10 V...+10 V
	0...20 mA
<b>AX522: 8 analog inputs, individually configurable for</b>	4...20 mA
	Pt100, -50 °C...+400 °C (2-wire)
	Pt100, -50 °C...+400 °C (3-wire), requires 2 channels
	Pt100, -50 °C...+70 °C (2-wire)
	Pt100, -50 °C...+70 °C (3-wire), requires 2 channels
	Pt1000, -50 °C...+400 °C (2-wire)
	Pt1000, -50 °C...+400 °C (3-wire), requires 2 channels
	Ni1000, -50 °C...+150 °C (2-wire)
	Ni1000, -50 °C...+150 °C (3-wire), requires 2 channels
	0...10 V with differential inputs, requires 2 channels
	-10 V...+10 V with differential inputs, requires 2 channels
	digital signals (digital input)

<b>AX521 and AX522: 4 analog outputs, individually configurable for</b>	unused (default setting)
	-10 V...+10 V
	0...20 mA
	4...20 mA
<b>only AX522: 4 analog outputs, individually configurable for</b>	unused (default setting)
	-10 V...+10 V

Resolution of the analog channels	
- Voltage -10 V... +10 V	12 bits plus sign
- Voltage 0...10 V	12 bits
- Current 0...20 mA, 4...20 mA	12 bits
- Temperature	0.1 °C
LED displays	AX521: 11 LEDs for signals and error messages AX522: 19 LEDs for signals and error messages
Internal power supply	through the expansion bus interface (I/O-Bus)
External power supply	via the terminals ZP and UP (process voltage 24 V DC)

## Electrical connection

The input/output modules are plugged on I/O Terminal Units TU515 or TU516. Properly seat 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 (TA526).

The electrical 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.



**Note:** Mounting, disassembling and electrical connection for the Terminal Units and the I/O modules are described in detail in the S500 system data chapters.

The terminals 1.8 to 4.8 and 1.9 to 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 to 4.8: Process voltage UP = +24 V DC

Terminals 1.9 to 4.9: Process voltage ZP = 0 V

The assignment of the other terminals:

### AX521:

Terminals	Signal	Meaning
1.0 to 1.3	I0- to I3-	Minus poles of the 4 analog inputs
2.0 to 2.3	I0+ to I3+	Plus poles of the 4 analog inputs
3.0 to 3.3	O0- to O3-	Minus poles of the 4 analog outputs
4.0 to 4.3	O0+ to O3+	Plus poles of the 4 analog outputs

**AX522:**

Terminals	Signal	Meaning
1.0 to 1.7	I0- to I7-	Minus poles of the 8 analog inputs
2.0 to 2.7	I0+ to I7+	Plus poles of the 8 analog inputs
3.0 to 3.7	O0- to O7-	Minus poles of the 8 analog outputs
4.0 to 4.7	O0+ to O7+	Plus poles of the 8 analog outputs



**Caution:** The minus poles of the analog inputs are electrically connected to each other. They form an "Analog Ground" signal for the module. The minus poles of the analog outputs are also electrically connected to each other to form an "Analog Ground" signal.



**Caution:** There is no electrical isolation between the analog circuitry and ZP/UP. Therefore, the analog sensors must be electrically isolated in order to avoid loops via the earth potential or the supply voltage.



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



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

**The supply voltage 24 V DC for the modules' electronic circuitry comes from the I/O-Bus of the FieldBusPlug or the CPU.**



**Caution:** Removal of energized modules is not permitted. All power sources (supply and process voltages) must be switched off while working on any AC500 system.

**Analog signals are always laid in shielded cables. The cable shields are earthed at both ends of the cables. In order to avoid unacceptable potential differences between different parts of the installation, low resistance equipotential bonding conductors must be laid.**

For simple applications (low disturbances, no high requirement on precision), the shielding can also be omitted.

The following figure shows the electrical connection of the analog input/output modules AX521 and AX522.

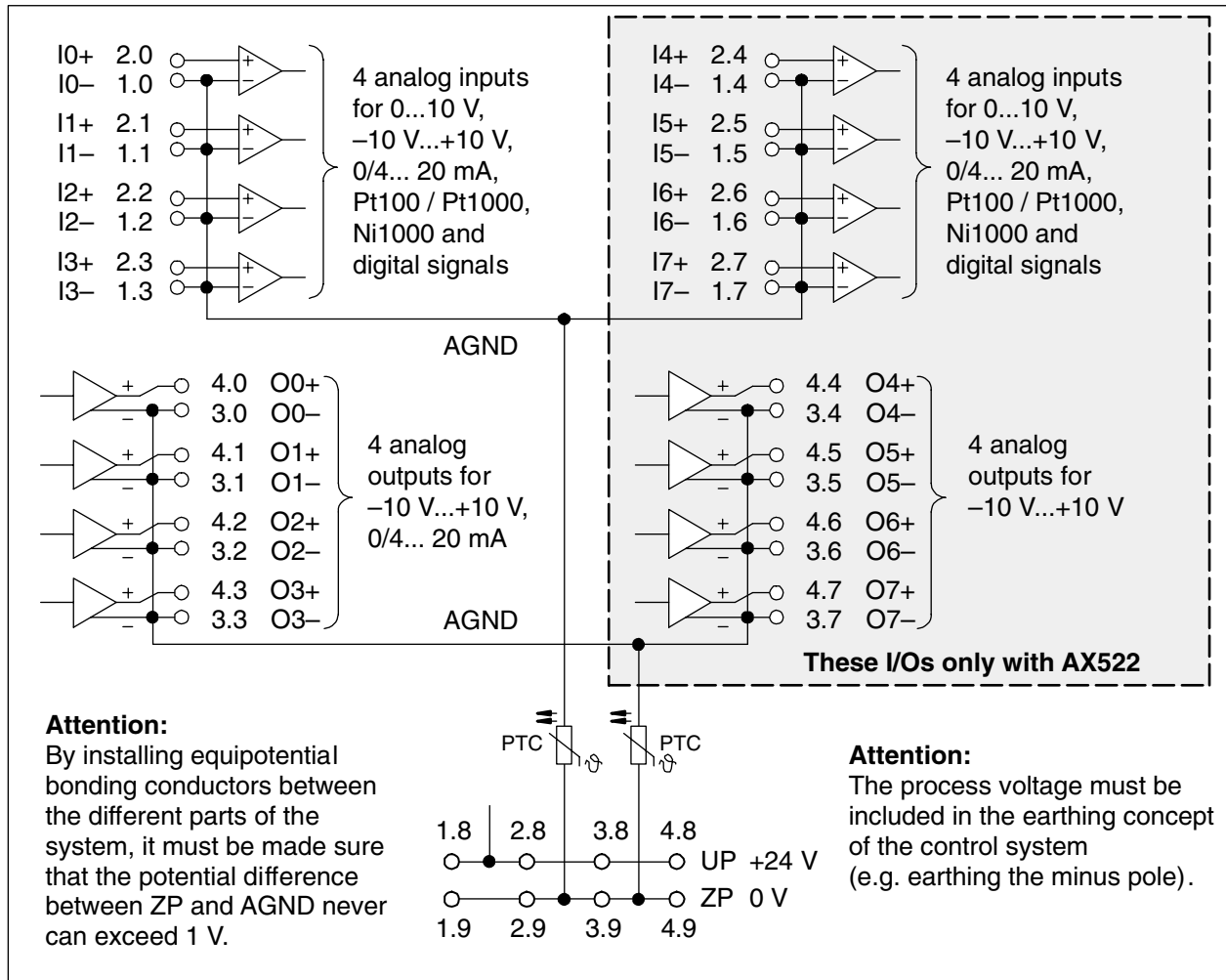


Figure: Terminal assignment of AX521 and AX522

The modules provide several diagnosis functions (see chapter "Diagnosis and display").

## 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 AX521/AX522 provides a constant current source which is multiplexed over the 8 analog channels.

The following figure shows the connection of resistance thermometers in **2-wire configuration**.

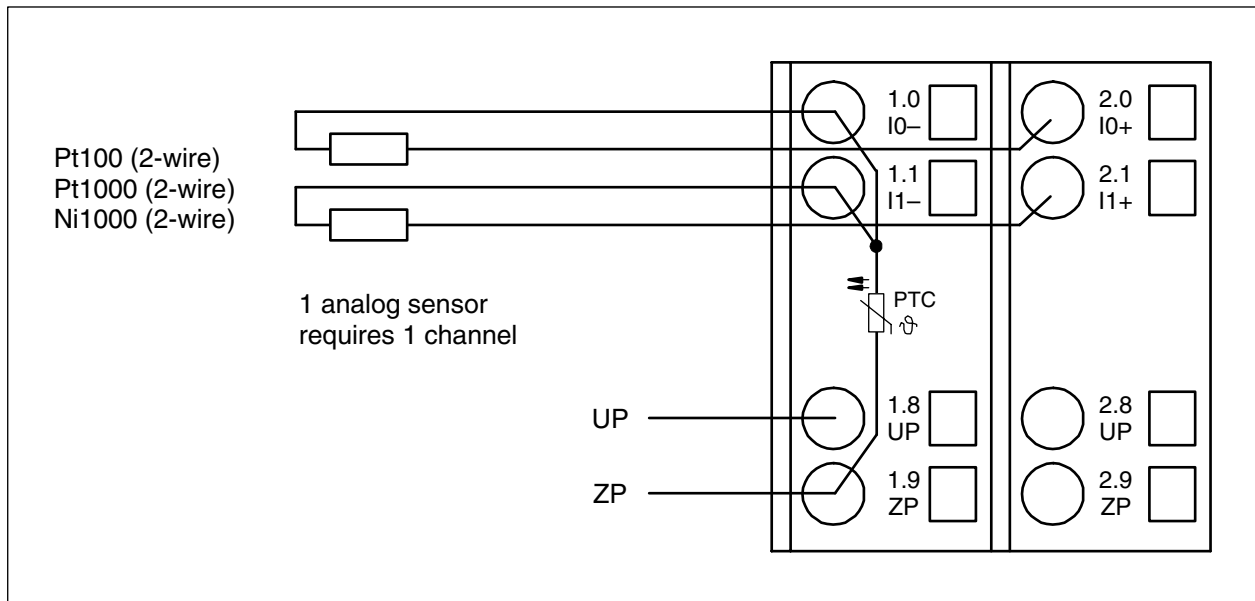


Figure: Connection of resistance thermometers in 2-wire configuration

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of resistances"):

Pt100	-50 °C...+70 °C	2-wire configuration, one channel used
Pt100	-50 °C...+400 °C	2-wire configuration, one channel used
Pt1000	-50 °C...+400 °C	2-wire configuration, one channel used
Ni1000	-50 °C...+150 °C	2-wire configuration, one channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

The modules AX521 and AX522 perform 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 AX521/AX522 provides a constant current source which is multiplexed over the max. 8 (depending on the configuration) analog channels.

The following figure shows the connection of resistance thermometers in **3-wire configuration**.

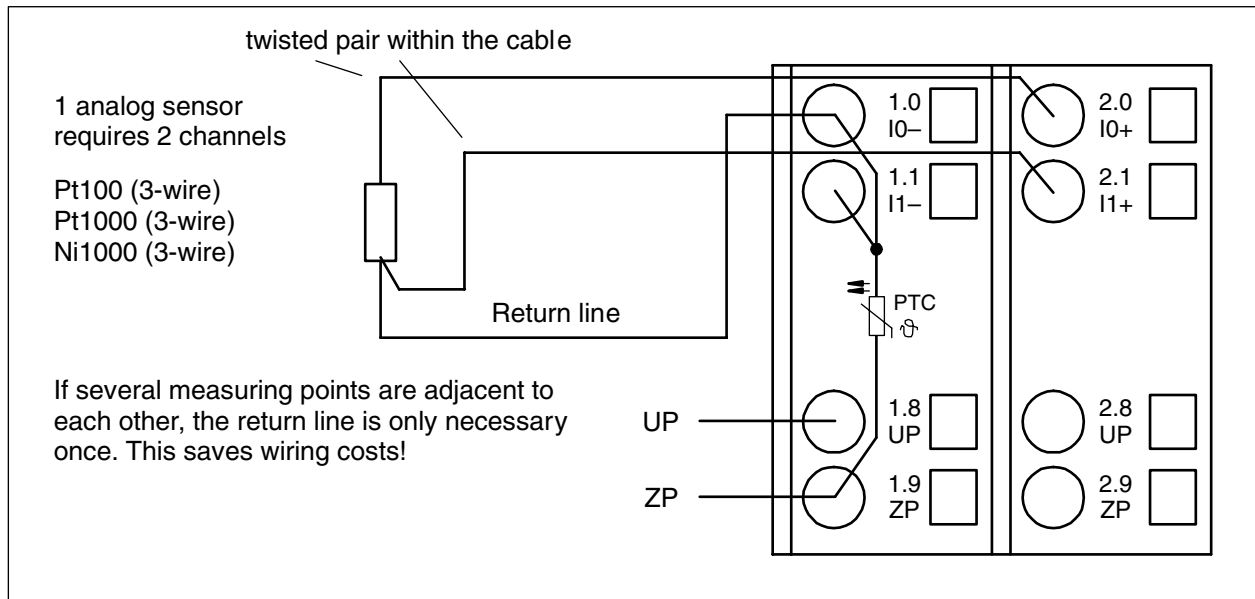


Figure: Connection of resistance thermometers in 3-wire configuration

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 following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of resistances"):

Pt100	-50 °C...+70 °C	3-wire configuration, two channels used
Pt100	-50 °C...+400 °C	3-wire configuration, two channels used
Pt1000	-50 °C...+400 °C	3-wire configuration, two channels used
Ni1000	-50 °C...+150 °C	3-wire configuration, two channels used

The function of the LEDs is described under "Diagnosis and displays / Displays".

The modules AX521 and AX522 perform 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 electrically isolated power supply

The following figure shows the connection of active-type analog sensors (voltage) with electrically isolated power supply.

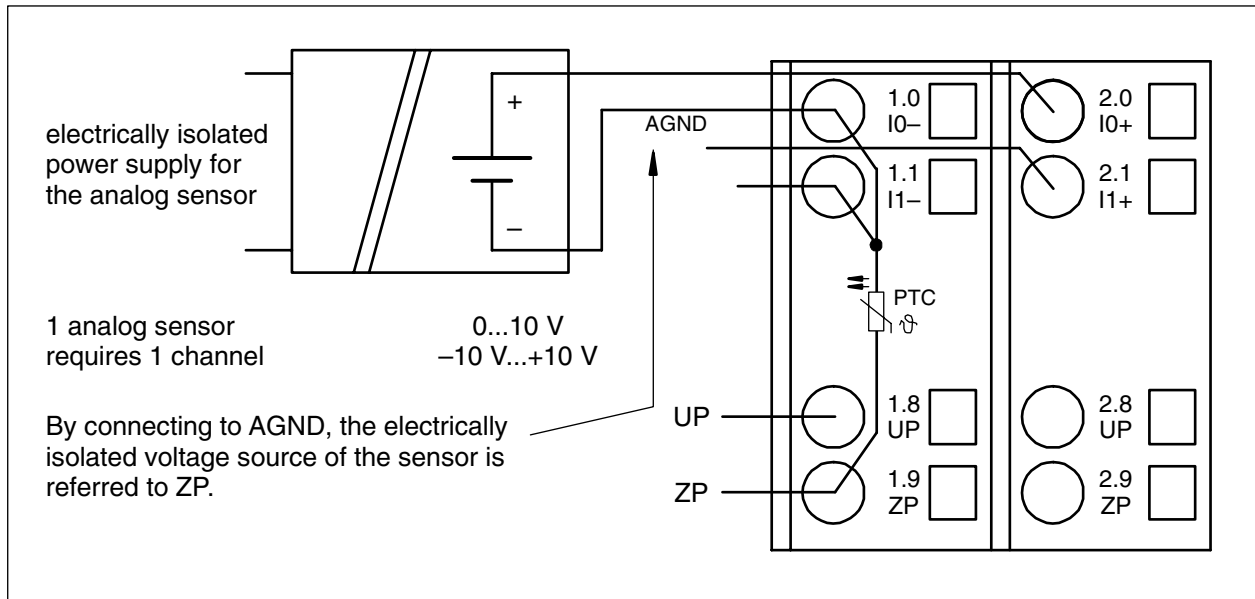


Figure: Connection of active-type analog sensors (voltage) with electrically isolated power supply

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	1 channel used
Voltage	-10 V...+10 V	1 channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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 electrically isolated power supply

The following figure shows the connection of active-type analog sensors (current) with electrically isolated power supply.

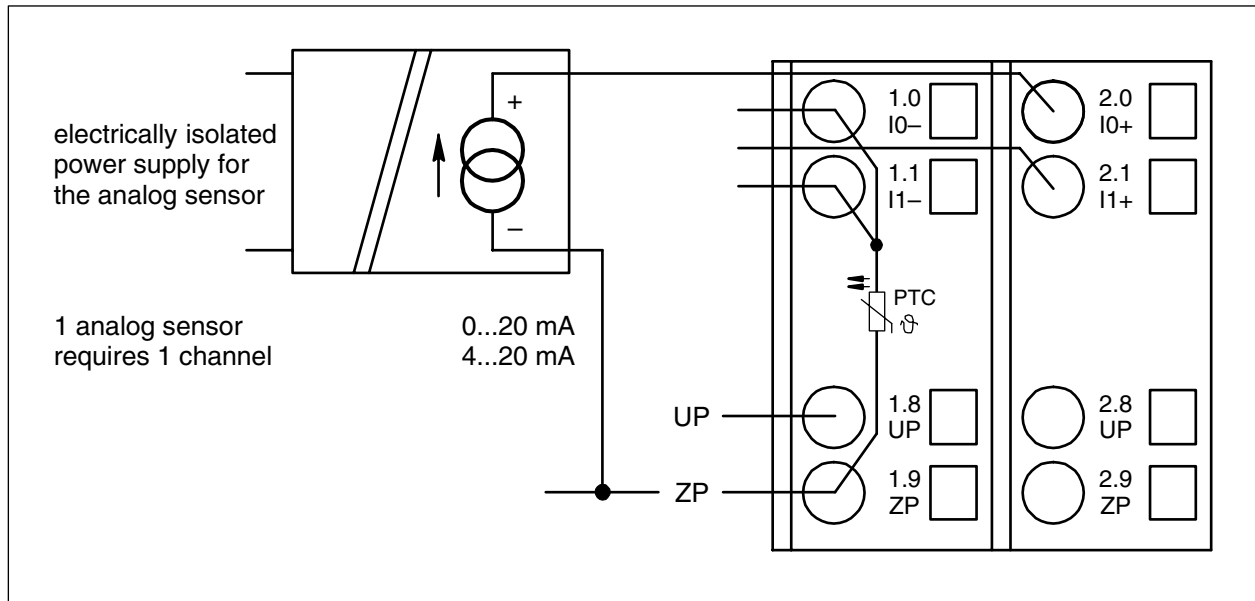


Figure: Connection of active-type analog sensors (current) with electrically isolated power supply

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Current	0...20 mA	1 channel used
Current	4...20 mA	1 channel used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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

## Connection of active-type analog sensors (voltage) with no electrically isolated power supply

The following figure shows the connection of active-type sensors (voltage) with no electrically isolated power supply.

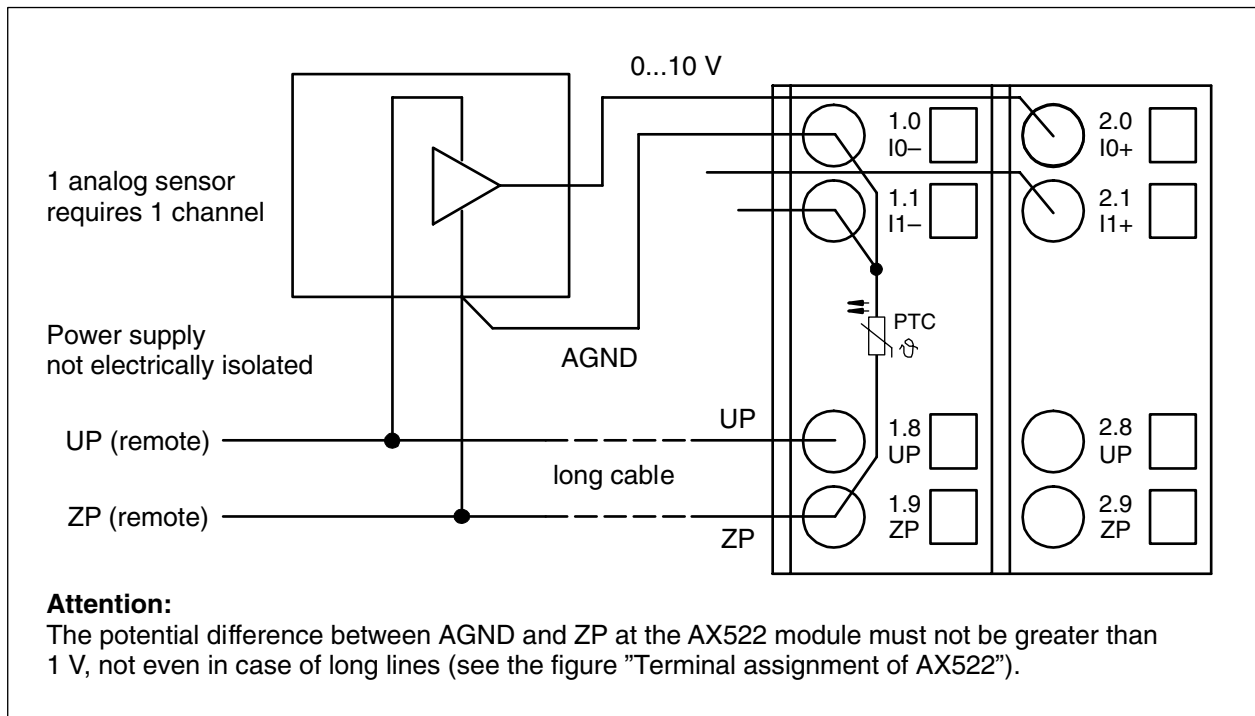


Figure: Connection of active-type sensors (voltage) with no electrically isolated power supply



**Note for the picture:** If AGND does not get connected to ZP, the sensor current flows to ZP via the AGND line. The measuring signal is distorted, since it flows a very little current over 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 has to be preferred.

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	1 channel used
Voltage	-10 V...+10 V *)	1 channel used

\*) if the sensor can provide this signal range

The function of the LEDs is described under "Diagnosis and displays / Displays".

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)

The following figure shows the connection of passive-type analog sensors (current).

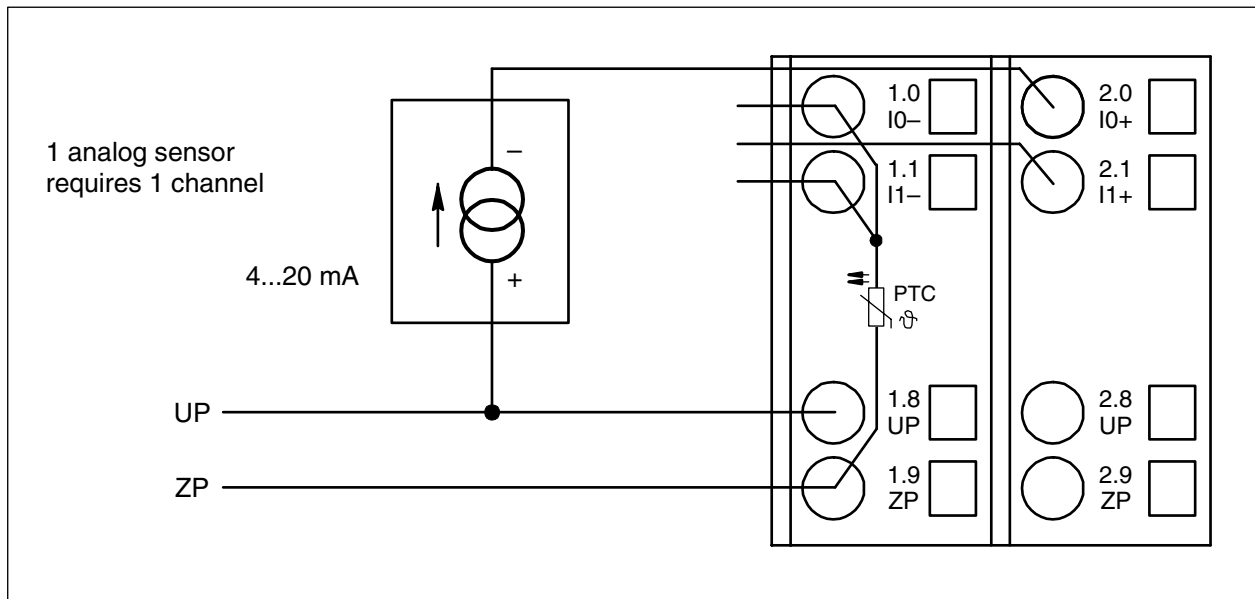


Figure: Connection of passive-type analog sensors (current)

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Current	4...20 mA	1 channel used
---------	-----------	----------------

The function of the LEDs is described under "Diagnosis and displays / Displays".

**⚠ Caution:** If, during initialization, an analog current sensor supplies more than 25 mA for more than 1 second into an analog input, this input is switched off by the module (input protection). In such cases, it is recommended, to protect the analog input by a 10-volt zener diode (in parallel to I+ and I-). But, in general, it is a better solution to prefer sensors with fast initialization or without current peaks higher than 25 mA.

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 are used which are remotely non-isolated (e.g. the minus terminal is remotely earthed).

The evaluation using differential inputs helps to considerably increase the measuring accuracy and to avoid earthing 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).

**!** **Important:** The earthing potential at the sensors must not have a too big potential difference with respect to ZP (max.  $\pm 1$  V within the full signal range). Otherwise problems can occur concerning the common-mode input voltages of the involved analog inputs.

The following figure shows the connection of active-type analog sensors (voltage) to differential inputs.

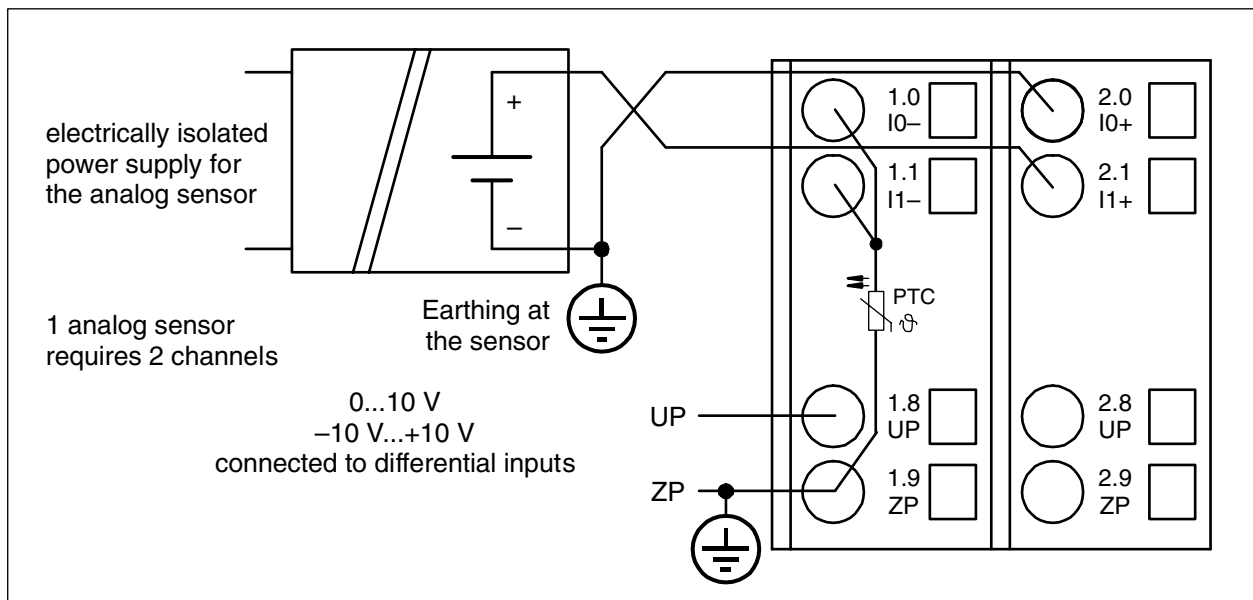


Figure: Connection of active-type analog sensors (voltage) to differential inputs

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Voltage	0...10 V	with differential inputs, 2 channels used
Voltage	-10 V...+10 V	with differential inputs, 2 channels used

The function of the LEDs is described under "Diagnosis and displays / Displays".

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 (see also "Technical Data / Technical data of the analog inputs, if they are used as digital inputs"). The inputs are not electrically isolated against the other analog channels.

The following figure shows the use of analog inputs as digital inputs.

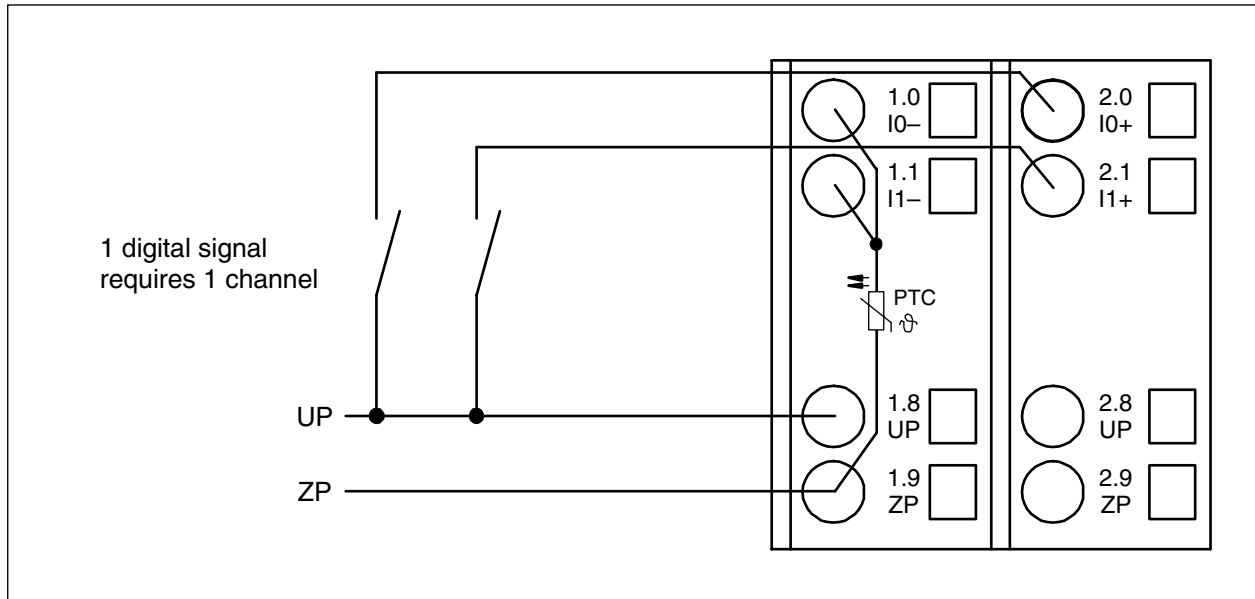


Figure: Use of analog inputs as digital inputs

The following operating mode can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Input ranges of voltage, current and digital input"):

Digital input	24 V	1 channel used
---------------	------	----------------

The function of the LEDs is described under "Diagnosis and displays / Displays".

## Connection of analog output loads (voltage, current)

The following figure shows the connection of analog output loads (voltage, current).

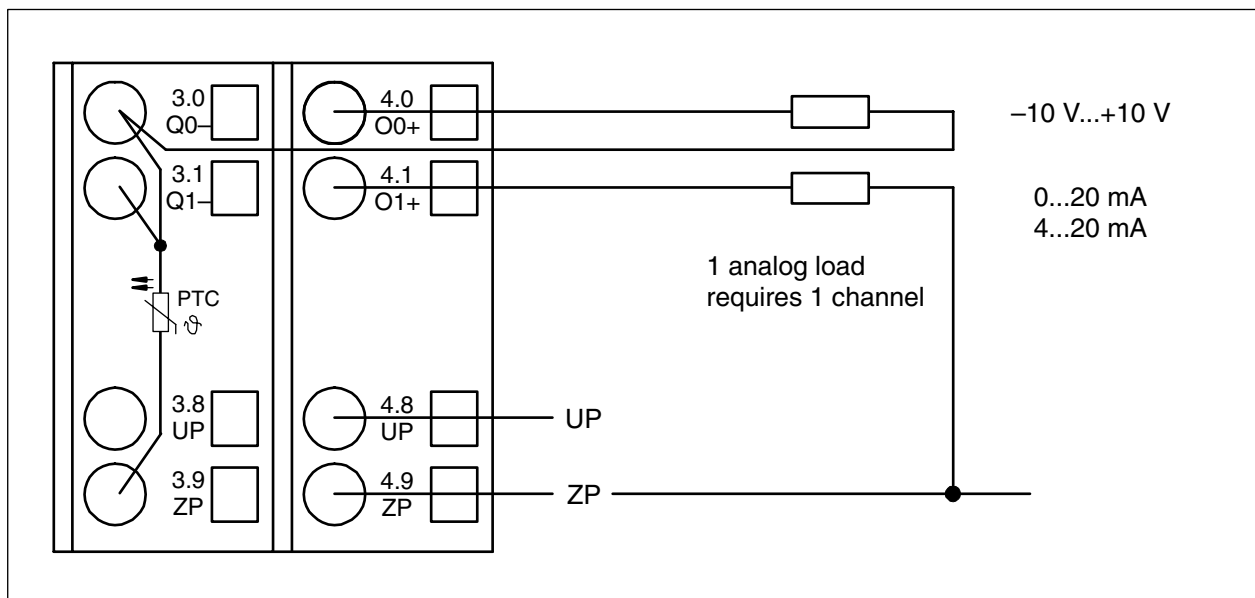


Figure: Connection of analog output loads (voltage, current)

The following measuring ranges can be configured (see also "Parameterization / Channel configuration" and "Measuring ranges / Output ranges of voltage and current"):

Voltage	-10 V...+10 V	Load max. $\pm 10$ mA	1 channel used
Current	0...20 mA	Load 0...500 $\Omega$	1 channel used
Current	4...20 mA	Load 0...500 $\Omega$	1 channel used

Only the channels 0...3 can be configured as current output (0...20 mA or 4...20 mA).

The function of the LEDs is described under "Diagnosis and displays / Displays".

Unused analog outputs can be left open-circuited.

### Internal data exchange

	<b>AX521</b>	<b>AX522</b>
Digital inputs (bytes)	0	0
Digital outputs (bytes)	0	0
Counter input data (words)	4	8
Counter output data (words)	4	8

### I/O configuration

The analog input/output modules AX521 and AX522 do not store configuration data themselves.



## Parameterization

The arrangement of the parameter data is performed by your master configuration software SYCON in connection with the S500 GSD files and in conjunction with the Control 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 AX521:

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Module ID	Internal	1505 *1)	Word	1505 0x05e1	0	65535
2 *2)	Ignore module	No Yes	0 1	Byte	No 0x00		
3	Parameter length in bytes	Internal	21	Byte	21	0	255
4	Check supply	Off On	0 1	Byte	On 0x01		
5	Analog data format	Default	0	Byte	Default 0x00		
6	Behaviour of outputs at communication errors	Off Last value	0 1	Byte	Off 0x00		

\*1) With CS31 and addresses less than 70 and FBP, the value is increased by 1

\*2) Not with FBP

**Module AX522:**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Module ID	Internal	1500 *1)	Word	1500 0x05dc	0	65535
2 *2)	Ignore module	No Yes	0 1	Byte	No 0x00		
3	Parameter length in bytes	Internal	37	Byte	21-CPU 37-FBP	0	255
4	Check supply	Off On	0 1	Byte	On 0x01		
5	Analog data format	Default	0	Byte	Default 0x00		
6	Behaviour of outputs at communication errors	Off Last value	0 1	Byte	Off 0x00		

**GSD file:**

<b>AX521</b>	Ext_User_Prm_Data_Len = Ext_User_Prm_Data_Const(0) =	24 0x05, 0xe2, 0x15, \ 0x01, 0x00, 0x00 \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00;
<b>AX522</b>	Ext_User_Prm_Data_Len = Ext_User_Prm_Data_Const(0) =	40 0x05, 0xdd, 0x25, \ 0x01, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00;

**Input channel (4x with AX521):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *2)	see below *2)	Byte	0 0x00 see below *3)		
2	Channel monitoring	see below *4)	see below *4)	Byte	0 0x00 see below *5)		

**Input channel (8x with AX522):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *2)	see below *2)	Byte	0 0x00 see below *3)		
2	Channel monitoring	see below *4)	see below *4)	Byte	0 0x00 see below *5)		

**- Channel configuration**

*2)	Internal value	Operating modes of the analog inputs, individually configurable
*3)	0	Unused (default)
	1	Analog input 0...10 V
	2	Digital input
	3	Analog input 0...20 mA
	4	Analog input 4...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 *)
		*) 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).

**- Channel monitoring**

*4)	Internal value	Monitoring
*5)	0	Plausibility, open-circuit (broken wire) and short-circuit
	1	Open-circuit and short-circuit
	2	Plausibility
	3	No monitoring

**Output channel 0 (1 channel):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *6)	see below *6)	Byte	see below *7)		
2	Channel monitoring	see below *8)	see below *8)	Byte	see below *9)		
3	Substitute value *10)	0...65535	0...0xffff	Word	0		

**Output channels 1...3 (3 channels with AX521):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *6)	see below *6)	Byte	see below *7)		
2	Channel monitoring	see below *8)	see below *8)	Byte	see below *9)		

**Output channels 1...7 (7 channels with AX522):**

No.	Name	Value	Internal value	Internal value, type	Default	Min.	Max.
1	Channel configuration	see below *6)	see below *6)	Byte	see below *7)		
2	Channel monitoring	see below *8)	see below *8)	Byte	see below *9)		

**- Channel configuration**

*6)	Internal value	Operating modes of the analog outputs, individually configurable
*7)	0	Unused (default)
	128	Analog output -10 V...+10 V
	129	Analog output 0...20 mA (not with the channels 4...7 and 12...15)
	130	Analog output 4...20 mA (not with the channels 4...7 and 12...15)

**- Channel monitoring**

*8)	Internal value	Monitoring
*9)	0	Plausibility, open-circuit (broken wire) and short-circuit (default)
	1	Open-circuit (broken wire) and short-circuit
	2	Plausibility
	3	No monitoring

**- Substitute value**

*10)	Intended behaviour of channel 0 when the control system stops:	Required setting of the module parameter "Behaviour of outputs in case of a communication error"	Required setting of the channel parameter "Substitute value"
	Output OFF	OFF	0
	Last value	Last value	0
	Substitute value	OFF or Last value	1...65535

## Diagnosis and display

Diagnosis:

E1..E4	d1	d2	d3	d4	Identifier 000..063	AC500 display	← Display in
Class	Comp	Dev	Mod	Ch	Err	PS501 PLC browser	
Byte 6 Bit 6..7	-	Byte 3	Byte 4	Byte 5	Byte 6 Bit 0..5	FBP diagnosis block	
Class	Inter- face	De- vice	Mod- ule	Chan- nel	Error identifier	Error message	Remedy
	1)	2)	3)	4)			
<b>Module error AX521 / AX522</b>							
3	14	1..7	31	31	19	Checksum error in the I/O module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	3	Timeout in the I/O module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	40	Different hard-/firmware versions in the module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	43	Internal error in the module	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	36	Internal data exchange failure	Replace I/O module
	11 / 12	ADR	1..7				
3	14	1..7	31	31	9	Overflow diagnosis buffer	New start
	11 / 12	ADR	1..7				
3	14	1..7	31	31	26	Parameter error	Check master
	11 / 12	ADR	1..7				
3	14	1..7	31	31	11	Process voltage too low	Check process voltage
	11 / 12	ADR	1..7				
4	14	1..7	31	31	45	Process voltage is switched off (ON → OFF)	Process voltage ON
	11 / 12	ADR	1..7				
<b>Channel error AX521 / AX522</b>							
4	14	1..7	1	0...3 0...7	48	Analog value overflow or broken wire at an analog input	Check input value or terminal
	11 / 12	ADR	1..7				
4	14	1..7	1	0...3 0...7	7	Analog value underflow at an analog input	Check input value
	11 / 12	ADR	1..7				
4	14	1..7	1	0...3 0...7	47	Short-circuit at an analog input	Check terminal
	11 / 12	ADR	1..7				
4	14	1..7	1	0...3 0...7	48	Analog value overflow at an analog output	Check output value
	11 / 12	ADR	1..7				
4	14	1..7	1	0...3 0...7	7	Analog value underflow at an analog output	Check output value
	11 / 12	ADR	1..7				

1)	In AC500 the following interface identifier applies: 14 = I/O-Bus, 11 = COM1 (e.g. CS31 bus), 12 = COM2. The FBP diagnosis block does not contain this identifier.
2)	With "Device" the following allocation applies: 31 = Module itself, 1..7 = Expansion module 1..7, ADR = Hardware address (e.g. of the DC551)
3)	With "Module" the following allocation applies dependent of the master: Module error: I/O-Bus or FBP: 31 = Module itself; COM1/COM2: 1..7 = Expansion 1..7 Channel error: I/O-Bus or FBP = Module type (2 = DO); COM1/COM2: 1..7 = Expansion 1..7
4)	In case of module errors, with channel "31 = Module itself" is output.

### Displays:

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

**Status of the LEDs** (see also section "Diagnosis LEDs" in the S500 system data)

LED	Status	Color	LED = OFF	LED = ON	LED flashes
inputs 00...03 or 00...07	analog input	yellow	input is OFF	input is ON (brightness depends on the value of the analog signal)	--
outputs 00...03 or 00...07	analog output	yellow	output is OFF	output 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 and initialization successful	module is not initialized correctly
CH-ERR2 CH-ERR4	Channel Error, error messages in groups (analog inputs or outputs combined into the groups 2 and 4)	red red	no error or process voltage is missing	serious error within the corresponding group	error on one channel of the group
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

Range	0...10 V	-10...+10 V	0...20 mA	4...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 : 10.0004	11.7589 : 10.0004	23.5178 : 20.0007	22.8142 : 20.0006		32511 : 27649	7EFF : 6C01
Normal range	10.0000 : 0.0004	10.0000 : 0.0004	20.0000 : 0.0007	20.0000 : 4.0006	ON	27648 : 1	6C00 : 0001
	0.0000	0.0000	0	4	OFF	0	0000
Normal range or measured value too low	-0.0004 -1.7593	-0.0004 : : : -10.0000		3.9994 : 0		-1 -4864 -6912 : -27648	FFFF ED00 E500 : 9400
Measured value too low		-10.0004 : -11.7589				-27649 : -32512	93FF : 8100
Underflow	<0,0000	<-11.7589	<0.0000	<0.0000		-32768	8000

The represented resolution corresponds to 16 bits.

### Input ranges resistance

Range	Pt100 / Pt 1000 -50...70 °C	Pt100 / Pt1000 -50...400 °C	Ni1000 -50...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 : 400.1 °C		4500 : 4001	1194 : 0FA1
			160.0 °C : 150.1 °C	1600 : 1501	0640 : 05DD
	80.0 °C : 70.1 °C			800 : 701	0320 : 02BD
Normal range	70.0 °C : 0.1 °C	400.0 °C : : : 0.1 °C	150.0 °C : : : 0.1 °C	4000 1500 700 : 1	0FA0 05DC 02BC : 0001
	0.0 °C	0.0 °C	0.0 °C	0	0000
	-0.1 °C : -50.0 °C	-0.1 °C : -50.0 °C	-0.1 °C : -50.0 °C	-1 : -500	FFFF : FE0C
	Measured value too low	-50.1 °C : -60.0 °C	-50.1 °C : -60.0 °C	-50.1 °C : -60.0 °C	-501 : -600
Underflow	< -60.0 °C	< -60.0 °C	< -60.0 °C	-32768	8000

## Output ranges voltage and current

Range	-10...+10 V	0...20 mA	4...20 mA	Digital value	
				decimal	hex.
Overflow	0 V	0 mA	0 mA	> 32511	> 7EFF
Measured value too high	11.7589 V	23.5178 mA	22.8142 mA	32511	7EFF
	: 10.0004 V	: 20.0007 mA	: 20.0006 mA	: 27649	: 6C01
Normal range	10.0000 V	20.0000 mA	20.0000 mA	27648	6C00
	: 0.0004 V	: 0.0007 mA	: 4.0006 mA	: 1	: 0001
	0.0000 V	0.0000 mA	4.0000 mA	0	0000
	-0.0004 V	0 mA	3.9994 mA	-1	FFFF
Measured value too low	: -10.0000 V	: 0 mA	: 0 mA	: -6912	: E500
	-11.7589 V	0 mA	0 mA	-27648	9400
Underflow	0 V	0 mA	0 mA	< -32512	< 8100

The represented resolution corresponds to 16 bits.

## Technical data

The system data of AC500 and S500 are valid here. Only additional details are therefore documented below.

Process voltage	
- Rated value	24 V DC
- max. ripple	5 %
- Protection against reversed voltage	yes
- Rated protection fuse on UP	10 A fast
- Electrical isolation	yes, per module
- Current consumption from UP at normal operation	0.10 A + output loads
- Inrush current from UP (at power up)	0.020 A <sup>2</sup> s
- Connections	Terminals 1.8 - 4.8 for +24 V (UP) and 1.9 - 4.9 for 0 V (ZP)
Max. length of analog cables, conductor cross section > 0.14 mm <sup>2</sup>	100 m
Conversion error of the analog values caused by non-linearity, adjustment error at factory and resolution within the normal range	typ. 0.5 %, max. 1 %
Weight	300 g
Mounting position	horizontal or vertical 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 switch-gear cabinet.



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



## Technical data of the analog inputs

Number of channels per module	AX521: 4 AX522: 8
Distribution of channels into groups	AX521: 1 group of 4 channels AX522: 1 group of 8 channels
Connections of the channels I0- to I3- Connections of the channels I0- to I7-	AX521: Terminals 1.0 to 1.3 AX522: Terminals 1.0 to 1.7
Connections of the channels I0+ to I3+ Connections of the channels I0+ to I7+	AX521: Terminals 2.0 to 2.3 AX522: Terminals 2.0 to 2.7
Input type	bipolar (not with current or Pt100/Pt1000/Ni1000)
Electrical isolation	against internal supply and other modules
Configurability	0...10 V, -10...+10 V, 0/4...20 mA, Pt100/1000, Ni1000 (each input can be configured individually)
Channel input resistance	Voltage: > 100 k $\Omega$ , current: ca. 330 $\Omega$
Time constant of the input filter	Voltage: 100 $\mu$ s, current: 100 $\mu$ s
Indication of the input signals	one LED per channel
Conversion cycle	2 ms (for 8 inputs + 8 outputs), with Pt/Ni... 1 s
Resolution	Range 0...10 V: 12 bits Range -10...+10 V: 12 bits + sign Range 0...20 mA: 12 bits Range 4...20 mA: 12 bits
Relationship between input signal and hex code	see tables "Input ranges voltage, current and digital input" and "Input ranges resistance"
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 they are used as digital inputs

Number of channels per module	AX521: max. 4 AX522: max. 8
Distribution of channels into groups	AX521: 1 group of 4 channels AX522: 1 group of 8 channels
Connections of the channels I0+ to I3+ Connections of the channels I0+ to I7+	AX521: Terminals 2.0 to 2.3 AX522: Terminals 2.0 to 2.7
Reference potential for the inputs	Terminals 1.8 to 4.8 (ZP)
Input signal delay	typ. 8 ms, configurable from 0.1 to 32 ms
Indication of the input signals	one LED per channel
Input signal voltage	24 V DC
Signal 0	-30 V...+5 V
Signal 1	+13 V...+30 V

## Technical data of the analog outputs

Number of channels per module	AX521: 4, all channels for voltage and current AX522: 8, all channels for voltage, the first 4 channels also for current
Distribution of channels into groups	AX521: 1 group of 4 channels AX522: 1 group of 8 channels
- Channels O0-...O3- - Channels O0-...O7-	AX521: Terminals 3.0...3.3 AX522: Terminals 3.0...3.7
- Channels O0+...O3+ - Channels O0+...O7+	AX521: Terminals 4.0...4.3 AX522: Terminals 4.0...4.7
Output type	bipolar with voltage, unipolar with current
Electrical isolation	against internal supply and other modules
Configurability	-10...+10 V, 0...20 mA, 4...20 mA (each output can be configured individually), current outputs only channels 0...3
Output resistance (load), as current output	0...500 $\Omega$
Output loadability, as voltage output	max. $\pm 10$ mA
Indication of the output signals	one LED per channel
Resolution	12 bits (+ sign)
Relationship between output signal and hex code	see table "Output ranges voltage and current"
Unused outputs	can be left open-circuited

## Ordering data

Order No.	Scope of delivery
1SAP 250 100 R0001	AX521, Analog input/output module, 4 AI / 4 AO, U/I/Pt100, 12 Bit + sign, 2-wires
1SAP 250 000 R0001	AX522, Analog input/output module, 8 AI / 8 AO, U/I/Pt100, 12 Bit + sign, 2-wires
1SAP 212 200 R0001	TU515, I/O Terminal Unit, 24 V DC, screw-type terminals
1SAP 212 000 R0001	TU516, I/O Terminal Unit, 24 V DC, spring terminals