

## 5.2 Analog Input Module 07 AI 91

8 inputs, configurable for temperature sensors or as voltage inputs,  
24 V DC, CS31 system bus

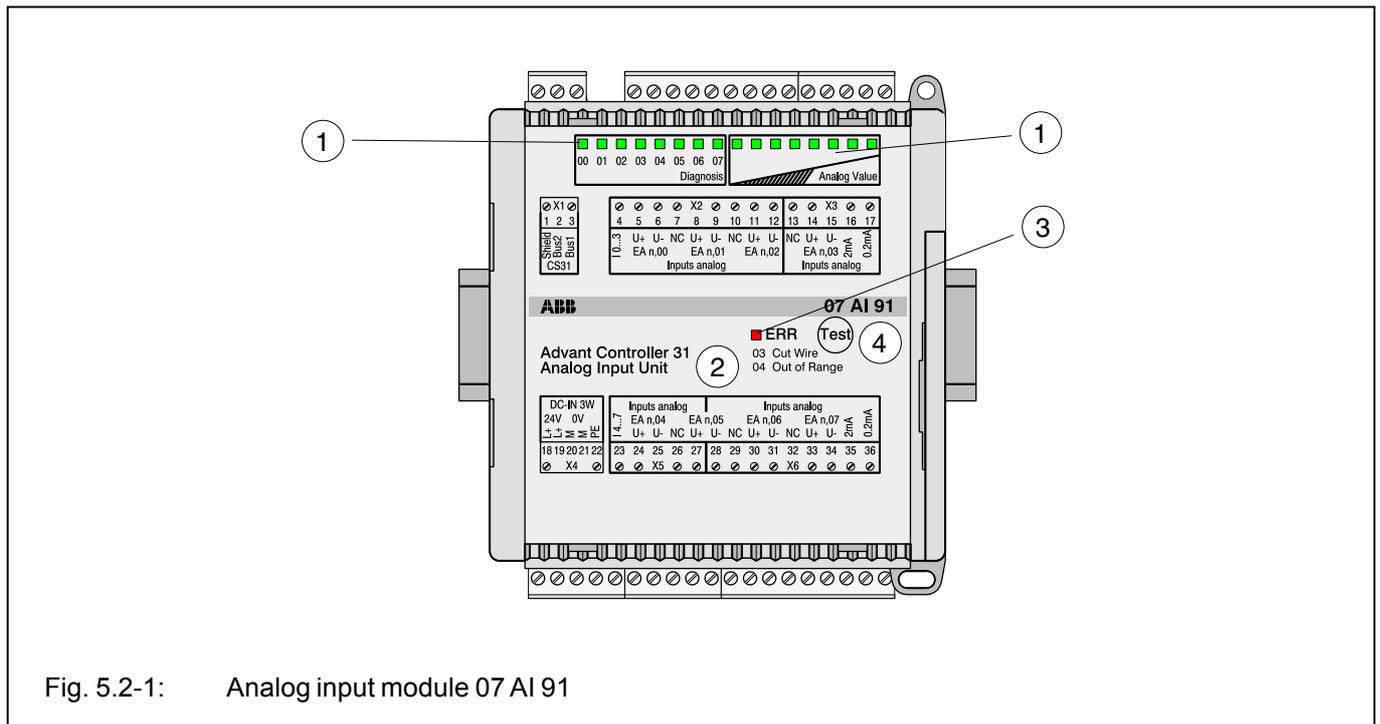


Fig. 5.2-1: Analog input module 07 AI 91

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### Intended purpose

The analog input module 07 AI 91 is used as a remote module at the CS31 system bus. It has 8 analog input channels with the following features:

- The channels can be configured in pairs for the connection of the following temperature or voltage sensors:
  - ± 10 V / ± 5 V / ± 500 mV / ± 50 mV
  - 4...20 mA (with external 250 Ω resistor)
  - Pt100 / Pt1000 with linearization
  - Thermocouples types J, K and S with linearization
  - Only electrically isolated sensors may be used.
- The range of ± 5 V can also be used for measuring 0...20 mA with an additional external 250 Ω resistor.

- The configuration of the input channels as well as the setting of the module address are performed with the DIL switches.

The 07 AI 91 uses **one** module address (group number) in the word input range. Each of the 8 channels use 16 bits. The unit is powered with 24 V DC. The CS31 system bus connection is electrically isolated from the rest of the unit. The module offers a number of diagnosis functions (see chapter "Diagnosis and displays"). The diagnosis functions perform a self-calibration for all channels.

### Displays and operating elements on the front panel

- 8 green LEDs for channel selection and diagnosis, 8 green LEDs for analog value display of one channel
- List of diagnosis information relating to the LEDs, when used for diagnosis display
- Red LED for error messages
- Test button

### Electrical connection

The module is mounted on a DIN rail (15 mm high) or with 4 screws. The following figure shows the electrical connection of the input module.

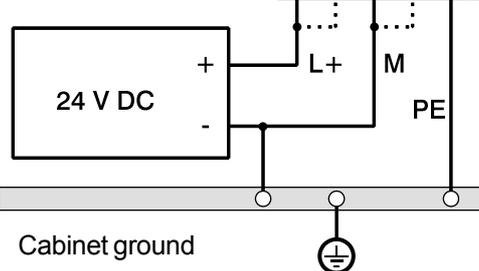
## Connection examples for temperature sensors

The terminals **SHIELD** of the CS31 system bus and **PE** of the power supply have **no** connection inside the module

Electrical isolation

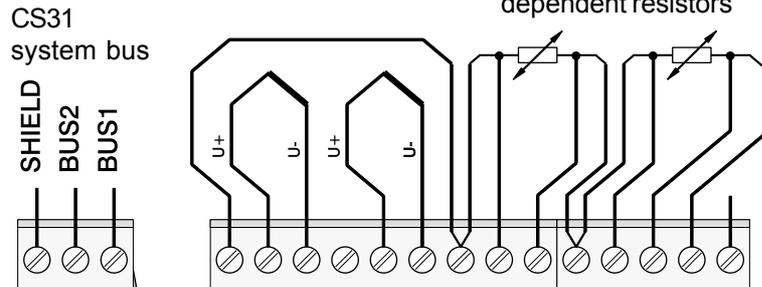
The analog part and the power input (L+ and M) are **not** electrically isolated from each other

DC/DC converter for the supply of the analog part

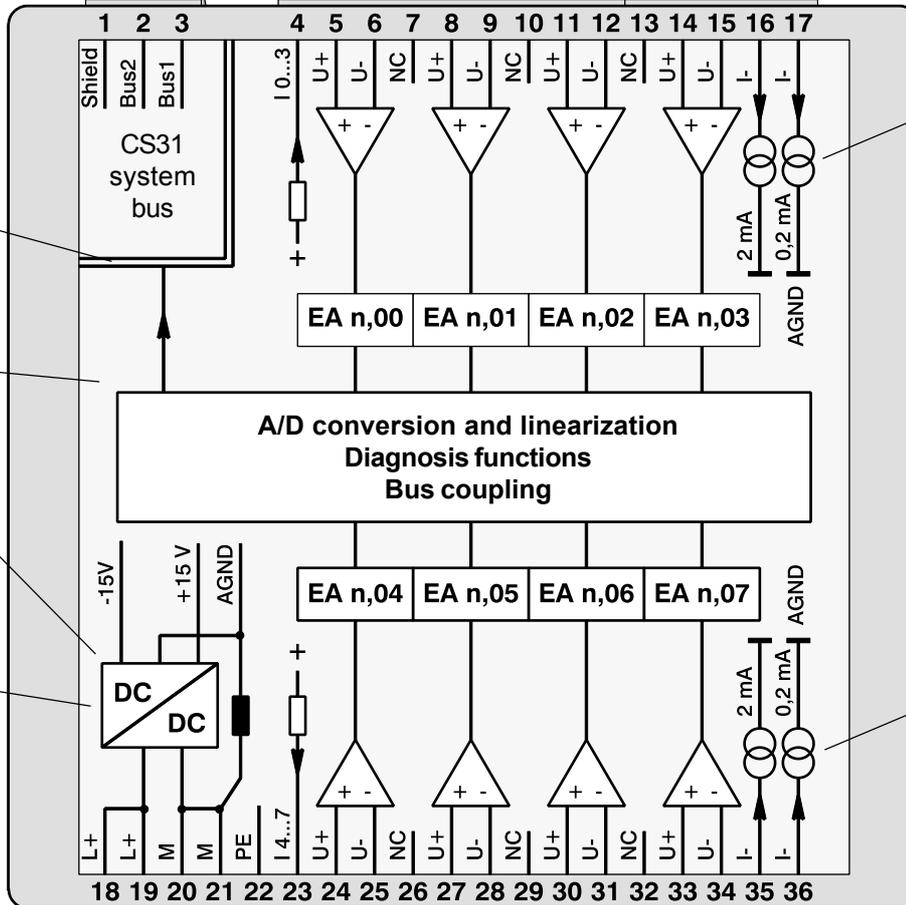


Cabinet ground

**Caution:** The process supply voltage must be included in the grounding concept of the control system (e.g. grounding of the minus terminal)



**Unused channels have to be bridged as follows:**  
**Pt100** with 120 Ω  
**Pt1000** with 1200 Ω  
**others** with jumper wire



Only one of these two current sinks may be used at the same time. The used sink may only be used for channels EA 00...03.

Only one of these two current sinks may be used at the same time. The used sink may only be used for channels EA 04...07.

**Unused channels have to be bridged as follows:**  
**Pt100** with 120 Ω  
**Pt1000** with 1200 Ω  
**others** with jumper wire

**The connections of all temperature and voltage sensors must be electrically isolated from their mounting environment.**

The cable shields of the temperature sensors are grounded to the cabinet at the entry into the cabinet.

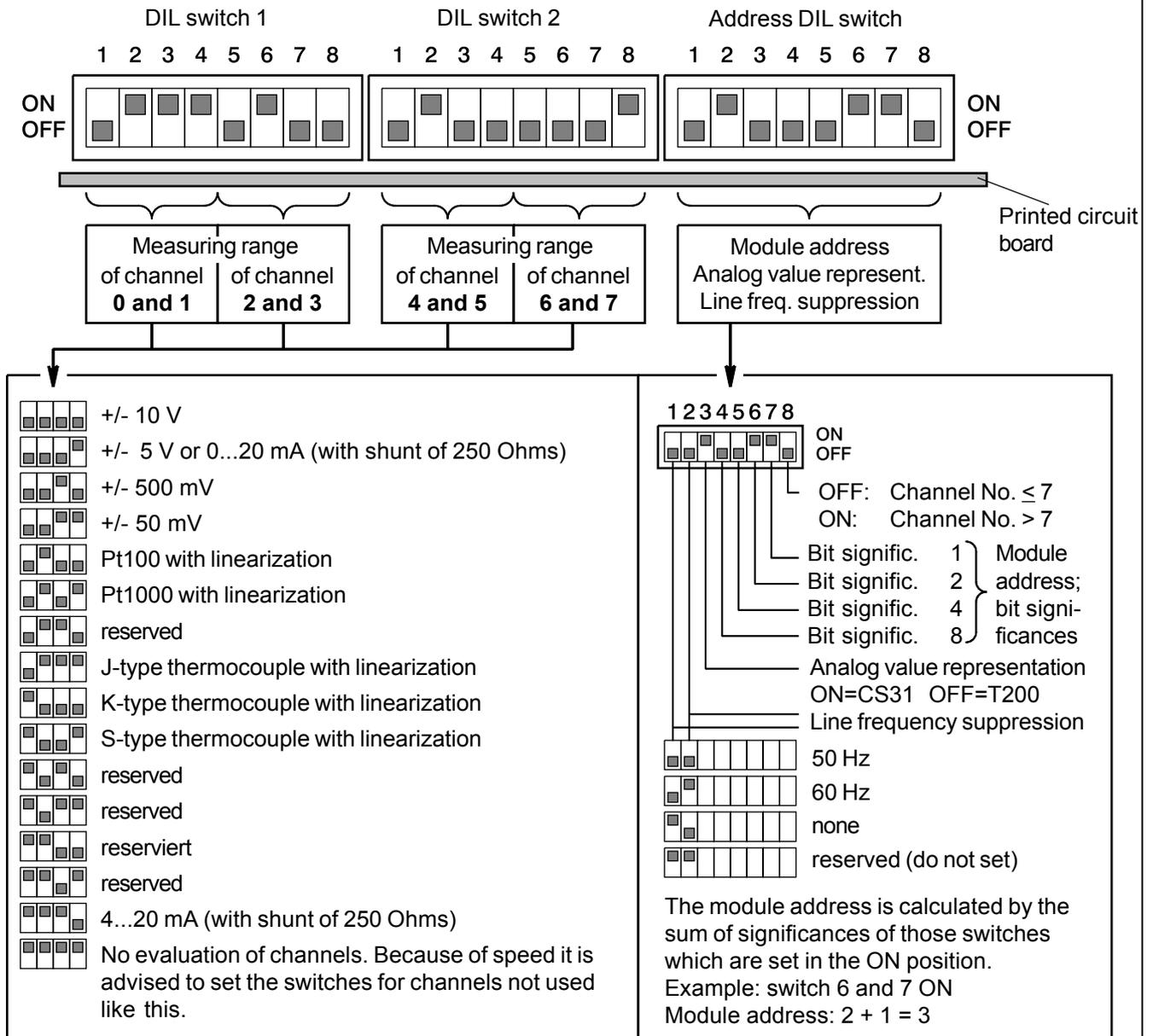
The setting of the module address as well as the configuration of the analog channels are performed with the DIL switches (see next page).

Fig. 5.2-2: Electrical connection of the analog input module 07 AI 91

## Configuration of input channels and setting of the module address at the CS31 bus

The measuring ranges for the analog channels are set in pairs (i.e. always for two channels together) using DIL switches 1 and 2. The setting of address DIL switch determines the module address, the analog value representation and the line frequency suppression (50 Hz, 60 Hz or none).

The switches are located under the slide cover on the right side of the module housing. The following figure shows the possible settings.



Specifications for the platinum temperature sensors are:

<b>Pt100</b>	= platinum 100 Ω at 0 °C	measuring range -50...400 °C	constant current 2 mA
<b>Pt1000</b>	= platinum 1000 Ω at 0 °C	measuring range -50...400 °C	constant current 0.2 mA

Specifications for the thermocouples are:

Type <b>J</b> = <b>Fe-CuNi</b>	0...1200 °C	iron / copper-nickel	+ = Fe	- = CuNi
Type <b>K</b> = <b>NiCr-NiAl</b>	0...1372 °C	nickel-chromium / nickel-aluminium	+ = NiCr	- = NiAl
Type <b>S</b> = <b>Pt10Rh-Pt</b>	0...1600 °C	platinum-10% rhodium / platinum	+ = Pt10Rh	- = Pt

Fig. 5.2-3: Configuration of the input channels and setting of module address at the CS31 system bus

## Measuring ranges of the input channels

All input signals are evaluated as differential signals. The sensor signal is connected with two poles to the inputs U+ and U- (example see Fig. 5.2-2). The relationship between input signal and the output numerical value is shown in figs. 5.2-7 and 5.2-8. All channels not used must be short-circuited (see also bridging of unused channels at Pt100/Pt1000 channels).

**± 10 V / ± 5 V / ± 500 mV / ± 50 mV**

The set measuring range resulting from the A/D conversion is displayed in the following number range:

-32760 ... 0 ... +32760

If input voltages overflow the measuring range, the overflow number of +32767 is output. If the input voltage underflows the measuring range, the underflow number of -32767 is output. In both cases, an error message is sent via the CS31 system bus.

All unused channels must be short-circuited.

### 4...20 mA / 0...20 mA

The following configurations must be set:

Measuring range	Setting
4...20 mA	4...20 mA
0...20 mA	± 5 V

Both channel input terminals must be externally bridged with a shunt of 250 Ω.

Unused inputs for 0...20 mA must be short-circuited. In this case, they do not need a shunt. Unused inputs for 4...20 mA can be circuited in parallel with another 4...20 mA input channel without requiring an extra shunt. In this way, error messages (underflow) can be avoided.

### Pt 100 / Pt 1000

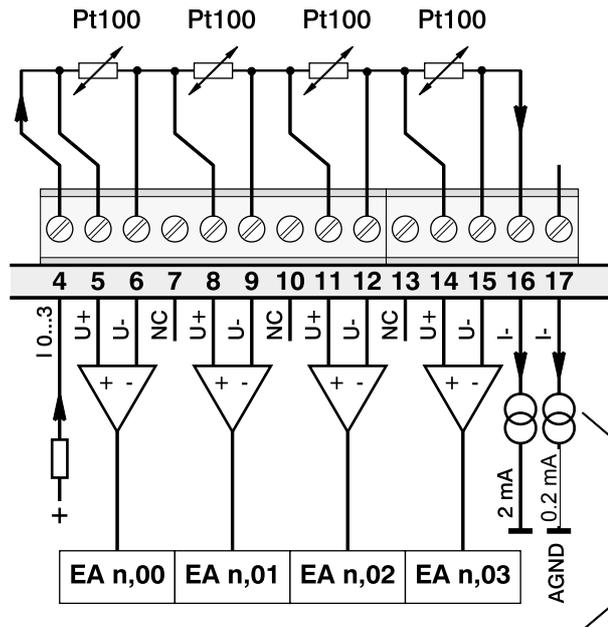
When resistance thermometers are used, a constant current must flow through the shunt to build the necessary voltage drop for the evaluation. For this purpose the module provides two constant current sinks.

The two following figures show the connection of Pt100 and Pt1000 resistance thermometers. In these configurations the module performs a linearization of the Pt100/Pt1000 characteristic curves. The integrated current sinks of 2 mA and 0.2 mA is also considered in these measuring circuits. This way their tolerances are compensated.

The following allocation applies to the constant current sinks:

For resistance thermometers connected to terminals 5 to 15 (channels EA n,00 to EA n,03), only one of the two sinks may be used on terminals 16 or 17 (2 mA or 0.2 mA).

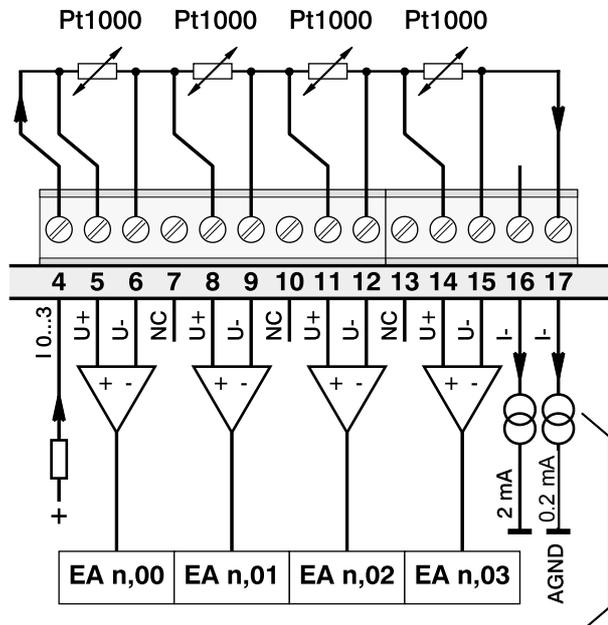
Setting for Pt100 with linearization:



Only one of the two sinks may be used at the same time. The used sink may only be used for channels EA 00...03.

Fig. 5.2-4: Connection of Pt100 sensors

Setting for Pt1000 with linearization:



Only one of the two sinks may be used at the same time. The used sink may only be used for channels EA 00...03.

Fig. 5.2-5: Connection of Pt1000 sensors

For resistance thermometers connected to terminals 24 to 34 (channels EA n,04 to EA n,07), only one of the two sinks may be used for terminals 35 or 36 (2 mA or 0.2 mA).

Simultaneous operation of Pt100 and Pt1000 sensors is possible when one group (i.e. Pt100) is connected to the upper terminal bank and the other (i.e. Pt1000) is connected to the lower terminal bank.

Terminals 7, 10, 13, 26, 29 and 32 (marked NC) can be used as connecting points for the current loop (see also Fig. 5.2-2).

The measuring range of **-50°C...400°C** is assigned linearly to the number range of **-1022...+8190** (see also Figs. 5.2-7 and 5.2-8).

If input voltages overflow the measuring range, the overflow number of +32767 is output. If the input voltage underflows the measuring range, the underflow number of -32767 is output. In both cases, an error message is sent via the CS31 system bus.

In case of open circuit (wire break in the current loop), the numeric value of -32767 is displayed. In case of wire breakage (in a sensor circuit), the numeric value +32767 is displayed. Both cases cause an error message via the CS31 system bus.

If unused Pt100/Pt1000 channels are bridged, the wire bridge simulates 0 Ω, the measuring value for very low temperature. This causes the error message "range underflow". To avoid such error messages, bridge unused Pt100/Pt1000 channels as follows:

- Pt 100 with a resistor of 120 Ω
- Pt 1000 with a resistor of 1200 Ω

### Connection of other temperature-dependent resistors

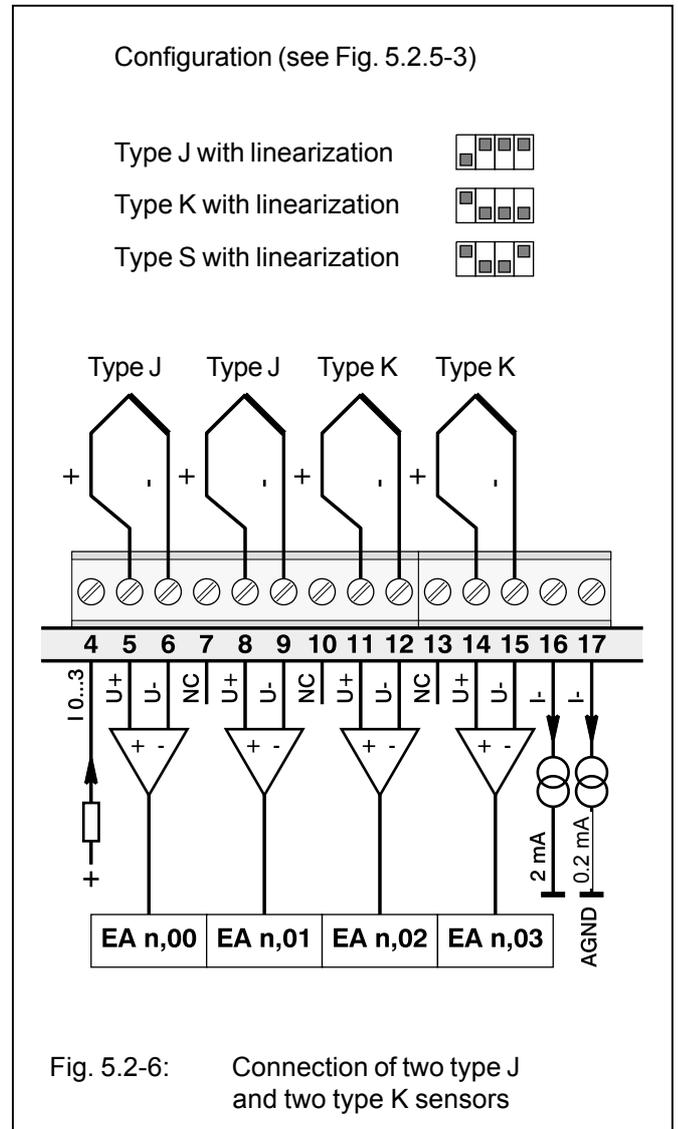
Basically all temperature-dependent resistors can be connected in place of the Pt100/Pt1000 sensors. For a configuration you can use the settings  $\pm 5\text{ V}$ ,  $\pm 500\text{ mV}$  and  $\pm 50\text{ mV}$ . If necessary, the linearization of the resistance characteristic must be performed in the PLC user program. The integrated current sinks can be used, however, consider the following:

- The voltage drop of all resistors connected in series must not exceed
  - 7 V** (when using the current sink of 0.2 mA),
  - 2,5 V** (when using the current sink of 2 mA)
- The tolerance of the integrated current sinks of  $\pm 1.5\%$  must be considered in the tolerance calculations for the temperature measurement (no compensation as for Pt100/Pt1000).

### Thermocouples types J, K, and S

Thermocouples are connected to terminals U+ and U-, either directly or via compensating wires to both poles. Be sure to observe polarity.

The reference junction temperature sensor is integrated in the module near the terminals. When evaluating the absolute temperature, the terminals are considered as the reference junction.



The thermoelectric voltage generated by the thermocouples is converted into binary values inside the module and then linearized according to the thermocouple type. In order to get the absolute temperature, the temperature of the reference junction is added.

The measuring value is allocated linearly to the numeric values as follows (see also Figs. 5.2-7 and 5.2-8):

- Type J:**    0°C...1200°C number range    0...24576
- Type K:**    0°C...1372°C number range    0...28096
- Type S:**    0°C...1600°C number range    0...32760

If input voltages overflow the measuring range, the overflow number of +32767 is output. If the input voltage underflows the measuring range, the underflow number of -32767 is output. In both cases, an error message is sent via the CS31 system bus. Temperatures below 0°C are considered as "underflow".

A wire break will cause the numerical value of -32767 as well as an error message via the CS31 system bus.

All channels not used must be short-circuited.

Note:

Since L type thermocouples (iron/constantan, Fe-CuNi according to DIN 43710) are similar to J type thermocouples, they also can be used in the temperature range of 0...900 °C. The slightly greater thermo emf generated by the L type thermocouple, however, pretends a little higher temperature. The following table illustrates this fact (all temperature data is referred to a reference temperature of 0 °C):

Temperature at the measuring point	Temperature evaluated by the module, if an L type thermocouple is used instead of a J type thermocouple
25 °C	25.63 °C
50 °C	51.23 °C
100 °C	101.89 °C
200 °C	203.13 °C
400 °C	405.69 °C
600 °C	609.78 °C
900 °C	920.41 °C

## Configuration of unused channels

No evaluation of the channels



Compare with configuration, Fig. 5.2-3

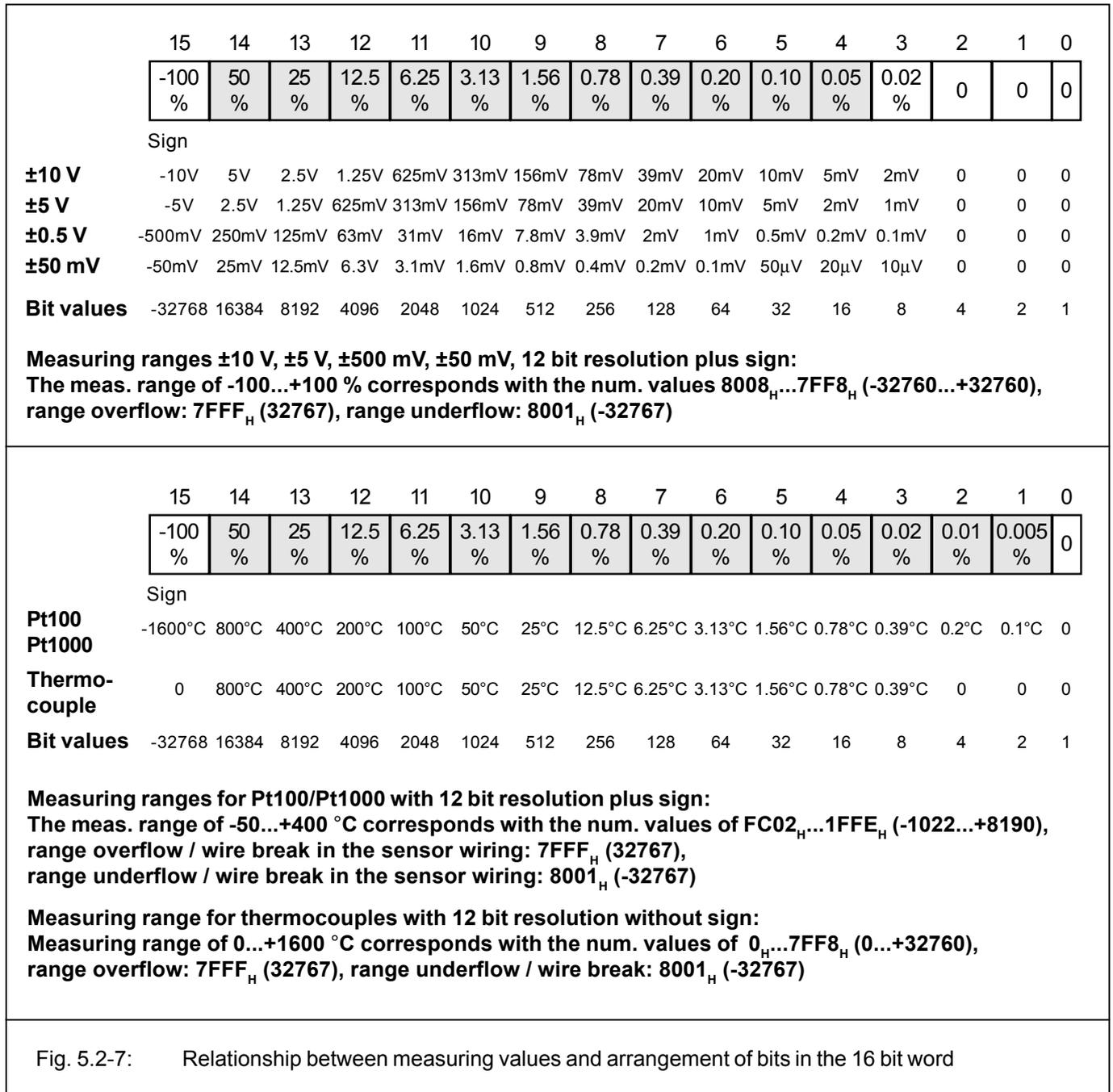
If the channels (in pairs) are not needed, we suggest to exclude them from the evaluation (acquisition of measuring values and processing within the software). The processing of the remaining channels is then faster. Unused channels must be short-circuited.

**Relationship between measuring values and the location of bits in a 16 bit word**

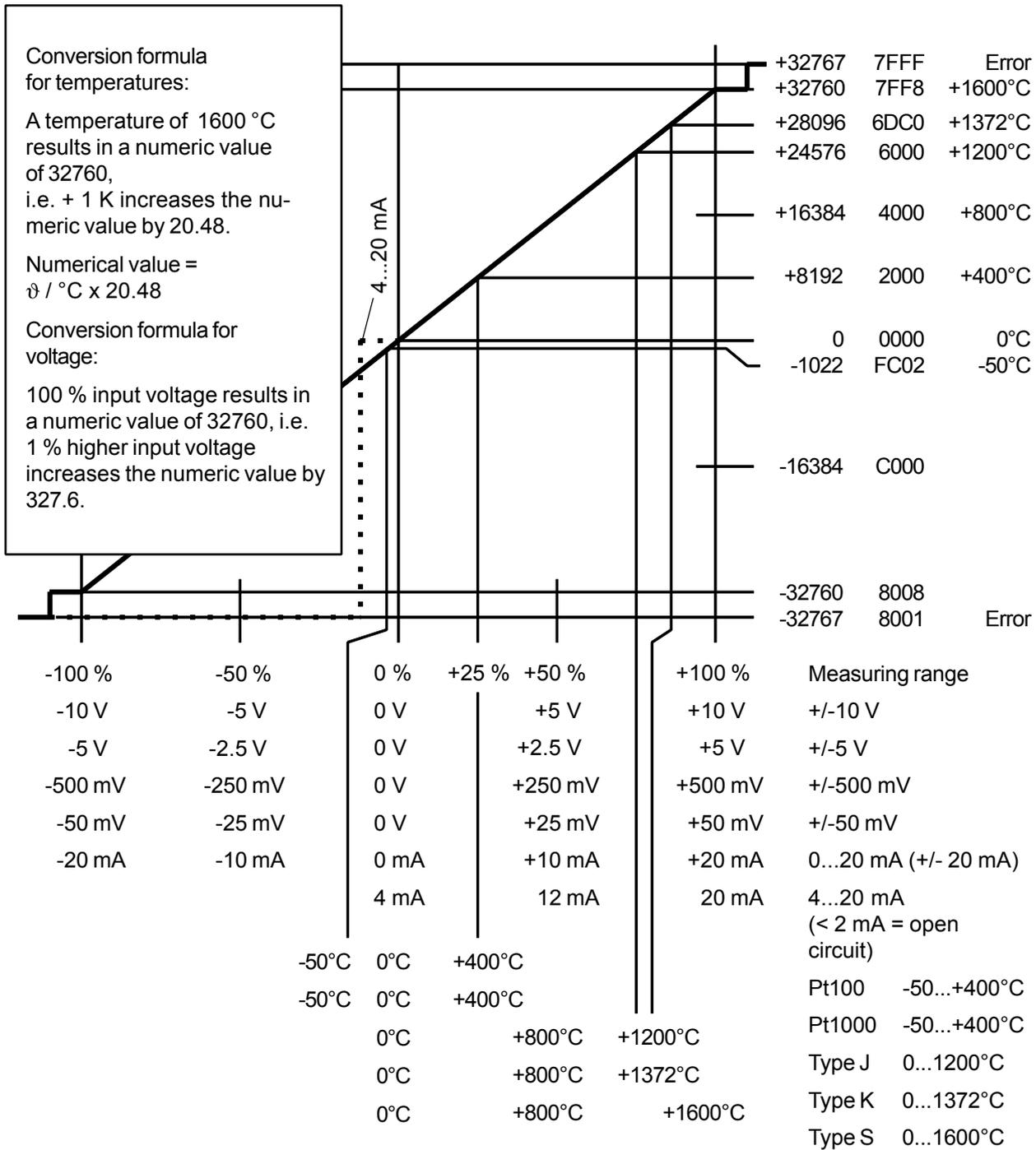
The measuring ranges for analog channels are configured in pairs (always together for two channels, see Fig. 5.2-3). When above or below a measuring range (out of range) or

when recognizing an open circuit, the numerical values +32767 or -32767 respectively will be displayed.

The following two illustrations show the evaluation functions of the module.



## Relationship between measuring value and numerical value, voltage and temperature inputs



Specifications for platinum resistance thermometers are:

**Pt100** = platinum 100 Ω bei 0 °C measuring range -50...400 °C

constant current 2 mA

**Pt1000** = platinum 1000 Ω bei 0 °C measuring range -50...400 °C

constant current 0.2 mA

Specifications for thermocouples (pairs) are:

Type J = **Fe-CuNi** 0...1200 °C iron / copper-nickel

+ = Fe - = CuNi

Type K = **NiCr-NiAl** 0...1372 °C nickel-chromium / nickel-aluminium

+ = NiCr - = NiAl

Type S = **Pt10Rh-Pt** 0...1600 °C platinum-10% rhodium / platinum

+ = Pt10Rh - = Pt

Fig. 5.2-8: Relationship between measuring value and numerical value

## Addressing

Each module must have an address installed to enable the central unit to correctly access the inputs and outputs.

**A detailed description about "Addressing" can be found in the chapter "Addressing" for the central processing unit and couplers.**

The address setting must be performed at the DIL switch under the slide cover on the right side of the module housing (see Fig. 5.2-3). If central units 07 KR 91, 07 KT 9x are used as bus master, the following address allocations apply:

Central units      07 KR 91 / 07 KT 9x			
The address switch DIL No. 8 is set to <b>OFF</b> :			
Channel	Address in PLC program	Channel	Address in PLC program
EA n,00	EW n,00	EA n,04	EW n,04
EA n,01	EW n,01	EA n,05	EW n,05
EA n,02	EW n,02	EA n,06	EW n,06
EA n,03	EW n,03	EA n,07	EW n,07
The address switch DIL No. 8 is set to <b>ON</b> :			
Channel	Address in PLC program	Channel	Address in PLC program
EA n,00	EW n,08	EA n,04	EW n,12
EA n,01	EW n,09	EA n,05	EW n,13
EA n,02	EW n,10	EA n,06	EW n,14
EA n,03	EW n,11	EA n,07	EW n,15
n: Group number of address, set with address DIL switch with switches 5...8. Addresses for 07 KR 91 / 07 KT 92 / 07 KT 93 as bus master: 00...05, as of 07 KT 94: 00...05 and 08...15.			

The module uses 8 analog inputs at the CS31 system bus.

## Normal operation

- The module initializes automatically after the power has been switched on. During this time all LEDs are switched on.

- If the CS31 system bus does not yet run, the red error LED will flash. Should an error occur during initialization, the error LED will also light up.

## Diagnosis and displays

Module 07 AI 91 offers the following diagnosis functions:

- Detection of open circuit at connection for Pt100/ Pt1000 resistance thermometers or thermocouples
- Storing and making this information available when recalled (kind of error and error location)
- Recognition of an internal module error
- Recognition of a transmission error

If one of these errors occur, the red Error LED will light up. **The error message is then sent to the central unit or to the coupler.**

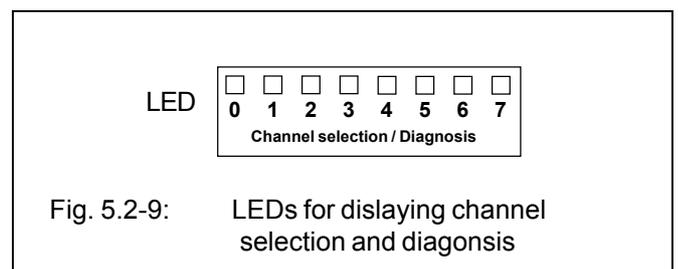
For central units 07 KR 91 / 07 KT 9x the errors will be displayed as follows:

- Open circuits (cut wire)
 

Error class 4	(FK4)	M 255.14
Error number:	09	-> MW 255.08
Unit type:	01	-> MW 255.09
Group number:		-> MW 255.10
Channel number:		-> MW 255.11
- Range exceeded (out of range)
 

Error class 4	(FK4)	M 255.14
Error number:	10 dec.	-> MW 255.08
Unit type:	01	-> MW 255.09
Group number:		-> MW 255.10
Channel number:		-> MW 255.11

Using the test button, all diagnosis functions can be separately selected for each channel. Pressing the test button for the first time selects channel 0 and LED 0 will flash.



When releasing the test button, the error information for this channel is displayed by the green LEDs 0 to 7 for about 3 seconds.

Explanation of LEDs when lighting up:

- 0 not used
- 1 not used
- 2 not used
- 3 Open circuit (cut wire)
- 4 Range exceeded (out of range)
- 5 not used
- 6 not used
- 7 not used

Explanations for the LEDs ② are also printed on the front panel.

The error messages at the module and at the central unit go out as soon as the error has been corrected, when no more faults have been detected **and** when the error correction has been acknowledged.

**Acknowledgement of an error after error correction:**

- by pressing the test button for about 5 seconds, or
- using the PC, or
- using the PLC program of the central unit.

With each pressing and releasing of the test button, the procedure is repeated for the other input channels.

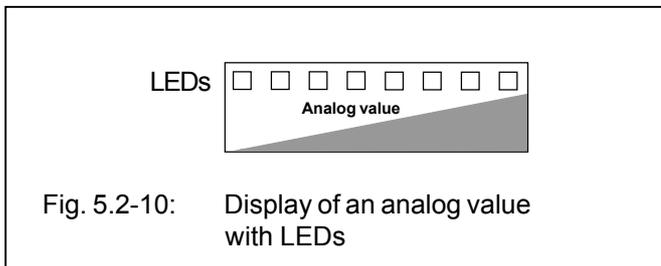
After checking the last channel by again pressing the test button, an LED test is performed. All LEDs of the module must light up. After that, the setting of the address DIL switch (module address at the CS31 system bus) is displayed for about 5 seconds. LED 0 shows the position of switch 1 (LEDs 0...7 are assigned to switches 1...8).

**Display of an analog value**

When the test button is not pressed, 8 LEDs display the analog value of the selected channel.

Explanation:

- all LEDs OFF -> minimum value
- all LEDs ON -> maximum value



Minimum and maximum values are:

Configuration	Min. value all LEDs OFF	Max. value all LEDs ON
+/- 10 V	-10 V	+10 V
+/- 5 V	-5 V	+5 V
+/- 500 mV	-500 mV	+500 mV
+/- 50 mV	-50 mV	+50 mV
+/- 20 mA	-20 mA	+20 mA
0 V / 0 mA = 4 LEDs ON		
4...20 mA	4 mA	20 mA
12 mA = 4 LEDs ON		
Pt100 Pt1000	-50 °C -50 °C	+400 °C +400 °C
0 °C = 1 LED ON		
Thermoc. type J Thermoc. type K Thermoc. type S	0 °C 0 °C 0 °C	+1600 °C +1600 °C +1600 °C
800 °C = 4 LEDs ON		
Fig. 5.2-11: Min. and max. values for analog display		

## Technical Data for 07 AI 91

In general, the technical system data listed under "System data and system configuration" in chapter 1 of volume 2 of the "Advant Controller 31" system description are valid. Additional data or data which are different from the system data are listed as follows.

### Technical data for the complete module

Permissible temperature range during operation	0...55 °C
Rated supply voltage	24 V DC
Max. current consumption	max. 0.15 A
Max. power dissipation	max. 3 W
Protection against reversed polarity of power connection	yes
Conductor cross section for the removable connectors	max. 2.5 mm <sup>2</sup>
Number of analog input channels	8
Electrical isolation	CS31 system bus interface from the rest of the unit
Addressing and configuration	Coding switch under right housing cover
Diagnosis	see chapter "Diagnosis and displays"
Operation and error displays	total of 17 LEDs, see chapter "Diagnosis and displays"

### Technical data for analog inputs (applies to all settings)

Number of channels per module	8 (each configurable in pairs)
Electrical isolation	from CS31 system bus
Line frequency suppression	can be configured for 50 Hz, 60 Hz, or none
Input delay	0 (no RC combination)
Line frequency hum suppression (software filter)	20.0 ms at 50-Hz suppression 16.7 ms at 60-Hz suppression
Permissible input overvoltage	max. +/- 30 V
Updating period per channel incl. input delay and conversion time	
- suppression 50/60 Hz	typ. 100 ms
- no suppression	typ. 30 ms
- when using thermocouples and suppression 50/60 Hz	typ. 150 ms

The total updating time is reduced when not all channels are used (configuration see Fig. 5.2-3).

### Voltage inputs

Input resistance	> 1 MΩ
Measuring ranges (nominal values)	+/- 10 V, +/- 5 V, +/- 500 mV, +/- 50 mV
Resolution	12 bit + sign
Total error	≤ ±0.5 % of full scale
Channels not used	must be bridged

## Current inputs 0...20 mA / 4...20 mA

By bridging the input terminals with a shunt, the voltage input can also be used for input currents. The following specifications are valid:

Current range	0...20 mA	4...20 mA
Selected measuring range	+/- 5 V	4...20 mA
Required external shunt	250 $\Omega$	250 $\Omega$
Destruction limits of the shunt	depends on its load capabilities	
Total error	$\leq \pm 0.5$ % of full scale $\pm$ tolerance of the shunt	
Channels not used	must be bridged	

## Pt100/Pt1000 input

Evaluation range with linearization	-50°C...+400°C	
Resistance of the sensors within the evaluation range		
Pt100	80.31 $\Omega$ ...247.04 $\Omega$	
Pt1000	803.1 $\Omega$ ...2470.4 $\Omega$	
Resolution	12 bit + sign (1 LSB = 0.1°C)	
Permissible total line resistance of both current-carrying lines	max. 50 $\Omega$ per sensor (in 4-wire configuration)	
Evaluation error within the range of -50...+400°C (linearity, linearization, temperature range, resolution, adjustment)	Pt100:	+/- 0.5 % of full scale
	Pt1000:	+/- 1.0 % of full scale
Constant current sinks for the sensors		
Pt100	2 mA	
Pt1000	0.2 mA	
Power dissipation in the sensor		
Pt100	meas. value = 0°C	0.4 mW
	meas. value = 400°C	1.0 mW
Pt1000	meas. value = 0°C	0.04 mW
	meas. value = 400°C	0.1 mW
No-load voltage of the current output	< +15 V	
Permissible total voltage drop at the sensors and lines circuited in series	max. 7.0 V (current sink 0.2 mA is used) max. 2.5 V (current sink 2.0 mA is used)	
Cable length, if cables have been laid in parallel		
shielded	max. 50 m	
two-core shielded and cross section $\geq 0.5$ mm <sup>2</sup>	max. 200 m	

## Unused input channels:

If unused Pt100/Pt1000 channels are bridged, the wire bridge with 0  $\Omega$  simulates the measuring value of a very low temperature. This will cause the error message "range underflow". To avoid such error messages, bridge unused Pt100/Pt1000 channels as follows:

Pt 100	with a resistor of 120 $\Omega$
Pt 1000	with a resistor of 1200 $\Omega$

## Connection of other temperature-dependent resistors:

Basically all temperature-dependent resistors (PTC, NTC) can be connected instead of Pt100/Pt1000 sensors. For the configuration use the settings  $\pm 5$  V,  $\pm 500$  mV and  $\pm 50$  mV. If necessary, the linearization of the resistor curves must be performed in the PLC user program. The installed current sinks can be used, however, note the following:

- The voltage drop of all series connected resistors must not exceed  
**7 V** (when using current sinks of 0.2 mA),  
**2.5 V** (when using current sinks of 2 mA).
- The tolerance of the installed current sinks ( $\pm 1.5\%$ ) must be added in the tolerance calculation for the temperature measurements (no compensation as for Pt100/Pt1000).

### Input by thermocouples

Possible thermocouples	types J, K and S		
Evaluation range with linearization			
Type J	Fe-CuNi	0°C...+1200°C	at 0...57.942 mV
Type K	NiCr-NiAl	0°C...+1372°C	at 0...41.269 mV
Type S	Pt10Rh-Pt	0°C...+1600°C	at 0... 9.585 mV

The module has an internal reference junction. The temperature value of this junction is added to the temperature measured by the thermocouple.

Resolution 12 bit + sign (1 LSB = 0.4°C)

Evaluation error within the range of 0...+1600°C  
 (linearity, linearization, temperature range,  
 resolution, adjustment) +/- 0.5 % of full scale

Cable length, if cables have been laid in parallel  
 shielded max. 50 m  
 two-core shielded and cross section  $\geq 0.5 \text{ mm}^2$  max. 200 m

Unused channels have to be short-circuited

### Connection to the CS31 system bus

Interface standard EIA RS-485

Electrical isolation versus supply voltage and inputs

### Mechanical data

Mounting on DIN rail according to DIN EN 50022-35, 15 mm deep.  
 The DIN rail is positioned centrally between the upper  
 and the lower edges of the module.

Mounting with screws by 4 screws M4

Width x height x depth 120 x 140 x 85 mm

Wiring method removable terminal blocks with screw-type terminals  
 conductor cross section max. 2.5 mm<sup>2</sup>

Weight 450 g

Installation dimensions see Fig. 5.2-13

### Installation instructions

Installation position vertical, connector terminals must point upward and  
 downward

Cooling The natural convection cooling must not be blocked  
 by cable ducts or other components installed in the  
 cabinet.

**Ordering data**

Module 07 AI 91

Order No. GJR5 2516 00 R0202

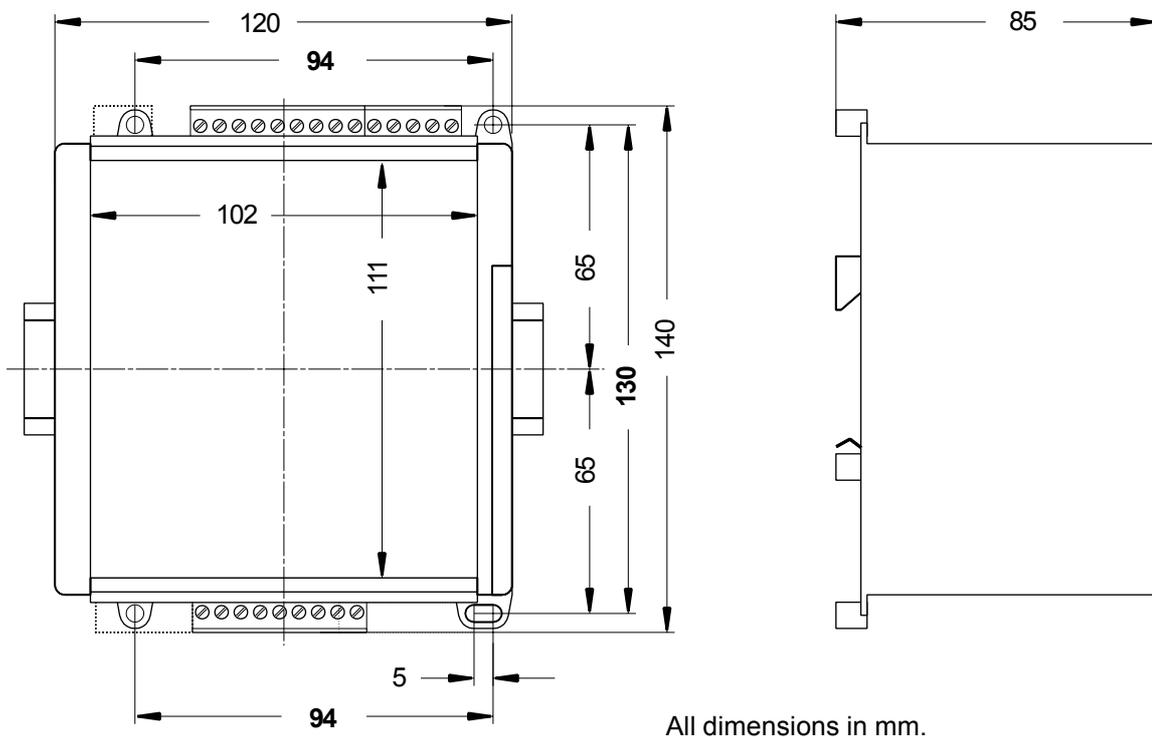
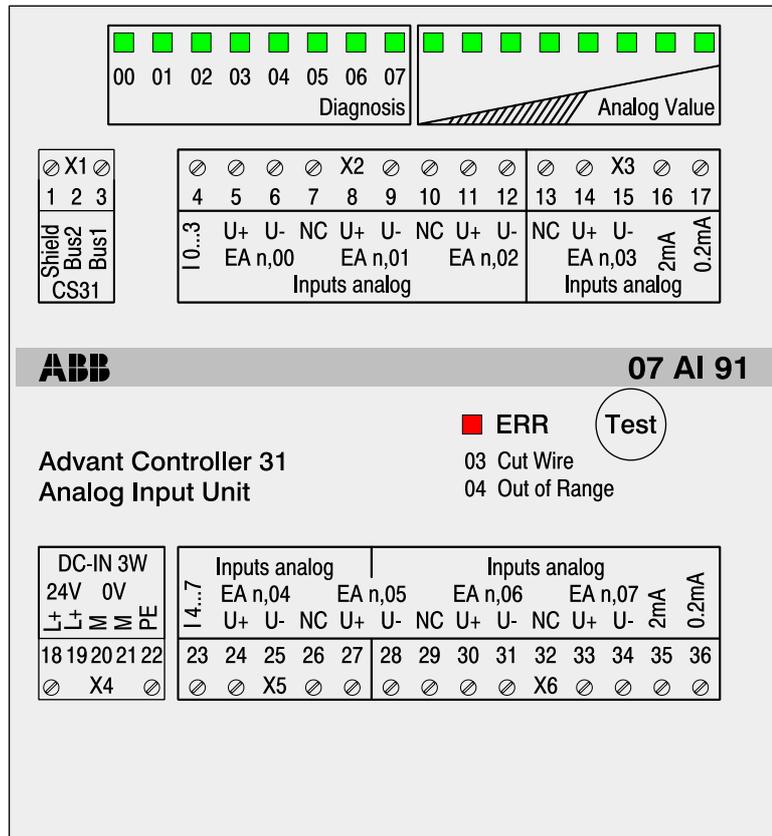
Scope of delivery:

Analog input module 07 AI 91

1 3-pole terminal block

3 5-pole terminal blocks

2 9-pole terminal blocks



**The depth of the device is 85 mm. If a DIN rail is used for the installation, the depth must be increased by the depth of the rail.**

Fig. 5.2-13: 07 AI 91, Front panel foil, **dimensions for installation holes are in bold print**

