

MANUFACTURER DOCUMENT PACKAGE

Manufacturer's Manual

Reference package for procurement and maintenance review

SIEMENS

6ES7650-8AR60-1AA0

EIGHT-CHANNEL THERMOCOUPLE AND RTD INPUT MODULE

Used with the applicable SIMATIC ET 200PA SMART configuration.

REFERENCE PACKAGE

OFFICIAL DOCUMENT

Selected official manufacturer pages follow this cover.

Source: Siemens SIMATIC ET 200PA SMART manufacturer documentation

Diagnostic message	Configurable	Possible cause of error	Corrective measure
Parameter assignment error	No	One parameter, or the combination of parameters, is not plausible	Reassign the module parameters
		The wire jumper (terminals 10 and 11) does not match the parameter assignment of the measurement type.	Check wire jumper
Wire break	Yes	The connection of the transducer is interrupted	Check the wiring
		Resistance of sensor protection circuit too high	Use a different type of sensor or modify the wiring, for example, use cables with larger cross-section
		Channel not connected (open)	Disable the channel group ("Measurement type" parameter) or connect the channel
Low limit violation of measuring range / under-range	Yes (Group diagnostics)	Analog value below the under-range	Check the measuring range selection
		In the case of measuring range 4 mA to 20 mA, sensor may be connected with reverse polarity.	Check terminals
High limit violation of measuring range / over-range	Yes (Group diagnostics)	Analog value above the over-range	Assign a different measuring range

10.4.5 Analog input module AI 8 x TC/4 x RTD

Article numbers

Standard module: 6ES7 650-8AR60-0AA0

Module with conformal coating: 6ES7 650-8AR60-1AA0

Properties

The analog input module AI 8 x TC/4 x RTD is characterized by the following properties:

- 8 inputs in 4 channel groups
- Measured value resolution, can be set for each channel group (depending on the set interference frequency suppression)
 - 9 bits + sign (integration time 2.5 ms) $\triangleq$ 400 Hz
 - 12 bits + sign (integration time 16.67 / 20 ms) $\triangleq$ 60/50 Hz
 - 15 bits + sign (integration time 100 ms) $\triangleq$ 10 Hz

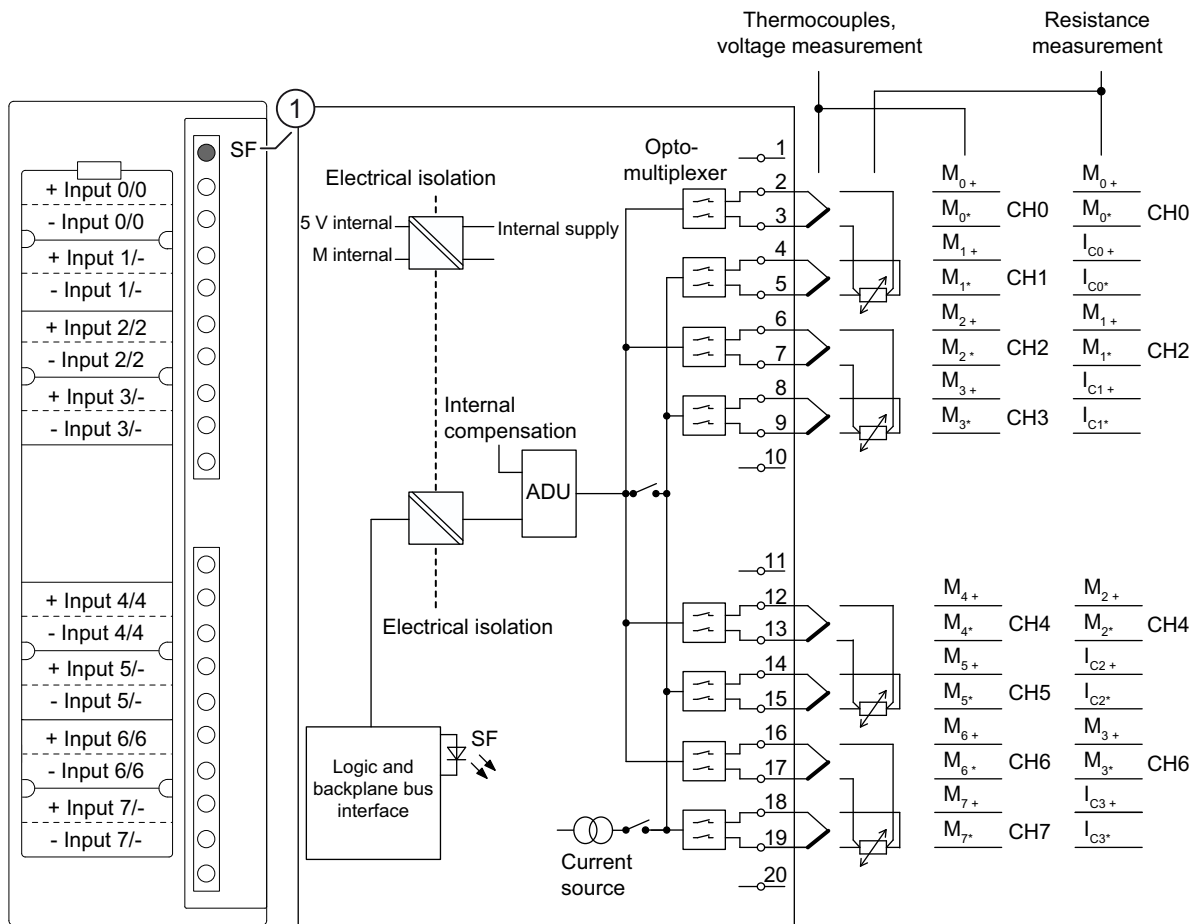
- Measurement type can be selected for each channel group:
 - Voltage
 - Resistance (in non-redundant use)
 - Temperature
- Any measuring range selection for each channel group
- Configurable diagnostics
- Configurable diagnostic interrupt
- Electrically isolated from the CPU
- Common mode < 60 V between the channels
- Configuration in Run (CiR) supported

Resolution

The resolution of the measured value is directly dependent on the integration time selected, i.e. the longer the integration time for an analog input channel is, the more accurate the resolution of the measured value will be.

Wiring and block diagrams of the AI 8 x TC/4 x RTD

Module view and wiring diagram of AI 8 x TC/4 x RTD.



① Group error display - red (SF LED)

Figure 10-18 Module view and block diagram of the AI 8 x TC/4 x RTD

Notes on the module

No external supply voltage L+ (24 V) is necessary for the analog input module AI 8 x TC/4 x RTD.

If thermal resistors (e.g. Pt100) are used for external compensation, connect them to channels 6 and 7.

If a compensation box is used for external compensation, connect it to channel 7.

Notes on the front connector

If you use the front connector 6ES7392-1AJ20-0AA0, you attain a higher accuracy of temperature measurements with thermocouples in the "Internal compensation" measurement type. The accuracy of the internal reference junction temperature is ± 1.5 K when this front connector is used at ambient temperatures from 0 to 60 °C.

You can connect cables of 0.25 mm² to 1 mm².

The use of this front connector results in no restrictions regarding the approvals of the module.

Alternatively, you can use the front connector 6ES7392-1AJ00-0AA0, but without the increased accuracy.

Non-connected input channels

You must short-circuit activated and non-connected channels of the analog input module. This way you ensure optimum interference immunity for the analog input module.

To reduce the cycle time of the module, also deactivate the channels that are not connected via the parameter assignment dialog of HW-Config (measurement type: "deactivated")

Special feature of resistance measurement

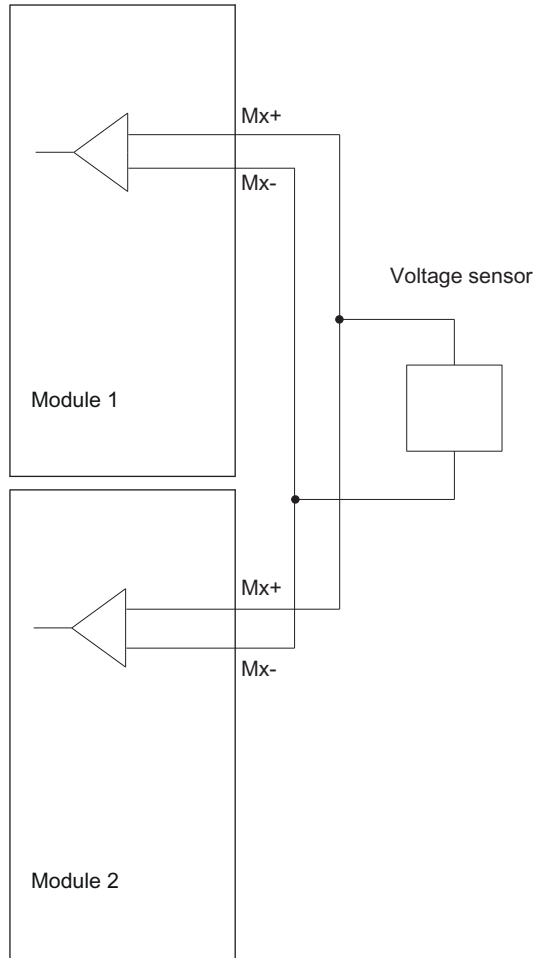
Only one channel per channel group is required for the "resistance measurement" and "thermal resistance measurement". The "2nd" channel of the group is used for the current injection (I_C).

With the "1st" channel of the group is accessed, the measured value is obtained. The "2nd" channel of the group is preset with the overflow value "7FFFH".

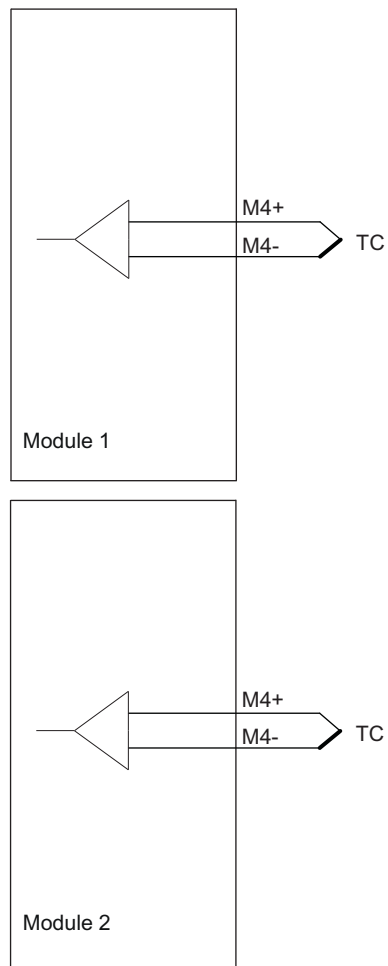
In the diagnostics, the 1st channel provides the actual status (based on parameter assignment) in each case and the 2nd channel the status "error-free". A resistance measurement is not possible in redundant use.

Redundant use

In the case of the voltage measurement, the voltage sensor can be connected to both modules for each channel without additional external protection circuit.



In the case of the thermocouple measurement, the sensors must be available redundantly. This is shown in the following figure for channel 4 as an example.



Note**Measurement of temperatures with thermocouples**

Observe the following when measuring temperatures by means of thermocouples and assigned redundancy:

The value specified on the "Redundancy" tab under "Tolerance window" is always based on 2764.8 °C. Thus, for example, based on the input of "1" a tolerance of 27 degrees is checked. When "5" is entered, a tolerance of 138 degrees is checked.

Technical specifications of the AI 8 x TC/4 x RTD

Technical specifications				
Dimensions and weight				
Dimensions W x H x D (mm)		40 x 125 x 120		
Weight		Approx. 210 g		
Module-specific data				
Number of inputs		8		
• With resistance transducers		4		
Cable length, shielded		Max. 200 m Max. 50 m for voltage ranges ≤ 80 mV and thermocouples		
Voltages, currents, potentials				
Bus power supply		5 V DC		
Current consumption from backplane bus		Max. 120 mA		
Power loss of the module		Typ. 0.6 W		
Electrical isolation				
• Between the channels and backplane bus		Yes		
• Between channels		No Permitted common-mode voltage: 75 V DC or 60 V AC		
Isolation, designed for basic isolation				
• Between the channels and backplane bus (U _{ISO})		75 V DC or 60 V AC		
Isolation tested with		500 V AC or 707 V DC, type test		
Analog value formation				
Measuring principle		SIGMA-DELTA		
Integration/conversion time/resolution (per channel)				
• Configurable		Yes	Yes	Yes
• Integration time in ms		2.5	16.67	100
• Basic conversion time =		7.5	50	60
• 3 x integration time +		+	+	+
• Transient recovery time of optomultiplexer in ms		2.5	2.5	2.5
• Additional conversion time for wire break detection in ms		2.5	2.5	2.5

Technical specifications				
• Resolution in bits (including overrange)	9 + sign	12 + sign	12 + sign	15 + sign
• Noise suppression at interference frequency f1 in Hz	400	60	50	10
Noise suppression, error limits				
Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency)				
• Common-mode interference suppression (U _{ISO} < 60 V)	> 130 dB			
• Series-mode interference suppression (interference peak value < rated value of input range)	> 40 dB			
Crosstalk attenuation between inputs (UISO < 60 V)	> 70 dB			
Operational limit (in total temperature range, relative to input range)				
• ± 25 mV	± 0.09%			
• ± 50 mV	± 0.06%			
• ± 80 mV	± 0.05%			
• ± 250 mV/± 500 mV/± 1 V	± 0.04%			
Basic error limit (Operational limit at 25°C, relative to input range)				
• ± 25 mV	± 0.018 %			
• ± 50 mV	± 0.014 %			
• ± 80 mV	± 0.011 %			
• ± 250 mV/± 500 mV/± 1 V	± 0.008 %			
Temperature error (relative to input range)				
• ± 25 mV	± 0.0019 %/K			
• ± 50 mV	± 0.0013 %/K			
• ± 80 mV	± 0.0011 %/K			
• ± 250 mV/± 500 mV/± 1 V	± 0.0010 %/K			
Linearity error (relative to input range)	± 0.003 %			
Repeatability (in steady-state condition at 25 °C, relative to input range)	± 0.003 %			
The accuracy of temperature measurement with <i>external compensation with thermal resistors</i> is derived from:	• Error for the analog input of the type of thermocouple used • Accuracy¹ of the type of thermal resistor used for compensation • Error¹ of the compensation input			
The accuracy of temperature measurement with <i>external compensation with compensation box</i> is derived from:	• Error for the analog input of the type of thermocouple used • Accuracy¹ of the compensation box • Error¹ of the compensation input			
The accuracy of temperature measurement with <i>compensation of the external reference junction maintained at 0 °C / 50 °C</i> is derived from:	• Error for the analog input of the type of thermocouple used • Accuracy¹ of the reference junction temperature			

Technical specifications

The accuracy of temperature measurement with *internal compensation* (*terminal temperature*) results from:

- Error for the analog input of the type of thermocouple used
- Accuracy ¹ of the internal reference junction temperature ± 2.5 K (in the range 0 to 60 °C)

¹ Due to the increasing slope of the thermocouple characteristic curve at higher temperatures, the error of the compensation element has less influence than at temperatures in the vicinity of the compensation temperature. Exception: Thermocouple types J and E (relatively linear curve). In the case of thermocouple type B, its negligible slope in the range from approximately 0 °C to 40 °C means that a missing compensation of the reference junction temperature has only a slight effect. When compensation is missing and "Compensation at 0 °C" measurement type is set, the discrepancy in the case of thermocouple type B for measurement temperatures between:

700 °C and 1820 °C is < 0.5 °C

500 °C and 700 °C is < 0.7 °C.

"Internal compensation" should be set if the reference junction temperature closely corresponds to the module temperature. This reduces the error for the temperature range from 500 °C to 1820 °C to < 0.5 °C.

Error limits of analog inputs for thermocouples			
(at 25 °C ambient temperature and 100 ms integration time)			
Type	Temperature range	Basic error ¹	Temperature error ² [°C/K]
T	-150 °C...+400 °C	± 0.2 K	± 0.006
	-230 °C... -150 °C	± 1 K	
U	-50 °C....+400 °C	± 0.2 K	± 0.006
	200 °C....-50 °C	± 1 K	
E	-100 °C....+1000 °C	± 0.2 K	± 0.0075
	-200 °C....-100 °C	± 1 K	
J	-150 °C....+1200 °C	± 0.2 K	± 0.02
	-210 °C ... -150 °C	± 0.5 K	
L	-50 °C....+1200 °C	± 0.2 K	± 0.02
	-200 °C....-50 °C	± 1 K	
K	-100 °C....+1372 °C	± 0.2 K	± 0.018
	220 °C....-100 °C	± 1 K	
N	-50 °C....+1300 °C	± 0.2 K	± 0.025
	150 °C....-50 °C	± 1 K	
R	+200 °C....+1769 °C	± 0.3 K	± 0.025
	-50 °C....+200 °C	± 1 K	
S	+100 °C....+1769 °C	± 0.3 K	± 0.025
	-50 °C....+100 °C	± 1 K	
B	+700 °C....+1820 °C	± 0.3 K	± 0.04
	+500 °C....+700 °C	± 0.5 K	
	+200 °C....+500 °C	± 3 K	

Error limits of analog inputs for thermal resistors			
(at 25 °C ambient temperature and 100 ms integration time)			
Type	Temperature range	Basic error ¹	Temperature error ² [°C/K]

Error limits of analog inputs for thermal resistors			
Pt100 climatic	-200 °C....+325 °C	± 0.05K	± 0.006
Pt200 climatic	-200 °C....+325 °C	± 0.05K	± 0.006
Ni 100 climatic	-60 °C....+250 °C	± 0.05K	± 0.003
Pt 100 standard	-200° C....+850 °C	± 0.2K	± 0.01
Pt200 standard	-200 °C....+850 °C	± 0.2K	± 0.01
Ni 100 standard	-60 °C....+250 °C	± 0.1K	± 0.003

Error limits of analog inputs for resistance sensors			
(at 25 °C ambient temperature and 100 ms integration time)			
Type	Resistance sensor	Basic error ³	Temperature error ² [°C/K]
150 Ω	0.000 Ω .176.383 Ω	± 0.006%	± 0.001
300 Ω	0.000 Ω...352.767 Ω	± 0.006%	± 0.001
600 Ω	0.000 Ω...705.534 Ω	± 0.006%	± 0.001
¹ The basic error includes the linearization error of the voltage temperature conversion and the basic error of the analog/digital conversion at T _u = 25°C. ² The total temperature error = temperature error x max. ambient temperature change DT _u as a temperature difference with respect to 25°C. ³ The basic error includes the errors in % of the measuring range of the analog/digital conversion at T _a = 25 °C.			

The operating error for the use of **thermocouples / thermal resistors** consists of:

- Basic error of the analog input at T_u = 25°C
- Total temperature error
- Errors that occur due to the compensation of the reference junction temperature
- Errors of the thermocouple / thermal resistor used

The operating error for the use of **thermal resistors** consists of:

- Basic error of the analog input at T_u = 25°C
- Total temperature error
- Error of the sensor used

Status, interrupts, diagnostics	
Status display	No
Group error display (SF LED)	Yes
Diagnostic interrupts	Configurable
Diagnostic functions	Configurable

Sensor selection data		
Input ranges (rated values) / input resistance	± 25 mV	/10 MΩ
• Voltage	± 50 mV	/10 MΩ
	± 80 mV	/10 MΩ
	± 250 mV	/10 MΩ
	± 500 mV	/10 MΩ
	± 1 V	/10 MΩ
• Resistance	150 Ω	/10 MΩ
	300 Ω	/10 MΩ
	600 Ω	/10 MΩ
• Thermocouples	Type: T, U, E, J, L, K, N, R, S, B	/10 MΩ
• Resistance thermometer	Pt100, Pt200, Ni100	/10 MΩ
Measuring current for thermal resistors and wire-break check	Approx. 0.5 mA	
Permissible input voltage for voltage input (destruction limit)	Max. 35 V permanent; 75 V for max. 1 s (pulse duty factor 1:10)	
Connecting the signal transmitter		
• For voltage measurement	Supported	
• For resistance measurement with 4-wire connection, with 3-wire connection ¹ with 2-wire connection ¹	Supported	
Characteristics linearization	Configurable	
• For thermocouples	• Type : T, U, E, J, L, K, N, R, S, B	
• For thermal resistors	• Pt100, Pt200, Ni 100 (standard and climatic range)	
Temperature compensation	Configurable	
• Internal temperature compensation	Supported	
• External temperature compensation with compensation box	Supported	
• External temperature compensation with thermal resistors (e.g. Pt100)	Supported	
• Compensation for 0 °C reference junction temperature	Supported	
• Compensation for 50° C reference junction temperature	Supported	
¹ Without cable resistance correction		

10.4.5.1 Parameters of the AI 8 x TC/4 x RTD

Parameter assignment

The parameters are assigned using the parameter assignment dialog of HW Config

Parameters of the AI 8 x TC/4 x RTD

The table below provides an overview of the assignable parameters and their default settings for the AI 8 x TC/4 x RTD.

The default settings apply when you have not assigned parameters in HW Config or you have not changed any parameters.

Table 10-19 Parameters of the AI 8 x TC/4 x RTD

Parameter	Value range	Default setting	Scope
Diagnostic interrupt enable	Yes / No	Yes	Module
Diagnostics			
• Group diagnostics	Yes / No	Yes	Channel
• Wire break check	Yes / No	Yes	Channel
Measurement type	Disabled U: Voltage R-4L: Resistance (4-wire connection) RT: Resistance (thermal resistance) TC-L00C: Thermocouple (Ref.Temp 0°C) TC-L50C: Thermocouple (Ref.Temp 50°C) TC-IL: Thermocouple (comp. internal) TC-EL: Thermocouple (comp. external)	U	Channel group
Measuring range	Corresponds to the set measurement type see below	+/- 1 V	Channel group
Interference frequency suppression / integration time	400 Hz (2.5 ms) 60 Hz (16.6 ms) 50 Hz (20 ms) 10 Hz (100 ms)	50 Hz (20 ms)	Channel group

Channel groups

In the analog input module AI 8 x TC/4 x RTD, 2 channels are combined to form one channel group. Parameters can always only be assigned to one channel group, i.e. parameters that are assigned for a channel group always apply to both channels of this channel group.

Table 10-20 Assignment of analog input channels of the AI 8 x TC/4 x RTD to channel groups

Channel	Assigned channel group
Channel 0	Channel group 0
Channel 1	
Channel 2	Channel group 1
Channel 3	
Channel 4	Channel group 2
Channel 5	
Channel 6	Channel group 3
Channel 7	