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Manufacturer's Manual

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SIMATIC S7-1200

6ES7231-5QD32-0XB0

SM 1231 THERMOCOUPLE ANALOG INPUT MODULE

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A.11 Thermocouple and RTD signal modules (SMs)

A.11.1 SM 1231 Thermocouple

Table A-167 General specifications

Model	**SM 1231 AI 4 x 16 bit TC**	**SM 1231 AI 8 x 16 bit TC**
Article number	6ES7231-5QD32-0XB0	6ES7231-5QF32-0XB0
Dimensions W x H x D (mm)	45 x 100 x 75	
Weight	180 grams	190 grams
Power dissipation	1.5 W	
Current consumption (SM Bus)	80 mA	
Current consumption (24 V DC) [1]	40 mA	

[1] 20.4 to 28.8 V DC (Class 2, Limited Power, or sensor power from PLC)

Table A-168 Analog inputs

Model		**SM 1231 AI 4 x 16 bit TC**	**SM 1231 AI 8 x 16 bit TC**
Number of inputs		4	8
Range Nominal range (data word) Overrange/underrange (data word) Overflow/underflow (data word)		See Thermocouple selection table (Page 1290).	
Resolution	Temperature	0.1 °C/0.1 °F	
	Voltage	15 bits plus sign	
Maximum withstand voltage		± 35 V	
Noise rejection		85 dB for selected filter setting (10 Hz, 50 Hz, 60 Hz or 400 Hz)	
Common mode rejection		> 120 dB at 120 V AC	
Impedance		≥ 10 MΩ	
Isolation	Field to logic	707 VDC (type test)	
	Field to 24 V DC	707 V DC (type test)	
	24 V DC to logic	707 V DC (type test)	
Channel to channel		120 V AC	
Accuracy		See Thermocouple selection table (Page 1290).	
Repeatability		±0.05% FS	
Measuring principle		Integrating	
Module update time		See Noise reduction selection table (Page 1290).	
Cold junction error		±1.5 °C	
Cable length (meters)		100 meters to sensor max.	
Wire resistance		100 Ω max.	

Table A-169 Diagnostics

Model	SM 1231 AI 4 x 16 bit TC	SM 1231 AI 8 x 16 bit TC
Overflow/underflow [1]	Yes	
Wire break [2, 3]	Yes	
24 V DC low voltage [1]	Yes	

[1] The overflow, underflow and low voltage diagnostic alarm information will be reported in the analog data values even if the alarms are disabled in the module configuration.

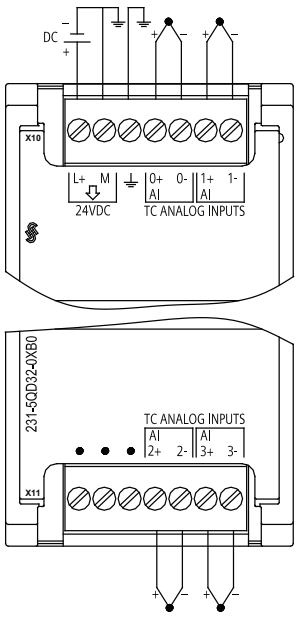
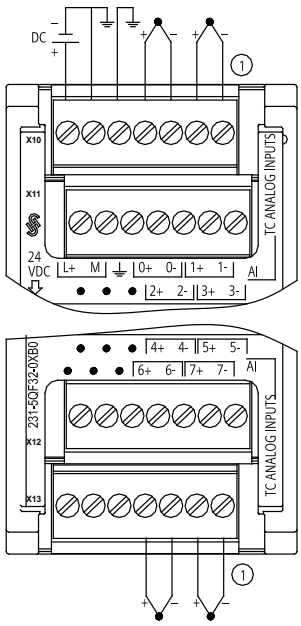
[2] When wire break alarm is disabled and an open wire condition exists in the sensor wiring, the module may report random values.

[3] The module performs wire break testing every 6 seconds, which extends the update time by 9 ms for each enable channel once every 6 seconds.

The SM 1231 Thermocouple (TC) analog signal module measures the value of voltage connected to the module inputs. The temperature measurement type can be either "Thermocouple" or "Voltage".

- "Thermocouple": The value will be reported in degrees multiplied by ten (for example, 25.3 degrees will be reported as decimal 253).
- "Voltage": The nominal range full scale value will be decimal 27648.

Table A-170 Wiring diagrams for the thermocouple SMs

SM 1231 AI 4 x TC 16 bit (6ES7231-5QD32-0XB0)	SM 1231 AI 8 x TC bit (6ES7231-5QF32-0XB0)
	
Note: Connectors must be gold. See Appendix C, Spare Parts for article number.	

① TC 2, 3, 4, and 5 not shown connected for clarity.

Table A-171 Connector pin locations for SM 1231 AI 4 x TC 16 bit (6ES7231-5QD32-0XB0)

Pin	X10 (gold)	X11 (gold)
1	L+ / 24 V DC	No connection
2	M / 24 V DC	No connection
3	Functional Earth	No connection
4	AI 0+ /TC	AI 2+ /TC
5	AI 0- /TC	AI 2- /TC
6	AI 1+ /TC	AI 3+ /TC
7	AI 1- /TC	AI 3- /TC

Table A-172 Connector Pin Locations for SM 1231 AI 8 x TC bit (6ES7231-5QF32-0XB0)

Pin	X10 (gold)	X11 (gold)	X12 (gold)	X13 (gold)
1	L+ / 24 V DC	No connection	No connection	No connection
2	M / 24 V DC	No connection	No connection	No connection
3	Functional Earth	No connection	No connection	No connection
4	AI 0+ /TC	AI 2+ /TC	AI 4+ /TC	AI 6+ /TC
5	AI 0- /TC	AI 2- /TC	AI 4- /TC	AI 6- /TC
6	AI 1+ /TC	AI 3+ /TC	AI 5+ /TC	AI 7+ /TC
7	AI 1- /TC	AI 3- /TC	AI 5- /TC	AI 7- /TC

Note

Unused analog inputs should be shorted.

The thermocouple unused channels can be deactivated. No error will occur if an unused channel is deactivated.

A.11.1.1 Basic operation for a thermocouple

Thermocouples are formed whenever two dissimilar metals are electrically bonded to each other. A voltage is generated that is proportional to the junction temperature. This voltage is small; one microvolt could represent many degrees. Measuring the voltage from a thermocouple, compensating for extra junctions, and then linearizing the result forms the basis of temperature measurement using thermocouples.

When you connect a thermocouple to the SM 1231 Thermocouple module, the two dissimilar metal wires are attached to the module at the module signal connector. The place where the two dissimilar wires are attached to each other forms the sensor thermocouple.

Two more thermocouples are formed where the two dissimilar wires are attached to the signal connector. The connector temperature causes a voltage that adds to the voltage from the sensor thermocouple. If this voltage is not corrected, then the temperature reported will deviate from the sensor temperature.

Cold junction compensation is used to compensate for the connector thermocouple. Thermocouple tables are based on a reference junction temperature, usually zero degrees Celsius. The cold junction compensation compensates the connector to zero degrees Celsius.

The cold junction compensation restores the voltage added by the connector thermocouples. The temperature of the module is measured internally, and then converted to a value to be added to the sensor conversion. The corrected sensor conversion is then linearized using the thermocouple tables.

For optimum operation of the cold junction compensation, the thermocouple module must be located in a thermally stable environment. Slow variation (less than 0.1 °C/minute) in ambient module temperature is correctly compensated within the module specifications. Air movement across the module will also cause cold junction compensation errors.

If better cold junction error compensation is needed, an external iso-thermal terminal block may be used. The thermocouple module provides for use of a 0 °C referenced or 50 °C referenced terminal block.

A.11.1.2 Selection tables for the SM 1231 thermocouple

The ranges and accuracy for the different thermocouple types supported by the SM 1231 Thermocouple signal module are shown in the table below.

Table A-173 Thermocouple selection table

Type	Under-range minimum[1]	Nominal range low limit	Nominal range high limit	Over-range maximum[2]	Normal range [3, 4] accuracy @ 25 °C	Normal range [1, 2, 6] accuracy -20 °C to 60 °C
J	-210.0 °C	-150.0 °C	1200.0 °C	1450.0 °C	±0.3 °C	±0.6 °C
	-346.0 °F	-238.0 °F	2192.0 °F	2642.0 °F	±0.5 °F	±1.1 °F
K	-270.0 °C	-200.0 °C	1372.0 °C	1622.0 °C	±0.4 °C	±1.0 °C
	-454.0 °F	-328.0 °F	2501.6 °F	2951.6 °F	±0.7 °F	±1.8 °F
T	-270.0 °C	-200.0 °C	400.0 °C	540.0 °C	±0.5 °C	±1.0 °C
	-454.0 °F	-328.0 °F	752.0 °F	1004.0 °F	±0.9 °F	±1.8 °F
E	-270.0 °C	-200.0 °C	1000.0 °C	1200.0 °C	±0.3 °C	±0.6 °C
	-454.0 °F	-328.0 °F	1832.0 °F	2192.0 °F	±0.5 °F	±1.1 °F
R & S	-50.0 °C	100.0 °C	1768.0 °C	2019.0 °C	±1.0 °C	±2.5 °C
	-58.0 °C	212.0 °F	3214.4 °F	3276.6 °F [5]	±1.8 °F	±4.5 °F
B	0.0 °C	200.0 °C	800.0 °C	--	±2.0 °C	±2.5 °C
	32.0 °F	392.0 °F	1472.0 °F	--	±3.6 °F	±4.5 °F
	--	800.0 °C	1820.0 °C	1820.0 °C	±1.0 °C	±2.3 °C
	--	1472.0 °F	3276.6 °F [5]	3276.6 °F [5]	±1.8 °F	±4.1 °F
N	-270.0 °C	-200.0 °C	1300.0 °C	1550.0 °C	±1.0 °C	±1.6 °C
	-454.0 °F	-328.0 °F	2372.0 °F	2822.0 °F	±1.8 °F	±2.9 °F
C	0.0 °C	100.0 °C	2315.0 °C	2500.0 °C	±0.7 °C	±2.7 °C
	32.0 °F	212.0 °F	3276.6 °F [5]	3276.6 °F [5]	±1.3 °F	±4.9 °F

Type	Under-range minimum[1]	Nominal range low limit	Nominal range high limit	Over-range maximum[2]	Normal range [3, 4] accuracy @ 25 °C	Normal range [1, 2, 6] accuracy -20 °C to 60 °C
TXK/XK(L)	-200.0 °C	-150.0 °C	800.0 °C	1050.0 °C	±0.6 °C	±1.2 °C
	-328.0 °F	302.0 °F	1472.0 °F	1922.0 °F	±1.1 °F	±2.2 °F
Voltage	-32512	-27648 -80mV	27648 80mV	32511	±0.05%	±0.1%

1 Thermocouple values below the under-range minimum value are reported as -32768.

2 Thermocouple values above the over-range maximum value are reported as 32767.

3 Internal cold junction error is ±1.5 °C for all ranges. This adds to the error values in this table. The module requires at least 30 minutes of warm-up time to meet this specification. For module ambient temperatures below -10 °C internal cold junction error can be greater than 1.5 °C.

4 In the presence of radiated radio frequency of 970 MHz to 990 MHz, the accuracy of the SM 1231 AI 4 x 16 bit TC may be degraded.

5 Lower limit of 3276.6 with °F reporting

6 Cold junction compensation error has not been characterized for module ambient temperatures below 0 °C and may exceed the specified value.

Note

Thermocouple channel

Each channel on the Thermocouple signal module can be configured with a different thermocouple type (selectable in the software during configuration of the module).

Table A-174 Noise reduction and update times for the SM 1231 Thermocouple

Rejection frequency selection	Integration time	4 Channel module update time (seconds)	8 Channel module update time (seconds)
400 Hz (2.5 ms)	10 ms[1]	0.143	0.285
60 Hz (16.6 ms)	16.67 ms	0.223	0.445
50 Hz (20 ms)	20 ms	0.263	0.525
10 Hz (100 ms)	100 ms	1.225	2.450

1 To maintain module resolution and accuracy when 400 Hz rejection is selected, the integration time is 10 ms. This selection also rejects 100 Hz and 200 Hz noise.

It is recommended for measuring thermocouples that a 100 ms integration time be used. The use of smaller integration times will increase the repeatability error of the temperature readings.

Note

After power is applied, the module performs internal calibration for the analog-to-digital converter. During this time the module reports a value of 32767 on each channel until valid data is available on that channel. Your user program may need to allow for this initialization time. Because the configuration of the module can vary the length of the initialization time, you should verify the behavior or the module in your configuration. If required, you can include logic in your user program to accommodate the initialization time of the module.
You can implement this logic using a polling read in the "Startup OB" which blocks operation until the initialization is complete. You must implement the polling read with an immediatede access. If the value of the thermocouple polling read is 32767, then the read must be repeated until the value changes. For each module this polling only needs to be executed for the highest numbered used input point in the module (the module inputs are initialized in order from 0 to 7).

Representation of analog values for Thermocouple Type J

A representation of the analog values of thermocouples type J is shown in the table below.

Table A-175 Representation of analog values of thermocouples Type J

Type J in °C	Units		Type J in °F	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.2	26420 : 21922	6734 : 55A2	Over-range
1200.0 : -150	12000 : 1500	2EE0 : FA24	2192.0 : -238.0	21920 : -2380	55A0 : F6B4	Rated range
-150.1 : -210	-1501 : -2100	FA23 : F7CC	-238.1 : -346.0	-2381 : -3460	F6B3 : F27C	Under-range
< -210.0	-32768	8000	< -346.0	-32768	8000	Underflow[1]

[1] Faulty wiring (for example, polarity reversal, or open inputs) or sensor error in the negative range (for example, wrong type of thermocouple) may cause the thermocouple module to signal underflow.