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AXL F UTH4 1H

Axioline F temperature module, 4 inputs for connection of thermocouple sensors

Data sheet
8672_en_02

1 Description

The module is designed for use within an Axioline F station.

It is used to acquire signals from standard thermocouples in industrial applications.

The module supports various types of thermocouple conforming to DIN EN 60584-1 and DIN 46710 as well as linear voltages from -100 mV to +100 mV.

It also offers a voltage input from -5 V to +5 V. Heating currents can be monitored here, for example, using a measuring transducer.

Both Pt 100 inputs (CJ1 and CJ2) can each be used as a sensor input or as an external cold junction.

Features

- 4 analog input channels to connect thermocouples or linear voltages from -100 mV to +100 mV
- 1 analog input channel to connect voltages from -5 V to +5 V
- Connection of sensors in 2-wire technology
- Internal detection and compensation of cold junction temperature (configurable)
- External connection of Pt 100 cold junction sensors possible
- Easy to use due to internal linearization of the sensor characteristic curves
- High level of accuracy (typically ±0.01% sensor type K)
- High level of accuracy, even in various mounting positions, thanks to built-in space compensation of the internal cold junction
- High temperature stability (typically 8 ppm/K)
- High level of immunity to EMI (Class A)
- Low emitted interference
- "Channel scout" function
- Device type label stored
- Diagnostic and status indicators
- Installation monitoring with indication via diagnostic LED for each channel

i	This data sheet is only valid in association with the UM EN AXL F SYS INST user manual.
i	Make sure you always use the latest documentation. It can be downloaded from the product at phoenixcontact.net/products.

2 Table of contents

3 Ordering data

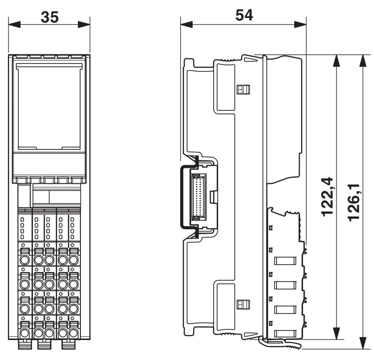
Description	Type	Order No.	Pcs. / Pkt.
Axioline F temperature module, 4 inputs for connection of thermocouple sensors (including bus base module and connectors)	AXL F UTH4 1H	2688598	1

Accessories	Type	Order No.	Pcs. / Pkt.
Axioline F bus base module for housing type H (Replacement item)	AXL F BS H	2700992	5
Axioline shield connection set (contains 2 busbar holders and 2 SK 5 shield connection clamps)	AXL SHIELD SET	2700518	1
Zack marker strip for Axioline F (device labeling), in 2 x 20.3 mm pitch, unprinted, 25-section, for individual labeling with B-STIFT 0.8, X-PEN, or CMS-P1-PLOTTER (Marking)	ZB 20,3 AXL UNPRINTED	0829579	25
Zack marker strip, flat, in 10 mm pitch, unprinted, 10-section, for individual labeling with M-PEN 0,8, X-PEN, or CMS-P1-PLOTTER (Marking)	ZBF 10/5,8 AXL UNPRINTED	0829580	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-CU/CUNI	3100059	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-FE/CUNI	3100046	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-NICR/CUNI	3100075	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-NICR/NI	3100062	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-E-CU/A-CU	3100091	50
Thermoelectric voltage terminal block, cross section: 0.2 - 2.5 mm^2, width: 10.4 mm, color: gray	MTKD-S-CU/E-CU	3100101	50
Insert label, Roll, white, unlabeled, can be labeled with: THERMOMARK ROLL, THERMOMARK X, THERMOMARK S1.1, Mounting type: snapped into marker carrier, Lettering field: 35 x 46 mm (Marking)	EMT (35X46)R	0801604	1

Documentation	Type	Order No.	Pcs. / Pkt.
User manual, English, Axioline F: System and installation	UM EN AXL F SYS INST	-	-
User manual, English, Axioline F: Diagnostic registers, and error messages	UM EN AXL F SYS DIAG	-	-

4 Technical data

Dimensions (nominal sizes in mm)



Width	35 mm
Height	126.1 mm
Depth	54 mm
Note on dimensions	The depth is valid when a TH 35-7.5 DIN rail is used (according to EN 60715).

General data

Color	traffic grey A RAL 7042
Weight	144 g (with connectors and bus base module)
Ambient temperature (operation)	-25 °C ... 60 °C
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Permissible humidity (operation)	5 % ... 95 % (non-condensing)
Permissible humidity (storage/transport)	5 % ... 95 % (non-condensing)
Air pressure (operation)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Air pressure (storage/transport)	70 kPa ... 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20
Protection class	III, IEC 61140, EN 61140, VDE 0140-1
Mounting position	Any (no temperature derating)

Connection data

Designation	Axioline F connector
Connection method	Push-in technology
Conductor cross section solid / stranded	0.2 mm² ... 1.5 mm² / 0.2 mm² ... 1.5 mm²
Conductor cross section [AWG]	24 ... 16
Stripping length	8 mm

Interface Axioline F local bus

Connection method	Bus base module
Transmission speed	100 MBit/s

Communications power

Communications power U_{Bus}	5 V DC (via bus base module)
Current consumption from U_{Bus}	typ. 112 mA, max. 160 mA
Power consumption at U_{Bus}	typ. 0.54 W, max. 0.8 W

I/O supply

Supply of analog modules U_A	24 V DC
Maximum permissible voltage range	19.2 V DC ... 30 V DC (including all tolerances, including ripple)
Current consumption from U_A	typ. 23 mA max. 40 mA
Power consumption at U_A	typ. 0.55 W, max. 0.96 W
Surge protection of the supply voltage	Electronic (35 V, 0.5 s)
Polarity reversal protection of the supply voltage	Polarity protection diode
Transient protection	Suppressor diode

Total power consumption of the module

Power consumption	typ. 1.05 W (entire device), max. 1.76 W (entire device)

The typical values for current and power consumption (logic/I/O/total) are measured values, the maximum values are theoretical worst-case values.

Analog inputs

Number of inputs	4 +1 (4 inputs for thermocouples or linear voltage, plus 1 input -5 V to +5 V)
Connection method	Spring-cage connection with direct connector-in method
Connection method	2-wire (shielded, twisted pair)
Sensor types that can be used (TC)	U, T, L, J, E, K, N, S, R, B, C, W, HK
Sensor types (RTD) that can be used	Pt 100 (2 external cold junctions, can also be used as a sensor input)
Resolution A/D	24 bit
Measuring principle	Sigma/Delta process
Measured value representation	16 bits (15 bits + sign bit)
Input filter time	40 ms, 60 ms, 100 ms, 120 ms (adjustable)
Relative accuracy	typ. 0.01 % (Thermocouple type K, NiCr-Ni; see tables under tolerance values)
Absolute accuracy	typ. ± 0.19 K (Thermocouple type K, plus tolerance of cold junction)
Short-circuit protection, overload protection of the inputs	yes
Transient protection of inputs	yes
Crosstalk attenuation	typ. 113 dB (Channel/channel, sensor type K) typ. 114 dB (Channel/channel, sensor type linear voltage ±100 mV) typ. 107 dB (Channel/channel, external Pt100 connection)
Common mode rejection (CMR): TC inputs/linear voltage	min. 100 dB (Channel/FE; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Common mode rejection (CMR): TC inputs/linear voltage	typ. 140 dB (Channel/FE; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Common mode rejection (CMR): TC inputs/linear voltage	min. 100 dB (Channel/AGND; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Common mode rejection (CMR): TC inputs/linear voltage	typ. 131 dB (Channel/AGND; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Common mode rejection (CMR): Voltage input -5 V ... +5 V	min. 95 dB (Channel/FE; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Common mode rejection (CMR): Voltage input -5 V ... +5 V	typ. 105 dB (Channel/FE; for DC up to 100 kHz, V_{cm} = -10 V ... +10 V)
Input resistance: TC inputs/linear voltage	typ. 20 MΩ (With 24 V I/O supply voltage present)
Input resistance: Voltage input -5 V ... +5 V	typ. 5 MΩ (With 24 V I/O supply voltage present)
Voltage at the TC input	max. 40 V DC (1 min.)

Fieldbus data telegram

Fieldbus system	PROFIBUS DP
Required parameter data	12 Byte
Need for configuration data	7 Byte

Electrical isolation/isolation of the voltage areas	
Test section	**Test voltage**
5 V communications power (logic), 24 V supply (I/O)	500 V AC, 50 Hz, 1 min
5 V supply (logic)/functional earth ground	500 V AC, 50 Hz, 1 min
24 V supply (I/O) / functional earth ground	500 V AC, 50 Hz, 1 min

Mechanical tests	
Vibration resistance in acc. with EN 60068-2-6/IEC 60068-2-6	5g
Shock in acc. with EN 60068-2-27/IEC 60068-2-27	30g
Continuous shock according to EN 60068-2-27/IEC 60068-2-27	10g

Conformance with EMC Directive 2004/108/EC	
Noise immunity test in accordance with EN 61000-6-2	
Electrostatic discharge (ESD) EN 61000–4–2/IEC 61000–4–2	Criterion B; 6 kV contact discharge, 8 kV air discharge
Electromagnetic fields EN 61000–4–3/IEC 61000–4–3	Criterion A; Field intensity: 10 V/m
Fast transients (burst) EN 61000–4–4/IEC 61000–4–4	Criterion A for shielded cables; 2 kV
Transient surge voltage (surge) EN 61000–4–5/IEC 61000–4–5	Criterion B; supply lines DC: ±0.5 kV/±0.5 kV (symmetrical/asymmetrical); ±1 kV to shielded I/O cables
Conducted interference EN 61000–4–6/IEC 61000–4–6	Criterion A; Test voltage 10 V
Noise emission test according to EN 61000-6-3	
Radio interference properties EN 55022	Class B
Conducted noise emission test according to EN 55016-2-1 and EN 55016-1-2; 9 kHz ... 30 MHz	Class A

Approvals

For the latest approvals, please visit phoenixcontact.net/products.

5 Additional technical data

5.1 Maximum permissible cable lengths

Connecting cable and maximum cable length specifications				
Maximum permissible cable length	**Sensor type**	**Connection method**	**Sensor cable**	**Cable type**
10 m	TC inputs channel 1 ... 4	2-wire	Unshielded, twisted	TC sensor cable or equalizing conductor (according to DIN EN 60584–3, IEC 60584–3, DIN 43722)
250 m	TC inputs channel 1 ... 4	2-wire	Shielded, twisted	TC sensor cable or equalizing conductor (according to DIN EN 60584–3, IEC 60584–3, DIN 43722)
10 m	Inputs channel 1 ... 4, -100 mV ... +100 mV	2-wire	Unshielded, twisted	Reference cable type LiYY (TP) 2 x 2 x 0.5 mm^2
250 m	Inputs channel 1 ... 4, -100 mV ... +100 mV	2-wire	Shielded, twisted	Reference cable type LiYCY (TP) 2 x 2 x 0.5 mm^2
2 m	Pt 100 external cold junction sensor	2-wire	Unshielded, twisted	Reference cable type LiYY (TP) 2 x 2 x 0.5 mm^2
10 m	Pt 100 external cold junction sensor	2-wire	Shielded, twisted	Reference cable type LiYCY (TP) 2 x 2 x 0.5 mm^2
5 m	-5 V ... +5 V input	2-wire	Shielded, twisted	Reference cable type LiYCY (TP) 2 x 2 x 0.5 mm^2

TC inputs: select the appropriate TC equalizing conductors for TC sensors (according to DIN EN 60584–3, IEC 60584–3, and DIN 43722).

Other inputs: the values are valid when reference cable type LiYCY (TP) 2 x 2 x 0.5 mm^2 is used in accordance with the Axioline F installation instructions.

The maximum cable length specification is valid from the sensor to the connection terminal block and includes the maximum specified tolerances.

Observe the cable resistance values when operating the externalPt 100 cold junction. Long cables and/or small cable cross sections increase measuring tolerances.

The measuring tolerances of all channels will only be observed if the permissible cable types are used.

Using the Axioline shield connection set (AXL SHIELD SET), connect the braided shield of long sensor cables at one end to the functional earth ground potential upstream of the AXL F UTH4 1H module.

5.2 Measuring ranges of the TC inputs

No.	Input	Sensor type	Standard	Measuring range		Average basic value for sensitivity	Voltage level at measuring range final value
				Lower limit	Upper limit		
1	Thermocouples	B	DIN EN 60584	+50 °C	+1820 °C	6 µV/K	13.820 mV
2		E	DIN EN 60584	-270 °C	+1000 °C	65 µV/K	76.373 mV
3		J	DIN EN 60584	-210 °C	+1200 °C	54 µV/K	69.553 mV
4		K	DIN EN 60584	-270 °C	+1372 °C	42 µV/K	54.886 mV
5		N	DIN EN 60584	-270 °C	+1300 °C	27 µV/K	47.513 mV
6		R	DIN EN 60584	-50°C	+1768 °C	10 µV/K	21.101 mV
7		S	DIN EN 60584	-50°C	+1768 °C	10 µV/K	18.693 mV
8		T	DIN EN 60584	-270 °C	+400 °C	40 µV/K	20.872 mV
9		C		-18 °C	+2316 °C	15 µV/K	37.07 mV
10		W		-18 °C	+2316 °C	12 µV/K	38.56 mV
11		HK		-200 °C	+800 °C	69 µV/K	66.42 mV
12		L	DIN 43710	-200 °C	+900 °C	54 µV/K	53.14 mV
13		U	DIN 43710	-200 °C	+600 °C	40 µV/K	34.31 mV

5.3 Tolerances of the measuring inputs at T_A = +25°C

No.	Input	Sensor type	Measuring range		Absolute tolerance		Relative tolerance (with reference to MRFV)	
			Lower limit	Upper limit	Typical	Maximum	Typical	Maximum
1	Thermocouples	B	+500°C	+1820 °C	±0.5 K	±4.17 K	±0.03%	±0.23 %
2		E	-226 °C	+1000 °C	±0.15 K	±1.38 K	±0.02%	±0.19%
3		J	-210 °C	+1200 °C	±0.19 K	±1.67 K	±0.02%	±0.14 %
4		K	-200 °C	+1372 °C	±0.19 K	±0.71 K	±0.01%	±0.05 %
5		N	-200 °C	+1300 °C	±0.39 K	±3.15 K	±0.03%	±0.23 %
6		R	-50°C	+1768 °C	±0.8 K	±2.5 K	±0.05 %	±0.14 %
7		S	-50°C	+1768 °C	±0.8 K	±2.5 K	±0.05 %	±0.14 %
8		T	-270 °C	+400 °C	±0.18 K	±0.63 K	±0.04 %	±0.16 %
9		C	-18 °C	+2316 °C	±0.53 K	±0.81 K	±0.02%	±0.03%
10		W	+250°C	+2316 °C	±1.33 K	±2.5 K	±0.06%	±0.11 %
11		HK	-200 °C	+800 °C	±0.16 K	±1.3 K	±0.02%	±0.16 %
12		L	-200 °C	+900 °C	±0.15 K	±1.67 K	±0.02%	±0.19%
13		U	-200 °C	+600 °C	±0.15 K	±0.75 K	±0.03%	±0.13%
14	Internal cold junction	Pt DIN	-70°C	+150°C	±0.25 K	±1.6 K	±0.17 %	±1.07 %
15	External external cold junction sensor	Pt DIN	-100°C	+400 °C	±0.3 K	±0.8 K	±0.08%	±0.20 %
			-100°C	+100 °C	±0.10 K	±0.60 K	±0.03%	±0.15 %
16	Voltage input	Linear voltage	-100 mV	+100 mV	±10 µV	±100 µV	±0.01%	±0.10%
			-30 mV	+30 mV	±7 µV	±30 µV	±0.007 %	±0.03%
			-10 mV	+10 mV	±5 µV	±25 µV	±0.005 %	±0.03%
17	5 V DC voltage input channel	Linear voltage	-5 V	+5 V	±1.5 mV	±10 mV	±0.03%	±0.10%

MRFV= Measuring range final value

The tolerances of the thermocouple inputs (TC sensors) are based on differential temperature recording plus the tolerances due to cold junction compensation during nominal operation in the preferred mounting position.

Please observe the notes in the "Notes on the tolerance tables" section.

5.4 Temperature and drift response

	Measuring range	Drift	
		Typ.	Max.
External Pt 100	-100 °C ... +400 °C	±15 ppm/K	±30 ppm/K
	-100°C ... +100°C	±10 ppm/K	±25 ppm/K
Linear voltage	-10 mV ... +10 mV	±3 ppm/K	±12 ppm/K
	-30 mV ... +30 mV	±6 ppm/K	±15 ppm/K
	-100 mV ... +100 mV	±11 ppm/K	±20 ppm/K
±5 V voltage input		±13 ppm/K	±25 ppm/K
TC inputs	Type K	±8 ppm/K	±20 ppm/K

1. The data refers to nominal operation (U_A = 24 V) in the preferred mounting position (horizontal).
2. The measurement is performed within an Axioline F station in which another AXL F UTH4 1H module is located to the right and left of the module in question.
3. The drift values refer to the full measuring range final value, i.e., 1372°C in the case of TC sensor type K, +400°C in the case of the external Pt 100, and +100 mV in the case of the linear voltage.

5.5 Tolerances for TC sensor type K with internal cold junction compensation

No.	Temperature	Absolute tolerance		Relative tolerance (with reference to MRFV)	
		Typ.	Max.	Typ.	Max.
1	+25°C	±0.20 K	±2.4 K	±0.01%	±0.17 %
2	-25 °C ... +60 °C	±0.71 K	±3.9 K	±0.05 %	±0.28 %

MRFV= Measuring range final value

The tolerances of the thermocouple inputs (TC sensors) are based on absolute temperature recording during nominal operation in the preferred mounting position.

> Please observe the notes in the "Notes on the tolerance tables" section.

5.6 Notes on the tolerance tables

The following notes apply for the tables:

– Tolerances of the measuring inputs at T_A = +25°C
– Tolerances for TC sensor type K with internal cold junction compensation

1. The measurement is performed within an Axioline F station in which another AXL F UTH4 1H module is located to the right and left of the module in question.
2. In order to achieve optimum accuracy in the various mounting positions of the station, different installation positions can be configured.
3. The tolerance values for the TC inputs are based on the average basic values for sensitivity (see table for measuring ranges of the TC inputs).
4. The typical values were determined from the maximum tolerances of the measured practical values.
5. The maximum tolerances represent the worst-case measurement inaccuracy. They contain the theoretical maximum possible tolerances in the measuring ranges as well as the theoretical maximum possible tolerances of the test and calibration equipment. The data is valid for at least 24 months from delivery of the module. Thereafter the modules can be recalibrated by the manufacturer at any time.
6. An additional path calibration function for maximum accuracy is possible at any time in the application (see object $008F_{hex}$ path calibration values). Using the temperature offset, you can finely tune the tolerances for each channel by means of the connecting cables and the sensors. The specified tolerances are then reduced accordingly.
7. The tolerances increase slightly for a short time immediately after power up (see switch-on behavior section).
8. In the -100 mV ... +100 mV linear voltage input range, smaller measuring windows with closer tolerances were also specified. The reference value of the relative tolerance value is always based on +100 mV.
9. Please note when using linear voltage signals: for voltages above +32.7 mV and below -32.7 mV, parameterize the process data resolution as 10 µV/LSB (instead of 1 µV/LSB) in order to prevent overrange or underrange messages from occurring.
10. Always position temperature modules at the end of the station. For modules that must be positioned next to a bus coupler, the typical measuring tolerance can be increased by up to 0.9 K.
11. The maximum tolerances are observed even in the event of electromagnetic interference (see also Table "Tolerances influenced by electromagnetic interference"). They apply for both shielded and unshielded I/O cables.

5.7 Switch-on behavior of TC inputs with internal cold junction compensation

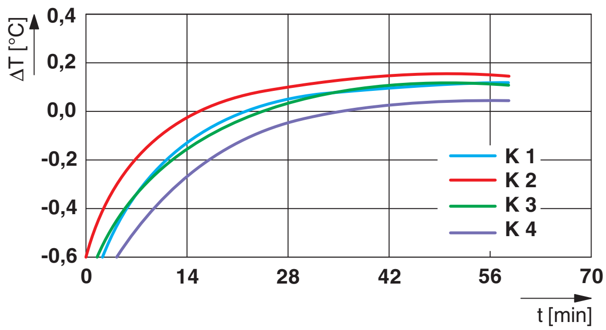


Figure 1 Typical switch-on behavior of type K TC sensors with internal cold junction compensation

K1 ... K4 Channel 1 ... channel 4

Transient period	Typical tolerance
5 minutes	-0.7 K
10 minutes	-0.3 K
35 minutes	±0.2 K
45 minutes	±0.2 K

1. The switch-on behavior must only be taken into consideration for TC measurements with internal cold junction temperature, it does not apply for differential measurements or measurements with external compensation.
2. The typical characteristic curves of the TC inputs after power up were recorded in the preferred mounting position (horizontal), in nominal operation (U_A = 24 V, T_A = 25°C), and with unobstructed ventilation ducts (free air flow).
3. The measurement is performed within an Axioline F station in which another AXL F UTH4 1H module is located to the right and left of the module in question.
4. Different installation positions or arrangements where the module is affected by external sources of heat can result in a different thermal switch-on behavior.
5. The measuring probes of the type K TC sensors were kept at a constant temperature.

In the event of sudden changes in the ambient temperature of the temperature module (e.g., from T_A = +25°C to T_A = +60°C), the time curve for the transient response is comparable with that of the switch-on behavior.

5.8 Switch-on behavior of TC inputs with external cold junction compensation

The module supports the connection of up to two external Pt 100 cold junction sensors.

Connection example: Figure 8

If you use this function, use copper cables from the isothermal cold junction up to the module connector.

The advantage of this is the very fast warm-up behavior of just a few seconds.

Even in the event of extreme temperature fluctuations in the environment where the Axioline F station is located, the system operates very quickly and precisely. There is also the option of adjusting all sensor and cable tolerances in the application via an additional path calibration function.

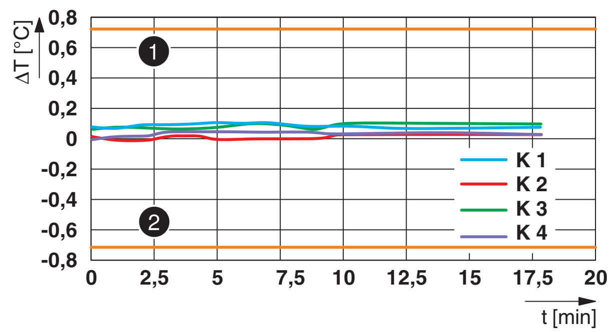


Figure 2 Typical switch-on behavior of type K TC sensors with external Pt 100 cold junction compensation and path calibration function for the cold junction at connector 1 at an ambient temperature of +25°C

1	Maximum tolerance limit
2	Minimum tolerance limit
K1 ... K4	Channel 1 ... channel 4

5.9 Technical data for cold junctions

Internal cold junctions

Simple cold junction compensation can be implemented for the thermocouple inputs using the internal cold junctions.

To read the temperature of each internal cold junction for TC channels, parameterize the sensor type as "Cold Junction".

For the accuracy, please refer to the tables of the tolerance values.

Internal cold junction	
Connection method	2-wire connection
Sensor type	Pt 100 DIN
R_0 (sensor resistance at T_A = 0°C)	100 Ω
Measuring range	-55°C ... +125°C
Resolution (process data)	0.1 K/LSB
Resolution (floating point object)	< 0.001 K
Filter time	120 ms

Compensation of the mounting position of the internal cold junction

In order that maximum accuracy is also achieved when installed in various different mounting positions, it is possible to compensate the mounting position of the internal cold junction.

Parameterize this compensation using the ParaTable object, data format, mounting position.

Tolerances of the internal cold junction

No.	Tolerance structure	Temperature	Tolerances	
			Typ.	Max.
1	Cold junction temperature drift	-25 °C ... +60 °C	10 ppm/K	25 ppm/K
2	Total tolerance of the internal cold junction	+25°C	±0.15 K	±1.76 K
3	Total tolerance of the internal cold junction	-25 °C ... +60 °C	±0.85 K	±2.4 K

* Thermally steady system without external heat influence

1. The data refers to nominal operation (U_A = 24 V) in the preferred mounting position (horizontal).
2. The measurement is performed within an Axioline F station in which another AXL F UTH4 1H module is located to the right and left of the module in question.

ExternalPt 100 cold junctions

When using external isothermal blocks or distributed terminal boxes, an external cold junction is recommended. The advantage of this is an improved switch-on behavior and the very fast thermal transient period in the event of sudden changes to the ambient temperature of the measuring station.

You can connect up to two Pt 100 sensors to the AXL F UTH4 1H module.

You can also use the inputs for the external cold junction sensors as sensor inputs for any applications with Pt 100 and connection with 2-wire technology. To do so, parameterize the sensor type as “Cold junction” and the cold junction type as “External Pt 100” on the corresponding connector.

ExternalPt 100 cold junctions	
Connection method	2-wire connection
Sensor type	Pt 100 DIN
R_0 (sensor resistance at T_A = 0°C)	100 Ω
Measuring range	-100 °C ... +400 °C
Resolution (process data)	0.1 K/LSB
Resolution (floating point object)	< 0.001 K
Filter time	120 ms

Tolerances of the external Pt100 cold junction inputs

No.		Ambient temperature	Tolerances	
			Typ.	Max.
1	Tolerances	+25°C	±0.3 K	±0.8 K
2	Drift	-25 °C ... +60 °C	±10 ppm/K	±25 ppm/K

The data contains the offset error, gain error, and linearity error in its respective setting.

The data is valid for nominal operation (preferred mounting position, U_A = 24 V).

The documented typical tolerances were determined for reference cable type LiYCY (TP) 2 x 2 x 0.5 mm^2 with a connection length < 1 m.

The drift data and the tolerances specified as a percentage refer to the measuring range final value of +400°C.

The typical data has been determined in an example Axioline F station.

Typical tolerance values are measured application values that are based on the maximum variance of all test objects.

The **maximum tolerance values** represent the worst-case measurement inaccuracy. They contain the theoretical maximum possible tolerances in the corresponding measuring ranges as well as the theoretical maximum possible tolerances of the calibration and test equipment. The data is valid for at least 24 months from delivery of the module. Thereafter the modules can be recalibrated by the manufacturer at any time.

> To achieve maximum accuracy (< ±0.1 K, it is possible to calibrate a measuring section.
> To do so, carry out fine adjustment of the tolerances of the connecting cables and the external Pt 100 sensor with object 008F$_{hex}$: local adjust values.

Drift response of the TC inputs with external cold junction compensation

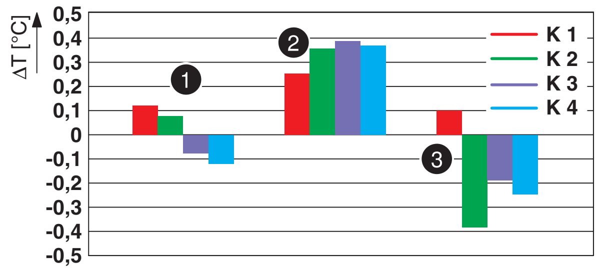


Figure 3 Typical tolerance distribution of type K TC detection with external cold junction compensation and path calibration function for the cold junction

1	Ambient temperature +25°C
2	Ambient temperature +60°C
3	Ambient temperature -25°C
K1 ... K4	Channel 1 ... channel 4

The diagram shows the typical tolerance distribution in the entire ambient temperature range of the module with external Pt 100 compensation and path calibration of the cold junction in the entire ambient temperature range of T_U = -25°C ... +60°C.

The advantages of external cold junction compensation are, on the one hand, immediate measuring accuracy without thermal switch-on behavior and, on the other hand, high temperature stability.

For maximum accuracy, path calibration is possible. This can be carried out channel-specific using object 008F$_{hex}$. You can therefore calibrate the tolerances of the entire measuring section including the sensor and connecting cable.

5.10 Technical data for the ±5 V DC voltage input

This input is used to acquire additional voltage signals.

Connect a signal converter to the input. This can be used to acquire any AC or DC currents which are converted by the converter into an electrically isolated ±5 V signal. This ±5 V signal is processed by the module.

Connection example: Figure 13

±5 V voltage input	
Connection method	2-wire connection
Measuring range	-5 V ... +5 V
Format	IB IL
Resolution	16-bit
Quantization	166.7 µV/LSB
Filter time	120 ms
Input resistance	typ. 5 MΩ

Tolerances of the voltage input

No.		Temperature	Absolute		Relative	
			Typ.	Max.	Typ.	Max.
1	Tolerance	+25°C	±1 mV	±10 mV	±0.02%	±0.20 %
2	Tolerance	-25 °C ... +60 °C	±2.3 mV	±15 mV	±0.05 %	±0.30%
3	Drift	-25 °C ... +60 °C	±8 ppm/K	±20 ppm/K		

Typical tolerance values are measured application values that are based on the maximum variance of all test objects.

The **maximum tolerance values** represent the worst-case measurement inaccuracy. They contain the theoretical maximum possible tolerances in the corresponding measuring ranges as well as the theoretical maximum possible tolerances of the calibration and test equipment. The data is valid for at least 24 months from delivery of the module. Thereafter the modules can be recalibrated by the manufacturer at any time.

Use an isolating amplifier to decouple from the field the sensor signals which go to the sensor input. The MCR range from Phoenix Contact offers various solutions (see also connection example "Universal AC and DC current acquisition by means of combination with a current transducer").

5.11 Cycle times

Filter time	Channel conversion time for TC operation with internal compensation
120 ms	120 ms
100 ms	100 ms
60 ms	60 ms
40 ms	40 ms

Filter time	Typical scan repeat time for all four measuring channels
	TC operation with internal cold junction compensation
120 ms	962 ms
100 ms	880 ms
60 ms	720 ms
40 ms	640 ms

Filter time	Typical scan repeat time for a measuring channel
	TC operation with internal cold junction compensation; channels 2 ... 4 deactivated
120 ms	600 ms
100 ms	580 ms
60 ms	540 ms
40 ms	520 ms

5.12 Tolerances influenced by electromagnetic interference

Type of electromagnetic interference	Standard	Level	Additional tolerances of measuring range final value	Criterion
Electromagnetic fields	EN 61000-4-3/IEC 61000-4-3	10 V/m	None	A
Fast transients (burst)	EN 61000-4-4/IEC 61000-4-4	1.1 kV	None	A
Conducted interference	EN 61000-4-6/IEC 61000-4-6	150 kHz ... 80 MHz, 10 V, 80% (1 kHz)	None	A

The values determined apply for both shielded and unshielded twisted sensor cables. The maximum cable lengths should be taken into consideration.

For all tested electromagnetic interferences (see table), the measured values were within the maximum tolerances.

The values were determined under nominal conditions with the following sensor settings and sensor circuits:

– Thermocouple type K (NiCr-Ni) with internal cold junction compensation, filter = 120 ms
– External RTD sensor type Pt 100 as sensor input, filter = 120 ms
– -100 mV ... +100 mV linear voltage signals, 1 µV/LSB resolution, filter = 120 ms

No additional tolerances occur due to the influence of high-frequency interference caused by wireless transmission systems in the near vicinity.

The specifications refer to nominal operation. The modules are directly exposed to interference without the use of additional shielding measures (e.g., steel cabinet).

6 Internal circuit diagram

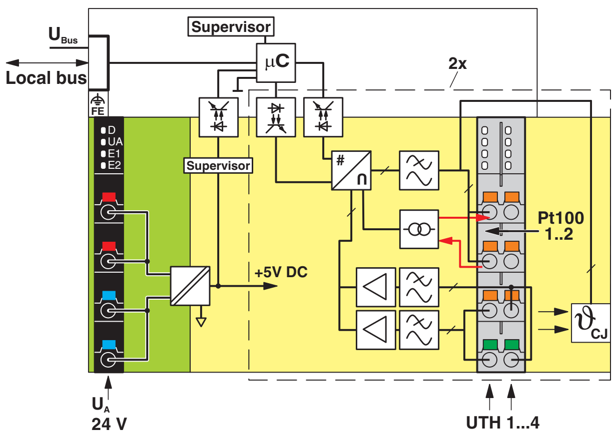
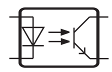
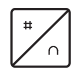
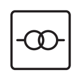
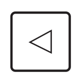


Figure 4 Internal wiring of the terminal points

Key:

Local bus	Axioline F local bus (hereinafter referred to as local bus)
µC	Microcontroller
	Optocoupler
	Power supply unit with electrical isolation
	Analog/digital converter
	Low pass filter
Supervisor	Hardware monitoring
	Constant current source
	Difference amplifier
	Reference ground for communications power
	Noiseless ground
	Electrically isolated areas
	Cold junction (CJ)

7 Terminal point assignment

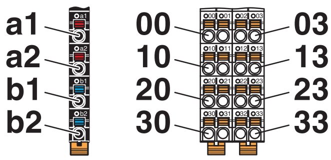


Figure 5 Terminal point assignment

Termi-nal point	Color	Assignment	
Supply voltage input			
a1, a2	Red	24 V DC (U_A)	Analog module supply (internally jumpered)
b1, b2	Blue	GND	Reference potential of the supply voltage (inter-nally jumpered)
Analog inputs			
00, 02	Orange	CJ1+, CJ2+	External external cold junction sensor (+)
01	Orange	-	Not used
10, 12	Orange	CJ1-, CJ2-	External external cold junction sensor (-)
11	Orange	-	Not used
03	Orange	U+	Voltage input 5 V (+)
13	Orange	U-	Voltage input 5 V (-)
20 ... 23	Orange	TC1+ ... TC4+	Thermocouple (+)
30 ... 33	Orange	TC1- ... TC4-	Thermocouple (-)

8 Connection examples

8.1 Absolute temperature measurement with internal cold junction compensation

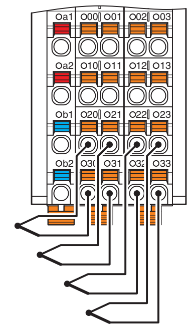


Figure 6 Connection example: absolute temperature measurement

A thermocouple sensor is connected to each of the four channels.

For example, sensor type J (TC1) and sensor type K (TC2) are used at channels 1 and 2.

The measuring temperature of TC1 and TC2 is automati-cally determined by the module by means of internal cold junction compensation.

Parameterize the cold junction type as "Internal" (preset by default).

This application is the simple standard application for tem-perature recording with thermocouples.

8.2 Differential temperature measurement

Precise differential temperature recording is a special application, e.g., in process engineering and process technology. You can determine the exact differential temperature, e.g., between an inlet and return temperature, by connecting two thermocouples in series to one channel of the module.

Parameterize the cold junction type as "Disabled".

The pure differential temperature between the measuring points will therefore be recorded.

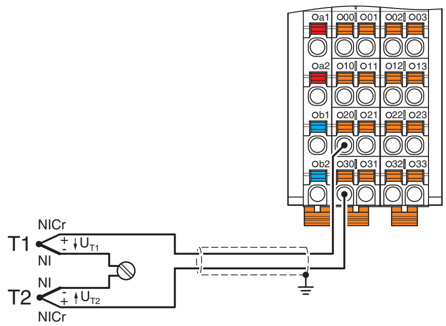


Figure 7 Differential temperature measurement

By linking the two thermocouples (here type K, NiCr-Ni), the temperature difference between both thermoelectric voltages is determined.

$$T_D = T1 - T2$$
$$U_M = UT1 - UT2$$

Where:

T_D	Temperature difference
T1/T2	Temperature at sensor 1/2
U_M	Differential thermoelectric voltage
U_{T1}/U_{T2}	Thermoelectric voltage sensor 1/2

The advantage of this application is the high degree of precision without a waiting time to warm up.

8.3 Thermocouple detection with external cold junction compensation

For applications with a high degree of precision, the module offers the option of compensation using an external cold junction.

Each connector has a connection for an external Pt 100 cold junction sensor.

External cold junction compensation is implemented for each channel.

Proceed as follows:

- Route the sensor cables of the thermocouple to an isothermal block.
- For each channel, wire a copper (Cu) connecting cable from the isothermal block to the input terminals of the module.
- Connect the external Pt 100 cold junction sensor to the isothermal block using a Pt 100 input of connector 1 or 2 (connector 1 in the example).
- Parameterize the cold junction type of the desired input channel as “External, Pt 100, connector x” (x = 1 or 2; channel 1 in the example)

The advantage of this application is the improved warm-up behavior in the first few minutes after the module is switched on.

> As an input is available at each connector for an external Pt 100 cold junction sensor, you can operate up to two external cold junction sensors. If you have connected two cold junction sensors, you can then select any cold junction type, i.e., you can use the Pt 100 of connector 1 or 2.

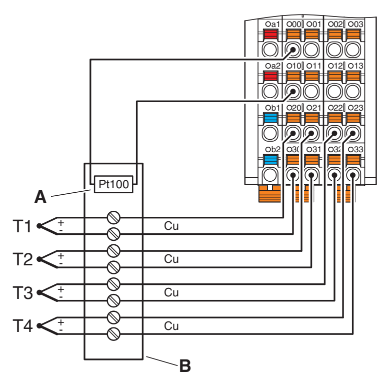


Figure 8 Thermocouple detection with external cold junction compensation at channel 1

A	Pt 100 external cold junction sensor
B	Isothermal block

8.4 Thermocouple detection with cold junction temperature specification via process data

Another option for compensating the cold junction temperature externally is to specify the cold junction temperature via process data.

In this way, the temperature of the external cold junction can be recorded at the isothermal block via any system and used for compensation.

Proceed as follows:

- Route the sensor cables of the thermocouple to an isothermal block.
- For each channel, wire a copper (Cu) connecting cable from the isothermal block to the input terminals of the module.
- Write the cold junction temperature recorded externally by the isothermal block to the first process data output word of the module in your application (IB IL format).
- Parameterize the cold junction type of the desired input channel as "Process data".

For each module, you can use a digital external process data value for cold junction compensation.

OUT1 = T_{CJ}	0	0	0	0

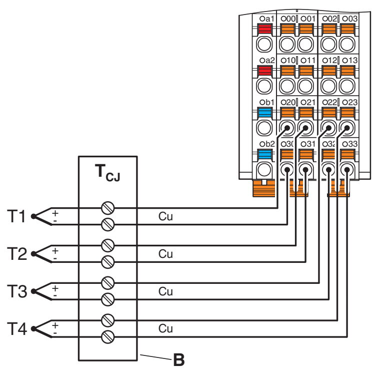


Figure 9 Thermocouple detection with cold junction temperature specification via process data

T_{CJ} Cold junction temperature
B Isothermal block

8.5 Measurement of linear mV voltage signals

You can connect sensors to each channel which supply a linear voltage in the mV range, e.g., pressure or Hall sensors.

- Parameterize the corresponding channel as sensor type “Linear voltage ±100 mV”.

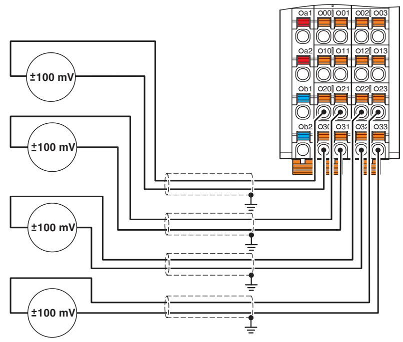


Figure 10 Measurement of linear voltages ±100 mV

A cable break on the sensor cables is monitored and detected.

The ±10 mV and ±30 mV ranges are more accurate than the entire ±100 mV range and have therefore also been specified.

For mV sensors, cable lengths of up to 250 m are possible. Please note the cable length specifications and suitable sensor cable types.

For voltages above +32.7 mV and below -32.7 mV, parameterize the process data resolution as 10 µV/LSB (instead of 1 µV/LSB) in order to prevent overrange or underrange messages from occurring.

8.6 Pt 100 detection

You can also use the inputs for external Pt 100 cold junction sensors as Pt 100 sensor inputs.

To do this, proceed as follows:

- Connect the Pt 100 sensor with 2-wire technology to connector 1 or 2.
- Parameterize a desired channel as sensor type “Cold junction (CJ)” and parameterize the cold junction type as “External, Pt 100, connector x” (x = 1 or 2).
- Record the temperature value of the external Pt 100 sensor at the parameterized channel with a resolution of 0.1 K/LSB.

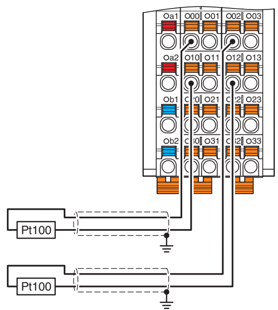


Figure 11 Pt 100 detection

> Make sure that the sensor cable is no more than 10 m in length.

> To achieve maximum accuracy (< ±0.1 K, it is possible to calibrate a measuring section.
> To do so, carry out fine adjustment of the tolerances of the connecting cables and the external Pt 100 sensor with object 008F$_{hex}$: local adjust values.

8.7 Measurement of a ±5 V signal

A -5 V ... +5 V input is available for acquisition from a wide range of signal sources.

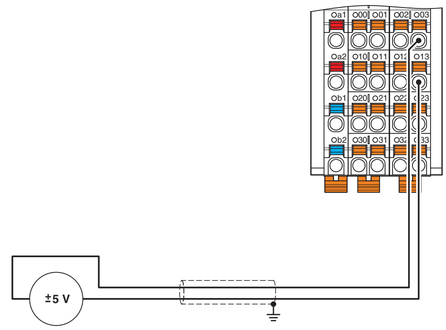


Figure 12 Measurement of a linear voltage ±5 V DC

> Make sure that the shielded twisted sensor cable is no more than 5 m in length at the ±5 V input.
>
> If longer cable lengths are required, connect appropriate converters or signal conditioners upstream.
>
> The MCR range from Phoenix Contact offers a comprehensive range of products for this.

In this way, you can acquire isolated Pt 100 signals, for example, from very remote areas (> 100 m) with a temperature transducer (e.g., MCR-T-UI-E) in 4-wire technology and read them in via the -5 V ... +5 V input. You can use this for external cold junction compensation of very remote control boxes, if copper TC sensor cables need to be used.

8.8 Universal AC and DC current acquisition in combination with a current transducer

Any AC or DC currents with 300 V AC safe isolation according to EN 50178, EN 61010, such as heating currents, can be acquired via the ±5 V voltage input (terminal points 02 and 12) using a current transducer.

For signal conditioning, use the MCR-S-1-5-UI(-SW)-DCI current transducer from Phoenix Contact, for example.

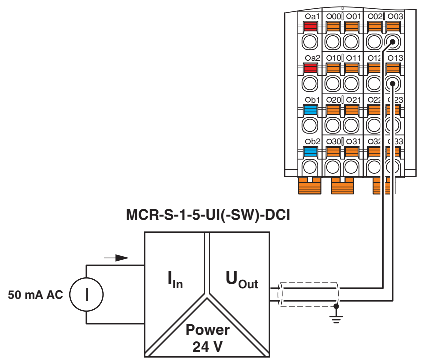


Figure 13 Measurement of an AC or DC current signal at the -5 V voltage input ... +5 V DC in combination with a current transducer (heating current acquisition)

I_{In}	AC/DC input current, 0 mA ... 200 mA up to 0 A ... 11 A, 15 Hz ... 400 Hz
U_{Out}	-5 V DC ... +5 V DC output voltage
MCR-S-1-5-UI(-SW)-DCI	Current transducer

Make sure that the shielded twisted sensor cable is no more than 5 m in length from the current transducer to the temperature module.

If longer cable lengths are required, connect appropriate converters or signal conditioners upstream.

The MCR range from Phoenix Contact offers a comprehensive range of products for this.

9 Connection notes

Use encapsulated thermocouples.

Always connect the thermocouples using twisted pair equalizing conductors.

Use shielded twisted pair equalizing conductors for a cable length from 10 m.

For mV sensors in environments prone to interference as well as for sensor cables which are longer than 10 m. use shielded twisted connecting cables (e.g., LiYCY (TP) 2 x 2 x 0.5 mm^2).

For TC sensors, use the corresponding shielded TC connecting cable according to DIN EN 60584-3/ISO 60584-3.

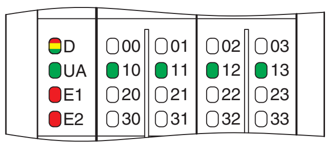
For optimum shield connection directly before the module, use the AXL SHIELD SET Axioline shield connection set (see ordering data).
Please refer to the UM EN AXL SYS INST user manual for information on how to install the set and connect the shield.

For installation in a control cabinet: connect the cable shield to functional earth ground immediately after the cables enter the control cabinet. Route the shield as far as the Axioline F temperature module without interruption.

10 Configuration notes

Always position temperature modules at the end of the station. For modules that must be positioned next to a bus coupler, the typical measuring tolerance can be increased by up to 0.9 K.

11 Local status and diagnostic indicators



Channel errors are errors that can be associated with a channel.
Periphery errors are errors that affect the entire module.

Figure 14 Local status and diagnostic indicators

Designation	Color	Meaning	State	Description
D	Red/yellow/green	Diagnostics of local bus communication		
		Power down	OFF	Device in (power) reset.
		Not connected	Red flashing	Device operating, but there is no connection to previous device.
		Reset	Red ON	Application reset Device operating, but there is still a connection to the previous device, the application is reset.
		Ready	Yellow ON	Device operating, there is still a connection to the previous device, but the device has not yet detected a valid cycle after power on.
		Connected	Yellow flashing	Valid data cycles have been detected, but the device is (not) yet part of the current configuration.
		Device application not active	Green/yellow alternating	Valid data cycles are being detected. The master application set the output data to valid, however, the slave application has not set the input data to valid as yet.
		Active	Green flashing	Device operating, communications within the station is OK. The master application does not read the input data. (The connection to the controller has not yet been established, for example.)
		Run	Green ON	Valid data cycles are being detected. All data is valid
UA	Green	U_{Analog}	ON	Supply of analog modules present
			OFF	Supply of analog modules not present
E1	Red	Supply voltage error	ON	Supply voltage is faulty.
			OFF	Supply voltage is present.
E2	Red	Error	ON	I/O or channel error has occurred.
			OFF	No error
10 ... 13	Red/orange/green	Channel Scout/error message		
		Channel Scout	Orange flashing	Channel searched for
		Error message	Red ON	Open circuit, overrange or underrange or voltage U_A not present
				Errors which affect the entire device (e.g., parameter table invalid); Such errors are only displayed on active channels.
		OK	Green ON	Normal operation, installation OK
		Inactive	OFF	Channel is parameterized as inactive.

Error code and status of the E1 and E2 LEDs

Error	E1 LED	E2 LED
No error	OFF	OFF
Underrange	OFF	ON
Overrange	OFF	ON
Open circuit	OFF	ON
Faulty supply voltage	ON	ON
Parameter table invalid	OFF	ON
Device error	OFF	ON
Flash format error	OFF	ON

12 Process data

The module uses five words of IN process data and five words of OUT process data.

12.1 Input words IN1 to IN5

The measured values of the TC channels are transmitted to the controller board or the computer via process data input words IN1 to IN5.

IN5 is used to transmit the measured value for the voltage input.

The measured values are depicted in IB IL or S7-compatible format. In both cases, the measured value is displayed in 16 bit format. The data type is Integer 16 from a technical programming point of view.

IN1: measured value channel 1
:
IN4: measured value channel 4
IN5: measured value voltage input

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Analog value															

In the IB IL format a diagnostic code is mapped to the input data in the event of an error.

Code (hex)	Cause
8001	Measuring range exceeded (overrange)
8002	Open circuit
8004	Measured value invalid/no valid measured value available
8008	Cold junction defective
8010	Parameter table invalid
8020	Faulty supply voltage
8040	Device faulty
8080	Below measuring range (underrange)

Note regarding code 8008_{hex}:in the event of a cold junction error, code 8008_{hex} is indicated for the channel to which the affected cold junction is assigned.
In order to determine the exact cause of the error, select the "Cold junction" sensor type via the parameterization. The detailed error message is then output for this channel (8080_{hex}, 8001_{hex} or 8002_{hex}).

12.2 Output words OUT1 to OUT5

OUT1: cold junction temperature specification
OUT2: -
:
OUT5: -

13 Open circuit

13.1 Channels 1 to 4 (TC/linear voltage)

Channels 1 to 4 have open circuit detection.

As soon as an open circuit occurs, this is indicated in the process data and in PDI object 0018_{hex}.

In addition, the corresponding diagnostic LED for the channel lights up red.

13.2 Voltage input ±5 V

In the event of an error, the voltage input value goes to 0.

A diagnostic message is not generated, this error is not indicated at the diagnostic LEDs either.

14 Significant values in various formats

14.1 Significant values in IB IL format

Input data		Temperature sensors		Linear voltage ±100 mV	
Resolution		1°C or 1°F	0.1°C or 0.1°F	1 µV	10 µV
hex	dec	°C or °F	°C or °F		
8001	Overrange	> Limit value	> Limit value	> 32.512 mV	> 100 mV
03E8	1000	+1000.0	+100.0	+1 mV	+10 mV
0001	1	+1.0	+0.1	+1 µV	+10 µV
0000	0	0	0	0 µV	0 µV
FFFF	-1	-1	-0.1	-1 µV	-10 µV
FC18	-1000	-1000.0	-100.0	-1 mV	-10 mV
8080	Underrange	< Limit value	< Limit value	< -32.512 mV	< -100 mV

14.2 Significant values in S7-compatible format

Input data		Temperature sensors		Linear voltage ±100 mV	
Resolution		1°C or 1°F	0.1°C or 0.1°F	1 µV	10 µV
hex	dec	°C or °F	°C or °F		
8000	Overrange	> Limit value	> Limit value	> 32.512 mV	> 100 mV
03E8	1000	+1000.0	+100.0	+1 mV	+10 mV
0001	1	+1.0	+0.1	+1 µV	+10 µV
0000	0	0	0	0	0
FFFF	-1	-1	-0.1	-1 µV	-10 µV
FC18	-1000	-1000.0	-100.0	-1 mV	-10 mV
7FFF	Underrange	< Limit value	< Limit value	< -32.512 mV	< -100 mV

15 Parameter, diagnostics and information (PDI)

Parameter and diagnostic data as well as other information is transmitted via the PDI channel of the Axioline F station.

The standard and application objects stored in the module are described in the following section.

The following applies to all tables below:

Please refer to the UM EN AXL F SYS INST for an explanation of the object codes and data types.

Abbreviation	Meaning
A	Number of elements
L	Length of the elements in bytes
R	Read
W	Write

Every visible string is terminated with a zero terminator (00_{hex}). The length of a visible string element is therefore one byte larger than the amount of user data.

For detailed information on PDI and the objects, please refer to the UM EN AXL F SYS INST user manual.