smartIO 4RTD

Technical data and description

The **smartIO 4RTD** provides four analog inputs for resistance temperature detectors with a measuring range of 20 Ω … 4 kΩ at a sampling rate of approx. 10 Hz. This allows temperature sensors such as Pt100 or Pt1000 to be connected.

The measuring input is designed for 3-wire connection, whereby a fourth, internally not connected input can accommodate the 4th connection, if present.

Each module in the RAIL version is individually tested with regard to dielectric strength and insulation. With the stable aluminum housing and nano-coating of the board, the requirements for use on rail vehicles are also met.

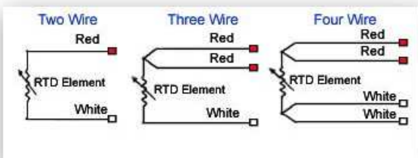
In the version for smartRAIL, the connectors for power supply and communication are designed as M12 connectors. (Figure similar)

Measurement functions

The measuring module records the ratio between the voltage drop at the sensor and the sensor current, i.e. the resistance value, with a sampling rate of 10 Hz; the bandwidth is limited to 4.8 Hz by analog aliasing filters. For the two measuring ranges up to 400 Ω (Pt100) or 4 kΩ (Pt1000) the amplification is switched in the measuring amplifier. The module converts the measured resistance value into a temperature. Raw data are directly available on the CAN bus via CAN messages.

Resistance measurement with line compensation

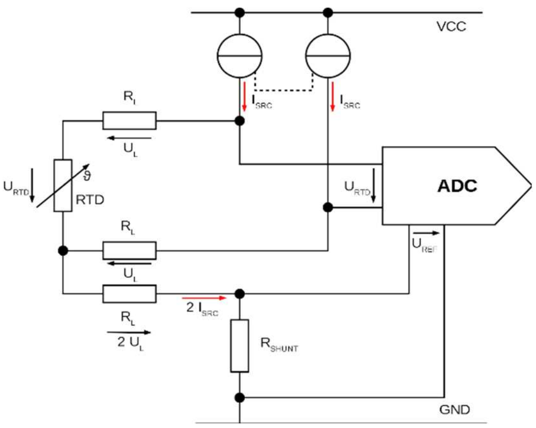
The resistance changes of an RTD for small temperature changes are in the same order of magnitude as the resistances of the connecting leads themselves [1]. Since these also change their value with the ambient temperature, in practice not only 2 leads but 3 or 4 leads are used to connect the RTD sensor. Three different strategies are followed:



[1] For 100 m Cu conductor, 0.22 mm^2, this results in a line resistance of 7.8 Ω.

1. **Separation of supply current and measuring voltage**
   The voltage that drops at the sensor is fed to the high-impedance measuring system via a separate pair of lines (sense), so that no current flows in these lines and thus the measuring signal arrives at the input of the measuring system unaltered.
   => 4-wire (Wire) connection
2. **Measuring the voltage drop on the line and taking it into account in the measurement result.**
   The voltage drop across the supply line is measured via a single line (sense) and subtracted from the voltage drop measured across the same line via resistor and return line. Here very small voltage levels must be processed, the circuit becomes correspondingly complex. **=> 3-wire (Wire) connection**
3. **Compensation of voltage drops by double power supply**
   Instead of one current source for sensor supply, 2 are used and the supply currents are fed to the sensor via a pair of lines (white/red). The return current is fed via the third line (red). The voltage difference applied to the supply lines corresponds to that applied to the sensor resistor, since the same voltage drops across both lines in the same direction. The accuracy of the current sources does not matter if the supply current is measured in total. The noise immunity is higher, because all lines are "low impedance" terminated by the current sources.
   => 3-wire (Wire) connection

This third measuring method is implemented in the **smartIO 4RTD.** A constant current of approx. 100 µA is applied to the outgoing and one return line. The two currents flow back through the third conductor into the measuring system and are measured here as a sum. The current sources are designed to be permanently short-circuit-proof for each sensor input. Due to the current direction in the same direction, the same voltage drop occurs across each feeding sensor cable and the voltage drop at the RTD sensor can thus be measured without distortion.

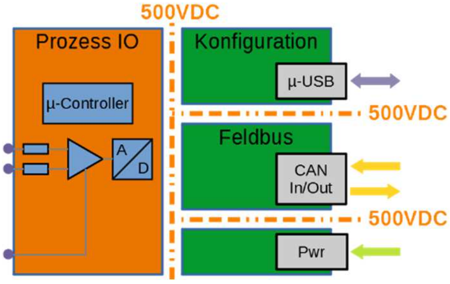


The 16-bit AD converter used directly measures the ratio between the voltage at the sensor and the supply current, i.e. the actual resistance value. A switchable gain factor allows optimized adaptation to Pt100 or Pt1000 sensors.

The small supply current of 100µA results in a power output of 1µW at the sensor and is thus negligible for most applications.

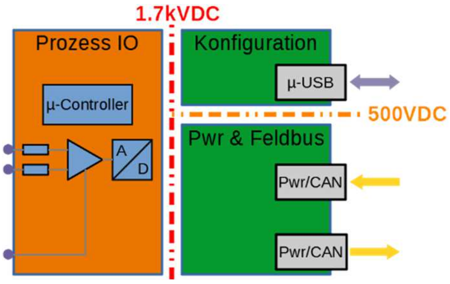
Isolation of the terminal groups

In the standard version, the supply voltage, CAN and process inputs are isolated from each other. This means that the CAN bus in this variant is potential-free. In addition to CAN-H and CAN-L, the CAN-GND must also be connected in the system for a secure data connection.



In the RAIL version, the CAN bus is routed in the same cable as the power supply. Here, the ground potential of the power supply is identical to that of the CAN bus. The isolation to the process IO is designed for 1.7 kV DC.

Process inputs among each other are, depending on the design of the module, connected with high impedance against the internal analog reference point and thus, if this is not specified, also among each other. This GND is available as "*opt GND*" at the terminal strip and can be connected to an external process ground, if *any* influence of the inputs among each other shall be avoided. Normally this is not necessary.

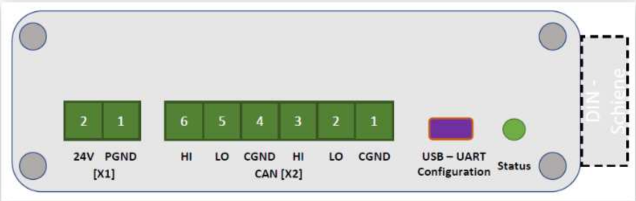


Interfaces of the module

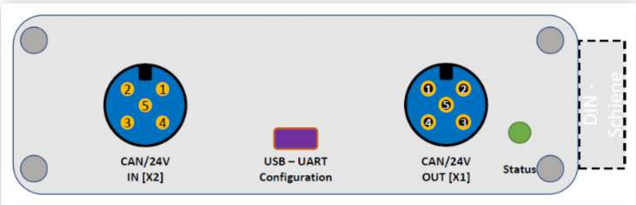
Power supply and CAN bus

The measuring module is equipped with reverse polarity protection and has a self-healing fuse against overload of the internal electronics.

Power supply and communication line to the higher-level device of the smart family (smartMINI, smartRAIL, etc.) are implemented in the basic version with Phoenix terminals with 3.5mm pitch. The isolated CAN bus is looped through the device, so that a simple cascading of several measuring modules is also possible with the terminals. The reference potential CGND is isolated from the supply voltage PGND.



In the RAIL version, supply and CAN are available on two M12 connectors according to the Device-Net assignment. The 24V power supply and the CAN bus connection are looped through from the plug to the socket. This allows several different smartIO modules to be connected in series. If no further smartIO module follows, the CAN bus must be terminated using a connector with integrated terminating resistor (120 Ω) or directly at the Phoenix terminal. CAN-GND is identical to the supply ground.



Pin	Signal	Description
1	CAN Shield	
2	+24V	Voltage supply +24V (wide range see technical data)
3	GND	Reference ground for voltage supply and CAN bus
4	CAN_H	CAN bus: CAN high
5	CAN_L	CAN bus: CAN-LOW

Commercially available Device-Net cables that lead from socket to plug can be used. In the case of assembled cables, twisted pair cable bundles must be selected for connection pairs 2 and 3 as well as 4 and 5.

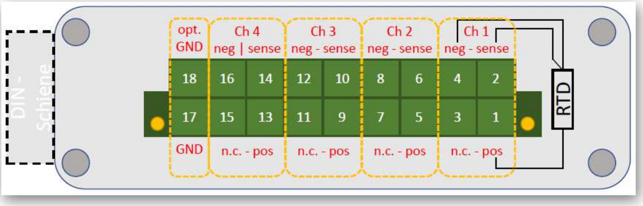
Configuration

Behind the USB-UART configuration interface there is a USB-Serial converter (CP2102N), which is mapped as Virtual COM port under Windows. For the configuration of the module the ASCII based SCPI protocol is used. A description of the commands is available on request.

For the configuration of the smartIO modules the optiCONTROL software from optiMEAS is recommended, which implements this protocol and provides a graphical user interface with appropriately prepared dialogs.

Measurement input

For the measuring inputs, double-row Phoenix terminals with 3.5 mm pitch are used in both versions. Due to the coding of the connectors, a pre-assembly of the plugs and a confusion-proof connection is possible.



Special approvals and declarations

For the ***smartRAIL version, in*** addition to the CE declaration of conformity, the following certifications to EN50155 are also carried out:

EC Declaration of Conformity	CE	The CE mark indicates compliance with the • EMC Directive, • RoHS 2011/65/EU (08.06.2011) and the • Low Voltage Directive an.

Railroad applications -
Electronic devices on
Rail vehicles.
EN 50155:2008
	EN50155
	IEC61373
	EN50121
	EN45545
		The systems meet the standard for the following properties:
		• *Environmental conditions*:
		  ○ AX (2000m) EN50125-1 §4.2.1
		  ○ TXEN50155 §4.1.2
		• *Climate*[2]
		  ○ RefrigerationEN50155 §13.4.5.2
		  ○ Dry heatEN50155 §13.4.5.3
		  ○ Humid heatEN50155 §13.4.5.7cyclic
		• *SwingIEC61373* §8 + 9
		• *ShockIEC61373* §10
		• *EMC, insulationEN50121-3-2* EN 61000-3-2/3 EN 55016-2-1/2
		• *Fire protectionEN45545-2*
		
		routine tests according to EN50155 §12.2
		• *Visual inspection* EN50155 §12.2.1
		• *Insulation* EN50155 §12.2.9.1
		• *Withstand voltage* EN50155 §12.2.9.2

[2] Already according to EN 50155:2017

Technical data

Supply voltage / ambient conditions

Symbol	*Parameter*	*Comment*	*Min*	*Type*	*Max*	*Unit*
V_{CC}	Supply voltage	with reverse polarity protection	7		36	V DC
	Overvoltage protection		no			
	ESD protection	TVS diode			40	V
I_{CC}	Current consumption	@ 24V		40	100	mA
	Connector (standard)		Phoenix, pitch 3.5mm			
	Connector (smartRAIL)	together with CAN bus	M12 in / M12 out			
$T_{operating}$	Operating temperature	EN 50155 / Range TX	-40		85	°C
	Relative humidity	Nano coating, 50°C	5		95	%
	Housing		Aluminum			
L	Dimensions: Length	without plug / feet / clip		104		mm
B	Wide			85		mm
H	Height			35		mm
m	Weight			250		g
	Screw connection	Front panels against carcass	M3, stainless steel VA2, lock washers			
	Mounting (standard)	Option mounting feet or mounting rail (EN 50022)				
	Mounting (RAIL)		TS 35			
	Cooling		passive			
	Protection class	(ISO 20653 - 2013)	IP54			
	Insulation resistance RAIL	@500V	10			GΩ
	Withstand voltage test, 60s **RAIL**	To measurement input		1.7		kV

Analog inputs

Symbol	*Parameter*	*Comment*	*Min*	*Type*	*Max*	*Unit*
N_{AInR}	Type / Quantity	**Resistance**		8		
R_{Mess}	Measuring range	for Pt100	18,5	100	375	Ω
			-200	0	800	°C
		for Pt1000	185	1000	3750	Ω
			-200	0	800	°C
I_{SENSOR}	Feed current		90	100	110	µA
ΔR	Resolution ADC	for Pt100 @ 20 °C			0,1	°C
		for Pt1000 @ 20 °C			0,1	°C
R_{Ain}	Input resistance			30		kΩ
	Converter	Sigma Delta		16		bit
f_{Ain}	Sampling rate	128x oversampling		10		Hz
f_{-3dB}	Bandwidth			4		Hz
	Accuracy	On measuring range		0,5		%

CPU

Symbol	*Parameter*	*Comment*	*Min*	*Type*	*Max*	*Unit*
	Processor			SAMC21E		
	Family			ARM Cortex-M0+		
	Clock			48		MHz
	ROM	FLASH		256		kByte
	RAM	SRAM		32		kByte
	Data bus width			32		bit

Interfaces

Symbol	*Parameter*	*Comment*	*Min*	*Type*	*Max*	*Unit*
	Type / Quantity	**CAN 2.0B**		1		
	Baud rate	parameterizable		500		kBit/s
	Connector (standard)		Phoenix, pitch 3.5mm			
	Connector (RAIL)	Together with supply	M12 in / M12 out			
	Terminating resistor		no			
	Isolation RAIL	To measurement input	1.7 kV			
	Isolation standard	to measurement input / CAN	500 V			
	Type / Quantity	**Serial / USB**		1		
	Baud rate	Fixed		38400		Bit/s
	Connector		Micro USB			
	Chipset	Supply through USB	CP2102N			
	Isolation	To CAN/supply	isolated			

Process image

The following messages[3] are transmitted via the CAN bus:

Status

Approx. 60 seconds after the start of the module, the following information is transmitted once:

- Serial number
- Firmware version

The module periodically sends messages for self-diagnosis, which can be evaluated by the higher-level system as a heartbeat. The following functions are mapped via this message:

- Status bit as the result of a verification of the set parameters against a checksum generated during configuration. In this way, an accidental change in the configuration can be detected and reported.
- Counters for the independent program loops and interrupt service routines. If the counter values change in each message, it can be assumed that all functions of the module are served.
- Further status bits, e.g. for sensor diagnostics (if available)

[3] For the description of the CAN messages the DBC format of the company Vector-Informatik GmbH, developed already in 1992, is used here. This represents a de facto standard in the context of CAN bus systems.

DBC Description:

BO_ 2147499695 Module_Info: 8 Vector__XXX
SG_ u32_TypSerial : 8|32@1+ (1,0) [0|4.29497e+009] "" Vector__XXX
SG_ u8_year of construction : 0|8@1+ (1,0) [0|255] "" Vector__XXX
SG_ u8_FIRMWARE_MINOR : 56|8@1+ (1,0) [0|255] "" Vector__XXX
SG_ u8_FIRMWARE_MIDDLE : 48|8@1+ (1,0) [0|255] "" Vector__XXX
SG_ u8_FIRMWARE_MAJOR : 40|8@1+ (1,0) [0|255] "" Vector__XXX

BO_ 2147499895 Module_Status: 8 Vector__XXX
SG_ u16_Modulsttaus : 48|16@1+ (1,0) [0|65535] "" Vector__XXX
SG_ u8_RTD_Rollercounter : 0|8@1+ (1,0) [0|255] "" Vector__XXX

Raw data

After acquiring the raw data and calculating the temperatures, the measured values are transmitted in two messages as 16-bit values.

DBC Description:

BO_ 80 Temperature_1_2_3_4: 8 Vector__XXX
SG_ Temperature_04 : 48|16@1- (0.1,0) [0|3276.7] "°C" Vector__XXX
SG_ Temperature_03 : 32|16@1- (0.1,0) [0|3276.7] "°C" Vector__XXX
SG_ Temperature_02 : 16|16@1- (0.1,0) [0|3276.7] "°C" Vector__XXX
SG_ Temperature_01 : 0|16@1- (0.1,0) [0|3276.7] "°C" Vector__XXX

BO_ 81 Resistance_1_2_3_4: 8 Vector__XXX
SG_ i16_Resistance_4 : 48|16@1- (0.1,0) [-3276.8|3276.7] "" Vector__XXX
SG_ i16_Resistance_3 : 32|16@1- (0.1,0) [-3276.8|3276.7] "" Vector__XXX
SG_ i16_Resistance_2 : 16|16@1- (0.1,0) [-3276.8|3276.7] "" Vector__XXX
SG_ i16_Resistance_1 : 0|16@1- (0.1,0) [-3276.8|3276.7] "" Vector__XXX

Contact

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