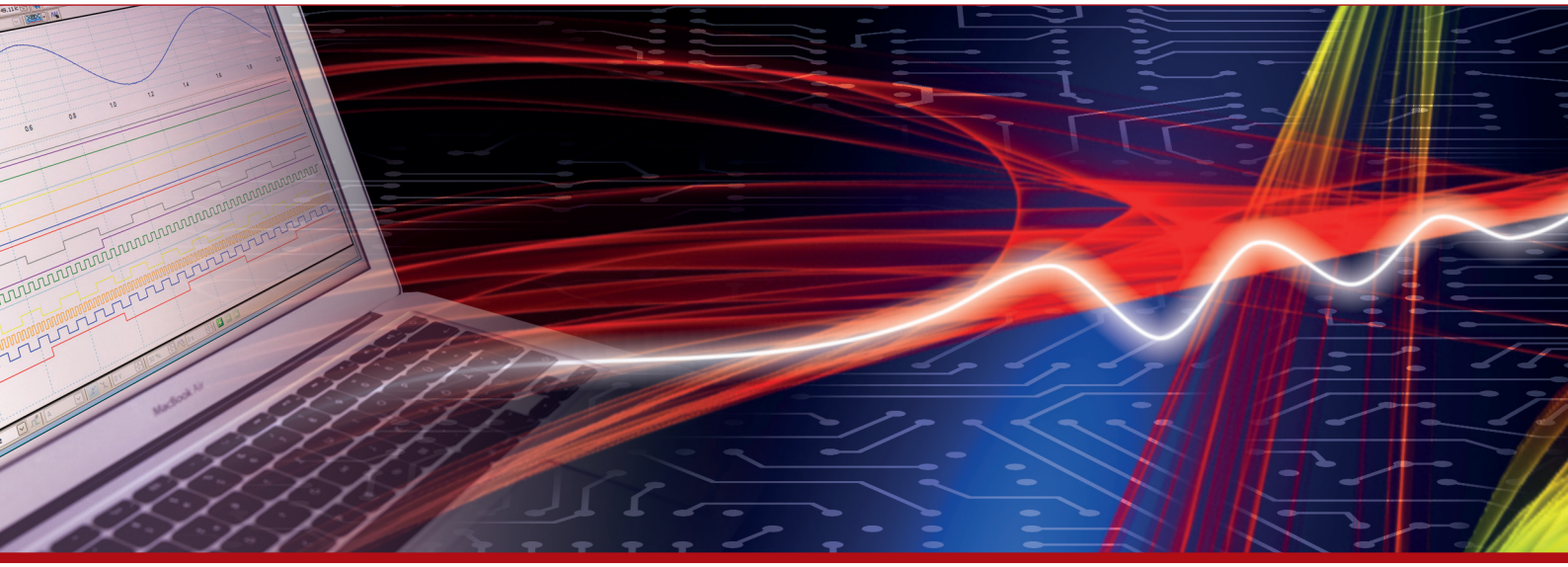
Product Datasheet - Technical Specifications



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Specifications

Typical for 25 °C unless otherwise specified.
All specifications apply to all temperature and voltage input channels unless otherwise specified.
Specifications in *italic* text are guaranteed by design.

Analog input

Table 1. Generic analog input specifications

Parameter	Conditions	Specification
A/D converter type	T0x-T3x, V0x-V3x	AD42_321 Dual 24-bit Sigma-Delta
Number of channels	Voltage input V0x-V3x	4 differential 4 single-ended
	Temperature input T0x-T3x	4 differential
Input isolation		*500 VDC minimum between field wiring and USB interface*
Channel configuration	T0x-T3x	Temperature input. Software programmable to match sensor type
	V0x-V3x	Voltage input
Analog input modes	Power up and reset state	Factory default configuration is Disabled mode. Once configured, each channel reverts to the mode previously set by the user.
	Single-ended	Vx_H inputs are connected directly to their screw terminal pins. Vx_L inputs are disconnected from their screw terminal pins and internally connected to GND.
	Differential	Vx_H and Vx_L inputs are connected directly to their screw terminal pins.
		Tx_H and Tx_L inputs are connected directly to their screw terminal pins.
Input ranges	Thermocouple T0x-T3x	±0.080 V
	RTD T0x-T3x	0 to 0.5 V
	Thermistor T0x-T3x	0 to 2 V
	Semiconductor sensor T0x-T3x	0 to 2.5 V
	Voltage V0x-V3x	±10 V, ±5 V, ±2.5 V, ±1.25 V software selectable
Absolute maximum input voltage	*T0x-T3x relative to GND* *(pins 9, 19, 22, 27, 30, 33, 36, 39, 49)*	*±25 V maximum (power on)* *±40 V maximum (power off)*
	V0x-V3x relative to GND *(pins 9, 19, 22, 27, 30, 33, 36, 39, 49)*	*±25 V maximum (power on)* *±15 V maximum (power off)*
Input impedance	*T0x-T3x*	*5 Gigohm (power on)* *1 Mohm (power off)*
	V0x-V3x	*10 Gigohm (power on)* *2.49 kohm (power off)*

Parameter	Conditions	Specification
Input leakage current	*T0x-T3x, with open thermocouple detect disabled.*	*30 nA maximum*
	T0x-T3x, with open thermocouple detect enabled.	*105 nA maximum*
	V0x-V3x	*±1.5 nA typical., ±25 nA maximum*
Input bandwidth (-3 dB)	T0x-T3x	50 Hz
	V0x-V3x	3 kHz
Maximum working voltage (signal + common mode)	V0x-V3x	±10.25 V maximum
Common mode rejection ratio	*T0x-T3x, f_{IN} = 60 Hz*	*100 dB*
	V0x-V3x, f_{IN} = 60 Hz, all input ranges	*83 dB*
ADC Resolution		24 bits
ADC No missing codes		*24 bits*
Input coupling		DC
Warm-up time		30 minutes minimum
Open thermocouple detect	T0x-T3x	Automatically enabled when the channel pair is configured for thermocouple sensor. The maximum open detection time is 3 seconds.
CJC sensor accuracy	T0x-T3x, *15 °C to 35 °C*	*±0.25 °C typical, ±0.5 °C maximum*
	T0x-T3x, *0 °C to 70 °C*	*–1.0 to +0.75 °C maximum*

Channel configurations

Table 2. Channel configuration specifications

Channel	Category	Conditions	Specification
T0x-T3x	Disabled	All temperature input channels are disconnected from screw terminals and internally connected to GND.	See Note 4
T0x-T3x	Thermocouple Note 1		4 differential channels
T0x-T3x	Semiconductor sensor Note 1		4 differential channels
T0x-T3x	RTD and Thermistor Note 1	2-wire input configuration with a single sensor	2 differential channels
		2-wire input configuration with two sensors	4 differential channels
		3-wire configuration with a single sensor per channel pair	2 differential channels
		4-wire input configuration	4 differential channels
V0x-V3x	Disabled	All voltage input channels are disconnected from screw terminals and internally connected to GND.	See Note 4
V0x-V3x	Differential Note 2		4 differential channels
V0x-V3x	Single-ended		4 single-ended channels

Note 1: Internally, the USB-TEMP-AI has four, dual-channel, fully differential A/Ds providing a total of eight input channels. The temperature input channels are configured as two channel pairs with T0x/T1x and T2x/T3x accepting temperature sensor type inputs. This "channel-pairing" requires T0x/T1x, and T2x/T3x to be configured to monitor the same category of temperature sensor. Mixing different sensor types of the same category (such as a type J thermocouple on temperature channel 0 and a type T thermocouple on temperature channel 1) is valid.

Note 2: The voltage input channels, channels V0x, V1x, V2x, and V3x are *not* configured as channel pairs. Therefore each channel can be configured independently. When connecting differential inputs to floating input sources, you must provide a DC return path from each differential input to ground. To do this, simply connect a resistor from each of the differential inputs to GND. A value of approximately 1Meg ohm can be used for most applications.

Note 3: Channel configuration information is stored in the EEPROM of the isolated microcontroller by the firmware whenever any item is modified. Modification is performed by commands issued over USB from an external application, and the configuration is made non-volatile through the use of the EEPROM.

Note 4: The factory default configuration is **Disabled**. The Disabled mode disconnects the temperature and voltage inputs from the terminal blocks, and internally connects ground (GND) to all of the A/D inputs. This mode also disables each of the current excitation sources.

Compatible sensors: T0x-T3x

Table 3. Compatible sensor type specifications

Parameter	Conditions
Thermocouple	J: -210 °C to 1200 °C
	K: -270 °C to 1372 °C
	R: -50 °C to 1768 °C
	S: -50 °C to 1768 °C
	T: -270 °C to 400 °C
	N: -270 °C to 1300 °C
	E: -270 °C to 1000 °C
	B: 0 °C to 1820 °C
RTD	100 ohm PT (DIN 43760: 0.00385 ohms/ohm/°C)
	100 ohm PT (SAMA: 0.003911 ohms/ohm/°C)
	100 ohm PT (ITS-90/IEC751:0.0038505 ohms/ohm/°C)
Thermistor	Standard 2,252 ohm through 30,000 ohm
Semiconductor / IC	TMP36 or equivalent

Accuracy

Thermocouple measurement accuracy: T0x-T3x

Table 4. Thermocouple accuracy specifications, including CJC measurement error. All specifications are (±).

Sensor Type	Sensor temperature range	Accuracy error maximum (°C)	Accuracy error typical (°C)	Tempco (°C/°C)
J	-210 °C	2.028	0.707	0.031
	0 °C	0.835	0.278	
	1200 °C	0.783	0.288	
K	-210 °C	2.137	0.762	0.035
	0 °C	0.842	0.280	
	1372 °C	0.931	0.389	
S	-50 °C	1.225	0.435	0.021
	250 °C	0.554	0.195	
	1768 °C	0.480	0.157	
R	-50 °C	1.301	0.458	0.019
	250 °C	0.549	0.190	
	1768 °C	0.400	0.134	

Sensor Type	Sensor temperature range	Accuracy error maximum (°C)	Accuracy error typical (°C)	Tempco (°C/°C)
B	250 °C	2.193	2.185	0.001
	700 °C	0.822	0.819	
	1820 °C	0.469	0.468	
E	-200 °C	1.976	0.684	0.030
	0 °C	0.954	0.321	
	1000 °C	0.653	0.240	
T	-200 °C	2.082	0.744	0.035
	0 °C	0.870	0.290	
	400 °C	0.568	0.208	
N	-200 °C	2.197	0.760	0.028
	0 °C	0.848	0.283	
	1300 °C	0.653	0.245	

Note 5: Thermocouple measurement accuracy specifications include polynomial linearization, cold-junction compensation and system noise. These specs are for one year, or 3000 operating hours, whichever comes first, and for operation of the USB-TEMP-AI between 15 °C and 35 °C. There is a CJC sensor on each temperature sensor input side of the module. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Errors shown do not include inherent thermocouple error. Contact your thermocouple supplier for details on the actual thermocouple accuracy error.

Note 6: Thermocouples must be connected to the USB-TEMP-AI such that they are floating with respect to GND (pins 9, 19, 22, 27, 30, 33, 36, 39, 49). The USB-TEMP-AI GND pins are isolated from earth ground. You can connect thermocouple sensors to voltages referenced to earth ground as long as the isolation between the GND pins and earth ground is maintained.

Note 7: When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results, we recommend using insulated or ungrounded thermocouples when possible.

Semiconductor sensor measurement accuracy: T0x-T3x

Table 5. Semiconductor sensor accuracy specifications

Sensor type	Temperature Range	Accuracy Error maximum
TMP36 or equivalent	-40 to 150 °C	±0.50 °C

Note 8: Error shown does not include errors of the sensor itself. These specifications are for one year while operation of the USB-TEMP-AI unit is between 15 °C and 35 °C. Contact your sensor supplier for details on the actual sensor error limitations.

RTD measurement accuracy: T0x-T3x

Table 6. RTD measurement accuracy specifications, I_{x+} = 210 µA. All specifications are (±).

RTD	Sensor temperature range	Accuracy error (°C) maximum	Accuracy error (°C) typical	Tempco (°C/°C)
PT100, DIN, US or ITS-90	-200 °C	2.913	2.784	0.001
	-150 °C	1.201	1.070	0.001
	-100 °C	0.482	0.349	0.001
	0 °C	0.261	0.124	0.001
	100 °C	0.269	0.127	0.001
	300 °C	0.287	0.136	0.001
	600 °C	0.318	0.150	0.001

Note 9: The error shown does not include errors of the sensor itself. The sensor linearization is performed using a Callendar-Van Dusen linearization algorithm. The accuracy and tempco specifications *include* the accuracy of the Callendar-Van Dusen linearization algorithm. These specifications are for one year while operation of the USB-TEMP-AI unit is between 15 °C and 35 °C. The specification does not include lead resistance errors for 2-wire RTD connections. Please contact your sensor supplier for details on the actual sensor error limitations.

Note 10: Resistance values greater than 660 ohms cannot be measured by the USB-TEMP-AI in the RTD mode. The 660 ohm resistance limit includes the total resistance across the current excitation (±Ix) pins, which is the sum of the RTD resistance and the lead resistances.

Note 11: For accurate three wire compensation, the individual lead resistances connected to the ±Ix pins must be of equal ohmic value. To ensure this, use connection leads of equal lengths.

Thermistor measurement accuracy: T0x-T3x

Table 7. Thermistor measurement accuracy specifications, I_{x+} = 10 µA. All specifications are (±)

Thermistor	Sensor temperature range	Accuracy error maximum (°C)	Accuracy error typical (°C)	Tempco (°C/°C)
2252 Ω	-40 °C	0.001	0.0007	0.001
	0 °C	0.021	0.008	0.001
	50 °C	0.263	0.130	0.001
	120 °C	3.473	1.750	0.001
5000 Ω	-35 °C	0.001	0.0006	0.001
	0 °C	0.009	0.004	0.001
	50 °C	0.115	0.049	0.001
	120 °C	1.535	0.658	0.001
10000 Ω	-25 °C	0.001	0.0005	0.001
	0 °C	0.005	0.002	0.001
	50 °C	0.060	0.028	0.001
	120 °C	0.771	0.328	0.001
30000 Ω	-10 °C	0.001	0.0005	0.001
	0 °C	0.002	0.001	0.001
	50 °C	0.019	0.009	0.001
	120 °C	0.267	0.128	0.001

Note 12: Error shown does not include errors of the sensor itself. The sensor linearization is performed using a Steinhart-Hart linearization algorithm. The accuracy and tempco specifications *include* the accuracy of the Callendar-Van Dusen linearization algorithm. These specifications are for one year while operation of the USB-TEMP-AI unit is between 15 °C and 35 °C. The specification does not include lead resistance errors for 2-wire thermistor connections. Contact your sensor supplier for details on the actual sensor error limitations. Total thermistor resistance on any given channel pair must not exceed 180k ohms. Typical resistance values at various temperatures for supported thermistors are shown in Table 8.

Table 8. Typical thermistor resistance measurement range

Temp	2252 Ω thermistor	3000 Ω thermistor	5 kΩ thermistor	10 kΩ thermistor	30 kΩ thermistor
-40 °C	76 kΩ	101 kΩ	168 kΩ	240 kΩ (Note 13)	885 kΩ (Note 13)
-35 °C	55 kΩ	73 kΩ	121 kΩ	179 kΩ	649 kΩ (Note 13)
-30 °C	40 kΩ	53 kΩ	88 kΩ	135 kΩ	481 kΩ (Note 13)
-25 °C	29 kΩ	39 kΩ	65 kΩ	103 kΩ	360 kΩ (Note 13)
-20 °C	22 kΩ	29 kΩ	49 kΩ	79 kΩ	271 kΩ (Note 13)
-15 °C	16 kΩ	22 kΩ	36 kΩ	61 kΩ	206 kΩ (Note 13)
-10 °C	12 kΩ	17 kΩ	28 kΩ	48 kΩ	158 kΩ
-5 °C	9.5 kΩ	13 kΩ	21 kΩ	37 kΩ	122 kΩ
0 °C	7.4 kΩ	9.8 kΩ	16 kΩ	29 kΩ	95 kΩ

Note 13: Resistance values greater than 180 k ohms cannot be measured by the USB-TEMP-AI in the thermistor mode. The 180 k ohm resistance limit includes the total resistance across the current excitation (±Ix) pins, which is the sum of the thermistor resistance and the lead resistances.

Note 14: For accurate three wire compensation, the individual lead resistances connected to the ±Ix pins must be of equal ohmic value. To ensure this, use connection leads of equal lengths.

Absolute Accuracy: V0x-V3x

Table 9. Calibrated absolute accuracy specifications

Range	Absolute Accuracy (mV)
±10 V	±2.779
±5 V	±1.398
±2.5 V	±0.707
±1.25 V	±0.362

Note 15: When connecting differential inputs to floating input sources, the user must provide a ground return path from each differential input to ground. To do this, simply connect a resistor from each of the differential inputs to GND. A value of approximately 1 Meg ohm can be used for most applications.

Note 16: All ground pins on the USB-TEMP-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground when using both voltage inputs and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground

Note 17: Unused voltage inputs should not be left floating. These inputs should be placed in the Disabled mode or connected to GND.

Table 10. Accuracy components. All values are (±)

Range	Gain error (% of reading)	Offset error (µV)	INL error (% of range)	Gain Temperature Coefficient (ppm/°C)	Offset Temperature Coefficient (µV/°C)
±10 V	0.0246	16.75	0.0015	3.68	0.42
±5 V	0.0246	16.75	0.0015	3.68	0.42
±2.5 V	0.0246	16.75	0.0015	3.68	0.42
±1.25 V	0.0246	16.75	0.0015	3.68	0.42

Table 11. Noise performance specifications

Range	Peak to peak noise (µV)	RMS noise (µVrms)	*Noise-Free resolution (bits)*
±10 V	41.13	6.23	*19.09*
±5 V	30.85	4.67	*18.51*
±2.5 V	17.14	2.60	*18.36*
±1.25 V	11.14	1.69	*17.98*

Table 11 summarizes the noise performance for the USB-TEMP-AI. Noise distribution is determined by gathering 1000 samples with inputs tied to ground at the user connector. Samples are gathered at the maximum specified sample rate of 2 S/s.

Settling time: V0x-V3x

Table 12. Settling time specifications

Range	Accuracy
	±0.0004% (seconds)
±10 V	15.0
±5 V	0.40
±2.5 V	0.40
±1.25 V	0.40

Settling time is defined as the time required for a channel to settle within a specified accuracy in response to a full-scale (FS) step input.

Analog input calibration

Table 13. Analog input calibration specifications

Parameter	Specifications
Recommended warm-up time	30 minutes minimum
Calibration	Firmware calibration
Calibration interval	1 year
Calibration reference	+10.000 V, ±5 mV maximum. Actual measured values stored in EEPROM
	Tempco: 5 ppm/°C maximum
	Long term stability: 30 ppm/1000 h

Throughput rate

Table 14. Throughput rate specifications

Number of Input Channels	Maximum throughput
1	2 Samples/second
2	2 S/s on each channel, 4 S/s total
3	2 S/s on each channel, 6 S/s total
4	2 S/s on each channel, 8 S/s total
5	2 S/s on each channel, 10 S/s total
6	2 S/s on each channel, 12 S/s total
7	2 S/s on each channel, 14 S/s total
8	2 S/s on each channel, 16 S/s total

Note 18: The analog inputs are configured to run continuously. Each channel is sampled twice per second. The maximum latency between when a sample is acquired and the voltage/temperature data is provided by the USB unit is approximately 0.4 seconds.

Digital input/output

Table 15. Digital input/output specifications

Digital type	5V CMOS
Number of I/O	8 (DIO0 through DIO7)
Configuration	Independently configured for input or output. Power on reset is input mode.
Pull-up/pull-down configuration	All pins pulled up to +5 V via 47 K resistors (default). Contact MCC factory for pull-down to ground (GND) capability.
Digital I/O transfer rate (software paced)	▪ Digital input – 50 port reads or single bit reads per second typical. ▪ Digital output – 100 port writes or single bit writes per second typical.
Input high voltage	2.0 V minimum, 5.5 V absolute maximum.
Input low voltage	0.8 V maximum, –0.5 V absolute minimum
Output low voltage (IOL = 2.5 mA max.)	0.7 V maximum
Output high voltage (IOH = -2.5 mA max.)	3.8 V minimum

Note 19: All ground pins on the USB-TEMP-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground when using both digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

Counter

Table 16. CTR I/O specifications

Parameter	Conditions	Specification
Pin name		CTR
Number of channels		1
Resolution		32-bits
Counter type		Event counter
Input type		TTL, rising edge triggered
Input source		CTR screw terminal
Counter read/writes rates (software paced)	Counter read	System dependent, 33 to 1000 reads per second.
	Counter write	System dependent, 33 to 1000 reads per second.
Schmidt trigger hysteresis		20 mV to 100 mV
Input leakage current		*±1.0 µA typ.*
Input frequency		1 MHz max.
High pulse width		*500 nS min.*
Low pulse width		*500 ns min.*
Input high voltage		4.0 V min, 5.5 V absolute max
Input low voltage		1.0 V max, –0.5 V absolute min

Note 20: All ground pins on the USB-TEMP-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground with both the counter (CTR) and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

Memory

Table 17. Memory specifications

EEPROM	1,024 bytes isolated micro reserved for sensor configuration 256 bytes USB micro for external application use

Microcontroller

Table 18. Microcontroller specifications

Type	Two high-performance 8-bit RISC microcontrollers

USB +5V voltage

Table 19. USB +5V voltage specifications

Parameter	Specification
USB +5V (VBUS) input voltage range	4.75 V minimum to 5.25 V maximum

Power

Table 20. Power specifications

Parameter	Conditions	Specification
Supply current	USB enumeration	<100 mA
Supply current (Note 21)	Quiescent mode with all inputs configured for Disabled mode	270 mA typical
User +5V output voltage range (terminal block pin 21)		4.9 V minimum to 5.1 V maximum
User +5V output current (terminal block pin 21)	Bus-powered and connected to a self-powered hub. (Note 21)	5 mA maximum
Isolation	Measurement system to PC	500 VDC minimum

Note 21: This is the total current requirement for the USB-TEMP-AI which includes up to 10 mA for the status LED.

USB specifications

Table 21. USB specifications

USB device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
Device power capability	Self-powered
USB cable type	*A-B cable, UL type AWM 2527 or equivalent. (min 24 AWG VBUS/GND, min 28 AWG D+/D–)*
USB cable length	3 meters maximum

Current excitation outputs (±Ix, T0x-T3x)

Table 22. Current excitation output specifications

Parameter	Conditions	Specification
Configuration		2 dedicated pairs: ▪ ±I1: T0x/T1x ▪ ±I2: T2x/T3x
Current excitation output ranges	Thermistor	10 µA
	RTD	210 µA
Tolerance		±5.0%
Drift		200 ppm/°C
Line regulation		*2.1 ppm/V maximum*
Load regulation		*0.3 ppm/V*
Output compliance voltage (relative to GND pins 9, 19, 22, 27, 30, 33, 36, 39)		3.90 V maximum -0.03 V minimum

Note 22: The USB-TEMP-AI has two current excitation outputs, with ±I1 dedicated to the T0x/T1x analog inputs, and ±I2 dedicated to T2x/T3x. The excitation output currents should always be used in this dedicated configuration.

Note 23: The current excitation outputs are automatically configured based on the sensor (thermistor or RTD) selected.

Environmental

Table 23. Environmental specifications

Operating temperature range	0 to 55 ° C maximum
Storage temperature range	-40 to 85 ° C maximum
Humidity	0 to 90% non-condensing maximum

Mechanical

Table 24. Mechanical specifications

Dimensions	127 mm (L) x 88.9 mm (W) x 35.56 (H)
User connection length	3 meters maximum

Screw terminal connector type and pin out

Table 25. Screw terminal connector specifications

Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

Screw terminal pin out

Table 26. Screw terminal pin out

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	I1+	T0/T1 current excitation source	27	GND	
2	NC		28	V3L	V3 voltage input (-)
3	T0H	T0 sensor input (+)	29	V3H	V3 voltage input (+)
4	T0L	T0 sensor input (-)	30	GND	
5	4W01	T0/T1 4-wire, 2 sensor common	31	V2L	V2 voltage input (-)
6	IT01	T0/T1 2-sensor common	32	V2H	V2 voltage input (+)
7	T1H	T1 sensor input (+)	33	GND	
8	T1L	T1 sensor input (-)	34	V1L	V1 voltage input (-)
9	GND		35	V1H	V1 voltage input (+)
10	I1-	T0/T1 current excitation return	36	GND	
	CJC sensor				
11	I2+	T2/T3 current excitation source	37	V0L	V0 voltage input (-)
12	NC		38	V0H	V0 voltage input (+)
13	T2H	T2 sensor input (+)	39	GND	
14	T2L	T2 sensor input (-)	40	CTR	Counter Input
15	4W23	T2/T3 4-wire, 2 sensor common	41	DIO7	Digital Input/Output
16	IT23	T2/T3 2 sensor common	42	DIO6	Digital Input/Output
17	T3H	T3 sensor input (+)	43	DIO5	Digital Input/Output
18	T3L	T3 sensor input (-)	44	DIO4	Digital Input/Output
19	GND		45	DIO3	Digital Input/Output
20	I2-	T2/T3 current excitation return	46	DIO2	Digital Input/Output
21	+5V	+5V output	47	DIO1	Digital Input/Output
22	GND		48	DIO0	Digital Input/Output
23	NC		49	GND	
24	NC		50	NC	
25	NC		51	NC	
26	NC		52	NC	