TMP02 Quad RTD Monitor
24-Bit, 3 kHz, PT Resistors, NTC Sensor, Low Temperature Diodes

Product Description

The TMP02 device is a versatile and easy-to-use temperature monitor. With four inputs, it can be used with a variety of different temperature sensors. The device was designed to meet the demands of scientific or industrial applications where the high temperature range, ultra-low noise and high resolution are important concerns.

Standardized temperature curves are provided for Platinum resistors, NTC sensors and low temperature diodes suitable for cryogenic measurements. In addition custom sensors can effortlessly be utilized with selectable excitation currents of 10 µA or 1 mA and voltage measurement ranges 0.5 V, 1 V, 2.5 V and 5 V.

The channels are multiplexed, amplified, conditioned and sampled by the 24-Bit delta-sigma A/D converter. This ensures maximum data acquisition rates of up to 3 kHz at lowest noise levels.

Features

- Connected to 10/100BASE-TX Ethernet over RJ45 jack
- Four independent sensor inputs
- Supports PT sensors, NTC thermistors and low temperature diodes
- Measures temperatures between 1.4 K and 1,121 K
- Alternating data acquisition of selected channels
- Low crosstalk and low capacitive coupling between the channels
- High input resistance and small sampling capacitor
- High sampling rates of up to 3 kHz
- Highest accuracy is guaranteed when the device is operated within ±5 °C (±9 °F) of the last calibration
- Surveillance of all voltages and board temperature
- Short-circuit-proof and over-voltage protected pins up to ±30 V
- Powered via PoE (Power over Ethernet)
- Idle power consumption of less than 1.4 W
- Compatible with all modern Ethernet standards
- Drivers for Microsoft® Visual C++™, MathWorks® MATLAB™, Python and National Instruments® LabVIEW™ programming environment

Temperature Response Curves

The TMP02 device has standard temperature response curves for platinum resistors (from 1 Ω up to 1 kΩ nominal resistance, IEC 751 / DIN EN 60751), for NTC sensors KTY 81-1, 81-2, 82-1, 82-2, 83-1, 84-1 from NXP™ Semiconductors and for low temperature diodes DT470 and DT670 from Lake Shore Cryotronics, Inc. Depending on the standard, the curves consist of more than 1,000 points and the corresponding temperature is interpolated using cubic splines.

The TMP02 device can also be configured for non-listed temperature sensors. In that case the device uses the internal constant current source and measures the voltage across the sensor. This enables the subsequent manual computation of the temperature.

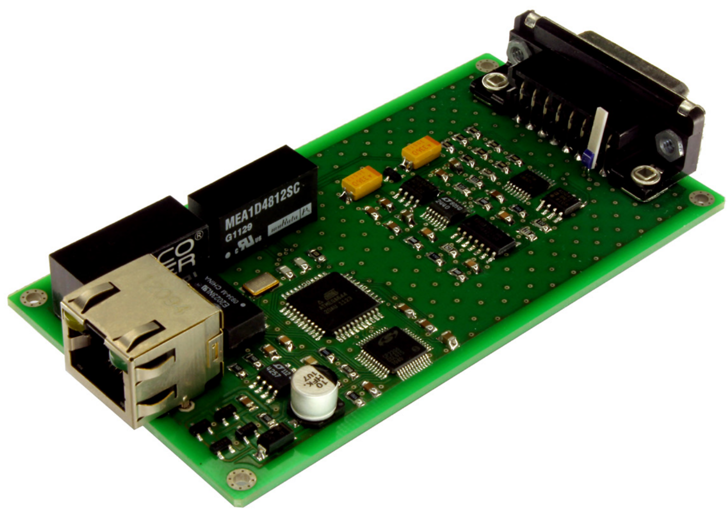
Sensor Selection

Depending on the desired temperature range and the desired accuracy, the user can choose from a variety of different temperature sensors. The TMP02 device is able to utilize the following sensor types: resistance wire detectors (RTDs), thermistors (thermally sensitive transistors), and temperature diodes. Sensors are interchangeable and for most applications they do not require individual calibration.

RTDs like platinum sensors offer very high accuracy and wide temperature range. Various accuracy classes are avaliable depending on the application. They have a positive temperature coefficient (PTC) by increasing resistance with temperature increase.

Thermistors are generally negative temperature coefficient (NTC) by decreasing resistance with temperature increase. Despite their reduced accuracy they are widely utilized and respresent a low-cost alternative to RTDs.

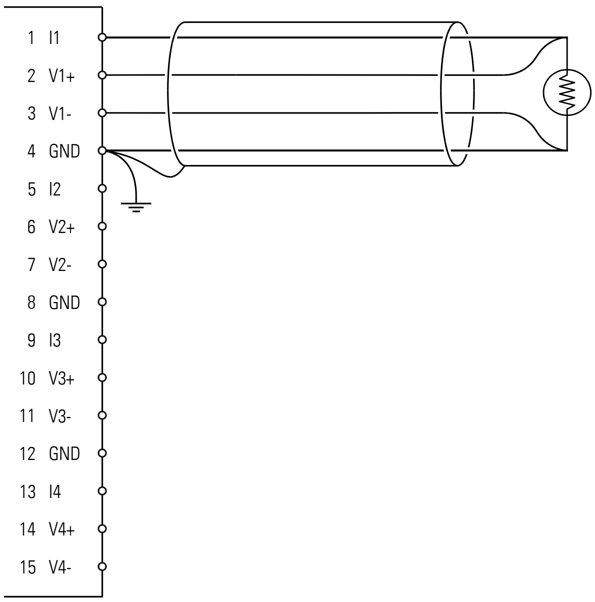
Almost any silicon diode can be utilized as a temperature transducer but diodes specifically designed and optimized for that purpose offer higher sensitivity and reproducibility. In cryogenic applications silicon temperature diodes are commonly utilized due to their increased sensitivity towards absolute zero.



Sensor Inputs

The following figure shows the recommended pin configuration of the TMP02 device - for sake of clarity only the first of all four sensors is illustrated. All pins are continuously protected against over-voltage of up to ±40 V. The gold-plated connector pins ensure superior sensor connectivity.

Since the channels are sampled alternately, the sampling rate per channel depends on the number of configured channels. Therefore unused channels should be disabled.



Shielding and Grounding

For lowest noise every sensor should be connected to the TMP02 device by the use of shielded twisted pair cables. All shieldings must be grounded - otherwise the multiplexed current source might become unstable. Long cables should be avoided in any case when highest accuracy is a major concern. The ground pins 4, 8 and 12 are internally connected and all input signals are referenced to their common potential.

Current Source

A high-precision and fast settling internal current source is utilized to excite the connected temperature sensors. The channels are multiplexed and depending on the sensor type the excitation current can either be 10 μA or 1 mA. The settling time depends on the inductance and the capacitance of the sensor cable and the selected sampling frequency should not be too high if long cables are being utilized.

The current source is automatically disabled when no sensor is configured which prevents the sensor from heating up. This technique should be applied to low temperature diodes when temperature measurement is temporarily not required.

The following table shows the typical accuracy for both ranges of the internal current source.

Current	2σ Accuracy	RMS Noise	Therm. Drift	Hysteresis[1]
10 μA	±5.6 nA	8.0 nA	< 0.15 nA/K	< 0.5 nA
1 mA	±0.2 μA	9.0 nA	< 10.0 nA/K	< 50 nA

[1] Sweep of PCB temperature from 280 K to 330 K at 10 K/h

Voltage Measurement

The TMP02 device offers four voltage ranges which are 0.5 V, 1 V, 2.5 V and 5 V and ten internal A/D converter sampling rate settings which are 6 Hz, 12 Hz, 25 Hz, 50 Hz, 100 Hz, 200 Hz, 400 Hz, 800 Hz, 1,500 Hz and 3,000 Hz. The typical input current is less than ±5 nA.

Depending on the application the lowest possible voltage range and frequency should be chosen in order to keep the measurement inaccuracy and noise at a minimum. The desired update rate should be slightly lower than the configured internal A/D converter sampling frequency. The default setting is 6 Hz which is sufficient for most applications.

Voltage Range	2σ Accuracy	Resolution	Therm. Drift	Hysteresis[1]
0.5 V	±38 μV	0.03 μV	< 6 μV/K	< 5 μV
1.0 V	±70 μV	0.06 μV	< 11 μV/K	< 7 μV
2.5 V	±170 μV	0.15 μV	< 27 μV/K	< 12 μV
5.0 V	±330 μV	0.30 μV	< 53 μV/K	< 21 μV

[1] Sweep of PCB temperature from 280 K to 330 K at 10 K/h

The voltage measurement noise depends on the selected voltage range and sampling rate. The following table shows typical RMS noise values.

Sampling Rate	0.5 V	1.0 V	2.5 V	5.0 V
6 Hz	1 μV	1 μV	1 μV	1 μV
12 Hz	1 μV	1 μV	1 μV	1 μV
25 Hz	2 μV	2 μV	2 μV	2 μV
50 Hz	2 μV	2 μV	2 μV	2 μV
100 Hz	5 μV	5 μV	5 μV	5 μV
200 Hz	6 μV	6 μV	6 μV	6 μV
400 Hz	6 μV	6 μV	6 μV	6 μV
800 Hz	6 μV	6 μV	6 μV	7 μV
1,500 Hz	7 μV	7 μV	7 μV	8 μV
3,000 Hz	9 μV	10 μV	14 μV	32 μV

Typical Sensor Performance

Platinum resistors belong to the most accurate temperature sensors. The wide temperature range and tight tolerance classes make them ideal for most applications where accuracy is a major concern.

The overall temperature measurement accuracy is affected by the electronic measurement accuracy and the accuracy of the sensor itself. The table below summarizes these values for PT 100, PT 200, PT 500 and PT 1000 temperature sensors and the most accurate tolerance classes A and AA.

Sensor	Temp.	Resistance	Sensitivity	2σ Accuracy[1]	Class A	Class AA
PT 100	200 K	71.13 Ω	0.40 Ω/K	0.10 K	0.30 K	0.22 K
	300 K	110.51 Ω	0.39 Ω/K	0.12 K	0.20 K	0.15 K
	600 K	221.59 Ω	0.35 Ω/K	0.17 K	0.80 K	0.66 K
	1000 K	353.45 Ω	0.31 Ω/K	0.28 K	1.60 K	1.34 K
PT 200	200 K	142.27 Ω	0.80 Ω/K	0.10 K	0.30 K	0.22 K
	300 K	221.02 Ω	0.78 Ω/K	0.11 K	0.20 K	0.15 K
	600 K	443.18 Ω	0.71 Ω/K	0.17 K	0.80 K	0.66 K
	1000 K	706.90 Ω	0.61 Ω/K	0.27 K	1.60 K	1.34 K
PT 500	200 K	355.67 Ω	2.00 Ω/K	0.09 K	0.30 K	0.22 K
	300 K	552.55 Ω	1.94 Ω/K	0.11 K	0.20 K	0.15 K
	600 K	1107.94 Ω	1.77 Ω/K	0.16 K	0.80 K	0.66 K
	1000 K	1767.24 Ω	1.53 Ω/K	0.27 K	1.60 K	1.34 K
PT 1000	200 K	711.34 Ω	4.00 Ω/K	0.09 K	0.30 K	0.22 K
	300 K	1105.09 Ω	3.88 Ω/K	0.10 K	0.20 K	0.15 K
	600 K	2215.88 Ω	3.53 Ω/K	0.16 K	0.80 K	0.66 K
	1000 K	3534.48 Ω	3.06 Ω/K	0.27 K	1.60 K	1.34 K

[1] Electronic accuracy, 1 mA excitation current, the overall accuracy depends on the sensor and its tolerance class. Consult the manufacturer for detailed specifications.

For accurate measurements in the low temperature regime, semiconductors diodes are commonly utilized. As shown in the following table, at ultra-low temperatures the sensitivity drastically increases which results in outstanding accuracy towards absolute zero.

Sensor	Temp.	Voltage	Sensitivity	2σ Accuracy[1]	Uncalibrated
DT 470 Band 11	4.2 K	1.626 V	-33.58 mV/K	0.00 K	0.25 K
	75.0 K	1.025 V	-1.90 mV/K	0.09 K	0.25 K
	300.0 K	0.519 V	-2.41 mV/K	0.07 K	0.50 K
	475.0 K	0.091 V	-2.26 mV/K	0.07 K	1.00 K
DT 670 Band A	4.2 K	1.578 V	-31.58 mV/K	0.01 K	0.25 K
	75.0 K	1.032 V	-1.69 mV/K	0.10 K	0.25 K
	300.0 K	0.560 V	-2.31 mV/K	0.07 K	0.50 K
	500.0 K	0.091 V	-2.19 mV/K	0.08 K	0.50 K

[1] Electronic accuracy, 10 µA excitation current, the overall accuracy depends on the sensor and individual calibration. Consult the manufacturer for detailed specifications.

In comparison with Platinum resistors NTC thermistors are lower in accuracy and the temperature range is more restricted, as shown in the following table.

Sensor	Temp.	Resistance	Sensitivity	2σ Accuracy[1]	Uncalibrated
KTY 81 110	220 K	499.21 Ω	4.97 Ω/K	0.04 K	2.98 K
	300 K	1014.74 Ω	7.97 Ω/K	0.03 K	1.31 K
	420 K	2237.74 Ω	12.46 Ω/K	0.04 K	7.83 K
KTY 81 210	220 K	998.42 Ω	9.94 Ω/K	0.04 K	2.98 K
	300 K	2029.48 Ω	15.94 Ω/K	0.03 K	1.31 K
	420 K	4475.48 Ω	24.92 Ω/K	0.04 K	12.68 K
KTY 82 110	220 K	499.21 Ω	4.97 Ω/K	0.04 K	2.98 K
	300 K	1014.74 Ω	7.97 Ω/K	0.03 K	1.31 K
	420 K	2237.74 Ω	12.46 Ω/K	0.04 K	7.83 K
KTY 82 210	220 K	998.42 Ω	9.94 Ω/K	0.04 K	2.98 K
	300 K	2029.48 Ω	15.94 Ω/K	0.03 K	1.31 K
	420 K	4475.48 Ω	24.92 Ω/K	0.04 K	12.68 K
KTY 83 110	220 K	509.14 Ω	4.95 Ω/K	0.07 K	3.05 K
	300 K	1014.29 Ω	7.72 Ω/K	0.05 K	1.36 K
	450 K	2558.61 Ω	12.92 Ω/K	0.05 K	6.80 K
KTY 84 130	230 K	349.40 Ω	2.98 Ω/K	0.11 K	6.52 K
	300 K	611.25 Ω	4.52 Ω/K	0.08 K	5.82 K
	420 K	1310.93 Ω	7.17 Ω/K	0.06 K	6.95 K
	570 K	2631.00 Ω	10.46 Ω/K	0.06 K	20.90 K

[1] Electronic accuracy, 1 mA excitation current, the actual accuracy depends on the sensor and individual calibration. Consult the manufacturer for detailed specifications.

Physical Specifications

Dimensions: 100 mm x 54 mm x 18 mm (3.94 in x 2.13 in x 0.71 in)
Mounting: 4 holes Ø 2.2 mm (0.087 in) at a distance of 94 mm x 48 mm (3.70 in x 1.89 in), intended for the use with metric M2 screws
PCB operating temperature: 0 °C to 70 °C (32 °F to 158 °F), ambient operating temperature depends on the case and its thermal isolation
Weight: 42 g (1.48 oz)