TMP01 Octal Thermocouple Monitor
24-Bit, 3 kHz, Types B, C, D, E, G, J, K, M, N, P, R, S, T

Product Description

The TMP01 device is a versatile and easy-to-use temperature monitor. With eight inputs, it can be used with nearly any thermocouple type. 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 voltage-temperature curves are utilized and automatic software-based cold-junction compensation is automatically performed for highest precision.

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.

Temperature Response Curves

The TMP01 device has standard temperature response curves for thermocouple types B, E, J, K, N, R, S and T from the National Institute of Standards and Technology, for type C from Omega Engineering Inc., for types M and P from Pyromation Inc. and for types D and G from TC Ltd. Depending on the standard, the curves consist of more than 2,000 points and the corresponding temperature is interpolated using cubic splines.

The TMP01 device can also be configured for non-listed or arbitrary thermocouples. In that case the device measures the voltage across the sensor and the temperature can be calculated manually. It is also required to perform cold-junction compensation.

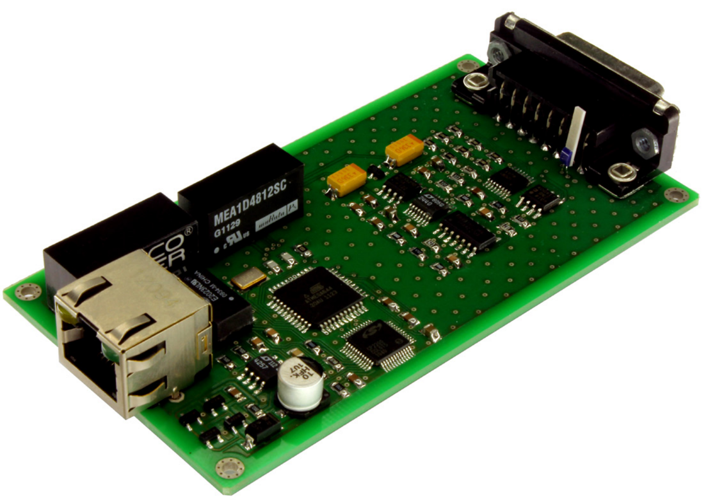
Features

- Connected to 10/100BASE-TX Ethernet over RJ45 jack
- Eight independent sensor inputs
- Supports thermocouple types B, C, D, E, G, J, K, M, N, P, R, S and T
- Measures temperatures from as low as 3 K up to more than 2,593 K with appropriate sensors
- 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 1.2 W
- Compatible with all modern Ethernet standards
- Drivers for Microsoft® Visual C++™, MathWorks® MATLAB™, Python and National Instruments® LabVIEW™ programming environment

Sensor Selection and Temperature Range

Depending on the desired temperature range, the user can choose between different thermocouples. The materials and the temperature ranges are illustrated in the following table. The most versatile and cost efficient thermocouple types are J and K. For higher temperature ranges types C, D, G, R and S are commonly utilized. In low temperature applications or experiments thermocouple types E, N and T are suitable. Other exotic types are rarely utilized but may be appropriate for special experimental setups or industrial production processes.

TC Type	Materials	Extended Temp. Range	Cont. Temp. Range
B	platinum, rhodium	294 K to 2,092 K	473 K to 1,973 K
C	tungsten, rhenium	273 K to 2,593 K	273 K to 2,593 K
D	tungsten, rhenium	273 K to 2,763 K	273 K to 2,593 K
E	chromel, constantan	3 K to 1,273 K	73 K to 1,173 K
G	tungsten, rhenium	273 K to 2,593 K	273 K to 2,593 K
J	iron, constantan	63 K to 1,473 K	273 K to 1,023 K
K	chromel, alumel	3 K to 1,645 K	73 K to 1,523 K
M	nickel, molybdenum, cobalt	223 K to 1,683 K	223 K to 1,683 K
N	nickel, chromium, silicon	3 K to 1,573 K	3 K to 1,573 K
P	platinum, palladium, gold	273 K to 1,668 K	273 K to 1,668 K
R	platinum, rhodium	223 K to 2,041 K	273 K to 1,723 K
S	platinum, rhodium	223 K to 2,041 K	273 K to 1,673 K
T	copper, constantan	3 K to 673 K	23 K to 623 K



Electronic Accuracy

The TMP01 device offers 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. Depending on the application the lowest possible frequency should be chosen in order to keep the measurement 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.

The cold-junction compensation accuracy is ±0.5 K which adds up to the measurement error specified in the table on the right. Undesirable thermoelectric voltages arise from material junctions which should be avoided for highest accuracy.

A warm-up time of at least 30 minutes is recommended. Thermal stress like fast transients, cycles or under- and over-temperature may derate accuracy.

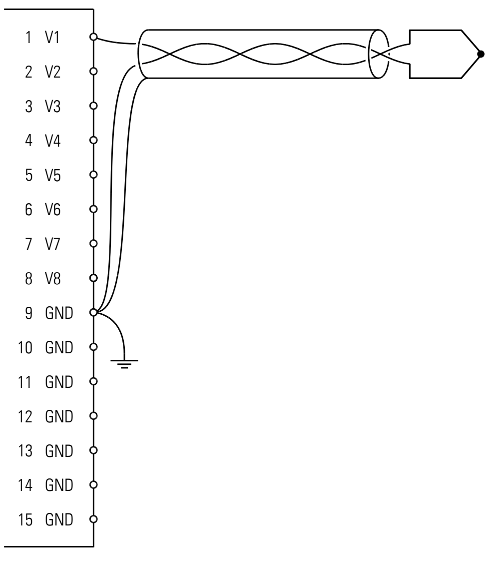
Sampling Rate	2σ Accuracy	Resolution	RMS Noise	Therm. Drift	Hysteresis[1]
6 Hz	±8.0 µV	5.4 nV	0.1 µV	< 1.2 µV/K	< 1.0 µV
12 Hz	±8.0 µV	5.4 nV	0.1 µV	< 1.2 µV/K	< 1.0 µV
25 Hz	±8.0 µV	5.4 nV	0.1 µV	< 1.2 µV/K	< 1.0 µV
50 Hz	±8.0 µV	5.4 nV	0.2 µV	< 1.2 µV/K	< 1.0 µV
100 Hz	±8.0 µV	5.4 nV	0.2 µV	< 1.2 µV/K	< 1.0 µV
200 Hz	±8.0 µV	5.4 nV	0.3 µV	< 1.2 µV/K	< 1.0 µV
400 Hz	±8.0 µV	5.4 nV	0.4 µV	< 1.2 µV/K	< 1.0 µV
800 Hz	±8.0 µV	5.4 nV	0.6 µV	< 1.2 µV/K	< 1.0 µV
1,500 Hz	±8.0 µV	5.4 nV	0.8 µV	< 1.2 µV/K	< 1.0 µV
3,000 Hz	±8.0 µV	5.4 nV	1.2 µV	< 1.2 µV/K	< 1.0 µV

[1] Sweep of PCB temperature from 290 K to 330 K at 10 K/h

Sensor Inputs

The TMP01 device incorporates ultra-precision low-noise amplifiers which scale input voltages from -12 mV to +79 mV. This range is suitable for all thermocouple types within their approved temperature range. The typical input current is less than ±1 nA. The temperature of the printed circuit board is accurately measured in the vicinity of the DSUB connector which guarantees excellent cold-junction compensation for all thermocouple types. Since the channels are sampled alternately, the sampling rate per channel depends on the number of configured channels. Therefore unused channels should be disabled.

The following figure shows the recommended pin configuration of the TMP01 device - for the sake of clarity only one thermocouple is shown. All pins are continuously protected against over-voltage of up to ±30 V. The gold-plated connector pins ensure superior sensor connectivity. It is strongly recommended to use crimp D-sub connectors instead of a break-out board to ensure minimal cold-junction errors.



Typical Sensor Performance

In general thermocouple temperature sensors do not follow a linear curve and the sensitivity depends on the temperature. They only achieve highest sensitivity and consequently best results in certain temperature ranges.

The temperature error resulting from the electronic measurement accuracy and the tolerance classes I and II are illustrated in the table below. Refer to manufacturer's manuals for choosing the appropriate thermocouple for your application.

TC Type	Temp.	Voltage	Sensitivity	Class I	Class II	2σ Accuracy[1]
B	500 K	0.236 mV	1.7 µV/K	–	–	±4.76 K
	900 K	1.955 mV	5.9 µV/K	–	±1.57 K	±1.37 K
	1,400 K	6.045 mV	9.3 µV/K	–	±2.82 K	±0.87 K
	1,900 K	12.745 mV	10.7 µV/K	–	±4.07 K	±0.76 K
C	300 K	0.368 mV	14.1 µV/K	–	–	±0.57 K
	1,000 K	13.080 mV	19.1 µV/K	–	–	±0.42 K
	1,700 K	25.577 mV	14.9 µV/K	–	–	±0.54 K
	2,500 K	36.209 mV	9.3 µV/K	–	–	±0.87 K
D	300 K	0.271 mV	10.7 µV/K	–	–	±0.76 K
	1,000 K	12.673 mV	20.0 µV/K	–	–	±0.40 K
	1,700 K	26.361 mV	17.7 µV/K	–	–	±0.46 K
	2,500 K	38.593 mV	9.3 µV/K	–	–	±0.87 K
E	100 K	-8.064 mV	31.2 µV/K	–	–	±0.26 K
	400 K	8.160 mV	69.4 µV/K	±1.50 K	±2.50 K	±0.12 K
	700 K	31.100 mV	79.2 µV/K	±1.71 K	±3.20 K	±0.10 K
	1,100 K	63.118 mV	78.2 µV/K	–	±6.20 K	±0.10 K
G	300 K	0.050 mV	2.4 µV/K	–	–	±3.37 K
	1,000 K	8.868 mV	18.6 µV/K	–	–	±0.44 K
	1,700 K	23.345 mV	20.5 µV/K	–	–	±0.39 K
	2,500 K	37.409 mV	13.0 µV/K	–	–	±0.62 K
J	300 K	1.373 mV	52.3 µV/K	±1.50 K	±2.50 K	±0.15 K
	500 K	12.270 mV	56.8 µV/K	±1.50 K	±2.50 K	±0.14 K
	700 K	23.330 mV	54.0 µV/K	±1.71 K	±3.20 K	±0.15 K
	1,000 K	40.812 mV	61.5 µV/K	±2.91 K	±5.45 K	±0.13 K
K	100 K	-5.418 mV	20.3 µV/K	–	–	±0.40 K
	600 K	13.325 mV	40.0 µV/K	±1.50 K	±2.50 K	±0.20 K
	1,100 K	34.373 mV	41.0 µV/K	±3.31 K	±6.20 K	±0.20 K
	1,500 K	49.813 mV	35.4 µV/K	–	–	±0.23 K
M	300 K	1.022 mV	39.3 µV/K	–	–	±0.21 K
	700 K	19.362 mV	42.8 µV/K	–	–	±0.19 K
	1,100 K	39.730 mV	55.9 µV/K	–	–	±0.14 K
	1,600 K	69.128 mV	55.9 µV/K	–	–	±0.14 K
N	100 K	-3.677 mV	12.7 µV/K	–	–	±0.64 K
	600 K	10.300 mV	35.4 µV/K	±1.50 K	±2.50 K	±0.23 K
	1,100 K	29.508 mV	38.2 µV/K	±3.31 K	±6.20 K	±0.21 K
	1,500 K	44.841 mV	37.3 µV/K	–	–	±0.22 K
P	300 K	0.825 mV	32.5 µV/K	–	–	±0.25 K
	700 K	16.866 mV	43.8 µV/K	–	–	±0.18 K
	1,100 K	34.537 mV	42.8 µV/K	–	–	±0.19 K
	1,600 K	53.127 mV	31.7 µV/K	–	–	±0.26 K
R	300 K	0.152 mV	6.0 µV/K	±1.00 K	±1.50 K	±1.35 K
	800 K	4.765 mV	10.7 µV/K	±1.00 K	±1.50 K	±0.76 K
	1,300 K	10.863 mV	13.5 µV/K	±1.00 K	±2.57 K	±0.60 K
	1,700 K	16.420 mV	14.0 µV/K	±1.98 K	±3.57 K	±0.58 K
S	300 K	0.154 mV	6.0 µV/K	±1.00 K	±1.50 K	±1.35 K
	700 K	3.517 mV	10.1 µV/K	±1.00 K	±1.50 K	±0.80 K
	1,100 K	7.638 mV	10.7 µV/K	±1.00 K	±2.07 K	±0.76 K
	1,600 K	13.485 mV	12.6 µV/K	±1.68 K	±3.32 K	±0.64 K
T	100 K	-5.131 mV	19.8 µV/K	–	–	±0.41 K
	300 K	1.068 mV	41.0 µV/K	±0.50 K	±1.00 K	±0.20 K
	500 K	10.735 mV	54.5 µV/K	±0.91 K	±1.70 K	±0.15 K
	600 K	16.437 mV	57.7 µV/K	±1.31 K	±2.45 K	±0.14 K

[1] Electronic accuracy, the overall accuracy depends on the sensor and its classification. Consult the manufacturer for specifications.

Shielding and Grounding

For lowest noise every thermocouple should be connected to the TMP01 device by the use of shielded twisted pair cables. All shieldings must be grounded. Long cables should be avoided in any case when highest accuracy is a major concern. The ground pins 9 to 15 are internally connected and all input signals are referenced to their common potential.

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)