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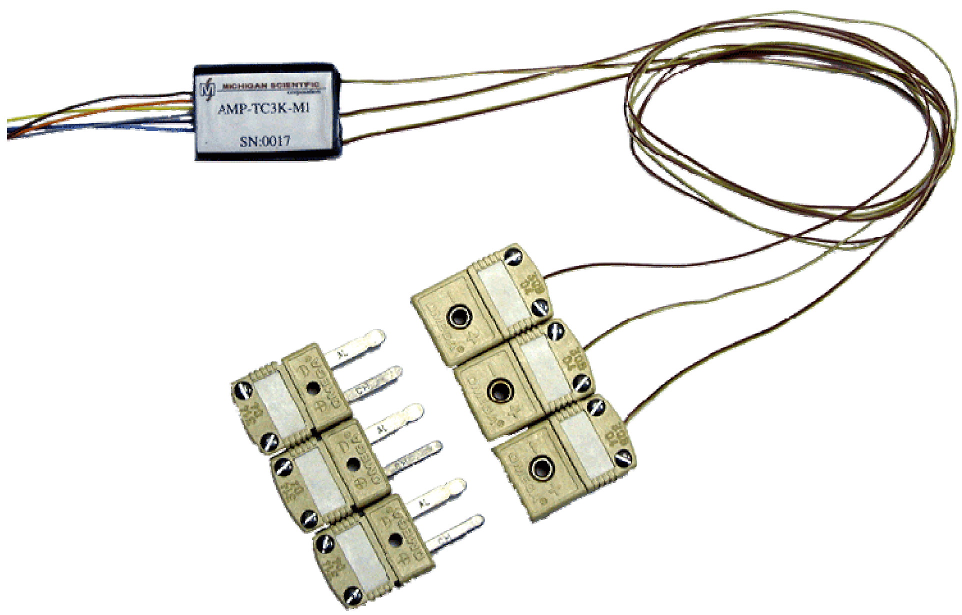
AMP-TC#*-M1
AMP-TC#*-EH1.5

MINIATURE THERMOCOUPLE AMPLIFIER OPERATOR'S MANUAL



OBSERVE
PRECAUTIONS FOR
HANDLING
ELECTROSTATIC
SENSITIVE DEVICES

# Indicates the number of channels 1-3

* Indicates type of thermocouple (J,K,T)

Table of Contents

Introduction

The *Miniature Thermocouple Amplifier* is designed to provide cold junction compensation and amplification of thermocouple sensors. These amplifiers may be used in conjunction with Michigan Scientific slip rings. Although all Michigan Scientific slip ring assemblies are manufactured with instrumentation quality rings and brushes, superior data accuracy is achieved by locating the thermocouple amplifier on the rotating side of the slip ring. This configuration greatly improves signal quality because the amplifier is located closer to the sensor, which reduces errors due to temperature gradients across dissimilar metals in the slip ring and magnetic interference.

The *Miniature Thermocouple Amplifier* consists of stable differential amplifiers and a cold junction compensator. Each amplifier provides amplification for one, two or three thermocouples depending on the model selected. Amplifiers are available for J, K, E, or T thermocouples. For more channels, more than one amplifier may be used with a single control unit. The amplifiers can be adhered, potted or strapped to many different types of parts. Some Michigan Scientific slip rings are available with the amplifiers built into the rotor.

Features

- Available with one, two or three-thermocouple amplifier channels.
- Cold junction compensation.
- Signal is amplified to 10 mV per degree Celsius (at 25 degrees Celsius).
- Precision, low noise, differential amplifier.
- Units available in K, J and T types (other types made by special order).
- Signal is greatly immune to external noise sources.
- Wide signal bandwidth, near 1.6 kHz (depending on thermocouple type).
- Input signals can be grounded or isolated.

Operation

General Operation

The AMP-TC#*-M1 must be powered with ± 15 Volts and a common. See electrical installation for instructions on how to connect these supplies to the proper wires. The AMP-TC#*-M1 signals should be measured with respect to the common gray wire.

Current flows in the ground line, so there will be a voltage drop along the length of the conductor. This will create an offset if the signals are measured with respect to the common at the Remote Amplifier Control Unit. Michigan Scientific recommends that the signals be measured with respect to the common wire at the amplifier. This can be accomplished by adding a second common line from the amplifier to the recording device.

The thermocouple sensor should be attached using the provided mating connector (Omega® HMPW-*-M). If a thermocouple input is left unused or if the thermocouple opens, the output of the amplifier will saturate negatively (near –13.5 V). The amplifier will not be damaged if a thermocouple is left unattached.

The signal from the thermocouple is cold junction compensated and amplified, but not linearized. Linearization polynomials can be found in the Linearization Formula section.

Operation with PS Series Amplifier Control Units

Any Michigan Scientific Remote Amplifier Control Unit will provide the ±15 Volts and common. These control units have switches that control bridge excitation and shunt calibration. Both switches are used with Michigan Scientific's strain gage amplifiers, and have no impact on the operation of the thermocouple amplifier.

The Remote Amplifier Control Units reverse the polarity of the ±15 V terminals when the bridge excitation switch is off. The thermocouple amplifier will continue to work under this condition.

Specifications

PARAMETER	SPECIFICATION
OUTPUT	Output is not linearized over temperature, if necessary, the output may be linearized externally
Range	± 10V Max
Sensitivity @ 25°C TC Temperature	10 mV/°C
Capacitive load	1000 pF Max
TEMPERATURE ERROR	Includes errors due to cold junction compensator
Initial @ 25°C Case Temperature	± 2°C Max
-25°C to +85°C Case Temperature	± 3°C Max
-55°C to +125°C Case Temperature	± 5°C Max
NOISE	Referred to input of amplifier
0.01 - 10 Hz	0.8 µV p-p
DYNAMIC RESPONSE	Higher Bandwidths available
Frequency Response -3dB	1.56 kHz
Slew rate	0.4 V / µs
Settling Time 0.1% / 0.01%	40 µs / 50 µs
POWER REQUIREMENTS	
Voltage	± 15 VDC
Quiescent Current	± 5 mA Max Total (1 channel)
	± 10 mA Max Total (2 channels)
	± 15 mA Max Total (3 channels)
ENVIRONMENT	
Specification	-25 to +85°C (-13 to +185°F)
Operation	-55 to +125°C (-67 to +257°F)
MECHANICAL (without connectors)	**AMP-TC#*-M1 AMP-TC#*-EH1.5**
Weight	14.17 G (0.50 Oz) 35 G (1.25 Oz)
Overall Length	31.75 mm (1.250 in) 38.1 mm (1.500 in)
Overall Height	6.35 mm (0.250 in) 12.7mm (0.500 in)
Overall Width	20.32 mm (0.800 in) 25.4mm (1.000 in)

Table 1

Installation

Electrostatic Sensitivity

The AMP-TC#*-M1 is an electrostatic sensitive device. The conductors of the wires should not be touched except during soldering. Soldering should be performed at an electrostatic discharge protected workstation.

If an electrostatic discharge protected workstation is not available, use a grounded wrist-strap and ground the strain gage amplifier. Do not handle the device in areas where static charges are obviously present. Always store the AMP-TC#*-M1 in an anti-static bag or container when not in use.

Mechanical Installation

The AMP-SG-M1 could be adhered to a clean surface with Dow Corning 3145 RTV adhesive/sealant. Manufacturer's directions for curing should be followed.

Caution should be used to protect the hook-up wires from cutting or breakage.

Electrical Installation

The hook up wires on the AMP-TC#*-M1 are color coded to help determine which supply or output signal corresponds to which wire. The signals and wire colors are shown in the table below.

SIGNAL	WIRES
OUTPUT CONNECTIONS:	
Positive 15V	Blue
Negative 15V	Violet
Common	Gray
Amplifier Output Channel 1	Yellow
Amplifier Output Channel 2	Orange
Amplifier Output Channel 3	Brown
THERMOCOUPLE CONNECTIONS:	
Thermocouple Positive*	Yellow
Thermocouple Negative	Red

* Yellow for K-type, White for J-type, Blue for T-type

Figure 1

The output high is measured relative to the ground wire. Michigan Scientific recommends that a separate wire for signal common be added to the common wire to reduce errors from voltage drops along the power common wire. This wire can be added to the stator of a slip ring to decrease the amount of rings needed, but care should be taken to physically place the amplifier as close as possible to the slip ring.

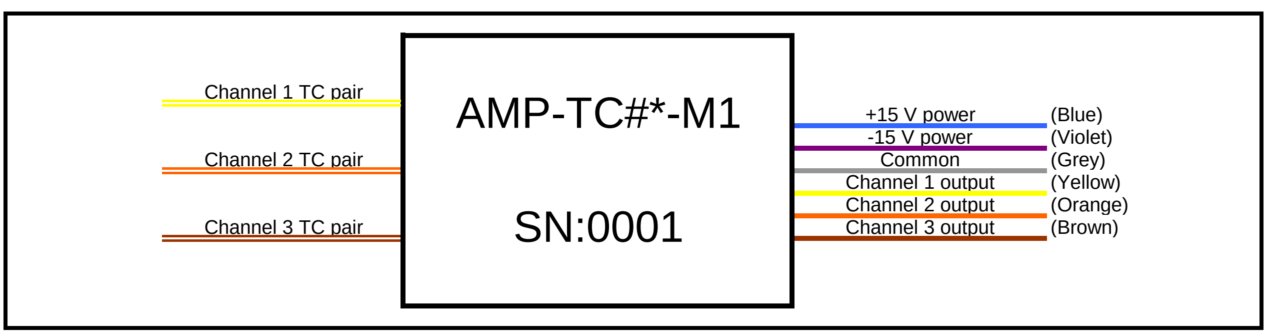


Figure 2

Linearization Formulas

Each channel of the AMP-TC#*-M1 cold junction compensates and amplifies the thermocouple input signal, but it does not linearize the signal. The polynomial equations given below may be used to linearize the output signals. These polynomial equations use raw voltage from the amplifier as the independent variable and generate temperature in degrees C.

Higher order polynomial equations are accurate over wider temperature ranges. Reducing the number of significant digits reduces the accuracy. Each of the following polynomial equations are accurate to less than one degree Celsius over the temperature range specified. The cold junction compensator can create an additional error, which is dependent upon the case temperature of the amplifier (see specifications, temperature error). These polynomial equations are inaccurate outside their specified temperature ranges.

J Type

Temperature Range: 0 °C to 100 °C

$$T = 98.0 \times V + 0.607$$

Temperature Range: -100 °C to 200 °C

$$T = 1.621 \times V^3 - 6.911 \times V^2 + 103.5 \times V + 0.02736$$

Temperature Range: -150 °C to 760 °C

$$\begin{aligned} T = & \left(-3.08190 * 10^{-4}\right) \times V^8 + \left(9.39996 * 10^{-3}\right) \times V^7 - 0.112851 \times V^6 \\ & + 0.674855 \times V^5 - 2.13994 \times V^4 + 3.83305 \times V^3 \\ & - 5.35333 \times V^2 + 101.034 \times V - 0.0875775 \end{aligned}$$

Where: T is temperature in degrees C
V is voltage from amplifier

T Type

Temperature Range: -100 °C to 400 °C

$$T = -0.0090 \times V^6 + 0.151 \times V^5 - 1.040 \times V^4 + 4.149 \times V^3 - 13.436 \times V^2 + 105.278 \times V + 0.142$$

Where: T is temperature in degrees C
V is voltage from amplifier

K Type

Temperature Range: 0 °C to 100 °C

$$T = 98.9 \times V + 0.464$$

Temperature Range: -100 °C to 200 °C

$$T = 2.949 \times V^3 - 7.916 \times V^2 + 104.1 \times V + 0.0289$$

Temperature Range: 0 °C to 1370 °C

$$T = \left(2.5499 * 10^{-4}\right) \times V^6 - \left(1.1161 * 10^{-2}\right) \times V^5 + 0.18766 \times V^4 - 1.3957 \times V^3$$
$$+ 4.0742 \times V^2 + 95.47 \times V + .91578$$

Where: T is temperature in degrees C
V is voltage from amplifier

E Type

Temperature Range: -200 °C to 0 °C

$$T = -20.2126 \times V^6 - 70.0606 \times V^5 - 97.8193 \times V^4 - 58.4793 \times V^3$$
$$- 28.2248 \times V^2 + 101.71 \times V - 0.0156$$

Temperature Range: -250 °C to 100 °C

$$T = -9.1873 \times V^8 - 12.7315 \times V^7 + 18.6945 \times V^6 + 26.1679 \times V^5 - 14.4087 \times V^4 - 10.9076 \times V^3$$
$$- 6.505 \times V^2 + 105.786 \times V - 0.1216$$

Temperature Range: 0 °C to 1000 °C

$$T = -0.0001 \times V^6 + 0.0056 \times V^5 - 0.1081 \times V^4 + 1.1712 \times V^3$$
$$- 7.5977 \times V^2 + 102.687 \times V + .2195$$

Where: T is temperature in degrees C
V is voltage from amplifier

Troubleshooting

Symptom	Possible Cause	Test to Verify Problem	Solution
Output saturated near –13.5 V	Open thermocouple	Connect known good thermocouple to amplifier input. If saturated voltage is a result of the open thermocouple; the output should now be near room temperature	Repair thermocouple junction
Output noisy with thermocouple spinning	Thermocouple could be opening momentarily; frequency response of data acquisition system may be to slow to show complete drop out of signal	Look at dynamic signal with an oscilloscope	Repair thermocouple junction Restrain thermocouple better
Output near 0 V regardless of thermocouple temperature	Amplifier Out High could be shorted to Common	With amplifier power off, measure resistance from Amplifier Out High to Common. The resistance should be greater than 1 MΩ	Remove short
	Amplifier Out High or Common conductor could be open	Measure resistance from one end of conductor to the other	Repair open wire
Output has an undesired offset	Voltage drop along Common wire offsets measurement	Measure voltage from Amplifier Out High to Common at amplifier.	Add a wire from the common at the amplifier. Measure signal relative to this common. There should be minimal current in this conductor.
Output near 11 V when thermocouple is at room temperature	- 15 V supply is disconnected	Measure continuity from power supply to amp's violet terminal	Repair broken wire
Output near –2.2 V when thermocouple is at room temperature	15 V supply is disconnected	Measure continuity from power supply to amp's blue terminal	Repair broken wire
Output near –0.5 V when thermocouple is at room temperature	Common is disconnected	Measure continuity from power supply to amp's gray terminal	Repair broken wire

Table 2