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AMP-TC2-*2
AMP-TC3-*2

MODULAR THERMOCOUPLE SPINNING AMPLIFIER

OPERATOR'S MANUAL

OBSERVE
PRECAUTIONS FOR
HANDLING
ELECTROSTATIC
SENSITIVE DEVICES

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

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Introduction

The *Modular Spinning Thermocouple Amplifier* is designed to mount on the rotor (spinning side) of all Michigan Scientific SR series 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 signal 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 *Modular Spinning Thermocouple Amplifier* consists of stable differential amplifiers, and a cold junction compensator. Each amplifier provides amplification for two or three thermocouples depending on the model selected. Amplifiers are available for J, K, E, T or N thermocouples. For more channels, the amplifiers may be stacked or arrayed around an adapter plate.

Features

- Available with two or three-thermocouple amplifier channels.
- Cold junction compensation.
- Amplified signal is at high level voltage (±10 Volts full scale).
- Signal is amplified to about 10 mV per degree Celsius (non-linear).
- Precision, low noise, differential amplifier.
- Units available in K, J, T, E and N types (other types made by special order).
- Signal is greatly immune to external noise sources.
- Wide signal bandwidth, near 1.56 kHz.
- Input signals can be grounded or isolated.
- SR series slip ring rotors pilot onto the amplifiers.
- Amplifiers are stackable for multiple channel use.

Operation

General Operation

AMP-TC2-*2 and AMP-TC3-*2 must be powered with ± 15 Volts and a common. See electrical installation for instructions on how to connect these supplies to the proper terminals. The AMP-TC2-*2 signals should be measured with respect to the common which is supplied for convenience on the brown terminal. AMP-TC3-*2 signals should be measured with respect to the common gray terminal.

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 power supply. Michigan Scientific recommends signals should be measured with respect to the common terminal at the amplifier. This can be accomplished by adding a second common line from the amp to the recording device.

A thermocouple should be attached to the provided mating connector (Omega® SMP-*-M) and plugged into the connector on the amplifier (Omega® SMP-*-F). 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 formula section.

Operation with PS Series Power Supplies

Any Michigan Scientific power supplies will provide the ±15 Volts and common. These power supplies 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.

These power supplies 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	± 1°C Max
-25°C to +85°C Case Temperature	± 2°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	
Frequency Response	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	± 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)

Table 1

Installation

Electrostatic Sensitivity

AMP-TC2-*2 and AMP-TC3-*2 are electrostatic sensitive devices. The terminals should not be touched except during soldering. Soldering should be performed at electrostatic discharge protected workstations.

Wires attached to terminals should not be touched.

If an electrostatic discharge protected work station is not available, use a grounded wrist-strap and ground the thermocouple amplifier.

Mechanical Installation

SR Series Michigan Scientific slip rings pilot onto AMP-TC2-*2 and AMP-TC3-*2 amplifiers. The shaft that the amplifier will mount to should be machined to allow the amplifier to pilot onto it. The pilot should have a minimum depth of 0.050 inch and be machined for flatness and concentricity with tolerances no greater than specified in the figure below.

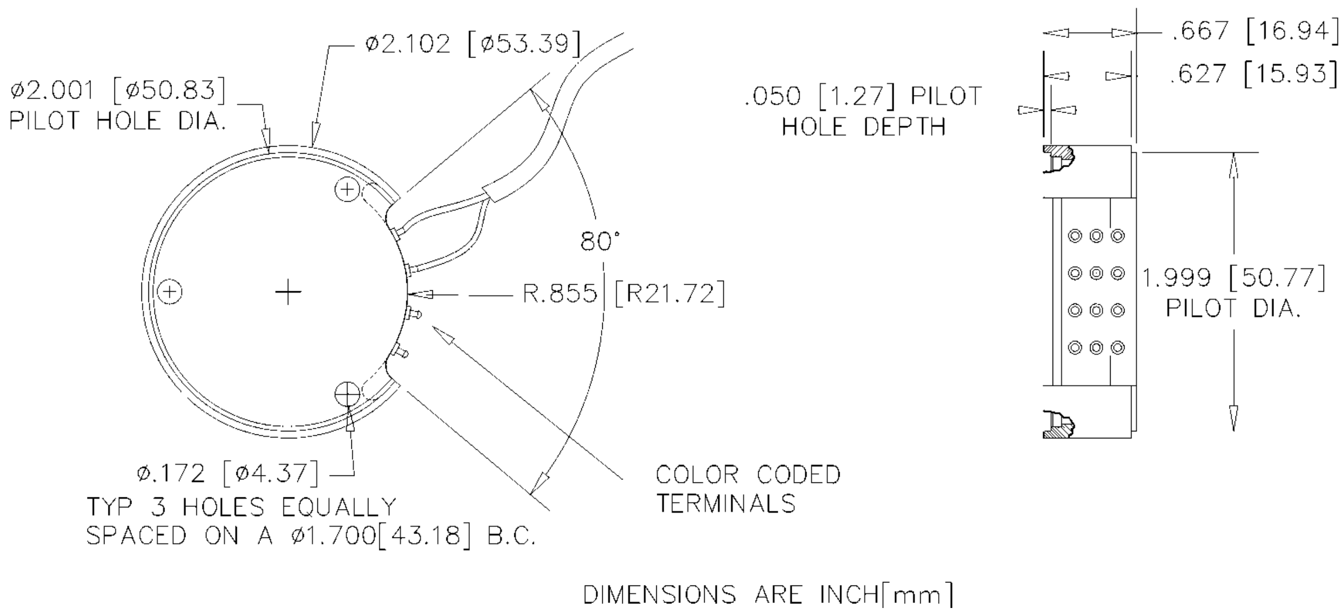

Figure 1

Three #8 socket head cap screws should be tightened to no more than 45 inch-pounds to secure the amplifier.

The total indicated runout (t.i.r.) is <0.003 inches per module. Using a pilot will reduce runout better than bolts through the mounting holes alone.

The module is not waterproof. Michigan Scientific does manufacture a slip ring / amplifier cover. Please contact factory for specifications.

Electrical Installation

Solder terminals on the AMP-TC2-*2 and the AMP-TC3-*2 are color coded to help determine which supply or signal corresponds to which terminal.

Signal	Terminals
Slip Ring Connections:	
Positive 15V	Blue
Negative 15V	Violet
Common	Gray
Amplifier Output Channel 1	Yellow
Amplifier Output Channel 2	Orange
Amplifier Output Channel 3[1]	Brown
Thermocouple Connections:	
Thermocouple Positive[2]	Yellow
Thermocouple Negative	Red

[1]Common for AMP-TC2-*2
[2]Yellow for K, White for J, Blue for T, Violet for E, Orange for N type Thermocouple

Figure 2

The output high is measured relative to the ground pin. Michigan Scientific recommends that a separate wire for signal common be added to the common pin 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 given to physically place the amplifier and slip ring as close as possible to the thermocouple.

+15 Volts	Channel 1 Output	TC 1 Low Input	TC 1 High Input[2]
-15 Volts	Channel 2 Output	TC 2 Low Input	TC 2 High Input[2]
Common	Channel 3 Output[1]	TC 3 Low Input	TC 3 High Input[2]

[1]Common for AMP-TC2-*2
[2]Yellow for K, White for J, Blue for T, Violet for E, Orange for N type Thermocouple

Figure 3

Linearization Formulas

AMP-TC2-*2 and AMP-TC3-*2 cold junction compensate and amplify thermocouple signals but it does not linearize the signal. These polynomials use raw voltage from the amplifier as the independent variable and generate temperature in degrees C.

Higher order polynomials are accurate over wider temperature ranges. Reducing the number of significant digits reduces the accuracy. Each of the following formulas 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 polynomials 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

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

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

$$T = (2.5499e-4) \times V^6 - (1.1161e-2) \times V^5 + 0.18766 \times V^4 - 1.3957 \times V^3 + 4.0742 \times V^2 + 95.47 \times V + .91578$$

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

N Type

Temperature Range: 0 °C to 100 °C

$$T = -14.55 \times V^2 + 156.2 \times V + 0.02$$

Temperature Range: 0 °C to 1100 °C

$$T = -0.000724 \times V^6 + 0.0264 \times V^5 - 0.39666 \times V^4 + 3.3006 \times V^3 - 16.9743 \times V^2 + 156.07 \times V + 0.1$$

Temperature Range: -100 °C to 200 °C

$$T = 2.858 \times V^3 - 17.312 \times V^2 + 156.4 \times V + 0.252$$

Temperature Range: -130 °C to 1300 °C

$$T = -0.00071 \times V^6 + 0.0282 \times V^5 - 0.4474 \times V^4 + 3.762 \times V^3 - 18.66 \times V^2 + 158.2 \times V + 0$$

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 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