# User's Guide

An OMEGA Technologies Company

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# OMNI-AMP IV Series
## Thermocouple Amplifier

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**WARNING**: These products are not designed for use in, and should not be used for, patient-connected applications.

## Features

- 100% Encapsulated
- 2 µV/°C Zero Stability
- 0.025°F/°F Reference Junction Stability
- Up or Down Scale TC Burn-out
- 115 VAC or 230 VAC Power
- Easy Mounting
- ±10 VDC Output
- Input Protection to 115 VAC or DC
- Scale Factor of 10 mV/°F
- Over 120 dB CMRR at 60 Hz

## Description

The OMNI-AMP IV is a high performance rugged epoxy encapsulated thermocouple amplifier with built-in power supply. It can be used with Type E, J, T, or K thermocouples by changing only the span adjustment. Types R, S, and B can be accommodated by ordering the 1 mV/°F scale factor option. Only the highest quality industrial components are used for reliable and long operation. Connections are made with an ordinary screwdriver to rugged terminal strips. The amplifier can be mounted using the set of bolts supplied with the unit.

A reference junction temperature output is also supplied. Figure 1 shows a block diagram of the amplifier.

## Amplifier

The amplifier is a multiple IC instrumentation amplifier with excellent zero and gain stability. Gain can be adjusted from 40 to 1500 so the amplifier can be used with a variety of thermocouple signals. An internal path is provided for amplifier input bias current. The amplifier has excellent common mode rejection allowing the thermocouple input leads to be several hundred feet long without degraded performance due to 60 Hz common mode pick-up. The amplifier is also protected against an accidental over-voltage applied to the input. Please note that the amplifier has cold junction compensation but not linearization. The maximum output is ±10 Volts, providing up to 1000°F output at 10 mV/°F or 10,000°F at 1 mV/°F.

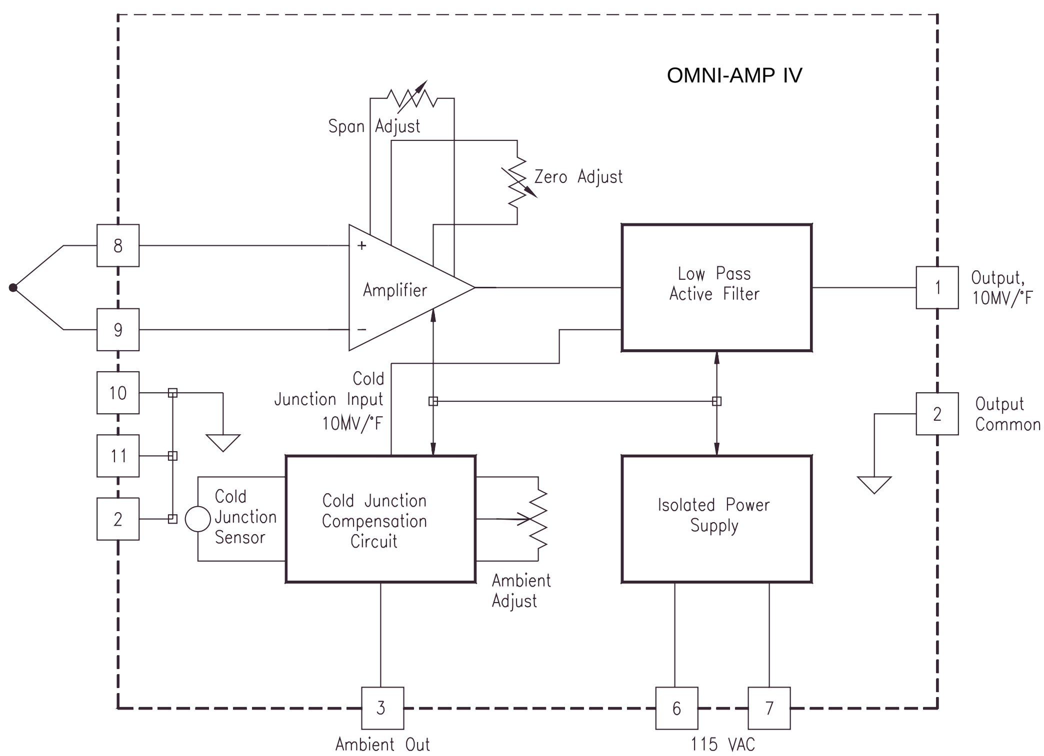



**FIGURE 1.** OMNI-AMP IV Block Diagram

## Specifications

| | | | |
|---|---|---|---|
| **Span (Gain)** | | **Output** | |
| Range | 40 to 1500 | ±10V into 10k ohms minimum | |
| Nonlinearity | ±0.005% | **Temperature** | |
| Resolution | Infinite | Operating | 0 to 55°C (32 to 130°F) |
| **Stability (After 30 Minute Warm-up)** | | Storage | -20 to 80°C (-4 to 175°F) |
| Zero | 2 µV/°C (1 µV/°F) | **Power** | |
| Long Term Zero | ±1 µV/Month | 115 VAC @ 3 VA maximum | |
| Span | ±0.01%/ °C (±0.006%/ °F) | **Protection** | |
| Long Term Span | ±0.05% | Input | up to 115 VAC<br>or DC common mode<br>or differential |
| **Cold Junction Compensation** | | | |
| ±0.045 °C/°C ( ±0.025 °F/°F) | | Output | continuous short circuit proof |
| **Input Impedance (Differential)** | | **Common Mode Range** | |
| 2 megohms | | +10 to -10 VDC or 20 Volts peak-to-peak AC | |
| **Frequency Response** | | **Scale Factor** | |
| 3 dB down at 1.5 Hz | 40 dB/decade roll-off | 10 mV/°F (1 mV/°F optional) | |
| **Noise Rejection** | | **Size** | |
| Common Mode Rejection Ratio | 120 dB min @ 60 Hz | 3.75" x 2.0" x 2.87" | |
| Normal Mode Rejection ratio | 80 dB min @ 60 Hz | **Weight** | |
| Noise (RTI) 0 to 1.5 Hz | 1.4 µVRMS | 18 ounces | |

| | |
|---|---|
| **Model Numbering System OMNI-AMP IV-OX-OY-VV** | |
| OMNI-AMP IV = Basic model number | |
| - OX = Open thermocouple, direction of temperature output | - 01 = Up scale, or increase in temperature<br>- 02 = Down scale, or decrease in temperature |
| - OY = Ambient temperature output scale factor | - 03 = 10 mV/°F<br>- 04 = 1 mV/°F |
| - VVV = Power line voltage | - 115 = 105 to 125 Volts, AC, 50-60 Hz<br>- 230 = 210 to 250 Volts, AC, 50-60 Hz |
| **Options: Add Dashes to Model Number** | |
| -01 -03 -115 Up Scale, 10 mV/°F; 115 VAC | -01 -03 -230 Up Scale, 10 mV/°F; 230 VAC |
| -01 -04 -115 Up Scale, 1 mV/°F; 115 VAC | -01 -04 -230 Up Scale, 1 mV/°F; 230 VAC |
| -02 -03 -115 Down Scale, 10 mV/°F; 115 VAC | -02 -03 -230 Down Scale, 10 mV/°F; 230 VAC |
| -02 -04 -115 Down Scale, 1 mV/°F; 115 VAC | -02 -04 -230 Down Scale, 1 mV/°F; 230 VAC |

## Low Pass Filter

The output of the amplifier is sent through a 2-pole low pass active filter. Since temperature changes are usually quite slow, it is advantageous to filter out any high frequency noise. This is valuable if the output signal is used to operate comparators for alarm or control purposes. If the output noise is kept low, the alarm or control comparators can be set very precisely without fear of set point chatter or having to rely on an excessive amount of comparator hysteresis. The Model 470 pole frequency is approximately 1.5 Hz.

## Power Supply

The power supply operates from 115 VAC 50-60 Hz (a 230 VAC version is available) and utilizes a split bobbin isolated transformer. Thus the common of the amplifier may be floated above earth ground if desired. The power supply is conservatively designed and provides regulated power for the amplifier and filter plus a very stable reference voltage for the cold junction compensation circuit. An external line fuse of 1/8 Amp may be used for protection.

## Cold Junction Compensation

The temperature of the cold junction is measured with a solid state sensor that is typically linear to 1°C. This sensor is in close thermal contact with the amplifier input terminal block which is the cold junction. The cold junction signal is scaled to 10 mV/°F (or 1 mV/°F) and is added to the amplifier output and is not effected by changing the gain of the amplifier. This requires the gain of the amplifier to be adjusted for the same scale factor as the ambient temperature output when changing thermocouple types.

A separate ambient temperature output is provided. Note that this is the temperature of the 470 module and will be a few degrees above the actual ambient temperature due to its own heat dissipation.

## Application Information

### General Information

As delivered, the zero and cold junction adjustments have been set. The span adjustment has been set up for a type K thermocouple and a scale factor of 10 mV/°F (unless 1 mV/ °F has been ordered). The thermocouple to be used is connected to the + and - terminals using either bare wire or a lug termination. Polarity should be observed. The table below lists thermocouple wire color coding.

### Zero Adjustment

In case the zero or cold junction calibrations are disturbed, follow these adjustment steps after allowing 30 to 45 minutes for warm-up.

1. Remove the input thermocouple and replace with a tin plated copper wire short.
2. Jumper the ambient temperature output terminal to common.
3. Observe the output voltage with a 4½ digit DVM.

4. Adjust the zero pot until the output voltage is zero ±0.001 Volt.
5. Return the amplifier to normal state.

### Cold Junction Temperature Adjustment

1. Remove the input thermocouple and replace with a tin plated copper wire short.
2. Measure the cold junction temperature with an auxiliary thermometer accurate to ±0.5°F.
3. Observe the output voltage with a 4 ½ digit DVM.
4. Adjust the cold junction pot until the output reads the cold junction temperature within ±0.5°F.
5. Return the amplifier to normal state.

The temperature of the cold junction is measured with a solid state sensor that is typically linear to 1°C. This sensor is in close thermal contact with the amplifier input terminal block which is the cold junction. The cold junction signal is scaled to 10 mV/°F (or 1 mV/°F) and is added to the amplifier output and is not effected by changing the gain of the amplifier. This requires the gain of the amplifier to be adjusted for the same scale factor as the ambient temperature output when changing thermocouple types.

A separate ambient temperature output is provided. Note that this is the temperature of the 470 module and will be a few degrees above the actual ambient temperature due to its own heat dissipation.

### Cold Junction Compensation

| Table of Colors | | |
|---|---|---|
| **Thermocouple Type** | **+ Wire Color** | **- Wire Color** |
| **J** | White | Red |
| **K** | Yellow | Red |
| **T** | Blue | Red |
| **E** | Purple | Red |
| **S** | Black | Red |
| **R** | Black | Red |
| **B** | Black | Red |

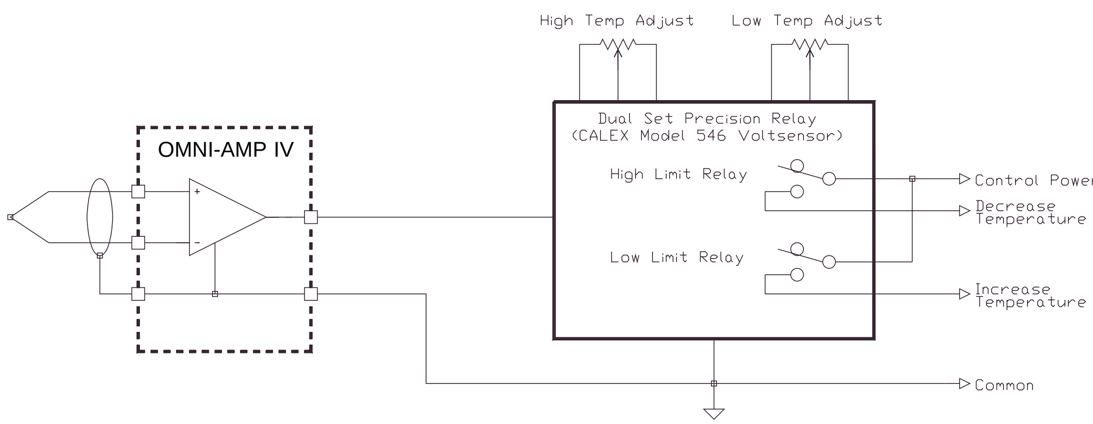



**FIGURE 2.** Simple Temperature Control or Alarm System

### Span Adjustment

The span, i.e. gain, of the amplifier must be set for the type of thermocouple being used. Either a known temperature source and the desired thermocouple, or a low voltage source such as a thermocouple calibrator may be used. It is generally best to set the gain near the temperature of most interest to obtain the best accuracy around that temperature.

First adjust the zero and leave the ambient temperature output terminal jumper to common. Look in a table on the thermocouple to be used for the thermocouple voltage at the temperature of interest. A type K has an output of 11.289 mV at 532°F, i.e. 500°F above 32°F. The gain required is 5.000V/.011289 = 442.9. You can then apply .010 Volts to the amplifier inputs and adjust the gain for an output between pins 1 and 2 of 4.429 Volts, or apply 11.289 mV and adjust for an output of 5.000 Volts. Remove the ambient output jumper and connect up the thermocouple.

## Shielding Considerations

### The Question of Shielding

Several types of electromagnetic interference can be encountered in industrial plants. Table 1 lists the most common sources. With un-shielded thermocouple wires the usual problem is a common mode voltage caused by the electric field from power distribution lines. The CMR (Common Mode Rejection) of the amplifier will help to minimize this effect. For severe cases, caused by very long leads or high electric fields, it may be necessary to shield the thermocouple wires with copper braid.

If the thermocouple must be grounded, then a common mode voltage may be induced because of stray magnetic fields acting on the large loop formed by the thermocouple wires and the ground plane. The CMR of the amplifier will be adequate to prevent measurement errors in most cases. For severe cases, caused by very long runs or large magnetic fields, shielding the input leads in steel conduit may be required.

Ground loops, where both ends of the thermocouple wires or the shield are grounded, should always be avoided. Only ground one end of any shield. Stray magnetic fields can induce large currents which in turn can cause normal mode interference capable of swamping the amplifier. It is generally best to ground the common of the amplifier. In the special case where the thermocouple must operate at a high potential from ground, the common of the amplifier should be connected to one of the thermocouple inputs.

| Table 1 | | | |
|---|---|---|---|
| **Type of Noise** | **Encountered in Industry** | **Typical Source** | **Effective Shield Material** |
| Low Frequency* Electric Fields | Often | Power Distribution Lines (60 Hz) | Copper Braid |
| Low Frequency Magnetic Fields | Often but very localized | Tranformers (60 Hz) | Magnetic Material |
| Static Electric or Magnetic Fields | Occasionally | High DC Voltage<br>or Current Sources | Usually not required unless fields are very high |
| High Frequency Electromagnetic Fields (R.F.) | Occasionally | Induction Heater,<br>Radio Transmitter<br>SCR Controlled Motors | Copper Braid |

* Low Frequency means 50-60 Hz

**THERMOCOUPLE OUTPUT BY TYPE**

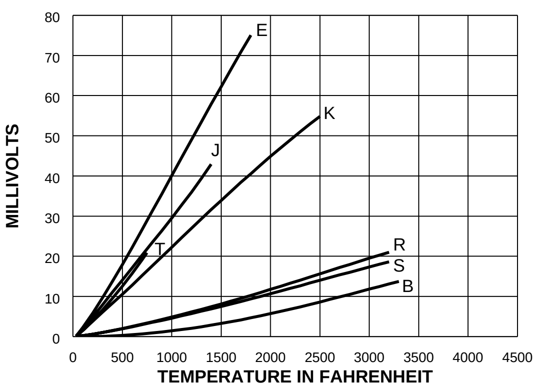



**FIGURE 3.**

## Other Useful Data

### Fahrenheit to Celsius Conversion

**F** = 9/5 (C°) + 32

**C** = 5/9 (°F -32)

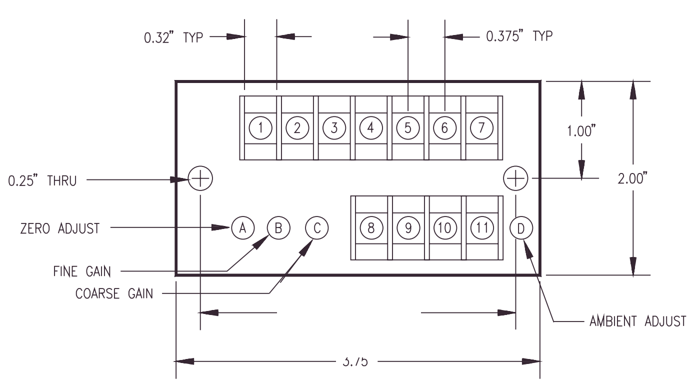
| **Thermocouple Material** | | **Temp. Range** |
|---|---|---|
| **J** | Iron-Constantan | -346 to +1400°F |
| **K** | Chromel-Alumel | -450 to +2300°F |
| **T** | Copper-Constantan | -450 to +750°F |
| **E** | Chromel-Constantan | -450 to +1700°F |
| **S** | Platinum-Platinum 10% Rhodium | - 58 to +2650°F |
| **R** | Platinum-Platinum 13% Rhodium | - 58 to +2650°F |
| **B** | Platinum-6% Rhodium | -266 to +3300°F |

**Note:** The thermocouple temperature ranges are NIST specified material range, and do not indicate the useful range using the 470.

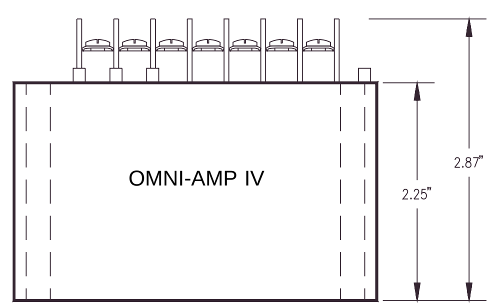
As can be seen in the thermocouple output curves, linearization is not a significant factor for most thermocouples, particularly over a limited range.

## Mechanical Specifications

Top View




Side View




| Terminal Strip Assignments | | | |
|---|---|---|---|
| **Screw Terminal** | **Function** | **Screw Terminal** | **Function** |
| 1 | OUTPUT | 7 | AC |
| 2 | CMN | 8 | +INPUT |
| 3 | AMBIENT OUT | 9 | -INPUT |
| 4 | NOT USED | 10 | CMN |
| 5 | NOT USED | 11 | CMN |
| 6 | AC | | |

## WARRANTY/DISCLAIMER

OMEGA ENGINEERING, INC. warrants this unit to be free of defects in materials and workmanship for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal one **(1) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product.

If the unit malfunctions, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective, it will be repaired or replaced at no charge. OMEGA's WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of having been damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear are not warranted, including but not limited to contact points, fuses, and triacs.

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The purchaser is responsible for shipping charges, freight, insurance and proper packaging to prevent breakage in transit.

FOR <u>WARRANTY</u> RETURNS, please have the following information available BEFORE contacting OMEGA:

1. Purchase Order number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR <u>NON-WARRANTY</u> REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:

1. Purchase Order number to cover the COST of the repair,
2. Model and serial number of product, and
3. Repair instructions and/or specific problems relative to the product.

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