

# Accutech™

Smart Process Instrumentation

MODEL  
AI-2000

Revision 4

## Two-Wire "Smart" Temperature Transmitter

For High-Precision Industrial  
Temperature Measurements



### Highlights

- **Accuracy**  
Exceptionally Accurate Measurements  
To  $\pm 0.04\%$  of Reading with RTD Input  
To  $\pm 0.02^\circ\text{C}$  with Thermocouple Input  
To  $\pm 0.05^\circ\text{C}$  Linearization
- **Stability**  
To  $\pm 0.02\%$  of Reading Repeatability  
Automatic Self-Calibration  
Digital Temperature Compensation  
Two-Year Calibration Warranty
- **Versatility**  
2-Wire, 3-Wire, 4-Wire RTD Input  
B, E, J, K, N, R, S, and T Thermocouple  
Differential Temperature RTD Input  
One Transmitter for all output ranges  
No board swapping, no minimum span
- **Remote Communication**  
Communication up to 5,000 Feet  
2-Wire, RS-232 Compatible
- **Ease-of-Use**  
Conventional calibration, standard  
Display setup, optional  
PC configuration, optional  
Hand-Held terminal, optional
- **Field Proven Design**  
Rugged, sealed, industrial design  
Hardened to EMI/RFI interference  
Suitable for field or panel mounting

### Description

The Model AI-2000, Revision 4, refines the field-proven Accutech "Smart" Transmitter. It maintains the operational simplicity and ease-of-use that is familiar to Accutech users. But the AI-2000, Revision 4, goes further. It provides unmatched accuracy and, for the first time in an industrial field-mounted transmitter, the AI-2000 guarantees calibration stability up to 24 months. Install an AI-2000 today. Two years from now, it will still be within calibration and you won't have to recalibrate!

To give you maximum flexibility, the AI-2000 will accept eight different types of thermocouples, three types of single RTD inputs, a millivolt input, or dual RTD input for differential temperature measurements. This versatility allows the AI-2000 to be used for nearly any temperature transmitter application.

Installation and operation are simple. Choose one of four configuration methods to set up the transmitter. Select the desired sensor and output range. Set the zero and full-scale anywhere within the usable range of the sensor. Independent zero and full-scale settings have no interaction and may be set up for normal or reverse acting.

The remote communication capability is RS-232 compatible. You can talk to the AI-2000 from a location up to 5,000 feet away. Configure or check transmitter status from a central control room. Physical access to the device itself is not necessary.

With everything it has going for it, the AI-2000, Revision 4, stacks up as the finest temperature transmitter available.



## Applications

Use the AI-2000, Revision 4, in industrial environments for field or panel-mounted installations. It is offered with a full complement of thermocouples, thermowells, RTDs, and a variety of housing options to complete your temperature measurement needs.

### Where Maximum Performance is Necessary

In many process industry applications, precision temperature measurements to a fraction of a degree are necessary for maximum production throughput and assurance of the highest product quality. The AI-2000 is right at home in these applications. Its accuracy, repeatability, and long-term stability are unmatched. The AI-2000 has been proven in the most demanding applications. You can feel comfortable giving it the most difficult temperature measurements that you have to make.

### Where Standardization is Advantageous

The AI-2000 can handle the toughest operations in the plant. At the same time, it is cost-effective enough to be used in less demanding locations. Standardizing on the AI-2000 affords across-the-board savings in personnel training and storeroom inventories. You can use this transmitter everywhere a temperature transmitter is called for and pocket the returns.

### Where Remote Communications Pays Dividends

Remote communications can pay big dividends. In start-up, if you need to change a transmitter range, you can do this right from the control room in just a couple of minutes. During operation, if you suspect that a sensor or transmitter is not functioning properly, you can call up the AI-2000 and ask. No need to run out to the transmitter, make sure the area is safe, open the cover of the transmitter, and start troubleshooting. Industrial studies show that savings that result from a remote communication alone are worth \$350 per transmitter *annually*!

### Where Elimination of Periodic Maintenance Cuts Costs

The AI-2000 has built-in zero and full-scale calibration checks performed every three seconds. This automatic self-calibration virtually eliminates the need for manual periodic transmitter recalibration. The AI-2000 also checks for sensor and transmitter failures—significantly reducing your maintenance costs.

### Where Guaranteed Accuracy will Enhance Your Operations

The self-calibration features in the AI-2000 have been proven in industrial processes. They put a virtual end to periodic transmitter calibration maintenance. With years of real world experience behind it, Accutech guarantees the AI-2000 transmitter to hold calibration to factory specified tolerances for a period of two years! This guarantee gives you added assurance that your transmitter is giving you the precision information that you need to run your process at top efficiency.

## Industrial Construction

The AI-2000 is packaged in a rugged, nickel plated, aluminum enclosure suitable for mounting on a flat surface. The sealed metal housing provides protection against moisture, condensation, and the effects of electromagnetic and radio frequency interference (EMI/RFI).

## Product Features

### Simple Installation

Installation requires only two low-voltage wires which provide the 4 to 20 mA output signal as well as the transmitter's power.

### Factory Calibration

Each AI-2000 is calibrated in ambient operating temperatures from  $-40$  to  $+167^{\circ}\text{F}$  ( $-40$  to  $+75^{\circ}\text{C}$ ) using fully automated, NIST traceable equipment. This factory calibration data is permanently retained in the transmitter's memory.

### Automatic, On-Line Self-Calibration

In normal operation, the AI-2000 automatically checks the NIST traceable zero and full-scale calibration reference standards every three seconds. Internal corrections are made, if necessary, without disturbing the 4 to 20 mA loop current.

### Temperature Compensation

Critical circuit component temperatures are continuously measured and digitally compared to stored ambient temperature calibration data. This digital ambient temperature compensation maintains stable performance at any ambient temperature from  $-40$  to  $+167^{\circ}\text{F}$  ( $-40$  to  $+75^{\circ}\text{C}$ ).



### Automatic Cold Junction Compensation

Automatic cold junction compensation is performed when a thermocouple sensor is selected. Cold junction compensation, unique to each type of thermocouple, is calculated based on the measured temperature of the sensor input terminals.

### Input Versatility and Linearization

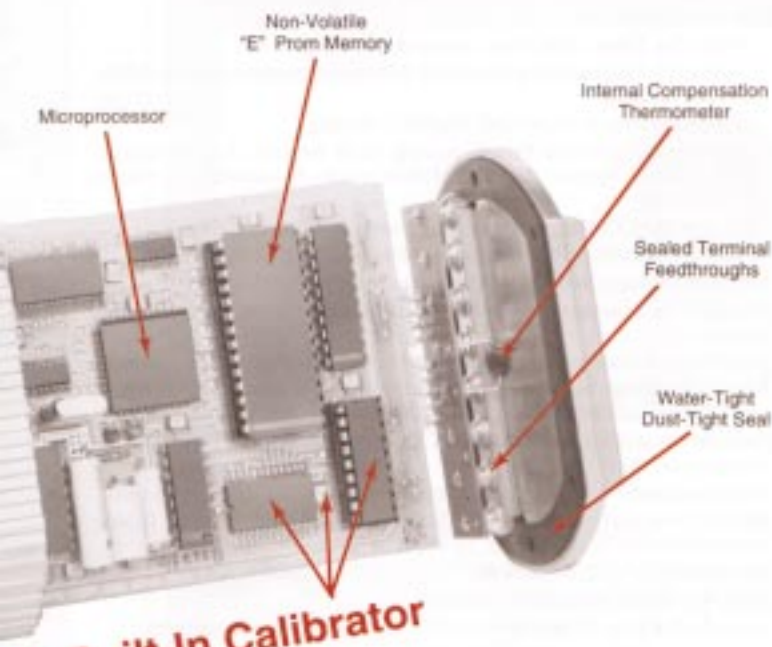
The AI-2000 accepts the most popular thermocouple, millivolt, and RTD sensors. All inputs are precision linearized to  $\pm 0.05^{\circ}\text{C}$  over the entire input range as shown in the accompanying table. Sensor input selection is easily made in the field using simple tools.

## Operation

In operation, the input signals are filtered to eliminate electrical noise. This input is then converted into digital format by a 50,000 count Analog to Digital Converter and passed to the microprocessor, which is the heart of the device. The microprocessor linearizes the readings and passes the temperature data to the output circuits and the optional display.

Once every three seconds, the microprocessor reads the onboard calibration standards, the cold junction, and the circuit temperatures. This information is used for automatic self-calibration and digital ambient temperature compensation.

All set-up and calibration data is stored in a nonvolatile memory, which will retain the values even when power is removed. There are no potentiometers, batteries, switches, or internal jumpers that tend to degrade reliability. All changes are made through the external terminals of the transmitter without breaking the AI-2000 seal.



## Advanced Features

### Remote Communication

The AI-2000 can function as a conventional analog two-wire transmitter. Or, its advanced features can be accessed via digital communications along the same pair of wires. Connecting the CA-100 communications adapter module anywhere along the loop produces an RS-232 communications link which can be directed into a process or personal computer. The Accutech HHT-420 can also be used to address and set up the AI-2000. These options are covered in the AI-2000 competitive comparison brochure, where the advantages of Accutech's "Smart Communication" are compared to the other available industrial protocols.

### Dynamic Response

Most transmitters are specified under laboratory conditions with stable inputs and stable ambient conditions. This is fine for the lab, but you need to know how it is going to perform in the real world where conditions are rapidly changing. Accutech is the first "Smart" transmitter manufacturer to specify performance under dynamic conditions. In dynamic environments, the AI-2000 delivers. It responds quickly to the changes you want to see and ignores the effects of outside variables.

### NIST Traceable

Most international quality standards, such as ISO 9000, require traceable measurement instrumentation. These calibrations must consider the effects of temperature, rate of change of temperature, humidity, lightning, vibration, and dust. The factory calibration and physical construction of the Accutech 2000 series products take into account each of these factors, and included with each AI-2000 is a NIST traceable calibration certification.

### Calibration Guarantee

International standards also require recalibration schedules to be established. Accutech 2000 series products cut your recalibration expense with a standard two-year calibration guarantee.



Thermocouple Input - NBS Curve		
	Range	
Type B	+ 43 to + 1820°C	+109 to + 3308°F
Type E	- 270 to + 1000°C	- 454 to + 1832°F
Type J	- 210 to + 1200°C	- 346 to + 2192°F
Type K	- 270 to + 1372°C	- 454 to + 2502°F
Type N	- 260 to + 1300°C	- 436 to + 2372°F
Type R	- 50 to + 1768°C	- 58 to + 3214°F
Type S	- 50 to + 1768°C	- 58 to + 3214°F
Type T	- 270 to + 400°C	- 454 to + 752°F
RTD, Resistance Thermometer Input, 2-, 3-, or 4-Wire		
	Range	
Pt 100ΩDIN	- 200 to + 850°C	- 328 to + 1562°F
Pt 100ΩNBS	- 200 to + 850°C	- 328 to + 1562°F
Ni 120Ω	- 80 to + 320°C	- 112 to + 608°F

## Industrial Temperature Systems

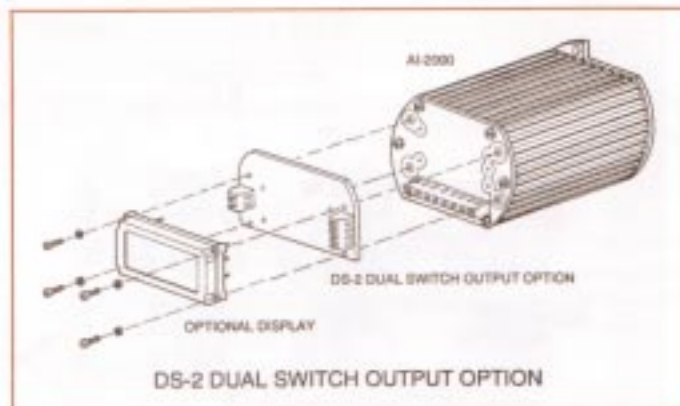
Accutech offers a complete assortment of thermocouples, RTDs, thermowells, and housings for head mounting, field mounting, and panel mounted applications. Explosion-proof housings available with and without windows are CSA certified and FM approved for Class I, Div I and II, Groups B, C, and D; Class II, Div I and II, Groups E, F, and G, and are rated for NEMA 4X and NEMA 7 environments.

Complete Accutech temperature systems can be supplied to industrial users for both critical and noncritical measurements. Please see the companion literature on temperature assemblies for complete information.

## Output Switches

With the plug-in, DS-2 Dual Switch Output Option, you can use the AI-2000 as a temperature transmitter with programmable switches. The switches will turn ON/OFF DC loads such as solenoids, enunciators, lights or relays rated to 1 amp at 28VDC. The DS-2 switch points and deadbands are fully adjustable. Switches can be set for normally open or normally closed operation with trip points anywhere within the usable range of the sensor.

The two switches can be set to initiate a number of external control or alarm functions, such as: "HI/LO", "HI/TOO HI", "LO/TOO LO", etc.

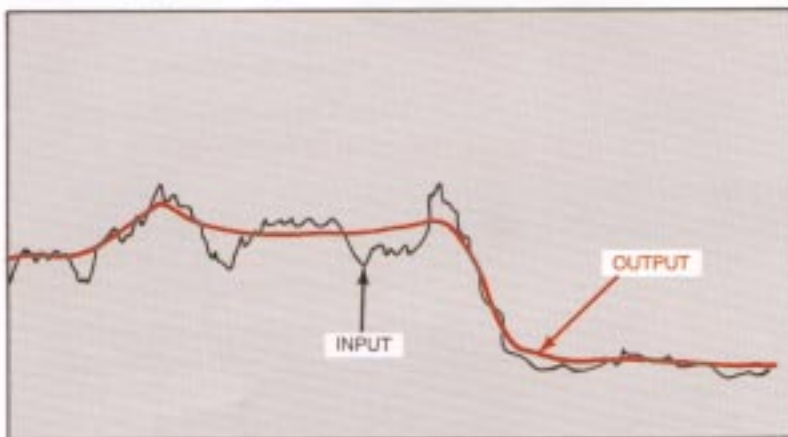


## Eliminating "Noise" Surges

Noise and surges often present difficulties in process measurement and control systems. The AI-2000 has a number of capabilities to remove these unwanted fluctuations.

In temperature measurement applications, it is often necessary to measure electrical signals of less than one microvolt (or 0.000001V). Conventional temperature transmitters often have great difficulty differentiating between noise and signal at these very low voltage levels.

Low voltage noise in the 50 or 60 Hz frequency range arises from electrical generation sources and motors at most industrial facilities. Higher frequency noise is generated with hand-held walkie-talkies, radio stations, and other sources. Lightning and switching electrical loads often create large power surges.



The AI-2000 addresses the problem of unwanted noise with a combination of hardware and software filters. These filters are designed to recognize unwanted fluctuations and remove them. One filter is user settable to the frequency of the plant's main power source. In addition, broad band filters block out electrical noise over a broad spectrum of frequencies. For particularly "noisy" installations, the AI-2000 may be switched to run with higher levels of digital filtering at the expense of transmitter update speed. We have also implemented custom filters targeted to remove specific problematic noise. Please contact Accutech for further information on this subject.

## Special Applications

The standard AI-2000, without modification, can handle many special situations that arise in the process industries. You may need to activate an option or use a factory installed option. In extreme cases, a special unit can be fabricated to get your job done.

### Ultra-Precision Temperature Measurements

For ultra-precise measurements, use the AI-2000 UP. The AI-2000 UP, with an individually calibrated 4-wire RTD, can make temperature measurements with an accuracy of  $\pm 0.1^\circ\text{F}$ . This is a total measurement system accuracy, fully NIST traceable! On-site calibration and "tweaking" are not required to achieve this level of accuracy. Order the AI-2000 UP, or request Accutech Tech-Note No. 208 for further information.

### Differential and Multiple Temperature Sensors

A single output from more than one sensor is possible with Accutech Temperature Transmitters. The standard AI-2000 allows a dual RTD input for differential and average measurements. The AI-2000 S13 special allows a single output from two or three thermocouple inputs. With two thermocouple inputs, the AI-2000 S13 can be programmed for a true temperature difference.

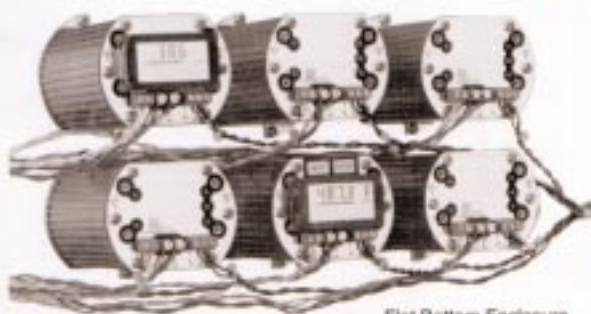
The normal practice of wiring thermocouples in series will not give you a true temperature difference, because of the thermocouple nonlinearity. The AI-2000 S13, with its microprocessor precision, will give a true temperature difference, regardless of the measured temperature.

With three inputs, and the mean value selected, the transmitter output will still be valid even with one failed thermocouple. Please see Accutech Tech-Note No. 211.

### Special Sensor Inputs

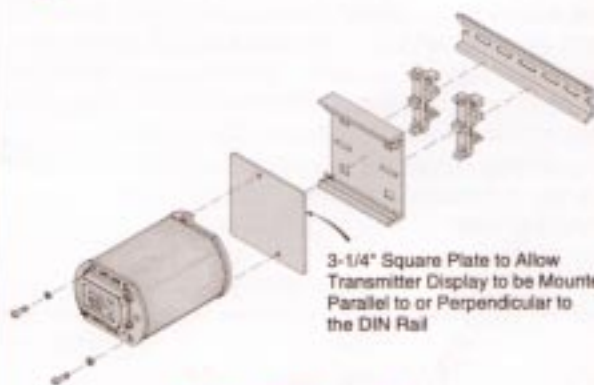
The Accutech AI-2000 lets you field program a custom curve with 21 user-specified points. For even greater precision, we will custom fit a segmented polynomial curve to any sensor on special request. For further information, request Accutech Tech-Note No. 204.

## Mounting Configurations



Flat Bottom Enclosure  
For Easy Panel Mounting

**Panel Mounting**



3-1/4" Square Plate to Allow  
Transmitter Display to be Mounted  
Parallel to or Perpendicular to  
the DIN Rail

**DIN Rail Mounting**

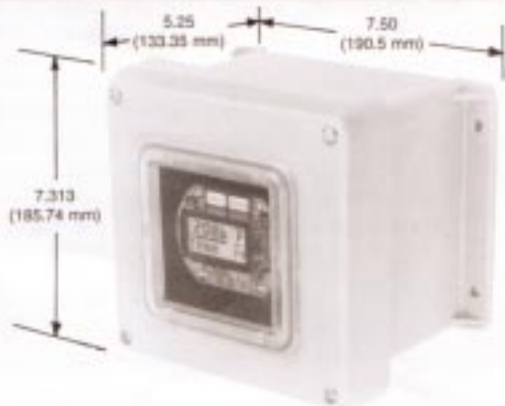


Explosion Proof

**Head Mounting**



**2" Pipe Bracket Mounting**



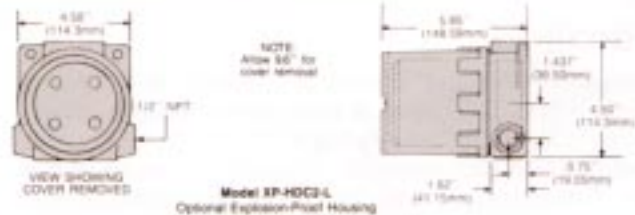
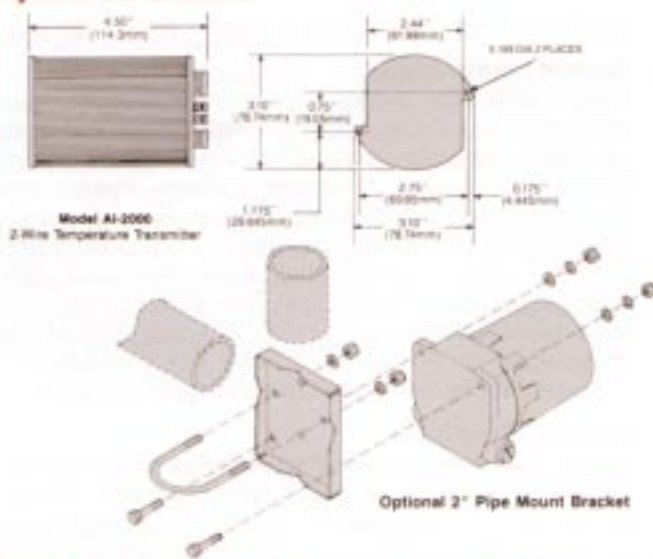
NOTE: Dimensions include height of plastic bezel.

**Heavy Duty NEMA 4X Housing**

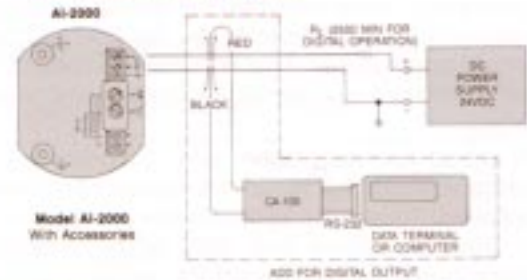


**NEMA 4X Housing**

## Physical Dimensions



## Connection Diagram



## AI-2000, Revision 4 Specifications

**Thermocouple Sensors:** NBS Types B, E, J, K, N, R, S, T

**RTD Resistance Sensors**

100Ω Platinum DIN curve ( $\alpha = 0.00385$ ).....	2-, 3-, or 4-Wire
100Ω Platinum NBS curve ( $\alpha = 0.00392$ ).....	2-, 3-, or 4-Wire
120Ω Nickel.....	2-, 3-, or 4-Wire
10Ω Copper, consult factory.....	2-, 3-, or 4-Wire

**Millivolt Input Range:** -15 to 160 mV DC

**Linearization:** Thermocouple and RTD linearization to  $\pm 0.05^\circ\text{C}$  Custom linearization user programmable at 21 points

**Output:** Analog, Two-wire 4 to 20 mA

Digital, Two-wire (RS-232, 300 baud with CA-100 adapter)

**Output Ranging Adjustments**

Analog Zero:	} { 100% of sensor range—Noninteracting
Analog Full-scale:	
Digital Mode:	{ Normal or Reverse Acting
	{ $^\circ\text{C}$ , $^\circ\text{F}$ , $^\circ\text{K}$ , $^\circ\text{R}$ , mV (No ranging req)

**Minimum Output Span:** None

**Output Resolution:** Analog, 2.1  $\mu\text{A}$ ; Digital, 0.01 $^\circ$ , 0.001 mV

**Transmitter Accuracy:** Includes repeatability, hysteresis, load and ambient temperature effect. For a detailed analysis, refer to Accutech Application Note No. 203. Enhanced accuracy calibrations available from the factory.

**Digital Output Accuracy:**  $\pm 0.04\%$  of the millivolt or ohm equivalent reading, or the accuracy from the table below, whichever is greater, plus the effect of a cold junction measurement error of  $\pm 0.25^\circ\text{C}$  ( $\pm 0.45^\circ\text{F}$ ) if using a thermocouple sensor.

Sensor	Digital Accuracy	Sensor	Digital Accuracy
B T/C	$\pm 0.8^\circ\text{C} \pm 1.44^\circ\text{F}$	S T/C	$\pm 0.6^\circ\text{C} \pm 1.08^\circ\text{F}$
E T/C	$\pm 0.2^\circ\text{C} \pm 0.36^\circ\text{F}$	T T/C	$\pm 0.2^\circ\text{C} \pm 0.36^\circ\text{F}$
J T/C	$\pm 0.2^\circ\text{C} \pm 0.36^\circ\text{F}$	Millivolt	$\pm 0.008$ mV
K T/C	$\pm 0.2^\circ\text{C} \pm 0.36^\circ\text{F}$	Pt RTD DIN	$\pm 0.1^\circ\text{C} \pm 0.18^\circ\text{F}$
N T/C	$\pm 0.2^\circ\text{C} \pm 0.36^\circ\text{F}$	Pt RTD NBS	$\pm 0.1^\circ\text{C} \pm 0.18^\circ\text{F}$
R T/C	$\pm 0.6^\circ\text{C} \pm 1.08^\circ\text{F}$	Ni RTD	$\pm 0.1^\circ\text{C} \pm 0.18^\circ\text{F}$

**Reference Condition Accuracy:** Equal to transmitter repeatability. When set up in the "Tap Mode," the transmitter is referenced to the prevailing conditions. Accuracy at this reference condition will include repeatability, linearity, cold junction, and hysteresis effects. If using a thermocouple, add  $0.05^\circ\text{F}$  for reference condition cold junction effect. ("Reference Condition Accuracy" is comparable in scope to that generally specified for analog-based signal conditioners.)

**Analog Accuracy:** Digital accuracy plus  $\pm 4 \mu\text{A}$

**Repeatability:** One-half the respective accuracy

**Dynamic Response**

**Turn-On Time:** Less than 5 seconds after power-up

**Ambient Temperature Gradient:** Automatic compensation to  $20^\circ\text{C}/$  hour change

**Update Time:** 0.15 second; Digital, 1 second

**Response to Step Input:** Analog: 0.25 second, typical Digital: 1 second, typical, to 95% of final value, 5 seconds, to stated accuracy

**Cold Junction Compensation:** Automatic correction to  $\pm 0.25^\circ\text{C}$

**Ambient Operating Temperature:**  $-40$  to  $+167^\circ\text{F}$  ( $-40$  to  $+75^\circ\text{C}$ )

**Ambient Storage Temperature:**  $-58$  to  $+185^\circ\text{F}$  ( $-50$  to  $+85^\circ\text{C}$ )

**Ambient Temperature Stability:** Self-correcting over the operating temperature

**Long-Term Stability:** Less than 0.05% of reading plus  $\pm 2.1 \mu\text{A}$  per year

**Automatic Diagnostics:** Every 3 seconds, self-checks for zero, span, cold junction, calibration references, malfunction, and sensor failure

**Failsafe:** Analog, user settable to 21 mA, 3.9 mA or "OFF" Digital, message or "OFF"

**Interchangeability:** All units interchangeable without field calibration

**EMI/RFI Immunity:** Less than 0.5% of reading (SAMA PMC 33.1c test method) 20 kHz to 1000 MHz, 10 V/meter

**Isolation:** 850 VDC or peak AC

**Common Mode Rejection:** 120 dB

**Reverse Polarity Protection:** 42 VDC applied with either polarity

**Power and Load:** No load supply: 12 to 42 VDC

**Supply Voltage Under Load:**

$$V_{\text{SUPPLY}} = (12) + (R_{\text{LOAD}} \text{ in k}\Omega) \times (23 \text{ mA})$$

For Digital Operation,  $R_{\text{LOAD}} = 250\Omega$  min.

**Voltage Supply Effect:** Digital, none; Analog, less than  $\pm 0.005\%$  of span per volt.

**Weight:** 12 oz

**Standard Configuration:** Factory configured for J thermocouple, analog output, 40 to  $200^\circ\text{F}$ . Configuration can be user-performed in analog or digital mode. Custom factory configurations available to suit your requirements. See Price List.

**Options:** LD-2 Local Digital Display, KB-2 keyboard, CA-100 RS-232 Interface, HHT-420 Hand-Held Terminal, Explosion-Proof Housings, Sensors, Probes, and Thermowells. See Price List.

**Ordering Information:** Please order Model AI-2000. Specify any custom configuration, if desired. Order companion products as required.