MODEL

AI-2000 (Rev 4.3)

"Smart" Temperature Transmitter

Operating Information

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1.0 INTRODUCTION

The AI-2000 is a smart, isolated, two-wire, transmitter that accommodates any one of eight types of thermocouples, three types of RTD's, millivolt input or ohm inputs. The unit is precision linearized to the measured temperature over the entire usable range of the selected sensor. This transmitter is simple to set up and operates much like high performance analog transmitters.

In addition, the AI-2000 can be set-up remotely through digital communications. By accessing the transmitter with digital communications, you can select some of the AI-2000's more advanced features such as custom curve fitting at 21 points, dual RTD for average or difference temperature.

In addition to the features that you can select, the AI-2000 has a number of advanced capabilities that are continuously active and compensate for changing external effects. These features include automatic self-correction for changes in the ambient temperature or the supply voltage, self-diagnostics, precision linearization, independent zero and full scale settings, digital filtering and many more. These numerous advanced features are achieved through the use of digital signal processing and micro-controller technologies and are transparent to the user.

The transmitter can accept an optional smart local display, the LD-2, and a two key keyboard, the KB-2. These accessories facilitate local configuration and ranging of the transmitter. In operation, the local LCD display indicates the temperature and the units of measure to five digit resolution, an analog percent of range indication and also provides a seven character alphanumeric label or message indication.

This manual is divided into several sections. After a brief *INTRODUCTION*, the section on *UNPACKING AND INSTALLATION* contains much useful information for the first time installer. The section called *IN A HURRY?* helps get the system operating provided the sensor and transmitter were purchased at the same time and thus most of the set up was completed at the factory. The next three sections explain the method of *CONFIGURATION* using the patented "TAP" mode, or with the display or with a hand-held terminal. Finally, there is additional *APPLICATION INFORMATION* and *TECHNICAL SPECIFICATIONS* included in the sections under those headings.

The AI-2000 temperature transmitter does not have any potentiometers or internal DIP switches to set and there are no user serviceable components inside the enclosure. Opening the enclosure will void the manufacturer's warranty. All reconfiguration, re-ranging and "calibration" can be done in the field without opening the transmitter using one of the methods indicated below:

The Tap Mode Setup
The Display and Keyboard Setup
Hand-Held Terminal Setup
Personal Computer Setup

The Tap Mode requires no special options and makes it possible to reconfigure and re-range the transmitter in the field using just a calibrator and a milliammeter.

The Display and Keyboard are inexpensive plug-in options that are available and provide an exceptionally easy method of reconfiguring and re-ranging the transmitter. No calibrator and no other tools are required.

The AI-2000, with its digital communications capability, can also be reconfigured and re-ranged even from a remote location, using the HHT-420 hand-held terminal, or the CA-100 adapter and a personal computer. No special calibration tools are required.

2.0 UNPACKING AND INSTALLATION

2.1 Unpacking

Remove the Packing List to check off the actual equipment received. If you have any questions on your shipment, please call AWS Customer Service Department at (508) 568-0500. Upon receipt of shipment, inspect the container for any signs of damage in transit. Especially take note of any evidence of rough handling. Report any apparent damage immediately to the shipping agent.

> ***NOTE:*** *The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing the contents, save the packing material and carton in the event reshipment is necessary.*

2.2 Mechanical Installation

Proper installation of the transmitter will assure highest performance and will minimize errors of the measured variable. The transmitter should be mounted in a location that minimizes temperature extremes, vibration and shock. It is important to survey the area to ascertain the best location for installation. Will the location be subjected to flooding? Is the location directly above, below or in proximity to a known high heat source? Does the location make the transmitter unserviceable?

The installation recommendations outlined in this section are provided to act as a guideline only and cannot cover all possible variations. The final installation must be made at the discretion and approval of the user.

2.2.1 Weather Proof/Explosion Proof Housing

Several optional transmitter housings are available. The XP-HDC2-L is an explosion proof housing that accommodates a transmitter when the display option is not required. The XP-HDGC2-L, with its glass window, may be used in hazardous locations when the display option is desired. Two NEMA 4X housings are available. The 4X-HDG is a heavy duty, weatherproof housing. Another light duty splash proof plastic housing with a clear cover, the 4X-LDG, is also available. These housings have appropriate mounting means in the bottom to attach the AI-2000 in any of four orientations 90^{0} apart. In addition, if the transmitter and housing have been ordered at the same time special captive 6-32 machine screws are installed on the transmitter to facilitate installation and removal.

2.2.2 Mounting

Most transmitters may be mounted on a 2 inch pipe (vertical or horizontal), on a bulkhead, in a panel, on a DIN rail or affixed to other rigid support members utilizing the various mounting brackets and associated hardware available from AWS . These types of mounts provide greater flexibility in installation and removal of the transmitter for service. In locations where extreme temperature variations are encountered, it is strongly recommended that enclosures be provided to maintain a somewhat constant temperature at the transmitter. Heaters or steam tracing should be provided if the ambient temperature variations are extreme.

2.2.2.1 DIN Rail Mounting

A bracket is available if DIN rail mounting of the AI-2000 is desired.

2.2.2.2 Head Mounting

When the transmitter is mounted in the optional weather-proof / explosion-proof housing, this housing can be attached directly to an RTD or thermocouple installed in a thermowell. The housing has two 1/2" female NPT conduit entries. One of these can be used to mount directly onto a 1/2" male NPT extension of a sensor. Alternatively, a 1/2" union coupling can be placed between the weatherproof housing and the temperature sensor.

2.2.2.3 Pipe Mounting

A stainless steel bracket, the PB-2, is available for mounting the XP-HDC2-L, XP-HDGC2-L and 4X-HDG housings onto any 2" pipe in any of four orientations.

2.2.2.4 Surface Mounting

The transmitter has two mounting holes through the body of the transmitter. These mounting holes allow the transmitters to be attached to any flat surface by means of two bolts or screws. With these mounting holes, the transmitter may be mounted on to most any flat surface.

2.3 ELECTRICAL INSTALLATION

The AI-2000 has three groups of terminals. Terminals 3, 4, 5 and 6 are for the sensor input. Terminals 8 and 9 are the 4 to 20mA output terminals. These are normally connected to the corresponding polarity terminals of the power supply of the current loop. The third group of terminals, 1 and 2 also serve as the mounting screw locations for the display. These terminals, in conjunction with terminal 5 as common, are used for set-up configuration and trim purposes as described under the TAP MODE. The terminals 1 and 2 are labeled as SET 1 and SET 2 and are located near the upper left and upper right areas of the transmitter cover. There is a slanted line pointing directly from the word SET 1 towards the corresponding terminal inside of a round black insulating area. The Set 2 terminal can be found similarly on the right hand side of the transmitter.

2.3.1 Output Terminals

The output terminals, 8 and 9, labeled "+ OUT" and "- OUT", are connected generally to a power supply having a nominal 24 Volt DC voltage and capable of supplying a maximum 100mA for the AI-2000. Although in the analog mode, the AI-2000 transmitter requires a maximum of only 24mA, for digital communications with the AI-2000, the power supply capacity should be 100mA. The +OUT and -OUT terminals of the transmitter are connected to the corresponding polarity terminals of the power supply. Optionally a load resistor, typically 250 ohms, may be connected in series with either terminal of the transmitter. For digital communications with the AI-2000, this 250Ω resistor is required. The maximum series resistance in the circuit (including wiring lead resistance) can be calculated using the formula:

$$Rs = \frac{Vs - 12}{0.023}$$

The following chart gives maximum series resistance:

Max. Series Resistance Rs	Supply Voltage Vs
1300 ohms	42.0 Volts
520 ohms	24.0 Volts
417 ohms	21.6 Volts
250 ohms	18.0 Volts
0 ohms	12.0 Volts

2.3.2.1 Millivolt, and Thermocouple Input

Apply the input signal to terminals 5(-) and 6(+). Terminal 5 is the negative and Terminal 6 is the positive.

2.3.2.2 Two-Wire RTD Input

Apply signal leads to terminals 4 and 5.

2.3.2.3 Three-Wire RTD Input

Apply the common legs from the RTD (generally the same color RTD leads) to terminals 5 & 6. Apply the other signal lead to terminal 4.

2.3.2.4 Four-Wire RTD Input

Apply one set of the common legs from the RTD (generally the same color RTD leads) to terminals 3 & 4. Apply the other signal lead pair to terminals 5 & 6.

2.3.2.5 Dual RTD Input for Differential & Average Temperature

Connect the two leads of RTD 1 to terminals 4 and 6. connect the two leads of RTD 2 to terminals 6 and 5. In the Dual RTD mode, two wire RTD's are the only choice available. In the differential temperature mode, a higher RTD 1 temperature will give a positive delta reading.

For leadwire connections, limitation in length, and limitations in total resistance apply. See Section 7.3 and the specifications in Section 9.

3.0 TRANSMITTER OPERATION

3.1 In a hurry?

When in a hurry, this short set of instructions and references will help get the transmitter running.

3.1.1 Factory Configuration

Input	= *Type J Thermocouple*
Output	= *Analog*
4.00mA	= *40°F*
20.00mA	= *200°F*
Sensor Fail-safe	= *21.00mA*

On special request the factory will set the transmitter to any desired configuration. Special configurations are identified on a tag attached to the unit.

3.1.2 Operation Without a Display

If the unit was ordered with the standard factory configuration, it will be set-up for a Type J Thermocouple input. The packing slip should indicate if the unit was set up to any other customer requested special configuration. If there is a need to change the configuration of the transmitter to accommodate a different sensor, or to re-range the transmitter, refer to the procedures described in *SECTIONS 4, 5 and 6. .*

> ***NOTE:*** *Even when "In a Hurry", the use of an appropriate power supply is important. A 24V DC supply having a current handling capacity of at least 0.1A is commonly used. Do not use a power supply whose output voltage drops to 20 volts or below when a 0.1 ampere load is connected to it. Always use a DC (direct current) supply, or suitable size battery.* **Never connect the transmitter directly to 115VAC.**

With the power supply off, connect the + side of the power supply to the +OUT terminal nine (9) of the transmitter. Connect the - side of the power supply to the -OUT terminal eight (8) of the transmitter. Optionally a resistor, typically 250 ohms may be added in series with either lead.

Connect a Type J thermocouple to the transmitter input.
Thermocouple high (+) (terminal 6)
Thermocouple low (-) (terminal 5)

To connect other sensors to the input refer to *Section 2.3.2* for the proper sensor connections.

The output can be monitored by connecting a milliammeter in series with either of the two output terminals, or by connecting a high impedance voltmeter across the 250 ohm resistor. Now turn on the power supply. In about 5 seconds the AI-2000 loop current will settle to its normal value in the range of 4 to 20mA, unless the input terminals are open, in which case the output current will be 21.00mA. Note that for a Type J Thermocouple, if 4mA = 40 °F and 20mA = 200ºF, each additional 10 °F increases the current by 1.0mA.

3.1.3 Analog Operating Mode With Display

If the transmitter was ordered with the display option, it will have a small local LCD display module plugged in and attached to the top of the unit. This display option can be ordered already installed on the AI-2000 or it can be ordered and field installed at any time.

Having the display option as part of the transmitter does not affect its operation in the analog mode and the description of the previous section applies. However, the display option does provide some very useful local indication of the measured temperature and other diagnostic functions. The Figure 3.1 below indicates the arrangement of the display screen and some of the symbols that are available.

In operation, the top row of the LD-2 display shows the process temperature, the units of measurement, “C”, “F”, “R”, or “K” and a minus sign if applicable.

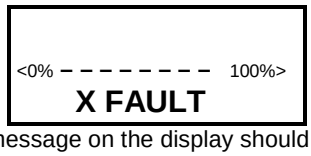
The mid portion is an analog bar graph display showing the % of range based on the ZERO and FULL SCALE setting of the transmitter. When power is applied, the leftmost segment of the bar graph becomes energized along with the 0% and the 100% indications. If the measured temperature is below what the ZERO is set to, then the

upper line of the LD-2 display will display the measured temperature, the output will be pegged at 4.0mA and the left arrow in the bargraph will be energized. If the measured temperature is above the FULL SCALE setting, then the upper line of the LD-2 display will display the measured temperature, the output will be pegged at 20.0mA and the right arrow in the bargraph will be energized.

The bottom portion of the LD-2 display is capable of displaying alphanumeric messages. In normal operation this row shows a label, which is factory set to display “AI-2000”. Seven characters are available. The user may program a desired label in place of AI-2000 to be displayed on the bottom line of the LD-2 display. This can be done using the digital communications explained in Section 6

When the unit is first turned on, the display will show the measured temperature. It is frequently the case that no sensor is connected when the transmitter is first turned on. In this case, the display will show a sensor failure. In the event of a sensor or transmitter failure, the indication on the LD-2 display changes to read:

In the event of certain transmitter failure modes the indication changes to



Once the proper sensor is connected the fault message on the display should clear and the transmitter output should go to the proper value.

The LCD displays takes full advantage of the precision of these transmitters. The digital display of measurement does not include the small D/A error otherwise present in the analog output. It provides highly accurate local indication of the measurement, local fault diagnostics, and transmitter identification. The LCD continues to display the measured temperature even if it is beyond the zero and full scale limits set for the analog output. The value of this display as a set-up, calibration and reconfiguration tool may even be greater, as will be seen in later chapters.

If you should desire to change the sensor input or to re-range or reconfigure the transmitter, please refer to Sections 4, 5 or 6 of this manual, which show you how to set-up the transmitter with the LD-2 display, with the “Tap” Mode or with the digital communications.

3.1.4 Digital Operating Mode

When the AI-2000 is configured to produce an analog output, it behaves much like any other 4 to 20mA two-wire transmitter regulating its loop current in response to the measured temperature. However, as an added feature, the AI-2000 can also be set-up to send out the measurement results in a digital form over the same pair of loop wires, although not simultaneously with an analog signal. There are three digital operating modes available.

1) In the DIGITAL MODE, the AI-2000 transmits digitally a series of ASCII characters approximately once per second, representing the results of the measurement and the units of measurement. When appropriate, it sends out the message “SENSOR FAILURE” or “XMITTER FAILURE”.

2) In the COMPUTER MODE, the AI-2000 remains at the nominal 23.0 digital loop current waiting for a request for data from the master. Upon receipt of an uppercase “M” character, the transmitter sends one series of ASCII characters, much like above, representing the most recent measurement results. Then the transmitter remains again at the nominal 23.0 level awaiting the next “M” character.

3) In the IEEE MODE, the transmitter behaves much like it is described under 2) above, except the digital information is sent in IEEE standard floating point format.

These digital operating modes are convenient in some installations where the measurement results need to be processed by a computer. A small additional gain in accuracy is realized by avoiding the D/A and A/D conversion of the signal. It is also useful to temporarily place the AI-2000 in the DIGITAL MODE during set-up to verify the measurement performance of the system using the hand-held terminal.

Note that when the AI-2000 is operated in the DIGITAL MODE, there is no need to set the Upper or Lower Range Values. The transmitter simply sends out the measurement data in digital form at any temperature over the permissible operating range of the selected sensor.

When set to any of the three digital operating modes, the magnitude of the 4 to 20mA loop current of the AI-2000 does not represent the measured signal.

4.0 CONFIGURATION USING THE TWO-LINE DISPLAY

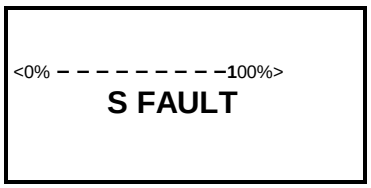
To configure a transmitter using the **DISPLAY MODE**, the LD-2 local LCD display and the KB-2 two key keyboard are required. These are available as an option and can be plugged into the top of the AI-2000 transmitter. The transmitter can also be purchased with these options already installed. These inexpensive options make the reconfiguration, or re-ranging of the transmitter very simple and easy to follow. Without the use of a calibrator, or any other tools, the transmitter can be set up for a different sensor, or new range limits can be set much like one would set the time on a digital watch.

In the event that the KB-2 keyboard or the LD-2 display are not purchased at the same time as the transmitter, carefully follow the field installation instructions supplied with the display to avoid damage to the transmitter or the display.

• 4.1 Entering the Display Mode

To start the **DISPLAY MODE**, first connect the transmitter to an appropriate DC power supply. Typically a 24VDC supply is connected with the **+** side of the power supply connected to the transmitter's output "+" terminal 9 and **-** side of the power supply connected to the transmitter's output "-" terminal 8. A series resistor in the loop is optional, but not required. A sensor may be connected to the transmitter's input terminals, but this is not required for setting up the transmitter.

Once the transmitter is powered up, it comes on in the normal operating mode that it was previously set to. The standard factory set-up puts the transmitter in the analog operating mode. With the standard factory set-up and no sensor connected, the LD-2 display will give the following indication:



The transmitter is indicating **SENSOR FAULT**, since no sensor is connected, and the analog output is indicating greater than 100%, loop current at 21.00mA, which is the standard over range condition. Please note that if you plug the display in to the transmitter while the transmitter is powered up, you may not start the menu sequence at the beginning. You should power down the transmitter without disconnecting the display or simply wait about two minutes for the transmitter to reset itself.

Press the key marked **NEXT**. The display starts to alternate asking if the user wishes to enter the **DISPLAY MODE**, or return to the Operate Mode?

To enter the **DISPLAY MODE** the answer would be yes, therefore, press the **ENTER** key. This will allow you to configure the transmitter using the **DISPLAY MODE**. A flow chart summarizing the operation of the **DISPLAY MODE** appears in the center of this manual.

Note that when more than seven characters are required to describe a function, the display keeps sequencing through two or more screens. In this manual, the sequencing of the display is indicated by placing the two or more parts of the message adjacently. With some functions, the LD-2 display indicates a numeric value and unit of measurement on the top line of the display in addition to the message on the lower display line.

4.2 Display Mode Operation

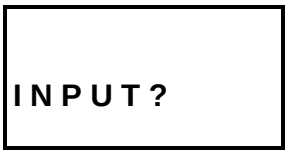
THE **DISPLAY MODE** will allow the user to do the following:

- Select a Sensor Input
- Select a desired temperature unit, such as ºF
- Change the 4mA Lower Range Value (CHANGE ZERO)
- Change the 20mA Full Scale Value (CHANGE FULL SCALE)
- Change the Sensor Fail Safe detection (SELECT SENSOR FAIL SAFE)
- Change the Transmitter Fail-Safe detection (SELECT XMITTER FAIL SAFE)
- Trim the 4.0mA output current (TRIM 4 MA)
- Trim the 20.0mA output current (TRIM 20 MA)
- Compensate for a Sensor Offset

Each of these functions is presented in sequence on the LCD display. If the indicated function need not be performed, press **NEXT**, and the next function is displayed on the screen. To perform any function press the **ENTER** key. This will cause additional screens to be displayed which enable you to perform the function. These are described in detail below and summarized on the LD-2 flowsheet found in the centerfold of this booklet.

4.3 Select a Sensor Input

THE **SELECT INPUT** is the first function in the sequence. The display will read as follows to indicate this position on the menu:



If neither the sensor or the units need to be changed press **Next** and skip to Section 4.5 of this manual; otherwise press **Enter**. After pressing the **Enter** key, the display will change to:

Indicating that the transmitter is set to a Type J Thermocouple input. If this is the desired sensor, then press **Enter**, otherwise press **Next** repeatedly to sequence through the available sensors. Each time **Next** is pressed, the next available sensor selection is displayed.

Press the **Next** key to go the next sensor

Note: This is the 100Ω Platinum DIN Curve with α = 0.00385

Note: This is the 100 Ω SAMA Platinum Curve with α = 0.00392. There are a number of "US" curves. Be very careful that your curve conforms to the SAMA curve when selecting this sensor. If you have any questions, call AWS .

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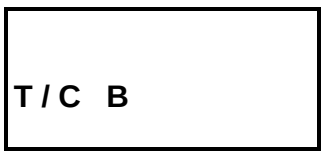


Pressing **Next** key again returns you to the J thermocouple selection. Repeated pressing of **Next** key will recycle you again through the input selection submenu. You can stop at any one of the thermocouple or RTD or mV selections by pressing the **Enter** key. This action changes the transmitter mode to that sensor. If no sensor change is desired, then, without sequencing through the various sensor options, just pressing the **Enter** key will allow one to confirm the sensor selection and leave it unchanged. Assume that the sensor is left as T/C J. After pressing **Enter** the display will return to the main menu entry of **SELECT INPUT**. Pressing the **Next** key then takes the transmitter to the next selection section of the of **SELECT INPUT** menu.

4.4 Select Units

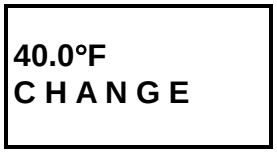
If the selected sensor is a thermocouple or RTD, the next menu entry is **SELECT UNITS**.

This series of screens indicates that the transmitter is currently set to degrees F. By repeatedly pressing the **Next** key, the display will sequence through the following screens:

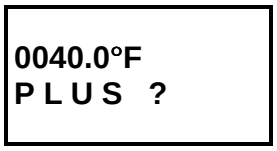
These correspond to F=Fahrenheit, K=Kelvin, R=Rankine and C=Celsius. Stopping the selection at any one of these units and then pressing **Enter** will set the transmitter to the corresponding new units. For the purposes of this example the units of measure can be left at DEG F by pressing **Enter**.

4.5 Change Zero (LRV)

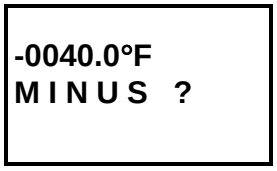
The display will then alternate between the following screens to indicate that one may now change the zero, or 4mA output point.

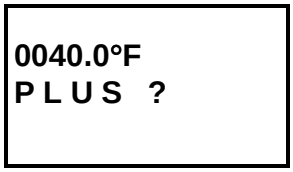


The numeric value seen on the upper portion of the screen is the current ZERO value of the transmitter. One can now change this ZERO, or LOWER RANGE VALUE, (LRV), totally independent of the FULL SCALE, or UPPER RANGE VALUE, (URV), without the use of any calibrators or external sensor inputs. To change the ZERO, press **ENTER**. The display changes to

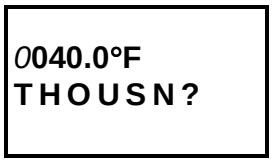


indicating that the existing ZERO is set to "plus" 0040.0ºF. The question mark "?" indicates a question asking if this value is to remain positive (PLUS ?). By repeatedly pressing the **NEXT** key the display will alternate





After deciding whether the ZERO value, LRV, is to remain positive (PLUS), press the **ENTER** key. In this example assume it is to remain positive. The display changes to

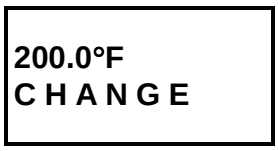


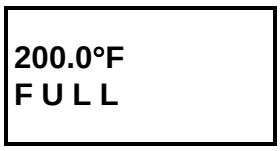
and the leftmost digit position will start blinking (shown here in italics) asking if the thousands position needs to be changed. To change the thousands position, start pressing the **NEXT** key and the leftmost digit will increment through 1 2 3 4 5 6 7 8 9 0. Stop pressing the **NEXT** key at any of the numerals desired, then press **ENTER** to accept the selection. If the numeral selected before pressing **ENTER** was 0, then the display would change to

and the second digit from the left will start blinking (shown here in italics) asking if the hundreds position needs to be changed. As before, to change the number in this digit position repeatedly press the **NEXT** key until the desired numeral is reached. Then press **ENTER** to go to the next lower significant digit position. Each time the **NEXT** key cycles through the ten choices for that digit position and the **ENTER** key enters the selected number. The digit position being changed is the one that is blinking. The legend on the display will change successively to

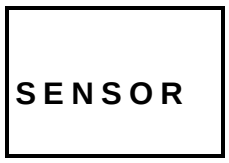
After the tenth's digit position has also been changed to the desired value, the next pressing of the **ENTER** key returns the transmitter to the alternating display of **CHANGE ZERO**. Since changing of the zero has just been completed, press the **NEXT** key to proceed to the next menu selection, **CHANGE FULL SCALE.**

4.6 Change Full Scale (URV)



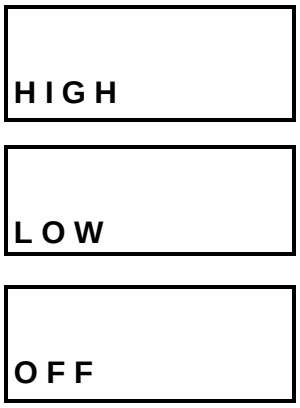


To change the full scale value press **ENTER**. The procedure for selecting Plus or Minus is identical to that described for changing the ZERO. Similarly, the procedure for changing each of the digit positions is identical to that described for changing the ZERO. Once the steps of changing the FULL SCALE have been completed and the **ENTER** key is pressed at the end of the procedure, the display returns to **CHANGE FULL SCALE**. Press **NEXT** for the next function **SELECT SENSOR FAIL SAFE DETECTION**.



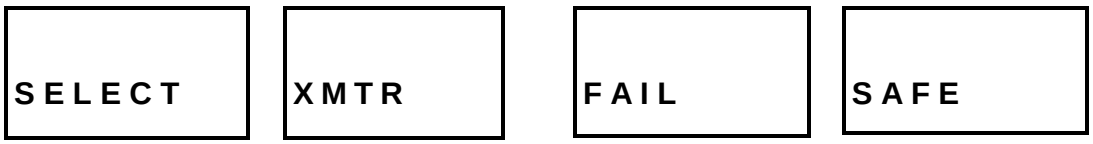
4.7 Select Sensor Fail-Safe

If you want to change the setting of the **SENSOR FAIL SAFE** detection press **ENTER**. The present status of the **SENSOR FAIL SAFE** is displayed. It is recommended that one turns off the Sensor fail-safe when using the AI-2000 with an input simulator. It should then be turned on when reconnecting the transmitter to the actual sensor. Turning on the **SENSOR FAIL SAFE** may be done by selecting to drive the loop to the High fail-safe condition of 21.0mA or to the low fail-safe condition of 3.9mA.

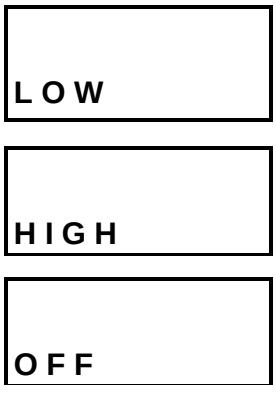


When the desired fail-safe condition is displayed, pressing the **ENTER** key will change to the new setting and the screen returns to the **SELECT SENSOR FAIL SAFE** display. Pressing the **NEXT** key will bring up the **TRANSMITTER FAIL SAFE** selection screen.

4.8 Select Transmitter Fail-Safe

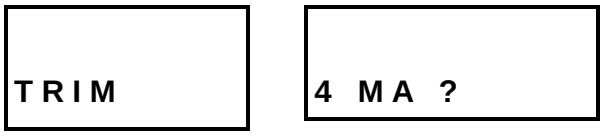


Should the transmitter fail to successfully perform one of its self-diagnostics, the Transmitter Fail-Safe allows the transmitter to change the 4-20mA loop to indicate a failure condition. In this event, the user may select to drive the loop to 21.0mA, corresponding to the “HI” selection; to 3.9mA, corresponding to the “LO” selection or to turn the function “OFF”.



4.9 Trim 4.0mA

This allows trimming of the 4.00mA output current.



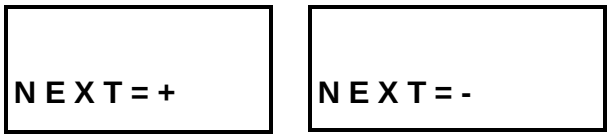
Note: *This function is only for the purpose of adjusting the 4.00mA limit of the transmitter loop current to be exactly 4.00mA according to the plant's local standard. This is* ***NOT*** *for the purpose of ranging the transmitter!*

If trimming the 4.00mA limit is still desired then press **ENTER**. The transmitter will now output a milliamp current equal to its internally set 4mA. This 4 mA value should be read on an external meter and compared to a local standard. It is advisable to use a very good voltmeter to make these comparisons. It is very possible that the transmitter will be more accurate than a great many voltmeters. In this case, trimming will make the transmitter less accurate rather than more accurate!

Once trimming the 4.00mA value has been selected, the display will alternate as follows:

By pressing the **NEXT** key the display then alternates as

When it is decided whether to raise or lower the output current, then press **ENTER** and the display changes to one of the following depending on whether the raise or lower function has been selected.

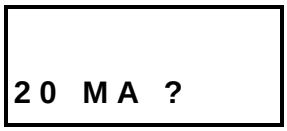


Now every time the **NEXT** key is pressed, the display blinks, and the 4.0mA output limit decreases (-), or increases (+). The decrease or increase is in approximately 3.5 micro ampere increments.

Note: *The 4.00mA limit is factory calibrated to a precision standard. Do not arbitrarily trim the output unless a qualified and accurate local standard is available to measure the adjusted 4.00mA output! Also note that the 4.0mA limit should not be trimmed by more than about ±50uA, or transmitter operation may be impaired.*

Once the desired trim is reached, pressing **ENTER** will return to one of the corresponding **TRIM 4MA** screen. At this point one may still go back and do further trimming of the 4.0mA limit by pressing the **ENTER** key, or pressing the **NEXT** key changes to the next function.

4.10 Trim 20.0mA



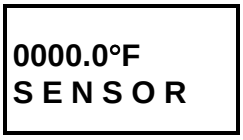
Note: *This function is only for the purpose of adjusting the20.00mA limit of the transmitter loop current to be exactly 20.00mA according to the plant's local standard. This is* ***NOT*** *for the purpose of ranging the transmitter!*

Trimming of the 20.0mA current limit is done in exactly the same manner as was described for trimming the 4.0mA point. Similar precautions apply. After completing the trim 20.0mA pressing the **NEXT** key brings up the **SENSOR OFFSET.**

4.11 Sensor Offset

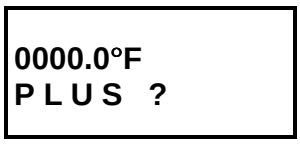
Often, the sensor that is connected to the AI-2000 differs from its standard curve by a small amount. In some installations, it is desirable to trim out this sensor offset. Setting the AI-2000 sensor offset in the display mode will allow the AI-2000 display to read exactly the same value as an external calibration source at a desired point. The sensor offset allows the transmitter output and the display to be trimmed by a desired offset amount. The sensor offset operates as a zero shift. It shifts the transmitter readings by the same amount everywhere along the entire sensor range. With the **SENSOR OFFSET** function in the Display Mode, it is not possible to trim the display to make it agree with an external device at more than one point. If this level of precision is required, one should consider using the 21 point custom calibration curve that is available through the digital communications capability of the AI-2000. See section 6.3.3. This custom calibration curve allows for multi point corrections.

When you press the **ENTER** key the display changes to

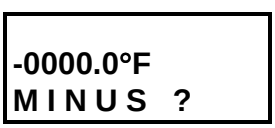


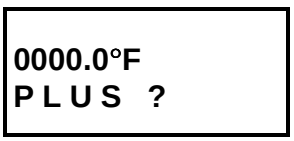
You can now enter a sensor offset. Suppose that the display reads 530ºF, at a time when an external device that you want to agree with reads 525ºF. You would then want to enter a -5ºF offset in the sensor offset. This is done exactly the same way as setting the zero and full-scale values:

The numeric value seen on the upper portion of the screen is the existing Sensor Offset. Normally this is set to zero. One can now change this Offset totally independent of the ZERO, or LOWER RANGE VALUE, (LRV) or the FULL SCALE, or UPPER RANGE VALUE, (URV), without the use of any calibrators or external sensor inputs. To change the sensor offset, press **ENTER**. The display changes to



indicating that the existing OFFSET is set to "plus" 0000.0ºF. The question mark "?" indicates a question asking if this value is to remain positive (PLUS ?). By repeatedly pressing the **NEXT** key the display will alternate

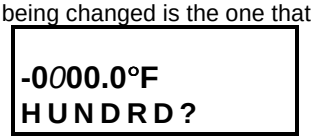


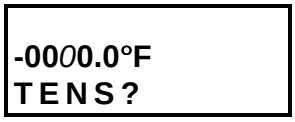


After deciding whether the OFFSET VALUE is to become negative (MINUS), press the **ENTER** key. In this example the offset is assumed to be negative and a minus sign will be carried through this example. The display then changes to read:

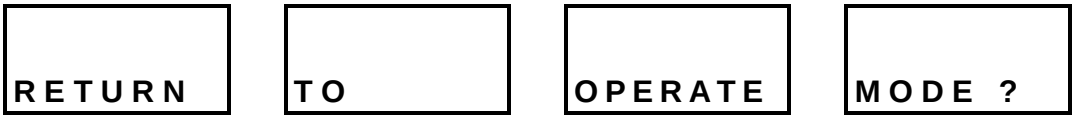
and the leftmost digit position will start blinking (shown here in italics) asking if the thousand's position needs to be changed. To change the thousands position, start pressing the **NEXT** key and the leftmost digit will increment through 1 2 3 4 5 6 7 8 9 0. Stop pressing the **NEXT** key at any of the numerals desired, then press **ENTER** to accept the selection. If the numeral selected before pressing **ENTER** was 0, then as you press the **ENTER** key, the display would change to

and the second digit from the left will start blinking (shown here in italics) asking if the hundreds position needs to be changed. As before, to change the number in this digit position repeatedly press the **NEXT** key until the desired numeral is reached. Then press **ENTER** to go to the next lower significant digit position. Each time the **NEXT** key cycles through the ten choices for that digit position and the **ENTER** key enters the selected number. The digit position being changed is the one that is blinking. The legend on the display will change successively to





After the tenth's digit position has also been changed to the desired value, the next pressing of the **ENTER** key returns the transmitter to the alternating display of **SENSOR OFFSET**. Since changing of the offset value has just been completed, press the **NEXT** key to proceed to the next menu selection. Note, if trimming the transmitter to external devices is desirable, it may be necessary to trim the 4 and 20mA output **after** setting the Sensor Offset.



If all of the set-up and re-ranging operations have been satisfactorily completed, then pressing **ENTER** will return the transmitter to the normal operate mode in about five seconds. Pressing the **NEXT** key at this point will return the display to the first screen in the sequence, SELECT INPUT.

Note again that besides exiting to the Operate Mode at this point in the Display menu, there are two other ways to return to the Operate Mode. Any changes that have been completed in the Set-up procedure will be automatically saved upon returning to the Operate Mode via any one of the several paths.

1) At any point in the flowchart, simply abandon the setup process for about 2 to 3 minutes. After that period, the transmitter returns to the operate mode.

2) Disconnect the power to the transmitter for at least 30 seconds. The next time power is applied, the transmitter will operate in its newly set mode.

5.0 CONFIGURATION USING THE TAP MODE

To configure a transmitter using the **TAP MODE**, reconfiguration of the transmitter is accomplished by momentarily shorting the SET1 or SET2 terminals to terminal (5) with a jumper wire and observing as the output current changes in 0.5 mA increments after each operation. The simple flow diagram at the centerfold of this manual indicates the options that can be selected or operation performed and the steps required to get there. In the following description, references to "short SET1" or "short SET2" mean shorting of the SET 1 to terminal (5) or shorting of the SET2 to terminal (5).

The transmitter is connected as normally with its +OUT and -OUT terminals to the corresponding polarity terminals of the power supply, but with the milliammeter in series to indicate the output current. A load resistor, typically 250 Ω may be used, but is not required.

The tools required to change sensors or otherwise change the configuration consist of 1) a jumper wire, 2) a milliammeter with a full scale range of 25 to 50mA and 3) a 24 VDC power supply. To set the Zero and Span an additional calibrated and stable resistance or millivolt source is also required.

When shorting the SET1 and (5) terminals or the SET2 and (5) terminals, the connection should be held a minimum of one second but can be held indefinitely or until the expected change in output current has occurred. Subsequently removing this short does not produce any further action. Repeated reconnection of the SET1 and (5) terminals will cause the output current to change as indicated in the flowchart in the centerfold of this manual.

5.1 Entering the Tap Mode

To start the **TAP MODE**, first connect the transmitter to an appropriate DC power supply. Typically a 24VDC supply is connected with the **+** side of the power supply connected to the transmitter's output "+" terminal (9) and the **-** side of the power supply connected to the transmitter's output "-" terminal (8). A series resistor in the loop is optional, but not required. A sensor may be connected to the transmitter's input terminals, but this is not required for setting up the transmitter. The milliammeter, installed in series in the output loop will guide you through the process.

As seen in the flowchart in the centerfold of this manual, the reconfiguration process is started by shorting the SET1 terminal. This causes the output current to change to Iout = 21.0mA indicating that the transmitter has entered the main menu. Each subsequent shorting action of the SET1 terminal will sequence the unit to the next function through the main menu, as the arrow in the left portion of the flow diagram indicates. The milliammeter reading, Iout, confirms each new selection. When the output current reaches Iout = 16.0 mA, the next shorting of the SET1 terminal starts the main menu over again at Iout = 19.5 mA. Sequencing through the main menu selections does not change the configuration or calibration of the transmitter and if desired, the transmitter can be returned to the operate mode from the main menu through either one of the two methods described below. Once the desired main menu function is reached, a momentary shorting of the SET2 terminal will select that function.

5.2 Getting In; Iout = 21.0mA

As was just described in reference to the flow chart, the first time the SET1 terminal is shorted, the main loop of the chart is entered at the top left corner. Subsequent shorting of the SET1 terminal sequences down the main loop on the left side of the chart. CAUTION! JUST AFTER FIRST SHORTING OF THE SET1 TERMINAL WHEN THE LOOP CURRENT BECOMES 21.0mA, DO NOT SHORT THE SET2 TERMINAL, BUT INSTEAD SHORT SET1 A SECOND TIME! SHORTING SET2 AT THIS TIME CAUSES THE TRANSMITTER TO ENTER THE DISPLAY MODE AND THEN FURTHER SHORTING OF THE SET1 AND SET2 TERMINALS NO LONGER FOLLOWS THE TAP MODE FLOW CHART.

5.3 Getting Out: Iout = 16.0mA

When reaching the last position on the bottom of the chart, signified by Iout = 16.0mA of loop current, a shorting of the SET2 terminal returns the transmitter to its normal operating mode. One can also abort the set-up procedure by simply turning off the loop power for about 30 seconds and then turning it back on again. It is also possible to just do nothing for about 2½ minutes after entering the setup menu. After this period of time, the transmitter simply returns to its previous operating mode.

5.4 Select Sensor Type; Iout = 19.5mA

This function is used to set the desired type of sensor. Sensor selection should always be done before setting the zero or the span. After reaching the corresponding main menu selection, short the SET2 terminal momentarily. The output current will change to a level corresponding to the existing sensor selection as seen on the right hand portion of the flowchart. Each subsequent shorting of SET1 advances in the sub menu to the next sensor selection as indicated by the arrow. The output current follows these selection steps as a confirmation of the selection. After the desired sensor has been selected, a second shorting of the SET2 terminal reconfigures the unit to the new sensor and returns it to the corresponding main menu selection with the output current Iout = 19.5mA as a confirmation.

5.5 Set Output Zero (LRV); Iout = 19.0mA

This function is used to set the 4mA zero output or lower range value (LRV) of the output current range to correspond to a desired input. The LRV set function should be used only after the desired sensor has been selected.

Apply the signal to the input that is to correspond to 4.0mA of output current. This can be a millivolt signal if the selected sensor is a thermocouple or a known resistance in the case of an RTD. Set the unit to the corresponding main menu selection, Iout = 19.0mA and then momentarily short the SET2 terminal. The flowchart indicates that this function is now entered and the output current Iout = 4.00mA is a confirmation. Then momentarily short the SET terminal again. The output current will change to Iout = 15.0mA for about 30 seconds and then return to Iout = 19.0mA confirming that setting the zero of the output range has been accomplished. During these 30 seconds, the transmitter is making an accurate measurement of the input, measurements of its internal references and then storing in its not-volatile memory the appropriate readings. See Section 7 for a discussion on determining the correct millivolt input for thermocouple calibration.

When setting the range limits for an RTD sensor, use a resistor decade box instead of an RTD calibrator. The AI-2000 transmitters do not emit a steady state RTD excitation current. This may cause erroneous results when using some of the RTD calibrators designed for analog transmitter calibration. When setting the range limits for a T/C sensor first turn off the sensor fail-safe. The sensor fail-safe function periodically emits 4μA of current that may disturb some T/C calibrators.

5.6 Set Output Full Scale (URV) (Span); Iout = 18.5mA

This function is used to set the full-scale, or upper range value (URV) or 20.0mA of the output current range to correspond to a desired input. The URV set function should be used only after the desired sensor has been selected.

Apply the signal to the input that is to correspond to 20.0mA of output current. This can be a millivolt signal if the selected sensor is a thermocouple, or a known resistance in the case of an RTD. Set the unit to the corresponding main menu selection, Iout = 18.5mA and then momentarily short the SET2 terminal. The flowchart indicates that this function is now entered and the output current Iout = 20.0mA is a confirmation. Then momentarily short the SET2 terminal again. The output current will change to Iout = 15.0mA for about 30 seconds and then return to Iout = 18.5mA confirming that the setting the full scale of the output range (span) has been accomplished. See Section 7 for a discussion on determining the correct millivolt input for thermocouple calibration. Also see comments in paragraph 7.2.2 about calibrating RTD sensors.

5.7 Set Sensor Fail-safe; Iout = 18.0mA

This function is used to set a high or a low indication in the event of a sensor malfunction or to turn off this indication. A high setting will drive the output to 21.0mA when a sensor failure is detected; a low setting will drive the output to 3.90 mA under similar conditions. Sensor failure is an open thermocouple, open or shorted RTD or any open RTD lead.

Set the unit to the corresponding main menu selection, Iout = 18.0mA, then short the SET2 terminal. The output current will change to Iout = 21.0mA or Iout = 3.9mA, or Iout = 15.0mA depending on where the fail-safe is presently set. At this time, SET1 can be shorted to sequence the setting between the 3.90mA, signifying low, or 15.0mA signifying that the feature is being turned off, or the 21.0mA limits, signifying a high fail-safe, as the arrow in the flowchart indicates. When the desired setting has been selected, a second shorting of the SET2 terminal changes the unit to the new setting and returns it to the corresponding main menu selection as confirmed by an output current of Iout = 18.0mA.

5.8 Set Transmitter Fail-safe: Iout = 17.5mA

This function is used to set a high or a low indication for certain internal transmitter malfunctions or to turn off this feature. A high setting will drive the output to 21.0mA when a malfunction is detected; a low setting will drive the output to 3.9mA under similar conditions.

Set the unit to the corresponding main menu selection, Iout = 17.5mA, then short the SET2 terminal. The output current will change to Iout = 21.0mA or Iout = 15.0mA, or Iout = 3.9mA depending on where the fail-safe is presently set. At this time, SET1 can be shorted to sequence the setting between the 3.9mA limit, signifying low, the 15.0mA signifying off condition and 21.0mA, signifying a high fail-safe limit as the arrow in the flowchart indicates. When the desired setting has been selected, a second shorting of the SET2 terminal changes the unit to the new setting and returns it to the corresponding main menu selection as confirmed by an output current of Iout = 17.5mA.

5.9 Trim 4.0mA; Iout = 17.0mA

This function is used to check or adjust the trim of the low end of the output current that is required to be 4.0mA. The AI-2000 has a calibrated stable output current of 4.0mA, when the output is “pegged” at the low limit. This calibration step, if performed, should always be done prior to setting of the output range zero. **Do not change this factory calibration unless a suitably accurate milliammeter is available. Do not use this function to set the “Output Zero” that is described in Paragraph 5.5.**

To check the transmitter output and select the proper Increment, Decrement, or no change necessary function, first set the unit to the Trim 4.0mA main menu selection as described. Then short the SET2 terminal momentarily. The transmitter output current will change to Iout = 4.0mA. If the output current measures lower than 4.0mA it needs to be incremented. If the output measures within its specifications, no change needs to be made. If the output measures above 4.0mA, it needs to be decremented.

To Increment
With the output measuring slightly lower than 4.0mA, repeated shorting of the SET1 terminal will increment the output current in approximately 2µA steps.

After reaching the correct output current, shorting the SET2 terminal again stores the new output current setting and returns the unit to the main menu with the output current Iout = 17.0mA, confirming the action.

If the process of incrementing, the desired output current was overshot, then return to the main menu. Then select the Decrement function as described below, to make the correction.

To Decrement
With the output measuring slightly higher than 4.0mA, short the SET2 terminal a second time. No change will be observed in the output current, which will continue to read slightly higher than 4.00mA. Shorting the SET1 terminal now decrements the output. Repeated shorting of the SET1 terminal will decrement the output current in approximately 2 µA steps.

Do not use the decrement function to reduce the output current below 3.90mA. The transmitter will fail to function properly when reduced to this minimum current level.

After reaching the correct output current, shorting the SET2 terminal again stores the new output current setting and returns the unit to the main menu with the output current, Iout = 17.0mA, confirming the action.

If in the process of decrementing, the desired output current was overshot, then return to the main menu. Then select the Increment function, as described above, to make the correction.

To Make No change
With the output measuring within specification, shorting the SET2 terminal two successive times will return the unit to the main menu. No change will be observed in the output current at these two taps, which will read 4.0mA until returning to the Iout = 17.0mA that confirms the return to the main menu.

5.10 Trim 20mA; Iout = 16.5mA

This function is used to check or adjust the trim of the high end of the output current that is required to be 20.00mA. The AI-2000 has a calibrated stable output current of 20.00mA, when the output is “pegged” at the high limit. This calibration step, if performed, should always be done prior to setting of the output range zero. **Do not change this factory calibration unless a suitably accurate milliammeter is available. Do not use this function to set the “Output Zero” that is described in Paragraph 5.6.** To check the transmitter output and select the proper Increment, Decrement, or no change necessary function, first set the unit to the Trim 20.00mA main menu selection as described. Then short the SET2 terminal momentarily. The transmitter output current will change to Iout = 20.00mA. If the output current measures lower than 20.00mA it needs to be incremented. If the output measures within its specifications, no change needs to be made. If the output measures above 20.00mA, it needs to be decremented.

To Increment
With the output measuring slightly lower than 20.00mA, repeated shorting of the SET1 terminal will increment the output current in approximately 2µA steps.

After reaching the correct output current, shoring the SET2 terminal again stores the new output current setting and returns the unit to the main menu with the output current Iout = 16.50mA, confirming the action.

If the process of incrementing, the desired output current was overshot, then return to the main menu. Then select the Decrement function as described below, to make the correction.

To Decrement
With the output measuring slightly higher than 20.0mA, short the SET2 terminal a second time. No change will be observed in the output current, which will continue to read slightly higher than 20.0mA. Shorting the SET1 terminal now decrements the output. Repeated shorting of the SET1 terminal will decrement the output current in approximately 2 µA steps.

After reaching the correct output current, shorting the SET2 terminal again stores the new output current setting and returns the unit to the main menu with the output current, Iout = 16.5mA, confirming the action.

If in the process of decrementing, the desired output current was overshot, then return to the main menu. Then select the Increment function, as described above, to make the correction.

To Make No change
With the output measuring within specification, shorting the SET2 terminal two successive times will return the unit to the main menu. No change will be observed in the output current at these two taps, which will read 20.0mA until returning to the Iout = 16.5mA that confirms the return to the main menu.

5.11 Return to Normal Operate Mode: Iout = 16.0mA

After the desired changes in settings have been made and calibrations performed in the transmitter can be returned to the normal operate mode in one of three ways.
1) Sequence to the menu selection “Return to Operate Mode” in the main menu, Iout = 16.0mA, and then short terminal SET2 momentarily. In about 5 seconds the transmitter returns to the normal operate mode.
2) At any point in the flowchart, simply abandon the setup process for about 2 to 3 minutes. After that period, the transmitter returns to the operate mode.
3) Disconnect the power to the transmitter for at least 30 seconds. The next time power is applied, the transmitter will operate in its newly set mode.

6.0 CONFIGURATION THROUGH DIGITAL COMMUNICATIONS

6.1 FEATURES AVAILABLE, OVERVIEW

While the AI-2000 can operate like any two-wire 4 to 20mA transmitter in an analog current loop, if desired, advanced features can also be accessed through digital communications along the same pair of wires. By clipping the two wires of the HHT-420 hand-held terminal anywhere along the two wires of the current loop, you can digitally communicate with the AI-2000. In place of the HHT-420, you can use a CA-100 communications interface connected to the RS-232 serial port of a personal computer. Entering an uppercase P from the terminal places the AI-2000 in the digital mode. By means of a series of descriptive menus sent by the transmitter to the terminal, you can perform the set-up or calibration functions already described. In addition, the digital communications mode allows access to some other advanced features, described below.

Sending an uppercase P causes the AI-2000 to display a **CONFIGURATION MENU** on the display terminal. The **CONFIGURATION MENU** lets you configure and set-up the transmitter to meet the needs of a particular application. A brief description of each set of available functions follows.

6.1.1 Setup Status

In the **CONFIGURATION MENU**, the first selection is SETUP STATUS.

```
CONFIGURATION MENU
1) SETUP STATUS      2) INPUT SETUP
3) OUTPUT SETUP      4) OPTIONS SETUP
5) OUTPUT TRIM       6) WIRING INFO
7) PASSWORD          8) EXIT
SELECTION? 8
```

The **SETUP STATUS MENU** shows how the transmitter is currently set up. It is a read-only listing directly from the transmitter's non-volatile memory. In the **SETUP STATUS MENU**, nothing can be altered or changed. When the power is turned off and then turned on again, the transmitter's status will not be altered.

It is generally a good idea to check the status after a configuration is complete, just to be sure the transmitter is set up the way it is intended to be. Status can also be checked as desired to verify the set up of the AI-2000. See paragraph 6.3.2 for further details.

6.1.2 Input Setup

The Input setup in the **CONFIGURATION MENU** allows a choice of sensors to be made, as in the **TAP MODE** and **DISPLAY MODE** menus. In the Digital Mode, additional features can also be accessed. A tag number and display label can be assigned, signal damping can be selected, and dual RTD sensors can be used.

The calibration correction, selected in the input setup, permits custom linearization in terms of up to 21 data points. The user can first select the number of data points desired, and then enter from the keyboard the value of each data point and the corresponding ± correction values. The system will automatically perform curve fitting through linear interpolation between the points and make the desired corrections. When Calibration Correction is activated along with one of the temperature sensor selections, then the correction is applied in addition to the linearized sensor characteristic. This is particularly useful with custom calibrated sensors where the calibration data is available. If the Calibration Correction function is activated along with the millivolt input, then a custom transfer function can be created from a normally linear input/output relationship. See paragraph 6.3.3 for details.

6.1.3 Output Setup

In the OUTPUT MENU, the type of output and desired range can be specified. Either a 4 to 20mA analog output, or a digital output can be selected. With digital output, there are three possible formats from which to choose:

- Continuous digital data in ASCII characters
- ASCII characters that are sent only when requested by the master
- IEEE floating-point decimal

With analog output, the zero and full scale can be defined. The zero, or lower range value (LRV); and the full-scale, or upper range value (URV) can be entered from the terminal. The transmitter, using its factory-stored calibration data, will exhibit the correct calibrated settings. With this method, there is no need to use any calibration source millivolt source whenever re-ranging the transmitter. See paragraph 6.3.4 for more details.

It is also possible to set the transmitter's output to the desired fail-safe limits when sensor or transmitter failure are detected.

6.1.4 Options Setup

In this menu, a variety of transmitter options may be selected. Display format can be selected for compatibility with almost any display terminal.

Display interval can be set, which determines how rapidly the local display will update. Filtering parameters, related to the 50/60Hz line frequency can be adjusted. Smart Smoothing, a unique digital filtering algorithm, can be altered. It is possible to turn off sensor linearization, or to disable Tap Mode.

A turn-around character can be enabled and selected. The user may choose any one of the ASCII character set as a turn-around character. This turn-around character is then sent by the transmitter each time as the last character of a message. This feature is particularly useful when interfacing with a computer to indicate when a message transmission is complete. If the ASCII BELL character (ASCII character 7) is selected as the turn-around character, then most data terminals emit a beep tone when the transmitter completes each message. The turn-around character is active only in the Digital Mode. See paragraph 6.3.5 for more details.

6.1.5 Output Trim

The output trim can be used to trim the transmitter output current at the 4 and 20mA limits to agree with the local plant standard. At times, there may be a small discrepancy between the calibration standard used at the time of transmitter manufacture and the standard reference used at the customer plant site. The transmitter output can be trimmed, if desired, to agree with the standard reference used at the plant site. This function can also be used to correct for minor changes in the precision voltage reference in the transmitter, which may occur over long periods. See paragraph 6.3.6 for details. Note that using the Output Trim function voids the NIST traceability.

6.1.6 Wiring Information

The AI-2000 has portions of the user manual stored in its memory and can display the proper terminal connections for any sensor configuration selected. See paragraph 6.3.7 for more details.

6.1.7 Password

The Password Menu allows the user to set and change the password. The password can be modified and selectively any of the seven sections of the configuration menu can be separately protected by password. Once enabled, the affected menu items can only be accessed by entering the correct password. It is important to make a record of the new password, because without it no access can be gained to the selected menu items. See paragraph 6.3.8 for more details.

6.2 DIGITAL ACCESS TO THE AI-2000

6.2.1 Accessories Required

1. Power supply, 24VDC, 100mA minimum, such as the AWS model PS-2412
2. Hand-held terminal, AWS model HHT-420

Or, alternatively,

1. Power supply, 24VDC, 100mA minimum, such as the AWS model PS-2412
2. Communications Interface, AWS model CA-100
3. A personal computer that has an RS-232 serial port
4. Terminal emulator software, supplied free of charge with CA-100

During communication, the load current in the loop increases to 100mA in short pulses. Therefore, the power supply must have sufficient capacity to deliver 24 volts at 100mA load current. The data terminal or computer must have an RS-232 compatible serial communications port. If the device is a computer, it requires some suitable data communications software to make the computer act as a data terminal. Data terminal emulation software to run on a PC, XT, or AT compatible computer is supplied on a floppy diskette that comes with the CA-100 purchase.

6.2.2 The HHT-420 Hand-held Terminal

The HHT-420 is a battery-operated hand-held terminal that is directly compatible with the AI-2000 transmitters. This terminal has two clip leads, one red and one black, which must be clipped to the +OUT (9) and the -OUT (8) output transmitter terminals anywhere along the pair of loop wires. Accidental reverse connection will not damage the unit, but it will not operate. For more connections detail, see paragraph 6.2.4. After the HHT-420 is connected and turned on, press the uppercase P key, and the transmitter sends a **CONFIGURATION MENU**.

Such simple operation makes the HHT-420 exceptionally convenient for reconfiguration, re-ranging and diagnostics of AI-2000 transmitter installations. The HHT-420 is a simple ASCII terminal with a built-in CA-100 communications

adapter. It does not have any transmitter-specific software; therefore, there will be no need to update the software in the hand-held. A high capacity built-in NICAD battery and a separate charger give the HHT-420 complete portability, or trouble-free bench-top operation.

One significant advantage of the HHT-420 is that it is ready for use. Just hook up the two leads, turn it on, and it is ready to communicate.

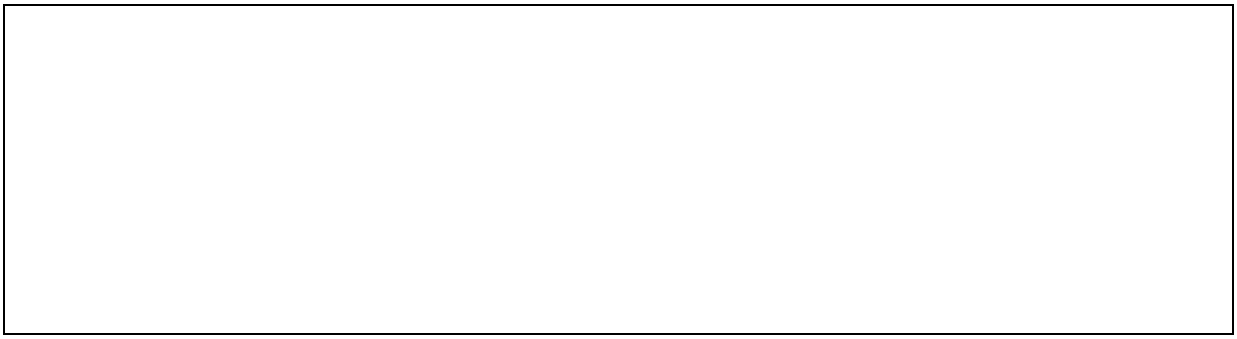
6.2.3 The CA-100 Communications Interface

The CA-100 Communications interface is a module available from AWS . It connects a data terminal or computer to the two current loop wires of an AI-2000 smart transmitter. At one end, the CA-100 has a 25 terminal DB-25 male connector and also a similar female connector, which can be used for interfacing to the serial I/O port of a data terminal or computer. This serial I/O port must conform to EIA (Electronic Industries Association) RS-232 standard. At the other end, the CA-100 module has two test leads, one red and one black, intended to connect across the current loop terminals The red lead is connected to the +OUT, and the black lead to the -OUT transmitter terminals. Accidental reverse connection will not damage either unit, but it will not operate.

The serial port of the data terminal or computer must be set to:

300 Baud	8 Data Bits	2 Stop Bits	No Parity	Full Duplex	No Protocol

The CA-100 has some internal jumpers that may need to be shifted, depending on the electrical setup of the RS-232C port on the terminal. The terminals provided inside the CA-100 are accessible after removing the two screws that keep the two halves of the enclosure together.



Programming terminals 1 through 5 are used to establish the correct connection of the transmit and receive signals of the RS-232 port. If the CA-100 is connected to a DTE (Data Terminal Equipment), such as a data terminal, then the terminals jumpered should be 1 to 2 and 3 to 4. If the CA-100 is connected to a DCE (Data Communications Equipment), such as a computer or modem, then the terminals jumpered should be 2 to 3 and 4 to 5. It is not always obvious which of these two connections is required. If communications with the AI-2000 cannot be achieved otherwise, these two jumpers may be shifted to experiment with the reverse connection. No damage will be caused to either equipment by the reverse connection of the two signal lines.

Some DCE equipment require other signals to operate properly. These signals can be provided by including jumpers on the remaining terminals inside the CA-100. Generally, these jumpers can remain in place regardless of the equipment used. The function of these jumpers is indicated in the following table.

Programming Terminal	**RS-232C Terminal**	**Signal Name**
6	4	RTS
7	5	CTS
8	6	DSR
9	20	DTR
10	20	DTR
11	8	RLSD

The normal position of these additional jumpers on the CA-100 follow:

6 to 7	8 to 9	10 to 11

Excessive capacitive loading across the AI-2000 output terminals prevents the unit from communicating properly. Communication with minimal error rate should be possible over a twisted pair of wires up to 5000 feet in length.

Note that the BLACK negative lead of the CA-100 is also the circuit common of the data terminal. If the data terminal is line-operated equipment, then this circuit common may also be connected to the AC ground. In this case, the -OUT of the AI-2000 will also become connected to AC ground through the CA-100. To avoid ground loop problems, this should be considered. In case of a hand-held, or battery-operated terminal, such ground loop problems do not arise.

6.2.4 Transmitter Output Connections

When digital communication with the AI-2000 is desired, a load resistor of 250 ohms minimum resistance is required. The transmitter, power supply, and the load resistor can be interconnected in many possible ways, some of which are indicated in Figures 6-2 through 6-4. Each of these interconnections has certain characteristics, as described below. When using the HHT-420 hand-held terminal, these restrictions do not apply.

In the preceding connection examples, whenever one side of the power supply is connected to the circuit common that one power supply can operate several transmitters. It is necessary to allocate a power supply capacity of 25 to 30mA for each transmitter and 100mA of current for the unit that is digitally communicating.

Whenever the black lead of the CA-100 is not connected to circuit common, as shown in Figure 6-4, the data terminal should be battery-operated. Generally, line-operated data terminals or computers have the circuit ground connected to the ground of the AC line. Through the RS-232 port of the terminal and through the CA-100 interface, this power line ground also appears on the black lead of the CA-100. Therefore, line operated data terminals should be used only with system interconnections where the black lead of the CA-100 is connected to the current loop ground point.

The connection in Figure 6-2 has the ability to provide a ground-referenced 1 to 5 volt signal, and it can communicate with most any computer or terminal. Note, however, that analog output is not available during the time that the transmitter is communicating digitally.

6.3 COMMUNICATING WITH THE AI-2000

After the AI-2000 has been properly connected to a 24VDC or 28 VDC power supply through a load resistor of 250 ohms minimum, connect the black lead of the HHT-420, or the CA-100 to the -OUT and the red lead to the +OUT terminal of the transmitter anywhere along the two wires of the current loop. In case of the CA-100, be certain it is plugged into the serial port of the data terminal and the port parameters are set as described in paragraph 6.2.3.

Turn on the DC power supply. After five seconds, the transmitter enters its normal operating mode. If the transmitter has been previously placed in Digital Mode, then during the start-up cycle, it will send out the message: TRANSMITTER ON. Similarly, with the display option, the display screen will temporarily indicate XMIT ON.

When the AI-2000 is normally operating and is properly connected to a communications terminal, then an uppercase P entered on the terminal will place the transmitter in the Digital Communications Mode and cause it to send out a menu. Note that you needn't press the RETURN or ENTER key after you press the Uppercase P. If the transmitter is in Digital Mode and is transmitting measurement data, it may be necessary to press the P two or three times before the transmitter responds.

After you enter P at the keyboard, the output current will fluctuate for a couple of seconds and then rise to approximately 24mA. If the communications link from the transmitter to the data terminal is also functioning, then the response to P entered at the keyboard will be a menu displayed on the screen.

When digitally communicating with the AI-2000, the transmitter goes off-line, and the loop current does not represent the measured variable. After digital communication with the transmitter is completed, and if the transmitter was set to the Analog Mode, then the loop current returns to representing the measured temperature.

Note that depending on the type of data terminal used and the display setup of the AI-2000, there may be some variations to the menus and responses, which are described in the following sections. For clarity, the menus are described for the case when the AI-2000 is set to the 24-line display mode. When using the HHT-420, the transmitter is set to the four-line mode. The menus will appear identical to those shown here, except that you must press the RETURN key after four lines or a larger menu have appeared on the hand-held terminal screen.

The menus follow certain conventions. Following a ? requires an operator input. When you press the ENTER key, the system accepts the default entry represented by the numeral that followed the ?. If you enter an invalid numeral, the system repeats the request. Note that in 4, and 8 line modes, the display may stop and wait for the operator to press the ENTER key to display the balance of the menu.

6.3.1 CONFIGURATIONS MENU

Whenever you place the transmitter in the Digital Communications Mode by entering an uppercase P, the following menu appears:

```
CONFIGURATION MENU
1) SETUP STATUS      2) INPUT SETUP
3) OUTPUT SETUP      4) OPTIONS SETUP
5) OUTPUT TRIM       6) WIRING INFO
7) PASSWORD          8) EXIT
SELECTION? 8
```

The user can select any one of the items from the **CONFIGURATION MENU** by entering the corresponding number and pressing RETURN (or on some terminals, ENTER). The default selection is 8. If no numeral is entered, but RETURN is pressed, the transmitter will reset and return to the normal Operate Mode in about five seconds.

If the transmitter was previously left in the Digital Mode, then after approximately five seconds after power is applied, it sends the following message:

TRANSMITTER ON

Then it displays digital readings on the screen.

When the **CONFIGURATION MENU** displays, if the operator takes no action for approximately 2.5 minutes, the transmitter will reset and return to the previous operating mode. This time-out takes place at any stage of the set-up procedure if the operator appears to abandon the process.

If password protection has not been previously selected, any of the above menu items can be accessed by entering the corresponding number and pressing RETURN. The normal factory configuration uses the 123 password to protect all but the Setup Status and Wiring Information menus. If some of the menu entries have been password-protected, when you enter the corresponding menu selection number, the following prompt appears:

ENTER PASSWORD? _____

After you enter the password, you can access that menu. In the normal factory setup, the password access to all menu items is turned off, and a standard password of 123 is used as a default.

Be sure to remember the new password, or access to those menus will be denied. (For a nominal charge, you may return the transmitter to the factory where the password may be reset to its normal default state.)

6.3.2 SETUP STATUS MENU

If you select item 1) in the **CONFIGURATION MENU**, the current setup status of the transmitter displays:

```
TAG NUMBER   XXXXXXXXX
SERIAL NUMBER 000XXXXXX
VERSION 4.3T
T/C TYPE J
LINEARIZATION ON
CORR. SYSTEM OFF
DAMPING IN SEC. 0
SENSOR FAILSAFE HIGH
XMITTER FAILSAFE HIGH
OUTPUT MODE ANALOG
OUTPUT UNITS   F
ZERO 40.0000
FULL SCALE 200.0000
PRESS RETURN TO CONTINUE
```

This selection does not allow changing any parameters; it simply indicates the setup status of the transmitter. Note that if the transmitter was in Digital Mode, a different set of menu items would appear.

6.3.3 INPUT SETUP MENU

If you select Item 2) in the **CONFIGURATION MENU**, the **INPUT SETUP MENU** appears.

```
INPUT SETUP
TAG NUMBER?_____
```

The system expects the operator to enter the desired tag number. If a number was previously entered, it displays. Any alphanumeric combination of digits may be entered to overwrite the previously entered number, then press ENTER. If you do not wish to change a previously entered number, press ENTER to leave that entry unchanged. The following message appears:

DISPLAY LABEL?
AI-2000

You can also enter a seven-character label that appears on the lower part of the local display when a display option is installed. The factory configuration assigns the label AI-2000. You may overwrite this with any other seven-character label. After you press ENTER, the following message appears:

SENSOR SELECTION 1 = MV 2 = 2WRTD
3=3WRTD 4=4WRTD 5=T/C 6=TC CJ
7=DUAL RTD
SENSOR TYPE? 5

This display indicates that currently the thermocouple input (T/C) is selected. The display prompts the user to enter a new selection.

Selections for millivolts, two-wire, three-wire, four-wire RTD's, thermocouples, and dual RTD's may be selected along with a selection for the thermocouple cold-junction temperature. Selecting Entry "1" will disable the automatic cold junction compensation.

Note that selecting the thermocouple as the sensor input automatically provides the selected thermocouple with cold junction compensation. It is possible to read out the temperature of the cold junction by selection 6=TC CJ. When making selection 6, the transmitter reads the temperature of the two brass thermocouple terminals on its top and provides that measurement as its output. Note that for accurate cold junction compensation, it is necessary to wait three minutes after the transmitter has been placed in Operate Mode. If Thermocouple is selected, then a submenu asks for additional choices:

THERMOCOUPLE SELECTION
0=B 1=E 2=J 3=K 4=N 5=R 6=S 7=T
TYPE? 2

Enter the thermocouple type number you wish, then press ENTER.

If instead of thermocouple, a four-wire RTD sensor was selected, the following menu appears:

4 WIRE RTD SELECTION
14=PT DIN
15=PT US
16=NI
TYPE? 8

Type the number for the RTD type you wish, press ENTER. Note that selections 14 and 15 refer to platinum RTD

After selecting your input sensor, you may select the Engineering units you wish to work in.

TEMP UNITS SELECTION
1=C 2=F 3=K 4=R
OUTPUT UNITS? 2

Select the units you desire, enter the proper number and press ENTER. Then, select the desired damping and press ENTER again. This feature provides an exponential damping. The number of seconds entered, up to 30, represents the time constant of damping.

DAMPING IN SEC.? 0

If in the Sensor Selection Menu, you selected DUAL RTD, the following options appear:

DUAL RTD
11=PT DIN 12=PT US 13=N1
TYPE? 11

1=DIFFERENCE 2=AVERAGE
DUAL RTD TYPE? 1

The dual RTD option allows the use of two (2) two-wire RTD sensors to be connected to the one transmitter to make either differential, or average temperature measurements. Make the appropriate selections if you wish this feature. To maintain system accuracy, the wires on these RTD's should be no longer than a few inches, and both wires of each of the two RTD's should be equal length and identical gauge. Correct response of the transmitter when in the dual RTD mode may be delayed up to approximately eight seconds. Therefore, the dual RTD mode may not be appropriate where you need to measure rapidly changing temperatures. One can select a differential measurement, with RTD1 (terminals 4, 6) being the higher temperature for a positive difference. Or one can select average to get the average value of the two RTD channels.

The **CALIBRATION CORRECTIONS MENU** offers the option of modifying the transfer function of the transmitter. If the CALIBRATION CORRECTIONS are turned on, the system asks for the number of data points, 2 to 21. At each of the data points, enter the corresponding ± correction. A more detailed description of this feature appears later in this section. Even after correction data has been entered, the correction system can be turned off by selecting 2=OFF.

CALIBRATION CORRECTIONS
1=ON 2=OFF
CORR. SYSTEM? 2

Again enter the appropriate numbers, press ENTER. The Calibration Correction system, when ON, displays the next question:

NUMBER OF CORRECTION POINTS
CORRECTION POINTS? 21

The number of sets of points selected, up to twenty-one, is entered in the following menu:

ENTER VALUES FROM LOW TO HIGH
DATA POINT
1
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT

2
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT
3
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT
4
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT
5
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT
6
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
DATA POINT
7
INDICATED VALUE? 0.0000000
CORR. (OFFSET)? 0.0000000
etc.

One can select as few as two (2), or as many as twenty-one (21) points. These data points can be located anywhere over the operating range of the selected sensor. Often the points are distributed over the operating region within the 4.0mA and 20.0mA settings of the transmitter. A positive correction value will cause the output to be higher by the entered value. For negative corrections, a minus sign should be entered preceding the value. Corrections are made in terms of the engineering units selected earlier. Note that once the correction table is entered, it can be alternately enabled or disabled without the need to reenter the data. For more information, see AWS Tech Note 204.

6.3.4 OUTPUT SETUP MENU

Making selection 3) of the **CONFIGURATION MENU** will evoke the following display:

```
OUTPUT MODE
1=DIGITAL MODE  2=ANALOG MODE
3=COMPUTER MODE 4=IEEE MODE
OUTPUT MODE? 2
```

If the 1=DIGITAL MODE selection is made, the transmitter will transmit the measurement information in Digital Mode, sending new measurement data about once every second. The 4-20mA loop is then used for digital communication exclusively.

If the 2=ANALOG MODE is selected, then the next menu announces the temperature units that were previously selected and prompts for the ZERO and the FULL SCALE values. These are the measurement values that are desired to correspond to the 4mA and 20mA loop current.

```
OUTPUT UNITS F
ZERO? 40.000000000

FULL SCALE? 200.000000000
```

After these values are entered, the transmitter returns to Analog Mode and continues to transmit the measurement data in the conventional analog 4-20mA form.

Note that changing the engineering units at a later date will not change the numeric limits entered here. As an example, if the transmitter was set to zero=40°F full scale=200°F, then changing the units to °C results in a zero=40°C and full scale=200°C. One of the advantages of the AI-2000 transmitter is that it stores its precision factory calibration and can be zeroed and spanned in the field without any calibration equipment.

The 3=COMPUTER MODE is very similar to the Digital Mode. In this mode, the transmitter transmits a new measurement data every time it receives a prompt in the form of an M from the data terminal or computer. This mode is more suitable when the transmitter is used with a computer. In this case, the computer or master, can request information when the computer is ready for it.

Selection 4=IEEE MODE is similarly intended for interactions with a computer. In this case, the transmitter sends all measurement information in the form of standard IEEE floating point format. In all the previously described digital modes, the transmitter sends digital data in terms of ASCII characters.

The transmitter can detect numerous sensor failure conditions. The response to these detected sensor failures can be selected to be a 3.9mA loop current, 1=LOW, or 21.0mA, 2=HIGH. If the feature is turned 3=OFF, the loop current in case of sensor failure is not readily predictable. It may go to 4.0mA or to 20.0mA or may remain anywhere between these limits depending on setup and the type of sensor failure.

```
SENSOR FAILSAFE
1=LOW 2=HIGH 3=OFF
SENSOR FAILSAFE? 2
```

Note that in the case of a thermocouple sensor, the AI-2000 periodically injects a few micro amperes of the current into the sensor to test for an open condition. Some T/C calibrators introduce an error when subjected to such current pulses. By turning of the Sensor Fail-safe, one disables these current pulses and erroneous operation of such calibrator units is prevented.

The transmitter can similarly detect various possible internal failures and the response to these can also be user-selected.

```
XMITTER FAILSAFE
1=LOW 2=HIGH 3=OFF
XMITTER FAILSAFE? 2
```

The AI-2000 has the capability to add the DS-2 dual switch alarm module. This provides two programmable switches that may be used to drive alarms, relays, etc. The menu choices allow you to select the various states of

these two switches. The “NO HI” selection means that the switch is normally open. When the temperature passes above the trip point this switch closes. Likewise, “NC LO” means that the switch is normally closed. It opens when the temperature passes below the trip point.

```
SWITCH1 STATE
0=NOT INSTALLED
1=NO HI 2=NO LO
3=NC HI 4=NC LO
SWITCH1 STATE?
0
```

If the DS-2 module is installed and if you have activated the switches, you will be asked to set the trip setpoints as shown below:

```
SETPOINT UNITS
F
SWITCH1 SETPNT?
100.00
```

The second switch is set in the same manner.

```
SWITCH2 STATE?
0=NOT INSTALLED
1=NO HI 2=NO LO
3=NC HI 4=NC LO
SWITCH2 STATE?
4

SETPOINT UNITS
F
SWITCH2 SETPNT?
50.00
```

The transmitter then asks you to set the switch deadband:

```
DEADBAND UNITS
F
SWITCH DEADBAND?
1.000
```

Note that the DS-2 switch module does not have “dry contact” switches. It utilizes an edge trip interrupt of 10 microsecond duration as a self test on about a one-second interval. If your application requires a dry contact relay, you should use the switches to trip the dry contact relay. Some very high-speed applications can sense a switch trip in less than 10 microseconds. In these installations use the DS-2 switch to drive a dry contact relay. The dry contact can then be used to drive the application trip. For further information on this subject, please request Application TechNote # 212 on DS-2 Applications.

6.3.5 OPTIONS SETUP MENU

The AI-2000 transmitter can accommodate various size displays for user interface. The most convenient format is a display screen that accommodates 24 lines of 40 or 80 characters. If the terminal or computer used to set up the transmitter accommodates 24 lines, then the corresponding selection should be made. Some smaller hand-held terminals have a more restricted display capacity. In that case, the closest available selection should be made.

```
OPTIONS SETUP

24, 8, 4, OR 1 DISPLAY LINES
DISPLAY LINES? 24
```

Enter the appropriate number, and the transmitter requests a number of additional selections:

```
DISPLAY INTERVAL IN SECONDS?
0.75000
```

This allows changing of the display update or blinking interval. It should be set to a period, which is comfortable for reading the local display, if that option is installed. Similarly, to test an installed local display, the following selection is also available:

RUN DISPLAY SELF TEST 1=ON 2=OFF
DISPLAY TEST? 2

Entering a "1" will cause the display to execute a self-test. In self-test, the local display to cycle through a series of patterns for test purposes.

The next selection may be important when the transmitter installation is surrounded by power lines, which is often the case.

60/50 HZ FILTER 1=50HZ 2=60HZ
60/50 HZ FILTER? 2

In a country where the power line frequency is 60 Hz select two (2). This selection may have an effect on susceptibility of the transmitter to power line-induced interference.

For even further immunity to power line-induced interference, additional filtering can be selected at the sacrifice of response time. In the next filter selection, Selecting 2=OFF, leaves the transmitter in its normal factory set high speed mode. Selecting 1=ON turns on an additional filter, which also slows the update time to about one-half of its previous rate.

HI FILTER ON/OFF
1=ON W/LOW SPEED
2=OFF W/HI SPEED
FILTER ON/OFF? 2

SMART SMOOTHING
IN SECONDS? 10

For Smart Smoothing, a selection of 0 to 10 can be made. The Al-2000 has the ability to average successive A/D readings to achieve its high level of accuracy. With the exceptional speed of the transmitter, this averaging is accomplished very quickly. This Smart Smoothing feature is different from Damping, as was previously described, and it normally does not interfere with operation in a control loop. Nevertheless, Smart Smoothing can be turned off in those rare cases where it may interfere with control loop performance.

Smart Smoothing works by establishing a narrow tolerance band which defines an acceptable deviation of one A/D reading to the next. This tolerance band may be about $\pm$ 5 micro volts referenced to the input. With Smart Smoothing turned on, each A/D reading is averaged if it is within the tolerance band surrounding the existing average A/D value. If a new A/D reading falls outside the tolerance band, the Smoothing Function is reset, and the new value is reported out immediately. This ensures that any significant change in the process variable is reflected in the transmitter output without delay.

The magnitude of the tolerance band is determined on the basis of the transmitter electronics and its characteristics and it cannot be adjusted. However, the length of the smoothing time can be adjusted. It is factory-set to 10 seconds and can be adjusted in one second increments from 0 seconds, in which case it is turned off, to 10 seconds, In certain applications, where the process variable moves rapidly over a small range, and the transmitter is used in a control loop, it may be desirable to shorten the averaging time of Smart Smoothing to three (3) seconds or less.

In the large majority of applications, there should be no need to alter the Smart Smoothing time constant. Reducing the time constant of Smart Smoothing improves transmitter response time to very small changes of input. The tradeoff is a small increase in the uncertainty of measurement, meaning that successive readings may vary slightly.

LINEARIZATION
1=ON 2=OFF
LINEARIZATION? 1

This allows the user to turn sensor linearization ON or OFF. This option is normally enabled at the factory and the selected sensor is mathematically linearized to a precision of 0.05 degrees C. In some circumstances, the user may

wish to turn off this linearization. With linearization turned off, the 4 to 20mA values can be set in the Tap Mode. In the Digital Mode with the linearization turned off and with thermocouples, the URV and LRV's should be entered in terms of micro volts per a standard thermocouple table, referenced to 0°C. For RTD's, with the linearization turned off, the URV and LRV should be entered in Ohms from the appropriate resistance table. If using the transmitter with the linearization turned off, it is advisable to check with the factory for further instruction.

```
TAP MODE ON/OFF 1=ON 2=OFF
TAP MODE? 1
```

This selection allows the Display Mode as well as the Tap Mode to be turned ON or OFF. Normally, the TAP mode is left in the ON state so that the transmitter could be reconfigured even when a hand-held terminal or other digital communications are not available. (See description of Tap Mode in Section 4.) In some installations, it may be desirable to turn OFF the Tap Mode for increased security against tampering with the transmitter setup.

```
HALF DUPLEX
1=ON 2=OFF
HALF DUPLEX? 2
```

The half duplex selection refers to an option affecting digital communications. This should be normally left in the 2=OFF Mode.

```
TURN AROUND SYSTEM
1=ON 2=OFF
T/A SYSTEM? 1
T/A CHAR. ASCII DECIMALVALUE
T/A CHARACTER? 7
PRINTING T/A CHARACTER
```

The Turn-around System, when activated, causes the transmitter to emit a selected ASCII character as the last character of each message. This system is particularly useful when communicating with a computer. The turn-around character can be used by the software to know when a message from the transmitter is completed. A typical choice of a turn-around character is the decimal 7, which corresponds to the ASCII BELL character. With most data terminals, this BELL character activates a short beep tone.

6.3.6 OUTPUT TRIM MENU

The **OUTPUT TRIM MENU** allows the user to adjust the output current of the transmitter in various ways. Selecting 5) OUTPUT TRIM from the **CONFIGURATION MENU** gives the following submenu:

```
OUTPUT TRIM
1) TRIM 4MA          2) TRIM 20MA
3) SET MA OUTPUT     4) REINITIALIZE
5) EXIT
SELECTION? 5
```

Item 1) TRIM 4MA in the **TRIM MENU** allows the user to make minor adjustment to the 4mA limit of the loop current. This may be desirable if the precision factory calibration of the transmitter's 4.000mA output does not fully agree with the local standard at the site. The display looks like the following example:

```
1=FAST INCREASE      2=SLOW INCREASE
3=FAST DECREASE      4=SLOW DECREASE
E TO EXIT
```

The loop current assumes its 4mA value. Then each time the 1 key is depressed, the transmitter output current increments by approximately two micro amperes. Depressing the 2 key increments the loop current by 20 micro amperes. Similarly, depressing the 3 or the 4 key decrements the loop current by approximately two, or 20 micro amperes. Once the 4mA limit of the loop current is properly calibrated to the local standard, the E key is depressed.

Item 2) TRIM 20 MA in the **TRIM MENU** allows the user to make minor adjustment the 20mA limit of the loop current. The purpose and the adjustment process is the same as in the case of the TRIM 4MA function. The display looks like the following:

1=FAST INCREASE 2=SLOW INCREASE
3=FAST DECREASE 4=SLOW DECREASE
E TO EXIT

Note that the 1) TRIM 4MA and the 2) TRIM 20MA selections are not intended to make gross changes in the setting of the loop current limits. Do not use these functions to set the ZERO or the SPAN!

In the event you wish to undo the Trim Operation and to return the transmitter to its initial factory-calibrated condition, select 4) REINITIALIZE from the **TRIM MENU**.

It is also possible to use the AI-2000 transmitter as a calibrated and stable current source. By selecting 3) SET MA OUTPUT from the OUTPUT TRIM menu the following display will appear:

MA VALUE? 12.000000
E TO EXIT PLEASE WAIT

The system permits the entry of any mA value within 3.9mA and 21.0mA. The loop current is set to that value and held until the E key is depressed. After entering the millampere value, the transmitter adjusts its output current to the new value. It will take 2 or 3 seconds for the loop current to change from its digital value of 24mA to the new analog value, which is the reason for displaying the message, PLEASE WAIT. To return to the Output Trim Menu, press the E key. To exit from the **OUTPUT TRIM MENU**, enter 5, then press ENTER.

Note that using the Output Trim function voids the NIST traceability of calibration. However, it is possible to reinitialize the transmitter back to its original factory trim condition by selecting 4. After selecting REINITIALIZE, at the next restart of the transmitter it returns to its original factory trim.

6.3.7 WIRING INFORMATION MENU

Item 6) in the CONFIGURATION MENU is an onboard user's manual that gives information on how to connect the selected sensor to the top terminals. It is important to first select the sensor to be used and only then query the system on how to connect it. A typical display when selecting a three-wire RTD is as shown. Here, we have identified the single lead from the RTD as the "HI1". The two leads going to the other side of the RTD are generally of the same color. these are identified as "LO1" and LO2".

WIRING INFORMATION
3 WIRE RTD
INPUT HI1 4 INPUT LO1 5
INPUT LO2 6
CASE GROUND 7

PRESS RETURN TO CONTINUE

6.3.8 PASSWORD MENU

Selection 7) in the **CONFIGURATION MENU** offers password control individually to any of the **CONFIGURATION MENU** items. Password access can be turned ON or OFF for each of the items in the **CONFIGURATION MENU**. The password can be changed as desired.

Note! When the password system is activated, the menu item it protects cannot be accessed unless you enter the correct password. Remember your password if you have changed it.

When the password is enabled for a particular **CONFIGURATION MENU** item, the following message appears as that item is accessed:

ENTER PASSWORD? _____

If the incorrect password is entered, access to that item will be denied. It is good practice to password protect at least the PASSWORD entry in the **CONFIGURATION MENU**. Once the PASSWORD entry in the **CONFIGURATION MENU** is selected, the following sequence of prompts displays:

PASSWORD PROTECT 1)STATUS
1=ON 2=OFF
SELECTION? 2

PASSWORD PROTECT 2)INPUT SETUP
1=ON 2=OFF
SELECTION? 1

PASSWORD PROTECT 3)OUTPUT SETUP
1=ON 2=OFF
SELECTION? 1

PASSWORD PROTECT 4) OPTIONS SETUP
1=ON 2=OFF
SELECTION? 1

PASSWORD PROTECT 5)OUTPUT TRIM
1=ON 2=OFF
SELECTION? 1

PASSWORD PROTECT 6)WIRING INFO
1=ON 2=OFF
SELECTION? 2

PASSWORD PROTECT 7) PASSWORD
1=ON 2=OFF
SELECTION? 1

CAUTION: CHANGES PASSWORD
ENTER PASSWORD? 123 _____

PASSWORD 123

PRESS RETURN TO CONTINUE.

If the password system is enabled, the transmitter sends the current password, The user can change this password by typing in any alpha-numeric sequence. When the ENTER Key is pressed, the transmitter sends the new password as a confirmation. Depressing the ENTER Key twice brings back the **CONFIGURATION MENU**.

6.3.9 EXIT MENU

Selecting item 8) in the **CONFIGURATION MENU** is the way to leave Configuration Mode and return the transmitter to Operate Mode. Selection 8) is the default in this menu and, therefore, once the Configuration Menu appears, pressing the ENTER Key initiates the EXIT process. It takes approximately five seconds for the transmitter to return to its Operate Mode. If you wish to perform additional configuration, enter an uppercase P once the transmitter has returned to Operate Mode.

7.0 APPLICATIONS INFORMATION

7.1 SENSOR FAIL-SAFE DETECTION

The AI-2000 detects a sensor failure condition by making various measurements across its sensor input terminals. As a result of these measurements, the unit can detect an open thermocouple or open RTD condition. In addition, the AI-2000 can detect if an RTD is short circuited, or if any of its terminal wires (2, 3, or 4-wire RTD's) are open. Any one of these conditions will cause a "FAIL-SAFE" report indication.

In the process of performing these sensor failure checks, the unit periodically passes small pulses of current through the sensor and its connecting wires. The transmitter measures the resulting voltage drop. One of the conditions resulting in a FAIL-SAFE reporting condition is if this voltage drop exceeds 180mV.

In the case of an RTD, the fail-safe detection is part of the normal excitation for the RTD and therefore both the temperature measurement and some of the sensor fail-safe detection routines are done simultaneously. In the case of a thermocouple, during the temperature measurement cycle, there is no open sensor test current in the thermocouple. Thermocouple open circuit is detected by making a second measurement with the test current through the thermocouple.

This method of testing for sensor failure has the following advantages:

1) In the case of thermocouples, there is no steady current through the sensor during measurement and therefore accuracy is not degraded.
2) During open sensor detection, the test current is sufficiently high that even if there is some leakage resistance between the sensor leads, an open sensor will be positively detected.

There are certain precautions to be observed when using this method of sensor failure detection. If the lead wire resistance is too great, then a false FAIL-SAFE report could be generated. The maximum lead wire resistance is dependent on the type of sensor being used and the maximum temperature expected to be measured. Knowing the sensor excitation current and the open sensor detection threshold, 180mV, the maximum allowable lead wire resistance can be determined for any application.

7.1.1 Maximum lead Resistance for RTD

The maximum total resistance including the RTD and the two lead wires that carry the RTD excitation current is:

$$\frac{180\text{mV}}{0.3\text{mA}} = \frac{0.180}{0.0003} = 600 \text{ Ohms}$$

If a 100ΩPt RTD is used to measure a maximum temperature of 700°C, then the RTD resistance is 345 ohms and the maximum lead wire resistance for both leads combined is 600-345 = 255 Ohms. Similarly, the permissible maximum lead wire resistance can be calculated for other RTD applications.

7.1.1 Maximum lead Resistance for Thermocouples

Assuming the resistance of the thermocouple junction is negligible, the total resistance of the two lead wires is:

$$\frac{180\text{mV} - (\text{T/C mV Output})}{0.005\text{mA}} = \frac{0.180 - (\text{T/C mV}) \times 0.001}{0.000005}$$

Consider a type J thermocouple to be operated up to a temperature of 1200 °F. The approximate output of this thermocouple is 36mV (reference junction at 32°F). The maximum lead resistance (both leads combined) is:

$$\frac{.180 - 0.036}{0.000005\text{mA}} = 28{,}800 \text{ Ohms}$$

7.2 CONFIGURATION WITH AN EXTERNAL SOURCE

When setting the AI-2000 to agree with an external source, it is generally advisable to use the “TAP MODE”. The external source may be set to the desired value for 4 and 20mA and these values “tapped” in. This procedure will ensure agreement with the external source at these points.

When attempting to calibrate or check the calibration of the AI-2000 transmitter with an external thermocouple or RTD calibrator, it is generally advisable to disable the "SENSOR FAIL-SAFE" feature. Because the open sensor test periodically injects about 5µA of current into the input terminals, the millivolts generated by the calibration source is periodically disturbed and depending on the characteristics of the external calibration source used, erroneous voltages may be applied to the transmitter. The "SENSOR FAIL-SAFE" can be disabled by turning it off in the configuration menus. After the calibration has been completed, this function can be re-enabled.

7.2.1 Thermocouple Input

Setting the ZERO and FULL SCALE with a thermocouple sensor requires some added steps because of the automatic cold-junction compensation. Thermocouple tables are normally available for a reference junction at the ice point of water. These table entries must be adjusted for the actual cold-junction temperature. In the case of the AI-2000 transmitter, the two cold-junctions are measured with an internal calibrated thermometer.

It is generally good practice to operate the transmitter for 30 minutes or more prior to calibration to allow it to reach thermal equilibrium.

CALIBRATION USING A MILLIVOLT SOURCE
The procedure starts with the selection of the thermocouple type. Then determine the temperature of the thermocouple terminals on top of the transmitter. This can be done by measuring with a thermometer the temperature of the thermocouple terminals on the transmitter. One can also assume that the terminals are approximately at room temperature and then determine the room temperature, or set the transmitter to output the cold-junction temperature and read it digitally, on the display or through the 4 to 20mA output. Then you can go back to reading the input and setting-up the transmitter.

Next, locate the appropriate table of temperature versus mV for the selected thermocouple.

Find the table entry corresponding to the terminal block temperature, (mV @ TB°C)

Calculate the mV to be applied as follows:

(mV applied for LRV) = (mV @ LRV Table°C) -(mV @ TB°C)

Apply the millivolts (mV applied) to the transmitter and record the temperature displayed on the display for the ZERO (LRV) or 4 mA value. Then record the FULL SCALE (URV) using a similar procedure. These recorded values will then be set into the transmitter as the zero and full-scale values using the display set-up procedure. A similar result may be obtained using the "TAP" mode by just setting the millivolt source and tapping the values in following the instructions in the "TAP" mode.

CALIBRATION USING A THERMOCOUPLE CALIBRATOR
Some of the thermocouple calibrators available on the market provide a means of measuring the temperature of the terminal block and automatically apply the corrected mV to the transmitter. This procedure is rather simple. However, there can be an appreciable difference between the temperature of the simulator and the transmitter terminals. With some thermocouple types, this error could be amplified 5 of 10 degrees, resulting in large measurement errors.

7.3 FOR BEST MEASUREMENT ACCURACY

The AI-2000 transmitter is a stable instrument, precision calibrated at the factory for any operating range the user may select. However, the automatic cold-junction compensation requires certain precautions to obtain best accuracy when used with a thermocouple sensor. Please See AWS technical applications Note #207 for additional information.

The cold-junction compensation operates by attempting to measure accurately the temperature of the thermocouple terminals on top of the instrument. If these terminals are exposed to thermal radiation or convection, the cold-junction compensation will introduce an error. With certain types of thermocouples and temperature measurement ranges, the sensitivity of the cold-junction is greater than the sensitivity of the measurement couple. Under those conditions, a one degree error in the cold-junction temperature that the transmitter senses can result in a greater than one degree temperature measurement error. Also see AWS TechNote #203.

For best measurement accuracy with thermocouple sensors, it is advisable to shield the top terminals by placing the transmitter into a weatherproof housing, such as the model XP-HDC2-L. In addition, sufficient time should be allowed for the housing and the transmitter to reach equilibrium temperature in a given operating environment before best accuracy is reached.

For best accuracy with any sensor, or in the millivolt mode, it is advisable to allow the transmitter to operate with the desired fixed input signal for a period of 30 seconds before the reading is taken. The transmitter periodically measures certain internal references. These internal measurements and the external signal undergo digital averaging and the full accuracy of the instrument is only achieved after several readings have been averaged.

When using an RTD sensor, a four-wire connection is generally recommended. With a three-wire RTD the AI-2000 makes two separate measurements before calculating the temperature, whereas, only a single measurement is required when using a four-wire RTD. Conceptually, a better accuracy is possible using a single measurement as

compared with calculating the difference of two separate measurements. See AWS Tech Note # 208 for further information on the measurement accuracy improvement that is possible with true four-wire RTD measurements.

7.4 MORE ON DIGITAL COMMUNICATIONS

Interfacing any device to the serial communications port of a computer or data terminal often requires some experimentation. Although the Electronic Industries Association (EIA) has established a standard for these interfaces, designated as RS-232, the standard leaves many optional features up to the discretion of the manufacturers implementing the communications.

In this section, a more specific example will be given so the first time user of the AI-2000 may establish a digital communications link with the minimum of problems. A personal computer, PC, XT, AT, etc. is selected as the data terminal, since it is probably the most readily available standard hardware. A simple data communications program is provided on a floppy diskette with the purchase of a CA-100 interface to emulate a data terminal on the computer. Connect the AI-2000, the power supply and the 250 ohm load resistor as indicated in Figure 6-4.

Connect the RED lead of the CA-100 Communications Interface to the +OUT terminal of the AI-2000 transmitter and the BLACK lead to the -OUT terminal.

Connect the DB-25 connector of the CA-100 to the COM1 serial port of the PC. With many computers, you will need to obtain a 25 to 9 pin RS232 connector. You may also need to convert the male pins on the CA-100 to female pins. These “gender benders” are generally available at most computer or electronic stores. You will need to see what will be required to make the proper connections with your computer. Avoid using a “make-shift” arrangement for a cable between the computer and the CA-100, since many of the lines defined by the RS-232 standard must be properly connected.

The HHT-420 hand-held terminal is also available to use in place of the CA-100. With the HHT-420, all of the electronic interconnections are already in place and all you will need to do is to connect to the loop with the proper polarity.

7.4.1 Computer Setup

For this demonstration, the computer must emulate a “dumb” terminal. You may use the terminal emulator supplied or other emulator packages that you may have.

Place the diskette supplied with the CA-100 into drive A and log onto A:

Type COMM (RETURN)

A menu appears with the following choices available:

1 Terminal Mode
2. Disk Catalog
3. Send File
4. Receive File
5. Configuration
6. Exit Program

First select 5 CONFIGURATION. Menu entries 2, 3 and 4 are not used. From the CONFIGURATION submenu set the configuration as follows:

1 Baud rate 300
2 Word Length 8 Bits
3 Stop Bits 2 Bits
4 Parity 1 None
5 Serial Port 1 COM 1
6 Exit configuration

Next, from the main menu, select 1 Terminal Mode (RETURN)

Now the computer is set up to behave like a dumb terminal and should be able to communicate with the AI-2000. Connect the CA-100 to the COM 1 port on the computer. Some computers will allow you to configure the terminal emulation software for COM 2 port if COM 1 is already in use. However, this is a frequent source of problems and should be avoided. Use of the COM 1 port is highly recommended. Follow the transmitter hookup described in paragraph 3.1.4, Digital Operating Mode. Depress the CAPS LOCK key on the computer keyboard so that only capital letters are generated. This is important because the AI-2000 recognizes only capital letters.

You must remember to press the F1 key on the computer to exit from the terminal emulator.

7.4.2 Operation

Turn on the 24VDC power supply and wait for approximately 30 seconds for the AI-2000 to enter its normal operate mode.
Now press the capital P (note that having previously pressed the shift lock, the shift key no longer needs to be depressed). In a second or two, the screen would show the response from the transmitter as:

```
CONFIGURATION MENU
1) SETUP STATUS     2) INPUT SETUP
3) OUTPUT SETUP     4) OPTIONS SETUP
5) OUTPUT TRIM      6) WIRING INFO
7) PASSWORD         8) EXIT
SELECTION?
8
```

If the screen does not show this menu then perhaps a lower case p was being entered.

If that is not the case, then terminals 2 and 3 of the data terminal's serial port may be incorrectly connected to the CA-100. These two pins on the DB-25 connector are the transmit and receive terminals. Of course, if the transmit signal of one device is connected to the transmit terminal of the other device, nothing will work. This has to do with defining which device is the Data Communications Equipment (DCE) and which is the Data Terminal Equipment (DTE). This definition determines which connector pin will be the transmit of one device and the receive of the other device. The DCE, DTE definition can be changed either on the computer I/O board or on the CA-100 board. In this case, it is suggested to leave the computer I/O board unchanged and instead shift a couple of jumpers on the CA-100 PC board. Figure 6-1 indicates the arrangement of the jumpers on the CA-100 PC board. Normally terminals 1-2 and 3-4 are jumpered. Shift these jumpers to 2-3 and 4-5.

After making these jumper changes on the CA-100 try again entering an upper case P from the keyboard. The transmitter should now respond with the CONFIGURATION MENU.

7.4.3 Possible Problems

Be certain the power supply voltage is greater than 20 volts DC even when the transmitter is connected.

Check the connection for correct polarity. The positive side of the power supply must be connected to the +OUT (9) terminal of the transmitter either directly or through a 250 ohm resistor. The negative side of the supply connects to the -OUT (8) terminal of the transmitter.

After energizing the transmitter, wait at least 30 seconds or more for the transmitter to assume its normal operating mode.

If the loop current remains at 21mA, it may be because the input terminals are open, the transmitter is set to thermocouple or RTD and the open sensor fail-safe is set to HIGH. Under these conditions, the transmitter should produce 21mA loop current.

If the loop current is jumping between about 12mA and 23mA every second, then the transmitter is set to the digital mode and is transmitting the measurement data in digital form. To get out of the digital mode without a data terminal, short the SET1 terminal to terminal 5 for a couple of seconds and observe the loop current settling to 21.0mA. Now continue to briefly short circuit the same two terminals and observe the loop current decreasing in mostly 0.5mA increments each time. After the loop current is reduced in this manner to 16.0mA, short circuit for one second terminal 5 and the SET2 terminals. This will cause the transmitter to restart in the analog mode. Also consult Section 4 CONFIGURATION, THE TAP MODE.

In case of problems in establishing digital communications:

- Be certain a 250 ohm resistor is connected as shown in the various connections drawings in Chapter (6)
- Use the connection shown in Figure 6-3
- The power supply should be preferably regulated and capable of 100mA of current.
- The terminal should be set to full duplex operation, (i.e., Half Duplex OFF).

It is possible that there is more than one problem preventing proper communications. Be methodical to try all possible combinations of alternatives before "giving up". You may also consider calling for customer support from the factory. These problems can be difficult to sort out, but there generally is a solution that works.

Interfacing with an RS-232 port can often be the most annoying of tasks. There are available in electronics stores such items as an "RS-232 breakout box". This box allows the user to examine the voltages on the various pins of the connector and to switch leads, such as the leads on pins 2 and 3. Pin 7, which is also accessible on this box, is the circuit common. When neither of the units is communicating, measuring the potential of pin 2 and pin 3 relative to pin 7 should indicate a negative 5 to 12 volts in both cases. Indication of a non zero, or positive potential is a sign of a problem. Try then reversing the leads on terminals 2 and 3. If all else fails, factory support is available to provide technical guidance.

Once these initial problems are worked out, digital communications with the AI-2000 is simple and reliable.

8.0 ACCESSORIES & INFORMATION

Other accessories available from AWS are:

LD-2	Local Display
KB-2	Local Keyboard
DS-2	Dual Switch Module
XP-HDC2-L	Explosion/Weather proof Housing (No Display Option)
XP-HDGC2-L	Explosion/Weather proof Housing with mounting lugs (Display Option)
4X-HDG	Heavy Duty NEMA 4X Housing
4X-LDG	Light Duty NEMA 4X Housing
PB-2	Pipe mount bracket (for 2" pipe)
PS-2412	Power Supply, 24/28 VDC, 1.2/0.8A
PS-2405	Power supply, 24 VDC, 0.5A
DIN-KIT	Kit for DIN rail mounting

A variety of signal conditioners, thermocouples, RTD sensors and thermowells are also available.

The following Technical Application Notes are also available on special request.

Tech Note #203: Smart Temperature Transmitter Accuracy Considerations
Tech Note #204: Custom Calibration Correction for AI-2000 Smart Transmitter
Tech Note #206: Digital Communications
Tech Note #207: Using the AI-2000 with Thermocouples
Tech Note #208: Achieving State-of-the-Art Temperature Measurement Accuracy without Individual, on-site Calibration

9.0 SPECIFICATIONS

THERMOCOUPLE SENSORS:
NIST Types B, E, J, K, N, R, S, T,

RTD Resistance Sensors:

100 Ω PT US SAMA curve (α = 0.00392)	2, 3 or 4 Wire
100 Ω PT DIN curve (α = 0.00385)	2, 3 or 4 Wire
120 Ω Ni	2, 3 or 4 Wire
10 Ω Cu, Consult Factory	2, 3 or 4 Wire

MILLIVOLT INPUT RANGE: -15 to 160mVDC

THERMOCOUPLE AND RTD LINEARIZATION: Linearization with temperature conforms to NIST & DIN curves within ±0.05ºC. Custom linearization user programmable at 21 points.

OUTPUT: Analog, Two wire 4 to 20mA

OUTPUT RANGING ADJUSTMENTS:

Analog Zero	100% of sensor range, non interacting
Full Scale	Normal or reverse acting
Digital Mode	°C, °F, °K, °R, mV (No ranging required)

MINIMUM OUTPUT RANGE: None

OUTPUT RESOLUTION: Analog, 2.1µA; Digital 0.01°, 0.001mV

TRANSMITTER ACCURACY: Includes repeatability, hysteresis, load and ambient temperature effect. For detailed analysis, refer to AWS Application Note #203. Enhanced accuracy calibrations available from the factory. Refer to the AI-2000UP, Ultra Precision transmitter.

Digital Output Accuracy:
± 0.04% of the millivolt or ohm equivalent reading, or the accuracy from the table below, whichever is greater; plus the effect of cold junction measurement error or ± 0.25ºC (±0.45ºF), if using a thermocouple sensor.

Sensor Type		Accuracy
E, J, K, N, T	T/C's	± 0.2ºC (± 0.36ºF)
R, S	T/C's	± 0.6ºC (± 1.08ºF)
B	T/C's	± 0.8ºC (± 1.44ºF)
mV		± 0.008mV
100Ω Pt DIN RTD		± 0.10ºC (± 0.18ºF)
100Ω Pt US RTD		± 0.10ºC (± 0.18ºF)
120Ω Ni RTD		± 0.10ºC (± 0.18ºF)
10Ω CU RTD		Consult Factory
Ohms		± 0.06 Ohm

Analog Accuracy:
Digital Accuracy plus ± 4µA

TRANSMITTER REPEATABILITY: One half of accuracy.

REFERENCE CONDITION ACCURACY:
Equal to transmitter repeatability, when set-up under reference conditions in the "Tap" mode to an external source. The transmitter is then referenced to the prevailing conditions and transmitter accuracy at this reference condition will include repeatability, linearity, and hysteresis effects. If using a thermocouple add 0.05ºF for reference condition accuracy cold junction effect. Reference condition accuracy is comparable in scope to the accuracy generally specified for analog based transmitters and is consistent with the ANSI/ISAS51.1-1979 definition of "Accuracy".

SPECIFICATIONS (CONTINUED)

DYNAMIC RESPONSE:
Turn On Time: Less than 5 seconds after power up
Ambient Temperature Gradient: Automatic compensation to 20ºC/Hour Change
Update Time: 0.15 Seconds; Digital, 1 second
Response to Step Input: 0.25 Seconds, Typical

COLD JUNCTION COMPENSATION:
Self-correction to ±0.25°C

OPERATING TEMPERATURE RANGE:
-40°F to +167°F (-40°C to +75°C) Electronics
-4°F to +158°F (-20°C to +70°C) Display

STORAGE TEMPERATURE RANGE:
-58°F to +185°F (-50°C to +85°C)

AMBIENT TEMPERATURE STABILITY: Self-correcting over the operating temperature range. Refer to AWS Application Note #203 for full discussion.

LONG TERM STABILITY: Less than 0.05% of reading plus ±2.1µA per year.

AUTOMATIC DIAGNOSTICS: Every 3 seconds the AI-2000 transmitter performs self-checks for zero, span, cold-junction temperature, open T/C, open RTD element, shorted RTD element, each open RTD lead and transmitter malfunction.

FAILSAFE: User settable 21.0mA, 3.9mA, or OFF

INTERCHANGEABILITY: All units interchangeable without field calibration.

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

ISOLATION: 250 VAC rms or 800VDC

COMMON MODE REJECTION: 120dB

REVERSE POLARITY PROTECTION:
42 VDC applied with either polarity

POWER AND LOAD:
Supply voltage (no load resistance); 12 to 42VDC;
Supply voltage (with load resistance);
Vsupply=(12)+(R_{load} in Kohm) x (21mA)
for Digital operation, R_{load} = 250Ω minimum
Supply Voltage Effect: < +/-0.005% of Span per Volt

WEIGHT: 12 oz. (340g)

STANDARD CONFIGURATION:
Factory configured for Type J thermocouple, 40ºF=4.0mA, 200ºF=20mA, with HI failsafes. Special configurations are available to suit your requirements. See Price List.

OPTIONS: LD-2, Local Display; KB-2 Local Keyboard, Sensors, Probes, and Thermowells. See Price List.

LIMITED WARRANTY

This warranty is in lieu of all other warranties, expressed or implied. The AWS 2000 series products (Product) are warranted by Adaptive Instruments Corporation (The Seller) to be free from defects in workmanship and materials, under conditions of normal use and service, for a period of two years from the date of shipment. The Product or Products is further warranted to hold its original factory calibration within its specified tolerance, for a period of two years from the date of shipment under conditions of normal use and service. At its option, the Seller will repair, replace, or re calibrate, free of charge, any Product or Products found and determined to be defective by the Seller if returned to the Seller, per the procedure below, within two years of its original purchase.

To claim a repair or replacement under this warranty, a Return Material Authorization (RMA) number must be obtained from AWS, and the Product returned, postpaid to the Seller. Final warranty defect determination and determination of the cost, if any, to repair or replace will be made by the Seller upon examination of the returned Product. Returned units may be subject to an evaluation or re calibration charge as listed in the Seller's price list.

Defects arising from negligence, misuse, improper installation, accident, modification or alteration of this Product (or Products) are not warranted nor are Products that have been opened for on-site or field inspection or repair.

LIABILITY OF THE SELLER

Liability of the Seller is limited to repair or replacement of the Product or Products as outlined above. Purchaser assumes full responsibility for determining that the Product or Products purchased will meet the Purchaser's requirements or those of the Purchaser's customers. Purchaser agrees to indemnify, defend and hold the Seller harmless from any liability, loss, or damage, whatsoever, caused or alleged to be caused directly or indirectly by the Product or Products including, but not limited to any interruption of business, loss of business, personal injury or consequential damages resulting from the use or operation of the Product or Products.

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