MODEL

SC-2000

Two-Wire "Smart" Signal Conditioner

Operating Information

Accutech
Smart Process Instrumentation

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SC-2000 PROGRAMMABLE SIGNAL CONDITIONER

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SECTION 1 INTRODUCTION

The SC-2000 is a programmable two wire, isolated signal conditioner that accommodates DC milliamperes, DC millivolts, DC volts, Potentiometer (slidewire), two and three wire resistance as inputs. This instrument is exceptionally versatile and can be used when any one or all of the following requirements exist:

* Signal isolation
* Conversion of signal types (e.g. Millivolt input to 4 to 20mA output)
* Linearization of non-linear input signals through standard mathematical relationships
* A user defined input/output relationship accommodated by up to 21 custom data points
* Signal integration (Averaging)
* Multiple mathematical or user developed functions to operate on the signal
* User tailored noise filter to eliminate noise without damping
* Local digital display in engineering units
* Bar graph display indicating percent of span
* Local or remote configuration without external calibration sources
* NIST traceable calibration warranted for 24 months.

The SC-2000 achieves its performance through the use of digital signal processing and microcontroller technologies. Many of the features, such as the automatic self diagnostics and the exceptional temperature stability, are transparent to the user.

The unit can accept three separate functions which consecutively operate on the signal. Functions #1 and #2 each offer a selection from square, square root, log, ln, linear and smoothed. In addition, the SC-2000 makes available a maximum of 21 points for user entered custom curve fitting.

It is simple to setup and operate the SC-2000, much like any other signal conditioner. It can be set up either locally, without any tools, or remotely through digital communications. An optional smart local display, the LD-2, and a two key keyboard, the KB-2, are also available. These accessories facilitate local configuration and ranging of the signal conditioner. In operation, the local LCD display indicates the measured signal and units of measurement to six digit resolution, an analog percent of range indication and also provides a seven character alphanumeric label or message indication. Configuration of the unit can be accomplished through any of the following methods:

Tap Mode Setup
Display & Keyboard
Hand Held Terminal
Personal Computer, or Terminal

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

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

The SC-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 adaptor and a personal computer. No calibrator and no other tools are required.

The SC-2000 signal conditioner does not have any potentiometers or switches to set, and there are no user serviceable components inside the enclosure. It has a two year NIST traceable calibration warrantee. Opening the enclosure will void the manufacturer's warranty.

This manual is divided into nine main sections. The first entitled "INTRODUCTION" describes briefly the signal conditioner and the organization of this manual. Section two deals with UNPACKING AND INSTALLATION. SIGNAL CONDITIONER OPERATION is covered in section three, which deals with both the normal analog mode of operation and the digital output of measurement data. The next three sections deal with the CONFIGURATION of the signal conditioner in THE TAP MODE, the DISPLAY MODE, and by DIGITAL COMMUNICATIONS. Section six covers the features available through digital communications when a data terminal or computer is available. Section seven contains additional applications information which can be useful when setting up the signal conditioner for a specific application. Section eight lists available accessories and nine deals with the specifications for the signal conditioner.

SECTION 2 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 ACCUTECH 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

2.2.1 Weather Proof Housing

Optional weather proof and explosion proof housings are available. The XP-HDC2-L accommodates a signal conditioner when the display option is not required. The XP-HDGC2-L, with its glass window, is used when the display option is desired. These housings have appropriate mounting plates in the bottom to attach the SC-2000 in any of four orientations 90° apart. In addition special captive 6-32 machine screws are installed on the signal conditioner to facilitate installation and removal. These captive screws are installed only if the signal conditioner and housing are ordered at the same time. Figure 2-1 indicates the dimensions of these housings.

2.2.2 Conduit Mounting

The weatherproof housing has two 1/2" female NPT conduit entries. These can be used to mount the housing directly onto the 1/2" male NPT ends of conduits. Alternatively, a 1/2" union coupling can be placed between the weatherproof housing and the wiring from the signal source.

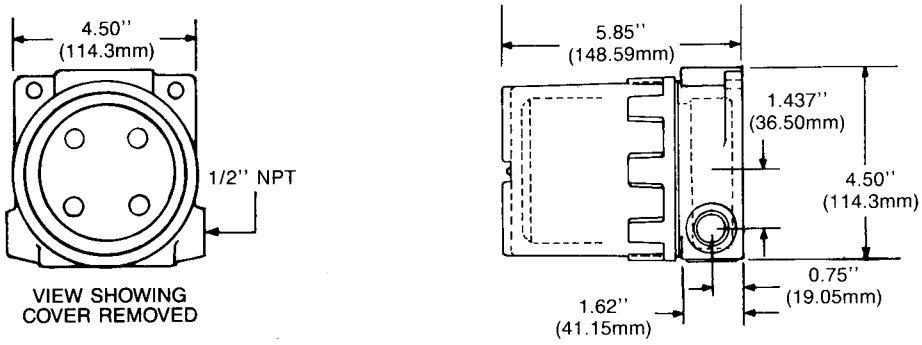


Figure 2-1
Optional Weather Proof Housing

2.2.3 Pipe Mounting

A stainless steel bracket, the PB-2, is available for mounting the weatherproof housing onto any 2" pipe in any of four orientations. The housing is attached to the bracket as shown in Figure 2-2.

2.2.4 Surface Mounting

The weatherproof housings, type XPHDC2-L and the XP-HDGC2-L, have two mounting ears allowing them to be attached to any flat surface by means of two bolts. If the additional weather resistance is not required, the SC-2000 can be mounted directly on a flat surface by the two mounting ears found on these units. In applications requiring several signal conditioners, these can be mounted on the plate normally found inside of NEMA-4 rated rectangular metal enclosures.

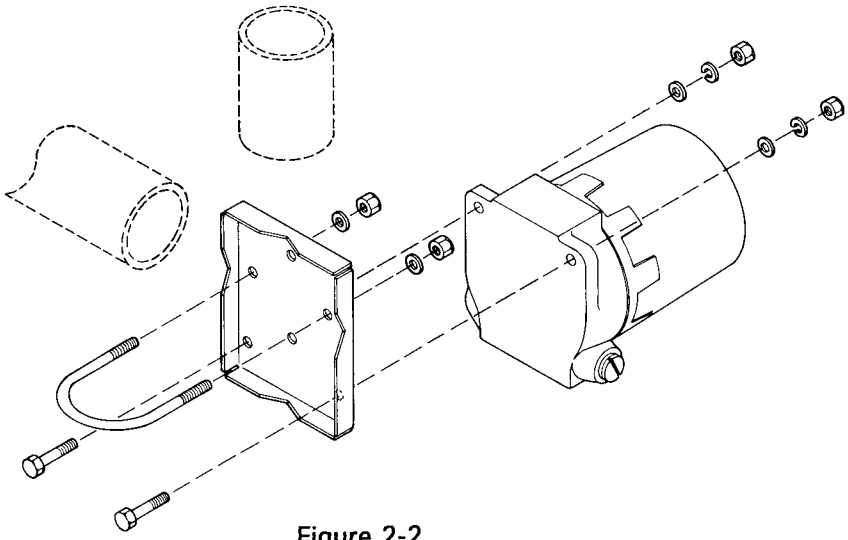


Figure 2-2
Pipe mounting bracket

2.3 ELECTRICAL INSTALLATION

The SC-2000 has two groups of terminals. Terminals 9 and 10 are the 4 to 20mA output terminals. These are normally connected to the corresponding polarity terminals of the power supply of the current loop. Refer to figure 2-3 for the arrangement of the terminal connections.

Terminal 8 is used to ground the enclosure.

Terminals 3, 4, 5, 6 and 7 are used in various connections to accommodate the different input signals.

Terminals 1 and 2, also serve as the mounting screw locations for the LCD display. These terminals, designated as SET 1 and SET 2, in conjunction with terminal 7 as common, are used for set-up, configuration and trim purposes as described under TAP MODE. The SET 1 and the SET 2 terminals are marked as such and are located near the upper left and upper right areas of the signal conditioner 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 signal conditioner.

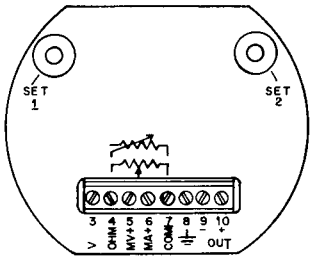


Figure 2-3
Terminal connections

2.3.1 Output Terminals

The output terminals, 9 & 10, are connected generally to a power supply having a nominal 24 Volt DC voltage and capable of supplying 100mA for the SC-2000. Although in the analog mode these signal conditioners require a maximum of only 24mA, for digital communications with the SC-2000 the power supply capacity should be 100mA. The +OUT and -OUT terminals of the signal conditioner 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 signal conditioner (for digital communications with the SC-2000 this 250 ohm resistor is required). The maximum series resistance in the circuit (including wiring lead resistance) can be calculated using the formula:

$$Rs = \frac{Vs - 12}{0.023} \quad \text{in ohms}$$

The following chart gives maximum series resistances:

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

2.3.2 Case Ground

Terminal 8 provides a connection to the metal enclosure of the signal conditioner. For safety, optimum performance and EMI immunity the case of the instrument should be connected to a good local earth ground. When using grounded sensors which are connected to the local electrical ground, then the signal conditioner case should be connected to that same ground point.

2.3.3 Input Terminals

2.3.3.1 DC Milliampere Input

Apply signal to 6(+) & 7(-).

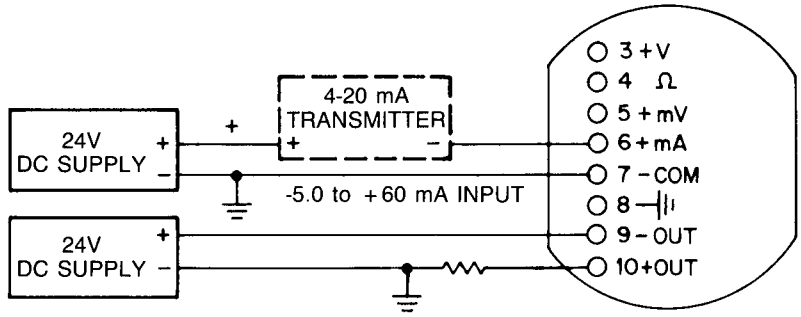


Figure 2-4
Typical Connection for Milliampere Input

2.3.3.2 DC Millivolt Input

Apply signal to 5(+) & 7(-).

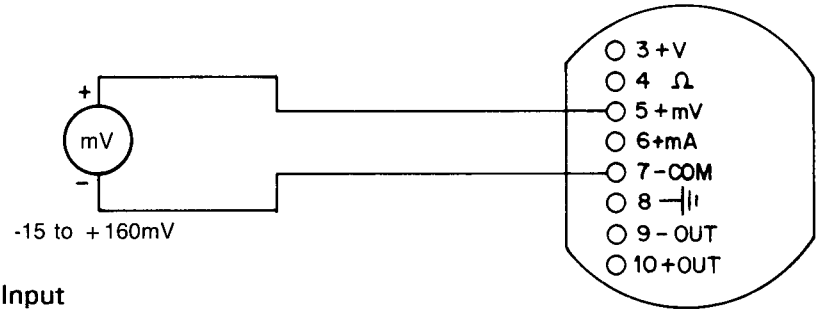


Figure 2-5
Typical Connection for Millivolt Input

2.3.3.3 DC Volt Input

Apply signal to 3(+) & 7(-).

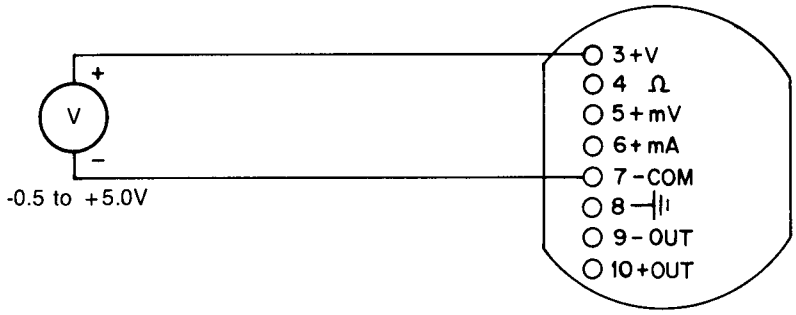


Figure 2-6
Typical Connection for Voltage Input

2.3.3.4 Potentiometer

Connect high side to 4,
center wiper to 5 & low side to 7.

2.3.3.5 Three wire Ohms

Connect high side of the resistor to 4,
one wire from the low side to 5, and the
second wire from the low side to 7.

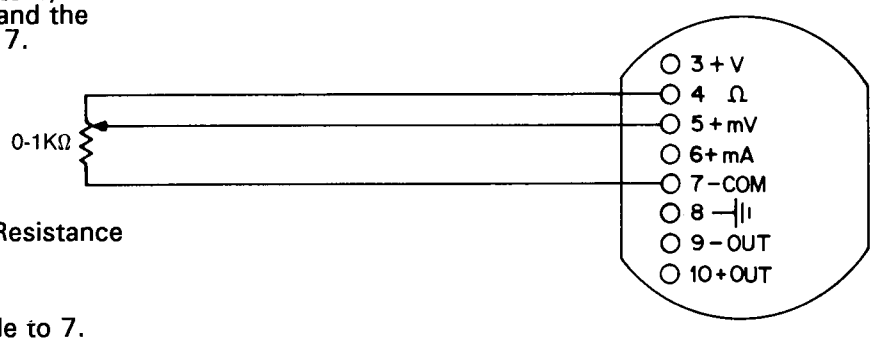


Figure 2-7
Typical Connection for Slidewire/Resistance

2.3.3.6 Two wire Rheostat (Ohms)

Connect high side to 4, & low side to 7.

SECTION 3 SIGNAL CONDITIONER OPERATION

3.1 IN A HURRY?

When in a hurry, these short set of instructions and references will help get the signal conditioner running.

3.1.1 Factory Configuration

Milliampere mode, Analog output
4.00mA Input = 4.0mA Output
20.00mA Input = 20.0mA Output
Sensor Failsafe = 21.00mA

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

3.1.2 Analog Operating Mode

If the unit was ordered with the standard factory configuration the input required is a 4 to 20mA current loop. 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 signal conditioner, or to re-range it, refer to the procedures described in SECTIONS 4, 5 & 6. 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 signal conditioner directly to 115VAC!*

With the power supply off, connect the + side of the power supply to the +OUT (10) terminal of the signal conditioner. Connect the - side of the power supply through a 250 ohm resistor to the -OUT (9) terminal of the signal conditioner. See figure 6-2. Connect the input terminals 6 & 7 in series with the current loop to be measured. Terminal 6 should be more positive than 7.

Current Input High (+MA) (6)
Current Input Low (-COM) (7)

To connect other sensors to the input refer to paragraphs 2.3.3 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 SC-2000 loop current will settle to its normal value in the range of 4 to 20mA. In this configuration the SC-2000 is a loop powered isolator. The output current will duplicate the current applied to the input terminals.

3.1.3 Analog Operating Mode With Display

If the signal conditioner 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. The display option can be ordered already installed on the SC-2000 signal conditioner. Having the display option as part of the signal conditioner 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 variable and other diagnostic functions. The figure below indicates the arrangement of the display screen and some of the symbols that are available.

In operation, the top row displays the measured variable, and a minus sign if applicable. The number of decimal places displayed changes to be appropriate for the input selected.

The mid portion is an analog bar graph display showing the % of range based on the ZERO and FULL SCALE setting of the signal conditioner. When power is applied the leftmost segment of the bar graph, the 0% and the 100% become energized. If the input signal is below what the ZERO is set to, then the left arrow is energized. If the input signal is above the FULL SCALE setting, then the right arrow becomes energized.

The bottom portion of the LCD is capable of displaying alphanumeric messages. In normal operation this row shows a label, which is factory set to display SC-2000. Seven characters are available and the user can set in any other desired label in place of SC-2000. In the event a sensor failure indication is called for, the lower portion of the display changes to

S FAULT

In the event of certain signal conditioner failure modes the indication changes to

X FAULT

This LCD display takes full advantage of the precision of these signal conditioners. 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 signal conditioner identification. The LCD continues to display the measured variable even if it is beyond the zero and span 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.

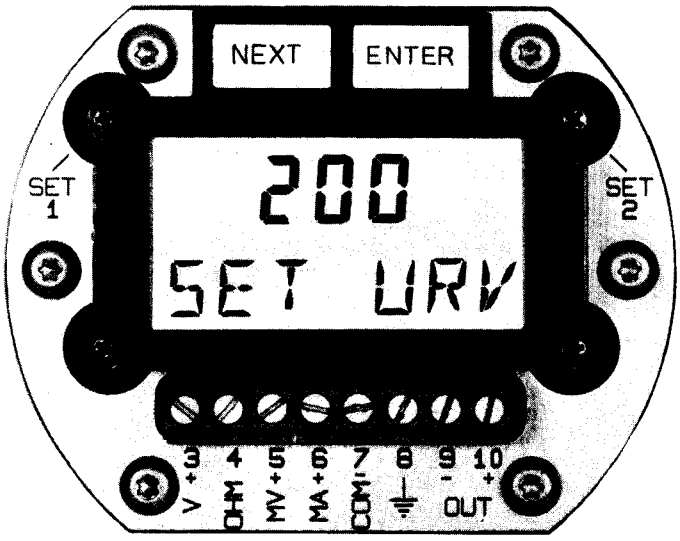


Figure 3-1
Appearance of the Local Display, LD-2

3.1.4 Digital Operating Mode

When the SC-2000 is configured to produce an analog output it behaves much like any other 4 to 20mA two wire signal conditioner regulating its loop current in response to the measured variable. However, as an added feature, the SC-2000 can also be set-up to send out the measurement results in 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 SC-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 SC-2000 remains at the nominal 23.0mA digital loop current waiting for a request for data from the master. Upon receipt of an uppercase M, the signal conditioner sends one series of ASCII characters, much like above, representing the most recent measurement results. Then the signal conditioner remains again at the 23.0mA level awaiting the next M character.

3) In the IEEE mode, the signal conditioner 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 SC-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 SC-2000 is operated in the digital mode, there is no need to set the Upper or Lower Range Values. The signal conditioner simply sends out the measurement data in digital form at any input value over the permissible operating range of the selected variable.

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

SECTION 4 CONFIGURATION, THE TAP MODE

4.1 Overview And Tools Required

With the TAP Mode, reconfiguration of the signal conditioner is accomplished by momentarily shorting of either the SET1 or the SET2 terminals to terminal (7) with a jumper wire and observing as the output current changes in 0.5mA increments after each operation. The simple flow diagram on the centerfold page 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 SET1 to terminal (7), or shorting of the SET2 to terminal (7).

The signal conditioner 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 ohms, 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 source of the selected variable is also required. This may be an adjustable millivolt source, a voltage source, a milliampere source, or a decade resistance box, as the case may be.

4.2 Timing of Inputs

When shorting the SET1 and (7) terminals, or the SET2 and (7) 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 (7) terminals will cause the output current to change as indicated in the flowchart on the centerfold page.

4.3 Selecting the Function

As seen in the flowchart on the centerfold page, the reconfiguration process is started by shorting the SET1 terminal. This causes the output current, to change to Iout=21.00 mA indicating that the signal conditioner 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 = 16.00 mA the next shorting of the SET1 terminal starts the main menu over again at Iout = 19.50 mA. Sequencing through the main menu selections does not change the configuration or calibration of the signal conditioner and, if desired, the signal conditioner 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.

4.3.1 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 SET 1 TERMINAL, WHEN THE LOOP CURRENT BECOMES 21.0mA, DO NOT SHORT THE SET 2 TERMINAL, BUT INSTEAD SHORT SET 1 A SECOND TIME! SHORTING SET 2 AT THIS TIME CAUSES THE SIGNAL CONDITIONER TO ENTER THE DISPLAY/KEYBOARD SET-UP MODE, AND THEN FURTHER SHORTING OF THE SET 1 AND SET 2 TERMINALS NO LONGER FOLLOWS THE TAP MODE FLOW CHART.

4.3.2 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 signal conditioner 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 2 1/2 minutes after entering the setup menu. After this period of time the signal conditioner simply returns to its previous operating mode.

4.3.3 Select Input; Iout = 19.5mA

This function is used to set the desired type of input. Input 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 input selection as seen on the right hand portion of the flowchart. Each subsequent shorting of SET1 advances in the sub menu to the next input selection as indicated by the arrow. The output current follows these selection steps as a confirmation of the selection. After the desired input has been selected, a second shorting of the SET2 terminal reconfigures the unit to the new input and returns it to the corresponding main menu selection with the output current, Iout = 19.50 mA, as a confirmation.

4.3.4 Set Output Zero; Iout = 19.0mA

This function is used to set the zero output, or lower range value, LRV, (4.00mA) of the output current range to correspond to a desired input. The LRV set function should be used only after the desired type of input has been selected.

Apply the signal to the input that is to correspond to 4.00mA of output current. This can be a millivolt signal if millivolt input was selected, or a known resistance in the case of a rheostat input. 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 SET2 terminal again. The output current will change to Iout = 15.00mA for about 30 seconds and then return to Iout = 19.00mA confirming that setting the zero of the output range has been accomplished. During these 30 seconds the signal conditioner is making an accurate measurement of the input, measurements of its internal references, and then storing in its non-volatile memory the appropriate readings.

When setting the range limits for a resistor type input, use a resistor decade box instead of an electronic resistance calibrator. The SC-2000 signal conditioners do not emit a steady state excitation current. This may cause erroneous results when using some of the electronic resistance calibrators designed for analog signal conditioner calibration.

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

This function is used to set the full scale, or upper range value, URV, (20.00mA) of the output current range to correspond to a desired input. The URV set function should be used only after the desired input type, mA, mV, V, or R has been selected.

Apply the signal to the input that is to correspond to 20.00mA of output current. This can be a millivolt signal if mV input was selected, or a known resistance in the case of a resistive input. Set the unit to the corresponding main menu selection, Iout = 18.50mA, 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 = 15.00mA for about 30 seconds and then return to Iout = 18.5mA confirming that setting the full scale of the output range (span) has been accomplished.

4.3.6 Set Sensor Failsafe; 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 21.00 mA 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 resistance input, or any other input variable exceeding the specified limits.

Set the unit to the corresponding main menu selection, Iout = 18.0mA, then short the SET2 terminal. The output current will change to Iout = 21.00mA or Iout = 3.90mA, or Iout = 15.00mA depending on where the failsafe is presently set. At this time, SET1 can be shorted to sequence the setting between the 3.90 mA, signifying low, or 15.00mA signifying that the feature is being turned off, or the 21.00 mA limits, signifying a hi failsafe, 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 = 18.00mA.

4.3.7 Set Signal Conditioner Failsafe; Iout = 17.5mA

This function is used to set a high or a low indication for certain internal signal conditioner malfunctions, or to turn this feature off. A high setting will drive the output to 21.00 mA when a malfunction is detected; a low setting will drive the output to 3.90 mA 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=21.00mA or Iout=15.00mA, or Iout=3.90mA depending on where the failsafe is presently set. At this time SET1 can be shorted to sequence the setting between the 3.90 mA limit, signifying low, the 15.00mA signifying off condition, and 21.00 mA, signifying a high failsafe 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=17.50mA.

4.3.8 Trim 4.00 mA; Iout=17.0mA

This function is used to check or adjust the trim of the low end of the output current which is required to be 4.00 mA. The SC-2000 has a calibrated stable output current of 4.00 mA, 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" which is described in Paragraph 4.3.4. Using the trim function voids the NIST traceability of the factory calibration.*** To check the signal conditioner output and select the proper Increment, Decrement, or no change necessary function, first, set the unit to the Trim 4.00mA main menu selection as described. Then short the SET2 terminal momentarily. The signal conditioner output current will change to Iout=4.00mA. If the output current measures lower than 4.00mA it needs to be incremented. If the output measures within its specification, no change needs to be made. If the output measures above 4.00mA, it needs to be decremented.

To Increment

With the output measuring slightly lower than 4.00mA, repeated shorting of the SET1 terminal will increment the output current in approximately 2uA 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=17.00mA, confirming the action.

If in 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 4.00mA, 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 2uA steps.

Do not use the decrement function to reduce the output current below 3.90mA. The signal conditioner 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=17.00mA, 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 4.00mA until returning to the Iout=17.00mA which confirms the return to the main menu.

4.3.9 Trim 20.00 mA; Iout=16.5mA

This function is used to check or adjust the trim of the high end of the output current which is required to be 20.00 mA. The SC-2000 has a calibrated stable output current of 20.00 mA, 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 Full Scale" which is described in Paragraph 4.3.5. Using the trim function voids the NIST traceability of the factory calibration.*** To check the signal conditioner 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 signal conditioner 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 specification, 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 2uA 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=16.50mA, confirming the action.

If in 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 20.00mA, short the SET2 terminal a second time. No change will be observed in the output current, which will continue to read slightly higher than 20.00mA. Shorting the SET1 terminal now decrements the output. Repeated shorting of the SET1 terminal will decrement the output current in approximately 2uA 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=16.50mA, 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 20.00mA until returning to the Iout=16.50mA which confirms the return to the main menu.

4.3.10 Return to Normal Operate Mode; Iout=16.0mA

After the desired changes in settings have been made and calibrations performed the signal conditioner 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=16.00mA, and then short terminal SET2 momentarily. In about 5 seconds the signal conditioner 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 signal conditioner returns to the operate mode.

3) Disconnect the power to the signal conditioner for at least 30 seconds. The next time power is applied the signal conditioner will operate in its newly set mode.

SECTION 5 CONFIGURATION, THE DISPLAY MODE

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

In the event that the keyboard and the local display are purchased separately, follow carefully the field installation instructions supplied to avoid damage to the signal conditioner or the display.

5.1 Entering the Display Setup Mode

To start the Display Set-up Mode, first connect the signal conditioner to an appropriate DC power supply. Typically a 24VDC supply is connected with the + side to signal conditioner terminal (10) and - side to terminal (9). A series resistor in the loop is optional, but not required. A sensor may be connected to the other terminals, but this is not required for setting up the signal conditioner.

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

```
                00.00
<0%-                      100%
     SC-2000
```

This means that no current signal is applied to the input and therefore, the digital indication is 00.00. The analog output is set to have 4.0mA input give 4.0mA output. Therefore, with zero current applied to the input the analog indication will be under range, as indicated by the left arrowhead. The bottom row of the display indicates the factory entered label, SC-2000. If the signal conditioner had been configured for 2 or 3 wire resistance, then without the sensor connected the display would indicate the following:

0%----------100%>
S FAULT

The signal conditioner 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 over range condition.

Press the key marked NEXT. The display starts to alternate between

DISPLAY MODE?

asking if the user wishes to enter the display mode? The answer should be yes, therefore, press the key marked ENTER. Next the display will alternate between

SELECT INPUT?

asking if the user wishes to Select a different sensor, or Input? This is the first one of eight main menu selections. Each menu selection allows a different set-up function to be performed. As an overview, one may scan through the eight menu entries by pressing the NEXT key every time a new menu item is displayed.

Note that when more than seven characters are required to describe a menu item, the display keeps sequencing through two or three screens. In this manual, the sequencing of the display is indicated by placing the two or three parts of the message on the same line, but spaced apart. With some menu entries the display also indicates a numeric value and unit of measurement in addition to the message at the bottom.

Now keep pressing the NEXT key until the display returns to the SELECT INPUT function.

4.00 CHANGE	4.00 ZERO ?	
20.00 CHANGE	20.00 FULL	20.00 SCALE ?

SELECT	SENSOR	FAIL	SAFE ?
SELECT	XMITTER	FAIL	SAFE ?
TRIM	4 MA ?		
TRIM	20 MA ?		
RETURN	TO	OPERATE	MODE ?
SELECT	INPUT ?		

The above is the sequence of main menu entries with factory set limits of 4.00 and 20.00. The flow diagram indicating all of the Display Mode menu options is also given in the centerfold of this manual.

After having sequenced through the main menu selections the signal conditioner is back to the first entry, which is

SELECT INPUT ?

If the Input selection does not require changing, then press NEXT, otherwise press ENTER. After pressing ENTER the display will change to

MAMPS

indicating that the signal conditioner is set to the milliampere input. If this is the desired input, 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.

MAMPS	(Milliamperes)
MVOLTS	(Millivolts)
VOLTS	(Volts)
RHEOST	(Rheostat, or 2 wire ohms)
OHMS 3W	(Three wire ohms)
SLIDEW	(Slidewire, or Potentiometer)

One can stop at any one of the input type selections and pressing of the ENTER key changes the signal conditioner mode to that input type. If no input change is desired, then, without sequencing through the various input options, but just pressing the ENTER key will allow one to confirm the input selection and leave it unchanged. We will assume that the input is left as MAMPS. After pressing ENTER the display returns to:

SELECT INPUT ?

Now that the input selection has been completed, press NEXT and the display will start alternating as

4.00	4.00
CHANGE	ZERO ?

The numeric value seen on the upper portion of the screen is the zero value that the signal conditioner is currently set to. One can now change this zero, or lower range value, LRV, totally independent of the upper range value, URV, and without the use of any calibrators or external sensor inputs. To change the ZERO, press ENTER. The display changes to

004.00
PLUS ?

indicating that the existing ZERO is set to "plus" 4.00 and asking if this value is to remain positive (PLUS ?). By repeatedly pressing the NEXT key the display will alternate

```
-004.00
MINUS  ?

004.00
PLUS  ?
```

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

```
004.00
HUNDRD?
```

and the leftmost digit position will start blinking asking if the hundreds position needs to be changed? To change the hundreds 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 1, then the display would change to

```
104.00
HUNDRD?
```

and the second digit from the left will start blinking asking if the tens position needs to be changed? Like before, to change the number in this digit position press repeatedly 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 to

```
1040.00
ONES  ?
```

1040.00
TENTHS?

1040.00
HUNDTH ?

After the Hundredth digit position has also been changed to the desired value, the next pressing of the ENTER key returns the signal conditioner to the alternating display of

104.00	104.00
CHANGE	ZERO ?

Since changing of the zero has just been completed, press the NEXT key to proceed to the next menu selection, which is

20.00	20.00	20.00
CHANGE	FULL	SCALE ?

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

20.00	20.00	20.00
CHANGE	FULL	SCALE ?

If at any of these main menu selections the indicated function need not be performed, then just press NEXT, and the next main menu selection appears sequencing on the screen.

SELECT	SENSOR	FAIL	SAFE ?

If one desires to change the sensor fail safe condition, then press ENTER and the current failsafe setting appears on the screen

HIGH ?

The available settings can be sequenced through by pressing the NEXT key each time

OFF ?

LOW ?

When the desired failsafe condition is reached, pressing the ENTER key will change to the new setting and the screen returns to the main menu selection

SELECT SENSOR FAIL SAFE ?

Pressing the NEXT key will bring up the signal conditioner fail safe selection screen

SELECT XMITTER FAIL SAFE ?

Using a similar procedure as above, the signal conditioner fail safe condition can be changed to HIGH, OFF or LOW. When the selection is completed and the screen is back to the main menu item

SELECT XMITTER FAIL SAFE ?

press the NEXT key to bring up the main menu selection

TRIM 4 MA ?

This menu item allows trimming of the 4.0mA output current. Note that this function is only for the purpose of adjusting the 4.00mA limit of the signal conditioner loop current to be exactly 4.00mA according to the plant's local standard. This is NOT for the purpose of ranging the signal conditioner! Also note that using the Trim 4mA, or the Trim 20mA functions voids the NIST traceability of calibration. If trimming the 4.0mA limit is still desired then press ENTER. The display will alternate

RAISE MA OUT ?

By pressing the NEXT key the display then alternates as

LOWER MA OUT ?

When it is decided whether to raise or lower the output current, then press ENTER and the display changes to one of the following

NEXT = +

or

NEXT = -

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 2 micro ampere increments. Note that the 4.0mA limit is factory calibrated to a precision NIST traceable standard. Do not arbitrarily trim the output unless a qualified and accurate local standard is available to measure the adjusted 4.0mA output! Also note that the 4.0mA limit should not be trimmed by more than about +/-50uA, else signal conditioner operation may be impaired. Once the desired trim is reached, pressing ENTER will return to one of the corresponding screens

TRIM 4 MA ?

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 menu option

TRIM 20 MA ?

Trimming of the 20.0mA current limit is done in exactly the same manner as was described for trimming the 4.0mA point. Similarly the same precautions apply. After completing the trim 20.0mA pressing the NEXT key brings up the final menu option, sequencing through

RETURN TO OPERATE MODE ?

If all of the set-up and re-ranging operations have been satisfactorily completed, then pressing ENTER will return the signal conditioner to the normal operate mode. Pressing the NEXT key at this point will return the display to the first main menu option

SELECT INPUT ?

Note again, that whenever the signal conditioner is in the display set-up mode, if no activation of the keyboard occurs for approximately 2 1/2 minutes, the signal conditioner returns to the operate mode. One can also return to the operate mode at any point in the Display Mode by removing power from the signal conditioner for about 30 seconds.

SECTION 6 CONFIGURATION THROUGH DIGITAL COMMUNICATIONS

6.1 FEATURES AVAILABLE, OVERVIEW

While the SC-2000 can operate like any two wire 4 to 20mA signal conditioner 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 one can digitally communicate with the SC-2000. In place of the HHT-420, one 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 SC-2000 in the digital mode, and by means of a series of descriptive menus sent by the signal conditioner to the terminal the user can perform most of the set-up or calibration functions already described. In addition, the digital communications mode allows access to some other advanced features as described below.

Sending an uppercase P causes the SC-2000 to display a configuration menu on the display terminal. The "Configuration Menu" allows the user to configure and set-up the signal conditioner to meet the needs of a particular application. Following is a brief description of each set of functions available.

6.1.1 Setup Status

In the "Configuration Menu", the first selection is "Setup Status". The Setup Status menu shows how the signal conditioner is currently set-up. It is a read only listing directly from the signal conditioner'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 signal conditioner'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 signal conditioner is set-up the way it is intended to be. Setup status can also be checked as desired to verify the set-up of the SC-2000. See paragraph 6.3.2 for further details.

6.1.2 Input Setup

The Input setup in the digital menu allows a choice of input types to be made, as in the Tap Mode and Display Mode menu. In the digital mode, other features can also be accessed. A tag number or display label can be assigned, signal damping can be selected, and various functions like square, square root, log natural log, etc. can be activated. The user defined curve fitting 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 Signal Correction is activated along with one of the other mathematical functions then the correction is applied in addition to the math function. One can activate a math function, then apply the user defined signal correction points and subsequently use a second math function. All of these math functions and user entered signal corrections are performed in terms of repetitive high precision mathematical calculations and they are not dependent on the imperfect characteristics of semiconductor devices.

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 to choose from. Continuous digital data in ASCII character format, or the same ASCII format but sent only when requested by the master. Finally the data can be sent in IEEE floating point decimal format.

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 keyboard. The signal conditioner, using its factory stored calibration data, will exhibit the correct calibrated settings. With this method there is no need to use any calibration source or millivolt source whenever re-ranging the signal conditioner. See paragraph 6.3.4 for more details.

It is also possible to set the signal conditioner's output to the desired failsafe limits when sensor or signal conditioner failure are detected.

6.1.4 Options Setup

In this menu a variety of signal conditioner options may be selected. Display format can be selected for compatibility with most 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 turnaround 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 signal conditioner each time as the last character of a message. This feature is useful particularly when interfacing with a computer to indicate when the transmission of a message is complete. If the ASCII "BELL" character is selected (7) as the turn around character, then most data terminals will emit a beep tone at the completion of each message from the signal conditioner. The turnaround 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 signal conditioner 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 signal conditioner manufacture and the standard reference used at the customer plant site. The signal conditioner output current 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 signal conditioner which may occur over longer periods of time. See paragraph 6.3.6 for details. Note that using the Output Trim function voids the NIST traceability.

6.1.6 Wiring Information

The SC-2000 has portions of the user manual stored in its memory and can display the proper terminal connections for any input 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 pass word, since 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 SC-2000

6.2.1 Accessories Required

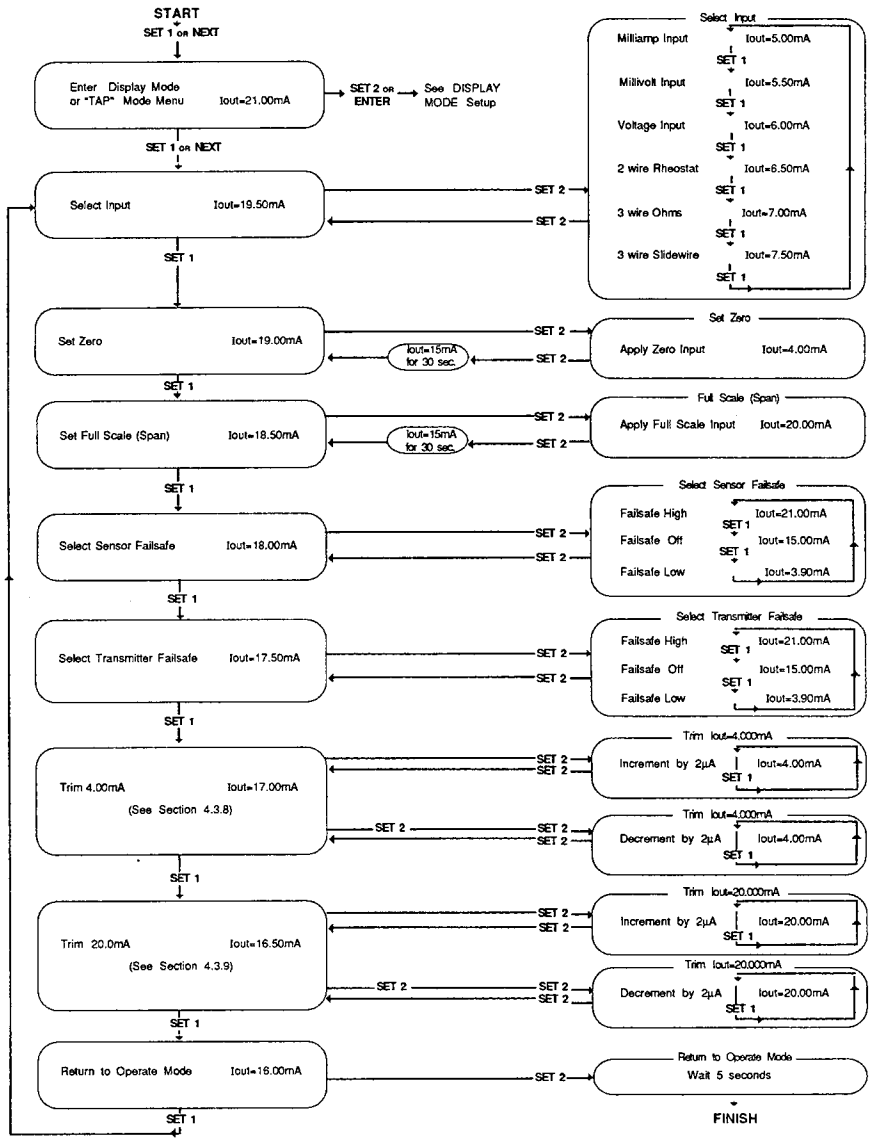
1) Power supply, 24VDC 100mA minimum, such as the Accutech model PS-2412
2) Hand held terminal, Accutech model HHT-420.

Or as an alternative

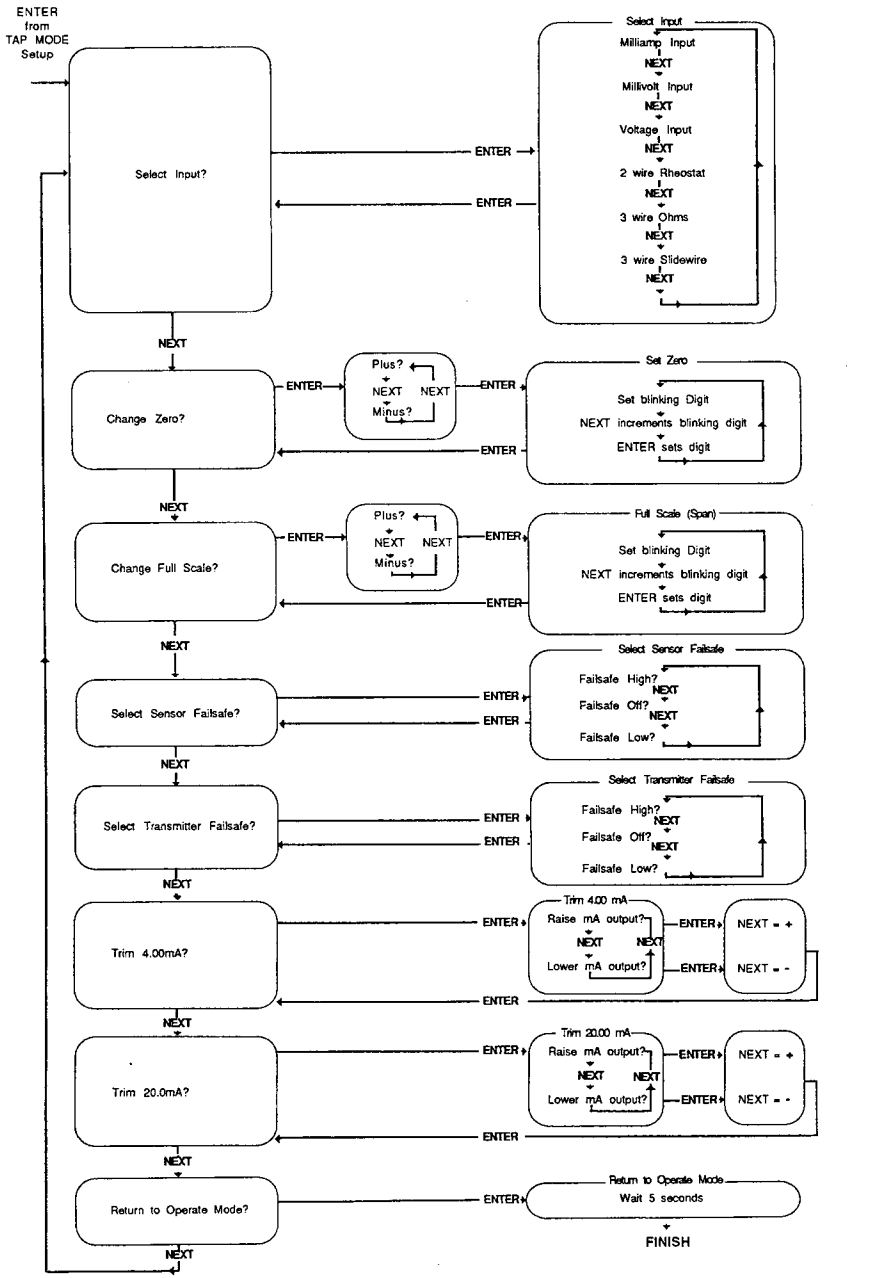
1) Power supply, 24VDC 100mA minimum, such as the Accutech model PS-2412
2) Communications Interface, Accutech model CA-100
3) A personal computer having an RS-232 serial port.
4) Terminal emulator software, supplied free of charge with CA-100

During communication the load current in the loop increases to 100mA in short pulses. Therefore, the power supply must be of sufficient capacity to deliver 24 volts at 100mA load current. The

Accutech SC-2000 Smart Signal Conditioner "TAP" Mode Configuration Setup Flowchart



Accutech SC-2000 Programmable Signal Conditioner DISPLAY Mode Configuration Setup Flowchart



data terminal or computer must have an RS-232 compatible serial communications port. If the device is a computer, then 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 with the purchase of a CA-100.

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 SC-2000 signal conditioners. This terminal has two clip leads, a red and a black lead, which need to be clipped onto the +OUT (10) and the -OUT (9) output terminals of the signal conditioner 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 entitled Signal conditioner Output Connections. After the HHT-420 is connected and turned on, all that one needs to do is press one key, the capital P, and the signal conditioner starts sending a Configuration Menu.

Such simple operation makes the use of the HHT-420 exceptionally convenient for reconfiguration, re-ranging and diagnostics of SC-2000 signal conditioner installations. The HHT-420 is a simple ASCII terminal with a built-in CA-100 communications adapter. It does not have any signal conditioner specific software, therefore, there will never be a 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 Accutech. It is used to connect a data terminal or a computer to the two current loop wires of an SC-2000 smart signal conditioner. 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 the EIA (Electronic Industries Association) RS-232 standard. At the other end the CA-100 module has two test leads, a red and a black one, intended for connecting across the current loop terminals. The red lead is connected to the +OUT,

and the black lead to the -OUT terminals of the signal conditioner. 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 which may need to be shifted depending on the electrical set-up of the RS-232C port on the terminal. The terminals provided inside of the CA-100 are accessible after removing the two screws which keep the two halves of the enclosure together. These terminals may be designated as follows:

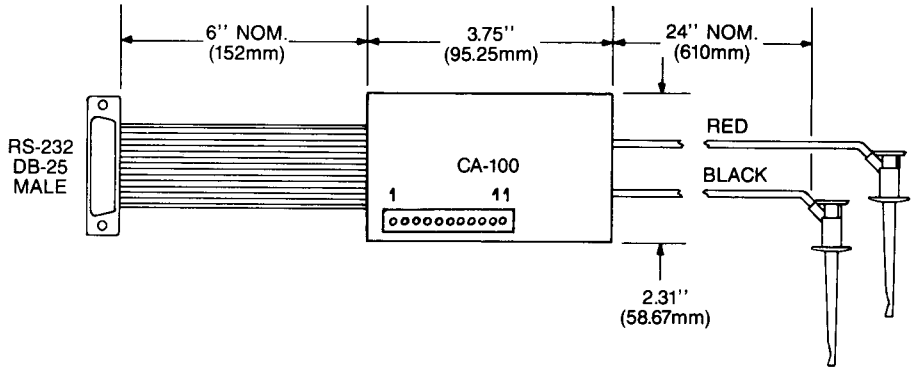


Figure 6-1
Location of Programming Terminals on the CA-100

Programming terminals 1 through 5 are used for establishing the correct connection of the transmit and receive signals of the RS-232 port. If the CA-100 is connected to a Data Terminal Equipment, DTE, 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 Data Communications Equipment, DCE, 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 are required. If communications with the SC-2000 cannot be achieved otherwise, then 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 also 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 are:

6 to 7 8 to 9 10 to 11

Excessive capacitive loading across the SC-2000 output terminals will prevent 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 a line operated equipment, then this circuit common may also be connected to the AC ground. In this case the -OUT of the SC-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 Signal Conditioner Output Connections

When digital communication with the SC-2000 is desired a load resistor of 250 ohms minimum resistance is required. The signal conditioner, 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, and the most useful connection may be that of figure 6-4.

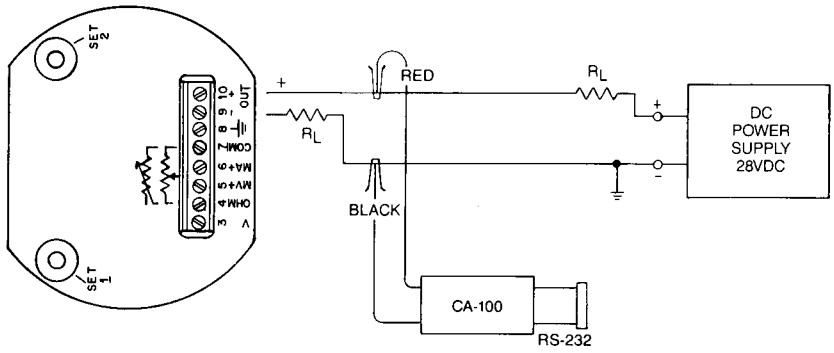


Figure 6-2
Connection to accommodate analog output.

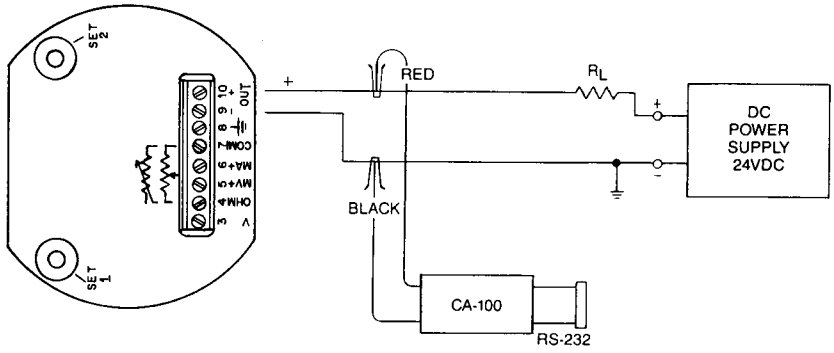


Figure 6-3
Connections for digital communications.

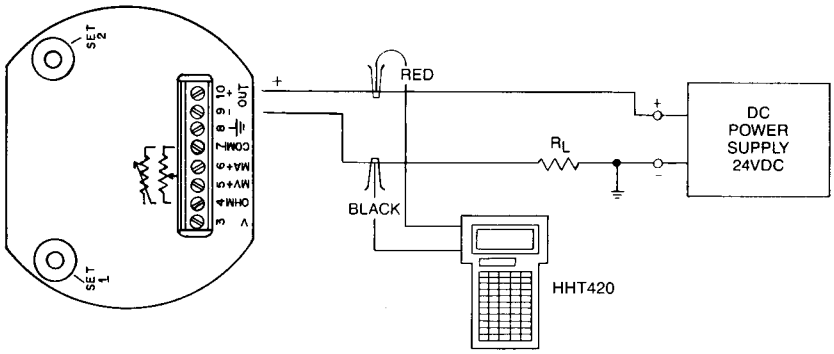


Figure 6-4
Connections to use with the HHT-420.

In the above connection examples whenever one side of the power supply is connected to the circuit common that one power supply can be used to operate several signal conditioners. It is necessary to allocate a power supply capacity of 25 to 30mA for each signal conditioner and 100mA of current for the unit which is digitally communicating.

Whenever the black lead of the CA-100 is not connected to circuit common, such as 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 signal conditioner is communicating digitally.

6.3 COMMUNICATING WITH THE SC-2000

After the SC-2000 has been properly connected to a 24VDC, or 28VDC 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 signal conditioner 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 under paragraph 6.2.3.

Turn on the DC power supply. After 5 seconds the signal conditioner enters its normal operating mode. If the signal conditioner has been previously placed in the 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 SC-2000 is normally operating and is properly connected to a communications terminal, then an uppercase P entered on the terminal will place the signal conditioner in the digital response mode and cause it to send out a menu. Note that the Return or Enter key need not be pressed after pressing the capital P. If the signal conditioner is in the digital mode and transmitting measurement data, it may be necessary to press the P two or three times for the signal conditioner to respond.

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

When digitally communicating with the SC-2000 the signal conditioner goes "off line" and the loop current does not represent the measured variable. After digital communication with the signal conditioner is completed, and if the signal conditioner was set to the analog mode, then the loop current returns to representing the measured variable.

Note that depending on the type of data terminal used and the display set up of the SC-2000 there may be some variations to the menu's and responses described in the following sections. For clarity the menus are described for the case when the SC-2000 is set to the 24 line display mode. When using the HHT-420, the signal conditioner is set to the 4 line mode. The menu's will appear identical to those shown here, except one needs to press the RETURN key after four lines of a larger menu have appeared on the screen of the hand held terminal.
The menus follow certain conventions. Following a ? requires an operator input. By just pressing the enter key, the system will accept the default entry represented by the numeral that followed the ?. If an invalid numeral is entered, the system will repeat the request. Note that in 4, and 8 line modes, the display may stop and wait for the operator to press the enter key so that the balance of the menu may be displayed.

6.3.1 The Configurations Menu

Whenever the signal conditioner is placed in the digital response mode by the entry of an uppercase P, the menu that appears on the terminal is:

```
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 the Return (or on some terminals the Enter) key. The default selection is 8. If no numeral is entered, but the Return key is pressed, then the signal conditioner will reset and in about 5 seconds return to the normal operate mode.

If the signal conditioner was previously left in the digital mode then about 5 seconds after applying power it will send the message:

TRANSMITTER ON

Then it will start displaying digital readings on the screen.

When the CONFIGURATION MENU is displayed, if the operator takes no action for approximately 2.5 minutes, then the signal conditioner will reset and return to the previous operating mode. This time out will take place at any stage of the set up procedure if the operator appears to abandon the process.

If password protection has not been selected previously, then any of the above menu items can be accessed by merely entering the corresponding number and pressing the return key. The normal factory configuration protects with the password 123 all but the Status and Wiring Info. menus. If some of the menu entries have been chosen to be password protected, then upon entering the corresponding menu selection number the following message will appear:

ENTER PASSWORD? _____

Upon entering the user selected password, access to that menu selection is available. 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 certain to remember any new password entered, or else access to those menu selections will be denied. (For a nominal charge the factory can reset the password in a signal conditioner to its normal default state.)

6.3.2 The Setup Status Menu

If item 1) in the CONFIGURATION menu is selected, then the current setup status of the signal conditioner is displayed:

```
TAG NUMBER    XXXXXXXXX
SERIAL NUMBER 000XXXXXX
VERSION  1.0
MILLIAMPS
DAMPING IN SEC. 0
INPUT FAILSAFE  HIGH
XMITTER FAILSAFE HIGH
OUTPUT MODE ANALOG
OUTPUT UNITS    MA
ZERO 4.0000
FULL SCALE 20.0000
PRESS RETURN TO CONTINUE
```

This selection does not allow changing any of the parameters, but merely indicates the setup status of the signal conditioner. Note that if the signal conditioner was in the digital mode a different set of menu items would be displayed.

6.3.3 The Input Setup Menu

If item 2) in the CONFIGURATION menu is selected, then the Input Setup Menu will be displayed:

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

The system expects the operator to enter the desired tag number. If there was a number previously entered then that is displayed. Any alpha or numeric combination of digits may be entered and the previously entered number can be over written. The entry is terminated by pressing the Enter key. If a previously entered number requires no change, then pressing the Enter key leaves that entry unchanged. The next message is:

```
DISPLAY LABEL?      SC-2000
```

One can also enter a seven (7) character label that is displayed on the lower part of the local

display when a display option is installed. The factory configuration assigns the label "SC-2000". However, this can be overwritten with any other desired seven character label. After pressing the Enter key the next message is:

```
INPUT SELECTION      0=MILLIAMPS
1=MILLIVOLTS         2=VOLTS
3=2W RHEOSTAT        4=3W OHMS
5=POT/SLIDEWIRE
SENSOR TYPE? 0
```

This screen indicates that currently the milliampere input is selected. The screen is prompting the user to enter a new selection. Enter the desired number and then press ENTER. The next selection will be

```
DAMPING IN SEC.? 0
```

Enter the desired damping constant and press enter again. This feature provides an exponential damping. The number of seconds entered, up to 30, represents the time constant of damping. After pressing enter the next selection is

```
FUNCTION ONE      0=NONE   1=SQ
2=SQRT   3=LN   4=LOG  5=SMOOTH
6=EXP    7=EXP10
FUNCTION ONE? 0
```

The signal conditioner allows the user to select a mathematical operation, Function One, as the first one to operate on the applied signal. Any one of the mathematical operations of square, square root, natural logarithm and its inverse, log to the base 10 and its inverse can be selected. In addition, one can select a Smooth function, which provides additional signal filtering for noisy environments. To select any desired mathematical operation as Function One, enter the number corresponding to that operation. To bypass Function One and not select any of these operations, enter the numeral 0.

Selection 5=Smooth allows the user to adjust the smart smoothing dead band. This is a very powerful feature to filter out electrical noise that may enter with the signal in some applications.

This feature is described in detail in paragraph 7.3. When 5 = Smooth is selected, the following sub menu appears

```
DEADBAND?  20.00000
```

Enter the desired dead band in terms of the engineering units appropriate for the input selected.

```
SIGNAL CORRECTIONS
1 = ON  2 = OFF
CORR. SYSTEM?  2
```

The SIGNAL CORRECTIONS menu offers the option of modifying the transfer function of the signal conditioner. If the SIGNAL CORRECTIONS are turned on, then the system asks for the number of data points, 1 to 21, desired. Then, at each of the data points a corresponding + or - correction needs to be entered. Even after correction data has been entered, the correction system can be turned off by selecting 2 = off. Note that if earlier, under Function One, a mathematical transfer function was selected, then the resulting data can be further modified by this user entered Signal Correction data.

```
NUMBER OF CORRECTION POINTS
CORRECTION POINTS? 21
```

The number of sets of points selected, up to twenty one, are 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 one (1), or as many as (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 signal conditioner. 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 Accutech Tech note 204. The next menu item is:

```
FUNCTION TWO      0=NONE    1=SQ
2=SQRT    3=LN    4=LOG
6=EXP     7=EXP10
FUNCTION TWO? 0
```

The selection of another mathematical operation, Function Two, is also possible as the last one to operate on the applied signal. Any one of the operations of square, square root, natural logarithm and its inverse, log to the base 10 and its inverse can be selected. As an example, one can select the Square function as Function One, then apply user entered Signal corrections, and finally use the Square Root function as Function Two. To bypass Function Two and not select any of these operations, enter the numeral 0.

```
LOCAL DISPLAY PRECISION
DIGITS AFTER DECIMAL POINT
0 THROUGH 4 ALLOWED
PRECISION? 3
```

The above menu allows user selection of the number of decimal places indicated on the local display. Note that there are a total of 6 digit positions to indicate the measured variable. Be certain to allocate sufficient number of digit positions to the left of the decimal point to indicate the highest value of the measured variable. For example, to measure up to 150mV requires 3 digit positions to the left of the decimal point. Therefore, the display precision should not be selected higher than 3.

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 signal conditioner will start transmitting 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 engineering units that were previously selected, and ask for entering 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 MA
ZERO? 4.000000000

FULL SCALE? 20.000000000

After these values are entered the signal conditioner returns to the 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 signal conditioner was set to zero = 4.00MA full scale = 20.00MA, then changing the units to OHMS will result in a zero = 4.00OHMS and full scale = 20.00OHMS. One of the advantages of the SC-2000 signal conditioner 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 signal conditioner will transmit 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 signal conditioner is used with a computer. In this case the computer, master, can request information when the computer is ready for it.

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

The signal conditioner can detect numerous sensor failure conditions. These may represent an open slide wire, or input conditions exceeding the specified limits. The response to these detected sensor failures can be selected to be a 3.9mA loop current, 1 = LOW, or 21mA, 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 4mA or to 20mA 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 slidewire, or 3 wire resistance the SC-2000 periodically injects a few micro amperes of current into the sensor to test for an open condition. Some electronic calibrators introduce an error when subjected to such current pulses. By turning off the Sensor Failsafe, one disables these current pulses and erroneous operation of such calibrator units is prevented.

The signal conditioner 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

6.3.5 Options Setup Menu

The SC-2000 signal conditioner can accommodate various size displays for user interface. The most convenient format is a display screen accommodating 24 lines of 40 or 80 characters. If the terminal or computer used to set up the signal conditioner can accommodate 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 signal conditioner will then request a number of additional selections as follows:

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
```

The display self test causes the local display to cycle through a series of patterns for test purposes.

The next selection may be important when the signal conditioner installation is surrounded by power lines, which is most 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 2. This selection may have an effect on susceptibility of the signal conditioner 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. Selecting 2=OFF, leaves the signal conditioner in its normal factory set high speed mode. Selecting 1=ON turns on an additional filter which also increases the update time by a factor of two.

```
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 SC-2000 has the ability to average successive A/D readings to achieve its high level of accuracy. With the exceptional speed of the signal conditioner, this averaging is accomplished very quickly. This Smart Smoothing feature is

different from Damping, as was described above, 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 +/- 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 of the tolerance band, the smoothing function is reset, and the new value is reported out immediately. This insures that any significant change in the process variable is reflected in the signal conditioner output without delay.

The magnitude of the tolerance band is determined on the basis of signal conditioner 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 increments of one second 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 signal conditioner is used in a control loop, it may be desirable to shorten the averaging time of smart smoothing to 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 signal conditioner 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.

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

This selection allows the TAP mode to be turned ON or OFF. Normally the TAP mode is left in the ON state so that the signal conditioner 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 signal conditioner set-up.

```
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 DECIMAL VALUE
T/A CHARACTER? 7

PRINTING T/A CHARACTER
```

The Turnaround System, when activated, causes the signal conditioner 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 signal conditioner 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 signal conditioner in various ways. Selecting 5) TRIM from the CONFIGURATIONS menu will give following sub menu:

```
OUTPUT TRIM MENU
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 the 4mA limit of the loop current. This may be desirable if the precision factory calibration of the signal conditioner's 4.000mA output does not fully agree with the local standard at the site. The display will look as follows:

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 signal conditioner 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 20MA 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 CAL 4MA function. The display will look as follows:

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 it is desired to undo the trim operation that was done and to return the signal conditioner to its initial factory calibrated condition, then function 4) REINITIALIZE is selected from the TRIM menu.

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

MA OUT VALUE? 3.900000
E TO EXIT

The system permits the entry of any mA value within 3.9mA and 21.0mA. The loop current is the set to that value and held until the E key is depressed. After entering the milliampere value the signal conditioner 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. To return to the OUTPUT TRIM menu just press the E key.

To exit from the OUTPUT TRIM menu just enter 5 and press return.

Note that using the Output Trim function voids the NIST traceability of calibration. However, it is possible to reinitialize the signal conditioner back to its original factory trim condition by selecting 4. After selecting "Reinitialize", upon the next restart of the signal conditioner, it will return to its original factory trim.

6.3.7 Wiring Information Menu

Item 6) in the CONFIGURATION menu is an onboard user's manual giving 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:

WIRING INFORMATION
MILLIAMPS
6 MA+ 7 MA-
CASE GROUND 8

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 CORRESPONDING MENU ITEM CANNOT BE ACCESSED

UNLESS THE CORRECT PASSWORD IS ENTERED. REMEMBER YOUR PASSWORD IF CHANGED! When the password is enabled for a particular CONFIGURATION menu item, then 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 a good practice to password protect at least the PASSWORD entry in the CONFIGURATION menu. Once the PASSWORD entry in the CONFIGURATION menu is entered, the following sequence of prompts will be displayed:

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 signal conditioner sends the current password. The user can change this password by typing in any alpha or numeric sequence. When the Return key is pressed the signal conditioner sends the new password as a confirmation. Depressing the Return key a second time brings back the Configuration menu again.

6.3.9 Exit Menu

Selecting item 8) in the CONFIGURATION menu is the method of leaving the Configuration mode and returning the signal conditioner to the Operate mode. Selection 8) is the default in this menu and therefore, once the Configuration menu appears on the screen, pressing the Return key initiates the Exit process. It takes approximately 5 seconds for the signal conditioner to return to its Operate mode. If it is desired to perform additional configuration, then an uppercase P can be entered again once the signal conditioner has returned to the operate mode.

SECTION 7 APPLICATIONS INFORMATION

7.1 SENSOR FAILSAFE DETECTION

The SC-2000 detects a sensor failure condition by making various measurements across its input terminals. As a result of these measurements the unit can detect an open slide wire or an open 2 wire or 3 wire resistor condition. In addition the SC-2000 can also detect if an input is applied that is outside of the specified limits for that type of signal. Any one of these conditions will cause a "sensor failsafe" indication.

In the process of performing sensor failure checks on resistive inputs the unit periodically passes a current, in the range of 5 to 300uA, through the connected resistive element and its connecting wires and measures the resulting voltage drop. One of the conditions resulting in a SENSOR FAILSAFE condition is if this voltage drop exceeds 180mV.

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 "sensor failsafe" condition could be generated. The total resistance of two of the lead wires and the resistive sensor should not exceed the specification of 1000 ohms.

7.2 SIGNAL TRANSFER FUNCTIONS

The SC-2000 has some exceptionally powerful capability to alter the relationship between the input signal and the resulting output. This relationship is normally referred to as the transfer function of the instrument. In this part of the manual some examples are given to illustrate how these various mathematical operations and user entered custom transfer functions can be used.

In its simplest form, when all of the special functions are turned off, the output loop current of the signal conditioner is linearly related to the applied signal input. This can also be made into an inverse linear relationship by setting the 4.0mA output to correspond to a higher input signal and the 20.0mA output to a lower input signal.

The user can modify this linear relationship by entering one or more (up to 21) correction points and thus creating a custom transfer function. This is done by enabling the Input Corrections in the Input Setup menu, see paragraph 6.3.3. Tech note #204 gives a detailed description on the use of these custom input correction points. Although, Tech note #204 is written specifically for temperature transmitters, the use of this feature is identical in the SC-2000 signal conditioner.

The Input Setup menu of the SC-2000 offers a choice from various mathematical functions, such as Square, Square Root, Log, and natural Ln. Any one of these functions can be enabled to operate on the input signal. These mathematical functions operate on the signal in the engineering units which are appropriate for the type of signal selected. For example when Millivolt input is enabled then the math function operates on millivolts in the range of -15.0mV to +160mV. If Voltage input is enabled then the math function operates on the signal in the range of -0.5V to +5.0V.

The following is an example on the use of the Square function to operate on the input signal. Assume that the SC-2000 is set to Millivolt input and Function One is set to the Square function. Now if we apply a signal to the millivolt terminals and observe the digital output on the HHT-420 hand held terminal, we will see the following relationship:

Input	Digital Out
-10mV	100
+0mV	0
+10mV	100
+20mV	400
+30mV	900
+40mV	1600
+50mV	2500

Note that a -10mV signal gives the same 100 digital indication as a +100mV signal. This of course is consistent with the application of this mathematical function. Now, as the next step, let us set the 4.0mA output current to equal 0.0 digital output and the 20.0mA output to correspond to 1600 digital output. We now expand our table to show these results.

Input	Digital Out	Analog Out
-10mV	100	5.0mA
+0mV	0	4.0mA
+10mV	100	5.0mA
+20mV	400	8.0mA
+30mV	900	13.0mA
+40mV	1600	20.0mA
+50mV	2500	20.0mA

Now we can observe that the output "pegs" at 20.0mA and an input of 50mV continues to produce the same 20.0mA as 40mV.

We can take this exercise one step further, and enable the user defined Input Corrections. Select 7 correction points. When the menu asks for Indicated Value? enter the numbers under Digital Out from our table, as seen below. For Corr. (Offset)? enter some desired set of numbers like those in the same table below.

Input	Digital Out	Correction	Analog Out
-10mV	100	+16	5.16mA
+0mV	0	+8.0	4.08mA
+10mV	100	+5.0	5.05mA
+20mV	400	+1.0	8.01mA
+30mV	900	-12	12.88mA
+40mV	1600	-40	19.60mA
+50mV	2500	-85	20.00mA

When the user defined Input Corrections are applied, the system interpolates linearly between two adjacent points. Usually the function that is approximated in this manner is smooth, rather than consisting of multiple line segments. For this reason, a custom curve can be most accurately represented by using the largest number of correction points.

In the above example, we have enabled the First Function and selected Square. We could have selected the Square Root instead, or any of the other functions available. It is often useful to prepare a table, like the one used in the above example, to determine how the analog output should be zeroed and spanned.

The SC-2000 has two sets of mathematical functions, Function One and Function Two. A selection made from Function One operates on the signal first. If the Input Corrections are enabled, these operate on the results of Function One. If a selection is made from Function Two then the results of the Input Corrections are operated upon by the selected Function Two. This ability to operate on the signal consecutively by different functions provides an exceptionally powerful linearization capability for most sensor signals encountered.

7.3 SMART DIGITAL SMOOTHING

The SC-2000 employs a feature known as smart smoothing to provide a highly accurate and stable output. Accutech's smart smoothing can filter out noise from the signal. It is very common in many installations for signals to be noisy. The noise may originate from the sensor or signal source, or picked up by the wiring from the sensor to the signal conditioner, and finally the electronics of the measurement circuit may exhibit some amount of random noise. At the same time, significant amount of damping or integration introduces undesirable delays into the system. The

SC-2000 can fix this by smoothing out noise of a predetermined magnitude while reacting immediately to a change in signal that exceeds the predetermined noise band. This action can best be seen in figure 7-1 showing how the output responds to varying input signals.

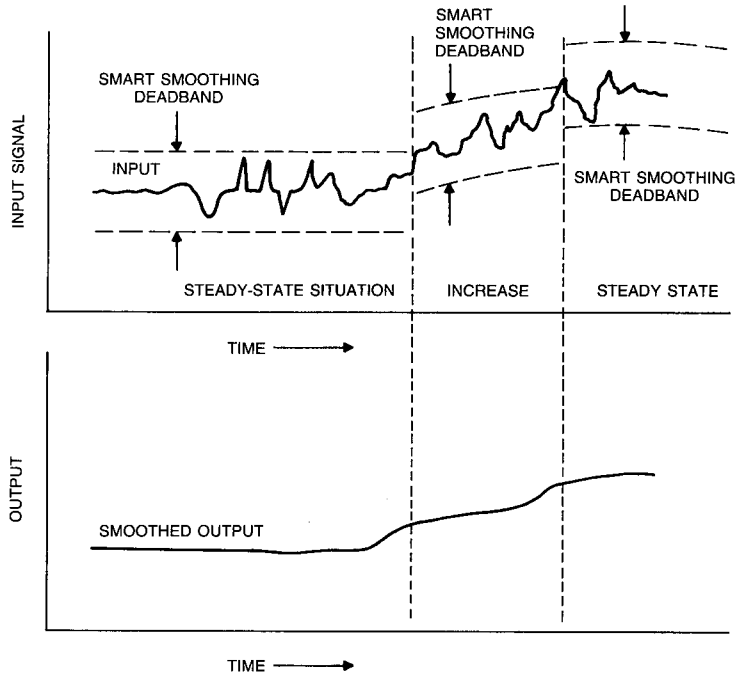


Figure 7-1
Illustration of Accutech's Smart Smoothing

Smart smoothing is a digital filtering algorithm which is active for a fixed band of input signal fluctuations. As long as the input signal fluctuates only within this smoothing band, the signal is averaged and produces a stable and smooth output. The upper and lower limits of the smart smoothing dead band shifts with the averaged signal as this signals changes. Therefore, smart smoothing continues to be active for such slowly changing signals.

When there is a more rapid change in the input signal, the smoothing dead band is immediately exceeded, and the output of the signal conditioner assumes the correct new value within one second. As long as the signal fluctuates with an amplitude greater than the dead band, the output keeps following this signal without any delay. Once the signal settles down to its new value, smart smoothing automatically takes effect again, and the output signal becomes stable and accurate.

The smart smoothing dead band in the SC-2000 is normally a very small fraction of the selected input range. As an example, when millivolt input is selected, the smoothing dead band is automatically set to approximately +/-15 micro volt. Other input types would have a different dead band in their appropriate engineering units.

However, the SC-2000 provides a facility to change this dead band to any desired value in term of the engineering units of the input selected. The dead band can be reduced to zero, or it can be increased to be a substantial percentage of the signal range. This facility allows the user to tailor the noise immunity of the transmitter to the prevailing conditions in any installation. In an environment that is heavily polluted with electrical noise, the user may experiment with the setting of the smart smoothing dead band until the noise is filtered out yet the signal conditioner still exhibits a fast response to rapidly changing signals.

The smart smoothing dead band is adjusted by using digital communications and entering the Input Setup menu. Under Function One select 5 Smooth. When the system asks for Deadband? enter the desired dead band in terms of the engineering units appropriate for the type of input. To return the SC-2000 to its factory set dead band, just do not select Smoothing under Function One.

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 manufacturers implementing it.

In this section we give a more specific example so the first time user of an SC-2000 may establish a digital communications link with the minimum of problems. A personal computer, PC or XT or AT or compatible is selected as the data terminal, for it is probably the most readily available standard hardware. A simple data communications program is provided on a 5.25" floppy diskette with the purchase of a CA-100 interface to emulate a data terminal on the computer.

Connect the SC-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 SC-2000 signal conditioner, and the BLACK lead to the -OUT terminal.

Connect the DB-25 connector of the CA-100 to the COM1 serial port of the IBM PC or compatible computer. Note that with an AT computer the serial port may be a nine pin rather than a 25 pin connector. In that case use a nine pin to 25 pin adapter cable available for those computers. The DB-25 male connector on the CA-100 Communications Interface module should directly plug into its DB-25 female counterpart on the computer. If both connectors are of the male configuration, then an adapter is generally available at most electronic stores. 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 available to use in place of the CA-100 and a personal computer.

7.4.1 Computer Setup

For this demonstration the computer must emulate a "dumb" terminal.

Place the diskette 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

From the Configuration sub menu set

1	Baud rate	300
2	Word Length	8 Bits
3	Stop Bits	2 Bits
4	Parity	1 None
5	Serial Port	1 COM1
6	Exit Configuration	

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

Now the computer is set up to behave like a terminal and should be able to communicate with the SC-2000. Connect the CA-100 to the COM1 port on the computer. Follow the signal conditioner hookup described in paragraph 6.2.4, Signal Conditioner Output Connections. Depress the CAPS LOCK key so that only capital letters are generated. This is important because the SC-2000 recognizes only capital letters.

You must remember to press the F1 key in order to get out or quit.

7.4.2 Operation

Turn on the 24 VDC power supply and wait for approximately 30 seconds for the SC-2000 to enter its normal operate mode.

Now hit 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 should show the response from the signal conditioner 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 the 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 we will suggest 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 signal conditioner 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 signal conditioner is connected.

Check the connection for correct polarity. The positive side of the power supply must be connected to the +OUT (10) terminal of the signal conditioner either directly or through a 250 ohm resistor. The negative side of the supply connects to the -OUT (9) terminal of the signal conditioner.

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

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

If the loop current is jumping between about 12 mA and 23 mA every second, then the signal conditioner 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 signal conditioner 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.
* 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. (ie. 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".

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 near zero, or positive potential is a sign of problem. Try then reversing the leads on terminals 2 and 3.If all else fails, factory support is available to provide further technical guidance.

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

SECTION 8 ACCESSORIES & INFORMATION

Other accessories available from Accutech are:

HHT-420	Hand Held Terminal
CA-100	Communications Interface
LD-2	Local Display
KB-2	Keyboard
XP-HDC2-L	Explosion/Weather proof Housing with mounting lugs (No Display Option)
XP-HDGC2-L	Explosion/Weather proof Housing with mounting lugs (Display Option)
PM-100	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

A variety of temperature transmitters, 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 AI-2000 Smart Transmitter, Custom Calibration Correction

Tech note #206 Data Terminals

SECTION 9 SPECIFICATIONS

INPUT TYPE & RANGE:

DC Milliamp	-5.0	to	+60.0mA
DC Millivolt	-15.0	to	+160mV
DC Volt	-0.5	to	+5.0V[1]
Potentiometer, 3 wire	0.0	to	1.0Kohm[2]
Resistance, 2- or 3-Wire	0.0	to	1.0Kohm[2]

[1] 10.0 VDC available, consult factory
[2] 10Kohm available, consult factory

INPUT RESISTANCE

DC Milliamp	2.75 ohms
DC Millivolt	>10M ohms
DC Volt	1.0M ohms

ISOLATION: 850 VDC or peak AC

LINEARIZATION: Square, square-root, log, and ln to +/-0.05% of input. Custom linearization user programmable at 21 points. Two selected functions and custom linearization can operate on the input signal.

OUTPUT: Analog, Two wire 4 to 20mA
Digital, Two wire (RS-232, 300 baud with CA-100 Adaptor)

OUTPUT RANGING ADJUSTMENTS:
Analog Zero: }{100% of sensor range, non interacting
Analog full-scale: }{normal or Reverse Acting
Digital Mode: °C,°F,°K,°R,mV (No ranging required)

MINIMUM OUTPUT RANGE: None

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

ACCURACY: Includes repeatability, hysteresis, load and ambient temperature effect and uncertainty of factory NIST traceable calibration equipment. Enhanced accuracy calibrations available from the factory.

Digital Output Accuracy:
+/-0.04% of the millivolt or ohm equivalent reading, or the accuracy from the table below, whichever is greater.

Input Type	Accuracy
Milliamp	+/-0.005mA
Millivolt	+/-0.008mV
Volt	+/-0.003V
Resistance	+/-0.12ohm

Analog Accuracy: Digital accuracy plus +/-4uA

REPEATABILITY: One half of accuracy specification.

REFERENCE CONDITION ACCURACY:
One-half of the accuracy specified above. When set-up in the "Tap" Mode, the SC-2000 is referenced to the prevailing conditions. Accuracy at this reference condition includes repeatability, linearity, and hysteresis effects. Reference condition accuracy is comparable in scope to the "Accuracy" or "Calibration capability" generally specified for analog based signal conditioners.

DYNAMIC RESPONSE:
Turn On Time: Less than 5 seconds after power up
Changing Ambient Temp.: Auto comp to 20°C/Hour change.
Update Time: 0.15 Seconds; Digital, 1 second
Step Response:Analog: 0.25 Seconds, Typical
Digital: 1 second, typical, to 95% of final value
5 seconds to stated accuracy

SPECIFICATIONS (CONTINUED)

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

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

AMBIENT TEMPERATURE STABILITY: Self-correcting over the operating temperature range.

LONG TERM STABILITY: Less than 0.05% of reading plus +/-2.1uA per year.

AUTOMATIC DIAGNOSTICS: Every 3 seconds the SC-2000 signal conditioner performs self-checks for zero, span, each open resistance sensor lead, signal over range condition and signal conditioner malfunction.

FAILSAFE: Analog, user settable to 21mA, 3.9mA, or OFF Digital, message or OFF.

INTERCHANGEABILITY: All units interchangeable without field calibration

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

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)+(Rload in Kohm) x (23mA)
For digital operation R_{load} =250ohm min.
Supply Voltage Effect: < +/-0.005% of Span per Volt

WEIGHT: 12 oz.

STANDARD CONFIGURATION:
Factory configured as a loop isolator for 4.00mA to 20.00mA input. Configurations can be user performed. Custom factory configurations available to suit your requirements. See price list.

OPTIONS: LD-2 Local Display, KB-2 Keyboard, Sensors, Probes, and Thermowells. See price list.

ORDERING INFORMATION: Please order Model SC-2000. Specify any custom configuration, if desired. Order companion products as required.

PACKAGING: The SC-2000 is packaged in a rugged, nickel plated, aluminum enclosure suitable for mounting on a flat surface. The metal enclosure is totally sealed against moisture and provides excellent immunity to the effects of electromagnetic interference (EMI/RFI). For hazardous environments, the SC-2000 will fit within an available explosion proof housing.

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LIMITED WARRANTY

This warranty is in lieu of all other warranties, expressed or implied.
The Accutech 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 recalibrate, 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 Adaptive Instruments Corporation or its operating division, Accutech, 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 recalibration 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.

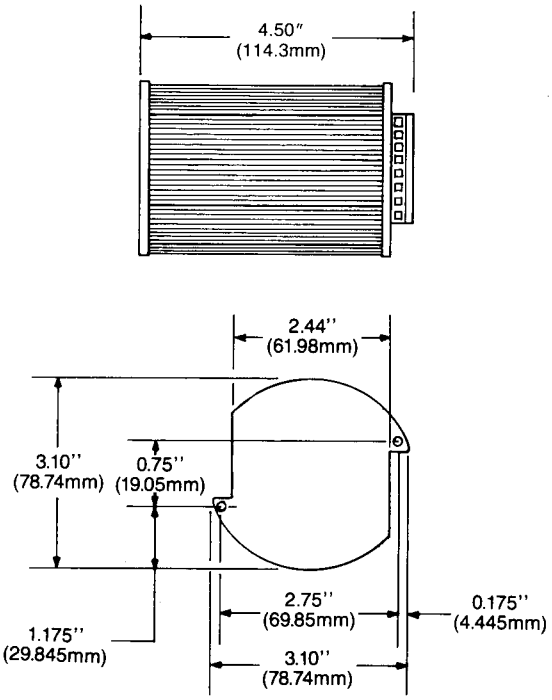

Figure 9-1
Mechanical Dimensions

Accutech

Smart Process Instrumentation

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