

MODEL 4212C

INSTRUCTION MANUAL

Table of contents

		Page
	1. GENERAL INFORMATION	
1	1.1 FEATURES	1
	1.2 INSTRUMENT IDENTIFICATION & OPTIONS	2
	1.3 TECHNICAL SPECIFICATIONS	3
	1.4 WARRANTY	6
	1.5 UNPACKING AND SHIPPING	6
	1.6 PRELIMINARY CHECK OUT	6
	2. STANDARD OPERATION	11
	2.1 SENSOR CONNECTION	11
	2.2 POWER CONNECTION	11
	2.3 MATCHING THE INSTRUMENT TO A SPECIFIC SENSOR	12
	2.3.1 Identifying ITS-90 Sub Ranges and Coefficients	12
	2.3.2 Formatting the ITS-90 Coefficients	12
	2.3.3 Programming the Coefficients into Memory	13
	2.3.4 Programming Examples	15

17	2.4	CHECKING CURRENT SENSOR COEFFICIENTS	
18	2.5	MAKING TEMPERATURE DIFFERENCE MEASUREMENT (ΔT)	
19	2.6	CHECKSUM VERIFICATION OF PROGRAMMED VARIABLES	
	3.0	OPTIONS	21
	3.1	RS 232C INTERFACE (OPTION 14)	21
	3.1.1	Programming 4212C Communications Parameters	21
	3.1.2	Operation with a Printer	24
	3.1.3	Operation with a Computer	24
	3.1.4	Summary of 4212C RS-232C Commands	33
	3.2	IEEE-488 INTERFACE (OPTION 15)	35
	3.2.1	Talk Only Mode	35
	3.2.2	Operation with IEEE-488 Controller	36
	3.2.3	Summary of 4212C IEEE-488 Commands	49
	3.3	REDUCED SENSOR EXCITATION CURRENT (OPTION 16A)	53
	3.4	USING SENSORS WITH R_o 'S OTHER THAN 10, 25 AND 100 OHMS (OPTIONS 18, 19, AND 20)	54
	3.5	ANALOG OUTPUT (OPTION 08)	55
	3.5.1	Analog Output Parameters	56
	3.5.2	Checking or Programming the Analog Output Parameters	56
	3.5.3	Analog Output Interface Commands	57
	3.5.4	Reading the Currently Programmed Analog Output	

3.5.5	Example of Programming via RS-232C Interface	59
3.5.6	Example of Programming via IEEE-488 Interface	60
3.6	IMPROVED RESOLUTION TO 0.001°C AND 0.001°F (OPTION 27)	61
	Page	
3.7	IMPROVED RESOLUTION TO 0.001°C, 0.001°F 0.0001 Ω (OPTION 33)	plus 61
4.	CALIBRATION PROCEDURES	62
4.1	Calibration of Ohmmeter Section	62
4.2	Verifying Resistance to Temperature Calculations	65
4.3	Spot Check of System Accuracy	66
5.	THEORY OF OPERATION	68
6.	TROUBLESHOOTING	71
7.	PARTS LIST	73

SCHEMATICS & ASSEMBLIES

MODEL 4212C

INSTRUCTION MANUAL

LIST OF ILLUSTRATIONS

Figure		Page
1a,b,c	Case Outline Drawing	7,8,9
2	Top View of Instrument Showing Programming Switches	10
3	Close up of S2 Showing Sensor Coefficient Programming Switches	13
4	Close up of S2 Showing RS-232C Switches	22
5	Close up of S2 Showing IEEE-488 Switches	38
6	Close up of S2 Showing Analog Output Programming Switches	56
7	Close up of S2 Showing Zero Offset Correction programming Switches	63
8	Ratio Measuring Techniques	69

Power Supply Schematic

Analog Schematic

Digital Schematic #1

Digital Schematic #2

Display Schematic & Assembly

RS-232C Schematic & Assembly

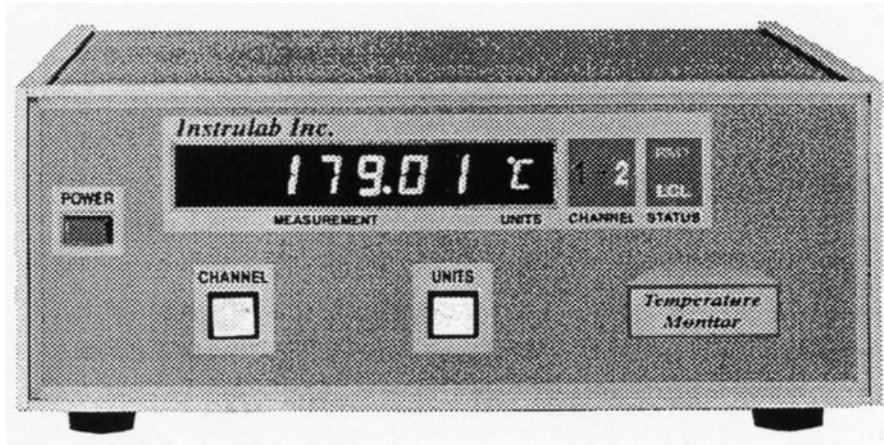
IEEE-488 Schematic & Assembly

Analog Out & RS232C Schematic & Assembly

Analog Out & IEEE-488 Schematic & Assembly

Master P.C. Board Assembly

1. GENERAL INFORMATION



1.1 FEATURES

The Instrulab programmable Platinum RTD Temperature Monitor utilizes microprocessor technology to produce a stable, high accuracy instrument with simple "customized" calibration capability. "Customized" calibration provides the ability to digitally calibrate the instrument to match the specific calibration curve of a Platinum RTD to optimize system accuracy. The use of nonvolatile RAM (Random Access Memory) allows the instrument to be easily programmed by simply entering the Platinum RTD sensor coefficients into memory.

The features include:

(See options on page 2 for additional features)

- Programmable Calibration
- Accepts Either 10, 25 or 100 ohm Platinum RTD Sensors
- Either Front Panel or Remote Selection of two different sensors, each with its own calibration program
- Extremely Accurate; +0.01 to 0.03°C
- Wide temperature Range; -218°C to +962°C
- °C or °F or Resistance in Milliohms
- Resolution and Repeatability of 0.01°

1.2 INSTRUMENT IDENTIFICATION AND OPTIONS

The instrument model number, serial number and other pertinent data is given on the rear of the instrument. The model number will appear as:

4212C- - - Etc,

Model Options

Option number	Description
06	Rack/Panel Mount Brackets (pair)
07	Instrument Wired 230 Volt Operation.
08	Analog Output
14	RS-232C Interface
15	IEEE-488 Interface
16A	Reduced Sensor Excitation Current
18	Using a Sensor with an R_0 of 200 ohms
19	Using a Sensor with an R_0 of 400 or 500 ohms
20	Using a Sensor with an R_0 of 1000 ohms
27	0.001°F or °C Resolution. Ohms resolution remains at 0.001 ohms.
32	Resistance Range Extension to 410 Ohms to accommodate 100 Ω R_0 Sensors which operate to 850°C
33	0.001°F or °C Resolution plus ohms resolution to 0.0001 ohms.

1.3 TECHNICAL SPECIFICATIONS

(See options on page 2)

Instrument Range -218.00°C to 962.00°C or
 (See Note Page 4) -360.00°F to +1765.00°F
 or 0.000 to 340.000 ohms

Instrument Uncertainty (Single Measurement Mode) @ 23°C+3°C	±0.10°C (+0.18°F) for 10 Ohm Sensors
Calibration in Accordance with ITS-90	±0.03°C (+0.06°F) for 25 ohm sensors
(Also see option 27	and option 33 on page 61)
±0.02°C (0.04°F) for	100 ohm sensors
	±0.002% of reading in ohms
or +0.003 ohms, whichever is greater.	
Instrument Uncertainty (Delta T Mode) channel 1 in °F or °C ohms with virtually no error.	±1 LSD; The instrument subtracts channel 2 from or
Short Term Uncertainty hour with constant line voltage and ambient temper- ature after two hour warm-up.	±0.01°C (+0.02°F) for one
Calibration Check Interval	1 Year
Resolution and Repeatability scales, 0.001 on ohms	0.01° on both °C and °F
Excitation Current	1 milliamp DC (nominal)
Sensor Type 25 ohms or 100 ohms.	Platinum RTD R ₀ = 10 ohms, Any Alpha from (nominally) 0.00385 to 0.003925
Sensor Coefficients sensor coefficients, the number of which are dependent on the sub- range. 5° to 45°C	Rtp plus the required 3perating Ambient Temp.
Non-operating Ambient Temp.	-20° to +65°C
Humidity condensing	Less than 80% non-

Warm-up Time turn-on, optimum performance after 2 hours.	Within specifications upon
Temperature Coefficient (Reference 23°C ambient) ambient change or +0.003 ohms for a 20°C change in ambient temperature, whichever is greater.	±0.0003% of reading in ohms per degree Celsius
Display digits plus F, ohms, C and polarity indicator. Also "Channel" indication along with "Local" or "Remote" control status.	0.4" high red LEDs: six
Display Update (single measurement). (Delta T measurement).	Approximately every second From 1 to 3 seconds
Display Overrange input over 340 ohms	Display reads EEEEEEE for
Weight	Net 9 lbs. (4kg) Shipping 12 lbs. (5kg)
Power optionally, 50/400 Hz, VA nominal, supplied with a six foot 3 wire line cord.	115 VAC standard, 230 VAC 12
Size	3 1/2" High x 8 1/2" Wide x 11 3/8" Deep, Half Rack

NOTE

The 962 °C temperature limit listed on page 3 pertains to the Rosemount model 162W 10 Ω Ro sensor which uses ITS 90 coefficients a, b, & c only. The R vs. T for this sensor is extrapolated above 660 °C. However due to the excellent smoothness of ITS 90 an additional error of only .05 °C is incurred when compared to the uncertainty that would result if a "d" coefficient were used.

INTENTIONALLY
BLANK

1.4 WARRANTY

Instrulab warrants its products to be free from defects in material and workmanship for one year after date of shipment, provided the units have been used within published ratings. The warranty is limited to our repairing or replacing without charge, F. O. B. our factory any defective product if returned to our plant, transportation prepaid. No other representation or warranty, either expressed or implied, is made, and in no event shall Instrulab be liable for consequential or other damages.

1.5 UNPACKING AND SHIPPING

After having unpacked the instrument, carefully examine it and any enclosed accessories for physical damage and compliance with the packing list. If any of the articles are missing or damaged, inspect the packing case for signs of damage or theft during shipment and immediately report it to the carrier.

If it should become necessary to return the instrument to Instrulab, use the original packing material, if possible.

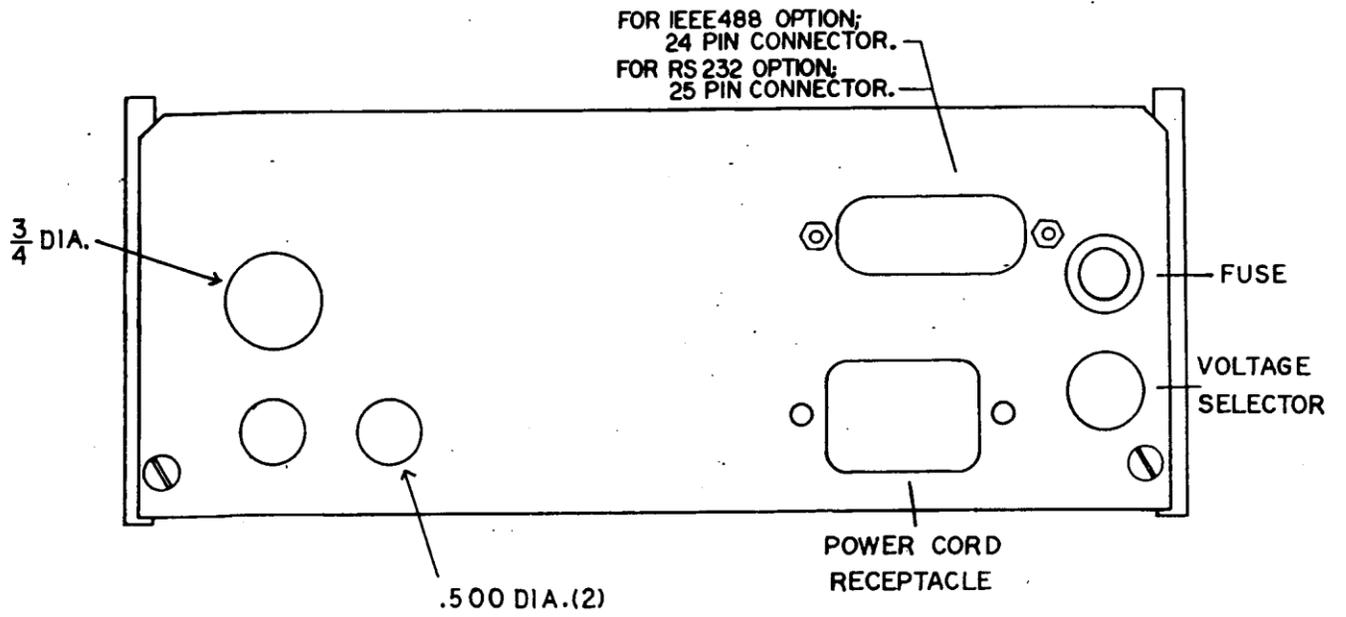
When returning instruments to the factory, give a full description of the failure and the mode of operation that was used when the instrument failure occurred. Please include the name and phone number of someone we can contact, should we have any questions. Ship via UPS or parcel post prepaid to:

Instrulab
1205 Lamar Street
Dayton, Ohio 45404

1.6 PRELIMINARY CHECK-OUT

Please use the following procedure before applying power for the first time:

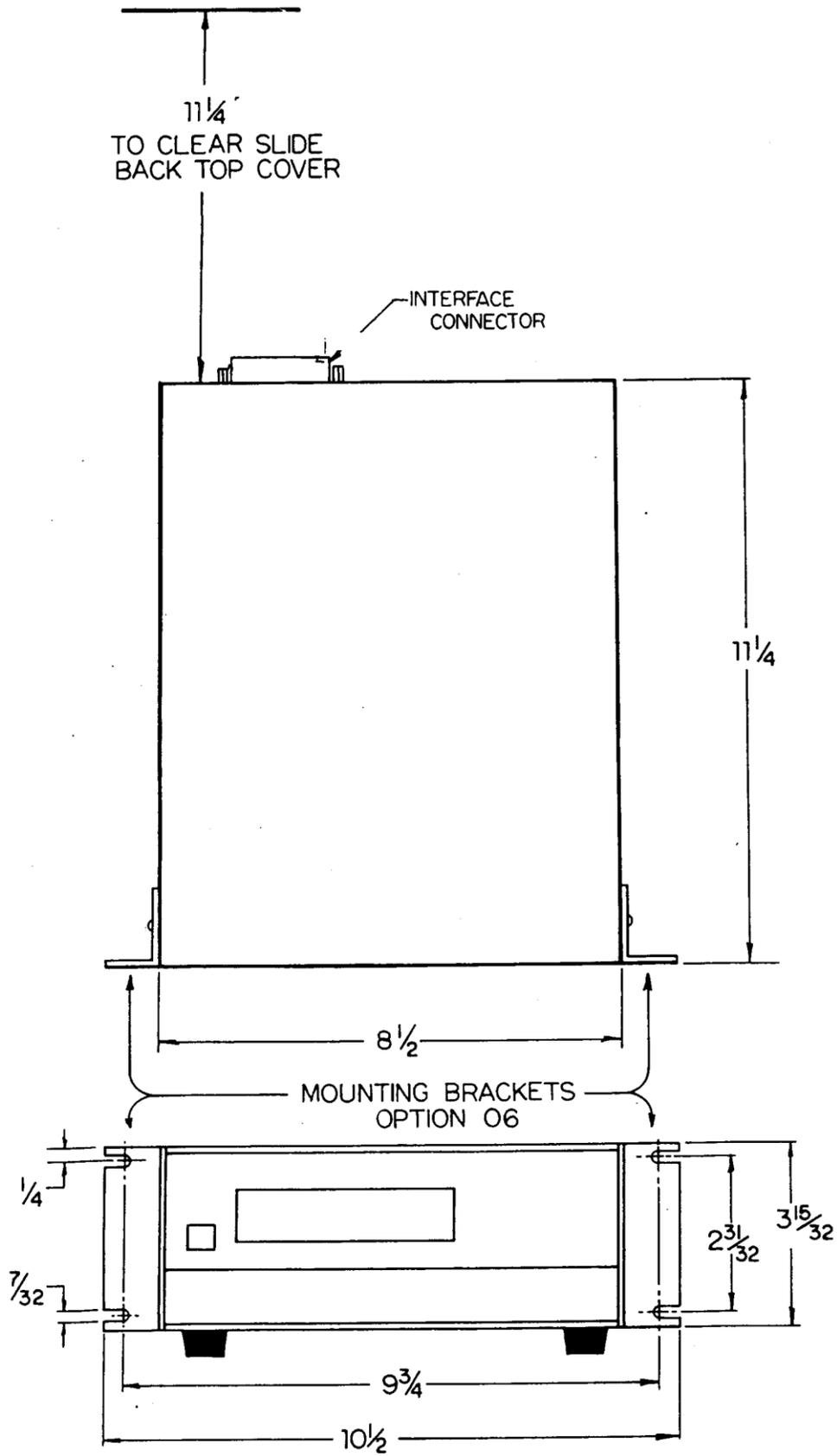
1. Remove the two top screws at the rear of the case.
2. Slide the top cover to the rear to inspect the instrument.
3. Verify that the vertical board(s), Display Board and option Board(s) and their cables are properly seated in their connectors.



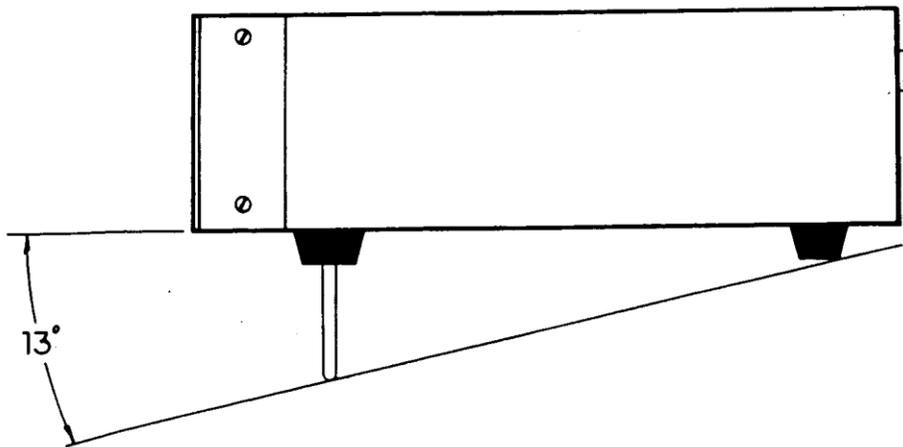
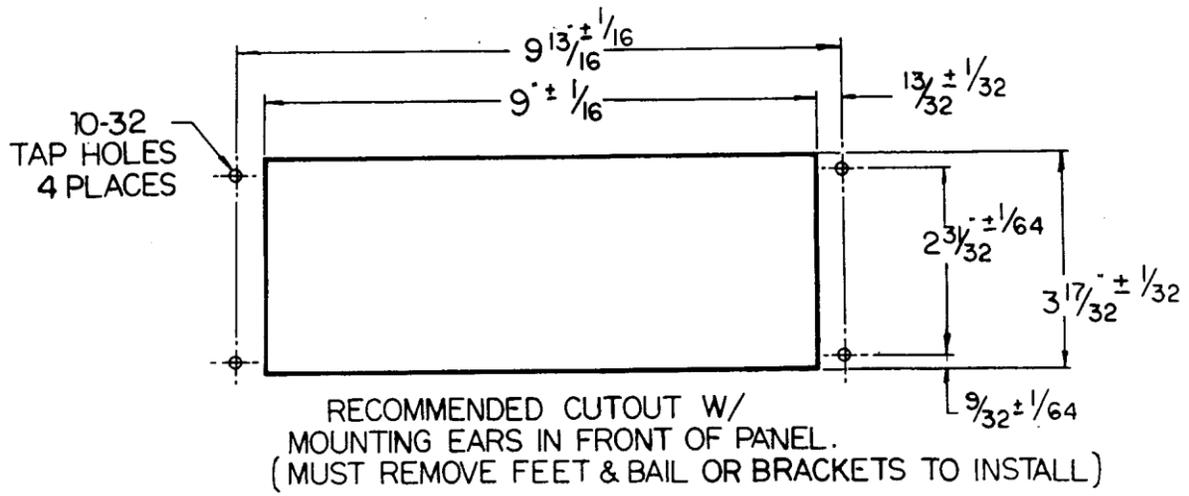
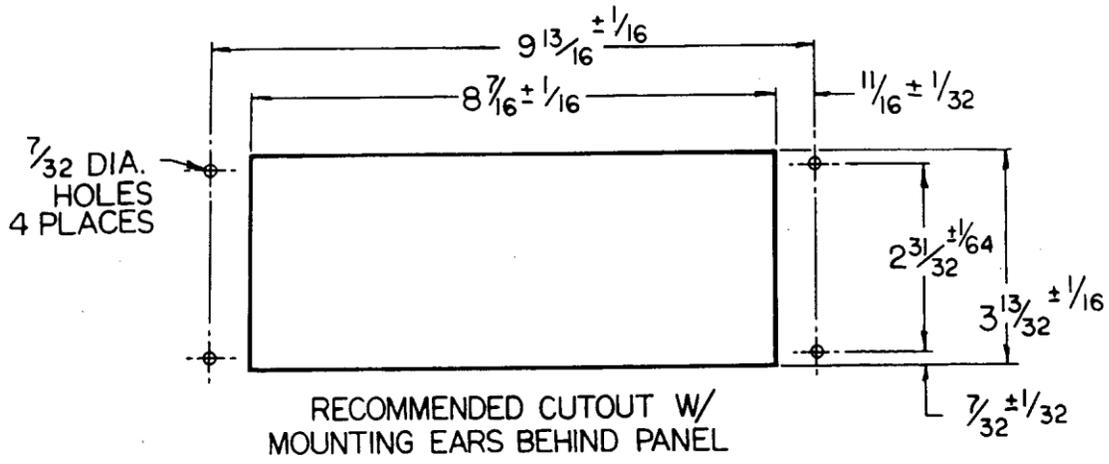
Back View

Case Outline Drawing

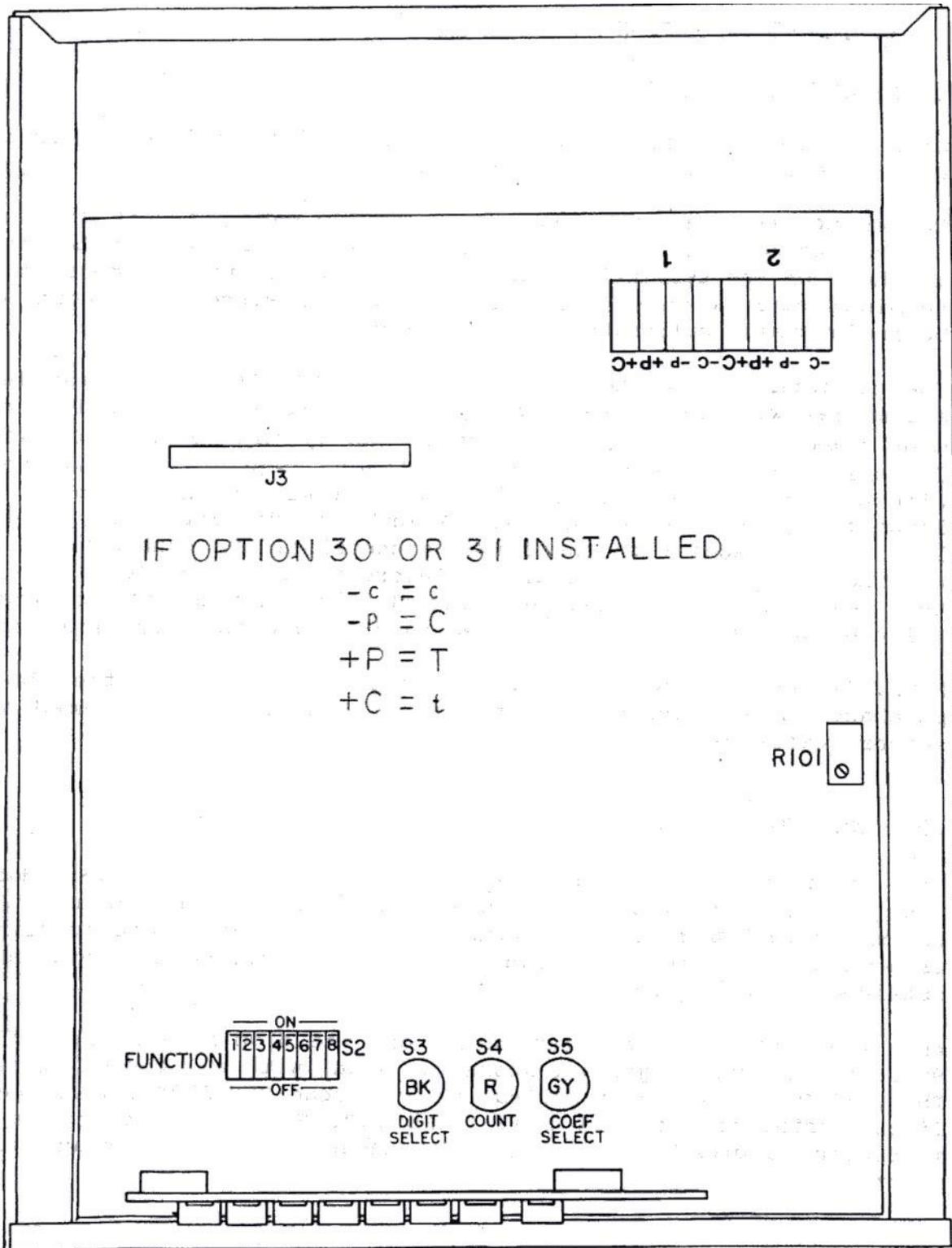
Figure 1a



Case Outline Drawing
Figure 1b



Case Outline Drawing
Figure 1c



TOP VIEW

Top View of Instrument Showing Programming Switches
Figure 2

2.0 STANDARD OPERATION

2.1 SENSOR CONNECTIONS

Sensors are connected to a terminal strip that is located directly under the top cover of the instrument

To connect the sensor leads, remove the top cover, insert the leads through the hole in the back panel and connect to the four terminals as shown on the terminal strip diagram. Note the input number on the terminal strip when making your connections, since each input will be individually calibrated to a specific sensor.

The terminals are marked -c, -p, +P, and +C. If your sensor leads are marked with the letters -c, -p, +P, and +C such as the Instrulab models 840 or 832, simply connect to the terminals as indicated. If your sensor has four unmarked leads, connect the two leads with a common connection to the -c & -p terminals and the other two leads to the +P & +C terminals. The order is not important, just as long as the leads with the common connections are connected to the terminals with a common polarity. Interchanging of leads -p & -c or the leads +P & +C will not affect the instrument's accuracy. Failure to use a four-lead system will result in a reading error.

NOTE: If sensor(s) were purchased from Instrulabat the time of purchase of the instrument, the unit will be preprogrammed with sensor coefficients.

2.2 POWER CONNECTION

The standard model is designed to operate 115 VAC +10%. Models designed for 230 VAC operation contain the option number 07. We recommend that a 3 wire U-ground receptacle be used. The instrument is within rated specification at turn on. Optimum performance is obtained after 2 hours.

When the instrument is first turned on, the display will read "ItS90", then it will light all segments, along with all decimal points. Then, if Option 14 is installed, it will read "rS-232" or, if Option 15 is installed, it will read "IEEE 07". The two numbers are the instrument address. Instrument will then commence to read sensor input.

2.3 MATCHING THE INSTRUMENT TO A SPECIFIC SENSOR

2.3.1 IDENTIFYING ITS-90 SUB RANGES AND COEFFICIENTS

1. Instrument can be programmed for any range or sub range that falls within the limits of:

-218.7916°C (TP of Oxygen) to +660.323 °C (FP of Aluminum)
(See note page 4)

2. The actual range depends on the calibration of your sensor and may be negative temperatures, positive temperatures or a combination of both.

3. The following table lists the "a, b, and c" coefficients for various sub ranges that may be programmed into the instrument.

LOWEST CALIBRATION TEMP. IDENTIFICATION °C	HIGHEST CALIBRATION °C		INSTRULAB ASSIGNED COEFFICIENT							
	°C	°C	TEMP. 0	1	2	3	4	5	6	
	0.00	to 962	Rtp	a7	b7	c7	(See note page4)			
	0.00	to 660	Rtp	a7	b7	c7	-	-		
-	0.00	to 419	Rtp	a8	b8	0	-	-		
-	0.00	to 231	Rtp	a9	b9	0	-	-		
-	0.00	to 156	Rtp	a10	0	0	-	-		
-	-38	to +0.01	to 29	Rtp	a5	b5	0	-	-	
-	-189	to +0.01		Rtp	-	-	-	a4	b4	0
-	-218	to +0.01		Rtp	-	-	-	a3	b3	C1

Rtp = Resistance of sensor at the triple point of water, i.e. +0.01°C.

2.3.2 FORMATTING THE ITS-90 COEFFICIENTS

1. The coefficients received with your sensor(s) should appear similar to the following example.

Sub range = -189 to +500°C (419°C)

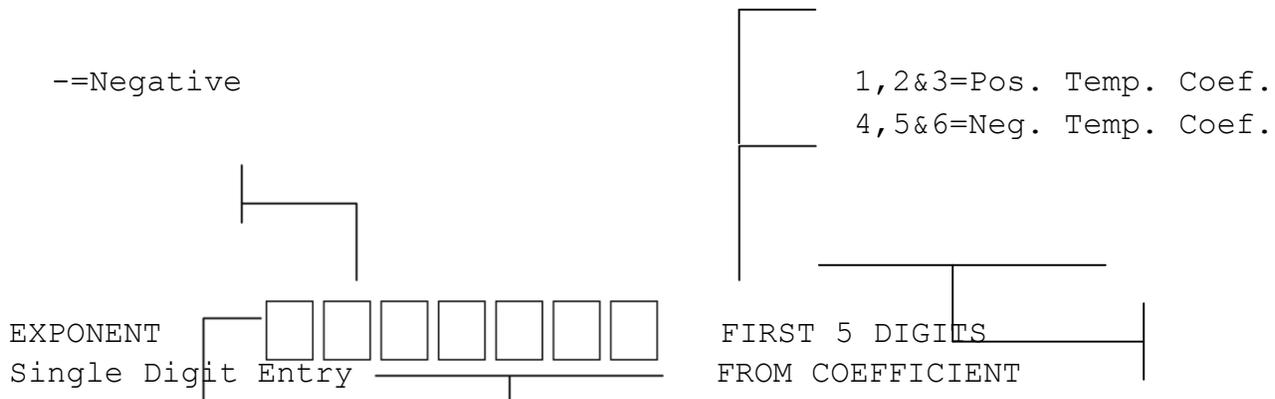
```
Rtp = 25.4768 ohms
a4 = -1.6448498E-04
b4 = -5.2486782E-04
a8 = -9.2035954E-06
b8 = -1.1031022E-04
```

2. Entry of Rtp is directly as listed. Be sure to observe decimal point.

3. The required format for coefficient entry is as follows:

COEFFICIENT POLARITY
P=Positive

COEFFICIENT ID#
0=R_{tp}



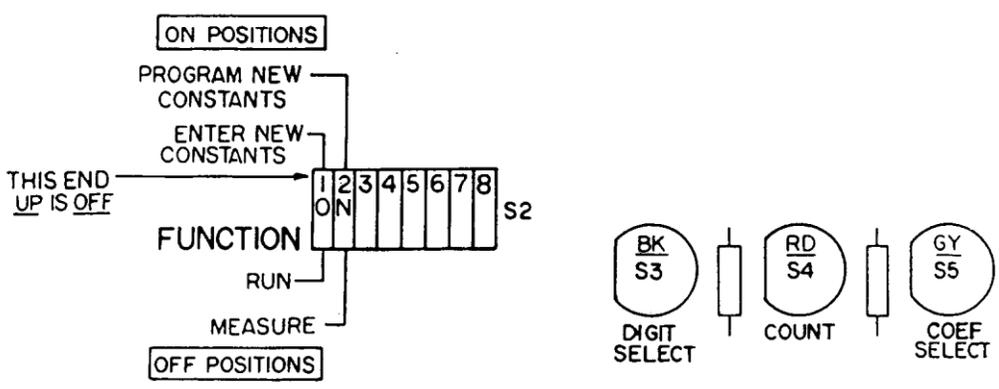
NOTE that correct formatting of the Coefficients requires the relocation of only the exponent to the beginning of the string.

2.3.3 PROGRAMMING THE COEFFICIENTS INTO MEMORY

Since the two inputs (input 1 & 2) are digitally independent of each other, the programming procedure must be performed for both inputs. Select the desired input using the front panel input selection switch and proceed with the programming, then depress the input switch to change the input selection and proceed to program the second sensor.

First remove the two top cover retaining screws and slide off the top cover, then turn on the power. A warm-up period is not necessary since only the digital coefficients are being programmed. Now locate the function switch and the black, red, and gray pushbutton switches, near the front of the instrument. (See Figure 2 for component locations.)

At this time, [prior to programming] the FUNCTION switch, positions #1 and 2 should be in the "off" position. See Figure 3.



Close up of S2 Showing Sensor Coefficient Programming Switches Figure 3

1. Move the FUNCTION switch, position 2 to the "on" position. A small number "0" should appear in the far right hand side of the digital display. This indicates that Rtp, is ready to be programmed. You will also note that the far left hand digit is flashing This indicates that this digit will accept a change in numerical value. Use the RED COUNT button to change this digit to the number desired.
2. After the first digit is programmed, advance to the second digit by pressing the BLACK DIGIT SELECT button. The second digit should now flash. Now program the number for this digit just like the first digit, using the RED COUNT button.
3. Now program the rest of the digits using the BLACK and RED buttons, until all digits have been programmed.
4. To move to the next constant, press the GRAY COEF SELECT button. The number "1" should appear in the far right hand side of the display and the first digit should be flashing.
5. Proceed using the GRAY, RED, and BLACK push buttons until all coefficients are programmed. You will notice that each time the GRAY button is pressed, the number at the far right hand side will change, from 1 to 2 to 3, etc. until all coefficients have been programmed.
6. After all the coefficients have been programmed, press the GRAY button once more. All digits should stop flashing and the instrument should indicate "rEAdY".

NOTE

If you are aware of an error in programming one or more of the coefficients, continue with the programming procedure, then go back through the procedure a second time and make your changes. This technique allows you to retain the coefficients that are correct and change only those coefficients that are incorrect .

7. Go back to the FUNCTION switch, S2, and move position 1 to the "on" position and then move it back to the "off" position. The display will read "buSY". After about 1 second, the display should change to "donE".

During the 1 second pause, the instrument programs the sensor coefficient data, that you programmed, into the non-volatile memory and checks to see if the information was programmed properly. If it was programmed properly, the instrument will respond with the word "donE" on the display. If the data was not programmed properly, a number followed by the word "Error" will appear on the display. if this should happen, turn the instrument "off" then back "on" again and return to step 1 and repeat the entire programming procedure again.

8. After the instrument has told you that it is "done", move the FUNCTION switch, position 2, to the "off" position. Make sure

that position 1 is also in the "off" position at this time. The instrument should now be reading the temperature of your sensor.

Now depress the "CHANNEL" switch on the front panel and repeat the programming procedure for the second RTD sensor.

2.3.4 PROGRAMMING EXAMPLES:

SAMPLE #1: Sub range = -189 to +500°C (419°C)

Rtp = 25.4768 ohms

a4 = -1.6448498E-04

b4 = -5.2486782E-04

a8 = -9.2035954E-06

b8 = -1.1031022E-04

Using the sample coefficients listed above, their entry would appear as follows:

.1 Turn ON instrument

.2 Operate SW #2 of S2 to ON

.3

2	5	4
---	---	---

7	6
---	---

0	8	0
---	---	---

 Enter Rtp using 'DIGIT SELECT' and 'COUNT' buttons.

.4 Press "COEF SELECT" button.

.5

-	9	2
---	---	---

0	3
---	---

 Enter a8 Enter a8 using "DIGIT SELECT" and "COUNT" buttons

6	6	1
---	---	---

.6 Press "COEF SELECT" button

.7

-	9	2
---	---	---

0	3
---	---

 Enter b8 using "DIGIT SELECT" and "COUNT" buttons

4	6	2
---	---	---

.8 Press "COEF SELECT" button

.9

--

0	0
---	---

0

0

 There is no "c" coefficient for this sub range. Enter as zeros using "DIGIT SELECT" and "COUNT" buttons.

0

.10 Press "COEF SELECT" button

.11 Enter a using "DIGIT SELECT" and "COUNT" buttons

.12 Press "COEF SELECT" button
.13 Enter b4 using "DIGIT SELECT" and "COUNT" buttons 4

.14 Press "COEF SELECT" button

.15 There is no "c" coefficient for this sub range. Enter as zeros using "DIGIT SELECT" and "COUNT" buttons

.16 Press "COEF SELECT" button

.17

.18 Operate SW #1 of S2 to ON. Entries are now being programmed into memory

.19 When display reads "done" operate SW #1 and #2 of S2 to OFF

.20 Programming is now complete.

SAMPLE #2:

.1 Sub Range -189 to +500°C (419°C)

.2 Coefficients

Rtp = 100.0246 ohms
a4 = -9.8769E-04
b4 = -3.0704E-04
a8 = -5.8230E-04
b8 = 1.1108E-05 .3 Entry into the instrument of SAMPLE #2 coefficients should appear as follows

.4 Enter Rtp

.5 Enter a8

.6 Enter b8

.7 Enter as Zero's

.8 4 - 9 8 7 6 9 4 Enter a4

.9 4 - 3 0 7 0 4 5 Enter b4

.10 0 P 0 0 0 0 6 Enter as Zero's

For details on realizing the ITS-90, changes from the IPTS-68, differences between T90 and T68 (and T76), and means of approximating the ITS-90, see NIST Technical Note 1265, entitled "Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90)", by B. W. Mangum and G. T. Furukawa.

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Gaithersburg, MD 20899
(301) 975-3058

2.4 CHECKING CURRENT SENSOR COEFFICIENTS

.1 Operate "FUNCTION" switch position 2 to "ON".
(See Fig. 3)

.2 "0" constant is displayed. $0=R_{tp}$.

.3 Operate the gray "COEF SELECT" pushbutton and note the constant that is displayed each time the pushbutton is depressed.

.4 Operate "COEF SELECT" pushbutton after constant "6" is displayed. All blinking should stop. Instrument reads "READY".

.5 Operate "FUNCTION" switch 2 to "OFF". Instrument will commence reading sensor input.

2.5 MAKING A TEMPERATURE DIFFERENCE MEASUREMENT

To make a temperature difference measurement, press the front panel "CHANNEL" switch until the "channel" leds indicate "1-2" (Input 2 is subtracted from Input 1). The display will now indicate the temperature difference in Fahrenheit, Celsius or resistance in ohms. Sensors can be mixed for the two channels, either value of R_0 or Alpha is acceptable.

The temperature difference can also be selected remotely with Option 14 or 15. See sections 3.1 or 3.2 for details.

2.6 CHECKSUM VERIFICATION OF PROGRAMMED VARIABLES

The 4212C insures the integrity of the programmed variables stored in the Zero Power RAM (ZPRAM) by the use of checksums. The checksum for each set of variables is programmed into the ZPRAM when the set of variables is programmed. Then, each time the instrument is turned on, the checksum of each set of variables is computed and compared to programmed checksum. In the case of an error, the 4212C displays a message, as below, to indicate which set of variables needs to be reprogrammed and waits until the variables have been checked.

P	r	o	g			
---	---	---	---	--	--	--

 = Sensor Coefficients for Sensor #1

1

This indicates there is an error in the Sensor coefficients or the Zero Offset Correction. The 4212C will display "Prog 1" until FUNCTION switch, position 2 is moved to the ON position. Refer to 2.3.3 of the manual for programming instructions for the Sensor Coefficients and 4.1.2 for verification of Zero Offset Correction.

NOTE: The 4212C will ignore the setting of the front panel selector switch and will automatically select Sensor #1.

If the Sensor Coefficients and Zero Offset Correction are checked without being reprogrammed, (Refer to 2.4 and 4.1.2.1 of the 4212C manual) both the resistance reading and the temperature readings may be incorrect and the "Prog 1" message will be displayed the next time the instrument is turned on.

P	r	o	g			
---	---	---	---	--	--	--

 = Sensor Coefficients for Sensor #2

2

This indicates there is a error in the Sensor Coefficients or the Zero Offset Correction for Sensor #2. The 4212C will display "Prog 2" until FUNCTION switch, position 2 is moved to the ON position. Refer to 2.3.3 of the manual for programming instructions for the Sensor Coefficients and 4.1.2 for verification of Zero Offset Correction.

NOTE: The 4212C will ignore the setting of the front panel selector switch and will automatically select Sensor #2.

If the Sensor Coefficients and Zero offset Corrections are checked without being reprogrammed, (Refer to 2.4 and 4.1.2.1 of the manual) both the resistance reading and the temperature readings may be incorrect and the "Prog 2" message will be displayed the next time the instrument is turned on.

E	E
---	---

P	r	o	g	I	E
---	---	---	---	---	---

 = IEEE-488 Interface Address

This indicates there is a problem with the IEEE-488 primary address. The 4212C will display "Prog IEEE"

until FUNCTION switch, position 3, is moved to the ON position. Refer to 3.2 of the manual for programming instructions for the IEEE-488 primary address.

If the primary address is checked without being reprogrammed, the instrument will read resistance and temperature correctly but the interface may not work and the "Prog IEEE" message will be displayed the next time the instrument is turned on.

P	r	o	g		2
---	---	---	---	--	---

 = RS-232C Interface parameters

3	2
---	---

This indicates there is a problem with the RS-232C Interface parameters. The 4212C will display "Prog 232" until FUNCTION switch, position 3 is moved to the ON position. Refer to 3.1 of the manual for programming instructions for the RS-232C interface parameters.

If the parameters are checked without being reprogrammed, the instrument will read resistance and temperature correctly, but the interface may not work and the "Prog 232" message will be displayed the next time the instrument is turned on.

3. OPTIONS

Remove Power before Proceeding.

Before using the remote option, remove the top cover and check to ensure that the vertically mounted remote option card is securely plugged in and that the internal cable is connected.

3.1 RS-232C INTERFACE (OPTION 14)

The RS-232C option on the model 4212C can be used with either a printer or a computer using terminal emulation software or application software: (Application software example descriptions are using National Instrument's LabVIEW™ 5.0.1)

Operation with a Printer

In this configuration, a switch in the 4212C controls if readings are sent directly from the 4212C to a printer or a computer using terminal emulation software. Refer to Section 3.1.2 for further explanation of this configuration.

Operation with a Computer

The 4212C can be interfaced to a computer using terminal emulation software or application software. In this configuration, the following functions are available:

- (1) Read the current 4212C reading
- (2) Select the measurement scale/channel. This automatically puts the instrument in the Remote mode which disables the front panel switches.
- (3) Read current ITS-90 sensor coefficients
- (4) Program new ITS-90 sensor coefficients
- (5) Check Status of the 4212C
- (6) Return the 4212C to Local.
This enables the front Panel switches.
- (7) Return the 4212C to power up condition.

Refer to Section 3.1.3 through Section 3.1.3.5 for further explanation of functions available in this mode.

3.1.1 Programming the 4212C Communication Parameters

The communication parameters of the 4212C must match the software:

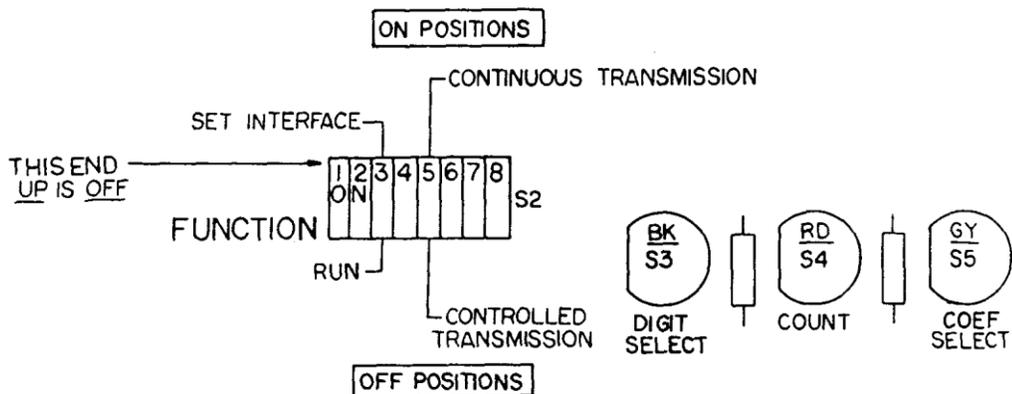
Baud Rate: The 4212C can be programmed for 110, 150, 300, 600, 1200, 2400, 4800, or 9600 baud.

Data Bits: The 4212C can be programmed for either 7 or 8 bits per character.

Stop Bits: The 4212C can be programmed for either 1 or 2 stop bits.

Parity: The 4212C can be programmed for odd, even, or no parity.

Echo: The 4212C can be programmed for echo on or off.



Close Up of S2 Showing RS-232C Switches
Figure 4

Programming the communication parameters:

Refer to Figure 2 and Figure 4 to locate the programming switches.

Move position 3 of the FUNCTION Switch S2 to the "ON" Position to put the 4212C in the SET INTERFACE mode.

The 4212C will display "br" followed by the current baud rate.

To change the Baud Rate, press the red "COUNT" button until the desired baud rate is displayed.

Press the gray "COEF SELECT" button to continue.
The 4212C will display the current number of bits per character, "7 bits" or "8 bits".

To change the number of bits per character, press the red "COUNT" button until the desired number of bits per character is displayed.

Press the gray "COEF SELECT" button to continue.

The 4212C will display the current number of stop bits, "1 StoP" or "2 StoP".

To change the number of stop bits, press the red "COUNT" button until the desired number of stop bits is displayed.

Press the gray "COEF SELECT" button to continue.

The 4212C will display the current parity, "no PAr", "odd PAr", or "EvEnPAr".

To change the parity, press the red "COUNT" button until the desired parity is displayed.

Press the gray "COEF SELECT" button to continue.

The 4212C will display the current Echo selection, "ECHO on" or "ECHO OFF".

Echo on: The 4212C will echo each character it receives back to the computer.

Echo off: The 4212C does not echo characters back to the computer.

To change the Echo selection, press the red "COUNT" button until the desired Echo selection is displayed.

Press the gray "COEF SELECT" button to continue.

The 4212C will display "rEAdy".

To return the 4212C to normal operation without changing The previous communication parameters, return position 3 of The FUNCTION switch to the "OFF" position.

To program the 4212C with the new communication parameters, Move the FUNCTION switch S2 position 1 to the "ON" [Program New Coefficients] position.

The 4212C will display "donE" after the new parameters are programmed. Return the FUNCTION switch S2 positions 1 & 3 to the "OFF" position to return the 4212C to normal operation.

Note: If the 4212C displays "Error", turn the 4212C off and then on and perform programming steps again.

3.1.2 Operation with a Printer

The 4212C may be connected to a printer or a computer using terminal emulation software.

The sending of readings can be controlled by FUNCTION switch S2 position 5, see Figure 4.

When the switch is in the "OFF" position, no readings are sent.

When the switch is in the "ON" position, a reading will be sent each time the 4212C updates the display, approximately once per second, except when measuring in Delta channel operation, Sensor 1 - Sensor 2, every fourth update will be approximately three seconds. See Section 3.1.3.1 for the reading format.

The sending of readings can also be controlled by commands sent over the interface. Type "E1" followed by <CR><LF> to turn continuous transmission on. Type "E0" followed by <CR><LF> to turn continuous transmission off. See Section 3.1.3 for more information on sending commands.

3.1.3 Operation with a Computer

When the 4212C is used with a computer using terminal emulation software or application software, the functions listed in the Summary of 4212C RS-232C Commands are available. In the following descriptions of the RS-232C commands, their use is illustrated using example programs written in LabVIEW™. The following explanations are provided to help in using the 4212C with other programming languages.

Programming Notes

1. Be sure to match the communication parameters of the 4212C and your hardware/software combination. Use the Serial Port Init VI to program the communication parameters to match the parameters set on the 4212C.

The Serial Port Init VI is found in Functions / Instrument I/O / Serial. You probably will not need the "Flow Control Etc." Control box. If you do, right click on the connection and create control.

2. The 4212C uses data messages to chose "Local" or "Remote" selection of measurement scale/channel. When "Remote" selection is chosen, the front panel switches are ignored.
3. The data terminator for output to the 4212C can be a Carriage Return <CR>, a Line Feed <LF>, or a <CR><LF>. The data terminator for input from the 4212C is a <CR><LF> ">" <CR>><CF>.

If you have problems with the computer hanging up, check the data terminators.

Another cause for the 4212C hang up is overloading the 4212C. Overloading the 4212C is caused by rapid repeating commands to the 4212C. It takes CPU time for the 4212C to transmit serial data. If too much time is demanded by the serial communications port the 4212C will hang up. The most common cause of this is rapidly repeating the status to see when the 4212C has updated.

4. It is possible to reset the 4212C to the power-on state by sending it a "^C". To send the 4212C the "^C" use Concatenate

Strings VI to append the string end of line constant to a string constant of "03". Both these are found in Functions/String. Use the Serial Write Function to send the concatenated string to the 4212C. The Serial Write VI is found in Functions/Instrument I/O and Serial.

5. ALL COMMANDS ARE UPPER CASE. Two character commands, such as "RC", are two consecutive characters and may not be separated by a space. All commands must have an end of line termination which is a line feed and carriage return. The end of line string constant is found in Functions/String.
6. Programming note 4 above explains how to append the end of line constant to the Command.
7. The procedure for reading and displaying a reading is in the next section.

3.1.3.1 Readings from the 4212C

If the 4212C is not in the Read ITS-90 Coefficients mode or the Program ITS-90 Coefficients mode, it will send the currently displayed reading when it receives a "T". The data is sent from the 4212C as the reading with leading polarity sign, followed by a space, a character for the measurement scale (C, F or O for Ohms) and a digit for the measurement channel (1 or 2), then the data terminator: [Note the > after the first <LF>.]

```
+138.500          O1<CR><LF>><CR><LF>
or
+0100.00    C1<CR><LF>><CR><LF>
or
+0212.00 F1<CR><LF>><CR><LF>
```

For Delta channel operation, Sensor 1 - Sensor 2, the reading is sent as two (2) data segments:

The first (1) data segment will have a "," after the channel number followed by a space. The second data segment will be formatted as above, with the channel character of 'D' for Delta. The data terminator, <CR><LF> ">" <CR><LF> follows the "D".

For example:

```
+138.500 O1, +038.500 OD<CR><LF>><CR><LF>
or
+0100.00 C1, +0100.00 CD<CR><LF>><CR><LF>
or
+0212.00 F1, +0180.00 FD<CR><LF>><CR><LF>
```

To display the current reading of the 4212C use the following LabVIEW™ steps. A 500 ms delay is in each of the following routines.

- Send a "T" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
- Use the

"bytes at serial port" VI to ascertain the number of bytes the 4212C has sent. This VI is found in Functions/Instrument I/O and Serial.

- Connect the "byte count" terminal of the above terminal to the "Serial Number of Bytes read" to the "Serial Port Read" VI found in Functions/Instrument I/O and Serial.
- Add an indicator to the Data Read port of the "Serial Port Read" VI for the reading.
- Enlarge the indicator to display all the lines received with the prompt ">".
- Hint: You can chose not to display the prompt ">" by using the "Split String" VI (In Functions/String) between the Serial Read and the reading indicator. Use ">" as the "Search Char"

3.1.3.2 Selection of Measurement Scale

4212C REMOTE COMMANDS

R1	Selects Sensor 1 channel
R2	Selects Sensor 2 channel
RD	Selects Delta channel operation, (Sensor 1 - Sensor 2)
RC	Selects Celsius measurement scale
RF	Selects Fahrenheit measurement scale
RO	Selects Ohms (resistance) measurement scale

L Returns selection of the measurement scale and channel to the front panel switches.

After power-on reset initialization, the measurement scale and channel of the 4212C are selected from the front panel. The measurement scale may be selected by the Remote commands "RC", "RF", or "RO". The measurement channel may be selected by the Remote commands "R1", "R2", or "RD". When a Remote command is received, the front panel switches are ignored until a Local command ("L") returns selection of the measurement scale and channel to the front panel switches. If a Remote scale command is received without a channel command, the current channel is locked in until a Remote channel command is received or until a Local command ("L").

If a Remote channel command is received without a scale command, the current scale is locked in until a Remote scale command is received or until a Local command ("L").

Remote channel selection commands are ready on the third update. After the command is received.

Remote scale selection commands are ready on the next update after the command is received.

NOTE: All Remote commands are two letters. They cannot be combined into three letter commands. For example, to set Celsius measurement of channel 2 send the 4212C "RCR2" and not "RC2"

The following LabVIEW™ routine remotely selects and displays a reading in Celsius, then selects and displays a Delta reading in Fahrenheit, then returns to Local mode. It Displays the Delta reading on the computer as described above.

1. Send a "RC" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
2. Allow a couple of seconds for the reading to settle out.
3. Send a "T" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
4. Use the "bytes at serial port" VI to ascertain the number of bytes the 4212C has sent. This VI is found in Functions/Instrument I/O and Serial.
5. Connect the "byte count" terminal of the above terminal to the Serial Number of Bytes read" to the "Serial Port Read" VI found in Functions/Instrument I/O and Serial.
6. Add an indicator to the Data Read port of the "Serial Port Read" VI for the reading.
7. Enlarge the indicator to display all the lines received with the prompt ">".
8. Send a "RFRD" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
9. Repeat 2 to 7 for the display of Delta F.
10. Send an "L" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.

Hint: You can choose not to display the prompt ">" by using the "Split String" VI (In Functions/String) between the Serial Read and the reading indicator. Use ">" as the "Search Char"

3.1.3.3 Reading ITS-90 Sensor Coefficients

QUERY COMMANDS

- | | |
|----|--|
| Q1 | sends the ITS-90 coefficients for Sensor 1 |
| Q2 | sends the ITS-90 coefficients for Sensor 2 |

Sending a Query command ("Q1" or "Q2") asks the 4212C to send the current ITS-90 Coefficients for a sensor. After the 4212C receives a Query command, it will respond with the Probe Channel Number followed by the seven (7) ITS-90 coefficients, labeled C0 to C6 as follows:

PROBE 2

C0 = 100.0246
C1 = -5.8320e-04
C2 = 1.1108e-05
C3 = 0.0000e+00
C4 = -9.8769e-04
C5 = -3.0704e-04
C6 = 0.0000e+00

The 4212C returns to normal operation after C6 is sent. Note: A "?" may be used in place of "Q" in the query command.

The following subroutine will read and display the coefficients for the Sensor 2. The coefficients are printed twice, first as a string as read from the 4212C and then converted to a real number.

To read and display the coefficients for Sensor 1, replace the "Q2" command with "Q1".

- Send a "Q2" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3. • Use the "bytes at serial port" VI to ascertain the number of bytes the 4212C has sent. This VI is found in Functions/Instrument I/O and Serial.
- Connect the "byte count" terminal of the above terminal to the "Serial Number of Bytes read" to the "Serial Port Read" VI found in Functions/Instrument I/O and Serial.
- Add an indicator to the Data Read port of the "Serial Port Read" VI for the reading.
- Enlarge the indicator to display all seven lines received with the prompt ">".
- Hint: You can chose not to display the prompt ">" by using the "Split String" VI (In Functions/String) between the Serial Read and the reading indicator. Use ">" as the "Search Char"

3.1.3.4 Programming ITS-90 Sensor Coefficients

P1 programs new ITS-90 coefficients for Sensor 1
P2 programs new ITS-90 coefficients for Sensor 2

Sending a PROGRAM COEFFICIENTS command ("P1" or "P2") to the 4212C allows you to program new ITS-90 Coefficients for a sensor.

When the 4212C receives a PROGRAM COEFFICIENTS command, there is a slight delay until the 4212C enters the ENTER PROGRAM COEFFICIENTS mode and is ready to receive the new ITS-90 coefficients.

When the 4212C enters the ENTER PROGRAM COEFFICIENTS mode, it will display "rS-232" on the front panel display. While in this mode, the 4212C will respond with the Status each time it receives a data terminator. See Section 3.1.3.5 for further information on Status.

When the 4212C is in the ENTER PROGRAM COEFFICIENTS mode, any or all of the seven ITS-90 coefficients, C0 to C6, can be sent to the

4212C. The coefficients can be sent in either floating point format (usually C0) or exponential format (C1 to C6).

Floating point format:

e.g.

C0 = 100.0246

There may be an optional number of spaces before the Coefficient Identifier, between the Coefficient Identifier and the equal sign, and between the equal sign and the floating point number.

Exponential format:

e.g.

C1 = -5.8320e-04 or

C1 = -5.8320E-04

There may be an optional number of spaces before the Coefficient Identifier, between the Coefficient Identifier and the equal sign, and between the equal sign and the exponential format number.

There can be no spaces in the exponential format number, i.e. before or after the "e" or "E".

After the new coefficients have been sent to the 4212C, the 4212C can be returned to normal operation with or without programming the new coefficients into non-volatile memory.

To exit the ENTER PROGRAM COEFFICIENTS mode without programming the new coefficients into non-volatile, send "N" with the end of line terminator to the 4212C.

The 4212C will return to normal operation and use the previous coefficients to calculate the temperature.

To exit the ENTER PROGRAM COEFFICIENTS mode with programming the new coefficients into non-volatile memory, send "Y" to the 4212C:

The 4212C will briefly display "donE" and then return to normal operation and use the new coefficients to calculate the temperature.

The following subroutine will program new coefficients into the non-volatile memory for Sensor 2.

To program new coefficients for Sensor 1, replace the "P2" command with "P1".

1. Send a "P2" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
2. Send "C0 = 25.56123 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
3. Send "C1 = -5.8320E-04 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.

4. Send "C2 = 1.1108E-05 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
5. Send "C3 = 0.0000E+00 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
6. Send "C4 = -9.8769E-04 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
7. Send "C5 = -3.0704E-04 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
8. Send "C6 = 0.0000E+00 string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.
9. Send a "Y" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3.

Note: When using a computer with terminal emulation software, there are no editing commands when entering coefficients. If you make a mistake, simply send a data terminator and re-enter the coefficient.

3.1.3.5 Reading the 4212C Status

Sending a Status command ("S") to the 4212C allows the computer to read the current 4212C Status. The Status command presents the 4212C Status information in a single character.

After the 4212C receives a Status command, it will respond with a character that represents the 4212C Status as follows:

- P - Power-on reset initialization mode.
- F - Front panel busy.
- W - Waiting to enter the ENTER PROGRAM COEFFICIENTS mode. .
- B - Busy in the ENTER PROGRAM COEFFICIENTS mode.
- U - Updated reading has not been read.
- N - Reading has been read.

The 4212C Status is "P" following turn on of the 4212C or after a Device Clear command until the display is updated with the first reading.

The 4212C Status is "F" when the front panel is busy calibrating coefficients, calibrating the Analog Output option or changing communication parameters. The Status changes to "F" when the selected position of the internal FUNCTION switch is moved to the "ON" position. When the function is concluded, the Status changes to "N".

The 4212C Status is set to "W" when the 4212C receives a PROGRAM COEFFICIENTS Command and remains "W" until the 4212C enters the ENTER PROGRAM COEFFICIENTS mode.

The 4212C Status is set to "B" when the 4212C enters the ENTER PROGRAM COEFFICIENTS mode. The Status is set to "N" when the 4212C exits the ENTER PROGRAM COEFFICIENTS mode.

NOTE: The Status command is automatic when the 4212C is in the ENTER PROGRAM COEFFICIENTS mode. The 4212C will respond with the Status each time it receives a data terminator until it exits the ENTER PROGRAM COEFFICIENTS mode.

Each time the display is updated, the Status is changed to "U" to indicate that the current reading has been updated since the last time the 4212C was read.

When the current reading is read, the Status is changed to "N", to indicate the reading has been read, and is changed to "U" the next time the display is updated.

The following LabVIEW subroutine uses the Status command to wait until the 4212C updates the displayed reading.

- Draw a while loop (Found in Functions/Structures) in the diagram section of a VI. • Put three sequence frames (Found in Functions/Structures) inside the while loop
- In the first frame use the serial write VI to send an "S" string with the end of line terminator appended. (Also in this frame put in a 500 ms delay)
- In the second frame find the number of bytes at the serial port using the Bytes at Serial Port VI. (Also in this frame put in a 50 ms delay)
- In the third frame put the Serial Port Read VI. (Also in this frame put in a 50 ms delay)
- Connect the "byte count" terminal of the above terminal to the Serial Number of Bytes read" to the "Serial Port Read" VI found in Functions/Instrument I/O and Serial.
- Connect the data out of the Serial Port Read VI to a Match Pattern VI found in Functions/string with the pattern to be match a "U". • Connect the output of the matched pattern and a string "U" to a Not Equal? found in Functions/Comparisons.
- Connect the output of the Not Equal? to the conditional terminal of the aforementioned while loop.
- When the 4212C has updated the condition is met and this routine is complete.

3.1.4 SUMMARY OF 4212C RS-232C COMMANDS

FUNCTION	COMMAND	DESCRIPTION
DEVICE CLEAR	^C	Resets the 4212C to the power-on reset state..
CONTINUOUS TRANSMISSION	E1	Enables Continuous Transmission
ENABLE/DISABLE (Sec. 3.1.2)	E0	Disables Continuous Transmission
LOCAL (Sec. 3.1.3.2) front panel switch.	L	Returns selection of the measurement scale to the
REMOTE (Sec. 3.1.3.2) RO Celsius, Fahrenheit or	RC RF	Changes selection of measurement scale to Ohms.
Changes measurement channel to		selection of
	R1	Sensor 1,
	R2	Sensor 2, or
	RD	Delta (Sensor 1 - Sensor 2).
PROGRAM COEFFICIENTS (Sec. 3.1.3.4) ITS-90 sensor coefficients.	P1 P2	Enters 4212C into program mode to allow programming of new
QUERY COEFFICIENTS (Sec. 3.1.3.3) coefficients.	Q1 Q2	Provides read-out of current programmed ITS-90 sensor
SEND STATUS (Sec. 3.1.3.5)	S	Provides read-out of Status of 4212C.
TRANSMIT READING (Sec. 3.1.3.1)	T	Provides read-out of front panel reading.

ALL COMMANDS ARE UPPER CASE

INTENTIONALLY

BLANK

3.2 IEEE-488 INTERFACE (OPTION 15)

The IEEE-488 option can be used two ways:

Talk Only Mode

The 4212C can be used with an IEEE-488 printer with Listen Only capability. In this configuration, readings are sent directly from the 4212C to the printer. No remote commands can be used because there is no controller present. Refer to Section 3.2.1 for further explanation of this mode.

Operation with an IEEE-488 System Controller

The 4212C can be used in an IEEE 488 bus system with a system controller and up to 13 other devices, since the IEEE-488 standard permits up to 15 devices to be configured within one system. In this configuration, the following functions are available:

- (1) Read the current 4212C reading
- (2) Select the measurement scale/channel
- (3) Read current ITS-90 sensor coefficients
- (4) Program new ITS-90 sensor coefficients
- (5) Check status of the 4212C using Serial Poll
- (6) Check status of the 4212C using Status command
- (7) Enable SRQ generation when the 4212C updates the display.

Refer to Section 3.2.2 through Section 3.2.2.8 for further explanation of functions available in this mode.

3.2.1 TALK ONLY MODE

To use the 4212C in the Talk Only mode, connect the 4212C directly to an IEEE-488 printer set for the Listen Only mode. The sending of readings is controlled by FUNCTION switch S2 position 5 (see Figure 2 & Figure 5).

When the switch is in the "OFF" position, no readings are sent.

When the switch is in the "ON" position, a reading will be sent each time the 4212C updates the display. The measurement scale and channel are selected by the front panel switches. See Section 3.2.2.2 for the reading format. The 4212C will update approximately once per second, except when measuring in Delta channel operation, Sensor 1 - Sensor 2, every fourth update will be approximately three seconds.

NOTE: While the 4212C is in the Talk Only mode, the programmed 4212C device address has no effect.

3.2.2 OPERATION WITH AN IEEE-488 SYSTEM CONTROLLER

When the 4212C is used with a system controller, the functions listed in the Summary of IEEE-488 COMMANDS are available. In the following descriptions of the IEEE-488 commands, their use is illustrated using National Instruments visual programming language, LabVIEW™. The examples are for use with a National Instruments GPIB card with NI-488 and NI-488.2 VI's. The following explanations are provided to help use the 4212C

with other programming languages and other IEEE-488 interface hardware and software combinations.

Programming Notes

1. The following examples assume that the 4212C device address is programmed to 07. Be sure to use your device address.
2. The 4212C uses data messages to chose "Local" or "Remote" selection of measurement scale and channel. When "Remote" selection is chosen, the front panel switches are ignored. The 4212C does not use the Remote Enable line "REN" (IOTECH "REMOTE" command) or the "Local Lockout" command.
3. The data terminator for bus output to the 4212C and for bus input from the 4212C should be set for Carriage Return <CR> followed by Line Feed with EOI set <LF w/EOI>.

If you have problems with the controller or the bus hanging up, check the data terminators. Also you need to put in delays between input commands and output data of the 4212C. 1/2 to 1 second delay is recommended.

4. ALL COMMANDS ARE UPPER CASE. Two character commands, such as "RC", are two consecutive characters and may not be separated by a space.
5. The following LabVIEW™ routine will program the 4212C to go to remote and read °C:
 - Connect a string constant "RC" to the data input of the GPIB Write VI found in Functions/Instrument I/O and GPIB.
 - Connect a string control with the IEEE address of the 4212C to the address terminal of the above VI.
 - Connect an integer constant 3 to the mode terminal of the above VI.
 - Run VI.
6. The following LabVIEW™ routine will read the front panel of the 4212C:
 - Connect a string indicator to the data terminal of the GPIB Read VI found in Functions/Instrument I/O and GPIB.
 - Connect a string control with the IEEE address of the 4212C to the address terminal of the above VI.
 - Connect an integer constant 0 to the mode terminal of the above VI.
 - Connect an integer constant 20 to the byte count terminal of the above VI.
 - Run VI.

3.2.2.1 PROGRAMMING THE DEVICE ADDRESS

Each device connected to the IEEE-488 bus must have a unique address for proper operation. The 4212C can be programmed for any address between 00 and 30. The current device address of the 4212C is displayed during power-on initialization following Lamp Test.

1. Checking current device address

To check the current device address, locate the FUNCTION Switch S2 and move position 3 to the "ON" position, see Figure 2 and Figure 5. The display on the 4212C will indicate "Addr", followed by the current device address.

To return the 4212C to normal operation without changing the current device address, locate the gray COEF SELECT button {Figure 2} and press it once. The 4212C will Display "rEady". Return switch position 3 to OFF.

2. Programming a new device address

Locate the FUNCTION switch S2 and move position 3 to the "ON" Position. The 4212C will display will display "Addr" followed By the current address.

Locate the red "COUNT" button, see Figure 2.

Press the "COUNT" button until the desired device address is displayed.

NOTE: "Addr 00" follows "Addr 30".

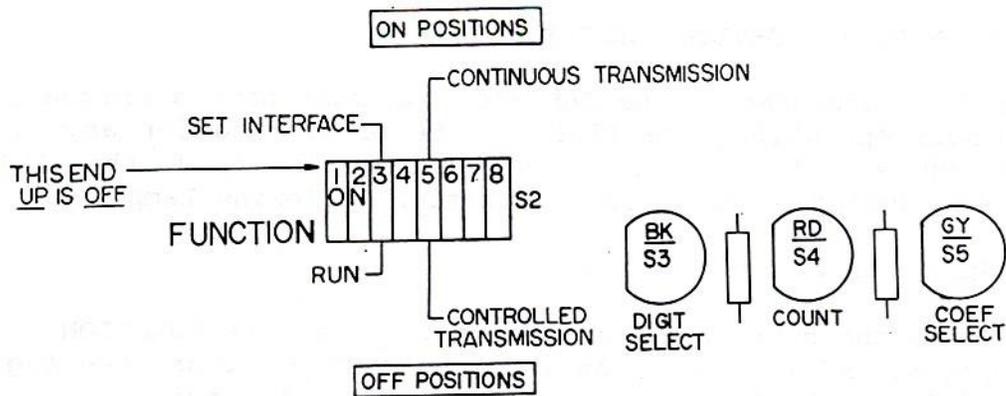
Locate the gray "COEF SELECT" button.

Press the "COEF SELECT" button to enter the desired device address.

The 4212C will now display "rEady".

To program the new device address into the 4212C, move the FUNCTION switch S2 position 1 to the "ON" (Program New Coefficients) position. The 4212C will display "buSY" briefly, then it will display "donE".

The new device address is now programmed. Return the FUNCTION switch S2 positions 1 & 3 to the "OFF" position to return the 4212C to normal operation.



Close-up of S2 Showing IEEE-488 Switches
Figure 5

3.2.2.2 READINGS FROM THE 4212C

If the 4212C is not in the Read ITS-90 Coefficients mode or the Program ITS-90 Coefficients mode, it will send a reading for the current display mode, when addressed to talk. The format of the reading depends on the current display mode. For single channel operation, Sensor 1 or Sensor 2, The data is sent from the 4212C as the reading with leading polarity sign, followed by a space, a character for the measurement scale (C, F or O for Ohms) and a digit for the measurement channel (1 or 2), then the data terminator: [Note the EOI is sent with the <LF>.]

+138.500 O1<CR><LF w/EOI>

or

+0100.00 C1<CR><LF w/EOI >

or

+0212.00 F1<CR><LF w/EOI >

For Delta channel operation, Sensor 1 - Sensor 2, the reading is sent as two (2) data segments:

The first (1) data segment will have a "," after the channel number followed by a space. The second data segment will be formatted as above, with the channel character of 'D' for Delta. The <LF> will be attended with the EOI signal.

For example:

+138.500 O1, +038.500OD<CR><LF w/EOI>

or

+0100.00 C1, +0100.00CD<CR><LF w/EOI>

or

+0212.00 F1, +0180.00FD<CR><LF w/EOI>

3.2.2.3 SELECTION OF MEASUREMENT SCALE

4212C REMOTE COMMANDS

R1	Selects Sensor 1 channel
R2	Selects Sensor 2 channel
RD	Selects Delta channel operation, (Sensor 1 - Sensor 2)
RC	Selects Celsius measurement scale
RF	Selects Fahrenheit measurement scale
RO	Selects Ohms (resistance) measurement scale
L	Returns selection of the measurement scale and channel to the front panel switches.

After power-on reset initialization, the measurement scale and channel of the 4212C are selected from the front panel. The measurement scale may be selected by the Remote commands "RC", "RF" or "RO". The measurement channel may be selected by the Remote commands "R1", "R2" or "RD". When a Remote command is received, the front panel switches are ignored until a Local command ("L") returns selection of the measurement scale and channel to the front panel switches. If a Remote scale command is received without a channel command, the current channel is locked in until a Remote channel command is received or until a Local command ("L").

If a Remote channel command is received without a scale command, the current scale is locked in until a Remote scale command is received or until a Local command ("L").

Remote scale selection commands are ready on the next 4212C update after the command is received.

Remote channel selection commands are ready on the third update after the command is received.

NOTE: All Remote commands are two letters. They cannot be combined into three letter commands. For example, to set Celsius measurement of channel 2 use the GPIB Write as described in 3.2.2 Programming note 5 send the string "R2RC" and not "R2C":

The following procedure remotely selects and displays a reading in Celsius, then selects and displays a Delta reading in Fahrenheit, and then returns to Local mode. It uses the procedures shown in Section 3.2.2.

- Send "RC" to the 4212C using the routine described in programming note 5 of 3.2.2.
- Wait 750 ms or more using the Wait function found in Functions/Time and Dialog.
- Read the 4212C using the routine described in programming note 6 of 3.2.2.
- Wait 750 ms or more using the Wait function found in

Functions/Time and Dialog.

- Send "RFRD" to the 4212C using the routine described in programming note 5 of 3.2.2.
- Wait 750 ms or more using the Wait function found in Functions/Time and Dialog.
- Read the 4212C using the routine described in programming note 6 of 3.2.2.
- Wait 250 ms or more using the Wait function found in Functions/Time and Dialog.
- Send "L" to the 4212C using the routine described in programming Note 5 of 3.2.2.

3.2.2.4 READING THE ITS-90 SENSOR COEFFICIENTS

4212C QUERY COMMANDS

Q1	sends the ITS-90 coefficients for sensor 1
Q2	sends the ITS-90 coefficients for sensor 2

Sending a Query command ("Q1" or "Q2") to the 4212C allows the controller to read the current ITS-90 coefficients for the selected sensor. After the 4212C receives a Query command, the next eight (8) times the 4212C is addressed to talk, it will respond with the Probe Channel Number followed by the seven (7) ITS-90 coefficients, labeled C0 to C6 as follows:

```
PROBE 2
C0 = 100.0246
C1 = -5.8320e-04
C2 = +1.1108e-05
C3 = +0.0000e+00
C4 = -9.8769e-04
C5 = -3.0704e-04
C6 = +0.0000e+00
```

The 4212C returns to normal operation after C6 is read.

The next time the 4212C is addressed to talk, it will send the displayed reading.

The following procedure will read and display the coefficients for Sensor 2 as strings.

To read and display the coefficients for Sensor 1, replace the "Q2" command with "Q1".

- Create a VI

- On the front panel of the VI place eight (8) string indicators and label the first one "Probe under Test." Label the Second one through the eighth one, "C0" through "C6". The string indicators are found in Controls/String and Table.
- Switch to the diagram.
- On the diagram put a sequence loop with two (2). The sequence frame is found in Functions/Structures. • In the first frame send "Q2" to the 4212C using the routine described in programming note 5 of 3.2.2.
- Wait 750 ms or more in that frame using the Wait function found in Functions/Time and Dialog.
- Put a For loop in the seconded frame.
- Put a Wait function in the for loop with the constant 750 connected to it.
- Connect the digit 8 to the N terminal of the for loop. The for loop is found in Functions/Structures.
- Inside the for loop place a sequence loop with 8 frames.
- Also in the for loop read the data as described in programming note 6 of 3.2.2 except use mode 3 and bytes read 30.
- Connect the data terminal of the GPIB Read VI to an input tunnel of the sequence loop. Use mode 0 and a byte count of 30.
- In the #0 frame place the indicator labeled "Probe Under Test" with the tunnel wired to the indicator.
- In the #1 frame place the indicator labeled "C0" with the tunnel wired to the indicator.
- In the #2 frame to the #7 frame place the indicator labeled "C2" to "C7". •Return to the front panel and run the VI.

3.2.2.5 PROGRAMMING SENSOR COEFFICIENTS FROM THE CONTROLLER

PROGRAM COEFFICIENT COMMANDS

P1 Programs new ITS-90 coefficients for sensor 1

P2 Programs new ITS-90 coefficients for sensor 2

Sending a PROGRAM COEFFICIENTS command ("P1" or "P2") to the 4212C allows the controller to program new ITS-90 Coefficients for a sensor.

When the 4212C receives a PROGRAM COEFFICIENTS command, there is a slight delay until the 4212C enters the ENTER PROGRAM COEFFICIENTS mode and is ready to receive the new ITS-90 coefficients. While the 4212C is waiting, the Serial Poll response will be 2, (bit 2 set ON), and if the 4212C is addressed to talk, it will respond with status character of "W". (See Sec.3.2.2.8)

When the 4212C enters the ENTER PROGRAM COEFFICIENTS mode, it will display "IEEE488" on the front panel display, the Serial Poll

response will be 4 (bit 4 set ON) and, if the 4212C is addressed to talk, it will respond with status of character of "B".

When the 4212C is in the ENTER PROGRAM COEFFICIENTS mode, any or all of the seven ITS-90 coefficients, C0 to C6, can be sent to the 4212C. The coefficients can be sent in either floating point format (typically C0) or exponential format (typically C1 to C6).

Floating point format:

e.g.

C0 = 100.0246

There may be an optional number of spaces before the Constant Identifier, between the Constant Identifier and the equal sign, and between the equal sign and the floating point number.

Exponential format:

e.g.

C1 = -5.8320e-04 or

C1 = -5.8320E-04

C2 = 1.1108e-05 or

C2 = +1.1108e-05

There may be an optional number of spaces before the Constant Identifier, between the Constant Identifier and the equal sign, and between the equal sign and the exponential format number.

There can be no spaces in the exponential format number, i.e. before or after the "e" or "E".

The plus sign in front of positive coefficients is optional.

After the new coefficients have been sent to the 4212C, the 4212C can be returned to normal operation with or without programming the new coefficients into the non-volatile RAM.

To exit the ENTER PROGRAM COEFFICIENTS mode without programming the new coefficients into non-volatile RAM, send "N" to the 4212C:

The 4212C will return to normal operation and use the previous coefficients to calculate the temperature.

To exit the ENTER PROGRAM COEFFICIENTS mode with programming the new coefficients into non-volatile RAM, send "Y" to the 4212C:

The 4212C will briefly display "donE" and then return to normal operation and use the new coefficients to calculate the temperature.

The following procedure will program new coefficients into the non-volatile RAM for the Sensor 2. To program new coefficients for Sensor 1, replace the "P2" command with "P1".

- Create a VI
- On the front panel of the VI place eight (8) string controls and label them "C0" through "C6". The string controls are found in Controls/String and Table.
- Write in each string control box desired data as formatted above.
- Switch to the diagram.
- On the diagram put a sequence loop with 11 frames. The sequence frame is found in Functions/Structures.
- In frame #0 send "P2" to the 4212C using the routine described in programming note 5 of 3.2.2.
- Wait 750 ms or more in that frame using the Wait function found in Functions/Time and Dialog.
- Put a while loop in frame #1. The sequence frame is found in Functions/Structures.
- In the While loop, put a (Serial) Poll VI, found in Function/instrument I/O/ and GPIB addressed to the 4212C. • Connect the Serial poll byte to one input of a not equal comparison with a numeric constant of 4 to the other terminal. • Connect the output of the not equal comparison to the conditional terminal of the While loop.
- In the #3 frame place the connect the control for "C0" to the data input of a GPIB write VI wired to mode 3. Place a 500 ms delay in this frame.
- In the #4 frame place the connect the control for "C1" to the data input of a GPIB write VI wired to mode 3. Place a 500 ms delay in this frame.
- Repeat the above step for the rest of the coefficient.
- In the 11th frame send the 4212C a "Y" using the procedure described in 3.2.2 Programming note 5
- Return to the front panel and run the VI.

NOTE: It is not necessary to program all coefficients at the same time. You can leave out some of the above frames.

3.2.2.6 SERIAL POLL RESPONSE

When the 4212C is serial polled by the controller, it responds with a value between 0 and 255 representing the decimal equivalent of its eight-bit status response. The following is a description of the meaning of each of the eight possible bits.

reset	Bit 7 (128)	ON =	4212C is in the	Power-on
bit	initialization	mode.		This
the	is	following	turn	on
	4212C	or	a	Device
				Clear

command until the display is updated with the first reading.

OFF = Normal Operation.

Bit 6 (64) ON = Device is requesting service (it has asserted the SRQ line).

When the Service Request on 4212C update is disabled, Command "E0", this bit will not be set.

When Service Request on 4212C update is enabled, Command "E1", this bit is set ON when the 4212C is updated to the 4212C is requesting reading indicate that the device service.

OFF = Reset to OFF the first time the 4212C is serial polled.

Bit 5 (32) ON = When the Service Request on 4212C update is disabled, Command "E0", this bit will not be set.

When Service Request on 4212C update is enabled, Command "E1", this bit is set ON at the same time as bit 6.

OFF = Reset to OFF the first time the updated 4212C reading is read by the controller.

Bit 4 (16) Not Used
Bit 3 (8) Not Used

Bit 2 (4) ON = The 4212C is in the ENTER PROGRAM COEFFICIENTS mode and is ready to receive ITS-90 coefficients. new

(See Sec. 3.2.2.5)

OFF = Reset to OFF when the 4212C
leaves the ENTER PROGRAM
COEFFICIENTS mode.

Bit 1 (2) ON = The 4212C is waiting to
enter the ENTER PROGRAM
COEFFICIENTS mode. This
bit is set on when a PROGRAM
COEFFICIENTS Command is
received by the 4212C.
(See Sec. 3.2.2.5)

OFF = Reset to OFF when the 4212C
enters the ENTER PROGRAM
COEFFICIENTS mode.

Bit 0 (1) ON = Set ON when the 4212C
reading is updated.

OFF = Reset to OFF the first
time the updated 4212C
reading is read by the
controller.

The following procedure will wait until the 4212C updates the
displayed reading. It can be used to wait until a new measurement
scale or measurement channel is displayed (See Sec 3.2.2.3) or to
read consecutive updates from the 4212C.

NOTE: The serial poll is the preferred way to wait for an update rather
than using the status command.

- In the diagram for a VI put a While loop.
- In the while loop Put a (Serial) Poll VI, found in
Function/instrument I/O and GPIB addressed to the 4212C.
- Connect the Serial poll byte to one input of an "and" found in
Functions/Boolean with the other input connected to a constant 1. •
Connect the Serial poll byte also to one input of a not equal
function and the above "and" connected to the other input. • Connect
the output of the not equal comparison to the conditional terminal of
the While loop.
- When the 4212C is updated the condition for while loop will be met
and the program will proceed.

3.2.2.7 SRQ GENERATION ON 4212C UPDATE

The 4212C can be programmed to generate a Service Request (SRQ)
each time the 4212C updates the display, approximately once per

second, except when measuring in Delta channel operation, Sensor 1 - Sensor 2, every fourth update will be approximately three seconds.

The controller must be programmed to recognize the SRQ and to then serial poll each device on the IEEE-488 bus to determine which device requested service. This allows the controller to read the 4212C each time the display is updated and perform other operations while the 4212C is between update cycles instead of continually monitoring the Serial Poll response of the 4212C. The 4212C will request service only when a new reading is ready.

Operation in this mode is selected by the SERVICE REQUEST DISABLE/ENABLE command. After power-on reset initialization, the SERVICE REQUEST is disabled. It is enabled by the command "E1" and disabled by the command "E0".

When this mode is enabled, the 4212C will assert the SRQ line to request service each time it updates the display (i.e. completes a measurement cycle). It will release the SRQ line the first time the 4212C is serial polled.

NOTE: When this mode is disabled (Command "E0"), Bits 5 and 6 will stay off when turned OFF and the 4212C will not request service via the SRQ line when it updates a reading.

Whether this mode is enabled (command "E1") or disabled (command "E0") has no effect on Bit 0. Bit 0 is always set ON with each update and set OFF each time the 4212C is read. When this mode is enabled, the first response to a serial poll after the 4212C has requested service will be the decimal value 97 (Bits 6,5 and 0 set ON).

Bit 6 and 5 both indicate that the 4212C has requested service.

Bit 0 indicates that latest reading has not been read by the controller.

Bit 6 is turned off by the First Serial Poll.

Bit 5 and Bit 0 (decimal number 33) are turned off the First time the 4212C reading is read.

The following procedure will wait until the 4212C requests service before proceeding. It can be used to wait until a new measurement scale or measurement channel is displayed (See Sec 3.2.2.3) or to read consecutive updates from the 4212C.

NOTE: The service request (SRQ) is used to tell the controller that the 4212C has updated its reading.

- Send "E1" to the 4212C using the routine described in programming note 5 of 3.2.2.
- In the diagram for a VI put a While loop.

- In the while loop Put a SRQ test VI, found in Function/instrument I/O and GPIB 488.2 with the bus number wired to the input of the VI.
- Connect the output of the SRQ test VI the input of a "not" function, found in Functions/boolean, with the output connected to the conditional terminal of the While loop.
- When the 4212C request service the condition for while loop will be met and the program will proceed.
- NOTE: You must use the serial poll routine found in 3.2.2.6 in order to turn off SRQ.

3.2.2.8 READING THE 4212C STATUS

Sending a Status command ("S") to the 4212C allows the controller to read the current 4212C Status. The Status command presents the same 4212C Status information as the Serial Poll Response byte (except there is no Service Request information) in a single character instead of the eight-bit format of the Serial Poll response.

After the 4212C receives a Status command, the next time it is addressed to talk it will respond with a character that represents the 4212C Status as follows:

- P - Power-on reset initialization mode.
 - F - Front panel busy.
 - W - Waiting to enter the ENTER PROGRAM COEFFICIENTS mode.
- B - Busy in the ENTER PROGRAM COEFFICIENTS mode.
- U - Updated reading has not been read.
- N - Reading has been read.

The 4212C status is "P" following turn on of the 4212C or after a Device Clear command until the display is updated with the first reading.

The 4212C Status is "F" when the front panel is busy calibrating coefficients, calibrating the Analog Output option or changing the device IEEE address. The Status changes to "F" when the selected position of the internal FUNCTION switch is moved to the "ON" position. When the function is concluded, the status changes to "N".

The 4212C status is set to "W" when the 4212C receives a PROGRAM COEFFICIENTS Command and remains "W" until the 4212C enters the ENTER PROGRAM COEFFICIENTS mode.

The 4212C status set to "B" when the 4212C enters the ENTER PROGRAM COEFFICIENTS mode. The Status is set to "N" when the 4212C exits the ENTER PROGRAM COEFFICIENTS mode.

NOTE: The Status command is automatic when the 4212C Status is "W" or "B", that is when the 4212C is waiting to enter or is in the ENTER PROGRAM COEFFICIENTS mode. The 4212C will respond with the Status each time it is commanded to talk until it exits the ENTER PROGRAM COEFFICIENTS mode.

Each time the display is updated, the Status is changed to "U" to indicate that the current reading has been updated since the last time the 4212C was read.

When the current reading is read, the Status is changed to "N", to indicate the reading has been read, and is changed to "U" the next time the display is updated.

NOTE: The use of the SRQ test is preferred to using the Status command. The SRQ test examines the IEEE488 command lines without interrupting the 4212C. The status command interrupts the 4212C.

3.2.3 SUMMARY OF 4212C IEEE-488 COMMANDS

3.2.3.1 4212C IEEE-488 Device Specific Commands

FUNCTION	COMMAND	DESCRIPTION
SERVICE REQUEST DISABLE / ENABLE (Sec. 3.2.2.7)	E0	Disables Service Request Generation on Update.
	E1	Enables Service Request Generation on Update.
LOCAL (Sec. 3.2.2.3) front panel switch.	L	Returns selection of the measurement scale to the
REMOTE (Sec. 3.2.2.3)	RC	Changes selection of measurement scale to Celsius,
	RF	Fahrenheit or
	RO	Ohms.
	R1	Changes selection of measurement channel to Sensor 1,
	R2	Sensor 2, or
	RD	Delta (Sensor 1 - Sensor 2).
PROGRAM COEFFICIENTS (Sec. 3.2.2.5) of new coefficients.	P1	Enters 4212C into program
	P2	mode to allow programming ITS-90 sensor
QUERY COEFFICIENTS	Q1	Provides readout of current

(Sec. 3.2.2.4) Q2 programmed ITS-90 sensor coefficients.

STATUS S Provides a character
(Sec. 3.2.2.8) representing the Status of the 4212C.

ALL COMMANDS ARE UPPER CASE

3.2.3.2 IEEE-488 General Bus Commands

The following general bus commands are supported:

IFC - Interface Clear

The 4212C enters the talk and listen idle states with the Service Request on Update disabled.

DCL - Device Clear (Device Clear Universal)

The 4212C returns to the power up state.

A. The display will perform a Lamp Test, all 8's, followed by a display of the IEEE address. B.

Status character is set to "P".

C. Serial Poll Response byte set to 80H
(Bit 7 = ON)

D. Service Request on Update disabled.

E. Measurement scale returned to Local (Setting of Front Panel Switch)

SDC - Selective Device Clear (Device Clear Addressed)

The 4212C returns to the power up state.

(Same as DCL)

SPE - Serial Poll Enable

SPD - Serial Poll Disable

A serial polling sequence is used to determine the current operating status of the 4212C. Normally the 4212C is polled along with the other devices on the bus to determine which device requested service. The 4212C responds to the serial polling sequence with a Serial Poll Response byte which identifies the current status. Refer to Programming note 3.2.2.6 for more information on the Response byte format.

The following general bus commands are NOT supported:

REN - Remote Enable

This command is not used. Remote selection of the measurement scale is available using the "R" command.

GTL - Go To Local

This command is not used. Control of the measurement scale is returned to the front panel switch by the "L" (Local) command.

LLO - Local Lockout

This command is not used. The front panel switch is "Locked Out" after a "R" (Remote) command until a "L" (LOCAL) command.

3.2.3.3 IEEE-488 Interface Function Subsets

The 4212C implements the following subsets of the Interface

Functions:

SH1 - Source Handshake

Full Capability

AH1 - Acceptor Handshake
Full Capability

T5 - Talker

Basic Talker, Serial Poll,
Talk Only Mode, Unaddresses if MLA

TE0 - Extended Talker

No Capability

L4 - Listener

Basic Listener, Unaddresses if MTA

LE0 - Extended Listener

No Capability

SR1 - Service Request

Full Capability

RL0 - Remote Local

No Capability

(The 4212C uses messages for remote operation)

PP0 - Parallel Poll

No Capability

DC1 - Device Clear

Full Capability

DT0 - Device Trigger

No Capability

C0 - Controller

No Capability

E2 - Driver Electronics
Tri State
(May be jumpered for E1 [Open Collector] for use
with Parallel Poll)

INTENTIONALLY

BLANK

3.3 REDUCED SENSOR EXCITATION CURRENT (OPTION 16A)

This option is used for applications where sensor self-heating is a problem, such as measuring in still air or worse, measuring in a partial vacuum, or when the sensor itself has poor self-heating characteristics. Lowering the excitation current greatly improves the self-heating characteristics.

The reduced excitation current is 0.707 mA on both channels.

The standard 1 ma. excitation current is the minimum current available for a 25.5 ohm sensor; however, an excitation current of 0.707 mA is acceptable for use with a 100 ohm sensor, with no change in performance specifications. A 0.707 mA excitation current produces $\frac{1}{2}$ the heat of a 1 mA excitation current.

NOTE: Most sensors are calibrated at 1 mA.

3.4 USING SENSORS WITH Ro's OTHER THAN 10, 25 AND 100 OHMS (OPTIONS 18, 19, AND 20)

Platinum RTD sensors that have an ice point resistance (Ro) of 200, 400, 500, or 1000 ohms may be used by requesting this option. Use of sensors with a higher Ro is accompanied by a proportional reduction in excitation current. This allows the instrument to maintain the same measuring sensitivity while reducing sensor selfheating -- a definite advantage for application in mediums that cannot dissipate normal self-heating.

EXAMPLE: A 100 ohm sensor at 1 mA excitation current would have a wattage of $.001 \times .001 \times 100 = 100 \text{ u watts}$. A 500 ohm sensor with an excitation current of 0.2 mA., would have a wattage of $.0002 \times .0002 \times 500 = 20 \text{ u watts}$. The results; only 1/5 the amount of heat to dissipate.

Temperature measuring resolution remains the same at 0.01° as with the standard 4212C. However, the resistance reading resolution is reduced to 0.01 ohm.

Ro	CURRENT	EXCITATION OHMS	MAX. NUMBER	OPTION
	200*	0.5 ma.	650	18
	400**	0.2 ma.	1500	19
	500**	0.2 ma.	1500	19
	1000	0.1 ma.	3000	20

* A 200 ohm sensor can also be used with the standard 4212C having a 1 mA excitation current. When the standard model is used, the maximum resistance remains at 340 ohms or approximately 165°C for a sensor with an alpha of 0.00385. Resolution with the standard model remains at 0.001 ohm.

**Option 19 can be used for both 400 and 500 ohm sensors.

3.5 4212C SERIES ANALOG OUTPUT (OPTION 08)

The 4212C Series Analog output option uses a 12 bit DAC with a switched reference to give an output of -4.095 volts to +4.095 volts with 1 mV resolution. The analog output follows the displayed channel, (i.e. Channel 1, Channel 2 or Delta [1 - 2]), and is controlled by three parameters:

- Analog Output Scale
- Analog Output Resolution
- Analog Output Zero Offset

These three parameters are stored in non-volatile memory and can be programmed using the 4212C internal switches or using the interface, either IEEE-488 or RS-232, if installed.

The value of the analog output is the difference between the value of the sensor, in the selected Analog Output scale, and the Analog Output Zero Offset, multiplied by the Analog Output Resolution. Note that the analog output follows the displayed sensor but is independent of the displayed scale.

For example, assume the displayed sensor is at 138.500 Ohms, 100.00 C and 212.00 F.

With Analog Output Scale = F
Analog Output Resolution = 1mV / 0.1
Analog Output Zero Offset = +000.000
The analog output would be:
$$(212.00 - 0.000) * 1\text{mV} / 0.1 = 2120 \text{ mV} = 2.120 \text{ V}$$

With Analog Output Scale = F
Analog Output Resolution = 1mV / 0.1
Analog Output Zero Offset = +200.000
The analog output would be:
$$(212.00 - 200.000) * 1\text{mV} / 0.1 = 120 \text{ mV} = 0.120 \text{ V}$$

With Analog Output Scale = F
Analog Output Resolution = 1mV / 0.01
Analog Output Zero Offset = +200.000
The analog output would be:
$$(212.00 - 200.000) * 1\text{mV} / 0.01 = 1200 \text{ mV} = 1.200 \text{ V}$$

3.5.1 ANALOG OUTPUT PARAMETERS

Analog Output Scale

The analog output can represent the resistance of the sensor in Ohms or the temperature of the sensor in Celsius or Fahrenheit. The scale of the analog output is independent of the displayed scale as selected by the front panel switch or remotely by either the IEEE-488 or RS-232 interface.

Analog Output Resolution

The resolution giving a 1 millivolt step can be selected from the following:

1 mV / 1.0 C, F or Ohm
1 mV / 0.1 C, F or Ohm

1 mV / 0.01 C, F or Ohm
 1 mV / 0.001 C, F or Ohm

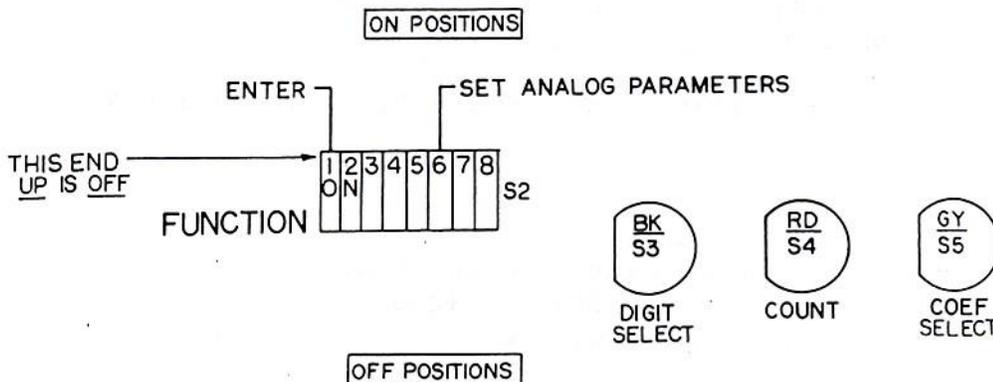
Analog Output Zero Offset

The Zero Offset can be from -999.999 to +999.999.

3.5.2 CHECKING OR PROGRAMMING THE ANALOG OUTPUT PARAMETERS

1. Refer to Figure 6 to locate the programming switches.

Move position 6 of the FUNCTION Switch S2 to the "ON" position to put the 4212C in the SET ANALOG PARAMETERS mode.



Close up of S2 showing Analog Output Programming Switches
 Figure 6

2. The 4212C will display "Aout" briefly , followed by the current analog output scale:

"SCALE C" for C
 "SCALE F" for F
 "SCALE O" for Ohms

To change the analog output scale, press the red "COUNT" pushbutton until the desired scale is displayed.

Press the gray "COEF SELECT" pushbutton to continue.

3. The 4212C will then display the current analog output resolution.

"r 1.0" for 1 mV / 1.0 C, F or Ohm
 "r 0.1" for 1 mV / 0.1 C, F or Ohm
 "r 0.01" for 1 mV / 0.01 C, F or Ohm
 "r 0.001" for 1 mV / 0.001 C, F or Ohm

To change the analog output resolution, press the red "COUNT" pushbutton until the desired resolution is displayed.

Press the gray "COEF SELECT" pushbutton to continue.

4. The 4212C will then display the current analog output Zero Offset. 'P' is displayed for the '+' sign. To change the Zero Offset.

Press the black "DIGIT SELECT" pushbutton to select the desired digit to change.

Press the red "COUNT" pushbutton to change the value of the digit.

When the desired Zero Offset is displayed, press the gray "COEF SELECT" pushbutton to continue.

5. The 4212C will then display "rEAdY".

To return the 4212C to normal operation without changing the previous Analog Output Parameters, return position 6 of the FUNCTION switch to the "OFF" position.

To program the 4212C with the new Analog Output Parameters, move the FUNCTION switch S2 position 1 to the "ON" (Program New Coefficients) position.

The 4212C will display "donE" after the new parameters are programmed. Return the FUNCTION switch S2 positions 1 & 6 to the "OFF" position to return the 4212C to normal operation.

3.5.3 ANALOG OUTPUT INTERFACE COMMANDS

If an interface option is installed, either the IEEE-488 or the RS232 interface, commands are available to set the three Analog Output Parameters and to read the current Analog Output Parameters.

Analog Output Scale Commands

WC	Selects Celsius
WF	Selects Fahrenheit
WO	Selects Ohms

The scale of the analog output is independent of the displayed scale as selected by the front panel switch or remotely by either the IEEE-488 or RS-232 interface.

Analog Output Resolution

COMMAND

W0	Selects 1 mV / 1.0	C, F or Ohm
W1	Selects 1 mV / 0.1	C, F or Ohm
W2	Selects 1 mV / 0.01	C, F or Ohm

W3 Selects 1 mV / 0.001 C, F or Ohm

Analog Output Zero Offset

COMMAND

X Sets Zero Offset to current value of sensor in Analog Output Scale.

When an X command is received, the Zero Offset will be set to the current value of the sensor in the current Analog Output Scale. This will cause the Analog Output to go to zero.

Z = szzz.zzz Sets Zero Offset to szzz.zzz
s = optional sign + or -
z = digit 0-9

The Z = szzz.zzz command is used to set the Analog Output Zero Offset to a desired number. The format of the number is not critical and can be scientific notation. For example,

Z = 100.000 will set the Zero Offset to 100.000
Z = 1e² will set the Zero Offset to 100.000
Z = -50.123 will set the Zero Offset to -50.123

3.5.4 READING CURRENT ANALOG OUTPUT PARAMETERS

If the 4212C is not in the Read ITS-90 Coefficients mode or the Program ITS-90 Coefficients mode, the current Analog Output Parameters may be read using the 'A' command. The parameters are sent as shown below:

COMMAND

A Sets 4212C to respond with current Analog Output Parameters

RESPONSE

R=xy Z=szzz.zzz

Response Format:

x = Analog Output Scale

C = Celsius

F = Fahrenheit

O = Ohms

y = Analog Output Resolution

0 = 1 mV / 1.0 C, F or Ohm

1 = 1 mV / 0.1 C, F or Ohm

2 = 1 mV / 0.01 C, F or Ohm

3 = 1 mV / 0.001 C, F or Ohm

szzz.zzz = Analog Output Zero Offset

s = sign, + or -

zzz.zzz = number, 000.000 to 999.999

3.5.5 EXAMPLE OF PROGRAMMING VIA RS-232C INTERFACE

The following VI written in LabVIEW™ will display the current Analog Output Parameters, both as the string as read from the 4212C and as characters for the Scale and Resolution and as a real number for the Zero Offset.

- Send an "A" string with the end of line terminator appended as explained in programming note four (4) of section 3.1.3. • Use the "bytes at serial port" VI to ascertain the number of bytes the 4212C has sent. This VI is found in Functions/Instrument I/O and Serial.
- Connect the "byte count" terminal of the above terminal to the Serial Number of Bytes read" to the "Serial Port Read" VI found in Functions/Instrument I/O and Serial.
- Add an indicator to the Data Read port of the "Serial Port Read" VI for the reading of the Response.
- See above for meaning of the response.
- Enlarge the indicator to display all the lines received with the prompt ">".
- Hint: You can chose not to display the prompt ">" by using the "Split String" VI (In Functions/String) between the Serial Read and the reading indicator. Use ">" as the "Search Char"

The following VI written in LabVIEW™ will set the Analog Output Scale to Celsius, the Analog Output Resolution to 0.01 C / millivolt and the Analog Output Zero Offset to 100.000.

- Send the 4212C a string formatted as "WC W2 Z = 100.0".
- Append the end of line terminator appended as explained in programming note four (4) of section 3.1.3. • Run the VI.

3.5.6 EXAMPLE OF PROGRAMMING VIA IEEE-488 INTERFACE

The following VI written in LabVIEW™ for the GPIB interface will display the current Analog Output Parameters, both as the string as read from the 4212C and as characters for the Scale and Resolution and as a real number for the Zero Offset.

- Send "A" to the 4212C using the routine described in programming note 5 of 3.2.2.
- Wait 750 ms or more using the Wait function found in Functions/Time and Dialog.
- Read the 4212C using the routine described in programming note 6 of 3.2.2.
- Note: Stretch the string indicator to read all the parameters. • Run the VI.

The following VI written in LabVIEW™ will set the Analog Output Scale to Celsius, the Analog Output Resolution to 0.01 C / millivolt and the Analog Output Zero Offset to 100.000.

- Connect a string constant "WC W2 Z = 100.0" to the data input of the GPIB Write VI found in Functions/Instrument I/O and GPIB. • Connect a string control with the IEEE address of the 4212C to the address terminal of the above VI.
- Connect an integer constant 3 to the mode terminal of the above VI.
 - Run the VI.

3.6 IMPROVED RESOLUTION (OPTION 27)

Resolution is increased to 0.001°C and 0.001°F. Ohms resolution remains at 0.001 Ω. Increased resolution is designed for use with 100 Ω R0 sensors. This option, while functional, is not recommended for sensors having R0's of 10 or 25.5 Ω.

Instrument ohmmeter uncertainty: ±15 ppm or 0.002 ohms whichever is greater.

Instrument temperature uncertainty as listed in the following table.

TEMP	-200°C	-100°C	0°C	+100°C	+200°C	+300°C	+400°C	+500°C
± °C	0.005	0.005	0.005	0.006	0.007	0.009	0.011	0.013

TEMP	-328°F	-148°F	+32°F	+212°F	+392°F	+572°F	+752°F	+932°F
± °F	0.009	0.009	0.009	0.011	0.013	0.016	0.020	0.023

3 7 ADDITIONALLY IMPROVED RESOLUTION (OPTION 33)

In addition to the 0.001°C and 0.001°F this option has 0.0001 ohms resolution, particularly useful when calibrating unknown platinum RTD's for optimum accuracy. Increased resolution is designed for use with 100 Ω R0 sensors. This option, while functional, is not recommended for a sensor having an R0 of 10Ω.

Instrument ohmmeter uncertainty: ± 6 ppm or 0.0006 ohms whichever is greater.

Instrument temperature uncertainty as listed in the following table.

TEMP	-200°C	-100°C	0°C	+100°C	+200°C	+300°C	+400°C	+500°C
± °C	0.003	0.003	0.004	0.004	0.005	0.006	0.006	0.007

TEMP	-328°F	-148°F	+32°F	+212°F	+392°F	+572°F	+752°F	+932°F
± °F	0.005	0.006	0.007	0.008	0.009	0.011	0.012	0.013

4.0 CALIBRATION PROCEDURES

The Model 4212C Temperature Monitor is calibrated in accordance with the International Temperature Scale of 1990 (ITS-90). The 4212C conforms to the R vs T tables generated by formulas from the NIST Technical Note 1265 within the range of -218 to +660°C.

The instrument is burned-in and factory calibrated prior to shipment. It is designed to remain in calibration for a minimum of one {1} year before a recalibration check is required.

There is only one calibration adjustment and it applies to both channels. This adjustment, if necessary, is performed during the Calibration of Ohmmeter Section (4.1) and is normally made at Full Scale.

4.1 CALIBRATION OF OHMMETER SECTION

Instrument accuracy, as an Ohmmeter, is ±20 PPM or ±0.003 Ohms, whichever is greater.

To verify calibration and linearity, readings should be made at 3 or 4 points, such as:

ACCURACY	INSTRUMENT ACCURACY (3:1 RATIO)	CALIBRATION STANDARDS
10 Ohms	±0.003 ohms (300ppm)	±0.001 ohms (100ppm)
100 Ohms	±0.003 ohms (30ppm)	±0.001 ohms (10ppm)
200 Ohms	±0.004 ohms (20ppm)	±0.0013 ohms (7ppm)
300 Ohms	±0.006 ohms (20ppm)	±0.002 ohms (7ppm)

Suitable calibration equipment would be:

Instrulab Resistor Card or
 Standard Resistors or
 Decade Resistance Box.

Be sure to use 4 wire connection.

After connections are made, the 4212C should be closed up and allowed to "soak" for a minimum of 45 minutes.

4.1.1 FULL SCALE CALIBRATION ADJUSTMENT

If there is a problem at low end calibration, i.e. 10 ohms, there is a "Zero" adjustment available. See Paragraph 4.1.2. This calibration, if required, must be performed before full scale calibration.

R101 is the only analog adjustment and is for full scale or for the highest resistance to which the instrument is used. It adjusts both channels. A clockwise rotation increases the reading.

It is acceptable to calibrate only one channel as they will track each other within ±1 LSD.

When making an adjustment, the top cover should be opened only as long as necessary. After closing the top cover, wait 5 to 10 minutes before taking a new reading.

4.1.2 ZERO OFFSET CORRECTION

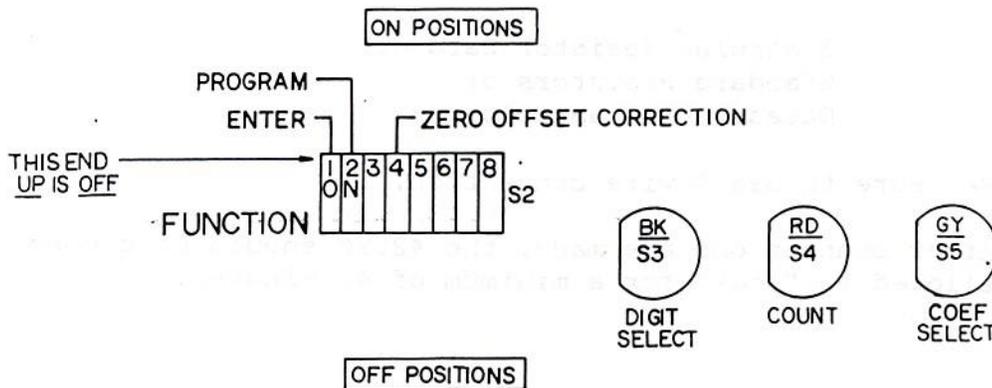
This correction is initially made at the factory and should not normally need to be made again, unless U2 is replaced.

MODEL _____ S/N _____
 ZERO OFFSET CORRECTION, INPUT 1 _____ OHMS

4.1.2.1 VERIFYING CURRENT ZERO OFFSET CORRECTIONS.

First, verify that the factory measured offset corrections are present in memory for each channel.

Refer to general programming procedures in paragraph 2.3.3. After SW #2 of function switch S2 is pushed to ON. Operate SW #4 of S2 to ON. You are now in the Program mode.



Close up of S2 showing Zero Offset Correction Programming Switches

Figure 7

Operate COEF SELECT pushbutton until menu #7 is displayed by the extreme right hand digit.



This display indicates the Zero Offset Correction that is currently in memory for the input selected. Compare this reading to the listing, if it agrees, check the other input. If it does not agree, adjust it in accordance with paragraph 4.1.2.2. Note that the display gives an extra decade of resolution over what is normally displayed. This menu will not come up if SW #4 of S2 is not ON.

To check the other input, press COEF SELECT until the display reads READY. Operate SW #2 and SW #4 of S2 to OFF. Display commences to read sensor input. Operate input selector switch to the other input. Repeat Paragraph 4.1.2.1.

4.1.2.2 PROGRAMMING NEW ZERO OFFSET CORRECTIONS INTO MEMORY.

For assistance, refer to Paragraph 2.3.3 for general programming procedures. Operate SW #2 & 4 of S2 to ON.

Operate CONSTANT SELECT pushbutton until Menu #7 is displayed by the extreme right hand digit.



7

This display indicates the ZERO OFFSET CORRECTION that is currently in memory for the input selected.

Use the COUNT and DIGIT SELECT pushbuttons to change the display to read the desired numbers. Note that the display gives an extra decade of resolution over what is normally displayed. This menu will not come up if SW #4 of S2 is not ON.

Operate COEF SELECT until the display reads READY.

Operate SW #1 of S2 to ON. Selected values are now being entered into memory.

When display reads DONE, operate SW #1,2 & 4 of S2 to OFF. Instrument will commence reading sensor input.

If the other input is to be done, operate the Input Selector Switch and repeat the procedure.

Full scale calibration should be done after any adjustment to ZERO OFFSET CORRECTION.

4.1.2.3 DETERMINING NEW ZERO OFFSET CORRECTIONS.

If for some reason the offset amount does not appear to be correct, a new offset can be determined. The preferred method is to use a 1 ohm (or alternately 10 ohms) standard resistor. Adjust the Zero Offset until the instrument reads the 1 ohm (or 10 ohm) Resistor exactly. See Paragraph 4.1.2.2 for programming instructions. Allow 2 to 3 hours of soak time between adjustments. Both channels need to be adjusted. Record new offset corrections with polarity.

An alternate, but less accurate method (by 1 to 2 LSD) is to short the four (4) input terminals together. Adjust the Zero offset until the instrument reads 0.000. See Paragraph 4.1.2.2 for programming instructions. The instrument has a "live" zero and will read negative numbers. Allow a two (2) hour warm-up when using this method. Do both channels. Record new data.

4.2 VERIFYING RESISTANCE TO TEMPERATURE CALCULATIONS

This section of the calibration procedure verifies the microprocessor controlled digital math function.

This 4212C function is not subject to aging or temperature drift, and has no adjustments. It will only calculate

erroneously if there is a component failure. Therefore frequent verification is not necessary, if at all.

4.2.1 PROCEDURE OUTLINE

To verify the 4212C math calculations you will need:

- A) A Decade Resistance Box with 0.001 ohm resolution. Accuracy is not important in this application.
- B) Four wire lead wire.
- C) An R vs T Table for a Platinum RTD calculated in accordance with ITS-90 or
- D) Use the Sample Math Test listed in this section.

The 4212C will be used to read the resistance of the decade box.

The instrument calculated temperature is then compared to the temperature obtained from the RvsT table.

If you are using the RvsT table for your sensor, this will also check the programming of the coefficients.

4.2.2 PROCEDURE

4.2.2.1 Program the 4212C with the proper coefficients or the RvsT table that you are using.

4.2.2.2 Disconnect the sensor and connect the Decade Resistance Box.

4.2.2.3 Switch the 4212C to OHMS and adjust the Decade Resistance Box until the instrument reads exact value in Ohms of the first selected temperature.

4.2.2.4 Operate "UNITS" Switch to °F and °C. Compare instrument calculated temperature to the RvsT table. It should agree within +0.01°.

4.2.2.5 Repeat for additional points, as desired.

4.2.2.6 When the test is concluded, disconnect the Resistance Decade Box and reconnect sensor. Observe correct terminal markings.

NOTE

If the coefficients were changed for this test, be sure to reprogram the 4212C with the coefficients for the sensor you are currently using.

Close up case and allow for the proper warm-up period.

4.3 SPOT CHECK OF SYSTEM ACCURACY

A simple, but effective, system calibration check can be performed using an Ice Bath.

Periodically immerse the system RTD sensor in a distilled water Ice Bath.

The distilled water Ice Bath may not read exactly 0.000°C but the readings should be consistent from test to test.

While this spot check will not verify full range system accuracy, the constancy of the Ice Bath readings is a useful indicator of system stability.

ITS-90

4200 MATH TEST

TOLERANCE = $\pm .01^{\circ}\text{C}$ or $^{\circ}\text{F}$

I. 25.5 ohm SPRT

0 = 025.4767	1 = 5-1.1733	2 = 4-1.0562
3 = 7-6.6604	4 = 4-1.6385	5 = 4-5.2488
6 = OPO.0000		

OHMS	$^{\circ}\text{C}$	$^{\circ}\text{F}$		OHMS	$^{\circ}\text{C}$	$^{\circ}\text{F}$
5.414	___-190.00	___-310.00		54.589	___300.00	___572.00
15.146	___-100.00	___-148.00		63.696	___400.00	___752.00
25.476	___0.00	___32.00		72.507	___500.00	___932.00
35.483	___+100.00	___+212.00		81.013	___600.00	___1112.00
45.185	___+200.00	___+392.00		85.967	___660.00	___1220.00

II. 100 ohm PRT

0 = 099.8526 1 = 4-5.1229 2 = 4-1.9492
 3 = OPO.0000 4 = 4-5.6753 5 = 4-2.5843
 6 = OPO.0000

OHMS	°C	°F	OHMS	°C	°F
25.620	___-180.00	___-292.00	177.054	___200.00	___392.00
59.384	___-100.00	___-148.00	213.884	___300.00	___572.00
99.849	___ 0.00	___ 32.00	249.555	___400.00	___752.00
139.049	___ 100.00	___ 212.00	284.060	___500.00	___932.00

5 THEORY OF OPERATION

The instrument consists of three basic sections:

1. Analog section
2. Analog to Digital section
3. Digital section

ANALOG SECTION

The purpose of the analog section is to convert the resistance of the Platinum RTD into voltages that can be measured by the Analog to Digital Conversion section. This is done by using a current generator to send a nominal 1 mA (on standard model) current through the RTD and an internal reference resistor connected in series (See Fig. 7). The voltage across the RTD (e1-e2) is equal to the current (I) times the resistance (R_{RTD}), i.e.

$$(e1 - e2) = I R_{RTD}$$

Similarly, $(e3 - e4) = I R_{REF}$

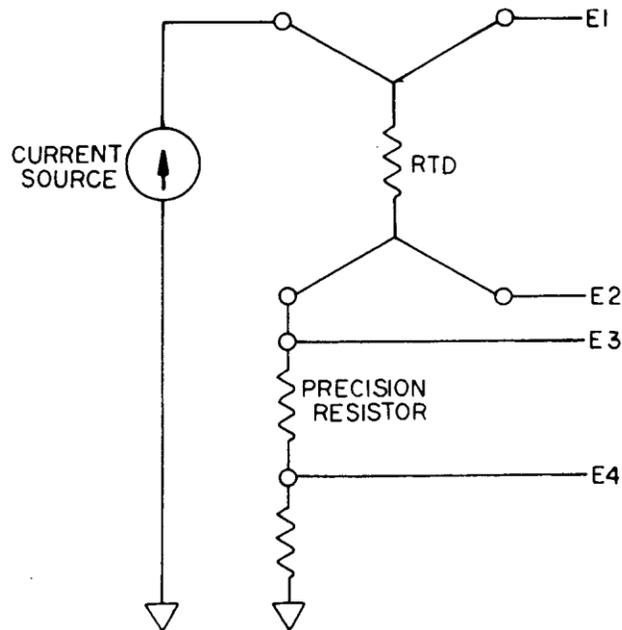
Since the RTD and the reference resistor are connected in series, the ratio of the voltages will be equal to the ratio of the resistances, i.e.

$$R_{RATIO} = \frac{(e1 - e2)}{I} = \frac{I R_{RTD}}{I} = R_{RTD}$$

(e3 - e4) I R_{REF} R_{REF}

The reference resistor is adjusted to exactly 100 Ohms so that:

$$R_{\text{RATIO}} = \frac{R_{\text{RTD}}}{100 \text{ Ohms}}$$



Ratio Measuring Technique
Figure 8

ANALOG TO DIGITAL CONVERTER SECTION

The purpose of the Analog to Digital Converter section is to transform the analog inputs (e1, e2, e3, and e4) into digital numbers that the Digital section can use to compute the resistance and temperature of the RTD.

Each resistance measurement cycle consists of four conversions, one for each input voltage. Since the

computation of the resistance depends on the differences of voltages ($e_1 - e_2$ and $e_3 - e_4$), any zero-offset errors in the A-to-D Converter will be canceled by the subtraction, as long as the zero-offset does not change significantly during a measurement cycle. Since the computation of the resistance is the ratio of two voltages ($[e_1 - e_2]/[e_3 - e_4]$) a small change in the scale factor of the A-to-D Converter will be divided out, if it does not change significantly during a measurement cycle.

The basic accuracy of the instrument is determined by the linearity of the A-to-D Converter and the accuracy and stability of the reference resistor. The dual slope integration technique is used for its excellent linearity and inherent noise rejection. The reference resistor has a low temperature coefficient, less than 1 PPM/°C.

DIGITAL SECTION

The Digital section controls the operation of the A-to-D Converter, computes the resistance and temperature of the RTD, displays the proper engineering units on the front panel, and allows the user to enter and store the coefficients for a particular RTD.

At the end of each measurement cycle, the Digital section computes the resistance of the RTD. It then averages this resistance with the last three readings. If the new resistance differs from the average by less than 7 milliohms, the average is used. If the difference is more than 7 milliohms, then the new reading is used. This technique divides random noise by a factor of 4, but allows the instrument to respond quickly to large changes in resistance.

The temperature is then computed using the formulas from NIST Technical Note 1265 and the coefficients of the RTD being measured. The instrument then displays the new reading in the selected engineering units.

TEMPERATURE DIFFERENCE

Temperature difference or Delta T measurements are made by first measuring the resistance of sensor #1, then converting the resistance to the appropriate measurement scale as with any standard measurement. Then, instead of displaying this value, the digital number is stored in temporary memory. The instrument then switches to sensor #2 and measures the temperature. After this measurement cycle

is completed, the temperature difference of the two digital readings are compared and the difference is displayed.

After displaying the temperature difference, the digital value of sensor #2 is stored and a new measurement is made of sensor #1. Upon completion of this measurement cycle, an updated reading is produced using the old value for sensor #2 and the new value for sensor #1. This constant updating continues as long as the instrument is in the temperature difference mode. Response time is typically 1 to 3 seconds.

6. TROUBLESHOOTING

The following troubleshooting hints will help you to locate most user associated problems. Please contact the factory if your problem cannot be solved using this guide.

PROBLEM

Instrument was working OK, but suddenly displays erratic unstable readings.

POSSIBLE CAUSE

Loose sensor lead.

PROBLEM

Display reading drifts down.

POSSIBLE CAUSE

Sensor high potential lead is open. (Terminal "+P")

PROBLEM

Display reading drifts up.

POSSIBLE CAUSE

Sensor low potential lead is open. (Terminal "-p")

PROBLEM

Display reads "OPEN"

POSSIBLE CAUSE

Sensor element is open or either current lead is open.

PROBLEM

Temperature readings are incorrect when compared to a known temperature.

POSSIBLE CAUSE

Check resistance reading against your R vs T table. If resistance is correct and temperature is incorrect, then error was made in programming. If both resistance and temperature readings are incorrect, check calibration of the instrument (see section 4). Also check to make sure that the calibration coefficients are for the sensor that you are using. Check for sensor damage by testing in an ice bath.

PROBLEM

Instrument works OK, but will not operate from the remote terminal (options 14 & 15).

POSSIBLE CAUSE

Loose remote card (see Figure 2). Loose wire, connecting remote card to the rear of instrument. Loose or broken interface cable. On RS-232C models (option 14) check Baud rate, word length, parity and stop bit requirements; reprogram if necessary. On IEEE-488 models (option 15) check to make sure the address has been programmed correctly.

PROBLEM

Display reads one of the following messages:

PROG 1 PROG 2 PROG IEEE PROG 232

POSSIBLE CAUSE

These messages mean that a programmed variable has changed. See paragraph 2.6, "Checksum Verification of Programmed Variables".

7. PARTS LIST (Models 4201C, 4202C, & 4212C)

NOTE: THE FOLLOWING PARTS LIST INCLUDES ALL POSSIBLE COMPONENTS THAT COULD BE INSTALLED, SOME OF THESE COMPONENTS MAY NOT BE INSTALLED FOR YOUR MODEL.

MASTER P.C. BOARD

SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N	INSTRULAB P/N
_	P.C. Board with all components assembled and tested				158C0371A

CAPACITORS:

C1	4700uf.@16 VDC	Nichicon	UVX1C472MHA		131-0155
C2,3	220uf.@35 VDC	Nichicon	UVX1V221MPA		131-0108
C4,7,8, 11,40,42, 43,44,46, 47,49,50, 51,52,60 61	1uf.@35 VDC	Kemet	T350A105M035AS		131-0103
C5,12,32	33uf.@10 VDC	Kemet	T354F336MO10AS		131-0125
C6,13,14 15,17,18, 19,20,21, 22,23,26, 27,28,30, 31,33	.1uf.@100 VDC	AVX	SR205E104MAA		131-0161
C9,10,29	6.8uf.@35 VDC	Kemet	T354F685MO35AS		131-0126
C16	.01uf.@100 VDC	Arco	TCP-RO1		131-0109
C24,25	33pf.@1000 VDC	Arco	CCD330		131-0137
C41	100pf.@1000 VDC	Arco	CCD101		131-0117
C45	.1uf.@67 VAC	Electrocube	910B1C104K		131-0148
C48	1.0uf.@135 VAC	Electrocube	935B1C105K		131-0127
C53,54,58	2.0uf@100 VDC	Electrocube	230B1B205K		131-0147
C57	1.0uf.@100 VDC	Electrocube	230B1B105K		131-0146
C59	1000pf@25 VDC	Mallory	SXK210		131-0162

MASTER P.C. BOARD (Continued)

SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N	INSTRULAB P/N
DIODES, RECTIFYING					
CR1,2,3,4,		Diodes,	J2		140-0084-001

5,6,7,8
DIODES, SIGNAL

Inc.

CR11,12,22,23
DIODES, ZENER

Fairchild 1N914A 140-0040

CR20,21
 CR24,25

Fairchild 1N758A 140-0503
 Motorola 1N827A 140-0186

TRANSISTORS

Q2 NPN
 Q3,4,5 FET
 Q6,7,8,9, FET
 10,11,12

Motorola MPS4124 140-0086
 Siliconix J201 140-0039
 Siliconix 2N5486 140-0195

RESISTORS

1/4 W CARBON FILM 5%
 R5,8,16,18
 R6

R ohm R25J 139-0162-ohms
 47K ohms
 24K ohms

R7,9,13,20,21

10K ohms

R15,29,30

100K ohms

R17

240K ohms

R19

100 ohms

R22,24,34,35

1K ohms

R23

3.3K ohms

R25,28

2.7K ohms

R26,33,38

1 meg

R27

2.7 meg

MASTER P.C. BOARD (Continued)

DESCRIPTION	MFG'R	MFG'R	P/N	INSTRULAB P/N	SYMBOL
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RESISTORS

1/8 W METAL FILM 1%

Dale CMF55 (RN55D) 139-0092

R31,49

100K ohms

R32,39

1K ohms

R43,46,48

6.19 K ohms

R44,45

154 ohms

R37

46.4K ohms

R40,42

1.47 ohms

R41 9.09K ohms

R50 10 ohms

RESISTOR, Special

R47 100.1 ohms+.05% Vishay S102K 139-0140

RESISTORS,

SIP

RP1,3	47K 9 resistors	Bourns	4610X-101-473	139-0430
RP2	47K 5 resistors	Bourns	4606X-101-473	139-0432
RP4	20K 4 resistors	Bourns	4608X-102-203	139-0434
RP5	20K 3 resistors	Bourns	4606X-102-203	139-0433

TRIMMERS

R101 50K ohms Bourns 3299W-1-503 153-0100

SWITCHES

S2	Function	Grayhill	76SB08	134-0057
S3	Digit Select	Schadow	D6 BK	134-0063
S4	Count	Schadow	D6 RD	134-0064
S5	Coef Select	Schadow	D6 Grey	134-0065

MASTER P.C. BOARD (Continued)

SYMBOL	DESCRIPTION	MFG'R	MFG'R P/N	INSTRULAB P/N
	TRANSFORMER, LOW EMI			149B0096
	INTEGRATED CIRCUITS			
U2		SGS THOMPSON	M48Z12-150PCI	167-0222
U4,17		NSC	DM74HC74AN	167-0194
U5		NSC	*27C256	167-0226
U6,9		NSC	DM74HC08N	167-0190
U7		NSC	DM74HC86N	167-0195
U8		NSC	DM74HC573N	167-0221
U10		HARRIS	82C54	167-0186
U11		NSC	DM74HC138N	167-0197
U12		NSC	DM74HC00N	167-0187

U13	OKI	80C85	167-0184
U14	NSC	DM74HC02N	167-0188
U15	NSC	DM74LS139N	167-0174
U16, 18	OKI	81C55	167-0185
U20, 23	NSC	LF356N	157-0112
U21	NSC	LM311N	157-0173
U22, 26	A.D.	OP77GP	157-0182
U24	NSC	LM393N	157-0206
U25, 27	NSC	LM339N	157-0064
U28	NSC	DM74HC32N	167-0193
U29	SILICONIX	DG403DJ	157-0204

*Programmed: Supply complete instrument model & serial number

MASTER P.C. BOARD (Continued)

INSTRULAB P/N	SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N
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VOLTAGE REGULATORS

VR1, 4	+5V. VDC	Motorola	MC7805CT	157-0047
VR2	+15V. VDC	Motorola	MC7815CT	157-0089
VR3	-15V. VDC	Motorola	MC7915CT	157-0176
VR5	+12V. VDC	Motorola	MC78L12ACP	157-0209
VR6	-12V. VDC	Motorola	MC79L12ACP	157-0210
VR7	+.5V. VDC	Motorola	MC78L05ACP	157-0110

XTAL	6.144 Meg. Hz.	M-tron	MP-1	140-0190
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CONNECTORS

J1	6 pin wafer	Molex	09-18-5061	169-0108
J3	44 pin header	Ap	929975-22	169-0124
J4	12 pin header	AP	929975-6	169-0122
J5	14 pin header	AP	929975-7	169-0122

PC TERMINAL BLOCKS

2pt interlocking	Phoenix Contact	1733415	170-0033
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DISPLAY P.C. BOARD

INSTRULAB P/N	SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N
_		P.C. Board with all components, assembled and tested			158B0372A

CAPACITORS

C1,2	.001uF@500 VDC	Arco	CCD 102		131-0081
C3	33uF@10 VDC	Kemet	T354F336M010AS		131-0125
C4,5,7, 8,9,10	.1uF@100 VDC	AVX	SR205E104MAA		131-0161
C6	.047uF@100 VDC	Sprague	1C10X7R473K100B		131-0165

L.E.D.'s

LD1,2,3, 4,5,6,7	Seven Segment	Qual. Tech.	MAN4910A		156-0007
LD8	Seven Segment	Qual. Tech.	MAN3910A		156-0008
LD9,10,11		Qual. Tech.	HLMP2400		156-0016
LD12		Qual. Tech.	HLMP2500		156-0017
LD13		Qual. Tech.	HLMP2300		156-0017

INTEGRATED CIRCUITS

U1,2	Display Drivers	N.S.C.	MM5450N		167-0164
U3		Motorola	MC14490P		167-0251
U4		NSC	74HC74		167-0194
U5,6,7		T.I.	SN75451BP		167-0250

CONNECTORS

P4	12 Pin	AP	929838-01-06		169-0121
P5	14 Pin	AP	929838-01-07		169-0121

DISPLAY P.C. BOARD (Continued)

MFG'R	MFG'R	P/N	INSTRULAB P/N	SYMBOL	DESCRIPTION
_					P.C. Board with all components, assembled and tested
					158B0372A

RESISTORS

W CARBON FILM 5%	R ohm	R25J	139-0162	1/4
R1,2	15K		139-0162	
R3,4,5, 6,7	270 to 390 ohm select		139-0162	

RESISTOR, SIP

RP1	330 ohms	Bourns	4608X-102-331	139-0434
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SWITCHES, PC MOUNT

SW1,2	"CHANNEL" "UNITS" "E"SWITCH		320E1-1-2	134-0085
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MISCELLANEOUS PARTS

Fuse	Buss	MDL 1/4A	136-0023
Fuse Holder	Littelfuse	345611	136-0024
Line Cord	Belden	17250B1-10	163-0091
Power Switch	Schadow	NE18	134-0072
Power Line Filter	Corcom	1ED2	134-0015
Volt Select Sw.	Schurter	SWA033.4501	134-0079

IEEE-488 P.C. BOARD

SYMBOL	DESCRIPTION	MFG'R	MFG'R P/N	INSTRULAB P/N
_	P.C. Board with all components assembled and tested			158B0326

CAPACITORS

C1,3	33uf@10 VDC	Kemet	T354F336M010AS	131-0125
C2	.01uf@100VDC	Arco	TCP-R01	131-0109

RESISTORS, 1/4 W CARBON FILM 5%	R ohm	R25J	
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R1	10K			139-0162
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INTEGRATED CIRCUITS

U1		T.I.	SN75161AN	167-0179
U2		T.I.	SN75160AN	167-0178
U3		T.I.	SN74LS04N	167-0128
U4		NAT'L.	NAT9914APD	167-0180
	INSTR.			

CONNECTORS

J6	26 pin header	Ansley	609-2627	169-0058
P3	44 pin conn.	AP	929838-01-22	169-0123

RS-232C P.C. BOARD

INSTR/LAB P/N	SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N
		P.C. Board with all components assembled and tested			158B0327D

CAPACITORS

C1,9	33uf@10VDC	Kemet	T354F336M010AS	131-0125
C2,4,6 7,8	.01uf.@100 VDC	Arco	TCP-RO1	131-0109
C3,5	6.8uf@35 VDC	Kemet	T354F685MO35AS	131-0126

INTEGRATED CIRCUITS

U1		N.S.C.	DS 14C88N	167-0151
U2		N.S.C.	DS 14C89AN	167-0152
U3		T.I.	TL16C450N	167-0153

VOLTAGE REGULATORS

VR1	+12V. Reg.	Motorola	MC 7812CT	157-0160
VR2	-12V. Reg.	Motorola	MC 7912CT	157-0161

CONNECTORS

J6	26 pin header	Ansley	609-2627	169-0058
P3	44 pin connector	AP	929838-01-22	169-0123

ANALOG OUT (WHEN SUPPLIED WITH IEEE-488) P.C. BOARD

INSTRULAB P/N	SYMBOL	DESCRIPTION	MFG'R	MFG'R	P/N
-		P.C. Board with all components assembled and tested			158C0349A

CAPACITORS

C4	.1uf.@50 VDC	Sprague	1C25Z5U104M050B	131-0166
C5,7	6.8uf.@35 VDC	Kemet	T354F685M035AS	131-0126
C6,8,9, 10	.01uf.@100 VDC	Arco	TCP-RO1	131-0109

RESISTORS:	1/8W	Dale	CMF55 (RN55D)	139-0092
R2	24.3K ohms			
R3	15K ohms			
R4,5	453K ohms			

RESISTORS, SIP:

RP1	47K ohms	Bourns	4610X-101-473	139-0430
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TRIMMERS:

R101	<u>2K ohms</u>	<u>Bourns</u>	<u>3006P-1-202</u>	135-0035
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ANALOG OUT (WHEN SUPPLIED WITH IEEE-488) P.C. BOARD
(continued)

SYMBOL	DESCRIPTION	MFG'R	MFG'R P/N	INSTRULAB P/N
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INTEGRATED CIRCUITS:

U5		T.I.	SN74HC573	167-0221
U6		T.I.	SN74HC10	167-0220
U7		P.M.I.	PM7542HP	157-0219
U8		T.I.	SN74HC74	167-0194
U9		Siliconix	DG444	157-0232
U10,11		P.M.I.	PM1012GP	157-0183

VOLTAGE REGULATORS:

VR1	+12V. Reg.	Motorola	MC78L12ACP	157-0209
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U3		T.I	TL16C450N	167-0153
U5		T.I.	SN74HC573	167-0221
U6		T.I.	SN74HC10	167-0220
U7		P.M.I.	PM7542HP	157-0219
U8		T.I.	SN74HC74	167-0194
U9		Siliconix	DG444	157-0232
U10,11		P.M.I.	PM1012GP	157-0183

VOLTAGE REGULATORS:

VR1	+12V. Reg.	Motorola	*MC78L12ACP	157-0209
VR2	-12V Reg.	Motorola	*MC79L12ACP	157-0210
VR3	2.5V Ref.	N.S.C.	LM385Z-2.5	157-0218

CONNECTORS:

J7	3 pin	Molex	09-88-1031	169-0132
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* (Note: These replace VR1 & VR2 on the RS-232C P.C. Board)