# INSTRUCTION MANUAL
# for
# 9650 MICROPROCESSOR-BASED
# DIGITAL TEMPERATURE
# INDICATORS/CONTROLLERS

| RECORD OF REVISIONS | | | | |
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# SECTION I

# GENERAL DESCRIPTION

## 1-1 INTRODUCTION

The 9650 Microprocessor-based Digital Temperature Indicator/Controller has been designed to interface with cryogenic refrigeration systems. The controller measures temperature using a calibrated temperature sensor mounted in the system, and controls power to a heater within the refrigeration system to maintain process temperature at a predetermined setpoint value. System data are presented to the operator as a sixteen-character reading on a front panel liquid crystal alphanumeric readout.

The proper power output to the heater for a given set of process conditions, is determined via an equation involving Proportional, Integral and Derivative terms. These terms can be changed by the operator at any time, by means of front panel controls.

An analog output feature is also provided enabling the 9650 to output a voltage (0 - 10 volts) that corresponds to a user definable temperature range.

In addition to its function as a temperature indicator, the sixteen-character alphanumeric readout permits the operator to monitor all principal indicator/controller operational parameters at any point in time without affecting system operation. Provisions are made whereby the operator can also change these parameters once they are accessed and displayed.

Data entry, including sensor calibration data, programmable setpoint and proportional, integral and derivative terms is made via a 3 X 4 membrane keypad mounted on the front panel. $E^2$PROMS provide nonvolatile memory capability. In addition there are three function switches on the front panel which allow the operator to activate each of three different modes of operation -- "Stop" mode, "Manual" mode and "Run" mode.

## 1-2 INDICATORS AND CONTROLS

A sixteen-character LCD alphanumeric readout, three function switches and a 3 X 4 membrane keypad are furnished on the front panel of the controller. These enable the operator to:

a) Input a number of operational parameters into nonvolatile memory,

b) Display any one of these parameters at any time without affecting the control process,

c) Select the desired control mode.

The operational parameters input and displayed via the front panel function switches include:

a) A temperature setpoint

b) Four terms (proportional, integral, derivative, rate) used in the power output control equation.

c) Multiple sensor calibration voltages, for each of two (2) temperature sensors

d) A calibration reference voltage

e) 100 temperature versus time Run mode program point pairs (Point 0 is the first point!)

f) Three terms (zero, span and Sn) used to set the temperature high and low limits for the analog output voltage, and

g) A remote address (for selection of IEEE-488 or RS-232C)

The temperature setpoint is the temperature that the 9650 will attempt to maintain in the system when in the "manual" control mode (see Section 1-3).

The four terms used in the heater output equation are input to define the relative amount of heater power to be applied to or removed from the heater for a given temperature deviation from the setpoint.

Calibration inputs match the controller to the temperature characteristics of the particular sensor employed. These need be entered only after initial installation of the sensor or after a replacement sensor has been installed.

The calibration reference voltage input is used as a scale factor in computing accurate voltage. This is set at the factory and should not be changed. In the unlikely event that this number is lost from permanent storage, it should be reset to the original value.

The temperature versus time program point inputs enable the 9650 to "ramp" to a series of temperatures in a specific time period (see 1-3 below).

The three terms used for the analog output voltage are input to enable the operator to configure the 9650 to output a voltage of 0 - 10 volts over a set range. (The Zero specifies the beginning point of the range, the Span specifies the width of the range and the Sensor value specifies which sensor data to use for calculating the voltage).

## 1-3 MODES OF OPERATION

Three modes of operation are available and are selectable by means of the front panel function switches. These are termed "Stop", "Manual" and "Run".
When placed into the "Stop" mode of operation (by pressing the "Stop" function switch or by powering up), the 9650 indicator/controller assumes a standby condition and the heater power output voltage from the controller circuit is set to zero.

If the temperature drops below the setpoint **OR** if the temperature is below the setpoint when the "Manual" mode is in effect, the controller will output power to the heater as determined by the power output control equation. The operator can change the temperature setpoint value at any time. He can also monitor all instrument operating parameters without affecting control of the process medium.

When in the "Run" mode, the 9650 operates through a previously-inserted set point temperature-versus-time program. This mode is intended for those applications where a detailed analysis of process characteristics under varying set point temperature conditions is desired.

Essentially, the program comprises a collection of continuous set point temperature-versus-time ramp functions. For any given program, the 9650 indicator/controller can store up to 100 individual set points with up to 999.9 minute intervals between points. In addition, when the Run mode is initiated by pressing the front panel function switch, a program may be started at any of the 100 points. The following sequential events will occur upon initiation of the "Run" mode.

1) The indicator/controller will establish the "starting" set point value at that temperature reading currently being displayed.

2) The set point will be increased (or decreased) toward the first program temperature point using the first time point as the time necessary to reach that point.

3) Immediately upon reaching point #1, the indicator/controller will begin adjusting the set point display value toward the second set point value.

4) Operation will continue in this fashion until the last point in the program is reached (defined by a zero temperature value). At that time the 9650 will switch to the 3 "Manual" mode and maintain the current set point value.

## 1-4 HEATER POWER PROTECTION CIRCUIT

The heater power supply incorporates internal short circuit protection to ground, in the event that the heater coil is inadvertently shorted as well as short circuit protection to the 50 volt supply in the event that the power transistor fails.

Internal circuitry monitors the heater output voltage and load current. Detection of a short circuit condition activates a dual stage integrator that is configured to discriminate between a catastrophic condition and spurious noise by verifying the presence of the short over a specific period of time. After verification a relay that is in series with the output opens, disconnecting power at the heater terminals. The bar graph then switches from percent heater power to a ramping display indicating that power has been removed.

## 1-5 QUICKSTART OF THE 9650

This section is provided solely to give the user some idea of the 9650's performance as quickly as possible. After following the procedures below, the operations section may be consulted to understand the 9650's full capabilities.

1) Apply A/C power (110/220) to the 9650

2) After the 9650 startup messages are displayed, perform the following:

    a) Activate the (DIAG) key to display "Diagnostics No:0".
    b) Activate the <edit> key to position the cursor to the digit after the colon.
    c) Activate the "9" key and press enter to edit the max heater voltage.
    d) Activate the numeric keys to select a desirable maximum voltage. (Many applications prefer 30, the 9650's maximum allowable voltage.)
    e) When satisfied with this entry pres (enter) to accept.

3) Connect a voltmeter to the heater output connector on the 9650.

4) Activate the <DIAG> key to display "Diagnostic No:0"

5) Activate the <edit> key to position the cursor to the digit after the colon.

6) Activate the "3" key then the <enter> key to display "Htr output 0.0". The voltmeter should also be displaying 0 voltage.

7) Activating any key will now change the 0.0 on the display to 7.5; the voltmeter should display a comparable value. Continue activating any key and checking the voltmeter in this manner until "30.0" appears on the display. This will then verify that the heater output on the 9650 is functioning properly.

8) Activating any key at this point will restore the normal 9650 temperature display.

9) All input/output connections between the controller and the external refrigerator system are made via rear panel connectors. Refer to drawing number B040-343 for details and connect the 9650 to the external refrigerator system.

10) Activate the <SET> key to display "Txxx.xx S000.0".

11) Activate the <edit> key to position the cursor to the first digit after the "S" (for temperature setpoint).

12) Activate the "1" key; then the <enter> key to accept a setpoint value of 100.0.

13) Activate the <HTR> key to display "Txxx.xx H00.0".

14) Activate the <MAN> front panel function switch. The 9650 will now attempt to control the temperature of the external refrigerator system at 100.0K.

15) Experiment with changing the setpoint value as done previously in steps 10-13.

16) Refer to the Operations section of the manual to gain a full understanding of all of the 9650's capabilities.

## SPECIFICATIONS - Model 9650-1 (Silicon Diode)

| | |
|---|---|
| **Sensors** (dual channel) | Silicon Diode, standard SII Model Si-410 |
| **Controller - Electrical** | |
| Temperature Range: | 1.5 to 450K |
| Sensor Excitation: | Constant current - 10 microamperes |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal 2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | E²PROM: Standard stored data is for Model SI-410 Silicon Diode Sensor. Other data can be stored |
| Resolution: | ±0.01K |
| Accuracy: | ±0.1K(1.5 to 35K)<br>±0.5K(35 to 450K) |
| Controllability: | ±0.1K(1.5 to 35K)<br>±0.2K(35 to 450K) |
| Repeatability: | ±0.1K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 450 Kelvin<br>(.1K resolution) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A).<br>@ 100/200 VAC min |
| Remote Interface:<br>desired | GPIB (IEEE-488) or RS-232C as |
| Program Control: | 100 points (multi-program capability) |
| Control Sensor:<br>sensor. | Programmable by operator to either |
| **Controller - Mechanical** ½ DIN Package | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

## SPECIFICATIONS-Model 9650-2 (Platinum R.T.D.)

| | |
|---|---|
| **Sensors** (dual channel) | Platinum R.T.D. 200 OHMS standard. Other values are optional |
| **Controller - Electrical** | |
| Temperature Range: | 50 to 600K |
| Sensor Excitation: | Constant current - 1.0 milliamp |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal 2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | $E^2$PROM: Calibration parameters and variables stored in non-volatile memory |
| Resolution: | 0.01K |
| Accuracy: | ±0.1K(50 to 600K) Based on standard table inputs |
| Controllability: | ±0.2K(50 to 600K) |
| Repeatability: | ±0.1K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 600 Kelvin (.1K resolution) (User Configurable) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A). @ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points(multi-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** ½ DIN Package | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

## SPECIFICATIONS-Model 9650-3 (Germanium Resistance Thermometer)

| | |
|---|---|
| **Sensors** (dual channel) | Germanium, calibrated SII Model N1V |
| **Controller - Electrical** | |
| Temperature Range: | 1.5 to 100K |
| Sensor Excitation: | Constant voltage - 10 millivolts |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal 2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | $E^2$PROM: For configuration and program points. |
| Resolution: | ±0.001K (1.5 to 60K)<br>±0.002K (60 to 100K) |
| Accuracy: | ±0.07K (1.5 to 60K)<br>±0.1K (60 to 100K) |
| Controllability: | ±0.01K (1.5 to 60K)<br>±0.05K (60 to 100K) |
| Repeatability: | ±0.05K |
| Set Point: | ±0.05K |
| Analog Output: | 0 to 100 Kelvin (.1K resolution)<br>0 to10volts |
| Heater Output: | 60 watts max (30VDC @ 2A).<br>@ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points (multi-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** ½ DIN Package | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

## SPECIFICATIONS - Model 9650-5 (Chromel vs Gold Theromocouple)

| | |
|---|---|
| **Sensors** (dual channel) | Standard SII Model CG07F |
| **Controller - Electrical** | |
| Temperature Range: | 4.2 to 550K |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal 2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | $E^2$PROM: For configuration, sensor calibration, and program points. |
| Resolution: | ±0.01K |
| Accuracy: | ±0.3K(matched to standard curve) |
| Controllability: | ±0.2K |
| Repeatability: | ±0.2K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 600 Kelvin (.1K resolution) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A). @ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points (multi-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** ½ DIN Package | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

## SPECIFICATIONS - Model 9650-6 (Gallium Arsenide)

| | |
|---|---|
| **Sensors** (dual channel) | Gallium Arsenide, calibrated SII Model GA-300NN |
| **Controller - Electrical** | |
| Temperature Range: | 1.5 to 450K |
| Sensor Excitation: | Constant current - 10 microamperes |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal 2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | E²PROM: For configuration, sensor calibration, and program points. |
| Resolution: | ±0.01K (1.5 to 35K)<br>±0.01K (35 to 450K) |
| Accuracy: | ±0.1K(1.5 to 35K)<br>±0.5K(35 to 450K) |
| Controllability: | ±0.1K(1.5 to 35K)<br>±0.2K(35 to 450K) |
| Repeatability: | ±0.1K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 450 Kelvin<br>(.1K resolution) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A).<br>@ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points (multi-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** ½ DIN Package | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

## SPECIFICATIONS - Model 9650-7 (Ruthenium Oxide)

| | |
|---|---|
| **Sensors** (dual channel) | SII Model RO-104 (100K ohms) |
| **Controller - Electrical** | |
| Temperature Range: | 1.5 to 273K |
| Sensor Excitation: | Constant current - 10 microampers |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal<br>2) Bar graph heater indication |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | E²PROM: For configuration, sensor calibration, and program points |
| Resolution: | 0.01K (1.5 to 20K)<br>0.01K to 0.03K (20 to 80K)<br>0.03K to 0.33K (80 to 273K) |
| Accuracy: | ±0.05K (1.5 to 20K)<br>±0.05K to ±0.15K (20 to 80K)<br>±0.15K to ± 5.0% (80 to 273K) |
| Controllability: | ±0.1K (1.5 to 20K)<br>±0.10K to ±0.30K (20 to 80K)<br>(Not Recommended Above 80K) |
| Repeatability: | ±0.1K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 450 Kelvin<br>(.1K resolution) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A).<br>@ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points (muli-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

**NOTE:** Due to the relatively high resistance of the Model RO-104 Sensor, accuracy can be affected by high resistance shorts. Be sure to clean all solder connections for best performance.

## SPECIFICATIONS - Model 9650-7 (Ruthenium Oxide)

| | |
|---|---|
| **Sensors** (dual channel) | SII Model RO-105 (100K ohms) |
| **Controller - Electrical** | |
| Temperature Range: | 2.0 to 273K |
| Sensor Excitation: | Constant current - 10 microampers |
| Operating Voltage Range: | 90-125/180-250 VAC, 50/60 Hz (switchable) |
| Display: | 1) Sixteen-character liquid crystal<br>2) Bar graph heater indication |
| Sensor Fault: | Open 000<br>Shorted 555 |
| Operator Controls: | Embossed Tactile Membrane switches |
| Data Storage: | E²PROM: For configuration, sensor calibration, and program points |
| Resolution: | 0.01K (1.5 to 20K)<br>0.01K to 0.03K (20 to 80K)<br>0.03K to 0.15K (80 to 273K) |
| Accuracy: | ±0.05K (1.5 to 20K)<br>±0.05K to ±0.15K (20 to 80K)<br>±0.15K to ± 2.2% (80 to 273K) |
| Controllability: | ±0.1K (1.5 to 20K)<br>±0.10K to ±0.30K (20 to 80K)<br>(Not Recommended Above 80K) |
| Repeatability: | ±0.1K |
| Set Point: | ±0.1K |
| Analog Output: | 0 to 450 Kelvin<br>(.1K resolution) 0 to 10 volts |
| Heater Output: | 60 watts max (30VDC @ 2A).<br>@ 100/200 VAC min |
| Remote Interface: | GPIB (IEEE-488) or RS-232C as desired |
| Program Control: | 100 points (muli-program capability) |
| Control Sensor: | Programmable by operator to either sensor. |
| **Controller - Mechanical** | |
| Dimensions: | 5.25"H x 8.00"W x 9.00"D |

**NOTE:** Due to the relatively high resistance of the Model RO-105 Sensor, accuracy can be affected by high resistance shorts. Be sure to clean all solder connections for best performance.

# SECTION II

# OPERATION

## 2-1 INTRODUCTION

Successful operation of the 9650 Temperature Indicator/Controller involves the following basic steps:

1) Properly connecting the 9650 to the external refrigerator system.

2) Powering-up the controller.

3) Entering the proper controller setup data (temperature setpoint, Proportional-Integral-Derivative values, sensor calibration data, etc.) via the front panel keypad.

4) Selecting the desired mode of operation.

5) Monitoring the control process via the front panel liquid crystal display (temperature, heater power and set point as desired).

## 2-2 CONNECTING THE 9650 TO THE EXTERNAL REFRIGERATOR SYSTEM

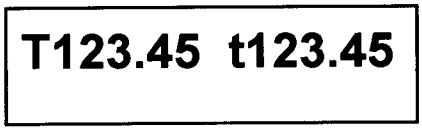
All input/output connections between the controller and the external refrigerator system are made via rear panel connectors. Drawing B040-343 in Section 3 details the required connections.

## 2-3 POWERING-UP THE 9650

The front panel of the 9650 Temperature Controller contains a POWER ON/OFF function switch, an alphanumeric readout, three function switches and a 3 X 4 membrane keypad. After properly making the I/O connections, place the power switch in its "on" position.

Upon initial power-up, the controller will display the "Scientific Instruments" product name and current value for maximum heater voltage output. the controller will then assume a standby condition, with the standard temperature display and "Stop" mode in effect.

Normally, the readout will display the temperature as shown below. However, when the operator is reviewing or changing controller data, the readout is employed to display instrument operating parameters.



## 2-4 ENTERING 9650 SETUP DATA

Reviewing and/or changing sensor calibration data, temperature setpoint, PID values, the temperature vs. time program points, analog output range values and remote address value is accomplished via the 3 X 4 membrane keypad.

In general, changing any of the above parameters involves the following sequential steps.

1) Display the desired parameter by pressing its corresponding key on the keypad.

2) Press the <edit> key to change the parameter.

3) The cursor will appear on the first digit of the first field to edit.

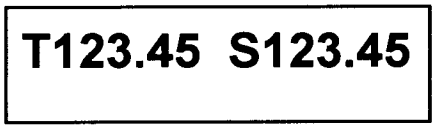
4) Press the numeric keys to edit the parameter as desired.

5) Press the <edit> key to advance to the next field.

6) Continue steps 4 and 5 until satisfied with all parameter settings. (Note: If the <edit> key is pressed while in the last field of the display the cursor will "wrap around" to the first field).

7) Press the <enter> key to accept and save the desired settings. For clarification, several examples follow:

### 2-4.1 Programming the Temperature Setpoint




1) Activate the <SET> key to display the temperature/setpoint values.

2) Activate the <edit> key to move the cursor to the setpoint field and to the first digit of that field.

3) Activate the numeric keys to change the setpoint parameter noting that the cursor increments automatically as each key is pressed. When the last digit of the field is reached the cursor wraps around to the beginning of the field.

4) After all digits have been changed to the desired setpoint value, activate the <enter> key to accept and save the new setpoint value. Activating the Manual" mode will now cause the controller to attempt to bring the process medium to the new setpoint and maintain it at that temperature.

### 2-4.2 Programming the PID Terms


1) Activate the <PID> key to display the PID parameters.

2) Activate the <edit> key to move the cursor to the Proportional term field and to the first digit of that field.

3) Activate the numeric keys as desired to change the proportional term.

4) Activate the <edit> key to advance to the next field (the integral term).

5) Repeat steps 3 and 4 until all terms have been changed to the desired values.

6) Press <enter> to accept and save the displayed values.

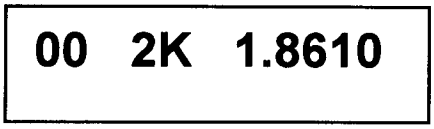
**NOTE:** The "R" parameter on the PID display signifies "RATE" and is used only in the Run mode. It is defined as the maximum rate at which temperature can change in degrees Kelvin per minute. While calculating the new setpoint, if the 9650 determines that it will exceed the "R" parameter, the "R" parameter is substituted in the calculations to insure that the maximum rate of temperature change does not exceed this value.

### 2-4.3 Programming the Sensor Calibration Data

1) Only whole numbers are displayed in this EDIT routine.

2) When shipped, default values from our standard curve data record are installed unless a calibrated sensor is purchased. In this case, the actual calibration data points are installed.

### 2-4.3.1 Silicon Diode -Ruthenium Oxide- Platinum RTD




1) Activate the <CAL> key to bring up the calibration point display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to select the desired calibration point number as shown below.

4) Activate the <edit> key to select the desired point and move the cursor to the first digit of the next field (the calibration voltage).

5) Activate the numeric keys to change the calibration voltage value, from the sensor calibration data sheet or standard data record.

6) After all digits have been changed to the desired value, activate the <edit> key to save the new value and "wrap around" to the first field.

7) Repeat steps 3 through 6 until all calibration data have been changed as desired.

8) Activate the <enter> key to accept and save the changes.

## Silicon Diode Sensors
## Ruthenium Oxide (100K Ω)

| Channel 1 | | Channel 2 | |
|---|---|---|---|
| 00 | 2.00K | 13 | 2.00K |
| 01 | 4.00K | 14 | 4.00K |
| 02 | 6.00K | 15 | 6.00K |
| 03 | 8.00K | 16 | 8.00K |
| 04 | 10.00K | 17 | 10.00K |
| 05 | 18.00K | 18 | 18.00K |
| 06 | 25.00K | 19 | 25.00K |
| 07 | 40.00K | 20 | 40.00K |
| 08 | 50.00K | 21 | 50.00K |
| 09 | 60.00K | 22 | 60.00K |
| 10 | 80.00K | 23 | 80.00K |
| 11 | 270.00K | 24 | 270.00K |
| 12 | 450.00K | 25 | 450.00K |

## Platinum

| Channel 1 | | Channel 2 | |
|---|---|---|---|
| 00 | 77.38K | 13 | 77.38K |
| 01 | 273.15K | 14 | 273.15K |
| 02 | 373.15K | 15 | 373.15K |

### 2-4.3.2 Gallium Arsenide Diode

| 43 77K 1.2345 |
|---|

1) Programming the calibration data is performed using the same procedure as for other sensors except the user is prompted to select sensor '1' or sensor 2' when editing the Cal points. Once selected, the Cal points are numbered from 00 thru 62 as shown below:

| | | | | | |
|---|---|---|---|---|---|
| 00 | 1.5K | 21 | 22.0K | 42 | 70.0K |
| 01 | 2.0K | 22 | 23.0K | 43 | 77.0K |
| 02 | 3.0K | 23 | 24.0K | 44 | 80.0K |
| 03 | 4.0K | 24 | 25.0K | 45 | 90.0K |
| 04 | 5.0K | 25 | 26.0K | 46 | 100.0K |
| 05 | 6.0K | 26 | 27.0K | 47 | 125.0K |
| 06 | 7.0K | 27 | 28.0K | 48 | 150.0K |
| 07 | 8.0K | 28 | 29.0K | 49 | 175.0K |
| 08 | 9.0K | 29 | 30.0K | 50 | 200.0K |
| 09 | 10.0K | 30 | 31.0K | 51 | 225.0K |
| 10 | 11.0K | 31 | 32.0K | 52 | 250.0K |
| 11 | 12.0K | 32 | 33.0K | 53 | 270.0K |
| 12 | 13.0K | 33 | 34.0K | 54 | 273.0K |
| 13 | 14.0K | 34 | 35.0K | 55 | 275.0K |
| 14 | 15.0K | 35 | 36.0K | 56 | 300.0K |
| 15 | 16.0K | 36 | 37.0K | 57 | 325.0K |
| 16 | 17.0K | 37 | 38.0K | 58 | 350.0K |
| 17 | 18.0K | 38 | 39.0K | 59 | 375.0K |
| 18 | 19.0K | 39 | 40.0K | 60 | 400.0K |
| 19 | 20.0K | 40 | 50.0K | 61 | 425.0K |
| 20 | 21.0K | 41 | 60.0K | 62 | 450.0K |

### 2-4.3.3 Germanium Resistance Thermometer

1) Programming the calibration data providing a specific E-Prom for each particular sensor. Sixty-three (63) data points are incorporated to provide the specified accuracy. These points are not accessible to the user for editing. A completecalibrated data table accompanies each sensor.

### 2-4.3.4 Chromel/Gold Thermocouple

As previously explained, stressing the thermocouple wires can cause the output voltage to deviate from the NBS values. By reading the voltage values at a known temperature, the voltages at other temperatures can be corrected for a specific thermocouple. To accomplish this correction, proceed as follows:

1) Select the diagnostic (6,7) DIAG-Edit-6 (CH1)7(CH2)-Enter

2) Place the thermocouple in one of the calibration liquids (Helium, Nitrogen and Ice Bath) and allow the display to stabilize.

3) Record the displayed value on the right side of bezel for that point. Record as many of the points as desired. It is not necessary to obtain all of the points, especially if the unit will not be operated in the affected temperature range. For example, if primary operation is in the range between 77K and 273K, it is not necessary to obtain a calibration point as 4.2K. However, if the unit is operated in the range between 4.2K and 77.38K, the temperature display may exhibit decreasing accuracy as the 4.2K point is approached if the 4.2K point is not obtained.

4) Exit the diagnostic function by pressing any key and enter calibrate function Cal-Edit-00-07 (Calibration datapoints **CH-1**: 00-4K, 01-77K, 02-273K, 03-450K.
**CH-2**: 04-4K, 05-77K, 06-273K, 07-450K. Use the Edit key to go through the needed calibration points, then when this is accomplished, press Enter.

5) The unit is now calibrated for the thermocouple being used. If a different thermocouple is connected, the calibration procedure should be repeated. If it is desired to return the unit to read the NBS table values, enter the NBS values supplied on the calibration sheet for the proper points. Each unit has a uniquely calibrated reference junction diode. The data for this diode is factory calibrated and should not be changed. This data is recorded on the "Instrumentation Data Record" and can be displayed as follows: Cal-Edit-08 (voltage-boiling water, 373K), then Edit-09 (voltage-ice-273K), press Enter to exit.

**Thermocouple Calibration Points** **Reference Diode**

| Channel 1 | | Channel 2 | | Channel 1 | |
|---|---|---|---|---|---|
| 00 | 4.21K | 04 | 4.21K | 08 | 373.15K |
| 01 | 77.38K | 05 | 77.38K | 09 | 273.15K |
| 02 | 273.15K | 06 | 273.15K | | |
| 03 | 450.00K | 07 | 450.00K | | |

6) It is not possible to immerse the thermocouple in the calibration liquids and you have a calibrated thermocouple, you may calculate calibration values for the unit by using the formula on page D-2 of manual (V = (T/C voltage/2) + 0.1). If ice was used as a reference to obtain calibration values for your thermocouple, proceed as the following example for the 77.38K point:

$$\frac{\text{Cal Pt}}{4218} - \frac{\text{N.B.S. Ice Point}}{5309.3} = \tilde{-1091.3}$$

V = (1.0913/2) + 0.1 = .6457

This is the value to be entered into M9650 Cal Point 01.

## 2-4.4 Programming a Temperature/Time Program

**00 T123.4 M000.5**

1) Activate the <PROG> key to bring up the temperature vs. time display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to select the desired program point number as desired. (**NOTE:** on power up the default value will be zero, otherwise the program point last edited will be displayed.)

4) Activate the <edit> key to select the desired point and move the cursor to the first digit of the next field (the program point temperature value).

5) Activate the numeric keys to change the program point temperature value.

6) After all digits have been changed to the desired value, activate the <edit> key to save the new value and move the cursor to the first digit of the next field (the program time point).

7) Activate the numeric keys to change the program point time value.

8) After all digits have been changed to the desired value, activate the <edit> key to save the new value and cause the cursor to wrap around to the first field (program point).

9) Repeat steps 3 through 8 until all desired program points have been changed.

**NOTE:** A maximum number of 100 program points may be entered (0 - 99). A program point with a temperature value of 000.0 defines the end of a program.

10) Activate the <enter> key to accept and save all changes.

### 2-4.5 Programming the Analog Output Range Values


1) Activate the <ANA> key to bring up the analog output display.

2) Activate the <edit> key to move the cursor to the first field and the first digit of that field.

3) Activate the numeric keys to change the Zero point temperature value. (**NOTE:** the Zero point defines the temperature range starting value -- minimum entry = 0; maximum entry = 650.)

4) Activate the <edit> key to save the desired zero value and move the cursor to the first digit of the next field (the Span temperature value).

5) Activate the numeric keys to change the Span point temperature value. (**NOTE:** The Span point defines the width of the temperature range -- minimum entry = 1; maximum entry = 650.)

6) Activate the <edit> key to save the desired span value and move the cursor to the first digit of the next field (the analog sensor number).

7) Activate the numeric keys to change the analog sensor number to the desired sensor. (**NOTE:** this value should be entered as 1 or 2 for best results. Any value other than 1 will be interpreted by the 9650 as a 2.)

8) After all digits have been changed to the desired value, activate the <edit> key to save the new value and cause the cursor to wrap around to the first field (Zero point).

9) Activate the <enter> key to accept and save all changes.

### 2-4.6 Programming the Remote Address Value


1) Activate the <REM> key to bring up the remote address display.

2) Activate the <edit> key to move the cursor to the numeric field and the first digit of that field.

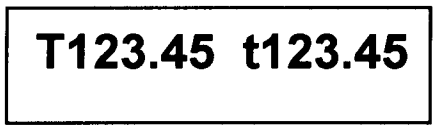
3) Activate the numeric keys to change the GPIB address to the desired address on the GPIB bus.

**NOTE:** This value must be less than 32 to enable the 9650 to function for IEEE-488. Any value over 32 disables the IEEE-488 function and configures the 9650 to function for RS232C.)

4) Activate the <enter> key to accept and save all changes.

**NOTE:** Whenever this configuration change occurs, the 9650 must be powered down and back up to function properly in either IEEE-488 or RS232C transmission mode.

### 2-4.7 Programming the Control Sensor




1) Activate the TEMP key to bring up the normal temperature display.

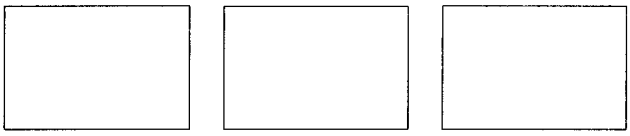
2) Activate the edit key to change the control sensor. The message CONTROL SENSOR will appear with the current control sensor number in the last digit on display.

3) Enter either a 1 or 2 using the numeric keys. Any number may be entered, but any number entered other than 1 will be treated in the program as sensor 2. To avoid confusion, only use the number 1 for sensor 1 and 2 for sensor 2.

4) Activate the enter key to accept and save the selection.

**NOTE:** When sensor 2 is selected as the control sensor, an arrow points to the"t" identifier. When sensor 1 is selected as control sensor, the display appears normally without the arrow.

## 2-5 SELECTING THE DESIRED MODE OF OPERATION



STOP MAN RUN

These three modes are explained fully in section 1-3. Pressing any one of these switches will activate that particular mode. Below are several important notations to consider when selecting a mode:

1) These three keys are ignored by the 9650 if the operator is in the process of editing **ANY** of the system parameters.

2) When selecting the PROG mode, the operator is prompted with **"Start Prog at: 00"**. The operator must enter a two digit number (0-99) which the 9650 will use as the starting point to begin a program. This feature enables the 9650 to begin a program from anywhere in its memory. This effectively permits an operator to keep many commonly used programs stored in memory to be activated on command.

3) A program is terminated when the 9650 reads a program point with a temperature of 000.0 and is accompanied by three high-pitched sounds.

4) If the Run mode is initiated at a starting point where the first temperature point is 000.0, the 9650 will display an error message - "No program - abort" accompanied by three **short,** high-pitched sounds.

## 2-6 MONITORING THE CONTROL PROCESS

The display can be caused to alternate between displaying temperature of the process medium, temperature and heater output, AND temperature and current setpoint (of particular interest when in the "Run mode") by activating the <TMP>, <HTR> and <SET> keys respectively.

**NOTE:** If the sensor is open, the 9650 will display 0.0 heater output and will automatically shut off the heater. (This feature is not available on the 9650-5.)

## SECTION III

## PICTORIALS


BLOCK DIAGRAM.....A030-037

DIAGRAM, PROGRAM LOGIC FLOW.....A031-004 (Shts 1-4)

THERMOCOUPLE CONNECTOR PREPARATION.....A040-389

INSTRUMENT DATA RECORD .....A054-158G

CABLE ASSEMBLY, SENSOR.....A162-195A

PICTORIAL, REAR PANEL.....B040-343B

PHOTO, MODEL 9650 TEMPERATURE CONTROLLER.....B040-355


### P/C ASSEMBLIES


ASSEMBLY, SIGNAL CONDITIONER GERMANIUM.....A150-314

ASSEMBLY, P/C THERMOCOUPLE OPTION BOARD..... .....A150-322A

ASSEMBLY, P/C REFERENCE JUNCTION.....A150-323

ASSEMBLY, SIGNAL COND. PLATINUM/GALLIUM ARSENIDE.....A151-002

ASSEMBLY, P/C $RU0_2$ OPTION BOARD.....A151-007

ASSEMBLY, P/C 2ND SENSOR.....B150-276

ASSEMBLY, P/C PROCESSOR BOARD.....C150-250C

ASSEMBLY, P/C POWER SUPPLY BOARD.....D151-001C


### SCHEMATICS


SCHEMATIC, 2ND SENSOR.....A060-242A

SCHEMATIC POWER SUPPLY.....C060-238E

SCHEMATIC PROCESSOR.....B060-240B

SCHEMATIC, DUAL GALLIUM SENSOR OPTION.....B060-261A

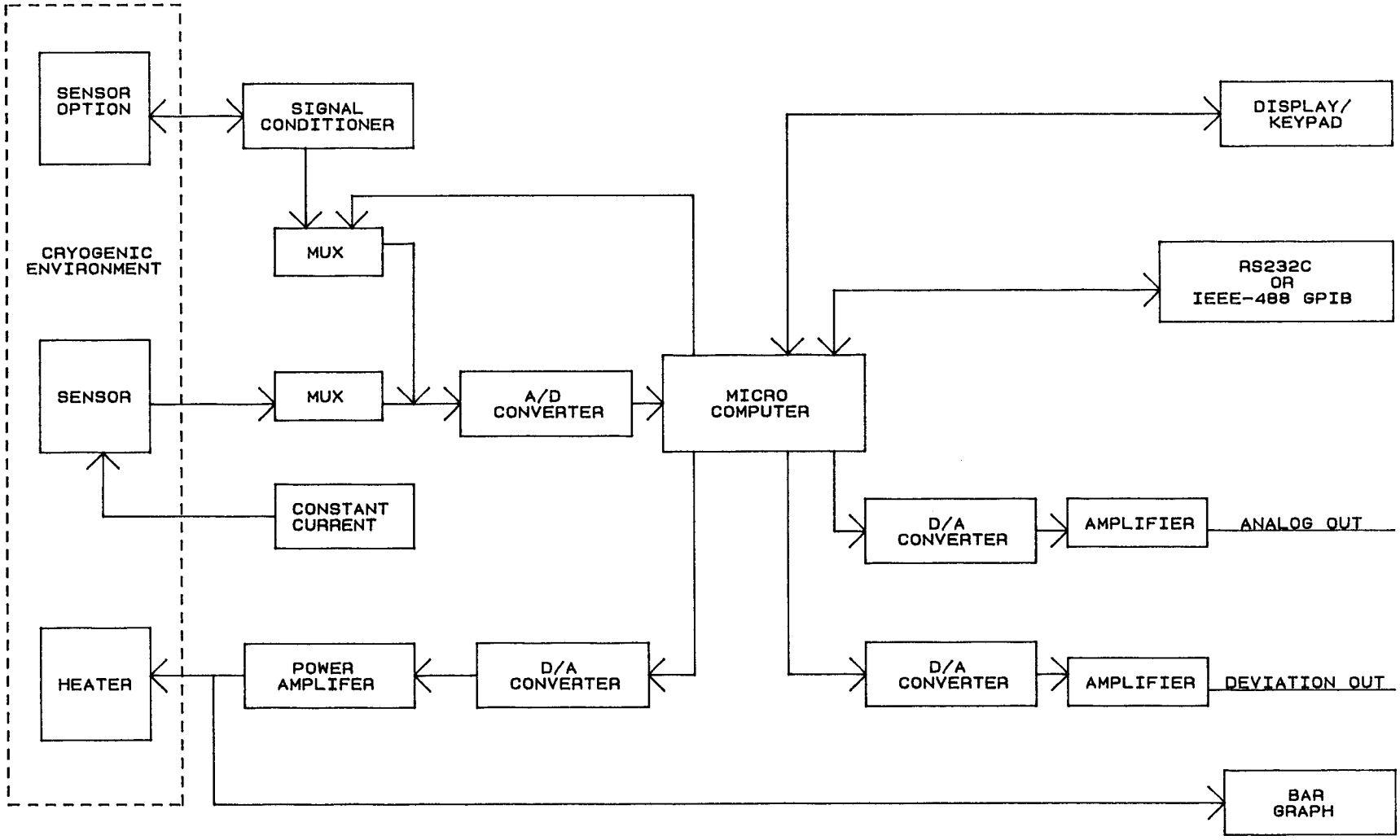
SCHEMATIC, DUAL PLATINUM SENSOR OPTION.....B060-268A

SCHEMATIC, RU02 OPTION.....B060-278

SCHEMATIC, GERMANIUM OPTION.....C060-271

SCHEMATIC, THERMOCOUPLE OPTION.....C060-272


**Note: All drawings are latest revision**




| SCIENTIFIC INSTRUMENTS, INC. West Palm Beach, Florida 33407 | | | | | |
|---|---|---|---|---|---|
| Model | Product: INST | Scale: N/A | Finish | | |
| | | | Dwn. W.W.J. | 10/26/88 | |
| Title: BLOCK DIAGRAM | | | Ckd. M.LEE | 10/26/88 | |
| | | | Apd. | | |
| .0 ± .030 .00 ± .015 .000 ± .005 | FSCM No.: 53547 | Size: A | Dwg. No.: 030-037 | Rev.: 0 | Sheet: 1 of 1 |

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1

| REVISION | | | |
|---|---|---|---|
| LTR | DESCRIPTION | DATE | APPROVED |
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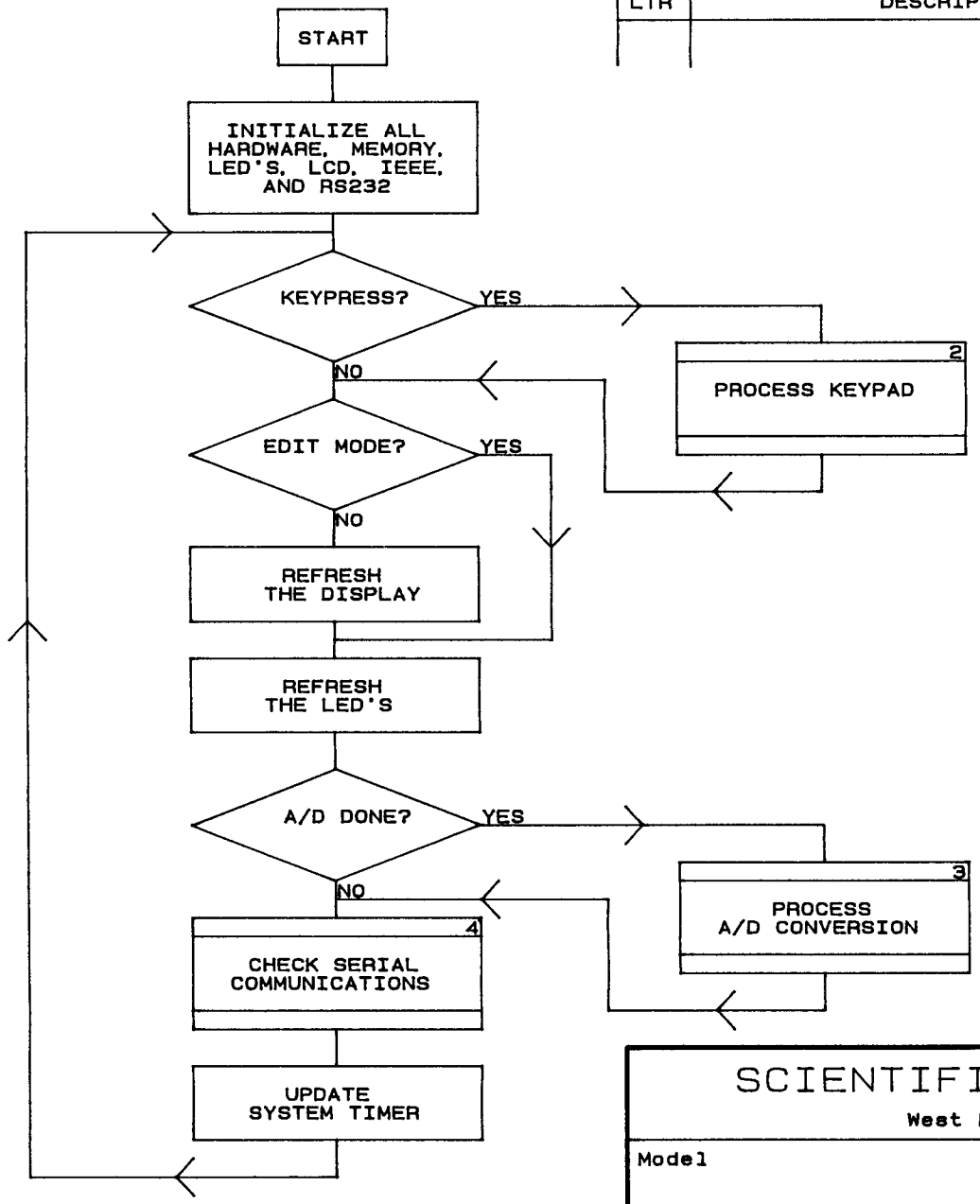


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| Model | Product | Scale | Finish | |
|---|---|---|---|---|
| | INST | N/A | Dwn. W.W.J. | 10/13/88 |
| Title: DIAGRAM, PROGRAM LOGIC FLOW | | | Ckd. J.ROUSE | 10/14/88 |
| | | | Apd. | |

| .0 ± .030<br>.00 ± .015<br>.000 ± .005 | FSCM No. | Size | Dwg. No. | Rev. | Sheet |
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| | 53547 | A | 031-004 | 0 | 1 of 4 |

PROCESS KEYPAD

2

| REVISION | | | |
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| LTR | DESCRIPTION | DATE | APPROVED |
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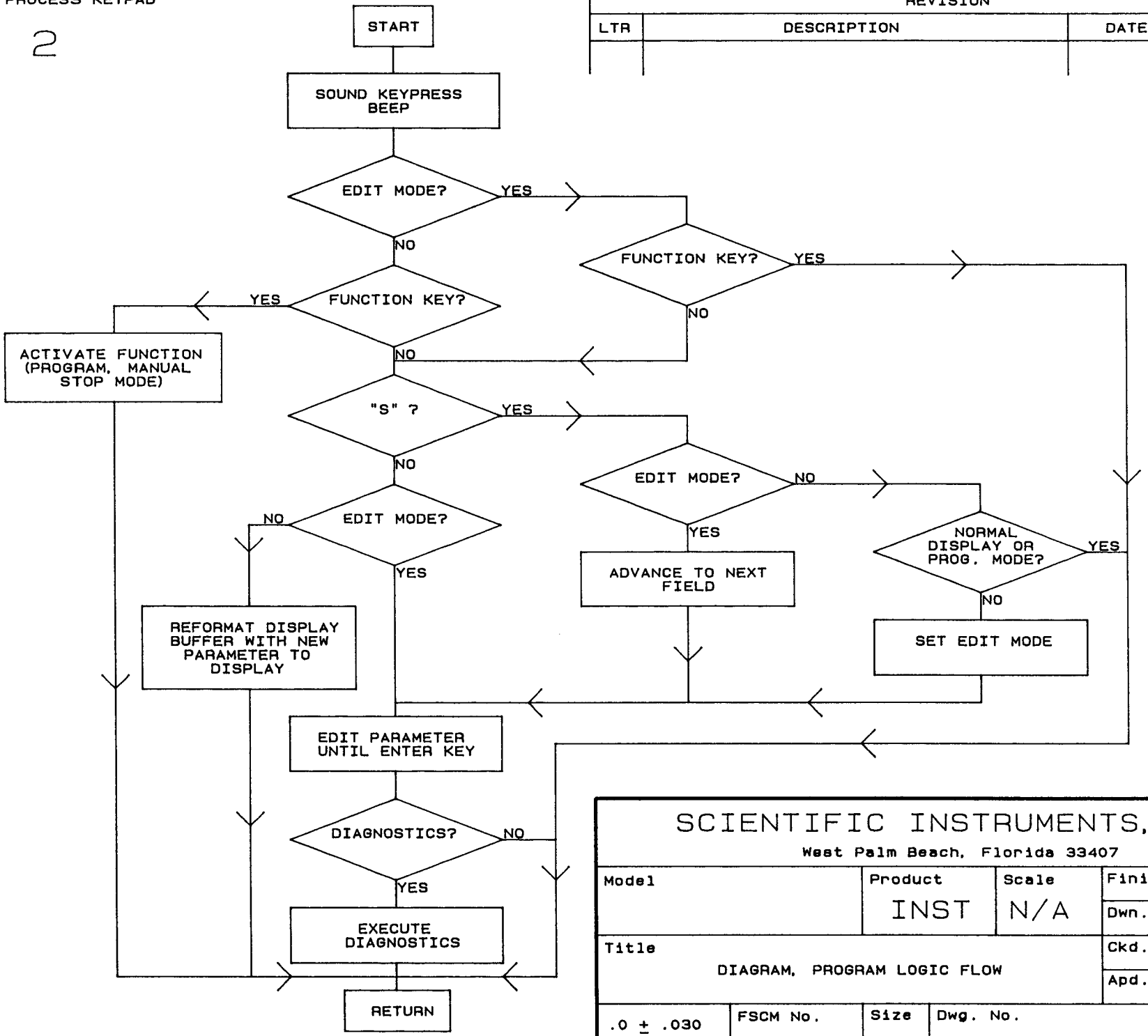


SCIENTIFIC INSTRUMENTS, INC.

West Palm Beach, Florida 33407

| Model | Product | Scale | Finish | |
|---|---|---|---|---|
| | INST | N/A | Dwn. W.W.J. | 10/13/88 |
| Title: DIAGRAM, PROGRAM LOGIC FLOW | | | Ckd. J.ROUSE | 10/14/88 |
| | | | Apd. | |

| .0 ± .030<br>.00 ± .015<br>.000 ± .005 | FSCM No. | Size | Dwg. No. | Rev. | Sheet |
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| | 53547 | A | 031-004 | | 2 of 4 |