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USER'S MANUAL

Model DRC-93C

Temperature Controller

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Obsolete Manual **March 1988**

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SERIAL NUMBER _____

MB SOFTWARE _____

DB SOFTWARE _____

I N S T R U C T I O N M A N U A L

M O D E L D R C - 9 3 C
T E M P E R A T U R E C O N T R O L L E R

Input Card Configuration

		Input A	Input B
9210-3	Standard 3 volt Configuration	☐	☐
-6	6 Volt Diode Configuration	☐	☐
9215-15	Standard 15 Nanofarad Capacitance Input	☐	☐
-150	150 Nanofarad Configuration	☐	☐
9220-3	Standard 3 volt Configuration	☐	☐
-6	6 Volt Configuration	☐	☐
-P2	100 ohm platinum conversion module	☐	☐
-P3	1000 ohm platinum conversion module	☐	☐
-R1	27 ohm Rh-Fe conversion module	☐	☐
9305	Thermocouple Input Card	☐	☐
9317C	Ultra-low (0.3K) Germanium input Card	☐	☐
9318C	Germanium/Carbon Glass Input Card	☐	☐
	No Input Card	☐	☐

8223 RS-232C Interface ☐

8225 Analog Output Interface (0-10 volt) ☐

8229 Scanner Input Option ☐

9126 High Resolution Set Point ☐

Precision Option(s)

8001 ☐ 8002 ☐

Output Power Option

W60 ☐

This manual applies directly to instruments with Serial Number 17000 and higher.

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SECTION I

GENERAL INFORMATION

1.1 INTRODUCTION

The information contained in this operations manual pertains to the installation, operation, remote programming, options and accessories for the Lake Shore Cryotronics, Inc. Model DRC-93C Temperature Controller. This manual also contains troubleshooting and calibration procedures, schematics, component layouts and replaceable parts lists.

This section contains general information for the Lake Shore Cryotronics, Inc. DRC-93C Temperature Controller. Included is an instrument description, specifications, instrument identification, option and accessory information.

1.2 DESCRIPTION

The DRC-93C Temperature Controller is a microprocessor based instrument which provides true analog control. It is capable of scanning multiple sensor inputs and displaying temperature with up to 5 digits of resolution in K, ^{o}C or ^{o}F or sensor units (volts, ohms or nanofarads) to five digits.

The DRC-93C can be used with either 1 or 2 input cards. When two input cards are used, these cards can be different to allow two separate types of sensors to be used with the controller.

The dual sensor input with the optional 8229 Scanner Conversion Card expand the input capability of the DRC-93C to up to 6 input sensors. Depending on the input option selected, the DRC-93C handles silicon (9210-3 or 9220-3) or the patented Gallium-Aluminum-Arsenide (9210-6 or 9220-6) diodes, platinum or rhodium-iron resistors (9220 series), germanium or carbon glass resistors (9317C, 9318C), or capacitance sensors (9215).

With or without the 8229 Scanner Card, the DRC-93C can be set to scan automatically with an individual dwell time of 1 to 99 seconds per channel or stepped to any available input and held there. Setting the dwell time to zero causes a particular channel to be skipped. If all dwell times are zero, the instrument stays on the channel selected.

The DRC-93C gives a direct reading in temperature when used with any DT-470 Series Temperature Sensor. All DT-470 Sensors follow the same temperature response curve. Four bands of tracking accuracy are available. Refer to DT-470 technical data for details.

Diode sensor voltages are digitized to a resolution of 100 microvolts with full scale dependent on input card configuration. The temperature display has a resolution capability of 0.01 kelvin above 100 kelvin and 0.001 kelvin below 100 kelvin.

For greater precision individual sensor calibrations can be accommodated with the 8001 Precision Calibration Option which programs the instrument with calibration data for a specific Sensor. The algorithm within the instrument interpolates between data points to an interpolation accuracy which exceeds 0.01K over the entire temperature range of the Precision Option. The 16 bit analog-to-digital converter is accurate to

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plus or minus the least significant bit, which for the 470 series sensor results in an uncertainty of 1mK below 28K and 45mK above 40K with a transitional region between these two temperatures. Therefore, at temperatures below 28K, the overall system accuracy, the sum of the instrument accuracy (11mK) and that of the calibration itself (Lake Shore calibrations are typically better than 20mK within this region) is ± 30mK. Above 28K, system accuracy gradually moderates to a typical value of ±75mK above 40K. See the Lake Shore Low Temperature Calibration Service brochure for additional discussion of calibration accuracy.

The Model DRC-93C can also be used with the 9220 input card which handles both diodes and positive temperature coefficient metallic resistors., i.e., platinum or rhodium-iron resistors. The DIN curve is standard within the instrument and is called up automatically unless a positive temperature coefficient precision option curve is selected for that input. The accuracy of the reading is dictated by the sensor and its conformity to the DIN curve. The tolerance on these devices is given on the technical data sheet for the Lake Shore PLATINUM RTD's. The combined accuracy of the instrument and a calibrated resistor with a precision option is on the order of 40mK over the useful range of the sensor (above 40K for the platinum). Note that a precision option is required for a rhodium-iron to read correctly in temperature.

The Model DRC-93C with the 9318C germanium/carbon-glass input card results in the most accurate system below 50K in temperature. For both sensors, a precision option is required to read in temperature. Near 4K, the overall accuracy of the system, including the calibration accuracy, the software interpolation accuracy and the calculation of the resistance results in an overall accuracy on the order of 10mK.

These input option cards are easily installed by the user; thus, units can be changed or upgraded to satisfy changing requirements.

The ample memory space provided in the DRC-93C allows several response curves to be stored in the instrument. Depending on the complexity of the curves, up to 25 can be programmed into the unit. The active curve is selected either from the front panel or over the remote interface.

The data for calibrated sensors can be stored in the instrument as an 8001 Precision Option or by the customer via the front panel or remote interfaces. These curves can contain up to 99 sensor temperature data points. With the standard precision option format of 31 data points and an 18 character information line, up to twenty curves can be stored.

Although data points are stored as a table, the interpolation algorithm used results in the equivalent of a high order Chebychev polynomial calculation in the converting of the input voltage (or resistance) to temperature. This is done by means of a proprietary algorithm developed at Lake Shore Cryotronics.

An averaging algorithm can be selected to average up to ten temperature readings. This mode eliminates noise within the system analogous to averaging with a digital voltmeter. This averaging mode can be disabled from the front panel or over the remote interface for a given input if the customer prefers not to average readings.

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The control set point is also displayed on the front panel and can be set from the front panel. The set point automatically takes on the units selected for the control sensor. In the units mode the set point can be set to five digits with the range of defined by the control sensor input card. The standard set point temperature can be set to 0.1 degree. This temperature is converted to an equivalent voltage with a resolution of 100 microvolts out of 3 volts full scale. The optional High Resolution Set point expands the set point resolution to 0.01 degrees 100 and 0.001 degrees below 100. The equivalent voltage is expanded to 25 microvolts out of 3 volts full scale. This results in a settability of approximately 0.01 kelvin above 40K and 0.001 kelvin below 28K for the DT-470 series sensors.

The control section of the DRC-93C provides three-term temperature control. Proportional (GAIN), integral (RESET) and derivative (RATE) are individually set with a range from 0.1 to 99 resulting in a 990 to 1 range.

Heater power output of the DRC-93C Temperature Controller is a maximum of 50 watts when a 50 ohm heater is used. A digital bar graph on the front panel displays the output as a percentage of output range selected. Thus, the user can conveniently monitor power applied to his system. To accommodate systems which require lower heater power, the maximum output can be attenuated in four steps of a decade each. Three resistance ranges are available; 0-25, 25-35 and 35-50 ohms.

The desired range is selected by a slide switch on the rear panel. The power must be off for this selection, since the transformer output is shorted momentarily by changing the setting.

The maximum power can also be limited by using the rheostat on the rear panel. Power can be reduced on the MAX scale to any value between MAX and a reduction of a factor of ten in power.

When greater output power is required, the optional W60 output stage can provide 60 watts into a 25 ohm load.

An IEEE-488 interface is standard in the DRC-93C. This interface can be used to remotely control all front-panel functions. When two input cards are used, data from both inputs is available via the interface.

1.3 SPECIFICATIONS

Instrument specifications are listed in Table 1.1. These specifications are the performance standards or limits against which the instrument is tested.

1.4 OPTIONS

The options for the DRC-93C Controller are listed in Section VII.

Three option ports are designed into the DRC-93C. The options are field installable by the user.

822x-series options can be factory installed in the DRC-93C or field-installed at a later time. The 8223 RS-232C Interface Option operates similar to the IEEE-488 interface. With the display in temperature units, the Model 8225 Analog Output option is available to provide a linearized analog output of 10mV/K independent of the display temperature units chosen. If the display is in sensor units, the output for diodes is 1V/V; for 100 ohm platinum, 10mV/ohm; for 1000 ohm platinum, 1mV/ohm; for

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rhodium-iron, 100mv/ohm; and for capacitance units, 100mV/nF and 10mV/nF. Since the 9317C and 9318C vary over such a large range of resistance, use of the 8225 with these two input cads is limitd to 10mV/K. The Model 8229 Scanner Option provides four additional channels of sensor input to the "A" input. The A input is channel A with the additional inputs designated 1-4 with the selection indicated on the display.

Table 1.1. Specifications, Model DRC-93C Temperature Controller

Input Characteristics:

Inputs: Two Sensor Inputs, A and B. The 8229 Scanner Conversion Option provides for four additional channels of Sensor Input. Display sensor can be selected from front panel or interface, or display can be set to scan between sensor inputs. Dwell time per channel can be set independently from 0 (skip) to 99 seconds. Input characteristics are a function of Sensor Input Option Installed. The DRC-93C can accommodate two input options which allows the A input and the B input to each be assigned their own input card. This allows concurrent use of different sensor types, dependent on the user's application.

Sensors: Ordered Separately. DRC-93C will handle all types of diodes; germanium, carbon glass, carbon, etc. negative temperature coefficient resistors; thermistors; platinum, rhodium-iron, etc. metallic resistors as well as capacitance thermometers with proper choice of input option cards. See the Lake Shore Cryotronics, Inc. Sensor catalog for details on the above Sensors.

Display Readout:

Display: 5-digit LED Display of Sensor reading in Sensor Units (Volts, Ohms or Nanofarads) or temperature in K, ^{O}C, or ^{O}F shown with annunciators.

Resolution: Display resolution is 0.001K below 100K, 0.01K above 100K (0.0001K below 10K for 9317C Resistance Sensor Input Card). Resolution can be user-limited to 1K, 0.1K or 0.01K. Same resolution considerations apply for °C and °F. Changes made by front panel keys or over interface.

Temperature Accuracy: Dependent on Sensor Input Card and Sensor. See Input Options available.

Temperature Range: Dependent of Sensor Input Card and Sensor.

Temperature Control:

Set Point: Keypad selection as a numeric value, as a step change from prior value, or incrementally via up/down counter. All keypad operations can be duplicated with optional interfaces.

Set Point Resolution: Selection in kelvin, celsius, fahrenheit or Sensor Units. Temperature to 0.1 in corresponding units; in Sensor Units, 0.1mV in voltage, 0.01 ohms but limited to five digits in resistance and 0.001 nanofarads out of 15 nanofarads (0.01 nanofarads out of 150 nanofarads for second scale) in capacitance. May also be set over the interface.

Typical Controllability: Dependent on Sensor, its temperature and the resultant Sensor "gain", i.e., sensitivity. Typically better than 1mK in a properly designed system below 30K and 5mK above 30K using a

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Diode Sensor. But, for example, a thermistor, due to its large sensitivity, may result in a controllability approaching 0.5mK above 200K over a narrow temperature range in certain systems and a germanium below 10K may control to 0.1mK in another system.

Control Modes: Proportional (GAIN), integral (RESET) and derivative (RATE). Set numerically (0.0 to 99. of internally established range) or incremented via front-panel keypad. Continuous two-digit display of each mode. Manual Mode allows 0 to 100% of available heater power to be selected via keypad. Auto and Manual modes can be used concurrently. All keypad operations can be duplicated thru interfaces.

Heater output: Up to 50 watts (1A,50V) standard. Five output ranges can be selected either from front-panel or interface and provide approximate decade step reductions of maximum power output. Optional 60 watt output available. Rear panel maximum current limit for MAX scale.

Heater output Monitor: BAR display continuously shows heater current or power output as a percentage of range with a resolution of 1%.

Control Sensor: Either Sensor Input (selected from front panel or remote interfaces).

General:

Sensor Voltage Monitor: For 9210 Option, buffered output of each diode sensor voltage. For 9220 Option diode configurations (-3,-6) give buffered output of diode sensor; for -6 configuration, buffer is 0.458 times sensor voltage; for 9220 Option positive temperature coefficient configurations (-P2, -P3, -R1), buffer is sensor voltage output times -10. For 9215, signal is proportional to capacitance value; for 9317C or 9318C, monitor not of use.

Response time (electronics): Less than 1 second to rated accuracy for non-Lagrangian calculations. Lagrangian curves result in update times between one and two seconds. Three readings on channel change or range change to reach rated accuracy.

IEEE-488 Interface: Allows remote control of set-point, gain, rate, reset, units and heater power range. Provides output of display in units chosen, units and all front panel functions (except power on/off). Allows input of curve data for calibrated sensors and internal ramping programs.

Dimensions, Weight: 432mm wide x 102mm high x 330mm deep (17in. x 4in. x 13in.) Style L, full-rack package. Net weight 8kg (17 lb.).

Power: 90-110, 105-125, or 210-250 VAC (selected via rear panel with instrument off), 50 or 60 Hz, 75 watts.

Accessories Supplied: Mating connector for sensor/monitor connector, instruction manual.

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SECTION II

INSTALLATION

2.1 INTRODUCTION

This Section contains information and instructions pertaining to instrument set-up. Included are inspection procedures, power and grounding requirements, environmental information, bench and rack mounting instructions, a description of interface connections, and repackaging instructions.

2.2 INITIAL INSPECTION

This instrument was electrically, mechanically and functionally inspected prior to shipment. It should be free from mechanical damage, and in perfect working order upon receipt. To confirm this, the instrument should be visually inspected for damage and tested electrically to detect any concealed damage upon receipt. Be sure to inventory all components supplied before discarding any shipping materials. If there is damage to the instrument in transit, be sure to file appropriate claims promptly with the carrier, and/or insurance company. Please advise Lake Shore Cryotronics, Inc. of such filings. In case of parts shortages, advise LSCI immediately. LSCI can not be responsible for any missing parts unless notified within 60 days of shipment. The standard Lake Shore Cryotronics Warranty is given on the first page of this manual.

2.3 PREPARATION FOR USE

2.3.1 Power Requirements

The Model DRC-93C requires a power source of 100, 120, 220 or 240 VAC (+5%, -10%), 50 to 60 Hz single phase.

CAUTION

Verify that the AC Line Voltage Selection Wheel (Figure 3-2,Key 1) located on the rear panel of the Model DRC-93C is set to the AC voltage to be used (Table 2-1) and that the proper fuse is installed before inserting the power cord and turning on the instrument.

2.3.2 Power Cord

A three-prong detachable power cord for 120 VAC operation which mates with the rear panel UL/IEC/ICEE standard plug is included with the instrument.

2.3.3 Grounding Requirements

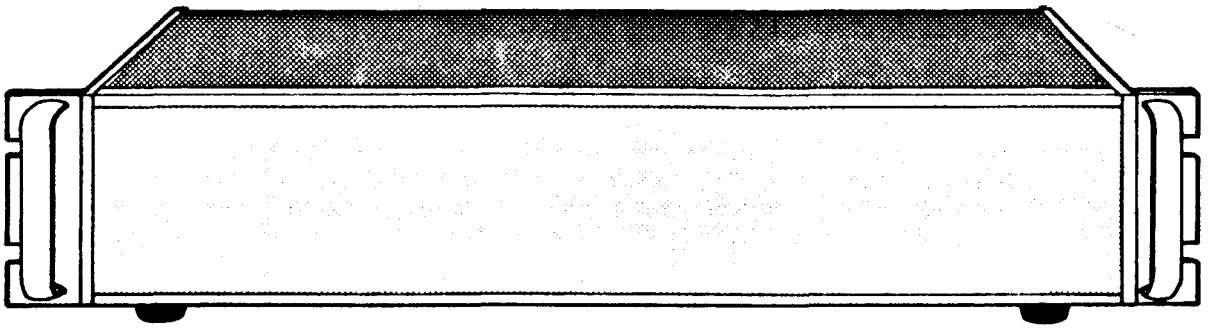
To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends, and some local codes require, instrument cabinets be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument.

Table 2-1. Line Voltage Selection

Line Voltage (Volts)	Operating Range (Volts)	Fuse (A)
100	90-105	2 - SB
120	108-126	2 - SB
220	198-231	1 - SB
240	216-252	1 - SB

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Figure 2-1. Typical Rack Configuration



2.3.4 Bench Use

The DRC-93C is shipped with plastic "feet" and a tilt stand installed and is ready for use as a bench instrument. The front of the instrument may be elevated for convenient operation and viewing by extending the tilt stand.

2.3.5 Rack Mounting

The DRC-93C can be installed in a standard 19 inch instrument rack by using the optional RM-3F or RM-3F-H rack mounting kit. A typical RM-3F-H kit installation is shown in Figure 2-1.

2.3.6 Sensor Input Connections

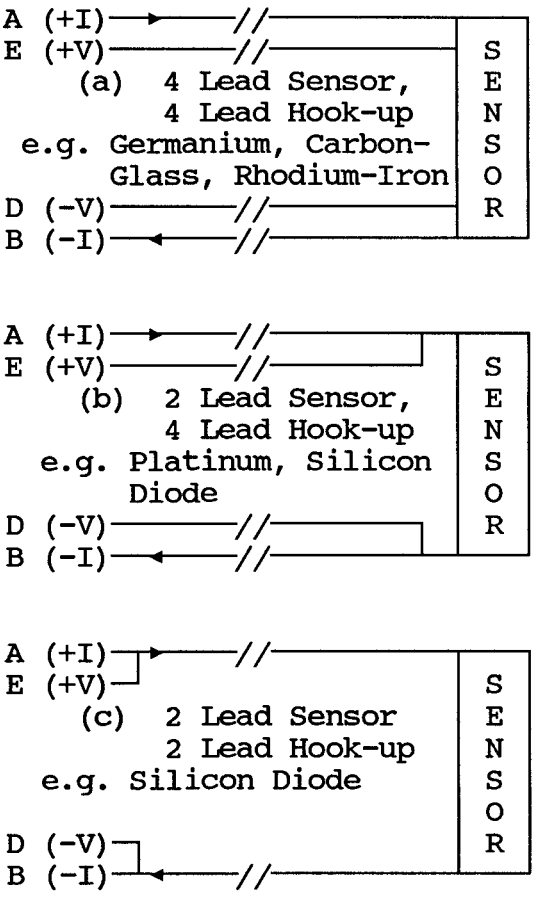
The DRC-93C has two rear panel 5-pin input connectors for sensors. The lead connection definition for the sensor(s) is given in Table 2-2 and is shown in Figure 2-2.

Table 2-2. INPUT Connections for J1 Input A and J2 Input B

Terminal	Description
A	+ Current Out
B	- Current Return
D	- Voltage Sense
E	+ Voltage Sense
H	Shield

The use of a four lead connection arrangement (a) is required for a four lead sensor.

Figure 2-2. Sensor Connections



The use of a four wire connection (Figure 2-2a and b) is highly re-

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commended for resistive elements to avoid introducing IR drops in the voltage sensing pair which translates into a temperature measurement error.

An alternate two line wiring method (Terminals A and E shorted together, B and D shorted) may be used for the DT-470 and TG-120 series diodes in less critical applications where lead resistance is small and small readout errors can be tolerated (c). Measurement errors due to lead resistance for a two lead hook-up can be calculated using; $\delta T = IR/[dV/dT]$ where I is 10 microamperes, R is the total lead resistance; dV/dT is the diode sensitivity and δT is the measurement error. For example, R = 250 ohms with dV/dT = 2.5 millivolts/kelvin results in a temperature error of 1 kelvin. Two wire connections are not recommended for other sensor types.

The Lake Shore Cryotronics, Inc. QUAD-LEAD™ 36 Gauge Cryogenic wire is ideal for connections to the sensor since the four leads are run together and color-coded. The wire is Phosphor Bronze with a Formvar insulation and Butryral bonding between the four leads. Color coding is red, green, clear and blue on the four leads which makes it extremely easy to determine one wire from another.

2.3.7 J3 Sensor Output MONITORS

Buffered voltage outputs for both Sensor Input A and B are available on the J3 connector on the back panel of the instrument. The voltage from the Model 8225 Analog Output Option is present on this connector also. The connector pin assignments are given in Table 2-3.

Table 2-3. J3 MONITORS Connections

Terminal	Description
A	Voltage Output (Input A)
B	Voltage Output (Input B)
C	10 mV/K Analog Output
D	Ground for Analog Output
E	Setpoint Output
F	Ground (A,B,Setpoint)
H	(Optional Shield)

2.3.9 Heater Power

The heater output leads should be electrically isolated from the sensor(s) ground(s) to preclude the possibility of any of the heater current affecting the sensor input signal. The heater leads should not run coincident with the sensor leads due to the possibility of capacitive pick-up between the two sets of leads. If they are in close proximity, they should be wound so as to cross the sensor leads at ninety degrees if at all possible.

The heater output is a current drive and does not have to be fused. The DRC-93C is designed to power a 50 ohm heater for maximum heater output. If a smaller resistance is used, the maximum heater power corresponds to the heater resistance, i.e., 10 ohms yields 10 watts. A larger heater can also be used. Since the compliance voltage is 50 volts; a 100 ohm heater will allow a maximum power output of 25 watts $[(50)^2/100]$.

A slide switch on the back panel sets the available output power dependent on the value of the heater resistance. This slide switch **must only** be changed with the instrument turned **off** since it shorts the windings of the output

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transformer between positions. The setting range of the switch should coincide with the heater resistance to minimize power dissipated within the DRC-93C. Three setting ranges are available: 10-25, 25-35 and 35 to 50 ohms.

An optional output power stage (W60) of 60 watts is available for the DRC-93C. The W60 is rated at 1.5 amperes at approximately 43 volts (into 25 ohm load).

A 50 ohm, 50 watt (1/4" dia. x 1" long) cartridge heater is available as well as a 25 ohm, 25 watt (3/8" dia. x 1" long) cartridge heater.

A 30 gauge stranded copper lead wire (ND-30) is recommended for connecting to the heater.

2.3.9.1 MAX HEATER POWER Limit

Make sure that the MAX HEATER POWER limit potentiometer is turned fully clockwise during the setup of the instrument so that full power is available on the MAX power scale, if desired.

2.3.9.2 Current or Power Output Display

The HEATER % meter can be set to read either % of output power or % of output current. The internal DIP switch setting (switch 1) controls whether the meter reads in % current (closed) or % power (open). The DRC-93C is shipped to read in % power.

2.4 REMOTE SENSOR ID Connector

The REMOTE SENSOR ID connector, J5, on the rear panel receives POSITION DATA from a Model 8084 or 8085 Sensor Scanner or a Model SW-10A Ten-Sensor Selector Switch. The REMOTE SENSOR ID Interconnecting Cable and REMOTE SENSOR ID connector assignments are given in Table 2-4.

Table 2-4. REMOTE SENSOR ID Connector Assignments

REMOTE SENSOR ID Connector Pin	Function
10	Bit 0 (B0-LSB)
8	Bit 1 (B1)
6	Bit 2 (B2)
4	Bit 3 (B3)
14	Bit 4 (B4-MSB)
12	Digital Ground

The POSITION DATA is the binary representation of the remote position. Table 2-4 gives the POSITION DATA binary combinations and equivalent hexadecimal remote position. The remote position input can be used to select specific sensor curve tables stored in the DRC-93C. The correlation between remote position and sensor curve is given in Section III.

2.5 IEEE-488 INTERFACE Connector

The IEEE-488 Connector on the back of the DRC-93C is in full compliance with the IEEE Standard 488-1978. The connector has metric threaded mounting studs, visually indicated by the color black. Metric threaded cable lockscrews (also black) must be used to secure an IEEE-488 interface cable to the instrument. Model 8072 IEEE-488 Interconnect Cables (one meter long) are available from Lake Shore.

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2.6 Options

2.6.1 8223 RS-232C Interface. Provides remote operation of the same parameters as the IEEE-488. The RS-232C interface option is described in Section VII of this manual including connections.

2.6.2 8225 Analog Output. Provides analog output proportional to kelvin temperature f display sensor (10mV/K) at <10 ohms output resistance. The 8225 Analog Output is described in Section VII of this manual.

2.6.3 8229 Scanner Input Option. Adds four additional channels to the "A" input. Scans up to six sensors with programmable dwell times. The 8229 Scanner Option is described in Section III and Section VII of this manual.

2.6.4 The High Resolution Set Point expands the set point resolution to 0.01 kelvin above 100K and 0.001 kelvin below 100K. The equivalent voltage is expanded to 25 microvolts out of 3 volts full scale. This results is a setability of approximately 0.01 kelvin above 40K and 0.001 kelvin below 28K for the DT-470 series sensors.

2.6.5 8001 Precision Option. Custom programming of specific Sensor calibration curve(s) at factory. Provides highest degree of readout accuracy.

2.6.6 The W60 Output Option will deliver 60 watts at 1.5 amperes at approximately 43 volts into a 25 ohm load. This is a factory installed option.

2.7 ENVIRONMENTAL REQUIREMENTS

WARNING

To prevent electrical fire or shock hazards, do not expose the instrument to rain or excess moisture.

2.7.1 Operating Temperature

In order to meet and maintain the specifications in Table 1-1, the DRC-93C should be operated at an ambient temperature range of 23°C ± 5°C. The unit may be operated outside the range of 15-35°C with less accuracy.

2.7.2 Humidity/Altitude

The DRC-93C is for laboratory use and no humidity or altitude specifications have been determined for this unit.

2.8 REPACKAGING FOR SHIPMENT

If the Model DRC-93C appears to be operating incorrectly, refer to the Troubleshooting Guide in Section 5.7. If the tests indicate that there is a fault with the instrument, contact Lake Shore or a factory representative for a returned Goods Authorization (RGA) number before returning the instrument.

When returning an instrument for service, photocopy and complete the Service Form found at the beginning of Appendix A. The form must be filled in to ensure efficient solution of the problem. The following information must be provided before Lake Shore will attempt any repair.

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1. Instrument Model and Serial #s
2. User's Name, Company, Address, and Phone Number
3. Malfunction Symptoms
4. Description of system
5. Returned Goods Authorization No.

If the original carton is available, repack the instrument in a plastic bag, place it in the carton using original spacers to protect protruding controls. Seal the carton with strong paper or nylon tape. Affix shipping labels and "FRAGILE" warnings.

If the original carton is not available, pack the instrument similar to the above procedure, being careful to use spacers or suitable packing material on all sides of the instrument.

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SECTION III

OPERATING INSTRUCTIONS

3.1 INTRODUCTION

This section contains information and instructions concerning the operation of the Model DRC-93C Temperature Controller. Included is a description of the front and rear panel controls and indicators.

3.2 INSTRUMENT CONFIGURATION

3.2.1 Input Card Configurations

The Model DRC-93C can be used with either one or two input cards. The input cards available for use with the DRC-93C are summarized in Section I. The input cards available allow the 93C to be used with almost any type of cryogenic sensor. Input cards can be mixed, allowing two different sensor types to be used with the DRC-93C.

3.2.2 Single Input Card

When only one input card is present within the unit, it occupies the INPUT CARD #1 slot of the DRC-93C mainframe and is connected to the Sensor A input of the controller. Only one sensor can be used with the controller under these conditions.

3.2.3 Dual Input Cards

When two input cards are present in the unit, the input card that occupies the INPUT CARD #1 slot is routed to the Sensor A input and the input card that occupies the INPUT CARD #2 slot is routed to the Sensor B input. Consequently, both sensors are energized at all times.

The second input card allows the instrument to mix sensor types, e.g., both a diode thermometer and a resistance thermometer can be used on the two inputs. Another possibility with the 9318C and 9220 Options would be the presence of a GR-200A Series Germanium Sensor as well as a PT-100 Series Platinum Resistance Sensor. Both inputs are updated independently, which allows them both to be displayed or queried under IEEE-488 or RS-232C control. The addition of an optional 8229 Sensor Scanner Card adds capability for 4 additional inputs to the A channel resulting in up to 5 sensors of the same type being allowed using the A input card.

3.2.4 Old Version Input Cards

The 8210, 8211 diode input cards can be used in the 93C as well as the 8219 series resistance input card. The installation of these cards is covered in Section 7-3 of this manual. Note that there are Dip Switch settings on the main board which must be set in order for these older cards to work properly.

3.3 CURVE ENTRY

The DRC-93C allows the user to enter his own sensor calibration via the front panel or over the remote interface. Section 3.9.3 discusses curve entry via the front panel and Section IV covers entry over the IEEE-488 or RS-232C interfaces. The curve is stored in a battery back-up non-volatile RAM (NOVRAM) which can be read and written an unlimited number of times. The number of data points stored per curve can be between 2 and 97; two being the lower limit which defines a straight line.

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3.4 PRECISION OPTIONS

3.4.1 The Model 8000 Precision Option

There are three types of Precision Options available for the DRC-93C. The Model 8000 Precision Option generates the data table from a Lake Shore calibrated sensor. The upper limit of data points is again 97, with a typical calibration ranging between 30 and 40 points, depending on sensor type and temperature range for the calibration. The data and accuracy of the fit is supplied to the user as a separate document. This information can then be entered by the user via the front panel or over the computer interface.

3.4.2 The Model 8001 Precision Option

Lake Shore can also generate custom sensor response curves from the individual sensor calibrations as indicated above and store them in the DRC-93C via the 8001 Precision Option prior to shipment. The data and accuracy of the fit is then supplied to the user in an Appendix of this manual.

3.4.3 The Model 8002-05 Precision Option

The 8002 Precision Option is used when the customer already owns a DRC-93C and wants new sensor calibration data stored in the instrument. LSCI stores the calibration data in a PROM chip and sends the programmed chip to the customer. The PROM is then installed in the DRC-93C by the customer.

Note that additional calibrations can be added to the instrument at a later time by specifying with the sensor calibration at time of order, the serial number of the instrument and with which input the sensor will be associated if remote operation is used.

3.5 CONTROL FUNDAMENTALS

An application note entitled "Fundamentals for Usage of Cryogenic Temperature Controllers" is included as an appendix in this manual and should be read in detail if you are not familiar with cryogenic temperature controllers.

3.6 CONTROLS AND INDICATORS

Figures 3-1 and 3-2 identify the DRC-93C displays, annunciators, controls, and connectors. The identification of each item is keyed to the appropriate figure.

FRONT PANEL DESCRIPTION

3.7 POWER ON

Before connecting AC power to the DRC-93C, make sure the rear panel voltage selector is set to correspond to the available power line voltage. Be certain the correct fuse is installed in the instrument.

3.7.1 Power Up Sequence

Immediately on POWER ON the DRC-93C runs through a power up sequence as follows:

1. Light Test

All digits, annunciators, and the bar graph turn on to test the lights.

The TEMPERATURE Block indicates ·+8.8.8.8.8. in both the upper, lower and setpoint windows. The CONTROL Block indicates 8.8. in the GAIN, RATE, and RESET windows. The

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HEATER POWER Bar Graph indicates 100%. The UPPER and LOWER DISPLAY SENSORS have ·8. The indicators for the six sets of UNITS for both the Upper and Lower displays are displayed to the far left of the front panel. The control (CTRL) annunciators are between the SENSOR annunciators. The RANGE from OFF to MAX annunciators are below the Bar graph and the LOCAL, REMOTE, PROG (programming) and INT (internal program) to the far right of the front panel.

2. Instrument Name and IEEE Address

Next the unit displays LSCI in the Upper Display, -93C- in the Setpoint Display and the IEEE-488 interface address in the Lower Display. For a factory set IEEE address of 12 the display would indicate Add12. This address can obviously be changed by the user and verification of that change is always given on power-up. Note that this address is only read by the instrument on power-up.

3. Input Card Configuration

The unit then displays the input cards associated with the inputs on the upper and the lower displays.

4. Normal Operation

The unit then goes into normal operation.

3.7.2 Power-up Status

A provision has been made to store parameter changes in the DRC-93C memory (NOVRAM). The sample and control units, as well as the curve numbers and scan dwell times can be stored as power-up settings. When enabled, any time the parameter is changed, either in the LOCAL or REMOTE mode, the NOVRAM is updated. The internal DIP switch setting (switch 2) controls whether or not the settings are updated. The updating is enabled (switch 2 on) at the factory prior to shipment.

3.7.3 Blue Legend Keys

At the beginning of an operation, if one of the grey keys of the keypad with Blue Legends (also labelled 0-9, and .) is pressed, the function described by the blue legend is immediately displayed or carried out. These functions are SENSOR, UNITS, CURVE#, RSLTN, FILTER, CONTROL, DEV, MATH, MAX, MIN, MAXDEV.

The CURVE#, RSLTN, FILTER, DEV, MATH, MAX, MIN, and MAXDEV keys must be held down in order to observe the quantity continuously. For example, if the RSLTN (resolution) key is pressed, the display will immediately show the resolution assigned to the Upper and Lower Displays. When the key is let up, operation will return to normal operation with the displays showing temperature, voltage, etc.

The CONTROL, SENSOR, UNITS, CURVE#, RSLTN, FILTER, DEV, and MATH keys provide operations that can be changed by the user. The ▲▲ (up) and ▼▼ (down) keys are used in conjunction with these Blue Legend keys to alter the quantity with the ▲▲ key referring to the Upper Display and the ▼▼ key referring to the Lower Displays. In order to change one of these quantities it is necessary to hold the Blue Legend key down while hitting the ▲▲ (up) key or ▼▼ (down) key. The ▲▲ key will change the entry of the Upper display and the ▼▼ key will change the Lower display.

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Figure 3-1. DRC-93C Temperature Controller Front Panel

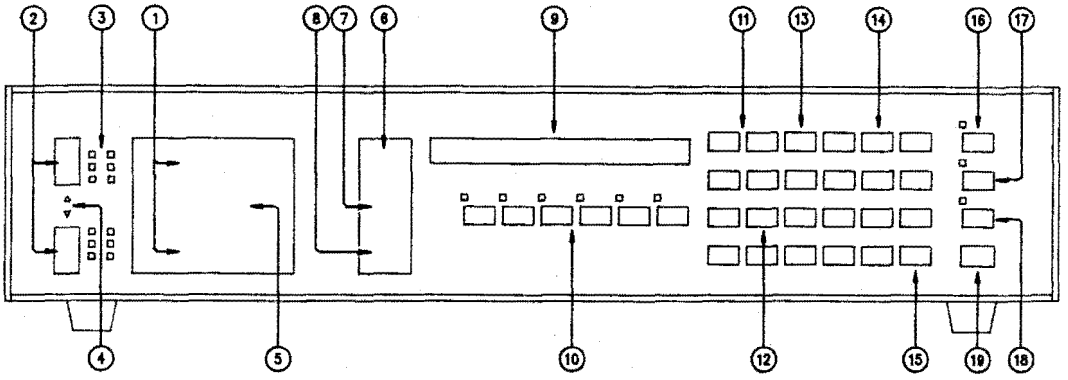


Figure 3-1. Model DRC-93C Temperature Controller Front Panel Description

Upper and Lower Displays

1. Sensor reading in temperature (Kelvin, Celsius, or Fahrenheit), or sensor units (Voltage, Resistance, Capacitance).
2. Sensor No. (A, b, 1, 2, 3, 4).
3. Annunciators indicating units of Sensor (K, F, C, Ω, V, N).

Set Point

4. CTRL (control) Arrow Annunciator indicating whether the sensor in the Upper or Lower Display is the control sensor.
5. Display of Set Point in temperature (kelvin, celsius, or fahrenheit), or sensor units (voltage, resistance or capacitance) in the units of the Control Sensor (as indicated by CTRL Arrow).

Control Display

6. GAIN (proportional) display.
7. RATE (derivative) display.
8. RESET (integral) display.
9. HEATER CURRENT or HEATER POWER Bar Graph in percent of full scale.
10. Full Scale selection of HEATER CURRENT or HEATER POWER for four orders of magnitude. Includes power OFF position.

Keyboard

11. Control Data input keys (Gain, Rate, Reset, Setpoint, and Manual Heater).
12. ▲▲ (Up) and ▼▼ (Down) keys.
13. PROG (Programming), ↑-↓ (SCAN and Sign), TIME, and POINT # keys.
14. Decimal Keypad with Blue Legend functions of SENSOR, CURVE#, FILTER, MATH, UNITS, RSLTN (ReSoLuTioN), DEV (DEViation), CONTROL, MAX (MAXimum), MIN (MINimum), and MAXDEV (MAXimum DEViation)
15. CLEAR and ENTER functions for use with keypad 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, decimal point and ↑-↓ minus sign.
16. Return-to-LOCAL key with annunciator.
17. REMOTE key with annunciator.
18. INT (INTernal Program) Key with annunciator.
19. POWER ON-OFF switch

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3.7.4 Black Legend Keys

When one of the Black Legend keys (GAIN, RATE, RESET, SETPOINT, MANUAL HEATER, TIME, or POINT#) is pressed it is not to be held down released immediately.

The quantity described by the key will begin to flash indicating that it can be changed.

The keypad (0-9 and .) is then used to enter the new value. Negative quantities are preceded by the minus ↑-↓ key. The ENTER key completes the operation and inserts the new value. The CLEAR key will cancel the entry and return the instrument to normal operation.

When the ▲▲ (up) and ▼▼ (down) keys are used after selecting a Black Legend key the ▲▲ key will increment and the ▼▼ key decrement the quantity. Detailed operation of these keys will be discussed in the sections dealing with the specific Black Legend functions.

SUMMARY: THE KEYPAD (0-9 AND .) ARE ONLY THE NUMBERS 0-9 AND DECIMAL POINT WHEN A DISPLAY (SETPOINT, GAIN, RATE, RESET, OR MANUAL HEATER POWER) IS FLASHING. OTHERWISE THE KEYS WILL CARRY OUT THE FUNCTION DESCRIBED BY THE BLUE LEGEND. THE ENTER AND CLEAR KEY ARE ONLY EFFECTIVE WHEN A QUANTITY IS FLASHING. THE ▲ KEY AND ▼ KEY ARE USED IN CONJUNCTION WITH BLUE LEGEND KEYS TO CHANGE THE QUANTITY BEING REQUESTED.

3.8 TEMPERATURE BLOCK

The TEMPERATURE block consists of the Upper Display, Setpoint Display and the Lower Display. The Upper and Lower Displays each have

1. SENSOR Number
2. ↑-↓ (SCAN) indicator in the upper left hand corner of the SENSOR Number
3. Units (K, C, F, V, Ω, N)
4. A 5 digit display with sign
5. An indicator in the upper left hand corner of the sign to signal FILTER ON.

A Control arrow (CTRL) to the far left of the TEMPERATURE block points to the Controlling Sensor.

The Setpoint Display is discussed in Section 3.10 with the CONTROL Block.

3.8.1 Sample and Control Sensor Inputs

The choice of which input is associated with the Control Sensor or the Sample Sensor is determined by the CONTROL key of the keypad and indicated by the CTRL annunciator arrow. If the CTRL Arrow points up then the Upper Display with its associated SENSOR Number and UNITS are the Control sensor. The Lower Display is then the Sample Sensor with its associated SENSOR number and UNITS. Similarly, if the CTRL Arrow points down then the Lower Display and its associated SENSOR and UNITS is the Control Sensor and the Upper Display is the Sample Sensor.

3.8.2 Upper and Lower SENSOR Number

The selection of A or B inputs for the Upper Display is changed by holding in the SENSOR key and pressing the ▲▲ (Up) key.

The selection of A or B inputs for the Lower Display is changed by holding in the SENSOR key and pressing the ▼▼ (Down) Key.

The A input is distinguished by a uppercase letter A in the Sensor window and the B input by a lowercase b in the Sensor window.

While the SENSOR key is held down, the Upper and Lower Displays will show the card types being used by the displayed sensor. The GAIN, RATE, and RESET windows are blank.

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They are used to indicate REMOTE POSITION DATA when an External Scanner (Models 8084 or 8085) are attached (see Section 3.9.2).

When the 8229 Scanner Conversion Option is not present the display toggles between the A and B input cards.

3.8.3 8229 Scanner Input Option

With the addition of the Model 8229 Scanner Input Option, four more inputs are added to the A channel input. These additional inputs are designated 1, 2, 3, and 4 in the SENSOR window.

With the scanner conversion option present, the SENSOR key and ▲▲ (Up) key increments the Upper Display inputs in the sequence A-1-2-3-4-b-A etc. Similarly for the Lower Display with the SENSOR key and ▼▼ (Down) key.

The 8229 Scanner Input Option is covered in Section VII.

3.8.4 SCAN Function

The SCAN function allows the instrument to step between the two inputs with a scan rate independently set between 0 (Skip) and 99 seconds for each input. Setting a dwell time to zero automatically skips the channel only when in the SCAN mode. If the scanner option is present, inputs (1-4) are included in the SCAN function and each has its own dwell time which is set independently.

3.8.5 The SCAN Dwell Time

The dwell time for the Sensor inputs associated with the Upper and Lower Display can be displayed by pressing the ↑-↓ key down for more than one second. The display will read dt-00 for a dwell time of 0 seconds. If it is desired to change the dwell shown in the upper display, the user continues to hold down the SCAN key and presses the ▲▲ key. Both keys can then be released. The dwell in the Upper Display will flash indicating that it can be changed by the keypad (0-9) and entered into the instrument with the ENTER key. Hitting the CLEAR key before the ENTER key will cancel the entry and return the instrument to normal operation.

To change the dwell shown in the Lower Display is the same except that the SCAN and ▼▼ keys are employed.

When the dwell is being changed, in addition to using the keypad (0-9) there are two other methods to modify the dwell displayed. The first method is to increment the dwell with the ▲▲ key and decrement it with the ▼▼ key. When the desired dwell is displayed hitting the ENTER key will store that dwell in the instrument and return to normal operation. The second method in which the entry can be changed is by using the keypad to enter an amount which is to be added or subtracted from the previous value. Hitting the ▲▲ key will add the amount and the ▼▼ key will subtract the amount. The two methods can be used at will. The ENTER key will enter the final value into the instrument or the CLEAR key will cancel the operation at any time.

3.8.6 Upper and Lower Display Units

3.8.6.1 Units Select

The units of the Upper Display is changed by holding down the UNITS key and pressing the ▲▲ (Up) key until the units desired are obtained. Each time the ▲▲ key is pressed the units of the Upper Display cycle clockwise. The units which do not pertain to the input card selected are automatically skipped, i.e., only one of the sensor units (V, Ω, or nF) is possible depending on which sensor input card is present

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within the instrument. Similarly the units of the Lower Display are changed by holding down the UNITS key and pressing the ▼▼ (Down) key.

For any input card except the 9215, the DRC-93C will read temperature regardless of whether a curve is stored within the instrument which corresponds to the temperature sensor being interrogated. For diodes, germanium, carbon glass, and all other negative temperature dependence sensors; the default curve is Curve 00 which is the D curve for the DT-500-DRC sensors. For a positive temperature dependence temperature sensor such as platinum and rhodium-iron, the default curve is Curve 03 which is the standard 3750 DIN curve for platinum. This default will only occur if a curve of opposite temperature dependence has been inadvertently selected by the user. In the case of the 9215 card, temperature units are not allowed due to the inability of this sensor to hold a calibration upon cycling.

3.8.6.2 Sensor Units Mode

3.8.6.2.1 Voltage Units

The voltage mode is allowed for the 9210-3 and -6 configurations, the 9220-3 and -6 configurations as well as the older version 8210 and 8211 cards. In the voltage mode, the display has a resolution of 0.1 millivolt with the full scale range dependent on the input card (2.9999 volts for the -3 configurations and the 8210 card and 6.5535 volts for the -6 configurations and the 8211 input card). The actual Input Card resolution is 0.05 millivolts and 0.1 millivolts, respectively. If a voltage exceeding full scale is applied to the displayed input an overload condition is present and is indicated by OL on the display.

3.8.6.2.2 Resistance Units

The Resistance mode is allowed for the 9317C, 9318C, and the 9220-P2,-P3, and -R1 configurations as well as the older 8219-P2, the 8219-P3 and 8219-R1 cards. The display range and resolution for the 9317C is 0.000 to 9999.9 ohms; the 9318C is 0.000 to 99999 ohms. Note that the resistance automatically ranges from --.--- to ---.-- to ----.- to ----- as the resistance increases in value. If the input resistance exceeds the resistance range for the card, an overload condition is present and is indicated by OL on the display.

The display ranges and resolutions for the 9220-P2 (and 8219-P2), 9220-P3 (and 8219-P3) and 9220-R1 (and 8219-R1) are 0.00 to 299.99 ohms, 0.0 to 2999.9 and 0.000 to 99.999 ohms respectively. Again, if a resistance exceeding full scale is applied to the input, OL is indicated on the display.

3.8.6.2.3 Capacitance Units

The capacitance mode is allowed for the 9215 Input Card which can be configured in the -15 or -150 configurations. The display range is 0.000 to 30.000 or 150.00 nanofarads, respectively. An input in excess of the configured maximum is indicated by OL on the display.

3.8.7 Display Resolution

The Model DRC-93C allows the user to set his display resolution over the range from 1 kelvin to 1 millikelvin (0.1 millikelvin for the 9317C input card). The temperature is rounded to the least significant digit of the resolution range selected. Since the temperature display resolution is dependent on both the sensor units (voltage, resistance or capacitance) resolution of the Input Card as well as the sensor sensitivity, temperature resolution is greatly dependent on the sensor. Refer to Table 3-1 for a representative summary of "system" resolution,

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(sensor plus instrument) versus sensor sensitivity.

3.8.7.1 Temperature Display Resolution Set

To examine the resolution of the Upper and Lower Display hold in the RSLTN key. The displays will read one of the following:

---. , ---.- , ---.-- , --.--- , -.----

If it is desired to change the resolution then while holding down the RSLTN key hit the ▲▲ key to cycle the resolution in the Upper Display through those shown until the desired resolution is obtained. When the keys are released the new resolution is entered in the DRC-93C. Similarly, holding in the RSLTN key and hitting the ▼▼ key will change the resolution in the Lower Display.

Changing the display resolution fixes the resolution transmitted over the computer interface as well but does not change the resolution of the "system". Display resolution can also be different for each input card, i.e., A and B. Also note, that the chosen resolution will only be displayed when "appropriate". In other words, only five digits can be displayed.

In the temperature mode, the chosen input is displayed in the selected scale (K, °C or °F) with a maximum display capability of 0.01 degrees above 100 kelvin, to 0.001 degrees between 1 and 100 kelvin and in the case of the 9317C resistance card to 0.0001 kelvin (0.1 millikelvin) below 1 kelvin. Please note that this is display capability and **neither** system resolution **nor** necessarily accuracy of the reading. Also note that if the sensitivity of the sensor is too low to support this resolution, i.e., one bit corresponds to greater than the above resolution, some temperatures may be skipped. This will be true for a silicon diode sensor between 30 kelvin and 100 kelvin where the sensitivity is approximately 2.5 millivolts per kelvin and the voltage resolution is 0.046 millivolts. For this case, the resulting temperature resolution is 0.046/2.5 = 0.018 kelvin. However, below 30 kelvin the silicon diode sensitivity is approximately 25 millivolts per kelvin which results in an approximate resolution of 0.002 kelvin (0.046/25).

TABLE 3-1. System Resolution Versus Sensor Sensitivity

Sensor Sensitivity	Maximum Temperature Resolution (in kelvin)		Sensor Sensitivity	Maximum Temperature Resolution (in kelvin)
Voltage Mode	9210/9220		Resistance Mode	9317C/9318C
mv/K	-3[1]	-6[1]	(1/R)(dR/dT), K^{-1}	9220-P2,-P3,-R1[2]
0.1	0.5	1.	0.001	0.1 to 0.01
1.0	0.05	0.1	0.01	0.01 to 0.001
10.0	0.005	0.01	0.1	0.001 to 0.0001
100.0	0.0005	0.001	1.	0.0001 to 0.00001

Note 1. The input resolution is 0.05 millivolts for the 9210/9220-3 and is 0.1 millivolts for the 9210/9220-6.

Note 2. This assumes an ability to resolve between 1 part in 10^4 and 1 part in 10^5, where $\Delta T = (\Delta R/R)/[(1/R)(dR/dT)]$ and $(\Delta R/R)$ varies between 10^{-4} and 10^{-5}.

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3.8.8 Filtering the A and B Inputs

An averaging algorithm within the instrument is available which averages up to ten readings. This reading mode eliminates noise within the cryogenic system analogous to averaging within a digital voltmeter. This function can be examined and selected or deselected by the FILTER key and the ▲▲ key and ▼▼ key.

When the FILTER key is pressed, the words On (filter on) and OFF (filter off) are presented in the Upper and Lower Displays. To toggle the filter of the input of the Sensor shown in the upper display hold down the FILTER key and press the ▲▲ key. Similarly holding the FILTER key and pressing the ▼▼ key toggles the filter of the input of the Sensor shown in the Lower Display from On to OFF.

In operation, an indicator will appear in the upper left hand corner of the sign digit in the Upper and/or Lower Displays to flag "Filter-on" for that input.

If the averaging algorithm is used, displayed temperature is the average of between 1 and ten readings depending on the temperature variation. If an abrupt change in temperature is observed, averaging is disabled and the last calculated reading is displayed. As the disturbance is reduced in value, the averaging gradually increases until a total of ten readings are considered.

3.8.9 Math Functions

The DRC-93C has three built-in Math Functions to retain the maximum and minimum temperatures as well as the maximum deviation from the setpoint for the Sensor in the Upper Display and the Sensor in the Lower Display.

The three keys MAX, MIN, and MAXDEV on the keypad (digits 9, 6, and 3 respectively) allow the user to observe the MAXimum and MINimum temperature, and MAXimum DEViation from the Setpoint. When one of these keys is depressed, the Upper and Lower Displays will contain the selected Math Function.

These Math Functions are enabled using the MATH key (decimal point on the keypad) and the ▲▲ key or ▼▼ key. In combination with the MATH key, the CLEAR key restarts the process.

When the MATH key is depressed, the Upper display shows "OFF" or "On". When "OFF" is displayed, the Math Functions are inhibited. When "On" is displayed, the Math Functions are enabled. To change from "OFF" to "On" and vice versa, hold the MATH key down and hit the ▲▲ key or ▼▼ key to toggle between "On" and "OFF". When the MATH key is released, operation returns to normal.
If the "On" was left in the Upper Display when the MATH key was released, then the instrument will begin calculating the Math Functions.

If "OFF" was left in the Upper Display when the MATH key was released, then the instrument freezes the contents of the Math Functions. The MAX, MIN, and MAXDEV keys can be used to observe the last readings of the Math Functions.

If it is desired to restart the calculation of the Math Functions, the MATH key is held down and the CLEAR key hit, the Lower Display will show the word "CLEAr" to indicate that the registers holding the Maximum, Minimum and Maximum Deviation have been zeroed. If the Math Functions were enabled ("On") then new Math Functions will be computed. Once the Math Functions have been cleared and enabled ("On"), changing the Sample or Control units will result in inconsistant values being stored in the Math Function regis-

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ters. The new Math Functions can be observed at any time by depressing and holding in the appropriate key (MAX, MIN, or MAXDEV).

3.9 SENSOR CURVE SELECTION

3.9.1 Standard and Precision Option Curves

The standard curves are given in Table 3-2. The Precision Option Curves are given in Table 3-3.

Table 3-2. Standard Curve Information

Curve No.	Temperature Range(K)	Description
00	1 - 324.9	DRC-D
01	1 - 324.9	DRC-E1
02	1 - 324.9	CRV 10
03	14 - 799.9	DIN-PT
04	1 - 474.9	CRV 10
05		RESVRD

3.9.1.1 The Precision Option

For Lake Shore stored Precision Option, a proprietary algorithm is used to fit the calibration data to within a few millikelvin over the entire temperature range.

The Precision Option Table shown in Table 3-3 gives the standard curves as well as any Precision Options which are factory installed including their address and the number of data points associated with each curve. This Table should be updated for the instrument if additional curves are added at a later time.

Up to 25 Precision Option Curves can be stored in the DRC-93C with an average of 31 lines per curve. A Precision Option Curve can have up to 97 points with two additional end points automatically put into the curve table by the DRC-93C software.

3.9.1.2 Display of Accessed Curve Number

To determine which curve is being used press and hold the CURVE# key. The displays will show the letters "CU" for Curve Number followed by a curve number in each display.

Table 3-3. Sensor Curve Table Information - Precision Option Table

Curve	#Lines	Address	Description
00	31	1D40	DRC-D
01	31	1DF0	DRC-E1
02	31	1EA0	CRV 10
03	31	1F50	DIN-PT
04	31	2000	CRV 10
05	31	20B0	RESVRD
06	___	_____	_____
07	___	_____	_____
08	___	_____	_____
09	___	_____	_____
10	___	_____	_____
11	___	_____	_____
12	___	_____	_____
13	___	_____	_____
14	___	_____	_____
15	___	_____	_____
16	___	_____	_____
17	___	_____	_____
18	___	_____	_____
19	___	_____	_____
20	___	_____	_____
21	___	_____	_____
22	___	_____	_____
23	___	_____	_____
24	___	_____	_____
25	___	_____	_____
26	___	_____	_____
27	___	_____	_____
28	___	_____	_____
29	___	_____	_____
30	___	_____	_____
31	___	_____	_____

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For Example, by holding down the CURVE# key the Displays might look as follows:

	SENSOR	DISPLAY
Upper Display	A	CU-02
Lower Display	b	CU-06

The CU-02 in the Upper Display indicates that the Sensor using the Upper Display is calculating the temperature with the data of Curve #02. Curve #02 from Table 3-2 is the CRV 10 for the DT-470 Series Sensors. The CU-06 in the Lower display indicates that the Precision Option is installed and the DRC-93C is calculating the temperature with the data stored in Curve #6.

Since the DRC-93C knows which type of input card is present for each input (assuming that two input cards were installed), it will not, for example, allow the selection of the platinum curve (Curve #03) for a diode input card. If Curve #03 is selected, the DRC-93C will default to the lowest curve number with the correct temperature coefficient, in this case, curve #00. For the case of a platinum input card and no Precision Option curves present, the DRC-93C will select Curve #03, regardless of the curve selected using the CURVE# key.

3.9.1.3 Addition of 8229 Scanner Option

Adding the 8229 Scanner to Input A adds four more Inputs 1, 2, 3, and 4. Each of these inputs has its own curve assigned using the CURVE# key.

3.9.1.4 Changing the Curve used by a Sensor (No External Scanners)

With the CURVE# key held in, pressing the ▲▲ (up) key allow the user to change the curve # used by the Upper Display Sensor. When the CURVE# key is let up, the instrument will return to normal operation with the new curve being selected for calculation by the Sensor associated with the Upper Display. Similarly, the CURVE# key and the ▼▼ (down) key change the curve # for the sensor associated with the Lower Display.

3.9.2 External Scanner Model 8085

Up to three 8085 Scanners can be daisy-chained together to give 30 remote positions for either the A input or the B input of the DRC-93C.

In order for the instrument to select the correct curve for the sensors connected to an 8084 or 8085 Scanner it is necessary for the user to make a connection between the REMOTE POSITION DATA Connector of the Scanner to the DRC-93C REMOTE SENSOR ID Connector. In this way the DRC-93C will have the data regarding which position the scanner is in and thus which external sensor is being examined. The data on the REMOTE SENSOR ID Connector will be called the REMOTE POSITION DATA.

The user must provide the DRC-93C the information which relates the REMOTE POSITION DATA to the Curve Number. This information is stored within the DRC-93C in its Correlation Table (See Table 3-4).

In addition, the user must enable the DRC-93C to use the REMOTE POSITION DATA. This is done by using the CURVE#, REM, ▲▲, and ▼▼ keys as described in the next section.

3.9.2.1 Selection of the REMOTE POSITION DATA

To allow the REMOTE POSITION DATA to determine the curve selection, the user does the following:

1. Press the CURVE# key and hold it down. The Curve # associated with the Upper and Lower Displays will be given and the GAIN, RATE, and RESET blanked.

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2. While holding in the CURVE# key, press the REM (REMote) key. Release the CURVE# key.

3. Now press the ▲▲ (Up) key to toggle the Upper Display External curve selection. The REMOTE POSITION DATA will appear in the GAIN windows to indicate that the REMOTE POSITION DATA will be used for curve selection by the Upper Display Sensor. Hitting the ▲▲ key again will blank the GAIN window indicating that the REMOTE POSITION DATA will not be used. The operation is the same for the ▼▼ key except that the Lower Display Sensor and RESET window are involved.

4. When the desired condition is reached, release all keys.

3.9.2.2 The Correlation Table

The CURVE# key will show that the External Scanner has been selected by indicating the REMOTE POSITION DATA in the GAIN window for the Upper and in the RESET window for the Lower Display. The instrument uses the REMOTE POSITION DATA (the signal applied to the REMOTE SENSOR ID Connector from the Scanner) in conjunction with the Correlation Table of Table 3-4 to obtain the Curve Number.

If the REMOTE POSITION DATA is zero, then instrument uses the same Curve Number assigned to the input without the Scanner. When there is an 8229 Scanner Option present, there are 5 Curve Number assignments for Input A---one each for A0, A1, A2, A3, and A4.

If the REMOTE POSITION DATA is non-zero, then the Curve Number is selected from the row of the Correlation Table corresponding to the value of the REMOTE POSITION DATA. When there is an 8229 Scanner Option present, there is only one Curve Number assignment for Input A---A0, A1, A2, A3, and A4 all use the Curve Number from the A column of the correlation table.

3.9.2.3 Modifying the Correlation Table from the Front Panel

The DRC-93C is shipped from the factory with curve 02 stored in all positions of the Correlation Table.

The Correlation Table is modified by using the CURVE# and ▲▲ key and ▼▼ key as follows.

1. Use the procedure described in the previous section to put the instrument in the External Scanner mode.

2. Apply a signal on the REMOTE SENSOR ID Connector to indicate a position number, the REMOTE POSITION DATA. This can be done by attaching a Scanner and selecting a position.

3. Select the Curve Number desired for that position from the front panel as described in section 3.9.1.4. The GAIN or RESET window must have the REMOTE POSITION DATA to show that the function is enabled.

4. When the ENTER key is pressed, the Curve Number will be stored in the Correlation Table in the Position indicated by the REMOTE POSITION DATA in the GAIN window if the Curve in the Upper Display was altered or in the RESET window if the Curve# in the Lower Display was altered.

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Table 3-4. Correlation Table for Curve # from REMOTE POSITION DATA

REMOTE POSITION DATA	Curve# for Input A		Curve# for Input B	
01	A01	_____	B01	_____
02	A02	_____	B02	_____
03	A03	_____	B03	_____
04	A04	_____	B04	_____
05	A05	_____	B05	_____
06	A06	_____	B06	_____
07	A07	_____	B07	_____
08	A08	_____	B08	_____
09	A09	_____	B09	_____
10	A0A	_____	B0A	_____
11	A0B	_____	B0B	_____
12	A0C	_____	B0C	_____
13	A0D	_____	B0D	_____
14	A0E	_____	B0E	_____
15	A0F	_____	B0F	_____
16	A10	_____	B10	_____
17	A11	_____	B11	_____
18	A12	_____	B12	_____
19	A13	_____	B13	_____
20	A14	_____	B14	_____
21	A15	_____	B15	_____
22	A16	_____	B16	_____
23	A17	_____	B17	_____
24	A18	_____	B18	_____
25	A19	_____	B19	_____
26	A1A	_____	B1A	_____
27	A1B	_____	B1B	_____
28	A1C	_____	B1C	_____
29	A1D	_____	B1D	_____
30	A1E	_____	B1E	_____
31	A1F	ERR09	B1F	ERR09

3.9.3 Programming Curves from the Front Panel

This section describes how the user can enter his own sensor calibration via the front panel. Section IV covers entry over the IEEE-488 or RS-232C interfaces. The curve is stored in a battery back-up non-volatile RAM (NOVRAM) which can be read and written an unlimited number of times. The number of data points stored per curve can be between 2 and 99; two being the lower limit which defines a straight line.

3.9.3.1 Accessing Stored Curve Data

In order to access stored curve data hit the PROG (Programming) key. The PROG indicator will turn on and flash. Next hit the CURVE# key. The PROG indicator will stop flashing and turn on. The Upper and Lower Displays will blank and the Setpoint Display will contain 00-00 with the second zero from the left flashing. The Upper Display UNITS will show K for kelvin and the Lower Display UNITS V for volts.

NOTE: At any time, if it is desired to exit from the Curve Programming routine hit the PROG key. Operation will return to normal. The CLEAR key is used to clear a number partially entered but not desired.

IF A KEY IS NOT HIT FOR A PERIOD OF 20 SECONDS, THE INSTRUMENT WILL ABORT THE CURVE PROGRAMMING ROUTINE AND RETURN TO NORMAL OPERATION.

The flashing quantity in the Setpoint Display is the Curve # to be examined. The other quantity is used to hold the number of points in the Curve Data of the selected Curve.

Using the keypad (0-9) type in the Curve# to be examined followed by the ENTER key. The CLEAR key may be used if there is an error in typing the curve #. Also the keypad can be used until the correct Curve # is displayed. For example if 30 shows in the display and the 2 key is hit, the 3 of the 30 will disappear and the 2 show up in the units digit to give 02. Hitting the ENTER key will cause the instrument to accept the entry and to search for Curve #02. Since Curve #02 is present (it is a Standard Curve--see Table 3-2), the instrument will find the curve and then show

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0.0
02-31
6.5536

in the displays. The 02 in the Set-point Display is the Curve# and the 31 indicates that there are 31 lines (or points) in the curve data. Points are numbered from 1 to the total number of points---here 31.

The 0.0 in the Upper Display is the temperature in kelvin for point #31 and the 6.5536 the sensor voltage of point #31 (at 0.0 K).

NOTE: A Standard Curve cannot be edited, but the standard curve data can be examined.

To examine Point#12 first hit the POINT# key. The Point# in the Set-point Display will begin to flash. Enter 12 using the keypad followed by the ENTER key. The displays will read

115.0
02-12
0.9445

to indicate that Point# 12 of Curve#02 is 0.9445 volt at 115.0 K.

At any time that the POINT# key is appropriate, the ▲ key and ▼ key can be used to examine the next higher numbered point and lower numbered point respectively. If the ▲ key was pressed after point# 12 was displayed in the example given above, the display would change to

95.0
02-13
0.9857

The ▲ key and ▼ key do not operate when the instrument is requesting a Curve#, temperature, or voltage.

To exit the Curve Programming routine hit the PROG key.

3.9.3.2 Entering New Curves

The user should know what Curve# is available for new data by keeping accurate records and updating Table 3-3 as curves are added. If an error is made in record keeping, the instrument will catch it since 00 number of points indicates an available set of data storage.

It is suggested that the curve data be put in ascending Raw Units order prior to the curve entry session. The data must be in ascending units order. The temperature will follow the temperature coefficient of the curve being entered. The temperature will be in decreasing order for a negative temperature coefficient curve and increasing for a positive temperature coefficient curve.

Let us say that we wish to enter a new set of curve data into an available slot at Curve#21. From normal operation, the user presses the PROG key followed by the CURVE# key to enter the Curve Programming routine. Pressing the 2, 1 and ENTER keys tell the instrument to find Curve#21 and will indicate that it is available by showing 00 number of points. The displays will read as follows:

21-00

The dashes indicate there is no data present for curve number 21. No entries will flash. At this time, one of four keys can be selected; PROG, CURVE#, or POINT#.

The PROG key will abort the curve programming and return the instrument to normal operation.

Pressing the CURVE# key will cause the Curve# portion of the Setpoint Display to flash allowing the user to select another curve.

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Pressing the POINT# key will cause the point # entry in the Setpoint Display to begin flashing and the Upper and Lower displays to be cleared. The keypad (0-9) is used to enter a point# to be inserted. Type 01 and press the ENTER key. Now the Upper and Lower displays will go to 0.0 and the Upper display will begin flashing. Use the keypad to enter the temperature of the point in kelvin. The decimal point can be used, but the resolution will be limited to ---.- . If the entry is begun but not as desired, the CLEAR key can be used to clear the display to restart.

The first and last points entered are determined by the temperature coefficient of the curve being entered. For a negative temperature coefficient (N) curve the first data point (#01) is 499.9K and 0.0000 volts. For a positive temperature coefficient (P) curve the first data point is 0.0K and 0.0000 volts.

The quantity is accepted for the temperature when the ENTER key is pressed.

NOTE: You cannot use the ▲ key or ▼ key when entering curve data. Only the keypad (0-9,and .) and the CLEAR key are active.

After the temperature is entered, the Lower Display will begin to flash. The keypad is used to enter the Raw Units Data for the point as described in Table 4-14. The entry is accepted when the ENTER key is pressed.

Another point can be added by pressing the POINT# key. After the curve has been entered, the last data point to enter is 0.0K and 6.5536 volts for N type and 999.9K and 6.5536 volts for P type curves.

NOTE: Failure to enter the correct curve end points will result in unpredictable results.

Pressing the PROG key will return operation to normal with the curve being entered into the memory of the instrument and available through an assignment as described in section 3.9.1.

3.9.3.3 Editing Existing Curve Data

Curve data can be modified using the same procedure described in the previous section. The difference is that the temperature and voltage (raw data) will be shown in the Upper and Lower displays respectively after the POINT# has been selected. If it is not desired to edit the point, then simply enter another point# using the POINT# key or press the PROG key to return to normal operation.

Following the editing of a data point, the unit compares the temperature and voltage entered against the existing curve to see if either match and existing point. The point is matched first in temperature, then voltage. If a match occurs, the point is edited to reflect the change. If no match occurs, the unit inserts the new point into the curve in the correct increasing Raw Units order.

3.9.3.4 Summary of Curve Programming from the Front Panel

1. The Curve Programming routine is entered by pressing the PROG key followed by the CURVE# key. The PROG light will remain on while in the routine and turnoff when operation returns to normal.

2. The displays have the following format during curve programming.

Upper Display:	Temperature in K
Setpoint Display:	Curve# - Point#
Lower Display:	Raw Units Data

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3. The Upper and Lower SENSOR windows are blank. The Upper UNITS show "K" and the Lower UNITS "V" to indicate Raw Units Data (see Table 4-19).

4. When no digits are flashing, the Curve# is accessed using the CURVE# key and the POINT# by the POINT# key.

5. The keypad (0-9) is used to enter a quantity after it begins to flash. The decimal point can be used with Temperature or Raw Units Data but not with Curve# or Point#.

6. The PROG key always returns operation to normal operation.

7. The CLEAR key clears the display if pressed after an entry is begun.

8. The instrument will return to normal operation if no key is pressed for 20 seconds.

3.10 SETPOINT and CONTROL BLOCK

Parameters entered using a blue key with a black legend (SETPOINT, GAIN, RATE, RESET, and MANUAL HEATER) require the use of the ENTER key. When one of these keys is pressed and released, the least significant digit or digits will flash to indicate that the parameter can be entered. The quantity can be entered in three ways.

NOTE: IN ALL CASES, pressing the CLEAR key will result in the old value being inserted and the operation completed. Pressing the ENTER key enters the quantity in the appropriate display into the DRC-93C.

1. Enter the digits via the keyboard. The ↑-↓ minus sign can be used with the Setpoint and must preced the digits. The decimal point can be entered as desired. The operation is completed with the ENTER key or cancelled with the CLEAR key.

2. Increment the quantity using the ▲▲ key or decrement the quantity with the ▼▼ key. The operation is completed with the ENTER key or cancelled with the CLEAR key.

3. The quantity can be incremented or decremented by any amount as follows. Enter the digits of the increment or decrement desired via the keyboard. The decimal point can be entered as desired. Pressing the ▲▲ key will add the quantity and the ▼▼ key will subtract the quantity. The operation is completed with the ENTER key or cancelled with the CLEAR key.

Methods 2 and 3 can be used together in any combination. This same procedure is also used to enter the dwell except that the minus sign and decimal point are not permitted. (See section 3.8.5).

3.10.1 SETPOINT

To change the Setpoint, press the SETPOINT key an then use methods 1, 2, and/or 3 described above.

If in degrees celsius or degrees fahrenheit, the (-) key can be used to change the sign of the setpoint.

3.10.2 GAIN

Variable gain (proportional) allows adjustment of overall controller gain over a range from 0.1 to 99.

To change the Gain, press the GAIN key and use methods 1, 2, and/or 3 described above.

3.10.3 RATE

Adjusts rate time constant of differentiator. Effectively sets time constant between 1 and 990 seconds.

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These are displayed as 0.1 to 99 which means that the displayed number is multiplied by ten to get the rate in seconds. For a discussion of beats per second and time constants, see the Application Note enclosed as an Appendix to this manual.

To change the Rate, press the RATE key and use methods 1, 2, and/or 3 described above.

3.10.4 RESET

Adjusts reset (integral) time constant of integrator. Effectively sets time constant between 1 second and 990 seconds. These are displayed as 0.1 to 99.

To change the RESET, press the RESET key and use methods 1, 2, and/or 3 described above.

3.10.5 MANUAL HEATER POWER

The DRC-93C provides a feature in which the heater power can be set manually. The Manual Heater Power value is indicated on the Bar Graph by a blinking segment at the percent at which it is set.

To change the Manual Heater Power, press the MANUAL HEATER key and use methods 1, 2, and/or 3 described above. If the decimal number 5 is entered, the Bar Graph will blink the segment at 5%. If a zero is entered immediately after the 5 (thus entering 50) the Bar Graph will blink the segment at 50%. The CLEAR key cancels anything entered and returns the instrument to normal operation. The ENTER key inserts the new Manual Heater Power and then returns to normal operation.

3.11 HEATER POWER

3.11.1 HEATER %.

The Bar Graph displays the magnitude of the heater power in percent of full scale. Full scale is defined as the product of the maximum heater current of one ampere squared times the heater resistance times the range setting. The DRC-93C Temperature Controller is shipped from the factory with the Bar Graph indicating power. If the user prefers, he can change this to a current reading by turning on switch 1 of the eight station dip switch located at the rear center of the main board.

3.11.2 The HEATER POWER RANGE

The heater power range setting is determined by the keys directly below the HEATER POWER Bar Graph. MAX corresponds to a 10^0 or 1 multiplier, while -1, -2, -3 and -4 corresponds to a 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4} multiplier respectively. The OFF key turns off the output power independent of the setpoint and the control parameters.

NOTE: The DRC-93C is equipped with a current limit vernier on the rear panel which can limit the output current on the MAX scale between 0.33 and 1 ampere, dependent on setting. If the instrument will not deliver full power, this vernier may be set wrong or the load resistance may be too large and the unit is compliance voltage limited.

NOTE: If a SETPOINT, GAIN, RATE, RESET, MANUAL HEATER POWER or HEATER POWER RANGE is entered too quickly, the unit may not update the parameter properly. The instrument Display and Main Boards verify entered parameters each update cycle. Changing a parameter more than once in an update cycle may result in inconsistant parameters being entered.

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Figure 3-2. DRC-93C Temperature Controller
Rear Panel

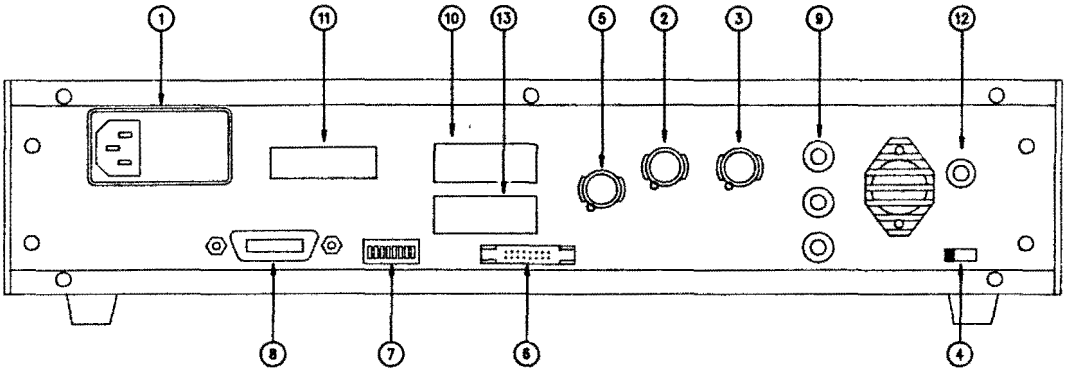


Figure 3-2. Model DRC-93C Temperature Controller Rear Panel Description

1. Line cord receptacle with fuse and voltage selection
2. Sensor INPUT A connector (J1)
3. Sensor INPUT B connector (J2)
4. HEATER RESISTANCE selector switch
5. Monitors output of Sensor INPUT A and Sensor INPUT B buffered voltages and 8225 linear analog output option (J3)
6. REMOTE SENSOR ID (J5) - Connects to POSITION DATA of Models 8084 or 8085 Scanner (optional)
7. IEEE-488 address switch
8. IEEE-488 connector (J4)
9. Heater Power output terminals (J6, J7, J8)
10. Optional interface access plate (J9) (8229 Scanner Option)
11. Optional interface access plate (J10) (8223 RS-232C Option)
12. MAX HEATER POWER Limit
13. Optional connector access plate (J11)

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3.12 LOCAL/REMOTE BLOCK

3.12.1 LOCAL.

The LOCAL key is used to return the instrument from remote control by the IEEE-488 BUS or the RS-232C optional interface to front-panel control.

3.12.2 REMOTE

The REMOTE key is used to place the controller under remote control and to disable the front panel. When the REMOTE key is pressed for more than one second, the display shows the IEEE-488 address of the instrument.

REAR PANEL DESCRIPTION

3.13 REMOTE SENSOR ID

The REMOTE SENSOR ID connector is connected to the REMOTE POSITION DATA output of a Model 8084 or Model 8085 Sensor Scanner or a Model SW-10A ten-position switch. This input is called the REMOTE POSITION DATA and allows the user to automatically call up different curves for different sensor/channel positions when the instrument is used with either remote switch (see Section 3.9.2). The Parallel input data format is given in Table 3-5. The user may supply to the REMOTE SENSOR ID his own parallel BCD 5 volt signal referred to the DIGITAL GROUND on pin 12.

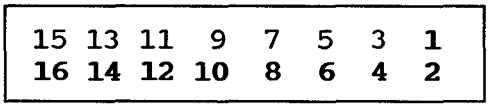
3.14 HEATER CURRENT LIMIT

The DRC-93C Temperature Controller has a current drive output with a maximum current rating of one ampere unless the optional 1.5 ampere output (W60) was ordered, or the current-limiting vernier has been set at a lower value.

With the current-limiting vernier on the back of the instrument, the output current on the MAX scale can be limited anywhere between 1 ampere and the maximum current for the 10^{-1} scale (330 mA). This allows the user to limit the maximum power to between 50 watts and 5 watts, dependent on his requirements.

Table 3-5. Pin Assignments for the J5 REMOTE SENSOR ID Connector

J5 CONNECTOR Pin Assignments



ONLY BOLD PINS USED

J5	Function
1	+5
2	RESERVED
4	Bit 3
6	Bit 2
8	Bit 1
10	Bit 0 (LSB)
12	DIGITAL GROUND
14	Bit 4 (MSB)
16	RESERVED

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SECTION IV

REMOTE OPERATION

4-1. IEEE-488 INTERFACE

The IEEE-488 INTERFACE is an instrumentation bus with hardware and programming standards designed to simplify instrument interfacing. The IEEE-488 INTERFACE of the DRC-93C fully complies with the IEEE-488-1978 standard and incorporates the functional, electrical and mechanical specifications of the standard. It also follows the supplement to that standard titled "Code and Format Conventions for use with IEEE Standard 488-1978". This section contains general bus information, Model DRC-93C interface capabilities, addressing and the programming instructions that control the DRC-93C functions.

4.2 GENERAL IEEE SPECIFICATIONS AND OPERATION

The following discussion covers the general operation of the IEEE-488 interface. For a more detailed description of signal level and interaction, refer to the IEEE Standard 488-1978 publication "IEEE Standard Digital Interface for Programmable Instrumentation".

All instruments on the interface bus must be able to perform one or more of the interface functions of TALKER, LISTENER, or BUS CONTROLLER. A TALKER transmits data onto the bus to other devices. A LISTENER receives data from other devices through the bus. The BUS CONTROLLER designates to the devices on the bus which function to perform.

The DRC-93C performs the functions of TALKER and LISTENER but cannot be a BUS CONTROLLER. The BUS CONTROLLER is your Digital Computer which tells the DRC-93C which functions to perform.

The interface works on a party line basis with all devices on the bus connected in parallel. All the active circuitry of the bus is contained within the individual devices with the cable connecting all the devices in parallel to allow the transfer of data between all devices on the bus.

The following discussion of the signal lines on the bus are for general information. Your digital computer handles these lines through its circuitry and software. The user need never concern himself with these lines or signals, however, knowledge of their purpose will help one to understand the operation of the Interface.

There are 16 signal lines contained on the bus:

1. 8 Data Lines
2. 3 Transfer Control Lines
3. 5 General Interface Management Lines

The data lines consist of 8 signal lines that carry data in a bit parallel, byte serial format. These lines carry universal commands, addresses, program data, measurement data and status to all the devices on the bus.

The three Transfer Control lines and the five Interface Management lines are asserted low which means that they carry out their function when pulled low. When the voltage on one of these lines is high then the line is not asserted and the function is inhibited. The General Interface Management Lines IFC (Interface Clear), ATN (Attention),

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REN (Remote Enable), EOI (End or Identify) and the SRQ (Service request) manage the bus and control the orderly flow of commands on the bus. The IFC, ATN, and REN management lines are issued only by the BUS CONTROLLER.

The IFC (Interface Clear) management line is pulled low by the BUS CONTROLLER to clear the interface.

The ATN (Attention) line is the management line used by the BUS CONTROLLER to get the attention of the devices on the bus. The BUS CONTROLLER does this by pulling the ATN line low and sending talk or listen addresses on the DATA lines. When the ATN line is low, all devices listen to the DATA lines. When the ATN line goes high, then the devices addressed to send or receive data (for example, the DRC-93C) perform their functions while all others ignore the DATA lines.

The REN (Remote Enable) management line is pulled low by the BUS CONTROLLER to enable a device (the DRC-93C) to perform the functions of TALKER or LISTENER.

The EOI (End or Identify) management line is pulled low by the BUS CONTROLLER or a TALKER (the DRC-93C) to indicate the end of a multiple byte transfer sequence. Also the EOI line along with the ATN line are pulled low by the BUS CONTROLLER to execute a polling sequence.

The SRQ (Service Request) management line is pulled low by a device (for example, the DRC-93C) to signal the BUS CONTROLLER that a process is completed, a limit, overload or error encountered. In some cases this means that service is required.

Transfer of the information on the data lines is accomplished through the use of the three signal lines: DAV (Data Valid), NRFD (Not Ready for Data) and NDAC (Not Data Accepted). Signals on these lines operate in an interlocking hand-shake mode. The two signal lines, NRFD and NDAC, are each connected in a logical AND to all devices connected to the bus.

The DAV line is pulled low by the TALKER after it places its data on the DATA lines. This tells the LISTENERS that information on the DATA lines is valid. A LISTENER holds the NRFD line low to indicate it is not ready. Since these lines are connected in a logical AND to all other devices, then the NRFD line will not go high until all of the devices are ready.

The NDAC line is pulled low by a LISTENER while it is receiving the DATA and lets it go high when the DATA is captured. Since the NDAC lines of all devices are connected in a logical AND, the NDAC line will not go high until all devices have received the DATA.

4.3 INTERFACE CAPABILITIES

The IEEE-488 Interface capabilities of the Model DRC-93C are listed in Table 4-1 as well as in mnemonic format on the instrument's rear panel.

Table 4-1. Interface Functions.

Mnemonic	Interface Function Name
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T5	Basic TALKER, serial poll capability, Talk only,Unaddressed to Talk if addressed to Listen
L4	Basic LISTENER, Unaddressed to Listen if addressed to Talk
SR1	Service Request capability
RL1	Complete Remote/Local capablty
PP0	No Parallel Poll capability
DC1	Full Device Clear capability
DT0	No Device Trigger capability
C0	No System Controller capablty
E1	Open Collector Electronics

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4.4 DRC-93C IEEE-488 ADDRESS SWITCH

The IEEE-488 Address Switch is located on the instrument's rear panel (see Figure 3-2, Key No. 7). Refer to Figure 4-1 for the following discussion.

4.4.1 Terminating Characters (delimiters)

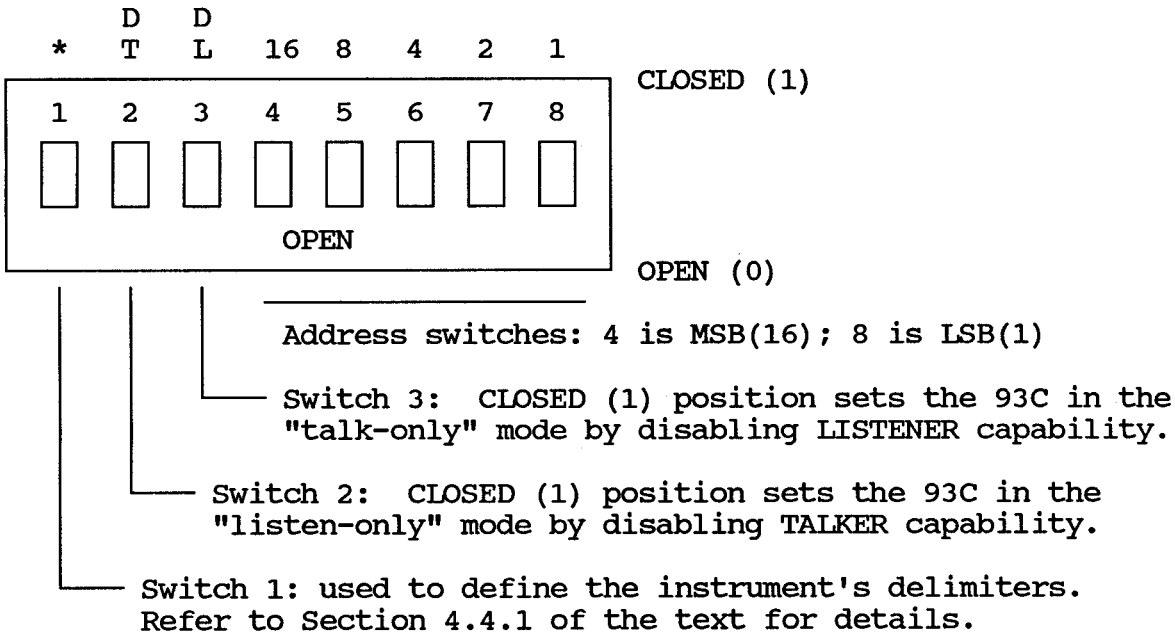
Switch 1 (*) is used to define the instrument's terminating characters (delimiters). The OPEN (0) position selects the ASCII characters CR and LF (Carriage Return and Line Feed) as the terminating characters for input and output data. For the output data from the DRC-93C back to the computer over the Bus, the EOI line is set by the DRC-93C with the output of the Line Feed (LF). This setting (0) for switch 1 is the setting for all Hewlett-Packard computers.

When Switch 1 (*) is CLOSED (1), a variable terminating character format may be selected for the input and output data. In this configuration the power-up (default) terminating characters are LF and CR with the EOI line being set with the output of the Carriage Return (CR). However, the two terminating characters can be changed via input data to the DRC-93C as detailed in Table 4-6. If the terminating characters are changed by the user, these are only in effect until the instrument is turned off.

4.4.2 TALKER and/or LISTENER Configuration

Since the DRC-93C is both a TALKER and a LISTENER, normally switches two and three should both be OPEN (0). These switches are usually of use when one instrument is a TALKER and another instrument is a LISTENER and they are to share the same address.

Figure 4-1. IEEE-488 Address Switch for the DRC-93C



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Table 4-2. Allowable Address Codes for the DRC-93C (Factory preset address is decimal 12)

ASCII Code Character		Bit 2*	3	Address Switches 4	5	6	7	8	5-bit Decimal Code
Listen	Talk	B7	B6	B5	B4	B3	B2	B1	
SP	@	0	0	0	0	0	0	0	00
!	A	0	0	0	0	0	0	1	01
"	B	0	0	0	0	0	1	0	02
#	C	0	0	0	0	0	1	1	03
$	D	0	0	0	0	1	0	0	04
%	E	0	0	0	0	1	0	1	05
&	F	0	0	0	0	1	1	0	06
'	G	0	0	0	0	1	1	1	07
(	H	0	0	0	1	0	0	0	08
)	I	0	0	0	1	0	0	1	09
*	J	0	0	0	1	0	1	0	10
+	K	0	0	0	1	0	1	1	11
,	L	0	0	0	1	1	0	0	12
-	M	0	0	0	1	1	0	1	13
.	N	0	0	0	1	1	1	0	14
/	O	0	0	0	1	1	1	1	15
0	P	0	0	1	0	0	0	0	16
1	Q	0	0	1	0	0	0	1	17
2	R	0	0	1	0	0	1	0	18
3	S	0	0	1	0	0	1	1	19
4	T	0	0	1	0	1	0	0	20
5	U	0	0	1	0	1	0	1	21
6	V	0	0	1	0	1	1	0	22
7	W	0	0	1	0	1	1	1	23
8	X	0	0	1	1	0	0	0	24
9	Y	0	0	1	1	0	0	1	25
:	Z	0	0	1	1	0	1	0	26
;	[	0	0	1	1	0	1	1	27
<	\	0	0	1	1	1	0	0	28
=	]	0	0	1	1	1	0	1	29
>	~	0	0	1	1	1	1	0	30

Factory preset address

* Only the first five bits of the binary code are listed. These bits are the same for the TALK and LISTEN address. The sixth and seventh bits (BUS CONTROLLER originated) determine whether the instrument is being addressed to TALK or LISTEN.

Function	Bit 2	3
TALK	1	0
LISTEN	0	1

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4.4.3 The IEEE-488 INTERFACE bus address for the DRC-93C is set by switches 4 through 8 which are reserved for the address selection. Switch 4 is the most significant bit (MSB[=16]) and 8 is the least significant bit (LSB[=1]).

The factory preset address of this instrument is 12 (see Table 4-2). Address switch numbers 5 and 6 should be CLOSED (1) which will result in the Address Switch having a setting of 00001100 or 10001100 dependent on the requirements for the delimiters.

4.5 IEEE-488 BUS COMMANDS

4.5.1 The Uniline Command

A Uniline Command (Message) is a command which results in a single signal line being asserted. The DRC-93C recognizes two of these messages from the BUS CONTROLLER, REN and IFC (See Table 4-3). When the BUS CONTROLLER executes the appropriate software code the effect is to pull the corresponding Interface Management line low. For example, when the software command REMOTE712 is executed by the HP86 digital computer, the management line REN is pulled low and the listen address 12 issued to signal the instrument having address 12 (DRC-93C) to go into the remote mode.

The SRQ is a uniline command asserted by the DRC-93C when it wishes to signal the BUS CONTROLLER. The BUS CONTROLLER will in turn use the Addressed command SPE (Serial Poll Enable) described below to interrogate the DRC-93C about the reason or reasons for the communication.

4.5.2 The Universal Commands

The Universal Commands shown in Table 4-3 are those multiline commands that address all devices on the bus. A multiline command involves a group of signal lines. All devices equipped to implement such commands will do so simultaneously when the command is transmitted. As with all multiline commands, these commands are transmitted with ATN line asserted (low). There are two Universal commands recognized by the DRC-93C, Local Lockout and Device Clear.

LLO (Local LOckout) - LLO is sent to instruments to lock out (prevent the use of) their front panel controls.

DCL (Device CLear) - DCL is used to return the DRC-93C to the power-up conditions.

4.5.3 The Addressed Commands

The Addressed Commands shown in Table 4-3 are multiline commands that must include the DRC-93C listen address before it will respond to the command in question. Note that only the addressed device will respond to these commands. The DRC-93C recognizes three of the Addressed commands; SDC (Selective Device Clear), GTL (Go To Local), and SPE (Serial Poll Enable).

SDC (Selective Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the SDC command.

GTL (Go To Local) - The GTL command is used to remove instruments from the remote mode. With some instruments, GTL also unlocks front panel controls if they were previously locked out with the LLO command.

SPE (Serial Poll Enable), SPD (Serial Poll Disable) - Serial polling is used to obtain the SRQ Status Register. The Status Register contains important operational information from the unit requesting service. The SPD command ends the polling sequence.

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4.5.4 The Unaddress Commands

The Unaddress Commands in Table 4-3 are used by the BUS CONTROLLER to remove any TALKERS or LISTENERS from the bus. The ATN line is asserted (low) when these commands are asserted.

UNL (Unlisten) - LISTENERS are placed in the listener idle state by the UNL command.

UNT (Untalk) - Previous TALKERS will be placed in the TALKER idle state by the UNT command.

Table 4-3 summarizes the IEEE-488 Bus Commands acknowledged by the DRC-93C.

4.5.5 Device-Dependent Commands

The DRC-93C supports a variety of device-dependent commands to allow the user to program the instrument remotely from a digital computer and to transfer measurements to the computer. These commands are sent from the computer (BUS CONTROLLER) to the DRC-93C as one or more ASCII characters that tell the device to perform a specific function. For example, the command sequence F0K sent by the BUS CONTROLLER to the DRC-93C is used to select kelvin as the set point units. The IEEE-488 bus actually treats these commands as data in that ATN is high when these device-dependent commands are transmitted.

4.5.6 TALKER and LISTENER Status

For the DRC-93C to be a LISTENER, it has to be in REMOTE and can be returned to LOCAL with the M0 (device-dependent) command or GTL (addressed) command as desired. For most, but not all computers, the DRC-93C as a TALKER does not have to be placed in REMOTE operation, but can remain under LOCAL control. This allows the user to collect data while maintaining front panel control. The HP computers will allow this mode of operation. If your computer automatically places the DRC-93C in remote and keeps it in remote after the transmission is over, sending the additional command M0 after the request for data will return the DRC-93C to LOCAL.

Table 4-3. IEEE-488 Bus Commands

Message Mnemonic	HP9825A Command	HP86 Command	IEEE-488 Bus Format
Uniline Commands			
Remote/REN	rem712	REMOTE712	?U*
Interface Clear/IFC			(IFC)
Universal Commands			
Local Lock Out/LLO	llo7	LOCAL LOCKOUT 7	?U(LLO)
Device Clear/DCL	clr7	CLEAR7	?U(DCL)
Addressed Command			
Selected Device Clear/SDC	clr712	CLEAR712	?U,(SDC)
Go to Local/GTL	lcl712	LOCAL712	?U,(GTL)
Serial Poll Enable/SPE	rds(712)→S	S=SPOLL(712)	?U,(SPE)
Unaddress Commands			
Unlisten/UNL			?
Untalk/UNT			-

* U is the controller (computer) Talk Address (Address 21)

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4.6 PROGRAMMING INSTRUCTIONS

The following discussion references the DRC-93C at address 12. The allowable address codes are given in Table 4-2. Therefore, its Talk ASCII Code is "L" and its LISTENER ASCII Code is "," (comma). The controller referred to in the following discussion is the BUS CONTROLLER and is normally a digital computer. It should not be confused with the temperature controller on the bus (DRC-93C). Set the IEEE Address of the DRC-93C to 12 by making Switches 5 and 6 CLOSED (1), 4, 7 and 8 (OPEN) (0) and make sure Switch 1 is OPEN (0) to select (CR)(LF) as the terminating characters. Note that this should be done prior to turning on the instrument since the DRC-93C updates the IEEE address on power-up **only**. Confirm that the address selected is correct by holding in the REMOTE button for longer than one second and observe the IEEE address on the front panel display as follows:

LSCI
93C
Add12

4.6.1 Commands and Requests

The device-dependent commands to program the DRC-93C are given in Table 4-4. The 93C must be addressed as a "LISTENER" to receive any instruction or string of instructions from the Command list.

The DRC-93C input data format does not require a set number or set sequence of Commands to implement proper instrument set-up. These Commands are processed only after the terminators [TERM1][TERM2] are sent across the bus. The listing and explanation of the 93C commands are summarized in Table 4-4. There are commands for Interface Setup, Instrument Setup, Control Setup, Scanner Setup, Status Register and restoring Executable Programs.

The Output Statement Requests are sent by the BUS CONTROLLER to the DRC-93C to tell the 93C what data to output when data output is requested. These requests are listed in Table 4-5 and the data formats are described in detail in the following tables as well as the adjoining text associated with those tables.

4.7 INSTRUMENT SETUP COMMANDS AND REQUESTS

4.7.1 EOI Status - The ZN_1 Command

When EOI (end or identify) is enabled ("Z0"; Table 4-6), the EOI line is set active concurrent with the last byte of a transfer. Use of EOI identifies the last byte allowing for variable length data transmissions. EOI can be disabled ("Z1"; Table 4-6).

4.7.2 Interface Mode - The MN_1 Command

4.7.2.1 Local - This message ["M0"; Table 4-6] clears the remote operation of the DRC-93C and enables front panel operation. Pressing the front panel LOCAL button also sets the instrument to local, provided the button has not been disabled by the Local Lockout Message (see Section 4.7.2.3).

See Section 4.5.6 for a discussion of the DRC-93C under local operation while acting as a TALKER.

4.7.2.2 Remote - The DRC-93C is in the local front panel mode when first turned on. A remote message ["M1"; see Table 4-6] allows the 93C to be controlled over the IEEE-488 interface. In Remote, the front panel controls are disabled (except the LOCAL button) and are then controllable over the IEEE Bus. The instrument's initial set up is determined by the front panel settings at the time when the

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instrument is placed into Remote. The DRC-93C may also be placed into remote by pressing the REMOTE button on the front panel or addressed to talk by the BUS CONTROLLER.

Table 4-4. DRC-93C Command Summary of Instrument Setup

Summary of Input Command Formats. Choices of the commands are:		
Table	Interface Setup Commands	
4-6	ZN_1 MN_1 TN_1 C	Selects EOI status Selects Remote Interface Mode Changes terminating Characters "Clear" Command
Table	Instrument Setup Commands	
4-7	$F0C_1$ $F1C_1$ $F2CC_1N_1$ $F2SC_1N_1$ $F3CN_1$ $F3SN_1$ F4CON, F4COFF F4SON, F4SOFF F5ON, F5OFF and F5CLR $NC_1N_1N_2N_3$	Select Control Units Select Sample Units Select Control (Setpoint) Sensor Select Sample Sensor Select the Control (Setpoint) Resolution Select the Sample Resolution Select the control Sensor Deviation ON or OFF Select the Sample Deviation ON or OFF Select the MATH Function ON, OFF or CLeaRed Assign Curve Number for Input Channel selected
Table	Control Setup Commands	
4-9 4-10	S,etc PN_1N_2,etc. IN_1N_2,etc. DN_1N_2,etc. RN_1 HN_1N_2	Set Point Input Proportional (GAIN) Integral (RESET) Derivative (RATE) Heater Range Manual Heater %
Table	Scanner Setup and Selection Commands	
4-11	$YAN_1N_2N_3$ or $YBON_2N_3$ YS YH	Set the Scanner channel dwell time Enable the (S)CAN function. Disable, or (H)old, the SCAN.
Table	Status Register Mask Command	
4-13	QC_1C_2	Set the Status Register mask
Table	Restoring Executable Programs Command	
4-14	$EN_1N_2C_1$-C_{60}	Transmit (Restore) Program Step # N_1N_2 data

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4.7.2.3 Local Lockout - This message ["M2"; Table 4-6] disables the DRC-93C's Local Front Panel controls, including the LOCAL button. The message is in effect until the message is cleared over the Bus or power is cycled.

Many IBM PC IEEE-488 cards automatically place addressed instruments into Local Lockout. To be able to place the DRC-93C into Remote without Local Lockout the user may need to reconfigure his IEEE-488 card.

4.7.3 Terminating Characters - The TN_1 Command

Terminating characters ["T0", "T1", "T2" and "T3"; Table 4-6] are used to indicate the end of a record. Record terminators are used when the unit has completed its message transfer. Switch 1 of the IEEE address defines the terminator status. If switch 1 is OPEN (0) the terminator status is defined as "T0" [(CR)(LF)] and terminator status can not be changed over the interface. When switch 1 is CLOSED (1) the terminator status is defined as "T1" [(LF))(CR)] and the status can be changed using the "T0", "T1", "T2" or "T3" commands.

4.7.4 Clear

The (C)lear Message [see Table 4-4] sets the DRC-93C to the turn-on state. This action is similiar to turning the instrument OFF and then turning it back ON, except that it occurs in milliseconds, rather than seconds and the DRC-93C does not go through the power-up display sequence.

Table 4-5. DRC-93C Summary of Output Requests

Table	Request	Output
4-6	W2 WI	Interface Status Input and Option Card Data
4-7	WD	Sample, Control,A and B Input Information
4-9	WP	Set Point Data
4-10	W3	Control Data (Gain, Reset, etc.)
4-11	WY	Scan Data
4-13	WQ	Service Request Data
4-14	WEN_1N_2	Program Step # N_1N_2 Data
4-15	WS WC W0 WM	Sample Sensor Data Control Sensor Data Sample & Control Sensors, Setpoint Data MAX, MIN and MAXDEV Data

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Table 4-6. DRC-93C Interface Setup Commands and Request Status

Command	Functional Description
ZN_1[a]	Selects IEEE EOI status. Forms of the command are Z0 and Z1. When N_1 is: — EOI Status is: 0 — EOI line is set/accepted on last character input or output. 1 — EOI line is not set on last character output or acknowledged on input.
MN_1	Selects Remote Interface mode. Forms of the command are M0, M1 and M2. When N_1 is: — Mode is: 0 — Local 1 — Remote 2 — Remote with Local Lockout
TN_1	Changes terminating characters (when IEEE Address Switch #1 is CLOSED [1]). Forms of the command are T0, T1, T2 and T3. When N_1 is: — Terminators are:[b] 0 — (CR)(END[c] ^ LF) [also with Switch OPEN] 1 — (LF)(END ^ CR) [default, unless changed] 2 — (END ^ LF) 3 — (END ^ DAB[d])
C	"Clear" command, returns unit to power up state (Restart).

****

Request	Functional Description
W2	Interface Status - ZN_1,MN_2,TN_3 8 Characters plus up to 2 Terminators where: ZN_1 is EOI status MN_2 is Mode status TN_3 is Terminator status
WI	Input and Option Card Data[e] $A\text{-}C_1C_2C_3C_4C_5C_6C_7,B\text{-}C_8C_9C_{10}C_{11}C_{12}C_{13}C_{14},$ $1\text{-}C_{15}C_{16}C_{17}C_{18},2\text{-}C_{19}C_{20}C_{21}C_{22},3\text{-}C_{23}C_{24}C_{25}C_{26}$ 40 Characters plus up to 2 Terminators where: C_1-C_7 is the A Input Card. C_8-C_{14} is the B Input Card. C_{15}-C_{18} is the Option 1 Present. C_{19}-C_{22} is the Option 2 Present. C_{23}-C_{26} is the Option 3 Present.

a) N_i corresponds to a numeric value (0 - 9)
b) The AND symbol (^) is used to indicate messages sent concurrently.
c) END = EOI; d) DAB = last data byte
e) C_i corresponds to an alphanumeric (0 - F)

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4.7.5 The "W2" Data String

For the case of W2, the data string would have the following format:

Z0,M2,T1[TERM1][TERM2]

where the Z0, M2 and T1 are defined in Table 4-6.

4.7.6 The "WI" Data String

This Data String gives the input cards present (9210, 9220, 9215, 9317C or 9318C) in Input A and B, and if the analog option, interface option or scanner is present. A typical data string would be:

A-9220-P2,B-9318C ,1-8225,2-8223, 3-8229

which indicates 9220 card configured as a 100 ohm platinum input for Input A; a germanium/carbon glass input for Input B; a linear analog option in Option Slot 1; a RS-232C option in Option Slot 2 and a Scanner Card option in Option Slot 3.

4.8 SELECTION OF QUANTITIES FOR THE CONTROL AND SAMPLE DISPLAYS- UNITS, SENSORS, RESOLUTIONS, AND DEVIATION (TABLE 4-7)

4.8.1 Units for Control Display and Setpoint - The F0C_1 Command

The F0C_1 command set the temperature or sensor units for the control display and for the setpoint. Sensor units (volts, ohms or nanofarads) are selected automatically by the input card type. Consequently, the command for selecting sensor units for control is F0S. Temperature units are selected with the same command with K, C, or F substituted for S.

Note that only one choice of sensor units (volts, ohms, or nanofarads) is available which is dependent on the input card type selected.

4.8.2 Units for Sample Display- The F1C_1 Command

The sample units may be set independently by the command F1C_1. The commands for selecting sensor units are F1K, F1C, F1F and F1S.

4.8.3 Control Sensor Selection- The F2CC_1N_1 Command

The sensor to be selected for the control display can be changed by the F2CC_1N_1 command. The quantity C_1N_1 is A0, A1, A2, A3, A4, or B0. Examples: F2CA0, F2CB0, F2CA4.

4.8.4 Sample Sensor Selection - The F2SC_1N_1 Command

The sensor to be selected for the sample display can be changed by the F2SC_1N_1 command. The quantity C_1N_1 is A0, A1, A2, A3, A4, or B0. Examples: F2SA0, F2SB0, F2SA4. **Caution** is advised when using this command **if** the control sensor is not on Channel B since this command may then be switching the control sensor.

4.8.5 Resolution for the Control and Sample - The F3CN_1 and F3SN_1 Commands

The resolution for the control and sample displays can be set independently with the F3CN_1 and F3SN_1 commands, respectively. The quantity N_1 is a number 0 thru 4 where

0	for a resolution of	xxx.
1	for a resolution of	xxx.x
2	for a resolution of	xxx.xx
3	for a resolution of	xx.xxx
4	for a resolution of	x.xxxx

Examples:

F3C1 for a resolution of xxx.x on the Control Sensor Display

F3S3 for a resolution of xx.xxx on the Sample Sensor Display

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4.8.6 Selection of Deviation for Control and Sample - The F4CON, F4COFF, F4SON and F4SOFF Commands

Deviation output instead of magnitude and sign output can be selected for the sample and control displays independently using the F4CON, F4COFF, F4SON and F4SOFF commands.

4.8.7 Selection of MATH Functions ON, OFF and CLEAR - The F5ON, F5OFF and F5CLR Commands

The MATH function can be turned on, off or cleared using the F5ON, F5OFF and F5CLR commands.

4.8.8 Sensor Curve # Selection - The $NC_1N_1N_2N_3$ Command

The Curve Number to be selected for the inputs can be changed by the $NC_1N_1N_2N_3$ command. The quantity C_1N_1 is the input A0, A1, A2, A3, A4, or B0. The quantity N_2N_3 is the curve number from 00 thru 30. Examples: NA000, NA006, NA405, NB002, etc.

4.8.9 The A and B Sensor ID Information - The AC_1C_2 and BC_1C_2 Commands

The purpose of this command is to select Filtering of the A or B input, whether the Remote Position Data is used to establish the curve numbers, the Temperature Coefficient sign for the 9215 card, and whether or not thermal correction is desired on the 9317C/9318C cards.

Table 4-8 defines C_1 and C_2 in the AC_1C_2 and BC_1C_2 commands. C_1 defines whether the Remote Position Data should be used to select the Curve Number. C_2 defines whether the thermal correction is on or off on the 9317C/9318C cards, filtering on or off, and the sign of the temperature coefficient with a 9215 Capacitance Card.

A02 - Enable digital filtering to be used to determine display value.

A10 - Enables the REMOTE SENSOR ID. If the remote position data is 0, then the sensor curve reverts to the curve in A00 (or B00) rather than being selected from the REMOTE SENSOR ID Table.

A12 - Enable digital filtering in addition to the A10 description.

4.8.10 The "WD" Data String

An example of the data received when requesting Sample, Control, A and B information using the WD command is as follows

A0,K,3,N,B0,K,2,N,00,A00,02,00,00,
00,00,B02,04

The above string indicates that the Sample Sensor is A0, sample units are kelvin, sample resolution is 3 (xx.xxx) and the sample form is normal; the Control Sensor is B0, control units are in kelvin, control resolution is 2 (xxx.x) and control form is normal; the remote position is off; the SENSOR A ID indicating that the Digital Filtering is Off and the REMOTE SENSOR ID is off; the curve being used for INPUT A0 is 2 and A1, A2, and A3 are using curve 0; the SENSOR B ID indicates that Digital Filtering for this channel is On and the curve assigned is 4.

Both channels are using the DT-470 "Curve 10", the difference is that INPUT A is set for an upper limit of 325K and INPUT B is set with an upper limit of 475K.

4.9 THE CONTROL COMMANDS

4.9.1 The Set Point Value - The S Command

The set point is sent from the controller to the DRC-93C in a free field format of which examples are given in Table 4-9. Note that the sign only has to be present if negative celsius or fahrenheit settings are desired. Although

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Table 4-7. DRC-93C Command Summary for Instrument Setup

Command	Functional Description
Selection of Units, Sensors, Resolution, and Deviation	
$F0C_1$	Function 0 - Select Control (Setpoint) Units. Forms of the command are F0K (kelvin), F0C (celsius), F0F (fahrenheit), and F0S for Sensor Units in volts, ohms or nanofarads.
$F1C_1$	Function 1 - Select Sample Units. Forms of the command are F1K (kelvin), F1C (celsius), F1F (fahrenheit), and F1S for Sensor Units in volts, ohms or nanofarads.
$F2CC_1N_1$	Function 2C - Select Control (Setpoint) Sensor. Forms of the command are F2CA0, F2CA1*, F2CA2*, F2CA3*, F2CA4* and F2CB (or F2CB0). * With 8229 Scanner Card Only.
$F2SC_1N_1$	Function 2S - Select Sample Sensor. Forms of the command are F2SA0, F2SA1*, F2SA2*, F2SA3*, F2SA4* and F2SB (or F2SB0). * With 8229 Scanner Card Only.
$F3CN_1$	Function 3C - Select the Control (Setpoint) Resolution. N_1 is 0 (xxx.), 1 (xxx.x), 2 (xxx.xx), 3 (xx.xxx) or 4 (x.xxxx). Forms of the command are F3C0, F3C1, F3C2, F3C3 and F3C4.
$F3SN_1$	Function 3S - Select the Sample Resolution. N_1 is 0 (xxx.), 1 (xxx.x), 2 (xxx.xx), 3 (xx.xxx) or 4 (x.xxxx). Forms of the command are F3S0, F3S1, F3S2, F3S3 and F3S4.
F4CON F4COFF	Function 4C - Select the Control Sensor Deviation ON or OFF.
F4SON F4SOFF	Function 4S - Select the Sample Sensor Deviation ON or OFF.
F5ON F5OFF F5CLR	Function F5 - Select the MATH Function on, off or cleared.
$NC_1N_1N_2N_3$	Function N assigns Curve Number to Input Channel. Forms of the command are NA000 thru NA031 (NA431 with Scanner Card) and NB000 thru NB031.
AC_1C_2 or BC_1C_2	Input A ID and B ID. C_1C_2 are 00 thru 1F. Forms of the command are A00 thru AFF. C_1 ranges between 0 and F. If C_2 is between 0 and 7, then C_1 selects the Sensor Curve number 00(0) thru 15(F). If C_2 is between 8 and F, then C_1 corresponds to a Remote Position between 0 and F.

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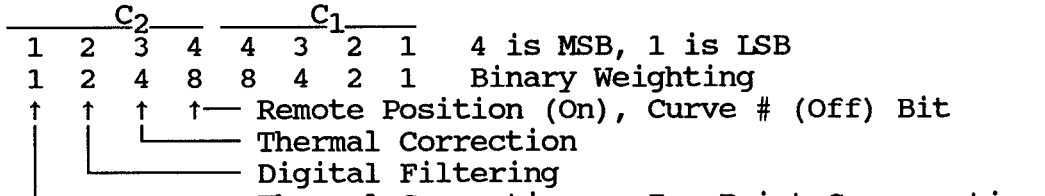
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Table 4-7 Cont'd. DRC-93C Request Summary for Instrument Setup

****

Request	Output of Instrument Variables
WD	Sample, Control, A and B Input Information $C_1C_2,C_3,N_1,C_4,C_5C_6,C_7,N_2,C_8,C_9C_{10},AC_{11}C_{12},$ $N_3N_4,N_5N_6,N_7N_8,N_9N_{10},N_{11}N_{12},BC_{13}C_{14},N_{13}N_{14}$ 46 characters plus up to 2 terminators where: C_1C_2 is the Sample Sensor A0, A1, A2, A3, A4 or B0. C_3 is the Sample Units K, C, F, V, N or R. N_1 is the Sample Resolution 0 (xxx) through 4 (x.xxxx) C_4 is the Sample Form - N for normal,D for Deviation C_5C_6 is the Control Sensor A0, A1, A2, A3, A4 or B0. C_7 is the Control Units (K, C, F, V, N or R). N_2 is the Control Resolution 0 (xxx) through 4 (x.xxxx) C_8 is the Control Form - N for normal, D for Deviation C_9C_{10} is the Remote Position (00 through 1F). $C_{11}C_{12}$ is the A ID (00 through 1F). N_3N_4 is the A0 curve number (00 through 30). N_5N_6 is the A1 curve number (00 through 30). N_7N_8 is the A2 curve number (00 through 30). N_9N_{10} is the A3 curve number (00 through 30). $N_{11}N_{12}$ is the A4 curve number (00 through 30). $C_{13}C_{14}$ is the B ID (00 through 1F). $N_{13}N_{14}$ is the B Curve Number (00 through 30).

Table 4-8. C_1 and C_2 in A ID and B ID, the SENSOR ID's



C_1	C_2			
Curve # or Remote Position	Select Curve # (0) or Remote Position (8)	9317C/9218C Card Thermal Correction	Digital Filtering	9215 Card Temperature Coefficient
0 to F	0 or 8	OFF (0)	OFF (0)	+ (0)
"	1 or 9	OFF (0)	OFF (0)	- (1)
"	2 or A	OFF (0)	ON (2)	+ (0)
"	3 or B	OFF (0)	ON (2)	- (1)
"	4 or C	ON (4)	OFF (0)	+ (0)
"	5 or D	ON (4)	OFF (0)	- (1)
"	6 or E	ON (4)	ON (2)	+ (0)
"	7 or F	ON (4)	ON (2)	- (1)

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input range may be above the values possible for the various sensors, the set point is limited by the input card present as shown in the table. Note that the temperature limit can be different for the DT-470 depending on whether curve 02 (324.9K) or curve number 04 (474.9K) has been selected. If a number above the limitation for the card is entered, the set point is set to the upper temperature limit. Also note that an S sent by itself to the 93C sets the set point to 0 kelvin (or its equivalent in the units chosen) which will result in shutting down the heater output stage of the temperature controller.

Table 4-9. DRC-93C Command/Request Summary for Setpoint Setup

Command	Functional Description
S or SN_1 or $SN_1.N_2$ or SN_1N_2 or $SN_1N_2.N_3$ or $SN_1N_2N_3.N_4$ or $SN_1.N_2N_3$ etc. or ( )SN_1 or ( )$SN_1.N_2$ or ( )SN_1N_2 or ( )$SN_1N_2.N_3$ etc.	Set Point Input. The decimal point is "FREE FIELD" and its allowable position depends on the control units. Limits are Units — Range K: 0 through 999.9 C,F: -999.9 through 999.9 V: 0.0000 through 9.9999 R: 0 through 99999 N: 0 through 99.999 or 999.99 The Set Point is limited based on input card and Sensor. Lower limit is 0 K (-273.1 °C or -459.6 °F).

Input Card	Sensor Type	Upper Set Point Limit K	°C	°F	Sensor Units
9210/20-3	DT-470, DT-500	324.9	51.7	125.1	2.9999 volt
9210/20-6	TG-100,TG-120	"	"	"	6.5535 volt
9317C	Germanium/Carbon Glass	"	"	"	9999.9 ohms
9318C	Germanium/Carbon Glass	"	"	"	99999 ohms
9215-15	CS-400,CS-501	N/A	N/A	N/A	29.999 nF
9215-150	CS-401,CS-501	N/A	N/A	N/A	149.99 nF
9210/20-3	DT-470	474.9	201.7	395.1	2.9999 volt
9220-P2	PT-100 Series	999.9	526.7	980.1	299.99 ohms
9220-P3	PT-1000 Series	"	"	"	2999.9 ohms
9220-R1	Rhodium-iron	"	"	"	99.999 ohms

****

Request	Output of Instrument Data
WP	Set Point Data - ( )$N_{11}N_{12}N_{13}(.)N_{14}N_{15}$( ) 8 Characters plus up to 2 terminators where the N_{11}-N_{15} variations are the same as for W0 (see Table 4-15).

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Note: Although limitations on the range of the set point are set within the software when in temperature units; these limits are not possible for sensor units due to the different characteristics for each sensor.

Since the set point is soft, the transition from REMOTE to LOCAL does not result in a change in the set point.

4.9.2 The "WP" Request Data String

This request is a subset of the "W0" command; the "WP" command giving the set point value by itself.

4.9.3 Setting the GAIN (Proportional) - The P Command

The gain is a multiplier between 0.1 and 99., a range of 990, i.e., 99./0.1 = 990. A gain of 0.0 is not allowed. The format is free field with examples of the command being P.1, P0.1, P9, P9., P9.0, P99, P99., etc.

The string P987.12 will be interpreted as P87, i.e., the first valid combination will be retained. A P transmitted by itself is equivalent to P0 or P0.0 and sets the gain to 0.1.

4.9.4 Setting the RESET (Integral) - The I Command

The reset is set from 0.1 through 99 (1 to 990) seconds. Like the gain command, it is free field with the same characteristics and format. A setting of 0.0 turns the reset off.

4.9.5 Setting the RATE (Derivative) - The D Command

The rate is also set in seconds/10 (from 0.1 to 99). It handles its input format exactly the same as both gain and reset commands. A setting of 0.0 turns the rate off.

4.9.6 Heater Range - The R Command

The heater range can be changed over the bus with the RN_1 command. R6 and up are equivalent to the R0 command (see Table 4-10).

4.9.7 % Manual Heater Power - The H Command

The Per Cent Manual Heater Power can be set between 00 and 99 with this command. Total power can be greater or less than this setting, dependent on control settings and actual control sensor temperature.

4.9.8 The "W3" Data String

The settings for the gain, rate, reset, manual heater power, heater range as well as the instantaneous % of Heater Power can be transmitted from the DRC-93C with the "W3" command.

The command "SPIDR" or any combination without a value following the letter sets the chosen parameters to 0, e.g., "SP" sets the set point and gain to 0.

4.10 THE SCANNER INPUT CARD

4.10.1 SCAN Programming Instructions

NOTE: The YA, YB (Table 4-11) and Y2S (Table 4-7) commands should be issued when the SCAN mode is Holding. Changing a SCAN time or Scanner Channel while the unit is actively scanning may cause unpredictable results.

4.10.2 Setting the Dwell Time - The $YAN_1N_2N_3$ and $YB0N_2N_3$ Commands

The time spent on a given scanner channel can be varied between 0 and 99 seconds by setting the dwell time for that channel. This can be done over the IEEE-488 Bus with these commands or from the front panel. Setting the dwell time to 0 skips that channel.

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Table 4-10. DRC-93C Command/Request Summary for the Control Parameters

Command	Functional Description
	Setting of all other Control Parameters
$PN_1.N_2$ or PN_1N_2	Proportional (GAIN). N_1N_2 is 0.1 through 99. Examples the command are P, P0, P0.0 and P99.
$IN_1.N_2$ or IN_1N_2	Integral (RESET). N_1N_2 is 0.0 (OFF) through 99. (three characters including the decimal point). Forms of the command are I0 (I0.0) through I99.
$DN_1.N_2$ or DN_1N_2	Derivative (RATE). N_1N_2 is 0.0 (OFF) through 99. (three characters including the decimal point). Forms of the command are D0 (D0.0) through D99.
RN_1	Heater Range. N_1 is 0 through 5. Forms of the command are R0 through R5. N_1 Range Heater Current 0 OFF 0 1 -4 10 mA 2 -3 33 mA 3 -2 100 mA 4 -1 330 mA 5 MAX 1 A
HN_1N_2	% Manual Heater Power. 00 to 99 % of Heater Range

****

Request	Functional Description
W3	Control Parameters $N_1N_2N_3,N_4N_5N_6,N_7N_8N_9,N_{10},N_{11}N_{12}N_{13},N1_4N_{15}$ 20 characters plus up to 2 terminators where: $N_1N_2N_3$ is the Gain Value $N_4N_5N_6$ is the Rate Value $N_7N_8N_9$ is the Reset Value N_{10} is the Heater Range $N_{11}N_{12}N_{13}$ is the % of Heater Power or Current out. $N1_4N_{15}$ is the % of Manual Heater Power or Current Out

4.10.3 Enabling the Scan Function - The YS Command

Upon sending the YS command from the BUS CONTROLLER, the DRC-93C starts its scan of the inputs from the channel input which it is currently on. The scan sequence is A, 1(A1), 2(A2), 3(A3),4(A4), A, etc. with any channel whose dwell time is set to zero being skipped.

It is strongly recommended that the control channel be the B channel when the scanner is used. If it is not, it will be changed if a scanner card is present, since one current source is associated with the A0-A4 inputs.

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Table 4-11. DRC-93C Command/Request Summary for Scanner

Command	Functional Description
$YAN_1N_2N_3$ or $YB0N_2N_3$ (After YH cmmd)	Set the AN_1 (A0 - A4) or B0 Scanner channel dwell time time to N_2N_3 seconds. N_2N_3 is 00 to 99 seconds. Forms are YA000 thru YA099, YA100 thru YA199, etc.
YS	Enable the (S)CAN function.
YH	Disable, or (H)old, the SCAN.

****

Request	Functional Description
WY	Scan Information $C_1,C_2C_3,C_4C_5,C_6C_7,C_8C_9,C_{10}C_{11},C_{12}C_{13},C_{14}C_{15}$ 22 characters plus up to 2 terminators where: C_1 is the SCAN status, (H)olding or (S)canning. C_2C_3-$C_{12}C_{13}$ is the A0 - A4 and B0 dwell times in seconds. $C_{14}C_{15}$ is the SCAN position A0, A1, A2, A3 or A4.

a) C_i corresponds to an alphanumeric

4.10.4 Holding the Scan Function - The YH Command

The Scan can be stopped any time over the IEEE-488 Bus by sending out the YH command. The scanner should be in hold when any of the other scanner commands are sent to the scanner.

4.10.5 The "WY" Data String

This request includes whether the instrument is scanning or holding, the channel dwell information and the scan position.

4.11 THE SERVICE REQUEST, STATUS REGISTER, STATUS REPORTS, AND THE STATUS REGISTER MASK

As mentioned earlier, a Service Request can be initiated by the DRC-93C to indicate a function has been performed, or a limit, overload or error has been encountered. The DRC-93C does this by pulling its SRQ (Service Request) management line low. The BUS CONTROLLER uses the serial poll (SPOLL) to obtain the contents of the register in the DRC-93C called the Status Register.

The DRC-93C Status Register is a single byte of data from the DRC-93C containing five bits called the Status Reports. These Status Reports indicate when certain processes are complete, whether the channel was changed, or a limit, overload or error encountered. The Status Register Mask is provided so that the Status Request interrupt and undesired Status Reports can be inhibited.

Reading the Status Register resets the Status Register to all zeros so that only new status reports will be registered by the DRC-93C. Thus, through the SRQ management line and the Status Register, the DRC-93C is able to signal Status Reports on five conditions immediately to the BUS CONTROLLER.

It is possible to disable the DRC-93C SRQ line thereby preventing the

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DRC-93C from interrupting the BUS CONTROLLER. However, the BUS CONTROLLER can still read the Status Register to determine appropriate instrument conditions.

4.11.1 The Service Request

The Service Request Message is independent of all other IEEE-488 activity and is sent on a single line called the SRQ line. When the Service Request is sent and more than one instrument on the Bus has the capability to send this message, the BUS CONTROLLER must decide which instrument is sending the request. This is done by conducting a "Serial Poll" of the instruments on the Bus. The instrument polled responds by sending a Status Register. The Status Register indicates whether the device has requested service and if so, for what reason.

Once the reading on a given channel becomes stable (or valid), a service request is issued by the DRC-93C provided that Bit 6 in the Status Register Mask is set (See 4.11.2.5). With the SRQ bit of the Status Register mask disabled, no SRQ interrupt by the DRC-93C will be generated, however, the BUS CONTROLLER can still read the Status Register to determine appropriate instrument conditions.

4.11.2 The Status Register and Status Reports

The DRC-93C Status Register is a single byte of data from the DRC-93C containing five bits called the Status Reports which give information indicating which process is complete, whether the channel was changed, or a limit, overload or error encountered.

The Status Register can be read at any time by means of a Serial Poll Enable command.
Reading the Status Register resets the Status Register to all zeros so that only new status reports will be registered by the DRC-93C. Executing the Q command (Section 4.11.3) also resets the Status Register to all zeros. Reading the Status Register resets all of its bits to zero.

4.11.2.1 Status Reports 0 and 1 - Display and Control Data Ready. Bit 0 of the Status Register is set when a valid Display data reading is available. Bit 1 of the Status Register is set when a valid Control data reading is available. If the Service Request is enabled, either one of these being set will cause the DRC-93C to pull the SRQ management low to signal the BUS CONTROLLER. These bit(s) are reset to zero upon reading the Status Register on response to a serial poll or if the reading is no longer valid.

These functions can be inhibited by turning their corresponding bits in the Status Register mask off.

4.11.2.2 Status Report 2 - The Control Channel Limit. When the control sensor reading gets within the chosen limit from the set point, bit 2 is set in the Status Register. If the Service Request is enabled this bit being set will cause the DRC-93C to pull the SRQ management low to signal the BUS CONTROLLER. As with all of the Status Reports, this bit is reset to zero upon reading the Status Register. The bit will not revert to zero if the control sensor difference from the set point later exceeds the limit selected.

The control channel limit is entered using the Q command. (See Section 4.11.3.2).

This function can be inhibited by turning off bit 2 in the Status Register mask.

4.11.2.3 Status Report 3 - Display Sensor Channel Change. Bit 3 of the

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Status Register is set when a channel change occurs for the Display. If the Service Request is enabled this bit being set will cause the DRC-93C to pull the SRQ management low to signal the BUS CONTROLLER. This Status Register bit is reset to zero upon reading the Status Register.

This function can be inhibited by turning off the bit 3 in the Status Register Mask.

4.11.2.4 Status Report 5 - Overload Error Indicator. If the display has an overload condition on any selected channel or an error occurs, then bit 5 of the Status Register is set and a Service Request is issued if enabled. This Status Register bit is reset to zero upon reading the Status Register.

This function can be inhibited by turning bit 5 off in the Status Register Mask.

4.11.2.5 When operating without the Service Request it is still possible for the BUS CONTROLLER to read the Status Register. The Service Request is inhibited by turning off the SRQ bit (bit 6) in the Status Register Mask.

However, it must be understood that certain bits in the Status Register are continually changing. The Status Reports for the Overload/Error, Display Data Ready, and Control Data Ready are continuously updated to reflect current instrument status. The Channel Change and Control Channel Limit once encountered are latched (set to 1) and remain latched until the Status Register is read.

4.11.3 The Status Register Mask - The QC_1C_2 Command

The Status Reports listed above may not be desired or perhaps only a few are of interest. The Status Register Mask is provided to allow the user to select whether he wants a given Status Report or not. The various bits of the Status Register Mask enable the various Status Reports. The bits in the Status Register Mask have the same bit position as the bits in the Status Register.

Only those bits which are allowed by the Status Register Mask Command are potentially changeable in the Status Register. Note that the corresponding bit in the Status Register Mask determines whether its counterpart in the Status Register can change.

The Status Register Mask is shown in Figure 4-2. It consists of 8 bits, one bit (bit 6) which determines whether the DRC-93C is to report via the SRQ line and five bits to determine which Status Reports to make. Bit 6 is the SRQ (Service Request) bit and if set allows the DRC-93C to send out a Service Request on the SRQ IEEE-488 line. If the SRQ bit is not set (off) then the DRC-93C is inhibited from producing a Service Request. The Status Register can still be read by the BUS CONTROLLER to examine the Status Reports, but the BUS CONTROLLER will not be interrupted by the Service Request. Five of the other seven bits select which of the five Status Reports to make. If one of these five bits is set (on), the DRC-93C will update the corresponding Status Report bit in the Status Register. Then if the SRQ bit (bit 6) of the Status Register Mask is set, the DRC-93C will send out a Service Request on the SRQ IEEE-488 line. By means of a serial poll enable (SPE), the BUS CONTROLLER determines that the DRC-93C has sent out a service request and then reads the Status Register. Reading the Status Register resets the Status Register to all zeros. Executing the Q command also resets the Status Register to all zeros. The Status Register Mask command is

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the ASCII letter Q followed by two alphanumerics representing the most significant four bits and the least significant four bits, respectively. Note that the controller can be programmed for more than one set of conditions simultaneously. To enable the Service Request, Bit 6 must be a 1.

4.11.3.1 Status Register Mask Bits 0 and 1 - Sample and Control Data Ready Enables. If either Bit 0 or Bit 1 of the Status Register Mask is set (1), then for that data, the corresponding bit in the Status Register is set when a valid data reading is available.

4.11.3.2 Status Register Mask Bit 2- The Control Channel Limit Enable. If the control channel limit (Figure 4-2, Bit 2) is selected, the limit **must** follow the Q command and is in a free field format. Examples are xxx.x, .x, x.x, xx.x, x., xx., etc. If Bit 2 of the Mask is set (1), then when the control sensor reading gets within the chosen limit from the set point, the corresponding bit is set in the Status Register.

4.11.3.3 Status Register Mask Bit 3- Sample Sensor Channel Change Enable If the Sensor Channel Change (Bit 3) is selected, then bit 3 in the Status Register is set when a channel change occurs.

4.11.3.4 Status Register Mask Bit 5 - Overload/Error Indicator Enable. If the Overload/Error Indicator Enable Bit (5) is set, then if the display has an overload condition on any channel or an error occurs, the corresponding bit on the Status Register is set and a Service Request is issued if the SRQ bit of the mask is a 1. The user can check which overload or error was detected by sending the Output Data Statement W0 (See Section 4.14.2 and Table 4-15).

For example, in Figure 4-2, Q21 will allow the setting of the Overload/Error Indicator and Sample Data Ready bits in the Status Register, but will not send an Service Request if either condition is met. Q61 however will allow either of these bits to be set and when either is set, an Service Request will be issued by the DRC-93C over the IEEE-488 Bus. This Service Request will remain on the Bus until either a Serial Poll is initiated or the cause of the setting of the SRQ is eliminated.

The Status Register mask and control channel limit is part of the power-up save settings like the set point and units. It is updated on power-up to the last settings with internal switch 2 set. On power up the Status Register mask is set to 00 and the control channel limit to 000.0 if switch 2 is off.

4.11.3.5 Examples for setting Mask

Example #1 - Q61 - Sample Data Ready with the Service Request bit (SRQ) on. - With the SRQ bit of the Status Register mask enabled, the DRC-93C SRQ interrupt will be generated. The BUS CONTROLLER can read the Status Register to determine appropriate instrument conditions. In this case bits 1 is continuously updated to reflect current instrument status of the Sample Data Ready. Q61 also results in a service request if an OVERLOAD/ERROR is indicated.

Example #2 - Q2F000.1 - All Status Reports with the SRQ bit off. - With the SRQ bit of the Status Register mask disabled, no SRQ interrupt by the DRC-93C will be generated, however, the BUS CONTROLLER can still read the Status Register and this command will give all five Status Reports.

Example #3 - Q06000.1 - Enable the Control Data Ready and Control Channel Limit with a band of 0.1 about the control point.

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Figure 4-2. DRC-93C Status Register Mask and Status Register Format

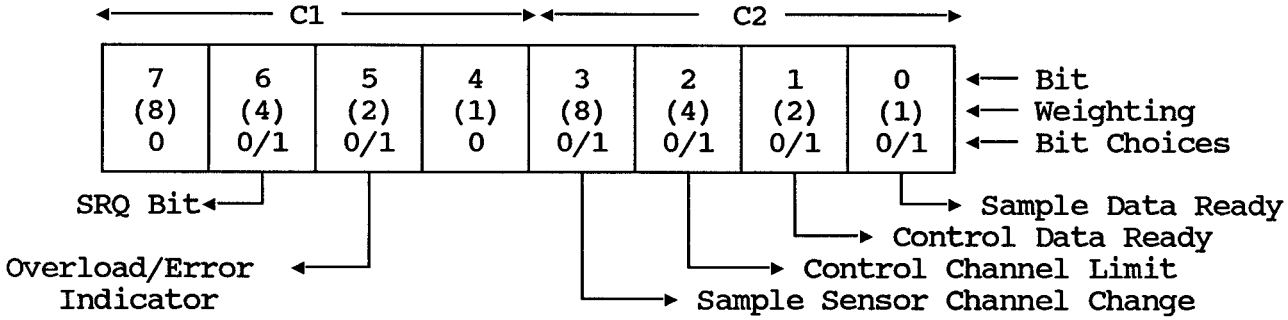


Table 4-12. Commands to Fix the Status Register Mask

QC_1C_2	Not Used	SRQ Bit	Overload /Error Indicator	Not Used	Sample Channel Change	Control Data Limit	Control Data Ready	Sample Data Ready
Bit	3	2	1	0	3	2	1	0
Q2F			On		On	On	On	On
Q40		On						
Q41		On						On
Q42		On					On	
Q43		On					On	On
Q44		On				On		
Q45		On				On		On
Q46		On				On	On	
Q47		On				On	On	On
Q48		On			On			
Q49		On			On			On
Q4A		On			On		On	
Q4B		On			On		On	On
Q4C		On			On	On		
Q4D		On			On	On		On
Q4E		On			On	On	On	
Q4F		On			On	On	On	On
Q60		On	On					
Q61		On	On					On
.		.	.		.	.	.	.
.		.	.		.	.	.	.
Q6E		On	On		On	On	On	
Q6F		On	On		On	On	On	On

Note: On means 1. Those entries left blank are OFF (0).

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Table 4-13. DRC-93C Command/Request Summary for Status Register Mask

Command	Functional Description
$QC_1C_2{}^e$	The Status Register mask is set using the Q command. Forms of the command are $Q0C_2$, $Q2C_2$, $Q4C_2$, $Q6C_2$ and QC_10, QC_11, QC_12, QC_13, QC_14, QC_15, QC_16, QC_17. When C_1 is: Status Register Mask is: 0 Service Request OFF;Error/Overload Indicator Request OFF 2 or 6 Error/Overload Indicator Request ON 4 or 6 Service Request is ON; When C_2 is: Status Register Mask Status is: 0 Sample Data, Control Data and Limit OFF 1, 3, 5 or 7 Sample Data Service Request is ON 2, 3, 6 or 7 Control Data Service Request is ON 4, 5, 6 or 7 Control Channel Limit SRQ is ON

****

Request	Output of Instrument Setup
WQ	SRQ Mask Data - $C_1C_2,N_1N_2N_3.N_4$ 8 Characters plus up to 2 terminators where: C_1C_2 is the SRQ Mask Byte $N_1N_2N_3.N_4$ is the control channel limit band

4.11.3.6 Status Register Mask at Power Up. The Status Register Mask is saved at power-down, provided switch 2 of the internal 8 switch package is on.

4.11.4 The "WQ" Data String

This command gives the Status Register Mask and control channel limit information.

4.12 SAVING AND RESTORING EXECUTABLE (INTERNAL) PROGRAMS

4.12.1 Requesting a Program Step for Saving - The WEN_1N_2 Command

The WEN_1N_2 command requests the Program Step # N_1N_2 from the 93C. The data of the Program Step will be in the next output transmitted from the instrument. The Data consists of the the Program Step # in ASCII followed by sixty characters. These characters are to be stored by the user for later transmission back to the instrument by the EN_1N_2 command described below. Examples of this command and the EN_1N_2 command are given in section 4.12.3.

4.12.2 Transmitting a Program Step to the 93C - The $EN_1N_2C_1$-C_{60} Command

The E command requests that Program Step # N_1N_2 and its data (C_1 thru C_{60}) be sent to the 93C. The form is $EN_1N_2C_1$-C_{60}. The data must have been previously received from the instrument using the WEN_1N_2 command and stored for transmission back to the instrument using this command. Examples of the E command in conjunction with the WEN_1N_2 command are given below.

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Table 4-14. DRC-93C Command/Request Summary for Program Step

Command	Functional Description
$EN_1N_2C_1$-C_{60}	Transmit (Restore) Program Step # N_1N_2 data (C_1-C_{60}) to the 93C

****

Request	Functional Description
WEN_1N_2	Request the Program Step # N_1N_2 for Saving $N_1N_2C_1$-C_{60} 62 Characters plus up to 2 terminators where: N_1N_2 is the Program Step Number C1-C_{60} are the sixty characters of Program Step # N_1N_2

4.12.3 Examples of Saving and Restoring Executable (Internal) Program Steps

4.12.3.1 Program to Request and Store Program Step # 1 thru 10 using the HP86B

The following program for the HP86B requests and get Program Steps #01 thru #10 and stores the data in a file called "PROGRAM1" on afloppy with volume label "93C". To initialize an unused floppy in slot 0 for this purpose the command INITIALIZE "93C", "D700" can be executed.

```
10 REM "STORE"
20 REM PROGRAM TO READ AND STORE AN INTERNAL PROGRAM
30 REM SET IEEE ADDRESS TO 12
40 ADDRESS SWITCH 1 OPEN (0) TO GET (CR)(LF)
50 DIM A$[62],N1$[1],N2[1]
60 REM CREATE "PROGRAM1.93C" ,99,32          ! ONLY USE FIRST TIME TO CREATE FILE
70 ASSIGN# 1 TO "PROGRAM1.93C"               ! OPEN THE FILE
80 FOR I=1 TO 10                             ! FOR PROGRAM STEPS #01 THRU #10
90 IF I<10 THEN GOTO 140
100 I$=VAL$(I)
110 N1$=I$[1,1]
120 N2$=I$[2,2]
130 GOTO 160
140 N1$="0"
150 N2$=VAL$(1)
160 OUTPUT 712;"WE";N1$;N2$ ! SEND THE WE COMMAND REQUESTING PROGRAM STEP I
170 ENTER 712; A$                            ! GET PROGRAM STEP I
180 DISP A$                                  ! DISPLAY ON THE SCREEN
190 PRINT# 1; A$                             ! SAVE PROGRAM STEP I IN THE FILE
200 NEXT I
210 ASSIGN# 1 TO *                           ! CLOSE THE FILE
220 END
```


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4.12.3.2 Program to Restore Program Step # 1 thru 10 using the HP86B

*The following program for the HP86B restores Program Steps #01 thru #10 from a file called "PROGRAM1" previously stored a floppy with the volume label "93C".

```
10 REM "RESTORE"
20 REM PROGRAM TO RESTORE THE INTERNAL PROGRAM AND PRINT ON THE SCREEN
30 DIM A$[62],N1$[1],N2$[1]
40 REM "PROGRAM1.93C" WAS CREATED AND WRITTEN BY PROGRAM STORE
50 ASSIGN# 1 TO "PROGRAM1.93C"      ! OPEN THE FILE
60 FOR I=1 TO 10                    ! PROGRAM STEP #01 TO #10
70 READ# 1 ; A$                     ! GET PROGRAM STEP I FROM THE FILE
80 OUTPUT 712 ;"E"; A$              ! SEND PROGRAM STEP I
90 DISP A$                          ! DISPLAY THE PROGRAM STEP ON THE SCREEN
100 WAIT 200                        ! WAIT 200 MILLISECONDS
110 NEXT I
120 ASSIGN# 1 TO *                  ! CLOSE THE FILE
130 END
```

4.12.3.3 National Instruments GWBASIC and BASICA IBM Example of WEN$_1$N$_2$ Request

This program will store Programs Step # 1 thru 10 in File "PROGRAM1" on Disk A: using GWBASIC or BASICA and the National Instruments GPIP-PC2 IEEE-488 Card for the IBM PC and compatibles.

```
10  CLEAR   ,60969  ' BASIC DECLARATIONS
20  IBINIT1 = 60969 ' This number is different for each computer
30  IBINIT2 = IBINIT1 + 3
40  BLOAD "bib.m",IBINIT1
50  CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
IBRSC,IBSRE,IBRSV,IPPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
60 CALL IBINT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,IBRDA,
IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,IBSTA%,IBER-
R%,IBCNT%)
70  TEMP$="93C"         '93C is IEEE address label set up when running IBCONF
80  CALL IBFIND(TEMP$,TEMP%)              'Required command to address 93C
90  OPEN "A:PROGRAM1" FOR OUTPUT AS #1    'Open file to store data
100 FOR I=1 TO 10                         'Program Steps #01 TO #10
110 IF I<10 THEN GOTO 150
120 N1$=MID$(STR$(I),2,1)
140 GOTO 160
150 N1$="0"
160 N2$=RIGHT$(STR$(I),1)
170 B$="WE"+N1$+N2$                       'Assemble command
180 B$=B$+CHR$(13)+CHR$(10)               'Add CR and LF to command
190 CALL IBWRT(TEMP%,B$)                  'Send request to 93C
200 CALL IBRD(TEMP%,A$)                   'Get data from 93C
210 PRINT A$                            'Display received information on screen
220 PRINT# 1;A$                           'Save in file "A:PROGRAM1"
230 NEXT I
240 CLOSE 1
250 END
```


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4.12.3.4 National Instruments GWBASIC and BASICA IBM Example of E Command

This program will restore Programs Step # 1 thru 10 previously stored in file "PROGRAM1" on Disk A: using GWBASIC or BASICA and the National Instruments GPIP-PC2 IEEE-488 Card for the IBM PC and compatibles.

```
10  CLEAR   ,60969              'BASIC DECLARATIONS
20  IBINIT1 = 60969             'This number is different for each computer
30  IBINIT2 = IBINIT1 + 3
40  BLOAD "bib.m",IBINIT1
50  CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
IBRSC,IBSRE,IBRSV,IPPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
60  CALL IBINT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,
IBSTA%,IBERR%,IBCNT%)
70  TEMP$="93C"  '93C is IEEE address label set up when running IBCONF
80  CALL IBFIND(TEMP$,TEMP%)              'Required command to address 93C
90  OPEN "A:PROGRAM1" FOR INPUT AS #1     'Open file to get data
100 FOR I=1 TO 10                         'Program Steps #01 TO #10
110 INPUT#1,C$
120 B$="E"+ $                             'Assemble command
130 B$=B$+CHR$(13)+CHR$(10)               'Add CR and LF to command
140 CALL IBWRT(TEMP%,B$)                  'Send data to 93C
150 FOR Z=1 TO 1000
160 NEXT Z
170 NEXT I
180 CLOSE 1
190 END
```

4.12.3.5 National Instruments QUICK BASIC IBM Example of WEN_1N_2 Request

```
'   Quick Basic 3.0 Example #2
'   THIS PROGRAM WAS WRITTEN FOR THE NATIONAL INSTRUMENTS GPIP-PC2
'   IEEE-488 CARD FOR IBM PC AND COMPATIBLES
'
'   This program will store Programs Step # 1 thru 10 in File "PROGRAM1"
'   on Disk A:
'
        COMMON SHARED IBSTA%, IBERR%, IBCNT%
        TEMP$="dev12"                          '93C
        CALL IBFIND(TEMP$,TEMP%)               'Required to address instrument
        OPEN "A:PROGRAM1" FOR OUTPUT AS #1 'Open file to store data
        FOR I=1 TO 10                          'Program Steps #01 Thru #10
        IF I<10 THEN
              N1$="0"
              N2$=LTRIM$(RTRIM$(STR$(I)))
        ELSE
              N$=RTRIM$(LTRIM$(STR$(I)))
              N1$=LEFT$(N$,1)
              N2$=RIGHT$(N$,2)
              N2$=RIGHT$(STR$(I),1)
          END IF
```


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```
B$="WE"+N1$+N2$              'Assemble command
B$=B$+CHR$(13)+CHR$(10)      'Add CR and LF to command
CALL IBWRT(TEMP%,B$)         'Request Program Step I
CALL IBRD(TEMP%,A$)          'Get Program Step I
PRINT A$                    'Display received information on screen
PRINT #1,A$                  'Save on disk in file PROGRAM1
NEXT I
CLOSE 1                      'Close the file
END
```

4.12.3.6 National Instruments QUICK BASIC IBM Example of E Command

```
'   Quick Basic 3.0 Example #3
'   THIS PROGRAM WAS WRITTEN FOR THE NATIONAL INSTRUMENTS GPIP-PC2
'   IEEE-488 CARD FOR IBM PC AND COMPATIBLES

'   This program will restore Programs Step # 1 thru 10 from File "PROGRAM1"
'   on Disk A:

        COMMON SHARED IBSTA%, IBERR%, IBCNT%

        TEMP$="dev12"                          '93C
        CALL IBFIND(TEMP$,TEMP%)               'address instrument
        OPEN "A:PROGRAM1" FOR INPUT AS #1      'Open file with data
        FOR I=1 TO 10                          'Program steps #01 Thru #10
        INPUT #1,C$                           'Get data from file "PROGRAM1"
        B$="E"+C$                              'Assemble command
        B$=B$+CHR$(13)+CHR$(10)                'Add CR and LF to command
        CALL IBWRT(TEMP%,B$)                   'Send command to instrument
        FOR Z=1 TO 1000: NEXT Z
        NEXT I
        CLOSE 1                                'Close the file
        END
```


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4.13 COMMAND OPERATIONS

The following example in HP Basic sets the set point to 123.4 K, the gain to 45, the reset (integral) to 30, the rate (derivative) to 25, the heater range to 10^{-1} and the output statement sent to be W3.

```
OUTPUT  712 ; "S123.4P45I30D25R4W3"
   |     |                  |
   |     |                  └── Data
   |     └── 12 = 93C preset address
   |          7 = IEEE-488 card address
   └── Output Data Command
```

If the user were to monitor the IEEE-488 Bus when the computer sent its command string over the Bus, the following IEEE-488 Format would be observed.

```
? L , S123.4P45I30D25R4W3(CR)(LF)
```

The Universal Unlisten Command (?) is sent so that no other instruments on the Bus will eavesdrop on the Bus and assume that the data being sent is for their attention. The DRC-93C's Talk Address (L) is sent to unaddress any existing TALKER. Note that the BUS CONTROLLER could have designated another instrument as the TALKER. Therefore, to keep the format consistent, it must send a Talk Address even when the DRC-93C is going to be that TALKER. The Listen Address (,) must be sent to tell which instrument on the Bus is to receive the Data String. Note that [TERM1][TERM2] have been indicated to be CR LF (carriage return, line feed); these are the correct terminators for the HP computer example.

Note that the string "P45I30P40" would result in a gain of 40 and an integral value of 30, i.e., only the last value sent over the bus for that command will be entered after the appropriate terminators have been sent over the bus.

4.14 OUTPUT DATA STATEMENTS

The DRC-93C's Output Requests for Data Statements are summarized in Table 4-5.

The DRC-93C will always respond when asked to talk with the last command sent to it, i.e., if W0 is sent once then the 93C will always output the W0 information whenever it is asked to talk as long as it has not received another output data statement.

4.14.1 The "WS", "WC" and "WP" Data Strings

These three commands are subsets of the "W0" command; the "WS" command giving the Sample Sensor reading, the "WC" command the control sensor reading while the "WP" command results in the set point value.

4.14.2 The "W0" Data String

The following example in HP Basic illustrate the commands associated with obtaining output data from the DRC-93C. The addition of the M0 command returns the instrument to front panel control where it stays even when data is requested from the 93C by the HP computer.

```
10   DIM  A$ [19]
20   OUTPUT  712; "W0M0"
30   ENTER   712; A$
```

The following information is sent across the bus in the IEEE-488 format as a result of the above software commands.

Request sent:

```
? U , W 0 M 0 (CR)(LF)
```

Data returned:

```
? 5 L +123.45K,+123.42,+123.40K
|   |   |                  |
|   |   |                  |          (CR)(LF)
|   |   |                  └── Data returned
|   |   └── 93C's Talk Address
|   └── BUS CONTROLLER's Listen Add
└── Universal Unlisten Command
```

The data above indicates that the

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display temperature is 123.45K and
that the set point is 123.40K.

Table 4-15. DRC-93C Output Data Statements

Request	Output of Instrument Data
WS	Sample Sensor Data - ( )$N_1N_2N_3$(.)N_4N_5( ) 8 Characters plus up to 2 Terminators where the N_1-N_5 variations are the same as for W0 (see below).
WC	Control Sensor Data - ( )$N_6N_7N_8$(.)N_9N_{10}( ) 8 Characters plus up to 2 terminators where the N_6-N_{10} variations are the same as for W0 (see below).
WP	Set Point Data - ( )$N_{11}N_{12}N_{13}$(.)$N_{14}N_{15}$( ) 8 Characters plus up to 2 terminators where the N_{11}-N_{15} variations are the same as for W0 (see below).
W0	Sample (WS), Control Sensor (WC) and Set Point (WP) Data ( )$N_1N_2N_3$(.)N_4N_5( ),( )$N_6N_7N_8$(.)N_9N_{10}( ),( )$N_{11}N_{12}N_{13}$(.)$N_{14}N_{15}$() 26 characters plus up to 2 terminators where: (.) may vary in position dependent on units and temperature. ( )N_1-N_5( ) is the Sign, Display Sensor reading and units. ( )N_6-N_{10}( ) is the Sign, Control Sensor reading and units. ( )N_{11}-N_{15}( ) is the Sign, Set Point and units. Examples of the Display reading are (±)$N_1N_2N_3$(.)N_4N_5(F), (±)$N_1N_2N_3$(.)N_4N_5(C), ( )$N_1N_2N_3$(.)N_4N_5(R) or ( )N_1(.)$N_2N_3N_4N_5$(V) Note that all are "free field" where the units are K, C, F, V or R and the sign ( ) may be (±) for the ° and °C scales.
WM	Display Math Data C_1,( )$N_1N_2N_3$(.)N_4N_5(),()$N_6N_7N_8$(.)N_9N_{10}( ), ( )$N_{11}N_{12}N_{13}$(.)$N_{14}N_{15}$( ),C_2,( )$N_{16}N_{17}N_{18}$(.)$N_{19}N_{20}$( ), ( )$N_{21}N_{22}N_{23}$(.)$N_{24}N_{25}$( ),( )$N_{26}N_{27}N_{28}$(.)$N_{29}N_{30}$( ) 57 characters plus up to 2 terminators where: (.) may vary in position dependent on units and temperature. C_1 is 0 if the MATH Function is off and 1 if on ( )N_1-N_5( ) is the Sign, MAX Sample Sensor reading and units. ( )N_6-N_{10}( )is the Sign, MIN Sample Sensor reading and units. ( )N_{11}-N_{15}( ) is the Sign, MAXDEV Sample Sensor reading and units. C_2 is 0 if the MATH Function is off and 1 if on ( )N_{16}-N_{20}( ) is the Sign, MAX Control Sensor reading and units. ( )N_{21}-N_{25}( ) is the Sign, MIN Control Sensor reading and units. ( )N_{26}-N_{30}( ) is the Sign, MAXDEV Control Sensor reading and units.

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4.15 SAMPLE PROGRAMMING

4.15.1 HP86B Keyboard Interactive Program

The following program for the HP86B is an interactive program with the keyboard of the computer. For example, when the user sees the prompt on the screen and types in a valid DRC-93C command such as "W0", the program will result in the display of the DRC-93C response on the screen.

```
10  REM Set IEEE Address to 12
20  REM Address Switch 1 OPEN(0) to get (CR)(LF)
30  REM This program allows the user to communicate with the 93C,
interactively from the computer keyboard
40  DIM A$[100]              ! Must be increased for curve information
50  INPUT B$                 ! INPUT KEYBOARD COMMAND
60  OUTPUT 712 ;B$           ! SEND COMMAND TO 93C
70  ENTER 712 ; A$           ! RECEIVE ANSWER FROM 93C
80  DISP A$                  ! DISPLAY ANSWER
90  GOTO 50
100 END
```

4.15.2 National Instruments GWBASIC or BASICA IBM Example

The following is the same program written for the National Instruments GPIP-PC2 IEEE-488 Card for IBM PCs and Compatibles using Quick Basic 3.0.

```
10  CLEAR   ,60969 ! BASIC DECLARATIONS
20  IBINIT1 = 60969 ! This number is different for each computer
30  IBINIT2 = IBINIT1 + 3
40  BLOAD "bib.m",IBINIT1
50  CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
IBRSC,IBSRE,IBRSV,IPPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
60  CALL IBINT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD-
,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,
IBSTA%,IBERR%,IBCNT%)
70  TEMP$="93C" ! 93C is IEEE address label set up when running IBCONF
80  CALL IBFIND(TEMP$,TEMP%) ! Required command to address 93C
90  A$=SPACE$(255)    ! 255 largest data transfer allowed by IBM format
100 INPUT B$                    ! Entered from keyboard while running
110 B$=B$+CHR$(13)+CHR$(10)     ! Add CR and LF to command
120 CALL IBWRT(TEMP%,B$)        ! Send command to 93C
130 CALL IBRD(TEMP%,A$)         ! ENTER from 93C (SEE NOTE BELOW)
140 PRINT A$                    ! Display received information on screen
150 A$=SPACE$(255)              ! Clear A$
160 GOTO 110
170 END
180 REM  The 93C will return data requested, but if the command input
does
190 REM  not request new information, the 93C will give the information
last requested.
```


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4.15.3 National Instruments QUICK BASIC IBM Example

```
'   IEEE-488 TEST PROGRAM   Quick Basic 3.0 Example
'   THIS PROGRAM WAS WRITTEN FOR THE NATIONAL INSTRUMENTS GPIP-PC2
'   IEEE-488 CARD FOR IBM PC AND COMPATIBLES

'   This program will allow the user to communicate with Lake Shore's
'   instruments, interactively from the keyboard of an IBM compatible
'   computer which has a National Instruments GPIB-PC2 installed.

    common shared IBSTA%, IBERR%, IBCNT%

    print "Input number for the type of instrument---820,93C,82C, or 93C
    print "0=820"
    print "2=82C"
    print "1=93C"
    print "3=93C"
    input I$
    if I$="0" then TEMP$="dev20" 'default address for 820
    if I$="1" then TEMP$="dev12" 'default address for 93C,etc.
    if I$="2" then TEMP$="dev12"
    if I$="3" then TEMP$="dev12"
                                 'set up when running IBCONF
    call IBFIND(TEMP$,TEMP%)     'Required command to address instrument
    A$=space$( 750)

Loop1: input B$                  'Entered from keyboard while running
    B$=B$+chr$(13)+chr$(10)      'Add CR and LF to command
    call IBWRT(TEMP%,B$)         'Send command to instrument
    call IBRD(TEMP%,A$)          'ENTER from instrument (SEE NOTE BELOW)
    print A$                     'Display received information on screen
    A$=space$(750)               'Clear A$
    goto Loop1

    end

'   Lake Shore Cryotronics instruments will return the data requested,
'   but if the command input to the instrument does not request any
'   information the instrument will respond with the information last
'   requested.
```

4.15.4 HP86B Bus Commands Program

The following program is for the HP86B and exercises the various bus commands.

```
10 REM Set IEEE Address to 12
20 REM Address Switch 1 OPEN (0) to get (CR)(LF)
30 DIM A$[42]                          ! For longest string
40 OUTPUT 712;"W0"                     ! Note W0
50 ENTER 712;A$                        ! Ask for string W0
60 DISP "W0 = ";A$                     ! Display string W0
70 DISP "Display Sensor =";A$[1,8]     ! Display Sensor reading
80 DISP "Control Sensor =";A$[10,17]   ! Display Control Sensor Reading
90 DISP "Set Point =";A$[19,26]        ! Display Set Point Reading
```


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```
100 DISP                                    ! Space a Line
110 OUTPUT 712;"W1"                         ! A and B Input information
120 ENTER 712;A$                            ! Ask for string W1
130 DISP "W1 = ";A$                         ! Display string W1
140 DISP                                    ! Space a Line
150 OUTPUT 712;"W2"                         ! Interface Status
160 ENTER 712;A$                            ! Ask for string W2
170 DISP "W2 = ";A$                         ! Display string W2
180 DISP                                    ! Space a Line
190 OUTPUT 712;"W3"                         ! Control Data (Gain, Reset, etc.)
200 ENTER 712;A$                            ! Ask for string W3
210 DISP "W3 = ";A$                         ! Display string W3
220 DISP "Gain =";A$[1,3]                   ! Display Gain setting
230 DISP "Rate =";A$[5,7]                   ! Display Rate setting
240 DISP "Reset =";A$[9,11]                 ! Display Reset setting
250 DISP "Heater Range =";A$[13]            ! Heater Range
260 DISP "% Power =";A$[15,17]              ! % Power
270 DISP                                    ! Space a Line
280 OUTPUT 712;"WS"                         ! Set for WS
290 ENTER 712;A$                            ! Ask for string WS
300 DISP "WS = ";A$                         ! Display Sensor Reading
310 DISP                                    ! Space a Line
320 OUTPUT 712;"WC"                         ! Set for WC
330 ENTER 712;A$                            ! Ask for string WC
340 DISP "WC = ";A$                         ! Display Control Sensor Reading
350 DISP                                    ! Space a Line
360 OUTPUT 712;"WP"                         ! Set for WP
370 ENTER 712;A$                            ! Ask for set point data
380 DISP "WP = ";A$                         ! Display string WP
390 DISP                                    ! Space a Line
400 OUTPUT 712;"WY"                         ! Set for WY
410 ENTER 712;A$                            ! Ask for Scan Information
420 DISP "WY = ";A$                         ! Display Scan Information
430 DISP                                    ! Space a Line
440 OUTPUT 712;"WI"                         ! Set for WI
450 ENTER 712;A$                            ! Ask Input Cards and Options
460 DISP "WI = ";A$                         ! Display string WI
470 END
```

4.16 SENSOR CURVE PROGRAMMING INSTRUCTIONS

The commands which will either output, input, edit or erase a Sensor Curve are given in Table 4-16. In addition, the commands to assign or change assignments of the various curves to the Sensor ID tables (both A and B) are given in Table 4-16.

4.16.1 The XDT Command

This command from the BUS CONTROLLER tells the DRC-93C that when it is asked to output data, that data should be the output of the standard Sensor Curves stored, Precision Option Curves stored and the format associated with the REMOTE SENSOR ID Remote Position to Sensor Curve assignments as given in Table 4-17. This output is defined as the Sensor Curve Information Table (SCIT). As can be seen from the output shown on this page, the instrument is shipped with all remote positions calling up Standard Curve 02.

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The information lines for Sensor Curves 05 through 31 will only be present if these curves are actually present either as user generated curves or as Precision Option curves. The Information Table is output as **one very long character string**.

The following program is for the HP86B and is an example of the XDT output (SCIT) for a unit with only Standard Curves 00 thru 05 present.

```
10 REM Program to Output SCIT
20 DIM FILETABLE$[321]
30 OUTPUT 712;"XDT"      !Ask for
40 ENTER 712;FILETABLE$ !Input SCIT
50 DISP FILETABLE$[1,16]!Bytes Free
60 DISP FILETABLE$[17,38] !Next Loc
70 DISP FILETABLE$[39,56] !Curve 00
80 DISP FILETABLE$[57,74] !Curve 01
90 DISP FILETABLE$[75,92] !Curve 02
100  DISP  FILETABLE$[93,110]!Curve
03
110  DISP  FILETABLE$[111,128]!Curve
04
110 DISP FILETABLE$[129,152] !A00
120 DISP FILETABLE$[153,176]
130 DISP FILETABLE$[177,200]
140  DISP  FILETABLE$[201,224]
!Thru A1F
150 DISP FILETABLE$[225,248] !B00
160 DISP FILETABLE$[249,272]
170 DISP FILETABLE$[273,296]
180  DISP  FILETABLE$[297,319]
!thru B1F
190 END
```

Note that the last character to be displayed is number 319 since the Terminators (CR)(LF) have to be input but not displayed. This program results in the following output of the Sensor Curve Information Table.

```
3584 BYTES FREE,
0200 IS NEXT LOCATION,
00,31,1D40,DRC-D ,
01,31,1DF0,DRC-E1,
02,31,1EA0,CRV 10,
03,31,1F50,DIN-PT,
04,31,2000,CRV 10,
05,31,20B0,RESVRD,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02,
02,02,02,02,02,02,02,02
```

4.16.2 The XDN_1N_2 Command

The XDN_1N_2 command is used to output a particular Sensor Curve (rather than all the curves stored within the instrument as in the XDA command) with N_1N_2 being the curve number 00 thru 31. The format of the Sensor Curve output is given in Table 4-18. The information is output as **one very long character string**. The following program is for the HP86B and is an example of the XDN_1N_2 to output Sensor Curve 00.

```
10 REM Program to output Curve
Table
20 DIM Curve$[462]
30 OUTPUT 720;"XD00"
40 ENTER 720;Curve$
50 REM Display Curve #, Title,
Temperature
60 REM Coefficient and Number of
Breakpoints 70 DISP Curve$[1,27]
80 REM Display voltage and temp
data points
90 I=28
100 DISP Curve$[I,I+41] ! Voltage;
Temp.
110 IF I=447 THEN 140 ! I=477 for
D.Pnt 31
120 I=I+42
130 GOTO 100
140 DISP Curve$ [448,460]
150 END
```

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Table 4-16. Sensor Curve Commands and Description

Commands	Output of Information Table, Sensor Curve or All Curves
XDT	Output the Sensor Curve Information Table. Refer to Table 4-17 for the format of the output.
XDN_1N_2	Output Sensor Curve number N_1N_2 where N_1N_2 is from 00 to 31. Refer to Table 4-18 for the format of the Sensor Curve output.
XDA	Output the Sensor Curve Information Table (XDT) and all the Sensor Curves stored in the unit. Refer to Table 4-17 for format of the Information Table output and Table 4-18 for format of the Sensor Curve output.
	Curve Input, Curve Edit and Curve Erasure
XCN_1N_2, $C_1....C_{18}$, X.XXXXX,TTT.T, ... *	Sensor Curve Input. N_1N_2 is Sensor Curve number from 06 to 31. Immediately after Sensor Curve cmmnd XCN_1N_2 a comma is required. Up to 18 characters can be input as a curve description. When all 18 characters are input, the last 6 are used in the Sensor Curve table (in the 8000 Series Precision Option curves these 6 characters are used to indicate the sensor serial no.) The 18 characters must be immediately followed by a comma. The data is input in units/temperature pairs with the units in the form of Voltage, R_{equiv} or LogR. Data points **must** be entered in ascending units order. The * character terminates the Sensor Curve input.
XEN_1N_2, X.XXXXX,TTT.T*	Edit Sensor Curve N_1N_2. The point is either inserted in its proper position in the curve or it is added to the curve as a new data point.
XKN_1N_2*	Erases (kills) Sensor Curve N_1N_2 and repacks all curve data (Standard Curves 00 thru 05 cannot be erased).
XR&I*	Command sent five times will delete all Precision Options and any curves stored in unit by user.
	Assignment of Curve # to Position # in Correlation Tables
$XAC_1C_2=N_1N_2$* $XBC_1C_2=N_1N_2$*	Assign the Input A or Input B Remote Position C_1C_2 to Sensor Curve number N_1N_2. C_1C_2 is the Remote Position 00 thru 1F. N_1N_2 is the Sensor Curve number 00 thru 31 This Command modifies the Remote Position to Sensor Curve Correlation Table 3-3 (and XDT output data).

NOTE: The * added to the end of the XAC_1C_2, XBC_1C_2, XCN_1N_2, XEN_1N_2 and XK commands is required for the command to operate properly. Due to the length of some of the data strings, appropriate computer time outs must be allowed when performing these functions. If a hardware problem is detected in modifying one of the NOVRAM locations, an **Err01** error will be displayed and instrument operation is halted. An **Err02** error is displayed if the unit detects a NOVRAM hardware problem.

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Table 4-17. Sensor Curve Information Table Output Format

Command	Output
XDT	$N_1N_2N_3N_4$(BYTES FREE)(,) $H_1H_2H_3H_4$(IS NEXT LOCATION)(,) (00)(,)(31)(,)(1D40)(,)(DRC-D)(,) (01)(,)(31)(,)(1DF0)(,)(DRC-E1)(,) (02)(,)(31)(,)(1EA0)(,)(CRV 10)(,) (03)(,)(31)(,)(1F50)(,)(DIN PT)(,) (04)(,)(31)(,)(2000)(,)(CRV 10)(,) (05)(,)(31)(,)(20B0)(,)(RESVRD)(,) . (31)(,).....(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,) C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2(,)C_1C_2 [TERM1][TERM2] A minimum of 321 Characters (when only the 6 Standard Curves are present) and a maximum of 805 Characters (when all 32 Curves are present) plus up to 2 Terminators where: $N_1N_2N_3N_4$ is the decimal number of curve locations available (BYTES FREE). $H_1H_2H_3H_4$ is the Hex address the next curve will start at. C_1C_2 is the Sensor Curve assigned to Remote Position A00 through A1F and B00 through B1F.

Table 4-18. XDN$_1$N$_2$ Sensor Curve Output Format

Command	Output
XDN$_1$N$_2$	N_1N_2(,) C_1.....C_{18}(,)C_{19}(,)N_3N_4(,) (X.XXXXX)(,)(TTT.T)(,) . (X.XXXXX)(,)(TTT.T) A minimum of 54 Characters (for a curve with the minimum of 2 data points) and a maximum of 1412 Characters (for a curve the maximum of 97 data points) plus up to 2 Terminators where: N_1N_2 is the Sensor Curve number 00 thru 31. C_1-C_{18} is the 18 Character Information line. C_{19} is the Temperature Coefficient, P or N. N_3N_4 is the number of data points 00 thru 99. X.XXXXX is the Voltage, Equivalent V or Log R. TTT.T is the Temperature to 0.1 only.

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Note that the last character to be displayed is number 460 since the Terminators (CR)(LF) have to be input but not displayed. This results in the following display.

```
00,      STANDARD DRC-D ,N,31,
0.00000,499.9,0.19083,365.0.0.24739,345.0,
0.36397,305.0,0.42019,285.0,0.47403,265.0,
0.53960,240.0,0.59455,220.0,0.73582,170.0,
0.84606,130.0,0.95327,090.0,1.00460,070.0,
1.04070,055.0,1.07460,040.0,1.09020,034.0,
1.09700,032.0,1.10580,030.0,1.11160,029.0,
1.11900,028.0,1.13080,027.0,1.14860,026.0,
1.07200,025.0,1.25070,023.0,1.35050,021.0,
1.63590,017.0,1.76100,015.0,1.90660,013.0,
2.11720,009.0,2.53660,003.0,2.59840,001.4,
6.55360,000.0
```

The N indicates that the silicon diode is a negative temperature coefficient device. For the platinum curve (03), which is a positive temperature coefficient device, a P will appear in that position.

4.16.3 The XDA Command

The XDA command asks for the output of the Sensor Curve Information Table as well as **all** the Sensor Curves stored in the unit. When the command XDA is used, the 93C will output the Information Table formatted as in Table 4-17 followed by a comma (in place of the Terminators) followed by each Sensor Curve in ascending order with a comma between each Sensor Curve (in place of the Terminators) as in Table 4-18 until all the curves have been output followed by the Terminators. The information is output as **one very long character string**.

4.16.4 The XCN_1N_2 Command

The XCN_1N_2 command is the most powerful curve command in the 93C. It allows for the remote input of Sensor Curves. The Sensor Curves that can be input using the XC command are 06 thru 31 (note that the first five curves 00 thru 04 are the Standard Curves with Curve 05 reserved). The format for the XC command is given in Table 4-16. The format for the XC command **must** be followed for the curve entry to be successful. Following the XCN_1N_2 (where N_1N_2 is between 06 and 31) is a comma. Then up to 18 characters can be entered as a curve information line. At least one character is required and any more than 18 characters are ignored. If 18 characters are input, the last 6 are used in the Sensor Curve Information Table as a capsule description of the curve (in the 8000 Series Precision Option curves these 6 characters are used to indicate the sensor serial number). The 18 characters must be immediately followed by a comma. The data points are then input in the form X.XXXXX, comma, TTT.T. The X.XXXXX input is in Voltage or LogR. Refer to Table 4-19 for the conversion of the raw units information into the format required for the XC command. The unit automatically fills in leading and trailing zeroes in the data point. A data point entered as ...,0.8,70,... would be converted by the unit into

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...,0.80000,070.0,... . The data points **must be entered in ascending units order**. After all the data points are entered the (*) character terminates the Sensor Curve input.

Following the input of the (*) to indicate to the unit that the there are no more data points, it determines and stores whether the curve is a positive or negative temperature coefficient curve. Based on temperature coefficient, the unit then stores the curve end points. For a negative temperature coefficient curve the first end point is 0.00000,499.9 and the last end point is 6.55360,000.0. For a positive temperature coefficient curve the first end point is 0.00000,000.0 and the last end point is 6.55360,999.9. Therefore, the minimum number of data points which the user can input for a curve is 1 (which would result in a 3 data point curve) and the maximum number of data points is 97 (which would result in a 99 point curve). The XC information **must be output to the unit as one very long character string**.

The first character of the 18 character management string indicates the type of breakpoints to be entered. If the character is an "L", then the unit performs Lagrangian calculations on the data. If the character is anything else, the unit performs Straight-Line interpolation on the data. See Appendix B for a description of the difference between the two. In addition, sensor type and temperature range is included in this 18 characters as well.

Curves 06 thru 31 are stored in Non-Volatile RAM (NOVRAM) where the first 0200 hex bytes are reserved for file management. There are 3584 bytes free for the storage of curves. If the curve stored has 31 data points, it will take up 177 bytes. For this length curve, up to 20 curves can be stored in the unit. Refer to Appendix B for additional information on curve entry and how the curves are generated.

4.16.5 The XEN_1N_2 Command

The command XEN_1N_2,X.XXXXX,TTT.T* either adds a point to or edits the N_1N_2 curve (provided that this curve is present). The * terminates the data point input. If either the units or temperature information matches one of the data points in the curve the curve data point edited to match the XE data point If the information does not match any of the data points for the curve, the unit inserts the point in its proper position in the table.

4.16.6 The XKN_1N_2* Command

The command XKN_1N_2* erases all the data associated with curve number N_1N_2 and repacks the remaining curves stored within the NOVRAM. Standard Curves 00 thru 05 are stored in a Prom and are not erasable by this command.

4.16.7 The $XAC_1C_2=N_1N_2$* and $XBC_1C_2=N_1N_2$* Commands

The XA an XB commands allows Table 3-4 which defines the correlation between the Remote Position and Sensor Curves for the REMOTE SENSOR ID. Note-that this correlation exists for both inputs and normally only one input would select the REMOTE SENSOR ID position data. Once this data has been changed, it would be good practice to read out the changed table by means of the XDT

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command and update Table 3-4. C_1C_2 is the hex Remote Position, 00 thru 1F, and N_1N_2 is the decimal curve number 00 thru 31.

Table 4-19. Conversion of Raw Units Data for the XC Command

Input Card	Units	Conversion
9210/20-3 9210/20-6	Voltage	Input range is 0.00000 to 6.55350 volts. No conversion is necessary.
9215	Capacitance	No conversion to temperature is allowed
9317C 9318C	Resistance	Input range is 1 to 10^4 Ω for the 9317C, 1 to 10^5 Ω for the 9318C. Input must be in Log R where 1 Ω would look like 0.00000 and 10^5 Ω would look like 5.00000.
9220-P2	Resistance	Input range is 0.00 to 299.99 ohms. 0.00 ohms looks like 0.00000 and 299.99 ohms looks like 2.99990 (0.01 times R).
9220-P3	Resistance	Input range is 0.0 to 2999.9 ohms. 0.0 ohms looks like 0.00000 and 2999.9 ohms looks like 2.99990 (0.001 times R).
9220-R1	Resistance	Input range is 0.00 to 100.00 ohms. 0.00 ohms looks like 0.00000 and 100.00 ohms looks like 3.00000 (0.03 times R).

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S E C T I O N V

M A I N T E N A N C E

5.1 INTRODUCTION

This section contains information necessary to maintain the Model DRC-93C. General maintenance, fuse replacement, line voltage selection and performance testing is contained in this section.

5.2 GENERAL MAINTENANCE

Clean the DRC-93C periodically to remove dust, grease and other contaminants. Use the following procedure:

1. Clean the front and back panels and case with a soft cloth dampened with a mild detergent and water solution.

Note: **DO NOT** use aromatic hydrocarbons or chlorinated solvents to clean the DRC-93C. They may react with the plastic materials used in the unit or the silk screen printing on the back panel.

2. Clean the surface of the printed circuit boards (PCB) using clean, dry air at low pressure. If grease is encountered, spray with Freon T.F. degreaser and remove grime with dry, low-pressure air.

5.3 FUSE REPLACEMENT

The line fuse is accessible from the rear of the DRC-93C. Use the following procedure to check and/or replace the fuse:

WARNING

To prevent shock hazard, turn off instrument and disconnect it from AC line power and all test equipment before replacing the fuse.

1. Set the POWER switch to OFF and disconnect the power cord from the unit. The fuse compartment is located just to the right of the power connector.

2. Open the fuse compartment by prying open the cover with a small screw driver.

3. Remove the lower fuse holder by sliding it out of its position with the aid of the small screw driver.

CAUTION

For continued protection against fire hazard, replace only with the same type and rating of fuse as specified for the line for the line voltage selected.

4. Replace the fuse per Table 2-1.

5. Replace fuse holder, close fuse compartment and connect power cord.

5.4 LINE VOLTAGE SELECTION

The rear-panel, three-pronged line power connector permits the DRC-93C to be connected to 100, 120, 220, or 240 VAC line voltages. Use the following procedure to change the line voltage:

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WARNING

To prevent shock hazard, turn off the instrument and disconnect it from AC line power and all test equipment before changing the line voltage selection.

1. Pull fuse compartment cover using the procedure found in Section 5.3.

2. Remove voltage selector wheel and insert with the proper voltage facing out. Note that the wheel can only be inserted with the writing read from the left.

3. Install the proper fuse as outlined in Section 5.3.

5.5 OPERATIONAL CHECKS

5.5.1 Test Connector

A test connector for the rear panel J1 INPUT A or J2 INPUT B connector to simulate a diode sensor input is required for operational checks of the DRC-93C. The test connector can be made by taking one of the plugs supplied with the DRC-93C and configuring a resistor to simulate the temperature sensor in the two wire configuration as described in Section 2.3.6. The test resistors specified in Table 5-1 are used in the operational checks.

5.5.2 Operational Test Procedure

The operational test procedure is designed to verify the overall operation of the DRC-93C and can be used as a periodic maintenance check. The following equipment is used in the test.

1. Digital Voltmeter - 4½ digit resolution or better.

2. Test Connector - fabricated per Section 5.5.1.

Complete the following set-up procedure for this test:

1. Plug the connector into INPUT A.

2. Connect the DVM across the test resistor of Input A.

3. Connect the DRC-93C to line power and turn the unit ON. Verify that the DRC-93C initializes to the proper POWER-ON state as defined in Section 3.7.

The following procedure is used to test the overall DRC-93C operation.

Note: The unit should be allowed a one-hour warm-up time to achieve rated specifications.

5.5.3 Current Source Check

The DVM across the test resistor should read as follows:

9210/20-3	1.0000V ± 100μV
9210/20-6	1.0000V ± 100μV
9220-P2	0.10000V ± 10μV
9220-P3	0.10000V ± 10μV
9220-R1	0.03000V ± 10μV
9317C	N/A
9318C	N/A

5.5.4 Monitor Voltage

The voltage across the sensor or test resistor is also available on the monitor plug. The connections are given in Section II of this manual. The monitor voltage will be equal to the sensor voltage for 3 volt (-3) diode inputs and all platinum (-P2, -P3) and rhodium iron (-R1) inputs. If the input is a GaAlAs Diode (-6) input then the monitor voltage will be 0.458 times the sensor voltage. This test is not applicable for the 9215, 9305, 9317C or 9318C input cards.

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5.5.5 Temperature Display

5.5.5.1 Determine Input Type - The first step to check the instrument's display and operation is to determine the type of sensor input.

a. The type of input option card(s) installed in the DRC-93C is located on the front page of every DRC-93C manual.

b. The DRC-93C displays the type of input card(s) installed in the A and B inputs sequentially when the instrument is powered on. Possibilities are 9210-3, 9210-6, 9215-30, 9215-150, 9220-3, 9220-6, 9220-P2, 9220-P3, 9220-R1, 9305, 9317C or 9318C.

c. The type of input can also be displayed by holding down the SENSOR key.

5.5.5.2 Check units display- Verify that the A units can be changed by holding in the UNITS key and using the ▲▲ or the ▼▼ to scroll through the sequence K, C, F, V, K, etc. (Note: the unit goes to V for a diode configuration 9210-3, -6 or 9220-3, -6) or Ω for a resistance card configuration (9220-P2, -P3, -R1 or 9317C/ 9318C Input card).

5.5.5.3 Check sensor units reading Next, check to see if the instrument is reading the correct sensor units (volts, ohms or nanofarads) value for the appropriate test resistor or capacitor from Table 5.1. The reading should match the value given in the Display in Sensor Units column of Table 5-1. The allowable error is provided in the Input A/D Accuracy column.

5.5.5.4 Check temperature reading- Confirm that the temperature in kelvin displayed corresponds to the selected curve number.

a. Check the Sensor Curve Table (Table 3-2 or below) to determine the curve number that selects the standard curve or precision option that is needed. A 9215 card will not read temperature. The 9317C/9318C will not read accurately in temperature unless a precision option is present.

b. Select the curve as described in Section 3-9.

Curve No.	Switch 45678	Temperature Displayed,K	Curve
00	00000	71.79	DRC-D
01	00001	71.42	DRC-E1
02	00010	87.77	CRV 10
03	00011	273.1	DIN-PT
04	00100	87.77	CRV 10

5.5.5.5 Check Input B - Change the connector from J1 INPUT A to J2 INPUT B. Repeat the above process by verifying the current source and the A/D settings for this input as well as the units change.

5.5.6 Heater Output Test

5.5.6.1 Heater Output Conditions- The heater should output power when the setpoint temperature is above the display temperature, as long as the heater is on and a gain value has been entered. If the sensor is a diode, the voltage across the device will change inversely with temperature. Therefore the higher the voltage the lower the temperature. For Platinum sensors the resistance increases as the temperature increases. Germanium and carbon glass sensors are negative temperature coefficient resistance sensors which vary several orders of magnitude in resistance with temperature.

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5.5.6.2 **Test Setup** - Test the heater by placing an appropriate test resistor (see Table 1) into the control sensor input, and place a 10 ohm (at least 10 watts) up to 50 ohm (at least 50 watts) resistor across the heater terminals.

5.5.6.3. **The Heater Display** - The heater display is shipped from the factory reading the percent of power out. If the heater is 10 ohms then at 100 percent output current, the heater will have 1 amp through it and 10 volts across it. If the heater bar graph is reading 50% then the instrument is delivering 5 watts (0.707 amps and 7.07 volts) to the 10 ohm load. If the unit is reading in current a reading of 50 will mean 2.5 watts (0.5 amps and 5 volts). The heater display can be changed from power to current by switching internal dip switch S4-1.

5.5.7 **Checking Gain, Reset and Rate**

Check the operation of the Gain, Rate and Reset as follows:

1. Place a dummy load into the selected sensor input.
   a. 50K to 100K for a diode.
   b. Short V^+ to V^- for 9317C or 9318C Input Card.
   c. 10nF capacitor for 9215 Input Card.

2. Place a 10 ohm, 10 watt (or greater) resistance load on the heater terminals.

3. Set the Display Units to Sensor Units, i.e., volts, ohms or nanofarads.
   a. If 9210-3/20-3 enter a voltage 0.01 volts less than the display.
   b. If 9317C or 9318C, enter a resistance of 1 ohm for the set point.
   c. If 9215 enter 11nF set point.

5.5.7.1. **Gain** - Enter a gain value. The heater display should now indicate that power is being delivered to the heater. The amount of power is a scaled factor of the error signal times the gain ([Sensor voltage - Setpoint voltage] * Gain). If the setpoint temperature is increased or the gain is increased the output power will increase.

Keep the LO lead of the DVM at TP1 and move the HI lead to TP29. Turn off the GAIN, RATE and RESET by entering a value of 0.0 for each. The DVM will now read approximately 0.0 volts. Change the GAIN to 1.0 and the DVM will read approximately 0.1 volts which is the error 0f 0.01 times the gain of 10. Change the GAIN to 10 and the DVM will read approximately 1 volt. Setting the GAIN to 99 will result in a reading of approximately 7.2 volts.

5.5.7.2 **Reset** - Set up the controller as instructed in step 5.5.6.1. Enter a gain and setpoint value that results in less than full power to the load. If a Reset value is now entered, the instrument will try to integrate out the error. With a test resistor in the control sensor input and a fixed setpoint, the error signal will be constant. With a constant error the Reset will continue to increase the analog output control signal until the heater display reads 100 percent. If the heater output increases to approximately 100 percent for these conditions the reset circuit is operating.

To check the RESET circuit in more detail use the same set point and a GAIN of 10. Move the HI lead of the DVM to TP30 and enter a RESET of 1.0. The reading on the DVM should gradually integrate to approximately 7.2 volts. The time required will depend on the amount

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of reset with time required being the shortest for higher settings. Next, turn the reset off and make sure that the reading returns to 0.0 volts.

5.5.7.3 Rate - The operation of the Rate can not be observed without measuring voltages in the unit.

To check the RATE move the DVM HI lead to TP31, keep the GAIN at 10, turn the RESET off (0.0) and enter a RATE to 99. The DVM should read 0.0 volts. Quickly change the set point value from approximately equal to the display value to a value 20% higher in equivalent kelvin temperature, e.g. from 1.00 volts to 0.80 volts. The DVM should show a positive transient whose peak value will lie between 0.1 and 7 volts depending on the rate at which you change the set point, the amount of gain, the speed at which you change the voltage as well as when the reading is read by the DVM. For the change from .80 to 1.00 the reading will be negative in value.

The GAIN, RATE and RESET values are summed together before the heater drive circuit with the GAIN being multiplied by two in signal strength before summation. The sum of the three terms can be measured at TP28 ANA OUT.

5.5.8 Checking the Heater Ranges

5.5.8.1 Standard 50 Watt output - Set up the unit so that 100 percent is output to the heater load. At full power out on the Max scale 1 amp should be through the resistor, as long as the resistor is 50 ohms or less. The heater circuit has a compliance voltage limit of 50 volts, so a resistor larger than 50 ohms will limit the current to 50 divided by the load's Resistance. If the next lower range (-1) is selected then the heater will put 0.33 amperes through the resistor at 100 percent. The -2 range will output 0.10 amperes at full scale output. At the -3 range the output will be 0.033 amperes full scale and at the -4 range the output will be 0.001 amperes

5.5.8.2 W60 Watt Option - If the unit has a W60 output option the Max scale has a 1.55 amp, 40 volt limit. If a 25 ohm resistor is used the controller will supply 60 watts to the load. If a 100 ohm resistor is used on the Max scale the unit will output 40 volts at 0.4 amps or 16 watts. The lower ranges are scaled as explained in 5.5.7.1 above except the voltage limit is 43 volts.

NOTE: The values given above are nominal values. If they are slightly off it should not effect operation since the heater circuit is part of a feedback loop.

5.6 CALIBRATION

The adjustments and test points referred to in this section are labeled on the instrument calibration cover. Remove the two top panel screws and slide the top cover off to gain access to the adjustments and test points.

Note: The unit should be allowed a one-hour warm-up time to achieve rated specifications. This calibration procedure is for a DRC-93C with standard diode A and B inputs. For other configurations, refer to Section VII for the specific Input Card present in the unit.

5.6.1 Input Card Calibration

Calibrate each input card as specified in Section VII for that card.

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5.6.2 Set Point Voltage Calibration

Calibrate the Set Point Voltage as follows:

1. Remove the instrument cover.

2. Calibrate with the Control Switch selecting either a 9210 or 9220 Input Card and the -3 configuration. If the DRC-93C does not contain one of these input cards, calibrate the set point by following the procedure described with that Input Card.

3. To calibrate the Set Point voltage with a 9210 or 9220 card, connect the LO lead of your DVM to TP1 and the HI lead to TP25 SP V.

4. Enter a set point of 0.0000V and adjust the potentiometer labeled SP ZERO ADJ until the DVM reads 0.0000 volts.

5. Enter a set point of 2.7000V and adjust the potentiometer labeled SP SPAN ADJ until the DVM reads -2.7000 volts.

6. Repeat the two settings until the values are constant.

5.6.4 Calibration of Power Output

If the heater output is not the standard 50 watts for the DRC-93C, the optional power output installed should be indicated on the front page of this manual.

1. Verify that the back panel HEATER RESISTANCE switch is on 10-25 and use a load resistor between 10 and 25 ohms with a wattage rating equivalent to its resistance. The W60 output requires a load between 10 and 25 ohms with a wattage rated 1.5 times the resistance value. Set a set point and gain value which results in full scale output on the MAX Heater Range scale.

2. With full power across the load resistor on the -1 scale, place the DVM LO probe in TP19 PWR V+ and the DVM HI probe in TP21 and adjust PWR V+ until the DVM reads 1.000 volts. There now should be one ampere through the load (1.5 amperes in the case of the W60). The heater can now be turned off.

3. Place the DVM LO into TP15 PWR V- and the DVM HI into TP17 HTR V+ and adjust PWR V- ADJ until the DVM reads 1.0000 volts.

4. Place the DVM LO into TP20 PWR LO and the DVM HI into TP16 VREF and adjust PWR VREF until the DVM reads 1.0000 volts.

5. Repeat 3 and 4 until they do not change.

Note: TP 24 CNT V is the control voltage. For the 9210/20-3 it is the voltage across the sensor; for the 9210/20-6 it is 0.45 times the voltage across the sensor. TP 25 is the set point voltage and is of opposite sign from TP 24. These two voltages algebraically sum to the error signal.

5.7 TROUBLESHOOTING

Information on troubleshooting the Model DRC-93C controller is contained in this Section.

5.7.1 Sensor Current

If the sensor current is not within specifications (Section 5.5.3) then adjust the current trimpot on the input card (Section VII).

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5.7.1 Monitor Voltage, Display Voltage or Resistance

The display reading in volts or resistance should match the monitor reading and the voltage across the sensor, except for the 9215, 9305, 9317C and 9318C input cards and the -6 configuration. If the readings do not match then the input card should be calibrated. If the monitor reading is incorrect and can not be adjusted then the following IC's may need to be replaced.

"Old" Input cards
1. 8210, 8211 cards - replace U5
2. 8219, 8220 cards - replace U5. If that does not solve the problem then replace U4.

"New" Input Cards
1. 9210, 9220 cards - replace U5
2. For the 9318C, the monitor voltage should be approximately ±10mV. If it is not between 5-16mV then U16, U13 or U10 could be bad. For the 9317C the monitor voltage should be approximately a factor of ten lower. The same three IC's are involved.

If the monitor voltage is incorrect, the input card may control at an offset or not at all.

If the sensor voltage matches the monitor voltage and the display voltage is incorrect then the A/D needs to be calibrated.

5.7.2 Units Display is correct but temperature reading is incorrect

If the units display matches the voltage or resistance value of the sensor, but the temperature display is incorrect then check the curve selected. This can be accomplished by holding down the CURVE# button or by reading the selected curve over the interface using the W1 command.

If the correct curve is selected, but the display in temperature is still incorrect, then check the data in the curve. This can be done over the IEEE by using the test program and the XDN_1N_2 command.

5.7.3 The Heater Circuit

If the DRC-93C does not have output power check to see that U13 on Figure 93C-1C (the LM317HVK) is tightly screwed into its heat sink. It is on standoffs near the fan in the left rear of the unit.

Configure the DRC-93C as in Section 5.5.6.2. Verify that there is heater current going to the load resistor.

Next, measure the analog out signal to be sure the PID circuits are operating correctly. The analog out signal can be measured at TP28 (Gnd at TP1). If this is a positive value that varies from 0-7.3 volts as the gain setpoint, or reset values are changed then the circuit is probably operating correctly. Now measure the voltage across from TP19 to TP21. The voltage should vary from 0 to 1 volt as the analog out signal varies from 0 to 7.3 volts. As the gain or manual heater is increased the analog signal will increase and the voltage between TP19 and TP21 will in-crease. If the voltage stays at 0 Volts then U45 or U46 is probably bad as long as the raw V+(TP21 to TP6) is close to 28 volts for the 10-25 Ohm Heater Range (37 and 53 volts for the 25-35 and 35-50 Ohm Heater Ranges respectively). The V+ can be checked by measuring approximately 28V from TP21 to TP1. The V+ value is 50 Volts if a W50 watt option is installed in a DRC-91C or if the resistor setting is 50 ohms on the DRC-93C. If a W60 Watt option is

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installed the V+ voltage should be approximately 44 volts.

NOTE: DO NOT CHANGE the Heater Range switch when the unit is on. Changing this switch with the unit on WILL DAMAGE the unit.

If the Voltage from TP19 to TP21 is correct, and there is no heater power on any range than U47 or U48 are probably bad and both should be replaced. Before it is decided that U47 and U48 are bad be sure the relays K4-K8 are working. If they can be heard clicking as they are turned off and on, then they are probably operating properly. They are turned off and on by selecting different heater ranges.

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Table 5-1: Input Card Characteristics

Sensor Input	Sensor Type	Temp Range and Units Range	Sensor Current	Input A/D Resolution	Input A/D Accuracy	Test Resistor	Display in Sensor Units	Standard Curves	Display with Std Curves (K)
8210 9210-3 9220-3	Si Diodes	1.4 to 475K 0-2.9999V	10μA	0.05mV	±0.1mV	100kΩ 0.01%	1.0000V	DRC-D (00) DRC-E1(01) CRV 10(02) CRV 10(04)	71.79 71.42 87.77 87.77
9210-6 9220-6	GaAlAs Diodes	1.4 to 325K 0-6.5535V	10μA	0.1mV	±0.2mV	100kΩ 0.01%	1.0000V	no std crv see note 3	
8219-P2 9220-P2	100Ω Pt RTD	14 to 800K 0-299.99Ω	1mA	0.005Ω	±0.01Ω	100Ω 0.01%	100.0Ω	Din 43760 (03)	273.1
8219-P3 9220-P3	1000Ω Pt RTD	14 to 800K 0-2999.9Ω	0.1mA	0.05Ω	±0.1Ω	1000Ω 0.01%	1000Ω	Din 43760 (03)	273.1
8219-R1 9220-R1	RhFe RTDs	14 to 800K 0-99.999Ω	3mA	0.003Ω	±0.01Ω	10Ω 0.01%	10.00Ω	no std crv see note 3	
9317C	Ge CGR	0.3 to 100K see note 1 1.4 to 325K 1 to 10,000Ω	see note 2	1 in 10^4	±0.1% fr 10-1000Ω ±0.5% fr 1k-100kΩ	100Ω 0.01%	100.00Ω	no std crv see note 3	
9318C	Ge CGR	1.4 to 100K see note 1	see note 2	1 in 10^4	±0.05%fr 10-10kΩ ±0.25%fr 10k-100k	100Ω 0.01%	100.00Ω	no std crv see note 3	

Note 1: The lower temperature limit is dependent upon resistance-temperature characteristic of sensor used.
Note 2: 0.1μA to 1.0mA. Sensor voltage pinned at 1mV (9317C) or 10mV (9318C).
Note 3: To read correctly in temperature these input cards must be used with calibrated sensors and the 8001 precision option.
Note 4: 9317C and 9318C will read to 1 ohm full scale with reduced accuracy.

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REPLACEABLE PARTS LIST - DRC-93C MAIN BOARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
C1	101-275	1	CAP,ELECT,9500MF,15V	MEP	3188BA952U015AMA1
C2,6,10 7,13,16 18,20, 26,28	101-225	10	CAP,ELECT,470MF,35V	PAN	ECEAIVV471S
C23	101-238	1	CAP,ELECT,2100MF,75V	MEP	3186BA212U075AMA1
C40,42 46,50	101-034	4	CAP,PP,1MF,100V	FDYNE	MPP2X-1.0-100-10
CR2-6, 11	102-008	6	BRIDGE RECTIFIER	GI	W02M
CR7-10 26-29	102-003	8	DIODE RECTIFIER	MOT	MR501
CR12,13	102-001	2	DIODE RECTIFIER	MOT	1N4006
CR19	102-058	1	DIODE, ZENER 24V	MOT	1N4749A
CR20	102-053	1	DIODE, ZENER 5.1V	MOT	1N751A
J4	106-310	1	CONNECTOR (IEEE)	AML	57-92245-12
J5	106-412	1	CONNECTOR (REMOTE ID)	TBAN	609-1602M
JA1,2	106-146	2	CONNECTOR (TX1 TO MB)	MOL	2630-09-74-1091
JC1,2	106-139	2	CONNECTOR (TX2 TO MB)	MOL	2630-09-74-1041
JF	106-143	1	CONNECTOR (BP TO MB)	MOL	2630-09-74-1061
JG,JH	106-129	4	CONNECTOR POSTS	SAMT	TSW-120-04-06
K1,2	106-321	2	RELAY,DPST,DRY REED	COTO	CR-3402-05-91
K3-K7	105-302	5	DRY REED RELAY, 20 W	EAC	B1A5AH
K8	105-304	1	DRY REED RELAY, 50 W	EAC	P1A5A
Q1	102-072	1	TRANSISTOR, PNP	MOT	2N3906
R35,36	113-063	2	RES,PREC,100K,.01% MATCHED PAIR	LSCI	
R63	103-209	1	RES,MTF,30.1 ,1/4W,1%		
R64	103-495	1	RES,MTF,9.84 ,1/4W,1%		
R65	103-540	1	RES,MTF,2.92 , 1 W,1%		
R66	103-586	1	RES,MTF,3.5 , 3 W,1%		
R67	103-583	1	RES,MTF,1.25 , 3 W,1%		
R76	103-675	1	RES,WWD,587 , 5 W,1%		
S1	105-014	1	POWER SWITCH (2 POLE)	ITT	F-01-2UEE/NE15-1B
S3,5,7	105-408	3	DIP SWITCH 8 POS	GYH	76SB08
SL0-3	106-229	4	CONNECTOR (25/50)	BRDY	PWBH25DBF1F
SL4-6	106-227	3	CONNECTOR (18/36)	BRDY	PWBH18DBS1B
U2,10	102-011	2	REGULATOR, +5V	MOT	MC7805ACT
U3	102-021	1	REGULATOR, -5V		7905CT
U4,7 11,12 14	102-014	5	REGULATOR, +15V		7815CT
U5,8,15	102-024	3	REGULATOR, -15V		7915CT
U6	102-012	1	REGULATOR, +8V		7808CT
U9	102-022	1	REGULATOR, -8V		7908CT
U13	102-036	1	REGULATOR, ADJ, 1.2-57V	NAT	LM317HVK-STEEL
U16	104-712	1	IC, IEEE CHIP	TI	TMS9914ANL
U17	104-710	1	IC, IEEE SUPPORT CHIP	TI	SN75160AN
U18	104-711	1	IC, IEEE SUPPORT CHIP	TI	SN75161AN
U19,20	104-529	2	IC, PORT EXPANDER	INT	82C55A-5
U21	104-310	1	IC, 8 BIT MULTIPLEXER	NAT	81LS95
U22	104-419	1	IC, 16 BIT D/A CONVERTER	BB	DAC703BH-5
U23	104-061	1	IC, DISPLAY DRIVER	NAT	MM5480N
U24-27	104-408	3	IC, 10 BIT D/A CONVERTER	ISL	AD7533JN
U28	104-076	1	IC, DUAL SPDT ANL SWITCH	HAR	HI5043-5
U29,30 32	104-088	3	IC, QUAD OP AMP	TSC	TSC914A
U31	104-162	1	IC, DISPLAY DRIVER	NAT	MM5451N
U33-37 43	104-355	6	IC, OPTOCOUPLER	GI	740L6000
U38	104-356	1	IC, OPTOCOUPLER	GI	740L6010
U39	104-453	1	IC, 8 BIT A/D CONVERTER	NAT	ADC0831CCN
U40,41	104-210	2	IC, HEX INVERTER, O.C.		7406
U42,44	104-010	2	IC,LIN,F/V OR V/F	NAT	LM331N
U45	104-022	1	IC, OP AMP, JFET INPUT	NAT	LF356N
U46	102-104	1	POWER MOSFET, 90V N-CH	SPTX	VN0109N5
U47	104-068	1	IC, OP AMP, DUAL MC1741	MOT	1458PI
U48	102-095	1	POWER MOSFET, 100V P-CH	IR	IRF9130
W1		1	CABLE (MB TO U1)	LSCI	
XU13	106-571	1	SOCKET, TO-3	AUG	M8080-1G40

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REPLACEABLE PARTS LIST - DRC-93C

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
MP3	113-131	1	CONNECTOR KIT consisting of	LSCI	113-131
	106-010	2	5 PIN PLUG - MATE TO J3:	AML	126-127
	106-012	1	7 PIN PLUG - MATE TO J5:	AML	126-195
	106-414	2	16 PIN IDC SOCKET	TBA	609-1630
	106-415	2	16 PIN STRAIN RELIEF	TBA	609-1631SP
	107-017	1	RMA INSERTS	LSCI	107-017
	115-006	1	POWER CORD		
	110-014	1	FUSE: 1.0A SB (115 VAC)	BUS	MDL-1
			0.5A SB (230 VAC)	BUS	MDL 1/2
H6	105-671	10	KEY TOP - BLUE	LSCI	105-671
H7	105-676	4	KEY TOP - LIGHT GREY	LSCI	105-676
H8	105-677	19	KEY TOP - MEDIUM GREY	LSCI	105-677
F1	106-028	1	AC LINE CORD PLUG/FUSE HOLDER/LINE VLTG SLCTR	SFR	FN372-6/22
JF	106-140	3	CNNCTR (J3 ON RB TO MB)	MOL	2139-09-50-3061
	110-150	18	CONNECTOR TERMINALS	MOL	2878-08-50-0116
J1/2	106-011	2	CONNECTOR 5 PIN SOCKET	AML	126-218
J3	106-013	1	CONNECTOR 7 PIN SOCKET	AML	126-198
J6	106-002	1	HEATER HI OUT - GRAY	EFJ	111-0113-001
J7	106-001	2	HEATER LO OUT - BLACK	EFJ	111-0103-001
J8			HEATER GND - BLACK		
R68	103-765	1	POT,20 OHM,10%,LIN TAPER	CLAR	LSCI-765
U48	102-095	1	POWER MOSFET, 100V P-CH	IR	IRF9130
XU48	106-571	1	SOCKET,TO-3	AUG	M8080-1G40
TX1	109-019	1	INPUT TRANSFORMER	LSCI	C696-114
TX2	109-021	1	OUTPUT TRANSFORMER	LSCI	C696-115
B1	107-180	1	FAN ASSEMBLY	LSCI	107-180

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REPLACEABLE PARTS LIST - DRC-93C DISPLAY AND DISPLAY DRIVER BOARDS

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
J1,2,4	106-151	3	CONNECTOR(HEADER ON DB)	ALP	TDB24SG
J3	106-150	1	CONNECTOR(HEADER ON DB)	ALP	TDB10SG
S1-33	105-651	33	SWITCH	ALPS	KEF10901
C1	101-132	1	CAP,TANT,1.5MF,10V	SPRG	150D155X9010A2
C14	101-137	1	CAP,TANT,10MF,35V	SPRG	119D106X0035DB1
C17	101-144	1	CAP,TANT,33MF,25V	SPRG	196D336X9025PE-14
CR1-3	102-062	3	DIODE,SIL,SWITCHING		1N459A
J1-2,4	106-153	3	CONNECTOR(SOCKET ON DDB)	AMP	1-103183
J3	106-152	1	CONNECTOR(SOCKET ON DDB)	AMP	103183-4
Q1-10	102-072	10	TRANSISTOR, SIGNAL PNP		2N3906
U2,16	104-526	2	IC, KEYBOARD INTERFACE	INT	P8279-5
U3,11	104-277	2	IC, 4-16 LINE DECODER		74HC154
U8	104-522	1	IC, I/O EXPANDER	INT	P8243
U12	104-270	1	IC, 4-10 LINE DECODER		74145
U15,24	104-120	2	IC, 3-8 LINE DECODER		74HC138
U17	104-654	1	IC, 2K NOVRAM W/CLOCK	MOS	MK48T08B-25
U18	104-661	1	IC, EPROM	MOS	27C256
U19	104-528	1	IC, 8 BIT LATCH	INT	82C82
U20	104-511	1	IC, MICROPROCESSOR	INT	P80C31BH
U23	104-653	1	IC, NOVRAM	DAL	DS1225Y

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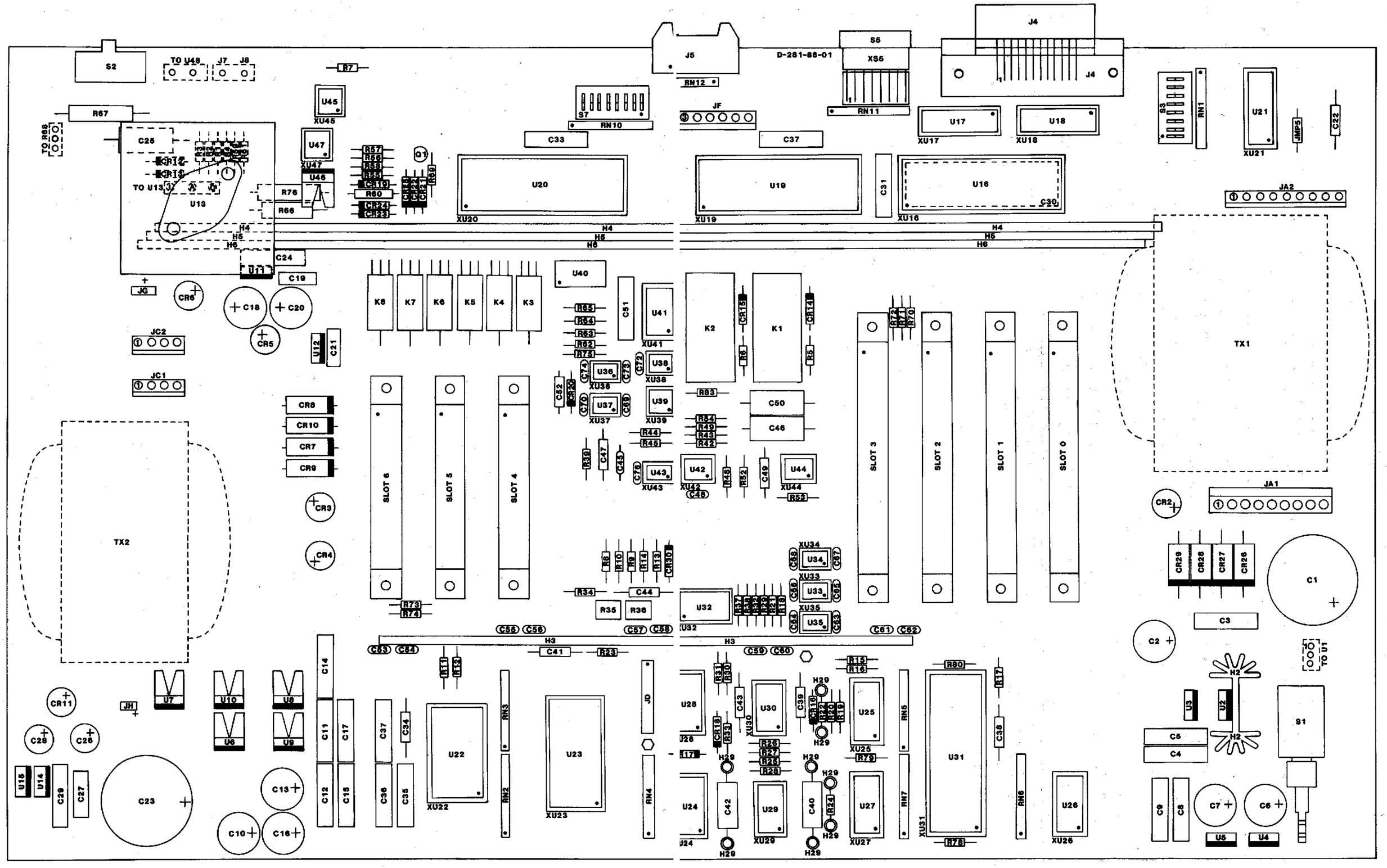


Figure 93C-1a. Component Layout - DRC-93C Main Board

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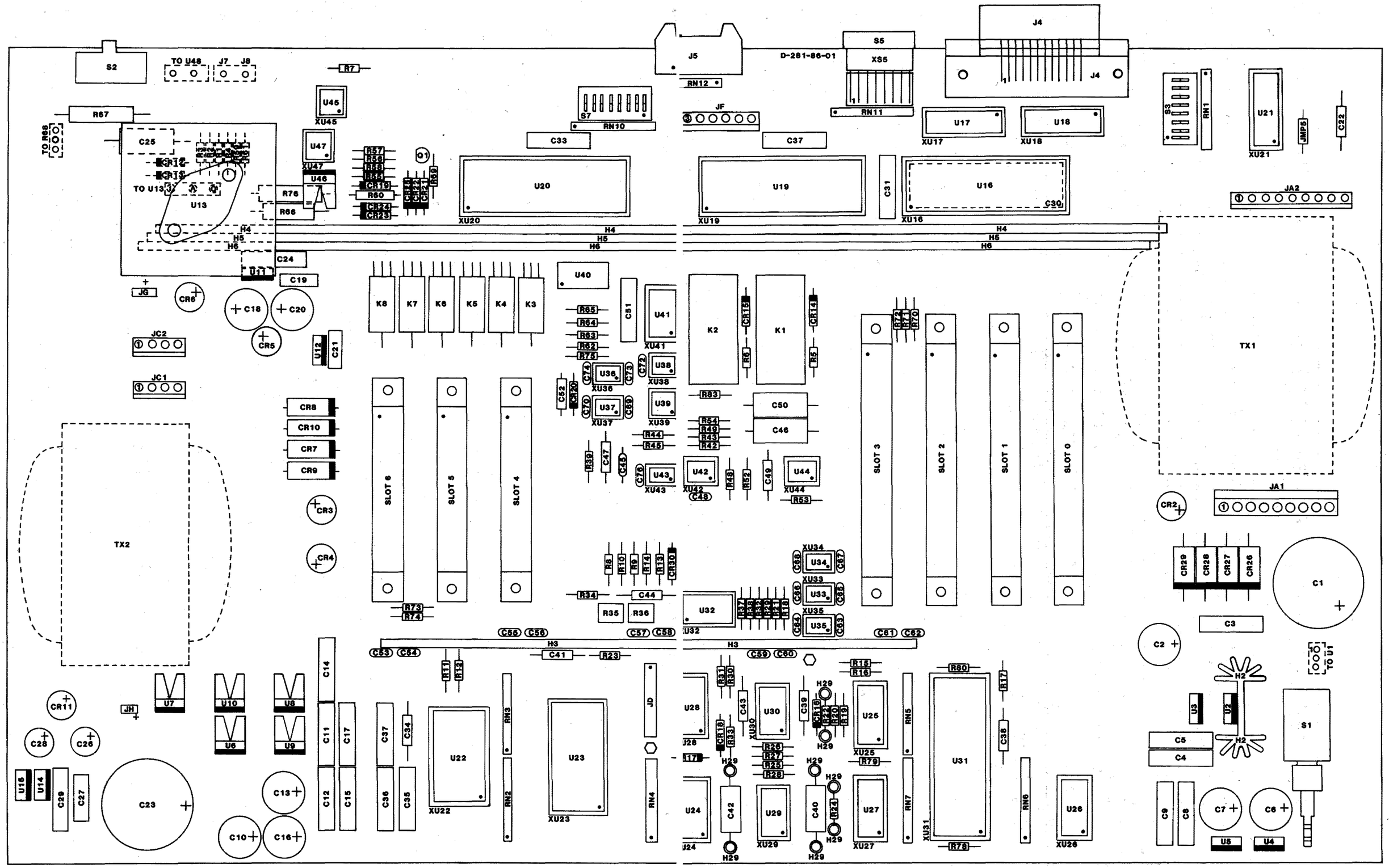


Figure 93C-1a. Component Layout - DRC-93C Main Board

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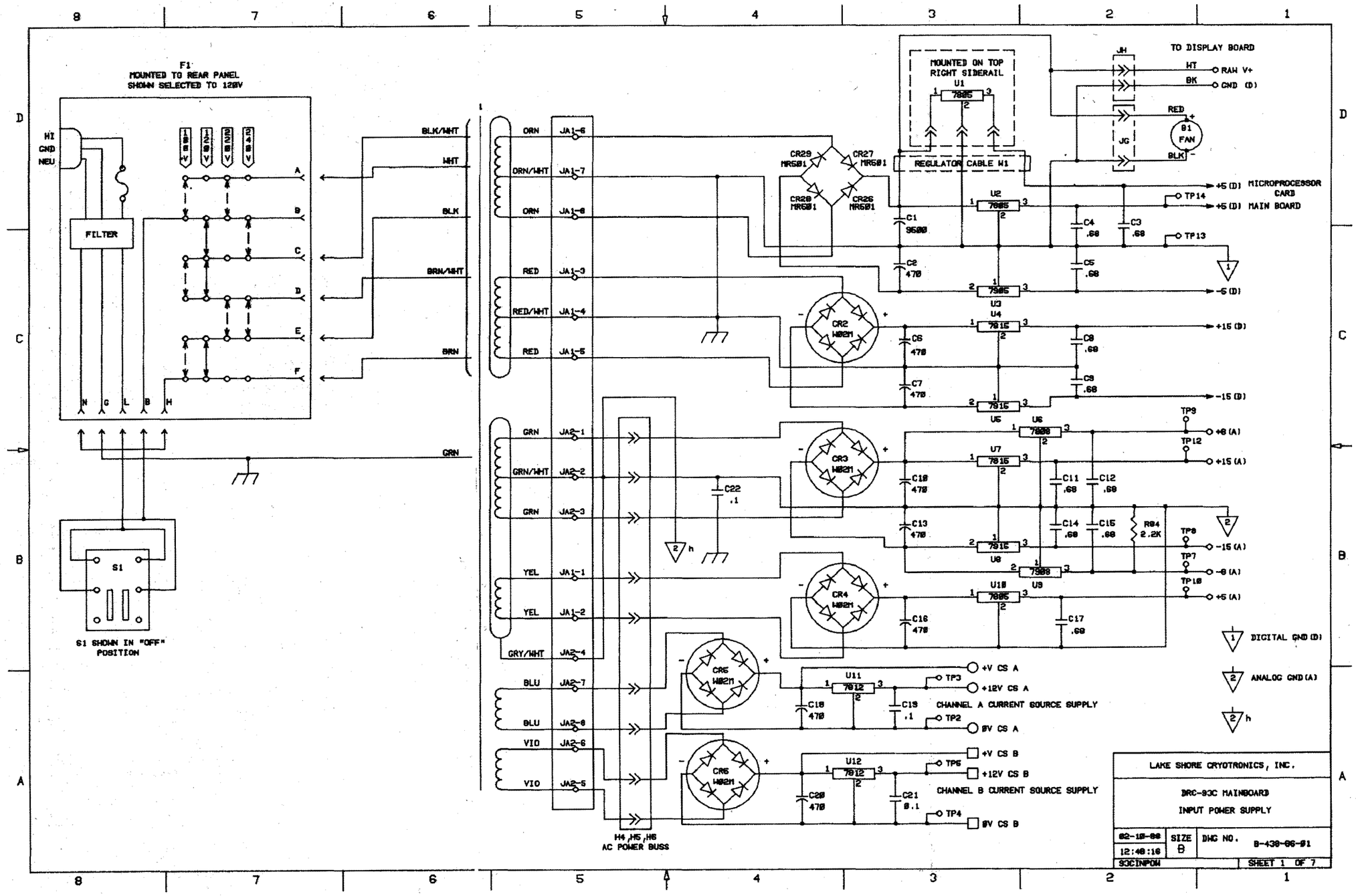
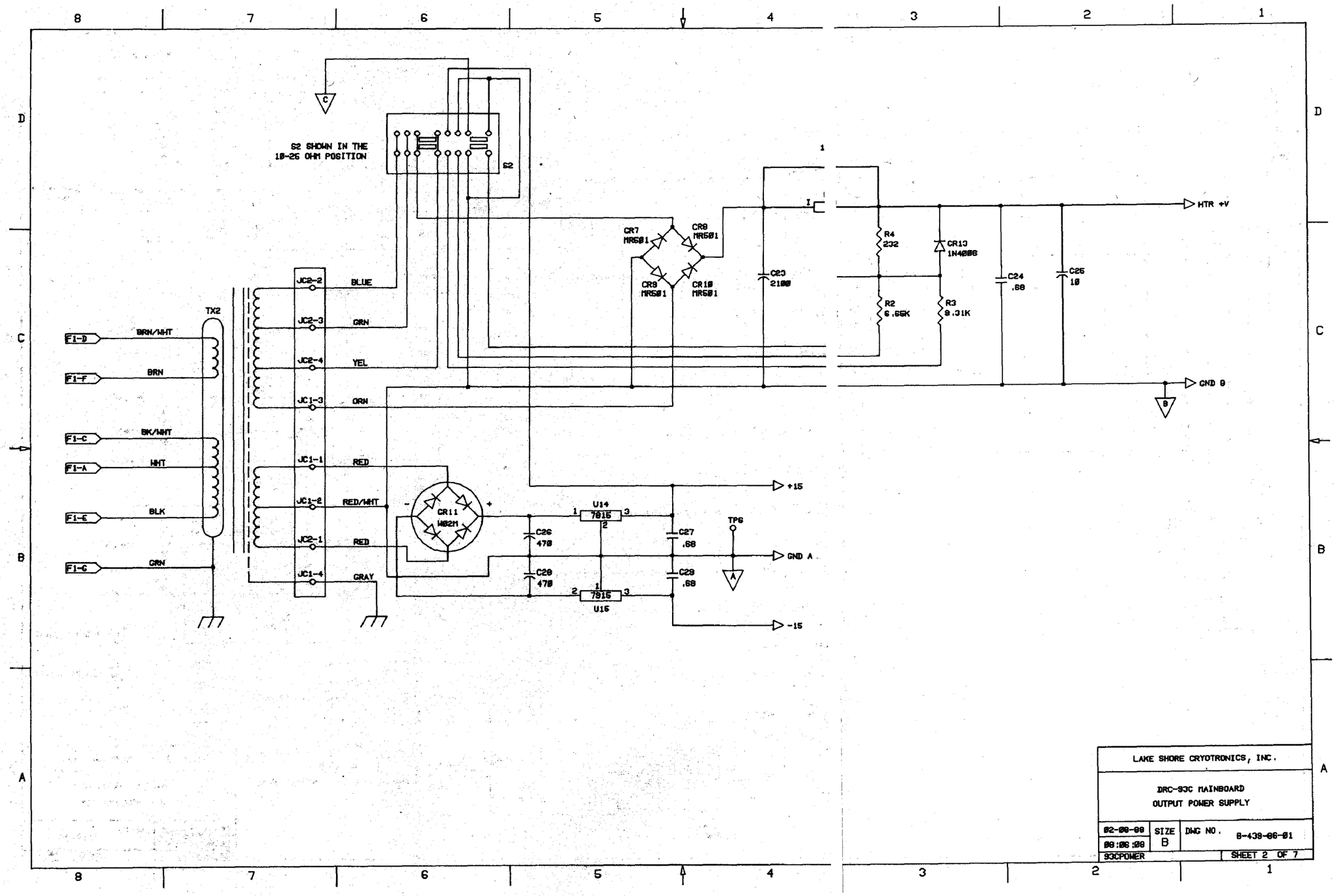


Figure 93C-1b. Schematic - DRC-93C Main Board #1 (Input Power Supply)

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LAKE SHORE CRYOTRONICS, INC.

DRC-93C MAINBOARD
OUTPUT POWER SUPPLY

92-00-00	SIZE	DWG NO.
00:00:00	B	B-438-66-01
93CPOWER		SHEET 2 OF 7

Figure 93C-1c. Schematic - DRC-93C Main Board #2 (Output Power Supply)

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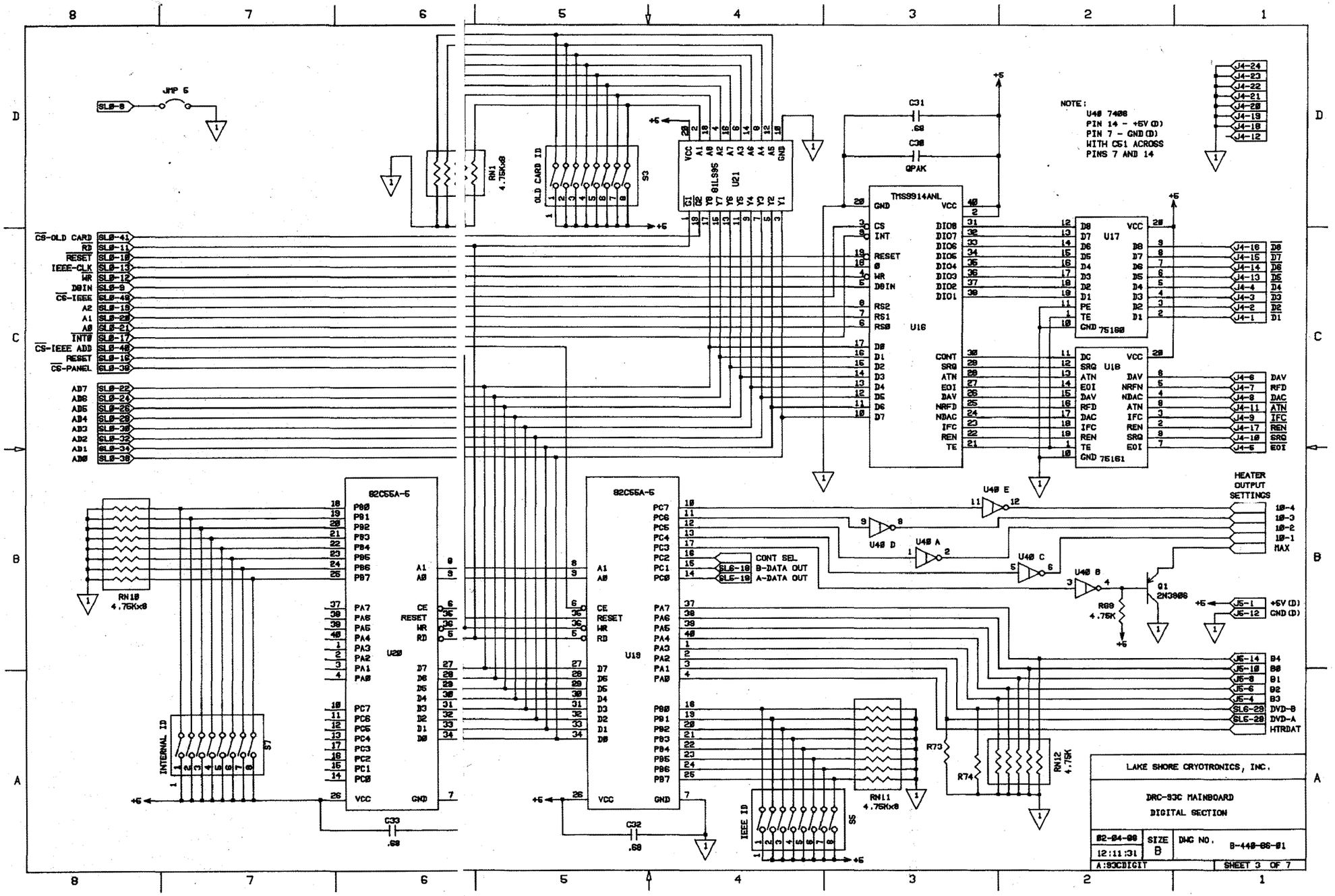


Figure 93C-1d. Schematic - DRC-93C Main Board #3 (Digital Section)

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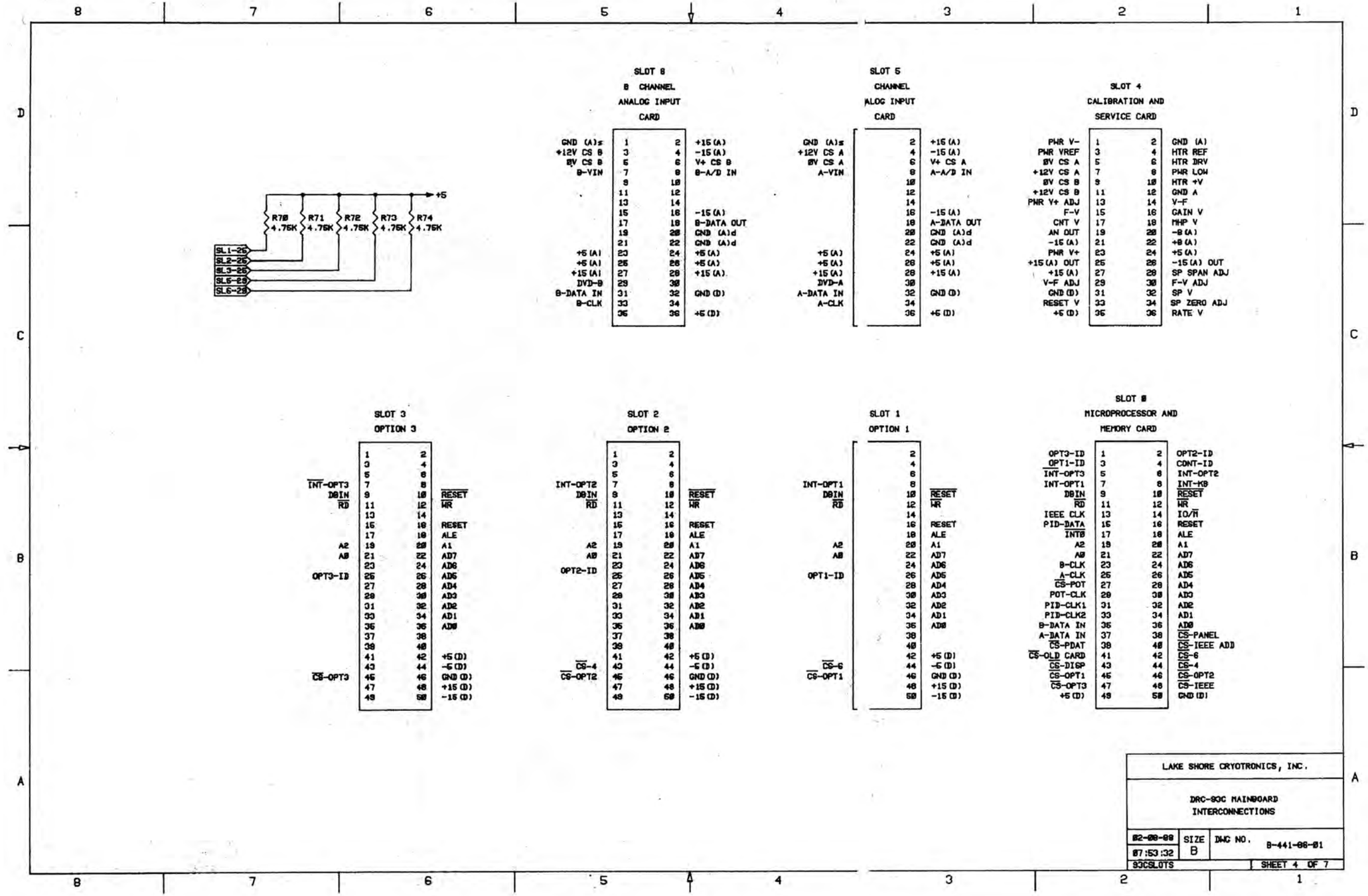


Figure 93C-1e. Schematic - DRC-93C Main Board #4 (Interconnections)

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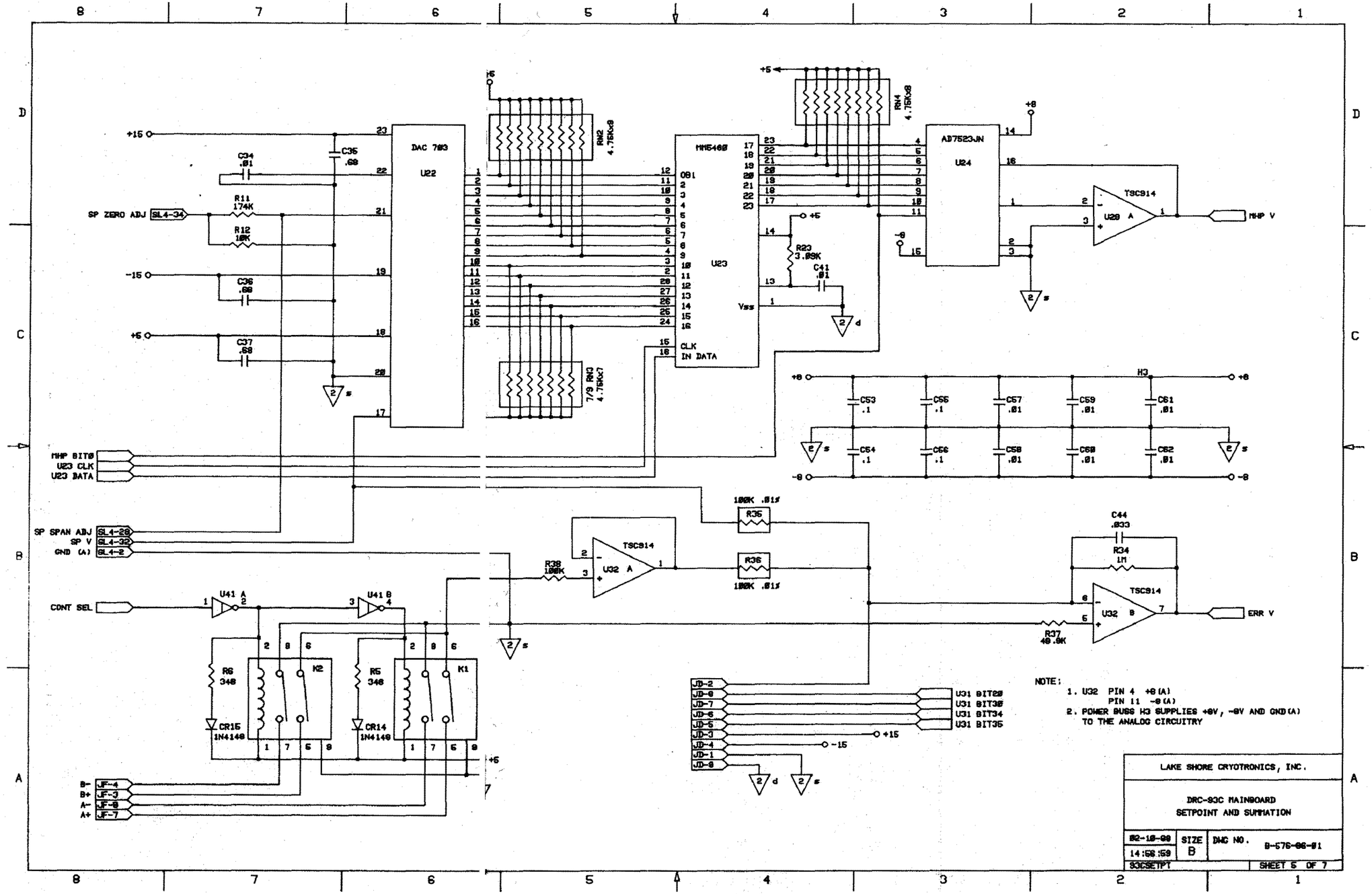


Figure 93C-1f. Schematic - DRC-93C Main Board #5 (Setpoint and Summation)

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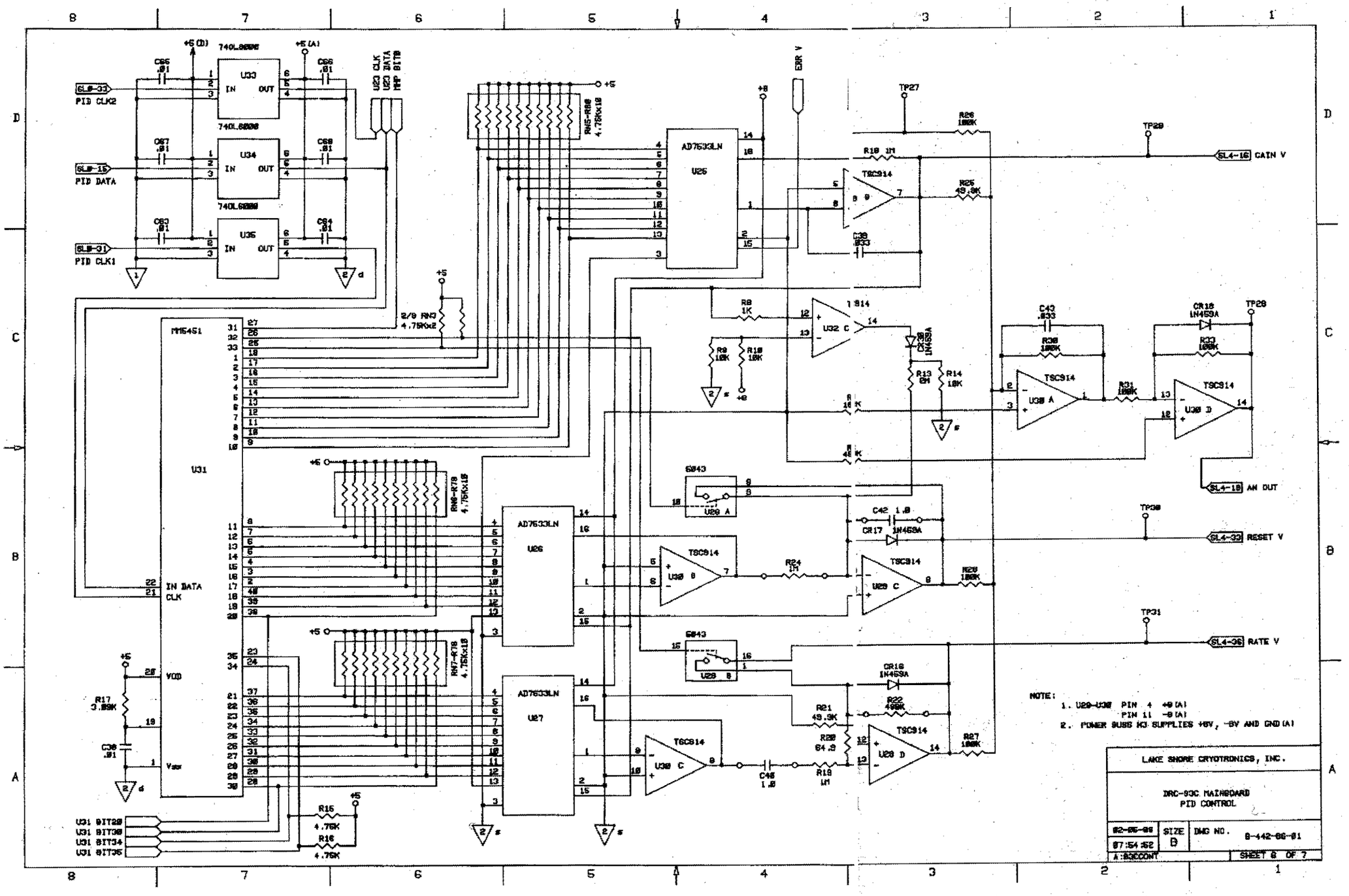


Figure 93C-1g. Schematic – DRC-93C Main Board #6 (PID Control)

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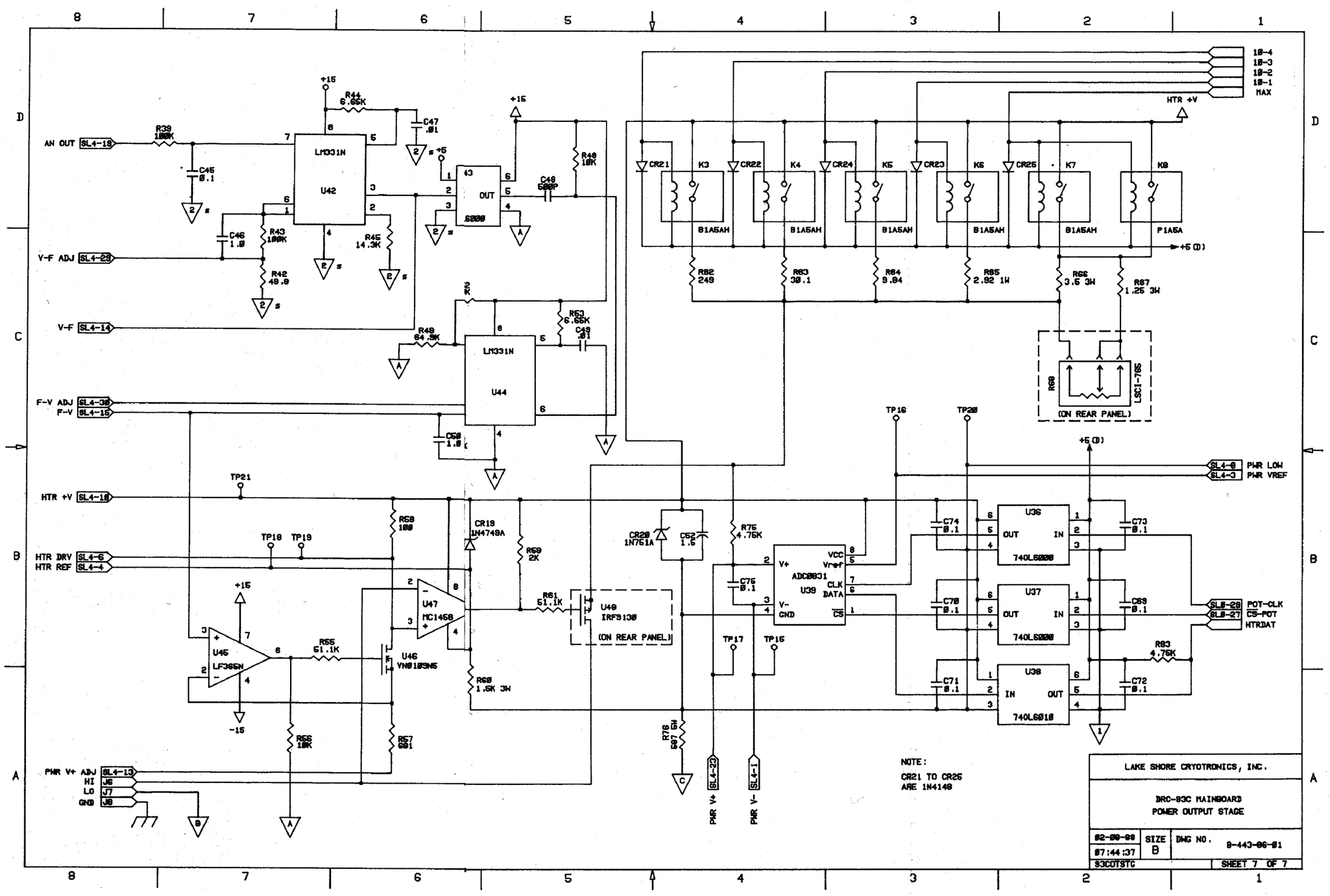


Figure 93C-1h Schematic – DRC-93C Main Board #7 (Output Stage)

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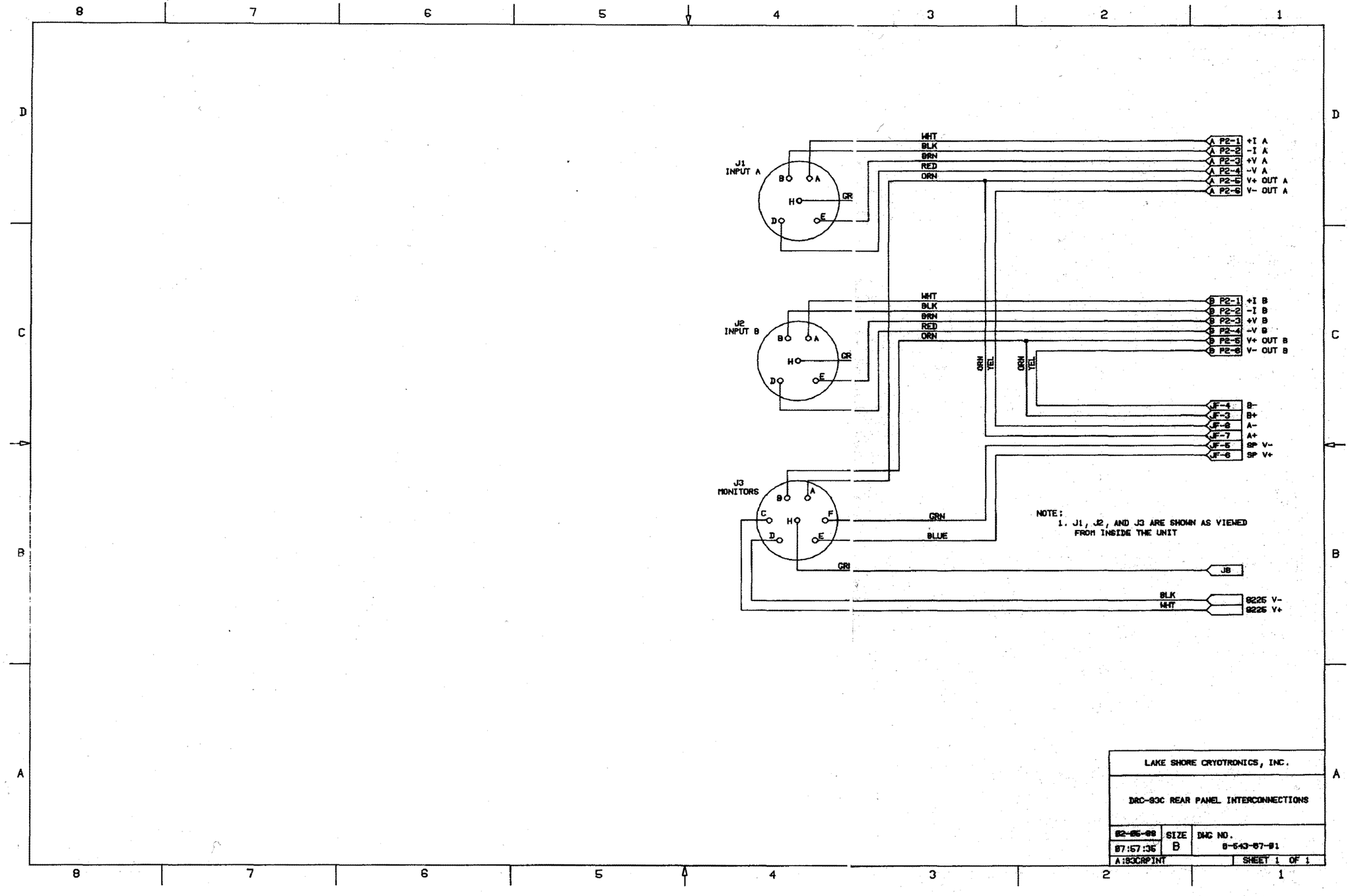


Figure 93C-1i. Schematic - DRC-93C Main Board #8 (Rear Panel Interconnectio

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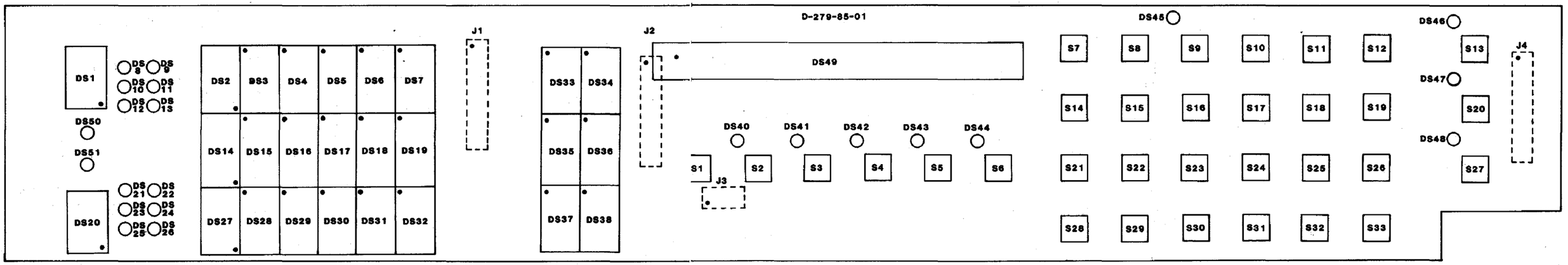


Figure 93C-2a. Component Layout - DRC-93C Display Board

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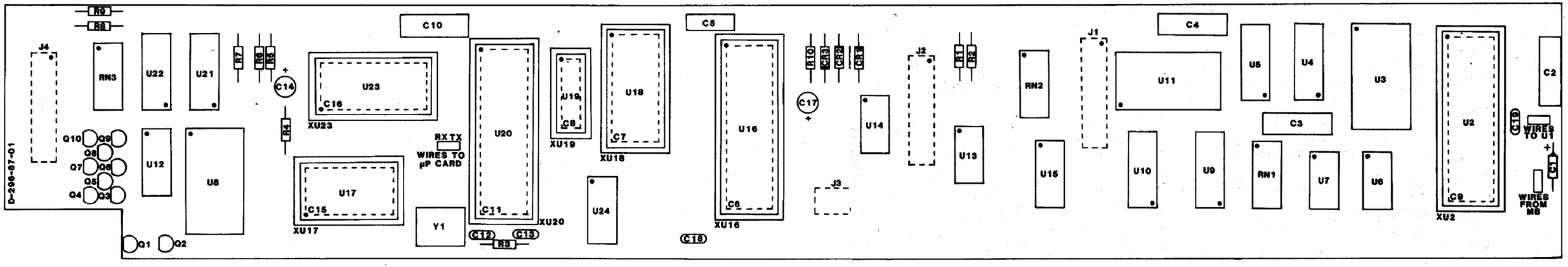


Figure 93C-2b. Component Layout - DRC-93C Display Driver Board

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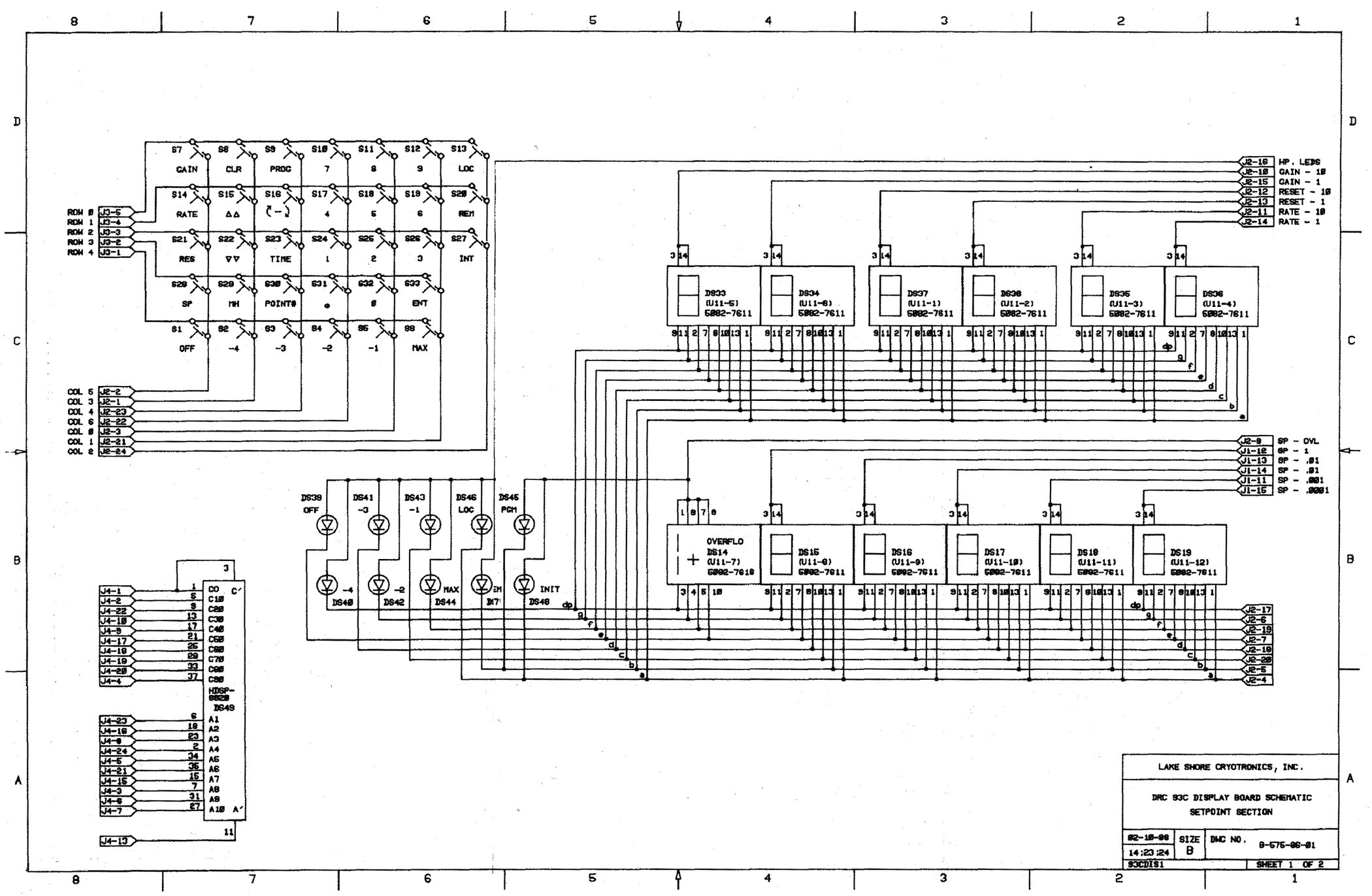


Figure 93C-2c. Schematic - DRC-93C Display Board #1 (Setpoint Section)

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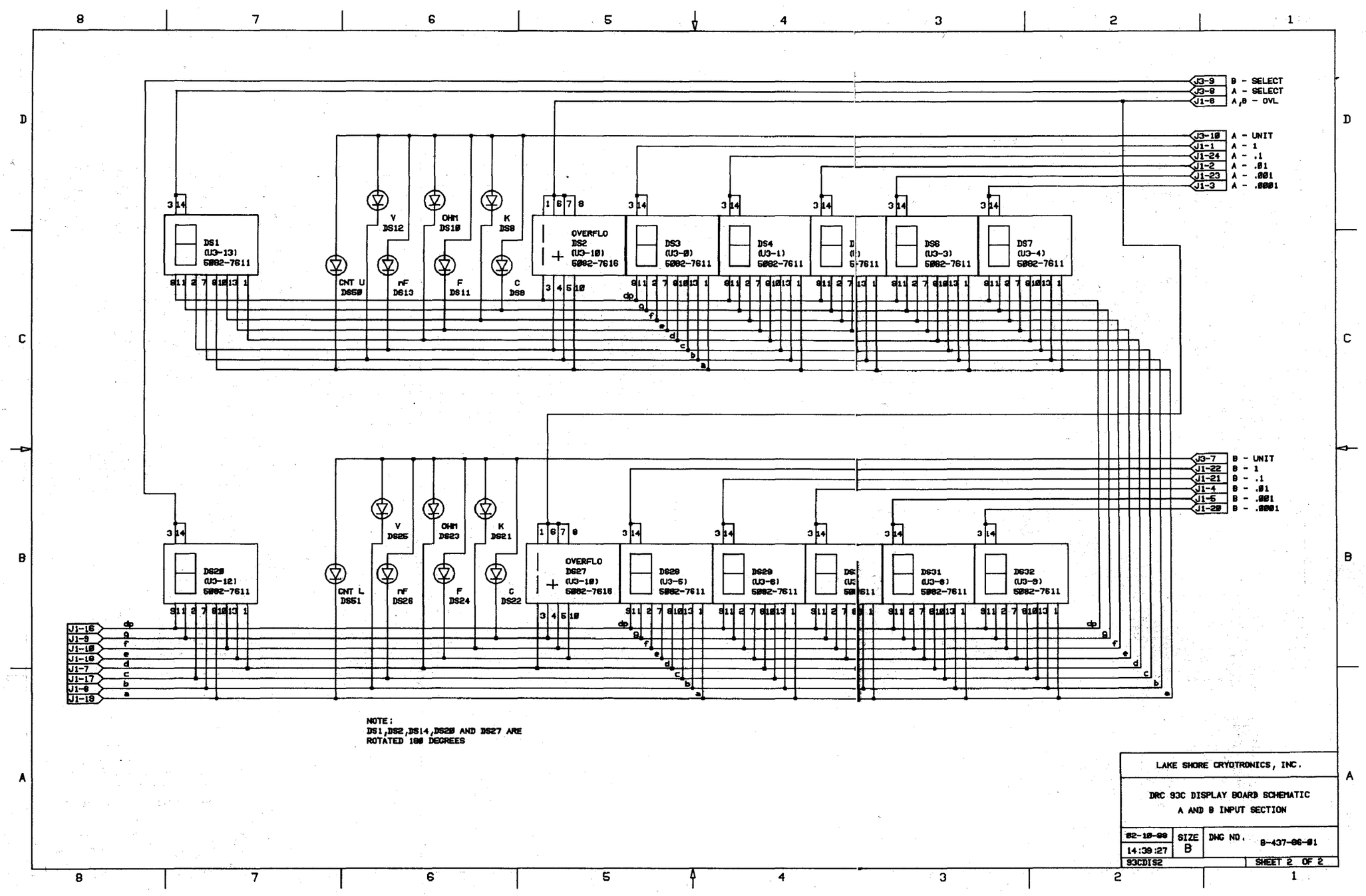


Figure 93C-2d. Schematic - DRC-93C Display Board #2 (Input Display Section)

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LAKE SHORE CRYOTRONICS, INC.

DRC-93C DISPLAY DRIVER BOARD
DIGITAL SECTION

92-08-06	SIZE	DWG NO.
13:13:46	B	8-498-87-01
93CD081		SHEET 1 OF 3

NOTE:
U14 PIN 14 - VCC
PIN 7 - GND

Figure 93C-2a. Schematic - DRC-93C Display Driver Board #1 (Digital Section)

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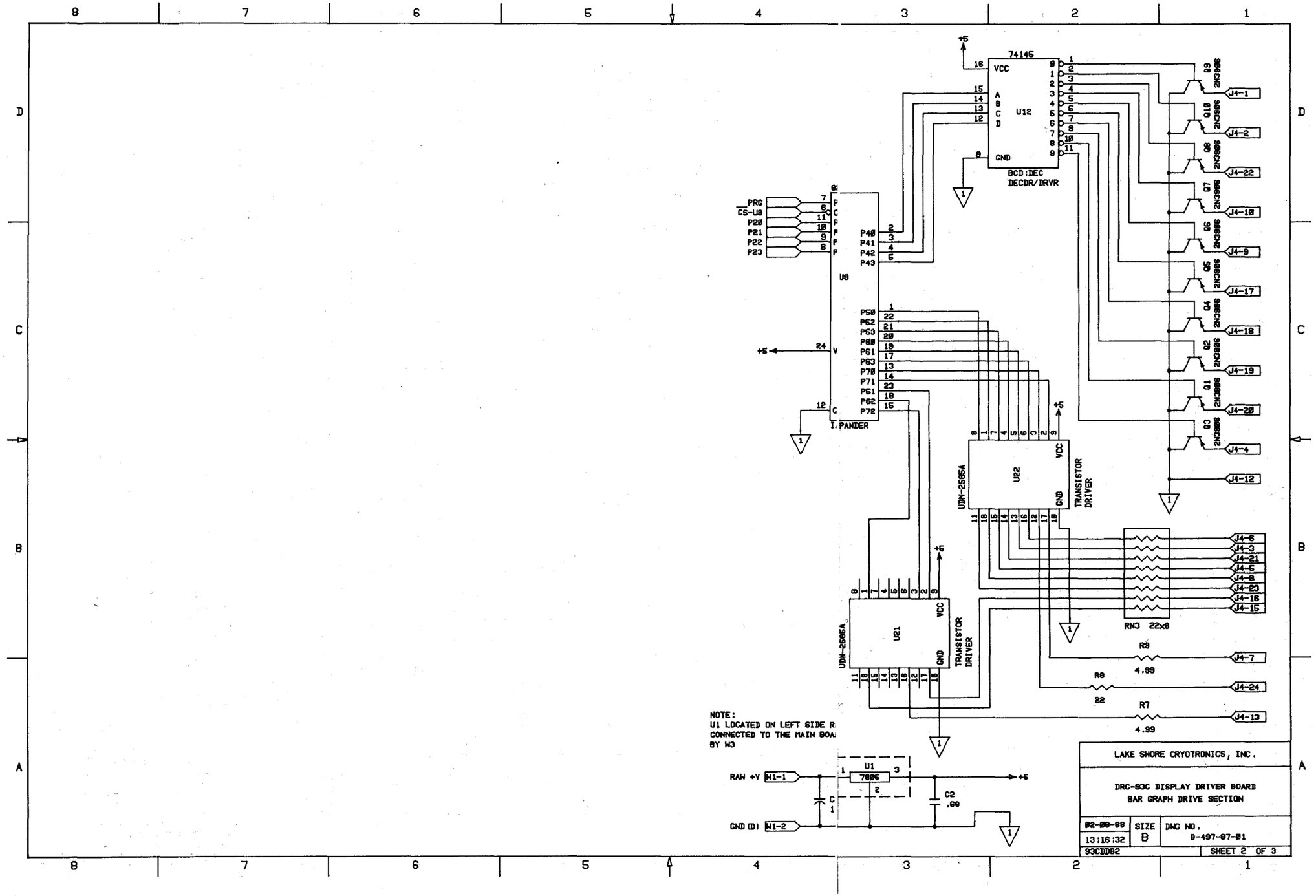


Figure 93C-2f. Schematic - DRC-93C Display Driver Board #2 (Bar Graph Drive S

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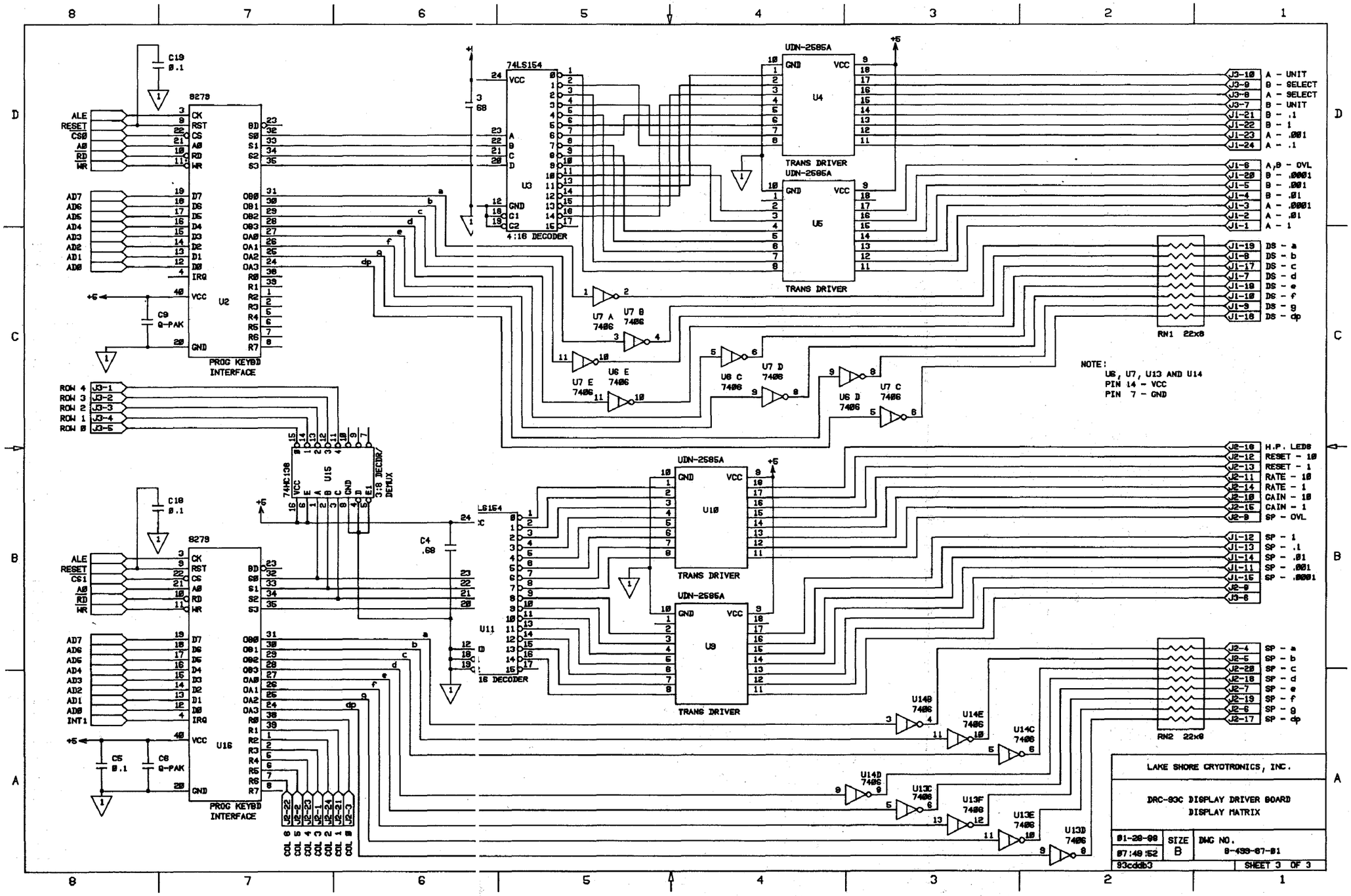
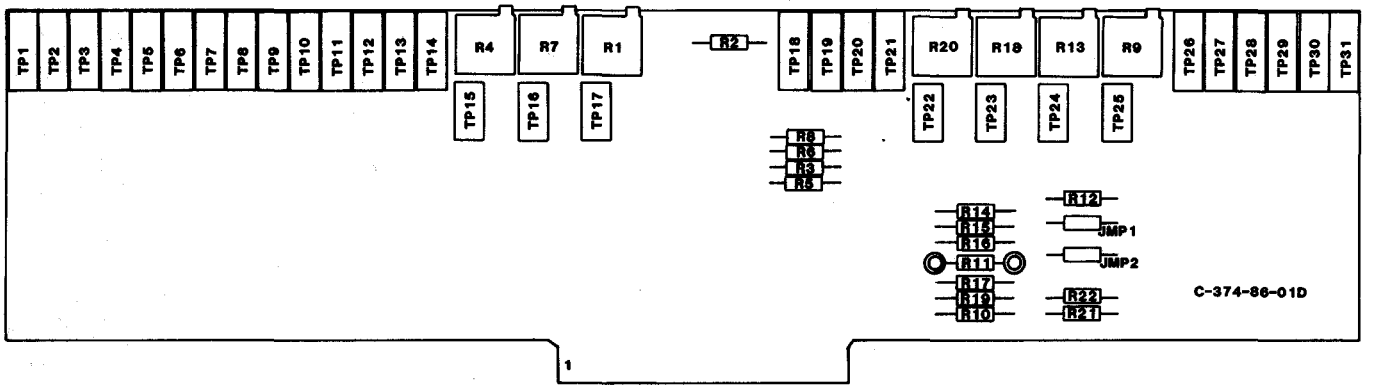


Figure 93C-2g. Schematic - DRC-93C Display Driver Board #3 (Display Matrix)

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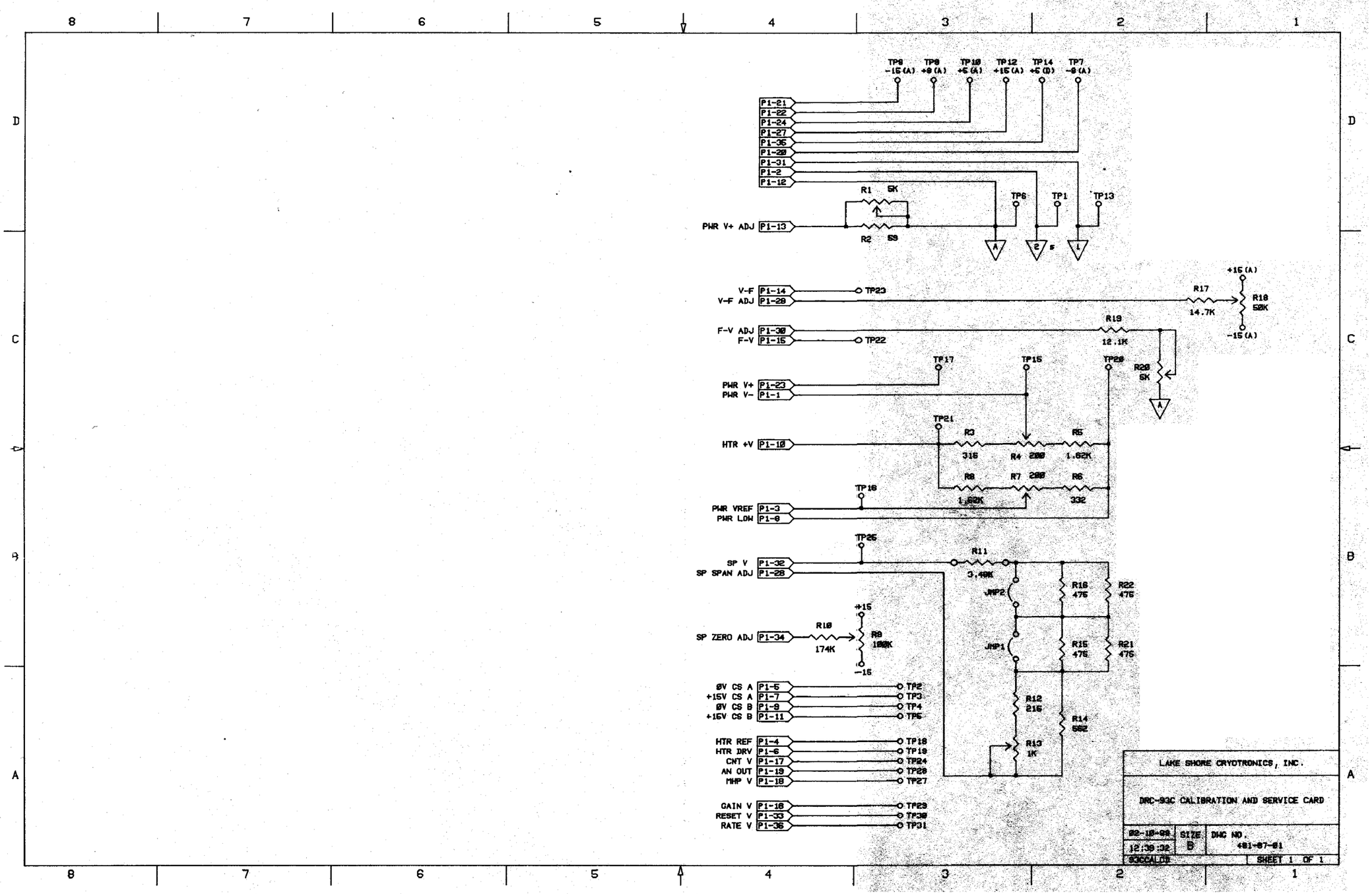


Figure 93C-3. Schematic and Component Layout - DRC-93C Calibration and Service Card

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