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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-91C. Thus, through the SRQ management line and the Status Register, the DRC-91C is able to signal Status Reports on five conditions immediately to the BUS CONTROLLER.

It is possible to disable the DRC-91C SRQ line thereby preventing the DRC-91C 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-91C provided that Bit 6 in the Status Register Mask is set (See Section 4.11.3).

With the SRQ bit of the Status Register mask disabled, no SRQ interrupt by the DRC-91C 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-91C Status Register is a single byte of data from the DRC-91C 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-91C. 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-91C 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

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set will cause the DRC-91C 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 4.11.4.2).

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 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-91C 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-91C is to report via the SRQ line and five bits to determine which Status Reports to make. Bit 6 is the SRQ

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(Service Request) bit and if set allows the DRC-91C to send out a Service Request on the SRQ IEEE-488 line. If the SRQ bit is not set (off) then the DRC-91C 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-91C 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-91C 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-91C 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 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 - Display 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- Display Sensor Channel Change Enable. If the Sensor Channel Change (Bit 3) is selected, the bit 3 in the Status Register is set when a channel change occurs.

4.11.3.4 Status Register 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 4.12.2 and Table 4-15).

For example, in Figure 4-2, Q21 will allow the setting of the Overload/-Error Indicator and Display 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-91C 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. If this switch is not set, then the Status Register mask is set to 00 and the control channel limit to 000.0.

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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-91C SRQ interrupt will be generated. The BUS CONTROLLER can read the Status Register to determine appropriate instrument conditions. In this case bit 1 is continuously updated to reflect current instrument status of the Sample Data Ready.

Example #2: Q2F - All Status Reports with the SRQ bit off. With the SRQ bit of the Status Register mask disabled, no SRQ interrupt by the DRC-91C 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.

4.11.3.6 Status Register Mask at Power Up

The Status Register Mask at power-up is set to zero as is the Status Register.

Table 4-13. DRC-91C 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. Status Register Mask is: C_1 C_2 Error/Overload Indicator Request Service Request 0 X OFF OFF 2 X ON OFF 4 X OFF ON 6 X ON ON -------Control-------- Display Data Data Channel Limit X 0 OFF OFF OFF X 1 ON OFF OFF X 2 OFF ON OFF X 3 ON ON OFF X 4 OFF OFF ON X 5 ON OFF ON X 6 OFF ON ON X 7 ON ON 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

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Figure 4-2. DRC-91C Status Register Mask and Status Register Format

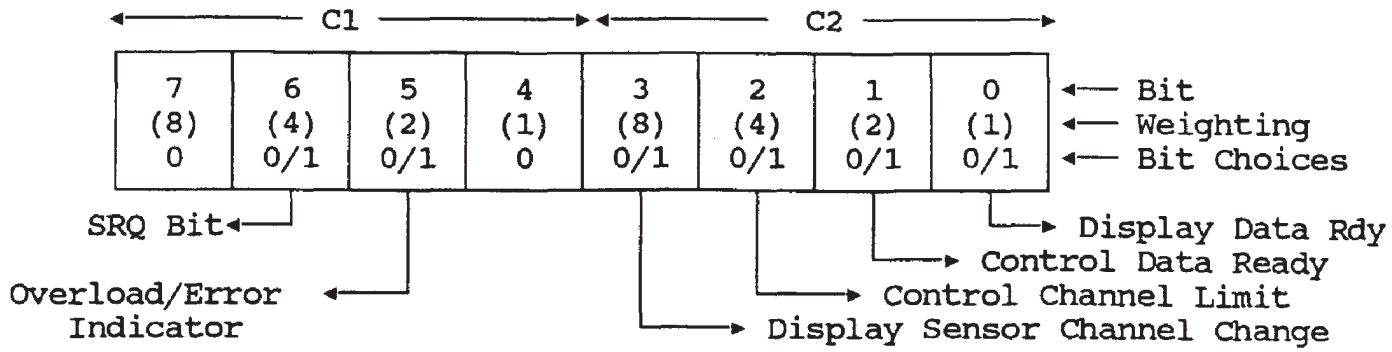


Table 4-14 Commands to Fix the Status Register Mask

QC_1C_2	Not Used	SRQ Bit	Overload /Error Indicator	Not Used	Display Channel Change	Control Data Limit	Control Data Ready	Display Data Ready
Bit	3	2	1	0	3	2	1	0
Weight	8	4	2	1	8	4	2	1
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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4.11.4 The "WQ" Data String

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

4.12 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 to be W1.

```
OUTPUT  712 ; "S123.4P45I30D25R4W1"
   |     |                  └── Data
   |     └── 12 = 91C preset address
   |           7 = IEEE 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.

```
? U , S123.4P45I30D25R4W1 (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-91C'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-91C 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 program code will be entered after the appropriate terminators have been sent over the bus.

4.12.1 Output Data Statements

The DRC-91C's Output Requests for Data Statements are summarized in Table 4-5.

The DRC-91C will always respond when asked to talk with the last command sent to it, i.e., if W0 is sent once then the 91C will always output the W0 information whenever it is asked to talk as long as it has not received another output data statement.

4.12.2 The "W0" Data String

The following example in HP Basic illustrate the commands associated with obtaining output data from the DRC-91C. The addition of the M0 command returns the instrument to front panel control where it stays even when data is requested from the 91C 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.

Command mode sent:

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

Data returned:

```
? 5 L +123.45K,+123.42,+123.40K
                        (CR)(LF)
                  └── Data returned
          └── 91C's Talk Address
      └── BUS CONTROLLER's Listen Add
  └── Universal Unlisten Command
```

The data above indicates that the display temperature is 123.45K and that the set point is 123.40K.

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Table 4-15. DRC-91C 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 $(\pm)N_1N_2N_3(.)N_4N_5(F)$, $(\pm)N_1N_2N_3(.)N_4N_5(C)$, $( )N_1N_2N_3(.)N_4N_5(R)$ 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 $(\pm)$ for the ° and °C scales.

4.13 SAMPLE PROGRAMMING

4.13.1 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-91C command such as "W0", the program will result in the display of the DRC-91C 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 91C, 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 91C
70  ENTER 712 ; A$                 ! RECEIVE ANSWER FROM 91C
80  DISP A$                        ! DISPLAY ANSWER
90  GOTO 50
100 END
```


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4.13.2 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$="91C"                    ! 91C is IEEE address label set up in IBCONF
80  CALL IBFIND(TEMP$,TEMP%)       ! Required command to address 91C
90  A$=SPACE$(255)                 ! 255 largest 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$)           ! Send command to 91C
130 CALL IBRD(TEMP%,A$)            ! ENTER from 91C (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 91C will return the data requested, but if the command input
190 REM  does not request new information, the 91C will give the information
200 REM  last requested.
```

4.13.3 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%
            TEMP$="dev12"
            call IBFIND(TEMP$,TEMP%)   'Required command to address instrument
            A$=space$(10000)
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 BELOW)
            FOR I = 1 to 10000
            C$ = MID$(A$, I,1)
            IF C$ = CHR$(13) THEN GOTO Loop2
            PRINT C$;
            NEXT I
Loop2:      PRINT
            A$ = space$(10000)             'Clear A$
            GOTO Loop1
            END
```


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```
'   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.
```

4.13.4 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$[19,26]                 ! Display Set Point Reading
100 DISP                                        ! Space a Line
110 OUTPUT 712;"W1"                             ! A and B Input information
120 ENTER 712;A$                                ! 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
```


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4.14 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.

4.14.1 The XDT Command

This command from the BUS CONTROLLER tells the DRC-91C 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.

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] !Nxt 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] !Crv 03
110 DISP FILETABLE$[111,128]!Crv 04
110 DISP FILETABLE$[129,152]!A00
120 DISP FILETABLE$[153,176]
130 DISP FILETABLE$[177,200]
140 DISP FILETABLE$[201,224]!TO A1F
150 DISP FILETABLE$[225,248]!B00
160 DISP FILETABLE$[249,272]
170 DISP FILETABLE$[273,296]
180 DISP FILETABLE$[297,319]!TO 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
```

4.14.2 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 4-17. 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.

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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_1N_2 Sensor Curve Output Format

Command	Output
XDN_1N_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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```
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
```

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.

4.14.3 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 91C 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**.

4.14.4 The XCN_1N_2 Command

The XCN_1N_2 command is the most powerful curve command in the 91C. 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, Capacitance 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

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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 ...,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 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.

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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-91C. General maintenance, fuse replacement, line voltage selection and performance testing is contained in this section.

5.2 GENERAL MAINTENANCE

Clean the DRC-91C 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-91C. 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-91C. 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-91C 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-91C. The test connector can be made by taking one of the plugs supplied with the DRC-91C 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-91C 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-91C to line power and turn the unit ON. Verify that the DRC-91C initializes to the proper POWER-ON state as defined in Section 3.7.

The following procedure is used to test the overall DRC-91C 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-91C is located on the front page of every DRC-91C manual.

b. The DRC-91C 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 A or B Display 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 5-1) 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 S7-1.

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 25 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 25 ohms or less. The heater circuit has a compliance voltage limit of 25 volts, so a resistor larger than 25 ohms will limit the current to 25 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 44 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-91C with standard diode A and B inputs. For other configurations, refer to Section VI for the specific Input Card present in the unit.

5.6.1 Input Card Calibration

Calibrate each input card as specified in Section VI 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 25 watts for the DRC-91C, the optional power output installed should be indicated on the front page of this manual.

1. Use a load resistor between 10 and 25 ohms with a wattage rating equivalent to its resistance. The W60 output requires a 25 ohm load 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 0.458 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-91C 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 VI).

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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 LOCAL 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-91C does not have output power check to see that U13 on Figure 91C-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-91C 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 increase. 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. The V+ can be checked by measuring approximately 28V from TP21 to TP1. The V+ value is over 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 installed the V+ voltage should be approximately 44 volts.

If the Voltage from TP19 to TP21 is

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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 I0-1000Ω +0.5% fr Ik-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 I0-10kΩ +0.25%fr I0k-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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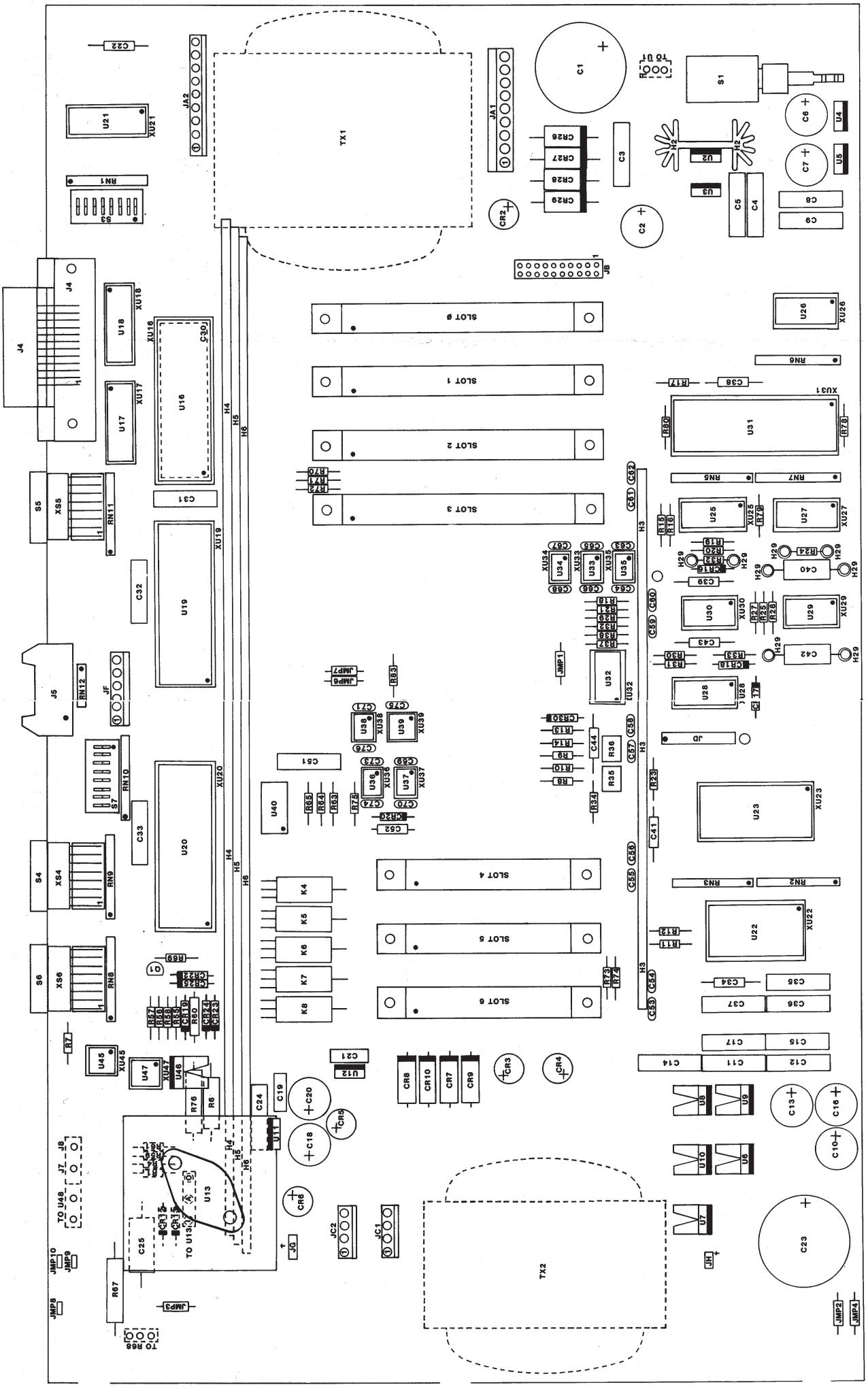


Figure 91C–1a. Component Layout – DRC–91C Main Board

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REPLACEABLE PARTS LIST - DRC-91C 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	101-225	8	CAP,ELECT,470MF,35V	PAN	ECEAIVV471S
C23	101-238	1	CAP,ELECT,2100MF,75V	MEP	3186BA212U075AMA1
C40,42	101-034	2	CAP,PP,1MF,100V	FDYNE	MPP2X-1.0-100-10
CR2-6	102-008	5	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
JB	106-419	1	CONNECTOR (DB TO MB)	3M	3592-6002
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
K4-K7	105-302	4	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	103-399	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 ,1/4W,1%		
R66	103-586	1	RES,MTF,3.5 , 1 W,1%		
R67	103-583	1	RES,MTF,1.25 , 3 W,1%		
R76	103-675	1	RES,WWD,587 , 3 W,1%		
S1	105-014	1	POWER SWITCH (2 POLE)	ITT	F-01-2UEE/NE15-1B
S3-7	105-408	5	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
U1,2,10	102-011	3	REGULATOR, +5V	MOT	MC7805ACT
U3	102-021	1	REGULATOR, -5V		7905CT
U4,7 11,12	102-014	4	REGULATOR, +15V		7815CT
U5,8	102-024	2	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
U25-27	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	104-355	5	IC, OPTOCOUPLER	GI	740L6000
U38	104-456	1	IC, OPTOCOUPLER	GI	740L6010
U39	104-453	1	IC, 8 BIT A/D CONVERTER	NAT	ADC0831CCN
U40	104-210	1	IC, HEX INVERTER, O.C.		7406
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-91C

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
H5	105-671	1	KEY TOP - BLUE	LSCI	105-671
H6	105-676	2	KEY TOP - LIGHT GREY	LSCI	105-676
H7	105-143	3	KNOBS	ALCO	KNS501BA
H8	105-677	12	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	1	HEATER LO OUT - BLACK	EFJ	111-0103-001
J8	106-001	1	HEATER GND - BLACK	EFJ	111-0103-001
R68	103-765	1	POT,20 OHM, 10%,Z TAPER	CLAR	LSCI-765
S8	105-504	1	A/B CONTROL SELECT	C&K	7301-M-Y-Z-Q
U48	102-095	1	POWER MOSFET, 100V P-CH	IR	IRF9130
XU48	106-571	1	SOCKET,TO-3	AUG	M8080-1G40
JA	106-147	2	TX1 TO MB 9 POST CNNCTR	MOL	2139-09-50-3091
	110-150	16	CONNECTOR TERMINALS	MOL	2878-08-50-0116
TX1	109-019	1	INPUT TRANSFORMER	LSCI	C696-114
JC	106-135	2	TX2 TO MB 4 POST RCPTCL	MOL	2139-09-50-1041
	110-150	3	CONNECTOR TERMINALS	MOL	2878-08-50-0116
TX2	109-021	1	OUTPUT TRANSFORMER	LSCI	C696-115
B1	107-180	1	FAN ASSEMBLY	LSCI	107-180

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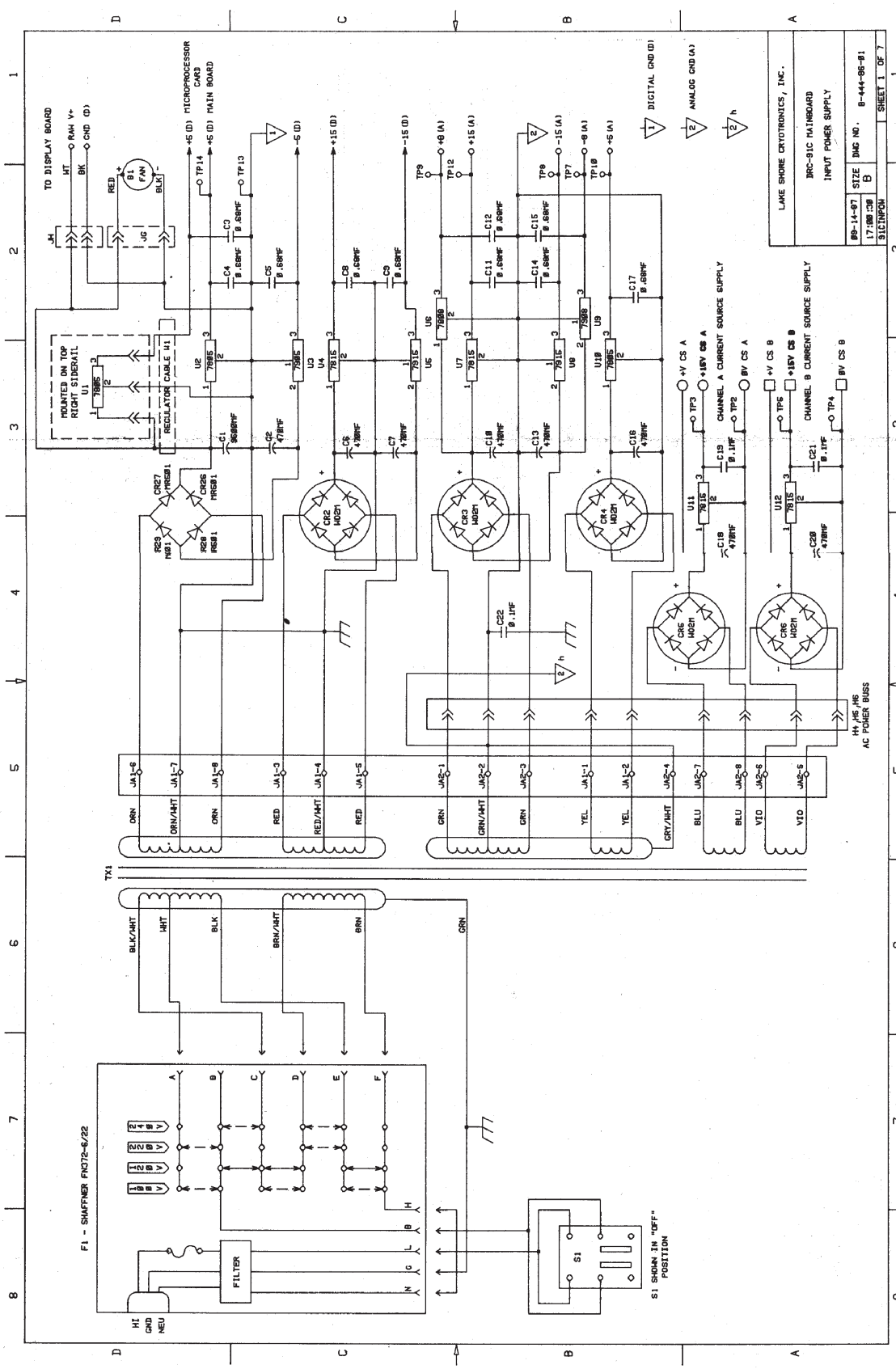


Figure 91C-1b. Schematic – DRC-91C Main Board #1 (Input Power Supply)

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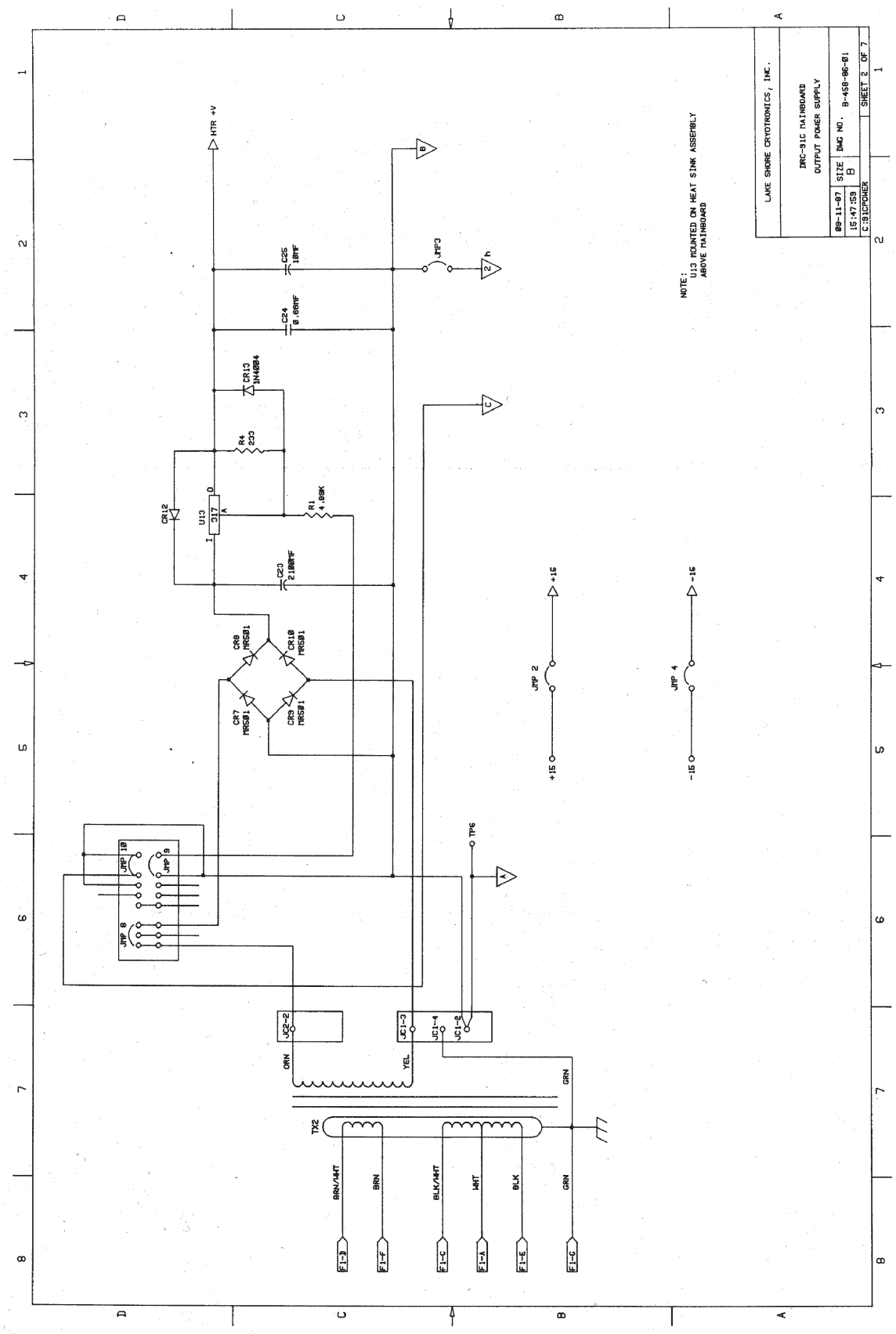


Figure 91C-1c. Schematic - DRC-91C Main Board #2 (Output Power Supply)

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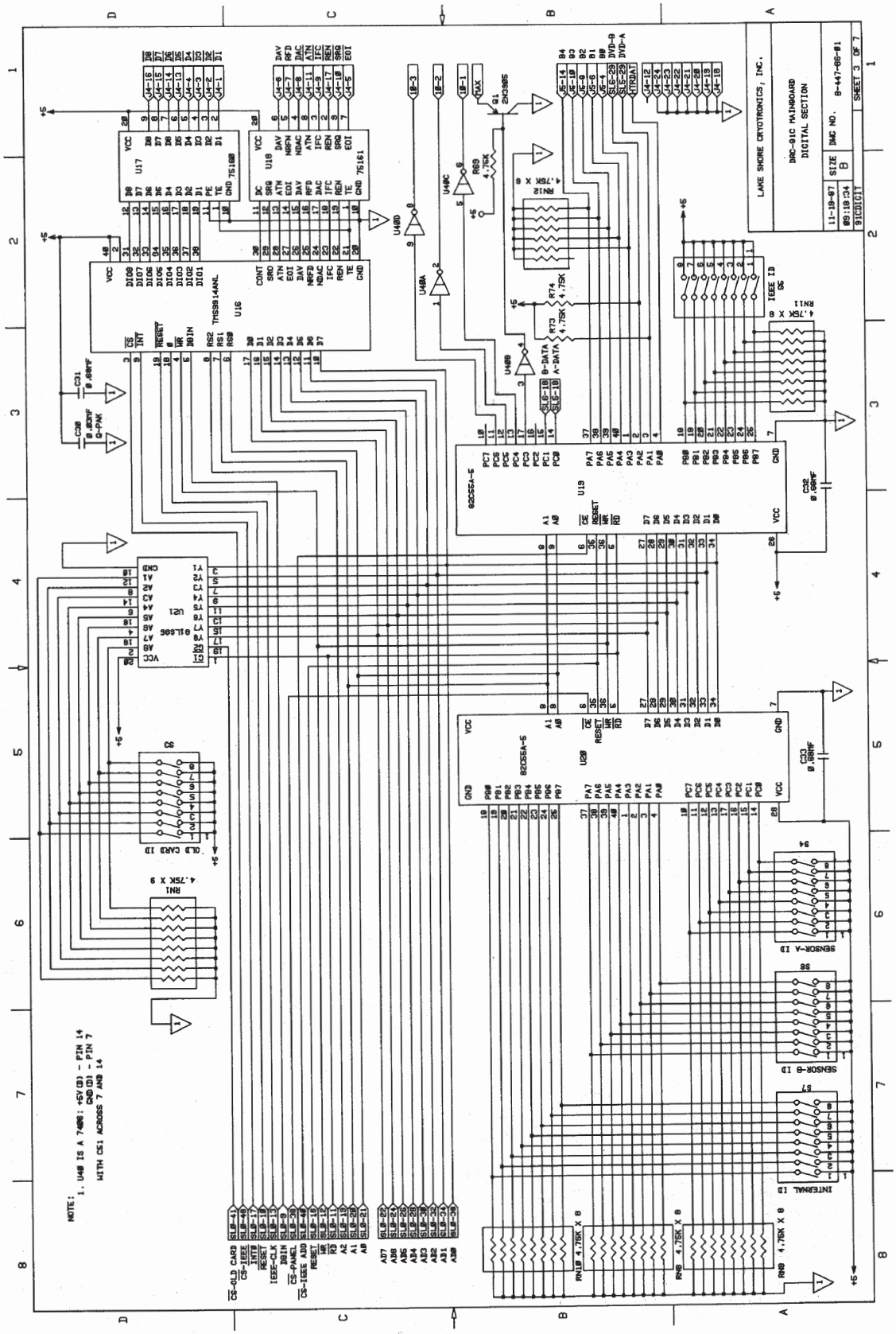


Figure 91C–1d. Schematic – DRC–91C Main Board #3 (Digital Section)

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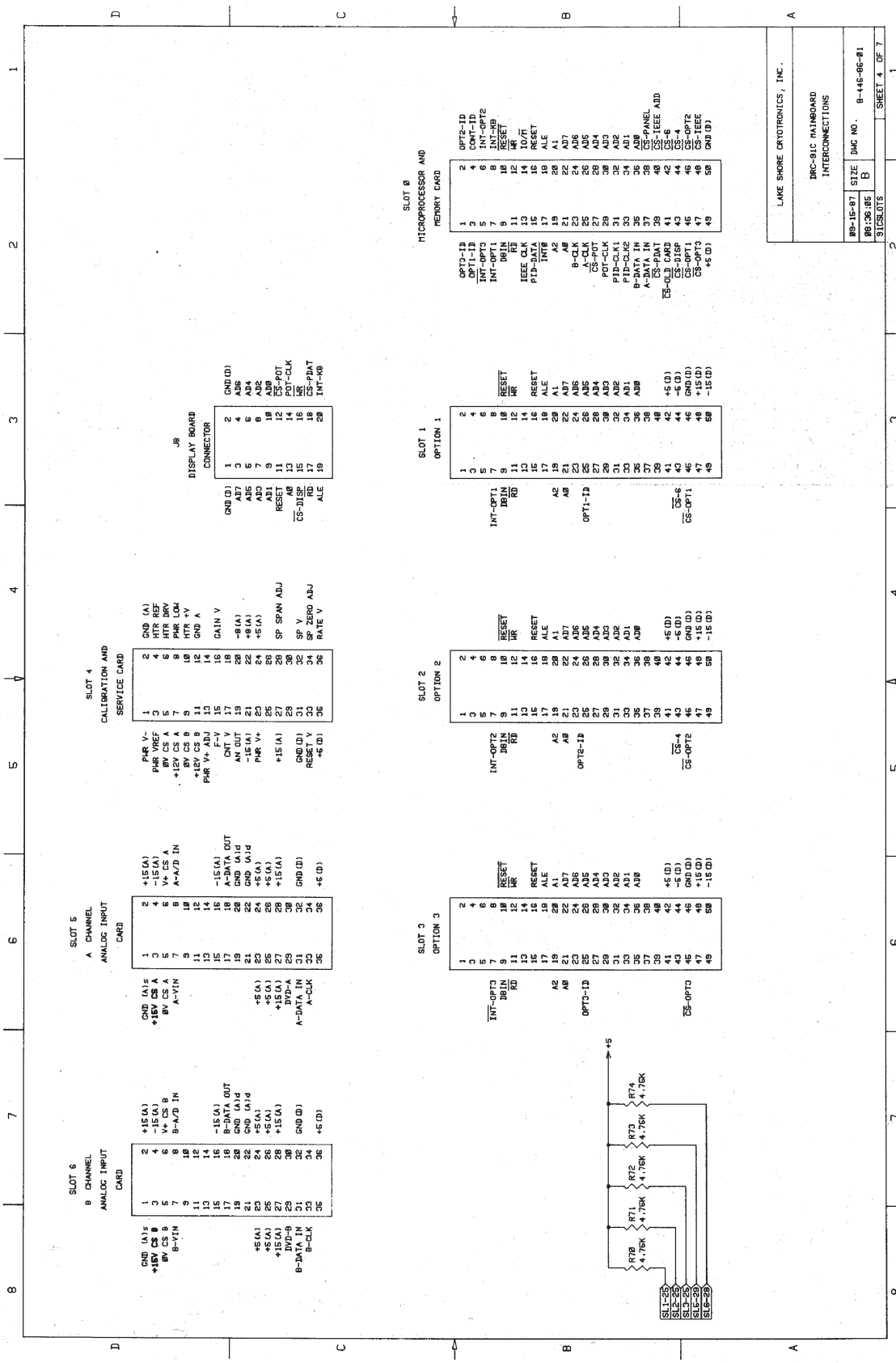


Figure 91C-1e. Schematic – DRC-91C Main Board #4 (Interconnections)

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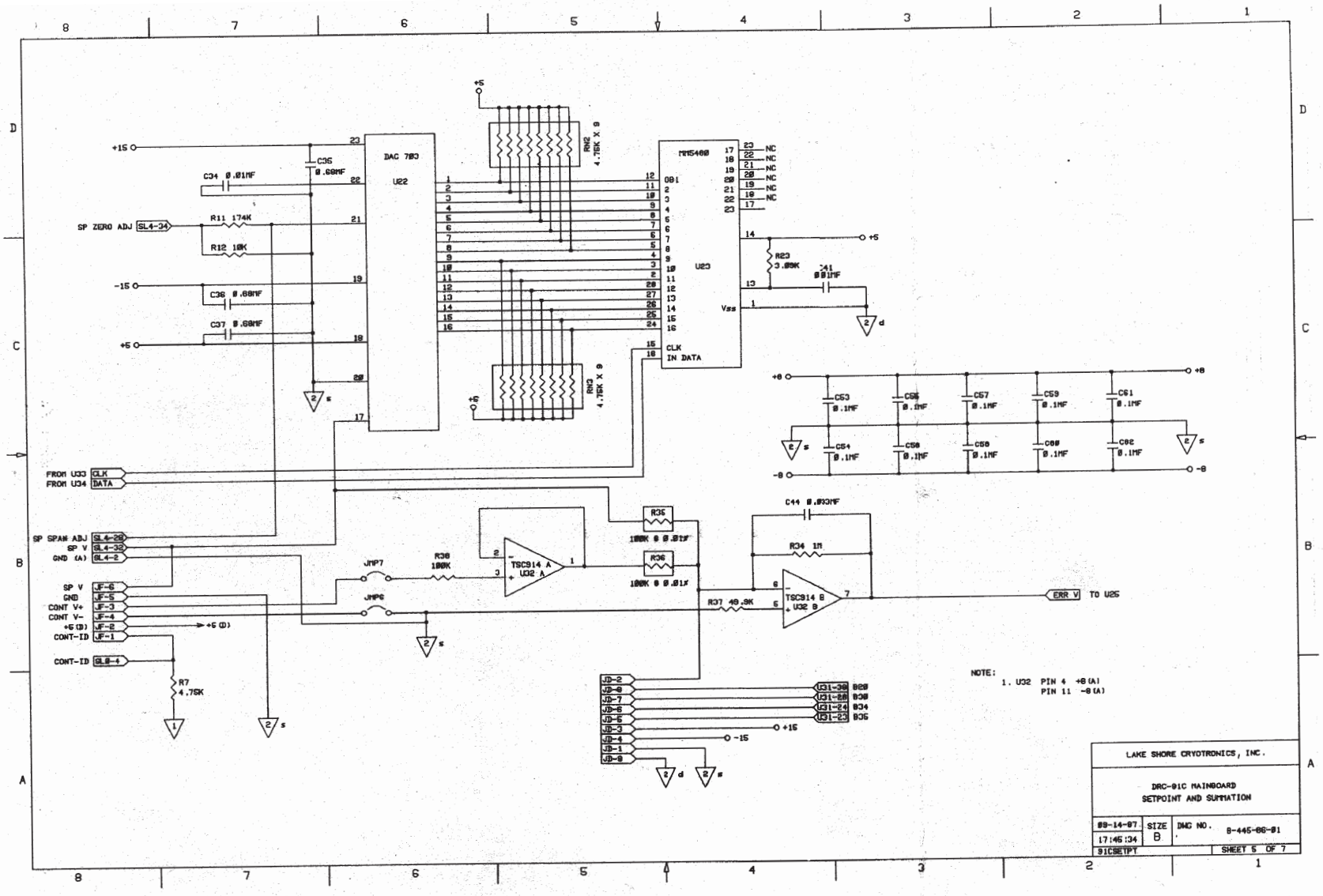


Figure 91C-1f. Schematic – DRC91C Main Board #5 (Setpoint and Summation)

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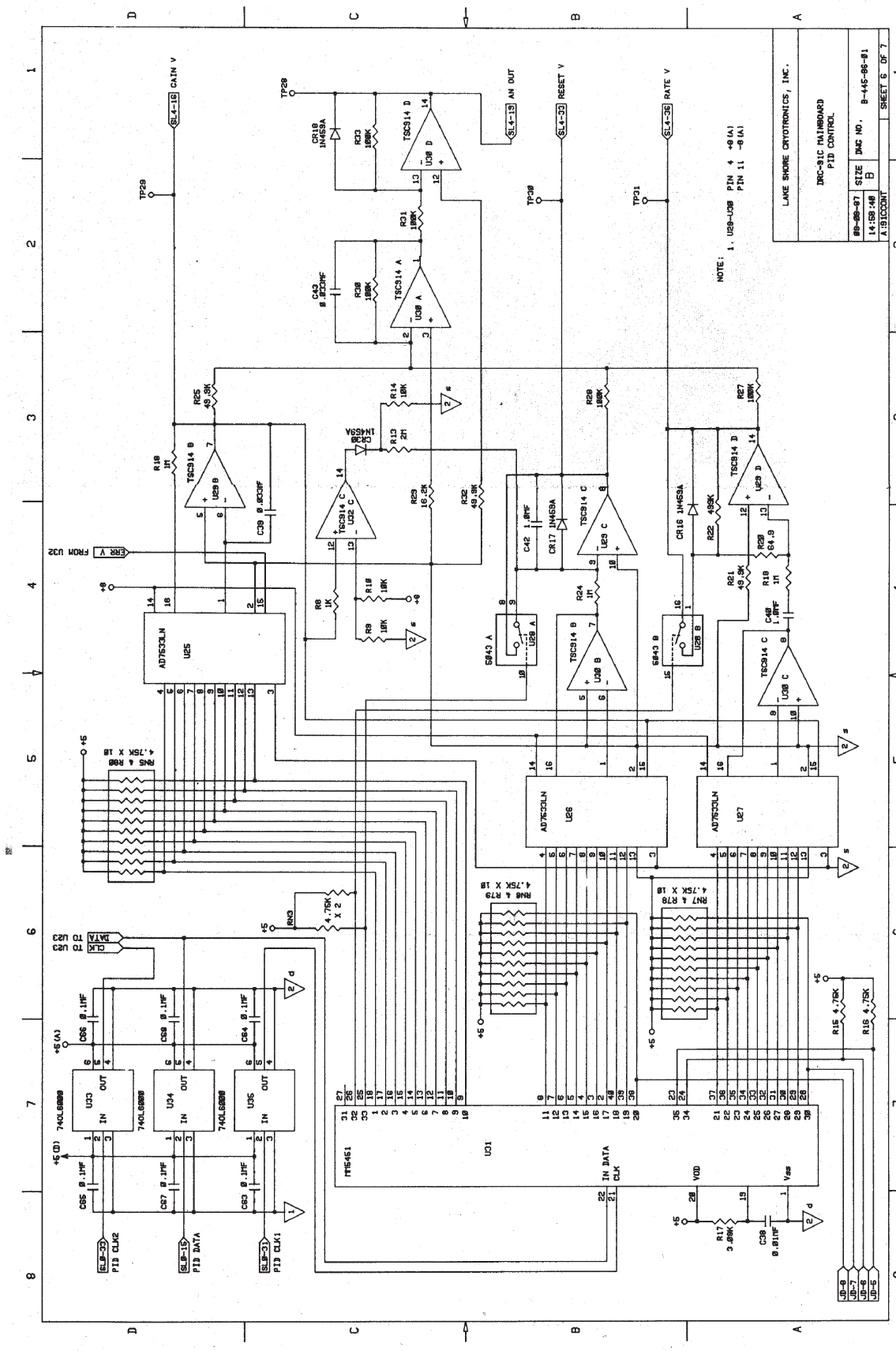


Figure 91C-1g. Schematic – DRC-91C Main Board #6 (PID Control)

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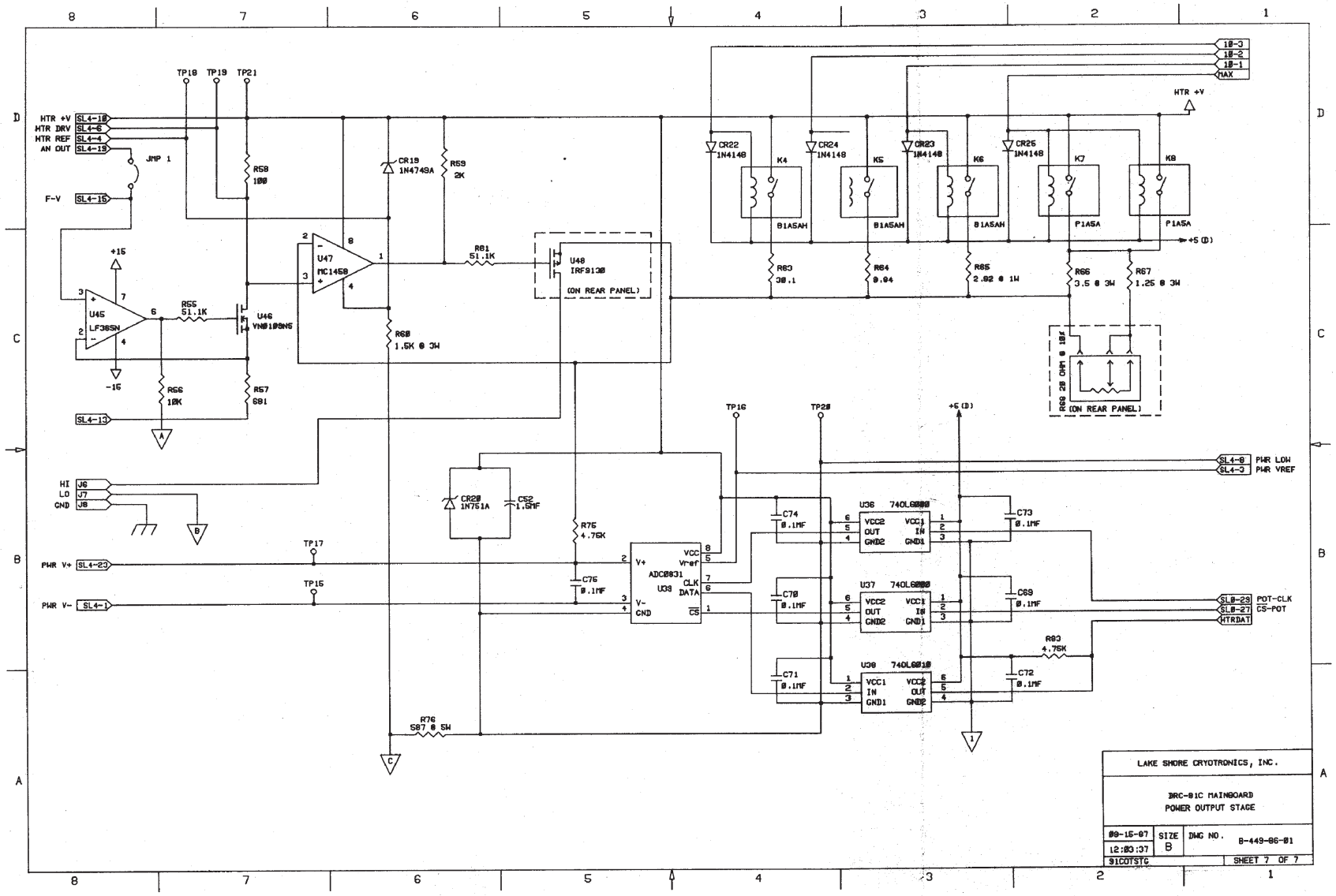


Figure 91C-1h. Schematic - DRC-91C Main Board #7 (Output Stage)

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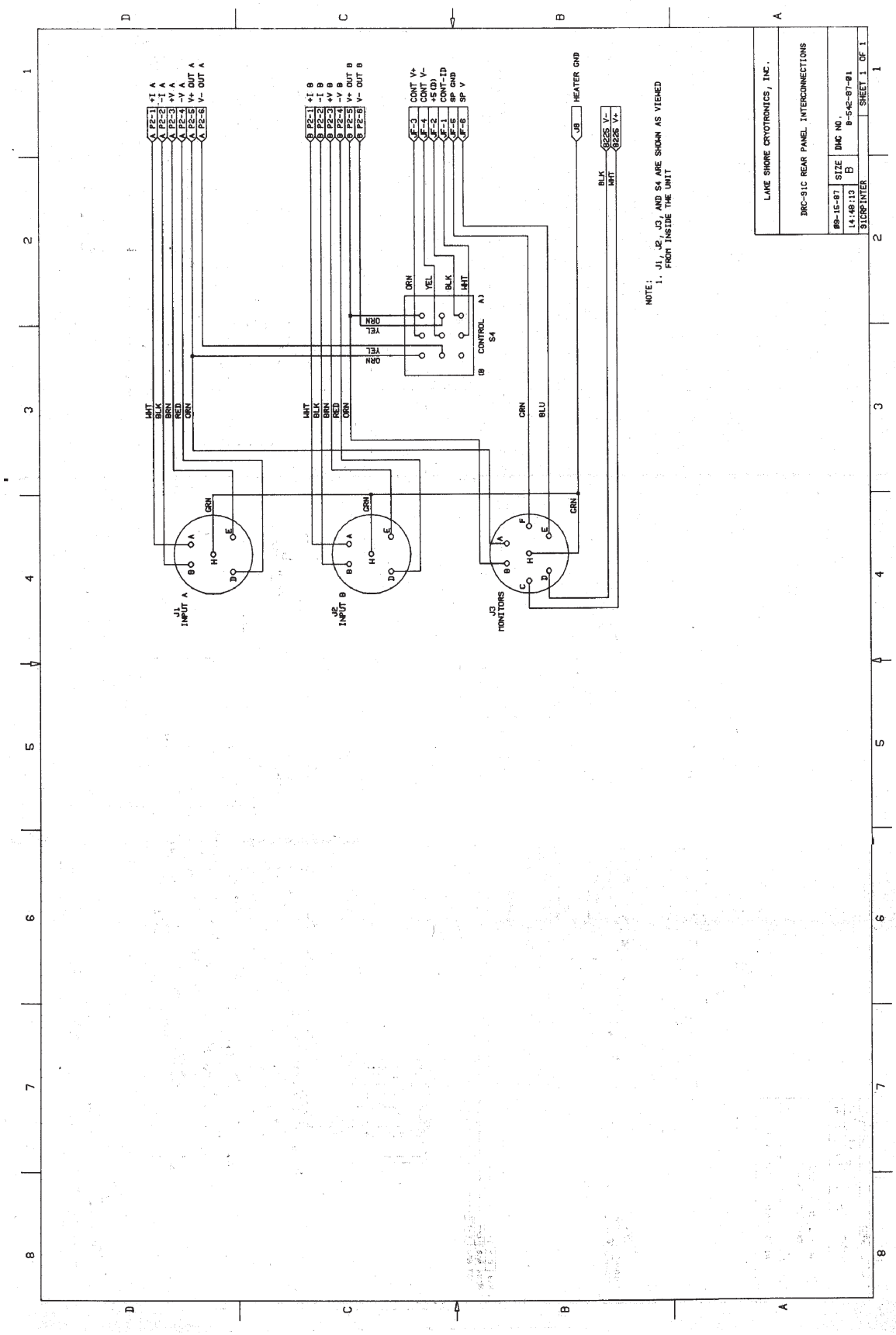
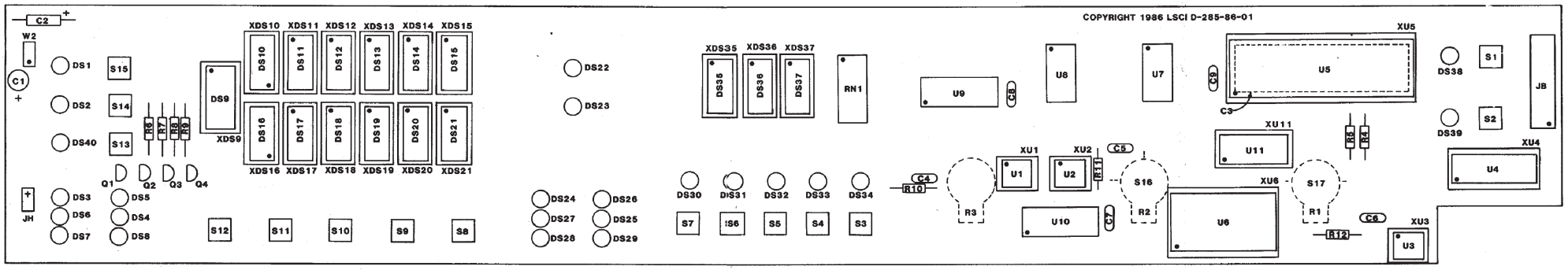


Figure 91C-1i. Schematic – DRC-91C Main Board #8 (Rear Panel Interconnections)

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REPLACEABLE PARTS LIST - DRC-91C DISPLAY BOARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
JB		1	CABLE (MB TO DB)	LSCI	
Q1-4	102-072	4	TRANSISTOR, SIGNAL PNP		2N3906
R1/S17	105-146	2	SWITCH POT, 100K,CCW DET	CENT	BA12030018
R2/S16					
R3	105-145	1	POT, 100K	CENT	BA12010043
R6-9	103-200	4	RES, MTF, 4.99, 1W		
RN1	103-181	1	RES NET, 8X22 OHM IND	BOR	4116R-001-220
S1-15	105-651	15	SWITCH	ALPS	KEF 10901
U1-3	104-453	3	IC, 8 BIT A/D CONVERTER	NAT	ADC0831CCN
U4	104-310	1	IC, 8 BIT MULTIPLEXER	NAT	DM81LS95AN
U5	104-526	1	IC, KB/DISPLAY INTERFACE	INT	P8279-5
U6	104-277	1	IC, 4-16 LINE DECODER		74LS154N
U7,8	104-210	2	IC, INVERTER, O.C.		7406
U9,10	104-160	2	IC, TRANSISTOR DRIVER	SPRG	UDN-2585A
U11	104-261	1	IC, 3-8 LINE DECODER		74LS138
W1		1	CABLE (DB TO MB)	LSCI	
W2		1	CABLE (DB TO U12)	LSCI	

Figure 91C-2a. Component Layout - DRC-91C Display Board

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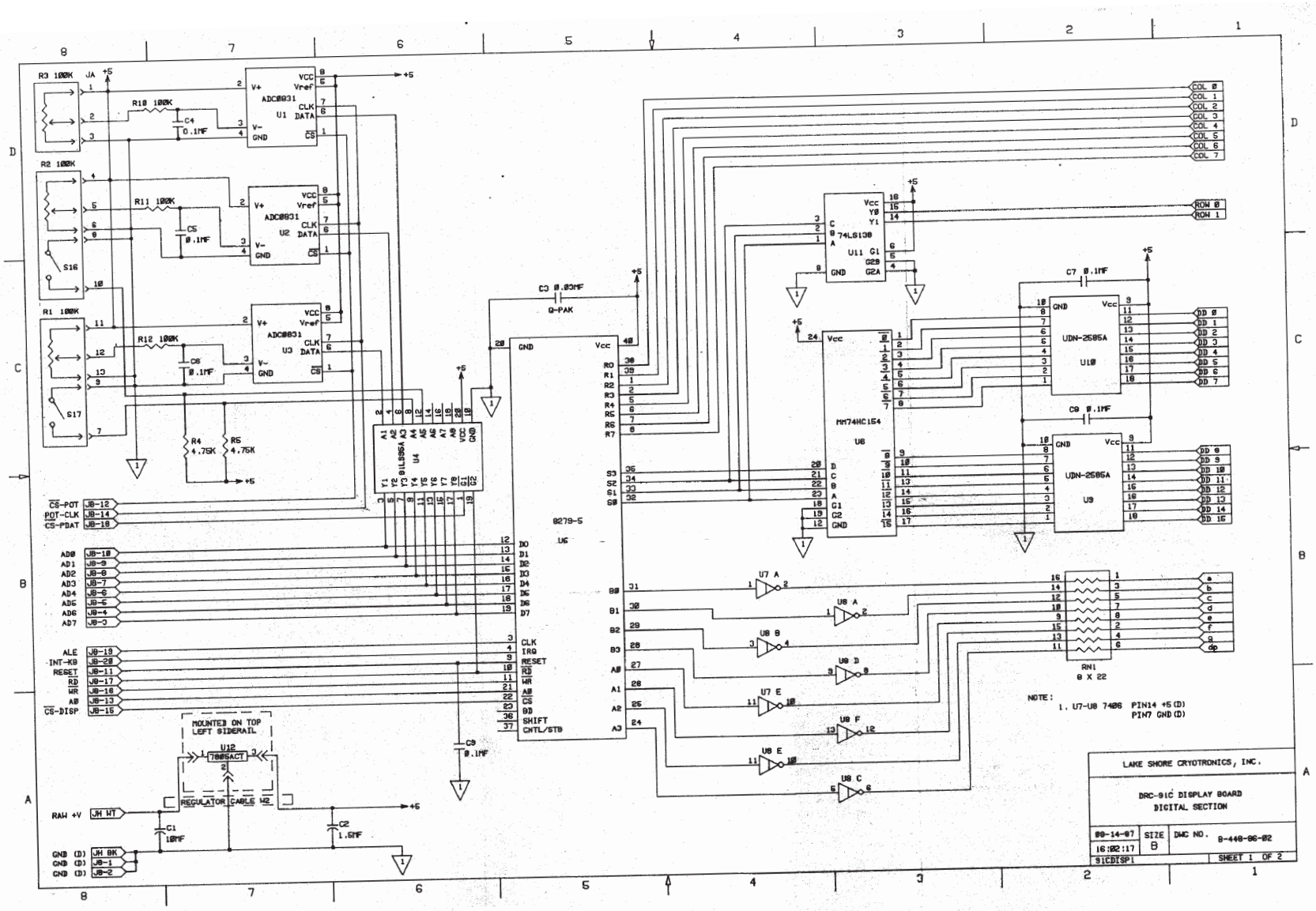


Figure 91C-2b. Schematic – DRC-91C Display Board #1

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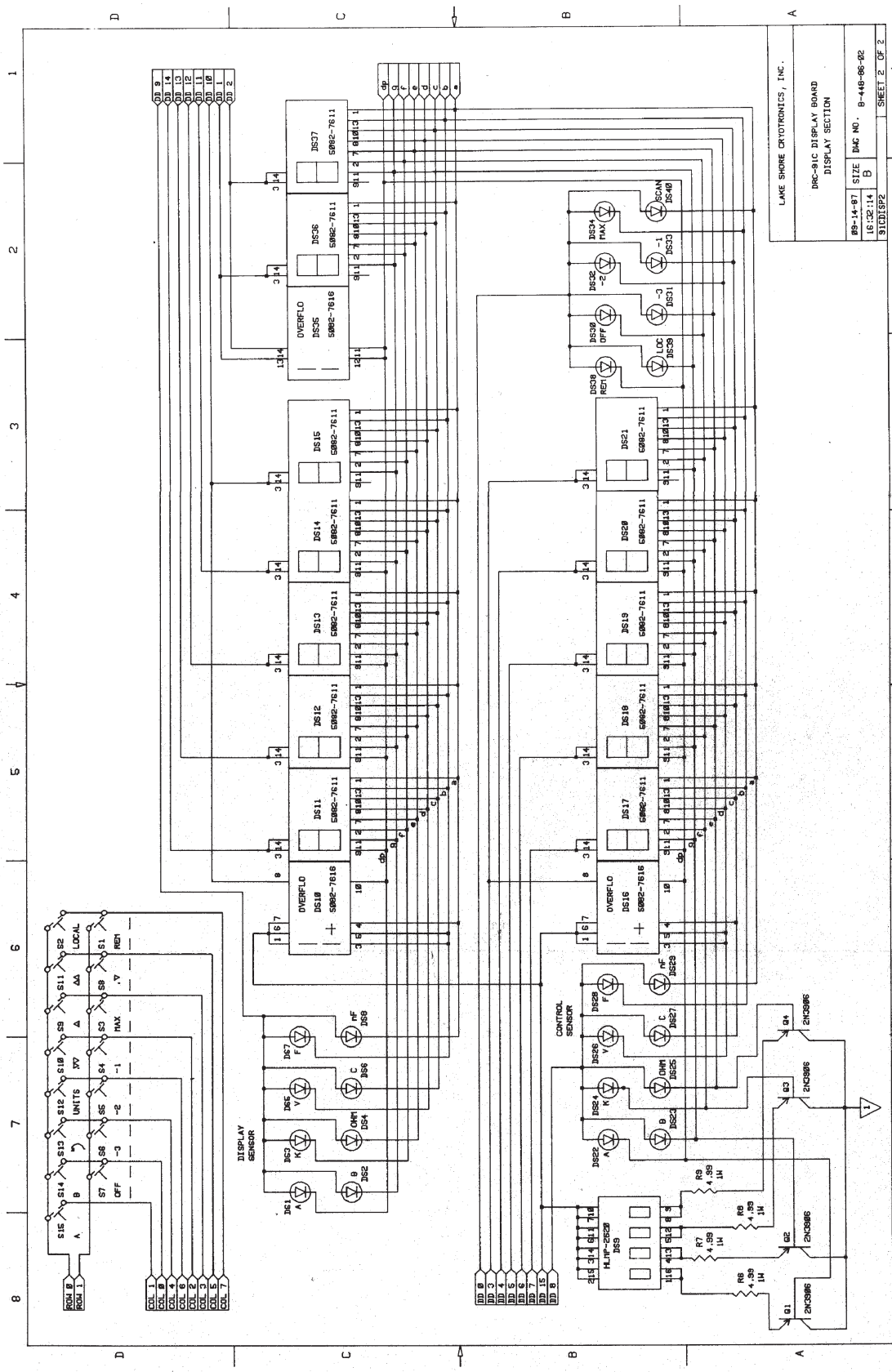
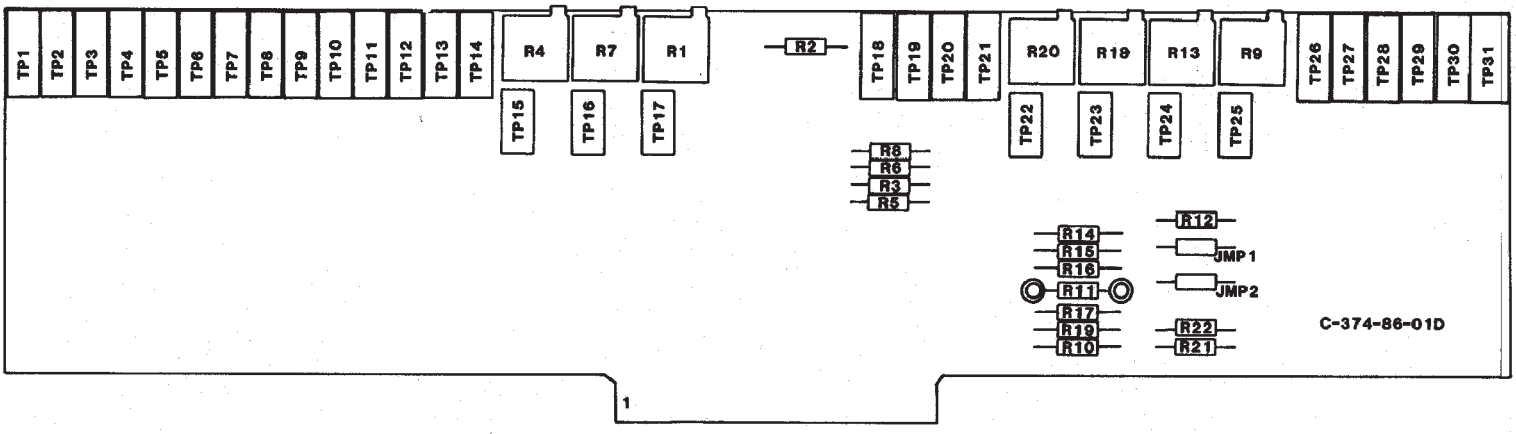


Figure 91C-2c. Schematic – DRC-91C Display Board #2

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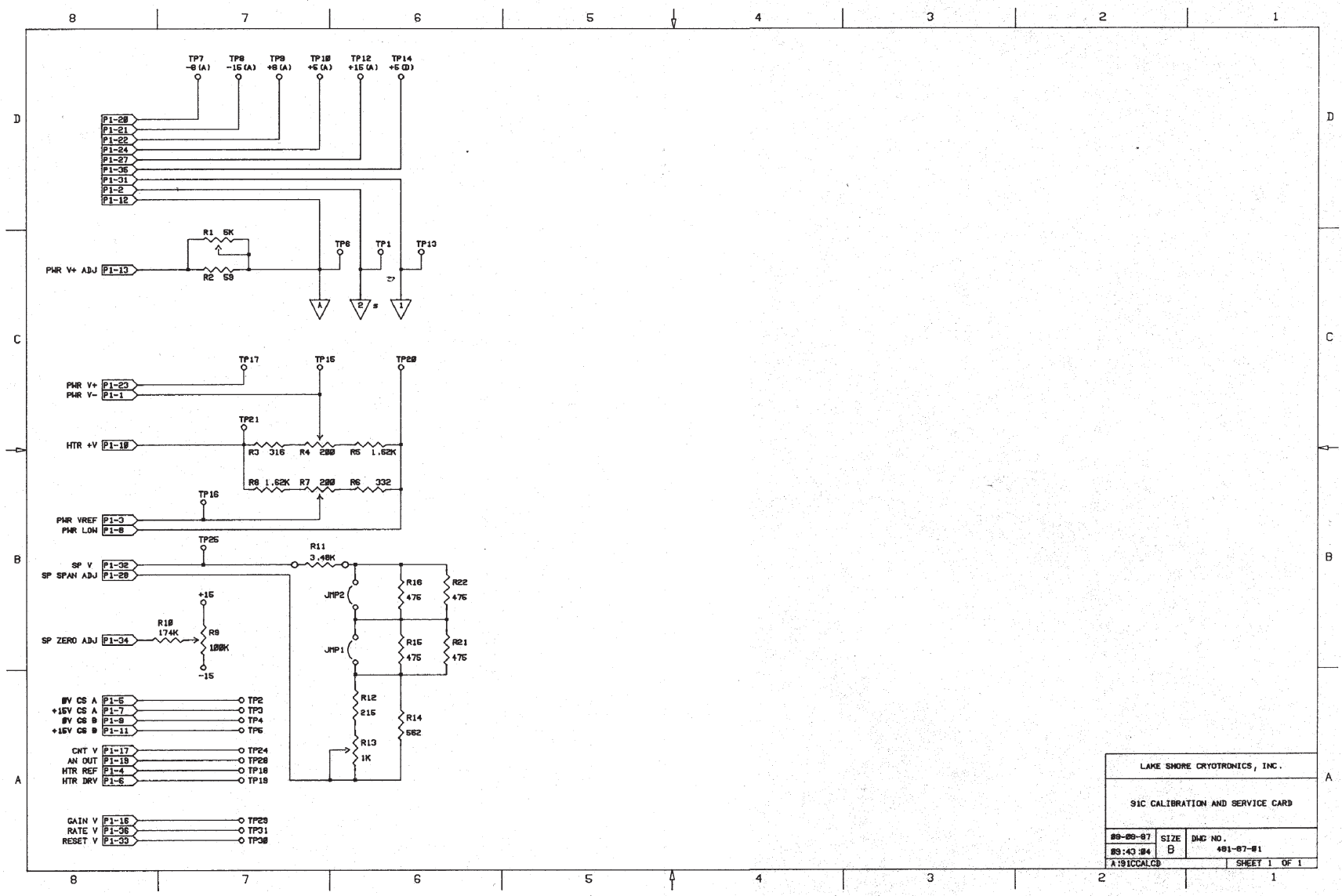
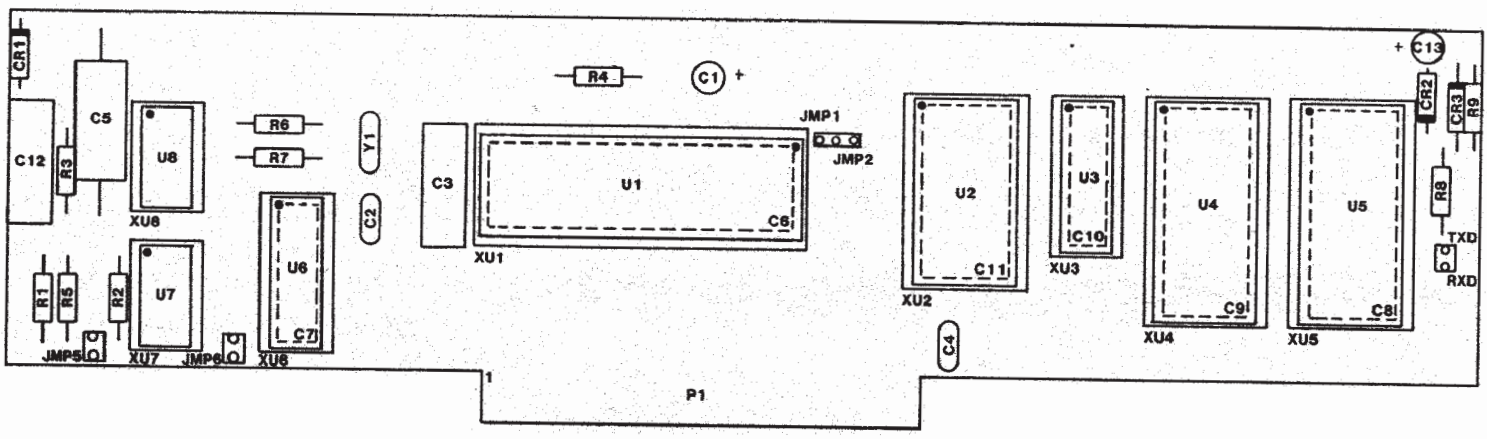


Figure 91C-3. DRC-91C Calibration and Service Card

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REPLACEABLE PARTS LIST - A9 MICROPROCESSOR CARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
C1	101-137	1	CAP,TANT,10MF,10V	SPRG	119D106X0035DB1
C2	101-059	1	CAP,MICA,10PF,500V	CDE	CD15CD100D03
C5	101-018	1	CAP,.047MF,POLY,600V	CDE	WMF6S47
C13	101-144	1	CAP,TANT,33MF,25V	SPRG	199D336X0025EA2
U1	104-511	1	IC,MICROPROCESSOR	INT	P80C31
U2	104-125	1	IC,4-16 LINE DECODER		74HC154
U3	104-528	1	IC,8 BIT LATCH		P82C82
U4	104-661	1	IC,EPROM (PROGRAM)		27C256
U5	104-653	1	IC 8KX8 NOVRAM	DAL	DS1225Y
U6	104-310	1	IC,8 BIT MULTIPLEXER	NAT	DM81LS95
U7	104-210	1	IC,O.C. HEX INVERTER		7406
U8	104-207	1	IC,HEX INVERTER		74LS04
Y1	103-990	1	CRYSTAL,5.000 MHZ	MTRON	MP1 5.000 MHZ

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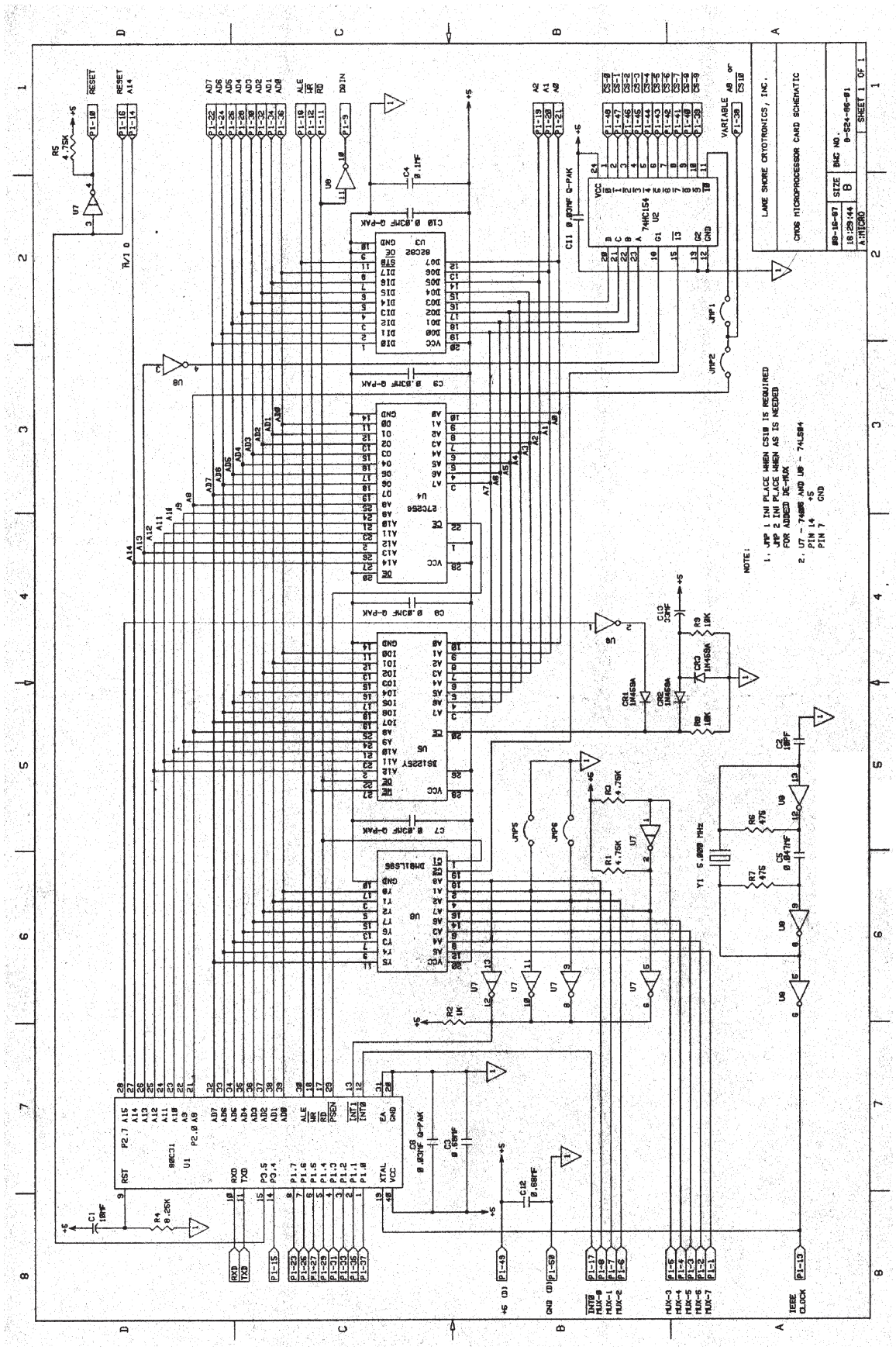


Figure 053. Microprocessor Card

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SECTION VI

ACCESSORIES, INPUT CARDS AND OPTIONS

TABLE OF CONTENTS

MODEL OR PART NUMBER	DESCRIPTION	PAGE
	ACCESSORIES	
RM-3F	Rack Mounting Kit	6-2
8072	IEEE-488 Interface Cable	6-2
8271-04	Scanner Sensor Cable for 8229	6-2
8271-21	Sensor/Heater Cable	6-2
8271-22	Sensor/Heater/Output Cable	6-2
HTR-50	50 ohm Cartridge Heater, 50 W	6-3
HTR-25	25 ohm Cartridge Heater, 25 W	6-3
	INPUT CARDS	
	"Old" Input Card Dip Switch Definitions (8210, 8211, 8219-P2, 8219-P3, 8219-R1)	6-3
9210	Diode Input Card	9210-1
9215	Capacitance Input Card	9215-1
9220	User configurable Input Card	9220-1
9305	Thermocouple Input Card	9305-1
9317C	Ultra-low (0.3K) Resistance Card . . .	9317C-1
9318C	Germanium/Carbon Glass Resistance Card	9318C-1
	OPTIONS	
8223	RS-232C Interface Option	8223-1
8225	Analog Output Option	8225-1
8229	Scanner Conversion Option	8229-1
9126	High Resolution Set Point Option . . .	9126-1

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6.1 INTRODUCTION

This section contains information concerning the Accessories, Input Cards and Options for use with the DRC-91C Temperature Controller. Each Accessory, Input Card and Option is listed by part number in the Table on page 6-1.

6.2 ACCESSORIES

6.2.1 RM-3F Rack Mounting Kit

The DRC-91C can be rack mounted in a standard 19 inch instrument rack by using the RM-3F Rack Mounting Kit. The RM-3F mounts one controller in a height of 3.5 inches. Use the following procedure to install the RM-3F Kit.

1. Remove the two blue rack mount access covers, if present, from the front-side corners of the unit to be rack mounted. This is easily done by sliding the cover up as far as possible and using a blade screwdriver on the bottom edge to remove it from its position.

2. If the -H (handles) option was added, mount the handles onto the rack ears.

3. Attach the rack ears on opposite sides of the unit.

6.2.2 Cables

6.2.2.1 8072 IEEE-488 Interface Cable - The 8072 IEEE-488 Interface cable is one meter long and is equipped with double-ended connectors so it may be interconnected in serial or star patterns common in IEEE-488 instrument configurations.

6.2.2.2 8271-04 Scanner Sensor Cable - The 8271-04 Scanner Sensor cable for the 8229 Scanner Card is 3 meters long and brings out leads for the four additional input sensors provided by the 8229 Option. The cable's mechanical and electrical specifications are included with the cable.

6.2.2.3 8271-21 Sensor/Heater Cable - The 8271-21 Sensor/Heater Cable. is a six pair individually shielded cable with two five pin miniature hexagonal plugs which mate with the SENSOR A and SENSOR B connectors on the back panel of the DRC-91C Temperature Controller. In addition to the sensor connectors, it has a dual banana plug for heater output and a single banana plug for heater output shield.

The cable's mechanical and electrical specifications are included with the cable.

6.2.2.4 8271-22 Sensor/Heater/ Output Cable - The 8271-22 Sensor/Heater/Output Cable consists of two discrete cables. The first is a six pair individually shielded cable with two five pin miniature hexagonal plugs which mate with the SENSOR A and SENSOR B connectors on the back panel of the DRC-91C Temperature Controller. In addition to the sensor connectors, it has a dual banana plug for heater output and a single banana plug for heater output shield. The second cable is a three pair overall shielded cable for the Monitors Outputs.

The cable's mechanical and electrical specifications are included with the cable.

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6.2.3 Cartridge Heaters

6.2.3.1 50 Ohm Cartridge Heater

This cartridge heater is 1/4" in diameter by 1" in length and is rated at 50 watts.

6.2.3.2 25 Ohm Cartridge Heater

This cartridge heater is 3/8" in diameter by 1" in length and is rated at 25 watts.

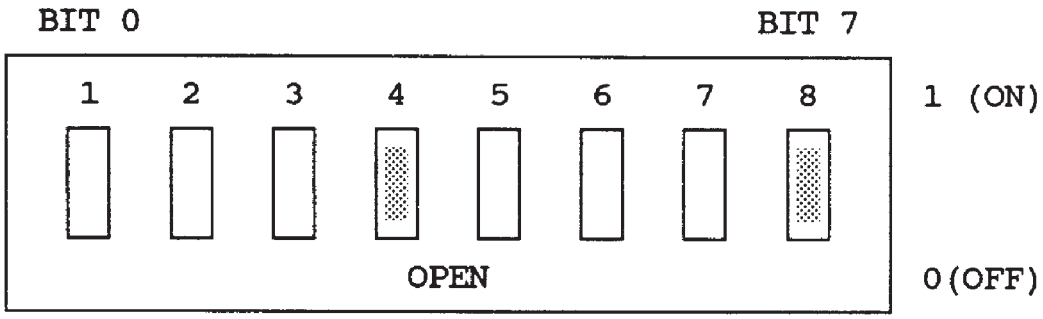
6.3 Installation of Input Cards from a DRC-81C or DRC-82C

Input cards from the DRC-81C or DRC-82C can be used in the DRC-91C. The DRC-91C will recognize these cards if the dip switch settings are set correctly. This Dip Switch is located in the rear right hand corner of the main board below the AC input connector.

WARNING

To prevent shock hazard, turn off the instrument and disconnect it from the AC line power before changing the Input Card switch settings.

"OLD" INPUT CARD DIP SWITCH DEFINITIONS



1	2	3	4	5	6	7	8	A INPUT CARD	B INPUT CARD
0	0	0	X	0	0	0	X	NEW CARD (NON 8210,8211 OR 8219)	
0	0	1	X	0	0	0	X	8210	NEW CARD
0	1	0	X	0	0	0	X	8211	NEW CARD
1	0	0	X	0	0	0	X	8219-P2	NEW CARD
1	0	1	X	0	0	0	X	8219-P3	NEW CARD
1	1	0	X	0	0	0	X	8219-R1	NEW CARD
1	1	1	X	0	0	0	X	EMPTY	NEW CARD
0	0	0	X	0	0	1	X	NEW CARD	8210
0	0	0	X	0	1	0	X	NEW CARD	8211
0	0	0	X	1	0	0	X	NEW CARD	8219-P2
0	0	0	X	1	0	1	X	NEW CARD	8219-P3
0	0	0	X	1	1	0	X	NEW CARD	8219-R1
0	0	0	X	1	1	1	X	NEW CARD	EMPTY
ALSO COMBINATIONS OF A AND B									

X DON'T CARE - SWITCHES 4 AND 8 ARE RESERVED

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9210 DIODE INPUT CARD OPTION

9210.1 INTRODUCTION

This section contains information pertaining to the Model 9210 Diode Input Card. Included is a description, specifications, installation, operation and maintenance information.

9210.2 DESCRIPTION

The Model 9210 Diode Input Card is designed to be installed in a DRC-91C or DRC-93C to convert either the Input A or Input B (or both with two options) to accommodate diode sensors with a voltage output of up to 3.0000 volts (9210-3 configuration). The 9210-3 is used with Lake Shore DT-500-DRC or DT-470 Series Sensors. Calibrated DT-500 or DT-470 Series Sensors can be accommodated with an 8000 Series Precision Option.

The 9210-6 configuration will accommodate diode sensors (TG-120 series) with voltages between 0 and 6.5535 volts. A calibrated sensor and 8001 Precision Option is required for the DRC-91C/93C to read accurately in temperature. 9210-3 can be converted to 9210-6 configuration by switch on the 9210 Diode Input Option Card. This configuration will also read DT-470 and DT-500 series sensors but with reduced resolution and accuracy. See Table 9210-1.

9210.3 SPECIFICATIONS

Specifications for the Model 9210 Diode Input Card are given in Table 9210-1. The card can be configured by the user as either a 3 volt (9210-3) or a 6 volt (9210-6) card.

Table 9210-1. 9210 Diode Card

Sensor (ordered separately): DT-470 series, DT-500 series and TG-120 series from LSCI as well as any other diode sensor. See Lake Shore Diode Sensor brochures.

Temperature Range: Dependent on Diode Sensor. See Sensor brochure.

Sensor Excitation: DC current source. 10 microamperes (±0.005%). AC current noise less than 0.01% of DC current.— Compliance voltage - 7 volts minimum

Maximum Sensor Power Dissipation 20 microwatts @ 4.2K for DT-470 Series. 25 microwatts @ 4.2K for DT-500 Series. Dissipation under other conditions is a product of Sensor Excitation Current and developed sensor voltage.

9210-3:
Input Voltage Range: 0 to 3 V
Resolution: 0.05 millivolts
Accuracy: 0.1 millivolts
Display Resolution: 5 digits. Displays 0.0000 to 2.9999 volts. Equivalent temperature accuracy is a function of sensor type, sensitivity and curve specification or Precision Option.

9210-6:
Input Voltage Range: 0-6.5535V
Resolution: 0.1 millivolts
Accuracy: 0.2 millivolts
Display Resolution: 5 digits. displays 0.0000 to 6.5535 volts. equivalent temperature accuracy is a function of sensor type and sensitivity. Precision Option required for TG-120 Sensors.

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9210.4 INSTALLATION

The 9210 can be installed in the 91C/93C as either Input A or Input B (or both with two options). The 9210 is factory installed if ordered with a DRC-91C/93C Temperature Controller or can be field installed at a later date. If field installation is required, use the following procedure.

1. Set the POWER switch to OFF and disconnect the power cord from the unit. Remove the three top panel screws and slide the panel off. Note on the calibration cover the position of the Input Card the 9210 will occupy.

WARNING

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

2. Remove the four screws that secure the calibration cover to its clips and remove the cover.

3. If an Input Card must be removed, disconnect the wiring harness mating connector by lifting the locking tab on the Input Card connector and gently pulling on the body of the wiring harness mating connector.

4. Plug the new 9210 Input Card into the A Input Card Slot 5 or the B Input Card Slot 6 with the component side to the left of the unit as viewed from the front. Connect the wiring harness mating connector to the 9210 making sure that the wiring harness locking tab is seated over the extended edge of the wiring harness mating connector. Verify that the wiring harness is in place correctly by noting that the "A" or "B" on the harness mating connector is facing up (if it is not, review the harness installation again). Thread the wiring harness along the rear edge of the unit and slip it into the harness strain relief on the rear panel.

5. Install the calibration cover by reversing procedure 2.

6. Install the top panel.

9210.5 OPERATION

The Model 9210-3 Diode Configuration provides the 10 microampere excitation current to the sensor. The resulting sensor voltage is digitized by a 16 bit A/D converter with a resolution of 50 microvolts and a full scale input voltage of 3.0000 volts (100 microvolts and 6.5535 volts for the 9210-6 configuration). The digitized value is converted to a serial data string and transferred to the main microprocessor using optical isolation. The sensor voltage is also buffered and transferred to the rear panel MONITORS connector for external monitoring as well as for control selection. For the 9210-3 configuration, it is multiplied by 1, for the 9210-6 configuration it is multiplied by 0.457771 (3.0000/6.5535).

9210.6 CALIBRATION

The 9210 was calibrated to specification in the configuration specified prior to shipment. If recalibration is needed, refer to the following procedure. The following equipment is used to calibrate the 9210 Diode Input Card:

1. Digital Voltmeter/Multimeter (DVM) - 4½ digit resolution or better.

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2. Precision Standard Resistor - 100 kilohms with a tolerance of ±0.01% or better.

3. Precision Voltage Source - capable of supplying a voltage with an accuracy and resolution of 100 microvolts out of 10 volts or better.

The unit should be allowed a one hour warm-up time to achieve rated specifications. Use the following procedure to calibrate the 9210 Diode Input Card.

1. Remove the three top panel screws and slide the panel cover off.

2. **Set 10μA Current** - Connect the precision resistor across the A (+I) and B (-I) pins of the five pin input connector for the input the 9210 occupies. Connect the DVM plus lead to the +I pin and the minus lead to the -I pin. Adjust the trimpot marked 10μA on the calibration cover for the appropriate Input Card until the voltage across the resistor is 1.0000 ± 0.0001 volts.

3. **Calibrate the Buffered Sensor Output Signal.** Connect the DVM plus lead to the +V Buffered Sensor Output Signal pin for the appropriate Input Card and the minus lead to the -V pin on the MONITORS connector. Connect the precision voltage source across the E (+V) and D (-V) pins of the five pin input connector for the appropriate input. Set the standard to 1.5000 volts and adjust the trimpot marked **B** on the calibration cover until the DVM reads as close to 1.5000 volts as possible for the 9210-3 configuration and adjust the value to 0.68666 volts for the 9210-6 configuration.

4. **Calibrate the A/D Converter.** Verify that the Display selects the desired Input Card and that the units selected are V. Set the standard to 1.5000 volts for the 9210-3 and adjust the trimpot marked **A/D** until the display reads 1.5000 V. Check linearity by inputting 2.0000 and 1.0000 volts and verify that the unit displays those settings within ± 0.0001 volts (5.0000 and 1.0000 volts for the 9210-6). If this specification is not met, check the Technical Service Guide for further instructions.

5. Install the top cover panel.

9210.7 SENSOR CURVE INFORMATION

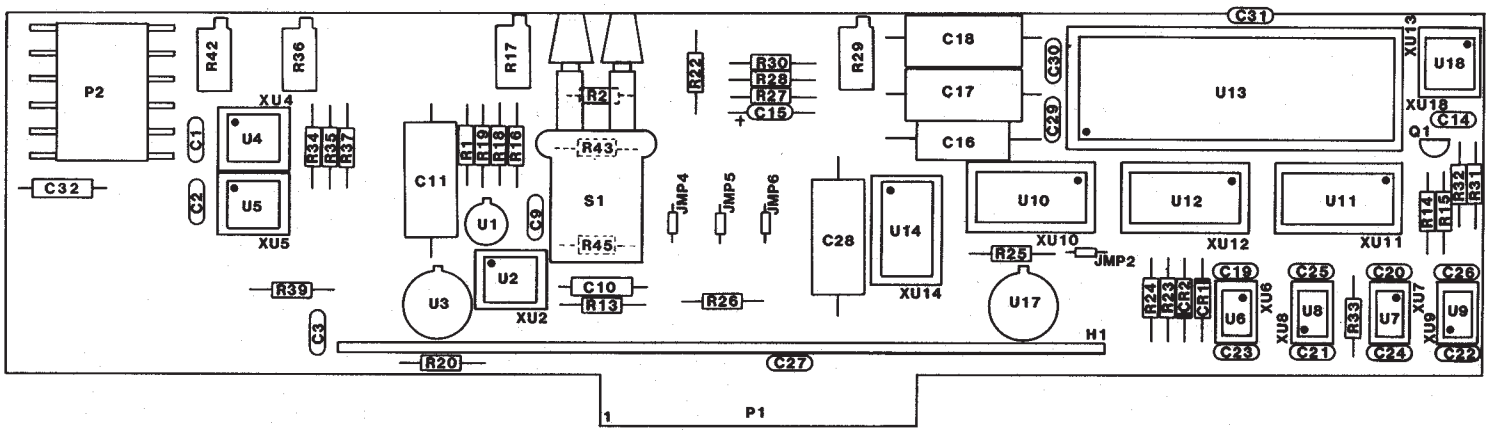
Sensor Curve data for use with the 9210 Diode Input Card must be put in table form consisting of voltage and temperature points with the voltage in ascending voltage order. Refer to Section 4 of this manual for a discussion of how the data must be formatted for entry into the unit over the remote interfaces and to Appendix B for a discussion of Precision Option curves and examples of curves that would be used with the 9210.

9210.8 REPLACEABLE PARTS

Included in this section is Figure 9210-1. It includes the Model 9210 Diode Input Schematics, replaceable parts list and illustrated component layout. Refer to the manual for ordering information.

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REPLACEABLE PARTS LIST - 9210 ANALOG INPUT CARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
C11,17 18,28	101-034	4	CAP,PP,1.0MF,100V	FDYNE	MPP2X-1.0-100-10
C16	101-025	1	CAP,PP,.33MF,100V	FDYNE	MPP-11.33MFD
P2	106-142	1	CONNECTOR, (IC TO BP) 6 POST LOCKING HEADER	MOL	2420-09-75-1061
Q1	102-072	1	TRANSISTOR,PNP,SIGNAL		2N3906
S1	105-649	1	SWITCH,2 POS,4 POLE INTERLOCKING	EGC	2XMTA7.5(NONE) 4UGRP
U1	102-074	1	MOSFET,P CHANNEL	SIL	3N163
U2	104-005	1	IC, OP AMP		LM308
U3,17	102-043	2	VOLTAGE REFERENCE,6.95V	NAT	LM399H
U4,5	104-001	2	IC, OP AMP	PMI	OP07E
U6,8,9	104-355	3	IC, OPTOCOUPLER	GI	740L6000
U7	104-356	1	IC, OPTOCOUPLER	GI	740L6010
U10-12	104-099	3	IC, P-S SHIFT REGISTER		CD4021BCN
U13	104-461	1	IC, A/D CONVERTER	ISL	ICL7104-16CPL
U14	104-460	1	IC, A/D REFERENCE	ISL	ICL8068ACPD
U18	104-051	1	IC, TIMER	ISL	ICM7555IPA

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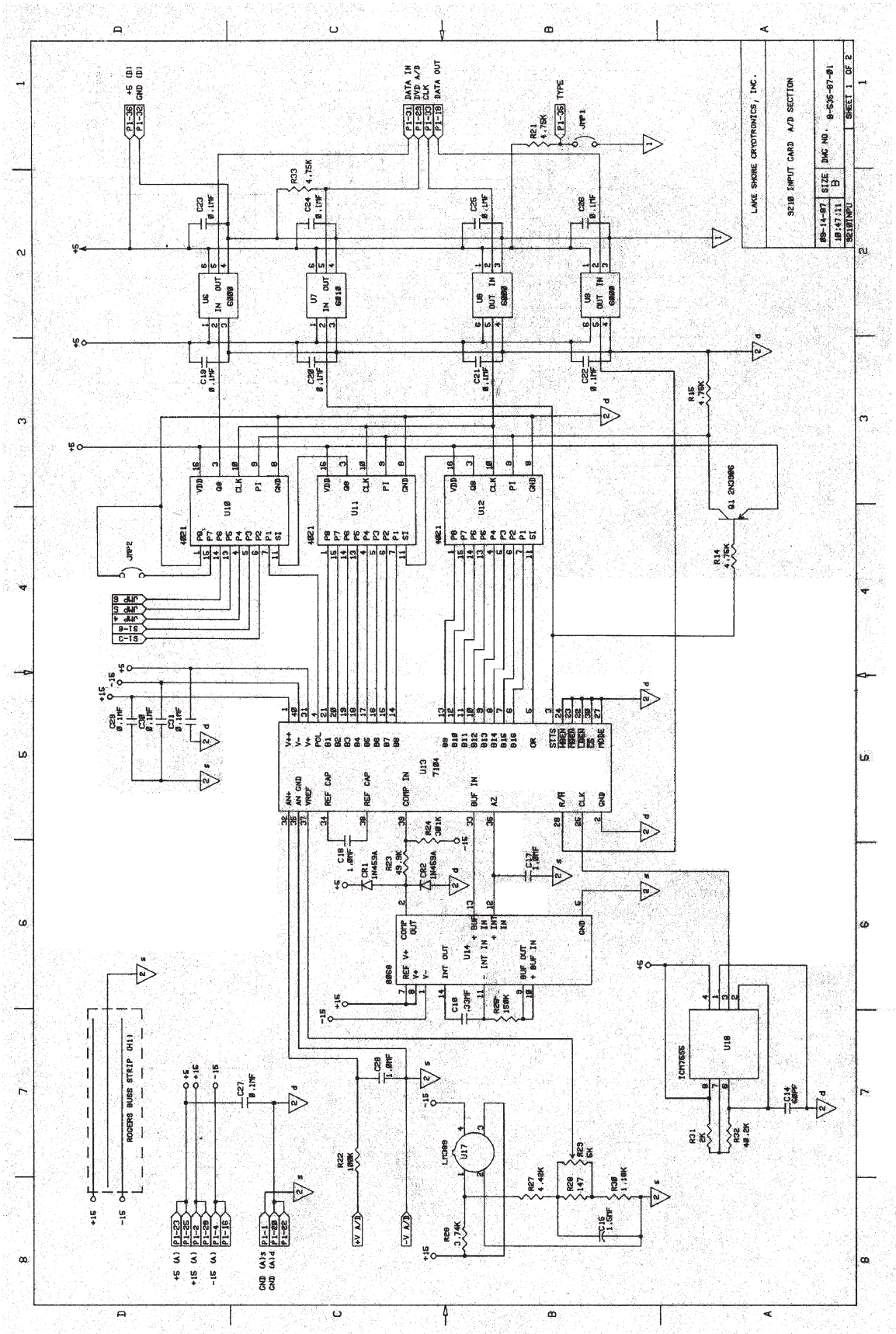
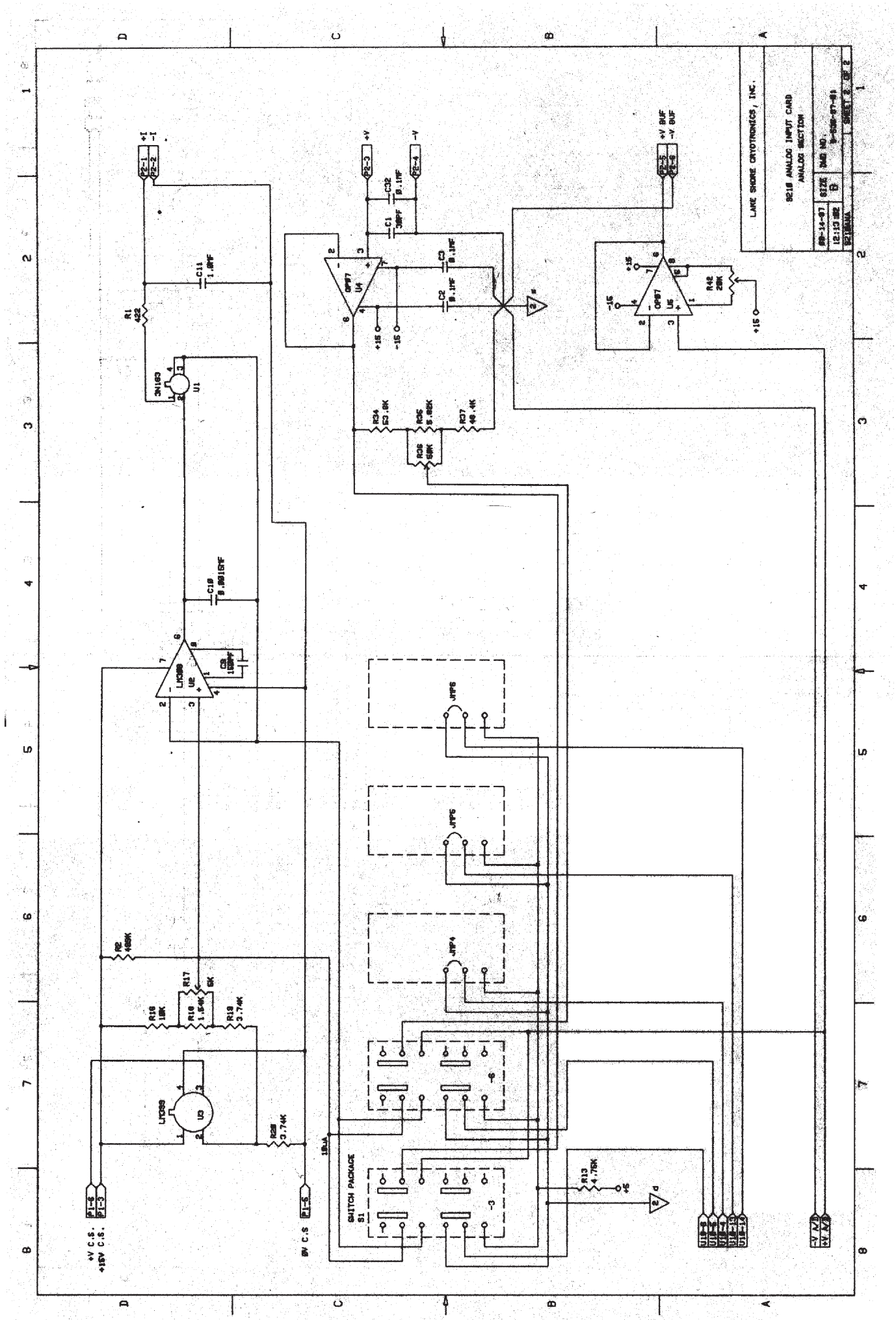


Figure 9210–1. Model 9210 Diode Input Card

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9215 CAPACITANCE INPUT CARD OPTION

9215.1 INTRODUCTION

This section contains information pertaining to the Model 9215-15/9215-150 Capacitance Input Card Configurations. Specifications, installation and operating instructions, a description of the principle of operation, and maintenance information are included. Section 9215.3 describes some characteristics of Capacitance sensors.

9215.2 DESCRIPTION AND SPECIFICATIONS

The Model 9215 Capacitance Input Card is designed to be installed in a DRC-91C or DRC-93C to convert either Input A or Input B to accommodate Capacitance sensors. When used to control temperature in magnetic fields the capacitance sensor is superior to other sensors since the displacement current in a capacitor is magnetic field independent. Accurate temperature reading requires the use of another type of sensor in zero magnetic field. This accurate sensor can be placed in the other Input Slot of the DRC-91C/DRC-93C.

The 9215-15 configuration is used with Capacitance sensors with a maximum of 30 nanofarads (for example, Lake Shore CS-401 Series Sensors).

The 9215-150 configuration will accommodate Capacitance sensors of up to 150 nanofarads (for example, Lake Shore CS-501 Series).

The card can be configured by the user as either a 15 nanofard (9215-15) or a 150 nanofarad (9215-150) card by switches on the card.

Specifications for the Model 9215 Capacitance Input Card Configurations are given in Table 9215-1.

Table 9215-1. Specifications of the Capacitance Input Card

Display Resolution: 5 digits.

Display Units: Capacitance in nanofarads.

Temperature Accuracy: A function of sensor sensitivity. See Table 9215-2. Unit supports capacitance only.

Sign of Temperature Coefficient: User Selectable by Switch on on DRC-91C, Keys on DRC-93C or via Computer Interface.

Magnetic Field Sensitivity: < ±0.15% for B < 19 Tesla and T > 4.2K. See Section 9215.3.

9215-15:
Sensor Excitation: 5 kilohertz charging current.
Capacitance Range: 0 to 15 nF, 0-30 nF with reduced accuracy.
Sensor (ordered separately): CS-401 Series from LSCI or or other Capacitance Sensor.
Resolution: 0.001 nF
Accuracy: ±0.25% of Full Scale
Range: 0.000 to 29.999 nF
Analog Output Signal: 0.1 times capacitance (nF) in volts

9215-150:
Sensor Excitation: 1 kilohertz charging current.
Capacitance Range: 0 to 150 nF
Sensor (ordered separately): CS-501 Series from LSCI or other Capacitance Sensor.
Resolution: 0.01 nF
Accuracy: ±0.25% of Full Scale
Range: 0.00 to 149.99 nF
Analog Output Signal: 0.02 times capacitance (nF) in volts.

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Table 9215-2 Typical Temperature Ranges and Sensitivities

Sensor Type	T (K)	C (nf)	dC/dT (pf/K)
CS-401GR-A[1] (1184)	4.2	1.7609	20.77
	20.0	2.0347	15.30
	60.0	2.4227	2.42
	80.0	2.3544	- 9.14
	140.0	1.4847	-12.91
	200.0	0.9445	- 5.95
	295.0	0.6307	- 1.83
CS-401GR-B[1] (1186)	4.2	5.3155	65.22
	20.0	6.1118	44.63
	60.0	7.2357	7.38
	80.0	7.0525	-25.61
	140.0	4.5379	-38.46
	200.0	2.9062	-18.10
	270.0	2.1054	- 7.07
	295.0	1.9492	- 5.55
CS-401LG-B[1]	---[3]	------	-------
CS-401LG-C[1] (1248)	4.2	11.1972	137.
	20.0	12.9423	94.8
	60.0	15.3912	21.2
	80.0	14.9303	-60.7
	140.0	9.3561	-81.3
	200.0	5.9762	-37.1
	270.0	4.3180	-14.0
	295.0	3.9989	-12.2
CS-501[2] (10002)	4.4	6.5884	30.74
	20.0	7.1334	37.61
	60.0	9.0452	56.19
	80.0	10.1940	57.52
	140.0	14.0355	82.44
	200.0	21.7233	197.4
	270.0	91.0746	4025.
	295.0	130.140	-1226.

Notes:

1. 9215-15 configuration.
2. 9215-150 configuration.
3. No Calibration Data Available

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9215.3 NOTES ON CS-501 CAPACITANCE SENSORS

9215.3.1 Short-Term Stability

The capacitance sensor provides very stable temperature control over long periods of time. However, since an operational "aging" phenomenon exists some care must be exercised in their use. The short-term (minutes to hours) capacitance/temperature drift is initiated by a thermal perturbation of the sensor.

In order to minimize this short-term drift, it is recommended that approximately one hour be allowed for the sensor to stabilize after the initial cooldown. The short-term drift is then on the order of a few tenths of millikelvin/minute at 4.2K, several millikelvin/minute at 77K and one millikelvin/minute at 305K. For temperatures less than 290K the short-term drift is such that the equivalent temperature will decrease with time and for temperatures above 290K will increase with time.

9215.3.2 Thermal Cycling and Reproducibility

Thermal cycling of capacitance sensors can produce variations in capacitance/temperature values equivalent to several tenths of a degree over the short term (days). Thermal cycling over the long term (weeks) can result in variations that exceed a degree. These variations are always such that the equivalent temperature increases with time and with increased cycling. The reduced capacitance C(T)/C(4.2K) for T<290K is stable to within ±0.5K on the average. Also these variations do not create instabilities and do not impair the sensors primary function as a control device in magnetic fields. They also are not seen within a temperature cycle.

9215.3.3 Magnetic Field Dependency

Magnetic field sensitivity is less than ±0.15 % at 4.2K and less that ±0.05 % between 77K and 305K for fields up to 18.7 Tesla.

9215.3.4 Frequency Dependence

For frequencies between 1 and 5 kilohertz the frequency sensitivity is as follows:

-0.18K/kilohertz at 4.2K

-1K/kilohertz at 77K

+0.06K/kilohertz at 305K

9215.4 INSTALLATION

The 9215 can be installed in the DRC-91C/93C as either Input A or Input B. The card is factory installed if ordered with a DRC-91C/93C Temperature Controller or can be field installed at a later date. If field installation is required, use the following procedure.

1. Set the POWER switch to OFF and disconnect the power cord from the unit. Remove the three top panel screws and slide the panel off. Note on the calibration cover the position of the Card will occupy.

WARNING

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

2. Remove the four screws that secure the calibration cover to its clips and remove the cover. Remove the two back panel

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mounting clips that secure the J11 blank cover plate to the interface opening and remove the plate. (Note: some early DRC-91Cs do not have the J11 opening. Use the J9 8229 Scanner option opening. If an 8229 is present move the 8229 to the J10 RS-232 slot.

3. If an Input Card must be removed, disconnect the wiring harness mating connector by lifting the locking tab on the Input Card connector and gently pulling on the body of the wiring harness mating connector.

4. Plug the new Input Card into the A Input Card Slot 5 or the B Input Card Slot 6 with the component side to the left of the unit as viewed from the front. Connect the wiring harness mating connector to the card making sure that the wiring harness locking tab is seated over the extended edge of the wiring harness mating connector. Verify that the wiring harness is in place correctly by noting that the "A" or "B" on the harness mating connector is facing up (if it is not, review the harness installation again). Thread the wiring harness along the rear edge of the unit and slip it into the harness strain relief on the rear panel. Thread the 9215 internal cable along the inside edge of the rear panel so that it won't interfere with the installation of the calibration cover or top cover.

NOTE: Be sure that the card is centered in the slot. The harness will have a tendency to push the card forward and may in some instances cause the card and instrument to not behave properly.

5. Position the 9215 connector plate in the appropriate opening and secure it in place using the screws provided.

6. Install the calibration cover by reversing procedure 2.

7. Select either the 9215-15 or 9215-150 configuration by pressing the appropriate pushbutton switch.

8. Install the top panel.

9215.5 SENSOR CONNECTIONS

The 9215 connector plate supplies two independent dual isolated BNC connectors for the sensor connections. A four lead measurement is used to minimize the effect of series resistance on the capacitance measurement. Since the capacitance sensor is non-polarized, one pair should be used for the current connections and the other pair for the voltage connections. The pin contact of the connector is + and the socket -.

9215.6 SELECTION OF THE SIGN OF THE TEMPERATURE COEFFICIENT

The temperature coefficient of some Capacitance Sensors can be positive or negative depending on the temperature range. The 9215 Card produces a voltage proportional to the Capacitance which is sent to the control circuitry of the DRC-91C/93C to be compared to a user selected setpoint. For control to operate properly, the sign of the voltage must reflect the temperature coefficient of the sensor. It is necessary for the user to determine which range the sensor is in and to inform the controller of the sign of the temperature coefficient. This is accomplished on the DRC-91C by a switch (switch 1 of the SENSOR ID) on its rear

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panel and on the DRC-93C by a sequence of key strokes from its front panel. Also the Sign of the temperature coefficient can be entered via the computer interface using the AC_1C_2 or BC_1C_2 command.

9215.6.1 Selection of Temperature Coefficient Sign on the DRC-91C

The sign to be used on the Temperature Coefficient of the capacitance is selected using Switch 1 of the appropriate SENSOR ID located on the rear panel of the DRC-91C.

When Switch 1 of the SENSOR ID is **closed** the Temperature Coefficient is Positive. When Switch 1 of the SENSOR ID is **open**, the Temperature Coefficient is Negative.

9215.6.2 Selection of Temperature Coefficient Sign on the DRC-93C

When a 9215 Capacitance Input Card is installed, pressing the SENSOR key will display for the appropriate channel either ±15-15 or ±15-50; the -15 for the 9215-15 configuration or -50 for the 9215-150 configuration. The (±) sign indicates whether the Temperature Coefficient is positive or negative. The plus (+) means that the Temperature Coefficient is positive. The minus (-) means that the Temperature Coefficient is negative.

Select the Temperature Coefficient sign from the front panel by using a combination of the SENSOR key, SCAN (↑↓) key and the ▲▲ key and ▼▼ key as follows:

1. Press and hold the SENSOR key.

2. While holding down the SENSOR key, press the SCAN (↑↓) key. You may now let up on the SENSOR key.

3. To change the sign if in the upper display hit the ▲▲ key while still holding down the SCAN (↑↓) key. Similarly, to change the sign if in the lower display hit the ▼▼ key while still holding down the SCAN (↑↓) key.

4. Now let up on the ▲▲ key (or ▼▼ key) and then the SCAN (↑↓) key.

You should press the SENSOR key to make sure that the sign is as desired.

9215.6.3 Selection of the Sign of the Temperature Coefficient via the Computer Interface

To select the sign of the temperature coefficient via the IEEE interface, check the AC_1C_2 and BC_1C_2 commands in the instrument manual.

9215.7 PRINCIPLE OF OPERATION

The 9215-15 configuration provides a charging current switched at a frequency of 5 kilohertz. The frequency is precisely controlled by a crystal oscillator. The operation of the 9215-150 is identical except that the frequency is 1 kilohertz. The charging current produces a sawtooth voltage waveform with a peak-to-peak voltage of about 7 volts. Another voltage of precise amplitude is generated which has a duty cycle dependent on the charging time of the capacitor. This waveform is averaged and filtered to produce a positive DC voltage proportional to the capacitance. This DC voltage is sent to a 16 bit A/D converter on the card. The A/D converter has a resolution of 50 microvolts and a full scale input voltage of 3.0000 volts. With the 9215-15 Configuration the 3.0000 volts corresponds to a capacitance of 30 nanofarads; and on the 9215-150 configuration to 150 nanofarads. The digitized

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value is converted to a serial data string and transferred to the main microprocessor using optical isolation.

A relay on the Card configures the sensor voltage as negative or positive based on the temperature coefficient sign selected by the user (Section 9215.5). That voltage is buffered and transferred to the rear panel MONITORS connector for external monitoring as well as to the main board control circuitry.

9215.8 CALIBRATION

The 9215 was calibrated to specification prior to shipment. The card meets specification for operation either in the 9215-15 or 9215-150 configuration by simply pressing the switches located on the card. This Section provides information to permit recalibration if needed.

NOTE: Calibration for zero capacitance may be required to meet accuracy specifications if your sensor lead capacitance or stray capacitance is excessive.

The following equipment is used to calibrate the 9215 Capacitance Input Card:

1. Digital Voltmeter/Multimeter (DVM) - 4½ digit resolution or better.

2. Precision Standard Capacitors - 10 nanofarad and 100 nanofarad with tolerance of ±0.1% or better.

3. Precision Voltage Source - capable of supplying a voltage with an accuracy and resolution of 100 microvolts out of 10 volts or better.

The unit should be allowed a one hour warm-up time to achieve rated specifications. To begin remove the three top panel screws and slide the panel off. The procedure is divided into three parts as follows.

1. Calibration of the A/D Converter.

2. Zero calibration.

3. Span Calibration.

The zero and span calibration is done with the instrument and system wiring configured as it will be used. This will provide optimum accuracy because lead and stray capacitance will be taken into account.

9215.8.1 A/D Calibration

1. Locate DIP switch package S1A-Switch 2. Under normal operation this switch is CLOSED(1). Change this switch to the OPEN(0) position.

2. Connect the DVM plus lead to the +V Buffered Sensor Output Signal pin for the appropriate Input Card and the minus lead to the -V pin on the MONITORS connector. Connect the precision voltage source across the E (+V) and D (-V) pins of the five pin input connector for the input corresponding to the Capacitance Card.

3. Set the standard to 1.5000 volts.

4. Verify that the Display indicates the Capacitance Input Card.

5. Adjust the trimpot marked **A/D** until the display reads 15.000nF for the 9215-15 or 75.00nF for the 9215-150. Check linearity by inputting 2.0000 and 1.0000

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volts and verify that the unit displays 20.000 and 10.000nF within ±0.001nF for the 9215-15 or 100.0 and 50.0nF within ±0.01nF for the 9215-150.

6. Return S1A - Switch 2 to the CLOSED(1) position.

9215.8.2 Zero Calibration

1. Be sure that the leads are in the configuration which will be used in your system. Detach the capacitance sensor.

2. Verify that the Display indicates the Capacitance Input Card.

3. Adjust the trimpot marked **ZERO** so that the display reads 0.000 on the 9215-15 or 0.00 on the 9215-150.

9215.8.3 Span Calibration

1. Be sure that the leads are in the configuration which will be used in your system. Attach the standard capacitor in place of the capacitance sensor.

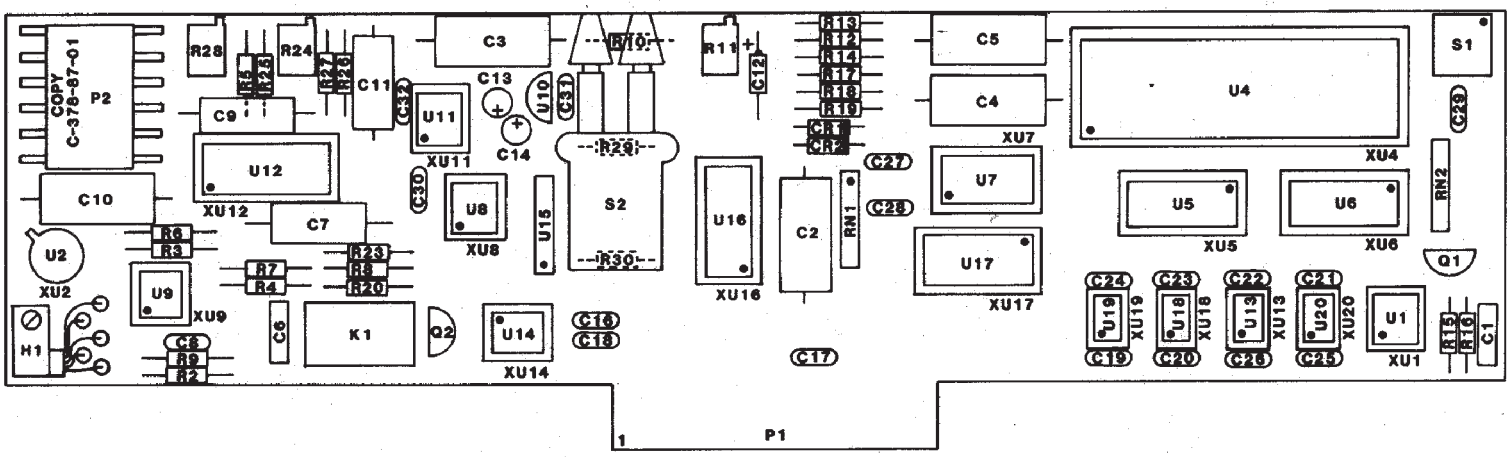
2. Verify that the Display indicates the Capacitance Input Card.

3. Adjust the trimpot marked **SPAN** so that the display reads the value of the standard capacitor.

9215.9 REPLACEABLE PARTS

Included in this section is Figure 9215-1. It includes the Model 9215 Capacitance Input Schematics, replaceable parts list and illustrated component layout. Refer to the manual for ordering information.

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REPLACEABLE PARTS LIST - 9215 CAPACITANCE INPUT CARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
C2,3,4	101-034	3	CAP,PP,1.0MF,100V	FDYNE	MPP2X-1.0-100-10
C5	101-025	1	CAP,PP,.33MF,100V	FDYNE	MPP-11.33MFD
P2	106-142	1	CONNECTOR, (IC TO BP) 6 POST LOCKING HEADER	MOL	2420-09-75-1061
Q1	102-072	2	TRANSISTOR,PNP,SIGNAL		2N3906
S1	105-649	1	SWITCH,2 POS,4 POLE INTERLOCKING	EGC	2XMTA7.5(NONE) 4UGRP
U1	104-051	1	IC, TIMER	ISL	ICM7555IPA
U2	102-075	1	MOSFET,N CHANNEL		VN0535N2
U4	104-461	1	IC, A/D CONVERTER	ISL	ICL7104-16CPL
U5,6,17	104-099	3	IC, P-S SHIFT REGISTER		CD4021BCN
U7	104-460	1	IC, A/D REFERENCE	ISL	ICL8068ACPD
U8	104-001	1	IC, OP AMP	PMI	OP07E
U9	104-010	1	IC, F/V CONVERTER	NAT	LM331N
U10	102-020	1	REGULATOR,-5	MOT	79L05
U11	104-087	1	IC, DUAL OP AMP	TDYN	TSC913A
U12	104-078	1	IC, SWITCHED CAPACITOR	LT	LT1043CN
U13,18, 20	104-355	3	IC, OPTOCOUPLER	GI	740L6000
U14	102-037	1	VOLTAGE REFERENCE, 10V	LT	REF-01EN8
U15	104-054	1	IC, OSCILLATOR	EPS	SG-10-10KA
U16	104-101	1	IC, DECADE COUNTER		4029CBN
U19	104-356	1	IC, OPTOCOUPLER	GI	740L6010

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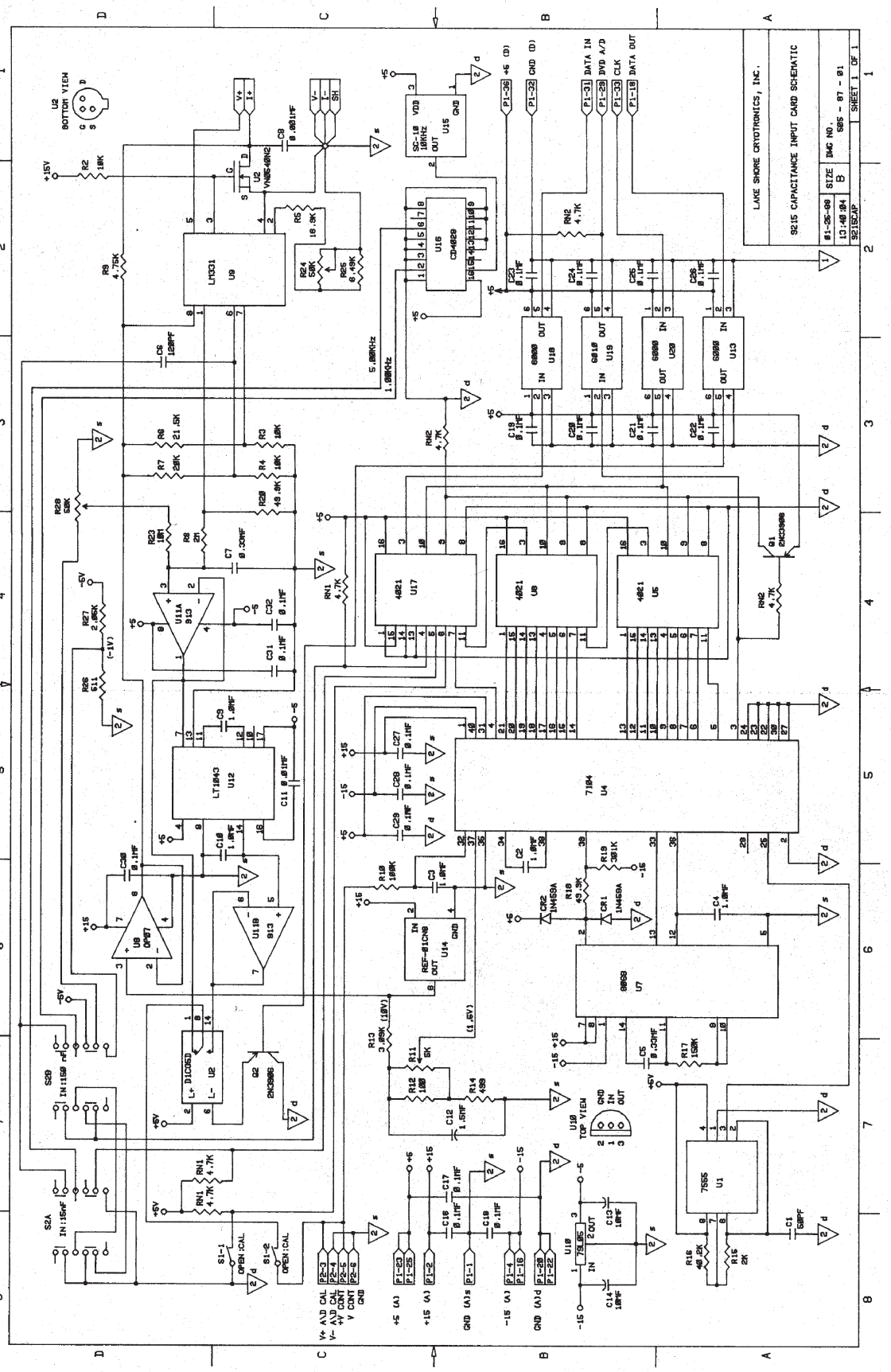


Figure 9215-1. Model 9215 Capacitance Input Card

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9220 USER CONFIGURABLE INPUT CARD OPTION

9220.1 INTRODUCTION

This section contains information pertaining to the Model 9220 Diode and Platinum User Configurable Input Card. Included is a description, specifications, installation, operation and maintenance information.

9220.2 DESCRIPTION

The Model 9220 Diode and Platinum Input Card is designed to be installed in a DRC-91C or DRC-93C to convert either the Input A or Input B (or both with two options) to accommodate either diode or positive temperature coefficient sensors such as platinum or rhodium-iron.

The 9220-3 configuration is equivalent to the 9210-3 configuration described earlier. The 9220-6 configuration is equivalent to the 9210-6 configuration.

The 9220-P2 converts either Input A or B (or both with two options) to accommodate 100 ohm platinum RTD's which conform to DIN 43760 tolerances ± 0.1K, have an interchangeability of 0.1% at 0°C and a temperature coefficient of 0.00385/°C from 0 to 100°C. This card may also be configured as a 9220-P3 (1000 ohm platinum) or 9220-R1 (rhodium-iron) input card.

9220.3 SPECIFICATIONS

Specifications for the Model 9220 User Configurable Input Card are given in Table 9220-1 of this manual. The card can be configured as a 9220-3 or 9220-6 diode card, a 9220-P2 or 9220-P3 platinum card or a 9220-R1 rhodium-iron input card.

Table 9220-1. 9220 Configurable Input Card

9220-3: See 9210-3 specifications.

9220-6: See 9210-6 specifications.

Sensor (ordered separately):
Platinum RTD sensor. PT-100 series or any other 100 ohm or 1000 ohm platinum sensor.
27 ohm rhodium-iron sensor. See Lake Shore Sensor brochures.

Temperature Range: Dependent on Sensor. See Sensor brochure.

RTD Sensor Power Dissipation: Depends on Sensor Resistance. Dissipation is the product of sensor excitation current squared and the Sensor resistance.

9220-P2: 100 ohm platinum
Current Excitation: 1mA(±0.005%)
Resistance Range: 0.00-299.99Ω.
Resolution: 0.005 ohms
Accuracy: 0.01 ohms
Display Resolution: 5 digits. Displays 0.00 to 299.99 ohms.*

9220-P3: 1000 ohm platinum
Current Excitation: 0.1mA(±0.005%)
Resistance Range: 0.0 to 2999.9 Ω.
Resolution: 0.05 ohm
Accuracy: 0.1 ohm
Display Resolution: 5 digits. Displays 0.0 to 2999.9 ohms.*

9220-R1: 27 ohm platinum
Current Excitation: 3 mA(±0.005%)
Resistance Range: 0.000 to 99.999Ω
Resolution: 0.003 ohm
Accuracy: 0.003 ohm
Display Resolution: 5 digits. Displays 0.000 to 99.999 ohms.*

*Equivalent temperature accuracy is a function of sensor type, sensitivity and Precision Option.

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9220.4 INSTALLATION

The 9220 can be installed in the 91C/93C as either Input A or Input B (or both with two options). The 9220 is factory installed if ordered with a 91C or 93C Temperature Controller or can be field installed at a later date. If field installation is required, use the following procedure.

WARNING

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

1. Set the POWER switch to OFF and disconnect the power cord from the unit. Remove the three top panel screws and slide the panel off. Note on the calibration cover the position of the Input Card the 9220 will occupy.

2. Remove the four screws that secure the calibration cover to its clips and remove the cover.

3. If an Input Card must be removed, disconnect the wiring harness mating connector by lifting the locking tab on the Input Card connector and gently pulling on the body of the wiring harness mating connector.

4. Plug the new 9220 Input Card into the A Input Card Slot 4 or the B Input Card Slot 5 with the component side to the left of the unit as viewed from the front. Connect the wiring harness mating connector to the 9220 making sure that the wiring harness locking tab is seated over the extended edge of the wiring harness mating connector. Verify that the wiring harness is in place correctly by noting that the "A" or "B" on the harness mating connector is facing up (if it is not, review the harness installation again). Thread the wiring harness along the rear edge of the unit and slip it into the harness strain relief on the rear panel.

5. Install the calibration cover by reversing procedure 2.

6. Install the top panel.

9220.5 OPERATION

The 9220-3 and 9220-6 configurations are equivalent to the 9210-3 and 9210-6 configurations in terms of operation.

The Model 9220-P2 Configuration provides the 1 milliampere excitation current to the platinum sensor (the 9220-P3 supplies 0.1 milliampere and the 9220-R1 supplies 3 milliamperes). The resulting sensor voltage is amplified by a factor of -10 (negative 10) and digitized by a 16 bit A/D converter with a resolution of better than 100 microvolts out of 3.0000 volts full scale. The digitized value is converted to a serial data string and transferred to the main microprocessor using optical isolation. The amplified (-10) sensor voltage is transferred to the J3 MONITORS connector for external monitoring.

9220.6 CALIBRATION

The 9220 was calibrated to specification prior to shipment. If recalibration is needed, refer to the following procedure. The following equipment is used to calibrate the 9220 Input Card:

1. Digital Voltmeter/Multimeter (DVM) - 4½ digit resolution or better.

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2. Precision Standard Resistor - 1 kilohms for 9220-P3 or 100 ohms for 9220-P2 and 9220-R1 with a tolerance of +/- 0.01% or better.

3. Precision Voltage Source - capable of supplying a voltage with an accuracy and resolution of 10 microvolts out of 1 volt or better.

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

Refer to the 9210 section for the calibration procedure for the 9220-3 and 9220-6 configurations.

Use the following procedure to calibrate the 9220-P2, -P3 and -R1 Configurations.

1. Remove the three top panel screws and slide the panel off.

2. **Set 100 µA, 1mA, 3mA Current-** Connect the appropriate precision resistor across the A (+I) and B (-I) pins of the five pin input connector for the input (J1 or J2) the 9220 occupies. Connect the DVM plus lead to the +I pin and the minus lead to the -I pin. Adjust the trimpot marked **1mA** (for -P2) on the calibration cover (**100µA** for -P3, **3mA** for -R1) for the appropriate Input Card until the voltage across the resistor is equal to the sensor current times the resistance ± the tolerance of the resistor.

3. **Calibrate the Input -10 Amplifier** -Connect the DVM plus and minus leads to the + V and -V Sensor Output Signal pins for the appropriate Input Card of the J3 MONITORS connector. Connect the precision voltage source across the E(+V) and D(-V) of J1 INPUT A or J2 INPUT B for the appropriate input and set the standard to 0.0000 volts. Adjust the trimpot marked **AMP Z** on the calibration cover until the DVM reads as close to 0 volts as possible. Set the standard to 0.2500 volts and adjust the trimpot marked **AMP S** on the calibration cover until the voltage reads -2.5000 volts.

4. **Calibrate the A/D Converter-** Verify that the Display Sensor is the desired Input Card and that the units are ohms. Set the standard to 0.2700 volts and adjust the trimpot marked **A/D** until the display reads 270.00 ohms (for the 9220-P3 an input of 0.2700 volts results in a display of 2700.0 ohms and for the 9220-R1 an input of 0.2700 volts results in a display of 81.00 ohms). Check linearity by inputting 0.2000 and 0.1000 volts and verify that the unit displays 200.00 and 100.00 ohms within +/- 0.01 ohms (or equivalent for the 9220-P3 and 9220-R1).

5. Install the top panel.

9220.7 SENSOR CURVE INFORMATION

Sensor Curve data for use with the 9220 RTD Configurations must be put in table form consisting of voltage and temperature points with the voltage in ascending voltage order. Since the 9220 raw data would be in resistance form, it must be converted prior to entering. Refer to Section 4 of this manual for a discussion of how the data must be converted and formatted for entry into the unit over the remote interface and to Appendix B for a discussion of Precision Option curves and examples of curves that would be used with the 9220.

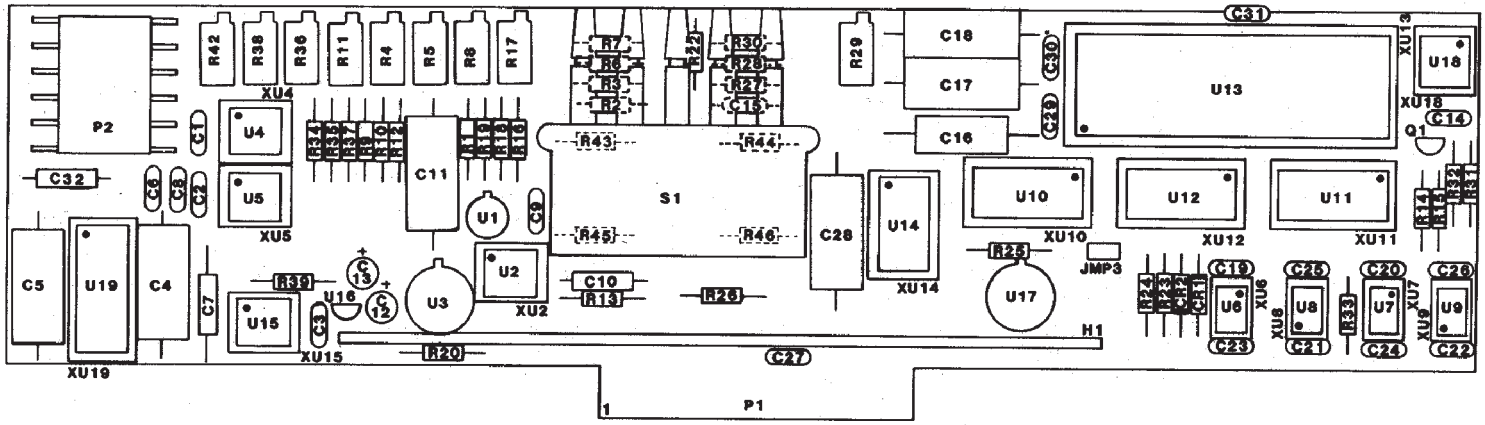
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9220.8 REPLACEABLE PARTS

Included in this section is Figure 9220-1. It includes the Model 9220 input schematics, replaceable parts list and illustrated component layout. Refer to the manual for ordering information.

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REPLACEABLE PARTS LIST - 9220 ANALOG INPUT CARD

ITEM NO	LSCI Part Number	Qty	Description	MFR	MFR PART NO
C4,5,11 17,18,28	101-034	6	CAP,PP,1.0MF,100V	FDYNE	MPP2X-1.0-100-10
C16	101-025	1	CAP,PP,.33MF,100V	FDYNE	MPP-11.33MFD
P2	106-142	1	CONNECTOR, (IC TO BP) 6 POST LOCKING HEADER	MOL	2420-09-75-1061
Q1	102-072	1	TRANSISTOR,PNP,SIGNAL		2N3906
S1	105-649	1	SWITCH,2 POS,4 POLE INTERLOCKING	EGC	2XMTA7.5(NONE) 4UGRP
U1	102-074	1	MOSFET,P CHANNEL	SIL	3N163
U2	104-005	1	IC, OP-AMP		LM308
U3,17	102-043	2	VOLTAGE REFERENCE,6.95V	NAT	LM399H
U4,5,15	104-001	3	IC, OP AMP	PMI	OP07EP
U6,8,9	104-355	3	IC, OPTOCOUPLER	GI	740L6000
U7	104-356	1	IC, OPTOCOUPLER	GI	740L6010
U10-12	104-099	3	IC, P-S SHIFT REGISTER		CD4021BCN
U13	104-461	1	IC, A/D CONVERTER	ISL	ICL7104-16CPL
U14	104-460	1	IC, A/D REFERENCE	ISL	ICL8068ACPD
U16	102-020	1	REGULATOR, -5V	MOT	79L05CT
U18	104-051	1	IC, TIMER	ISL	ICM7555IPA
U19	104-078	1	IC, SWITCHED CAPACITOR	LT	LTC1043

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