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HANDBOOK FOR OPERATION AND MAINTENANCE OF AN NBS MULTISENSOR AUTOMATED EM FIELD MEASUREMENT SYSTEM

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October 1986

NBSIR 86-3056

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

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A system is described that monitors and collects electromagnetic (EM) field strength information at five (optionally 10) locations simultaneously. The system has two modes of operation: (1) for sampling EM fields that are stationary for times of the order of 200 ms, and (2) for sampling changing EM fields with a system resolution of 10 μs. Sensing elements for Mode 1 consist of three electrically short orthogonal dipoles mounted together, single dipole elements, or small loop antennas. Each element feeds a separate data input channel for a total of 15 (optionally 30) channels. Rf energy is converted to dc by a diode detector at each dipole. Mode 2 sensors will be diode detectors driven by broadband antennas. Real time system data processing includes calculation of field strength based on probe calibrations and processing of resultant data to satisfy measurement goals.

Key words: automated measurement; electromagnetic field probe; high impedance; high speed; simultaneous sampling.

1. GENERAL INFORMATION

1.1 Introduction

This system was developed in response to work performed at the National Bureau of Standards (NBS) directed toward characterization of the EM environment in reverberation chambers [1]. One approach to mapping the EM fields in a test chamber is to use a single probe and move it through the area while continuously sampling the probe response. This has been done using a track made of nonconductive materials on which the probe is mounted. This method works well for environments which are stable and require a single probe reading at each location. However, some measurements require a large number of readings at each location (for example, to compute the average field during one rotation of the tuner in the reverberation chamber) which makes the track method very time-consuming.

A second method [2] uses several stationary probes at selected positions throughout the test volume. This approach is more appropriate when multiple readings are needed at each location. Problems associated with determining the physical location of the probe and with the perturbation of the EM environment due to bulky dielectric objects (track hardware) are minimized with the multiple probe system.

1.2 Background Requirements

The system described in this report is the second generation implementation. The list of specifications for the amplifier and data handling portion of the system, includes the following desired characteristics:

a. Multiple sensor input with adjustable gain to accommodate a wide variety of probes.

b. Parallel data acquisition for simultaneous reading of all probes.

c. Interface to desktop microcomputer (for control and data processing).

d. Channel modularity for reliability and maintenance.

e. Minimum size and weight.

In addition to the above, it was desired that the antennas and signal detection portion of the system produce the maximum bandwidth possible for the detected signal. While thermocouple detectors have good rms conversion characteristics and high rf frequency response, they are relatively insensitive and have response times of the order of 1.0 s, which is considered slow for our applications. To reduce response time, Schottky N-type beam-lead diodes with low barrier and as high a frequency response (low capacitance) as possible were chosen. A reverse breakdown voltage of 4 V results in an anticipated maximum measurable field strength of 1.5 kV/m.

1.3 Implementation

The system consists of an interface and backplane assembly with addressing capability of up to 31 card slots. (This number may be increased by adding address lines to the hardware, but the need for a larger system has not yet appeared). Each card slot will support one amplifier/digitizer circuit card containing the analog amplifiers, analog to digital (A/D) converter, and support circuits. The system samples all enabled inputs simultaneously by strobing the A/D converters on each card in parallel. After all signals have been converted from analog to digital representation, the digital numbers are read out serially under control of the desktop computer.

A system may be configured to utilize any or all addressable card slots. The two systems currently being used have 15 and 30 channels.

This manual is written for the 15-channel (5-probe) system. It is understood that the discussion would equally well apply to a system of 30 channels (10 probes), the only difference being the presence of more hardware and the additional time required to read twice as many channels after conversion.

1.3.1 Functional Diagram

Figure 1 shows the functional circuit blocks comprising one channel of this 15 channel system. An antenna probe and resistive leads (not shown in figure 1) supply a balanced, slowly varying dc voltage to the input labeled "Balanced High Impedance Inputs." From here the signal is filtered, amplified, switch-selected, and fed to an A/D converter. Upon command, the converter converts the signal to a 13-bit digital number (12 bits plus sign). The interface, under control of the desktop computer, transfers the digital number to the computer. All 15 channels begin conversion simultaneously. When all converters are finished, the computer sequentially reads data from each converter. The system is reset and is ready for the next measurement cycle.

1.3.2 Probes

This system was designed for use with two types of antennas or sensing probes: (1) high-impedance, slow-speed, 8-mm dipoles which are supplied with the system, complete with connecting cables, and are described below; (2) low-impedance (50 to 2000 Ω), high-speed probes for pulse work which are not supplied with the system and will not be discussed further in this document. Input circuits for future (optional) high-speed probes are, however, discussed in the following section on input circuits.

The five high-impedance probes supplied with the system were developed at NBS and are described in detail elsewhere [3]. The five probes each consist of 3 individual miniature dipoles arranged orthogonally to pick up electric fields independently of the direction of arrival. The probes have an isotropic response of ±0.3 dB up to 8 GHz. They are designed to measure fields from 10 to 1600 V/m. The frequency range is from below 100 MHz to 8 GHz. The initial shipment of probes has response from 8 to 12 GHz but with some degradation of pattern. This implies an amplitude uncertainty of the order of ±3 dB in the range from 8 to 12 GHz, in addition to the system accuracy of ±1 dB.

Each individual dipole is a miniature, resistively loaded, tapered dipole 8-mm long, as shown in figure 2. By itself it has a spectrum response flatness of ±2 dB. However, since the use is intended for single frequency test environments, amplitude corrections as a function of frequency are applied in the computer section of this system, producing a system flatness of ±1 dB between 300 MHz and 8 GHz. The system can be used at frequencies down to 100 MHz but flatness between 100 and 300 MHz is ±2 dB. Below 100 MHz and for lower strength fields, other members of a family of probes may be used.

1.3.3 Input Circuits

The system has two sets of input ports with two different specifications. The primary set, intended for use with the supplied probes, has a high-impedance input and a slow response time. This signal path, when selected, is directly connected to the analog to digital converter which has a conversion time of about 200 ms. This requires that input signals be stable (1 part in 4000) over this 200 ms time period. These inputs are referred to as High-Impedance (HI) throughout this handbook. They are accessible through 50-pin D connectors on the rear of the equipment and are intended to be used with 8-mm dipole probes connected by high-resistance carbon-loaded leads.

The second set of inputs is intended for a higher speed response and lower impedance antennas and detectors. The inputs are sampled by a sample-and-hold circuit, which is triggered by a pulse either from the desktop computer or from an external source. This sample-and-hold circuit has an aperture uncertainty time of about 10 μsec, which means input signals should be stationary for that length of time. The input preamplifier preceding the sample-and-hold circuit, has a bandwidth of 100 kHz, which matches the 10 μs specification of the sample-and-hold circuit. This amplifier inverts the input signal and has a fixed amplitude gain of 50. A switch connects both types of input to the A/D. As with the slower speed input, the A/D speed is about 200 ms, with the sequential readout of all channels after conversion requiring another 250 ms or so. The total time between high speed samples can therefore be no less than about 500 ms.

1.3.4 Computer Software

The software was initially developed on a *Hewlett-Packard (HP) 9836. However, it is intended to operate on any HP series 200/300 machine. The GPIO interface discussed in this handbook is common for all models in this series. Software details are discussed in section 3.0.

2. EQUIPMENT SET UP AND OPERATION

2.1 Cabling

Figure 3 shows the cabling diagram for the rf probe system. Supplied high impedance probes are shown. Optional high-speed components are not shown.

Shielding of resistive line leading from the probes to the bulkhead box (and their hardwire lines on to the interface) may be accomplished using any of several means to suit local conditions. Common-mode rejection and filtering remove most 60 Hz stray pickup, but the high impedance of the input (about 20 MΩ) makes some shielding of open lines desirable.

2.2 Computer GPIO Card

Figure 4 shows a diagram of the GPIO card (HP 98622A) which is inserted into the back of the computer. The switches on the card must be set as shown in figure 4 for the system to operate properly.

*Certain commercial equipment is identified in this document. This identification does not imply endorsement by the National Bureau of Standards nor does it imply that the equipment identified is necessarily the best available for this purpose.

2.3 Amplifier/Digitizer Configuration

The system consists of a series of identical amplifier/digitizer modules or channels, each of which has a unique address which the computer uses to interrogate the output of the A/D converter. For proper operation each amplifier/digitizer channel must be configured for the specific measurement and reside at a unique and legal address. (Note: each isotropic probe requires three channels, one for each of the three antennas). The amplifier operation may be configured on the front panel. The address is set on the circuit board using the ADDRESS-SELECT switches.

2.3.1 Front Panel

The front panel shown in figure 5 is typical of each amplifier/digitizer channel. The panel controls allow the operator to select either the high-impedance or the high-speed amplifier section (switch 15, lower left position), and to adjust the zero drift of each section independently via the active/zero switches (switch 13 in the upper left position for high-impedance, and switch 16, upper right, for high-speed) and their respective zero-adjust trimmer potentiometers (R9 and R12). The gain of the high-impedance amplifier may be changed with the GAIN-SELECT knob (switch 14) located in the center of the panel. The gain values are related to the resistors associated with each switch setting and may be tailored to meet specific needs (i.e., a new generation of probes with different output levels). The final feature on the front panel is a channel select indicator light (lower right position) which indicates when this particular card has been addressed by the computer.

The high-speed section is not currently utilized and setup criteria are left for future applications. The remaining discussions involve only the high-impedance amplifier section with the associated probes mentioned in section 1.3.2.

2.3.2 Front Panel Setup (High-Impedance)

The switch settings shown in figure 5 indicate normal operation of the high-impedance amplifier. The high-impedance amplifier is selected (switch 15) and the input signals are connected to the amplifier by setting switch 13 to 'active'. It is assumed that the individual channels have been previously aligned. Alignment is needed if the digital output is not zero for a zero input (switch 13 set to 'zero') or if other problems are noticed. Refer to section 4.2.1, Alignment and Test Points for the recommended procedures.

2.3.3 Amplifier/Digitizer Card Address

When the input signal from each probe has been digitized, each A/D is interrogated in turn by the controlling desktop computer. Each A/D is accessed by the computer calling for one of fifteen addresses or channels sequentially one after the other. If an amplifier is inserted or replaced in the channel numbered 1, to be properly interrogated in sequence as the first amplifier, the address switches must be set to 1. Figure 6 shows the location of the address switch and an example address for channel 1. Note that only the first 10 positions of the switch are used. Also note that when rocker switches are used, the depressed side selects the function; on slide switches the raised portion denotes the function selected. Both rocker and slide switches are installed with open (off) to the left, and closed (on) to the right. Figure 7 shows the address select switch coding needed to select up to 31 channels; only the first 15 are used in this equipment.

2.4 System Operation and Software

First the system hardware is assembled. Next the computer is booted up in its basic operating system, and the software supplied with the system is loaded into memory. Operation is commenced by depressing the run key. A detailed discussion of the software is covered in Section 3.

3. SYSTEM SOFTWARE

The software for the NBS multi-probe system is written for Hewlett-Packard series 200/300 laboratory computers in HP Enhanced Basic. The program controls the GPIO interface and supplies all control signals to the probe system hardware. As may be observed by looking at the hardware information, the probe interface board has no provisions to latch information and relies entirely upon the GPIO card to maintain internal conditions.

The program allows the operator to configure the system to any given combination of probes and amplifiers within the limits of the available hardware and to extract the correct calibration data for that antenna.

3.1 SUB Program Descriptions

The software allows relatively simple integration into larger measurement programs. The multi-probe system is recognized as part of a larger rf generation and measurement laboratory system, and the measurement programs will consist of modules controlling many different instruments. The multi-probe system programs are constructed as SUB programs that may be loaded and CALLed by the main program written by the user. These modules (SUB programs) are defined as follows:

1) Multiprobe_menu
2) Read_probes
3) Probe_fill_cal
4) Apply_probe_cal
5) Get_cal_value (general purpose)
6) Errortrap (general purpose)

These modules are interrelated; 'Multiprobe_menu', 'Read_probes', and 'Apply_probe_cal' provide the necessary linkage to a main program. A description of the structure and functions of each module follows.

3.1.1 Multiprobe_menu

This module provides all the system definitions and linking parameters necessary for operation of the system. A series of parameters defines the hardware configuration and the number of antennas available to the system. These parameters are defined in the program listing given in appendix I.

An array of index values is established as a result of interacting with the menu selections. These values define the probe connections and the calibration values to be used when the A/D readings are interpreted. The user can connect the antennas to the amplifiers in any order and must then reflect this information in the menu selections. A large part of the code in this module provides a simple means of adding, deleting or moving antenna connections among the amplifier channels while maintaining all the correct index values in the linking array 'Probe_addr(*)'. The configuration can be saved on a floppy disk (to be defined by the programmer in the main program), and the linking array can be printed for help in debugging the system. The module titled 'Probe_fill_cal' is called by the menu SUB program to initialize the calibration data files to interpret the A/D readings. A complete description of the variables used is provided at the beginning of the menu program.

3.1.2 Read_probes

This module performs the actual measurements by calling the necessary routines to read and interpret the readings. Along with the menu routine, this SUB program provides the required link with the main program to operate the probe hardware. The main program can specify that several readings will be averaged together; this average value or a single reading of each channel may be specified. The program will always read all amplifier channels that were specified in the menu and passed into the linking array. There is no provision for selecting subsets of the configuration without returning to the menu and performing the desired changes.

This module contains the subroutine that actually toggles the control lines on the GPIO such that the measurement sequence is initiated and readings taken from every A/D converter specified in the linking array. The setup and read sequence may be easily followed by reading the program in appendix I. The address of the lowest numbered amplifier channel is first set as this becomes the trigger channel for the interrupt signifying completion of the A/D conversion. The initial control signals are then established, followed by the sample/hold circuit going into the hold mode. The start conversion pulse is then generated (simultaneously to all channels), and the interrupt is enabled. The computer idles until the interrupt is detected and then proceeds to read the A/D converters sequentially. The data is masked to 12 bits and checked for an overrange bit. Corrections and calibrations are not applied at this point.

3.1.3 Probe_fill_cal

See the last two sentences of the Multiprobe_menu description.

3.1.4 Apply_probe_cal

The information returned after reading the probes is the decimal A/D output, which is proportional to the probe output voltage. When the system is reading the zero field offset values it is not necessary to translate the A/D values to field strength (see example 1 section 3.2.1). The zero field offset corrections are exactly those A/D readings. These corrections compensate for any amplifier drift that may occur. This module is called by the main program only when actual measurements are in progress and values of field strength are required (see example 1 section 3.2.1). This module translates the A/D readings into electric field strength in volts/meter. The calibration values for amplitude are the coefficients of a two-parameter curve fitted to calibrations taken in a transverse electromagnetic (TEM) cell at 300 MHz. There are two sets of parameters for each antenna because the response of the diode extends from the square law region to the linear region, and one equation will not cover both regions adequately. The frequency response of the probe is also corrected based on calibrations of the antenna in the anechoic chamber at several frequencies. Hence this routine requires knowledge of the measurement frequency. The common point for the amplitude and frequency calibrations is 300 MHz where the amplitude detail is given. All frequency response data are then related to a given amplitude at 300 MHz. The sequence of correction is to apply the curve fit equation to the A/D reading to get an equivalent volts/meter at 300 MHz, and then make corrections for the actual frequency of operation. If the frequency is outside the limits of calibration, no modification is applied. The results of this calibration reside in the Probe_v_m(*) matrix in the order given by the Probe_addr(*) linking matrix.

3.1.5 Get_cal_value

This is a general purpose module (which may be used by any other routine) that performs a binary search along the X axis of a file and returns a Y value as a linear interpolation between data points. The Apply_probe_cal uses this routine for finding the frequency calibration value to be used from the data given. The file parameters must conform to:

File (i,1) = X value
File (i,2) = Y value
Target = real number indicating the X value to search for
Result = real number returned, the Y value at target
Endpoint = index of the last data point (i) in the file
Baddata = flag that is set if there is an error or the
    Target is outside the x range of the file.

3.1.6 Errortrap

This is a catch-all error handling routine that is necessary for proper disk operations, etc.

3.2 Examples

3.2.1 Example 1

The following is a suggested method for interfacing a measurement program to the multiprobe system. It assumes that all COM declarations reside in the main program giving access to the variables.

```
Measurement program code
"

"
"
! Remove rf power
"
"
! Read zero field offset values
If Total_chans > 0 THEN      ! do only if probes are active
    MAT Probe_zero = (0)     ! not necessary, but good idea
    CALL Read_probes (@Gpio) ! read all active probes
    MAT Probe_zero = Probe_volts   ! set values, must do
END IF
"
"
"
"
"
"
! Set up measurement environment, apply rf power
"
"
! Read the probe system
"
IF Total_chans > 0 THEN       ! do only if probes are active
    CALL Read_probes (@Gpio)  ! read all active probes
    Too_hot = 0               ! begin search for overranges
    FOR P=1 to Total_chans
           Too_hot = Too_hot OR Overrange(P)   ! look at each
    NEXT P
    IF Too_hot THEN           ! do something quick
        GOSUB Reduce_power
        GOTO Restart_point
    END IF
    ! not overranged, so interpret
    CALL Apply_probe_cal (Frequency)
END IF
GOSUB Print_results           ! Print results as in Probe_v_m(*)
GOSUB Save_results
"
"
"
```

At this point the results are in the matrix called Probe_v_m(*). The values are in the order dictated in the Probe_addr(*) matrix.

3.2.2 Example 2

You have selected amplifiers 5,6,7,8,10,12 with probes 2-Y, 2-Z, 3-X, 3-Y, 4-X, 4-Y respectively, then Probe_v_m(*) would contain the readings of the probes in that same order.

i.e. Probe_v_m(1) = 2-Y reading in volts/meter
Probe_v_m(2) = 2-Z
"
"
"
Probe_v_m(6) = 4-Y reading in volts/meter

Also note that Total_chans = 6 for this example.

4. SYSTEM MAINTENANCE AND TROUBLESHOOTING

4.1 Probes

Probe diode integrity and resistive lead integrity can be determined with an ohmmeter. However, care must be taken that no ohmmeter is used with a maximum output of more than 4 volts. This continuity measurement should be made at the pins on the probe connector, to keep some protective resistance line between the test meter and the probe diode. The diodes are Schottky diodes which are very subject to static damage.

A test jig that normally inserts 2 MΩ across the line must be constructed before testing. See figure 8. When the push button is pushed, the jig inserts 1 MΩ in series with each side of the line and removes the 2 megohms across the line. Trouble is indicated if there is an open circuit (infinite resistance) or short circuit (the same reading in both directions). Forward resistance should be 3 to 3 1/2 MΩ including the line and series resistor. Normal back resistance will be in the range from 7 to 20 MΩ.

If probes are found to be unserviceable, and are replaced with new probes, the calibration curve contained in the computer software should be replaced with the curve corresponding to the new probes.

4.2 Probe Amplifier Cards

The overall schematic diagram for the rf probe amplifier card is given in figure 9. More detailed schematic diagrams are given as follows:

Schematic Diagram Title	Figure Number
High-impedance amplifier	10
High-speed amplifer	11
Clock squaring and regulators	12
Address circuits	13
Analog to digital converter	14

When the system was initially delivered, all 15 probe amplifier cards were properly aligned. The most common indication of need for simple zero adjust is non-zero digital readout with zero signal input. This is generally taken care of by adjusting the zero control on the front panel.

If a more complete alignment is desired, the table in figure 15 delineates a complete alignment sequence. Figure 16 shows test point and potentiometer locations on the probe amplifier card.

If the card is suspected of not working properly, the table in figure 17 gives a list of normal test point data. Figure 18 illustrates typical system waveforms at the analog to digital converter. These may be used to assist in locating card troubles.

4.3 System and Interconnect Schematics

4.3.1 Probe Cabling Code

Figure 19 shows probe pin numbers and color codes. Figure 20 shows the 10.7 m (35 ft) rf probe amplifier cable color code and SMA cable pin assignments.

4.3.2 Backplane Interconnect Schematics

This system uses fifteen separate amplifier cards, with the outputs all connected in parallel using tri-state logic. These paralleled outputs, as well as controlling input lines, are connected through an interface to the controlling desktop computer. Figures 21 and 22 show the interconnections employed on each backplane. Each backplane is (1) capable of holding up to 8 individual probe amplifier cards, (2) capable of being connected to other backplanes via jumper cables, and (3) capable of being connected to an interface card via jumper cables. Figure 23 shows the backplane component locations. System primary power is ± 15 V, which is injected into one backplane plug, J25 or J30, and distributed by daisy chain connections to other backplanes and to the interface card. All 5.0 volt power is generated by regulators on each individual card.

4.3.3 Interface and Cabling Schematics

The interface card is mounted on the back of one of the backplane cards. It is used to interface digital signals to the computer. It also contains the 250 kHz sinewave oscillator whose signal is fed to each card, where it is squared, and then used to clock the analog to digital converters. The interface card also has alternate input ports and switches for selecting Track/Hold and Start (the A/D converter) signals from a source other than the computer. Figure 24 shows the schematic for the interface card. Figure 25 shows the interface card component locations. The table in Figure 26 shows the interface cable color code. The cables are connected to the computer.

4.4 Parts List

System parts lists are listed in the following 3 figures:

Figure Number	Figure Title
27	Probe amplifier parts list
28	Interface parts list
29	Backplane parts list

5. REFERENCES

[1] Crawford, M.L. Evaluation of a reverberation chamber facility for performing EM radiated fields susceptibility measurements. Nat. Bur. Stand. (U.S.) IR 81-1638; 1981 February.

[2] Bronaugh, E.; Rose, M. Jr.; Rethmann, H. Multiple isolated probe electromagnetic field measuring system. IEEE Internat. Symp. on Electromagn. Compat. 80 1538-8; Switzerland. 151; 1980.

[3] Kanda, M.; Driver, L. A broadband electric-field probe using resistively tapered dipoles, 100 kHz - 18 GHz. IEEE Conf. EMC; 1986 September (in preparation).

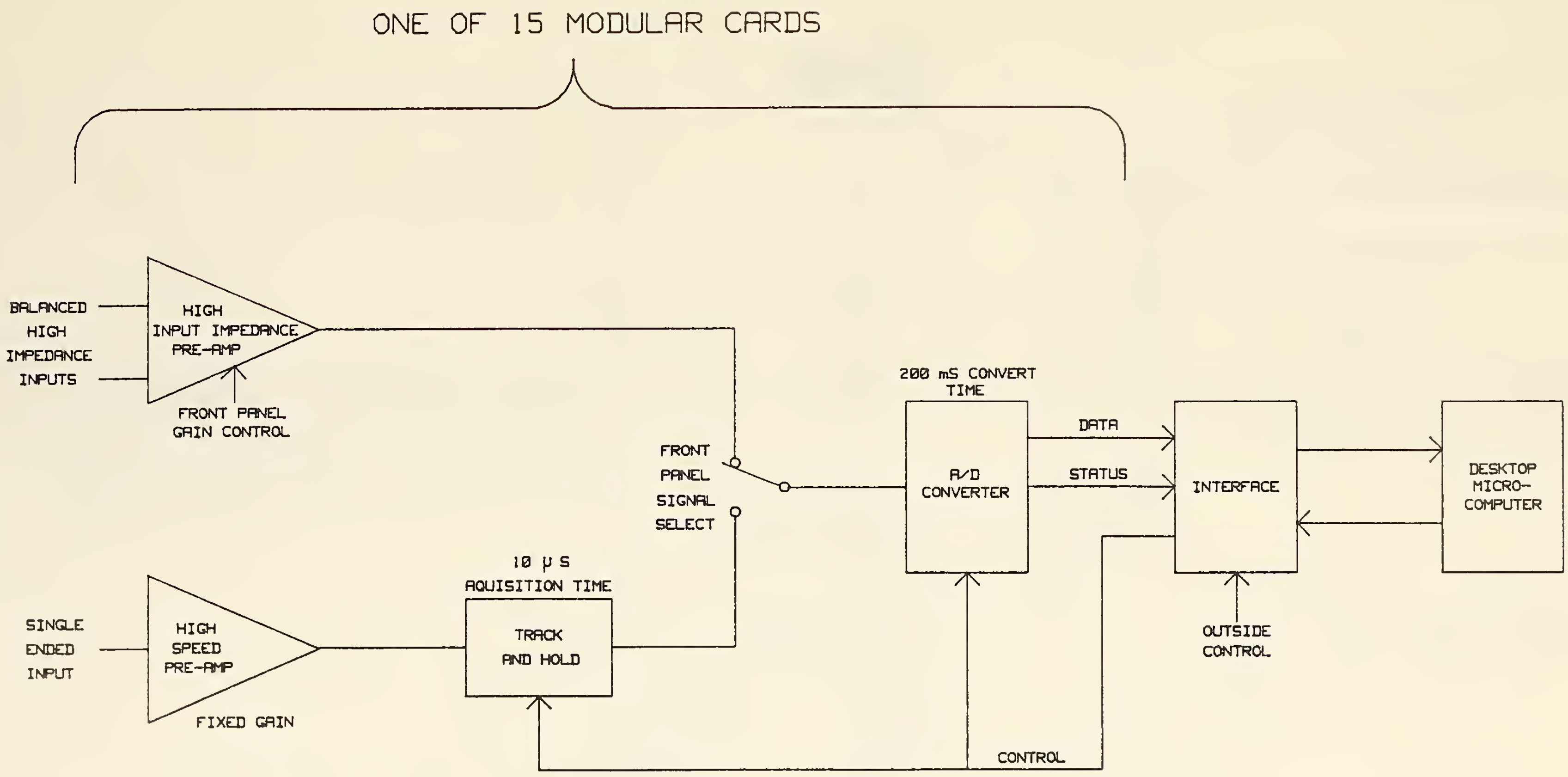


Figure 1. Block diagram of multisensor automated EM field measurement system.

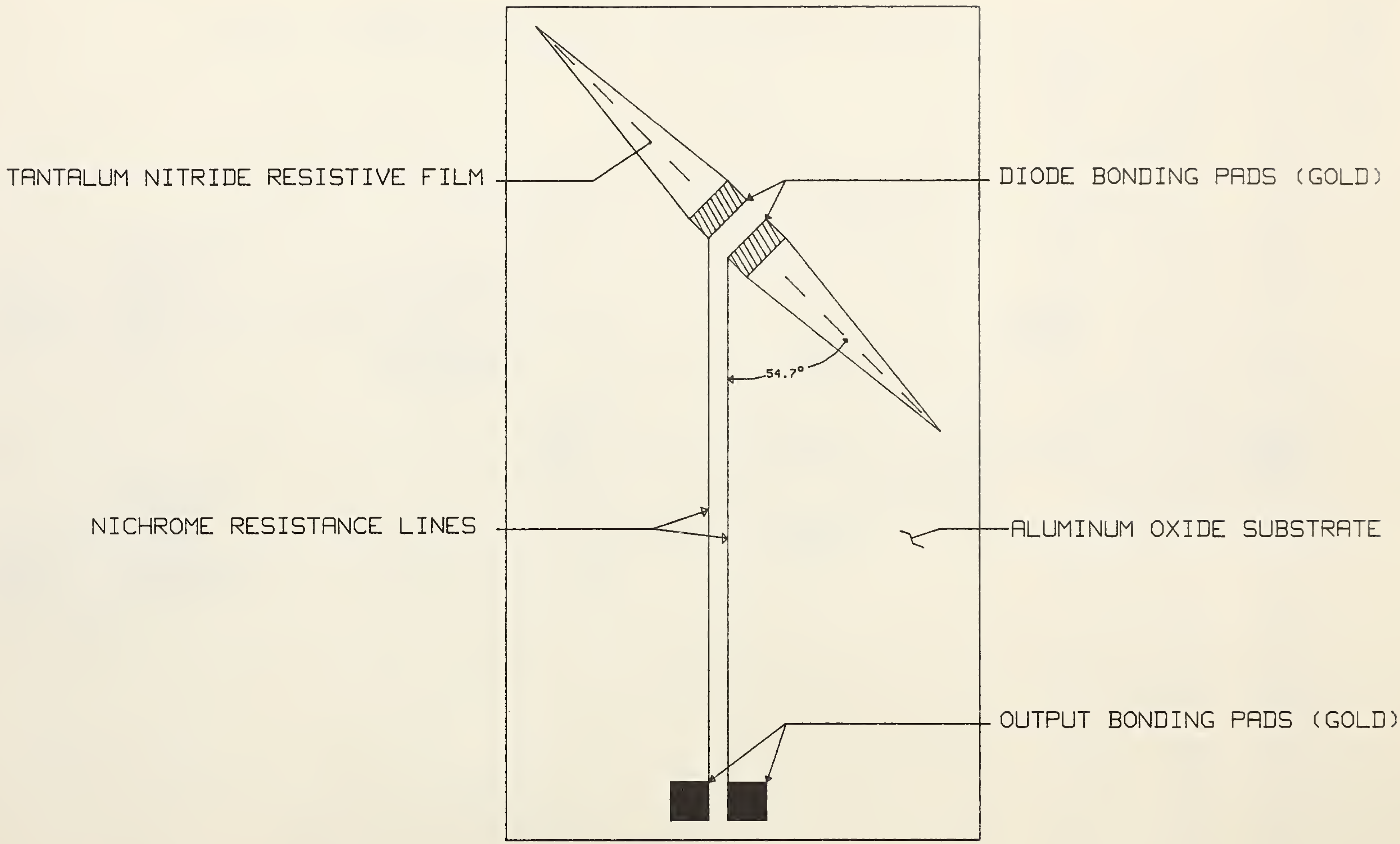


Figure 2. The 8mm thin-film dipole antenna composite diagram.

NOTES:

1. GPIO=HP 98622A .
2. EXTRA RESISTIVE LEADS TO BE COILED INSIDE BULKHEAD BOX TO REDUCE UNWANTED PICKUP.
3. THIS IS A TYPICAL SETUP; MAY HAVE CABLES SHIELDED INSIDE METALLIC DUCT, ETC.

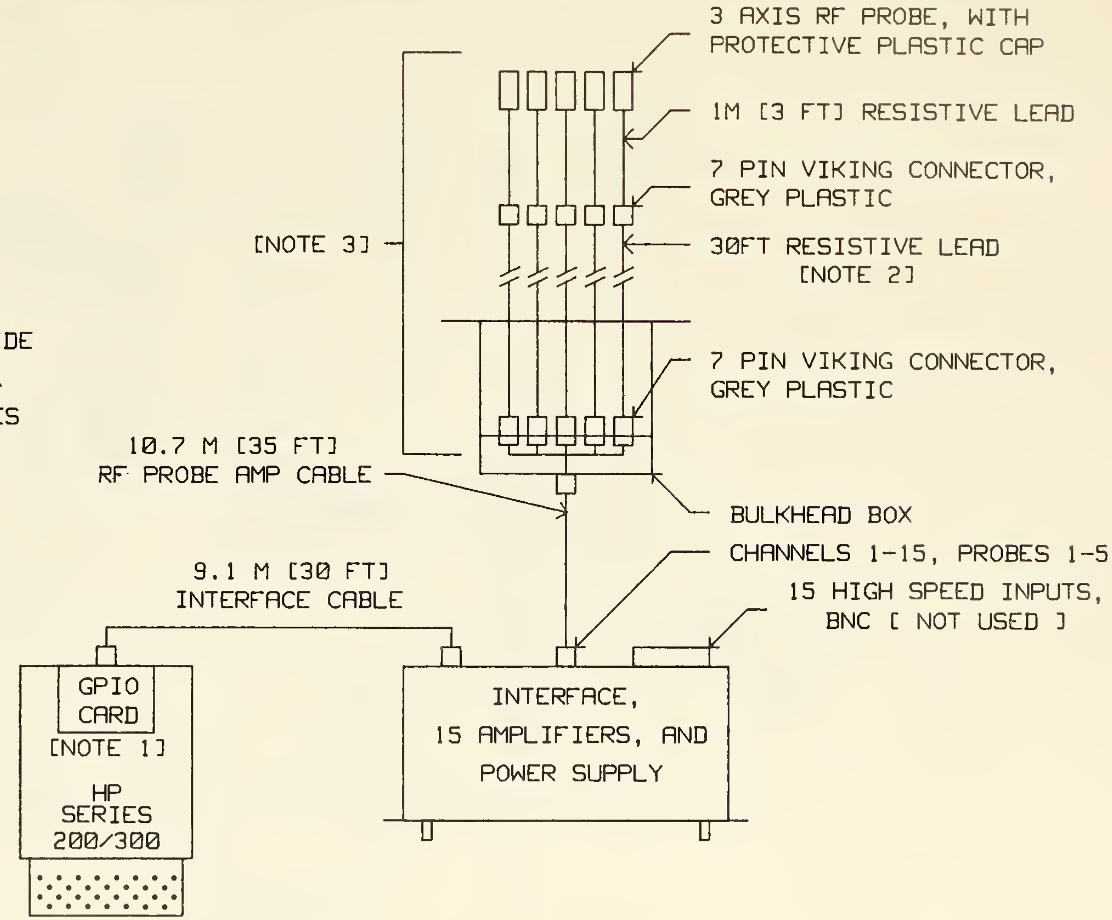


Figure 3. Cabling diagram, rf probe system.

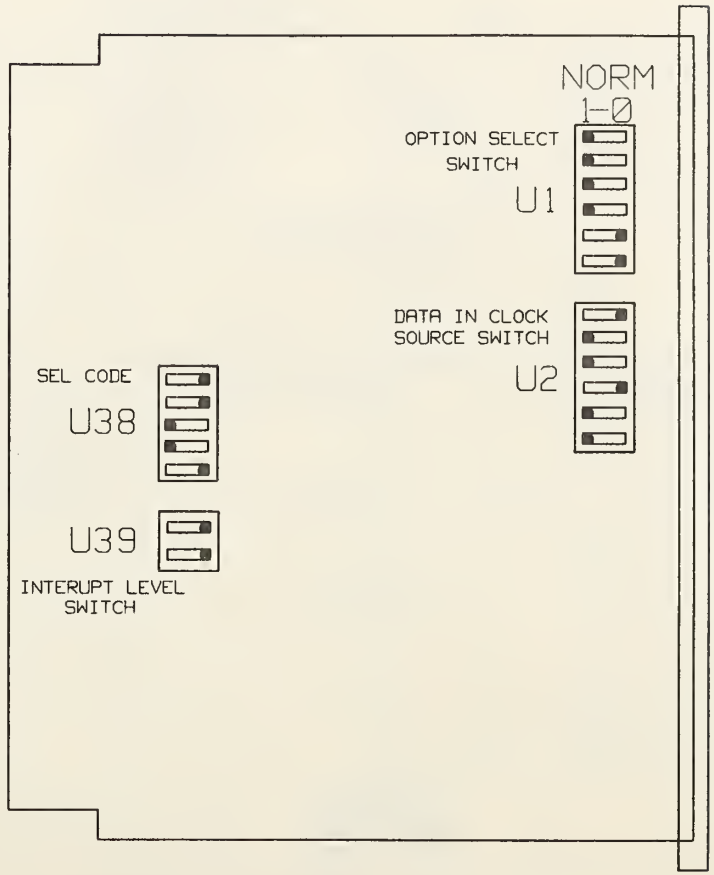


Figure 4. Setup for GPIO, HP98622A as used on HP Series 200/300.

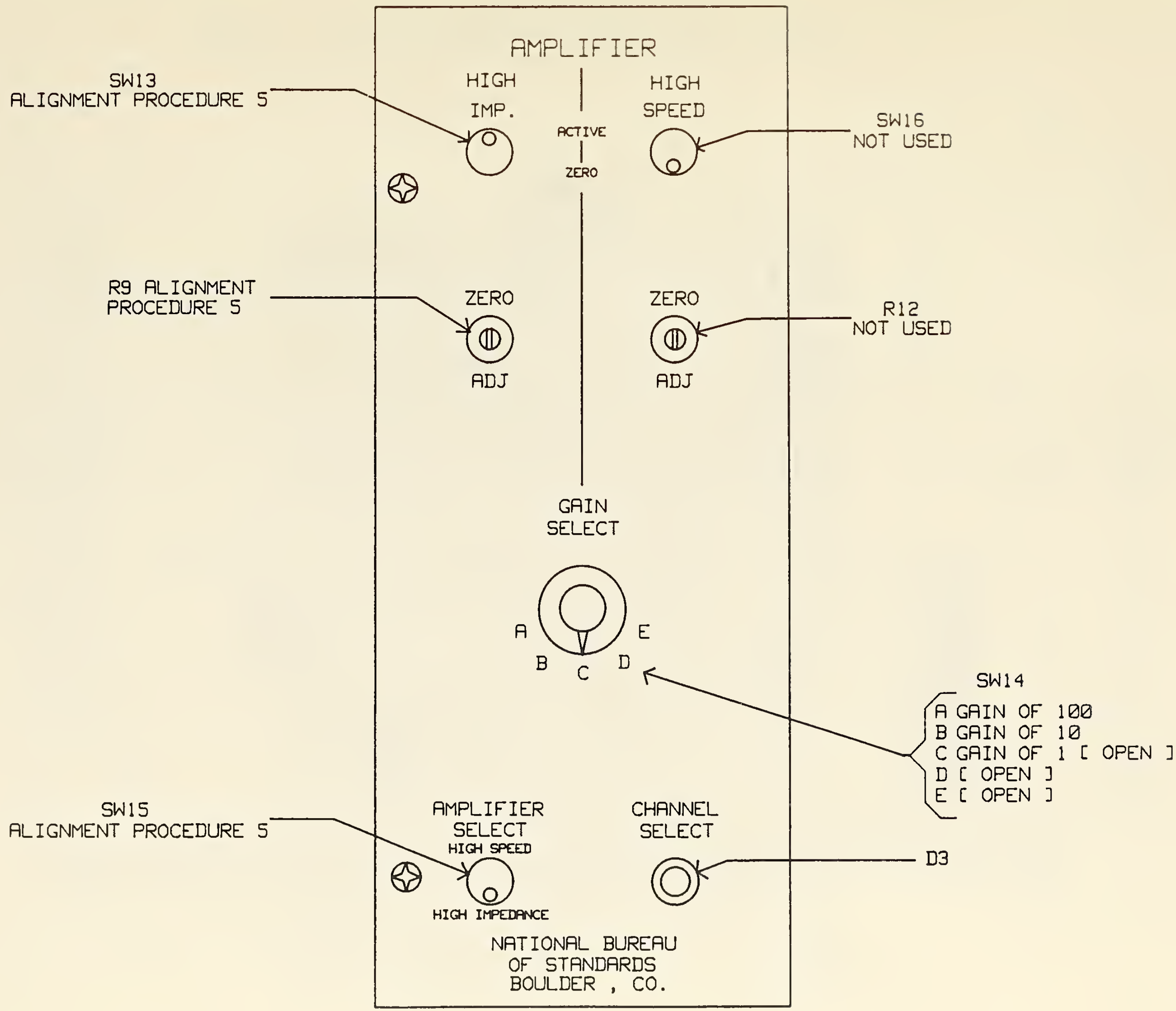


Figure 5. Front panel.

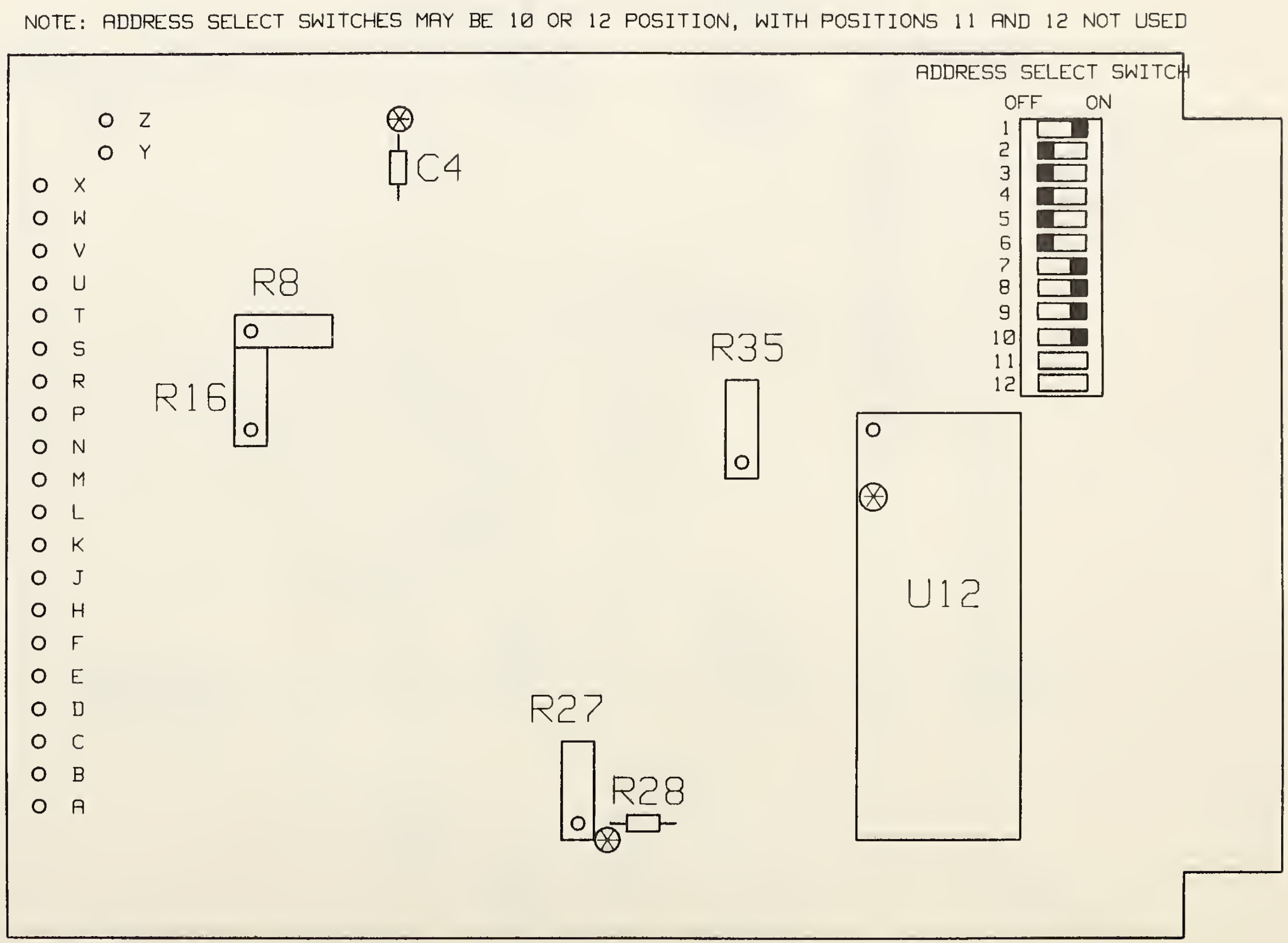


Figure 6. Address switch selection [CH 1 shown].

• = CLOSED(ON) & BLANK = OPEN(OFF)

ADDR	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	•						•	•	•	•
2		•				•		•	•	•
3	•	•						•	•	•
4			•			•	•		•	•
5	•		•				•		•	•
6		•	•			•			•	•
7	•	•	•						•	•
8				•		•	•	•		•
9	•			•			•	•		•
1Ø		•		•		•		•		•
11	•	•		•				•		•
12			•	•		•	•			•
13	•		•	•			•			•
14		•	•	•		•				•
15	•	•	•	•						•
16					•	•	•	•	•	
17	•				•		•	•	•	
18		•			•	•		•	•	
19	•	•			•			•	•	
2Ø			•		•	•	•		•	
21	•		•		•		•		•	
22		•	•		•	•			•	
23	•	•	•		•				•	
24				•	•	•	•	•		
25	•			•	•		•	•		
26		•		•	•	•		•		
27	•	•		•	•			•		
28			•	•	•	•	•			
29	•		•	•	•		•			
3Ø		•	•	•	•	•				
31	•	•	•	•	•					

Figure 7. Address select switch coding.

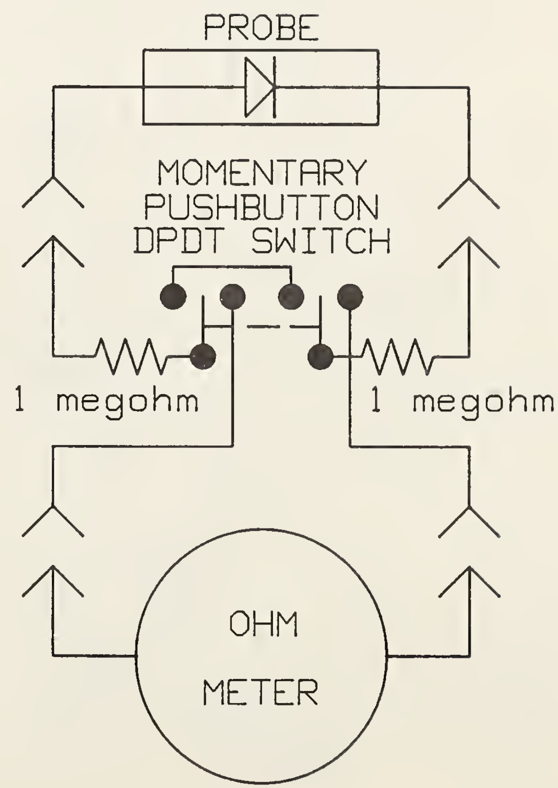
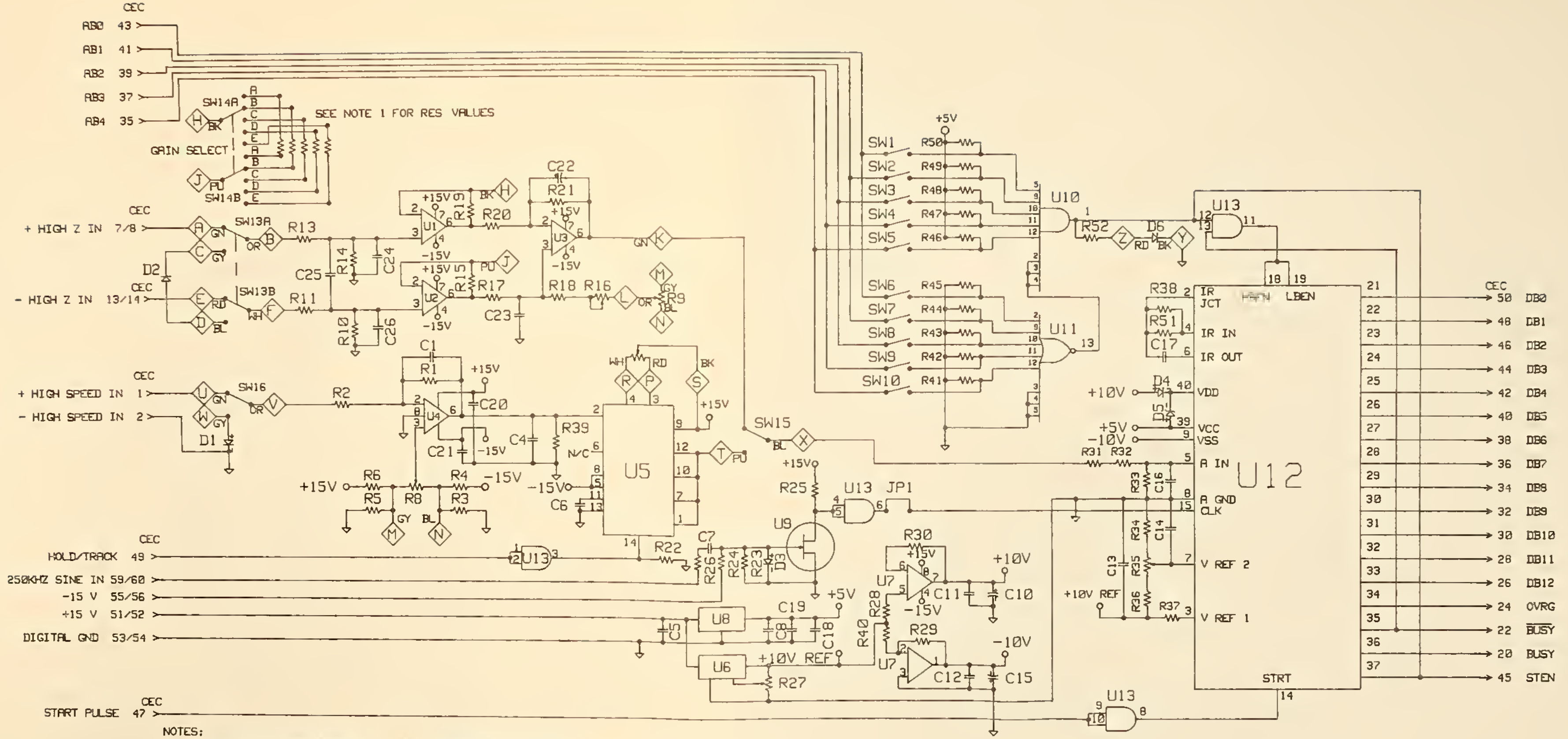


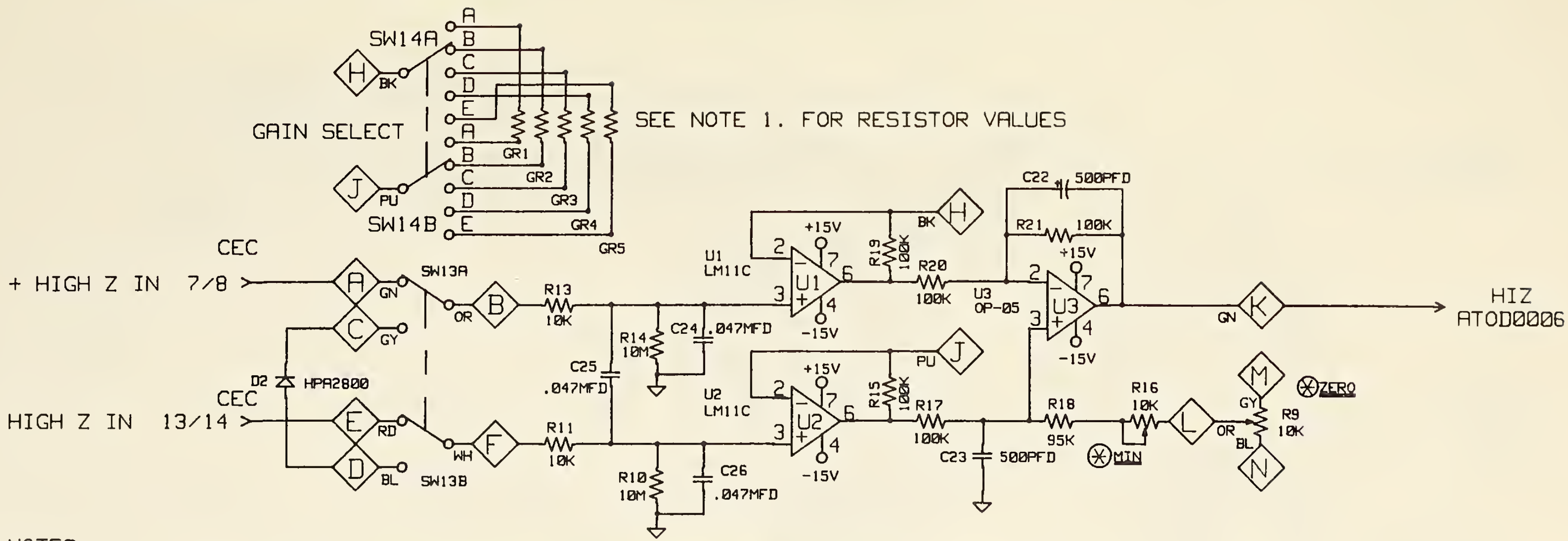
Figure 8. Probe test jig.



NOTES:
1. VALUES FOR GAIN RESISTORS TO BE DETERMINED BY END USER.
2. ◇ THIS SYMBOL WITH LETTER INSIDE INDICATES HARDWIRED CONNECTIONS TO THE FRONT PANEL.
3. CEC IS USED TO DENOTE THE CARD EDGE CONNECTOR. [8 AMPLIFIER CARDS PLUG INTO BACKPLANE SOCKETS LABELED CON1 THROUGH CON8].

Figure 9. RF probe amplifier general schematic. See figures 10, 11, 12, 13, and 14 for more detailed schematics containing component values, etc.

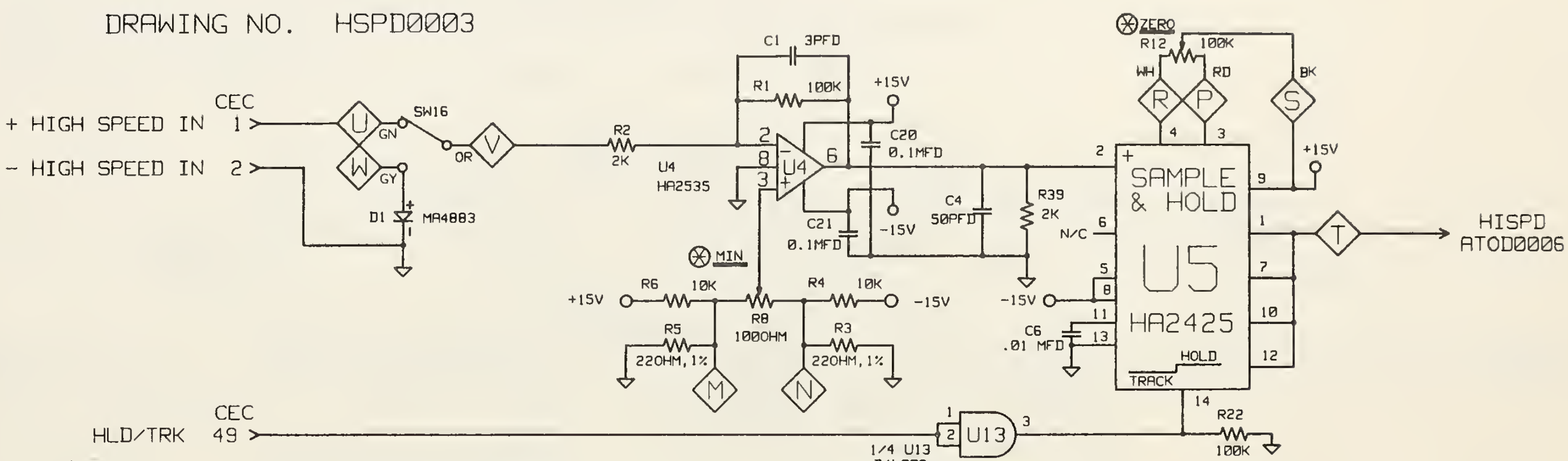
DRAWING NO. HIMP0002



NOTES:

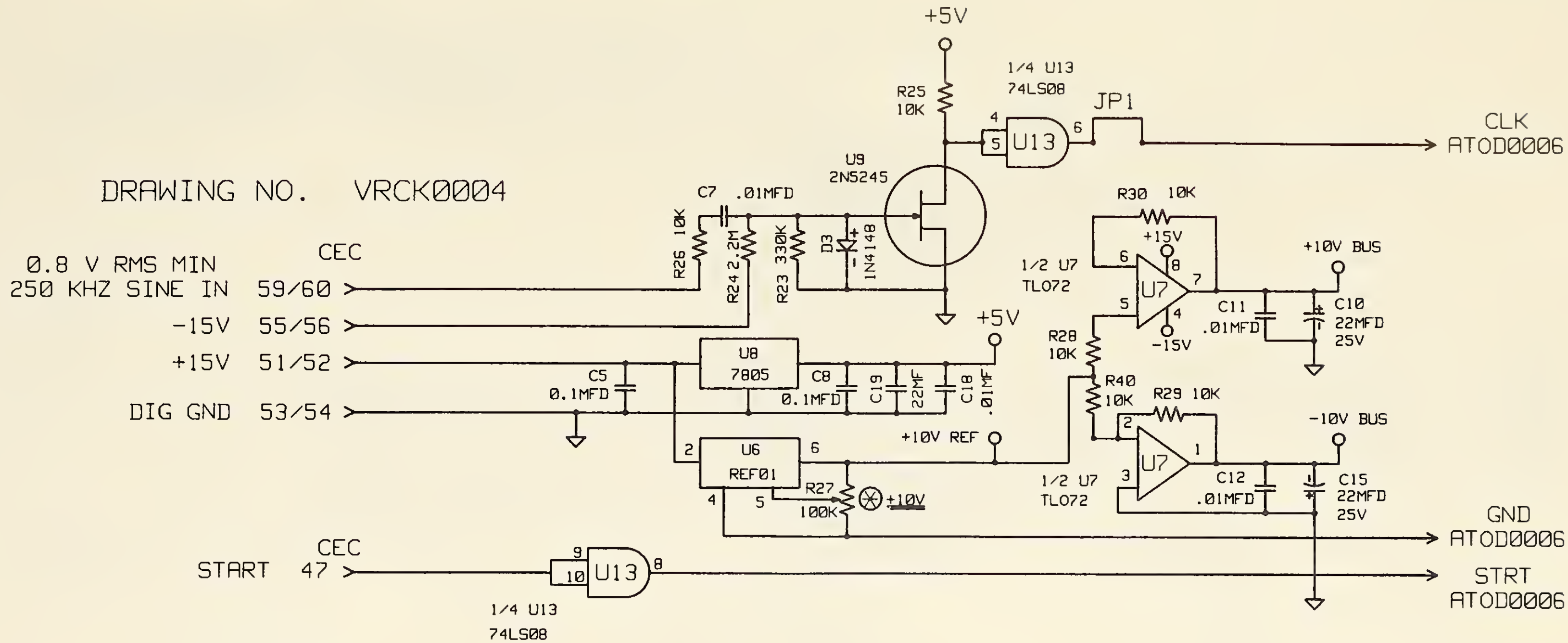
1. ⊛ IS USED TO DENOTE ADJUSTMENT POINTS, WITH THE ADJUSTMENT IN QUESTION UNDERLINED.
2. THE VALUE OF GAIN RESISTORS [GR1 THROUGH GR5] SHOULD BE DETERMINED BY THE END USER. HOWEVER, FOR THIS SYSTEM WITH THE N. B. S. SUPPLIED PROBES, THE FOLLOWING VALUES HAVE BEEN INSTALLED:
   GR1 - 2K - GAIN OF 100
   GR2 - 22.1K - GAIN OF 10
   GR3 - OPEN CIRCUIT - GAIN OF 1
   GR4 - NOT USED
   GR5 - NOT USED
3. ◇ THIS SYMBOL WITH LETTER INSIDE INDICATES HARDWIRED CONNECTIONS TO THE FRONT PANEL.
4. CEC IS USED TO DENOTE THE CARD EDGE CONNECTOR. [8 AMPLIFIER CARDS PLUG INTO BACKPLANE SOCKETS LABELED CON1 THROUGH CON8].

Figure 10. High impedance amplifier.



NOTES:
1. CEC IS USED TO DENOTE THE CARD EDGE CONNECTOR. [8 AMPLIFIER CARDS PLUG INTO BACKPLANE SOCKETS LABELED CON1 THROUGH CON8].
2. ◇ THIS SYMBOL WITH LETTER INSIDE INDICATES HARDWIRED CONNECTIONS TO THE FRONT PANEL.
3. ⊛ IS USED TO DENOTE ADJUSTMENT POINTS, WITH THE ADJUSTMENT IN QUESTION UNDERLINED.

Figure 11. High speed amplifier.



NOTES:
1. ⊗ IS USED TO DENOTE ADJUSTMENT POINTS, WITH THE ADJUSTMENT IN QUESTION UNDERLINED.
2. ◇ THIS SYMBOL WITH LETTER INSIDE INDICATES HARDWIRED CONNECTIONS TO THE FRONT PANEL.
3. CEC IS USED TO DENOTE THE CARD EDGD CONNECTOR. [8 AMPLIFIER CARDS PLUG INTO BACKPLANE SOCKETS LABELED CON1 THROUGH CON8].

Figure 12. Circuit diagram of clock squaring circuit, start circuit, and +/- 10 volt regulator circuit, for the probe amplifier card.

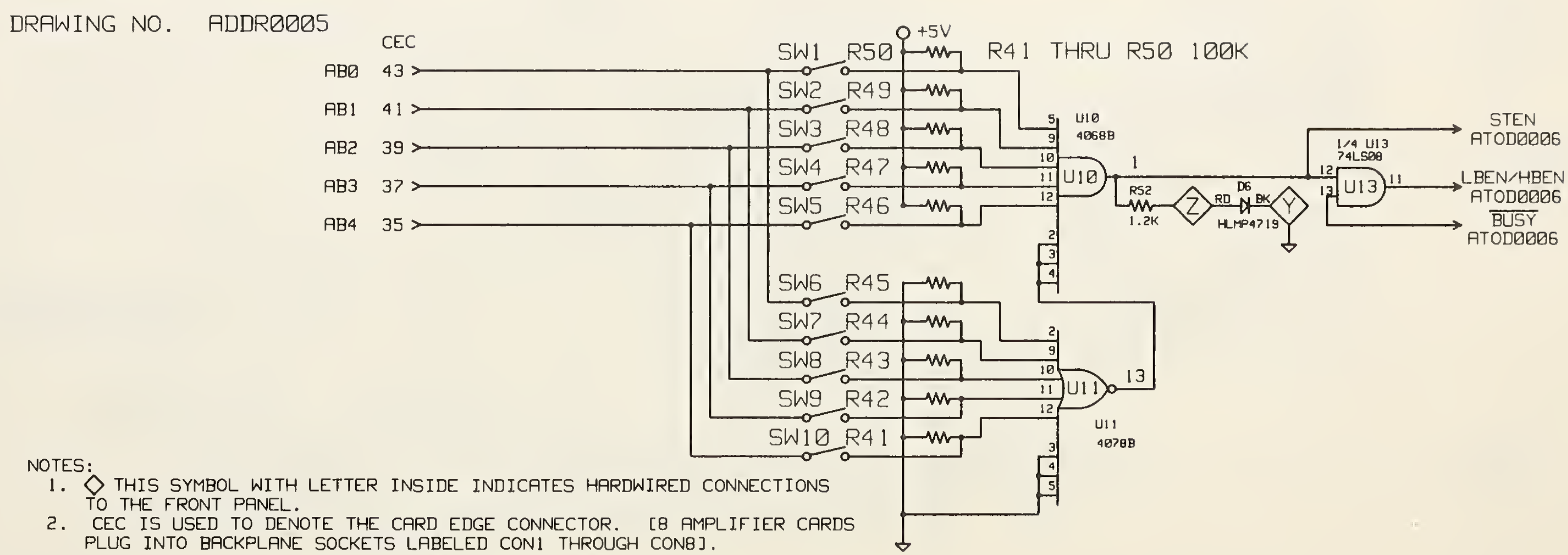
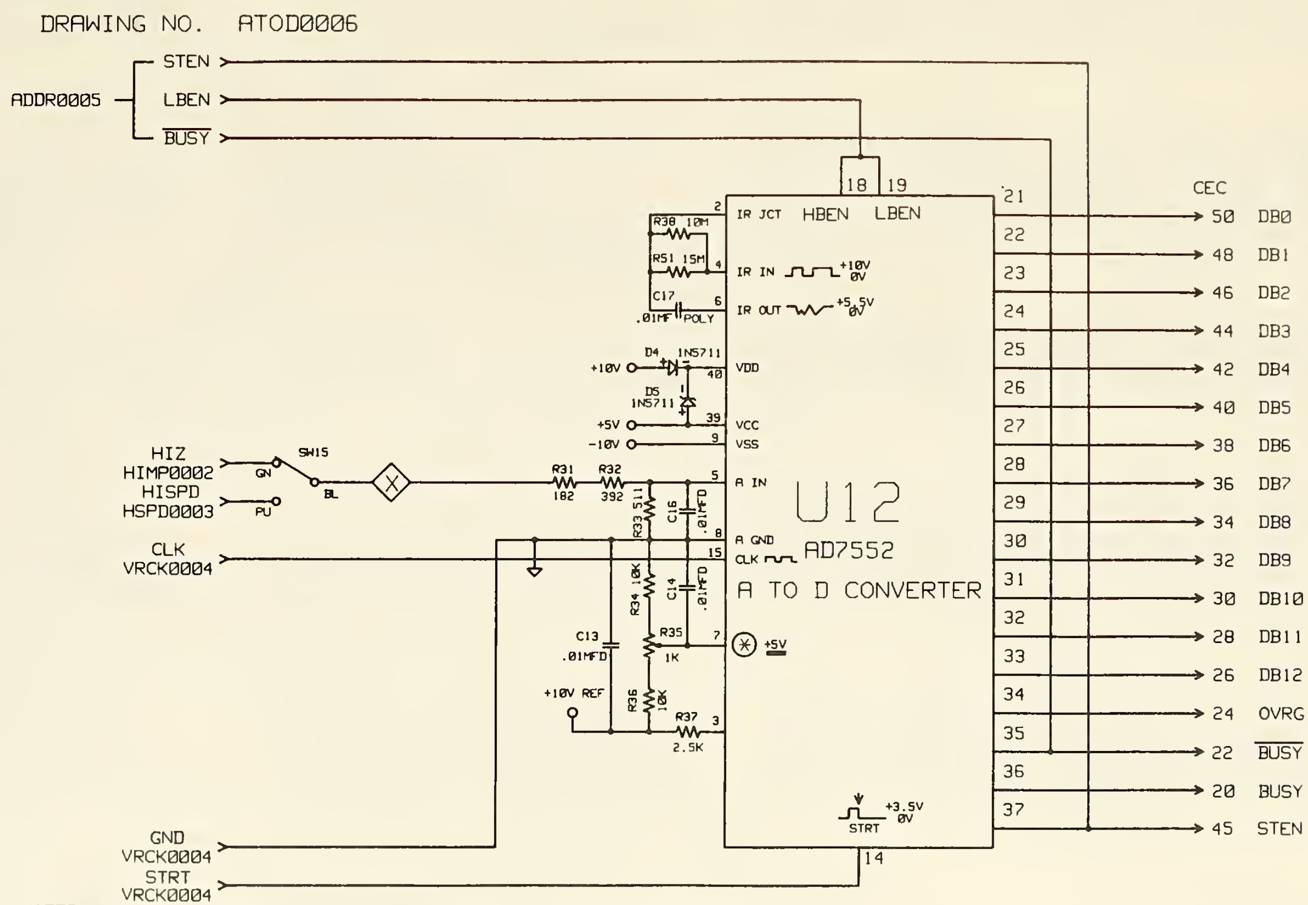


Figure 13. Address selection circuits.



NOTES:

1. ● IS USED TO DENOTE ADJUSTMENT POINTS, WITH THE ADJUSTMENT IN QUESTION UNDERLINED.
2. CEC IS USED TO DENOTE THE CARD EDGE CONNECTOR. [8 AMPLIFIER CARDS PLUG INTO BACKPLANE SOCKETS LABELED CON1 THROUGH CON8].

Figure 14. Analog to digital converter.

ALIGNMENT PROCEDURES

	COMPONENT	TEST POINT	CONDITION
1.	R8 [100 OHM POT] ON PC BOARD.	PIN 6 OF U4, JUNCTION OF R1 AND C4.	ADJUST TO 0 [0 OUTPUT AT HIGH SPEED AMP].
2.	R16 [10 K POT] ON PC BOARD.	PIN 6 OF U3, CENTER OF SW 15 [AMP SELECT] ON FRONT PANEL.	TIE HIGH IMPEDANCE INPUTS TOGETHER. EXCITE THESE WITH 60 HZ, 7V PEAK TO PEAK SIGNAL. ADJUST FOR MINIMUM OUTPUT.
3.	R27 [100 K POT] ON PC BOARD.	PIN 6 OF U6, JUNCTION OF R27 AND R28.	WITH AMP SELECT IN HIGH IMPEDANCE POSITION AND WITH HIGH IMPEDANCE/ZERO SWITCH IN HIGH IMPEDANCE POSITION, ADJUST TO +10.00 VOLTS.
4.	R35 [1 K POT] ON PC BOARD.	PIN 7 OF U12, THE A TO D CONVERTOR.	WITH THE HIGH IMPEDANCE/ZERO SWITCH IN THE HIGH IMPEDANCE POSITION, ADJUST TO +5.00 VOLTS.
5.	R9 [10 K POT] ON FRONT PANEL.	READ FROM CRT ON HP 9836 DIGITAL OUTPUT.	WITH AMP SELECT IN HIGH IMPEDANCE POSITION, AND HIGH IMPEDANCE/ZERO IN ZERO POSITION, AND WITH PROBES IN ZERO FIELD, ADJUST TO ZERO.
6.	R12 [100 K POT] ON FRONT PANEL.	READ FROM CRT ON HP 9836 DIGITAL OUTPUT.	WITH AMP SELECT IN HIGH SPEED POSITION, AND HIGH SPEED/ZERO IN ZERO POSITION, AND WITH WITH PROBES IN ZERO FIELD, ADJUST TO ZERO.

Figure 15. List of alignment procedures.

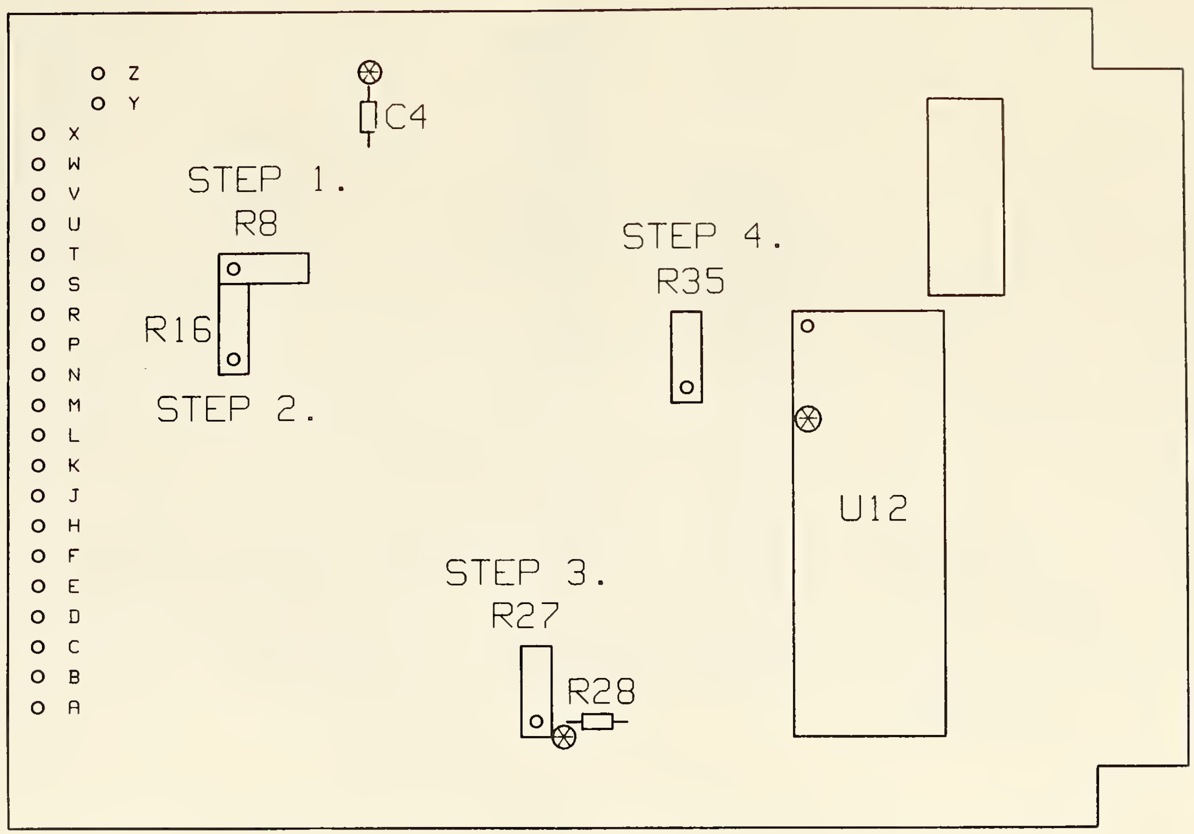


Figure 16. Probe amplifier parts locations for alignment procedures contained on figure 15. (Steps 5 and 6 adjustments are on front panel, figure 5.)

TEST POINT	OUTPUT
B	15V SINE
F	15V SINE
U1 PIN 2	15V SINE
U1 PIN 3	15V SINE
U1 PIN 6	15V SINE
U2 PIN 2	15V SINE
U2 PIN 3	15V SINE
U2 PIN 6	15V SINE
L	1 mV
M	23 mV
N	-23 mV
U3 PIN 2	15V SINE
U3 PIN 3	15V SINE
U3 PIN 6	15V SINE
R6	+15V SINE
R4	-15V SINE
JP-1	4V, 4 microSEC SQWV
U12 PIN 18	4.5V SQWV
U12 PIN 14	3.5V SQWV
U12 PIN 3	9.99V DC
U12 PIN 7	5.00V
U12 PIN 8	0
U12 PIN 5	0
U12 PIN 9	-10.03V
Ui2 PIN 39	5.00V
U12 PIN 40	9.66V

Figure 17. Normal test point data.

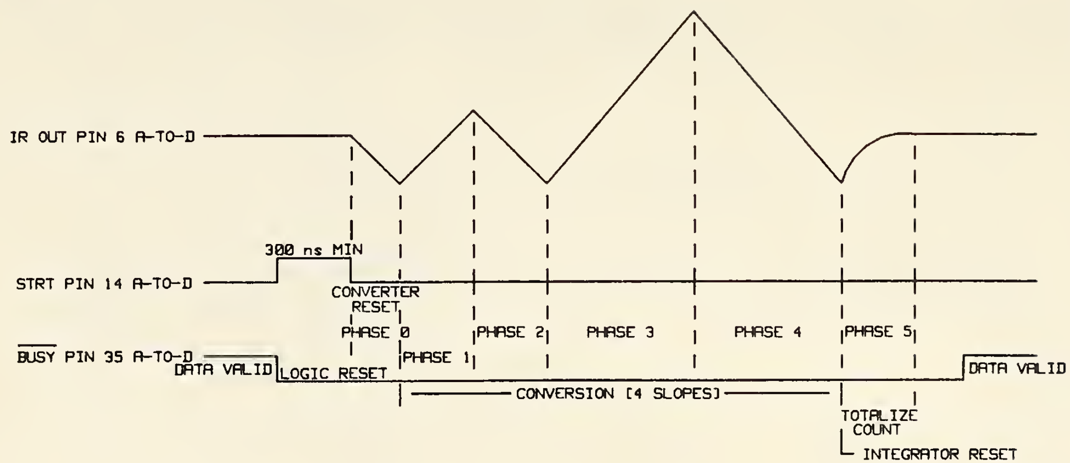
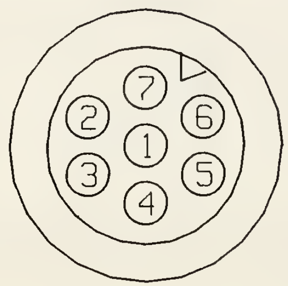


Figure 18. Typical system test waveforms.

PIN	COL	ASSIGN	50 PIN D CONN
1	GRN	GND	34,35,36
2	RED	X−	18
3	WHT	X+	1
4	ORG	Y−	19
5	BRN	Y+	2
6	GRY	Z−	20
7	PUR	Z+	3

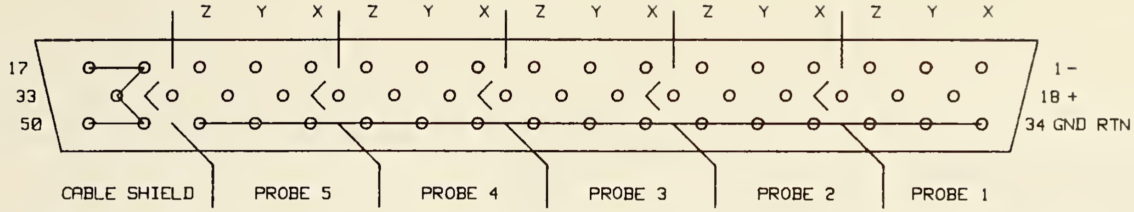


7 PIN VIKING CONNECTOR

FOR 4 OTHER PROBES, REPEAT ABOVE COLOR CODES AS FOLLOWS:

7 PIN PIN NO.	50 PIN D CONN	50 PIN D CONN	50 PIN D CONN	50 PIN D CONN
1	37,38,39	40,41,42	43,44,45	46,47,48
2	21	24	27	30
3	4	7	10	13
4	22	25	28	31
5	5	8	11	14
6	23	26	29	32
7	6	9	12	15

Figure 19. Probe color code.



COLOR CODE FOR 10.7M(35ft) PROBE AMP CABLE, 27 PR SHEILDED CABLE WITH [D] CONNECTOR ON EACH END

1 BK-----18 WH		34 GN/WH
2 RD-----19 WH		35 WH
3 BN-----20 WH		36 BK/GY/WH
4 OR-----21 WH		37 GY/WH
5 YL-----22 WH		38 WH
6 BL-----23 WH		39 BK/OR/WH
7 GN-----24 WH		40 PU/WH
8 PU-----25 WH		41 WH
9 GY-----26 WH		42 BK/PU/WH
10 BK/WH-----27 WH		43 RD/BK/WH
11 RD/WH-----28 WH		44 WH
12 BN/WH-----29 WH		45 BK/YL/WH
13 OR/WH-----30 WH		46 BL/BK/WH
14 YL/WH-----31 WH		47 WH
15 BL/WH-----32 WH		48 BK/GN/WH
16 SHIELD	33 SHIELD	49 SHIELD
17 SHIELD		50 SHIELD

PINS 1-15 ARE -, PINS 18-32 ARE +, PINS 34-48 ARE GND RTN.
PINS 16, 17, 33, 49 AND 50 ARE SHIELD/GND.
EACH PAIR IN CABLE HAS 1 WHITE WIRE.
1&18, 2&19, ETC. ARE PAIRS, FOR PINS 34-48 THE PRECEDING COLOR IS THE PAIR FOR EACH WHITE, 34&35, 37&38, ETC.

HIGH IMPEDANCE PROBE INPUTS
SMA CABLE FROM AMPLIFIERS TO 50 PIN [D] ON BACK PANEL
PIN ASSIGNMENTS

1 X-1	18 X+2	34 GND
2 Y-3	19 Y+4	35 GND
3 Z-5	20 Z+6	36 GND
4 X-7	21 X+8	37 GND
5 Y-9	22 Y+10	38 GND
6 Z-11	23 Z+12	39 GND
7 X-13	24 X+14	40 GND
8 Y-15	25 Y+16	41 GND
9 Z-17	26 Z+18	42 GND
10 X-19	27 X+20	43 GND
11 Y-21	28 Y+22	44 GND
12 Z-23	29 Z+24	45 GND
13 X-25	30 X+26	46 GND
14 Y-27	31 Y+28	47 GND
15 Z-29	32 Z+30	48 GND
16 SHIELD	33 SHIELD	49 SHIELD
17 SHIELD		50 SHIELD

PROBES 1-15
CHANNELS 1-15

Figure 20. 10.7 meter (35 ft) rf probe amplifier cable color code and SMA cable pin assignments.

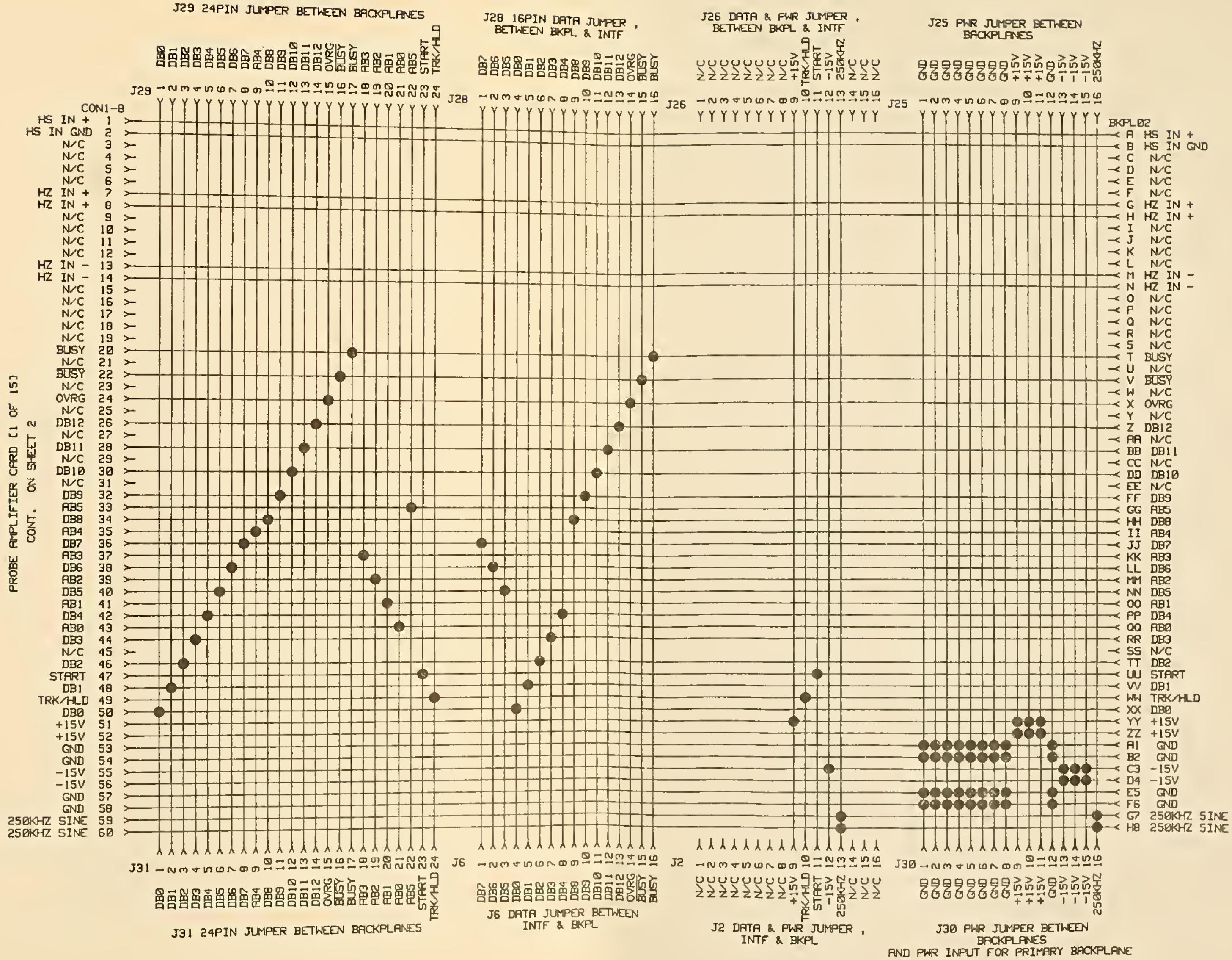


Figure 21. Backplane schematic and connector chart [sheet 1 of 2].

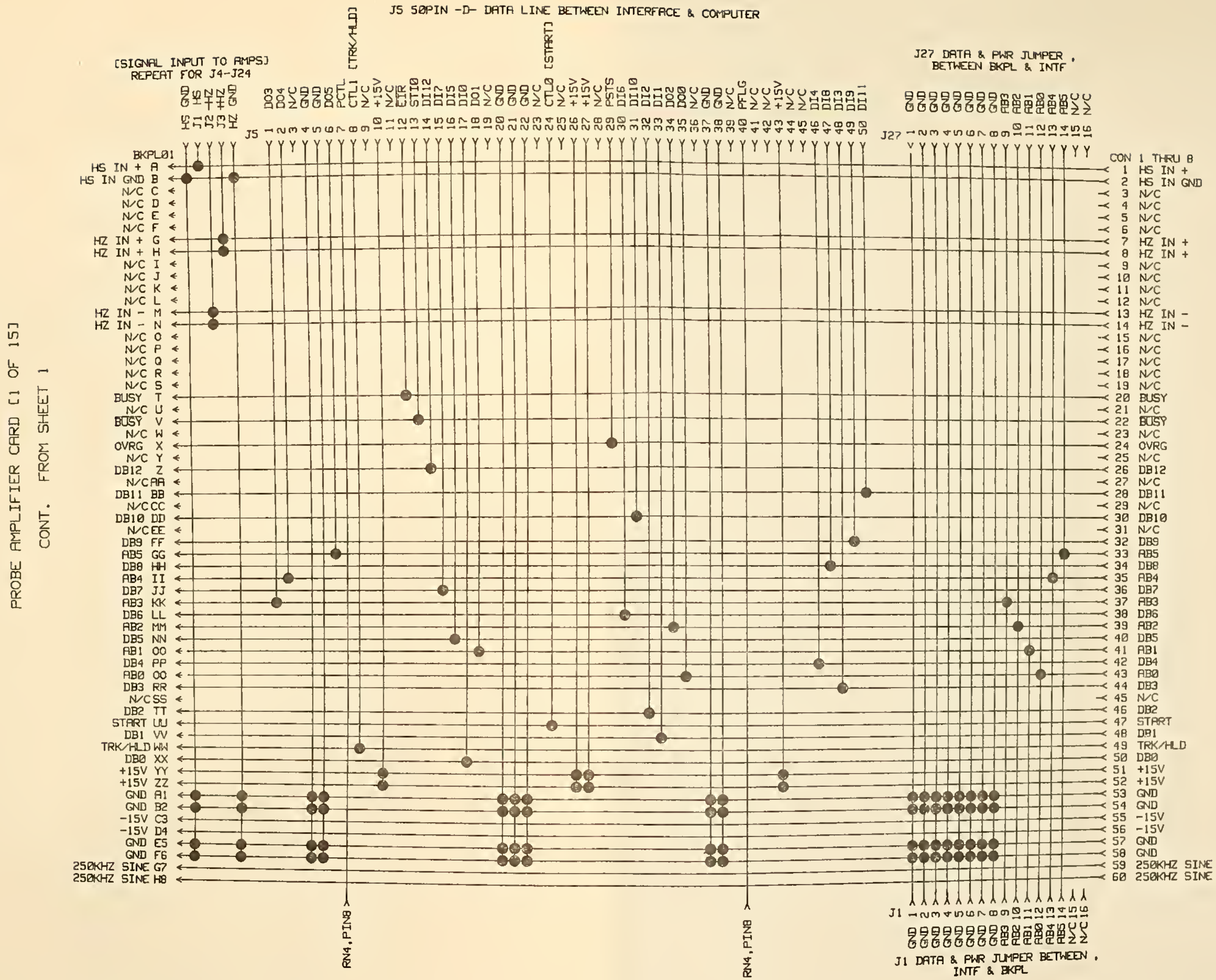


Figure 22. Backplane schematic and connector chart [sheet 2 of 2].

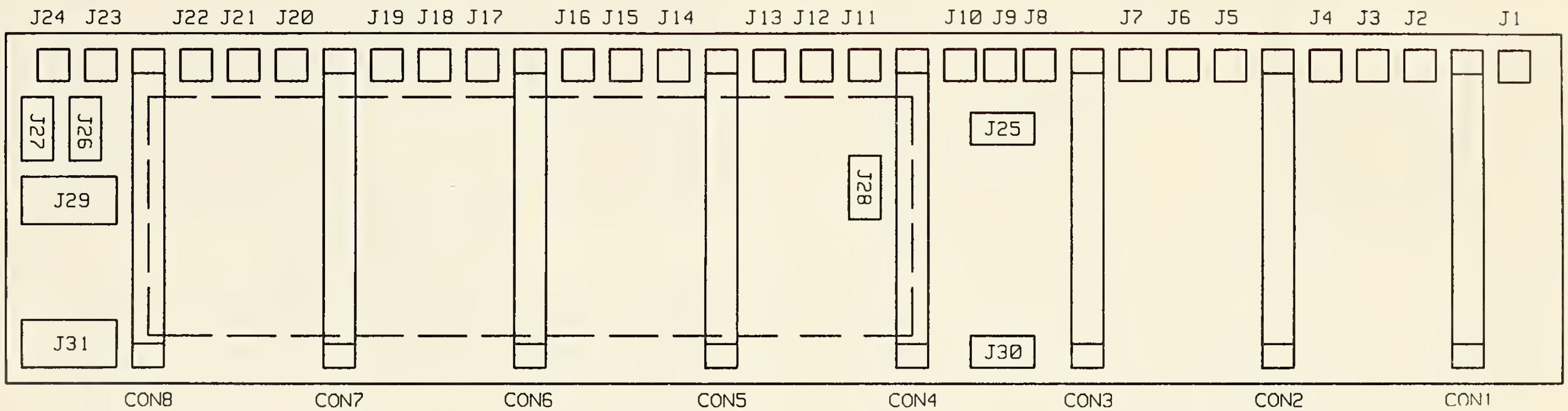


Figure 23. Backplane component locations [reference designator assignments].

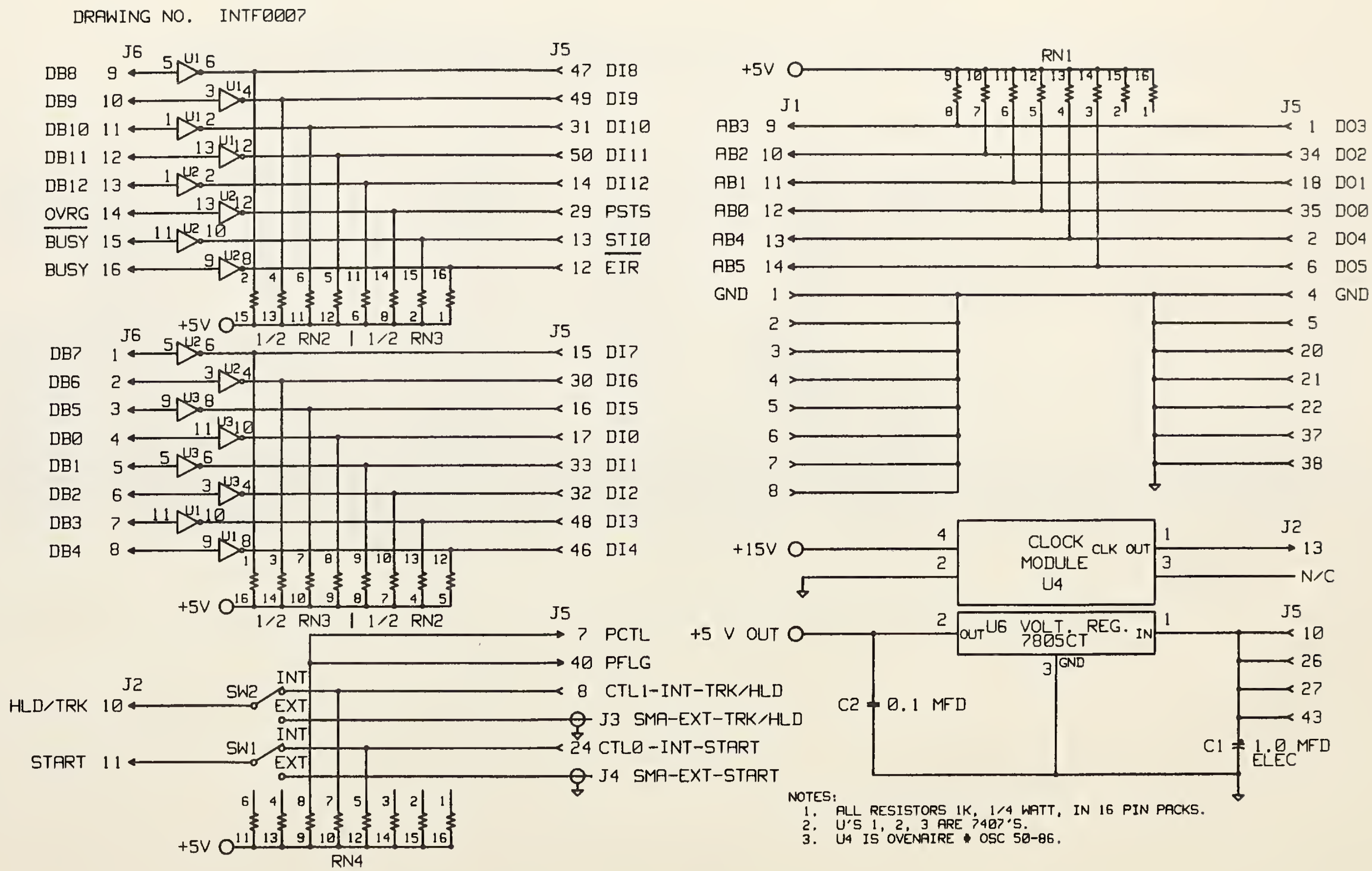


Figure 24. RF probe amplifier interface.

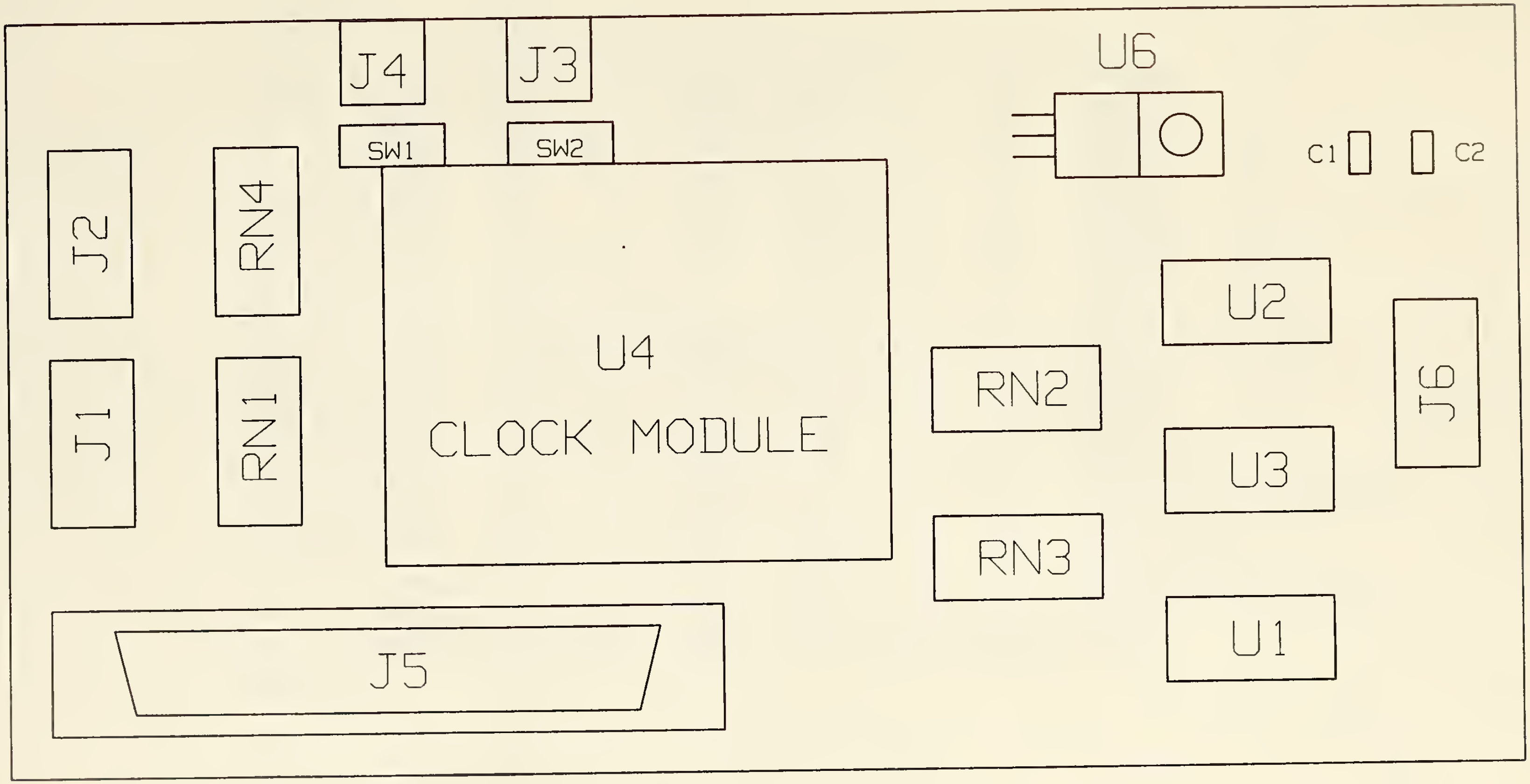


Figure 25. Interface component locations [reference designator assignments].

USE	J5-D	GPIO	COLOR	USE	J5-D	GPIO	COLOR
DO3	1	14	WH/OR	*DI13	26	29	WH/RD/GN
DO4	2	13	WH/YL	*DI14	27	28	WH/OR/GN
*DO6	3	11	WH/PU	*DO12	28	5	WH/RD/YL
GND	4	1	WH	PSTS	29	45	WH/BK/GY
GND	5	18	WH/GN/BK	DI6	30	36	BL
DO5	6	12	WH/GN	DI10	31	32	WH/YL/BN
PCTL	7	19	WH/[LT]BN	DI2	32	40	RD
CTL1	8	23	WH/RD/GY	DI1	33	41	BN
*DO7	9	10	WH/BL/PU	DO2	34	15	WH/RD
*STI1	10	48	WH/PU/GY	DO0	35	17	WH/BK
*DO8	11	9	WH/BL/YL	*DO13	36	4	WH/GY
$\overline{EIR}$	12	46	WH/BN/GY	GND[INNER]	37	43	WH/YL/PU
STI0	13	47	WH/BL/BN	*GND[OUTER]	38	25	SHIELD
DI12	14	30	WH/RD/OR	*DO14	39	3	WH/BK/PU
DI7	15	35	PU	PFLG	40	44	GY
DI5	16	37	GN	*DO15	41	2	WH/GN/BL
DI0	17	42	BK	*I/O	42	20	WH/BL
DO1	18	16	WH/BK/BN	*NOT USED	43	50	WH/BN/PU
*DO9	19	8	WH/GN/GY	*PRESET	44	21	WH/RD/BK
GND	20	24	WH/BK/OR	*DI15	45	27	WH/OR/YL
GND	21	26	WH/BK/BL	DI4	46	38	YL
GND	22	49	WH/BK/YL	DI8	47	34	WH/RD/BN
*DO10	23	7	WH/GN/PU	DI3	48	39	OR
CTL0	24	22	WH/RD/PU	DI9	49	33	WH/OR/BN
*DO11	25	6	WH/RD/BL	DI11	50	31	WH/GN/BN

COLORS NOT USED: WH/YL/GY, WH/OR/BL, WH/OR/GN, WH/BL/GY, WH/OR/PU.
POSITIONS MARKED WITH A * , ARE N/C ON HP CABLE.

Figure 26. Interface cable color codes.

RESISTORS:

22 OHM 5%	R3, R5
100 OHM TRIM	R8
182 OHM 1%	R32
392 OHM 1%	R31
511 OHM 1%	R33
1K OHM TRIM	R35
1.2K ohm 1%	R52
2K ohm 1%	R2, R39
2.5K ohm 1%	R37
10K ohm 1%	R4, R6, R7, R11, R13, R25, R26, R27, R29, R34, R36, R40
10K ohm TRIM	R16
10K ohm TRIM PANEL MOUNT	R9
10K ohm 5%	R28, R30
95K ohm 1%	R18
100K ohm 5%	R22, R41 THROUGH R50
100K ohm 1%	R1, R15, R17, R19, R20, R21
100K ohm TRIM	R27
100K ohm TRIM PANEL MOUNT	R12
330K ohm 5%	R23
2.2M ohm;1%	R24
10M ohm 1%	R10, R14, R38

CAPACITORS:

500pF CERAMIC	C22, C23
50pF MICA	C4
3pF MICA	C1
.01microF CERAMIC	C7, C11, C12, C13, C14, C16, C18
.01microF POLYSTY	C6, C17
.047microF POLYCARB	C24, C25, C26
.1microF CERAMIC	C5, C8, C20, C21
22microF TANT ELEC	C10, C15, C19

DIODES;

MA4883	D1
HPA2800	D2
1N4148	D3
1N5711	D4, D5
HLMP4719	D6

IC'S

LM11C	U1, U2
OP-05	U3
HA2535	U4
HA2425	U5
REF-01	U6
TL072	U7
MC7805C	U8
2N5245	U9
4068B	U10
4078B	U11
AD7552	U12
74LS08	U13

SWITCHES

12 POS DIP	SW1 THROUGH 12
DPDT TOGGLE	SW13
10 POS ROT	SW14
SPDT TOGGLE	SW15, SW16

Figure 27. Probe amplifier parts list.

RESISTORS	
1K OHM 1/4th WATT 16 PIN DIP	RN1, RN2, RN3, RN4,
CAPACITORS	
1.0 MFD ELEC	C1
0.1 MFD	C2
IC'S	
7407	U1, U2, U3
OVENAIRE OSC 50-86	U4
7805CT	U6
SWITCHES	
SPDT	SW1, SW2
JACKS AND CONNECTORS	
SMA FEMALE	J3, J4
16 PIN DIP	J1, J2, J6
50 PIN D MALE	J5

Figure 28. Interface parts list.

JACKS AND CONNECTERS	
J1 THROUGH J24	SMA FEMALE
J25, J26, J27, J28, J30	16 PIN DIP
J29, J31	24 PIN DIP
CON1 THROUGH CON8	50 PIN EDGE

4, 16PIN RIBBON, MALE BOTH ENDS, USED TO JUMPER INTERFACE AND BACKPLANES.

2, 24 PIN RIBBON, MALE BOTH ENDS, USED TO JUMPER BACKPLANES.

Figure 29. Backplane parts list [connectors].

APPENDIX

Computer Program Listing

```
100!   RE-STORE "Probe_Subs"
102    ! Original:  5 May 1984  G. Koepke  (303) 497-5766
104    ! Revision:  7 Nov 1985, 16:45
106    !
108    ! Second generation probe software SUB programs.
110    ! These SUBs allow any system size up to 48 probes
112    ! and for each antenna to have its' own amplitude and
114    ! frequency calibration data.
116    !
118    ! Currently set to 15 channels for the NSWC system.
120    !
122    OPTION BASE 1
124    DEG
126    PRINTER IS CRT
128    !
130 Dim_variables:!
132    !
134    COM /Probe_system/ INTEGER Sys_size,Total_chans,Probe_addr(15,3)
136    COM /Probe_system/ INTEGER Top_probe,Fcal_pts,Pr_avgs
138    COM /Probe_system/ INTEGER Probe_volts(15),Overrange(15)
140    COM /Probe_system/ INTEGER Probe_zero(15),REAL Probe_v_m(15)
142    COM /Probe_system/ REAL Amplitude_cal(5,3,5),Freq_cal(5,3,6,2)
144    COM /Probe_system/ REAL Readtime(15),Freq_crib(6,2)
146    COM /Interrupts/ INTEGER Intr_prty
148    COM /Bugs/ INTEGER Bug1,Bug2,Bug3,Printer
150    COM /Files/ Sourcedisk$[20],Outdisk$[20],Filename$[80]
152    !
154    INTEGER Local_prty,P_sams,P
156    REAL Frequency
158    Intr_prty=5
160    Local_prty=5
162    Printer=701
164    Sourcedisk$=":INTERNAL,4,0"
166    Outdisk$=":INTERNAL,4,1"      !    ":HP9133,700,0"
168 Bugs:!
170    Bug1=0
172    Bug2=1
174    Bug3=0
176    !
178    CALL Multiprobe_menu           ! Set up the 15 probe system.
180    P_sams=3                       ! Read Multiprobe 3 times and average.
182    MAT Probe_volts= (100)         ! dummy data   actual sequence below
184    MAT Overrange= (0)             ! dummy data
186    MAT Probe_zero= (0)            ! dummy data
188    Frequency=300                  ! dummy data
190    CALL Apply_probe_cal(Frequency)! Amplitude & frequency correction
192    STOP   ! END test subs......suggested sequence follows
194    !
196    ! Fill Probe_volts(*) using Probe_addr(*) and Total_chans
198    !
200    ! IF Total_chans>0 THEN   ! ZERO field offset reading (probe zero)
202    !    MAT Probe_zero= (0)
204    !    CALL Read_probes(@Gpio)
206    !    MAT Probe_zero= Probe_volts
208    ! END IF
210    ! IF Total_chans>0 THEN   ! Field applied, now read probes
212    !    CALL Read_probes(@Gpio)
214    !    Too_hot=0
216    !    FOR P=1 TO Total_chans
218    !        Too_hot=Too_hot OR Overrange(P)  ! Test for overrange
```

```
220     !     NEXT P
222     !     IF Too_hot THEN
224     !           GOSUB Reduce_power
226     !           GOTO Restart_point
228     !     END IF
230     !     CALL Apply_probe_cal(Frequency)! Amplitude & frequency correction
232     ! END IF
234     END
236     !
238     ! ************************************************************
240     !
242     SUB Multiprobe_menu
244 Multiprobe_menu: !
246         ! Provide a means of controlling the multi-probe system.
248         ! The menu allows one to select the Amplifier channel and
250         ! the probe connected to it.
252         ! This information will be used to draw calibration data from
254         ! the calibration matrix.
256         ! ..........................................................
258         ! ------ Variable and matrix index Definitions -----------
260         ! ..........................................................
262         !
264         ! Sys_size => Number of amplifiers in the system, this defines
266         !             menu limits so that one software package serves
268         !             systems of different sizes. (Sys_size = *)
270         !
272         ! Top_probe => The highest index for any probe in the system [<99]
274         !              This index ties the calibration data to the antenna.
276         !              Whatever number of probes are used, the index numbers
278         !              must be sequential and tied to the calibration matrix
280         !              with values entered for them.
282         !
284         ! Total_chans => Number of amplifiers currently enabled by menu.
286         !
288         ! Probe_addr(*,3) => (*,1) = Amplifier channel
290         !                    (*,2) = Probe index number up to Top_probe
292         !                    (*,3) = Probe channel 1=X, 2=Y, 3=Z, 4=Single
294         !                            (4 is the same as 1 in drawing out the
296         !                             calibration data)
298         !
300         ! Pr_avgs => The number of readings to be averaged together.
302         !
304         ! Probe_volts(*) => Actual reading of A/D output.
306         !
308         ! Overrange(*) => Overrange flag for each channel
310         !
312         ! Readtime(*) => Conversion and read time of each channel.
314         !
316         ! Probe_zero(*) => Zero field offset reading
318         !
320         ! Probe_v_m(*) => Final reading in Volts/meter.
322         !
324         ! Amplitude_cal(# probe,channel[1-3],curvefit coef[1-5]) =>
326         ! Amplitude calibration data: # probe = Top_probe
328         !                             channels 1=X or S, 2=Y, 3=Z
330         !                             curvefit coef 1= a1 (low)
332         !                                           2= b1 (low)
334         !                                           3= a2 (high)
336         !                                           4= b2 (high)
338         !                                           5= low-high crossing
```

```
340         !
342         ! Freq_cal(# probe,channel[1-3],CAL_pt,freq [1] or dB [2]) =>
344         ! Frequency calibration data: # probe and channels as above
346         !                               CAL_pt= up to Fcal_pts as below
348         !                               freq or dB;     1= frequency of cal
350         !                                               2= value dB at 1
352         ! Fcal_pts => Total number of calibration points in frequency
354         !
356         ! ..........................................................
358         !
360 System_defns: !
362         ! xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
364         ! ........ MULTI-PROBE SYSTEM DEFINITIONS ................
366         ! xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
368         !
370         OPTION BASE 1
372         COM /Probe_system/ INTEGER Sys_size,Total_chans,Probe_addr(15,3)
374         COM /Probe_system/ INTEGER Top_probe,Fcal_pts,Pr_avgs
376         COM /Probe_system/ INTEGER Probe_volts(15),Overrange(15)
378         COM /Probe_system/ INTEGER Probe_zero(15),REAL Probe_v_m(15)
380         COM /Probe_system/ REAL Amplitude_cal(5,3,5),Freq_cal(5,3,6,2)
382         COM /Probe_system/ REAL Readtime(15),Freq_crib(6,2)
384         !
386         Sys_size=15        ! SYSTEM SIZE set here!!!
388         Top_probe=5        ! Set all matrix dimensions accordingly in
390         Fcal_pts=6         ! above COM statements.
392         Pr_avgs=1          ! return single sample per reading.
394                            ! NOTE: Allow for three channels for every probe
396                            !       even if there is a single channel.
398                            !       You may, however, group several single
400                            !       channel devices together under one index
402                            !       number. (i.e. call first #25X, second one
404                            !       #25Y, etc.).  All probes in the system must
406                            !       be numbered sequentially.
408                            !       The calibration values are entered in the
410                            !       sub called Probe_fill_call.
412         !
414         ! xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
416         !
418         COM /Interrupts/ INTEGER Intr_prty
420         COM /Bugs/ INTEGER Bug1,Bug2,Bug3,Printer
422         COM /Files/ Sourcedisk$[20],Outdisk$[20],Filename$[80]
424         INTEGER I,J,K,Local_prty,Knobcnt_x,Knobcnt_y,Selectpoint
426         INTEGER Duplicated,Test_size,Poffset,Column1,Column2,Column3
428         INTEGER Interrupted
430         DIM Marker$[8],Test$[160]
432         Local_prty=Intr_prty
434         DISP CHR$(128)
436         IF Bug1 THEN
438             PRINTER IS Printer
440             PRINT TIME$(TIMEDATE);"******** ENTER Multiprobe_menu ********"
442         END IF
444         PRINTER IS CRT
446         GOSUB Print_bckgnd     !Print the heading and the amplifier channels.
448         GOSUB Select_configur  !Select source of probe system configure.
450                                !From disk, none or all probes.
452         GOSUB Configure_probe  !Select the amplifier and probe combination.
454         IF Bug1 THEN
456             PRINTER IS Printer
458             PRINT TIME$(TIMEDATE);"******** EXIT Multiprobe_menu ********"
```

```
460             PRINTER IS CRT
462         END IF
464         OUTPUT 2 USING "#,K";"K"  !Clear screen.
466         CALL Probe_fill_cal     ! Fill Amplitude_cal(*) and Freq_cal(*)
468         SUBEXIT
470         !
472         ! ////////////////////////////////////////////////////////////////
474         !
476 Select_configur:OFF KEY
478         DISP " SELECT SOURCE OF MULTI-PROBE CONFIGURATION "
480         ON KEY 0 LABEL "NO PROBES",Local_prty GOTO Noprobes
482         ON KEY 1 LABEL "ALL PROBES",Local_prty GOTO Allprobes
484         ON KEY 5 LABEL "CUR SETUP",Local_prty GOTO Config_selected
486         ON KEY 2 LABEL "FROM DISK",Local_prty GOTO Diskinfo
488         LOOP
490         END LOOP
492 Diskinfo:GOSUB Read_probe_disk
494         GOTO Config_selected
496 Allprobes:GOSUB Fill_addresses
498         GOTO Config_selected
500 Noprobes:Total_chans=0
502         MAT Probe_addr= (0)
504 Config_selected:OFF KEY
506         DISP CHR$(12)
508         FOR I=Total_chans+1 TO Sys_size
510             Probe_addr(I,1)=99
512             Probe_addr(I,2)=0
514             Probe_addr(I,3)=0
516         NEXT I
518         RETURN
520         !
522         ! ////////////////////////////////////////////////////////////////
524         !
526 Configure_probe: !
528         GOSUB Print_probeaddr
530         Marker$="===>"&RPT$(CHR$(8),4)
532         Knobcnt_x=0   !move up and down columns
534         Knobcnt_y=0   !move between rows.
536         Interrupted=1
538         Selectpoint=1
540         PRINT TABXY(1,Selectpoint+2);CHR$(128);Marker$;
542         LOOP
544             IF Interrupted THEN
546                 ON KNOB .05 GOSUB Movepointer
548                 ON KEY 5 LABEL "ALL DONE",Local_prty GOTO Allconfiged
550                 ON KEY 0 LABEL "CONFIG MENU",Local_prty GOSUB Sourcemenu
552                 ON KEY 1 LABEL "CHANGE PROBE",Local_prty GOSUB Changeprobe
554                 ON KEY 2 LABEL "ADD PROBE",Local_prty GOSUB Addprobe
556                 ON KEY 3 LABEL "READ DISK FILE",Local_prty GOSUB Read_disk
558                 ON KEY 4 LABEL "SAVE ON DISK",Local_prty GOSUB Saveondisk
560                 ON KEY 7 LABEL "DELETE PROBE",Local_prty GOSUB Deleteprobe
562                 ON KEY 9 LABEL "LIST ADDRS",Local_prty GOSUB List_addresses
564                 DISP CHR$(129);" USE (shift) KNOB TO SELECT AMPLIFIER ";
566                 DISP " and SOFTKEY TO SELECT ACTION. "
568                 Interrupted=0
570             END IF
572         END LOOP
574 Allconfiged:OFF KEY
576         OFF KNOB
578         DISP CHR$(12)      !Turn off display enhancements
```

```
580         PRINT CHR$(128)
582         RETURN
584         !
586         ! ////////////////////////////////////////////////////////////////
588         !
590 Sourcemenu: !
592         Interrupted=1
594         Local_prty=Local_prty+1
596         GOSUB Select_configur
598         GOSUB Print_probeaddr
600         GOSUB Reset_pointer
602         Local_prty=Local_prty-1
604         RETURN
606         !
608         ! ////////////////////////////////////////////////////////////////
610         !
612 Movepointer: ! Move selector on menu
614         Knobcnt_x=Knobcnt_x+KNOBX
616         Knobcnt_y=Knobcnt_y+KNOBY
618         IF ABS(Knobcnt_x)<5 AND ABS(Knobcnt_y)<10 THEN RETURN
620         IF ABS(Knobcnt_x)>=5 THEN
622             Selectpoint=Selectpoint+SGN(Knobcnt_x)
624             IF Selectpoint>Sys_size THEN Selectpoint=1
626             IF Selectpoint<1 THEN Selectpoint=Sys_size
628         END IF
630         IF ABS(Knobcnt_y)>=10 THEN
632             SELECT Selectpoint
634             CASE 1 TO Column1
636                 IF SGN(Knobcnt_y)>0 THEN
638                     IF Column2=Column1 OR Selectpoint<>Column1 THEN
640                         Selectpoint=Selectpoint+Column1
642                     END IF
644                 END IF
646             CASE Column1+1 TO Column1+Column2
648                 IF SGN(Knobcnt_y)>0 THEN
650                     IF Column3=Column2 OR Selectpoint<>Column1+Column2 THEN
652                         Selectpoint=Selectpoint+Column2
654                     END IF
656                 END IF
658                 IF SGN(Knobcnt_y)<0 THEN Selectpoint=Selectpoint-Column1
660             CASE Column1+Column2+1 TO Sys_size
662                 IF SGN(Knobcnt_y)<0 THEN Selectpoint=Selectpoint-Column2
664             END SELECT
666         END IF
668         Knobcnt_x=0
670         Knobcnt_y=0
672         OUTPUT 2;CHR$(255)&CHR$(84);    !Home the screen
674         PRINT CHR$(128);
676         PRINT "    ";
678         GOSUB Reset_pointer
680         PRINT Marker$;
682         RETURN
684         !
686         ! ////////////////////////////////////////////////////////////////
688         !
690 Reset_pointer:        !
692         PRINT TABXY(1,1);
694         SELECT Selectpoint
696         CASE 1 TO Column1
698             PRINT TABXY(1,Selectpoint+2);
```

```
700         CASE Column1+1 TO Column2+Column1
702             PRINT TABXY(31,Selectpoint-Column1+2);
704         CASE Column1+Column2+1 TO Sys_size
706             PRINT TABXY(61,Selectpoint-Column1-Column2+2);
708         END SELECT
710         RETURN
712         !
714         ! ////////////////////////////////////////////////////////////////
716         !
718 Position_pen:        ! Set the pen to the probe # column.
720         PRINT TABXY(1,1);CHR$(128);
722         SELECT Selectpoint
724         CASE 1 TO Column1
726             PRINT TABXY(13,Selectpoint+2);RPT$(" ",8);
728             PRINT TABXY(13,Selectpoint+2);
730         CASE Column1+1 TO Column1+Column2
732             PRINT TABXY(43,Selectpoint-Column1+2);RPT$(" ",8)
734             PRINT TABXY(43,Selectpoint-Column1+2);
736         CASE Column1+Column2+1 TO Sys_size
738             PRINT TABXY(73,Selectpoint-Column1-Column2+2);RPT$(" ",8);
740             PRINT TABXY(73,Selectpoint-Column1-Column2+2);
742         END SELECT
744         RETURN
746         !
748         ! ////////////////////////////////////////////////////////////////
750         !
752 Fill_addresses: ! Put all probes into the ADDR matrix.
754         K=1
756         MAT Probe_addr= (0)
758         Total_chans=MIN(Sys_size,Top_probe*3)
760         FOR I=1 TO Sys_size-2 STEP 3
762             FOR J=1 TO 3
764                 IF I+J-1<=Top_probe*3 THEN
766                     Probe_addr(I+J-1,1)=I+J-1
768                     Probe_addr(I+J-1,2)=K
770                     Probe_addr(I+J-1,3)=J
772                 ELSE
774                     Probe_addr(I+J-1,1)=99
776                     Probe_addr(I+J-1,2)=0
778                     Probe_addr(I+J-1,3)=0
780                 END IF
782             NEXT J
784             K=K+1
786         NEXT I
788         RETURN
790         !
792         ! ////////////////////////////////////////////////////////////////
794         !
796 Print_bckgnd: !
798         ! Set up the menu limits and column length.
800         Column1=(Sys_size DIV 3)+MIN(Sys_size MODULO 3,1)
802         Column2=(Sys_size DIV 3)+MAX(MIN((Sys_size MODULO 3)-1,1),0)
804         Column3=Sys_size DIV 3
806         !
808         OUTPUT 2 USING "K,#";"KT"
810         PRINT TABXY(1,1);CHR$(132);RPT$(">",26);
812         PRINT " MULTI-PROBE CONFIGURATION ";RPT$("<",26)
814         PRINT TABXY(1,2);CHR$(129);" Amplifier-Probe # "
816         PRINT TABXY(31,2);" Amplifier-Probe # "
818         PRINT TABXY(61,2);" Amplifier-Probe # "
```

```
820         PRINT CHR$(128)
822         FOR I=1 TO Column1
824             PRINT TABXY(5,I+2);
826             PRINT USING "MDD,#";I
828             PRINT " ----"
830         NEXT I
832         FOR I=1 TO Column2
834             PRINT TABXY(35,I+2);
836             PRINT USING "MDD,#";I+Column1
838             PRINT " ----"
840         NEXT I
842         FOR I=1 TO Column3
844             PRINT TABXY(65,I+2);
846             PRINT USING "MDD,#";I+Column1+Column2
848             PRINT " ----"
850         NEXT I
852         RETURN
854         !
856         ! ////////////////////////////////////////////////////////////////
858         !
860 Print_probeaddr: !
862         PRINT TABXY(1,1);CHR$(128);
864         J=1
866         FOR I=1 TO Column1
868             PRINT TABXY(13,I+2);RPT$(" ",8);
870             PRINT TABXY(13,I+2);
872             IF Probe_addr(J,1)=I THEN
874                 GOSUB Single_write
876                 J=J+1
878             ELSE
880                 PRINT "Not Used"
882             END IF
884         NEXT I
886         FOR I=1 TO Column2
888             PRINT TABXY(43,I+2);RPT$(" ",8)
890             PRINT TABXY(43,I+2);
892             IF Probe_addr(J,1)=I+Column1 THEN
894                 GOSUB Single_write
896                 J=J+1
898             ELSE
900                 PRINT "Not Used"
902             END IF
904         NEXT I
906         FOR I=1 TO Column3
908             PRINT TABXY(73,I+2);RPT$(" ",8);
910             PRINT TABXY(73,I+2);
912             IF Probe_addr(J,1)=I+Column1+Column2 THEN
914                 GOSUB Single_write
916                 J=J+1
918             ELSE
920                 PRINT "Not Used"
922             END IF
924         NEXT I
926         RETURN
928         !
930         ! ////////////////////////////////////////////////////////////////
932         !
934 Single_write: !
936         PRINT USING "DD,X,#";Probe_addr(J,2)
938         SELECT Probe_addr(J,3)
```

```
940         CASE 1
942             PRINT "X"
944         CASE 2
946             PRINT "Y"
948         CASE 3
950             PRINT "Z"
952         CASE 4
954             PRINT "Sngl"
956         CASE ELSE
958             PRINT "ERROR"
960         END SELECT
962         RETURN
964         !
966         ! ////////////////////////////////////////////////////////////////
968         !
970 Addprobe: !
972         Interrupted=1
974         IF Total_chans=Sys_size THEN
976             DISP " THERE IS A PROBE FOR EACH AMPLIFIER ALREADY "
978             BEEP
980             WAIT 1.8
982             DISP CHR$(12)
984             RETURN
986         END IF
988         FOR I=1 TO Total_chans
990             IF Probe_addr(I,1)=Selectpoint THEN
992                 DISP " THIS CHANNEL IS ALREADY ACTIVE "
994                 BEEP
996                 WAIT 1.8
998                 DISP CHR$(12)
1000                RETURN
1002            END IF
1004        NEXT I
1006        IF Total_chans<Sys_size THEN Total_chans=Total_chans+1
1008        Probe_addr(Total_chans,1)=Selectpoint
1010 Enterprobnum:!
1012        DISP "ENTER the index number for the probe ";
1014        LINPUT Test$
1016        ON ERROR GOTO Enterprobnum
1018        Probe_addr(Total_chans,2)=VAL(Test$)
1020        OFF ERROR
1022        IF Probe_addr(Total_chans,2)>MIN(Top_probe,99) THEN Enterprobnum
1024        IF Probe_addr(Total_chans,2)<1 THEN Enterprobnum
1026 Enterprobaxis:!
1028        LINPUT " ENTER THE ANTENNA AXIS (X,Y,Z, or Single (S) ",Test$
1030        SELECT UPC$(Test$[1,1])
1032        CASE "X"
1034            Probe_addr(Total_chans,3)=1
1036        CASE "Y"
1038            Probe_addr(Total_chans,3)=2
1040        CASE "Z"
1042            Probe_addr(Total_chans,3)=3
1044        CASE "S"
1046            Probe_addr(Total_chans,3)=4
1048        CASE ELSE
1050            Probe_addr(Total_chans,3)=99
1052            GOTO Enterprobaxis
1054        END SELECT
1056        PRINT CHR$(128);
1058        GOSUB Alreadyactive
```

```
1060       IF Duplicated THEN
1062           Probe_addr(Total_chans,1)=99
1064           Probe_addr(Total_chans,2)=0
1066           Probe_addr(Total_chans,3)=0
1068           Total_chans=Total_chans-1
1070           DISP " THIS PROBE IS ALREADY ACTIVE "
1072           BEEP
1074           WAIT 1.8
1076           DISP CHR$(12)
1078           RETURN
1080       END IF
1082       GOSUB Position_pen
1084       J=Total_chans
1086       GOSUB Single_write
1088       GOSUB Reset_pointer
1090       MAT SORT Probe_addr(*,1)
1092       RETURN
1094       !
1096       ! ////////////////////////////////////////////////////////////////
1098       !
1100 Alreadyactive:!  Test for this probe already existing in the matrix.
1102       Duplicated=0
1104       FOR I=1 TO Total_chans-1
1106           IF Probe_addr(I,2)=Probe_addr(Total_chans,2) THEN
1108               IF Probe_addr(I,3)=Probe_addr(Total_chans,3) THEN
1110                   Duplicated=1
1112               END IF
1114           END IF
1116       NEXT I
1118       RETURN
1120       !
1122       ! ////////////////////////////////////////////////////////////////
1124       !
1126 Changeprobe:!
1128       GOSUB Deleteprobe
1130       GOSUB Addprobe
1132       RETURN
1134       !
1136       ! ////////////////////////////////////////////////////////////////
1138       !
1140 Deleteprobe:!
1142       Interrupted=1
1144       !Find the amplifier channel
1146       FOR I=1 TO Total_chans
1148           IF Probe_addr(I,1)=Selectpoint THEN
1150               Probe_addr(I,1)=99
1152               Probe_addr(I,2)=0
1154               Probe_addr(I,3)=0
1156               Total_chans=Total_chans-1
1158           END IF
1160       NEXT I
1162       GOSUB Position_pen
1164       PRINT "Not Used";
1166       GOSUB Reset_pointer
1168       MAT SORT Probe_addr(*,1)
1170       RETURN
1172       !
1174       ! ////////////////////////////////////////////////////////////////
1176       !
1178 Read_disk:!
```

```
1180        Interrupted=1
1182        GOSUB Read_probe_disk
1184        GOSUB Print_probeaddr
1186        GOSUB Reset_pointer
1188        RETURN
1190        !
1192        ! ////////////////////////////////////////////////////////////////
1194        !
1196 Read_probe_disk:!
1198        DISP " NOW READING IN THE PROBE CONFIGURATION FROM DISK "
1200        ON ERROR CALL Errortrap
1202        ASSIGN @Datapath TO "Probe_cnfg"&Sourcedisk$
1204        ENTER @Datapath;Test_size
1206        IF Test_size<>Sys_size THEN
1208            BEEP
1210            DISP " FILE is for system size of ";Test_size;", the active";
1212            DISP " system is ";Sys_size
1214            PAUSE
1216            GOTO File_error
1218        END IF
1220        ENTER @Datapath;Total_chans
1222        ENTER @Datapath;Probe_addr(*)
1224 File_error: !
1226        ASSIGN @Datapath TO *
1228        OFF ERROR
1230        WAIT 1
1232        DISP CHR$(12)
1234        RETURN
1236        !
1238        ! ////////////////////////////////////////////////////////////////
1240        !
1242 Saveondisk:!
1244        Interrupted=1
1246        DISP " SAVING THE PROBE CONFIGURATION ON DISK "
1248        ON ERROR GOTO Cannotcreate
1250        CREATE BDAT "Probe_cnfg"&Sourcedisk$,5,256
1252        GOTO Creation_done
1254 Cannotcreate:IF ERRN<>54 THEN
1256            CALL Errortrap
1258            GOTO Saveondisk
1260        END IF
1262 Creation_done:OFF ERROR
1264        ON ERROR CALL Errortrap
1266        ASSIGN @Datapath TO "Probe_cnfg"&Sourcedisk$
1268        OUTPUT @Datapath;Sys_size
1270        OUTPUT @Datapath;Total_chans
1272        OUTPUT @Datapath;Probe_addr(*)
1274        ASSIGN @Datapath TO *
1276        OFF ERROR
1278        WAIT 1
1280        DISP CHR$(12)
1282        RETURN
1284        !
1286        ! ////////////////////////////////////////////////////////////////
1288        !
1290 List_addresses:!
1292        Interrupted=1
1294        PRINTER IS Printer
1296        PRINT RPT$("*",80)
1298        PRINT "TOTAL CHANNELS ENABLED =";Total_chans;
```

```
1300        PRINT ",  System Size =";Sys_size
1302        PRINT
1304 Imagine:IMAGE M3D," ------",M3D," -------  ",6A,#
1306        IF INT(Sys_size/2)=Sys_size/2 THEN
1308            Poffset=INT(Sys_size/2)
1310        ELSE
1312            Poffset=INT(Sys_size/2)+1
1314        END IF
1316        PRINT " Amp#     Probe#      Channel#";
1318        PRINT TAB(40);" Amp#     Probe#      Channel#"
1320        FOR I=1 TO Poffset
1322            J=Probe_addr(I,1)
1324            K=Probe_addr(I,2)
1326            SELECT Probe_addr(I,3)
1328            CASE 1
1330                Test$="X"
1332            CASE 2
1334                Test$="Y"
1336            CASE 3
1338                Test$="Z"
1340            CASE 4
1342                Test$="Single"
1344            CASE ELSE
1346                Test$="ERROR"
1348            END SELECT
1350            IF J<>99 THEN
1352                PRINT USING Imagine;J,K,Test$
1354            ELSE
1356                PRINT "  ** end of file.";
1358                GOTO Done
1360            END IF
1362            IF I+Poffset<=Sys_size THEN
1364                J=Probe_addr(I+Poffset,1)
1366                K=Probe_addr(I+Poffset,2)
1368                SELECT Probe_addr(I+Poffset,3)
1370                CASE 1
1372                    Test$="X"
1374                CASE 2
1376                    Test$="Y"
1378                CASE 3
1380                    Test$="Z"
1382                CASE 4
1384                    Test$="Single"
1386                CASE ELSE
1388                    Test$="ERROR"
1390                END SELECT
1392                IF J<>99 THEN
1394                    PRINT TAB(40);
1396                    PRINT USING Imagine;J,K,Test$
1398                ELSE
1400                    PRINT TAB(42);"**";
1402                END IF
1404            END IF
1406            PRINT
1408        NEXT I
1410 Done:  PRINT USING "5/"
1412        PRINTER IS CRT
1414        RETURN
1416        !
1418        ! ///////////////////////////////////////////////////////////////
```

```
1420      !
1422   SUBEND
1424   !
1426   ! ************************************************************
1428   !
1430   SUB Read_probes(@Gpio)
1432 Read_probes:!
1434       OPTION BASE 1
1436       COM /Probe_system/ INTEGER Sys_size,Total_chans,Probe_addr(*)
1438       COM /Probe_system/ INTEGER Top_probe,Fcal_pts,Pr_avgs
1440       COM /Probe_system/ INTEGER Probe_volts(*),Overrange(*)
1442       COM /Probe_system/ INTEGER Probe_zero(*),REAL Probe_v_m(*)
1444       COM /Probe_system/ REAL Amplitude_cal(*),Freq_cal(*)
1446       COM /Probe_system/ REAL Readtime(*),Freq_crib(*)
1448       COM /Bugs/ INTEGER Bug1,Bug2,Bug3,Printer
1450       COM /Interrupts/ INTEGER Intr_prty
1452       INTEGER I,P,Eir,Eir_bit,Readone,Ctl0,Ctl1
1454       INTEGER Power_off,Signbit
1456       ALLOCATE INTEGER Over_flag(Total_chans)
1458       ALLOCATE REAL Probe_ave(Total_chans)
1460       !
1462       IF Bug1 OR Bug2 THEN PRINTER IS Printer
1464       IF Bug1 THEN
1466           PRINT TIME$(TIMEDATE);" ******* ENTER Read_probes ********"
1468       END IF
1470       !
1472       IF Pr_avgs<1 THEN Pr_avgs=1
1474       MAT Probe_ave= (0.)
1476       MAT Over_flag= (0)
1478       MAT Probe_volts= (0)
1480       FOR I=1 TO Pr_avgs
1482           GOSUB Read_all_probes
1484           FOR P=1 TO Total_chans
1486               Probe_ave(P)=Probe_ave(P)+Probe_volts(P)
1488               Over_flag(P)=Over_flag(P) OR Overrange(P)
1490           NEXT P
1492       NEXT I
1494       FOR P=1 TO Total_chans
1496           Probe_volts(P)=INT(Probe_ave(P)/Pr_avgs)
1498           Overrange(P)=Over_flag(P)
1500       NEXT P
1502       IF Bug1 THEN
1504           PRINT TIME$(TIMEDATE);" ******* EXIT Read_probes ********"
1506       END IF
1508       IF Bug1 OR Bug2 THEN PRINTER IS CRT
1510       DEALLOCATE Probe_ave(*),Over_flag(*)
1512       SUBEXIT
1514       !
1516       ! /////////////////////////////////////////////////////////////
1518       !
1520 Read_all_probes:!
1522       MAT Readtime= (0.)
1524       MAT Probe_volts= (0)
1526       MAT Overrange= (0)
1528       IF Total_chans<1 THEN RETURN
1530       !
1532       ! SET Addr 1 and Check for power on at Probes via PFLG.
1534       !
1536       CONTROL 12,3;Probe_addr(1,1)
1538       STATUS 12,4;Power_off
```

```
1540        IF Power_off THEN
1542            DISP CHR$(129)
1544            DISP "The Power to Multi-probe is off....correct it.";
1546            DISP CHR$(128)
1548            BEEP
1550            PAUSE
1552            DISP CHR$(12)
1554        END IF
1556        !
1558        !  Initialize Track/Hold to TRACK with Start line low.
1560        !
1562        CONTROL 12,1;1                          ! SET PCTL.
1564        Ctl0=1                                  ! SET. (START PULSE low)
1566        Ctl1=1                                  ! set  (low....Track)
1568        CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out.
1570        !
1572        IF Bug3 THEN PRINT "SETTING CTL0, CTL1 to INITIAL CONDITIONS."
1574        !
1576        ! Track signal
1578        !
1580        Ctl0=1                                  ! SET. (START PULSE low)
1582        Ctl1=1                                  ! set  (low....Track)
1584        CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out
1586        WAIT .01                                ! Allow tracking for .01 sec.
1588        !
1590        ! Hold signal (only has meaning when High-Speed input enabled.)
1592        !
1594        Ctl0=1                                  ! Set (START PULSE low)
1596        Ctl1=0                                  ! clear (high....Hold)
1598        CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out
1600        !
1602        ! Begin start pulse.
1604        !
1606        IF Bug3 THEN PRINT "SEND TRIGGER PULSE"
1608        Ctl0=0                                  ! CLEAR (START PULSE HIGH)
1610        Ctl1=0                                  ! Keep on HOLD.
1612        CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out.
1614        Ctl0=1                                  ! SET (START PULSE LOW)
1616        Ctl1=0                                  ! SET TO HOLD.
1618        CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out.
1620        !
1622        ! Check EIR bit low (BUSY is high) to insure the A/D is working.
1624        !
1626        STATUS 12,5;Eir
1628        Eir_bit=BIT(Eir,2)
1630        IF Eir_bit THEN
1632            DISP "A/D not responding to START pulse....Check conditions."
1634            BEEP
1636            PAUSE
1638        END IF
1640        !
1642        ! Set up interrupt and wait for BUSY to go low.
1644        ! Address is set to first Probe address already
1646        !
1648        ON INTR 12,15 GOTO Continue_reads
1650        ENABLE INTR 12;1
1652        IF Bug3 THEN PRINT TABXY(1,18);"WAITING FOR DATA READY"
1654        DISP CHR$(12)
1656        Bigtime=TIMEDATE
1658        P=1
```

```
1660       LOOP
1662           IF TIMEDATE-Bigtime>1.5 THEN GOSUB Interface_dead
1664       END LOOP
1666 Continue_reads:! Interrupt detected ... read channel 1
1668       STATUS 12,3;Probe_volts(1)
1670       Signbit=BIT(Probe_volts(1),12)
1672       Probe_volts(1)=BINAND(Probe_volts(1),4095)
1674       IF Signbit=1 THEN Probe_volts(1)=Probe_volts(1)-4096
1676       STATUS 12,5;Overrange(1)
1678       Overrange(1)=BIT(Overrange(1),3)
1680       Readtime(1)=TIMEDATE-Bigtime
1682       FOR P=2 TO Total_chans
1684           CONTROL 12,3;Probe_addr(P,1)
1686           !
1688           ! Check EIR bit high (BUSY is low)....ready to read
1690           !
1692           Bigtime2=TIMEDATE
1694           LOOP
1696               STATUS 12,5;Eir
1698               Eir_bit=BIT(Eir,2)
1700           EXIT IF Eir_bit
1702               IF TIMEDATE-Bigtime2>1.5 THEN GOSUB Interface_dead
1704           END LOOP
1706           STATUS 12,3;Probe_volts(P)
1708           Signbit=BIT(Probe_volts(P),12)
1710           Probe_volts(P)=BINAND(Probe_volts(P),4095)
1712           IF Signbit=1 THEN Probe_volts(P)=Probe_volts(P)-4096
1714           STATUS 12,5;Overrange(P)
1716           Overrange(P)=BIT(Overrange(P),3)
1718           Readtime(P)=TIMEDATE-Bigtime
1720       NEXT P
1722     ! CONTROL 12,3;Probe_addr(1,1)    !Reset to channel 1 ??
1724       !
1726       !  Reset Track/Hold to TRACK with Start line low.
1728       !
1730       Ctl0=1                                  ! SET.  (START PULSE low)
1732       Ctl1=1                                  ! set   (low....Track)
1734       CONTROL 12,2;Ctl0+Ctl1*2                ! Send values out.
1736       RETURN
1738       !
1740       ! ///////////////////////////////////////////////////////////////
1742       !
1744 Interface_dead:!
1746       DISP CHR$(129)
1748       DISP " NO RESPONSE from channel ";Probe_addr(P,1);" ! ";
1750       DISP CHR$(128)
1752       BEEP
1754       WAIT 1.8
1756       DISP CHR$(12)
1758       Bigtime=TIMEDATE
1760       RETURN
1762       !
1764       ! ///////////////////////////////////////////////////////////////
1766       !
1768   SUBEND
1770   !
1772   ! ***********************************************************
1774   !
1776   SUB Probe_fill_cal
1778 Probe_fill_cal:!
```

```
1780        !
1782        !Fill the probe calibration matrix with values
1784        !
1786        OPTION BASE 1
1788        COM /Probe_system/ INTEGER Sys_size,Total_chans,Probe_addr(*)
1790        COM /Probe_system/ INTEGER Top_probe,Fcal_pts,Pr_avgs
1792        COM /Probe_system/ INTEGER Probe_volts(*),Overrange(*)
1794        COM /Probe_system/ INTEGER Probe_zero(*),REAL Probe_v_m(*)
1796        COM /Probe_system/ REAL Amplitude_cal(*),Freq_cal(*)
1798        COM /Probe_system/ REAL Readtime(*),Freq_crib(*)
1800        INTEGER I,J,K
1802        !
1804        IF Bug1 OR Bug2 THEN PRINTER IS Printer
1806        IF Bug1 THEN
1808           PRINT TIME$(TIMEDATE);" ******* ENTER Probe_fill_cal ********"
1810        END IF
1812        DISP " Filling Amplitude calibration array. "
1814 Calib_curvefit: !
1816                      ! fit to Field (V/m)= a(Decimal output)^b
1818                      ! where a1,b1 is for <low-high crossing
1820                      ! and a2,b2 is for >=low-high crossing
1822        RESTORE Calib_curvefit
1824        !       a1      b1      a2      b2  low-high crossing
1826        DATA 4.75115,.554942,1.67252,.755931,175     ! 1X
1828        DATA 4.21950,.562912,1.51002,.760065,189     ! 1Y
1830        DATA 3.80279,.591157,1.63280,.751374,200     ! 1Z
1832        !
1834        DATA 4.13591,.578563,1.65858,.755074,170     ! 2X
1836        DATA 4.09156,.568407,1.50863,.760301,180     ! 2Y
1838        DATA 3.90861,.579196,1.53843,.757005,180     ! 2Z
1840        !
1842        DATA 4.77555,.570532,1.88350,.751508,190     ! 3X
1844        DATA 4.48032,.550087,1.47673,.763525,170     ! 3Y
1846        DATA 4.42092,.556629,1.55505,.759144,175     ! 3Z
1848        !
1850        DATA 4.70342,.542879,1.61699,.749880,175     ! 4X
1852        DATA 4.42551,.554332,1.54252,.757989,180     ! 4Y
1854        DATA 4.35856,.558571,1.54460,.759468,175     ! 4Z
1856        !
1858        DATA 3.67584,.578890,1.39243,.763700,190     ! 5X
1860        DATA 4.36056,.548574,1.40885,.766072,175     ! 5Y
1862        DATA 4.21723,.559496,1.49515,.759377,180     ! 5Z
1864        !
1866        FOR I=1 TO Top_probe
1868           FOR J=1 TO 3         ! 3 channels; x,y,z or s,0,0
1870              FOR K=1 TO 5     ! a1,b1,a2,b2,l-h crossing
1872                 READ Amplitude_cal(I,J,K)
1874              NEXT K
1876           NEXT J
1878        NEXT I
1880        WAIT 1
1882        !
1884        !Fill frequency response data
1886        !
1888 Freq_caldata:!
1890        DISP " Filling Frequency calibration array. "
1892        RESTORE Freq_caldata
1894        DATA 300,1,500,.894,1000,.689,2000,.825,5000,.820,8000,.857 ! 1-X
1896        DATA 300,1,500,.898,1000,.702,2000,.860,5000,.874,8000,.941 ! 1-Y
1898        DATA 300,1,500,.900,1000,.687,2000,.814,5000,.796,8000,.835 ! 1-Z
```

```
1900        !
1902        DATA 300,1,500,.916,1000,.673,2000,.783,5000,.715,8000,.740 ! 2-X
1904        DATA 300,1,500,.915,1000,.680,2000,.796,5000,.733,8000,.740 ! 2-Y
1906        DATA 300,1,500,.908,1000,.664,2000,.779,5000,.712,8000,.726 ! 2-Z
1908        !
1910        DATA 300,1,500,.900,1000,.682,2000,.749,5000,.783,8000,.829 ! 3-X
1912        DATA 300,1,500,.921,1000,.706,2000,.750,5000,.793,8000,.852 ! 3-Y
1914        DATA 300,1,500,.913,1000,.690,2000,.745,5000,.746,8000,.776 ! 3-Z
1916        !
1918        DATA 300,1,500,.888,1000,.698,2000,.807,5000,.731,8000,.757 ! 4-X
1920        DATA 300,1,500,.866,1000,.684,2000,.801,5000,.753,8000,.803 ! 4-Y
1922        DATA 300,1,500,.883,1000,.700,2000,.802,5000,.755,8000,.813 ! 4-Z
1924        !
1926        DATA 300,1,500,.908,1000,.714,2000,.830,5000,.710,8000,.718 ! 5-X
1928        DATA 300,1,500,.917,1000,.713,2000,.823,5000,.755,8000,.803 ! 5-Y
1930        DATA 300,1,500,.922,1000,.720,2000,.819,5000,.716,8000,.742 ! 5-Z
1932        !
1934        FOR I=1 TO Top_probe
1936            FOR J=1 TO 3                    ! 3 channels; x,y,z or s,0,0
1938                FOR K=1 TO Fcal_pts        ! The frequencies where cal is done
1940                    READ Freq_cal(I,J,K,1),Freq_cal(I,J,K,2)
1942                NEXT K
1944            NEXT J
1946        NEXT I
1948        IF Bug1 THEN
1950            PRINT TIME$(TIMEDATE);" ******* EXIT Probe_fill_cal ********"
1952        END IF
1954        IF Bug1 OR Bug2 THEN PRINTER IS CRT
1956        DISP CHR$(12)
1958        SUBEXIT
1960    SUBEND
1962    !
1964    ! ************************************************************
1966    !
1968    SUB Apply_probe_cal(REAL Frequency)
1970 Apply_probe_cal:! Convert the decimal A/D output to V/m
1972        OPTION BASE 1
1974        COM /Probe_system/ INTEGER Sys_size,Total_chans,Probe_addr(*)
1976        COM /Probe_system/ INTEGER Top_probe,Fcal_pts,Pr_avgs
1978        COM /Probe_system/ INTEGER Probe_volts(*),Overrange(*)
1980        COM /Probe_system/ INTEGER Probe_zero(*),REAL Probe_v_m(*)
1982        COM /Probe_system/ REAL Amplitude_cal(*),Freq_cal(*)
1984        COM /Probe_system/ REAL Readtime(*),Freq_crib(*)
1986        COM /Bugs/ INTEGER Bug1,Bug2,Bug3,Printer
1988        INTEGER I,J,K,L,M,Amp,Probe,Zer,A_d,Org,Nogood
1990        REAL A,B,V_m,Fcal,Lhc
1992        DIM Ax$[1]
1994        ! IF Bug1 OR Bug2 THEN PRINTER IS Printer
1996        IF Bug1 THEN
1998            PRINT TIME$(TIMEDATE);" ******* ENTER Apply_probe_cal ********"
2000        END IF
2002        IF Bug2 THEN ! Tabulate the numbers, print heading.
2004            PRINT RPT$("_",80)
2006            PRINT "Frequency=";Frequency
2008            PRINT "Amp# Probe# Axis  Zero    A/D  Ovrng?    a  (aX^b)  b";
2010            PRINT "       Fcal => Volts/mtr"
2012        END IF
2014        !
2016        ! Subtract the zero field offset.
2018        !
```

```
2020       MAT Probe_volts= Probe_volts-Probe_zero
2022       FOR I=1 TO Total_chans
2024           ! Determine probe index pointers.
2026           J=Probe_addr(I,2)              ! Probe index number
2028           K=Probe_addr(I,3)              ! channel index number
2030           IF K>3 THEN K=1                ! Single channel uses slot 1.
2032           !
2034           ! GET AMPLITUDE calibration curvefit coefficients.
2036 Apply_am_cal:!
2038           !Amplitude_cal(J,K,5)=Low-high crossing value for curvefit coef.
2040           IF Probe_volts(I)>=Amplitude_cal(J,K,5) THEN
2042               !select high range coef.
2044               L=3
2046               M=4
2048           ELSE
2050               !select low range coef.
2052               L=1
2054               M=2
2056           END IF
2058           A=Amplitude_cal(J,K,L)
2060           B=Amplitude_cal(J,K,M)
2062 Apply_fr_cal:!
2064           ! GET frequency calibration data.
2066           ! Copy this channel's frequency cal data into Freq_crib(*)
2068           FOR L=1 TO Fcal_pts
2070               Freq_crib(L,1)=Freq_cal(J,K,L,1)
2072               Freq_crib(L,2)=Freq_cal(J,K,L,2)
2074           NEXT L
2076           CALL Get_cal_value(Frequency,Fcal,Freq_crib(*),Nogood,Fcal_pts)
2078           !
2080           ! SOCK it to the A/D output ... convert to Volts/meter?
2082           !
2084           IF Probe_volts(I)<0 THEN Probe_volts(I)=0
2086           Probe_v_m(I)=(A*(Probe_volts(I))^B)*Fcal
2088           !
2090           IF Bug2 THEN
2092               Amp=Probe_addr(I,1)
2094               Probe=Probe_addr(I,2)
2096               SELECT Probe_addr(I,3)
2098               CASE 1
2100                   Ax$="X"
2102               CASE 2
2104                   Ax$="Y"
2106               CASE 3
2108                   Ax$="Z"
2110               CASE 4
2112                   Ax$="S"
2114               CASE ELSE
2116                   Ax$="E"
2118               END SELECT
2120               Org=Overrange(I)
2122               Zer=Probe_zero(I)
2124               A_d=Probe_volts(I)
2126               V_m=Probe_v_m(I)
2128 Image1:       IMAGE M3D,2X,M3D,3X,A,3X,2(M4D,2X),MDD,2X,3(MD.6D,2X),M4D.2D
2130               PRINT USING Image1;Amp,Probe,Ax$,Zer,A_d,Org,A,B,Fcal,V_m
2132           END IF
2134       NEXT I
2136       IF Bug2 THEN PRINT RPT$("_",80)
2138       IF Bug1 THEN
```

```
2140            PRINT TIME$(TIMEDATE);" ******* EXIT Apply_probe_cal ********"
2142        END IF
2144        IF Bug1 OR Bug2 THEN PRINTER IS CRT
2146        SUBEXIT
2148    SUBEND
2150    !
2152    ! ************************************************************
2154    !
2156    SUB Get_cal_value(REAL Target,Result,File(*),INTEGER Baddata,Endpoint)
2158        !
2160        ! Original: 17 Jan 1984, by G. Koepke and Darlene Agee
2162        ! Revision: 26 Sep 1985, by G. Koepke
2164        !
2166        ! This routine will search the matrix of data using the binary-
2168        ! search method until the desired X value is bracketed.  Using
2170        ! the bracket values for Y the resulting Y value for the desired
2172        ! X value is found by linear interpolation.
2174        !
2176        ! Target=desired X as given during CALL.
2178        ! X_low=Low value of X used during binary search
2180        ! X_high=High "     "  "  "        "      "       "
2182        ! I_low=Index of low X  "        "      "       "
2184        ! I_high=Index of High X "       "      "       "
2186        ! I_cntr=Index of half way point.
2188        !
2190        OPTION BASE 1
2192        COM /Bugs/ INTEGER Bug1,Bug2,Bug3,Printer
2194        REAL X_low,Y_low,X_high,Y_high
2196        INTEGER I_low,I_high,I_cntr,Target_found
2198        !
2200        IF Bug1 THEN
2202            PRINT TIME$(TIMEDATE);
2204            PRINT "******* Begin Search for X=";Target;" in File *******"
2206        END IF
2208        !
2210        GOSUB Check_endpts
2212        IF Baddata OR Target_found THEN Go_home
2214        GOSUB Search_file
2216        GOSUB Interpolate
2218 Go_home:!
2220        IF Bug1 THEN
2222            PRINT TIME$(TIMEDATE);
2224            PRINT "********* End Search, returning Y=";Result;" *******"
2226        END IF
2228        SUBEXIT
2230        !
2232        ! //////////////////////////////////////////////////////////////
2234        !
2236 Check_endpts:!Check condition of file and verify Target is in range.
2238        Target_found=0
2240        Baddata=0
2242        Result=0
2244        IF Endpoint>0 THEN
2246            IF Target<File(1,1) OR Target>File(Endpoint,1) THEN
2248                Baddata=1
2250                Result=1.0
2252                IF Bug1 THEN
2254                    PRINT "Desired X-value outside range of data.":
2256                    PRINT "  Returning Y-value of 1.0 **********"
2258                    PRINT "Range=";File(1,1);" to ";File(Endpoint,1);
```

```
2260                  PRINT "; Desired value=";Target
2262              END IF
2264          ELSE
2266              IF Endpoint<2 AND Target=File(1,1) THEN !Only one data point
2268                  Result=File(1,2)
2270                  Target_found=1
2272              END IF
2274          END IF
2276      ELSE
2278          Baddata=1
2280          Result=1.0
2282          IF Bug1 THEN
2284              PRINT "This file is empty! ";
2286              PRINT "  Returning Y-value of 1.0 **********"
2288          END IF
2290      END IF
2292      RETURN
2294      !
2296      ! //////////////////////////////////////////////////////////////
2298      !
2300 Search_file: ! Target exists within X_low to X_high
2302              ! and file has at least two entries.
2304              !
2306      I_low=1
2308      I_high=Endpoint
2310      I_cntr=INT((I_high-I_low)/2)+I_low
2312      X_low=File(I_low,1)
2314      X_high=File(I_high,1)
2316      IF Bug3 THEN
2318          PRINT "---- Searching for ";Target;" ----"
2320          GOSUB Trace_search
2322      END IF
2324      IF (I_cntr=I_low) OR (Target=X_low) OR (Target=X_high) THEN Bullseye
2326      REPEAT
2328          IF Target>=File(I_cntr,1) THEN
2330              I_low=I_cntr
2332              X_low=File(I_low,1)
2334          ELSE
2336              I_high=I_cntr
2338              X_high=File(I_high,1)
2340          END IF
2342          I_cntr=INT((I_high-I_low)/2)+I_low
2344          IF Bug3 THEN GOSUB Trace_search
2346      UNTIL (I_cntr=I_low) OR (Target=X_low) OR (Target=X_high)
2348 Bullseye:!
2350      IF Bug3 THEN PRINT "---- Search ended. ----"
2352      RETURN
2354      !
2356      ! //////////////////////////////////////////////////////////////
2358      !
2360 Trace_search:! Print search parameters as they change.
2362      PRINT "Low I,X=";I_low;",";X_low;
2364      PRINT ": High I,X=";I_high;",";X_high;
2366      PRINT ": Center I,X=";I_cntr;",";File(I_cntr,1)
2368      RETURN
2370      !
2372      ! //////////////////////////////////////////////////////////////
2374      !
2376 Interpolate:!
2378      Y_low=File(I_low,2)
```

```
2380        Y_high=File(I_high,2)
2382        !
2384        IF ABS(X_high-X_low)>1.0E-10 THEN !Not same X value
2386            Result=((Y_high-Y_low)/(X_high-X_low))*(Target-X_low)+Y_low
2388        ELSE
2390            Result=(Y_high+Y_low)/2
2392        END IF
2394        !
2396        IF Bug3 THEN PRINT "Desired freq.=";Target;"    VALUE=";Result
2398        !Result=10.^(Result/10)
2400        !IF Bug3 THEN PRINT "Desired freq.=";Target;" RATIO=";Result
2402        RETURN
2404        !
2406        ! ///////////////////////////////////////////////////////////////
2408        !
2410    SUBEND
2412    !
2414    ! ************************************************************
2416    !
2418    SUB Errortrap
2420        !Trap disk errors here
2422        !
2424        COM /Files/ Diskin$,Diskout$,Filename$
2426        BEEP 400,.6
2428        SELECT ERRN
2430        CASE 54
2432            DISP "DUPLICATE FILE NAME:  ";Filename$;
2434            DISP "....PURGE old one? (Y/N)";
2436            INPUT Test$
2438            SELECT Test$[1,1]
2440            CASE "Y","y"
2442                PURGE Filename$&Diskout$
2444            CASE ELSE
2446                DISP "ENTER NEW FILE NAME";
2448                LINPUT Filename$
2450            END SELECT
2452        CASE 52,53
2454            DISP "Improper FILE NAME --- ENTER NEW FILE NAME";
2456            OUTPUT 2 USING "K,#";Filename$
2458            LINPUT Filename$
2460        CASE 64
2462            DISP "This disk is full, PLEASE insert clean disk"
2464            PAUSE
2466        CASE 80
2468            DISP "CHECK DISK drive door! ";
2470            DISP " ...CONTINUE when ready"
2472            PAUSE
2474        CASE ELSE
2476            DISP ERRM$;" 'CONTINUE' when fixed"
2478            PAUSE
2480        END SELECT
2482        DISP CHR$(12)
2484        SUBEXIT
2486    SUBEND
2488    !
2490    ! ************************************************************
2492    !
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NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 86-3056	2. Performing Organ. Report No.	3. Publication Date October 1986

4. TITLE AND SUBTITLE

HANDBOOK FOR OPERATION AND MAINTENANCE OF AN NBS MULTISENSOR AUTOMATED EM FIELD MEASUREMENT SYSTEM

5. AUTHOR(S)

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6. PERFORMING ORGANIZATION (*If joint or other than NBS, see instructions*)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (*Street, City, State, ZIP*)

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (*A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here*)

A system is described that monitors and collects electromagnetic (EM) field strength information at five (optionally 10) locations simultaneously. The system has two modes of operation: (1) for sampling EM fields that are stationary for times of the order of 200 ms, and (2) for sampling changing EM fields with a system resolution of 10 µs. Sensing elements for Mode 1 consist of three electrically short orthogonal dipoles mounted together, single dipole elements, or small loop antennas. Each element feeds a separate data input channel for a total of 15 (optionally 30) channels. Rf energy is converted to dc by a diode detector at each dipole. Mode 2 sensors will be diode detectors driven by broadband antennas. Real time system data processing includes calculation of field strength based on probe calibrations and processing of resultant data to satisfy measurement goals.

12. KEY WORDS (*Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons*)

automated measurement; electromagnetic field probe; high impedance; high speed; simultaneous sampling.

13. AVAILABILITY

☒ Unlimited
☐ For Official Distribution. Do Not Release to NTIS
☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

70

15. Price

USCOMM-DC 6043-P80

U.S. GOVERNMENT PRINTING OFFICE: 1986 - 773-668/65027