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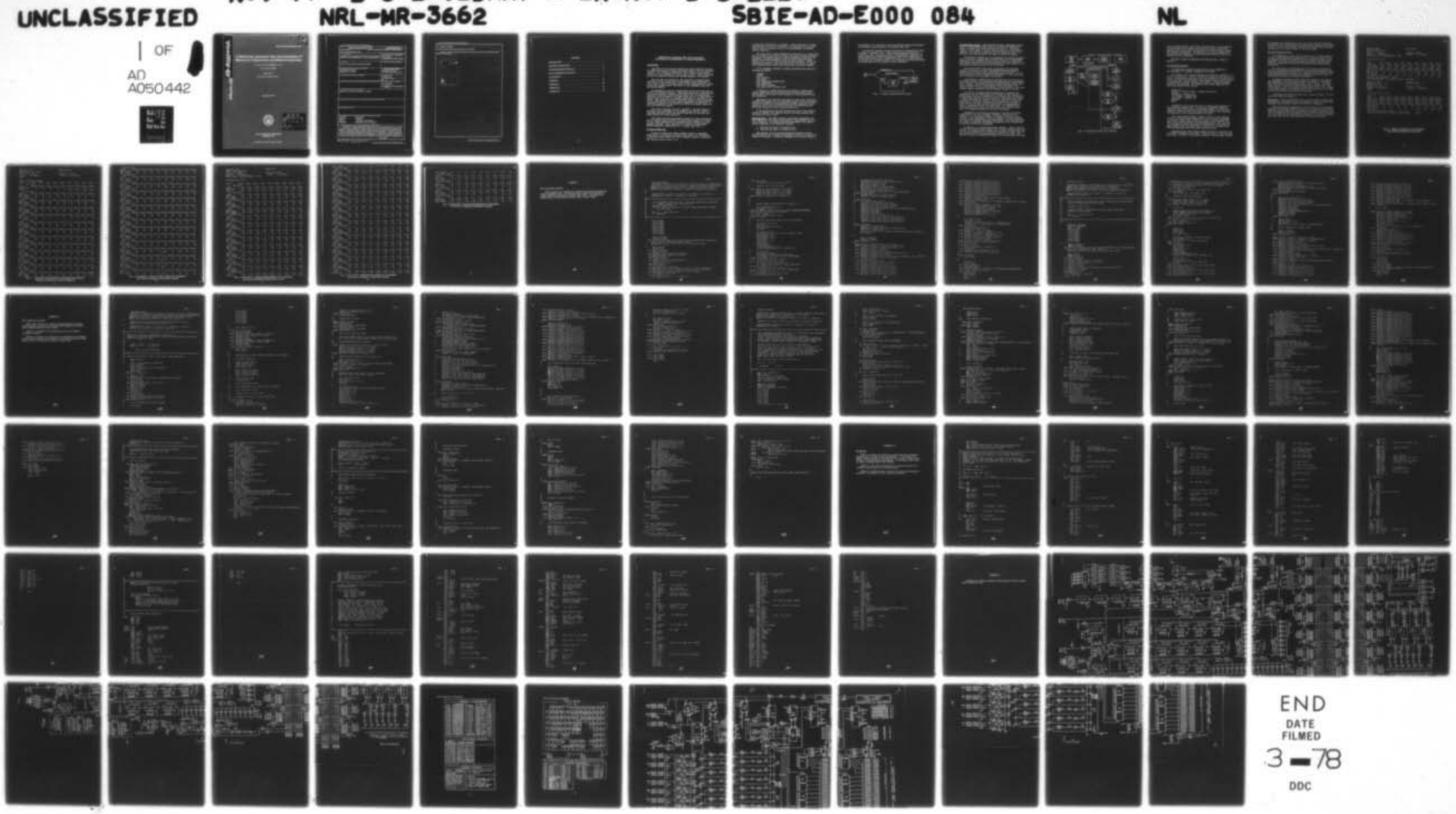

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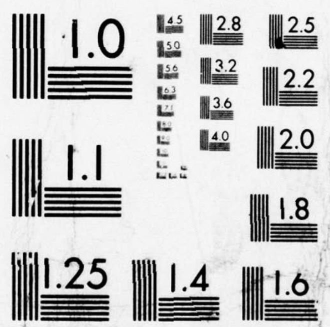

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NRL Memorandum Report 3662

A Method for Automatic Test and Evaluation of Microwave Transceivers at L-Band Frequencies

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Washington, D.C.

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Transmitter	Measurement, test and evaluation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Complexity of modern phased array radars requires that new high speed methods of microwave component test and evaluation be devised such that, not only is the specific device under test evaluated as to quality and accuracy, but also in terms of system errors, the total of all devices is evaluated in an appropriate statistical method to assure final use compatibility. This report summarizes the effort at Naval Research Laboratory, Washington, D.C. to devise such a computer controlled laboratory test and evaluation facility capable to measuring not only CW devices, such as receivers, but also pulse devices such as transmitters. More specifically, the program as devised to implement an all

(Continues)

20. Abstract (Continued)

solid state L-band transceiver module evaluation is described.

Samples of computer programs and special test equipment schematics are included along with samples of data printout.

CONTENTS

A METHOD FOR AUTOMATIC TEST AND EVALUATION OF MICROWAVE TRANSCEIVERS AT L-BAND FREQUENCIES

Introduction

The advent of the practical phased array radar introduced the need for complex testing and thorough statistical analysis into the microwave industry. The voluminous quantities of data required on each device coupled with the redundancy of devices used on even a single system made the use of automatic microwave test systems mandatory, not optional.

The long test and evaluation cycle required for acquiring large quantities of data coupled with the uniqueness of each device has in turn created a serious financial burden on most manufacturers who cannot justify the purchase and/or fabrication of such equipment based upon anticipated demands.

The gathering of data on a single device is only the first step in a chain of statistical analyses. Individual limits must be imposed upon each device produced to assure quality control but in a system using hundreds or even thousands of the same device (such as is experienced in phased arrays) then only the aggregate performance is important to the system. Thus through the test of individual devices, system performance can be predicted and as the data base is increased, the importance of individual parameters on the system can develop into higher quality and more cost effective products.

This report describes the effort expended at the Naval Research Laboratory in the attainment of an automatic test facility capable of acquiring individual device data and the reduction of such data into terms suitable for system statistics.

This effort has been concentrated primarily at L-band frequencies and on transmit/receive devices, the latest device being such a transceiver now in production by the General Electric Company, Aircraft Equipment Division, Utica, New York for the Naval Air Development Center, Warminster, Pennsylvania (Dr. J. Smith, Code 2040).

The Device Under Test

In order to reduce the complex testing required to manageable proportions, it is necessary to specifically tailor the test program to the unique device under test and to eliminate operator interaction

Note: Manuscript submitted November 10, 1977.

or reduce this interaction to a minimum. Towards this goal a thorough understanding of the device parameters to be evaluated and the conditions of test is indicated as well as an understanding of microwave testing techniques.

The device that is being considered in this report is a transceiver, used in a phased array radar at L-band, under pulse transmit conditions. In addition to microwave circuitry such as circulators, switches, and amplifiers, the device employs a 5 bit (32 state) electronic phase shifter, and a 3 bit (8 state) electronic step attenuator. Within the transceiver structure is the necessary electronic circuitry to translate incoming digital signals into appropriate performance commands.

It is, therefore, necessary to gather performance data under the following test modes:

transmit
receive
over frequency
over phase
over attenuation (receive only)
over temperature
over supply voltages
over input power (transmit only)

In addition, a typical device may be required to operate under various combinations of PRF and pulse width during transmit which greatly adds to the amount of data required to verify system performance capability.

Referring to the above list the number of data points considered necessary and adequate for the transceiver amounted to 2304 for receive and 864 for transmit for each temperature/voltage combination during acceptance with a total of 20736 receive and 7776 transmitter data points per transceiver module during qualification.

It can therefore be seen that entering into such a test endeavor without an adequate test sequence and plan or without adequate test facilities can lead to chaos.

Microwave Tests. The number and kind of microwave measurements are quite limited but from these limited number of measurements much data can be extracted. In automatic microwave measurement, after appropriate calibration, it is possible to measure

a. Amplitude and angle of reflected power
b. Amplitude and angle of transmitted power

Many systems, such as the Hewlett-Parkcard Automatic Network Analyzer define a set of device S-parameters from which the typical RF terms can be derived. In addition, dependent on the type of device to be evaluated, it is possible to vary the calibration model and therefore the correction factors applied to the device under test.

In each case, however, the four basic bits of information are used to derive all necessary data. VSWR is derived from the reflective properties. Gain (or loss) is derived from transmission magnitude and such properties as differential phase and differential attenuation are derived from various sets of transmission data. It is insufficient to just derive the S parameter values; it is necessary that data processing be incorporated into any program to permit evaluation.

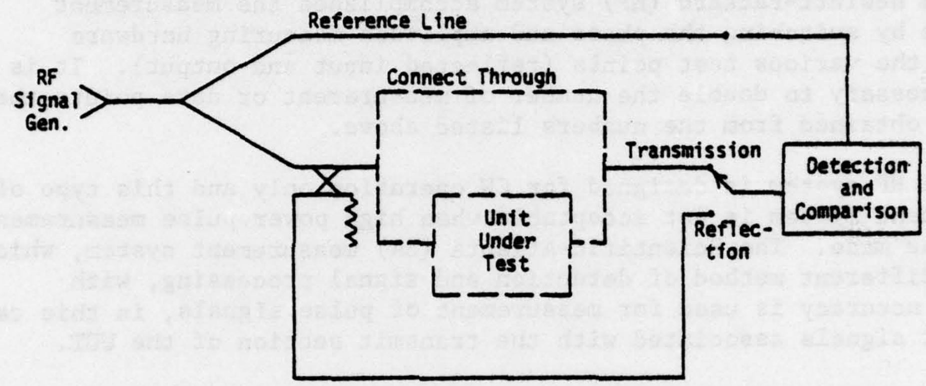


Fig. 1 - *Test by comparison test method*

The measurement system. Both microwave automatic measurement systems used for the measurements described in this report are similar in method, although quite diverse in design particulars. Referring to Figure 1, the RF signal is divided into two paths, one to be used as a reference, the other as a signal for the unit under test (UUT). In addition, the reflected wave at the input to the UUT is sampled.

To determine a complete set of S parameters, both phase and amplitude of the various signals must be known, first over all measurement frequencies under calibrate conditions with no UUT in the line from which system correction factors are determined and then repeated at the measurement frequencies with the UUT in the line.

The Hewlett-Packard (HP) system accomplishes the measurement sequence by switching the phase and amplitude measuring hardware between the various test points (reflected input and output). It is thus necessary to double the number of measurement or data points that must be obtained from the numbers listed above.

The HP system is designed for CW operation only and this type of measurement system is not acceptable when high power pulse measurements are to be made. The Scientific-Atlanta (SA) measurement system, which uses a different method of detection and signal processing, with reduced accuracy is used for measurement of pulse signals, in this case transmit signals associated with the transmit section of the UUT.

In addition, the Naval Research Laboratory has modified this equipment so that the input power can be leveled at each frequency to predetermined values for evaluation of such devices that are sensitive to input power especially those operating in a non-linear mode (class C transmit operation for the UUT). Also, the addition of pulse peak power meters, to measure forward power before and after the device under test and the input reflected power permits the measruement of powers by sampling (80 nsec) the pulse power. The sampling window can be moved through the RF pulse time and does not operate on the basis of averaging techniques as does the SA equipment.

Transmission and reflection properties of the UUT are measured simultaneously with this equipment, therefore, switching is not required. It is necessary, however, to measure at each data point, a series of five measurements, which are averaged to reduce instantaneous errors and eliminate erroneous measurements. This then means that the number of sequential measurements becomes 80,352 for qualification of each UUT and 8,928 for acceptance.

In addition to the signal measurement hardware, there is associated with the overall control system, a set of control hardware used with the UUT, and redesigned and/or modified as required for each device and test plan that has for its prime function control of the UUT. This control includes the necessary switching of the various module functions

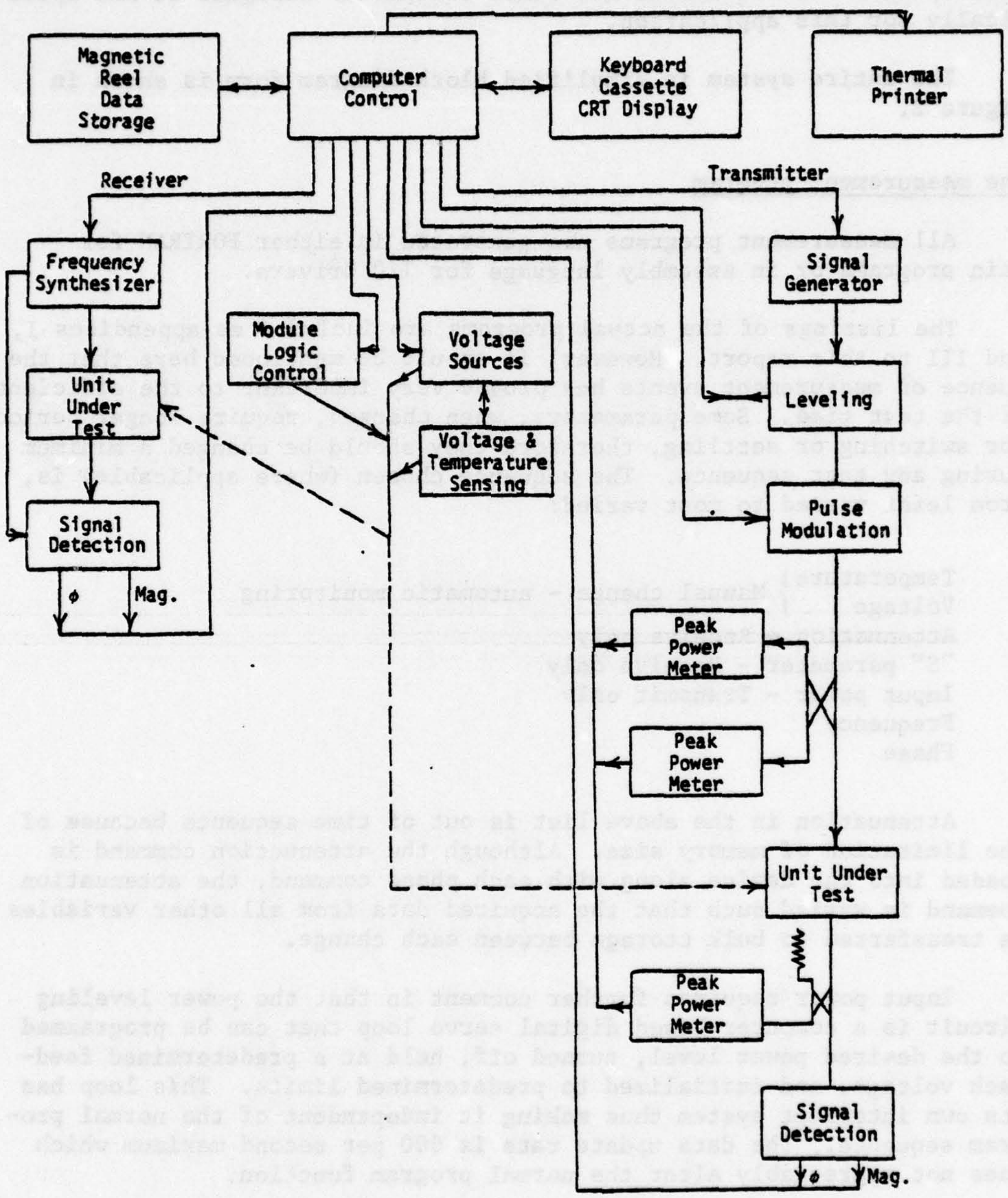


Fig. 2 - Simplified system block diagram

such as transmit/receive, phase shift and attenuation, by the generation of the necessary code sequences under computer control and also the generation and control and/or monitoring of the various supply voltages and operating temperatures. See appendix IV for detail schematics of this special test equipment and other equipments designed at NRL specifically for this application.

The entire system in simplified block diagram form is shown in Figure 2.

The measurement program

All measurement programs are generated in either FORTRAN for main programs or in assembly language for I/O drivers.

The listings of the actual programs are included as appendices I, II, and III to this report. However, it should be mentioned here that the sequence of measurement events has proved very important to the efficient use of the test time. Some parameters, when changed, require longer periods for switching or settling, therefore they should be changed a minimum during any test sequence. The sequence chosen (where applicable) is, from least varied to most varied:

Temperature } Manual change - automatic monitoring
Voltage }
Attenuation - Receive only
"S" parameter - Receive only
Input power - Transmit only
Frequency
Phase

Attenuation in the above list is out of time sequence because of the limitation of memory size. Although the attenuation command is loaded into the device along with each phase command, the attenuation command is varied such that the acquired data from all other variables is transferred to bulk storage between each change.

Input power requires further comment in that the power leveling circuit is a computer based digital servo loop that can be programmed to the desired power level, turned off, held at a predetermined feedback voltage, and initialized to predetermined limits. This loop has its own interrupt system thus making it independent of the normal program sequence. The data update rate is 600 per second maximum which does not appreciably alter the normal program function.

Programs and any other special command functions are entered by way of keyboard or magnetic tape cassette. Data is output to reel type magnetic tape. Each file of data first references a serial number followed by pertinent test parameters so that a tape can be easily searched for the desired file. The appendices include program listings for searching transmit or receive data tapes, extracting the desired data and processing the data in a similar manner to the main program.

Data processing and output

It is desirable to store the data obtained in raw form on magnetic tape for future processing and generation of overall statistics but it is likewise necessary for immediate use that a summary listing be made available. Many forms could be generated including curves and histograms but the quantity of print-out can rapidly reach uncontrollable proportions.

For this reason it was decided that the raw data as delivered by the test system would be processed into the various specification parameters and presented in tabular form. Because of the statistical nature of the application for the units to be evaluated much of the data is printed out in terms of statistical information.

In addition a keyboard switch option was included in the program that generates a long form print out where in addition to the summary data, information at each frequency-phase state is given. This long form print out is forced when power output under transmit test conditions reaches a level that causes large measurement errors (i.e. 0 dBm) so that the operator is immediately aware of the type of error and then can properly evaluate the statistical parameters.

A listing of the short form print-out is given in Figure 3 and the long form is given in Figure 4.

Conclusions. With the complexity of test and the number of data points necessary for a meaningful statistical analysis, the use of manual test equipment requiring much operator interaction is prohibited.

Thus for production components, or those that are to be produced in quantity where repeated similar tests are to be performed, the computer based test facility with data processing and storage is indicated. Not only can immediate data be obtained but the stored data can be processed at a later date in ways specifically meaningful to the end system use as well as in the form of useful statistics on classes of devices.

SER.NO. 001 RECEIVER

DATE: MAY 20,1977

VOLT1=-11.090 VOLT2= 23.890

TEMP1= 24.9DEG.C TEMP2= -24.9DEG.C

TAPE TEST, AS CALIBRATED XXX

ATTNUATION= 2DB.

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
VSWR MAX	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
VSWR MEAN	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
MAX-PH-ER	-349.	-349.	-349.	-349.	-349.	-349.	-349.	-349.	-349.
RMS-PH-ER	203.0	203.0	203.0	203.0	203.0	203.0	203.0	202.9	203.0
MAX-GN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
MIN-GN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
INS PHAS	-18.	-18.	-19.	-19.	-19.	-19.	-19.	-19.	-20.

OVERALL MEAN GAIN= -.0DB.

STD. DEVIATION IN OVERALL GAIN= -58.3DB.

SER.NO. TEST TRANSMITTER

DATE: MAY 17, 1977

VOLT1=-11.145 VOLT2= 24.150

TEMP1= 23.9DEG.C TEMP2= -34.6DEG.C

NONE

INPUT POWER=24.8DBM.

*FMT #3

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
VSWR MAX	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
VSWR MEAN	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PH-ER	-349.	-349.	-349.	-304.	-259.	-349.	-349.	-349.	-349.
RMS-PH-ER	203.0	202.9	202.9	165.6	130.8	203.0	203.0	203.1	203.0
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
MIN-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
INS PHAS	.	.	.	.	.	360.	360.	360.	360.

OVERALL MEAN PEAK POWER= .0WATTS

STD. DEVIATION IN OVERALL PEAK POWER= .0WATTS

Fig. 3 - Short form printout for transmitter and receiver sections of transceiver

SER.NO. TEST TRANSMITTER
DATE: MAY 17, 1977
VOLT1=-11.145 VOLT2= 24.150
TEMP1= 23.9DEG.C TEMP2= -34.6DEG.C
NONE

INPUT POWER=24.8DBM.

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
IPHS	.	.	.	.	.	360.	360.	360.	360.
11.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	-.0	.0	.0	-.0	.0	-.1	-.1
22.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	.0	-.0	-.0	.0	-.0	-.1
33.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	.0	.0	.0
45.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	.0	.0	.0	.0	-.0	-.0
56.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	-.0	-.0	.0	.0	-.0
67.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	.0	.0	.0	-.1	-.0	-.1
78.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
90.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	-.0	.0	-.0	-.0	-.0	-.0	-.1
101.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	-.0	-.1	-.0
112.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.0	-.1	-.0
123.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	-.0	-.1	-.0
135.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	-.0	-.0	.0	-.0	-.1	-.1

Fig. 4 - Long form data printout for transmitter and receiver sections of transceiver module (Continues)

146.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	.0	-.1	-.1
157.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.1	-.2	-.1
168.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	-.0	.0	-.0	-.0	-.0	-.2	-.1
180.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	-.0	.0	.0	-.0	-.2	-.2
191.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	.0	-.0	-.0	-.2	-.1
202.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.0	-.2	-.1
213.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	.0	-.0	-.0	-.0	-.2	-.0
225.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.1	-.0	-.2	-.1
236.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	-.0	-.1	-.0	-.2	.0
247.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	-.0	.0	.0	-.0	-.2	-.1
258.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	-.0	.0	.0	.0	.0	-.2	.0
270.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	.0	360.0	.0	-.0	-.1	-.0
281.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	-.0	.0	360.0	-.1	.0	-.2	.0
292.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	360.0	-.0	-.1	-.2	-.1
303.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	-.0	360.0	-.0	.0	-.1	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

SER.NO. 001 RECEIVER
DATE: MAY 20,1977
VOLT1=-11.090 VOLT2= 23.890
TEMP1= 24.9DEG.C TEMP2= -24.9DEG.C
TAPE TEST, AS CALIBRATED XXX

ATTNUATION= 2DB.

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
IPHS	-18.	-18.	-19.	-19.	-19.	-19.	-19.	-19.	-20.
11.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
22.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	.0	.0	.0
33.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
45.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
56.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0
67.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
78.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
90.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
101.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	.0	.0	.0
112.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	-.0	.0	.0
123.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	-.0	.0	.0
135.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
146.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0
157.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
168.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0
180.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	-.0	.0	.0
191.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
202.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	.0	.0	.0
213.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	-.0	.0	.0
225.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
236.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	-.0	.0	.0
247.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	.0	-.0	.0	.0	.0	.0	.0
258.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.0
270.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.0
281.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	-.0	.0	.0
292.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	-.0	.0	.0
303.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	.0	-.0	.0
315.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	.0	-.1	.0	.0	.0	.0	.0
326.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	.0	.0	.0
337.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
348.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

APPENDIX I

Data processing programs:

These programs are intended for locating data already obtained and stored on magnetic tape. The desired file is called by inputting the serial number and attenuation or input power level. The output processed data is in the form of Figures 3 and 4 of this report.

appendix I


```
      PROGRAM RDRCV
      DIMENSION NDATE(10),NSER(10),LTL1(20),CM(64,9),GMAG(32,9),
     1GANG(32,9),VMAG(32,9),AMAXV(9),AMENV(9),AMAXP(9),RMSPH(9),
     2DBGMX(9),DBGMI(9),BANG(9),F(9),VANG(32,9),VMG1(288),
     3VAG(288),GAG(288),GNG(288),TEMP8(9),TEMP9(9),ISER(10)
C
C
      EQUIVALENCE (VMAG(1,1),VMG1(1)),(VANG(1,1),VAG(1)),
     1(GMAG(1,1),GAG(1)),(GANG(1,1),GNG(1))
C
C***************************************************************
C
C     THIS PROGRAM SEARCHES MAG. TAPE FOR DATA WITH MATCHING
C          SERIAL NUMBER AND ATTENUATION.
C     RECEIVER DATA ONLY.
C     OUTPUT DATA TO VERSATEC IN BOTH LONG AND SHORT FORMAT
C          AS PER NADC1.
C
C     REV. C     MAY 20,1977
C     L. LAVEDAN
C
C***************************************************************
C
      F(1)=1235.
      F(2)=1260.
      F(3)=1280.
      F(4)=1295.
      F(5)=1300.
      F(6)=1305.
      F(7)=1320.
      F(8)=1340.
      F(9)=1365.
C
      CALL CLEAR(0)
      WRITE(9,100)
  100 FORMAT("PROGRAM FOR LOCATING AND PROCESSING RECEIVER"/
     110X," DATA STORED ON MAG. TAPE"//
     2"PLEASE SELECT TAPE AND PUT SYSTEM ON LINE")
C
      CALL PAUSE
      REWIND 18
  110 CALL CLEAR(0)
      WRITE(9,120)
  120 FORMAT("INPUT SERIAL NUMBER←")
      READ(8,130)(ISER(I),I=1,10)
  130 FORMAT(10A2)
      WRITE (9,131)
  131 FORMAT("INPUT ATTENUATION←")
      READ (8,*) NTTN3
  135 READ(18,140)
  140 FORMAT(I1)
      IF(IEOF(18)) 150,135
  150 READ(18,170)LET1,(NSER(I),I=1,10),ITTN3,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
  170 FORMAT(A1,10A2,I2,10A2,2F7.3,2F7.2,20A2)
      IF(IEOF(18))200,210
  210 DO 500 I=1,10
      IF(ISER(I)-NSER(I)) 135,500,135
```

```
  500 CONTINUE
      IF(NTTN3-ITTN3) 135,1000,135
C
C     CORRECT SER NO CONTINUES
C
 1000 READ(18,1001)(VMG1(I),I=1,288)
      READ(18,1001)(VAG(I),I=1,288)
      READ(18,1001)(GAG(I),I=1,288)
      READ(18,1001)(GNG(I),I=1,288)
 1001 FORMAT (28(10E12.7/)10E12.7)
C
C
C
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C
      CALL PHORD(GANG(1,1))
      DO 2060 J=2,9
 2030 IF(GANG(1,J-1)-GANG(1,J)+90.0)2040,2040,2050
 2040 GANG(1,J)=GANG(1,J)-360.0
      GO TO 2030
 2050 CALL PHORD(GANG(1,J))
 2060 CONTINUE
C
C     PROCESS DATA AND PRINT OUT ON VERSATEC
C
C     SET SUM GAIN TO 0
      SUMG=0.0
C     SET SUM(GAIN)↑2 TO 0
      SUMG2=0
C
      DO 2100 II=1,9
C     INITIALIZE VALUES TO FIRST PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAG(1,II)
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
      DO 2150 IP=2,32
C     DETERMINE REFLECTION COEFF MAX
      IF(VMAG(IP,II)-VMAX) 2070,2070,2065
 2065 VMAX=VMAG(IP,II)
C     DETERMINE SUM REF. COEFF.
 2070 VAVG=VAVG+VMAG(IP,II)
C     DETERMINE VOLTAGE GAIN MAX
      IF (GMAG(IP,II)-GMAX) 2080,2080,2075
 2075 GMAX=GMAG(IP,II)
C     DETERMINE VOLTAGE GAIN MIN
 2080 IF(GMIN-GMAG(IP,II)) 2090,2090,2085
 2085 GMIN=GMAG(IP,II)
C     DETERMINE SUM OF VOLT GAIN
 2090 SUMG=SUMG+GMAG(IP,II)
```

```
C       DETERMINE SUM(VOLT GAIN)↑2
        SUMG2=SUMG2+GMAG(IP,II)*GMAG(IP,II)
C       DETERMINE DELTA PHASE
        DELP=PH0-GANG(IP,II)
C       DETERMINE DELTA PHASE ERROR
        DDELP=DELP-(11.25*FLOAT(IP-1))
C       DETERMINE DEL PHAS ERR MAX
        IF(ABS(DDELP)-ABS(PHMAX)) 2150,2150,2095
 2095   PHMAX=DDELP
C       DETERMINE SUM(DEL PHAS ERR)↑2
        SUMP2 = SUMP2 + DDELP*DDELP
C
 2150   CONTINUE
C       ON A PER FREQ BASIS------
C       CONVERT MAX RHO TO VSWR MAX
        AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C       CONVERT AVG RHO TO MEAN VSWR
        AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C       CONVERT MAX PHASE
        AMAXP(II)=PHMAX
C       CONVERT RMS PHASE
        RMSPH(II)=SQRT(SUMP2/32.0)
C       CONVERT VOLT GAIN MAX TO MAX GAIN DB
        DBGMX(II)=20.*ALOG(GMAX)/ALOG(10.0)
C       CONVERT VOLT GAIN MIN TO MIN GAIN DB
        DBGMI(II)=20.*ALOG(GMIN)/ALOG(10.0)
C
 2100   CONTINUE
C       CONVERT TO MEAN GAIN
        DBGME=20.*ALOG(SUMG/288.0)/ALOG(10.0)
C       CONVERT TO RMS GAIN
        RMSG=20.*ALOG(SQRT((SUMG2-(SUMG*SUMG/288.0))/288.0))/
       1ALOG(10.0)
C
C
        CALL CLEAR(0)
        WRITE(11,2999)
 2999   FORMAT(10(//))
C
 3000   WRITE(11,3005)(NSER(I),I=1,10)
 3005   FORMAT("SER.NO. ",10A2,5X,"RECEIVER")
        WRITE(11,3010)(NDATE(I),I=1,10)
 3010   FORMAT("DATE: ",10A2)
        WRITE(11,3015)VOLT1,VOLT2
 3015   FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
        WRITE(11,3020)TEMP1,TEMP2
 3020   FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
        WRITE(11,3025)(LTL1(I),I=1,20)
 3025   FORMAT(20A2/)
        WRITE(11,3030)ITTN3
 3030   FORMAT("ATTNUATION=",I2,"DB."/)
        WRITE(11,3035)(F(I),I=1,9)
 3035   FORMAT("FREQ.",3X,9(2X,F4.0))
        WRITE(11,3040)(AMAXV(I),I=1,9)
 3040   FORMAT("VSWR MAX ",9(X,F5.2))
        WRITE(11,3045)(AMENV(I),I=1,9)
 3045   FORMAT("VSWR MEAN",9(X,F5.2))
        WRITE(11,3050)(AMAXP(I),I=1,9)
```

```
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(DBGMX(I),I=1,9)
 3060 FORMAT("MAX-GN-DB",9(X,F5.1))
      WRITE(11,3065)(DBGMI(I),I=1,9)
 3065 FORMAT("MIN-GN-DB",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)DBGME
 3075 FORMAT("OVERALL MEAN GAIN=",F5.1,"DB.")
      WRITE(11,3080)RMSG
 3080 FORMAT("STD. DEVIATION IN OVERALL GAIN=",F6.1,"DB.")
      CALL PAGE
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)ITTN3
      WRITE(11,3035)(F(I),I=1,9)
C
C
      DO 4100 I=1,32
      DO 4101 J=1,9
      TEMP9(J)=(1.+VMAG(I,J))/(1.-VMAG(I,J))
      TEMP8(J)=20.*ALOG(GMAG(I,J))/ALOG(10.0)
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("  ",F6.2," DEG.")
      WRITE (11,4105) (TEMP9(J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE (11,4110) (TEMP8(J),J=1,9)
 4110 FORMAT("GAIN-DB",2X,9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(1,L)-GANG(I,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
C
C
      REWIND 18
      GO TO 110
  200 CALL CLEAR(0)
      WRITE(9,205)
  205 FORMAT("SERIAL NUMBER AND ATTENUATION REQUESTED"
     1" NOT FOUND ON TAPE")
  220 REWIND 18
      CALL PAUSE
      GO TO 110

      END
```

```
      PROGRAM RDXMT
C
      DIMENSION NSER(10),NDATE(10),LTL1(20),TEMP(20),GNG(288),
     1GANG(32,9),GMAG(32,9),AVSWR(32,9),GAG(288),
     2VMG1(288),VMAG(32,9),AMAXV(9),F(9),ISER(10),
     3AMENV(9),AMAXP(9),RMSPH(9),PWRMX(9),PWRMI(9),BANG(9)
C
      EQUIVALENCE (GANG(1,1),GNG(1)),(GMAG(1,1),GAG(1)),
     1(VMAG(1,1),VMG1(1))
C
C*****************************************************************
C
C     THIS PROGRAM SEARCHES MAG. TAPE FOR DATA WITH MATCHING
C     SERIAL NUMBER AND DRIVE POWER.
C
C     TRANSMIT DATA ONLY
C
C     OUTPUTS DATA TO VERSATEC IN BOTH SHORT AND LONG
C     FORMAT AS PER NADC2.
C
C     REV. C    MAY 20,1977
C     L. LAVEDAN
C
C*****************************************************************
C
C
      RHO1=0.11512925
      RHO2=0.23025851
      F(1) = 1235.
      F(2)=1260.
      F(3)=1280.
      F(4)=1295.
      F(5)=1300.
      F(6)=1305.
      F(7)=1320.
      F(8)=1340.
      F(9)=1365.
C
      CALL CLEAR(0)
      WRITE(9,100)
  100 FORMAT("PROGRAM FOR LOCATING AND PROCESSING TRANSMITTER"/
     16X," DATA STORED ON MAG. TAPE"//
     2"PLEASE SELECT TAPE AND PUT SYSTEM ON LINE")
C
      CALL PAUSE
      REWIND 18
  110 CALL CLEAR(0)
      WRITE(9,120)
  120 FORMAT("INPUT SERIAL NUMBER←")
      READ(8,130)(ISER(I),I=1,10)
  130 FORMAT(10A2,F4.1)
      WRITE (9,131)
  131 FORMAT ("INPUT DRIVE LEVEL (23.8,24.8,25.8)←")
      READ (8,*) PWRB
  135 READ(18,140)
  140 FORMAT(I1)
      IF(IEOF(18)) 150,160
  160 GO TO 135
```

```
  150 READ(18,170)LET1,(NSER(I),I=1,10),PWRA,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
  170 FORMAT(A1,10A2,F4.1,10A2,2F7.3,2F7.2,20A2)
      IF(IEOF(18))200,210
  210 DO 500 I=1,10
      IF(ISER(I)-NSER(I)) 135,500,135
  500 CONTINUE
      IF(PWRA-PWRB) 135,1000,135
C
C     CORRECT SER NO CONTINUES
C
 1000 READ(18,1001)(VMG1(I),I=1,288)
      READ(18,1001)(GAG(I),I=1,288)
      READ(18,1001)(GNG(I),I=1,288)
 1001 FORMAT (28(10E12.7/)10E12.7)
C
      IFLG = 0
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C     PORD ORDERS POSITIVE PHASE DELAY
      CALL PORD(GANG(1,1))
      DO 1240 J=2,9
 1225 IF(GANG(1,J-1)-GANG(1,J)-90.0) 1235,1230
 1230 GANG(1,J)=GANG(1,J)+360.0
      GO TO 1225
 1235 CALL PORD(GANG(1,J))
 1240 CONTINUE
C
C
      SUMG=0.0
      SUMG2=0.0
C     FREQ LOOP
      DO 1600 II=1,9
C
C     INITIALIZE VALUES TO PHASE STATE
      GMAX=GMAG(1,II)
      IF (GMAG(1,II))1298,1299,1298
 1299 IFLG=1
 1298 GMIN=GMAX
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
      DO 1335 IP=2,32
      IF(GMAG(IP,II))1301,1302,1301
 1302 IFLG=1
 1301 IF(VMAG(IP,II)-VMAX) 1305,1305,1300
 1300 VMAX=VMAG(IP,II)
 1305 VAVG=VAVG+VMAG(IP,II)
      IF(GMAG(IP,II)-GMAX) 1315,1315,1310
 1310 GMAX=GMAG(IP,II)
 1315 IF(GMIN-GMAG(IP,II)) 1325,1325,1320
 1320 GMIN=GMAG(IP,II)
```

```
 1325 SUMG=SUMG+GMAG(IP,II)
      SUMG2=SUMG2+(GMAG(IP,II))*(GMAG(IP,II))
      DELP=GANG(IP,II)-PH0
      DDELP=DELP-(11.25*FLOAT(IP-1))
      IF(ABS(DDELP)-ABS(PHMAX)) 1335,1335,1330
 1330 PHMAX=DDELP
      SUMP2=SUMP2+DDELP*DDELP
 1335 CONTINUE
C
C
C     ON A PER FREQ BASIS
C     CONVERT MAX RHO TO VSWR MAX
      AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C     CONVERT AVG RHO TO MEAN VSWR
      AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C     CONVERT MAX PHASE
      AMAXP(II)=PHMAX
C     CONVERT RMS PHASE
      RMSPH(II)=SQRT(SUMP2/32.0)
      PWRMX(II)=GMAX
      PWRMI(II)=GMIN
 1600 CONTINUE
C
C     MEAN POWER
      PWRME=SUMG/288.0
C     RMS POWER
      RMSPW=SQRT((SUMG2/288.0)-(PWRME*PWRME))
C
C     PRINT SEQUENCE---SHORT FORM
C
      CALL CLEAR(0)
      WRITE(11,2999)
 2999 FORMAT(10(//))
C
 3000 WRITE(11,3005)(NSER(I),I=1,10)
 3005 FORMAT("SER.NO. ",10A2,5X,"TRANSMITTER")
      WRITE(11,3010)(NDATE(I),I=1,10)
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
      WRITE(11,3030)PWRA
 3030 FORMAT("INPUT POWER=",F4.1,"DBM.")
      IF(IFLG) 3031,3034,3031
 3031 WRITE(11,3032)
 3032 FORMAT ("CAUTION--ERRORS ENCOUNTERED IN DATA")
 3034 WRITE (11,3033)
 3033 FORMAT ("  ")
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMAXV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
```

```
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(PWRMX(I),I=1,9)
 3060 FORMAT("MAX-PWR-W",9(X,F5.1))
      WRITE(11,3065)(PWRMI(I),I=1,9)
 3065 FORMAT("MIN-PWR-W",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)PWRME
 3075 FORMAT("OVERALL MEAN PEAK POWER=",F5.1,"WATTS")
      WRITE(11,3080)RMSPW
 3080 FORMAT("STD. DEVIATION IN OVERALL PEAK POWER=",F5.1,
     1"WATTS")
C
      CALL PAGE
C
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)PWRA
      WRITE(11,3035)(F(I),I=1,9)
      DO 4100 I=1,32
      DO 4101 J=1,9
      VMAG(I,J)=(1.0+VMAG(I,J))/(1.0-VMAG(I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("   ",F6.2," DEG.")
      WRITE(11,4105)(VMAG(I,J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE(11,4110)(GMAG(I,J),J=1,9)
 4110 FORMAT("MAX-PWR-W",9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(I,L)-GANG(1,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
      REWIND 18
      GO TO 110
  200 CALL CLEAR(0)
      WRITE(9,205)
  205 FORMAT("SERIAL NUMBER AND DRIVE POWER REQUESTED"
     1" NOT FOUND ON TAPE")
  220 REWIND 18
      CALL PAUSE
      GO TO 110
      END
```

APPENDIX II

Data acquisition programs:

NADC 1 and 2 are the two primary programs employed in hardware control and data acquisition, processing, and storage for the transceiver modules described in this report.

CALS1 is a transmitter test subroutine used in the hardware calibration sequence.

BORIS is a receiver test subroutine for calibration of the Hewlett Packard network analyzer and is similar to that used by Newlett Packard except that it is tailored specifically to module test.

```
      PROGRAM NADC1
      DIMENSION NDATE(10),NSER(10),LTL1(20),CM(64,9),GMAG(32,9),
     1GANG(32,9),VMAG(32,9),AMAXV(9),AMENV(9),AMAXP(9),RMSPH(9),
     2DBGMX(9),DBGMI(9),BANG(9),F(9),VANG(32,9),VMG1(288),
     3VAG(288),GAG(288),GNG(288),TEMP8(9),TEMP9(9)
C
      COMMON LT1ST,LT2ND,LTSTP,LINFR,LINND,EXT(3),IS(2),
     1IDMY,LCAL,ICTYP,INEW,FCO,CAL(6,9)
C
      EQUIVALENCE (VMAG(1,1),VMG1(1)),(VANG(1,1),VAG(1)),
     1(GMAG(1,1),GAG(1)),(GANG(1,1),GNG(1))
C
C*****************************************************************
C
C   THIS IS A SPECISL MEASUREMENT PROGRAM FOR
C   MEASURING THE REFLECTION AND TRANSMISSION BEFORE OUTPUTING
C   DATA TO MAGNETIE TAPE.
C
C
C
C     BORIS SHELEG   10 MARCH77
C     REV M          18 MAY 77
C
C          THIS IS MODIFIED GPM1
C
C*****************************************************************
C
C   INITIALIZE FLAGS--FIRST TIME ONLY--AND CONSTANTS
C
      CALL CLRIO
C
C     TRAP 1 IS RETURN TO MEASURE
      CALL TRAP(1)
      GO TO 1000
C     TRAP 2 IS RETURN TO CALIBRATE
      CALL TRAP(2)
      GO TO 50
   50 CALL CLEAR(0)
C
      WRITE(9,80)
   80 FORMAT("PUT DATA TAPE ON DECK AND ON LINE")
      CALL PAUSE
      WRITE(9,85)
   85 FORMAT("NEW TAPE (Y OR N)=←")
      CALL NYES(IV)
      IF(IV) 99,90
   90 ENDFILE 18
      ENDFILE 18
      REWIND 18
   99 CONTINUE
      WRITE(9,100)
  100 FORMAT("DATE:",20X,"↑,10%"←")
      READ(8,105)(NDATE(I),I=1,10)
  105 FORMAT(10A2)
C
C     ENTER FREQUENCIES IN MHZ HERE
C
      F(1)=1235
```

```
      F(2)=1260
      F(3)=1280
      F(4)=1295
      F(5)=1300
      F(6)=1305
      F(7)=1320
      F(8)=1340
      F(9)=1365
C
C
      CALL BORIS(F(1))
C
 1000 CALL CLEAR(0)
      WRITE(9,1005)
 1005 FORMAT("SER.NO.=",20X,"↑,10↑↑"←")
      READ(8,1007)(NSER(I),I=1,10)
 1007 FORMAT(10A2)
      WRITE(9,1010)
 1010 FORMAT("REMARKS:",40X,"↑,20↑↑"←")
      READ(8,1012)(LTL1(I),I=1,20)
 1012 FORMAT(20A2)
      WRITE(9,1015)
 1015 FORMAT("CONNECT DEVICE------")
      CALL BELL
      CALL PAUSE
C
C
C     MEASUREMENT CYCLE--DATA RETURNED IN CM ARRAY
C
      DO 4000 ITTN=1,8
C
C     CHAN 1=TEMP DEG C
C     CHAN 2=TEMP DEG C
C     CHAN 4=40 VOLT
C     CHAN 5=12 VOLT
C
      CALL TVOLD(1,TEMP1)
      CALL TVOLD(2,TEMP2)
      CALL TVOLD(4,VOLT1)
      CALL TVOLD(5,VOLT2)
C
C     SET ATTENUATION
      ITTN2=ITTN-1
C
      CALL SETPH(0,ITTN2)
C
C     CALL MEASURE AT 9 FREQ AND 32 PHASES
C
      CALL MCOR1(F(1),CM)
C
C     OUTPUT DATA TO MAG TAPE
C
C     CONVERT CM ARRAY TO MAG AND ANGLE
C
 2000 DO 2020 J=1,9
      DO 2020 I=1,32
      GANG(I,J)=ANG(CM(2*I,J))
      GMAG(I,J)=CMAG(CM(2*I,J))
```

```
      VMAG(I,J)=CMAG(CM(2*I-1,J))
      VANG(I,J)=ANG(CM(2*I-1,J))
 2020 CONTINUE
      ITTN3=ITTN2*2
C
C     FIND END OF TAPE
C
 2021 READ(18,2022)
 2022 FORMAT(I1)
      IF(IEOF(18)) 2023,2021
 2023 READ(18,2022)
      IF(IEOF(18)) 2024,2021
 2024 BACKSPACE 18
C
C     PUT TITLE INFO ON TAPE
C
      WRITE(18,2025)(NSER(I),I=1,10),ITTN3,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
C
C     PUT MEASURED DATA ON TAPE
C
 2025 FORMAT("R",10A2,I2,10A2,2F7.3,2F7.2,20A2)
      WRITE(18,2027)(VMG1(I),I=1,288)
      WRITE(18,2027)(VAG(I),I=1,288)
      WRITE(18,2027)(GAG(I),I=1,288)
      WRITE(18,2027)(GNG(I),I=1,288)
 2027 FORMAT(28(10E12.7/)10E12.7)
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C
      CALL PHORD(GANG(1,1))
      DO 2060 J=2,9
 2030 IF(GANG(1,J-1)-GANG(1,J)+90.0)2040,2040,2050
 2040 GANG(1,J)=GANG(1,J)-360.0
      GO TO 2030
 2050 CALL PHORD(GANG(1,J))
 2060 CONTINUE
C
C     PROCESS DATA AND PRINT OUT ON VERSATEC
C     SW 1 IS QUAL LONG FORM OPTION
C
C     SET SUM GAIN TO 0
      SUMG=0.0
C     SET SUM(GAIN)↑2 TO 0
      SUMG2=0
C
      DO 2100 II=1,9
C     INITIALIZE VALUES TO FIRST PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAG(1,II)
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
```

```
C       PHASE LOOP
        DO 2150 IP=2,32
C       DETERMINE REFLECTION COEFF MAX
        IF(VMAG(IP,II)-VMAX) 2070,2070,2065
 2065   VMAX=VMAG(IP,II)
C       DETERMINE SUM REF. COEFF.
 2070   VAVG=VAVG+VMAG(IP,II)
C       DETERMINE VOLTAGE GAIN MAX
        IF (GMAG(IP,II)-GMAX) 2080,2080,2075
 2075   GMAX=GMAG(IP,II)
C       DETERMINE VOLTAGE GAIN MIN
 2080   IF(GMIN-GMAG(IP,II)) 2090,2090,2085
 2085   GMIN=GMAG(IP,II)
C       DETERMINE SUM OF VOLT GAIN
 2090   SUMG=SUMG+GMAG(IP,II)
C       DETERMINE SUM(VOLT GAIN)↑2
        SUMG2=SUMG2+GMAG(IP,II)*GMAG(IP,II)
C       DETERMINE DELTA PHASE
        DELP=PH0-GANG(IP,II)
C       DETERMINE DELTA PHASE ERROR
        DDELP=DELP-(11.25*FLOAT(IP-1))
C       DETERMINE DEL PHAS ERR MAX
        IF(ABS(DDELP)-ABS(PHMAX)) 2150,2150,2095
 2095   PHMAX=DDELP
C       DETERMINE SUM(DEL PHAS ERR)↑2
        SUMP2 = SUMP2 + DDELP*DDELP
C
 2150   CONTINUE
C       ON A PER FREQ BASIS------
C       CONVERT MAX RHO TO VSWR MAX
        AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C       CONVERT AVG RHO TO MEAN VSWR
        AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C       CONVERT MAX PHASE
        AMAXP(II)=PHMAX
C       CONVERT RMS PHASE
        RMSPH(II)=SQRT(SUMP2/32.0)
C       CONVERT VOLT GAIN MAX TO MAX GAIN DB
        DBGMX(II)=20.*ALOG(GMAX)/ALOG(10.0)
C       CONVERT VOLT GAIN MIN TO MIN GAIN DB
        DBGMI(II)=20.*ALOG(GMIN)/ALOG(10.0)
C
 2100   CONTINUE
C       CONVERT TO MEAN GAIN
        DBGME=20.*ALOG(SUMG/288.0)/ALOG(10.0)
C       CONVERT TO RMS GAIN
        RMSG=20.*ALOG(SQRT((SUMG2-(SUMG*SUMG/288.0))/288.0))/
       1ALOG(10.0)
C
C       PRINT SEQUENCE--SHORT FORM
C
        CALL CLEAR(0)
        WRITE(11,2999)
 2999   FORMAT(10(//))
C
 3000   WRITE(11,3005)(NSER(I),I=1,10)
 3005   FORMAT("SER.NO. ",10A2,5X,"RECEIVER")
        WRITE(11,3010)(NDATE(I),I=1,10)
```

```
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
C
      ITTN1=(ITTN-1)*2
      WRITE(11,3030)ITTN1
 3030 FORMAT("ATTNUATION=",I2,"DB."/)
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMAXV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(DBGMX(I),I=1,9)
 3060 FORMAT("MAX-GN-DB",9(X,F5.1))
      WRITE(11,3065)(DBGMI(I),I=1,9)
 3065 FORMAT("MIN-GN-DB",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)DBGME
 3075 FORMAT("OVERALL MEAN GAIN=",F5.1,"DB.")
      WRITE(11,3080)RMSG
 3080 FORMAT("STD. DEVIATION IN OVERALL GAIN=",F6.1,"DB.")
C
C     PUT PROCESSED DATA ON TAPE WITH ENDFILES
C
      CALL PAGE
      WRITE(18,3090)(AMAXV(I),I=1,9)
      WRITE(18,3090)(AMENV(I),I=1,9)
      WRITE(18,3090)(AMAXP(I),I=1,9)
      WRITE(18,3090)(RMSPH(I),I=1,9)
      WRITE(18,3090)(DBGMX(I),I=1,9)
      WRITE(18,3090)(DBGMI(I),I=1,9)
      WRITE(18.3090)(GANG(1,I),I=1,9)
      WRITE(18,3090)DBGME,RMSG
 3090 FORMAT(9E13.7)
      ENDFILE 18
      ENDFILE 18
      BACKSPACE 18
      BACKSPACE 18
C
C
C
C
C     SW 1 UP=LONG FORM FOR QUAL
      IF(ISP(1)) 4005,4006
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
```

```
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3930)ITTN1
      WRITE(11,3035)(F(I),I=1,9)
C
C
      DO 4100 I=1,32
      DO 4101 J=1,9
      TEMP9(J)=VSWRC(CM(2*I-1,J))
      TEMP8(J)=DBC(CM(2*I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("  ",F6.2," DEG.")
      WRITE (11,4105) (TEMP9(J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE (11,4110) (TEMP8(J),J=1,9)
 4110 FORMAT("GAIN-DB",2X,9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(1,L)-GANG(I,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
 4000 CONTINUE
      GO TO 1000
      END
```

```
      PROGRAM NADC2
C
      DIMENSION NSER(10),NDATE(10),LTL1(20),TEMP(20),GNG(288),
     1GANG(32,9),GMAG(32,9),AVSWR(32,9),GAG(288),
     2VMG1(288),VMAG(32,9),AMAXV(9),
     3AMENV(9),AMAXP(9),RMSPH(9),PWRMX(9),PWRMI(9),BANG(9)
C
      COMMON F(9),PIMC(9),POMC(9),PVSWR(9),S2PMC(9),SAFMC(9)
C
      EQUIVALENCE (GANG(1,1),GNG(1)),(GMAG(1,1),GAG(1)),
     1(VMAG(1,1),VMG1(1))
C
C***************************************************************
C
C     THIS PROGRAM CALIBRATES THE S.A. EQUIPMENT AND PERFORMS
C     THE NADC MEASUREMENT SEQUENCE.
C     INPUT COUPLER AND/OR PAD INFO IS NECESSARY.
C     INPUT, REFLECTED AND TRANSMITTED POWERS ARE MEASURED
C     USING SHORT WINDOW PEAK POWER METERS. THE WINDOWS CAN
C     BE MANUALLY MOVED THRU THE PULSE. AUTOMATIC INPUT
C
C     POWER LEVELING IS USED WHICH IS PROGRAMABLE.
C     A MAX OF 30 SAMPLES IS TAKEN AT EACH TEST CONDITION
C     AND IF 5 ARE NOT FOUND ACCEPTABLE FOR AVERAGING,
C     THEN PROGRAM GIVES ZEROS AND PROCEEDS.EQUIPMENT PULSES
C     IN STANDBY UNTIL OPERATOR GIVES OK FOR TEMPERATURE
C     STABILITY. PULSES ARE REMOVED BY HARDWARE WHEN
C     FREQ/VOLT/PHASE/POWERIN CHANGES ARE IN PROGRESS.
C     HARD COPY AND MAG TAPE OUTPUT.
C
C     SW 1 UP FOR QUAL. LONG FORM OUTPUT.
C
C     REV. H    5/17/77
C
C     L.LAVEDAN      4/20/77
C
C***************************************************************
C
C     SET S.A. INTERFACE
      CALL SETIP
C     SET UP PULSE GENERATOR
      CALL SPULG(1,30,10,5,64)
C     SET TO NOMINAL INPUT POWER
      CALL INITP(-6.0)
C
      RHO1=0.11512925
      RHO2=0.23025851
C     DEFINE FREQUENCY SEQUENCE
      F(1)=1235
      F(2)=1260
      F(3)=1280
      F(4)=1295
      F(5)=1300
      F(6)=1305
      F(7)=1320
      F(8)=1340
      F(9)=1365
C     SET FREQUENCY TO MIN BAND
```

```
      CALL SETFR(F(5))
C     TURN OFF OUTPUT POWER
      CALL OPULG
C
C     TRAP 1 IS RETURN TO MEASURE
      CALL TRAP(1)
      GO TO 1000
C
C     TRAP 2 IS RETURN TO CALIBRATION
      CALL TRAP(2)
      GO TO 50
C
   10 CALL CLEAR(0)
      WRITE(9,12)
   12 FORMAT(21X,"***S.A. TEST PROGRAM***"//"READ COUPLER"
     1" INFO FROM TAPE?←")
      CALL NYES(ITC)
      IF(ITC) 14,16
C
C     GET COUPLING INFO FROM KEYBOARD
C
   14 WRITE(9,18)
   18 FORMAT("TYPE IN THE FOLLOWING COUPLINGS"/"FREQ.  INPUT"
     1" COUP.(+DB)    OUTPUT COUP.(+DB)")
      DO 20 I=1,9
      WRITE(9,22)F(I)
   22 FORMAT(F8.1,":←")
      READ(8,*)PIMC(I),POMC(I)
   20 CONTINUE
      GO TO 50
C
   16 WRITE(9,24)
   24 FORMAT("POSITION TAPE IN DECK #2")
      CALL PAUSE
      READ(14,*)(PIMC(J),POMC(J),J=1,9)
      WRITE(9,28)(F(I),PIMC(I),POMC(I),I=1,9)
   28 FORMAT(9(3F10.2/))
C
   50 CALL CLEAR(0)
C
C     MAKE SURE POWER LOOP IS STILL ON
C
      CALL PLRST
      WRITE(9,80)
   80 FORMAT("PUT MAG TAPE FOR DATA IN DECK AND ON LINE")
      CALL PAUSE
      WRITE(9,85)
   85 FORMAT("NEW TAPE (Y OR N)=←")
      CALL NYES(IV)
      IF(IV) 99,90
   90 ENDFILE 18
      ENDFILE 18
      REWIND 18
   99 CONTINUE
C
      WRITE(9,25)
   25 FORMAT("DATE:",20X,"↑,10Y"←")
      READ(8,30)NDATE
```

```
   30 FORMAT(20A2)
C
      PMIN=23.8
      PNOM=24.8
      PMAX=25.8
C
C     CALIBRATION SEQUENCE
C
  100 CALL CLEAR(0)
      CALL CALS1
 1000 CALL OPULG
      CALL PLRST
C
      WRITE(9,1005)
 1005 FORMAT("SER.NO.="20X,"↑,10↑↑"←")
      READ(8,30)(NSER(I),I=1,10)
      WRITE(9,1010)
 1010 FORMAT("REMARKS:"40X,"↑,20↑↑"←")
      READ(8,30)(LTL1(I),I=1,20)
      WRITE(9,1015)
 1015 FORMAT("CONNECT DEVICE AND THERMOCOUPLE(1) TO DEVICE"/
     1"AND PUT SWITCH 2 DOWN")
      CALL BELL
      CALL PAUSE
C     SET PHASE AND AMPLITUDE
      CALL SETPH(0,0)
C     RESTORE PULSE GENERATOR
      CALL RPULG
C     TURN ON AT F(5) AND PNOM
      POWER=PNOM-PIMC(5)
      CALL SETPW(POWER)
      CALL SETFR(F(5))
C
      CALL CLEAR(0)
C
      WRITE(9,1020)
 1020 FORMAT("PUT UP SWITCH 2 FOR EXIT FROM TEMP. LOOP")
C     TEMPERATURE LLOP---CHAN 1 ON DEVICE
      DO 1035 I=1,20
      CALL TVOLD(1,TEMP(I))
      WRITE(9,1025)TEMP(I)
 1025 FORMAT(F7.2)
      IF(ISP(2)) 1060,1030
 1030 CALL DELAY(5000)
 1035 CONTINUE
 1037 DO 1040 I=1,19
      TEMP(I)=TEMP(I+1)
 1040 CONTINUE
      CALL TVOLD(1,TEMP(20))
      CALL CLEAR(0)
      WRITE(9,1020)
      WRITE(9,1045)(TEMP(I),I=1,20)
 1045 FORMAT(20(F7.2/))
      IF(ISP(2)) 1060,1050
 1050 CALL DELAY(5000)
      GO TO 1037
C     START MEASUREMENTS
C     POWER INPUT LOOP
```

```
C
C
 1060 DO 4000 IPL=1,3
      IFLG = 0
      DELPW=2-IPL
      PWRA=26.8-FLOAT(IPL)
      CALL CLEAR(0)
      WRITE(9,1065)PWRA
 1065 FORMAT("MEASUREING FOR POWER LEVEL OF",F5.1,"DBM.")
C
C
C     CHAN1=TEMP DEG.C OF MODULE
C     CHAN2=TEMP DEG.C
C     CHAN4=40 VOLT
C     CHAN5=12 VOLT
C
      CALL TVOLD(1,TEMP1)
      CALL TVOLD(2,TEMP2)
      CALL TVOLD(4,VOLT1)
      CALL TVOLD(5,VOLT2)
C     BEGIN FREQUENCY LOOP
      DO 1200 IFR=1,9
      POWER=PWRA-PIMC(IFR)
      CALL SETPW(POWER)
      CALL SETFR(F(IFR))
C
C     INITIATE A DELAY AND THROW FIRST DATA OUT
C
      CALL SETPH (0,0)
      CALL R5DAT(A1,A2,F1,A3,A4)
C
C     BEGIN PHASE LOOP
      DO 1200 IBT=1,32
      IBT1=IBT-1
      CALL SETPH(IBT1,0)
 1080 CALL R5DAT(A1,A2,F1,A3,A4)
      IF (A2) 1085,1089,1085
 1085 TMP=ABS(A2-S2PMC(IFR)-DELPW)
      IF(TMP-.3) 1090,1070
 1070 WRITE(9,1075)TMP
 1075 FORMAT("REF.CHAN.DIFF.=",F8.2,"DB. --ACCEPT IT?←")
      CALL NYES(ITC)
      IF(ITC) 1080, 1090
C
 1089 IFLG = 1
 1090 TMP=F1-SAFMC(IFR)
 1095 IF(TMP) 1100,1105
 1100 TMP=TMP+360.0
      GO TO 1095
 1105 IF(TMP-360.0) 1115,1110
 1110 TMP=TMP-360.0
      GO TO 1105
 1115 GANG(IBT,IFR)=TMP
      TEMP3=-A3+POMC(IFR)-30.0
      GMAG(IBT,IFR)=EXP(RHO2*TEMP3)
      TEMP3=-A4+PVSWR(IFR)
      VMAG(IBT,IFR)=EXP(RHO1*(TEMP3-PWRA))
C
```

```
 1200 CONTINUE
C
      POWER=PWRA-PIMC(1)
      CALL SETPW(POWER)
      CALL SETFR(F(1))
C
C     OUTPUT DATA TO MAG TAPE
C     FIND END OF TAPE
C
 2021 READ(18,2022)
 2022 FORMAT(I1)
      IF(IEOF(18)) 2023,2021
 2023 READ(18,2022)
      IF(IEOF(18)) 2024,2021
 2024 BACKSPACE 18
C
C     PUT TITLE INFO ON TAPE
C
      WRITE(18,2025)(NSER(I),I=1,10),PWRA,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
 2025 FORMAT("T",10A2,F4.1,10A2,2F7.3,2F7.2,20A2)
C
C     PUT MEASURED DATA ON TAPE
C
      WRITE(18,2027)(VMG1(I),I=1,288)
      WRITE(18,2027)(GAG(I),I=1,288)
      WRITE(18,2027)(GNG(I),I=1,288)
 2027 FORMAT(28(10E12.7/)10E12.7)
C
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C     PORD ORDERS POSITIVE PHASE DELAY
      CALL PORD(GANG(1,1))
      DO 1240 J=2,9
 1225 IF(GANG(1,J-1)-GANG(1,J)-90.0) 1235,1230
 1230 GANG(1,J)=GANG(1,J)+360.0
      GO TO 1225
 1235 CALL PORD(GANG(1,J))
 1240 CONTINUE
C
C
      SUMG=0.0
      SUMG2=0.0
C     FREQ LOOP
      DO 1600 II=1,9
C
C     INITIALIZE VALUES TO PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAX
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
```

```
      DO 1335 IP=2,32
      IF(VMAG(IP,II)-VMAX) 1305,1305,1300
 1300 VMAX=VMAG(IP,II)
 1305 VAVG=VAVG+VMAG(IP,II)
      IF(GMAG(IP,II)-GMAX) 1315,1315,1310
 1310 GMAX=GMAG(IP,II)
 1315 IF(GMIN-GMAG(IP,II)) 1325,1325,1320
 1320 GMIN=GMAG(IP,II)
 1325 SUMG=SUMG+GMAG(IP,II)
      SUMG2=SUMG2+(GMAG(IP,II))*(GMAG(IP,II))
      DELP=GANG(IP,II)-PH0
      DDELP=DELP-(11.25*FLOAT(IP-1))
      IF(ABS(DDELP)-ABS(PHMAX)) 1335,1335,1330
 1330 PHMAX=DDELP
      SUMP2=SUMP2+DDELP*DDELP
 1335 CONTINUE
C
C
C     ON A PER FREQ BASIS
C     CONVERT MAX RHO TO VSWR MAX
      AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C     CONVERT AVG RHO TO MEAN VSWR
      AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C     CONVERT MAX PHASE
      AMAXP(II)=PHMAX
C     CONVERT RMS PHASE
      RMSPH(II)=SQRT(SUMP2/32.0)
      PWRMX(II)=GMAX
      PWRMI(II)=GMIN
 1600 CONTINUE
C
C     MEAN POWER
      PWRME=SUMG/288.0
C     RMS POWER
      RMSPW=SQRT((SUMG2/288.0)-(PWRME*PWRME))
C
C     PRINT SEQUENCE---SHORT FORM
C
      CALL CLEAR(0)
      WRITE(11,2999)
 2999 FORMAT(10(//))
C
 3000 WRITE(11,3005)(NSER(I),I=1,10)
 3005 FORMAT("SER.NO. ",10A2,5X,"TRANSMITTER")
      WRITE(11,3010)(NDATE(I),I=1,10)
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
      WRITE(11,3030)PWRA
 3030 FORMAT("INPUT POWER=",F4.1,"DBM.")
      IF(IFLG) 3031,3034,3031
 3031 WRITE(11,3032)
 3032 FORMAT ("CAUTION--ERRORS ENCOUNTERED IN DATA")
 3034 WRITE (11,3033)
```

```
 3033 FORMAT ("  ")
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMAXV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(PWRMX(I),I=1,9)
 3060 FORMAT("MAX-PWR-W",9(X,F5.1))
      WRITE(11,3065)(PWRMI(I),I=1,9)
 3065 FORMAT("MIN-PWR-W",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)PWRME
 3075 FORMAT("OVERALL MEAN PEAK POWER=",F5.1,"WATTS")
      WRITE(11,3080)RMSPW
 3080 FORMAT("STD. DEVIATION IN OVERALL PEAK POWER=",F5.1,
     1"WATTS")
C
C     PUT PROCESSED DATA ON TAPE
C     WITH ENDFILES
      CALL PAGE
      WRITE(18,3090)(AMAXV(I),I=1,9)
      WRITE(18,3090)(AMENV(I),I=1,9)
      WRITE(18,3090)(AMAXP(I),I=1,9)
      WRITE(18,3090)(RMSPH(I),I=1,9)
      WRITE(18,3090)(PWRMX(I),I=1,9)
      WRITE(18,3090)(PWRMI(I),I=1,9)
      WRITE(18,3090)(GANG(1,I),I=1,9)
      WRITE(18,3090)PWRME,RMSPW
 3090 FORMAT(9E13.7)
      ENDFILE 18
      ENDFILE 18
      BACKSPACE 18
      BACKSPACE 18
C
C     SW 1 UP= LONG FORM FOR QUAL
      IF (IFLG) 4005,4004,4005
 4004 IF(ISP(1)) 4005,4000
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)PWRA
      WRITE(11,3035)(F(I),I=1,9)
      DO 4100 I=1,32
      DO 4101 J=1,9
      VMAG(I,J)=(1.0+VMAG(I,J))/(1.0-VMAG(I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("  ",F6.2," DEG.")
      WRITE(11,4105)(VMAG(I,J),J=1,9)
```

```
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE(11,4110)(GMAG(I,J),J=1,9)
 4110 FORMAT("MAX-PWR-W",9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(I,L)-GANG(1,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
 4000 CONTINUE
      CALL SETFR(F(5))
      CALL SETPW(-6.0)
      CALL OPULG
C
      GO TO 1000
      END
```

```
      SUBROUTINE CALS1
      COMMON F(9),PIMC(9),POMC(9),PVSWR(9),S2PMC(9),
     1SAFMC(9),
C****************************************************************
C
C     CALIBRATION ROUTINE FOR S.A. NADC PROGRAM
C     INCLUDING VSWR  AND VERIFICATION
C
C     REV.A     APR.21,1977
C
C****************************************************************
C
C     INITIAL SETUP
C
   10 CALL SPULG(1,30,10,5,16)
      POWER=24.8-PIMC(5)
      CALL SETPW(POWER)
      CALL SETFR(F(5))
      WRITE(9,110)
  110 FORMAT("ADJUST POWER LEVEL FOR ZERO VOLTS")
      CALL BELL
      CALL PAUSE
      POWER=26.8-PIMC(5)
      CALL SETPW(POWER)
      WRITE(9,100)
  100 FORMAT("MAX. GAIN OF MODULE (DB):←")
      READ(8,*)GMAX
      GMAX=-GMAX-2.0
      WRITE(9,120) GMAX
  120 FORMAT("ADJUST RECEIVER GAINS AS FOLLOWS:"/
     1  "REF. CHANNEL... -2.0 DB."/
     2  "TEST CHANNEL "F8.1" DB"/"TO CONTINUE, LIFT SWITCH 8")
  130 CALL RAPHD(A1,A2,F1,A3,A4)
      IF(ISP(8)) 140,130
  140 CALL R5DAT(A1,A2,F1,A3,A4)
      WRITE(9,150)
  150 FORMAT("PUT SWITCH 8 DOWN")
      CALL BELL
  160 IF(ISP(8)) 160,165
  165 CALL SPULG(1,30,10,5,64)
      CALL DELAY(20)
      CALL R5DAT(A11,A21,F1,A3,A4)
      TMP=-20.91515
      A1=A1+TMP
      A2=A2+TMP
      WRITE(9,170) A1,A2,A11,A21
  170 FORMAT("TEST AMPLITUDE READINGS WERE:"
     1  /"EXPECTED: TEST CHANNEL="F6.1"  REF. CHANNEL="F6.1
     2  /"MEASURED: TEST CHANNEL="F6.1"  REF. CHANNEL="F6.1
     3  /"OK TO CONTINUE?←")
      CALL NYES(ITC)
      IF(ITC) 10,200
  200 CALL CLEAR(0)
      DO 220 I=1,9
  210 CALL SETFR(F(I))
      POWER=24.8-PIMC(I)
      CALL SETPW(POWER)
      CALL DELAY(20)
```

```
      CALL R5DAT(A1,S2PMC(I),SAFMC(I),A3,A4)
  220 CONTINUE
  240 CALL SETFR(F(1))
      POWER=24.8-PIMC(1)
      WRITE (9,250)
  250 FORMAT ("VERIFY CALIBRATION?←")
      CALL NYES(ITC)
      IF (ITC) 290,260
  260 DO 280  I = 1, 9
      POWER = 24.8-PIMC(I)
      CALL SETFR(F(I))
      CALL SETPW(POWER)
      CALL DELAY(20)
      CALL R5DAT(A1,A2,F1,A3,A4)
      A2=A2-S2PMC(I)
      F1=F1-SAFMC(I)
 1000 IF (F1) 1001,1005
 1001 F1 = F1 + 360.0
      GO TO 1000
 1005 IF (F1-360.0) 1010,1006
 1006 F1 = F1 - 360.0
      GO TO 1005
 1010 A3 = -A3 + POMC(I)
      WRITE (9,270) F(I),A2,F1,A3
  270 FORMAT(4F10.2)
  280 CONTINUE
      GO TO 240
  290 CALL CLEAR(0)
      WRITE (9,300)
  300 FORMAT ("CONNECT SYSTEM AS FOLLOWS:"/
     1 "VSWR POWER METER TO VSWR PORT"/
     2 "SHORT ON MODULE/HI-POWER PORT AT END OF CABLE")
      CALL PAUSE
      DO 350  I = 1, 9
      POWER = 24.8 - PIMC(I)
      CALL SETFR(F(I))
      CALL SETPW(POWER)
      CALL DELAY(20)
      CALL R1DAT(A4)
C     SVSWR(I) IS TO BE SUBTRACTED FROM A4 DURING MEASUREMENT
      PVSWR(I) = 24.8 + A4
  350 CONTINUE
      CALL CLEAR(0)
      CALL SETFR(F(5))
      CALL SETPW(-6.0)
      END
```

```
      SUBROUTINE BORIS(F)
      DIMENSION F(2),C(6),IC(12),CAL(6,2),TEM(2,9)
      COMMON ID(11),IS(2),I1(3),INEW,FCO,ICAL(12,2)
      EQUIVALENCE (C,IC),(CAL,ICAL)
C
C*************************************************************
C     THIS IS A ONE PATH CALIBRATION
C     6 PARAMETER ERROR MODEL
C     CALLED BY BORIS(F)
C     WHERE F IS START FREQUENCY ARRAY
C     INEW IS FLAG TO TRAP CALL, SET TO - AT END
C     OF NORMAL CALIBRATION
C
C     BORIS SHEHEG  MAR. 4,1977
C     REV I         APR 26,1977
C
C     THIS IS MODIFIED CALB1
C
C*************************************************************
C
C     INITIALIZE AND DEFINE CONSTANTS
C
C     DEFINE S11 AND S21 FOR COMMON AND MCOR1
      IS(1)=11
      IS(2)=21
C
      F1=F(1)
      CALL FCALF(F1)
      CALL BCNT1(F1)
      CALL CPAK2(1.0,0.0,C1)
C
C     MEASURE LOADS
C
C
   75 CALL SSEL1(11)
      M=1
      MN=1
      IP=1
C
C
  110 KOP=3
      WRITE(2,905)
  905 FORMAT("PORT 1: CONNECT FEMALE SMA LOAD")
      CALL PAUSE
      GO TO 9000
C
C
C     MEASURE CROSSTALK
C
  200 CALL FREQ2(F1)
      WRITE(2,908)
  908 FORMAT("CONNECT FEMALE SMA LOADS, TWO PORTS FOR ISOL.")
      CALL SSEL1(21)
      CALL PAUSE
      IP=5
      KOP=4
      M=1
      GO TO 9000
```

```
C
C
C     TEST FOR DESTINATION
C
C     MEASURE SHORTS
C
  305 CALL SSEL1(11)
      CALL FREQ2(F1)
      IP=2
      KOP=5
  310 WRITE(2,913)
  913 FORMAT("PORT 1: CONNECT SMA FEMALE SHORT")
      CALL PAUSE
      M=1
      GO TO 9000
C
C
C     MEASURE OPEN
C
C
  400 M=1
      IP=3
      KOP=6
  430 CALL FREQ2(F1)
C
C
  480 WRITE(2,930)
  930 FORMAT("PORT 1: CONNECT SMA FEMALE OPEN")
      CALL PAUSE
      GO TO 9000
C
C
  550 RAD=2.0*ATAN(0.032*FL*3.14159E-4)
      T3=1.0
C
  560 CALL CSUB2(C(1),C(2),T1)
      CALL CSUB2(C(3),C(1),T2)
      CALL PSFT2(0.0,T3,RAD,T2,T3)
C
  580 CALL CSUB2(T3,T1,T3)
C
      CALL CADD2(T2,T1,T4)
      CALL CDIV2(T3,T4,T5)
      CALL CADD2(C1,T5,T3)
      CALL CMPY2(T3,T1,C(2))
      C(3)=T5
      GO TO 9250
C
C
C     CONNECT THRU S11 AND S21
C
 1005 WRITE(2,935)
  935 FORMAT("CONNECT THRU FEMALE/FEMALE SMA ADAPTER")
      CALL FREQ2(F1)
      CALL PAUSE
      M=1
C
C
```

```
C      REFLECTION
C
 1010 IP=6
      KOP=7
      GO TO 9000
C
C
C     TRANSMISSION
C
 1500 IP=4
      KQP=8
      M=M2
      CALL SSEL1(21)
      GO TO 9000
C
 1030 RL1=1.22
      T4=RL1*4.193E-4
      CALL CSUB2(C(6),C(1),T1)
      CALL CMPY2(T1,C(3),T2)
      CALL CADD2(T2,C(2),T2)
      CALL CDIV2(T1,T2,C(6))
      CALL PSFT2(0.0,FL,T4,C(6),C(6))
      GO TO 9250
C
C
 1130 T3=RL1*2.0965E-4
      CALL CSUB2(C(4),C(5),T1)
      CALL CMPY2(C(3),C(6),T2)
      CALL PSFT2(0.0,FL,T4,T2,T2)
      CALL CSUB2(C1,T2,T2)
      CALL CMPY2(T2,T1,C(4))
      CALL PSFT2(0.0,FL,T3,C(4),C(4))
      GO TO 9250
C
C
C      RETURN TO MAIN PROGRAM
C
C
 2000 CALL FREQ2(F1)
      INEW=-1
 1170 CALL CLEAR(0)
 1172 WRITE(9,1175)
 1175 FORMAT("VERIFY CALIBRATION(Y OR N)?←")
      CALL NYES(N1)
      IF(N1) 1180,1185
 1185 CALL CLEAR(0)
      WRITE(9,1190)
 1190 FORMAT("CONNECT THRU---")
      CALL PAUSE
C
C      VERIFICATION MEASUREMENT SEQUENCE
C
      CALL BCNT1(F(1))
      CALL SSEL1(11)
      DO 1200 I=1,9
      CALL FREQ2(F(I))
      CALL MEAS1(500,V1,V2)
      CALL CPAK2(V1,V2,V1)
```

```
      CALL CSUB2(V1,CAL(1,I),V1)
      CALL CDIV2(V1,CAL(2,I),V2)
      CALL CMPY2(V2,CAL(3,I),V1)
      CALL CADD2(C1,V1,V1)
      CALL CDIV2(V2,V1,TEM(1,I))
 1200 CONTINUE
      CALL SSEL1(21)
      DO 1210 I=1,9
      CALL FREQ2(F(I))
      CALLMEAS1(500,V1,V2)
      CALL CPAK2(V1,V2,V1)
      CALL CSUB2(V1,CAL(5,I),V1)
      CALL CDIV2(V1,CAL(4,I),V2)
      CALL CMPY2(TEM(1,I),CAL(3,I),V1)
      CALL CSUB2(C1,V1,V1)
      CALL CMPY2(V1,V2,TEM(2,I))
 1210 CONTINUE
C
      CALL CLEAR(0)
      DO 1220 I=1,9
      TE1=CMAG(TEM(1,I))
      TE2=ANG(TEM(1,I))
      TE3=CMAG(TEM(2,I))
      TE4=ANG(TEM(2,I))
      WRITE(9,1222)F(I),TE1,TE2,TE3,TE4
 1222 FORMAT(F4.0,4(5X,F9.3))
 1220 CONTINUE
      GO TO 1172
 1180 CALL CLEAR(0)
      CALL FREQ2(F(1))
      RETURN
C
C
C
C     TEST LOOP************************
C
C
 9000 NAVEC=-5
      CRA=0.2
      CALL CPAK2(CRA,0.0,CRA)
 9010 FN=F(M)
      IT1=-1
      M2=M
      CALL FREQ2(FN)
C
 9100 MN=M+1
      FL=FN
      FN=F(MN)
C
C
 9130 CALL MEAS1(100,T1,T2)
      IF(9-MN) 9552,9150
 9552 IT1=1
      GO TO 9140
 9150 CALL FREQ2(FN)
C
 9140 CALL CPAK2(T1,T2,T1)
      IF(NAVEC+5) 9220,9220,9200
```

```
 9200 CALL CADD2(CAL(IP,M),T1,T1)
 9220 CAL(IP,M)=T1
      IF(NAVEC+1) 9300,9230
 9230 CALL CMPY2(CRA,T1,CAL(IP,M))
          DO 9240 N=1,12
 9240          IC(N)=ICAL(N,M)
               GO TO(9300,200,9300,9300,9300,550,1030,1130)KOP
 9250     DO 9260 N=1,12
 9260          ICAL(N,M)=IC(N)
C
 9300 IF(IT1) 9320,9310
 9320 M=MN
      GO TO 9100
 9310 NAVEC=NAVEC+1
      IF(NAVEC) 9330,9920
 9330 M=M2
      GO TO 9010
C
C
 9920 GOTO(200,200,200,305,400,1005,1500,2000)KOP
C
C
      END
```

APPENDIX III

IO Drivers:

MCOR1 is a driver for calling the various microwave equipments necessary for an actual receiver measurement. It is similar to a Hewlett Packard program by the same name but has been tailored specifically for receiver module measurements. It includes a call to set the phase (and amplitude) of the receiver.

SIGDR is a four entry subroutine that controls and levels the transmitter input power on an interrupt basis.

SETPH is a subroutine used to control the phase and attenuation settings of the module for both transmit and receive.

```
      NAM MCOR1
      ENT MCOR1
      EXT .ENTR,FREQ2,MEAS1,CPAK2,CADD2,CMPY2,CDIV2
      EXT CSUB2,SSEL1,BCNT1,FLOAT,NBNDF,SETPH
      COM DMY1(11),IS(2),DMY2(6),CAL
*
*****************************************************************
*  MAKES CORRECTED MEASUREMENTS OF TRANSMISSION AND
*  REFLECTION. ACCESS FREQUENCY THRU ARRAY PASSED THRU
*  MAIN PROGRAM
*  FORM OF CALL FROM FORTRAN IS: CALL MCOR1(F1ST,CM)
*  WHERE F1ST IS THE STARTING ADDRESS OF THE FREQUENCY ARRAY
*  STORED IN THE CALLING PROGRAM. AND CM IS THE CORRECTED
*  DATA ARRAY.
*
*  IS(1)=11  AND IS(2)=21
*
*  CM ARRAY=CM(64,9)
*
*  REV. D   APR  25, 1977
*
*  MARCH 15, 1977      B. SHELEG
*****************************************************************
*
*
F1ST  NOP
CM    NOP
*                        DATA ARRAY ADDR
MCOR1 NOP
      JSB .ENTR
      DEF F1ST
*
      JSB BCNT1          BEAM CENTER
      DEF *+2
      DEF F1ST,I
*
*
      CLA,INA
      STA M
      LDA S1DEF          IP=INDERECT THRU S1
      STA IP
      CLA
      STA ITR            FULL REF. AND TRANS.
*
*
*  SCAN FOR S11    (IP PRESET)
*
A1    JSB SSEL1          SELECT REFLECTION
      DEF *+2
      DEF IS
      LDA CDI
      STA ATA1
      INA
      STA ATA2
      JSB AT1            START MEASUREMENT
*
*
*  MEASURE S21
```

```
*
A2     ISZ IP          S21
       NOP
       CCA
       STA ITR         FLAG ITR=-1
       LDA CDI         SET UP TRACKING
       ADA THRE        AND LEAKAGE CAL ADDRESSES
       STA ATA2
       INA
       STA ATA1
       JSB SSEL1       S21
       DEF *+2
       DEF IS+1
       JSB AT1         START MEASUREMENT SCAN
*
*
A10    JSB FREQ2       RESET TO FIRST FREQ
       DEF *+2
       DEF F1ST,I
       JMP MCOR1,I
*
*
*  CORRECTION FOR REFLECTION
CQRR   JSB CMPY2
       DEF *+4
       DEF C3,I
       DEF S1,I
       DEF T1
       JSB CADD2
       DEF *+4
       DEF CONE
       DEF T1
       DEF T1
       JSB CDIV2
       DEF *+4
       DEF S1,I        S1=T11/(1+T11*E11)
       DEF T1
       DEF S1,I
*
*
*  CORRECTION TO S21 FOR SOURCE MATCH ERROR
*
       JSB CMPY2       D=1-S1*E11
       DEF *+4
       DEF S1,I
       DEF C3,I
       DEF T1
       JSB CSUB2
       DEF *+4
       DEF CONE
       DEF T1
       DEF T1
       JSB CMPY2       S21=T1*T21
       DEF *+4
       DEF T1
       DEF S2,I
       DEF S2,I
       JMP AT8
```

```
*
*
*  TEST LOOP
*
AT1     NOP               ENTRY POINT
        JSB FREQ2         SET FIRST FREQUENCY
        DEF *+2
        DEF F1ST,I
        LDA DLY1          SET LONG DELAY
        STA IDLY
        CLA               SET FIRST PHASE
        STA P
        JSB SETPH
        DEF *+2
        DEF P
        CLA
        STA IT1           NOT LAST FREQ
        CCA
        STA IT3           NEED NEW CALIB DATA
        CLA,INA
        STA M             SET M=FIRST FREQ
*
*
        JMP AT3
*
AT2     LDA M             SET UP NEXT FREQ
        INA
        STA MN
        CMA,INA
        ADA NINE
        STA IT1           IF IT1<0 DOING LAST FREQ
        SSA
        JMP AT3           LAST FREQ--DONT SET NEW
        LDA M             M=MN-1
        ALS
        ADA F1ST          ADDRESS OF FREQ
        STA IFN           SAVE ADDRESS
*
*
AT3     LDA P             SET UP NEXT PHASE
        INA
        STA P
        CMA,INA
        ADA D31
        STA IT2           SET LAST PHASE FLAG
        SSA,RSS           YES--NEXT PHASE IS ZERO
        JMP AT4
        CLA
        STA P
*
*
AT4     JSB MEAS1         READ VOLTAGES
        DEF *+4
        DEF IDLY
        DEF T1
        DEF T2
        JSB SETPH         SET NEXT PHASE
        DEF *+2
```

```
      DEF  P
      LDA  DLY3       SET SHORT DELAY
      STA  IDLY
      LDA  IT2
      SSA,RSS         TEST FOR LAST PHASE
      JMP  AT5        NO, NO NEW FREQ
      LDA  IT1        WAS LAST FREQ?
      SSA
      JMP  AT5        YES, NO NEW FREQ
      JSB  FREQ2      NO, SET NEW FREQ
      DEF  *+2
IFN   NOP
      LDA  DLY2       SET MED DELAY
      STA  IDLY
      LDA  M1         SET NEW CALIB FLAG
      STA  IT3
      JMP  AT51       SKIP NEW CAL SECTION
*
AT5   LDA  IT3
      SSA,RSS         NEED NEW CALIB?
      JMP  AT51       NO
      LDA  M
      MPY  TWLV
      ADA  CALD       CALIB ADDER -12
      LDB  MSIX
      STB  CNTR
      LDB  CDEF
      STA  1,I        STORE POINTERS
      ADA  TWO
      INB
      ISZ  CNTR
      JMP  *-4
      CCA             -1 TO A
      ADA  M
      MPY  ON28
      ADA  CM         GET DATA SDDRESS
      STA  S1
      ADA  TWO
      STA  S2
      CLA             SET NEW CALIB FLAG TO NO
      STA  IT3
*
*
AT51  JSB  CPAK2      PACK DATA
      DEF  *+4
      DEF  T1
      DEF  T2
      DEF  T1
      JSB  CSUB2      SUBTRACT LEAKAGE
      DEF  *+4
      DEF  T1
ATA1  NOP
      DEF  T1
      JSB  CDIV2      DIVIDE BY TRACKING
      DEF  *+4
      DEF  T1
ATA2  NOP
      DEF  IP,I       STORE IN CM
```

```
        LDB ITR
        SSB
        JMP CORR         RETURN FOR CORRECTION
*
AT8     LDA S1
        ADA FOUR         UPDATE STORAGE
        STA S1
        ADA TWO
        STA S2
        LDA IT2
        SZA,RSS          LAST PHASE?
        JMP AT2          YES--SET UP NEW FREQ
        SSA,RSS          FREQ DONE?
        JMP AT3          NO--SET UP NEXT PHASE
        LDA MN           STARTING NEW FREQ
        STA M
        LDA IT1
        SSA,RSS          ALL DONE?
        JMP AT3          NO NEXT PHASE
        CLA,INA
        STA M            SET UP M AGAIN
        JMP AT1,I
*
*  VARIABLES
*
*
M       NOP
IP      NOP
T1      BSS 2
T2      BSS 2
MN      NOP
ITR     NOP
*  T11,T22 USE C1,C2,C4,C5
CNTR    NOP
IDLY    NOP
IT1     NOP
IT2     NOP
IT8     NOP
P       NOP
C1      NOP
C2      NOP
C3      NOP
C4      NOP
C5      NOP
C6      NOP
S1      NOP
S2      NOP
*
*
*  CONSTANTS
M1      DEC -1
TWO     DEC 2
THRE    DEC 3
FOUR    DEC 4
S1DEF   DEF S1,I
CONE    OCT 40000        COMPLEX ONE
        OCT 2
DLY1    DEC 500
```

```
DLY2   DEC 100
DLY3   DEC 1
D31    DEC 31
ON28   DEC 128
TWLV   DEC 12
CALD   DEF CAL-14B
MSIX   DEC -6
CDEF   DEF C1
CDI    DEF C1,I
B1     DEC -36
NINE   DEC 9
*
*
       END
```

```
      NAM SETPH
      ENT SETPH
      EXT .ENTR
*
*
*****************************************************************
*     8500 BCS COMPATABLE PHASE AND AMPLITUDE
*     CONTROL ROUTING
*
*                   MARCH 21,1977
*                   M. B. LAING
*                   REV. A   MAY 11, 1977
*
*     CALLING SEQUENCE
*     CALL SETPH(IPHASE,IATTN)
*        WHERE
*         IPHASE IS A PHASE CODE FROM 0 TO 31
*         OR -1 IF PREVIOUS VALUE IS TO BE USED
*         IATTN IS AN ATTENUATOR CONTROL CODE
*         FROM 0 TO 7 OR -1 IF PREVIOUS VALUE
*         IS TO BE USED
*
*
*****************************************************************
*
*     SET CONTROL CARD ADDRESSES
*
IPD   EQU 51B
      DEF IPHS
      DEF IO1
      DEF IO2
      DEF IO3
*
IPHS  NOP           PHASE WORD ADDRESS
IAMP  NOP           AMP. WORD ADDRESS
SETPH NOP           ENTRY
      JSB .ENTR
      DEF IPHS
      LDA IPHS,I    GET PHASE CODE
      SSA           TEST NEW VALUE
      LDA PHAS      NO, USE OLD
      AND MM37      MASK
      STA PHAS      SAVE
      ALS,ALS       SHIFT
      ALS
      STA TMP
      LDA IAMP,I    GET AMP CODE
      SSA           NEW VALUE?
      LDA AMP       NO, LOAD OLD
      AND MM3       MASK
      STA AMP       SAVE
      IOR TMP       COMBINE AMP AND PHASE
IO1   OTA IPD       OUTPUT
IO2   STC IPD,C     STROBE
IO3   CLC IPD,C     TURN OFF STROBE
      JMP SETPH,I   EXIT
*
*
```

```
MM37    OCT 037
MM3     OCT 03
AMP     BSS 1
PHAS    BSS 1
TMP     BSS 1
*
*
        END
```

```
      HED  POWER LEVELING LOOP ROUTINES
      NAM SIGDR
      ENT INITP,SETPW,PLOFF,PLRST
      EXT .ENTR,.DLD,.FMP,IFIX
      EXT  .DIV,.MPY,SRFLR
      SPC 1
*********************************************************************
*
*     SIGNAL GENERATOR DRIVER FOR USE WITH
*     S.A. TEST RACK.
*
*     CALLING SEQUENCES
*          CALL INITP (POWER)
*          CALL SETPW (POWER)
*          CALL PLOFF (VOLTS)
*          CALL PLRST
*
*     WHERE POWER IS THE DESIRED LOOP LEVEL
*     IN DBM, AND VOLTAGE IS DESIRED VOLTAGE
*     SETTING OF THE DVS.  POWER MUST BE IN
*     THE RANGE +5.0 DBM TO +23.0 DBM, AND
*     VOLTS MUST LIE BETWEEN -16.0 AND +16.0.
*     INITP INITIALIZES THE POWER LEVELING LOOP
*     AND SETPW ALLOWS THE CHANGING OF THE LOOP
*     LEVEL.  PLOFF DISABLES THE LOOP AND SETS
*     THE DVS TO THE DESIRED VOLTAGE.  PLRST
*     REARMS THE LOOP, USING THE PREVIOUS
*     POWER LEVEL AND VOLTAGE.  ALL ENTRIES
*     SET BOTH PERF (POWER ERROR FLAG) AND
*     OFRF (OUT OF RANGE FLAG) TO 1.
*
*
*     M.B.LAING      MODIFIED 3/29/77
*
*
*********************************************************************
      SPC  1
*     DEFINE POWER METER, DVS, AND STATUS PANEL SELECT SLOTS
      SPC  1
PMS   EQU  14B
DVS   EQU  17B
FLAGR EQU  50B
      SPC  1
      DEF  IPWR
      DEF  IO1
      DEF  IO2
      DEF  IO3
      DEF  IO4
      DEF  IO5
      DEF  IO6
      DEF  IO7
      DEF  IO8
      DEF  IO9
      DEF  IO9A
      DEF  IO10
      DEF  IO11
      DEF  IO12
      DEF  IO13
```

```
          DEF  IO14
          DEF  IO15
          DEF  IO16
          SKP
IPWR      BSS 1
INITP     NOP               ENTRY POINT FOR INITIALIZATION
          JSB .ENTR
          DEF IPWR
IO1       CLC PMS,C         DISABLE INTERUPT
          JSB GPTL          GET POWER LEVEL
          STA IDBMD         SET LEVEL
          STA LPR
          JSB .MPY          GET VOLTAGE
          DEF VCF
          JSB TVOLT         LIMIT TO +-5.0
          STA VOFST         SAVE
          JSB VOUT          SET VOLTAGE
          CLA
          STA VC
          LDA IJSB
IO2       STA PMS           SET TRAP
          JSB SFB           SET ERROR FLAGS
          STC 0             ARM INTERUPT SYSTEM
IO3       STC PMS,C         ARM POWER METER
          JMP INITP,I       EXIT
IJSB      JSB LINK,I
          ORB
LINK      DEF CONT          SET UP LINK
          ORR
IPWR1     BSS  1
SETPW     NOP
          JSB .ENTR         ENTRY POINT
          DEF  IPWR1
          LDA  IPWR1
          STA  IPWR
          JSB GPTL          GET POWER
          STA IDBMD         SET LEVEL
          JSB SFB           SET ERROR FLAGS
          JMP SETPW,I       EXIT
          SKP
IVLT      BSS 1
PLOFF     NOP               ENTRY LOOP OFF
          JSB .ENTR
          DEF IVLT
IO4       CLC PMS,C         DISARM LOOP
          CLA
IO5       STA PMS           CLEAR TRAP
          JSB .DLD          GET VOLTAGE
          DEF IVLT,I
          JSB .FMP
          DEF D2000         SCALE TO INTEGER
          JSB IFIX
          STA 1
          ADB HVLIM         LIMIT TO 16 VOLT RANGE
          SSB
          LDA LVLIM
          LDB 0
          ADB LVLIM
```

```
      SSB,RSS
      LDA HVLIM
      JSB VOUT       OUTPUT VOLTAGE
      JSB SFB        SET ERROR FLAGS
      JMP PLOFF,I
PLRST NOP            ENTRY TO RESET LOOP
      ISZ PLRST
      LDA VOFST      GET LAST VOLTAGE
      JSB VOUT       OUTPUT VOLTAGE
      JSB SFB        SET ERROR FLAGS
      LDA IJSB       SET TRAP
I06   STA PMS
      STC 0          ARM INTERUPT
I07   STC PMS,C      ARM POWER METER
      JMP PLRST,I    EXIT
      SKP
CONT  NOP            ENTRY POINT FOR LOOP
I08   CLC PMS,C      DISARM INTERUPT
      STA AR         SAVE REGISTERS
      STB BR
      ERA,ALS
      OCT  102201     OCT FOR SOC
      INA
      STA ER
I09   LIA PMS        READ POWER METER
      CMA
      LDB D13        SET FOR 13 BITS
      JSB BCDTB      CONVERT TO BINARY
      CMA,INA        GET CORRECT SIGN
      STA POWER      SAVE
      CPA IDBMD      COMPARE TO LEVEL
      JMP EXACT      GOOD LEVEL
      STA 1
I09A  LIA  FLAGR
      AND B4
      SZA
      JMP *+8
      LDA 1
      ADA D200       TEST FOR OUT OF RANGE
      SSA
      JMP OFR
      ADB M100       LIMITS OF -20 TO +10
      SSB,RSS
      JMP OFR
      LDA OFRF       RESET OFRF BIT
      CMA
      CLB
      JSB  SFLAG      RESET BIT
NVCF  LDA POWER
      CMA,INA
      ADA IDBMD      GET ERROR
      STA PWER       SAVE
      JSB .MPY       NEW VC
      DEF VCF
      SSA
      ARS            DIVIDE BY 2 IF NEG.
      STA VC
      LDA PWER
```

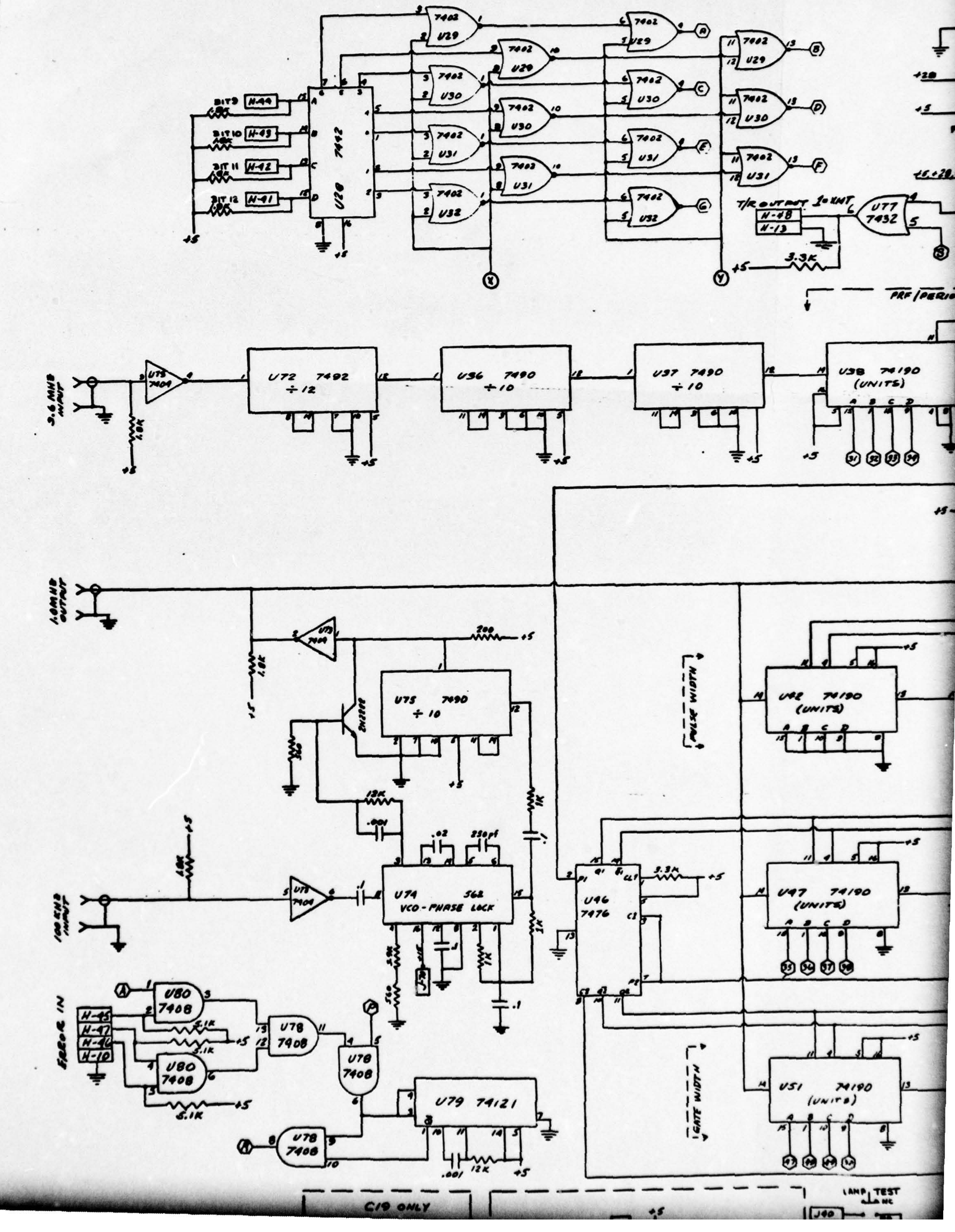
```
         SSA                 ABSOLUTE VALUE
         CMA,INA
         ADA PLEL            MINUS LIMIT
         CLB
         SSA,RSS
         LDB PEF
         LDA PEF
         CMA
         JSB  SFLAG           SET ERROR BIT
         LDA VC
         ADA VOFST           NEW VOLTAGE
         JSB TVOLT           TEST FOR LIMITS
         STA VOFST
         JSB VOUT            OUTPUT VOLTAGE
EXIT     LDB BR              RESTORE REGISTERS
         LDA ER
         CLO
         SLA,ELA
         STO
         LDA AR
IO10     STC PMS,C           ARM POWER METER
         JMP CONT,I          EXIT
OFR      LDA  PEF             OUT OF RANGE
         ADA  OFRF
         STA  1
         CMA
         JSB  SFLAG           SET ERROR BITS
         JMP EXIT
EXACT    LDA PEF
         ADA OFRF
         CMA
         CLB
         JSB  SFLAG           SET FLAGS GOOD
         JMP EXIT
         SKP
SFB      NOP                 SET BAD
         LDA PEF
         ADA OFRF
         STA 1
         CMA
         JSB SRFLR
         JMP SFB,I
         SPC 2
GPTL     NOP                 ENTRY, GET AND TEST POWER
         JSB .DLD
         DEF IPWR,I
         JSB .FMP
         DEF D10.0
         JSB IFIX
         STA 1
         ADB D150            TEST FOR -15 TO +3 RANGE
         SSB
         LDA M150
         LDB 0
         ADB M30
         SSB,RSS
         LDA D30
         JMP GPTL,I          EXIT
```

```
         SKP
TVOLT    NOP ENTRY TEST VOLTAGE
         STA VLTS         SAVE
         STA 1
         ADB VHLIM
         SSB
         LDA VLLIM
         LDB 0
         ADB VLLIM
         SSB,RSS
         LDA VHLIM
         CPA VLTS         TEST FOR CHANGE
         JMP TVOLT,I      GOOD, EXIT
         LDB VLTS
         CMB,INB
         ADB 0
         ADB VC
         STB VC           SET NEW VOLTAGE CHANGE
         JMP TVOLT,I
         SPC 2
VOUT     NOP              ENTRY, OUTPUT VOLTAGE
         LDB WRD2
IO11     CLC DVS,C
IO12     OTA DVS
IO13     OTB DVS
         LDB M625
IO14     SFC DVS          WAIT TILL DONE
         JMP VOUT,I
         INB,SZB
         JMP *-3
         JMP VOUT+1
         SPC 2
*        DATA AND STORAGE
         SPC 2
VCF      DEC 20
D2000    DEC 2000.002
HVLIM    DEC 16000
LVLIM    DEC -16000
D13      DEC 13
D200     DEC 200
M100     DEC -100
PEF      DEC 1
OFRF     DEC 2
D10.0    DEC 10.0
D150     DEC 150
M150     DEC -150
D30      DEC 30
M30      DEC -30
VHLIM    DEC 10000
VLLIM    DEC -10000
PLEL     DEC -2
WRD2     OCT 0100
M625     DEC -625
B4       OCT 4
IDBMD    BSS 1
LPR      BSS 1
VOFST    BSS 1
VC       BSS 1
```

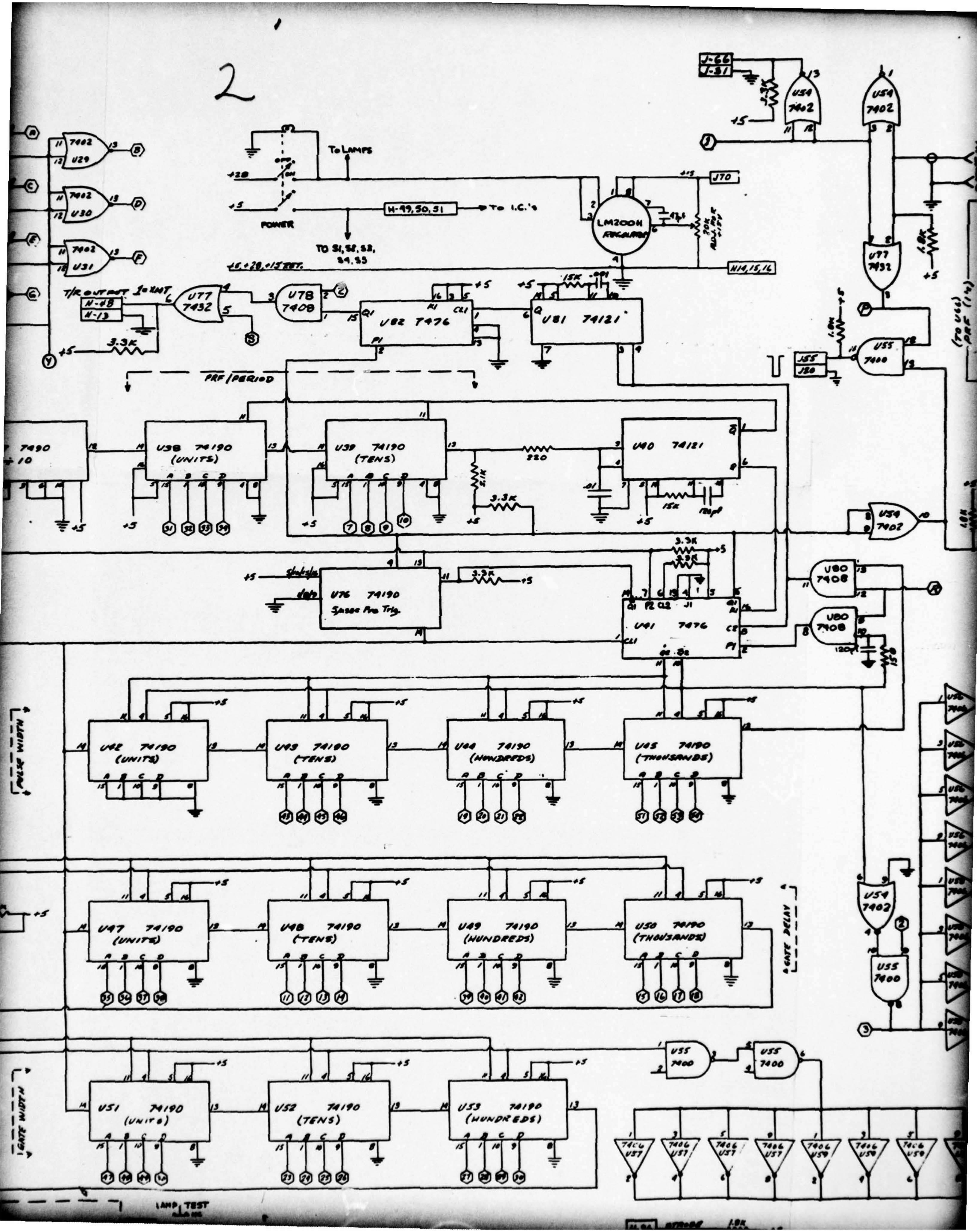
```
AR     BSS 1
BR     BSS 1
ER     BSS 1
POWER  BSS 1
PWER   BSS 1
VLTS   BSS 1
BCDTB  NOP
       CMB,INB
       STB CTR
       LDB DTABL
       STB PTR
       CLB
LOOP   SLA
       ADB PTR,I
       CLE,ERA
       ISZ PTR
       ISZ CTR
       JMP LOOP
       SLA
       CMB,INB
       LDA 1
       JMP BCDTB,I
TABLE  DEC 1,2,4,8,10,20,40,80,100,200,400,800
       DEC 1000,2000,4000,8000
DTABL  DEF TABLE
PTR    BSS 1
CTR    BSS 1
SFLAG  NOP                ENTRY
       STA  TMPSR
IO15   LIA  FLAGR
       AND  TMPSR
       ADA  1
IO16   OTA  FLAGR
       JMP  SFLAG,I     EXIT
TMPSR  BSS  1
       END
```

APPENDIX IV

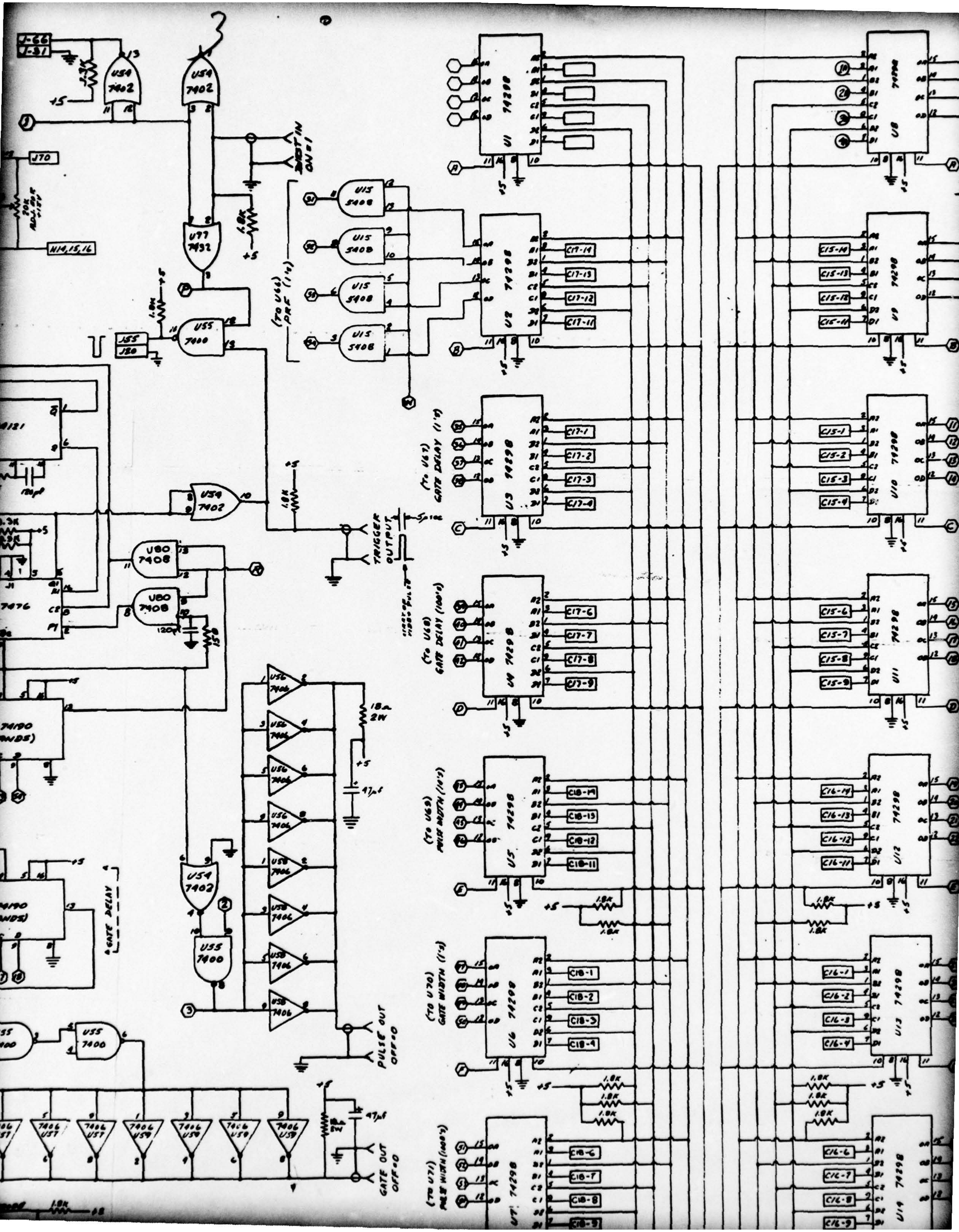
Schematics of hardware designed at NRL specially tailored towards L-band transceiver test.

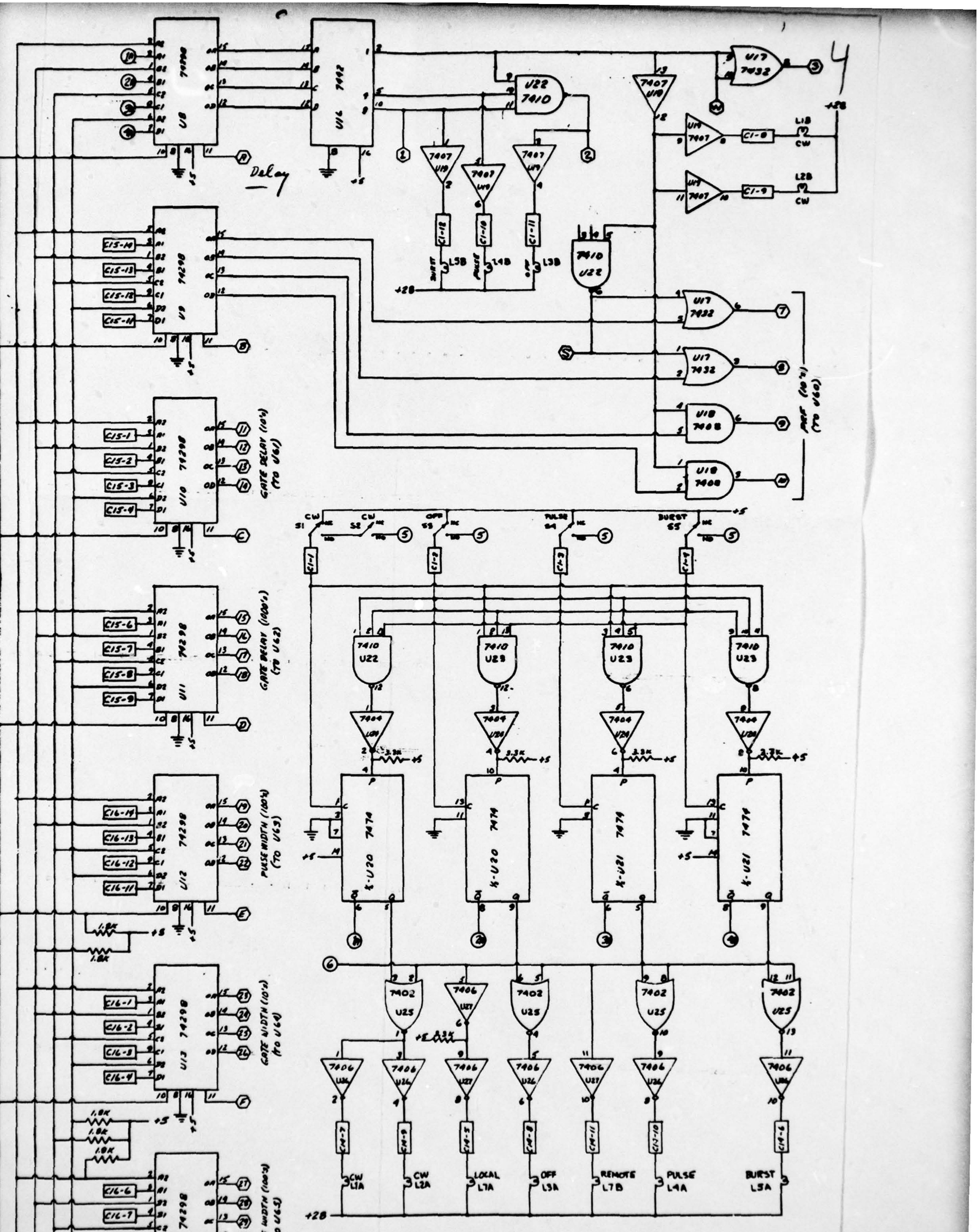


7402 U29
7402 U30
7402 U31
7402 U32
U28 7442
BIT 9 H-44
BIT 10 H-43
BIT 11 H-42
BIT 12 H-41
T/R OUTPUT 1=XMT
H-48
H-13
U77 7432
3.3K
PRF/PERIOD
3.6 MHZ INPUT
U73 7404
U72 7492 ÷12
U36 7490 ÷10
U37 7490 ÷10
U38 74190 (UNITS)
1.0 MHZ OUTPUT
U75 7490 ÷10
2N2222
U74 VCO-PHASE LOCK 562
100 KHZ INPUT
U46 7476
PULSE WIDTH
GATE WIDTH
U42 74190 (UNITS)
U47 74190 (UNITS)
U51 74190 (UNITS)
ERROR IN
H-45
H-47
H-46
H-10
U80 7408
U78 7408
U79 74121
C19 ONLY
LAMP TEST



2
POWER
To LAMPS
H-49,50,51
To I.C.'s
TO S1,S2,S3,S4,S5
LM200H
J70
H14,15,16
U77 7432
U78 7408
U82 7476
U81 74121
PRF / PERIOD
7490 ÷10
U38 74190 (UNITS)
U39 74190 (TENS)
U40 74121
U76 74190
U41 7476
U42 74190 (UNITS)
U43 74190 (TENS)
U44 74190 (HUNDREDS)
U45 74190 (THOUSANDS)
PULSE WIDTH
U47 74190 (UNITS)
U48 74190 (TENS)
U49 74190 (HUNDREDS)
U50 74190 (THOUSANDS)
GATE DELAY
U51 74190 (UNITS)
U52 74190 (TENS)
U53 74190 (HUNDREDS)
GATE WIDTH
U54 7402
U55 7400
U80 7408
7406 U57
7406 U59
LAMP TEST

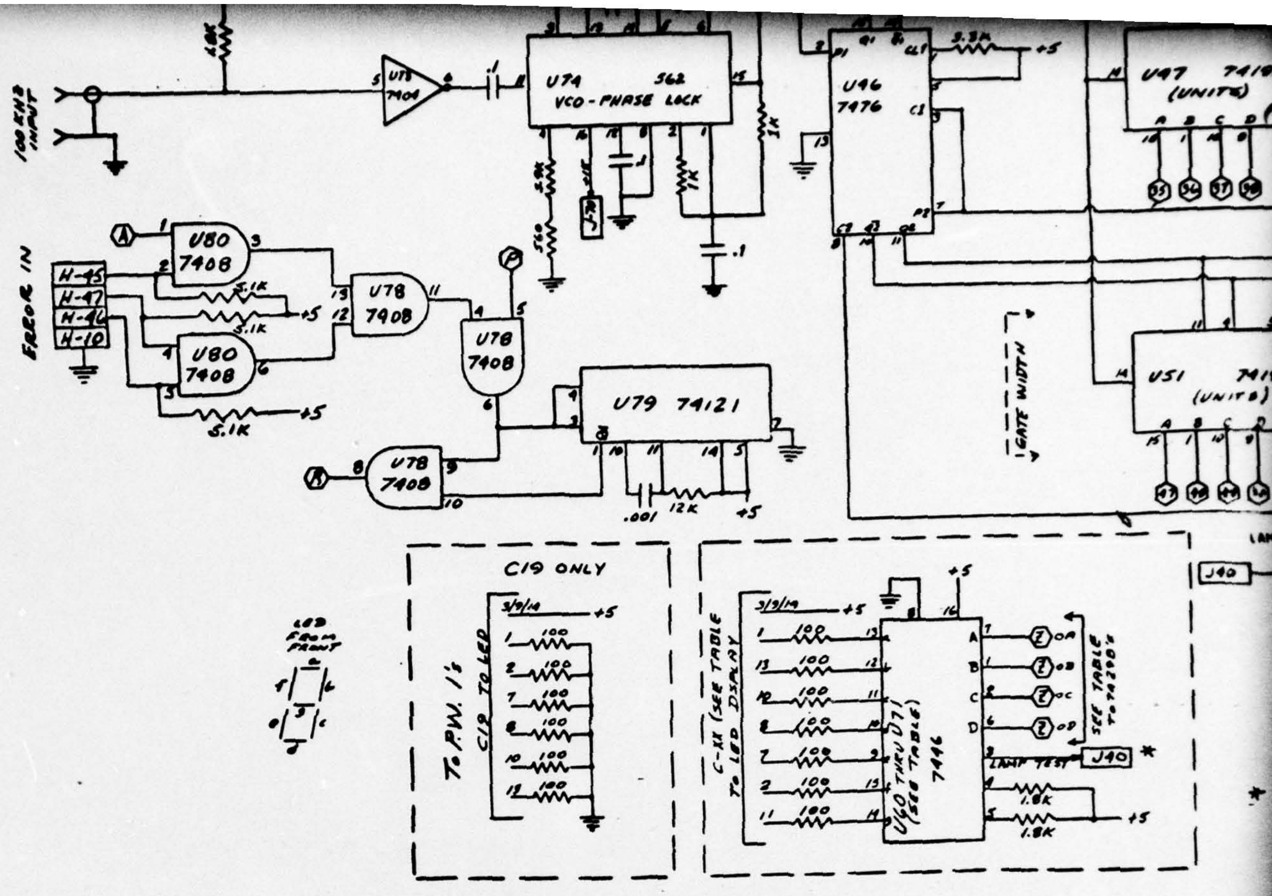

U54 7402
U77 7432
U55 7400
U15 5408
U80 7408
U56 7406
U58 7406
U57 7406
U59 7406
74121
7476
74190
J70
J55
J20
H14,15,16
TRIGGER OUTPUT
PULSE OUT OFF=0
GATE OUT OFF=0
GATE DELAY
(TO U66) PRE (1's)
(TO U67) GATE DELAY (1's)
(TO U68) GATE DELAY (100's)
(TO U69) PULSE WIDTH (10's)
(TO U70) GATE WIDTH (1's)
(TO U71) PULSE WIDTH (100's)
U1 74298
U2 74298
U3 74298
U4 74298
U5 74298
U6 74298
U7 74298
U8 74298
U9 74298
U10 74298
U11 74298
U12 74298
U13 74298
U14 74298
C17-14
C17-13
C17-12
C17-11
C17-1
C17-2
C17-3
C17-4
C17-6
C17-7
C17-8
C17-9
C18-14
C18-13
C18-12
C18-11
C18-1
C18-2
C18-3
C18-4
C18-6
C18-7
C18-8
C18-9
C15-14
C15-13
C15-12
C15-11
C15-1
C15-2
C15-3
C15-4
C15-6
C15-7
C15-8
C15-9
C16-14
C16-13
C16-12
C16-11
C16-1
C16-2
C16-3
C16-4
C16-6
C16-7
C16-8
C16-9



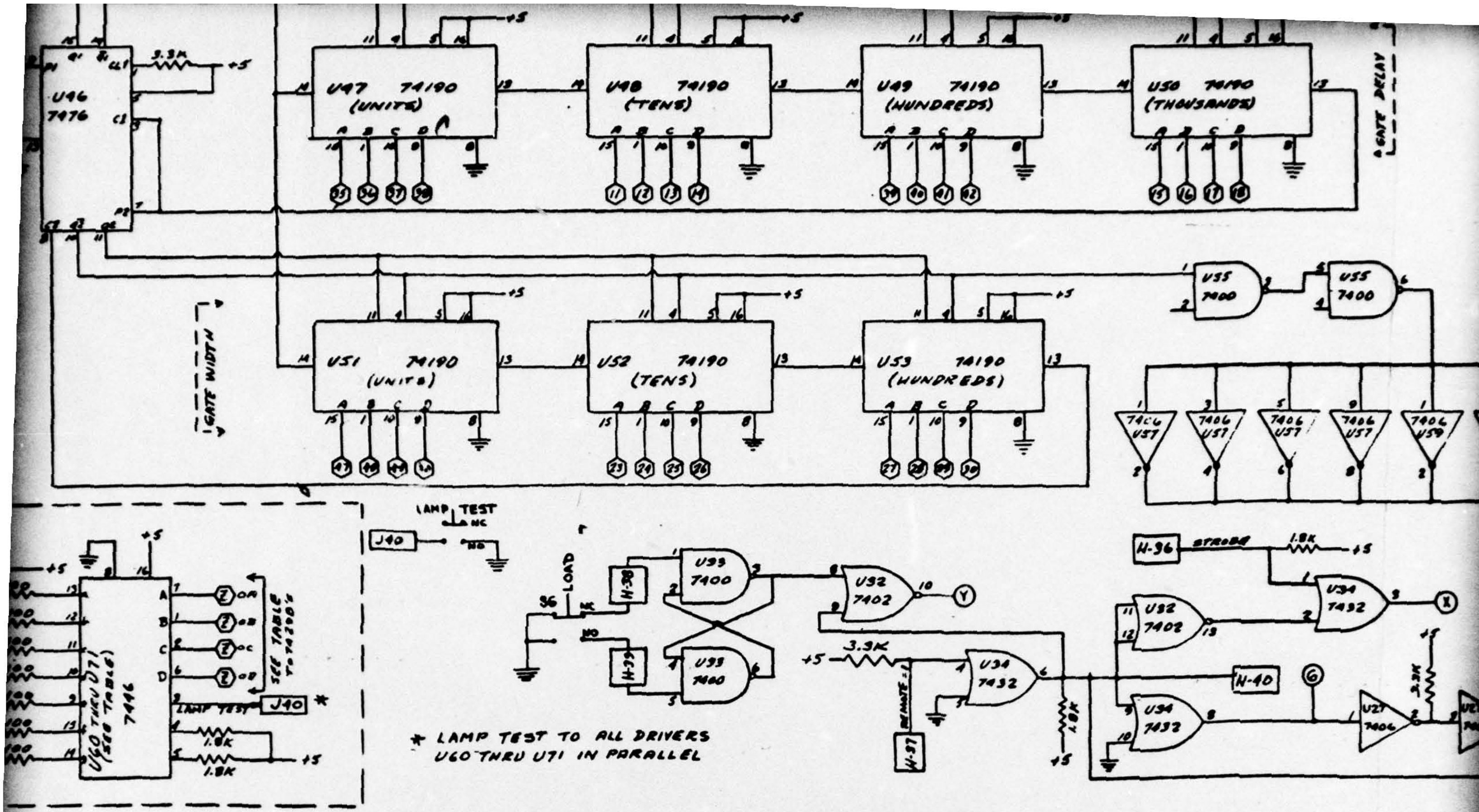
NOTES: ① 7400, 7402, 7404, 7406, 7407, 7408, 7410, 7432 : +5, PIN 14 ; GND, PIN 7

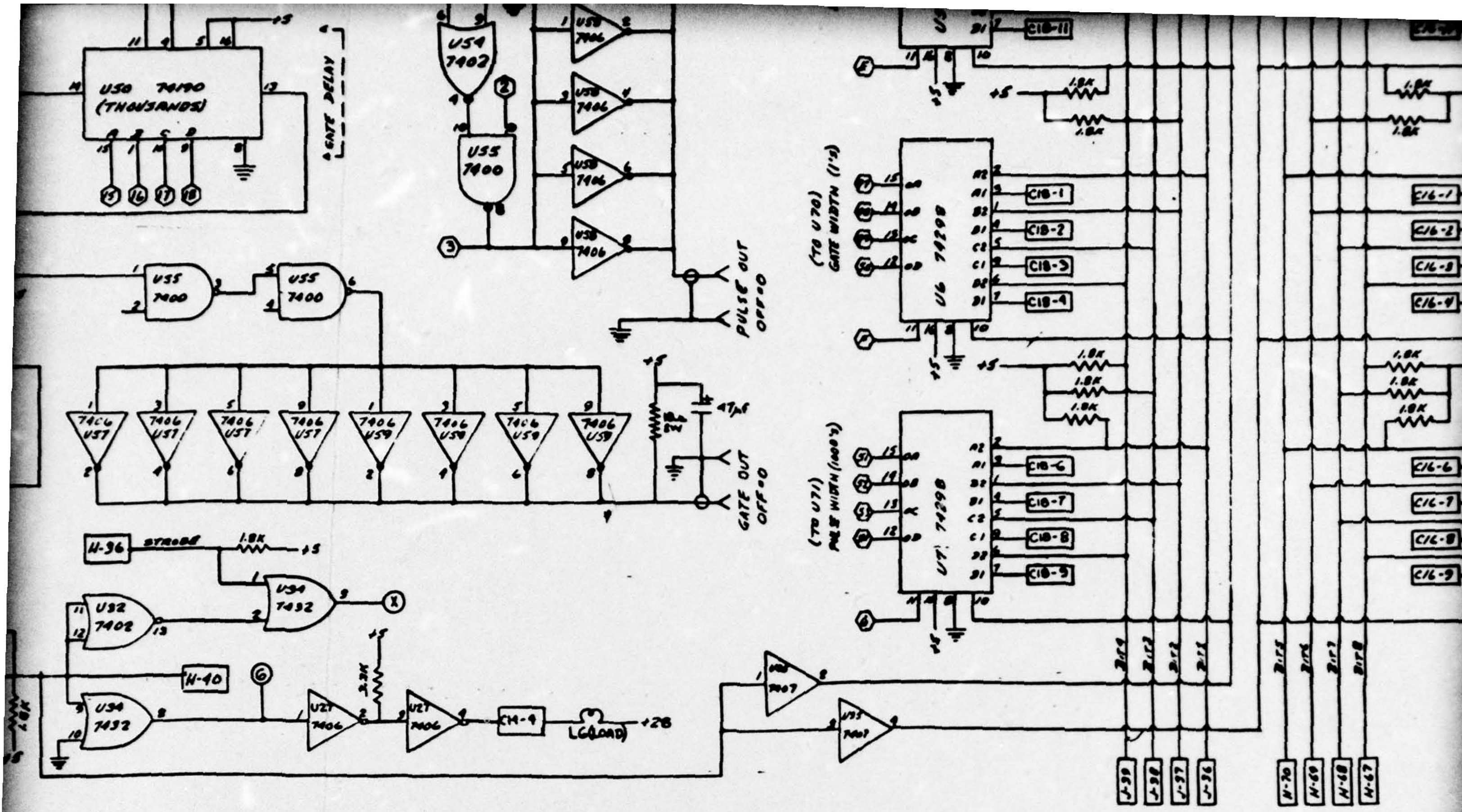
② ADDITIONAL +5 FILTER CAPACITORS AS REQD

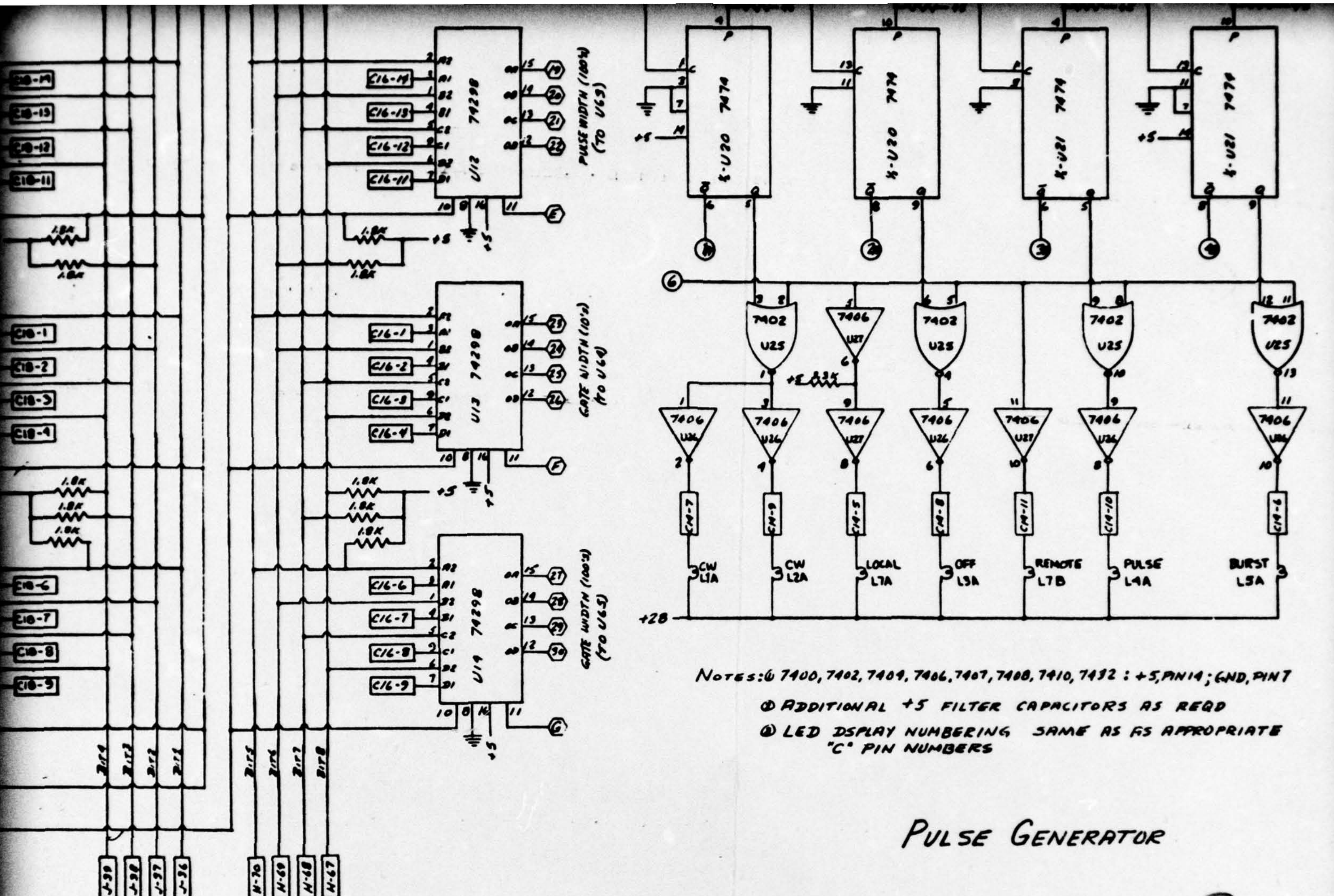
5



100 KHZ INPUT
U75 7404
U74 562 VCO-PHASE LOCK
U46 7476
U47 (UNITS)
ERROR IN
H-45
H-47
H-46
H-10
U80 7408
U78 7408
U79 74121
U51 (UNITS)
GATE WIDTH
.001
12K
5.1K
C19 ONLY
To P.W. 1's
C19 TO LED
C-XX (SEE TABLE
To LED DSPLAY
U60 THRU U71 (SEE TABLE)
7446
LAMP TEST
J40
SEE TABLE
1.8K
LED FROM FRONT


U46 7476
U47 74190 (UNITS)
U48 74190 (TENS)
U49 74190 (HUNDREDS)
U50 74190 (THOUSANDS)
GATE DELAY
GATE WIDTH
U51 74190 (UNITS)
U52 74190 (TENS)
U53 74190 (HUNDREDS)
U55 7400
7406 U57
7406 U59
LAMP TEST
J40
U60 THRU U71 (SEE TABLE) 7446
SEE TABLE TO 74200'S
LAMP TEST
LOAD
U33 7400
U32 7402
U34 7432
H-96
STROBE
H-40
H-37
U27 7406
* LAMP TEST TO ALL DRIVERS U60 THRU U71 IN PARALLEL


U50 74190
(THOUSANDS)
GATE DELAY
U54
7402
U55
7400
U58
7406
PULSE OUT
OFF=0
U55
7400
U57
U59
7406
47µf
GATE OUT
OFF=0
H-36
STROBE
1.8K
+5
U34
7432
U32
7402
H-40
U27
7406
CM-9
LG(LOAD)
+28
7407
(TO U70)
GATE WIDTH (1's)
U6 74298
C18-11
C18-1
C18-2
C18-3
C18-4
C16-1
C16-2
C16-3
C16-4
(TO U71)
PULSE WIDTH (100's)
U7 74298
C18-6
C18-7
C18-8
C18-9
C16-6
C16-7
C16-8
C16-9
J-39
J-38
J-37
J-36
H-70
H-69
H-68
H-67



NOTES: ① 7400, 7402, 7404, 7406, 7407, 7408, 7410, 7432 : +5, PIN 14 ; GND, PIN 7

② ADDITIONAL +5 FILTER CAPACITORS AS REQD

③ LED DSPLAY NUMBERING SAME AS AS APPROPRIATE "C" PIN NUMBERS

PULSE GENERATOR

Pulse Generator (Continued)

TABLE 1 LED DSPLAY

U#	INPUTS A	B	C	D	FROM	OUTPUTS TO	VIA
U-61	11	12	13	14	U-10	G.D. 10's	C-3
U-62	15	16	17	18	U-11	G.D.1000's	C-4
U-63	19	20	21	22	U-12	P.W. 100's	C-5
U-64	23	24	25	26	U-13	G.W. 10's	C-6
U-65	27	28	29	30	U-14	G.W. 100's	C-7
U-66	31	32	33	34	U-15	PRF 1's	C-13
U-67	35	36	37	38	U-3	G.D. 1's	C-12
U-68	39	40	41	42	U-4	G.D. 100's	C-11
U-69	43	44	45	46	U-5	P.W. 10's	C-10
U-70	47	48	49	50	U-6	G.W. 1's	C-9
U-71	51	52	53	54	U-7	P.W 1000's	C-8
U-60	7	8	9	10	U47 & U48	PRF 10's	C-2

COMPUTER INPUTS

BITS (1) 9	(2) 10	(4) 11	(8) 12	(1)(2)(4)(8) 1,2,3,4	(1)(2)(4)(8) 5,6,7,8
0	0	0	0	P.W 10's	P.W 100's
1	0	0	0	G.W 1's	G.W 10's
0	1	0	0	P.W 1000's	G.W 100's
1	1	0	0	G.D. 1's	G.D 10's
0	0	1	0	G.D 100's	G.D 1000's
1	0	1	0	PRF 1's	PRF 10's
0	1	1	0	X	SEE MODE TABLE

MODE INPUTS

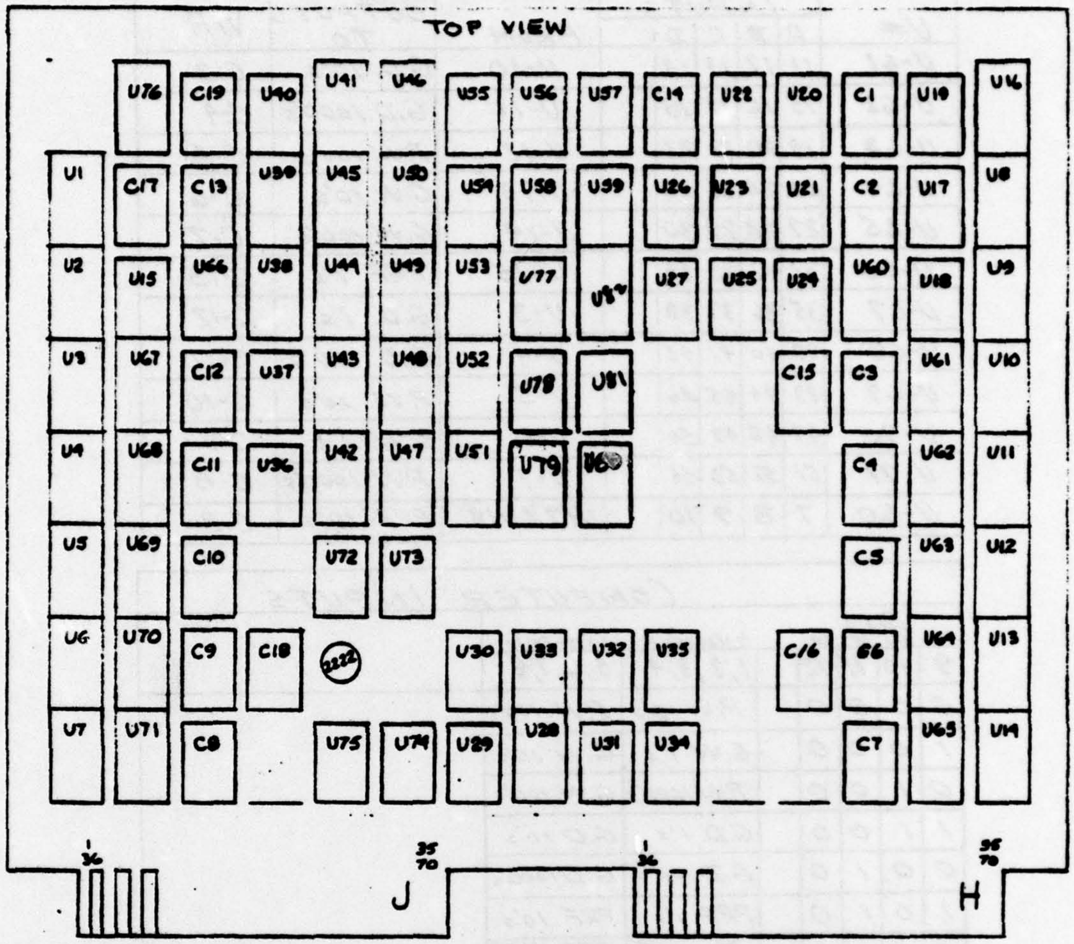
BITS 5	6	7	8	MODE FUNCTION
0	0	0	1	BURST
0	1	0	0	OFF
0	0	1	0	PULSE
1	0	0	0	CW

WITH BITS 9,10,11,12 SET AS ABOVE

NOTES:
1. FOR CW: TRIGGER OUTPUT COUNTS DOWN BY 30 TRIGGER PRF=100
2. ALL OTHER THAN BURST-PULSE-CW YIELDS OFF

Pulse Generator (Continued)

CIRCUIT BOARD



Note: Connectors C1-18 notch end (yellow/orange wires) is Pin 1 end.

COMPUTER CONNECTOR

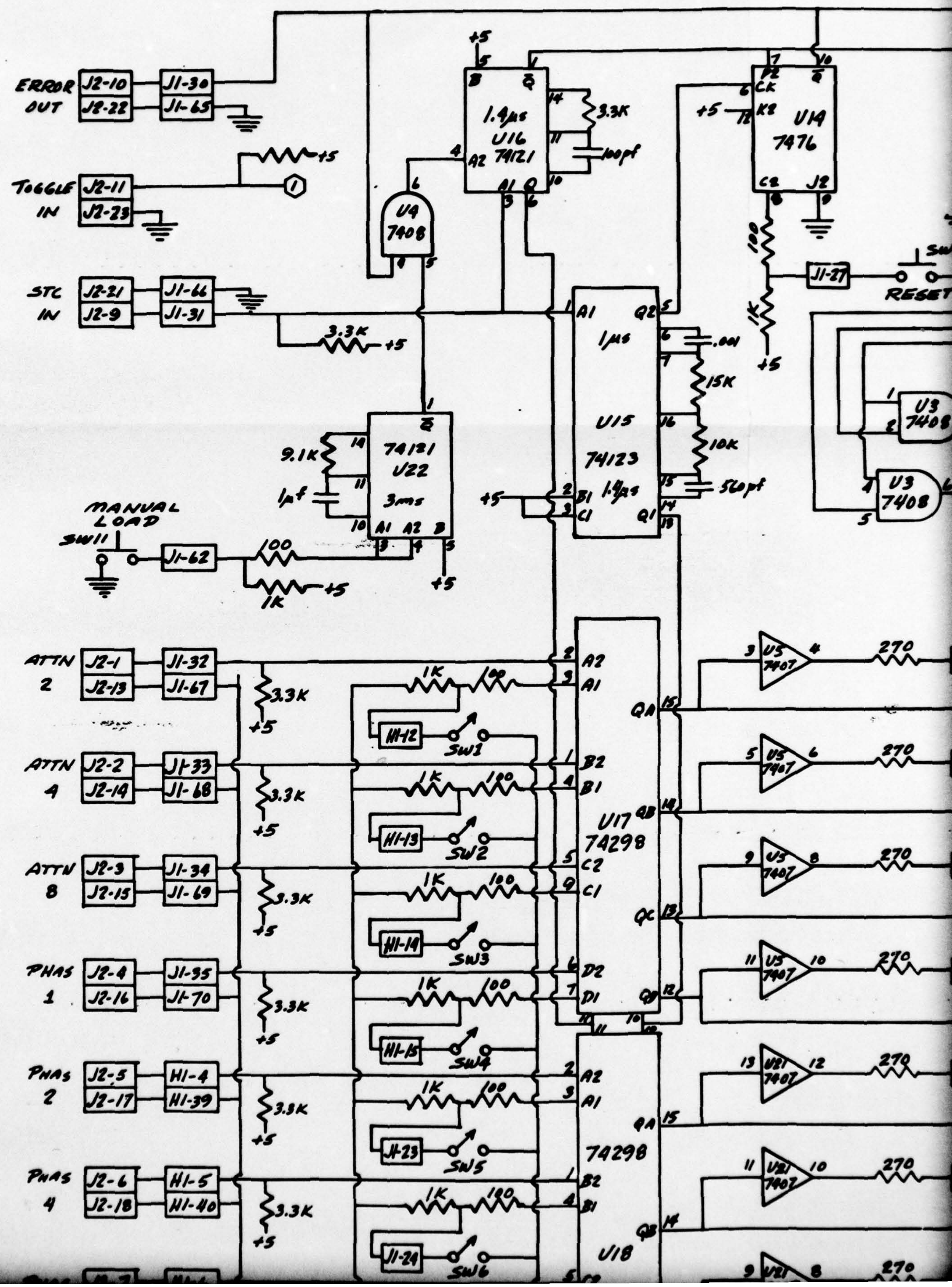
PIN	FUNCTION	TO
19	BIT 1	J-36
20	BIT 2	J-37
21	BIT 3	J-38
22	BIT 4	J-39
27	BIT 9	H-44
28	BIT 10	H 43
35	LOCAL/REMOTE REM=1	H-37
34	BURST LOGIC OUT BURST=1	J-62
33	TRIG. OUT BURST	J-55
14	ERROR IN	H-45
13	ERROR IN	H-46
32	ERROR IN	H-47
31	TR CONTROL-OUT	H-48

ALL GROUNDS TIED TO PIN 18 ON COMPUTER CONNECTOR

PIN	FUNCTION	TO
23	BIT 5	H-70
24	BIT 6	H-69
25	BIT 7	H-68
26	BIT 8	H-67
29	BIT 11	H-42
30	BIT 12	H-41
36	STROBE	H-36

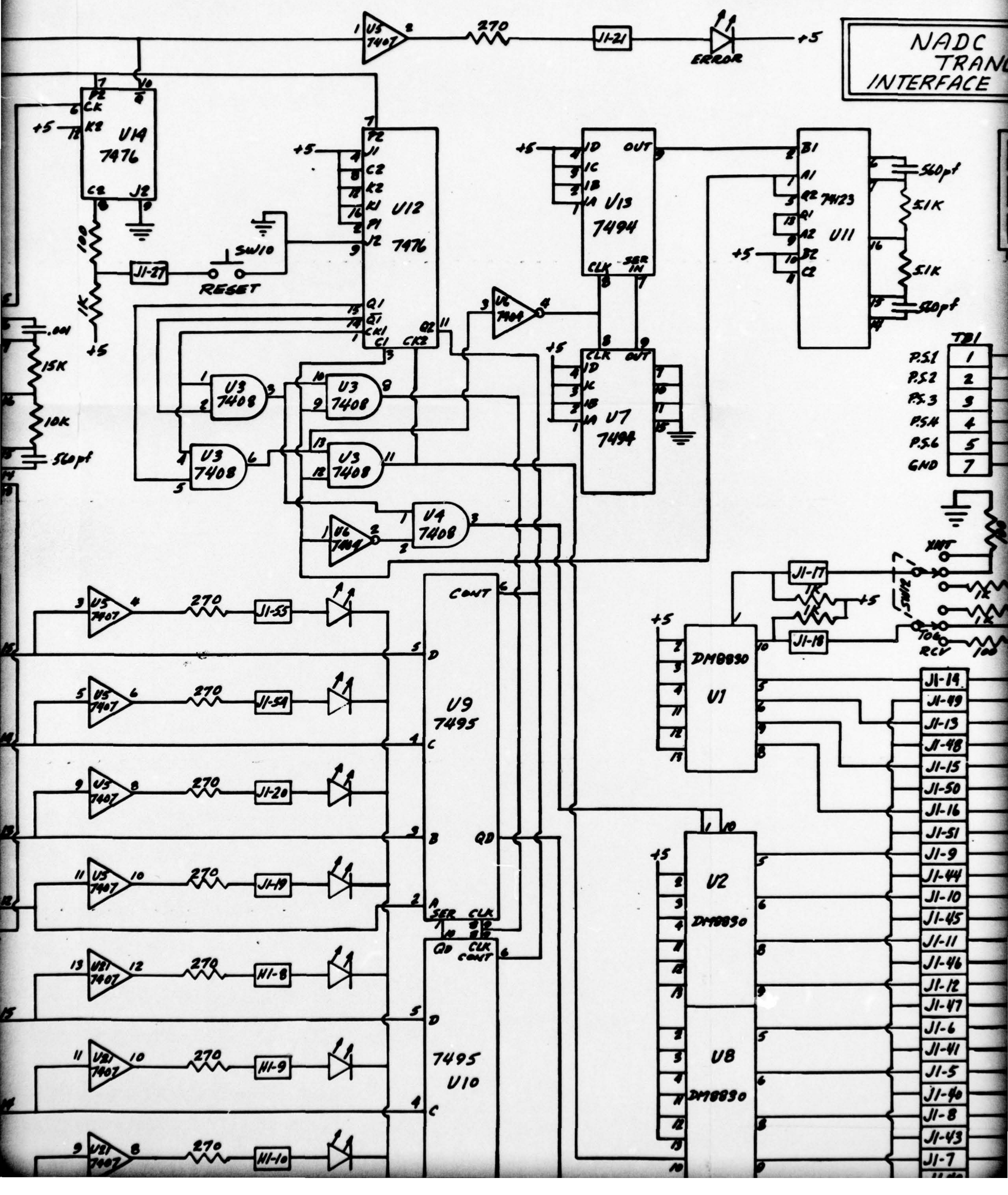
ALL CASES PIN 18 ON COMPUTER CONNECTOR

TP = TWISTED PAIR

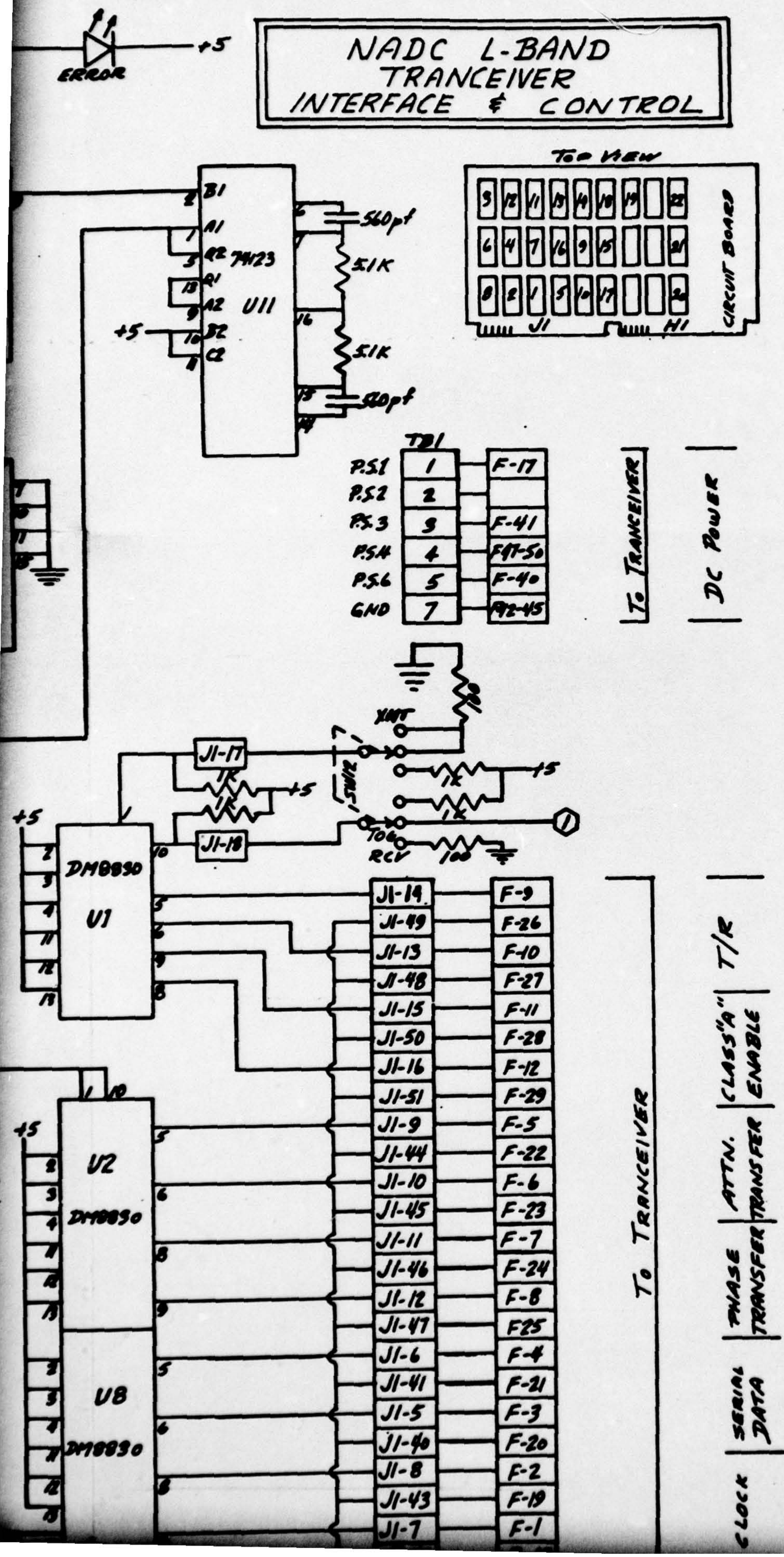


ERROR OUT
J2-10
J2-22
J1-30
J1-65
TOGGLE IN
J2-11
J2-23
STC IN
J2-21
J2-9
J1-66
J1-31
MANUAL LOAD
SW11
J1-62
1.4μs
U16
74121
U4
7408
1μs
U15
74123
1.4μs
74121
U22
3ms
9.1K
1μf
U14
7476
RESET
J1-27
U3
7408
ATTN 2
J2-1
J2-13
J1-32
J1-67
ATTN 4
J2-2
J2-14
J1-33
J1-68
ATTN 8
J2-3
J2-15
J1-34
J1-69
PHAS 1
J2-4
J2-16
J1-35
J1-70
PHAS 2
J2-5
J2-17
H1-4
H1-39
PHAS 4
J2-6
J2-18
H1-5
H1-40
H1-12
SW1
H1-13
SW2
H1-14
SW3
H1-15
SW4
J1-23
SW5
J1-24
SW6
U17
74298
74298
U18
U5
7407
U21
7407
270
3.3K
15K
10K
.001
560pf
100pf

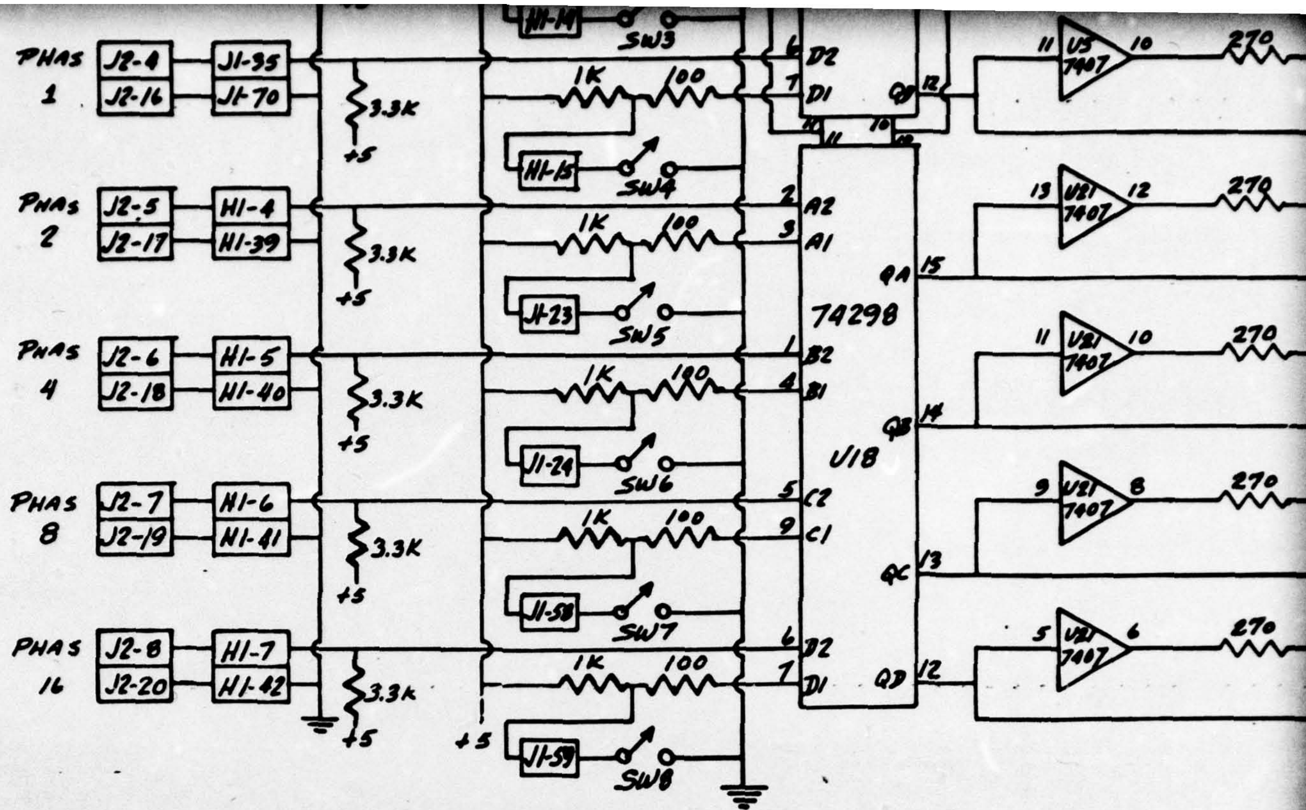
2



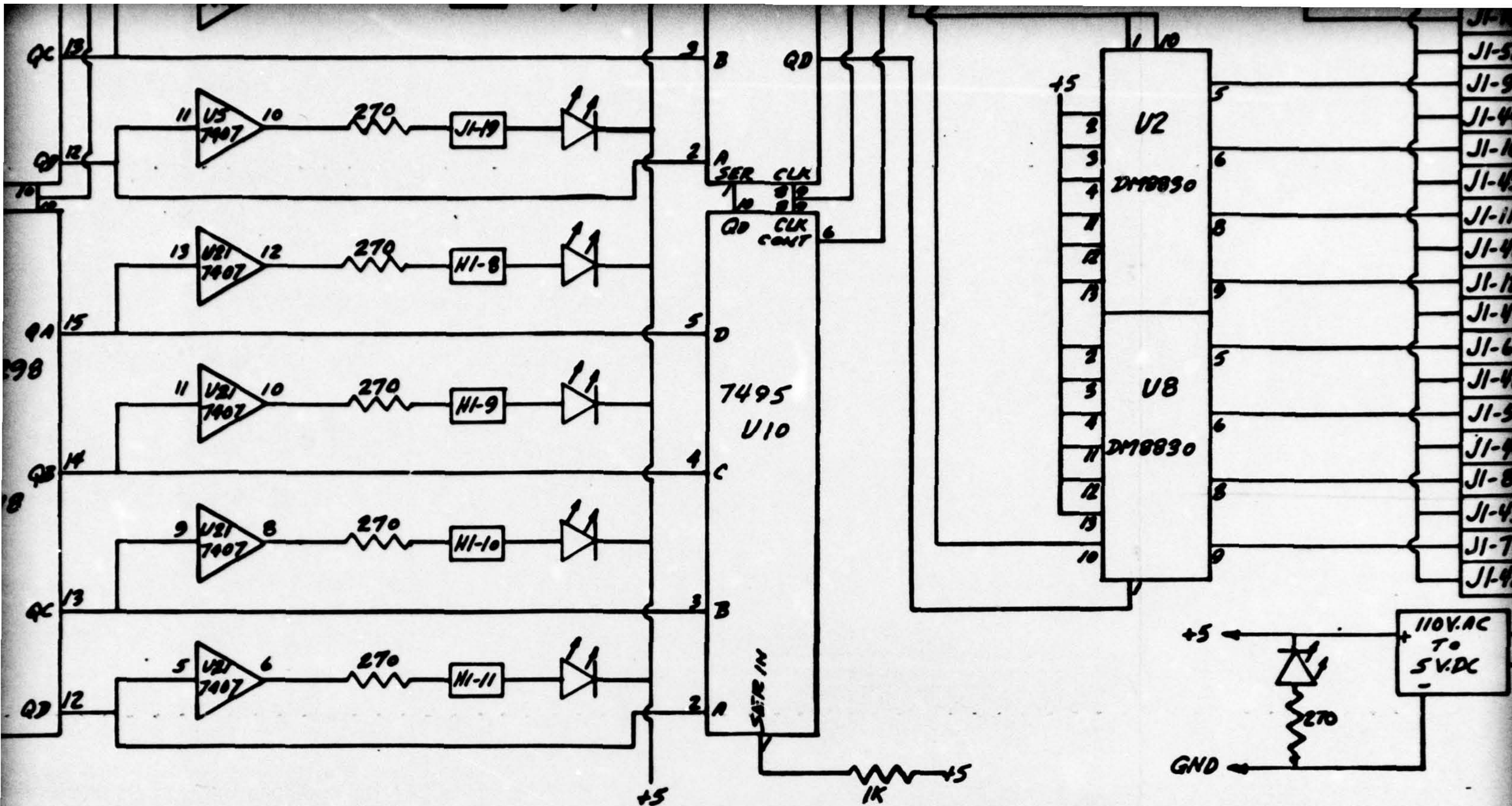
NADC
TRAN
INTERFACE
U14
7476
U12
7476
U13
7494
U7
7494
U11
74123
U9
7495
7495
U10
U1
DM8830
U2
DM8830
U8
DM8830
U3
7408
U4
7408
U6
7404
U5
7407
U21
7407
ERROR
RESET
SW10
XMT
RCV
TB1
P.S.1
P.S.2
P.S.3
P.S.4
P.S.6
GND
J1-21
J1-27
J1-17
J1-18
J1-55
J1-54
J1-20
J1-19
H1-8
H1-9
H1-10
J1-14
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7
270
560pf
5.1K
15K
10K
.001
+5

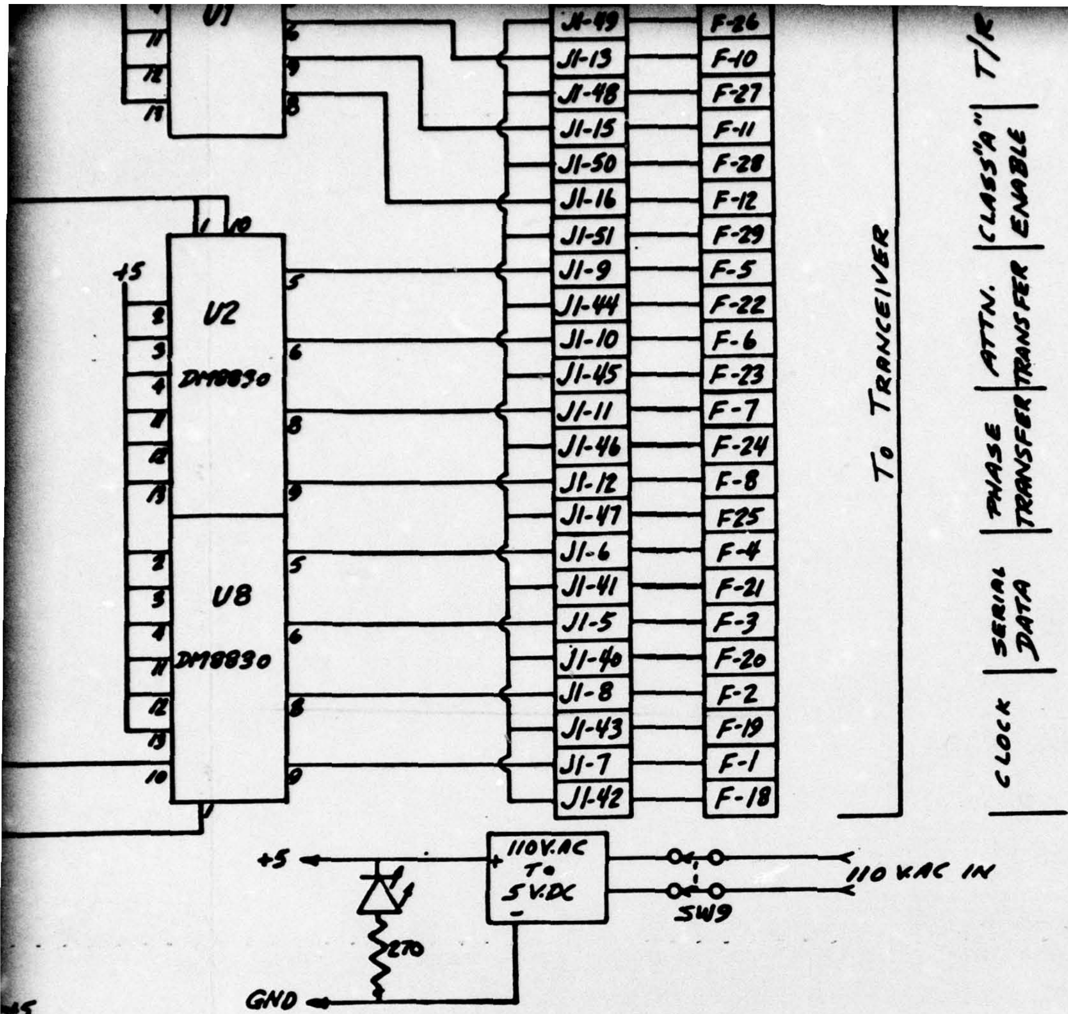

NADC L-BAND
TRANCEIVER
INTERFACE & CONTROL
ERROR
+5
TOP VIEW
CIRCUIT BOARD
J1
H1
74123
U11
B1
A1
A2
B2
C2
560pf
5.1K
5.1K
560pf
TB1
P.S.1
P.S.2
P.S.3
P.S.4
P.S.6
GND
F-17
F-41
F47-50
F-40
F42-45
To TRANCEIVER
DC POWER
XMT
SW2
TOG
RCV
J1-17
J1-18
1K
1K
1K
1K
100
DM8830
U1
U2
DM8830
U8
DM8830
J1-14
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7
F-9
F-26
F-10
F-27
F-11
F-28
F-12
F-29
F-5
F-22
F-6
F-23
F-7
F-24
F-8
F25
F-4
F-21
F-3
F-20
F-2
F-19
F-1
To TRANCEIVER
T/R
CLASS "A" ENABLE
ATTN. TRANSFER
PHASE TRANSFER
SERIAL DATA
CLOCK

4



PHAS 1
J2-4
J2-16
J1-35
J1-70
PHAS 2
J2-5
J2-17
H1-4
H1-39
PHAS 4
J2-6
J2-18
H1-5
H1-40
PHAS 8
J2-7
J2-19
H1-6
H1-41
PHAS 16
J2-8
J2-20
H1-7
H1-42
3.3K
+5
1K
100
SW3
SW4
SW5
SW6
SW7
SW8
H1-15
J1-23
J1-24
J1-58
J1-59
74298
U18
A2
A1
B2
B1
C2
C1
D2
D1
QA
QB
QC
QD
7407
270


7495
U10
U2
DM8830
U8
DM8830
7407
270
J1-19
H1-8
H1-9
H1-10
H1-11
SER
CLK
CLK CONT
SER IN
1K
+5
GND
110V.AC To 5V.DC


U7
U2
DM8830
U8
DM8830
+5
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7
J1-42
F-26
F-10
F-27
F-11
F-28
F-12
F-29
F-5
F-22
F-6
F-23
F-7
F-24
F-8
F25
F-4
F-21
F-3
F-20
F-2
F-19
F-1
F-18
To TRANCEIVER
CLOCK
SERIAL DATA
PHASE TRANSFER
ATTN. TRANSFER
CLASS "A" ENABLE
T/R
110V.AC To 5V.DC
+5
GND
270
SW9
110 V.AC IN