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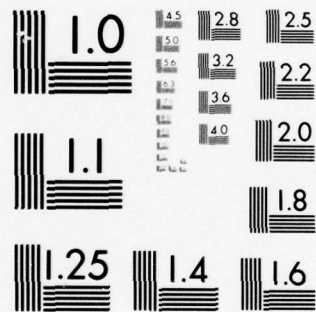
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by

(10) David K. Young

(11) Mar 1977

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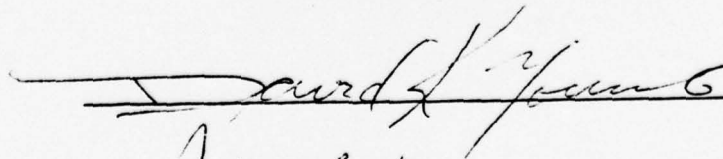
David Keith Young
Lieutenant, United States Navy
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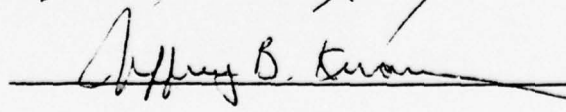
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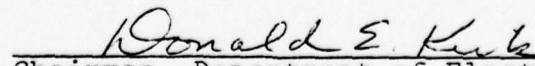
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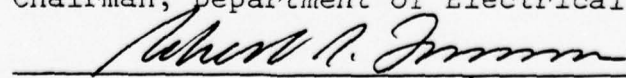
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ABSTRACT

A Hewlett Packard 8410S (Option 310) Microwave Network Analyzer System and the input/output interface to a Wang 600-14 Programmable Calculator are described. The original design of a digital to analog interface between the Wang 600-14 Calculator and a HP 8690B Sweep Oscillator is presented. Two system software programs which implement automatic S-parameter data collection and either external data storage or data reduction and display are described and documented.

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I. INTRODUCTION

The Microwave Network Analyzer System, as configured at the Naval Postgraduate School Microwave Measurement Laboratory, has as its major components the Hewlett Packard 8410S (option 310) Network Analyzer System, the Wang 600-14TP Programmable Calculator, three Wang 605-1A Micro-Interfaces and a digital to analog (D/A) interface between the Wang 600-14 Calculator and a HP 8690B Sweep Oscillator. Two system software programs enable the Wang Calculator to automatically collect S-parameter data from the HP 8410S Network Analyzer System and either store the data on cassette tape or massage the data to produce characteristic parameters for display. The system is fully automated so that once the system program is loaded and initiated, user intervention is required only when called for by the calculator. User intervention is limited to providing pertinent information to the calculator in order for the program to accomplish the job requested. For example, in collecting and storing S-parameter data, the calculator will call for a start frequency, a stop frequency and a step size. Once this information is provided by the user, the system program will step the HP 8690B Sweep Oscillator as specified, collect the associated S-parameter data, and build a tape file of the data.

Initial work in establishing this system was carried out by John C. Carlton Jr. and documented in Ref. 1. The work consisted of the input interface from the HP 8410S Network

Analyzer to the Wang 600-14 Calculator. Frequency acquisition was accomplished manually and data collection for each frequency was manually initiated. Data reduction and display was accomplished without further manual intervention. Limitations encountered were the time involved in manually setting the sweep oscillator and the number of data points which could be processed due to memory storage restrictions.

The purpose of this thesis was to build a digital to analog interface to enable the Wang 600 Calculator to automatically control the HP 8690B Sweep Oscillator. System software programs were developed to maximize the control functions performed by the calculator and to minimize manual intervention involved in data collection and display.

II. SYSTEM HARDWARE DESCRIPTION

The Microwave Network Analyzer System is composed of the HP 8410S (option 310) Network Analyzer System, a Wang 600-14 Programmable Calculator, input/output interface and a Wang 612 Flat-Bed Plotter. These components are configured as shown in Figure 1. A brief description of the system components is presented below. A more detailed description of the characteristics and the operational theory can be found in the appropriate operating and service manuals listed in Ref. 2-8. A thorough description of the characteristics of the digital to analog interface is presented in Chapter II-E.

A. HP 8410S (OPTION 310) NETWORK ANALYZER

The HP 8410S (option 310) Network Analyzer System performs the function of a ratiometer between two signals and then displays these complex ratios on one of two output display units. Depending upon the configuration of the components, it is capable of measuring both transmission and reflection scattering parameters from .1 GHZ to 12.4 GHZ.

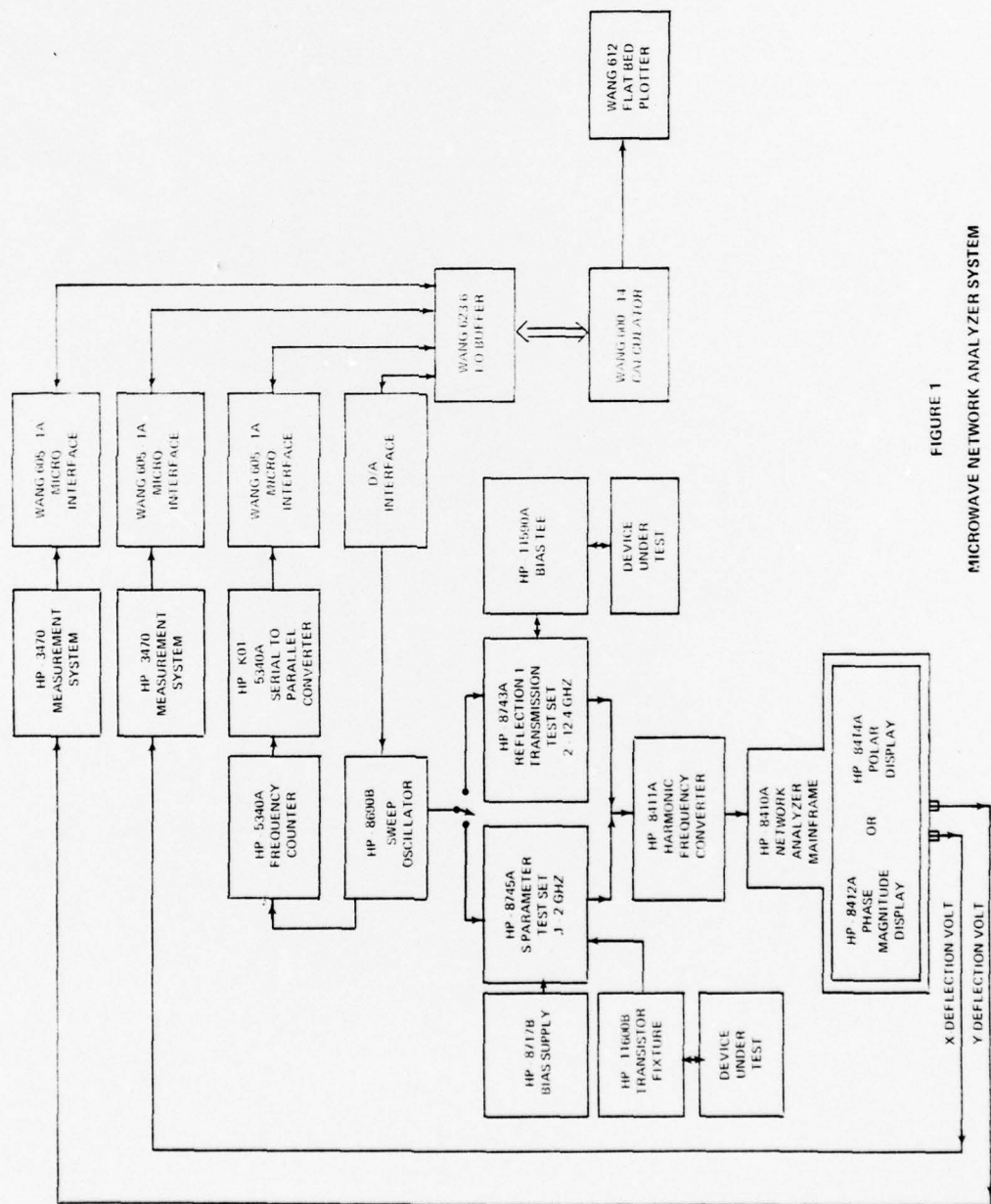


FIGURE 1
MICROWAVE NETWORK ANALYZER SYSTEM

"The HP 8690B Sweep Oscillator with the HP 8690B Series RF plug-ins serves as the RF Signal Source for one of two transducers, either the HP 8743A Reflection-Transmission Test Unit or the HP 8745A S-Parameter Test Set, depending on the frequency range of operation desired.

Both transducers are capable of reflection and transmission measurements. They use dual directional couplers to split the incoming signal into reference and test channels. The device under test is connected to the front panel of the transducer which operates over the frequency range desired. Pushbuttons located on the front panel of the transducer operate coaxial switches which connect the system correctly for the type of measurement desired.

Available with the transducers are the HP 11600B transistor fixture, HP 8717B bias supply and the HP 11590A Bias Tee, which allow S-parameter characterization of active Semiconductor devices. Bipolar Transistors, FET's diodes, negative resistance transferred electron devices, etc. can be easily and quickly analyzed for any specific bias condition.

The HP 8411A Harmonic Frequency Converter receives the test and reference channel signals from the transducer and converts them over a range up 0.11 to 12.4 GHZ to a 20.278 MHZ IF. Since the conversion is linear, the test and reference channel IF Signals maintain their same relative amplitudes and phases.

Comparison of the two signals is accomplished by low frequency circuitry in the displays mounted in the HP 8410A network analyzer mainframe. The mainframe provides phase lock circuitry over an octave bandwidth to maintain the 20.278 MHZ IF while frequency is being swept. It takes the ratio of the test and reference signals and then converts down to a second IF of 278 KHZ. It has a precision 0 to 69 dB attenuator for accurate measurement of gain or attenuation of test channel amplitude.

The measured S-parameters are displayed on the HP 8414A Polar Display or the HP 8412A Phase-Magnitude Display. If the polar display is used, the parameters are read directly as magnitude and angle. If the phase magnitude display is used, the parameters are in the form of return loss in dB, insertion loss or insertion gain in dB and phase in degrees versus frequency."¹

¹CARLTON, J. C., Calculator-Aided Microwave Network Analysis
P 13-15, MS Thesis, Naval Postgraduate School, 1974

B. WANG 600-14 CALCULATOR

The Wang 600-14 is a desktop programmable calculator. It has 1,848 memory locations (words) which are eight bits in length and are used for program storage, data storage, or any combination of both. A program instruction requires one word of storage, and a data storage register (DSR) requires eight contiguous words. Data storage registers are numbered 16 through 246. DRS number 16 occupies memory locations 1840 - 1847 and DSR number 246 occupies memory locations 0 - 7.

The range of numbers which can be represented and stored by the Wang 600-14 is $-9.999999999 \times 10^{-99}$ to $+9.999999999 \times 10^{+99}$. Numbers in either fixed point or floating point format, are represented in binary coded decimal (BCD) and are stored in memory, two digits per word.

The central processing unit (CPU) consists of sixteen registers numbered 00 through 15 and a display register which functions as the accumulator. All arithmetic/trigonometric instructions available on the Wang 600-14 are executed using the contents of the accumulator for single operand instructions, or using the contents of the accumulator and the contents of one of the 16 CPU registers for double operand instructions.

There are two external ports for connection of peripheral devices. One is a 36 pin input/output port connecting the CPU to a Wang 623-6 I/O Buffer. The second port is a 27 pin output only port which connects the CPU to a Wang 612 Flat-Bed Plotter.

Integral to the calculator is a 21-column drum printer for printing display register contents, as well as listing programs entered in memory. Also included is a tape cassette unit for loading or recording programs or data, either manually or under program control.

C. WANG 623-6 I/O BUFFER

The Wang 623-6 I/O Buffer is a 1 to 6 expander/isolator. It permits up to 6 peripheral interface devices to have on line access to the 36 pin I/O port of the Wang calculator

Due to irregularities in the manufacturer's design or wiring of the I/O buffer, all six interface ports do not function identically. All six output ports did not have pins 12 through 19 wired according to the manufacturer's specifications. The problem was brought to the attention of Wang Laboratories and corrective action was taken on only one of the six ports. Because of this, port number one (numbering from left to right) must be used for the D/A interface. The three Wang 605-1A Micro-Interface devices can be connected in any order to three of the five remaining interface ports.

D. ANALOG TO DIGITAL INTERFACE

There are three Wang 605-1A Micro-Interface devices connected to the 623-6 I/O Buffer. Two of the devices provide the X and Y deflection voltages taken from the HP 8410S Display Module. These voltages are fed through two HP 3470 Measurement Systems where they are converted from analog to

bit parallel, character parallel 8421 BCD. In the Wang 605-1A Micro-Interfaces, these voltages are further converted to serial hexadecimal for input to the I/O buffer. The third micro-interface provides a reading of the frequency output of the HP 8690B Sweep Oscillator. The sweep oscillator output is sampled by the HP 5340-A Frequency counter. The digital output of the counter is passed through a KOI 5340A Serial to Parallel Converter to the micro-interface where it is converted to serial hexadecimal and passed to the buffer.

The calculator initiates an input operation from one of the three micro-interface devices by the execution of the appropriate GROUP I - XXXX command sequence. The four digit address code which follows the GROUP I command specifies which interface device is to respond. A GROUP I 0701 command sequence causes the X deflection voltage to be sampled and passed to the display register. Likewise, a GROUP I 0702 command sequence samples the Y deflection voltage, and a GROUP I 0703 command sequence samples the frequency.

Calculator control is passed to the appropriate interface device by the execution of the GROUP I XXXX command sequence. The calculator does not regain control until the interface device returns a 0804 (GO) command and a 10 to 20 microsecond input strobe on connector pins 1 - 9.

E. DIGITAL TO ANALOG INTERFACE

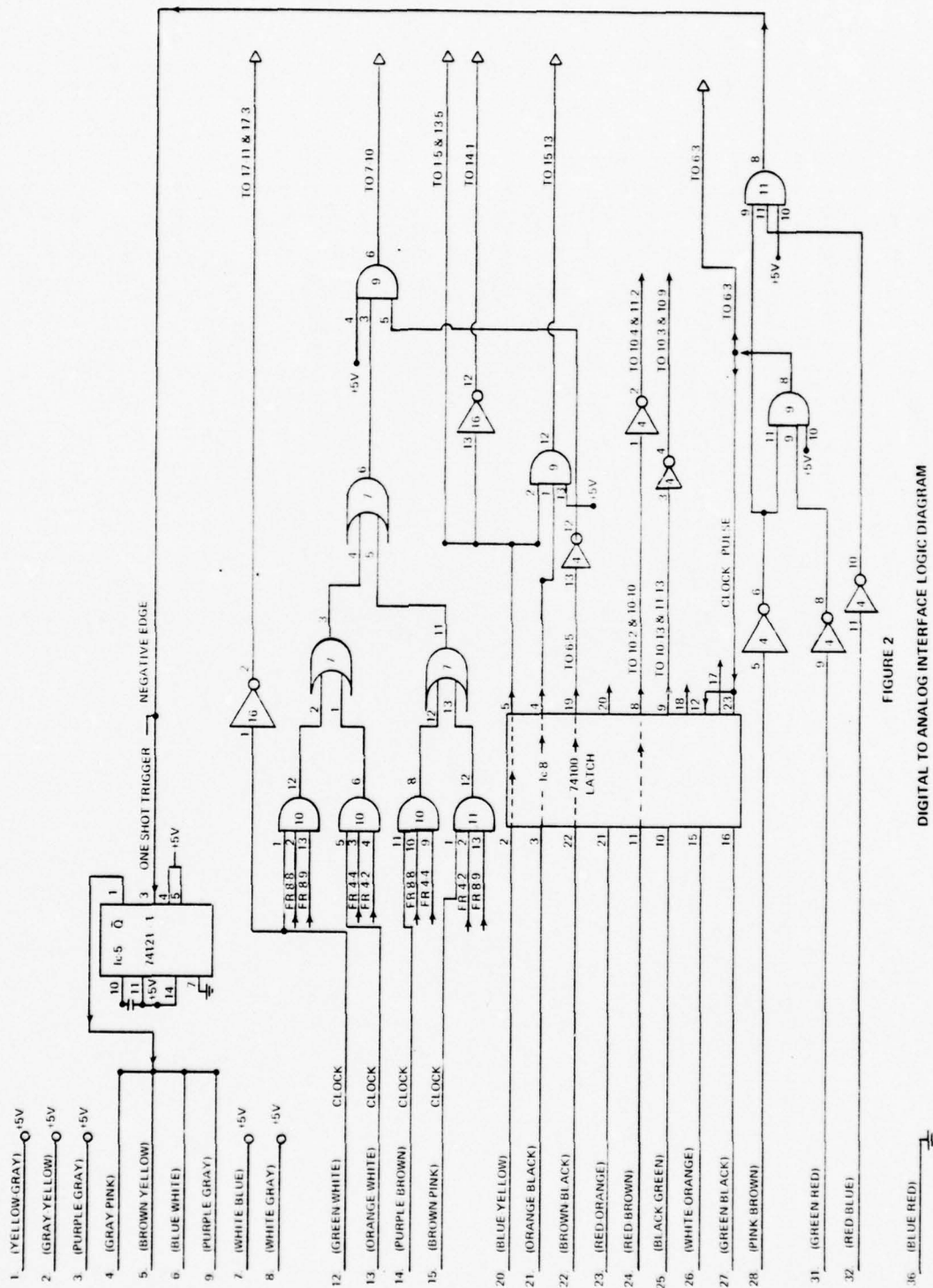
The digital to analog (D/A) interface is designed to drive the HP 8690B Sweep Oscillator to a frequency specified by, and under the control of, a software subroutine called

FREQUENCY ACQUIRE. The interface is composed of three cascaded 4 bit synchronous up/down counters (N74191), a Burr-Brown DAC 80 (V) Digital to Analog Converter and extensive control logic. The interface counts up or down at one of five different clock rates, specified by the subroutine, and generates an output voltage proportional to the state of the counter. The output voltage is fed to the external FM input of the sweep oscillator. The algorithm used for frequency acquisition is described in Appendix F. Figure 2 is the logic diagram for the D/A interface and Appendix A contains the wiring cross reference tables.

1. Control Logic

The control logic performs four basic functions. First, it recognizes whether the I/O command is a GROUP I or GROUP II command. Second, the control logic returns a 0803 (GO) command along with a 10 to 20 microsecond input strobe on pins 1 - 9 to the calculator. Third, it either stops the counter or it gates one of the five clocks to the twelve bit counter and specifies the direction it should count. The fourth function the control logic performs is to insure that the counter does not recycle to an all zero state when counting up or recycle to an all one state when counting down.

All GROUP II I/O commands from the calculator are reserved for use by the D/A interface. The signal on pin 28, which designates a GROUP I or GROUP II command (I = +5 volts, II = 0 volts), along with the 15 to 25 microsecond output



strobe on Pin 31 are combined through an AND gate to produce a 15 to 25 microsecond pulse. This pulse is used to latch all GROUP II address codes into a N74100 latch.

Pins 1 through 8 of the 36 pin I/O port are used for external inputs to the calculator. When a GROUP II command is received by the D/A interface, it generates a 0803 (GO) command on pins 1 - 8 and an input strobe on pin 9 to return control to the calculator. The static condition of pins 1 through 9 is +5 volts. To generate the 0803 command requires pins 1, 2, 3, 7, 8 to be at +5 volts and pins 4, 5, 6 to be at 0 volts. Pins 4, 5, 6 and 9 are pulled 0 volts for approximately 15 microseconds by a GROUP II command signal on pin 28 and a 0 volt keyboard condition indicator signal on pin 32.

The GROUP II I/O address codes on pins 20 through 27 are latched into a N74100 eight bit latch. These four digit address codes are normally used to access different I/O interfaces. The D/A interface uses these address codes as function codes to control the counter. The function codes, listed in Table 1, either stop the counter or specify the count rate and direction.

There are five clock rates available to the interface. Four of these clock rates are available on pins 12 through 15 of the I/O connector at 724HZ, 362HZ, 181HZ and 90.5HZ, respectively. The fifth clock rate is a single pulse generated by a monostable multivibrator (N74121). The combined signals sent to the interface on pins 22, 24 and 25,

TABLE I
DIGITAL TO ANALOG INTERFACE FUNCTION CODES

Function Code	Clock Rate	Count Direction	I/O Pin States					
			20	21	22	24	25	28
0406	724 HZ	Down	H	L	L	H	H	L
0306	362 HZ	Down	H	L	L	L	L	L
0206	181 HZ	Down	H	L	L	H	L	L
0106	90.5 HZ	Down	H	L	L	L	H	L
0702	STEP	Down	H	L	H	L	L	L
0405	724 HZ	Up	L	H	L	H	H	L
0305	362 HZ	Up	L	H	L	L	L	L
0205	181 HZ	Up	L	H	L	H	L	L
0105	90.5 HZ	Up	L	H	L	L	H	L
0701	STEP	Up	L	H	H	L	L	L
0704	STOP	-	H	H	L	L	L	L

specify which clock rate is to be used. The state of pins 20 and 21 specify the count direction. When pins 20 and 21 are both high the counter is disabled.

The function codes are overridden by control logic which automatically stop the counter at the all-one state while counting up and at the all-zero state while counting down. This logic ensures the D/A interface does not drive the sweep oscillator to one end of its frequency range or the other, and with one additional clock pulse force the sweep oscillator to the opposite end of its frequency range.

The all-one state of the three, four-bit, cascaded counters is detected by the simultaneous occurrence of an overflow pulse from each individual counter. When this occurs a D-type Flip-Flop is set and its output is fed to the enable/disable inputs of the counter, disabling it. The counter will remain disabled until a count down function code is received, causing the overflow Flip-Flop to be reset and the counter to count down.

The all-zero state is detected by taking the eight outputs from the second and third 4-bit counters and running them through a NOR gate. When a HIGH occurs out of the NOR gate along with an underflow condition from the first 4-bit counter, an underflow D-type Flip-Flop is set. The output of the Flip-Flop is fed to the enable/disable inputs of the counter and disables it. The underflow Flip-Flop is reset when a count-up function code is received by the interface.

2. Digital to Analog Converter

The Burr-Brown DAC 80 (V) Digital to Analog (D/A) Converter accepts complimentary binary inputs from the twelve bit counter. The requirement of the D/A converter to use complimentary binary causes the interface to drive the HP 8690B Sweep Oscillator down in frequency when a count-up code is received. Likewise, a count-down code drives the sweep oscillator up in frequency.

The output voltage range of the converter, as wired for the interface, is 0 volts to 9.9976 volts $\pm$ 2.44 mv. An operational amplifier is used to increase the maximum output voltage to 13 volts which enables the interface to drive the sweep oscillator to its maximum output frequency.

Frequency resolution obtainable is a function of the frequency range of the RF plug-in module being used. The theoretical frequency resolution obtainable for the 8694A RF-Module is presented below.

Frequency Range = 8 - 12.4 GHZ

Counter Resolution = $2^{-12} = 2.441 \times 10^{-4}$

Input FM Voltage Range = 0 to 13 volts

Voltage Resolution = (Voltage range) x (counter resolution)
= 3.173 mvolts.

Frequency Resolution = (Frequency range) x (voltage resolution) = 13.96 MHZ.

The theoretical frequency resolution has proven to be poorer than is actually obtainable. The software subroutine, FREQUENCY ACQUIRE, will drive the sweep oscillator to within 900 KHZ of the desired frequency, based upon the output of the HP 5340A Frequency Counter.

III. SYSTEM SOFTWARE DESCRIPTION

Two system software programs have been developed to enable automatic S-parameter data collection from the HP 8410S Network Analyzer. The first program, Collection and Storage, will collect S-parameter data and build a cassette tape file of the collected data. The second program, Collection and Display, collects S-parameter data and displays the data or characteristic parameters derived from the data, either on the drum printout or on the Wang Flat-Bed Plotter.

A. COLLECTION AND STORAGE SYSTEM PROGRAM

The Collection and Storage system program collects S-parameter data from the HP 8410S Network Analyzer System and builds a variable length file on cassette tape. The file consists of a file identification record and data records. There are N data records in a file, where N is the number of frequency steps between a user specified start frequency and stop frequency inclusively. Each data record consists of an identification block and up to ten data blocks. Data blocks are comprised of X and Y deflection voltages as measured from the display module of the network analyzer, and the frequency the sweep oscillator was generating when the voltages were measured. Tape formats are presented in Appendix E.

The number of data blocks which can be stored in each data record is from one to ten. This allows for storage of the four scattering parameters S_{21} , S_{12} , S_{11} , S_{22} and for the storage of two sets of calibration data comprising three blocks each. Calibration data is obtained by measuring the reflection coefficients with the network analyzer terminated in a direct short circuit and two offset short circuits for both the forward and reverse channels. This data can be used to compensate for network analyzer errors generated by directivity effects in couplers, tracking and cross coupling in the forward and reflected measuring channels, and the mismatch between the connectors and the sweep oscillator. The theory for implementing calibration data measurement and S-parameter correction is found in Ref. 9.

After loading and initiating execution of the Collection and Storage system program, the program will request four collection parameters from the user. The parameters are the desired start frequency, stop frequency, step size and a Collection Job Code (CJC). The program requests these parameters by interrupting program execution and displaying the numbers 1, 2, 3, 4 in the display register. The user replies by entering in the display register the parameter called for and depressing the GO Key on the calculator keyboard.

After the last collection parameter has been entered by the user, the program stops with a two or six digit number in the display register which tells the user which scattering

parameter or calibration short is to be measured first. The user configures the HP 8410S Network Analyzer for the specified measurement and then depresses the GO key. The program will then collect one block of data for each frequency step specified, including the stop frequency and start frequency. Execution is interrupted after the last block of data is stored. In the display register will be another two or six digit number indicating the next measurement to be taken. The user rewinds the cassette tape, sets up the network analyzer for the measurement, and depresses the calculator GO key. This process repeats until all S-parameters and calibration shorts, specified by the user, have been measured and stored.

A description of the Executive or mainprogram and the twelve subroutines which comprise the Collection and Storage system program is presented in Appendix F. Appendix B gives a step-by-step procedure for using the program and Appendix C contains the Collection Job Code tables.

B. COLLECTION AND DISPLAY SYSTEM PROGRAM

The Collection and Display system program is comprised of system programs and user programs. The system programs perform tasks which are directly related to system operation. These tasks include loading specified user programs, acquiring S-parameter data, retrieving calibration data, and preparing display devices. User programs compute characteristic parameters derived from S-parameter data and display

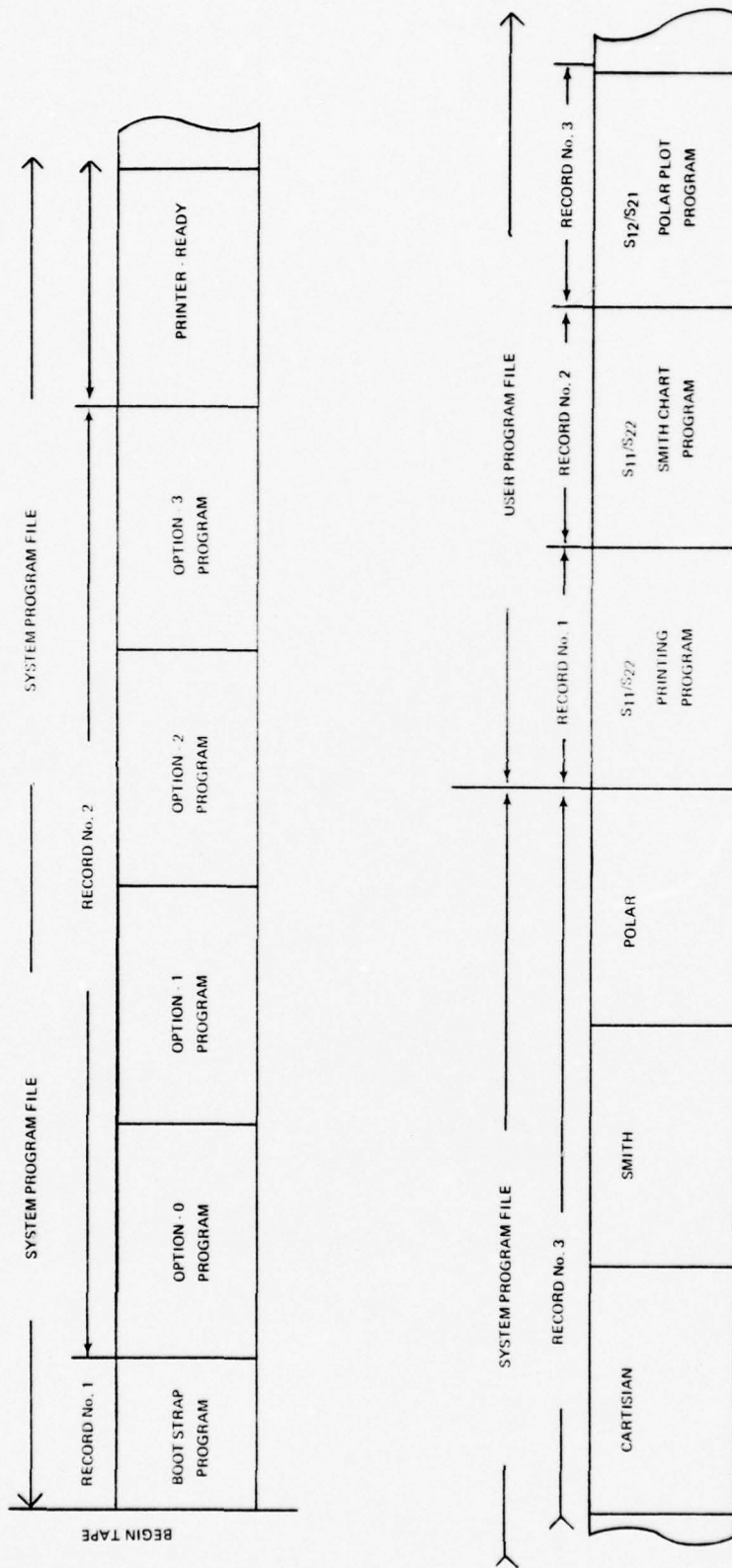


FIGURE 3
COLLECTION AND DISPLAY TAPE ORGANIZATION

the output product either on the 21-column drum printer or as a graphic plot on the flat-bed plotter.

The system programs and user programs are stored on cassette tape in files. The structure of the files, as shown in Figure 3, enable automatic loading and execution of the system.

1. System Programs

The system programs are stored on cassette tape in the System Program File. The file is comprised of three records. The first record contains the system bootstrap program, BOOT. The second record consists of four executive programs called OPTION-0, OPTION-1, OPTION-2 and OPTION-3. The last record in the file contains four display programs called PRINTER READY, CARTISIAN, SMITH, and POLAR.

a. Bootstrap Program

The bootstrap program (BOOT) is the first and only program manually loaded into the calculator memory by the user. BOOT accepts a Display Job Code (DJC) from the user and based upon the parameters specified in the DJC, loads one of the four executive programs over itself. The executive program selected is immediately executed upon the completion of the loading process.

b. Executive Programs

There exist four executive programs, two of which are operational. All four programs perform the same basic functions. They load and execute one of the four display programs; they interact with the user in defining

parameters and configuring equipment to carry out the display task; they load and pass system control to a specified User program; and they all contain a subroutine called GET DATA.

The four executive programs are configured according to the requirements of their GET DATA subroutines. S-parameter data is obtainable from either the HP 8410S Network Analyzer or from a data tape previously built by the Collection and Storage system program. The executive program, OPTION-0, contains a GET DATA subroutine and other required subroutines which enable automatic acquisition of S-parameter data from the HP 8410S Network Analyzer. OPTION-1 has a GET DATA subroutine and other associated subroutines which enable retrieval of S-parameter data from a cassette tape. The two remaining executive programs, OPTION-2 and OPTION-3, will apply calibration data, retrieved from cassette tape, to S-parameter data collected from either the network analyzer or cassette tape. The GET DATA subroutines and associated subroutines needed to obtain the calibration data and S-parameter data are operational in both programs. To make the programs operational, as designed, will require a subroutine which applies the calibration data to the S-parameter data.

The design of the four executive programs relieve User programs of having to interface to the devices which provide input data. They also permit User program flexibility since they can be written and executed independent of data source.

c. Display Programs

One of the four display programs, designated in the Display Job Code, is loaded and executed by the resident executive program to prepare either the Wang 612 Flat-Bed Plotter or the 21-column drum printer for use by a User program. The preparation involves either advancing the paper tape of the drum printer or plotting one of three coordinate systems on the plotter. The coordinate systems available to the User programs are Cartesian, Polar and a modified Smith Chart. This aspect of the system design relieves User programs of having to plot its own display coordinates.

2. User programs

The three user programs presently available were originally written by John Carlton [Ref. 9]. The programs have been modified to make them compatible with the systems programs.

a. S_{11}/S_{22} Printing Program

This program uses the calculator's 21-column drum printer to type out ten characteristics derived from reflection measurements obtained from the HP 8414A Polar Display module or cassette tape. These are frequency, VSWR, REF , $Im \Gamma$, $|\Gamma|$, $\angle \Gamma$, $RE Z$, $Im Z$, $|Z|$, and $\angle Z$. The program requests S-parameter data by calling the system subroutine GET DATA. GET DATA returns an X and Y deflection voltage and the frequency of the sweep oscillator. The output characteristics are computed and printed by the user program.

GET DATA is called again to provide the next data set and the process continues until all data has been collected and printed.

b. S_{11}/S_{22} Smith Chart Program

This program uses the flat-bed plotter as the display device. S-parameter reflection measurements are obtained by calling the system subroutine GET DATA. GET DATA returns the frequency and the real and imaginary parts of the reflection measurement to the program. The program prepares the input data for display and plots the output on the simplified Smith Chart drawn by the system display program. The normalized impedance of each point can be listed on the drum printer if desired.

The program can be used for devices which exhibit both negative and positive resistance. If $|\Gamma| > 1$, then the Smith Chart lines of constant resistance are interpreted as negative.

c. S_{12}/S_{21} Polar Plot Program

This program is designed for transmission measurements using the polar display. Transmission measurements provided by GET DATA are prepared and plotted on the polar coordinates previously drawn by the system display program. Frequency, magnitude and angle of each transmission coefficient can be listed on the drum printer, if desired.

d. Future User Programs

Additional User programs can be stored on tape in the User Program File without modification to the system

programs. To make them compatible with the Collection and Display System they must be written and stored in the User Program File as shown in Figure 4.

User programs may use registers 00 through 21. When requesting data from the system subroutine GET DATA, the X and Y displacement voltages are returned in registers 00 and 01. The measured frequency is returned in register 02. Data stored in registers 00 through 03 by the User program must be relocated prior to calling GET DATA if they are to be used upon return from GET DATA.

Subroutine address codes 1001 through 1015 are available for use by User programs. Address codes 1100 through 1115 are used by the System programs. All mark address codes except 0801 through 0915 are available for use by the user programs.

The calculator core memory available for a User program is dependent upon the executive program under which it is run. Under OPTION-0, a user program of up to 1000 program instructions can be stored and executed. OPTION-1 will allow programs with up to 1100 program instructions. The size of a user program, which can be run under OPTION-2 or OPTION-3, will depend upon the core requirement of the subroutine which applies the correction data to the S-parameter data.

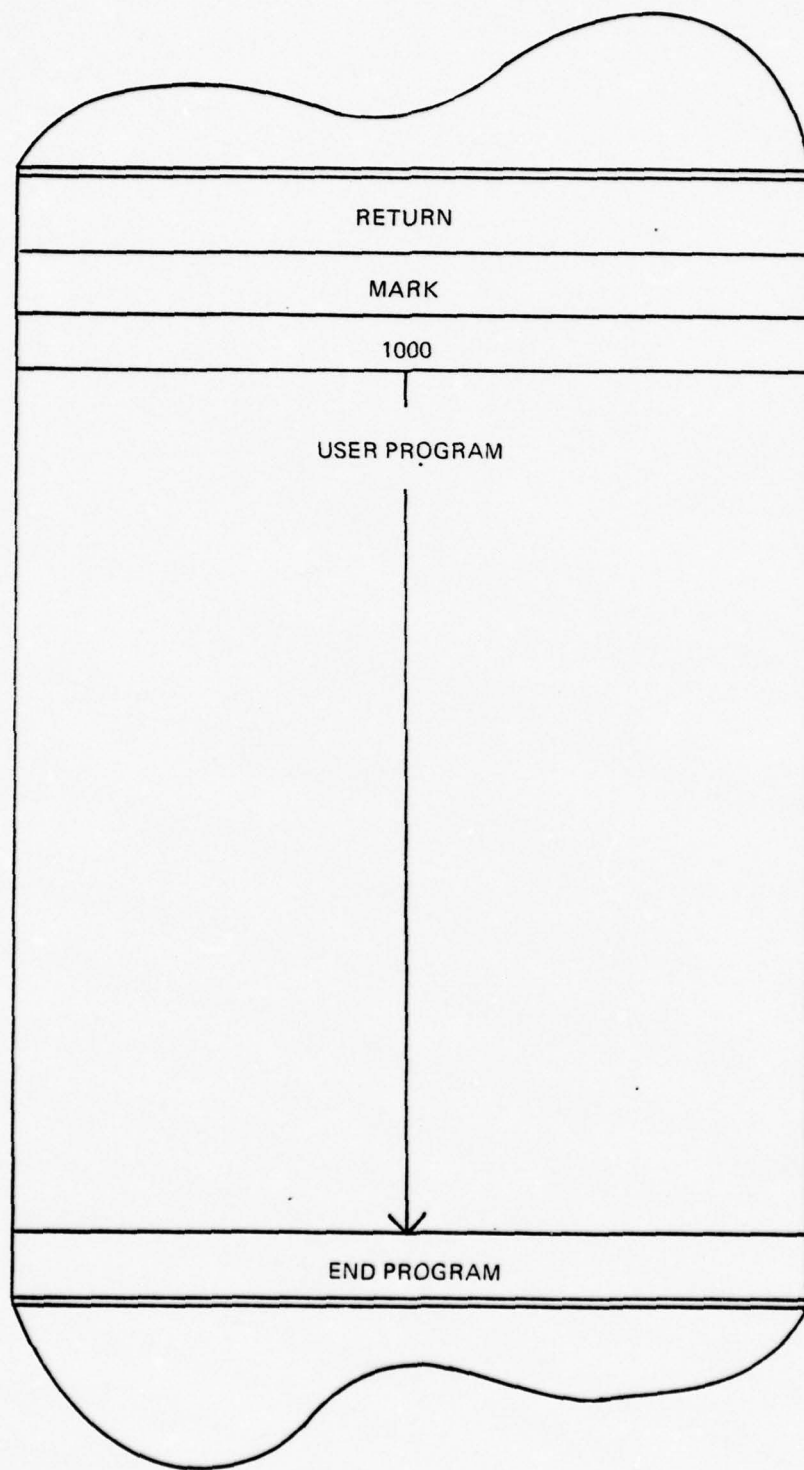


FIGURE 4
USER PROGRAM FORMAT

IV. CONCLUSIONS

The Wang 614 Programmable Calculator has proven capable of performing many of the functions normally associated with a micro-processor or mini-computer. While its processing and input/output speeds are slower than that expected of one of these units, it is capable of user/system interface and automatic, multichannel input/output functions.

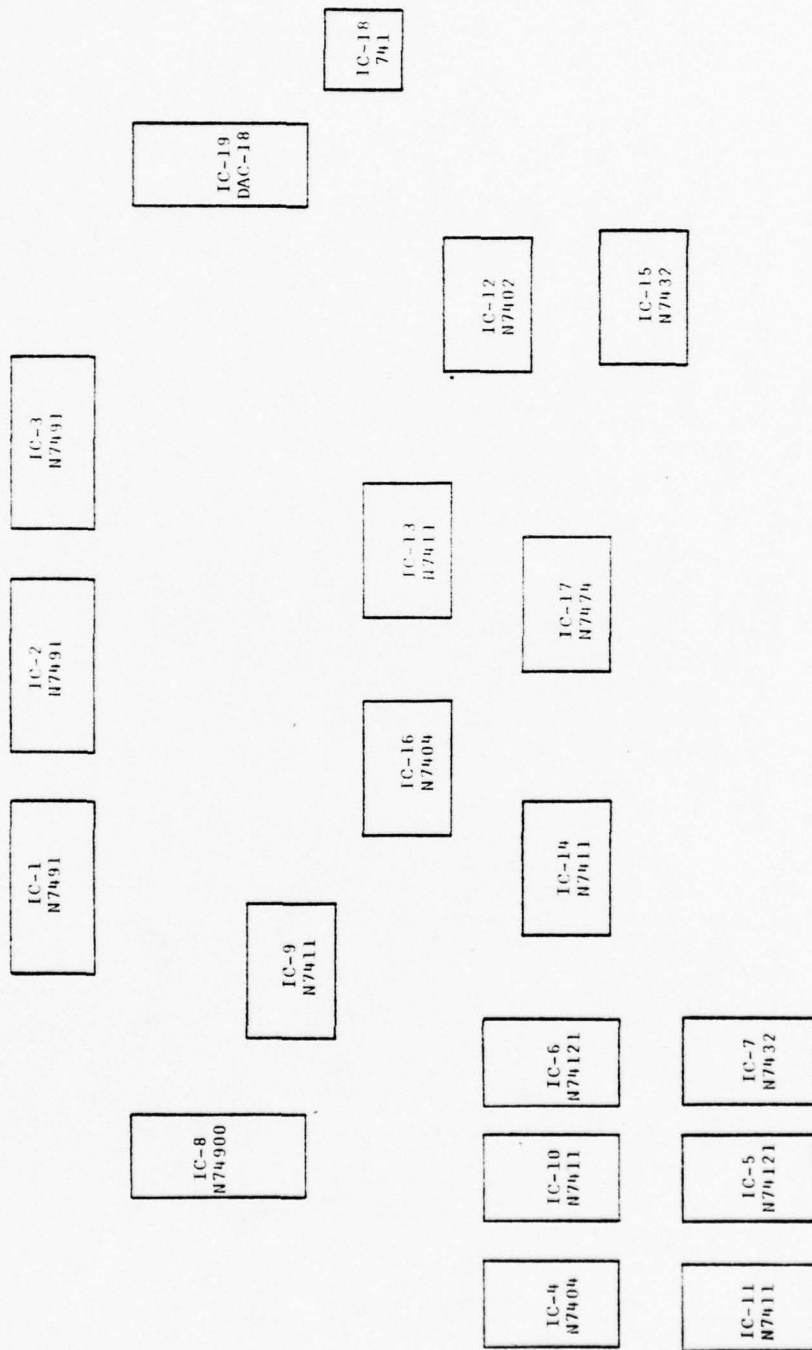
The design and implementation of the software programs and the digital to analog interface have changed the calculator-aided microwave network analyzer system described by John C. Carlton [Ref. 1], to a calculator controlled microwave network analyzer system.

V. RECOMMENDATIONS

An investigation into the feasibility of implementing S-parameter correction by the use of calibration data as described in the paper by Silva and McPhuw [Ref. 9] is recommended.

A user program which computes and plots the phase and magnitude transfer function of microwave devices is recommended. Also, additional user programs may prove desirable.

Appendix A Digital to Analog Interface Wiring Tables



[illegible]

[illegible]

[illegible]

IC-3

[illegible]

IC-4

NOTE * See Input Port Table

[illegible]

IC.5

NOTE * See Input Port Table
+ Pin 10 Connected to Pin 11
by a .01 Mfd Capacitor
o Pin 11 Connected to Vcc by
a 10M Resistor

[illegible]

IC-6

NOTE + Pin 10 is Connected to Pin 11 by a 1.0 μ F Capacitor
 o Pin 11 is Connected to Vcc by a 0HM Resistor

[illegible]

IC-7

PIn	IC-1	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
To								NC											
1								*											
2								*											
3								*											
4									1										
5	5	5	5						2				5			13			
6								NC											
7								GND											
8				1						2&10									
9				3						13	13								
10								*											
11								*											
12								23											
13								NC											
14								NC											
15								*											
16								*											
17								NC											
18								NC											
19				13		5													
20								NC											
21								*											
22								*											
23						3		12	8										
24								VCC											

IC-8

NOTE *See Input Port Table

Pfn	IC-1	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
To								4											
1								5					5			13			
2	5	5	5				6												
3									Vcc										
4																			
5				12			10												
6									GND										
7																			
8						3		23&12											
9				8															
10									Vcc										
11				6						9									
12															13				
13									Vcc										
14									Vcc										

IC-9

[illegible]

NOTE * See Input Port Table

NOTE * See Input Port Table

[illegible]

IC-12

P _{in}	IC-1	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
T ₀																			
1												4							
2												1							
3												13							
4	12													2					
5	5	5	5					5	2							13			
6													10						
7													GND						
8																	2		
9													V _{CC}						
10													6						
11													12						
12													11						
13												10							
14													V _{CC}						

PIn	IC-1	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
To																			
1																			
2	12												4						
3														12					
4			12																
5														VCC					
6																	12		
7														GND					
8														NC					
9														NC					
10														NC					
11														NC					
12														3					
13		12																	
14														VCC					

[illegible]

NOTE *See Input Port Table

IC-16

[illegible]

IC-17

Pfn	IC-1	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
To																			
1			7									8							
2			6									9							
3			2									11							
4			3									12							
5		7										6							
6		6										5							
7		2										3							
8		3										2							
9	7																		
10	6																		
11	2																		
12	3																		
13																			+5V
14																		4	-16V
15																			18
16																			
17																			GND
18																		3	15
19																			NC
20																			
21																			GND
22																			+16V
23																			
24																			

IC-19

PIn	PORT	IC-2	IC-3	IC-4	IC-5	IC-6	IC-7	IC-8	IC-9	IC-10	IC-11	IC-12	IC-13	IC-14	IC-15	IC-16	IC-17	IC-18	IC-19
1	V _{CC}																		
2	V _{CC}																		
3	V _{CC}																		
4					1														
5					1														
6					1														
7	V _{CC}																		
8	V _{CC}																		
9					1														
12																			
13																			
14																			
15																			
20										1						1			
21										5									
22										11									
23											1								
24																			
25																			
26																			
27																			
28																			
31																			
32																			

INPUT PORT

APPENDIX B

PROCEDURES FOR USING THE COLLECTION AND STORAGE SYSTEM PROGRAM

1. Energize all components of the HP 8410S Network Analyzer System and the Wang Calculator. Calibrate the display module. Ensure the HP 8690B Sweep Oscillator is in the CW mode and the External FM pushbutton is depressed.
2. Load the Collection and Storage system program.
3. Remove the tape containing the system program and insert a blank tape, rewind, and depress TAPE READY.
4. Depress the GO key on the calculator keyboard.
5. The calculator will occasionally interrupt execution with a number showing in the display register. Respond as specified below according to the number in the display register.

Display Register
Contents

Response

- | | |
|-----|--|
| 1 | Clear display,
Enter Start Frequency in HZ
Depress <u>GO</u> key |
| 2 | Clear Display
Enter Stop Frequency in HZ
Depress <u>GO</u> key |
| 3 | Clear Display
Enter Step Size in HZ
Depress <u>GO</u> key |
| 4 | Clear Display
Enter Collection Job Code Obtained
From Appendix C
Depress <u>GO</u> key |
| .21 | Rewind Tape
Depress <u>TAPE READY</u>
Configure Network Analyzer to Measure S_{21}
Clear Display
Enter Difference Between dB Calibration
Setting and dB Measurement Setting
[dB(c) - dB(m)]
Depress <u>GO</u> key |
| .12 | Rewind Tape
Depress <u>TAPE READY</u>
Configure Network Analyzer to Measure S_{12}
Clear Display
Enter Difference Between dB Calibration
Setting and dB Measurement Setting
[dB(c) - dB(m)]
Depress <u>GO</u> key |
| .11 | Rewind Tape
Depress <u>TAPE READY</u>
Configure Network Analyzer to Measure S_{11}
Clear Display
Enter Difference Between dB Calibration
Setting and dB Measurement Setting
[dB(c) - dB(m)]
Depress <u>GO</u> key |

Display Register
Contents

Response

.22	Rewind Tape Depress <u>TAPE READY</u> Configure Network Analyzer to Measure S_{22} Clear Display Enter Difference Between dB Calibration Setting and dB Measurement Setting [dB(c) - dB(m)] Depress <u>GO</u> key
10.2112	Rewind Tape Depress <u>TAPE READY</u> Configure Network Analyzer to Measure Transmission Coefficients with Channel Terminated in a Direct Short [L(0)] Clear Display Enter Line Length Depress <u>GO</u> key
11.2112	Rewind Tape Depress <u>TAPE READY</u> Configure Network Analyzer to Measure Transmission Coefficients with Channel Terminated in an Offset Short [L(1)] Clear Display Enter Line Length Depress <u>GO</u> key
12.2112	Rewind Tape Depress <u>TAPE READY</u> Configure Network Analyzer to Measure Transmission Coefficients with Channel Terminated in a Second Offset Short [L(2)] Clear Display Enter Line Length Depress <u>GO</u> key
10.1122	Rewind Tape Depress <u>TAPE READY</u> Configure Network Analyzer to Measure Reflection Coefficients with Channel Terminated in a Direct Short [L(0)] Clear Display Enter Line Length Depress <u>GO</u> key

Display Register
Contents

Response

11.1122	Rewind Tape Depress <u>TAPE</u> <u>READY</u> Configure <u>Network</u> Analyzer to Measure Reflection Coefficients with Channel Terminated in an Offset Short [L(1)] Clear Display Enter Line Length Depress <u>GO</u> key
12.1122	Rewind Tape Depress <u>TAPE</u> <u>READY</u> Configure <u>Network</u> Analyzer to Measure Reflection Coefficients with Channel Terminated in a Second Offset Short [L(2)] Clear Display Enter Line Length Depress <u>GO</u> key
5	Rewind Tape Depress <u>TAPE</u> <u>READY</u> Depress <u>GO</u> key
9.9999	Rewind Tape Remove Tape <u>Proper Termination</u>

APPENDIX C
COLLECTION JOB CODE TABLES

1. Choose the appropriate table:
 - a. If calibration data is not to be collected use Table 1.
 - b. If calibration data is to be collected use Table 2.
2. Choose the appropriate Collection Job Code:
 - a. Determine which S-parameters are to be collected and stored.
 - b. Find the row in the table which has a 1 in each S-parameter column decided upon.
 - c. Use the Collection Job Code specified for the appropriate row.

TABLE 1

NO CALIBRATION DATA

Display Job Code	S_{21}	S_{12}	S_{11}	S_{22}
0.0101	0	0	0	1
0.0102	0	0	1	0
0.0203	0	0	1	1
0.0104	0	1	0	0
0.0205	0	1	0	1
0.0206	0	1	1	0
0.0307	0	1	1	1
0.0108	1	0	0	0
0.0209	1	0	0	1
0.0210	1	0	1	0
0.0311	1	0	1	1
0.0212	1	1	0	0
0.0313	1	1	0	1
0.0314	1	1	1	0
0.0415	1	1	1	1

TABLE 2

CALIBRATION DATA

Collection Job Code	S_{21}	S_{12}	S_{11}	S_{22}
2.0600	0	0	0	0
1.0401	0	0	0	1
1.0402	0	0	1	0
1.0503	0	0	1	1
1.0404	0	1	0	0
2.0805	0	1	0	1
2.0806	0	1	1	0
2.0907	0	1	1	1
1.0408	1	0	0	0
2.0809	1	0	0	1
2.0810	1	0	1	0
2.0911	1	0	1	1
1.0512	1	1	0	0
2.0913	1	1	0	1
2.0914	1	1	1	0
2.1015	1	1	1	1

Appendix D Collection and Storage System Program Memory Map

Register Number:

16	17	18	19	20	21	22	23	24	25
# OF RECORDS	ID BLOCK FLAG	# OF CALIBRATION SETS	# BLOCK/ RECORD	5- PARAMETERS TO BE COLLECTED	COLLECTION JOB CODE	AF VS 0701/2	AF VS 0405/6	AF VS 0305/6	AF VS 0205/6

26	27	28	29	30	49	50	51	52
AF VS 0105/6	START FREQ	STOP FREQ	STEP SIZE		JOB CODE	START FREQ	STOP FREQ	STEP SIZE

53	54	55	56	57	58	59	60	61	62
TRANS. L(0)	TRANS. L(1)	TRANS. (2)	REFL. L(0)	REFL. L(1)	REFL. L(2)	S ₂₁ dB DIFF.	S ₁₂ dB DIFF.	S ₁₁ dB DIFF.	S ₂₂ dB DIFF.

Appendix E

Data Tape Formats

General Tape Format

FILE ID RECORD	DATA RECORD #1	DATA RECORD #2	DATA RECORD #3	DATA RECORD #N-2	DATA RECORD #N-1	DATA RECORD #N
-------------------	----------------------	----------------------	----------------------	------------------------	------------------------	----------------------

File ID Record

COLLEC- TION JOB CODE	START FREQ	STOP FREQ	STEP SIZE	TOTAL # OF DATA RECORDS	TRANS LC(0)	TRANS LC(1)	TRANS LC(2)	EFFL LC(0)	EFFL LC(1)	EFFL LC(2)	S ₂₁ dB DIFF	S ₁₂ dB DIFF	S ₁₁ dB DIFF	S ₂₂ dB DIFF
--------------------------------	---------------	--------------	--------------	----------------------------------	----------------	----------------	----------------	---------------	---------------	---------------	-------------------------------	-------------------------------	-------------------------------	-------------------------------

Data Record

DATA RECORD #1	JOB CODE	DESIRED MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ	X VOLT	DATA RECORD #2
DATA ID BLOCK			DATA BLOCK				DATA BLOCK				DATA BLOCK		

Data Record Format For
Collection Job Codes

0.0101
0.0102
0.0104
0.0108

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	-----------	-----------	-----------------

Data Record Format for
Collection Job Codes

0.0203
0.0205
0.0206
0.0209
0.0210
0.0212

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	-----------	-----------	-----------------	-----------	-----------	-----------------

Data Record Format For
Collection Job Codes

0.0307
0.0311
0.0313
0.0314

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ	X VOLT	Y VOLT	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	-----------	-----------	-----------------	-----------	-----------	-----------------

X VOLT	Y VOLT	MEASUR. FREQ
-----------	-----------	-----------------

Data Record Format For
Collection Job Codes

0.0415
1.0401
1.0402
1.0404
1.0408

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT CALIB L(0) OR S ₂₁	Y VOLT CALIB L(0) OR S ₂₁	MEASUR. FREQ	X VOLT CALIB L(1) OR S ₁₂	Y VOLT CALIB L(1) OR S ₁₂	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	--	--	-----------------	--	--	-----------------

X VOLT CALIB L(2) OR S ₁₁	Y VOLT CALIB L(2) OR S ₁₁	MEASUR. FREQ	X VOLT S _{xy} OR S ₂₂	Y VOLT S _{xy} OR S ₂₂	MEASUR. FREQ
--	--	-----------------	---	---	-----------------

Data Record Format For
Collection Job Codes

1.0503
1.0512

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT CALIB L(0)	Y VOLT CALIB L(0)	MEASUR. FREQ	X VOLT CALIB L(1)	Y VOLT CALIB L(1)	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	----------------------	----------------------	-----------------	----------------------	----------------------	-----------------

X VOLT CALIB L(2)	Y VOLT CALIB L(2)	MEASUR. FREQ	X VOLT Sxx OR Sxy	Y VOLT Sxx OR Sxy	MEASUR. FREQ	X VOLT Syy OR Syz	Y VOLT Syy OR Syz	MEASUR. FREQ
----------------------	----------------------	-----------------	-------------------------	-------------------------	-----------------	-------------------------	-------------------------	-----------------

Data Record Format For
Collection Job Code

2.0600

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT TRANS. CALIB L(0)	Y VOLT TRANS. CALIB L(0)	MEASUR. FREQ	X VOLT TRANS. CALIB L(0)	Y VOLT TRANS. CALIB L(0)	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	--------------------------------	--------------------------------	-----------------	--------------------------------	--------------------------------	-----------------

X VOLT TRANS. CALIB L(2)	Y VOLT TRANS. CALIB L(2)	MEASUR. FREQ	X VOLT REFL. CALIB L(0)	Y VOLT REFL. CALIB L(0)	MEASUR. FREQ	X VOLT REFL. CALIB L(0)	Y VOLT REFL. CALIB L(0)	MEASUR. FREQ
--------------------------------	--------------------------------	-----------------	-------------------------------	-------------------------------	-----------------	-------------------------------	-------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT REFL. CALIB L(2)	MEASUR. FREQ
-------------------------------	-------------------------------	-----------------

Data Record Format For
Collection Job Codes

2.0805
2.0806
2.0809
2.0810

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT TRANS. CALIB L(0)	Y VOLT TRANS. CALIB L(0)	MEASUR. FREQ	X VOLT TRANS. CALIB L(1)	Y VOLT TRANS. CALIB L(1)	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	--------------------------------	--------------------------------	-----------------	--------------------------------	--------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT TRANS. CALIB L(2)	MEASUR. FREQ	X VOLT REFL. CALIB L(0)	Y VOLT REFL. CALIB L(0)	MEASUR. FREQ	X VOLT REFL. CALIB L(1)	Y VOLT REFL. CALIB L(1)	MEASUR. FREQ
-------------------------------	--------------------------------	-----------------	-------------------------------	-------------------------------	-----------------	-------------------------------	-------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT REFL. CALIB L(2)	MEASUR. FREQ	X VOLT Sxy	Y VOLT Sxy	MEASUR. FREQ	X VOLT Sxx	Y VOLT Sxx	MEASUR. FREQ
-------------------------------	-------------------------------	-----------------	---------------	---------------	-----------------	---------------	---------------	-----------------

Data Record Format For
Collection Job Codes

2.0907
2.0911
2.0913
2.0914

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT TRANS. CALIB L(0)	Y VOLT TRANS. CALIB L(0)	MEASUR. FREQ	X VOLT TRANS. CALIB L(1)	Y VOLT TRANS. CALIB L(1)	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	--------------------------------	--------------------------------	-----------------	--------------------------------	--------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT TRANS. CALIB L(2)	MEASUR. FREQ	X VOLT REFL. CALIB L(0)	Y VOLT REFL. CALIB L(0)	MEASUR. FREQ	X VOLT REFL. CALIB L(1)	Y VOLT REFL. CALIB L(1)	MEASUR. FREQ
-------------------------------	--------------------------------	-----------------	-------------------------------	-------------------------------	-----------------	-------------------------------	-------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT REFL. CALIB L(2)	MEASUR. FREQ	X VOLT Sxx	Y VOLT Sxx	MEASUR. FREQ	X VOLT Sxx OR Sxx	Y VOLT Sxx OR Sxx	MEASUR. FREQ
-------------------------------	-------------------------------	-----------------	---------------	---------------	-----------------	----------------------	----------------------	-----------------

X VOLT Syy	Y VOLT Syy	MEASUR. FREQ
---------------	---------------	-----------------

Data Record Format For
Collection Job Code

2.1015

DATA RECORD #	COLLEC- TION JOB CODE	DESIRED MEASUR. FREQ	X VOLT TRANS. CALIB L(0)	Y VOLT TRANS. CALIB L(0)	MEASUR. FREQ	X VOLT TRANS. CALIB L(1)	Y VOLT TRANS. CALIB L(1)	MEASUR. FREQ
---------------------	--------------------------------	----------------------------	--------------------------------	--------------------------------	-----------------	--------------------------------	--------------------------------	-----------------

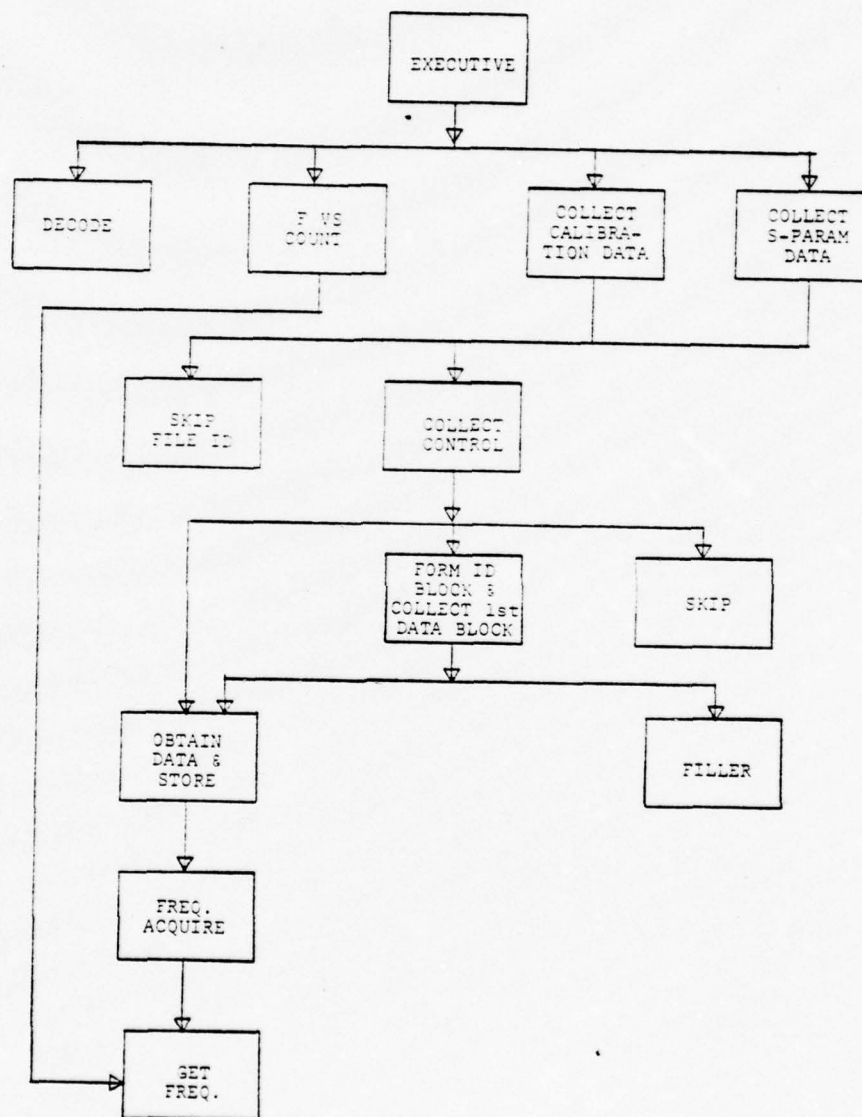
X VOLT TRANS. CALIB L(2)	Y VOLT TRANS. CALIB L(1)	MEASUR. FREQ	X VOLT REFL. CALIB L(0)	Y VOLT REFL. CALIB L(0)	MEASUR. FREQ	X VOLT REFL. CALIB L(1)	Y VOLT REFL. CALIB L(1)	MEASUR. FREQ
--------------------------------	--------------------------------	-----------------	-------------------------------	-------------------------------	-----------------	-------------------------------	-------------------------------	-----------------

X VOLT REFL. CALIB L(2)	Y VOLT REFL. CALIB L(2)	MEASUR. FREQ	X VOLT S ₂₁	Y VOLT S ₂₁	MEASUR. FREQ	X VOLT S ₁₂	Y VOLT S ₁₂	MEASUR. FREQ
-------------------------------	-------------------------------	-----------------	---------------------------	---------------------------	-----------------	---------------------------	---------------------------	-----------------

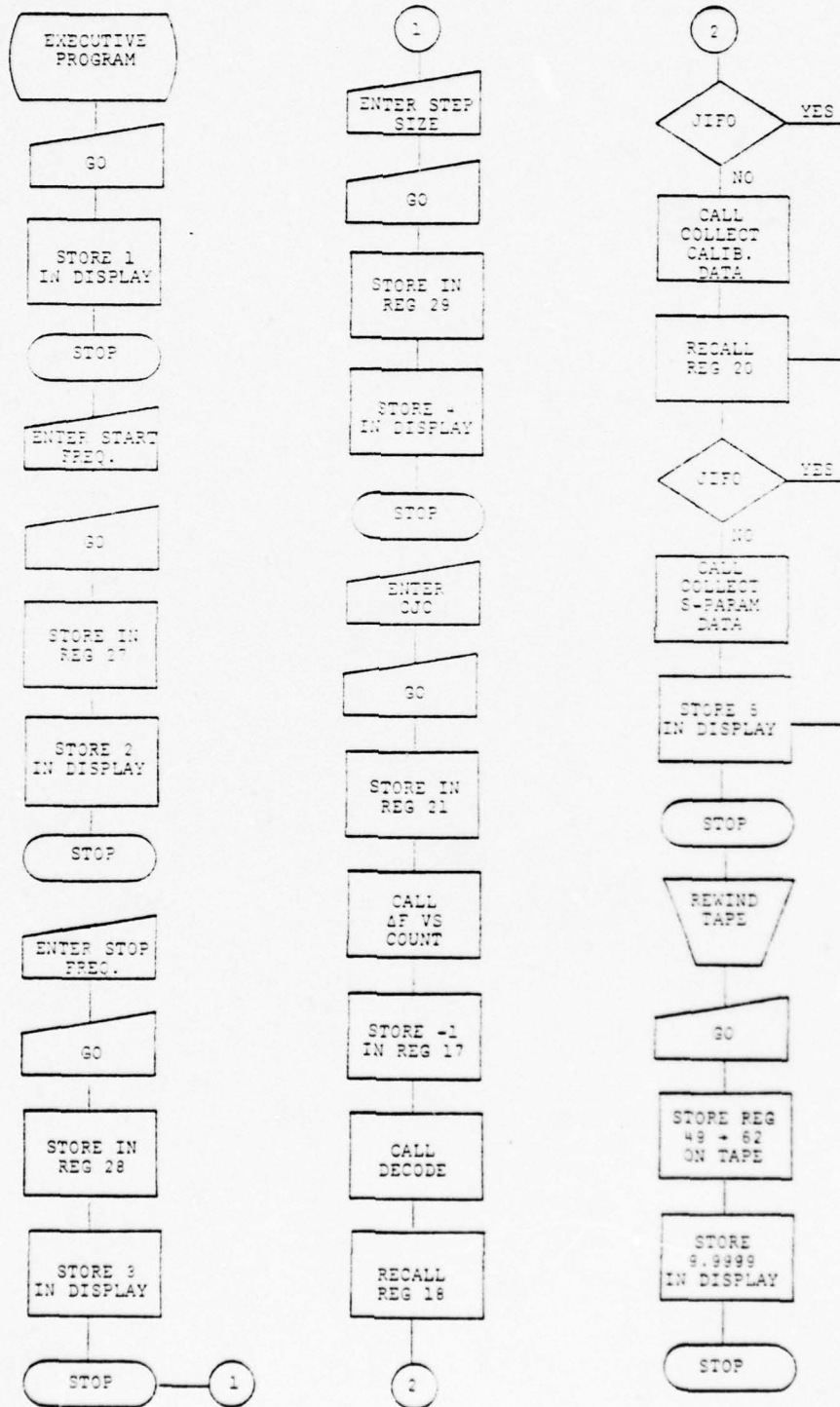
X VOLT S ₁₁	Y VOLT S ₁₁	MEASUR. FREQ	X VOLT S ₂₂	Y VOLT S ₂₂	MEASUR. FREQ
---------------------------	---------------------------	-----------------	---------------------------	---------------------------	-----------------

Appendix F

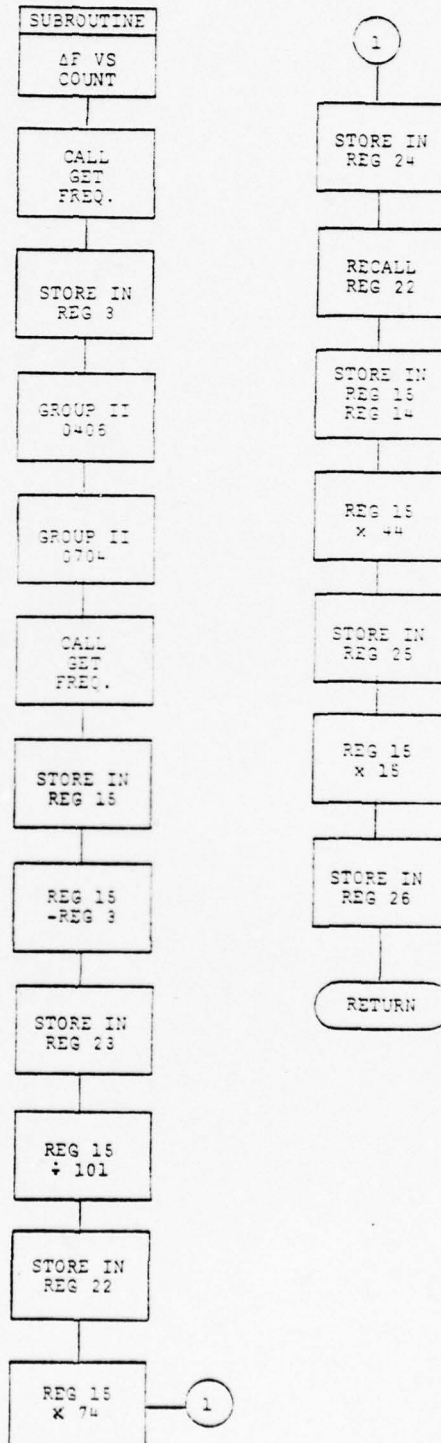
Collection and Storage System Program Flow Charts and Descriptions



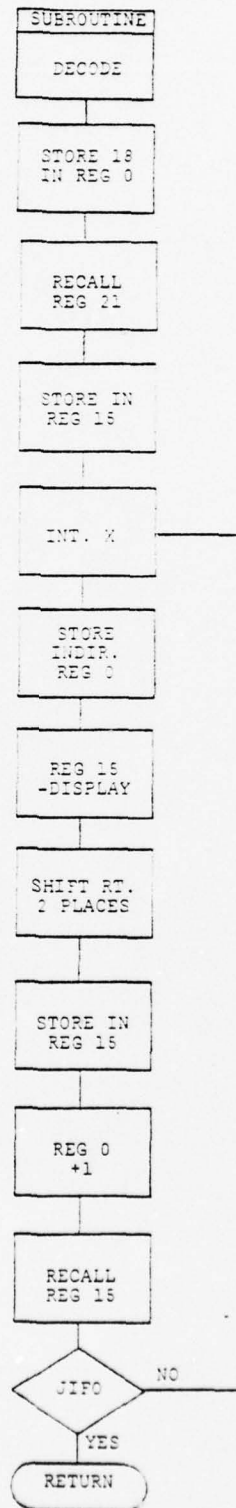
SUBROUTINE NAME: EXECUTIVE		ADDRESS CODE: 1000																								
DESCRIPTION: The EXECUTIVE program is the primary interface between the user and the system program. It calls upon the user to supply the collection parameters: start frequency, stop frequency, step size and a Collection Job Code (CJC). The program then calls the appropriate subroutines which carry out the tasks specified by the CJC. When collection and storage is complete, the program writes the file identification record on the data tape.																										
CALLED FROM:																										
CALLS SUBROUTINES:		ΔF VS COUNT DECODE COLLECT CALIBRATION DATA COLLECT S-PARAMETER DATA																								
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>17</td> <td>T+01</td> <td>Flag - First measurement</td> </tr> <tr> <td>18</td> <td>T+02</td> <td>Number of calibration data sets to be collected</td> </tr> <tr> <td>20</td> <td>T+04</td> <td>S-parameters to be collected</td> </tr> <tr> <td>21</td> <td>T+05</td> <td>Collection Job Code</td> </tr> <tr> <td>27</td> <td>T+11</td> <td>start frequency</td> </tr> <tr> <td>28</td> <td>T+12</td> <td>stop frequency</td> </tr> <tr> <td>29</td> <td>T+13</td> <td>step size</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	17	T+01	Flag - First measurement	18	T+02	Number of calibration data sets to be collected	20	T+04	S-parameters to be collected	21	T+05	Collection Job Code	27	T+11	start frequency	28	T+12	stop frequency	29	T+13	step size
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																								
17	T+01	Flag - First measurement																								
18	T+02	Number of calibration data sets to be collected																								
20	T+04	S-parameters to be collected																								
21	T+05	Collection Job Code																								
27	T+11	start frequency																								
28	T+12	stop frequency																								
29	T+13	step size																								



SUBROUTINE NAME: ΔF VERSES COUNT	ADDRESS CODE: 1001																		
DESCRIPTION: This subroutine is used to determine the frequency change caused by the execution of each of the five Group II function codes. When the subroutine FREQUENCY ACQUIRE drives the sweep oscillator to a desired frequency, it does so by executing a Group II function code immediately followed by a stop code. This causes the 12 bit counter of the interface to increase or decrease its count by a specific amount for each of the five function codes. The change in frequency which each code causes is dependent upon the frequency range of the RF plug-in unit being used. This subroutine determines the change in frequency caused by each function code and stores this information.																			
CALLED FROM: EXECUTIVE																			
CALLS SUBROUTINES: GET FREQUENCY																			
REGISTERS USED: <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="text-align: left; width: 15%;"><u>NUMBER</u></th> <th style="text-align: left; width: 15%;"><u>CODE</u></th> <th style="text-align: left; width: 70%;"><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>22</td> <td>T+06</td> <td>ΔF for 0701/0702 codes</td> </tr> <tr> <td>23</td> <td>T+07</td> <td>ΔF for 0405/0406 codes</td> </tr> <tr> <td>24</td> <td>T+08</td> <td>ΔF for 0305/0306 codes</td> </tr> <tr> <td>25</td> <td>T+09</td> <td>ΔF for 0205/0206 codes</td> </tr> <tr> <td>26</td> <td>T+10</td> <td>ΔF for 0105/0106 codes</td> </tr> </tbody> </table>		<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	22	T+06	ΔF for 0701/0702 codes	23	T+07	ΔF for 0405/0406 codes	24	T+08	ΔF for 0305/0306 codes	25	T+09	ΔF for 0205/0206 codes	26	T+10	ΔF for 0105/0106 codes
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																	
22	T+06	ΔF for 0701/0702 codes																	
23	T+07	ΔF for 0405/0406 codes																	
24	T+08	ΔF for 0305/0306 codes																	
25	T+09	ΔF for 0205/0206 codes																	
26	T+10	ΔF for 0105/0106 codes																	

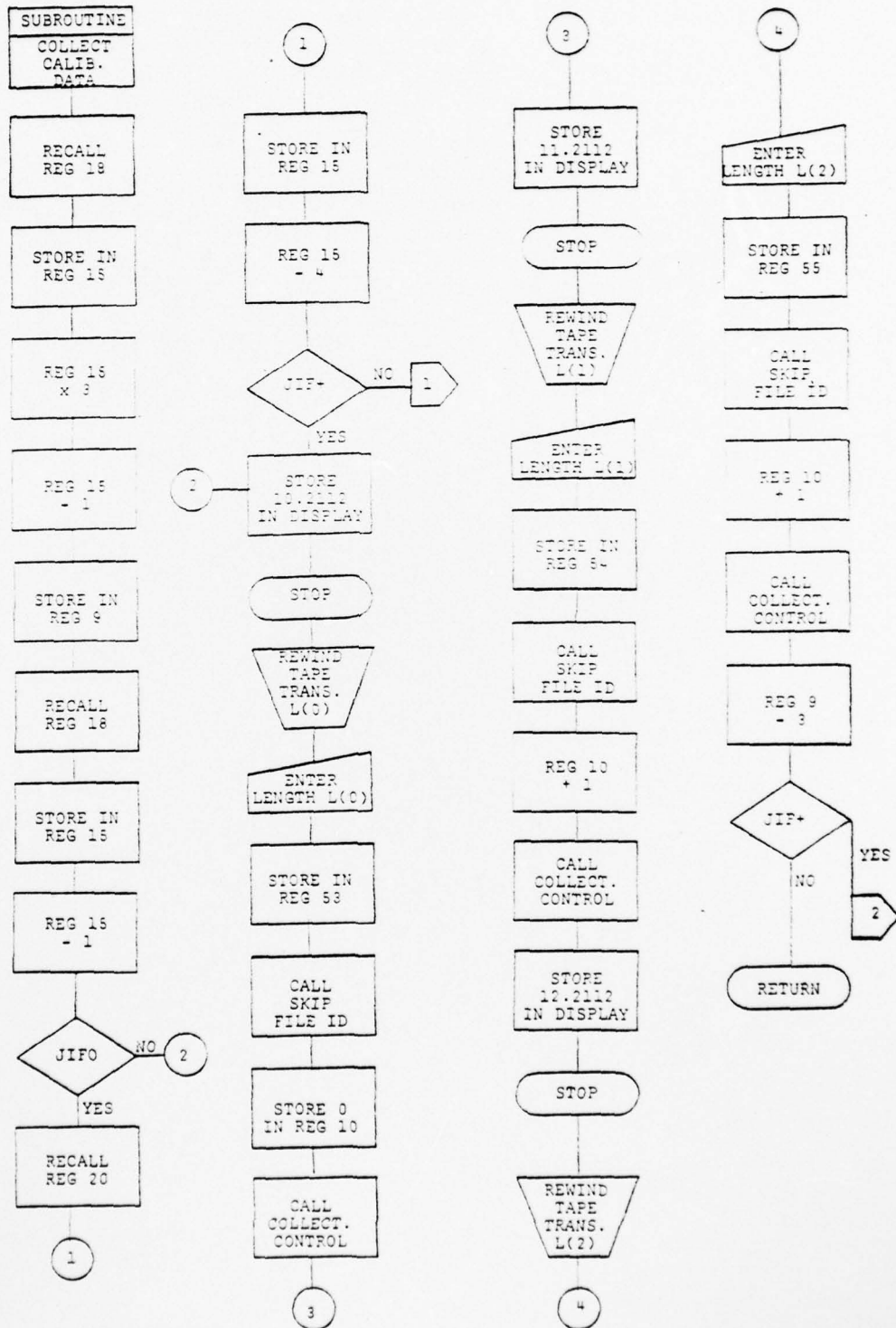


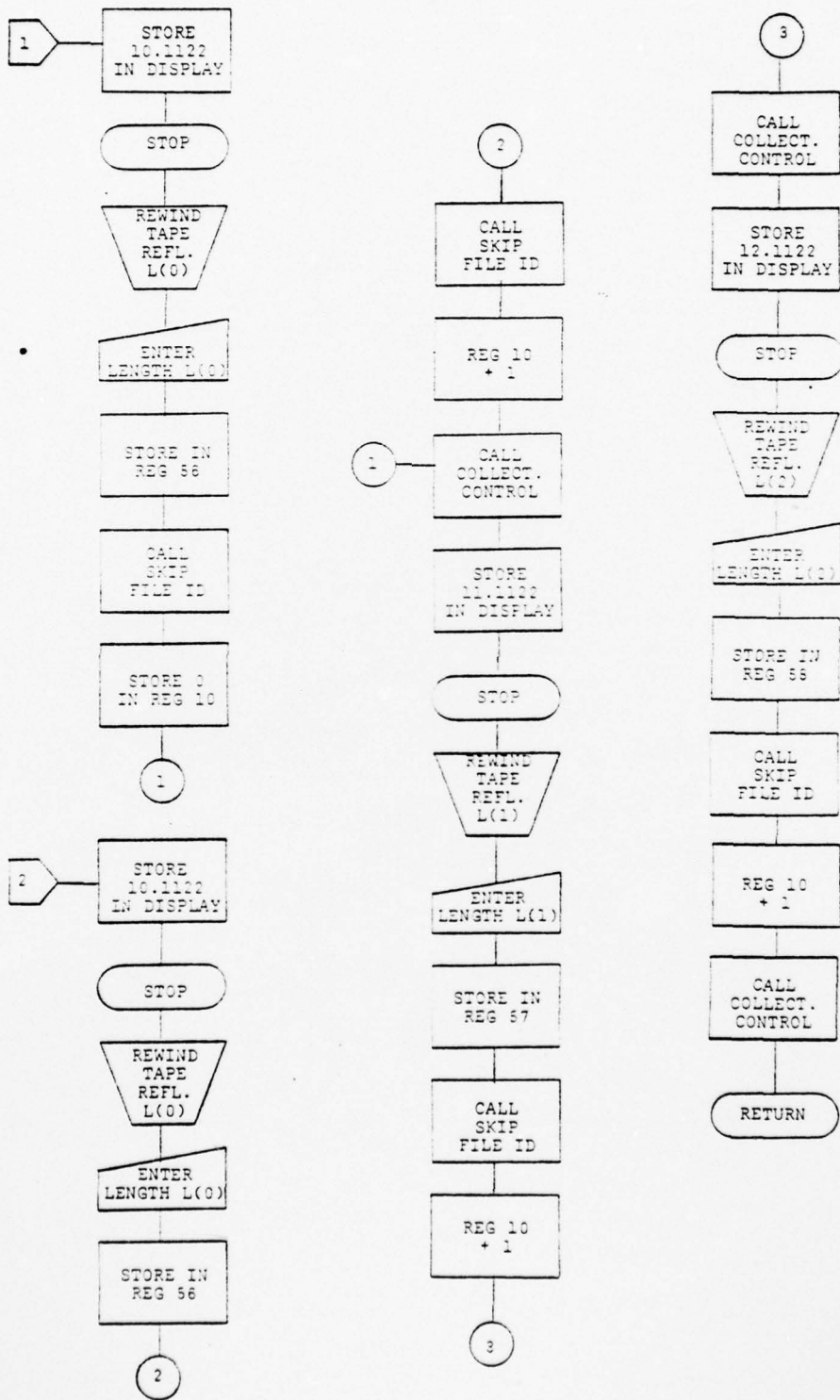
SUBROUTINE NAME: DECODE		ADDRESS CODE: 1002																		
DESCRIPTION: This subroutine takes the Collection Job Code (CJC) and decodes the number. The CJC is in the following format, X.YYZZ. The X is the number of calibration data sets that are to be collected, either 0, 1, or 2. The YY in the CJC is the number of data blocks/record which will be stored on tape. The ZZ is a coded representation of the S-parameters to be measured.																				
CALLED FROM: EXECUTIVE																				
CALLS SUBROUTINES: None																				
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>0</td> <td>00</td> <td>Indirect address pointer</td> </tr> <tr> <td>18</td> <td>T+02</td> <td>Number of calibration sets</td> </tr> <tr> <td>19</td> <td>T+03</td> <td>Number of data blocks/record</td> </tr> <tr> <td>20</td> <td>T+04</td> <td>S-parameters</td> </tr> <tr> <td>21</td> <td>T+05</td> <td>Collection Job Code</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	0	00	Indirect address pointer	18	T+02	Number of calibration sets	19	T+03	Number of data blocks/record	20	T+04	S-parameters	21	T+05	Collection Job Code
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																		
0	00	Indirect address pointer																		
18	T+02	Number of calibration sets																		
19	T+03	Number of data blocks/record																		
20	T+04	S-parameters																		
21	T+05	Collection Job Code																		



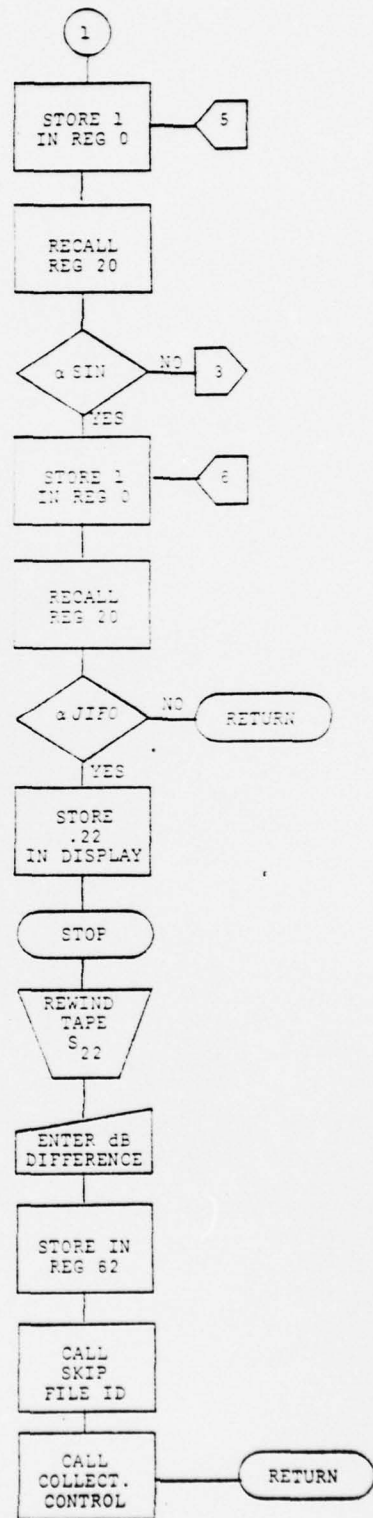
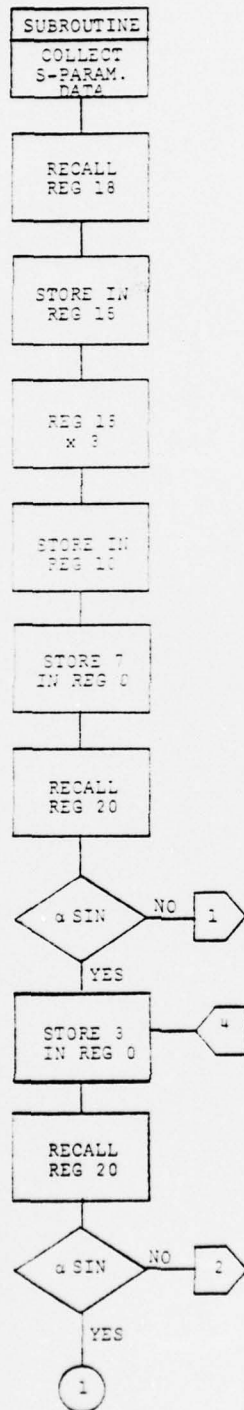
SUBROUTINE NAME:		ADDRESS																					
COLLECT CALIBRATION DATA		CODE: 1003																					
DESCRIPTION: This subroutine controls the collection of calibration data. If calibration data is to be collected, the user indicates this by putting a 1 or 2 as the first digit in the Collection Job Code. Whether the number is a 1 or 2 depends upon which scattering parameters are to be collected. If only transmission S-parameters or only reflection S-parameters are to be collected, then one set of data is required. If both a transmission and a reflection S-parameter are to be collected, then two sets of calibration data will be collected. The subroutine is called by the EXECUTIVE program when calibration data is to be collected. The subroutine determines which calibration data set is to be collected, and tells the user which channel of the test unit to activate and which of the three short circuits to set up. The user responds by: configuring the network analyzer as specified, entering in the display register the offset length of the short, and depressing the GO Key on the calculator. The offset length of the short is saved and is put in the file																							
CALLED FROM: EXECUTIVE																							
CALLS SUBROUTINES: COLLECTION CONTROL SKIP FILE ID																							
REGISTERS USED: <table> <tr> <th><u>NUMBER</u></th><th><u>CODE</u></th><th><u>PURPOSE</u></th></tr> <tr> <td>9</td><td>09</td><td>Number of blocks to be skipped to first available block</td></tr> <tr> <td>10</td><td>10</td><td>Number of calibration data blocks/record to be recorded</td></tr> <tr> <td>18</td><td>T+02</td><td>Number of calibration sets to be collected</td></tr> <tr> <td>20</td><td>T+04</td><td>S-parameter code</td></tr> <tr> <td>53</td><td>-+05</td><td>Transmission channel offset length L(0)</td></tr> <tr> <td>54</td><td>-+06</td><td>Transmission channel offset length L(1)</td></tr> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	9	09	Number of blocks to be skipped to first available block	10	10	Number of calibration data blocks/record to be recorded	18	T+02	Number of calibration sets to be collected	20	T+04	S-parameter code	53	-+05	Transmission channel offset length L(0)	54	-+06	Transmission channel offset length L(1)
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																					
9	09	Number of blocks to be skipped to first available block																					
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20	T+04	S-parameter code																					
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54	-+06	Transmission channel offset length L(1)																					

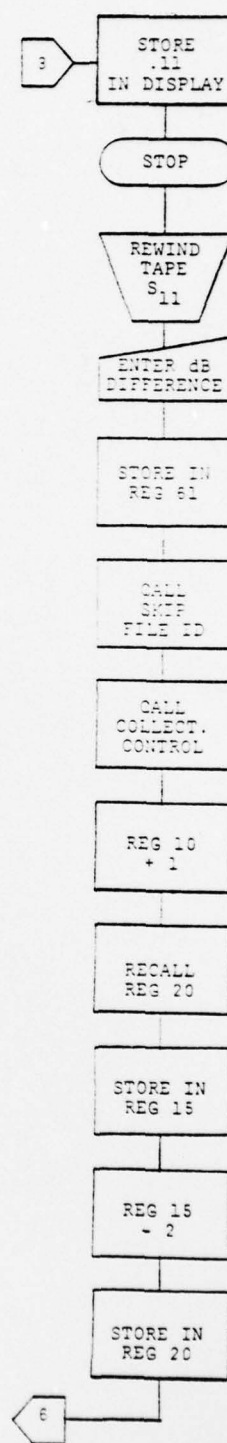
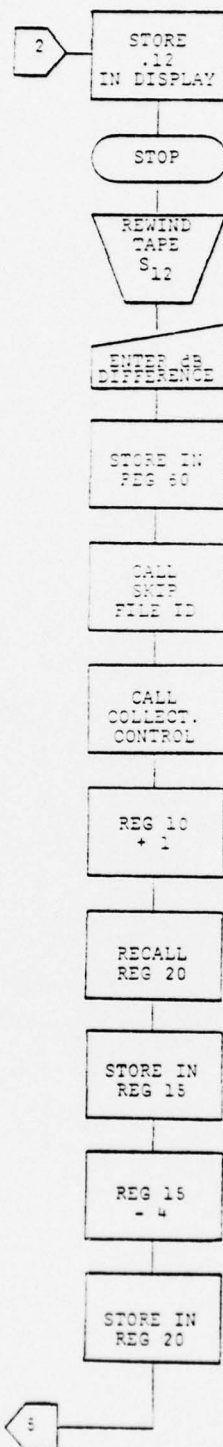
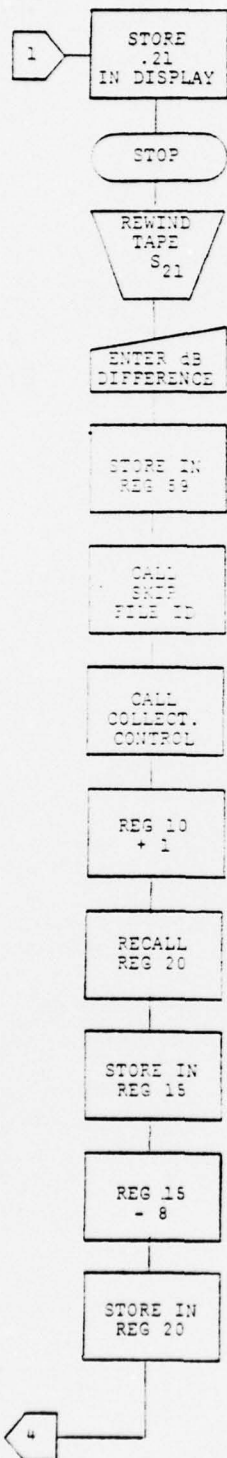
SUBROUTINE NAME:		ADDRESS
COLLECT CALIBRATION DATA		CODE:
		1003
DESCRIPTION CONTINUED:		
identification record later. The subroutine passes control to the COLLECTION CONTROL subroutine where the calibration data is collected. When all the calibration data for the configured short circuit is collected and stored, control returns to COLLECT CALIBRATION DATA. Here the program stops with a number in the display which tells the user which measurement to be taken next. The network is set up as indicated; the tape rewound, offset length entered, and the <u>GO</u> Key depressed. This routine is continued until all calibration data is collected. When this occurs, program control returns to the EXECUTIVE		
REGISTERS USED CONTINUED:		
55	-↓07	Transmission channel offset length L(2)
56	-↓08	Reflection channel offset length L(0)
57	-↓09	Reflection channel offset length L(1)
58	-↓10	Reflection channel offset length L(2)



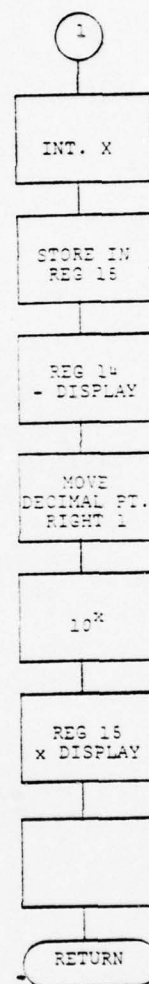
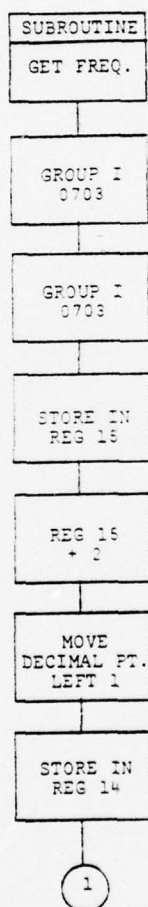


SUBROUTINE NAME:		ADDRESS CODE:
COLLECT S-PARAMETER DATA		1004
DESCRIPTION: This subroutine controls the collection of S-parameter data. It determines which S-parameters are to be collected by use of the two digit code provided in the Collection Job Code. It informs the user which parameter is to be collected by stopping execution and displaying a two-digit number in the display register. The user replies by: configuring the network analyzer for the measurement specified; entering in the display register the difference between the dB setting necessary to calibrate the network analyzer and the dB setting used for measurement; rewinding the tape; and depressing the GO key. The subroutine passes control to COLLECTION CONTROL where the data is collected and stored. When the last block of data for the S-parameter being measured is stored, control is returned to COLLECT S-PARAMETER DATA. The program is interrupted again with another two-digit number appearing in the display register. The user configures the network analyzer for the measurement specified, etc. until all the S-parameters, as specified by the Collection Job Code, have been collected and stored.		
CALLED FROM:		EXECUTIVE
CALLS SUBROUTINES:		COLLECTION CONTROL SKIP FILE ID
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
9	09	Number of S-parameters/record to be stored
10	10	Number of blocks to skip to first available
18	T+02	Number of calibration sets collected
20	T+04	S-parameters to be measured
59	-+11	dB difference for S ₂₁
60	-+12	dB difference for S ₁₂
61	-+13	dB difference for S ₁₁
62	-+14	dB difference for S ₂₂

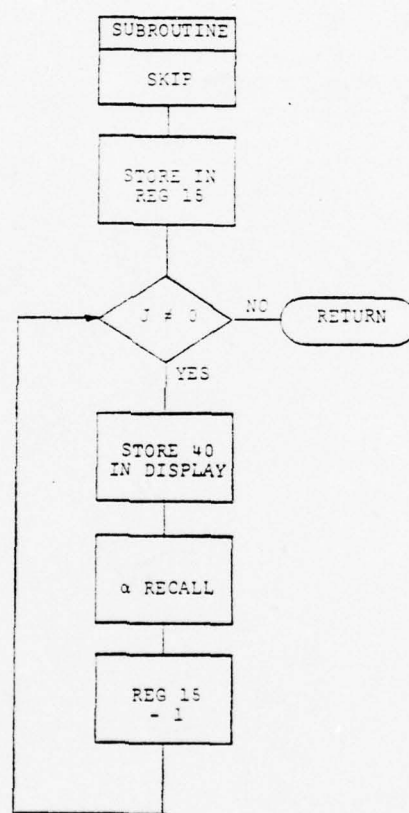




SUBROUTINE NAME:		ADDRESS						
GET FREQUENCY		CODE: 1005						
DESCRIPTION: This subroutine accesses the frequency counter with a Group I 0703 code and converts the number received in the display register to the correct frequency reading. The first Group I 0703 code sent to the counter triggers the counter to sample the sweep oscillator output RF signal. The second Group I 0703 code recovers the RF signal frequency in the following format: XXXXXY, where XXXXX are the five most significant digits of the frequency and the Y is the frequency exponent minus two. For example, a frequency of 8.1436×10^9 Hz would be received as 814363.000. The rest of the subroutine is used to convert this number (814363.000) to 8.1436×10^9.								
CALLED FROM:		ΔF VS COUNT COLLECTION CONTROL						
CALLS SUBROUTINES:		None						
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>display</td> <td>-</td> <td>Present frequency</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	display	-	Present frequency
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>						
display	-	Present frequency						



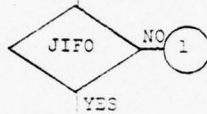
SUBROUTINE NAME:		ADDRESS CODE:
SKIP		1006
DESCRIPTION: This subroutine advances the cassette tape the number of blocks indicated by the number found in the display register. The tape is advanced by reading blocks from tape into a scratch I/O Buffer.		
CALLED FROM: COLLECTION CONTROL		
CALLS SUBROUTINES: None		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
38	+↓06	scratch I/O buffer
39	+↓07	scratch I/O buffer
40	+↓08	scratch I/O buffer
display	-	# blocks to be skipped



SUBROUTINE NAME:		ADDRESS																		
COLLECTION CONTROL		CODE:																		
		1007																		
DESCRIPTION: The subroutine controls the cassette tape for the collection of both S-parameter data and calibration data. It first determines if the ID block for each record has been written on tape by checking for a minus one in register 17. If register 17 equals minus 1, then the FORM ID BLOCK AND COLLECT FIRST DATA BLOCK subroutine is called. When the first two blocks of each record have been written on tape, control returns to COLLECTION.CONTROL, where registers are adjusted for the next measurement. Program control then returns to the calling subroutine, either COLLECT S-PARAMETER DATA or COLLECT CALIBRATION DATA, where the program is interrupted so that the network analyzer can be configured for the next measurement.																				
CALLED FROM: COLLECT CALIBRATION DATA COLLECT S-PARAMETER DATA																				
CALLS SUBROUTINES: FORM ID BLOCK AND COLLECT FIRST DATA BLOCK SKIP OBTAIN DATA AND STORE																				
REGISTERS USED: <table border="1"> <thead> <tr> <th>NUMBER</th> <th>CODE</th> <th>PURPOSE</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>10</td> <td>Number of blocks to skip to next available block</td> </tr> <tr> <td>16</td> <td>T+01</td> <td>Total number of records in file</td> </tr> <tr> <td>17</td> <td>T+02</td> <td>Flag to indicate if ID blocks recorded</td> </tr> <tr> <td>19</td> <td>T+04</td> <td>Number of blocks left to be recorded</td> </tr> <tr> <td>27</td> <td>T+11</td> <td>Desired frequency</td> </tr> </tbody> </table>			NUMBER	CODE	PURPOSE	10	10	Number of blocks to skip to next available block	16	T+01	Total number of records in file	17	T+02	Flag to indicate if ID blocks recorded	19	T+04	Number of blocks left to be recorded	27	T+11	Desired frequency
NUMBER	CODE	PURPOSE																		
10	10	Number of blocks to skip to next available block																		
16	T+01	Total number of records in file																		
17	T+02	Flag to indicate if ID blocks recorded																		
19	T+04	Number of blocks left to be recorded																		
27	T+11	Desired frequency																		

SUBROUTINE
COLLECT.
CONTROL

RECALL
REG 17



STORE 2
IN DISPLAY

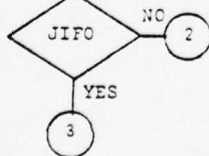
α RECALL

RECALL
REG 9

STORE IN
REG 13

RECALL
REG 16

REG 15
- DISPLAY



2

RECALL
REG 2

STORE IN
REG 27

RECALL
REG 10

CALL
SKIP

CALL
OBTAIN
DATA AND
STORE

RECALL
REG 19

CALL
SKIP

4

1

CALL FORM
ID BLOCK
& 1st DATA
BLOCK

5

3

RECALL
REG 2

STORE IN
REG 27

RECALL
REG 10

CALL
SKIP

CALL
OBTAIN
DATA AND
STORE

5

REG 19
- 1

RETURN

AD-A040 014

NAVAL POSTGRADUATE SCHOOL MONTEREY CALIF
A CALCULATOR CONTROLLED MICROWAVE NETWORK ANALYZER SYSTEM.(U)
MAR 77 D K YOUNG

F/G 17/2.1

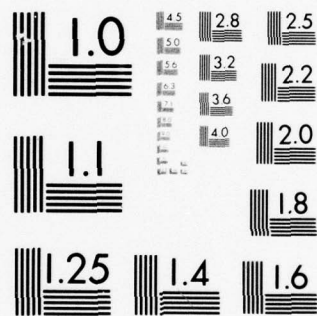
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2 OF 2

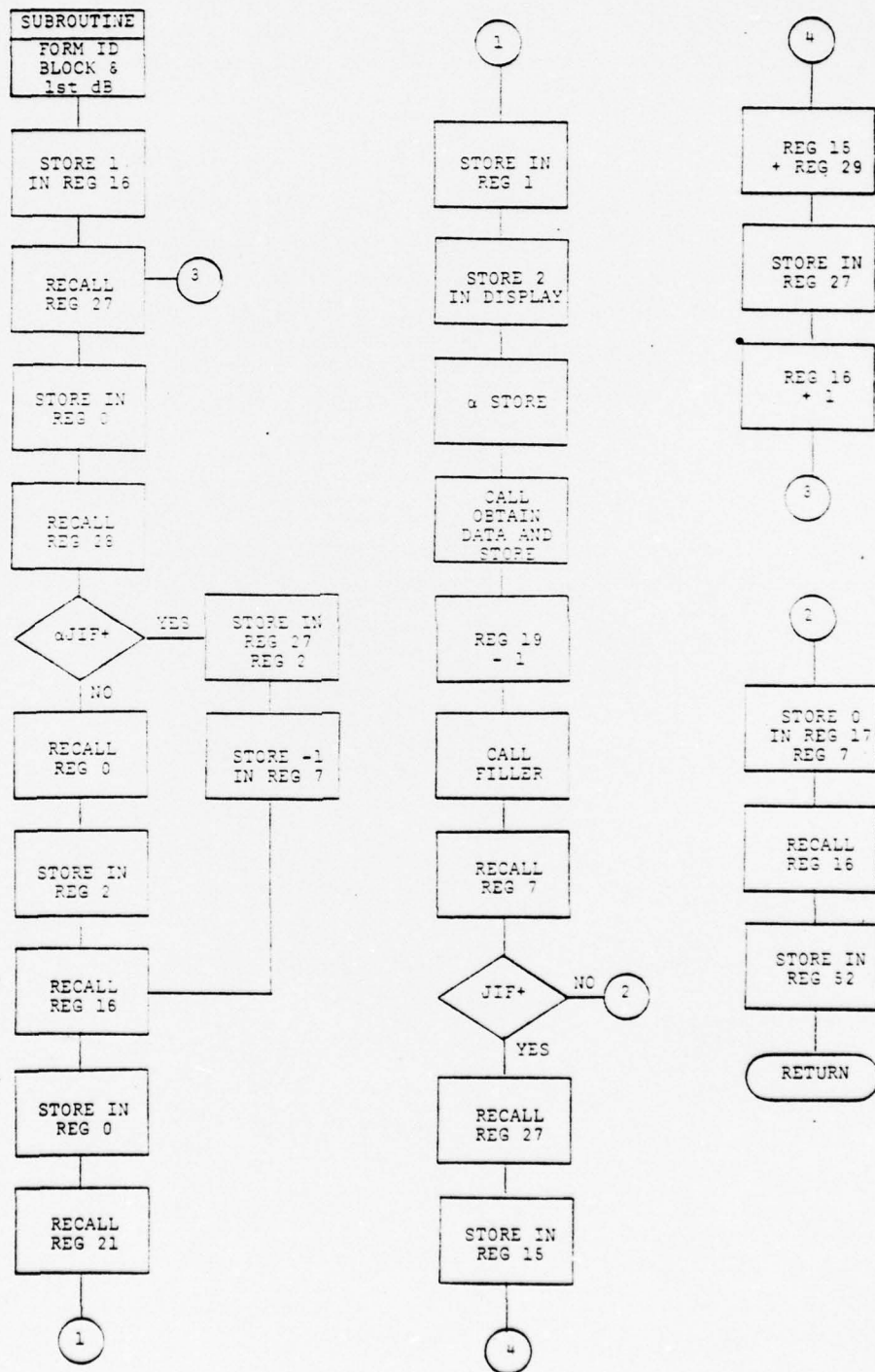
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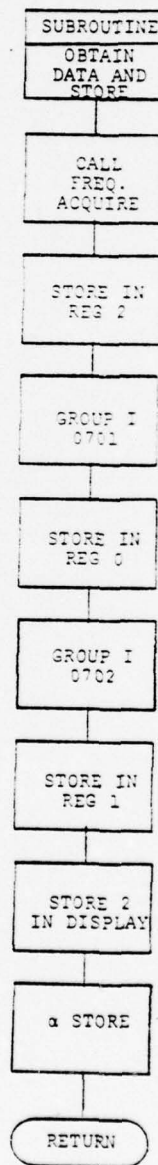


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUBROUTINE NAME: FORM ID BLOCK AND COLLECT FIRST DATA BLOCK		ADDRESS CODE: 1008
DESCRIPTION: This subroutine is called by the subroutine COLLECTION CONTROL the first time data is collected. Its purpose is to form the identification block and to collect the first block of data for each record. The ID block consists of an integer indicating the record number, the Collection Job Code, and the frequency at which all the data in the record is to be measured. Upon completion of the subroutine, register 17 is set to zero and register 16 is set to the number of data records in the file.		
CALLED FROM: COLLECTION CONTROL		
CALLS SUBROUTINES: OBTAIN DATA AND STORE, FILLER		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
7	07	Flag used to indicate last record
16	T+01	Running total of number of records
17	T+02	Flag - first measurement
19	T+04	Number of data blocks/record
21	T+06	Collection Job Code
27	T+11	desired frequency
28	T+12	stop frequency
29	T+13	step size



SUBROUTINE NAME: OBTAIN DATA AND STORE		ADDRESS CODE: 1009												
DESCRIPTION: This subroutine calls the FREQUENCY ACQUIRE subroutine which drives the sweep oscillator to the frequency found in register 27. It then collects the X and Y deflection voltages from the Wang 605-1A Interfaces. The X, Y deflection voltages and the frequency at which voltages were measured are then stored on the cassette tape.														
CALLED FROM:		COLLECTION CONTROL FORM ID BLOCK AND COLLECT FIRST MEASUREMENT												
CALLS SUBROUTINES:		FREQUENCY ACQUIRE												
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>00</td> <td>00</td> <td>Temporary storage X voltage</td> </tr> <tr> <td>01</td> <td>01</td> <td>Temporary storage Y voltage</td> </tr> <tr> <td>02</td> <td>02</td> <td>Temporary storage frequency</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	00	00	Temporary storage X voltage	01	01	Temporary storage Y voltage	02	02	Temporary storage frequency
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>												
00	00	Temporary storage X voltage												
01	01	Temporary storage Y voltage												
02	02	Temporary storage frequency												



SUBROUTINE NAME:		ADDRESS
FREQUENCY ACQUIRE		CODE:
		1010
DESCRIPTION:		
This subroutine is the software control of the D/A interface. The subroutine compares the desired frequency with the present frequency the sweep oscillator is generating. It compares them by first determining whether the present frequency (f_p) needs to be increased or decreased in order to match the desired frequency (f_d). A direction flag is set to minus one if f_p needs to be increased or set to plus one if f_p needs to be decreased. It next computes $f_p - f_d$ to determine how much f_p needs to be increased or decreased. If $f_p - f_d \leq 900$ KHZ, then f_p is put in the display register and control is returned to the calling subroutine. If $f_p - f_d > 900$ KHZ then the subroutine compares $f_p - f_d$ with the five ΔF/CODE values computed and stored by the ΔF VS COUNT subroutine. It chooses the function code which produces the smallest value		
CALLED FROM:		
OBTAIN DATA AND STORE		
CALLS SUBROUTINES:		
GET FREQUENCY		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
2	02	$ f_p - f_d $
3	03	Indirect pointer to F/Code registers
4	04	Present frequency
5	05	direction Flag
22	+06	ΔF for 0701/0702 codes
23	+07	ΔF for 0405/0406 codes
24	+08	ΔF for 0305/0306 codes
25	+09	ΔF for 0205/0206 codes
26	+10	ΔF for 0105/0106 codes
27	+11	desired frequency

SUBROUTINE NAME:

FREQUENCY ACQUIRE

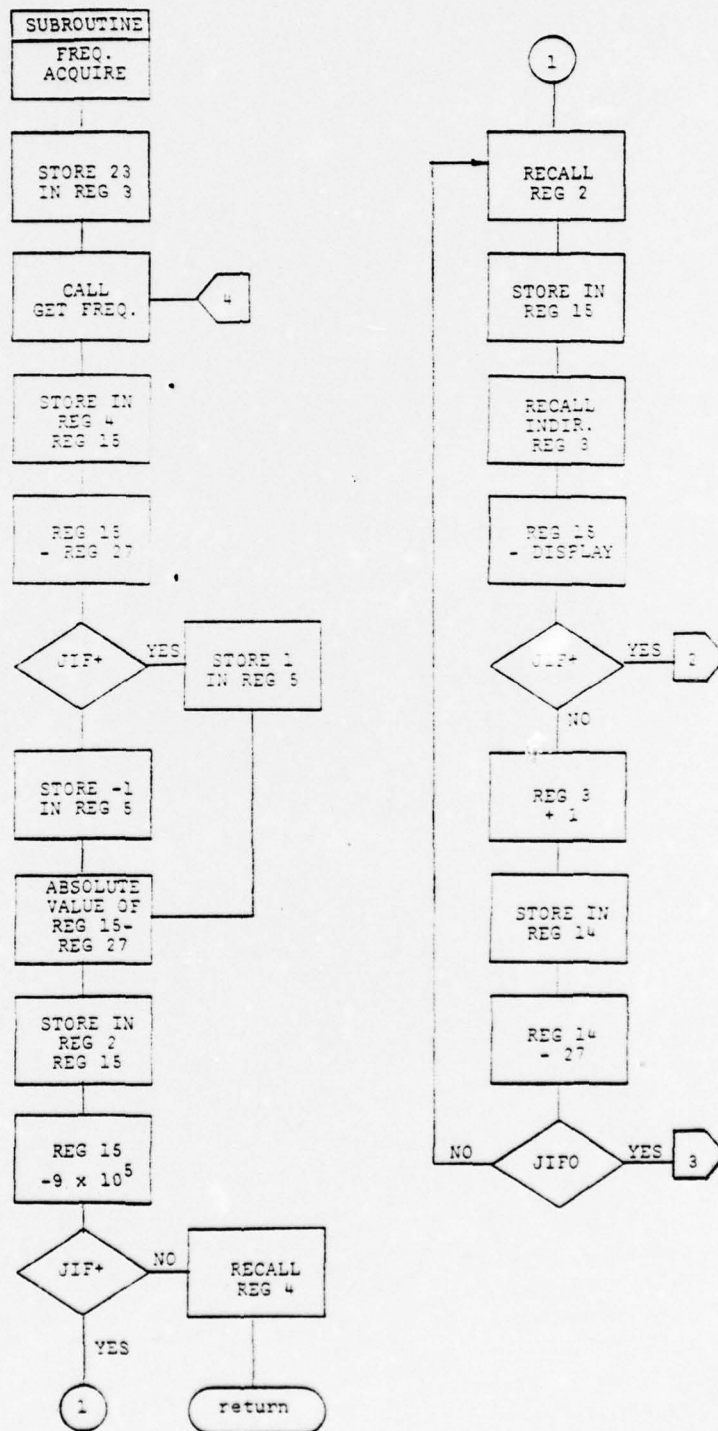
ADDRESS
CODE:

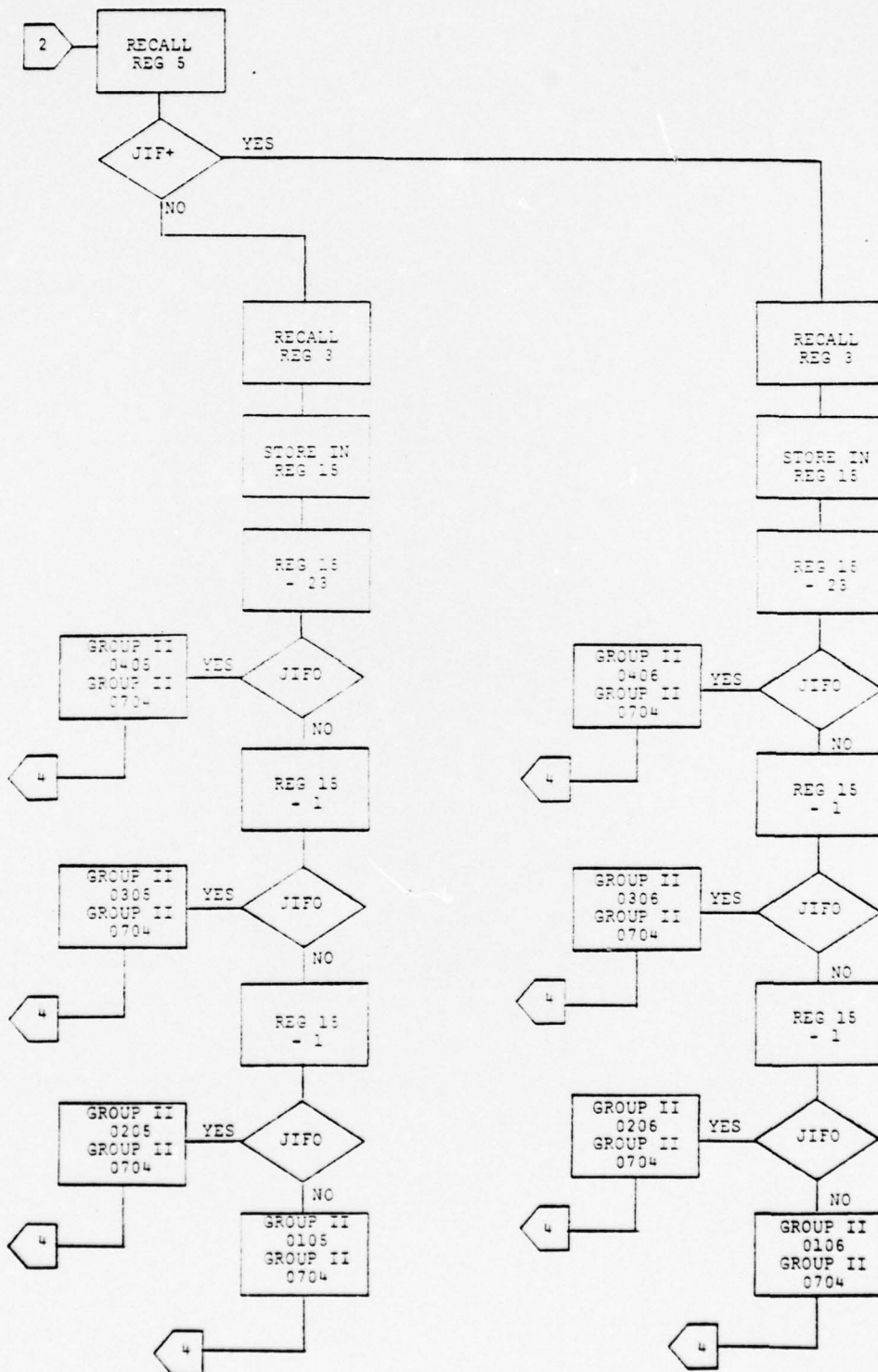
1010

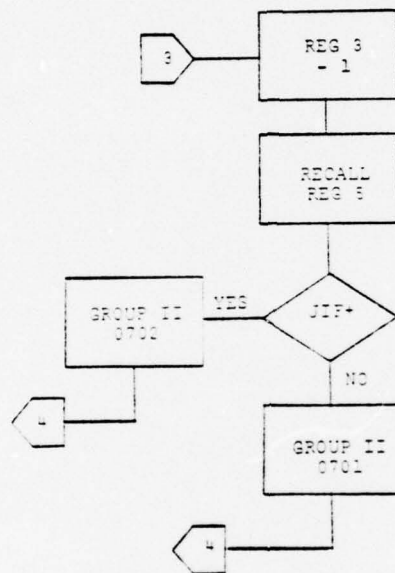
DESCRIPTION CONTINUED:

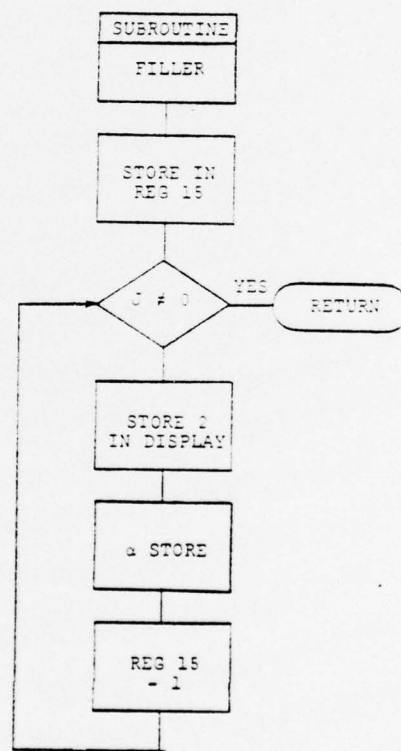
of $|\Delta F - |f_p - f_d||$. The chosen function code along with
with the direction flag are used to generate the GROUP II,
XXXX command sequence immediately followed by a GROUP II
0704 command. This procedure is repeated until

$|f_p - f_d| \leq 900 \text{ KHZ.}$









APPENDIX G

PROCEDURES FOR USING THE COLLECTION AND DISPLAY SYSTEM PROGRAMS

1. Energize hardware components as required. If data is to be obtained from the HP 8410S Network Analyzer System, calibrate the display module and ensure the HP 8690B Sweep Oscillator is in the CW mode and the External FM pushbutton is depressed. If data is to be obtained from cassette tape only, the HP 8410S Network Analyzer System need not be energized.
2. Insert the Collection and Display system program tape into the tape drive and depress the LOAD PROGRAM Key.
3. Enter in the display register the desired Display Job Code (see Appendix H) and depress the GO Key.
4. The calculator will occasionally interrupt execution with a number showing in the display register. Respond as indicated below according to the number in the display register.

Display Register
Contents

Response

- 1 Clear Display
Enter Start Frequency in HZ
Depress GO Key
- 2 Clear Display
Enter Stop Frequency in HZ
Depress GO Key
- 3 Clear Display
Enter Step Size in HZ
Depress GO Key
- 4 Clear Display
Enter Difference Between Calibration dB
Setting and dB Measurement Setting
[dB(c) - dB(m)]
Depress GO Key
- 5 Clear Display
Enter User Program Number (see Appendix I)
Depress GO Key
- 6 Rewind and Remove Collection and Display
Program Tape
Insert Data Tape, Rewind, Depress TAPE
READY
Clear Display
Depress GO Key
- 7 Clear Display
Enter a 1, 2, 3 or 4 to indicate S_{21} ,
 S_{12} , S_{11} or S_{22} , respectively.
Configure Network Analyzer to Measure
Parameter Specified
Depress GO Key
- 8 Data Specified as Being on Tape is Not
on Tape
Reinitiate Software System Using a Dif-
ferent Display Job Code Which Obtains
Data From the HP 8410S Microwave Net-
work Analyzer

APPENDIX H

DISPLAY JOB CODES

Display Job Codes are formed by the user to specify the display job to be performed by the system programs.

A Display Job Code is entered in the display register in the following format

W.XYZ

- W specifies whether or not calibration data is to be applied to the S-parameter data
- W = 0 → calibration data is Not to be applied.
- W = 1 → calibration data is to be applied and the data has been previously collected and is available on tape.
- X designates the location of the S-parameter data to be used
- X = 0 → data is to be collected from the HP 8410S Microwave Network Analyzer System
- X = 1 → data is to be retrieved from cassette tape
- Y designates which S-parameter is to be measured or retrieved
- Y = 1 → S_{21}
- Y = 2 → S_{12}
- Y = 3 → S_{11}
- Y = 4 → S_{22}
- Z specifies the display program needed by the user program
- Z = 0 → Printer Ready
- Z = 1 → Cartesian
- Z = 2 → Smith Chart
- Z = 3 → Polar

APPENDIX I
USER PROGRAM TABLE

User
Program
Number

1	S_{11}/S_{22} Printing Program
2	S_{11}/S_{22} Smith Chart Program
3	S_{12}/S_{21} Polar Plot Program
4	(Future Program)
5	(Future Program)
6	(Future Program)
7	(Future Program)
8	(Future Program)
9	(Future Program)
10	(Future Program)
11	(Future Program)

Appendix J Collection and Display System Memory Map

REGISTER NUMBER:

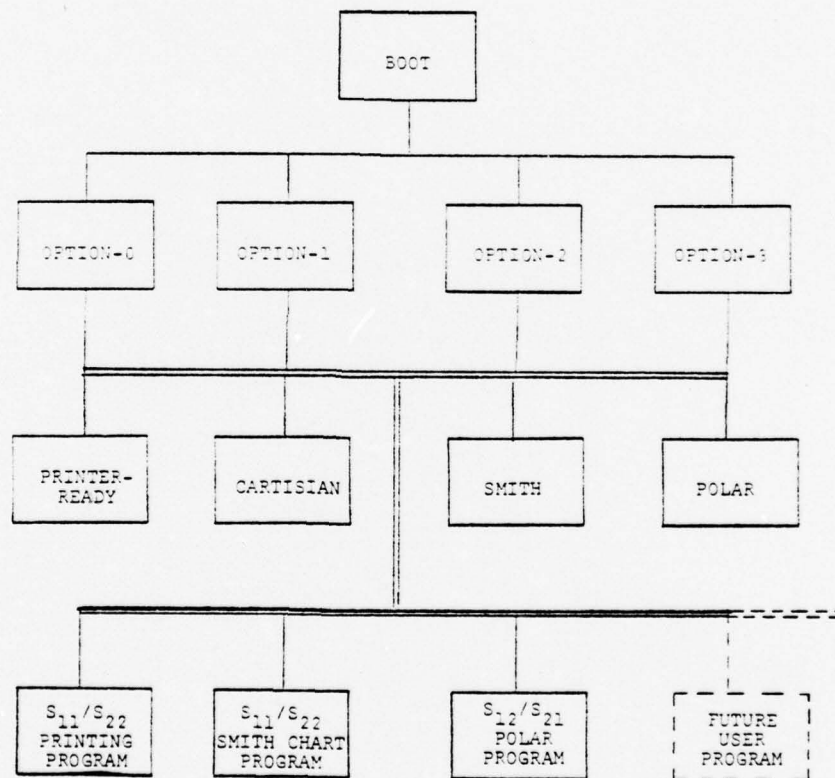
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
X VOLT L(0)	Y VOLT L(0)	MEAS FREQ	X VOLT L(1)	Y VOLT L(1)	MEAS FREQ	X VOLT L(2)	Y VOLT L(2)	HEAD FREQ	M OF DAC	X OF DAC	Y OF DAC	Z OF DAC	AF VS STEP	AF VS 000X

40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
AF VS 030X	AF VS 020X	AF VS 010X		# OF CALIB. SETS	# OF DATA BLOCK/ REC	S-PARA OR TAE	DATA RECORD #	CJC	DESR FREQ	STOP FREQ	STEP SIZE	N TOTAL # OF DATA REC	TRANS L(0)	TRANS L(1)

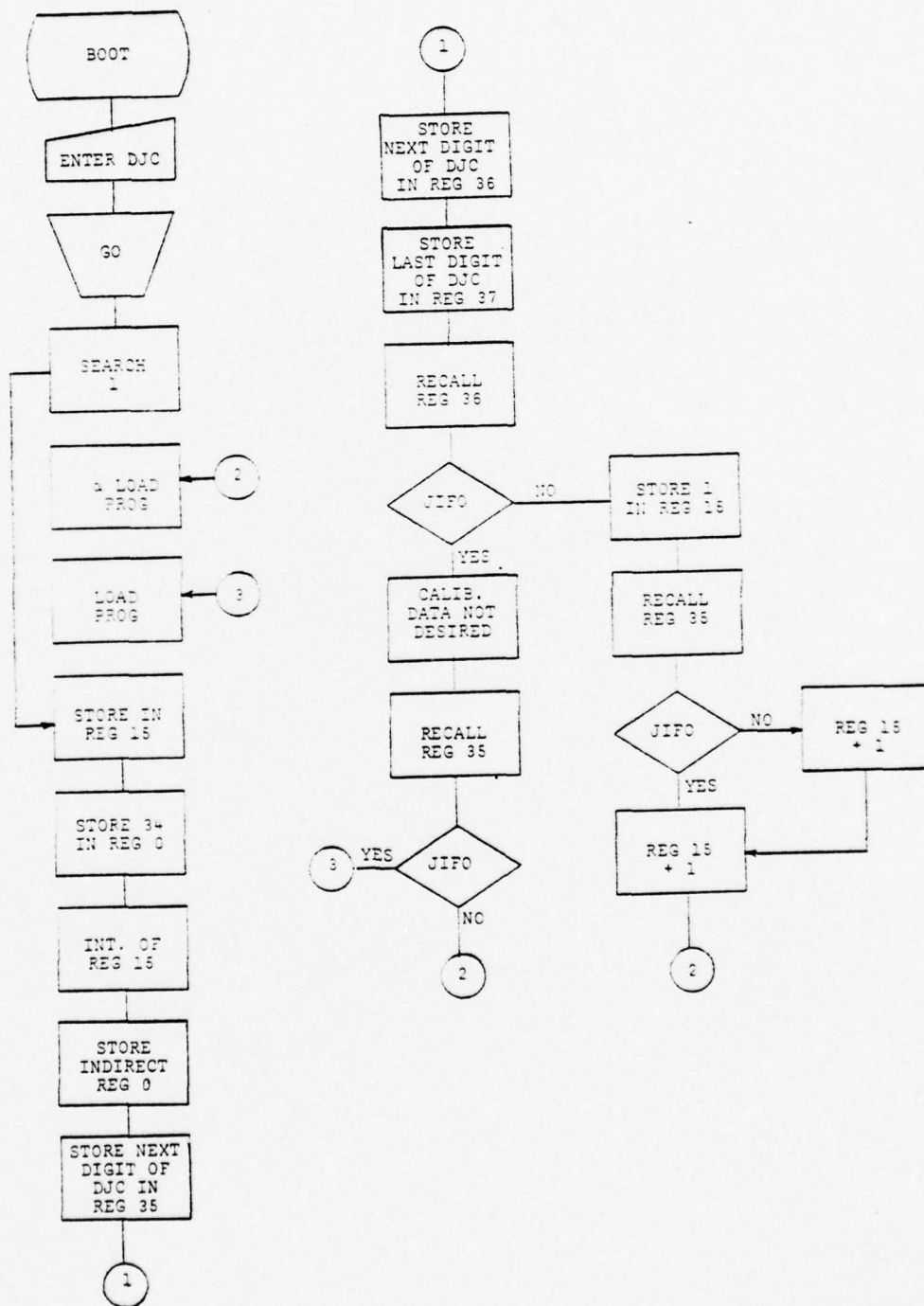
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
TRANS L(2)	REFL L(0)	REFL L(1)	REFL L(2)	S ₂₁ dB DIFF.	S ₁₂ dB DIFF.	S ₁₁ dB DIFF.	S ₂₂ dB DIFF.		# SKIPS TO DES. CALIB. SET	# SKIPS TO DES. S-PARA. ID BLK.	# SKIPS TO NEXT BUFER	SKIP BUFER	SKIP BUFER	SKIP BUFER

Appendix K

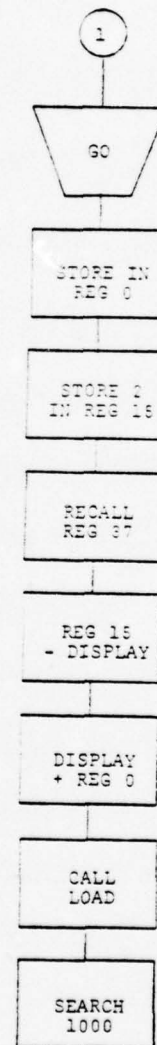
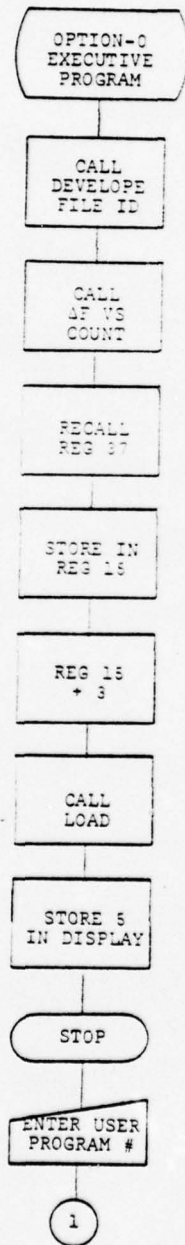
Collection and Display System Flow Charts and Descriptions



PROGRAM NAME:		ADDRESS CODE:
BOOT		None
DESCRIPTION: The bootstrap program BOOT decomposes the four digit Display Job Code (DJC) provided by the user and stores the individual digits in registers 34 through 37. Based upon the first two digits of the DJC, Boot loads, from tape, one of the four executive programs OPTION-0, OPTION-1, OPTION-2 or OPTION-3 over itself.		
CALLED FROM: Loaded by the system user		
CALLS PROGRAMS: Loads one of the four executive programs from tape		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
34	+↓02	W of DJC
35	+↓03	X of DJC
36	+↓04	Y of DJC
37	+↓05	Z of DJC

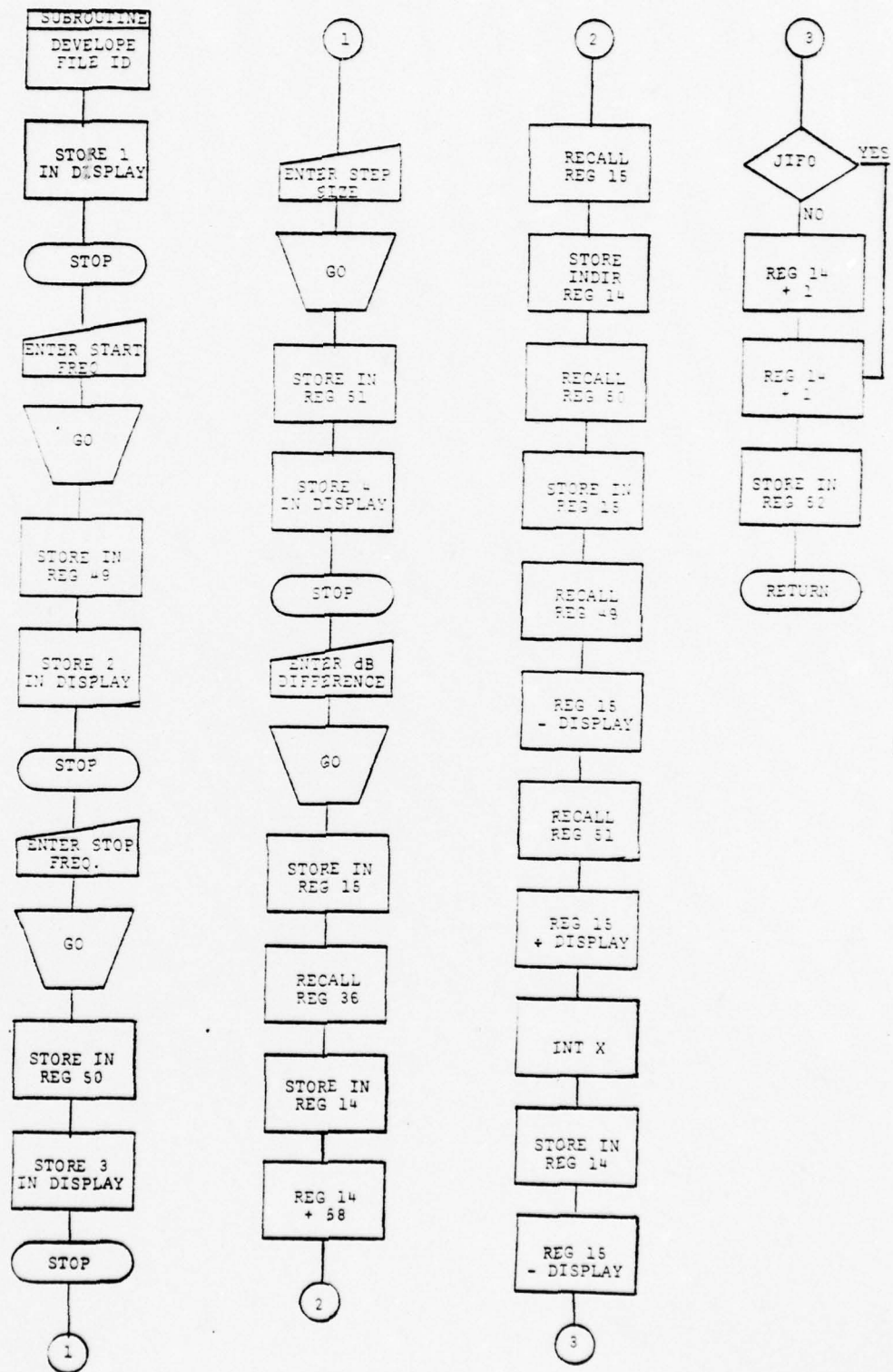


PROGRAM NAME:		ADDRESS CODE:														
OPTION-0		None														
DESCRIPTION: The executive program OPTION-0 is loaded by the system bootstrap program (BOOT). The program is composed of sub-routines which permit acquisition of S-parameter data from the HP 8410S Microwave Network Analyzer System. OPTION-0 loads and executes one of the four display programs as designated by the last digit of the DJC. It then requests a User Program Number from the user by interrupting execution with a 5 showing in the display register. The program then loads and passes control to the specified user program. OPTION-0 is composed of the following sub-routines: <table border="0"> <thead> <tr> <th></th> <th style="text-align: right;"><u>Address Code</u></th> </tr> </thead> <tbody> <tr> <td>ΔF VS COUNT</td> <td style="text-align: right;">1113</td> </tr> <tr> <td>DEVELOPE FILE ID</td> <td style="text-align: right;">1114</td> </tr> <tr> <td>GET DATA</td> <td style="text-align: right;">1112</td> </tr> <tr> <td>FREQUENCY ACQUIRE</td> <td style="text-align: right;">1111</td> </tr> <tr> <td>GET FREQUENCY</td> <td style="text-align: right;">1110</td> </tr> <tr> <td>LOAD</td> <td style="text-align: right;">1115</td> </tr> </tbody> </table>				<u>Address Code</u>	ΔF VS COUNT	1113	DEVELOPE FILE ID	1114	GET DATA	1112	FREQUENCY ACQUIRE	1111	GET FREQUENCY	1110	LOAD	1115
	<u>Address Code</u>															
ΔF VS COUNT	1113															
DEVELOPE FILE ID	1114															
GET DATA	1112															
FREQUENCY ACQUIRE	1111															
GET FREQUENCY	1110															
LOAD	1115															
CALLED FROM: Loaded by Boot																
CALLS PROGRAMS: DEVELOPE FILE ID ΔF VS COUNT LOAD																
REGISTERS USED: <table border="0"> <thead> <tr> <th style="text-align: left;"><u>NUMBER</u></th> <th style="text-align: left;"><u>CODE</u></th> <th style="text-align: left;"><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>37</td> <td>+405</td> <td>Z of DJC</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	37	+405	Z of DJC								
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>														
37	+405	Z of DJC														

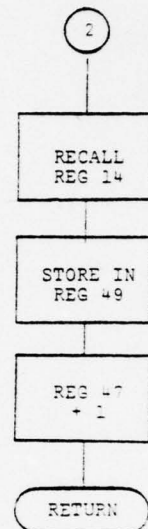
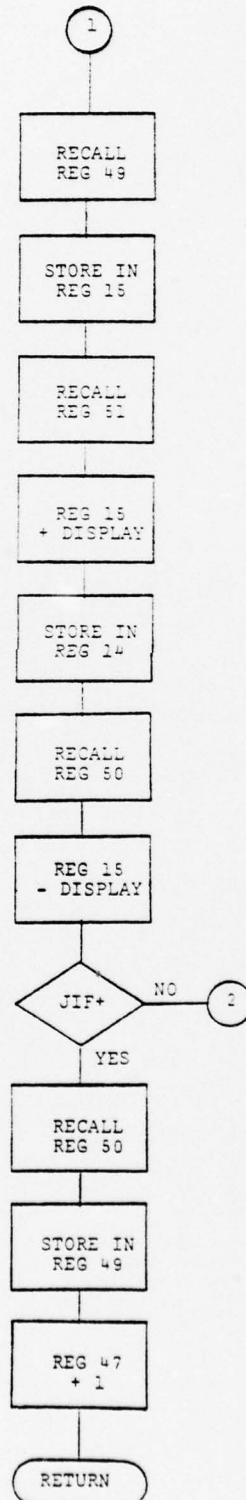
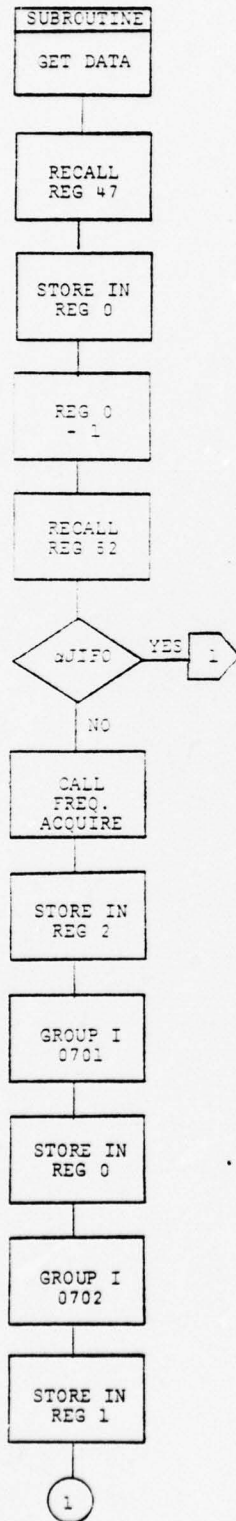


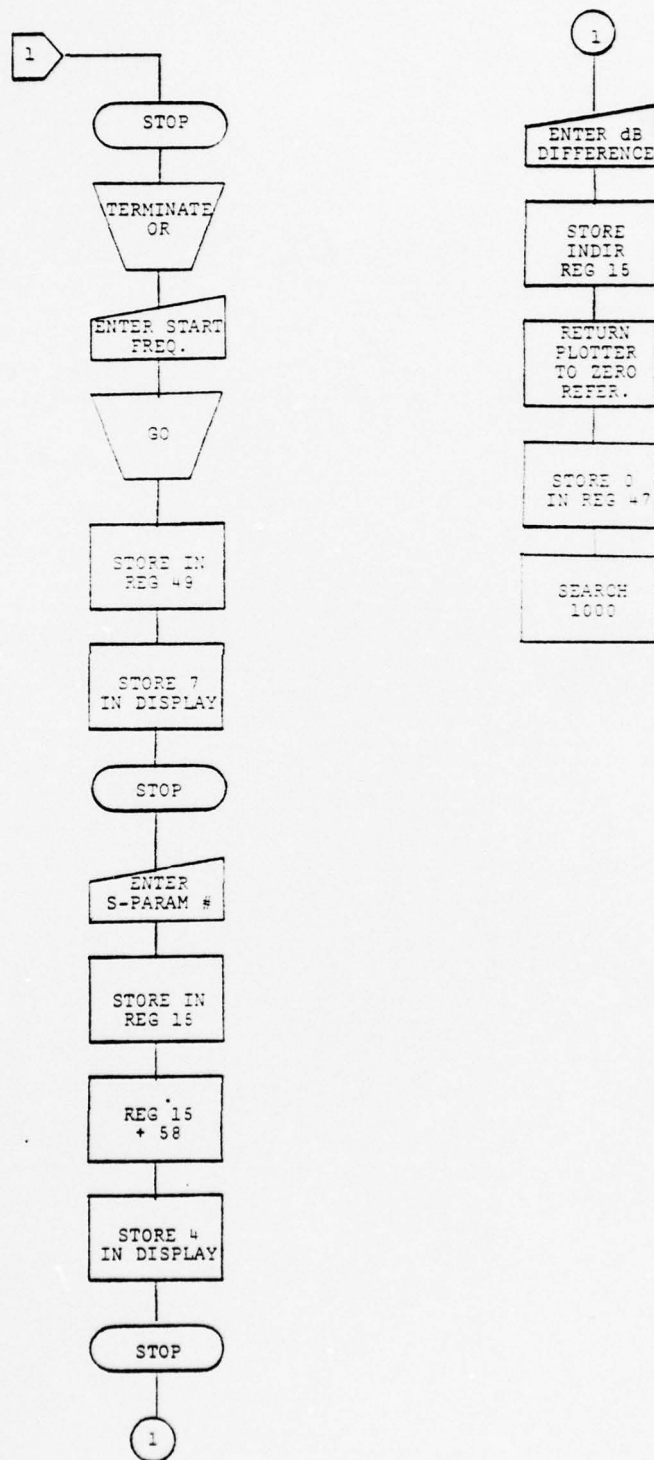
SUBROUTINE NAME: ΔF VS COUNT		ADDRESS CODE: 1113																		
DESCRIPTION: See description of subroutine ΔF VS COUNT in Appendix F. Flow chart is identical with the exception of the different registers used.																				
CALLED FROM: EXECUTIVE																				
CALLS SUBROUTINES: GET FREQUENCY																				
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>38</td> <td>+↓06</td> <td>ΔF VS 0701/0702</td> </tr> <tr> <td>39</td> <td>+↓07</td> <td>ΔF VS 0405/0406</td> </tr> <tr> <td>40</td> <td>+↓08</td> <td>ΔF VS 0305/0306</td> </tr> <tr> <td>41</td> <td>+↓09</td> <td>ΔF VS 0205/0206</td> </tr> <tr> <td>42</td> <td>+↓10</td> <td>ΔF VS 0105/0106</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	38	+↓06	ΔF VS 0701/0702	39	+↓07	ΔF VS 0405/0406	40	+↓08	ΔF VS 0305/0306	41	+↓09	ΔF VS 0205/0206	42	+↓10	ΔF VS 0105/0106
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																		
38	+↓06	ΔF VS 0701/0702																		
39	+↓07	ΔF VS 0405/0406																		
40	+↓08	ΔF VS 0305/0306																		
41	+↓09	ΔF VS 0205/0206																		
42	+↓10	ΔF VS 0105/0106																		

SUBROUTINE NAME: DEVELOPE FILE ID	ADDRESS CODE: 1114																											
DESCRIPTION: This subroutine interfaces with the system user by requesting collection information. It requests a start frequency, a stop frequency, a step size, and the difference between the dB setting used for calibration of the network display module and the dB setting used for measurement. The subroutine then computes the number of data points (N) between the start frequency and stop frequency inclusively.																												
CALLED FROM: EXECUTIVE																												
CALLS SUBROUTINES: None																												
REGISTERS USED: <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="text-align: left; width: 15%;">NUMBER</th> <th style="text-align: left; width: 15%;">CODE</th> <th style="text-align: left; width: 70%;">PURPOSE</th> </tr> </thead> <tbody> <tr> <td>36</td> <td>+04</td> <td>S-paramter to be measured</td> </tr> <tr> <td>49</td> <td>-01</td> <td>Start Frequency</td> </tr> <tr> <td>50</td> <td>-02</td> <td>Stop Frequency</td> </tr> <tr> <td>51</td> <td>-03</td> <td>Step Size</td> </tr> <tr> <td>52</td> <td>-04</td> <td>Total # of data points (N)</td> </tr> <tr> <td>59</td> <td>-11</td> <td rowspan="4"> { Used to store dB difference provided by user. Location depends on which S-parameter is to be measured as indicated by Reg 36 </td> </tr> <tr> <td>60</td> <td>-12</td> </tr> <tr> <td>61</td> <td>-13</td> </tr> <tr> <td>62</td> <td>-14</td> </tr> </tbody> </table>		NUMBER	CODE	PURPOSE	36	+04	S-paramter to be measured	49	-01	Start Frequency	50	-02	Stop Frequency	51	-03	Step Size	52	-04	Total # of data points (N)	59	-11	{ Used to store dB difference provided by user. Location depends on which S-parameter is to be measured as indicated by Reg 36	60	-12	61	-13	62	-14
NUMBER	CODE	PURPOSE																										
36	+04	S-paramter to be measured																										
49	-01	Start Frequency																										
50	-02	Stop Frequency																										
51	-03	Step Size																										
52	-04	Total # of data points (N)																										
59	-11	{ Used to store dB difference provided by user. Location depends on which S-parameter is to be measured as indicated by Reg 36																										
60	-12																											
61	-13																											
62	-14																											



SUBROUTINE NAME: GET DATA (OPTION-0)	ADDRESS CODE: 1112																		
DESCRIPTION: GET DATA is the system subroutine called by the user program to provide S-parameter data. The subroutine returns an X and Y deflection voltage obtained from the network analyzer and the output frequency of the sweep oscillator. The subroutine keeps track of how many data sets have been called for and will terminate the system when the (N + 1)st data set is requested. The GET DATA subroutine in the OPTION-0 program has one feature which is not found in the other three. When the (N + 1)st data set is called for by a user program the system interrupts execution with the total number of data sets returned showing in the display register. By entering the start frequency and depressing the <u>GO</u> Key on the calculator keyboard a recovery process is initiated. This allows for the measurement of more than one S-parameter under the same user program without having to reinitiate the whole system.																			
CALLED FROM: CORE RESIDENT User Program																			
CALLS SUBROUTINES: FREQUENCY ACQUIRE																			
REGISTERS USED: <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; width: 15%;"><u>NUMBER</u></th> <th style="text-align: left; width: 15%;"><u>CODE</u></th> <th style="text-align: left; width: 70%;"><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>47</td> <td>+15</td> <td># data sets returned to user program</td> </tr> <tr> <td>49</td> <td>-01</td> <td>Desired frequency</td> </tr> <tr> <td>50</td> <td>-02</td> <td>Stop frequency</td> </tr> <tr> <td>51</td> <td>-03</td> <td>Step size</td> </tr> <tr> <td>52</td> <td>-04</td> <td>Total # of Data sets between start and stop frequencies inclusively</td> </tr> </tbody> </table>		<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	47	+15	# data sets returned to user program	49	-01	Desired frequency	50	-02	Stop frequency	51	-03	Step size	52	-04	Total # of Data sets between start and stop frequencies inclusively
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																	
47	+15	# data sets returned to user program																	
49	-01	Desired frequency																	
50	-02	Stop frequency																	
51	-03	Step size																	
52	-04	Total # of Data sets between start and stop frequencies inclusively																	

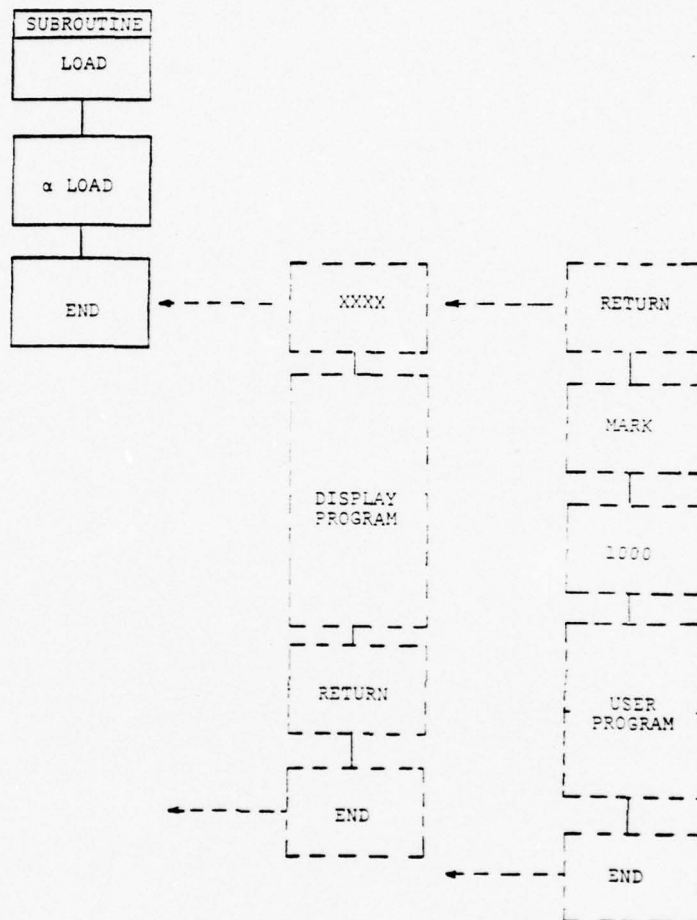




SUBROUTINE NAME:		ADDRESS CODE:
FREQUENCY ACQUIRE		1111
DESCRIPTION: See Description of subroutine FREQUENCY ACQUIRE in Appendix F. Flow chart is identical with the exception of the different registers used.		
CALLED FROM: GET DATA		
CALLS SUBROUTINES: GET FREQUENCY		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
0	00	$ f_p - f_d $
1	01	Indirect pointer to ΔF /codes Regs 39 - 42.
2	02	Present frequency
3	03	Direction Flag
49	-401	Desired Frequency

SUBROUTINE NAME: GET FREQUENCY		ADDRESS CODE: 1110
DESCRIPTION: See Description of subroutine GET FREQUENCY in Appendix F.		
CALLED FROM: ΔF VS COUNT FREQUENCY ACQUIRE		
CALLS SUBROUTINES: None		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
Display	-	Present frequency

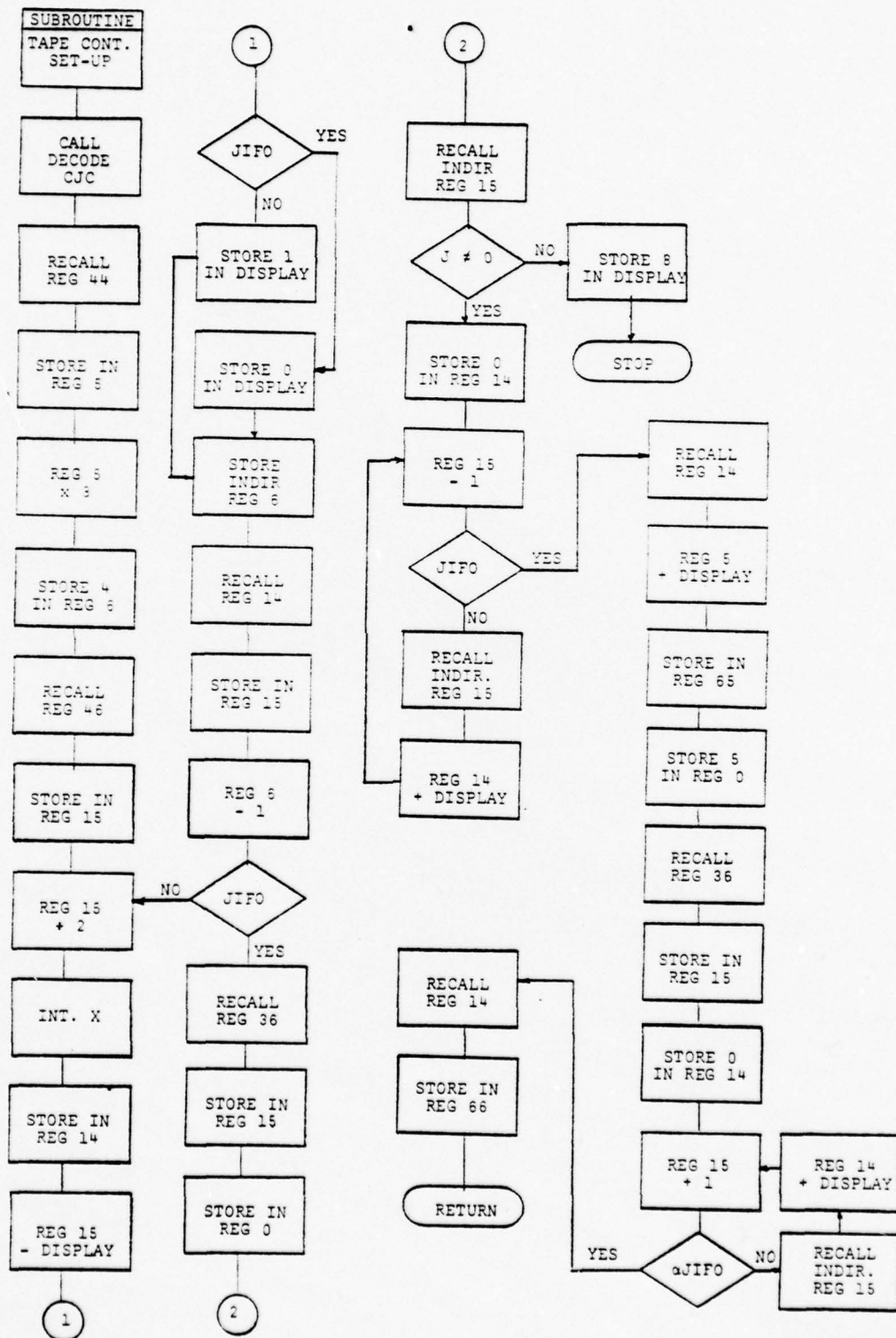
SUBROUTINE NAME:		ADDRESS CODE:						
LOAD		1115						
DESCRIPTION: LOAD is a three instruction subroutine which is called by the executive program to load programs found on tape. The instructions are MARK 1115, α LOAD, END PROGRAM. When called the α LOAD instruction skips the number of programs on tape indicated by the number in the display register. It then loads the next program into core beginning at the location of the END PROGRAM instruction. Once the program is loaded execution begins. Display programs which are loaded by this subroutine are immediately executed after loading. User programs which are also loaded by this subroutine are written with a RETURN instruction as its first executable instruction. When the return instruction is executed the calculator returns to the address which is on top of subroutine RETURN address stack; in this case it will be the location in the executive program from where the LOAD subroutine was called.								
CALLED FROM: EXECUTIVE								
CALLS SUBROUTINES: None								
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>Display</td> <td>-</td> <td># in display indicates how many programs on tape will be skipped before loading.</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	Display	-	# in display indicates how many programs on tape will be skipped before loading.
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>						
Display	-	# in display indicates how many programs on tape will be skipped before loading.						



PROGRAM NAME:		ADDRESS CODE:																				
OPTION-1		None																				
DESCRIPTION: The executive program OPTION-1 is loaded by the system bootstrap program (BOOT). The program is composed of subroutines which permit retrieval of S-parameter data from cassette tape. OPTION-0 loads and executes one of the four display programs as specified by the last digit of the DJC. It then requests a User Program Number from the user by interrupting execution with a 5 showing in the display register. The executive program loads the user program over the display program and then interrupts execution with a 6 showing in the display register. The user removes the program tape and inserts the data tape from which the S-parameter data is to be retrieved. Other preliminary functions are performed by OPTION-1 and then control is passed to the resident user program OPTION-1 is composed of the following subroutines: <table> <tr> <td>TAPE CONTROL SET-UP</td> <td>1114</td> <td>LOAD</td> <td>1115</td> </tr> <tr> <td>DECODE CJC</td> <td>1109</td> <td></td> <td></td> </tr> <tr> <td>GET DATA</td> <td>1112</td> <td></td> <td></td> </tr> <tr> <td>OBTAIN DATA</td> <td>1107</td> <td></td> <td></td> </tr> <tr> <td>SKIP</td> <td>1106</td> <td></td> <td></td> </tr> </table>			TAPE CONTROL SET-UP	1114	LOAD	1115	DECODE CJC	1109			GET DATA	1112			OBTAIN DATA	1107			SKIP	1106		
TAPE CONTROL SET-UP	1114	LOAD	1115																			
DECODE CJC	1109																					
GET DATA	1112																					
OBTAIN DATA	1107																					
SKIP	1106																					
CALLED FROM: LOADED BY BOOT																						
CALLS PROGRAMS: LOAD TAPE CONTROL SET-UP																						
REGISTERS USED: <table> <thead> <tr> <th>NUMBER</th> <th>CODE</th> <th>PURPOSE</th> </tr> </thead> <tbody> <tr> <td>37</td> <td>+↑05</td> <td>Z of Display Job Code</td> </tr> <tr> <td>48 thru</td> <td>-↑00</td> <td>Input buffer for the file ID record</td> </tr> <tr> <td>62</td> <td>thru</td> <td></td> </tr> <tr> <td></td> <td>-↑14</td> <td></td> </tr> </tbody> </table>			NUMBER	CODE	PURPOSE	37	+↑05	Z of Display Job Code	48 thru	-↑00	Input buffer for the file ID record	62	thru			-↑14						
NUMBER	CODE	PURPOSE																				
37	+↑05	Z of Display Job Code																				
48 thru	-↑00	Input buffer for the file ID record																				
62	thru																					
	-↑14																					

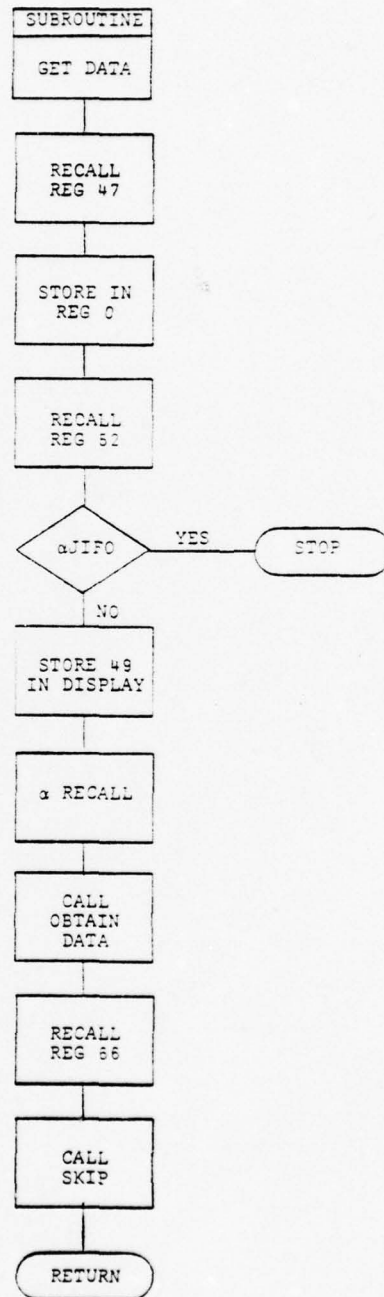


SUBROUTINE NAME:		ADDRESS CODE:																		
TAPE CONTROL SET-UP		1114																		
DESCRIPTION: This subroutine is used to set up control registers needed to extract data from tape. It determines how many data blocks must be skipped to drive the cassette tape to the data block containing the S-parameter data specified in the Display Job Code. It then computes how many data blocks must be skipped to drive the cassette tape to the beginning of the next record. This information is obtained through the use of the third digit of the Display Job Code (DJC) and the last two digits of the Collection Job Code (CJC). If a S-parameter specified in the DJC is not recorded on tape the subroutine will terminate the system by putting an 8 in the display register and stopping execution.																				
CALLED FROM: EXECUTIVE																				
CALLS SUBROUTINES: DECODE CJC																				
REGISTERS USED: <table border="1"> <thead> <tr> <th>NUMBER</th> <th>CODE</th> <th>PURPOSE</th> </tr> </thead> <tbody> <tr> <td>36</td> <td>+↓04</td> <td>S-parameter specified in DJC</td> </tr> <tr> <td>44</td> <td>+↓12</td> <td># calibration sets/record on tape</td> </tr> <tr> <td>46</td> <td>+↓14</td> <td>S-parameters on tape</td> </tr> <tr> <td>65</td> <td>X↓01</td> <td># skips to desired S-parameter</td> </tr> <tr> <td>66</td> <td>X↓02</td> <td># skips to next record ID block</td> </tr> </tbody> </table>			NUMBER	CODE	PURPOSE	36	+↓04	S-parameter specified in DJC	44	+↓12	# calibration sets/record on tape	46	+↓14	S-parameters on tape	65	X↓01	# skips to desired S-parameter	66	X↓02	# skips to next record ID block
NUMBER	CODE	PURPOSE																		
36	+↓04	S-parameter specified in DJC																		
44	+↓12	# calibration sets/record on tape																		
46	+↓14	S-parameters on tape																		
65	X↓01	# skips to desired S-parameter																		
66	X↓02	# skips to next record ID block																		

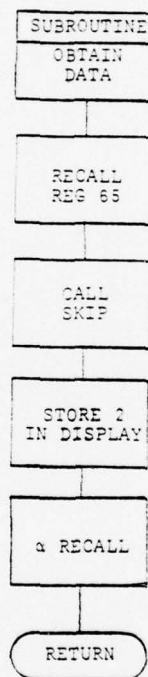


SUBROUTINE NAME:		ADDRESS																		
DECODE CJC		CODE: 1109																		
DESCRIPTION: See subroutine DECODE in Appendix F. Flow chart is identical with the exception of the registers used.																				
CALLED FROM: TAPE CONTROL SET-UP																				
CALLS SUBROUTINES: None																				
REGISTERS USED: <table border="1"> <thead> <tr> <th>NUMBER</th> <th>CODE</th> <th>PURPOSE</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>00</td> <td>Indirect address pointer</td> </tr> <tr> <td>44</td> <td>+v12</td> <td># of calibration sets</td> </tr> <tr> <td>45</td> <td>+v13</td> <td># of data blocks/record</td> </tr> <tr> <td>46</td> <td>+v14</td> <td>S-parameters on tape</td> </tr> <tr> <td>48</td> <td>-v00</td> <td>Collection Job Code</td> </tr> </tbody> </table>			NUMBER	CODE	PURPOSE	0	00	Indirect address pointer	44	+v12	# of calibration sets	45	+v13	# of data blocks/record	46	+v14	S-parameters on tape	48	-v00	Collection Job Code
NUMBER	CODE	PURPOSE																		
0	00	Indirect address pointer																		
44	+v12	# of calibration sets																		
45	+v13	# of data blocks/record																		
46	+v14	S-parameters on tape																		
48	-v00	Collection Job Code																		

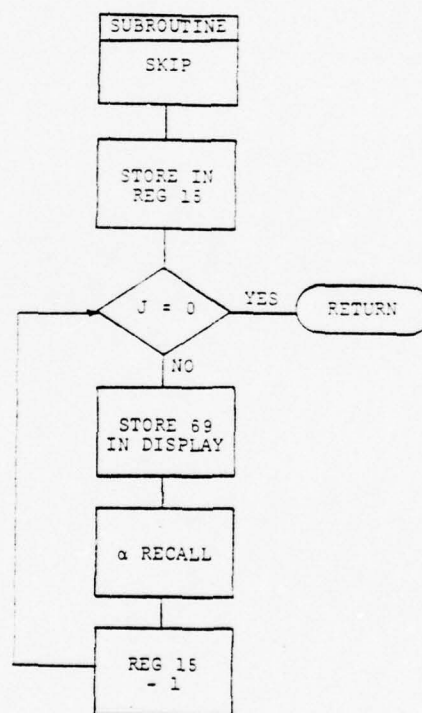
SUBROUTINE NAME: GET DATA (OPTION-1)	ADDRESS CODE: 1112															
DESCRIPTION: GET DATA, upon request of the user program, checks to see if the last data block sent to the user program was the last block available. If it was, the system is terminated if not, the next data block is obtained from the tape and passed to the user program.																
CALLED FROM: Resident User Program																
CALLS SUBROUTINES: OBTAIN DATA SKIP																
REGISTERS USED: <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="text-align: left;"><u>NUMBER</u></th> <th style="text-align: left;"><u>CODE</u></th> <th style="text-align: left;"><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>47</td> <td>+↓15</td> <td>Record # from record ID block</td> </tr> <tr> <td>48</td> <td>-↓00</td> <td>Collection Job Code from record ID block</td> </tr> <tr> <td>49</td> <td>-↓01</td> <td>Desired frequency from record ID block</td> </tr> <tr> <td>66</td> <td>X↓02</td> <td># skips to next record ID block</td> </tr> </tbody> </table>		<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	47	+↓15	Record # from record ID block	48	-↓00	Collection Job Code from record ID block	49	-↓01	Desired frequency from record ID block	66	X↓02	# skips to next record ID block
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>														
47	+↓15	Record # from record ID block														
48	-↓00	Collection Job Code from record ID block														
49	-↓01	Desired frequency from record ID block														
66	X↓02	# skips to next record ID block														



SUBROUTINE NAME: OBTAIN DATA		ADDRESS CODE: 1107
DESCRIPTION: This subroutine obtains the required S-parameter data from tape and loads the X and Y deflection voltages in registers 00 and 01 respectively. The measured frequency is loaded into register 03		
CALLED FROM: GET DATA		
CALLS SUBROUTINES: SKIP		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
0	00	Input buffer
1	01	Input buffer
2	02	Input buffer
65	X+01	# skips to desired S-parameter

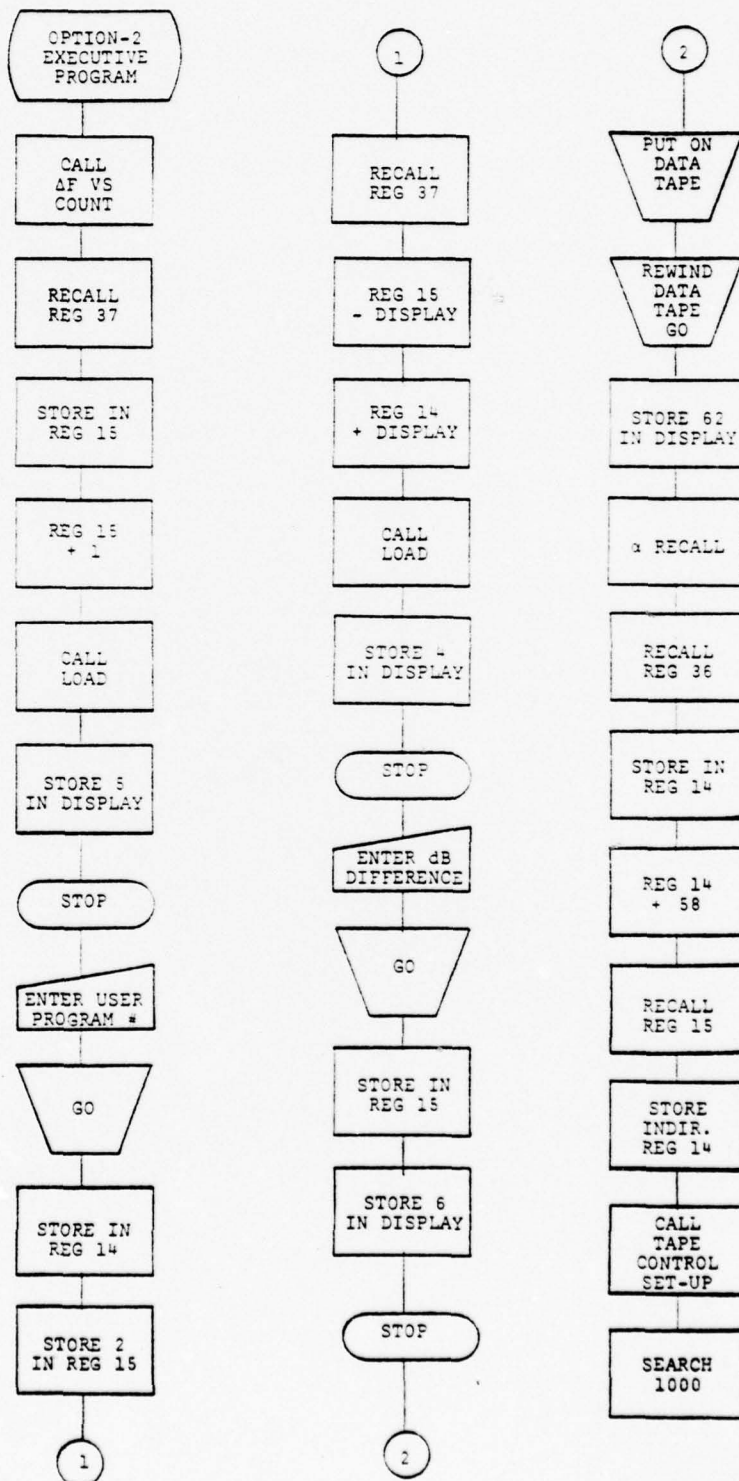


SUBROUTINE NAME:		ADDRESS CODE:												
SKIP		1106												
DESCRIPTION: SKIP advances the cassette tape the number of blocks specified by the contents of display register. The cassette tape is advanced by reading blocks of data into a scratch buffer.														
CALLED FROM:		GET DATA OBTAIN DATA												
CALLS SUBROUTINES:		None												
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>67</td> <td>X+03</td> <td></td> </tr> <tr> <td>68</td> <td>X+04</td> <td>Scratch Buffer</td> </tr> <tr> <td>69</td> <td>X+05</td> <td></td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	67	X+03		68	X+04	Scratch Buffer	69	X+05	
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67	X+03													
68	X+04	Scratch Buffer												
69	X+05													

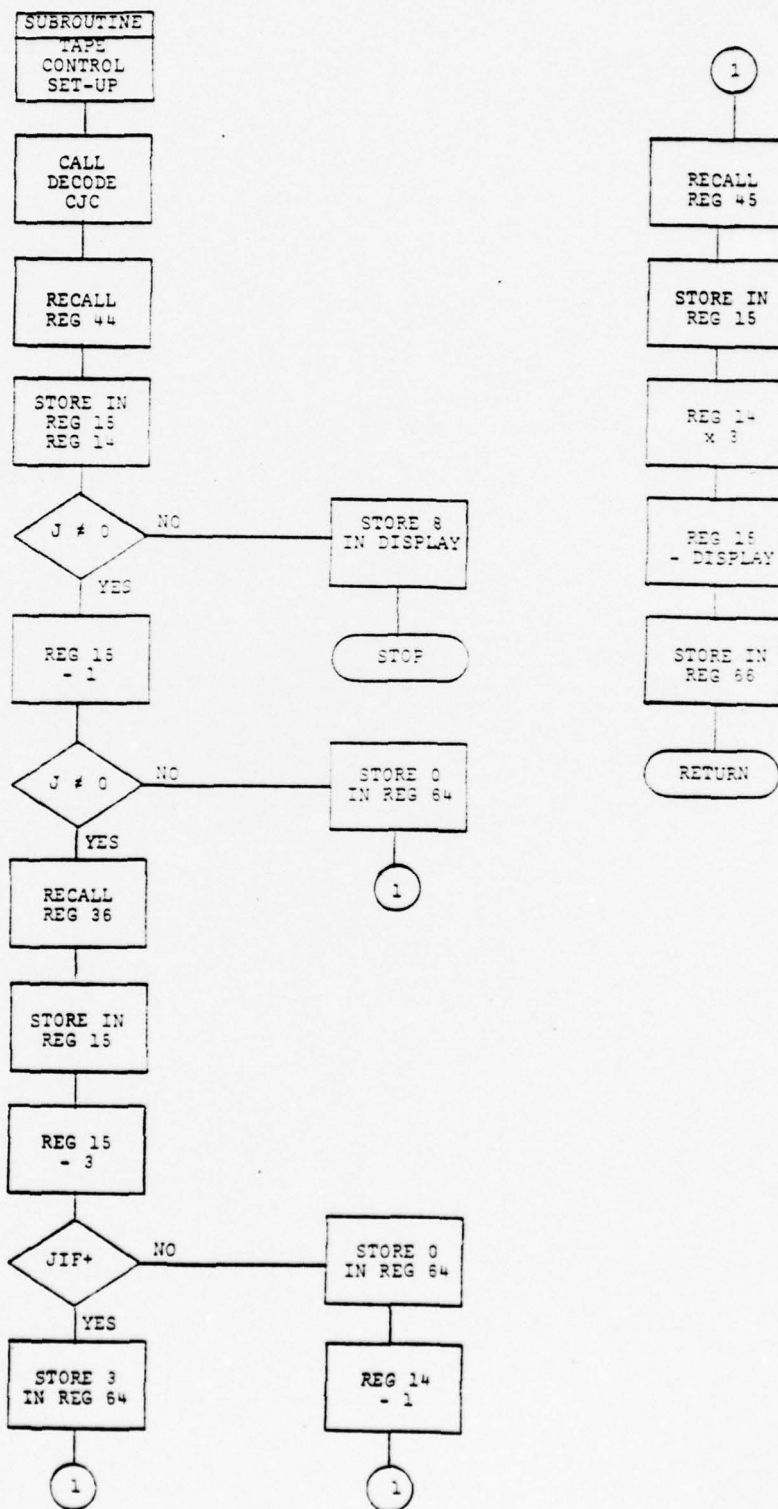


SUBROUTINE NAME:		ADDRESS						
LOAD		CODE: 1115						
DESCRIPTION: See description of subroutine LOAD in OPTION-0. Flow chart identical.								
CALLED FROM: EXECUTIVE								
CALLS SUBROUTINES: None								
REGISTERS USED: <table border="0"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>Display</td> <td>-</td> <td># in display indicates how many programs will be skipped before loading.</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	Display	-	# in display indicates how many programs will be skipped before loading.
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Display	-	# in display indicates how many programs will be skipped before loading.						

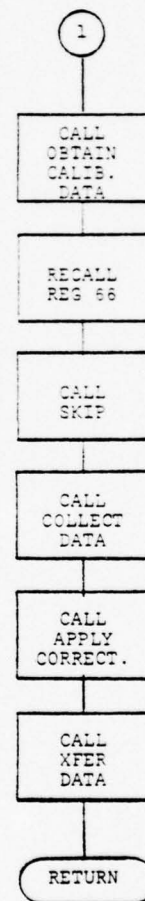
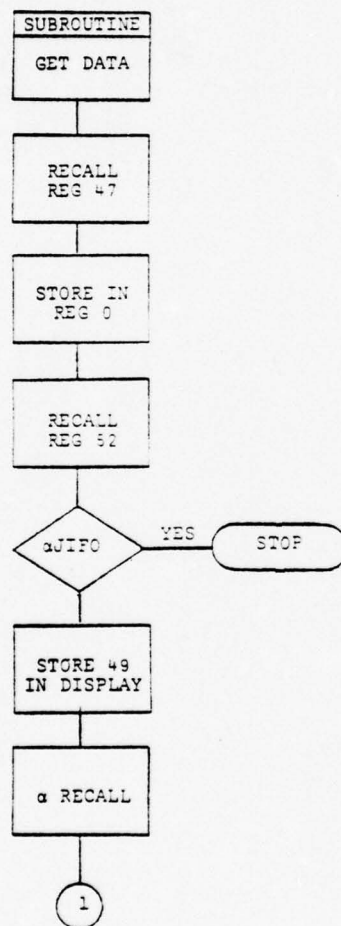
PROGRAM NAME:	ADDRESS CODE:																																	
OPTION-2	None																																	
DESCRIPTION: The executive program OPTION-2 is loaded by the system bootstrap program (BOOT). The program is composed of subroutines which permits retrieval of calibration data from cassette tape and collection of S-parameter data from the HP 8410S Microwave Network Analyzer. The program is operational with the exception of a subroutine called APPLY CALIBRATION DATA which is to apply the calibration data to the S-parameter data as described in Ref. 9. OPTION-2 is composed of the following subroutines: <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">TAPE CONTROL SET-UP</td> <td style="width: 25%;">1114</td> <td style="width: 25%;">LOAD 1115.</td> </tr> <tr> <td>F VS COUNT</td> <td>1113</td> <td></td> </tr> <tr> <td>DECODE CJC</td> <td>1109</td> <td></td> </tr> <tr> <td>GET DATA</td> <td>1112</td> <td></td> </tr> <tr> <td>OBTAIN CALIBRATION DATA</td> <td>1108</td> <td></td> </tr> <tr> <td>COLLECT DATA</td> <td>1105</td> <td></td> </tr> <tr> <td>APPLY CALIBRATION DATA</td> <td>1104</td> <td></td> </tr> <tr> <td>XFER DATA</td> <td>1103</td> <td></td> </tr> <tr> <td>SKIP</td> <td>1106</td> <td></td> </tr> <tr> <td>FREQUENCY ACQUIRE</td> <td>1111</td> <td></td> </tr> <tr> <td>GET FREQUENCY</td> <td>1110</td> <td></td> </tr> </table>		TAPE CONTROL SET-UP	1114	LOAD 1115.	F VS COUNT	1113		DECODE CJC	1109		GET DATA	1112		OBTAIN CALIBRATION DATA	1108		COLLECT DATA	1105		APPLY CALIBRATION DATA	1104		XFER DATA	1103		SKIP	1106		FREQUENCY ACQUIRE	1111		GET FREQUENCY	1110	
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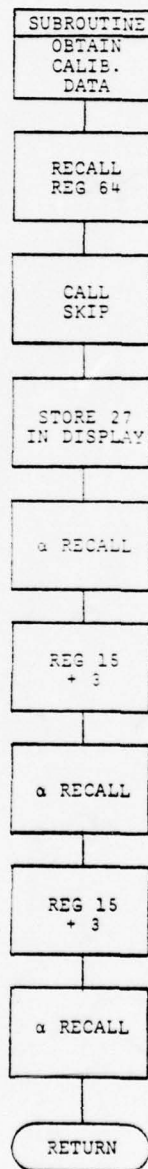
SUBROUTINE NAME:		ADDRESS CODE:																		
TAPE CONTROL SET-UP		1114																		
DESCRIPTION: TAPE CONTROL SET-UP initiates control registers needed to extract calibration data from cassette tape. Based upon the S-parameter designated by the Display Job Code, either three blocks of transmission calibration data or three blocks of reflection calibration data will be retrieved from each record. By using the Collection Job Code, the subroutine determines whether calibration data is on tape. If data is available, it determines which data sets are available and how many blocks within a record must be skipped in order to retrieve the desired set. This number is stored in register 64. The number of data blocks which must be skipped to drive the tape to the next data record is stored in register 65. If the desired set of calibration data is not available on tape the program terminates with a "8" in the display register.																				
CALLED FROM: EXECUTIVE																				
CALLS SUBROUTINES: DECODE CJC																				
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NUMBER	CODE	PURPOSE																		
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45	+↑13	# data blocks/record																		
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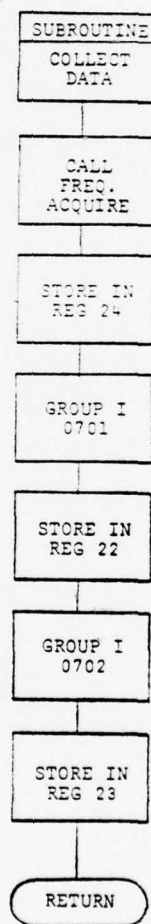
SUBROUTINE NAME:		ADDRESS CODE:																		
GET DATA (OPTION-2)		1112																		
DESCRIPTION: GET DATA, in OPTION-2, first determines if the last data block has been returned to the user program. If it has, the system stops. If there is still more data available, the subroutine calls OBTAIN CALIBRATION DATA, followed by COLLECT DATA and APPLY CORRECTIONS.																				
CALLED FROM: EXECUTIVE																				
CALLS SUBROUTINES: OBTAIN CALIBRATION DATA, SKIP, COLLECT DATA, APPLY CORRECTIONS, XFER DATA																				
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>47</td> <td>++15</td> <td>Record #</td> </tr> <tr> <td>48</td> <td>-+00</td> <td>CJC</td> </tr> <tr> <td>49</td> <td>-+01</td> <td>Desired frequency</td> </tr> <tr> <td>52</td> <td>-+04</td> <td>Total # of data records on tape</td> </tr> <tr> <td>66</td> <td>X+02</td> <td># skips to next record</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	47	++15	Record #	48	-+00	CJC	49	-+01	Desired frequency	52	-+04	Total # of data records on tape	66	X+02	# skips to next record
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																		
47	++15	Record #																		
48	-+00	CJC																		
49	-+01	Desired frequency																		
52	-+04	Total # of data records on tape																		
66	X+02	# skips to next record																		



SUBROUTINE NAME: OBTAIN CALIBRATION DATA		ADDRESS CODE: 1108									
DESCRIPTION: This subroutine loads the correct calibration data set from tape to registers 25 through 33.											
CALLED FROM: GET DATA											
CALLS SUBROUTINES: SKIP											
REGISTERS USED: <table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left;"><u>NUMBER</u></th> <th style="text-align: left;"><u>CODE</u></th> <th style="text-align: left;"><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>25 - 33</td> <td>T↓09 } to +↓01 }</td> <td>Input buffer for calibration data</td> </tr> <tr> <td>64</td> <td>X↓00</td> <td># of skips to calibration data</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	25 - 33	T↓09 } to +↓01 }	Input buffer for calibration data	64	X↓00	# of skips to calibration data
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>									
25 - 33	T↓09 } to +↓01 }	Input buffer for calibration data									
64	X↓00	# of skips to calibration data									

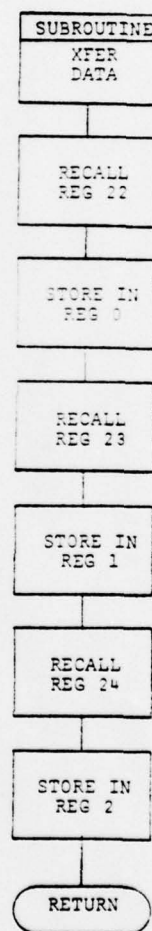


SUBROUTINE NAME:		ADDRESS CODE:												
COLLECT DATA		1105												
DESCRIPTION: This subroutine calls FREQUENCY ACQUIRE to drive the sweep oscillator to the desired frequency and then access the two micro-interface devices. The frequency returned from FREQUENCY ACQUIRE is stored in register 24 and the X and Y deflection voltages are stored in registers 22 and 23														
CALLED FROM: GET DATA														
CALLS SUBROUTINES: FREQUENCY ACQUIRE														
REGISTERS USED: <table border="1"> <thead> <tr> <th><u>NUMBER</u></th> <th><u>CODE</u></th> <th><u>PURPOSE</u></th> </tr> </thead> <tbody> <tr> <td>22</td> <td>T+06</td> <td>X voltage</td> </tr> <tr> <td>23</td> <td>T+07</td> <td>Y voltage</td> </tr> <tr> <td>24</td> <td>T+08</td> <td>Frequency</td> </tr> </tbody> </table>			<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>	22	T+06	X voltage	23	T+07	Y voltage	24	T+08	Frequency
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>												
22	T+06	X voltage												
23	T+07	Y voltage												
24	T+08	Frequency												



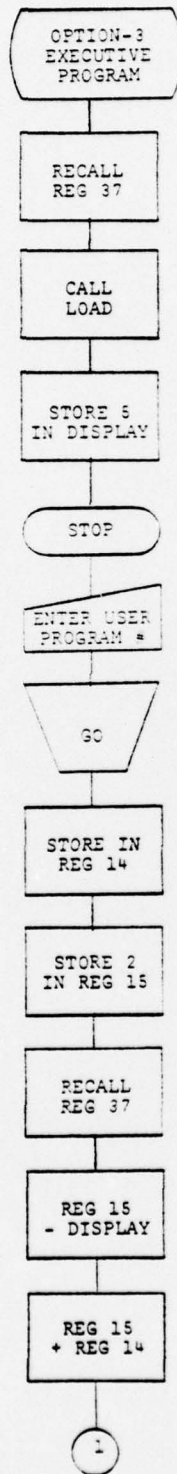
SUBROUTINE NAME:		ADDRESS
APPLY CORRECTIONS		CODE:
		1104
DESCRIPTION: The subroutine, at present, consists of just a RETURN instruction. This subroutine should apply the calibration data found in registers 25 - 33 to the S-parameter data found in registers 22 - 24. The offset lengths which were used in measuring the calibration data are found in registers 53 - 58. The corrected S-parameter data must be returned to registers 22 and 23 before returning from this subroutine.		
CALLED FROM:		
CALLS SUBROUTINES:		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>

SUBROUTINE NAME:		ADDRESS CODE:
XFER DATA		1103
DESCRIPTION: This subroutine transfers the data found in registers 22, 23, and 24 to registers 00, 01, 02, respectively.		
CALLED FROM: GET DATA		
CALLS SUBROUTINES: None		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
0	00	X volt
1	01	Y volt
2	02	Frequency
22	T↓06	X volt
23	T↓07	Y volt
24	T↓08	Frequency

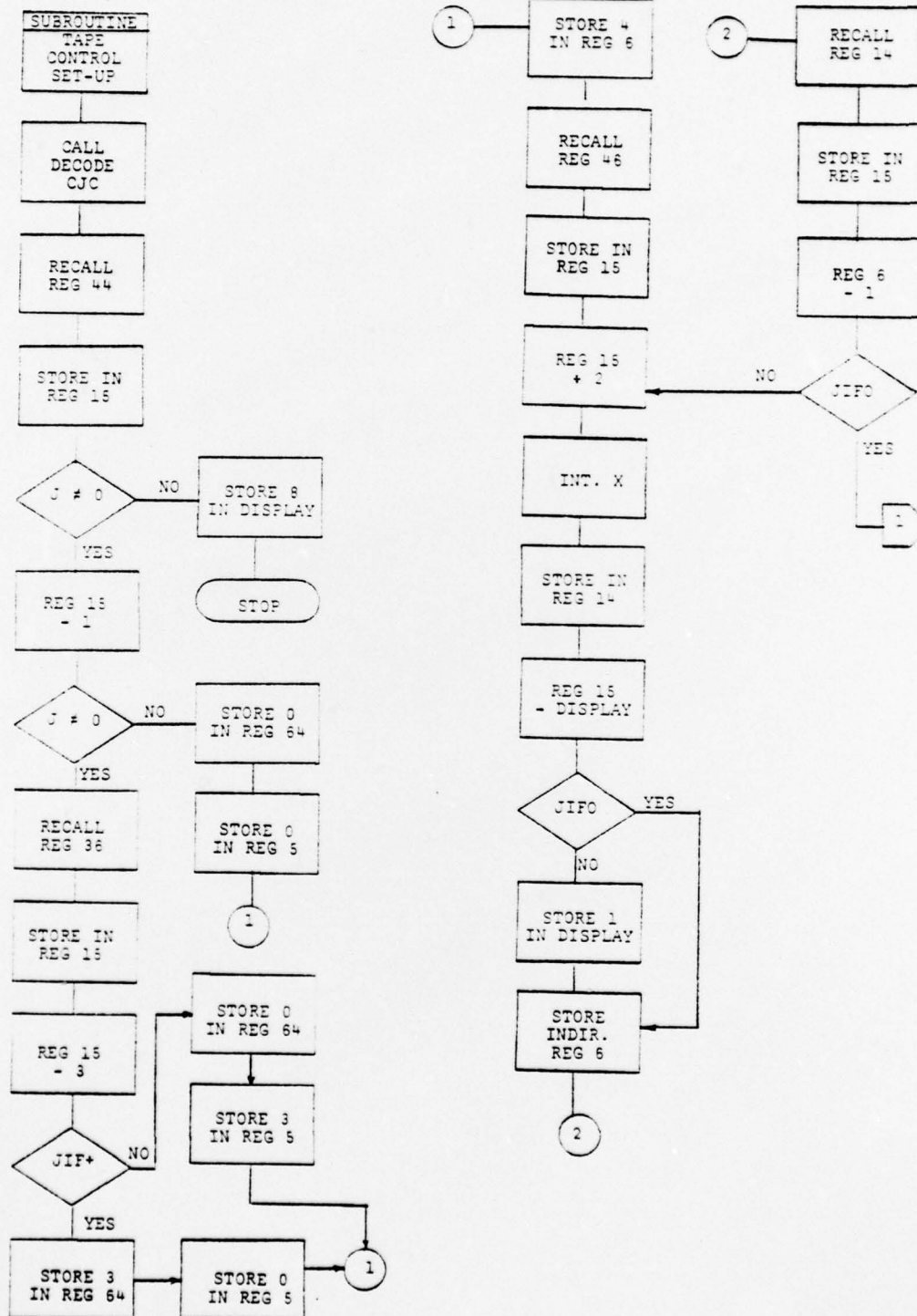


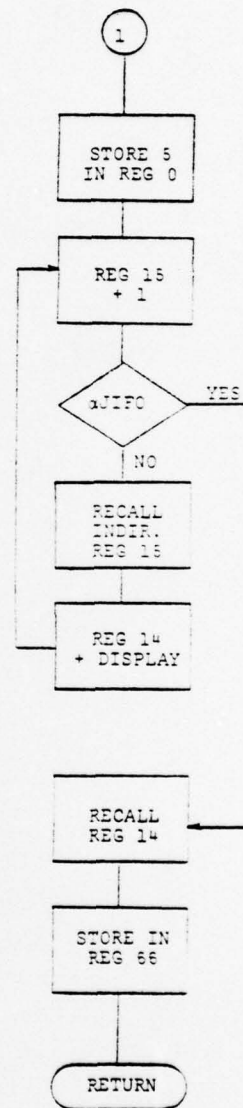
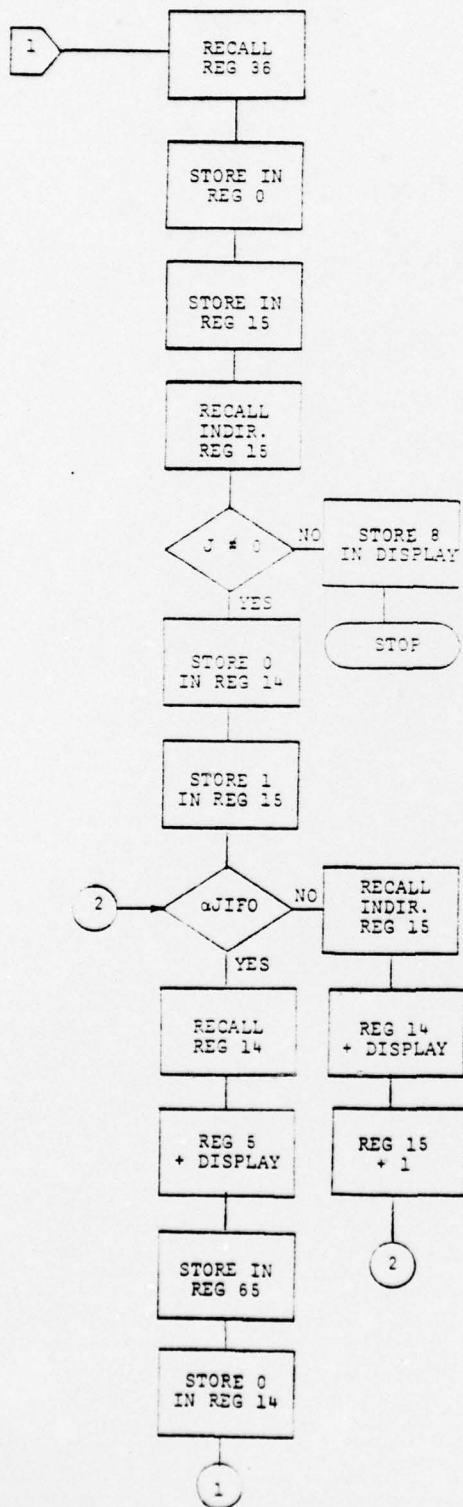
PROGRAM NAME:		ADDRESS CODE:									
OPTION-3		-									
DESCRIPTION: The executive program OPTION-3 is loaded by the bootstrap program (BOOT). The program is composed of sub-routines which enable retrieval of calibration data and S-parameter data from cassette tape. OPTION-3 loads and executes one of the four display programs as specified by the last digit of the Display Job Code (DJC). It then requests a User Program Number from the user by interrupting execution with a 5 showing in the display register. The executive program loads the user program over the display program and then interrupts execution with a 6 showing in the display register. The user removes the program tape and inserts the data tape from which the calibration data and S-parameter data is to be retrieved. Other preliminary functions are performed by OPTION-3 and then control is passed to the resident user program.											
CALLED FROM: LOADED by BOOT											
CALLS PROGRAMS: LOAD TAPE CONTROL SET-UP											
REGISTERS USED: <table border="1"> <thead> <tr> <th>NUMBER</th> <th>CODE</th> <th>PURPOSE</th> </tr> </thead> <tbody> <tr> <td>37</td> <td>+05</td> <td>Display program #</td> </tr> <tr> <td>48 to 62</td> <td>-00 } to -14 }</td> <td>Input buffer for the file ID record</td> </tr> </tbody> </table>			NUMBER	CODE	PURPOSE	37	+05	Display program #	48 to 62	-00 } to -14 }	Input buffer for the file ID record
NUMBER	CODE	PURPOSE									
37	+05	Display program #									
48 to 62	-00 } to -14 }	Input buffer for the file ID record									

PROGRAM NAME: OPTION-3	ADDRESS CODE: -
DESCRIPTION CONTINUED: OPTION-3 is composed of the following subroutines: TAPE CONTROL SET-UP 1114 DECODE CJC 1109 GET DATA 1112 OBTAIN CALIBRATION DATA 1108 OBTAIN DATA 1107 SKIP 1106 APPLY CORRECTIONS 1104 XFER DATA 1103 LOAD 1105	

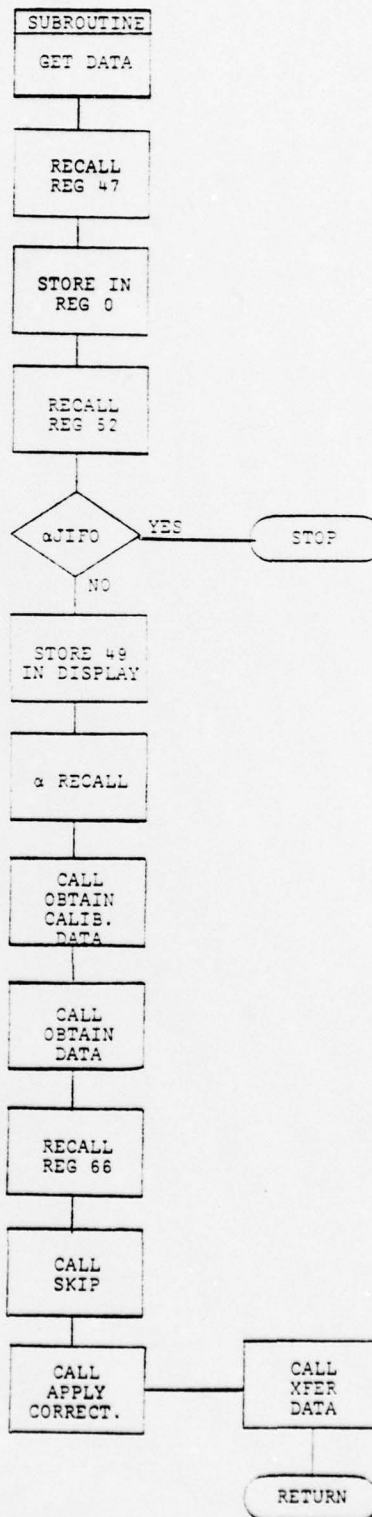


SUBROUTINE NAME:		ADDRESS CODE:
TAPE CONTROL SET-UP		1114
DESCRIPTION: This subroutine initiates control registers needed to extract the required calibration data and S-parameter data from the cassette tape. Based upon the S-parameter designated by the Display Job Code, either three blocks of transmission calibration data or three blocks of reflection calibration data along with the designated S-parameter data will be retrieved from each record. By using the Collection Job Code, the subroutine determines whether the required calibration and S-parameter data is on tape. If they are not available, the program terminates with an 8 showing in the display register. If the data is available, the subroutine computes the number of data blocks between the record ID block and the first block of required calibration data. This number is stored in register 64. It then computes the number of blocks from the last block of calibration data to the required S-parameter data. This number is stored in register 65. Finally, the subroutine computes the number of blocks between the required S-parameter data and the next record ID block. This number is stored in register 66.		
CALLED FROM:		EXECUTIVE
CALLS SUBROUTINES:		DECODE CJC
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>
36	+↓04	Desired S-parameter
44	+↓12	# of calibration sets on tape
46	+↓14	# S-parameters on tape
64	X↓00	# skips to calibration data
65	X↓01	# skips to S-parameter
66	X↓02	# skips to ID block





SUBROUTINE NAME: GET DATA (OPTION-3)		ADDRESS CODE: 1112																		
DESCRIPTION: This subroutine checks to see if the last data block has been retrieved from tape. If it has, the system is terminated. If not, it calls the necessary subroutines to obtain the calibration data and S-parameter data.																				
CALLED FROM: User Program																				
CALLS SUBROUTINES: OBTAIN CALIBRATION DATA, OBTAIN DATA, SKIP, APPLY CORRECTIONS, XFER DATA																				
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<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>																		
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48	+00	Collection Job Code																		
49	+01	Frequency																		
52	+04	Total # of data records																		
66	X+02	# skips to next ID block																		



SUBROUTINE NAME: DECODE CJC, OBTAIN CALIBRATION DATA, OBTAIN DATA, SKIP, APPLY CORRECTIONS, XFER DATA, LOAD		ADDRESS CODE:
DESCRIPTION: See subroutine DECODE CJC in OPTION-1 See subroutine OBTAIN CALIBRATION DATA in OPTION-2 See subroutine OBTAIN DATA in OPTION-1 See subroutine SKIP in OPTION-1 See subroutine APPLY CORRECTIONS in OPTION-2 See subroutine XFER DATA in OPTION-2 See subroutine LOAD in OPTION-1		
CALLED FROM:		
CALLS SUBROUTINES:		
REGISTERS USED:		
<u>NUMBER</u>	<u>CODE</u>	<u>PURPOSE</u>

BIBLIOGRAPHY

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9. DaSilva, E. F. and McPhun, M. K., "Calibration of Microwave Network Analyzer For Computer-Connected S-Parameter Measurements," Electronics Letters, v. 9, p. na, March 1973.

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