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DEVELOPMENT OF AN INTEGRATED DATA ACQUISITION AND HANDLING SYSTEM BASED ON DIGITAL TIME SERIES ANALYSIS FOR THE MEASUREMENT OF PLASMA FLUCTUATIONS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

• Reza Ghayspoor

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ABSTRACT

The nonlinear characteristics of data obtained by many plasma diagnostic systems requires the power of modern computers for on-line data processing and reduction. The objective of this work is to develop an integrated data acquisition and handling system based on digital time series analysis techniques. These techniques make it possible to investigate the nature of plasma fluctuations and the physical processes which give rise to them. The approach is to digitize the data, and to generate various spectra by means of Fast Fourier Transforms (FFT). Of particular interest is the computer generated auto-power spectrum, cross-power spectrum, phase spectrum, and squared coherency spectrum. Software programs based on those developed by Jae. Y. Hong at the University of Texas are utilized for these spectra. The LeCroy 3500-SA signal analyzer and VAX 11/780 are used as the data handling and reduction system in this work. In this report, the software required to link these two systems will be described.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE PAGE

FIGURE PAGE

INTRODUCTION

Recent advances in electronics make it possible to use transient recorders to digitize and store high frequency transient signals. Once stored, the data are available,for transfer via various digital input/output interfaces, to computers for signal analysis, to mass storage media for archiving, and in general to any device capable of accepting digital input. The data can also be reconstructed by a digital-to-analog channel for observation on an oscilloscope. The data transferred from the transient recorders to the memory of the computer constitute a series of numbers known as a time series.

The methods of digital time series analysis are applied to the data, which includes some noise, to find the desired information. One of these methods, the Fast Fourier Transform (FFT), is used extensively in this work. Since such fiduciary data as run number, data, anode voltage and current, front panel gain settings, for each transient recorder are needed for the calculation of various spectra, this information is stored along with the raw data.

With this introduction, it is the objective of this work to develop an integrated system that allows

a) Transfer of raw data from each transient recorder, and the storage of these raw data, along with their fiduciary data, in the histogram memory of the computer.

b) Sending this information to the VAX 11/780 system.

c) Processing these data on the VAX system and returning the processed data to the LeCroy 3500SA system.

d) Plotting various spectra on the LeCroy system.

There are three different software programs all written in Fortran. The first is an interactive program which reads the raw data from the histogram memory of the computer and stores these data on a floppy disk in drive B. This program also permits the operator to enter fiduciary data about the experimental run through the keyboard. The second is a digital spectral analysis program, which was written by Jae Y. Hong.[1] This program was modified for compatibility with the other two programs written for this system. Finally, the third program reads the processed data from the VAX system and uses this data to generate plots of data on the LeCroy 3500 SA screen. This program also allows plots to be screen dumped to the LeCroy 3931A printer.

A block diagram of the data acquisition system and detailed discussion of hardware and software related to this system can be found in the following chapter.

CHAPTER I

SYSTEM DESCRIPTION AND SCOPE OF WORK

The overall block diagram of the data acquisition and handling sytem is shown in Figure 1.1. The objective of this work is to make the LeCroy 3500 SA signal analyzer operate as a remote terminal for the VAX 11/780 system. By making the LeCroy 3500 SA two-way interactive with the VAX system, one can sample data on the LeCroy system, process the data on the VAX, and then return the data to the LeCroy for inspection and possible plotting. The work reported here falls into two categories; hardware and software. Detailed description of these two parts and individual components of this system are given below.

A. HARDWARE

The necessary hardware for this system is as follows.

a) Capacitive Probes:

As shown in Figure 1.1, two capacitive probes were used to measure potential fluctuations from which the wave number of plasma fluctuations can be obtained. These two capacitive probes are separated by a known angle at the same radius. The capacitive probes used in this system are Tektronix P6009.[2] These are low-input capacitance, high-voltage passive probes with a signal attenuation of 100x. Some important specifications for these probes are as follows:

Attenuation: 100x within 3%(including 1MΩ $\pm$ 2% amplifier input).

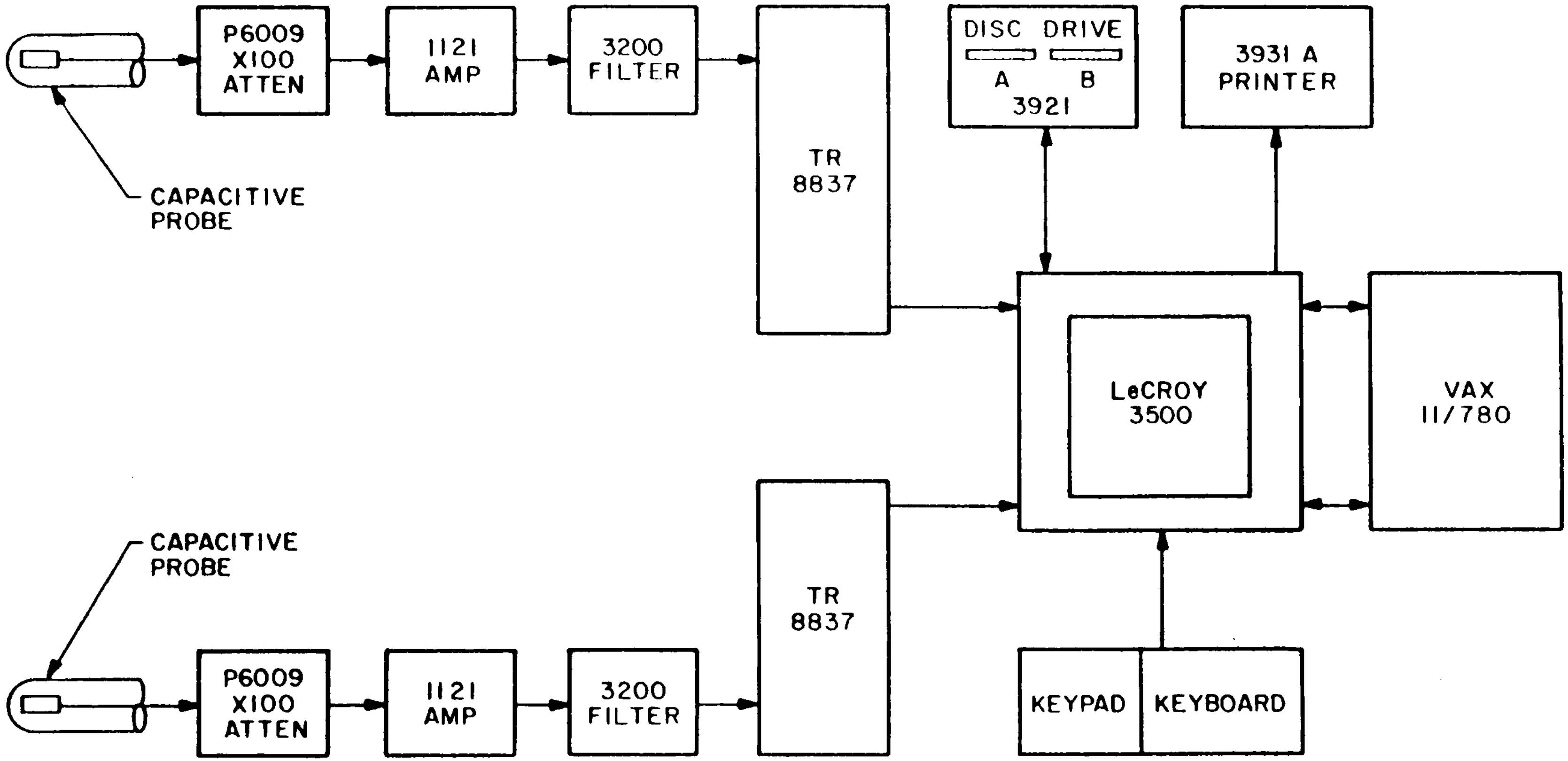

Figure 1.1. Block diagram of the data acquisition and handling system.

Input Resistance: 10 M Ω within 2%.

Input Capacitance: Approximately 2.5 pf.

Compensation Range: 15 pf or less to at least 47 pf..

Bandwidth (-3dB): At least 120 MHz.

Maximum Input Voltage: 1.5 kV (DC or RMS).

These probes will operate within specifications over the following range:

Temperature: -15°c to + 75°.

b) Amplifiers and Filters:

The amplifiers and filters used in this system are Tektronix 1121, and Kron-Hite model 3200 respectively. These are identical to amplifiers and filters reported by J. R. Roth and W. M. Krawczonek.[3]

c) Transient Recorders:

The analog signals from the filters are converted into digital form by two TR8837 transient recorders. These transient recorders are capable of sampling up to 32 megasample/second, and storing digitized signals sequentially in a dedicated 8K-x-8-bit memory. The user may program the system to use only a fraction of this memory. The amount of dedicated memory actually used is called the active memory or record length. When the recorder fills the active memory, it continues to digitize until a stop trigger is received. Upon stopping, the transient recorder informs the host computer that it has data available. The host computer then reads, stores, and displays the data. Figure 1.2 shows a simplified block diagram of a transient recorder and its associated host computer.

Listed below are the summarized specifications for the transient recorders. For detailed specifications refer to reference (4).

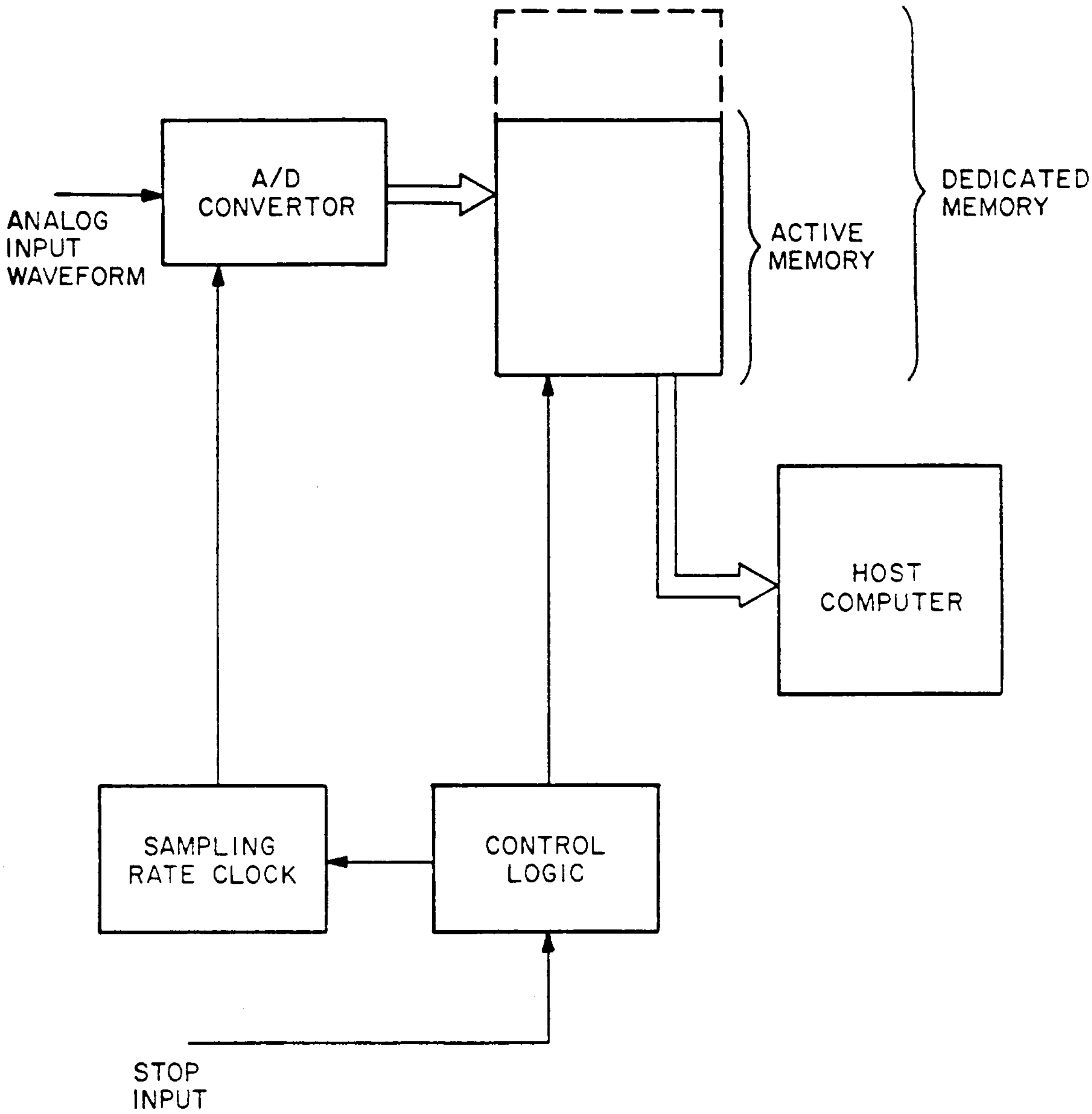

Figure 1.2. Block diagram of a transient recorder.

Signal Range: 512 mv peak to peak.

Offset: The input signal offset is adjustable via a front panel potentiometer. The offset range is $\pm$ 256 mv.

Bandwidth: > 16 MHz (1dB) for amplitude up to the full 512 mv signal range.

Impedance: 50Ω $\pm$ 1%, 12 pf.

Conversion clock: Internal clock frequency of 32, 16, 8, 4, 2, 1 or 0.5 MHz, or external clock.

Resolution: 8-bits (1 part in 256).

d) Central Units:

A three microprocessor (main, arithmetic, and display) memory board with 64k bytes of memory, histogram data memory boards, and Quad serial communication board constitute the central units of the LeCroy 3500 SA signal analyzer.

The main or central processor is an 8085A microprocessor. An 8085 A microprocessor is also dedicatd to display operation. An AM 9511 is the arithmetic processor unit which provides 32-bit floating point calculations. The histogram data memory board includes 8192 channels of 24-bit count capacity per channel. The Quad Serial communication board provides four RS-232-C ports for communication with other computers. For a detailed description of these units refer to reference 4.

B. SOFTWARE

The software necessary for this system to obtain the desired results consists of three different programs. The first program (Job1), which is written in Fortran 80, is an interactive program. This program, by itself, performs three different functions. The program first opens a data file on the disk residing in drive B, then prompts the user for memory size and the starting memory channel for the appropriate experiment (in this case two transient recorders require 4k byte of memory with starting memory location at channel zero). As its second function, the program prompts the user for various fiduciary experimental parameters such as date, file number, anode voltage and current, magnetic field, and pressure, all entered in appropriate units. In this part, the program also asks the user to enter the front panel settings for each transient recorder. Some examples of these selections are input range setting for each transient recorder and sample interval. As its third function, program Job1 reads the input values of two transient recorders directly from the histogram memory of the computer and stores these values along with fiduciary data on the data file which has already been opened on a floppy disk in drive B.

An example of the prompting signal is given in Figure 1.3. Figure 1.4 is a flowchart for this program. This program is run on the LeCroy 3500 SA.

The second program is the digital time series analysis program. This program, which was written by Jae. Y. Hong[1], makes extensive use of the Fast Fourier Transform (FFT). This program was modified for compatibility with the other two programs written for this system. The original program uses Calcomp plotting subroutines to plot various spectra. The modified program, which is run on the VAX 11/780 system, opens a data file and stores the processed data for each spectrum. This processed data is then sent to the

```
ENTER FILE NAME:
ENTER CHANNEL:
ENTER BLOCK SIZE:
ENTER FILE NUMBER:
ENTER DATE:
ENTER RUN NUMBER:
ENTER ANODE VOLTAGE (KV):
ENTER ANODE CURRENT (AMP):
ENTER MAX MAGNETIC FIELD (TESLA):
ENTER PRESSURE (MICROTORR):
ENTER AVERAGE PLASMA NUMBER DENSITY
(ELECTRONS/(M**3)):
ENTER RADIAL POSITION OF PROBES FROM THE CENTER OF
PLASMA (CM):
ENTER MICROWAVE SCATTERING ANGLE (DEGREE):

CHANNEL NO. 1 DATA.
ENTER INPUT RANGE SETTING (VOLT):
ENTER SAMPLE INTERVAL (MICROSEC):
ENTER ANTIALIAAS FILTER (MHZ):
ENTER OVERALL PROBE GAIN (VOLT):

CHANNEL NO. 2 DATA.
ENTER INPUT RANGE SETTING (VOLT):
ENTER INTERVAL (MICROSEC):
ENTER ANTIALIAS FILTER (MHZ):
ENTER OVERALL PROBE GAIN (VOLT):

CHANNEL NO. 3 DATA.
ENTER INPUT RANGE SETTING (VOLT):
ENTER SAMPLE INTERVAL (MICROSEC):
ENTER ANTIALIAS FILTER (MHZ):
ENTER OVERALL PROBE GAIN (VOLT):
ENTER D.C. VOLTAGE AT PREAMP INPUT (VOLT):
ENTER ADDITIONAL COMMENTS?
```

Figure 1.3. Prompting Signal for the Program Job1.

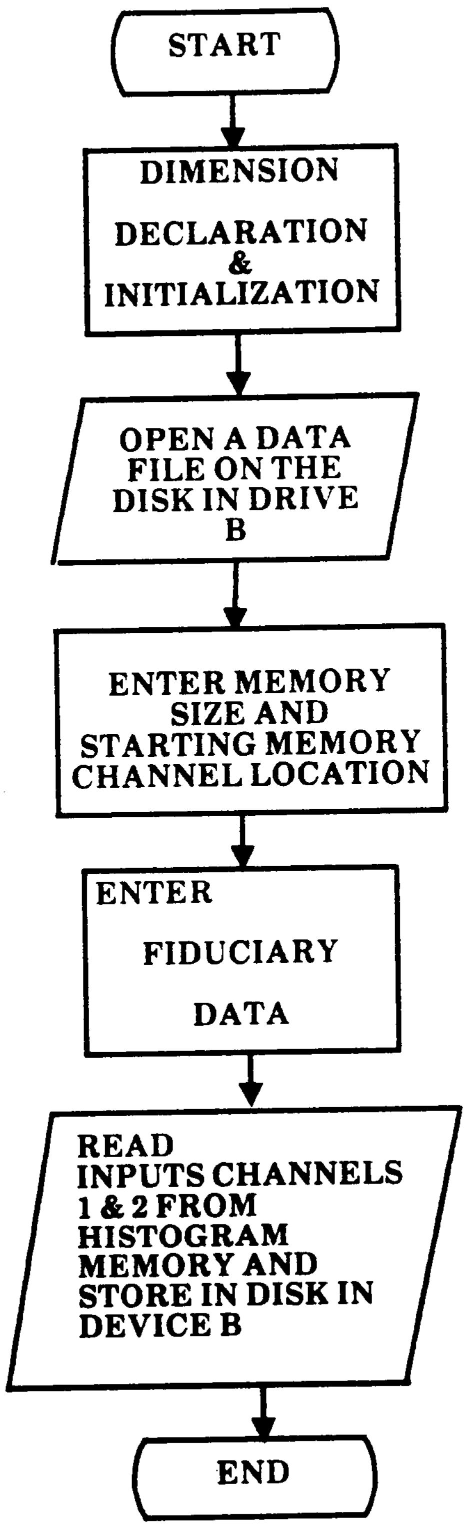

Figure 1.4. Flowchart for program Job1.

LeCroy 3500 SA system for plotting. The LeCroy system has its own plotting subroutine. Figure 1.5. is a simplified flowchart for this program. For detailed explanations of this program refer to references 1 and 3.

The third program, Job2, is written in Fortran 80. This program reads the processed data coming from the VAX 11/780 to the LeCroy and plots various spectra such as auto-power spectrum of channels 1 and 2, cross amplitude spectrum, phase spectrum, and squared coherency spectrum of channels 1 and 2. This program also plots the inputs for channel 1 and 2 in the time domain. Program Job2 screen dumps the plots to the printer for later viewing. Figure 1.6. shows a flowchart for this program.

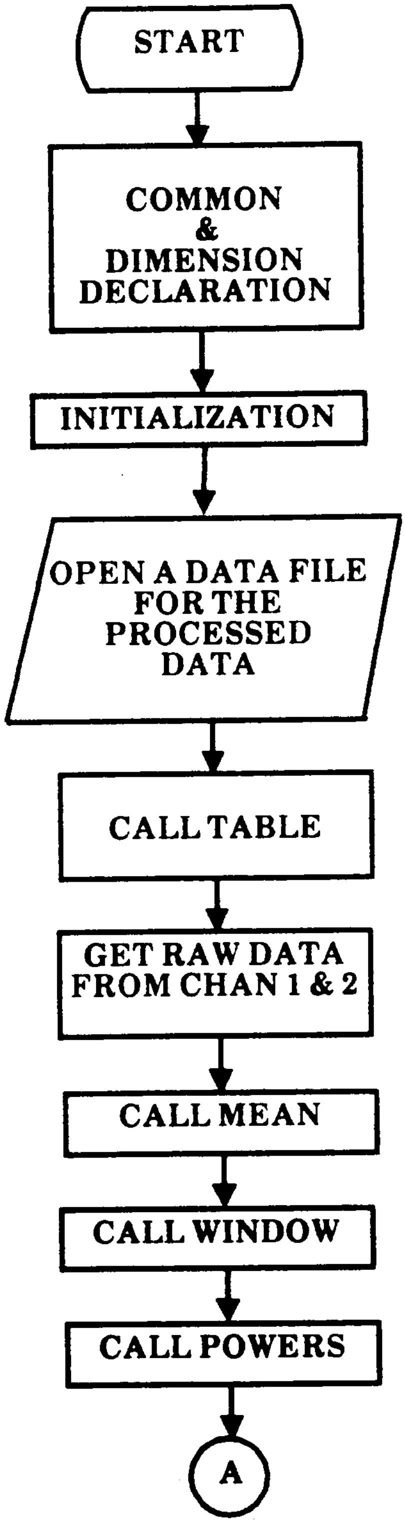

Figure 1.5. Flowchart for program TEST77.

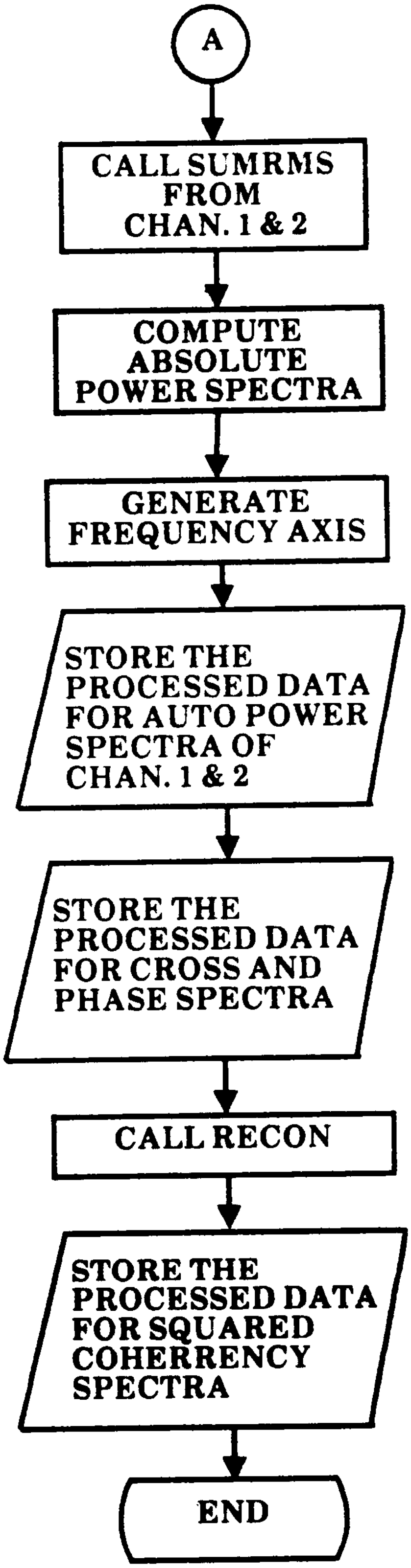

Figure 1.5. (continued).

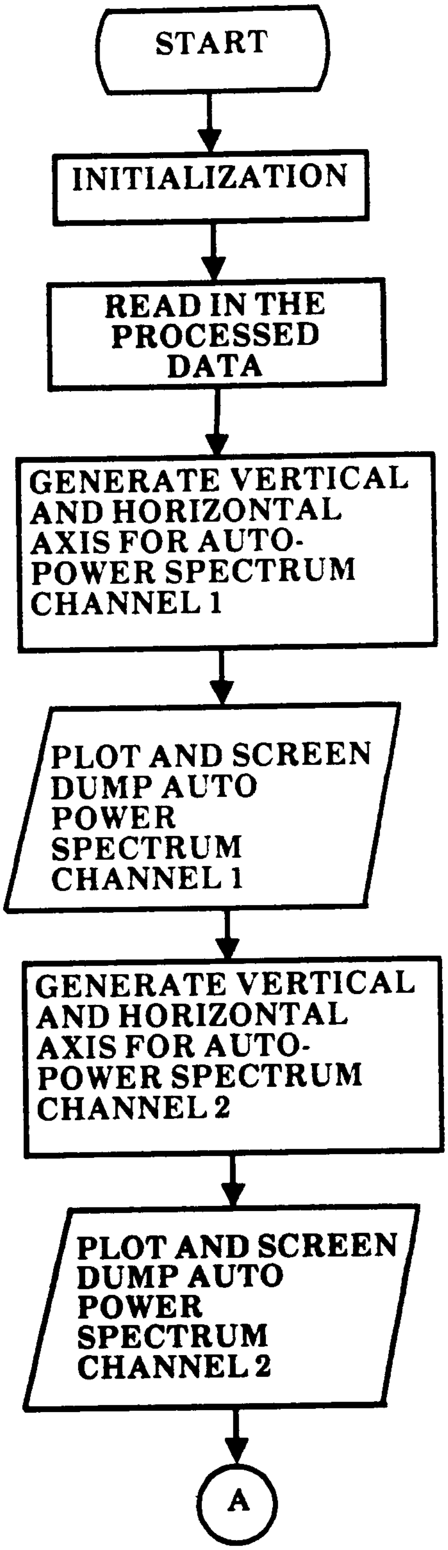

Figure 1.6. Flowchart for program Job2.

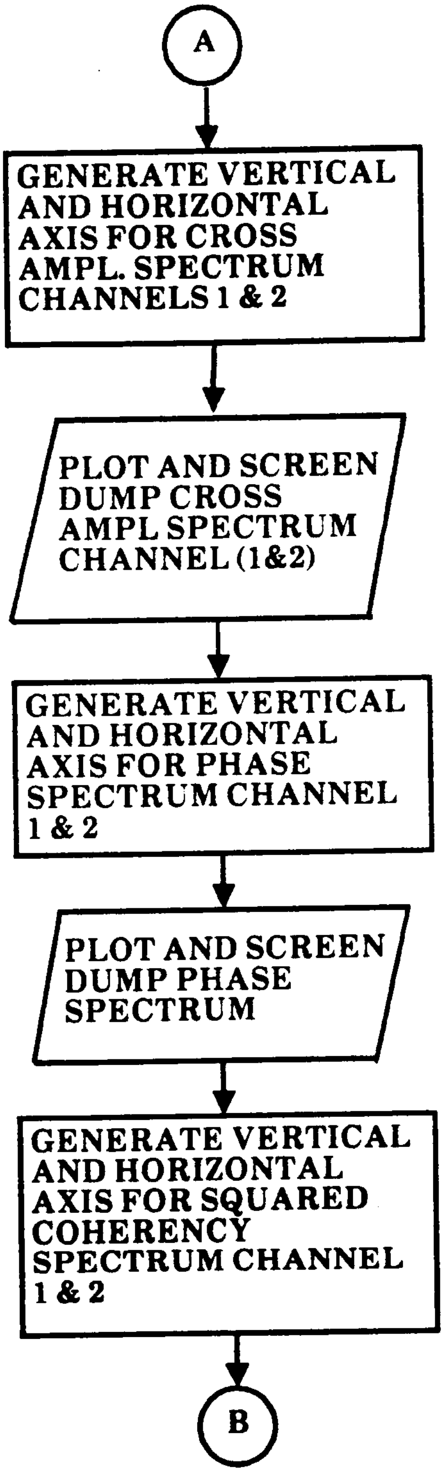

Figure 1.6. (continued).

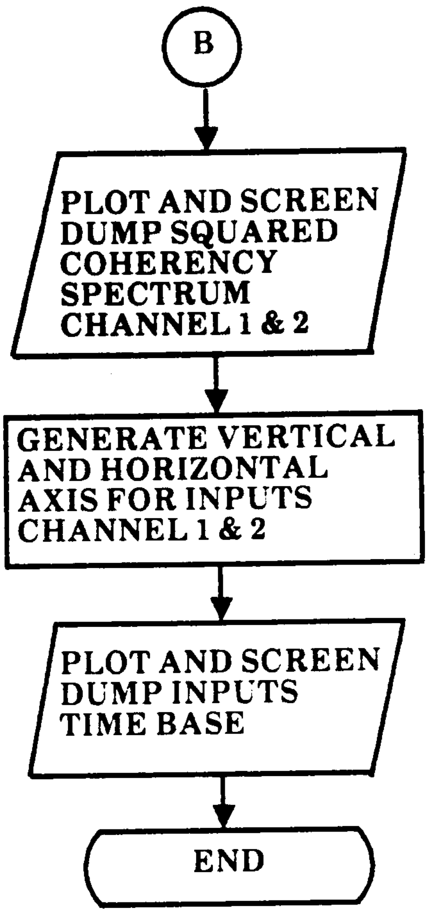

Figure 1.6. (continued).

CHAPTER II

OPERATING INSTRUCTIONS

An outline of the procedure followed for the acquisition of data from the 3500 SA system follows. For detailed instructions refer to the LeCroy's operator's manual[4]. Notational conventions in this section are:

<KEYPAD KEY>	represents an entry from the system's 16 keypad.
<keyboard key>	represents an entry from the system's main keyboard.
[LIGHT PEN REGION]	represents an entry made with the light pen.
STEP1	Apply power to the 3500 SA system by first turning on the peripherals and then the system 3500 SA. Following power up, your screen should appear as in Fig 2.1.
STEP2	Insert the 3910-SA diskette in drive A, then select [BOOT DISK SYSTEM] from the power up screen either with the light pen or by pressing <START>. The screen will appear as in Figure 2.2.
STEP3	select option 1. of the INITIALIZATION option menu by depressing: <1> or [STANDARD WITHOUT FFET]

LeCroy System 3500 SA

- BOOT DISK SYSTEM
- DEBUG MONITOR
- GO TO GRAPH
- OUTPUT SETUP
- TERMINAL MODE
- MORE

Figure 2.1. System 3500 SA's power up screen.

INITIALIZATION OPTIONS

1. standard without FET
2. FFT with FLAT window
3. FFT with HANNING window
4. FFT with HAMMING window
5. FFT with BLACKMAN window
6. reset system ram
7. Set system setup to default
8. Execute application program

Figure 2.2. System 3500 SA's screen after selecting "BOOT DISK SYSTEM".

STEP4

After 68 seconds the main SA menu will appear again. To access the graph select:
<2ND FUNCT> <M. GRP/SG DIS>
or [GO TO GRAPH]
At this point, the screen appears as in Figure 2.3.

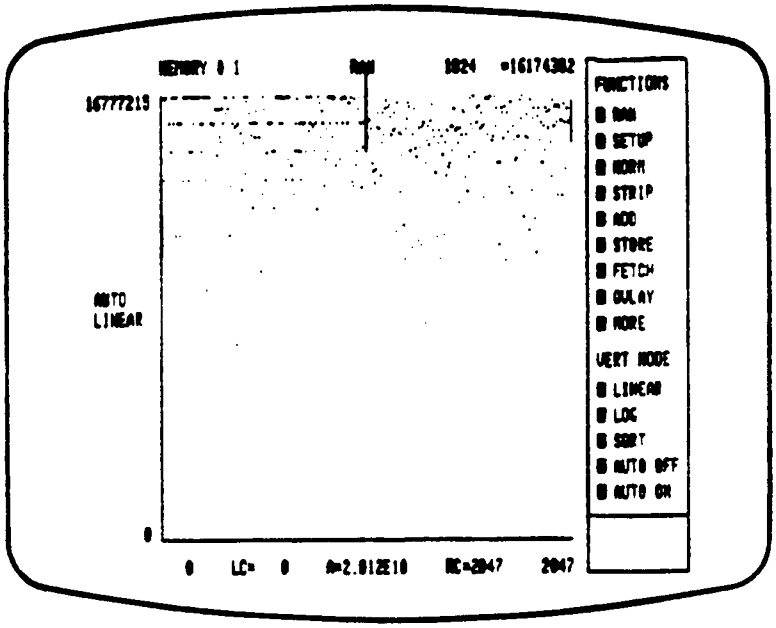

Figure 2.3. Graph of memory # 1

STEP5

Slect:
[MORE]
[UP/RIGHT ARROW]
This will display the graph containing the [MENUS] option, Figure 2.4.

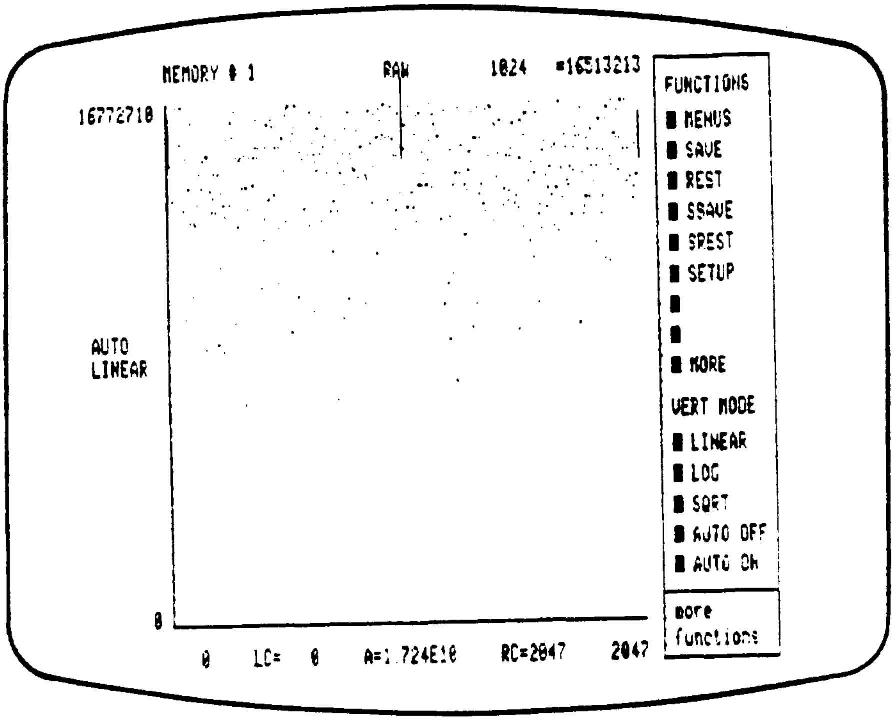

Figure 2.4. Graph display containing the [MENUS] option

STEP6 Select [MENUS] with the light pen. The result is the set up menu in the system 3500 SA shown in Figure 2.5.

STEP7 Select [SYSTEM ARCHITECTURE] with the light pen. The result is system 3500 SA's Architecture page shown in Figure 2.6.

3500 SA SETUP Version 3.8

- LOAD SYSTEM FILE
- SYSTEM ARCHITECTURE
- MODULE SET-UP
- SAVE SYSTEM FILE
- RETURN TO GRAPH

Figure 2.5. System 3500 SA's set up menu.

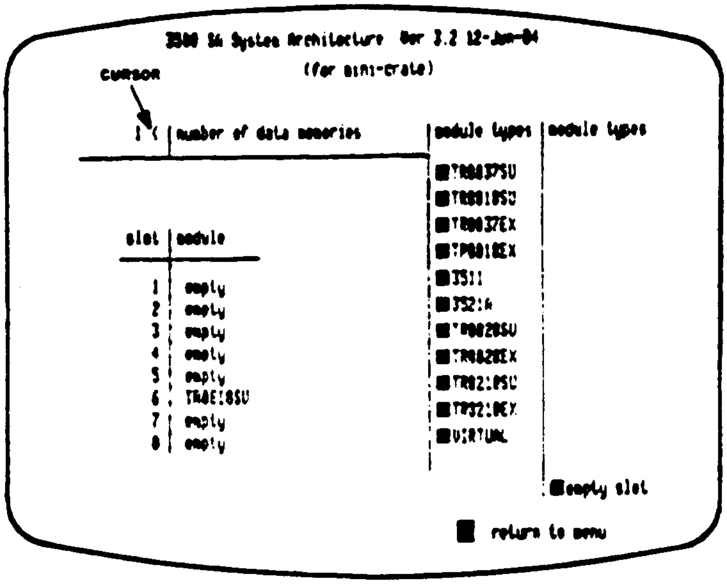

Figure 2.6. System 3500 SA's Architecture page.

The system Architecture page provides a means to inform the system:

1) how many model 3500-2 8k-x 24-bit data memory boards are present.
2) what acquisition modules are present in the 8-slot CAMAC minicrate and in which slots they reside.

To change the number of data memory boards (a number that must be between 1 and 8), simply type the appropriate number when the cursor is positioned at the "number of data memories" selection. The cursor will disappear as soon as any information is sent to the system Architecture page (via keyboard or list pen), therefore, changing the number of data memory cards must be done immediately after accessing the System Architecture page. (NOTE: System 3500 SA in the UTK Plasma Lab has two data memory boards, so type 2 for the number of data memories). To assign an acquisition module to a particular slot, follow the example shown in Figure 2.7.

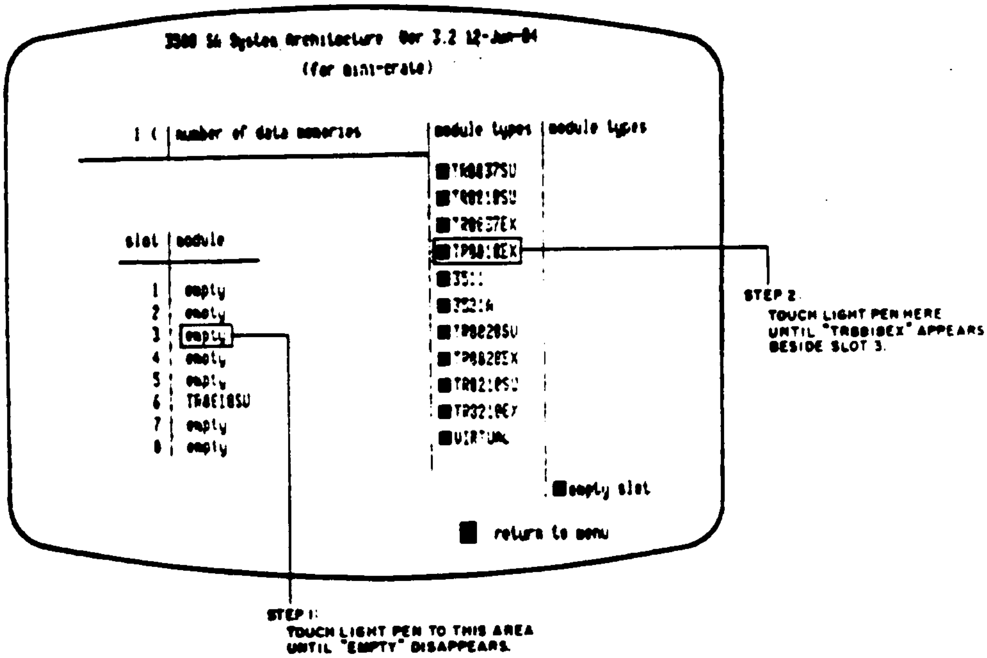

Figure 2.7. Assigning model TR8818EX to slot 3.

Assign two model TR8837, configured for averaging, to two slots.

STEP8 After defining system Architecture, return to the setup menu by selecting [RETURN TO

	MENU] with the light pen from the System Architecture page.
STEP9	Select [MODULE SET-UP] with the light pen from the system 3500 SA's set-up menu.

Each acquisition module that has been assigned to a mini-crate slot in system architecture has a module setup page. These pages allow the user to assign various data acquisition parameters to the modules present in the system. Each type of data acquisition module has a characteristic module setup page. Since two module TR8837 are used for this experiment, TR8837 Su's module setup page is shown in Figure 2.8.

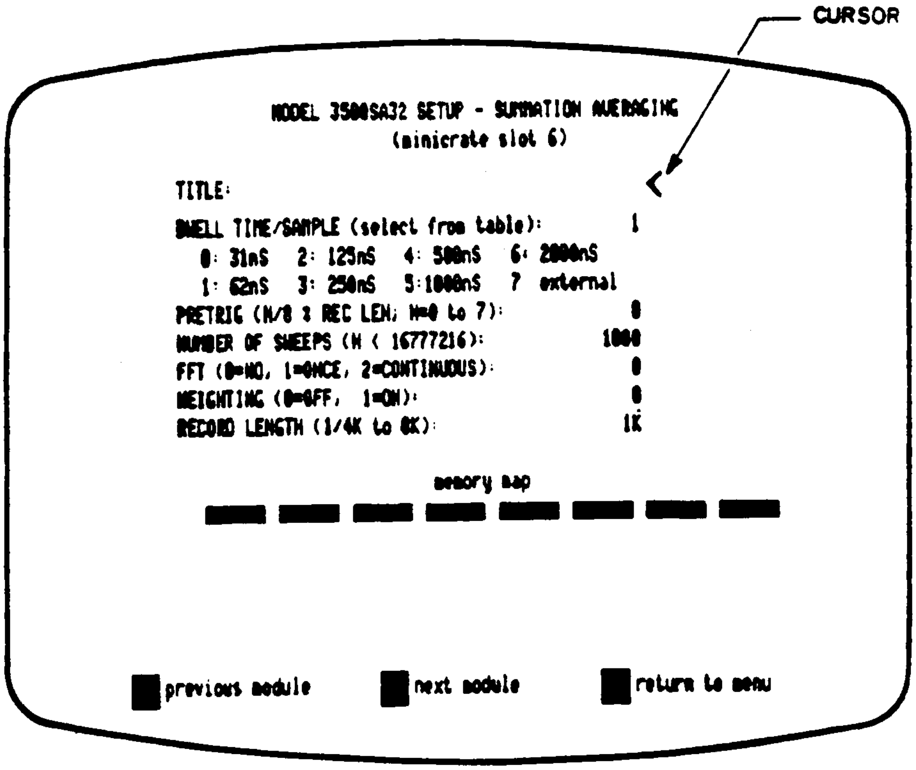

Figure 2.8. TR 8837 Su's module setup page.

Entries are made by pointing the cursor at the appropriate field and typing the desired entry followed by a carriage return. The <RETURN> key moves the cursor among the selections on the module setup page.

STEP10 Return to the system setup page by selecting [RETURN TO MENU] with the light pen from the module setup page.

STEP11 Select [RETURN TO GRAPH]. Display the memory-group graph for the acquisition module, by depressing:

<M-GRP/SG DIS>

To scroll through the various memory area use:

<UP/RIGHT ARROW>

STEP12 Clear any previous data from the memory group graph with:

<2ND FUNCT>

<START/CL DAT>

<START/CL DAT>

STEP13 If appropriate input signals are present at the data acquisition modules, the user may start acquisition with.

<ACQ/START>

<START/CL DAT>

Allow data acquisiton to halt automatically after a pre-programmed number of sweeps. At this point, the data resides in the histogram memory of the computer.

STEP14	Strike <RESET>. The result is system 3500 SA's Power up screen.
STEP15	Remove 3910-SA diskette and insert the diskette containing programs Job1, Job2, and TERMQ in drive A and a blank diskette in drive B.
STEP16	[BOOT THE SYSTEM]. At prompt A, type Job1. Program Job1 prompts the user for fiduciary data through the keyboard. This program then reads the data from the histogram memory of the computer and stores them along with the fiduciary data on the diskette in drive B.

Before proceeding to the next step, it is time to consider communication between the LeCroy 3500 SA and the VAX 11/780 system. Communication between the system 3500 SA and the VAX 11/780 can be accomplished by using the program TERM. The program TERM communicates with the VAX system via the standard RS-232-C port on the system 3500's rear panel. Because this port is used to communicate with the LeCroy 3931A printer, there remains another option. This option is to communicate via one of the four ports on the model 3500 -35 Quad serial interface board using the program TERMQ. Program TERMQ is a version of TERM configured for the quad serial interface board.

NOTE: Running under CP/M, TERMQ enables text emulation of a VT52 terminal. Once the connection is made, go to STEP17.

STEP17 At prompt A type

TERMQ B: myfile·DAT<CR>

(<CR> indicates the RETURN key)

NOTE: "TERMQ B: myfile·DAT" not only initiates the communication, but also saves the returning data from the VAX system in a file called "myfile·DAT" On drive B.

TERMQ begins with an interactive session which prompts the user for information necessary to make possible communication between the LeCroy 3500 and the VAX systems. First, the user must state which RS-232-C port is being used. The remaining prompts request information about the VAX 11/780 computer. The actual initialization session required to allow communication with the VAX 11/780 is shown in Figure 2.9. Note that a carriage return must not follow a "Y" or "N" response but it must follow a numeric entry. At the last stage of initialization, program TERMQ prompts the user for bit rate selection. Bit rate means the number of bits transferred per unit of time, usually expressed in bits per second (bps). Due to hardware limitations, the LeCroy 3500 SA can't handle bit rates higher than 1200 bits

```
Terminal program        Version 3.1     (START for help)

Port = 00 Change? Y
New value = 4

Stop bits (1 = > 1, 2 = > 1.5, 3 = > 2) = 01 Change? Y
New value = 3

Parity (1 = > odd, 2 = > none, 3 = > even) = 02 Change? Y
New value = 3

Number of bits (5 to 8) = 08 Change? Y
New value = 7

Bit rate selection:
0 = > 19200     4 = > 2400     8 = > 600     C = > 134
1 = > 9600      5 = > 2000     9 = > 300     D = > 118
2 = > 4800      6 = > 1800     A = > 200     E = > 75
3 = > 3600      7 = > 1200     B = > 150     F = > 58
Currently 04 Change? Y
New Value = 7
```

Figure 2.9. Initializing TERMQ for VAX - System 3500 Communication.

per second. With this bit rate, the time required to process 4K of raw data is as follows:

Time required to read values of two transient recorders from the histogram memory of the computer and store these values along with the fiduciary data on the data file on a floppy disk in drive B.	Approximate time 4 minutes
Time required to send this information from the LeCroy 3500 SA to the VAX 11/780	3 minutes
Time required to process the raw data in the VAX 11/780 system	4 seconds
Time required to bring the processed data to the LeCroy System	1.5 minutes
Time required to plot the various spectra	4 minutes
Total Approximately	**13 minutes**

When the final initialization has been entered, system 3500 is effectively a VAX terminal. Thus, a carriage return will elicit the VAX prompt

USERNAME:

Use the system 3500 keyboard to log into the VAX. A successful login results in the VAX/VMS prompt.

NOTE: The system 3500's keypad is used to implement certain functions of the TERMQ program. These functions are shown in Figure 2.10. For more information refer to 3500 SA's operator's manual.

PORT	FORMAT	X-ON	DUPLEX
CL BUF	DUMP	ECHO	STAT
SEND	SAVE	SUPR	ENABLE
HELP		EXIT	CL SCR

Figure 2.10. TERMQ keypad Functions.

The following steps document the means of transfering a file from the system 3500 to the VAX.

STEP1	At the dollar sign, enter the VAX/VMS command CREATE Filename <CR> where "Filename" is the name of the VAX file that will receive the system 3500 file and "<CR>" indicates the RETURN key.
STEP2	Depress the SEND key on the keypad (refer to Figure 2.10 for the location of this key).
STEP3	Respond to the inquiry: FILE to send: B: myfile·DAT
STEP4	Respond to the inquiry: Encode in HEX? N The answer is "N" because the file is an ASCII code.
STEP5	Respond to the inquiry; Send line feed after carriage return? with an "N"
STEP6	Await completion of the transfer. No prompt will appear, but the end of the file just transfered may be recognized if its contents are known, since the file being transferred is listed on the CRT display.
STEP7	Enter the end-of-file character, CTRL-Z, to inform the VAX/VMS operating system that the file it has been saving reached an end.

Figure 2.11 is an example of a data file being transferred from the 3500 system to the VAX system. As previously mentioned, it is time to run the modified program "Test 77" on these raw data and store the processed data in a file. The following steps document the means of transferring this file from VAX 11/780 to the system 3500.

STEP1	At the dollar sign prompt, enter the command TYPE Filename without striking the RETURN key. "Filename" is the VAX file to be transferred.
STEP2	Depress the CL BUF key on the keypad (refer to figure 2.10 for the key's location).
STEP3	Depress the SAVE key on the keypad.
STEP4	Depress the RETURN key to complete the entry of the VAX/VMS command started at step a).
STEP5	Await completion of file transfer. The dollar sign prompt will reappear when the transfer is completed.
STEP6	Depress the SAVE key on the keypad to inform TERMQ that the file it is saving has reached its end.
STEP7	Logoff the VAX system by entering CTRL-Z

```
FILE NUMBER:  2
DATE: 10/26/85
RUN NUMBER: APD5
ANODE VOLTAGE (KV):  1.30
ANODE CURRENT (AMP):  .002
MAX. MAGNETIC FIELD (TESLA):  .440
PRESSURE (MICROTORR):   30.0
AVERAGE PLASMA NUMBER DENSITY (ELECTRONS/ (M**3)): 1.00*10**14
RADIAL POSITION OF PROBES FROM THE CENTER  OF PLASMA (CM): 10.0
MICROWAVE SCATTERING ANGLE (DEGREE): 999.9

CHANNEL NO.1 DATA.
INPUT RANGE SETTING:    .512
SAMPLE INTERVAL (MICROSEC):  1.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):    .150

CHANNEL NO.2 DATA.
INPUT RANGE SETTING (VOLT):   .512
SAMPLE INTERVAL (MICROSEC):  1.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):    .150

CHANNEL NO.3 DATA.
INPUT RANGE SETTING (VOLT):  0.000
SAMPLE INTERVAL (MICROSEC):  0.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):   0.000
D.C. VOLTAGE AT PREAMP INPUT (VOLT):  0.00
ADDITIONAL COMMENTS ?
```

Figure 2.11. An example of a data file being transferred from the 3500 SA system to the VAX system.

256	125	151	167	169	149	136	135	135	145	156	164	151	129	120	124
132	147	164	163	137	117	110	109	124	144	163	157	139	135	129	113
119	134	151	150	146	151	142	135	145	156	155	140	126	127	127	127
143	152	151	138	123	107	101	104	124	142	148	143	131	121	111	103
106	114	117	112	109	115	118	115	124	132	123	102	92	94	101	115
136	151	139	122	111	103	93	98	116	132	130	129	126	113	108	116
120	111	101	101	109	116	130	141	140	125	115	106	99	99	118	137
146	146	130	116	110	113	127	139	134	128	130	132	138	142	145	145
137	130	123	123	132	150	167	165	150	137	132	129	138	149	154	148
138	135	135	136	142	141	130	123	118	118	128	139	146	137	119	106
98	94	109	127	133	125	118	109	100	100	104	110	109	108	111	118
124	127	126	115	101	93	96	111	132	146	145	129	118	116	120	130
136	141	139	141	145	147	148	151	150	148	143	145	150	156	154	154
142	126	119	128	147	162	170	171	162	155	153	150	144	141	142	146
155	163	171	167	159	147	135	124	119	130	149	156	160	159	147	143
142	138	133	126	131	144	150	159	159	146	137	136	141	147	148	149
151	156	167	164	156	153	150	144	143	151	158	161	164	166	157	149
149	150	151	151	152	156	152	165	171	161	148	149	149	149	147	152
159	161	156	158	151	143	135	127	131	139	145	149	143	143	147	143
137	136	134	134	137	142	145	148	148	141	132	127	126	124	125	132
137	141	135	130	123	114	107	110	114	118	121	126	126	123	118	111
103	99	101	105	117	131	138	134	126	123	118	108	102	113	132	146
156	152	141	135	130	129	131	134	136	137	141	153	154	142	135	138
138	134	134	142	145	150	154	150	141	139	137	142	143	146	150	145
145	158	156	143	139	140	138	135	138	148	150	153	154	144	133	128
126	130	133	136	136	132	140	147	141	132	128	125	121	124	132	139
140	142	137	126	123	120	119	122	121	123	130	124	130	132	123	114
110	113	117	122	125	126	123	121	117	113	113	106	102	103	114	130
135	128	119	108	97	98	108	121	127	128	129	129	135	135	129	115
103	106	126	146	159	159	134	112	117	139	148	146	135	119	123	156
175	175	165	142	125	121	135	159	174	170	163	147	127	127	152	172

Figure 2.11. (continued).

161	152	142	139	138	136	135	140	144	142	146	153	150	141	136	133
132	126	128	135	142	151	157	145	132	126	127	132	133	135	140	138
143	151	146	136	132	130	129	134	142	149	148	150	145	133	134	138
138	135	133	130	135	143	151	148	131	114	110	123	134	139	139	121
107	123	140	147	142	122	102	94	116	148	162	151	137	108	87	89
114	135	149	139	125	116	111	122	131	135	124	111	107	111	125	149
156	153	136	120	108	96	103	133	155	165	151	132	121	115	119	133
146	143	133	125	125	123	122	132	143	137	128	123	120	118	129	148
154	133	118	109	101	103	124	148	154	137	124	117	103	96	109	132
149	146	140	132	128	127	134	137	136	129	121	126	134	143	151	149
139	121	104	100	107	127	156	165	154	138	130	123	117	121	131	133
128	126	135	135	133	137	140	123	102	96	110	119	144	163	156	139
127	117	108	107	123	139	138	136	139	129	118	125	135	132	115	109
117	125	137	154	148	134	122	115	110	113	127	147	147	141	140	129
118	126	142	148	139	130	129	132	145	158	153	142	131	121	117	124
145	153	148	147	140	126	120	127	141	149	143	138	133	136	151	157
151	142	131	122	123	133	152	155	147	141	127	115	118	126	130	127
124	122	118	125	134	132	121	109	95	93	100	116	130	127	119	111
103	102	108	112	117	121	121	123	126	131	130	120	113	114	116	126
143	151	144	133	122	117	109	107	118	128	132	139	141	136	135	133
126	115	111	119	132	142	151	148	133	122	124	129	134	134	134	133
137	146	146	138	137	135	133	135	143	153	150	147	147	145	136	132
132	141	147	150	160	158	157	160	153	141	138	143	154	165	167	165
160	158	154	146	135	131	131	135	141	150	154	149	140	134	126	118
117	121	131	141	147	148	144	139	135	129	122	119	127	133	137	148
153	146	140	136	129	121	119	131	143	156	162	155	147	143	140	134
132	135	141	149	153	159	152	144	138	137	133	133	134	141	150	157
159	147	138	135	135	134	136	142	149	148	152	148	139	132	132	132
131	128	132	136	140	149	143	132	124	120	121	129	140	143	141	134
135	133	129	127	131	134	134	145	148	147	150	149	140	131	126	133
145	153	162	162	152	146	142	135	127	124	129	131	142	153	155	149

Figure 2.11. (continued).

149	146	140	132	128	127	134	137	136	129	121	126	134	143	151	149
139	121	104	100	107	127	156	165	154	138	130	123	117	121	131	133
128	126	135	135	133	137	140	123	102	96	110	119	144	163	156	139
127	117	108	107	123	139	138	136	139	129	118	125	135	132	115	109
117	125	137	154	148	134	122	115	110	113	127	147	147	141	140	129
118	126	142	148	139	130	129	132	145	158	153	142	131	121	117	124
145	153	148	147	140	126	120	127	141	149	143	138	133	136	151	157
151	142	131	122	123	133	152	155	147	141	127	115	118	126	130	127
124	122	118	125	134	132	121	109	95	93	100	116	130	127	119	111
103	102	108	112	117	121	121	123	126	131	130	120	113	114	116	126
143	151	144	133	122	117	109	107	118	128	132	139	141	136	135	133
126	115	111	119	132	142	151	148	133	122	124	129	134	134	134	133
137	146	146	138	137	135	133	135	143	153	150	147	147	145	136	132
132	141	147	150	160	158	157	160	153	141	138	143	154	165	167	165
160	158	154	146	135	131	131	135	141	150	154	149	140	134	126	118
117	121	131	141	147	148	144	139	135	129	122	119	127	133	137	148
153	146	140	136	129	121	119	131	143	156	162	155	147	143	140	134
132	135	141	149	153	159	152	144	138	137	133	133	134	141	150	157
158	147	138	135	135	134	136	142	149	148	152	149	138	132	132	132
131	128	132	136	140	149	143	132	124	120	121	129	140	143	141	134
135	133	129	127	131	134	134	145	148	147	150	149	140	131	126	133
145	153	162	162	152	146	142	135	127	124	129	131	142	153	155	149
141	131	117	108	114	127	134	141	144	135	128	124	122	117	108	103
111	127	134	140	133	122	113	109	111	118	125	127	125	127	130	126
126	125	127	127	125	134	143	145	144	139	126	122	125	134	147	153
157	148	137	139	143	134	125	120	124	141	162	174	169	153	128	122
135	147	154	153	135	131	155	175	185	183	165	135	116	124	160	187
197	186	156	136	126	139	151	159	143	131	128	130	136	146	152	152
127	102	93	95	113	137	157	152	128	110	100	93	102	118	127	127
127	127	114	99	106	119	124	108	104	112	116	117	126	130	127	110
101	105	110	120	132	135	138	129	109	101	102	114	132	146	150	136

Figure 2.11. (continued).

123	112	103	100	110	121	123	119	128	134	127	120	132	140	121	103
102	114	127	138	156	157	139	122	115	109	105	115	133	139	142	147
137	126	129	138	139	130	125	131	141	146	149	154	153	138	127	119
115	115	135	150	157	146	129	116	113	113	117	118	119	123	128	129
121	126	129	119	103	96	96	102	117	137	143	126	108	99	94	93
101	115	120	116	117	109	101	106	108	104	105	105	108	111	118	127
124	108	97	96	99	119	139	143	133	119	108	99	96	103	117	126
125	127	127	124	130	133	130	119	113	114	126	141	151	145	132	119
114	120	129	141	145	133	123	116	112	114	118	117	119	121	129	140
143	142	135	122	106	104	119	137	150	159	154	139	133	134	139	145
140	135	136	139	150	156	147	139	135	138	146	150	159	160	156	158
153	146	149	155	158	163	164	169	171	167	156	144	130	128	135	143
151	156	158	152	151	153	147	134	128	133	143	151	163	171	164	153
148	143	135	128	130	140	148	161	166	154	147	139	132	126	127	134
143	146	152	155	149	141	139	135	130	126	131	141	150	159	152	140
139	138	132	132	139	143	149	152	153	145	138	137	137	141	145	147
146	146	156	161	152	147	147	149	147	145	148	151	155	154	152	142
138	132	128	131	138	150	151	146	143	139	131	124	125	129	132	135
143	143	138	133	126	118	114	112	120	127	135	147	147	137	131	124
115	110	118	128	142	148	150	141	135	130	129	126	123	126	134	146
155	158	148	143	142	139	137	137	140	143	150	155	152	140	133	132
135	137	141	149	147	146	152	149	141	136	132	133	133	133	138	143
141	141	132	121	119	119	123	129	136	140	135	135	138	135	125	119
119	132	143	151	158	148	134	124	123	124	129	130	134	137	140	150
155	151	141	121	102	106	131	146	153	151	130	118	135	153	156	141
116	108	119	145	172	177	159	133	113	103	113	130	152	155	142	137
131	124	136	148	155	141	126	124	120	128	151	162	149	129	116	115
114	123	147	163	152	142	127	109	97	105	123	143	145	143	140	131
129	137	143	143	133	126	126	124	121	128	138	135	118	105	101	101
105	124	148	153	135	121	116	107	99	107	127	135	134	143	141	129
129	137	140	127	117	117	122	126	143	154	150	133	123	120	116	113

Figure 2.11. (continued).

99	111	126	135	131	122	116	111	117	121	124	120	115	113	115	122
133	134	134	126	119	111	107	110	125	138	145	136	124	120	117	118
125	134	134	127	125	126	121	118	123	130	127	126	124	122	118	124
134	135	124	118	111	108	109	122	135	138	130	121	117	109	105	111
126	137	136	133	125	124	124	125	127	127	125	122	125	130	133	136
135	132	120	111	110	114	124	140	146	139	130	125	121	117	118	125
129	126	127	132	127	127	127	129	118	108	108	116	120	133	143	139
131	123	117	111	113	121	130	131	132	132	124	119	122	127	126	118
117	121	124	131	136	132	126	121	117	114	116	125	135	135	134	131
123	119	123	131	135	132	127	127	129	134	139	137	134	127	125	122
126	137	141	139	138	132	123	121	126	134	140	137	136	132	134	140
141	139	134	129	123	125	131	141	141	139	135	125	118	119	124	127
127	127	125	121	123	127	125	119	111	106	103	109	119	126	123	118
113	105	104	108	111	118	121	120	119	120	122	120	115	111	114	116
122	132	135	132	125	120	115	111	111	118	125	128	131	131	127	127
126	121	115	116	120	127	132	137	133	125	121	121	125	129	130	130
130	132	136	134	131	130	129	127	132	136	142	140	138	138	135	130
129	129	135	139	143	148	143	143	146	140	134	134	138	146	152	155
153	150	148	143	138	133	131	132	134	137	143	145	140	133	130	124
121	121	125	131	135	139	138	134	132	127	126	123	122	127	131	133
139	140	135	131	127	125	121	121	128	134	142	147	141	136	133	132
127	129	131	135	140	143	146	139	134	132	130	130	131	133	136	140
143	143	137	131	129	130	130	132	137	139	140	141	137	130	126	127
129	126	127	132	131	133	137	134	125	123	121	122	127	135	135	133
129	130	125	125	125	127	129	130	136	137	136	138	137	131	125	124
129	134	142	148	147	140	136	133	127	125	125	129	129	135	142	141
137	133	125	119	115	119	126	130	134	135	127	125	122	120	116	113
111	118	124	127	130	124	118	114	111	111	117	122	123	121	123	122
119	118	119	122	123	123	129	131	131	132	130	120	120	122	129	134
140	142	135	129	130	131	125	125	123	125	134	145	151	148	139	126
123	128	134	141	142	134	132	142	151	157	158	149	132	122	127	147

Figure 2.11. (continued).

146	148	148	146	145	140	135	131	127	130	134	138	140	135	137	136
132	129	129	129	130	132	135	137	137	135	131	125	124	122	122	123
129	131	130	127	125	120	111	110	111	115	117	119	122	119	117	113
108	104	102	105	108	115	123	127	122	117	114	111	107	105	113	124
133	138	133	126	125	122	122	124	127	130	130	132	139	137	131	127
130	129	126	130	134	134	138	141	136	131	129	130	133	135	138	141
135	139	143	141	134	132	133	132	131	135	141	140	142	142	135	127
126	125	127	130	131	131	127	135	137	131	125	125	124	120	123	129
131	131	133	127	122	119	117	118	119	120	122	124	121	125	124	118
111	111	111	116	119	122	122	119	118	113	110	110	107	106	108	115
124	124	119	115	107	99	101	108	117	122	123	123	120	121	121	118
113	107	110	121	132	141	139	124	113	115	126	132	133	130	121	124
140	148	149	146	134	126	125	132	143	151	152	150	139	126	127	140
151	156	147	140	136	137	146	153	157	151	139	130	126	129	138	146
148	146	137	125	119	118	125	133	137	134	129	130	127	125	125	129
124	120	117	117	117	117	124	129	120	110	103	100	95	101	110	119
115	109	104	95	89	90	97	102	104	104	103	99	97	98	100	99
95	98	101	105	108	111	116	115	105	99	97	101	110	124	136	135
125	118	113	109	110	116	124	126	127	131	126	120	122	125	122	115
113	115	122	127	140	139	130	120	118	117	117	120	128	133	133	132
123	118	117	121	124	124	125	125	125	127	135	134	127	124	123	125
123	127	135	141	142	141	131	125	126	129	134	135	135	135	132	133
140	139	134	127	127	127	131	137	143	146	147	139	131	127	131	135
138	135	134	132	127	132	135	132	125	120	114	111	116	124	127	127
124	113	104	103	106	238	110	113	114	113	111	115	111	105	100	98
103	111	125	127	123	115	107	102	105	111	118	126	130	131	129	126
130	127	122	117	122	132	141	151	152	142	136	133	134	134	136	137
137	141	147	149	143	142	141	140	136	136	142	148	150	153	148	141
141	140	138	135	138	143	145	143	147	141	133	129	130	133	134	138
141	139	138	139	134	127	125	125	128	133	143	148	140	138	138	134
131	134	136	143	147	152	156	151	145	141	137	135	135	137	148	156

Figure 2.11. (continued).

177	155	141	136	139	157	175	178	166	144	127	121	122	141	158	163
156	143	126	114	111	127	143	146	137	130	133	132	127	130	138	131
117	110	111	111	116	130	143	130	108	97	90	84	92	109	125	117
108	102	89	77	82	95	102	99	99	99	95	92	100	105	103	92
92	97	104	110	119	127	127	109	95	94	99	114	137	157	158	139
125	117	111	111	119	130	133	134	141	138	126	131	136	129	112	106
111	123	133	155	161	143	126	119	116	113	119	132	141	138	138	128
117	118	127	130	125	123	124	124	127	147	151	139	127	123	127	125
129	144	154	156	154	139	130	131	136	144	142	137	135	135	137	153
153	142	131	126	126	132	145	159	161	160	150	137	132	135	143	146
139	135	133	129	135	146	142	130	118	108	105	111	127	133	132	126
113	101	100	105	109	106	109	112	114	115	120	118	105	95	90	100
112	131	140	132	119	109	103	105	114	121	132	138	143	143	141	144
142	126	116	121	140	157	173	177	159	148	142	142	142	143	143	144
149	159	166	159	152	149	147	141	141	148	156	159	165	162	153	151
148	143	139	141	150	155	154	159	153	139	131	133	137	136	140	145
145	144	147	142	133	125	123	130	138	154	163	152	147	149	146	138
142	143	153	159	165	174	166	156	151	145	139	140	141	159	173	178
177	168	165	159	149	144	149	157	165	171	172	170	167	162	154	142
132	133	138	143	147	152	148	142	136	127	119	111	110	118	126	134
145	138	129	124	122	116	112	116	129	141	151	154	144	140	137	134
129	130	137	146	150	160	158	147	139	138	140	140	137	143	149	155
161	152	142	139	138	136	135	140	144	142	146	153	150	141	136	133
132	126	128	135	142	151	157	145	132	126	127	132	133	135	140	138
143	151	146	136	132	130	129	134	142	149	148	150	145	133	134	138
138	135	133	130	135	143	151	148	131	114	110	123	134	139	139	121
107	123	140	147	142	122	102	94	116	148	162	151	137	108	87	89
114	135	149	139	125	116	111	122	131	135	124	111	107	111	125	149
156	153	136	120	108	96	103	133	155	165	151	132	121	115	119	133
146	143	133	125	125	123	122	132	143	137	128	123	120	118	129	148
154	133	118	109	101	103	124	148	154	137	124	117	103	96	109	132

Figure 2.11. (continued).

113	105	104	108	111	118	121	120	119	120	122	120	115	111	114	116
122	132	135	132	125	120	115	111	111	118	125	128	131	131	127	127
126	121	115	116	120	127	132	137	133	125	121	121	125	129	130	130
130	132	136	134	131	130	129	127	132	136	142	140	138	138	135	130
129	129	135	139	143	143	143	143	146	140	134	134	138	146	152	155
153	150	148	143	138	133	131	132	134	137	143	145	140	133	130	124
121	121	125	131	135	139	138	134	132	127	126	123	122	127	131	133
139	140	135	131	127	125	121	121	128	134	142	147	141	136	133	132
127	129	131	135	140	143	146	139	134	132	130	130	131	133	136	140
143	143	137	131	129	130	130	132	137	139	140	141	137	130	126	127
129	126	127	132	131	133	137	134	125	123	121	122	127	135	135	133
129	130	125	125	125	127	129	130	136	137	136	138	137	131	125	124
129	134	142	148	147	140	136	133	127	125	125	129	129	135	142	141
137	133	125	119	115	119	126	130	134	135	127	125	122	120	116	113
111	113	124	127	130	124	118	114	111	111	117	122	123	121	123	122
119	118	119	122	123	123	129	131	131	132	130	120	120	122	129	134
140	142	135	129	130	131	125	125	123	125	134	145	151	148	139	126
123	128	134	141	142	134	132	142	151	157	158	149	132	122	127	147
161	167	162	145	132	126	133	139	143	140	134	131	131	132	135	139
139	124	111	108	110	119	131	141	138	124	114	107	102	107	116	123
125	125	122	111	103	106	113	117	111	111	115	115	114	116	117	116
108	104	107	111	119	123	124	126	120	107	103	105	111	122	131	134
125	119	113	107	103	110	117	119	119	125	127	121	116	123	127	118
109	109	115	123	129	137	136	127	120	115	110	110	116	126	130	133
134	127	123	123	127	127	126	125	120	133	135	135	138	137	130	123
121	118	120	129	138	142	135	124	117	115	114	116	118	122	124	127
126	119	119	121	117	109	107	107	110	117	123	127	120	109	103	100
99	104	115	117	115	114	108	102	103	105	105	107	109	110	111	114
118	114	106	101	101	103	116	126	129	121	114	108	101	100	104	115
120	121	122	121	117	120	123	123	118	114	114	121	128	133	130	123
118	116	119	124	132	134	127	123	118	113	113	116	118	121	122	126

Figure 2.11. (continued).

117	116	122	134	143	139	133	121	113	105	110	121	133	135	134	130
124	123	125	128	127	126	124	125	122	119	122	127	126	116	107	105
107	108	119	133	135	124	118	114	108	103	110	122	127	128	133	127
124	122	126	127	124	119	119	121	123	133	134	132	123	121	118	116
116	125	133	139	138	127	119	118	117	124	132	134	130	126	126	127
123	123	125	123	119	117	117	118	123	128	126	118	109	105	104	104
113	124	125	115	110	107	101	100	105	108	111	114	117	117	114	117
119	111	105	104	110	119	130	141	138	127	122	117	111	117	124	133

Figure 2.11. (continued).

STEP8 Depress the EXIT key on the keypad to return to the CP/M operating system.

NOTE: These processed data will be saved under filename "myfile·DAT" in drive B. At this time, run the program Job2 which does the plotting. At prompt A type Job2. Programs Jobl, Job2, and Test77 are included in Appendix A. Appendix B contains spectra for three different runs.

REFERENCES

REFERENCES

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5. Wilfred P. Rule, Fortran77, a Practical Approach, Fourth Edition, 1980.

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APPENDIXES

APPENDIX A

COMPUTER PROGRAMS

PROGRAM JOB1

```
      PROGRAM JOB1
      DIMENSION IARRY(8000)
      LOGICAL LF
      INTEGER FN
      REAL INRS1,SI1,ANAF1,PG1,INRS2,SI2,ANAF2,PG2
      REAL INRS3,SI3,ANAF3,PG3,DCVOLT
      REAL AV,ACU,MMF,PRESS,RPOP,MSA
      DOUBLE PRECISION DATE ,RN,APND
      LOGICAL NAME(11),COMM(40)
      DATA NAME/8*' ','D','A','T'/
C
C
C
C     MAD    : STARTING HISTOGRAM MEMORY ADDRESS.
C     N      : NUMBER OF CHANNELS TO BE OPERATED ON.
C     LF     : LINE FEED.
C     FN     : FILE NUMBER.
C     NAME   : FILE NAME TO BE ASSIGNED TO A DATA FILE
C     RN     : RUN NUMBER FOR AN EXPERIMENT
C     AV     : ANODE VOLTAGE
C     ACU    : ANODE CURRENT
C     MMF    : MAX. MAGNETIC FIELD
C     PRESS  : PRESSURE (MICROTORR)
C     APND   : AVERAGE PLASMA NUMBER DENSITY
C     RPOP   : RADIAL POSITION OF PROBE
C     MSA    : MICROWAVE SCATTERING ANGEL
C     INRS1  : INPUT RANGE SETTING CHANNEL 1
C     INRS2  : INPUT RANGE SETTING CHANNEL 2
C     INRS2  : INPUT RANGE SETTING CHANNEL 3
C     SI1    : SAMPLE INTERVAL CHANNEL 1
C     SI2    : SAMPLE INTERVAL CHANNEL 2
C     SI3    : SAMPLE INTERVAL CHANNEL 3
C     ANAF1  : ANTIALIAS FILTER CHANNEL 1
C     ANAF2  : ANTIALIAS FILTER CHANNEL 2
C     ANAF3  : ANTIALIAS FILTER CHANNEL 3
C     PG1    : OVERALL PROBE GAIN CHANNEL 1
C     PG2    : OVERALL PROBE GAIN CHANNEL 2
C     PG3    : OVERALL PROBE GAIN CHANNEL 3
C     DCVOLT : D.C. VOLTAGE AT PREAMP INPUT
C
C
```

```
C
      LF=10
      WRITE(5,1)
1     FORMAT(2X,'ENTER FILE NAME: ')
10    FORMAT(8A1)
20    FORMAT(2X,'ENTER CHANEL: ')
      READ (5,10)(NAME(I),I=1,8)
      WRITE (5,20)
      READ(5,30) MAD
      WRITE(5,40)
40    FORMAT(2X,'ENTER BLOCK SIZE: ')
      READ(5,50) N
50    FORMAT(I4)
30    FORMAT(I4)
C
C     OPEN A DATA FILE ON A DISK IN DRIVE B
C
      CALL OPEN(6,NAME,2)
C
C
C     ENTER EXPERIMENTAL CONDITIONS
C
C
      WRITE(5,51)
51    FORMAT(2X,'ENTER FILE NUMBER: ')
      READ(5,52) FN
52    FORMAT(I2)
      WRITE(6,53) LF,FN
53    FORMAT(A1,'FILE NUMBER: ',I2 )
      WRITE (5,54)
54    FORMAT(2X,'ENTER DATE: ')
      READ  (5,55) DATE
55    FORMAT(A8)
      WRITE(6,56)LF,DATE
56    FORMAT(A1,'DATE: ',A8)
      WRITE (5,57)
57    FORMAT(2X,'ENTER RUN NUMBER: ')
      READ (5,58)RN
58    FORMAT(A8)
      WRITE(6,59) LF,RN
59    FORMAT(A1,'RUN NUMBER: 'A8)
```

```
      WRITE(5,60)
60    FORMAT(2X,'ENTER ANODE VOLTAGE (KV): ')
      READ(5,61) AV
61    FORMAT(F5.2)
      WRITE(6,62) LF,AV
62    FORMAT(A1,'ANODE VOLTAGE (KV): ',F5.2)
      WRITE(5,63)
63    FORMAT(2X,'ENTER ANODE CURRENT (AMP): ')
      READ(5,64) ACU
64     FORMAT(F5.3)
      WRITE (6,65) LF,ACU
65    FORMAT(A1,'ANODE CURRENT (AMP): ',F5.3)
      WRITE (5,66)
66    FORMAT(2X,'ENTER MAX. MAGNETIC FIELD (TESLA): ')
      READ(5,67)MMF
67    FORMAT(F5.3)
      WRITE (6,68) LF,MMF
68    FORMAT(A1,'MAX. MAGNETIC FIELD (TESLA): ',F5.3)
      WRITE (5,69)
69    FORMAT(2X,'ENTER PRESSURE (MICROTORR): ')
      READ (5,70) PRESS
70    FORMAT (F6.1)
      WRITE (6.71) LF,PRESS
71    FORMAT(A1,'PRESSURE (MICROTORR): ',F6.1)
      WRITE(5,72)
72    FORMAT(2X,'ENTER AVERAGE PLASMA NUMBER DENSITY
     1 (ELECTRONS/(M**3)): ')
      READ (5,73) APND,I
73    FORMAT(F4.2,5X,I2)
      WRITE(6,74) LF,APND,I
74    FORMAT(A1,'AVERAGE PLASMA NUMBER DENSITY (ELECTRONS/
     1 (M**3)): ',F4.2,'*10**',I2)
      WRITE (5,75)
75    FORMAT(2X,'ENTER RADIAL POSITION OF PROBES FROM THE
     1  CENTER OF PLASMA (CM): ')
      READ (5,76) RPOP
76    FORMAT (F4.1)
      WRITE(6,77) LF,RPOP
77    FORMAT(A1,'RADIAL POSITION OF PROBES FROM THE CENTER
     1 OF PLASMA (CM): ',F4.1)
      WRITE(5,78)
```

```
78      FORMAT(2X,'ENTER MICROWAVE SCATTERING ANGLE (DEGREE): ')
        READ (5,79)MSA
79      FORMAT(F5.1)
        WRITE(6,80) LF,MSA
80      FORMAT(A1,'MICROWAVE SCATTERING ANGLE (DEGREE): ',F5.1)
        WRITE (6,81),LF
81      FORMAT(A1)
C
C
C
C       ENTER INPUT SETTING FOR CHANNEL 1
C
C
C
        WRITE (5,82)
82      FORMAT(2X,'CHANNEL NO.1 DATA. ')
        WRITE (6,83),LF
83      FORMAT(A1,'CHANNEL NO.1 DATA. ')
        WRITE (5,84)
84      FORMAT(2X,'ENTER INPUT RANGE SETTING (VOLT): ')
        READ (5,85) INRS1
85      FORMAT(F8.5)
        WRITE (6,86) LF,INRS1
86      FORMAT(A1,'INPUT RANGE SETTING: ',F8.5)
        WRITE (5,87)
87      FORMAT(2X,'ENTER SAMPLE INTERVAL (MICROSEC): ')
        READ (5,88) SI1
88      FORMAT(F9.6)
        WRITE(6,89) LF,SI1
89      FORMAT(A1,'SAMPLE INTERVAL (MICROSEC): ',F9.6)
        WRITE (5,90)
90      FORMAT(2X,'ENTER ANTIALIAS FILTER (MHZ): ')
        READ (5,91) ANAF1
91      FORMAT(F5.3)
        WRITE(6,92) LF,ANAF1
92      FORMAT(A1,'ANTIALIAS FILTER (MHZ): ',F5.3)
        WRITE (5,93)
93      FORMAT(2X,'ENTER OVERALL PROBE GAIN (VOLT): ')
        READ(5,94) PG1
94      FORMAT(F3.4)
        WRITE (6,95) LF,PG1
```

```
95      FORMAT(A1,'OVERALL PROBE GAIN (VOLT): ',F8.4)
        WRITE (6,96),LF
96      FORMAT(A1)
C
C
C
C       ENTER INPUT SETTING FOR CHANNEL 2
C
C
C
        WRITE (5,97)
97      FORMAT(2X,'CHANNEL NO.2 DATA.  ')
        WRITEE (6,98),LF
98      FORMAT(A1,'CHANNEL NO.2 DATA.  ')
        WRITE (5,99)
99      FORMAT(2X,'ENTER INPUT RANGE SETTING (VOLT):  ')
        READ (5,101) INRS2
101     FORMAT(F8.5)
        WRITE(6,102) LF,INRS2
102     FORMAT(A1,'INPUT RANGE SETTING (VOLT):  ',F8.5)
        WRITE (5,103)
103     FORMAT(2X,'ENTER SAMPLE INTERVAL (MICROSEC):  ')
        READ(5,104) SI2
104     FORMAT(F9.6)
        WRITE (6,105) LF,SI2
105     FORMAT(A1,'SAMPLE INTERVAL (MICROSEC): ',F9.6)
        WRITE (5,106)
106     FORMAT(2X,'ENTER ANTIALIAS FILTER (MHZ): ')
        READ (5,107) ANAF2
107     FORMAT(F5.3)
        WRITE(6,108) LF,ANAF2
108     FORMAT(A1,'ANTIALIAS FILTER (MHZ): ',F5.3)
        WRITE(5,109)
109     FORMAT(2X,'ENTER OVERALL PROBE GAIN (VOLT): ')
        READ (5,110) PG2
110     FORMAT(F8.4)
        WRITE(6,111) LF,PG2
111     FORMAT(A1,'OVERALL PROBE GAIN (VOLT): 'F8.4)
        WRITE (6,112),LF
112     FORMAT (A1)
C
```

```
C
C
C       ENTER INPUT SETTING FOR CHANNEL 3
C
C
C
        WRITE (5,113)
113     FORMAT(2X,'CHANNEL NO.3 DATA.  ')
        WRITE(6,114),LF
114     FORMAT(A1,'CHANNEL NO.3 DATA.  ')
        WRITE (5,115)
115     FORMAT(2X,'ENTER INPUT RANGE SETTING (VOLT):  ')
        READ (5,116) INRS3
116     FORMAT(F8.5)
        WRITE(6,117) LF,INRS3
117     FORMAT(A1,'INPUT RANGE SETTING (VOLT): ',F8.5)
        WRITE (5,118)
118     FORMAT(2X,'ENTER SAMPLE INTERVAL (MICROSEC): ')
        READ(5,119) SI3
119     FORMAT(F9.6)
        WRITE(6,120) LF,SI3
120     FORMAT(A1,'SAMPLE INTERVAL (MICROSEC): ',F9.6)
        WRITE (5,121)
121     FORMAT(2X,'ENTER ANTIALIAS FILTER (MHZ): ')
        READ (5,122) ANAF3
122     FORMAT(F5.3)
        WRITE (6,123) LF,ANAF3
123     FORMAT(A1,'ANTIALIAS FILTER (MHZ): ',F5.3)
        WRITE (5,124)
124     FORMAT(2X,'ENTER OVERALL PROBE GAIN (VOLT):  ')
        READ (5,125) PG3
125     FORMAT(F8.4)
        WRITE (6,126) LF,PG3
126     FORMAT(A1,'OVERALL PROBE GAIN (VOLT): ',F8.4)
C
C
C
        WRITE (5,127)
127     FORMAT(2X,'ENTER D.C. VOLTAGE AT PREAMP INPUT (VOLT):  ')
        READ (5,128) DCVOLT
128     FORMAT(F5.2)
```

```
      WRITE (6,129) LF,DCVOLT
129   FORMAT(A1,' D.C. VOLTAGE AT PREAMP INPUT (VOLT): ',F5.2)
      WRITE (5,130)
130   FORMAT(2X,'ENTER ADDITIONAL COMMENTS ?',/)
      READ (5,131) COMM
131   FORMAT(40A1)
      WRITE(6,132) LF,COMM
132   FORMAT(A1,'ADDITIONAL COMMENTS ?' ,40A1)
      WRITE(6,133),LF
133   FORMAT(A1)
C
C
C     SUBROUTINE HMIRD READS THE DATA FROM THE HISTOGRAM
C     MEMORY OF THE COMPUTER AND TRANSFERS THE DATA TO THE
CC     ARRAY "IARRAY".
C
C
      CALL HMIRD(IARRY,MAD,N)
      DO 300 I=1,N,16
      K=I+15
      IF (K.GT.N) K=N
300   WRITE(6,100) LF,(IARRY(J),J=I,K)
100   FORMAT(A1,16(1X,I3))
      END
```

PROGRAM TEST77

```
        PROGRAM TEST77
      CHARACTER NAME*8
      DOUBLE PRECISION FNAME,IDATE,IRUNO,IPAR2,IPAR3,IFLNO
      DOUBLE PRECISION IPAR1,Z1,Z2,Z3,Z4,Z5,YY(8)
    DIMENSION ICOM(500),IPAR(23),PAR(23)
    COMMON/L/D1(2048),D2(2048),D3(2048)
    COMMON/PR/BMAX,AVDEN,RCM,RDG,R1,DTU,G1,R2,G2,R3,G3,VDC
    COMMON/TAB1/IDATE,IFLNO,IRUNO,Z1,Z2,Z3,Z4,Z5
      COMMON/TAB2/DTUB,M,IW
      IPEY=19
543   WRITE(5,1)
      IPEY=IPEY+1
      IF(IPEY.EQ.24)STOP
1     FORMAT(///////,1X,'TYPE THE NAME OF THE DATA FILE')
      READ(5,2)FNAME
2     FORMAT(A10)
      OPEN(UNIT=21,name=FNAME)
        WRITE(5,222)
222     FORMAT(2X,'ENTER FILE NAME FOR THE PROCCESSED DATA:')
        READ (5,333) NAME
333     FORMAT(A8)
        OPEN( UNIT=24,NAME=NAME)
      CALL PARMTR(PAR,IPAR1,IPAR2,IPAR3,Z1,Z2,Z3,Z4,Z5,YY,21)
*     READ PARAMETERS FROM THE COMMENT SECTION.
*
*     IPAR1:     FILE NUMBER (IFLNO)
*     IPAR2:     DATE (IDATE)
*     IPAR3:     RUN NUMBER (IRUNO)
*     PAR(4):      ANODE VOLTAGE  KV ,(VPL)
*     PAR(5):      ANODE CURRENT  AMP ,(CP)
*     PAR(6):      MAX. MAGNETIC FIELD  TESLA ,(BMAX)
*     PAR(7):      PRESSURE  MICRO-TORR ,(PSU)
*     PAR(8):      AVERAGE PLASMA NUMBER DENSITY  ELECTRONS/(M**3) ,
*                  (AVDEN).
*     PAR(9):      RADIAL POSITION OF PROBES FROM THE CENTRE OF PLASMA
*                   CM ,(RCM)
*     PAR(10):     POTENTIAL PROBE ANGULAR DISPLACEMENT  DEGREE ,(RDG)
*     PAR(11):     INPUT RANGE SETTING IN BIO.1  VOLT ,(R1)
*     PAR(12):     SAMPLE INTERVAL  MICRO-SEC ,(DTU)
*     PAR(13):     ANTI-ALIAS FILTER  MHZ ,(FCUT)
*     PAR(14):     PRE-AMP GAIN  VOLT IN BIO./VOLT IN PLASMA .
```

```
*                     (G1)
*       PAR(15):      INPUT RANGE SETTING IN BIO.2  VOLT ,(R2)
*       PAR(16):      SAMPLE INTERVAL  MICRO-SEC
*       PAR(17):      ANTI-ALIAS FILTER  MHZ
*       PAR(18):      PRE-AMP GAIN  VOLT IN BIO./VOLT IN PLASMA ,(G2)
*       PAR(19):      INPUT RANGE SETTING IN BIO.3  VOLT ,(R3)
*       PAR(20):      SAMPLE INTERVAL  MICRO-SEC
*       PAR(21):      ANTI-ALIAS FILTER  MHZ
*       PAR(22):      PRE-AMP GAIN  VOLT IN BIO./VOLT IN PRE-AMP ,(G3)
*       PAR(23):      D.C.VOLTAGE AT PRE-AMP INPUT  VOLT ,(VDC)
*
*
        IFLNO=IPAR1
        IDATE=IPAR2
        IRUNO=IPAR3
*
        VPK=PAR(4)
        CP=PAR(5)
        BMAX=PAR(6)
        PSU=PAR(7)
*
        AVDEN=PAR(8)
*
        RCM=PAR(9)
        RDG=PAR(10)
        R1=PAR(11)
        DTU=PAR(12)
*
        DTUB=DTU
*
        G1=PAR(14)
        R2=PAR(15)
        G2=PAR(18)
        R3=PAR(19)
        G3=PAR(22)
        VDC=PAR(23)
*
*     READ BIOMATIONS DATA
*
          CALL BIODAT(21,D1,N)
          CALL BIODAT(21,D2,N)
```

```
      CLOSE(UNIT=21)
*
*     SET ZERO FOR THE LAST 3 WORDS FROM BIOMATION
*
      N=2048
      NB=N-2
      DO 10 I=NB,N
      D1(I)=0
      D2(I)=0
      D3(I)=0
   10 CONTINUE
*
*     GENERATE THE POWER SPECTRA.
*
      M=9
      IW=2
      CALL NASA(M,IW,YY,IPEY)
      STOP
      END
      SUBROUTINE NASA(M,IW,YY,IPEY)
*
*     TQD(I) IS TEMPORARY STORAGE FOR QD BETWEEN CH.1 AND CH.3
*
      COMMON /TEMPQD/ TQD(1025),TRFCT
*
      COMMON/L/D1(2048),D2(2048),D3(2048)
      COMMON/PR/BMAX,AVDEN,RCM,RDG,R1,DTU,G1,R2,G2,R3,G3,VDC
      COMMON/PLTT/PX(1027),PY(1027),PP(1027)
      COMMON X(2050),Y(2050),Z(1025)
        DOUBLE PRECISION IA(3),YY(8)
      DOUBLE PRECISION IB(4),IC(4),ID(5),IE(4),IF(4),IG(4),IH(4)
      DIMENSION IU(4),IV(2),IDD1(2050),IDD2(2050)
      DIMENSION Q(1025,5)
      EQUIVALENCE(X(1),Q(1,1))
*
*     M     : NUMBER OF M-AVERAGINGS.
*     IW    : OPTIONAL NUMBER OF DATA WINDOW APPLIED.
*
      N=2048
      N2=N/2
      N21=N2+1
```

```
      DO 629 I=1,2048
      IDD1(I)=D1(I)
      IDD2(I)=D2(I)
629   CONTINUE
      RR1=R1
      RR2=R2
      DDD=DTU
*
*     SELECT CHAN. X AND Y FROM D1,D2 AND D3.
*
      DO 20 I=1,N21
      Z(I)=0.0
   20 CONTINUE
*
*     SCALE FACTOR FOR ABSOLUTE VALUE OF EACH CHANNEL.
*
      SC1=R1/G1
      SC2=R2/G2
C     SC3=(R3/G3)*(AVDEN/VDC)
      PI=3.1415926563
      RM=RCM*0.01
      RD=RDG*PI/180.
      TSC=1./(RM*RD*BMAX*0.28)
*
      RS=1.0/128.0
*
      WD=0.105
      CN=999.0
*
        WRITE(5,102)
102     FORMAT(10X,'TEST2')
      DO 5 K=1,1
*
*     IF K=1, POWER SPECTRUM BETWEEN CH.1 AND CH.2
*     IF K=2, POWER SPECTRUM BETWEEN CH.1 AND CH.3
*
      DO 10 I=1,N
      X(I)=RS*(D1(I))
      IF(K.EQ.1) Y(I)=RS*(D2(I))
      IF(K.EQ.2) Y(I)=RS*(D3(I))
   10 CONTINUE
```

```
*
*     SUBSTRACT THE MEAN VALUE FROM EACH ARRAY.
*
      CALL MEAN
*
*     MULTIPLY WINDOW FUNCTION TO DATA IN TIME DOMAIN.
*
        WRITE(5,101)
101     FORMAT(10X,'TEST1')
      CALL WINDOW(IW,SW)
*
      DT=DTU*1.0E-6
        KKKK=K
      CALL POWERS(M,NP,KKKK)
        WRITE(5,103)
103     FORMAT(10X,'TEST3')
      SWQ=SQRT(SW)
*
      IF(K-1) 61,61,62
*
*     CALCULATE RMS VALUE OF CHAN.1 AND CHAN.2 .
*
   61 CALL SUMRMS(1,NP,RMS)
        WRITE(5,104)
104     FORMAT(10X,'TEST4')
      RMS1=RMS*SC1*SWQ
      CALL SUMRMS(3,NP,RMS)
      RMS2=RMS*SC2*SWQ
*
      DO 56 L=1,NP
      Q(L,1)=Q(L,1)*SW*(SC1**2)
      Q(L,2)=Q(L,2)*SW*SC1*SC2
      Q(L,3)=Q(L,3)*SW*(SC2**2)
   56 CONTINUE
      GO TO 78
*
*     CALCULATE RMS VALUE OF CHAN. 3.
*
111     FORMAT(10X,'TEST10')
   62 CALL SUMRMS(3,NP,RMS)
        WRITE(5,111)
```

```
C       RMS3=RMS*SC3*SWQ
          WRITE(5,211)
211       FORMAT(10X,'TEST11')
*
          WRITE(5,112)
112       FORMAT(10X,'TEST12')
*
78        CONTINUE
*
*       PLOT ALL SPECTRA ON CALCOM PLOTTER.
*       POWER SPECTRA ARE PLOTTED WITH 10-INCH SEMI-LOG SCALE
*              UP TO NYQUIST FREQUENCY.
*
*       SFK IS IN KILO-HERZ.
*
        SFK=FLOAT(M)/(2.048*DTU)
        DO 30 I=1,NP
        PX(I)=SFK*FLOAT(I)
        write(24,*) PX(I)
   30 CONTINUE
*
          WRITE(5,115)
115       FORMAT(10X,'TEST15')
        PX(NP+1)=0.0
        PX(NP+2)=100./DTU
*
*
          DO 41 I=1,NP
        PY(I)=Q(I,1)
            WRITE(24,*) PY(1)
   41    CONTINUE
        DO 42 I=1,NP
        PY(I)=Q(I,3)
        write(24,*) PY(I)
42      continue
*
        IF(K.EQ.1) GO TO 48
        DO 46 I=1,NP
   46 PY(I)=TQD(I)
*
   48 DO 43 I=1,NP
```

```
      PY(I)=Q(I,2)
      WRITE(24,*) PY(I)
43    CONTINUE
*
      DO 44 I=1,NP
        PY(I)=Q(I,5)
        WRITE(24,*) PY(I)
44      CONTINUE
*
*     GENERATE RECONSTRUCTED PHASE SPECTRUM
*
      CALL RECON(NP)
      DO 53 I=1,NP
   53 PY(I)=Q(I,5)
      DO 45 I=1,NP
       PY(I)=Q(I,4)
       WRITE(24,*) PY(I)
45     CONTINUE
   5  CONTINUE
*
      DO 47 I=1,NP
   47 PY(I)=Q(I,1)
      DO 49 I=2,NP
   49 PY(I)=PY(I-1)+PY(I)
        CALL PEYMAN1(IDD1,1,RR1,DDD,-30.5,-5.5)
        CALL PEYMAN2(IDD2,2,RR2,DDD,19.0,0.0)
        return
        end
*
*
      SUBROUTINE MEAN
*
*     SUBTRACT MEAN VALUE FROM EACH ARRAYS.
*
      COMMON X(2050),Y(2050),Z(1025)
      N=2048
      FN=FLOAT(N)
      SUMX=0.0
      SUMY=0.0
      DO 10 I=1,N
      SUMX=SUMX+X(I)
```

```
      SUMY=SUMY+Y(I)
   10 CONTINUE
      AAVEX=SUMX/FN
      AVEY=SUMY/FN
      DO 20 I=1,N
      X(I)=X(I)-AVEX
      Y(I)=Y(I)-AVEY
   20 CONTINUE
      RETURN
      END
      SUBROUTINE WINDOW(IW,SW)
*
*     IF IW=1, HANNING WINDOW IS MULTIPLIED TO DATA.
*     IF IW=2, HAMMING WINDOW IS MULTIPLIED TO DATA.
*     IF IW=3, TAPERED COSINE BELL IS USED AS DATA WINDOW.
*     IF IW=4, NO WINDOW(BOXCAR)
*
      COMMON X(2050),Y(2050),Z(1025)
      N=2048
      IF(IW.EQ.1) SWL=1./0.375
      IF(IW.EQ.2) SWL=1./0.3974
      IF(IW.EQ.3) SWL=8./7.
      IF(IW.EQ.4) SWL=1.
      SW=SWL
*
      IF(IW.EQ.4) GO TO 40
      IF(IW.EQ.3) GO TO 30
      IF(IW.EQ.1) A=0.5
      IF(IW.EQ.1) B=0.5
      IF(IW.EQ.2) A=0.54
      IF(IW.EQ.2) B=0.46
      FN=N
      DO 10 I=1,N
      FI=I-1
      PIN=2.0*3.1415926535*FI/FN
      DW=A-B*COS(PIN)
      X(I)=DW*X(I)
      Y(I)=DW*Y(I)
   10 CONTINUE
      GO TO 40
   30 NA=205
```

```
      FNA=NA
      DO 20 I=1,NA
      FI=I-1
      PIC=3.1415926535*FI/FNA
      CS=0.5*(1.0-COS(PIC))
      X(I)=CS*X(I)
      Y(I)=CS*Y(I)
      NI=N-I+1
      X(NI)=CS*X(NI)
      Y(NI)=CS*Y(NI)
   20 CONTINUE
   40 RETURN
      END
      SUBROUTINE POWERS(M,NP,KT)
*
*     AVERAGE POWER SPECTRA ARE COMPUTED IN STEAD OF DENSITY SPECTRA.
*     M: THE NUMBER OF ELEMENTS OF M-AVERAGING AND IS ALWAYS ODD
*        NUMBER GREATER THAN 3.
*        IF M=1, THEN THERE IS NO M-AVERAGING.
*     PWXX,PX2: AUTO POWER SPECTRA OF X-CHANNEL.
*     PWYY,PY2: AUTO POWER SPECTRA OF Y-CHANNEL.
*     PWXY: CROSS POWER SPECTRA OF X-AND Y-CHANNEL.
*     PHXY: PHASE FUNCTION OF X- AND Y-CHANNEL.
*     COHXY: COHERENCE FUNCTION.
*     CO: CO-SPECTRA.
*     QD:: QUAD-SPECTRA.
*
      COMMON X(2050),Y(2050),Z(1025)
      DIMENSION PX2(1025),CO(1025),PY2(1025),QD(1025)
      DIMENSION PWXX(1025),PWXY(1025),PWYY(1025),COHXY(1025),
     1 PHXY(1025)
*
      COMMON /TEMPQD/ TQD(1025),TRFCT
*
*     THIS EQUIVALENCE IS USED FOR BEFORE-M-AVERAGING.
      EQUIVALENCE (X(1),PX2(1)),(X(1026),CO(1)),(Y(1),PY2(1)),
     1 (Y(1026),QD(1))
*
*     THIS EQUIVALENCE IS USED FOR AFTER-M-AVERAGING.
      EQUIVALENCE (X(1),PWXX(1)),(X(1026),PWXY(1)),(Y(1),PWYY(1)),
     1 (Y(1026),COHXY(1)),(Z(1),PHXY(1))
```

```
*
      LOGICAL INDEF,INCD
        DOUBLE PRECISION KIR
*
*     TAKE FOURIER TRANSFORM OF INPUT DATA WITH 2048 ELEMENTS.
*
      N=2048
      K=11
*
*     SMSV= MEAN SQUARED VALUE
*
      FM=M
      SMSV=2.0*FM/FLOAT(N)**2
      TSCALE=-1.0
      CALL FFTR(K)
*
*     SEPERATE FFT OF EACH X- AND Y-ARRAY.
*
      A=0.5
      ND=N/2+1
      NK=N+2
      DO 10 I=1,ND
      IF(I.EQ.1) GO TO 15
      NKI=NK-I
      XR=(X(I)+X(NKI))*A
      XI=(Y(I)-Y(NKI))*A
      YR=(Y(I)+Y(NKI))*A
      YI=(X(NKI)-X(I))*A
      GO TO 25
   15 XR=X(1)
      XI=0.0
      YR=Y(1)
      YI=0.0
   25 PX2(I)=XR**2+XI**2
      PY2(I)=YR**2+YI**2
*
*     CO AND QD ARE STORED IN REVERSE ORDER.
*
      NDI=ND-I+1
      CO(NDI)=XR*YR+XI*YI
      QD(NDI)=XI*YR-XR*YI
```

```
   10 CONTINUE
*
*     CO AND QD ARE REARRANGED IN RIGHT ORDER.
*
      N4=N/4
      DO 20 I=1,N4
      NI=ND-I+1
      TEMP=CO(I)
      CO(I)=CO(NI)
      CO(NI)=TEMP
      TEMP=QD(I)
      QD(I)=QD(NI)
      QD(NI)=TEMP
   20 CONTINUE
*
*     TAKE THE M-AVERAGING OF ALL 5 ARRAYS AS AN SMOOTHING PROCEDURE
*
      ML=M
      IF(ML-2) 45,45,35
   35 IOE=0
      CALL MAVR(ML,IOE,NPL)
*
*     ONLY QD(I) IS ODD FUNCTION. THUS QD(1) IS RESET TO 0.0
*
      QD(1)=0.0
*
   45 IF((ML-2).LT.0) NPL=ND
      NP=NPL
      TRFCT=0.0
      DO 30 I=1,NPL
      PX2I=PX2(I)
      PY2I=PY2(I)
      COI=CO(I)
      QDI=QD(I)
      COQD2=COI**2+QDI**2

*
      TQD(I)=-QDI
*
      IF(KT.EQ.1) PWXX(I)=PX2I*SMSV
      IF(KT.EQ.2) PWXX(I)=PHXY(I)*QDI*TSCALE*SMSV
```

```
      PWYY(I)=PY2I*SMSV
      PWXY(I)=SQRT(COQD2)*SMSV
*
*     THE NORMALIZING VALUE OF TRANSPORT FACTOR IS CALCULATED.
*
      IF(KT.EQ.2) TRFCT=TRFCT+PHXY(I)*PWXY(I)
*
        KIR=1.0E-20
      INDEF=ABS(COI).LT.KIR.AND.ABS(QDI).LT.KIR
      IF(.NOT.INDEF) PHXY(I)=-ATAN2(QDI,COI)
      IF(INDEF) PHXY(I)=3.222
*
      INCD=ABS(COQD2).LT.KIR.AND.ABS(PX2I).LT.KIR.AND.
     1  ABS(PY2I).LT.KIR
      IF(.NOT.INCD) COHXY(I)=COQD2/(PX2I*PY2I)
      IF(INCD) COHXY(I)=1.222
*
   30 CONTINUE
      RETURN
      END
      SUBROUTINE MAVR(M,IOE,NP)
      COMMON Q(1025,5)
*
*     IOE=0, THE INPUT FUNCTION TO BE SMOOTHED IS EVEN.
*     IOE=1, THE INPUT FUNCTION IS ODD.
*
      IMAX=1025
      JMAX=4
      MA=M
      FM=MA
*
*     COMPUTE THE STARTING POINT.
*
      IF(IOE) 25,25,15
   15 DO 10 J=1,JMAX
    10 Q(1,J)=0.0
      GO TO 45
   25 M2=(MA-1)/2+1
      DO 20 J=1,JMAX
      SUM=Q(1,J)
      DO 30 I=2,M2
```

```
30 SUM=SUM+Q(1,J)*2.0
20 Q(1,J)=SUM/FM
*
45 M1=(MA+1)/2+1
   DO 40 J=1,JMAX
   L=1
   DO 50 I=M1,IMAX,MA
   SUM=0.0
   IM=I+MA-1
   IF(IM.GT.IMAX) GO TO 40
   L=L+1
   DO 60 K=I,IM
60 SUM=SUM+Q(K,J)
50 Q(L,J)=SUM/FM
40 CONTINUE
   NP=L
   RETURN
   END
   SUBROUTINE FFTR(K)
*
*  DATA IS IN FR(REAL) AND FI(IMAGINARY) ARRAYS.
*  COMPUTATION IS IN PLACE,OUTPUT REPLACES INPUT.
*  NUMBER OF POINTS MUST BE N=2**K
*  FR(N) AND FI(N) SHOULD BE DIMENSIONED WITH 2**K ELEMENTS
*  BUT INSTEAD IS DIMENSIONED WITH 2**K+2 BECAUSE OF
*  COMMON BLOCK.
*
   COMMON FR(2050),FI(2050),Z(1025)
   N=2**K
   MR=0
   NN=N-1
   DO 2 M=1,NN
   L=N
1  L=L/2
   IF(MR+L.GT.NN) GO TO 1
   MR=MOD(MR,L)+L
   IF(MR.LE.M) GO TO 2
   TR=FR(M+1)
   FR(M+1)=FR(MR+1)
   FR(MR+1)=TR
   TI=FI(M+1)
```

```
      FI(M+1)=FI(MR+1)
      FI(MR+1)=TI
    2 CONTINUE
      L=1
    3 IF(L.GE.N) RETURN
      ISTEP=2*L
      EL=L
      DO 4 M=1.L
      A=3.141592б535*FLOAT(1-M)/EL
      WR=COS(A)
      WI=SIN(A)
      DO 4 I=M,N,ISTEP
      J=I+L
      TR=WR*FR(J)-WI*FI(J)
      TI=WR*FI(J)+WI*FR(J)
      FR(J)=FR(I)-TR
      FI(J)=FI(I)-TI
      FR(I)=FR(I)+TR
    4 FI(I)=FI(I)+TI
      L=ISTEP
      GO TO 3
      END
      SUBROUTINE SUMRMS(J,NP,RMS)
*
*     J IS ORDER NUMBER OF 3 AUTO POWER SPECTRUM.
*
      COMMON W(1025,5)
      SUM=0.0
      DO 10 I=1,NP
      SUM=SUM+W(I,J)
   10 CONTINUE
      RMS=SQRT(SUM)
      RETURN
      END
      SUBROUTINE RECON(NPL)
      COMMON X(2050),Y(2050),PHXY(1025)
      DO 6 J=1,2
      NP=NPL
      SXY=PHXY(1)
      SX=1.
      SY=PHXY(1)
```

```
      SX2=1.
      NP1=NP-1
      DO 1 I=2,NP1
      IF(I.GE.31) GO TO 3
      SXY=SXY+FLOAT(I)*PHXY(I)
      SX=SX+FLOAT(I)
      SY=SY+PHXY(I)
      SX2=SX2+FLOAT(I)**2
      GO TO 1
    3 SXY=SXY+FLOAT(I)*PHXY(I)-FLOAT(I-30)*PHXY(I-30)
      SX=SSX+FLOAT(I)-FLOAT(I-30)
      SY=SY+PHXY(I)-PHXY(I-30)
      SX2=SX2+FLOAT(I)**2-FLOAT(I-30)**2
      BA=30.
      D=BA*SX2-SX**2
      RM=(BA*SXY-SX*SY)/D
      C=(SX2*SY-SX*SXY)/D
      EY=RM*FLOAT(I+1)+C
      YP=PHXY(I+1)+6.283
      IF(ABS(YP-EY).GE.ABS(PHXY(I+1)-EY)) GO TO 5
      PHXY(I+1)=YP
      GO TO 1
    5 YM=PHXY(I+1)-6.283
      IF(ABS(YM-EY).LE.ABS(PHXY(I+1)-EY)) PHXY(I+1)=YM
    1 CONTINUE
    6 CONTINUE
      RETURN
      END

      SUBROUTINE BIODAT(IUNIT,DATA,N)
      DIMENSION DATA(2500),IDATA(16)
      N=0
      DO 100 I=1,128
      READ(IUNIT,20,ERR=200)(IDATA(J),J=1,16)
20    FORMAT(16(1X,I3))
      DO 80 K=1,16
      DATA(K+(I-1)*16)=FLOAT(IDATA(K))-127.0
80    CONTINUE
      N=N+16
100   CONTINUE
      WRITE(5,150)N
```

```
150     FORMAT(3X,'THE # OF DATA READ WAS',I4)
        RETURN
200     N=N+J-1
        WRITE(5,210)N
210     FORMAT(3X,'ERROR NUMBER=  ',I4)
        DO 30 L=1,J-1
        DATA(L+(I-1)*16)=FLOAT(IDATA(L))
30      CONTINUE
        STOP
        END

        SUBROUTINE PARMTR(PAR,IPAR1,IPAR2,IPAR3,Z1,Z2,Z3,Z4,Z5,YY,IUNIT

        DOUBLE PRECISION IPAR2,IPAR3,IPAR1
        DOUBLE PRECISION Z1,Z2,Z3,Z4,Z5,YY(8)
        CHARACTER*80LINE(29)
        CHARACTER*13STRING(29)
        DIMENSION PAR(29),JSTART(29),JEND(29)
        DO 20 I=1,29
                READ(IUNIT,10)LINE(I)
10              FORMAT(A80)
                JJ=I
                CALL FIND(LINE(JJ),JSTART(JJ),JEND(JJ))
20      CONTINUE
        JSTART(1)=JSTART(1)-1
        JEND(1)=JSTART(1)+1
        STRING(1)=LINE(1)(JSTART(1):JEND(1))
        READ(STRING(1),30)IPAR1
30      FORMAT(A2)
35      FORMAT(A6)
        JEND(2)=JSTART(2)+8
        STRING(2)=LINE(2)(JSTART(2):JEND(2))
        READ(STRING(2),45)IPAR2
45      FORMAT(A8)
        JEND(3)=JSTART(3)+6
        STRING(3)=LINE(3)(JSTART(3):JEND(3))
        READ(STRING(3),35)IPAR3
        DO 47 J=4,10
        STRING(J)=LINE(J)(JSTART(J):JSTART(J)+13)
        IF(J.EQ.4)THEN
        READ(STRING(J),50)PAR(J)
```

```
      READ(STRING(J),95)Z1
      ELSE
      IF(J.LE.5)THEN
       READ(STRING(J),60)PAR(J)
      READ(STRING(J),96)Z2
      ELSE
      IF(J.EQ.7)THEN
      READ(STRING(J),70)PAR(J)
      READ(STRING(J),97)Z3
      ELSE
      IF(J.EQ.8)THEN
      READ(STRING(J),80)PAR(J),I
      PAR(J)=PAR(J)*(10.0**I)
      ELSE
      READ(STRING(J),100)PAR(J)
      ENDIF
      ENDIF
      ENDIF
      ENDIF
47    CONTINUE
      READ(STRING(6),96)Z4
       READ(STRING(10),96)Z5
95    FORMAT(A4)
96    FORMAT(A5)
97    FORMAT(A6)
50    FORMAT(F4.1)
60    FORMAT(F5.3)
70    FORMAT(F6.1)
80    FORMAT(F4.1,5X,I2)
90    FORMAT(F4.1)
100   FORMAT(F5.1)
110   FORMAT(F4.2)
120   FORMAT(F5.2)
130   FORMAT(F3.1)
140   FORMAT(F7.3)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     READ THE BIO. PAR.
C
      K=12
      DO 250 JJ=1,3
             DO 200 II=1,4
```

```
              I=II+K
        STRING(I-2*JJ)=LINE(1)(JSTART(I):JSTART(I)+11)
              IF(I.EQ.K+1)THEN
              READ(STRING(I-2*JJ),110)PAR(I-2*JJ)
              ELSE
              IF(I.EQ.K+2)THEN
              READ(STRING(I-2*JJ),120)PAR(I-2*JJ)
              ELSE
              IF(I.EQ.K+3)THEN
              READ(STRING(I-2*JJ),130)PAR(I-2*JJ)
              ELSE
              READ(STRING(I-2*JJ),140)PAR(I-2*JJ)
              END IF
              END IF
              END IF
200           CONTINUE
              K=K+6
250     CONTINUE
        STRING(29)=LINE(29)(JSTART(29):JSTART(29)+5)
        READ(STRING(29),210)PAR(23)
210     FORMAT(F5.2)
        READ(IUNIT,220)(YY(I),I=1,8)
220     FORMAT(/,8A10)
        RETURN
        END
        SUBROUTINE FIND(LINE,ISTART,IEND)
        CHARACTER*80LINE
        J=INDEX(LINE,':')
        ISTART=J+2
        J=INDEX(LINE(JBEG:),'    ')
        IEND=ISTART+J
        RETURN
        END
        SUBROUTINE PEYMAN1(I1,JKL,R1,D,X0,Y0)
        DIMENSION I1(2051)
        DIMENSION Y1(402),X(402)
        NNN=0
        DO 10 I=1,400
        NNN=NNN+1
        X(NNN)=FLOAT(I-1)*D
        Y1(NNN)=I1(I)*(2.*R1)/127.
```

```
        WRITE(24,*)X(I)
10     CONTINUE
          DO 30 I=1,400
          WRITE(24,*) Y1(I)
30        CONTINUE
       WRITE(5,*)NNN
       X(NNN+1)=0.0
       X(NNN+2)=23.0*D
       WRITE(5,*)NNN
       XX1=X(NNN+1)
       XX2=X(NNN+2)
       YY1=Y1(NNN+1)
       YY2=Y1(NNN+2)
       WRITE(5,*)NNN
       RETURN
       END
       SUBROUTINE PEYMAN2(I1,JKL,R1,D,X0,Y0)
       DIMENSION I1(2051)
       DIMENSION Y1(402),X(402)
       NNN=0
       DO 10 I=1,400
          NNN=NNN+1
          X(NNN)=FLOAT(I-1)*D
          Y1(NNN)=I1(I)*(2.*R1)/127.
          WRITE(24,*) Y1(I)
10     CONTINUE
       END
```

PROGRAM JOB2

```
      PROGRAM JOB2
      REAL A(116),B(114),C(114),D(114),E(114),F(114)
      REAL T(400),A1(400),A2(400)
      REAL X(114),Y(114)
      LOGICAL NAME(11)
      DATA NAME/8*' ','D','A','T'/
C
C
C     N   : NUMBER OF DATA POINTS
C     S   : LENGTH OF THE AXIS IN INCHES
C     XMIN: MINIMUM VALUE OF THE COORDINATE
C     DX  : CHANGE IN COORDINATE PER INCH
C
C
C
C
C     THIS PROGRAM PLOTS VARIOUS SPECTRA PLUS
C     INPUTS OF CHANNELS 1 AND 2 IN TIME DOMAIN.
C
C
      WRITE(5,1)
1     FORMAT(5X,'ENTER DATA FILE NAME : ')
      READ(5,2) (NAME(I),I=1,8)
2     FORMAT(8A1)
      WRITE(5,3) NAME
3     FORMAT(5X,11A1)
C
C
C     ACCESS THE DATA FILE IN DRIVE B
C
C
      CALL OPEN(6,NAME,2)
C
C
C     READ IN THE PROCESSED DATA FOR VARIOUS SPECTRA
C
C
      READ (6,4) A,B,C,D,E,F,T,A1,A2
4     FORMAT(E15.7)
C
C
```

```
C     PLOT AUTO-POWER SPECTRUM OF CHANNEL 1
C
C
      N=114
      DO 12 I=1.N
12    A(I)=A(I+2)
      DO 88 I=1,114
88    B(I)=ALOG10(B(I))
      DO 7 I=1,N
      X(I)=B(I)
7     CONTINUE
      S=4.
      CALL SCALE(X,N,1,S,XMIN,DX)
      XMIN=XMIN-1.0
      IXMIN=XMIN
      XMIN=IXMIN
      DX=2.5
      YMIN=XMIN
      DY=DX
      CALL PLINIT
C
C
C     SUBROUTINE PLINIT INITIALIZE THE SCREEN FOR PLOTTING
C
C
      CALL AXIS(82,25,'AUTO POWER SPRM *1* LOG',-23,S,90.,XMIN,DX)
      DO 10 I=1,N
10    X(I+1)=A(I)
      X(1)=0.0
      M=N+1
      CALL SCALE(X,M,1,S, XMIN,DX)
C
C
C     ROUD OFF XMIN AND DX
C
C
      IXMIN=XMIN
      XMIN=IXMIN
      IDX=DX
C
C
```

```
C     CALIBRATE THE X-AXIS
C
C
      IF(DX .GT. (IDX+0.5)) DX=IDX+0.5
      IF(DX .LT. (IDX+0.5)) DX=IDX
      CALL AXIS(82,25,'WAVE FREQUENCY KHZ',18,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
C
C     SUBROUTINE PLOT SETS THE ORIGIN AT(82,25). THERE
C     ARE 82 DOTS PER INCH IN THE HORIZONTAL DIRECTION
C     AND 51 DOTS PER INCH IN VERTICAL DIRECTION.
C
      DO 16 I=1,N
      Y(I)=B(I)
16    CONTINUE
      CALL LINE(X,Y,N,1,XMIN,DX,YMIN,DY)
C
C
C     SUBROUTINE LINE DRAWS A LINE THROUGH THE DATA POINTS
C
C
      CALL SCRDMP
C
C
C     SUBROUTINE SCRDMP DUMPS THE SCREEN TO THE PRINTER
C
C
C     PLOT AUTO-POWER SPECTRUM OF CHANNEL 2
C
C
      DO 15 I=1,N
15    C(I)=ALOG10(C(I))
       DO 20 I=1,N
20    X(I)=C(I)
      CALL SCALE(X,N,1,S,XMIN,DX)
      XMIN=XMIN-1.0
      IXMIN=XMIN
      XMIN=IXMIN
      DX=2.5
      YMIN=XMIN
      DY=DX
```

```
      CALL PLINIT
      CALL AXIS(82,25,'AUTO POWER SPRM *2* LOG',-23,S,90.0,XMIN,DX)
      DO 30 I=1,N
30    X(I+1)=A(I)
      X(1)=0.0
      M=N+1
      CALL SCALE(X,M,1,S,XMIN,DX)
      IXMIN=XMIN
      XMIN=IXMIN
      IDX=DX
      IF(DX .GT. (IDX+0.5)) DX=IDX+0.5
      IF(DX .LT. (IDX+0.5)) DX=IDX
      CALL AXIS(82,25,'WAVE FREQUENCY KHZ',18,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      DO 40 I=1,N
      Y(I)=C(I)
40    CONTINUE
      CALL LINE(X,Y,N,1,XMIN,DX,YMIN,DY)
      CALL SCRDMP
C
C
C     PLOT CROSS AMPLITUDE SPECTRUM OF CHANNELS 1 AND 2
C
C
      DO 45 I=1,N
45    D(I)=ALOG10(D(I))
      DO 100 I=1,N
      X(I)= D(I)
100    CONTINUE
      CALL SCALE(X,N,1,S,XMIN,DX)
      XMIN=XMIN-1.0
      IXMIN=XMIN
      XMIN=IXMIN
      DX=2.5
      YMIN=XMIN
      DY=DX
      CALL PLINIT
      CALL AXIS(82,25,'CROSS AMPL SPRM 1&2 LOG',-23,S,90.0,XMIN,DX)
      DO 150 I=1,N
150   X(I+1)=A(I)
      X(1)=0.0
```

```
      M=N+1
      CALL SCALE(X,M,1,S,XMIN,DX)
      IXMIN=XMIN
      XMIN=IXMIN
      IDX=DX
      IF(DX .GT. (IDX+0.5)) DX=IDX+0.5
      IF(DX .LT. (IDX+0.5)) DX=IDX
      CALL AXIS(82,25,'WAVE FREQUENCY KHZ',18,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      DO 160 I=1,N
160    Y(I)=D(I)
      CALL LINE(X,Y,N,1,XMIN,DX,YMIN,DY)
      CALL SCRDMP
C
C
C     PLOT PHASE SPECTRUM OF CHANNELS 1 AND 2
C
C
      N=114
      DO 170 I=1,N
170    X(I)=E(I)
      XMIN=-4.0
      DX=2.0
      YMIN=XMIN
      DY=DX
      CALL PLINIT
      CALL AXIS(82,25,'PHASE SPECTRUM 1&2 RDA',-22,S,90.,XMIN,DX)
      DO 180 I=1,N
180   X(I+1)=A(I)
      X(1)=0.0
      M=N+1
      CALL SCALE(X,M,1,S,XMIN,DX)
      IXMIN=XMIN
      XMIN=IXMIN
      IDX=DX
      IF(DX .GT. (IDX+0.5)) DX=IDX+0.5
      IF(DX .LT. (IDX+0.5)) DX=IDX
      CALL AXIS (82,25,'WAVE FREQUENCY KHZ',18,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      DO 190 I=1,N
190    Y(I)=E(I)
```

```
      CALL LINE(X,Y,N,1,XMIN,DX,YMIN,DY)
      CALL PLOT(0,102,-3)
      CALL PLOT(328,0,2)
      CALL SCRDMP
C
C     PLOT COHERENCY SPECTRRUM OF CHANNELS 1 AND 2
C
C
C
      DO 200 I=1,N
200    X(I)=F(I)
      XMIN=0.000
      DX=0.25
      YMIN=XMIN
      DY=DX
      CALL PLINIT
      CALL AXIS(82,25,'SQ COHERENCY SPRM 1&2',-21,S,90.0,XMIN,DX)
      DO 210 I=1,N
210    X(I+1)=A(I)
       X(1)=0.0
       M=N+1
      CALL SCALE(X,M,1,S,XMIN,DX)
      IXIN=XMIN
      XMIN=IXMIN
      IDX=DX
      IF(DX .GT. (IDX+0.5)) DX=IDX+0.5
      IF(DX .LT. (IDX+0.5)) DX=IDX
      CALL AXIS(82,25,'WAVE FREQUENCY KHZ',18,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      DO 220 I=1,N
220    Y(I)=F(I)
      CALL LINE(X,Y,N,1,XMIN,DX,YMIN,DY)
      CALL SCRDMP
C
C
C     PLOT CHANNEL 1 INPUT IN TIME DOMAIN
C
C
      NN=400
      XMIN=-1.00
      DX=0.5
```

```
      YMIN=XMIN
      DY=DX
      CALL PLINIT
      CALL AXIS(82,25,'AMPL OF CH1 IN VOLTS',-20,S,90.0,XMIN,DX)
      CALL SCALE(T,NN,1,S,XMIN,DX)
      CALL AXIS(82,25,'TIME IN MICRO SECONDS',21,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      CALL LINE(T,A1,NN,1,XMIN,DX,YMIN,DY)
      CALL SCRDMP
C
C
C     PLOT CHANNEL 2 INPUT IN TIME DOMAIN
C
C
      XMIN=-1.00
      DX=0.5
      YMIN=XMIN
      DY=DX
      CALL PLINIT
      CALL AXIS(82,25,'AMPL OF CH2 IN VOLTS',-20,S,90.0,XMIN,DX)
      CALL SCALE(T,NN,1,S,XMIN,DX)
      CALL AXIS(82,25,'TIME IN MICRO SECONDS',21,S,0.0,XMIN,DX)
      CALL PLOT(82,25,-3)
      CALL LINE(T,A2,NN,1,XMIN,DX,YMIN,DY)
      CALL SCRDMP
      CALL PLINIT
      CALL PLTCLS
      END
```

APPENDIX B

VARIOUS PLOTS FOR
THREE DIFFERENT RUNS

This section includes three different runs. The first run, TEST, is a test on the system. The inputs to the transient recorders are two identical sine waves at the frequency of 50 KHz. The sampling frequency is 1μsec. Runs AQP1 and APD5 are actual plasma data. The conditions for these two runs are given at the beginning of each run.

```
FILE NUMBER:  1
DATE: 10/5/85
RUN NUMBER: TEST
ANODE VOLTAGE (KV):  0.00
ANODE CURRENT (AMP): 0.000
MAX. MAGNETIC FIELD (TESLA): 0.000
PRESSURE (MICROTORR):     0.0
AVERAGE PLASMA NUMBER DENSITY (ELECTRONS/ (M**3)): 0.00*10** 0
RADIAL POSITION OF PROBES FROM THE CENTER  OF PLASMA (CM):  0.0
MICROWAVE SCATTERING ANGLE (DEGREE): 999.9

CHANNEL NO.1 DATA.
INPUT RANGE SETTING:   .51200
SAMPLE INTERVAL (MICROSEC):  1.000000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):   1.0000

CHANNEL NO.2 DATA.
INPUT RANGE SETTING (VOLT):   .51200
SAMPLE INTERVAL (MICROSEC):  1.000000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):   1.0000

CHANNEL NO.3 DATA.
INPUT RANGE SETTING (VOLT):  0.00000
SAMPLE INTERVAL (MICROSEC):  0.000000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):   0.0000
D.C. VOLTAGE AT PREAMP INPUT (VOLT):  0.00
ADDITIONAL COMMENTS ?
```

Figure B.1. Experimental conditions for the TEST run.

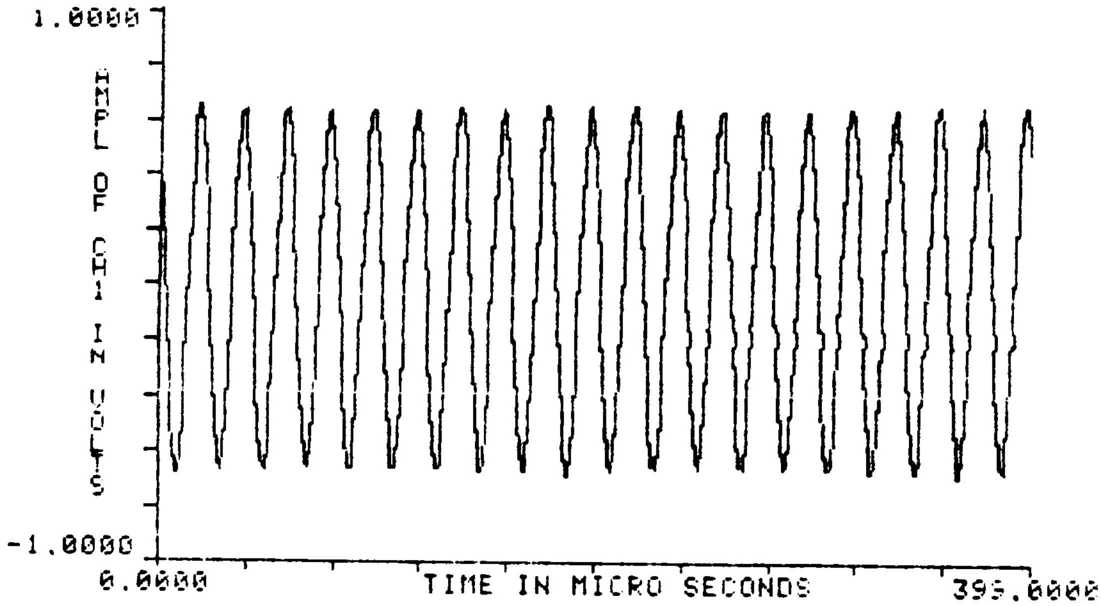

Figure B.2. Input of channel 1 in time domain
(TEST run)

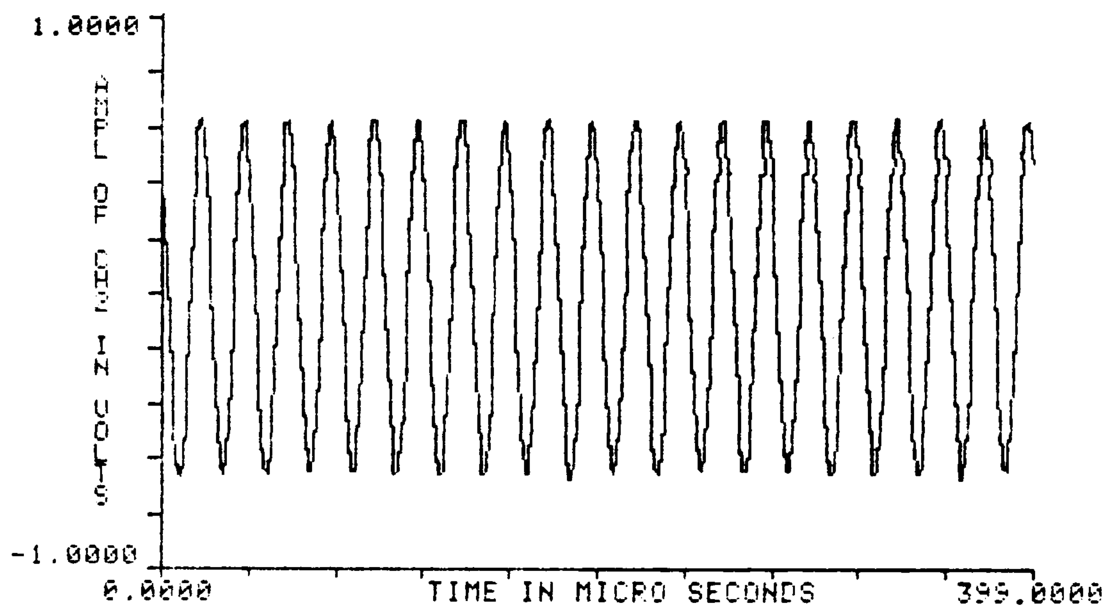

Figure B.3. Input of channel 2 in time domain (TEST run).

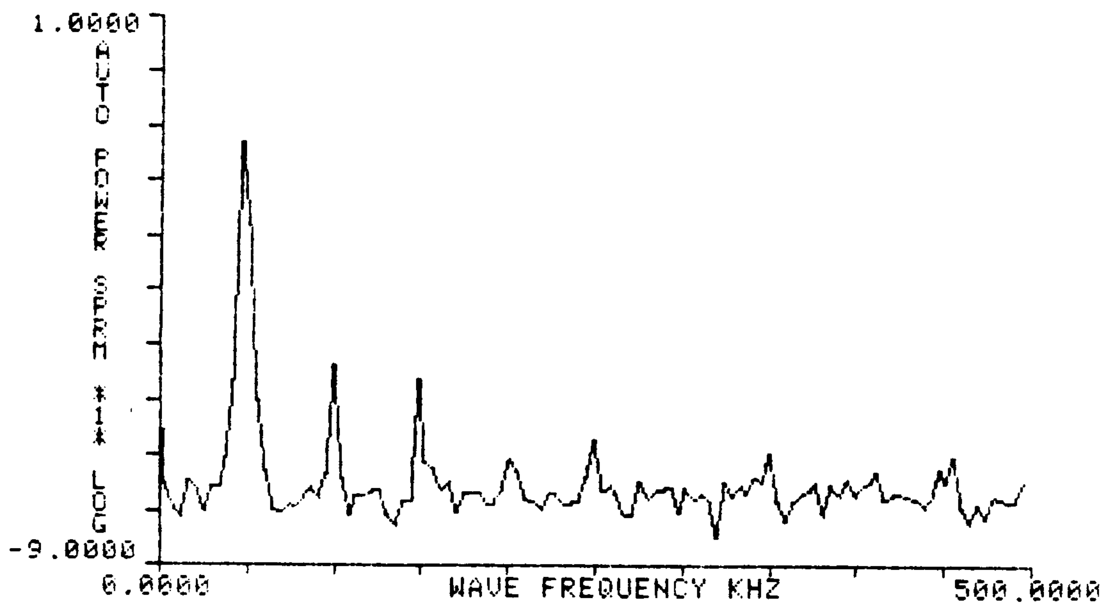

Figure B.4. Auto power spectrum of channel 1 (TEST run).

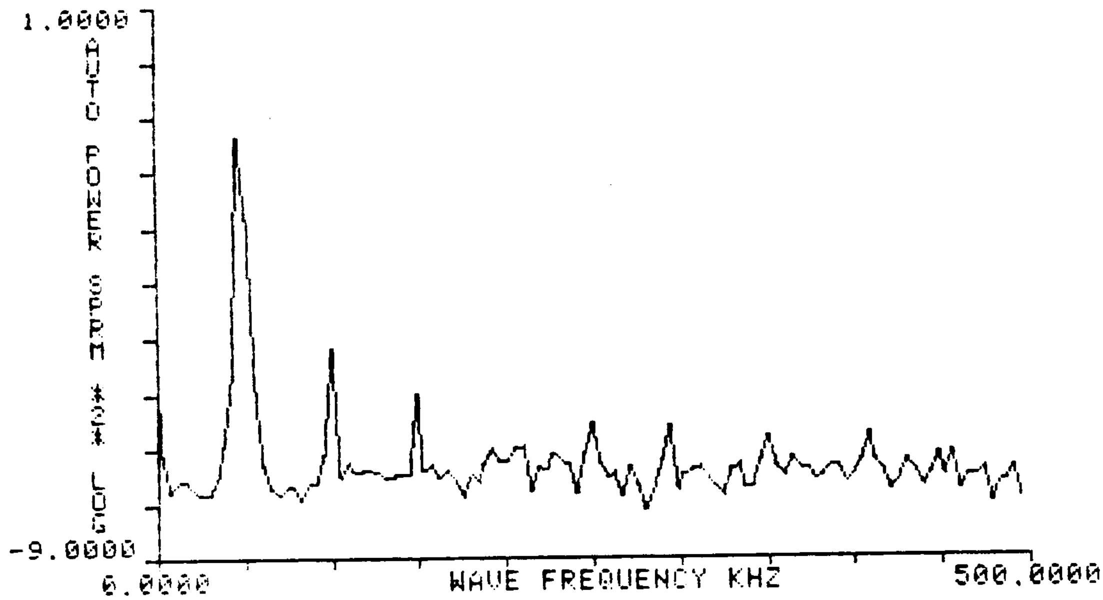

Figure B.5. Auto power spectrum of channel 2
(TEST run).

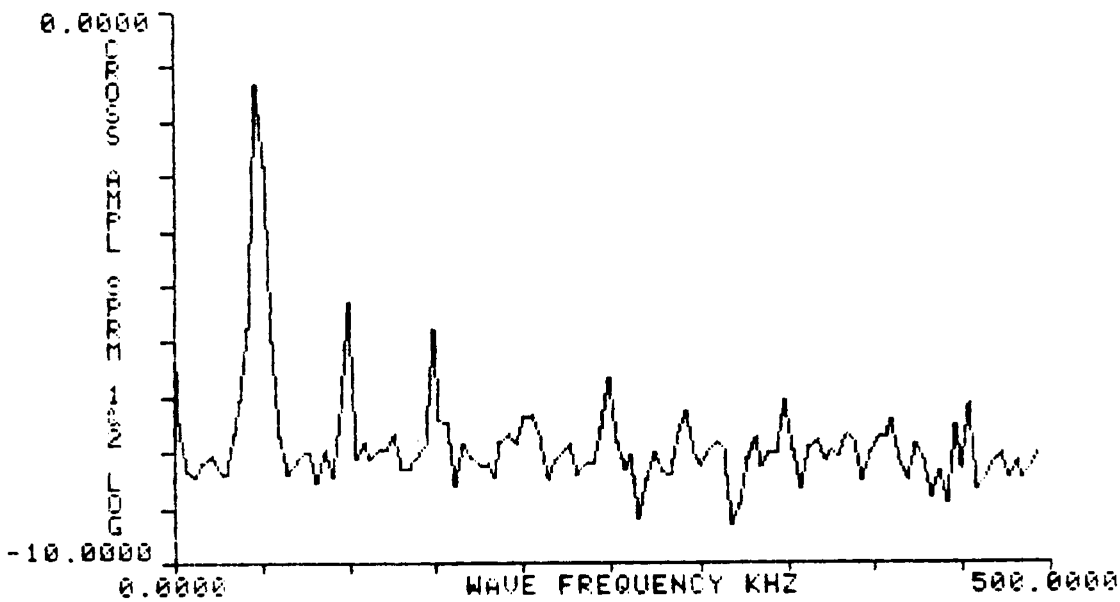

Figure B.6. Cross amplitude spectrum (1,2)
(TEST run).

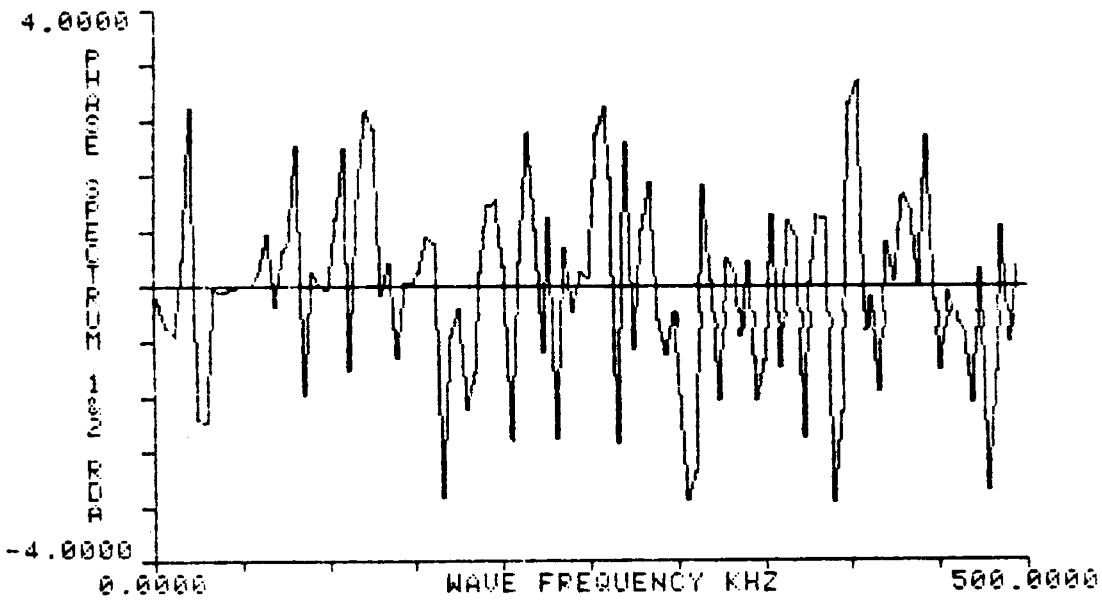

Figure B.7. Phase spectrum (1,2) in Radians (TEST run).

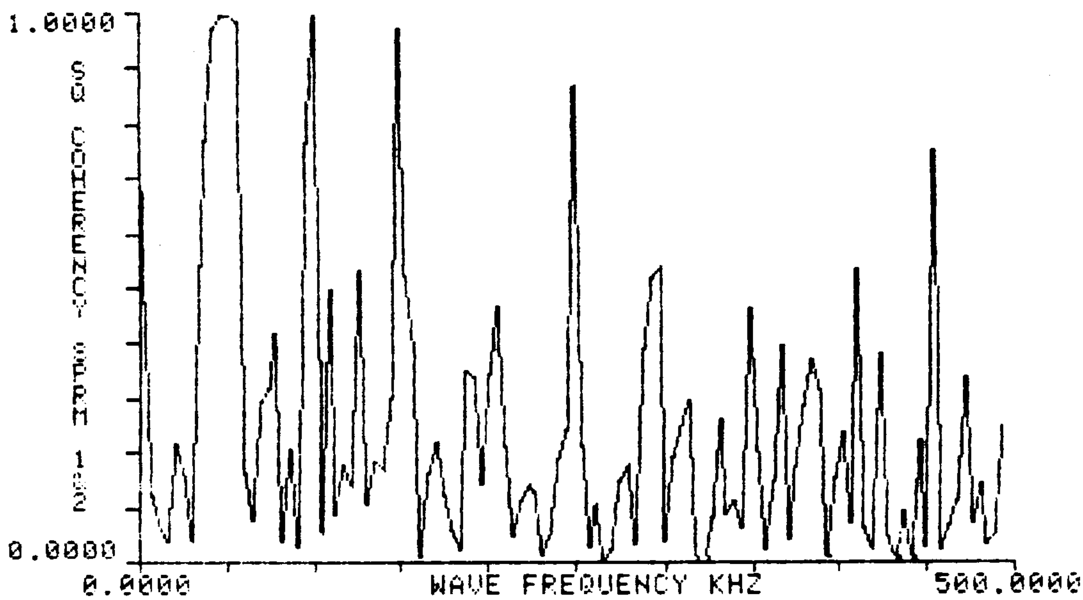

Figure B.8. Squared coherency spectrum (1,2) (TEST run).

```
FILE NUMBER:  1
DATE: 10/31/85
RUN NUMBER: AQP1
ANODE VOLTAGE (KV):  3.70
ANODE CURRENT (AMP):  .029
MAX. MAGNETIC FIELD (TESLA):  .280
PRESSURE (MICROTORR):   47.0
AVERAGE PLASMA NUMBER DENSITY (ELECTRONS/ (M**3)): 2.25*10**15
RADIAL POSITION OF PROBES FROM THE CENTER  OF PLASMA (CM): 10.0
MICROWAVE SCATTERING ANGLE (DEGREE): 999.9

CHANNEL NO.1 DATA.
INPUT RANGE SETTING:    .51200
SAMPLE INTERVAL (MICROSEC):    .166666
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):     .0320

CHANNEL NO.2 DATA.
INPUT RANGE SETTING (VOLT):    .51200
SAMPLE INTERVAL (MICROSEC):    .166666
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):     .0320

CHANNEL NO.3 DATA.
INPUT RANGE SETTING (VOLT):  0.00000
SAMPLE INTERVAL (MICROSEC):  0.000000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):   0.0000
D.C. VOLTAGE AT PREAMP INPUT (VOLT):  0.00
ADDITIONAL COMMENTS ?
```

Figure B.9. Experimental conditions for the run AQP1

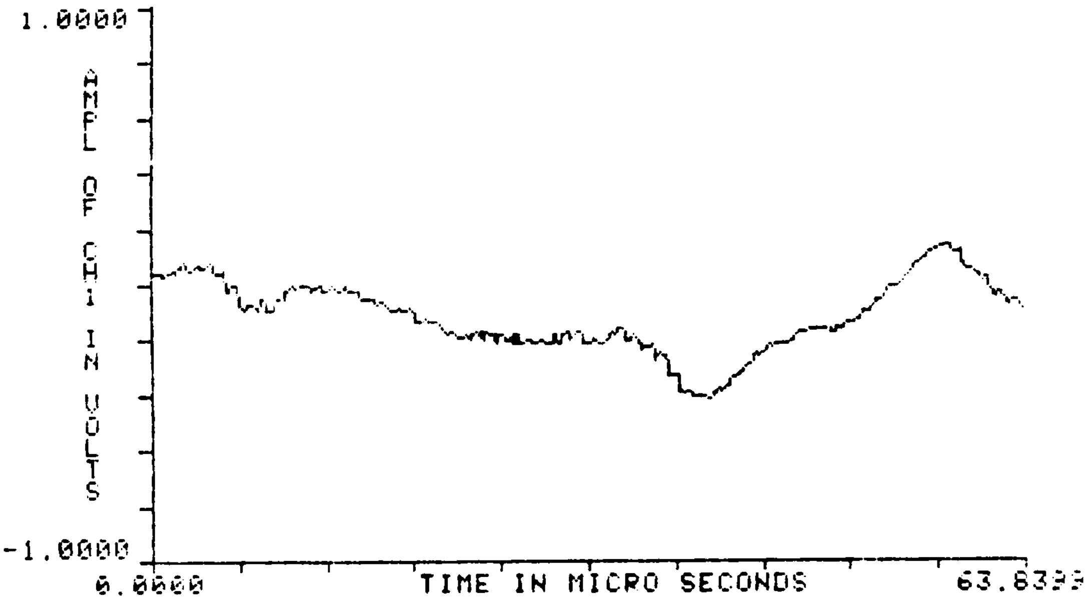

Figure B.10. Input of channel 1 in time domain (run # AQP1).

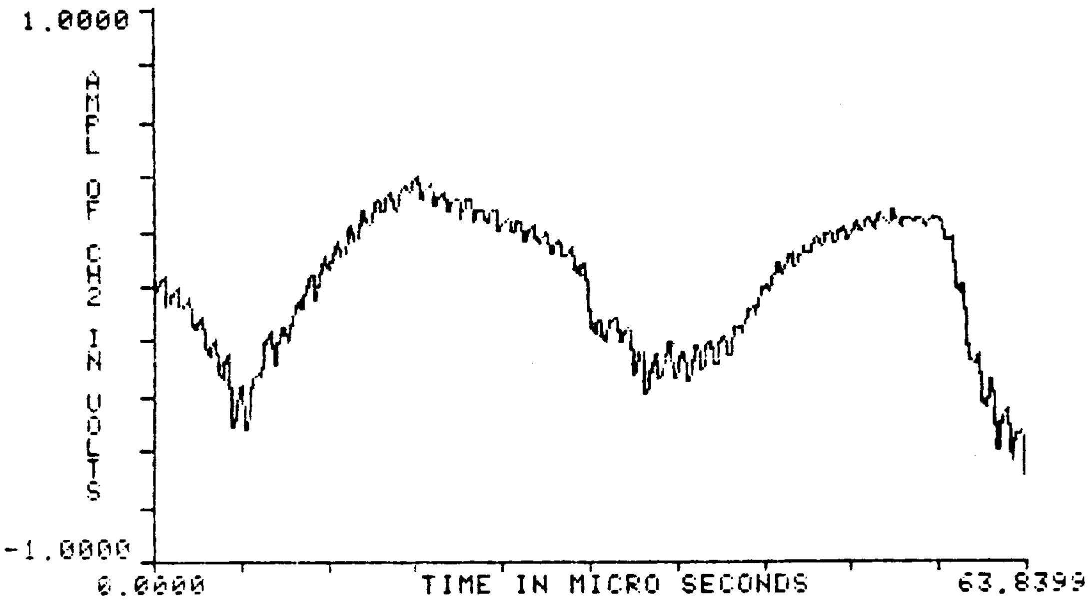

Figure B.11. Input of channel 2 in time domain
(run # AQP1).

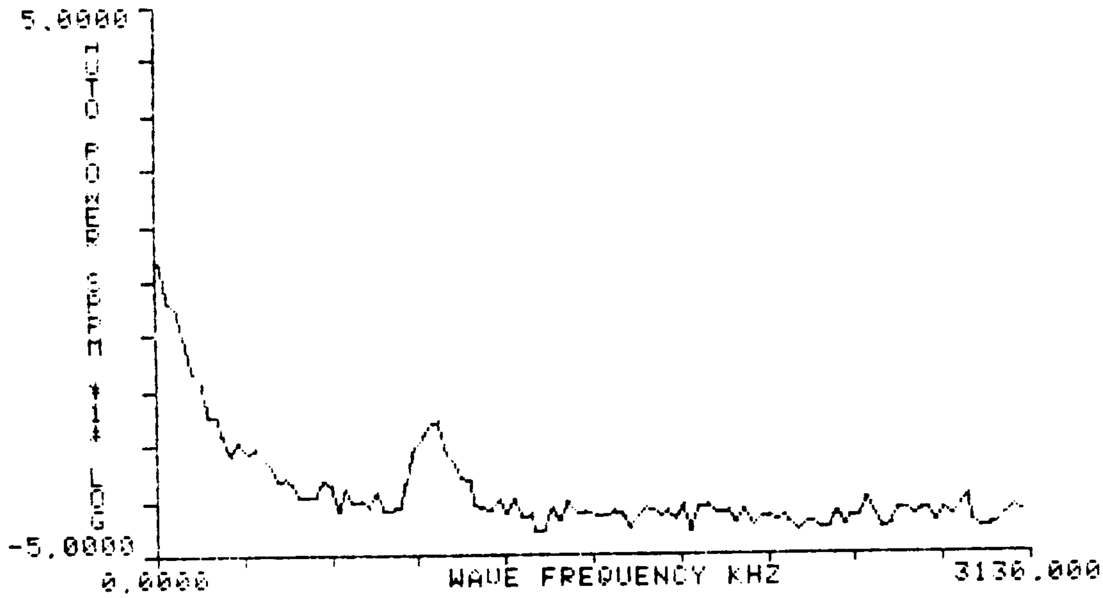

Figure B.12. Auto power spectrum of channel 1 (run # AQP1).

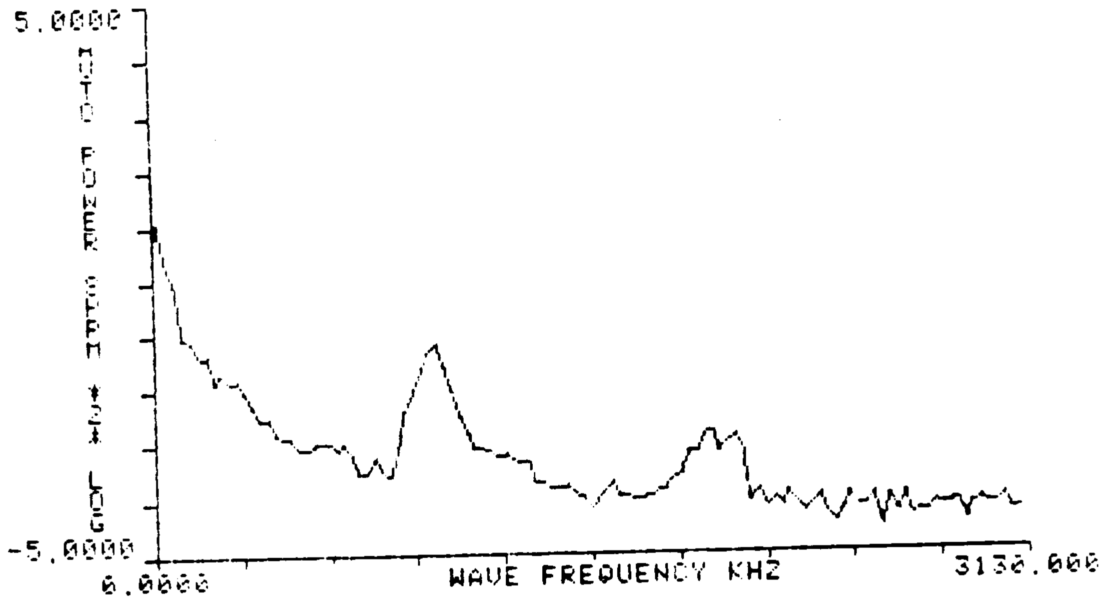

Figure B.13. Auto power spectrum of channel 2
(run # AQP1).

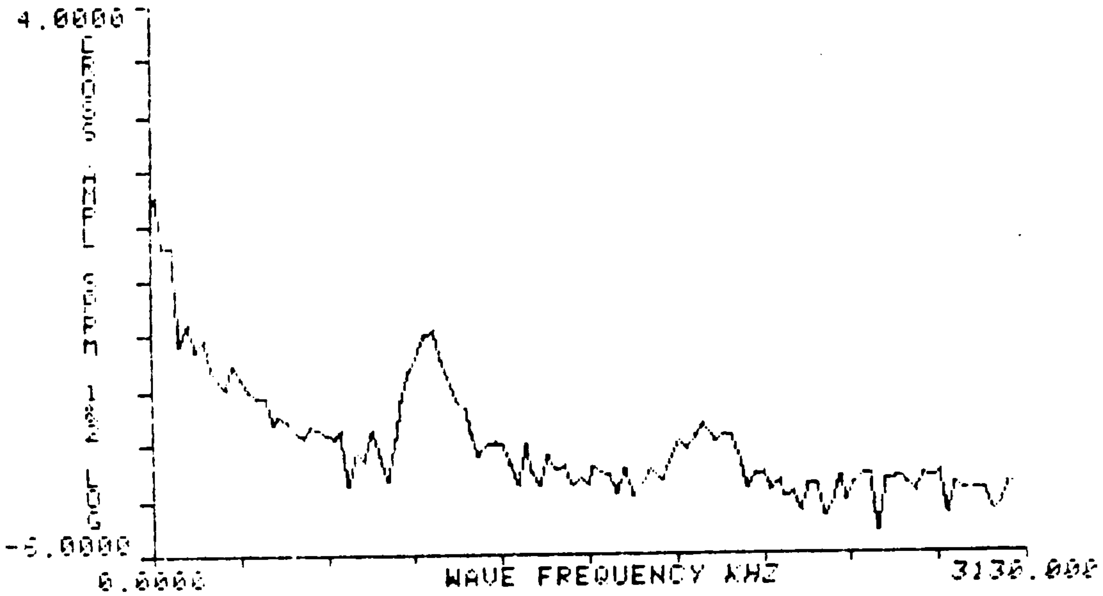

Figure B.14. Cross amplitude spectrum (1,2)
(run # AQP1).

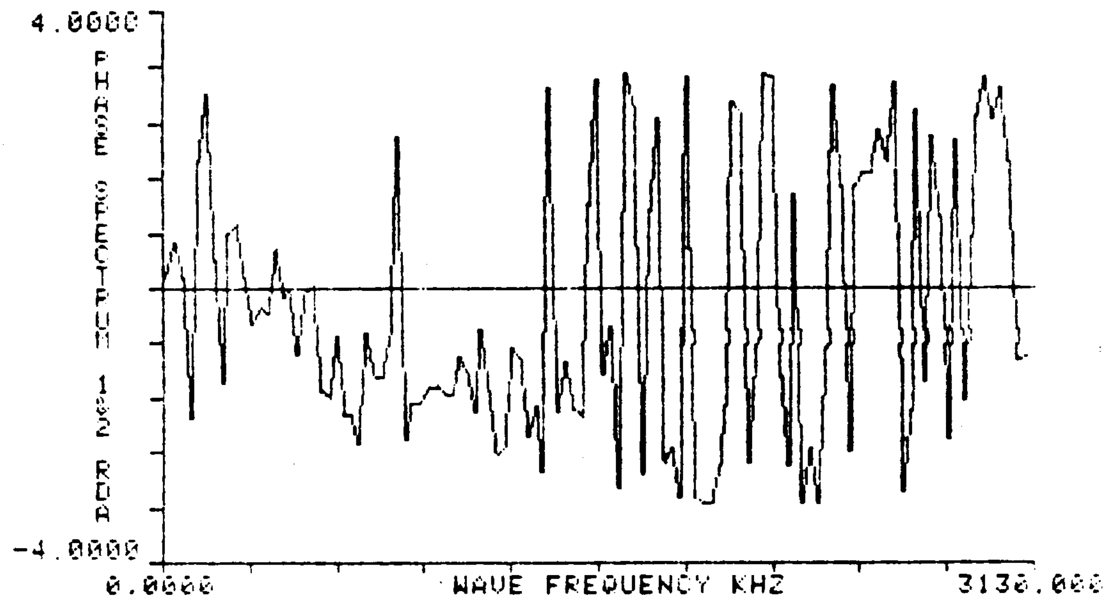

Figure B.15. Phase spectrum (1,2) in Radians
(run # AQP1).

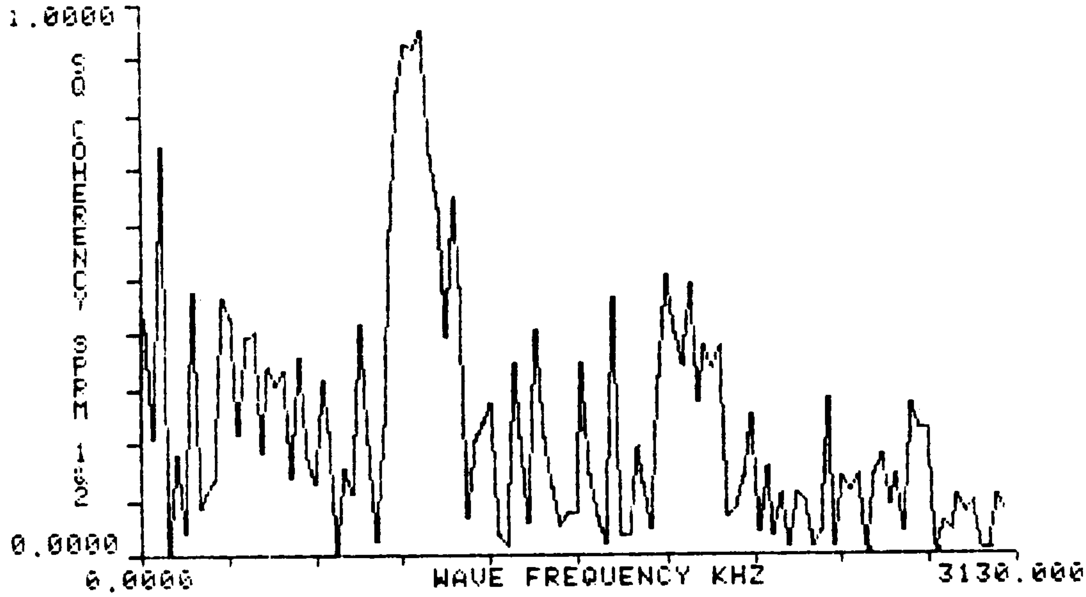

Figure B.16. Squared coherency spectrum (1,2) (run # AQP1).

```
FILE NUMBER:  2
DATE: 10/26/85
RUN NUMBER: APD5
ANODE VOLTAGE (KV):  1.30
ANODE CURRENT (AMP):  .002
MAX. MAGNETIC FIELD (TESLA):  .440
PRESSURE (MICROTORR):   30.0
AVERAGE PLASMA NUMBER DENSITY (ELECTRONS/ (M**3)): 1.00*10**14
RADIAL POSITION OF PROBES FROM THE CENTER  OF PLASMA (CM): 10.0
MICROWAVE SCATTERING ANGLE (DEGREE): 999.9

CHANNEL NO.1 DATA.
INPUT RANGE SETTING:   .512
SAMPLE INTERVAL (MICROSEC):  1.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):    .150

CHANNEL NO.2 DATA.
INPUT RANGE SETTING (VOLT):    .512
SAMPLE INTERVAL (MICROSEC):  1.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):    .150

CHANNEL NO.3 DATA.
INPUT RANGE SETTING (VOLT):  0.000
SAMPLE INTERVAL (MICROSEC):  0.000
ANTIALIAS FILTER (MHZ): 0.000
OVERALL PROBE GAIN (VOLT):  0.000
D.C. VOLTAGE AT PREAMP INPUT (VOLT):  0.00
ADDITIONAL COMMENTS ?
```

Figure B.17. Experimental conditions for the run APD5.

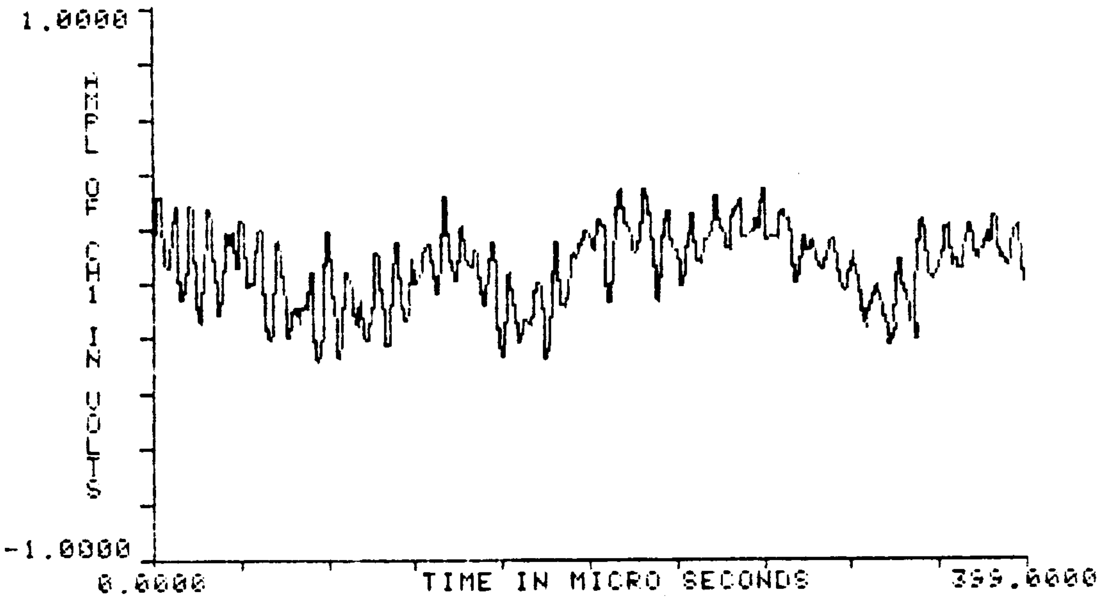

Figure B.18. Input of channel 1 in time domain (run # APD5).

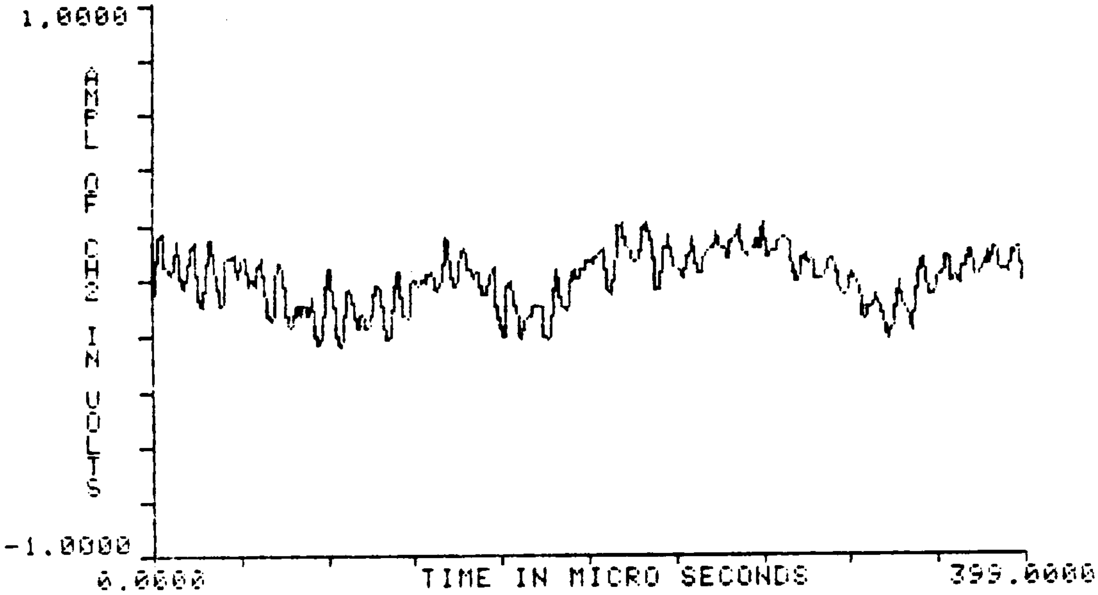

Figure B.19. Input of channel 2 in time domain (run # APD5).

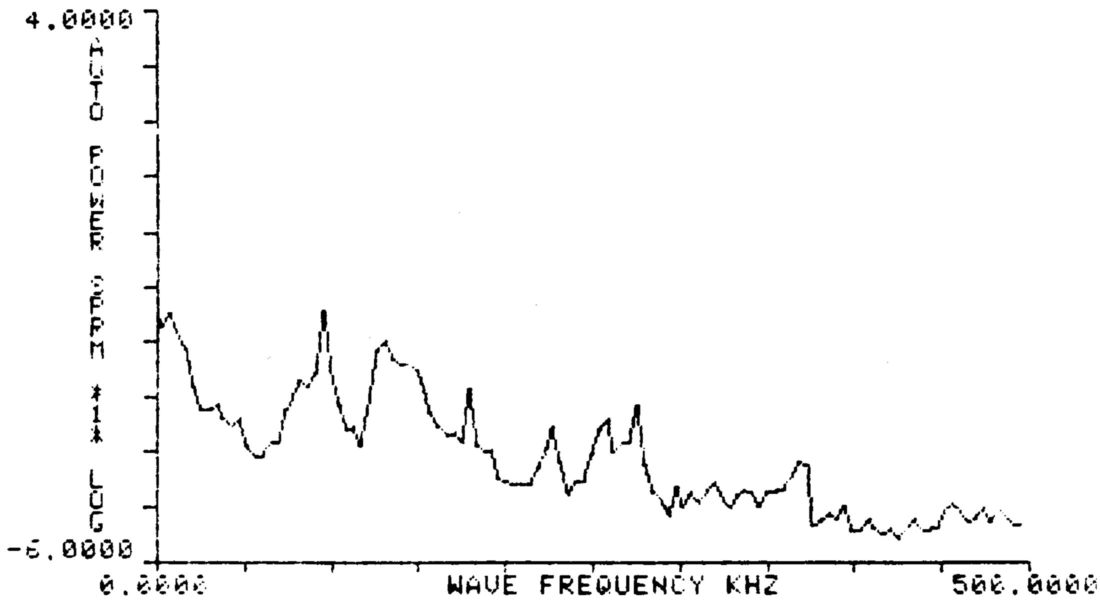

Figure B.20. Auto power spectrum of channel 1
(run # APD5).

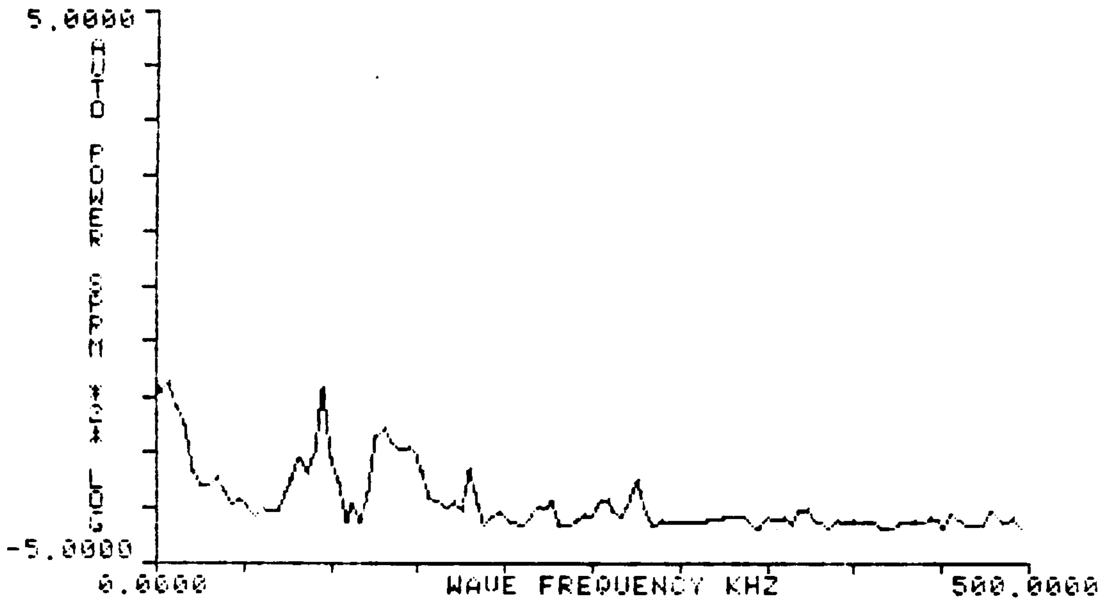

Figure B.21. Auto power spectrum of channel 2 (run # APD5).

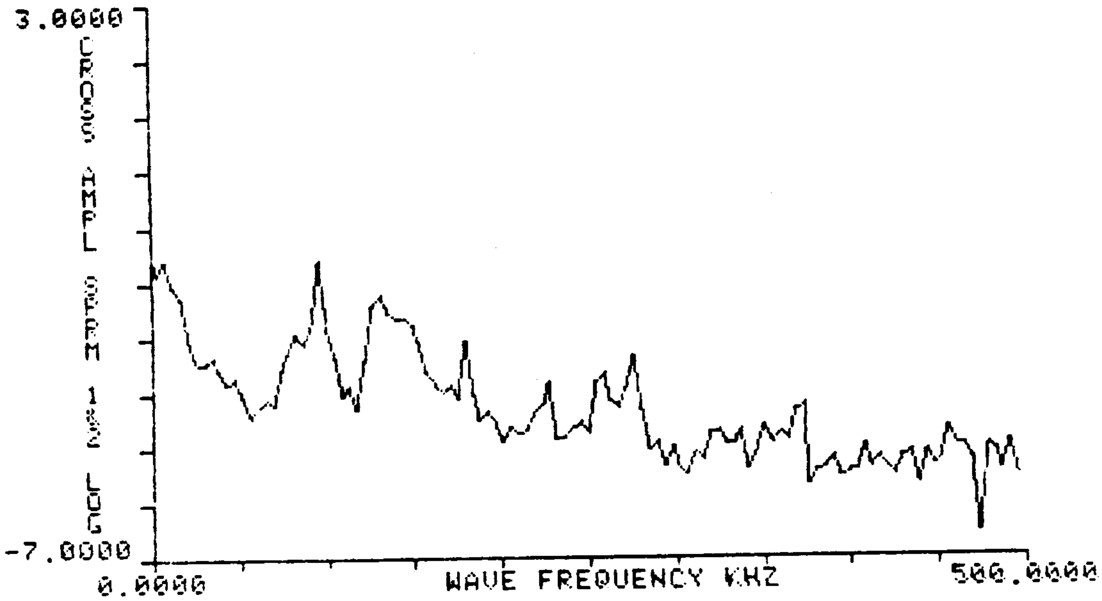

Figure B.22. Cross amplitude spectrum (1,2)
(run # APD5).

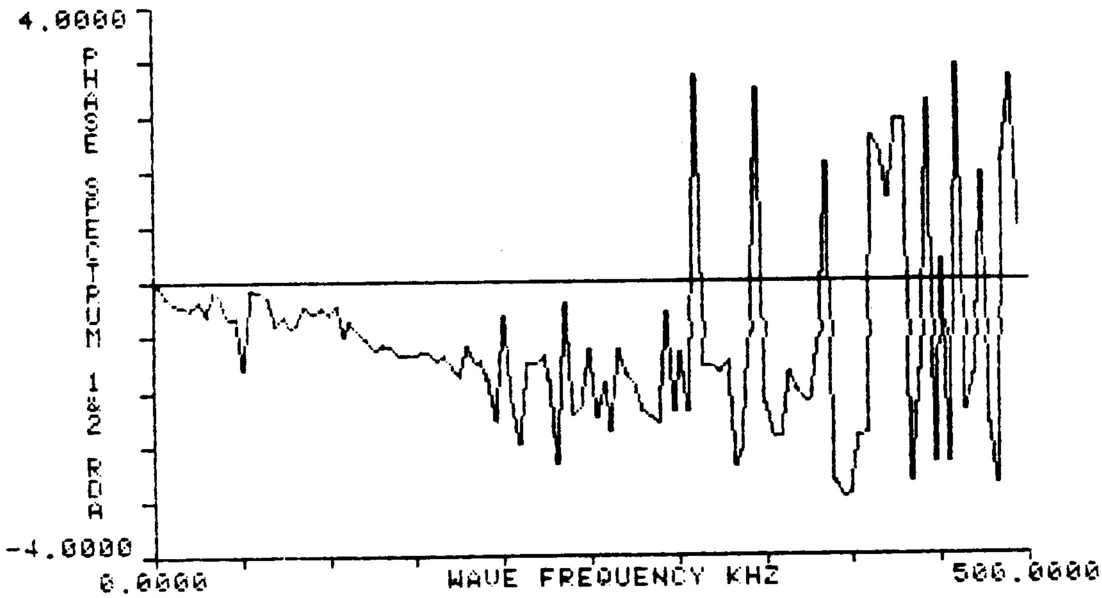

Figure B.23. Phase spectrum (1,2) in Radians (run # APD5).

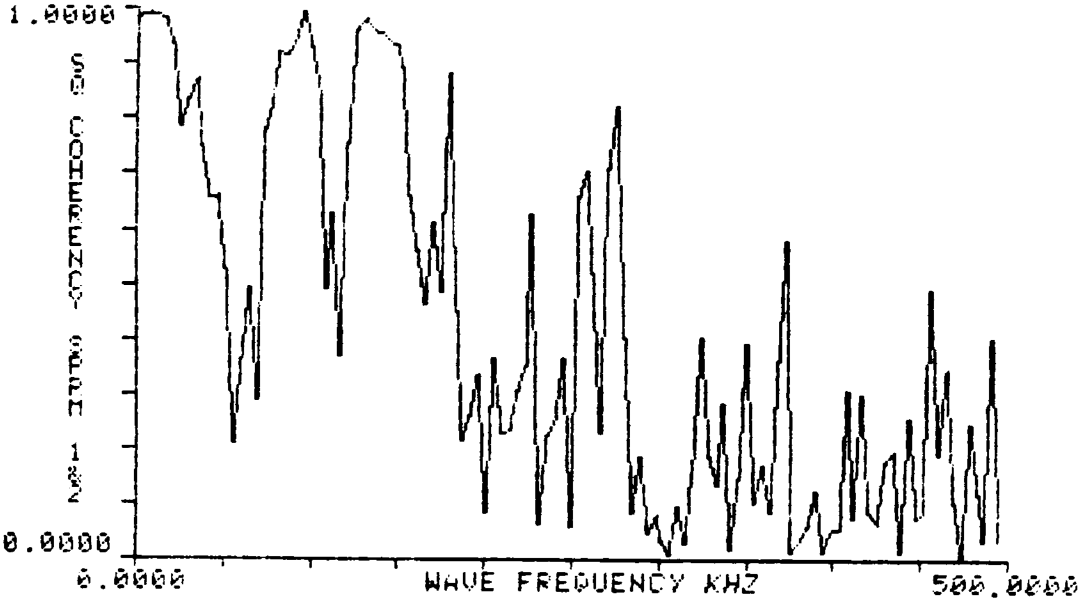

Figure B.24. Squared coherency spectrum (1,2) (run # APD5).

VITA

The author was born in Mashad, Iran, on January 21, 1952. He attended elementary school from September 1959 to June 1965 and high school from September 1965 to June 1971. He was admitted to the Institute of Technology of Mashad in August 1972 and obtained his Associate Degree in Mechanical Engineering in June 1974.

In the summer of 1978 he was admitted to the University of Tennessee, Martin in the Electrical Engineering Department. After one year at that University, he transferred to the University of Tennessee, Knoxville where he received the degree of Bachelor of Science with honors in Eletrical Engineering in March, 1982.

He began his studies for the Master of Science in the Electrical Engineering Department in September 1982. He held a teaching assistantship in September of 1983, and a research assistantship (funded by the Office of Naval Research) in the UTK Plasma Science Laboratory in September 1984, where he did his thesis research.

The author received his M.S. in Electrical Engineering in December 1985.

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