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DEPARTMENT OF ELECTRICAL ENGINEERING
SCHOOL OF ENGINEERING
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA

SOFTWARE DEVELOPMENT FOR INFRASOUND MEASUREMENT SYSTEM

By

Camille Khalaf

and

John W. Stoughton, Principal Investigator

Final Report
For the period January 3 to May 15, 1983

Prepared for the
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia

Under
NAS1-17099
Task Authorization No. 10
Allan J. Zuckerwar, Technical Monitor
Acoustics and Vibration Instruments Section

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Submitted by the
Old Dominion University Research Foundation
P.O. Box 6369
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SOFTWARE DEVELOPMENT FOR INFRASOUND MEASUREMENT SYSTEM

By

Camille Khalaf[1] and John W. Stoughton[2]

I. INTRODUCTION

A. General Description

This manual is a brief description of mainly a software package developed for detection and analysis of infrasounds produced by air turbulence. The software package operates on the APPLE®* computer with its peripherals, while infrasounds (.1 Hz to 10 Hz) are captured by a condenser microphone system deploying an array of 7 microphones developed by the NASA Acoustic and Vibration Instrumentation Section (AVIS).

The aim of this project is to identify and locate severe weather storms by infrasound as produced by air turbulence. Successful detection and location of severe weather storms will provide a positive basis for the detection and location of large scale clear air turbulence. The signal analysis techniques to be employed are based on the results provided by our software package DAISE (Digital Analysis of Infrasound Experiments). For more information about the microphone system and the auto-correlation technique, please refer to the NASA publication NASA TN D-8327 [1].

The following is a summary of what DAISE provides:

1. Samples raw data from the microphone system with a variable sampling frequency and stores it permanently on floppy disks.

2. Displays raw data, from any single microphone, on the video screen using the high resolution graphics (HGR) mode.

---

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*This trade name is used for descriptive purposes only and the authors do not intend any endorsement of the product.

3. Analyzes the data through computing:

   a. Amplitude spectrum of any channel as phase and magnitude.
   b. Power or cross-power spectrum between any 2 channels as phase and magnitude.
   c. Auto-correlation function of any channel or cross-correlation between any two.

4. Displays any of the above functions using HGR mode.

5. Saves results by printing any of the above displays.

B. System Description

a. System Block Diagram

A block diagram of the hardware system is illustrated in Figure 1. All parts are essential for proper operation. However, the user can do without the SILENTYPE®* printer if he does not wish to print any displays generated by the software. A description of the individual parts follows below.

b. Microphone System

This system provides the APPLE®, through an A/D converter, with the raw data needed for analysis. The number of outputs (microphones) could be as many as 8, the maximum channels the A/D can handle at one time.

Note that as long as the rest of the APPLE® system is concerned, this block could be any external source providing an output ranging from Ø to 5 volts.

c. A/D Converter

This block is the way of communication between the APPLE® and the outside world. It is an 8 bit Analog to Digital converter, that takes as many as 8 analog inputs, ranging from Ø to 5 volts, and converts them to an 8 bit digital output (Ø to 25 volts). When specified by the user, the APPLE® scans the A/D and, the digital data is transferred into its internal memory.

Note, for proper operation, any channel that is not used on the AID when sampling has to be grounded, otherwise the data on the used channels will be distorted. The AID unit has to be inserted in slot #4 in the back of the APPLE® monitor.

---

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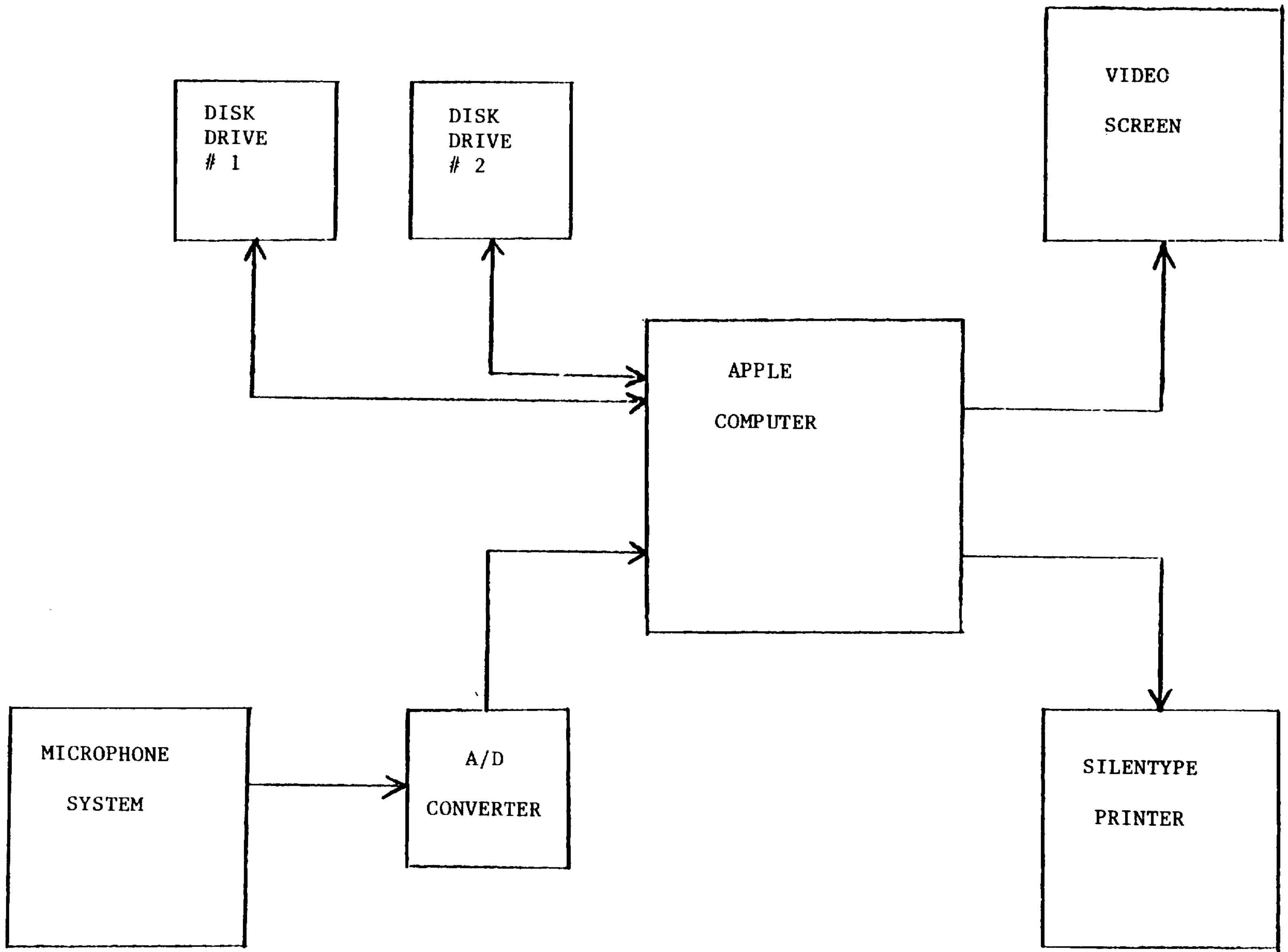


Figure 1. System Block Diagram

d. APPLE® Monitor

Obviously, this is the processing unit of the whole system and it communicates with all other blocks. It could be one of the following:

APPLE® computer - 64 K
APPLE II® computer - 64 K
APPLE II PLUS® computer - 64 K

If you remove the cover of your APPLE® , you will see 6 peripheral slots in the back, that is where all the other system blocks have to be connected. Please see the appropriate block description for the slot number in which it should be connected.

Note: Make sure to turn the power off before you try to insert or remove any of the peripheral cords.

e. Disk Drives

Two disk drives are required in order to run the software package. These 2 drives are connected through one peripheral card in one slot, typically slot #6. They use floppy diskettes on which programs and data are stored and retrieved by the APPLE®.

f. Video Display

This block is normally VIDEO 300 provided by APPLE® Computer Inc., but it could be any comparable video system. It must be connected through slot # Ø. The user interaction with the system takes place through the video screen as well as plotting results using the high resolution graphics capability of the APPLE®.

g. SILENTYPE® Printer

The SILENTYPE® is the only type of printer that can be interfaced to the system and interact with our software, and must be connected through slot #1. The printer is necessary in the sense that it is the only way of saving your results as printed displays for later use.

II. SOFTWARE DESCRIPTION

A. DAISE Block Diagram

The software structure is very straightforward and can be easily understood by the aid of the diagram on Figure 2. As shown, DAISE consists of 3 levels of subroutines. The first level includes the preliminary work that has to be done before any analysis, the second level is where all the computations take place, while displaying the results of the computations is directed through level 3. Any level is reached only from the previous one and whenever the command EX is entered the control is transferred to the previous level again. Upon execution of any subroutine DAISE will return to the same level from which the subroutine was called. In the next 3 sections the subroutines of all 3 levels are fully described.

B. Start-Up Procedure

a. Diskettes needed

In order to start up the system in addition to the hardware described in section I.B., at least three version 3.3 diskettes are required:

1. DAISE diskette containing the following binary files:

   - PASSØ
   - PASS1
   - PASS2
   - RUNTIME
   - ADC.0
   - DAISE.OBJ

   in addition to one text file:
   -MASTER

2. GPLE diskette, containing two binary files:

   - PLE DOS MDVER
   - PLE.DM

3. DATA diskette that may or may not contain any files, but it has to be at least initialized.

b. Step by Step Procedure

Step One

Insert DAISE diskette in disk drive 1 and GPLE diskette in disk drive 2, and then boot the system.

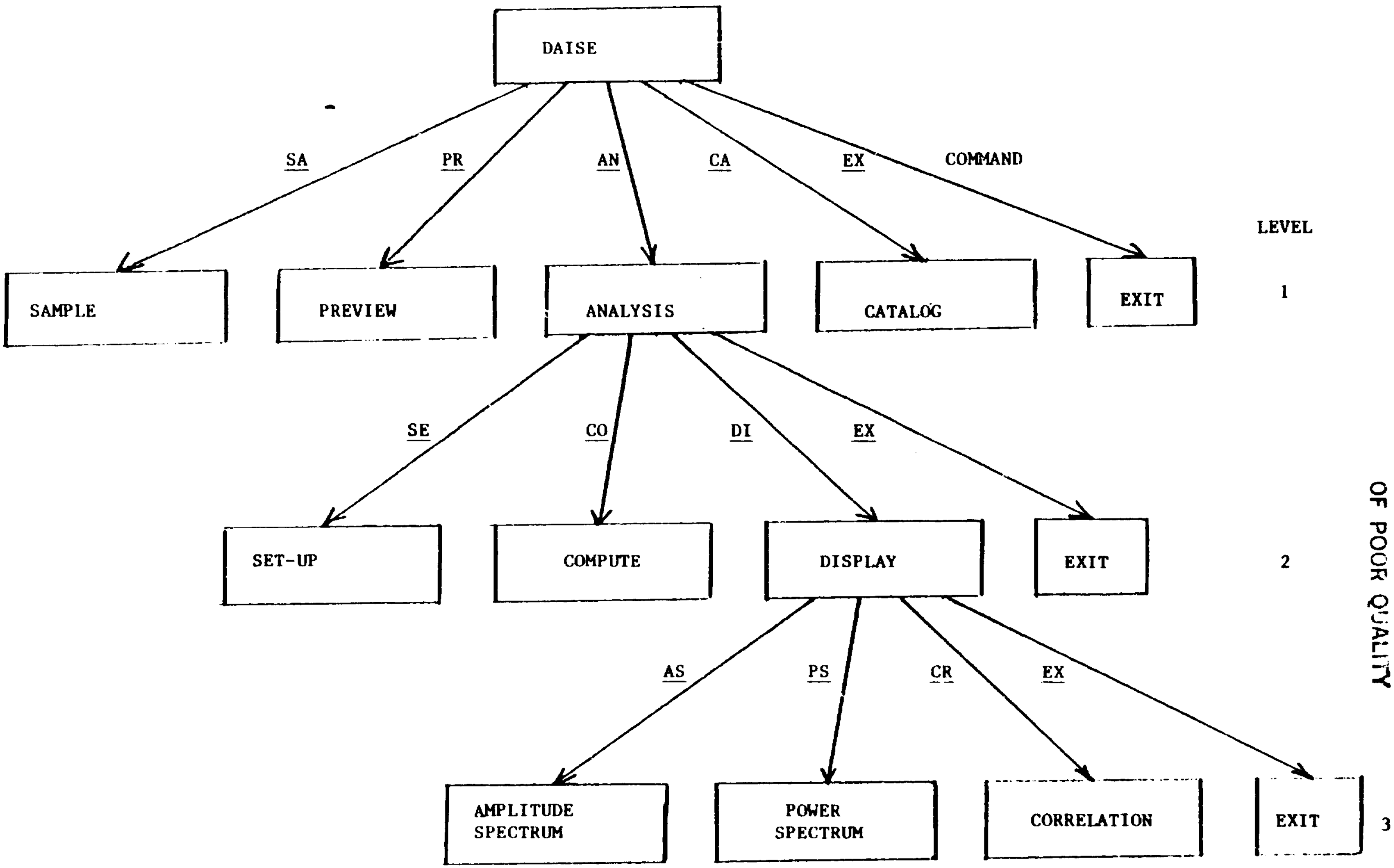


Figure 2. Block Diagram Description of DAISE.

Step Two

Type the command: EXEC MASTER, D1 (cr). This command will execute an executive file that moves DOS to the additional 16K memory card and then loads the compiler run time table for the APPLE® monitor.

Step Three

When indicator lights on both disk drives go off, remove GPLE diskette from disk drive 2 and insert DATA diskette insteed.

Step Four

Type the command:

BRUN DAISE.OBJ, D1 (cr)

The diskette in drive 1 will spin for a few seconds, and then the first three lines of DAISE will be printed on the video screen leaving you with the first level subroutines.

C. First Level Subroutines

a. SAMPLE command: SA

Description

This subroutine samples raw data from the microphone system through an A/D converter. The data is an 8 K byte block sampled at 8 channels (microphones), 1024 bytes per channel. The subroutine scans all 8 channels simultaneously and then stores the data on the disk (Drive 2) as 8 binary subfiles.

User Intervention

The user has to intervene twice. First, right after he gives the command SA, he will be asked to input the sampling frequency constant. At this point the APPLE® will be waiting for a real number as input. (See log graph in Figure 3 for range and frequency correspondence). Second, right before storing data on the disks the user is asked to input or file name as a string variable. This variable will be common to all 8 subfile names as: "File"-c"x" where "File" stands for file name specified by the user, x is an integer in the range 1-8 and c designates a channel.

ORIGINAL PAGE IS
OF POOR QUALITY

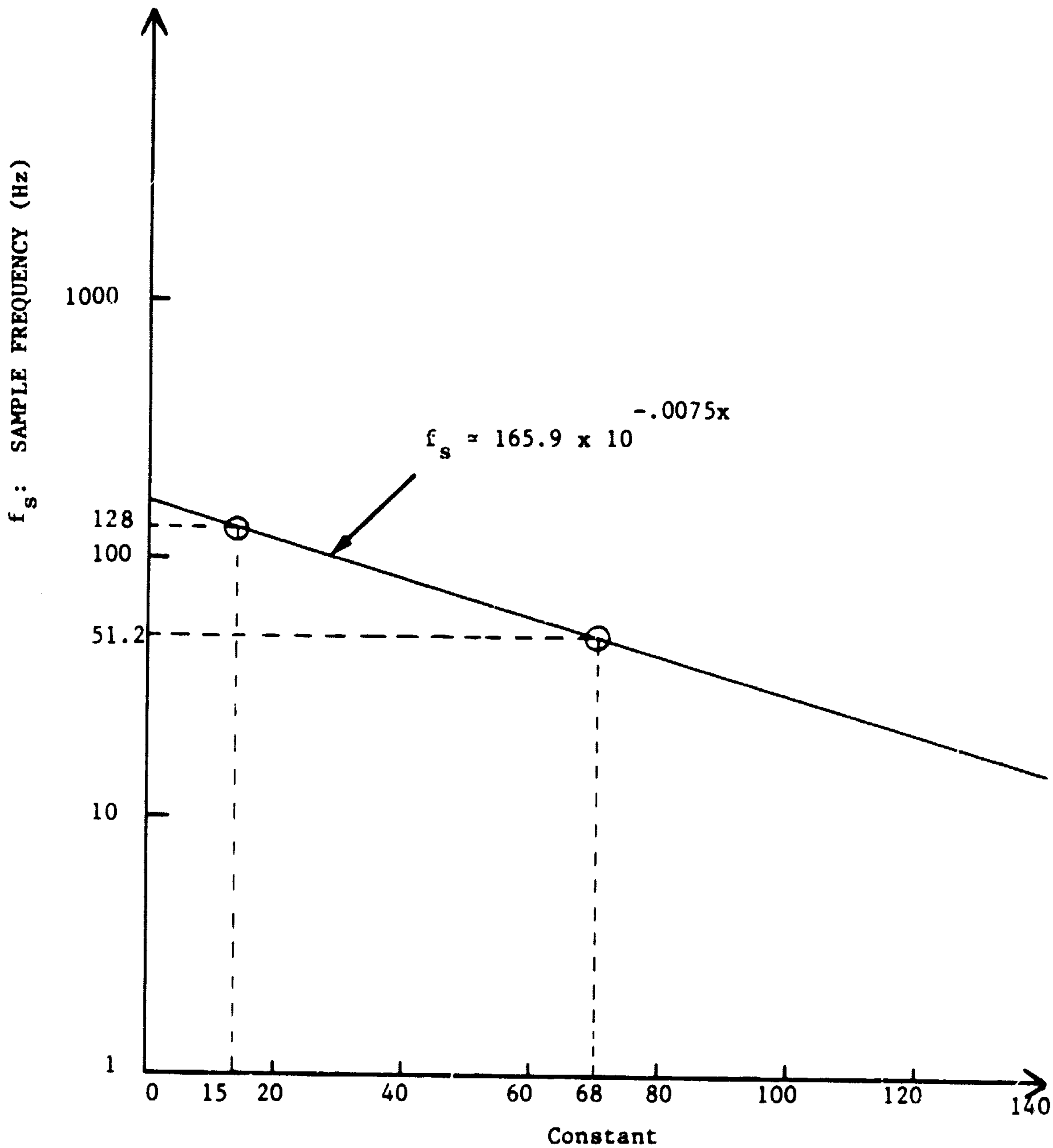


Figure 3. Log Sample Frequency Versus Input Constant.

Example

After you load and run DAISE, the following is displayed on your video screen:

```
1  TYPE COMMAND SA, PR, AM, CA, EX, FOR:
2  SAMPLE, PREVIEW, ANALYSIS, CATALOG, EXIT
3  ?
   AT THIS POINT TYPE "SA" FROM THE KEYBOARD, THEN YOU'LL SEE:
4  INPUT SAMPLING FREQUENCY CONSTANT
5  ?
   NOW TYPE "68".  THE APPLE® WILL SPEND 20 SECONDS SAMPLING (51.2 Hz)
   BEFORE REQUESTING:
6  INPUT FILE NAME
7  ?
   TYPE "TEST".  NOW THE APPLE WILL STORE 8 SUBFILES UNDER THE FOLLOWING
   NAMES:
     TEST-C1
     TEST-C2
     TEST-C3
     TEST-C4
     TEST-C5
     TEST-C6
     TEST-C7
     TEST-C8
```

Lines 1, 2, and 3 are printed on the video screen again, then waits for a new command.

Notes

- If an invalid command is typed in line 3 above, DAISE will simply refuse it, print the first 3 lines, and wait for a valid command.

b. PREVIEW, command: PR

Description

The PREVIEW subroutine allows a preview of the raw data sampled and stored on the disk at any earlier time. It displays the data on the video screen using the high resolution graphics display of the APPLE®. The displayed data consists of only 256 samples out of 1024 belonging to one subfile (channel). To preview another quarter, the user has to call PREVIEW another time. The vertical axis on the display is the voltage axis while the horizontal one is the time axis.

User intervention

At the very beginning of the subroutine the user is asked to input a subfile name. This name, as explained earlier, is of the form "File-name"-c"x" in which the file and the channel are specified. Then the user is asked to input the desired quarter as an integer in the range 1 to 4, representing the first, second, third and fourth 256 sample blocks of the subfile. After these two inputs the axis will be drawn on the display and the APPLE® will wait for a scaling factor for the data. The scaling factor could be any real number by which every data value will be divided before it is printed as a dot on the display. An optimum value for the scale is 1 since this is the value that scales the vertical axis between Ø and 5 volts.

Example

```
1  TYPE COMMAND SA, PR, AN, CA, EX, FOR:
2  SAMPLE.PREVIEW.ANALYSIS.CATALOG.EXIT
3  ?
   PR (cr)
4  INPUT FILE AND CHANNEL
   ?
   TEST-C1 (cr)
5  DESIRED QUARTER?
   ?
   3 (cr)
   (THE AXIS ARE DRAWN)
6  SCALING FACTOR?
   ?
   1 (cr)
```

Now the data will be displayed and the APPLE® goes back to lines 1, 2, and 3 above.

c. ANALYSIS, command: AN

Description

This subroutine includes most of the program since it is the route to all DAISE analysis features. It provides complete spectral as well as correlation analysis of the raw data. By selecting this subroutine you could compute and display the following:

- Ampl. spectrum of any channel as phase and MG.
- Power spectrum of any channel as phase and MG.
- Cross-power between any 2 channels as phase and MG.
- Printing real and imaginary values of any spectral comp. of ampl., power or x-power spectrum
- Auto-correlation function of any channel
- X-correlation between any 2 channels

In addition, you could print any of the above displays on the SILENTYPE® printer.

ANALYSIS leads you to the second level of the block diagram in which you have the choice of executing four different subroutines: SET-UP, COMPUTE, DISPLAY, EXIT. These subroutines will be studied later in this manual.

User intervention

There are many interventions that will not be listed here since they will be listed in second level subroutines. The major decision in ANALYSIS is choosing one out of the 4 subroutines listed above. You could chose any route at any time but for reasons that will be clear later the normal order of execution is:

SET-UP, COMPUTE, DISPLAY and then EXIT, please read about these subroutines before you try to execute any of them.

Example

1 TYPE COMMAND SA, PR, AN, CA, ER, FOR:
2 SAMPLE, PREVIEW, ANALYSIS, CATALOG, EXIT

3 ?

AN (cr)

4 TYPE COMMAND SE, CO, DI, EX, FOR:

5 SET-UP, COMPUTE, DISPLAY, EXIT

6 ?

SE (cr)

Notes

An invalid command in line 6 above will be ignored, lines 4, 5 and 6 will be printed again, and DAIS will be waiting for a valid command.

d. CATALOG, command: CA

Description

This command lets you look at the contente of the disk in Drive 2, where your data files are stored. The object of this subroutine is to review the file names so you can choose the right file to preview or analyze later. This is done by a normal catalog command of APPLE® software.

User intervention

If the file names do not fit in one screen, just press RETURN to look at the rest of the files. This can be repeated until DAISE returns the beginning of the program.

Example

1 TYPE COMMAND SA, PR, AN, CA, EX, FOR:

2 SAMPLE, PREVIEW, ANALYSIS, CATALOG, EXIT

3 ?

CA (cr)

4 DISK VOLUME 254

5 TEST-C1

6 TEST-C2

. . . .

. . . .

. . . .

12 TEST-C8

13 TYPE COMMAND SA, PR, AN, CA, EX, FOR:

14 SAMPLE, PREVIEW, ANALYSIS, CATALOG, EXIT

15 ?

e. EXIT, Command: EX)

Description

This command will simply end the program, with no intervention from the user.

Notes

If DAISE is mistakenly exited, type:

BRUN DAISE.OBJ, D1 (cr)

to start the program again.

D. Second Level Subroutines

Description

SET-UP sets the analysis mode and loads the user specified data from disk into the APPLE® monitor to be ready for computation and analysis. User decisions are very important in this subroutine, therefore, the user is advised to read the computation algorithm section in this manual, preview the data, have a clear idea of what channel(s) are desired, what the interesting part of the data is, and how many averages are needed before attempting to enter this subroutine.

User intervention

1 First, input a ref-channel (subfile) name. This is done whether you wish to have an auto or cross-correlation analysis.

2 Second, determine the option of AUTO-CORRELATION (AC) or CROSS-CORRELATION (CC). An AUTO-CORRELATION option is the route to (AFTER COMPUTATION) AMPL. and POWER SPECTRUM and AUTO-CORRELATION function of your ref-channel you entered in 1.

While a CC option is the route to AMPL. spec of the ref-channel, x-power spec. between ref-channel and x-channel (that you will specify next and a CROSS-CORRELATION of the two with selection of the CC option.

3 You will be asked to input a x-channel (subfile) name.

4 The 1 K bytes of data is divided into 8 blocks 128 bytes each. At this point you have to determine the block at which you want the computation to start. Your answer should be in the range of Ø to 7.

5 Now you have to specify the number of blocks you want to be operated on by one pass through the ocmpute subroutine. Your answer should be in the range of 1 to 8. Note that this corresponds to the number of times you want your spectral results to be averaged. Also note that a second pass through the computer subroutine will double the number of averages (in 5). However this number is limited to 8 average in any case, i.e.,

if your answer in 4 is 2
if your answer in 5 is 3
you can compute twice only.

Please read the description of COMPUTE subroutine to help understand the procedure.

<u>Example</u>

1 TYPE COMMAND SE, CO, DI, EX, FOR:

2 SET-UP, COMPUTE, DISPLAY, EXIT

3 ?

SE (cr)

4 INPUT REF-CHANNEL

5 ?

TEST-C1 (cr)

6 TYPE COMMAND AC, CC FOR:

7 AUTO-CORRELATION OR CROSS-CORRELATION

8 ?

CC (cr)

9 INPUT CROSS CHANNEL

10 ?

TEST-C5 (cr)

11 STARTING BLOCK (Ø - 7)?

12 ?

Ø (cr)

13 HOW MANY BLOCKS (1-8)?

14 ?

2 (cr)

15 TYPE COMMAND SE, CO, DI, EX, FOR:

16 SET-UP, COMPUTE, DISPLAY, EXIT

17 ?

Notes

In case of CC option, ref-channel should be the one that is expected to be delayed in time while the cross-channel is the advanced one.

Warnings

- Once you give the command SE all previous spectral and correlation results are lost and initialized to zero.

- If your answer in line 12 is x
  and your answer in line 14 is y
  then x+y has to be ≤ 8, otherwise DAISE will take you back to line 11.

- If the number of passes through COMPUTE subroutine is z then:

  $(z*y) + x \leq 8$, otherwise COMPUTE will not execute but rather takes you back to line 1, 2 and 3 above.

b. COMPUTE, command: CO

Description

Most of the computations are done in COMPUTE deploying the FFT routine. After execution, the real and imaginary components of ampl. and power spectrum or ampl. and cross-power spectrum are computed. These components will be the basis for the phase and magnitude displays as well as the correlation function in the third level subroutines.

No results are obtained from COMPUTE unless you go through SET-UP once. Every pass through COMPUTE causes the number of data blocks specified in SET-UP to be operated on and the results are averaged with the previous ones obtained by an earlier pass. There is no user intervention in this subroutine.

Example

Specified by SET-UP: Starting block is 1
number of blocks is 3

Then, as shown below, the first pass in COMPUTE operates on blocks 1, 2, and 3 while the second operates on blocks 4, 5, and 6.

Note that a third pass will cause the error message: ERROR:DATA BLOCKS ARE EXCEEDED to be printed and control will be transferred to the beginning of the second level, since there is only 1 remaining block.

Ø	1	2	3	4	5	6	7

↑ start of first pass ↑ start of second pass ↑ end of second pass

<u>Notes</u>

Due to the slow speed of APPLE® software in computing arithmatic functions, one pass through COMPUTE, operating on one single block, takes 70 seconds. As a result, one pass operating on 8 blocks at once takes 9 minutes and 20 seconds!

c. <u>DISPLAY, command: DI</u>

<u>Description</u>

Assuming that COMPUTE has been executed and the spectral results are ready, DISPLAY provides viewing of these results on the video screen as well as on the SILENTYPE® printer. The functions that could be displayed are listed in the description of ANALYSIS subroutine earlier.

DISPLAY takes DAISE into the third level of subroutine by grouping the displays of results into 3 categories as follows:

1 - Amplitude spectrum as phase and magnitude.

2 - Power or cross-power spectrum as phase and magnitude.

3 - Auto-correlation or cross-correlation function.

Description of these subroutines are provided in the subsequent sections.

<u>User intervention</u>

Only one decision has to be taken at this stage, that is choosing one out of 3 subroutines: AMPLITUDE SPECTRUM, POWER SPECTRUM, or CORRELATION. These subroutines are executed in any order and as many times as desired.

Example

1 TYPE COMMAND SE, CO, DI, EX, FOR:

2 SET-UP, COMPUTE, DISPLAY, EXIT

3 ?

DI (cr)

4 TYPE COMMAND AS, PS, CR, EX, FOR:

5 AMPLITUDE SPECTRUM, POWER SPECTRUM, CORRELATION, EXIT

6 ?

PS (cr)

d. EXIT, command: EX

Description

This command exits you from the second level subroutines back to the first level.

Example

1 TYPE COMMAND SE, CO, DI, EX, FOR:

2 SET-UP, COMPUTE, DISPLAY, EXIT

3 ?

EX (cr)

4 TYPE COMMAND SA, PR, AN, CA, EX, FOR

5 SAMPLE, PREVIEW, ANALYSIS, CATALOG, EXIT

6 ?

E. Third Level Subroutines

a. AMPLITUDE SPECTRUM, command: AS

Description

AMPLITUDE SPECTRUM generates the phase and magnitude of the amplitude spectrum of the reference channel specified in SET-UP. The viewing options are:

1 - Phase display

2 - Magnitude display

3 - Printing real and imaginary values of spectral components on the video screen.

These 3 options are, in turn, 3 subroutines that are called with commands as the previous ones. The order in which these routines are called is irrelevant and is left to the user's convenience.

1 - PHASE

Command: PH

In this case the first 128 components of the phase are drawn with an argument of + 180' to -180'. Underneath the display, a line is printed containing the name of the reference-channel. Next the user is asked whether he wishes to print the display using the SILENTYPE® printer or not. His answer must be Y (yes) or N (no). If it is a Y, then the SILENTYPE® prints a heading followed by the display, and the control is transferred back to the 3 options above. If the answer is N, then control will be transferred directly to level 3.

Example

```
1  TYPE COMMAND AS, PS, CR, EX, FOR:
2  AMPLITUDE SPECTRUM, POWER SPECTRUM, CORRELATION, EXIT
3  ?
   AS (cr)
4  TYPE COMMAND PH, MG, R & I, EX, FOR:
5  PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
6  ?
   PH (cr)
   (NOW THE PHASE IS PLOTTED)
7  XXXXPHASE PLOT:  TEST-C2 XXXX
8  WOULD YOU LIKE TO PRINT THE DISPLAY (Y/N)
9  ?
   Y (cr)
   THE SILENTYPE® WILL PRINT:
   PHASE PLOTXXX TEST-C2XXX 4 AVE
   AND THEN THE DISPLAY IS PRINTED.
10 TYPE COMMAND PH, MG, R & I, EX, FOR
11 PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
```

12 ?

Notes

An invalid command in line 6 or 9 will be refused and the question will be asked again.

Example

```
1   TYPE COMMAND PH, MG, R & I, EX, FOR
2   PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
3   ?
    MG (cr)
4   SUPPRESS SPECTRAL COMPONENTS (Y/N)?
5   ?
    Y (cr)
6   WHICH COMPONENT (0-127)?
7   ?
8   SUPPRESS SPECTRAL COMPONENTS (Y/N)?
9   ?
    N (cr)
10  FULL, HALF, QUARTER DISPLAY (F/H/Q)?
11  ?
    H (cr)
12  SCALING FACTOR?
13  ?
    1 (cr)
14  SCALING FACTOR?
15  ?
    10 (cr)
    (NOW THE MAGNITUDE IS PLOTTED)
16  XXX MG.PLOT:  TEST-C3 XXX
17  WOULD YOU LIKE TO PRINT THE DISPLAY (Y/N)?
18  ?
    N (cr)
19  TYPE COMMAND PH, MG, R & I, EX, FOR:
20  PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
```

21 ?

2 - MAGNITUDE

Command: MG

This option plots for you the first 128 components of the magnitude plot. The vertical axis represents a relative scale while the horizontal one is frequency.

Before plotting the magnitude, the user has to answer the following questions:

i - suppress spectral components (Y/N)?

This allows suppression of relatively large components (i.e. DC comp.) in order to have a better view of the rest of the spectrum by changing the scaling factor. If your answer is yes, then the user will be asked to specify the number of the components which can only be suppressed, one at a time.

ii - Full, half or a quarter display (F/H/Q)?

This allows changing the increment value on the frequency axis by displaying 128, 64 or 32 components.

F corresponds to 128 components
H corresponds to the first 64 components
Q corresponds to the first 32 components

iii - Scaling factor?

This input could be any real number by which all components are divided before they are plotted.

If the scale factor is too small the question will be repeated until the scaling factor is large enough for the components to fit on the APPLE® screen.

After answering these questions the magnitude is plotted. As in the PHASE plot information is printed underneath followed by the option of printing the display.

REAL AND IMAGINARY

Command: R & I

This option allows printing the real and imaginary value of any spectral component on the video screen. This command prints the values of one component at a time.

Example

```
1   TYPE COMMAND PH, MG, R & I, EX, FOR:
2   PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
3   ?
    R & I (cr)
4   WHICH COMPONENT (0-127)?
5   ?
    2 (cr)
6   REAL PART:  2356.712
7   IM.PART: -175.689
8   TYPE COMMAND PH, MG, R & I, EX, FOR:
9   PH-DSPLY, MG-DSPLY, REAL & IM., EXIT
10  ?
```

Notes

- The frequency resolution on the horizontal axis, in both PHASE and MAGNITUDE, is determined by the sampling frequency specified in the SET-UP.

  The relation is $\Delta f = \frac{\text{sampling frequency}}{256}$

- Along with PH, MG and R & I you have the EX command. This command takes DAISE back to level 3 subroutines.

- Suppressing spectral components in MAGNITUDE means setting their values to zero only on the display so that in subsequent passes through MAGNITUDE these components will still be suppressed while a second call of AMPLITUDE SPECTRUM will regenerate them.

b. POWER SPECTRUM, command: PS

Description

POWER SPECTRUM generates the phase and magnitude of the power spectrum of the reference-channel if the auto-correlation option was specified in the SET-UP, or it generates the phase and magnitude of the cross-power spectrum of the reference-channel and cross-channel if the cross-correlation option was specified.

Next, it leaves the user with the same options listed in the AMPLITUDE SPECTRUM description. From that point on, everything mentioned there is true in this case also and need not be repeated here.

Notes

The comments printed underneath the video displays and above the printed displays will refer in this case, to the power or cross-power spectrum rather than the AMPLITUDE SPECTRUM.

c. CORRELATION, command: CR

Description

This subroutine uses the results of the power, or cross-power, spectrum to generate the auto-correlation, or cross-correlation function by one pass through the inverse FFT.

After generation, the correlation function is displayed and could be printed by the printer.

The vertical axis represents a relative scale of the function while the horizontal one represents the delay time τ.

The number of points plotted is 256 with a time resolution determined by the sampling frequency as:

$$\Delta t = \frac{1}{F_s}$$

User intervention

1 At the very beginning, the user has the option of suppressing spectral components in the power spectrum before generating the correlation-function.

   This is included here to prevent undesirable components (i.e. noise components) from effecting the correlation results.

2 Once the function is generated, the axis will be drawn and the user is asked to input a scaling factor for the display.

3 A comment is printed underneath the display specifying the kind of function and the involved channel(s). Next the question:

Display CORR-FN again (Y/N)?

Is asked. This allows viewing the function on a different scale, and could be repeated as many times as desired.

4 Then the option of printing the display on the printer is offered.

<u>Example</u>

```
1   TYPE COMMAND AS, PS, CR, EX, FOR:
2   AMPLITUDE SPECTRUM, POWER SPECTRUM, CORRELATION, EXIT
3   ?
    CR (cr)
4   SUPPRESS ANY SPECTRAL COMPONENTS (Y/N)?
5   ?
    Y (cr)
6   WHICH COMPONENT (1-238)?
7   ?
    3 (cr)
8   SUPPRESS ANY SPECTRAL COMPONENTS (Y/N)?
9   ?
    N (cr)
    (AFTER 70 SECONDS OF COMPUTATION THE AXIS ARE DRAWN)
10  SCALING FACTOR?
11  ?
    8 (cr)
    (THE FUNCTION IS PLOTTED)
12  XXX CROSS-CORR:  TEST-C2 CROSS TEST-C7 XXX
13  DSPLY CORR-FN AGAIN (Y/N)?
14  ?
    Y (cr)
15  SCALING FACTOR?
16  ?
    4 (cr)
    (THE OLD FUNCTION IS DELETED AND THE NEW ONE IS PLOTTED)
17  DSPLY CORR-FN AGAIN (Y/N)?
18  ?
    N (cr)
```

19 WOULD YOU LIKE TO PRINT THE DISPLAY (Y/N)?

20 ?

N (cr)

21 TYPE COMMAND AS, PS, CR, EX, FOR:

22 AMPLITUDE SPECTRUM, POWER SPECTRUM, CORRELATION, EXIT

23 ?

Notes

- In this subroutine, suppressing spectral components means setting them to zero everywhere in the program and they cannot be generated again.

  i.e., A suppressed component in one pass through CORRELATION will still be suppressed in any subsequent passes, as well as in any power spectrum display.

Also note that the DC component is suppressed automatically before computing the correlation-function.

- Once the user answers "N" to the question in line 17 of the example above, the CORRELATION subroutine is exited. Therefore, a second view of the correlation function will require a second pass through the subroutine which in turn means waiting 70 seconds.

d. EXIT, command: EX

Description

This command takes DAISE back to level 2 subroutines.

F. Data Management

Data is stored and transferred between the APPLE® monitor and disk drive 2 at three major subroutines: SAMPLE, PREVIEW and SET-UP.

a. SAMPLE Data

In this case data is sampled at the A/D converter and stored directly in the APPLE® RAM as 8 blocks (channels), 1024 bytes each, stored at the following locations:

Channel 1 starts at 7600 HEX (30208 DEC)

Channel 2 starts at 7A00 HEX (31232 DEC)

Channel 3 starts at 7E00 HEX (3256 DEC)

Channel 4 starts at 8200 HEX (33280 DEC)

Channel 5 starts at 8600 HEX (34304 DEC)

Channel 6 starts at 8A00 HEX (34328 DEC)

Channel 7 starts at 8E00 HEX (36352 DEC)

Channel 8 starts at 9200 HEX (37376 DEC)

These blocks are transferred to disk drive 2 as 8 binary subfiles and the memory space (7600 to 9600 HEX) is freed.

b. PREVIEW Data

In the PREVIEW subroutine one subfile (1 k byte) is loaded from disk drive 2 into the RAM and occupies:

8E00 to 91FF HEX (36352 to 37375 DEC)

Once PREVIEW is exited this 1 K block of data is not accessed by any means.

c. SET-UP Data

In this case one subfile (reference-channel) is loaded from the diskette and stored in locations: 8E00 to 91FF EX(36352 to 37375 DEC) and in the case of cross-correlation the x-channel is stored in 9200 to 95FF HEX (37376 to 38399 DEC)

These 2 blocks of data are accessed by COMPUTE subroutine only.

Notes

- Memory locations 7600 to 95FF are used only for data management throughout DAISE.

- All spectral and correlation results are not stored permanently anywhere and will be lost unless the displays are printed.

III. COMPUTATION ALGORITHM

The algorithm used in DAISE for the computation of AMPLITUDE SPECTRUM and POWER SPECTRUM is based on two algorithms as described by Cooley et al.

[2] and Rader [3]. The reader is advised to review the papers for clear understanding. For our purposes a summary of the two algorithms is presented.

A. First Reference

From reference [2] we can compute the Fourier transform of 2 sets of real data in one pass through a DFT subroutine as follows:

Using the linearity property we see that if $x(n)$ and $y(n)$ are real sequences such that

$X(K)$ is the transform of $x(n)$ and

$Y(K)$ is the transform of $y(n)$

and if we form $s(n) = y(n) + i\, x(n)$

Then $S(n)$ has the transform

$$S(K) = Y(K) + i\, X(K) \qquad (1)$$

$$\text{and} \quad S^*(N-K) = Y(K) - i\, X(K) \qquad (2) \qquad 0 \leq K < \frac{N}{2}$$

where * designates complex conjugate and N is the total number of points. Now solving (1) and (2) for $Y(K)$ and $X(K)$ we get:

$$Y(K) = 1/2 \left[S^*(N-K) + S(K) \right]$$

$$X(K) = 1/2 \left[S^*(N-K) - S(K) \right]$$

Thus, $Y(K)$ and $X(K)$ can be computed by one pass through the DFT with a few extra additions and subtractions.

B. Second Reference

With respect to perform correlation operations as described by Rader [3], let $Y(N)$ be an N points sequence and construct $X(N)$ such that:

$$x(n) = \begin{cases} y(n) & \text{for } 0 \leq n < \frac{N}{2} \\ 0 & \text{for } \frac{N}{2} \leq n < N \qquad n \epsilon\ [0,N) \end{cases}$$

If we compute the DFTs of Y(N) and X(N):

$$Y(K) = \text{DFT}\left\{y(n)\right\}$$

$$X(K) = \text{DFT}\left\{x(n)\right\}$$

and for the product $W(K) = Y^*(K)\,X(K)$ we have the DFT, W(K) of the sequence

$$w(m) = \sum_{n=0}^{N/2\,-1} x(n)^*y(n+m) \qquad (2)$$

where m is a lag index.

It is easily seen that w(m) is nothing but the auto-correlation function of y(n) that, having W(K) computed, can be generated by on inverse DFT.

IF y(n) was a continuous series the above procedure can be repeated as many times as desired, considering N points at a time and averaging.

Note that Rader paper is more involved and does not stop at this point, but the above discussion is enough for our need.

C. Algorithm Description

Our algorithm is the merit of both papers. Let y(n) and x(n) be 2 real sequences of length N. The second $\frac{N}{2}$ points of x(n) are padded with zeroes as follows:

1) If auto-correlation is desired,

$$x(n) = \begin{cases} y(n) & \text{for } 0 \leq n < n/2 \\ 0 & \text{for } N/2 \leq n < N \end{cases}$$

2) If cross-correlation is desired,

$$x(n) = \begin{cases} x(n) & \text{for } 0 \leq n < N/2 \\ 0 & \text{for } N/2 < n < N \end{cases}$$

then $s(n) = y(n) + j\, x(n)$ is formed and its Fourier transform $S(K) = a(K) + i\, b(K)$ is obtained by one pass through the FFT routine.

a. Amplitude spectrum computation

We have seen in the first procedure that

$$Y(K) = 1/2 \left[S^*(N-K) + S(K) \right]$$

or using the results of the FFT routine,

$$\text{Real part of } Y(K) = 1/2 \left[a(N-K) + a(K) \right] = \text{Real part of } Y(N-K)$$

and imaginary part of $Y(K) = 1/2 \left[-b\,(N-K) + b(K) \right] =$ -Imaginary part of $Y(N-K)$

The last two expressions are the ones used to evaluate the AMPLITUDE SPECTRUM.

b. Power or Cross-Power Spectrum Computation

We saw that $Y(K) = 1/2 \left[S^*(N-K) + S(K) \right]$

and its complex conjugate would be

$$Y^*(K) = 1/2 \left[S^*(N-K) + S^*(K) \right]$$

so that the POWER SPECTRUM $W(K)$, in the Rader paper can be written as:

$$W(K) = Y^*(K)\, X(K) =$$
$$1/2 \left[S(N-K) + S^*(K) \right] \cdot 1/2 \left[S^*(N-K) - S(K) \right].$$

Evaluation of the above expression in terms of the output of the FFT routine, $S(K) = a(K) + i\, b(K)$ yields,

$$\text{Real part of } W(K) = \text{Real part of } W(N-K) =$$
$$1/2 \left[a(K)\, b(N-K) + a(N-K)\, b(K) \right]$$

and imaginary part of $W(K) = -$ Imaginary part of $W(N-K)$

$$= 1/4 \left[a^2(N-K) - a^2(K) + b^2(N-K) - b^2(K) \right]$$

where $0 < K < \frac{N}{2} - 1$

Again the last two expressions are the ones used for evaluation.

c. Algorithm Summary

Step 1 Load data sequences $y(n)$ and $x(n)$, and then zero pad the second $N/2$ points of $x(n)$.

Step 2 Form s(n) as y(n) + i x(n) and pass it to the FFT routine to get

$$S(K) = a(K) + i\ b(K)$$

Step 3 Compute the AMPLITUDE SPECTRUM of y(n) and the power (or cross-power) spectrum as specified earlier.

Step 4 Repeat the above steps as many times as desired and average the results in Step 3. (In DAISE the number of averges is limited to 8).

Step 5 Pass the power (or cross power) spectrum results to the inverse FFT to obtain the auto (or cross) correlation function.

Notes for the User

1 - In DAISE y(n) has been called the reference-channel while x(n) is the cross-channel.

2 - Amplitude spectrum of y(n) is computed whether the user specifies the auto-correlation or the cross-correlation option.

3 - Our sequences (subfiles) are 1024 points long, divided into 8 blocks, 128 points each. The value of N is 256 points and

$$\frac{N}{2} = 128 = 1 \text{ block.}$$

4 - DAISE deploys a 256 point FFT routine so that by one pass through the first 3 steps of the algorithm two blocks of y(n) and 1 block of x(n) (second block is padded with zeros) are operated on. This leaves us with 8 possible passes or averages.

i.e., First average : y(n) = {first and second block}
x(n) = {first block and 128 zeros}
Second average : y(n) = {second and 3rd block}
x(n) = {second block and 128 zeros}
and so on.

5 - In SET-UP subroutine, when the user answers the question "HOW MANY BLOCKS (1-8)?" He is specifying the number of averages desired in one pass through COMPLETE subroutine.

IV. REFERENCES

1. Holmes, H.K., and A. J. Zuckerwar, "A Unified Acquisition System for Acoustic Data," NASA TN D-8327, 1977.

2. Cooley, J.W., P. Lewis, and P. Welch, "The Fast Fourier Transform Algorithm and its Application," IBM Research Paper RC-1743, 1967.

3. Rader, C.M., "An Improved Algorithm for High Speed Auto Correlation with Application to Spectral Estimation," IEEE Trans. Audio Electroacoustics, Vol. AU-18, pp. 439-441, December 1970.

V. APPENDICES

A. Memory Map

Address	Contents
0000 (80000)	APPLE System Use
2048 (80800)	Compiler Library
6063 (817AF)	Free for future expansion
8192 (82000)	High-resolution graphics, Page 1
16364 (84000)	DAISE
26666 (8682A)	Free for future expansion
30208 (87600)	Raw data buffer
38400 (89600)	DAISE variables
45056 (8B000)	Free for future expansion
49151 (8BFFF)	

<u>Note</u>

In the above configuration DOS, the disk operating system has been moved to the extra 16 K memory card.

B. Time-Frequency Relations

F_s = sampling frequency

Δf = frequency resolution (spectral plots)

Δt = time resolution (correlation plots)

Γ = total sampling time (N points)

relations: $\Delta t = \frac{1}{F_s}$

$$\Delta f = \frac{F_s}{N}$$

$$\Gamma = \frac{1}{\Delta f}$$

Examples: a) F_s = 128 Hz, N = 256

$$\Delta t = \frac{1}{128} = .0078 \text{ seconds}$$

$$\Delta f = \frac{128}{256} = .5 \text{ Hz}$$

$$\Gamma = \frac{1}{.5} = 2 \text{ seconds}$$

b) F_s = 51.2 Hz, N = 256

$$\Delta t = \frac{1}{51.2} = .02 \text{ seconds}$$

$$\Delta f = \frac{51.2}{256} = .2 \text{ Hz}$$

$$\Gamma = \frac{1}{.2} = 5 \text{ seconds}$$

C. DAISE Error Messages

a. "Out of Range" Errors

- Input in line 1080
  Message: "ERROR:QUARTER RANGE IS 1 TO 4, INPUT AGAIN"

- Input in line 1870
  Message: "ERROR: YOUR INPUT RANGE IS 0 TO 7, INPUT AGAIN"

- Input to line 1890
  Message: "ERROR: YOUR INPUT RANGE IS 1 TO 8, INPUT AGAIN"

- If input in line 1870 plus input in line 1890 is greater than 8
  Message: "ERROR: DATA RANGE IS EXCEEDED!"

- Input in line 5513 or line 5724
  Message: "ERROR: COMPONENT RANGE IS 0 TO 12, INPUT AGAIN"

- Input in line 5885
  Message: "ERROR: COMPONENT RANGE IS 0 TO 128, INPUT AGAIN"

b. DOS Related Errors

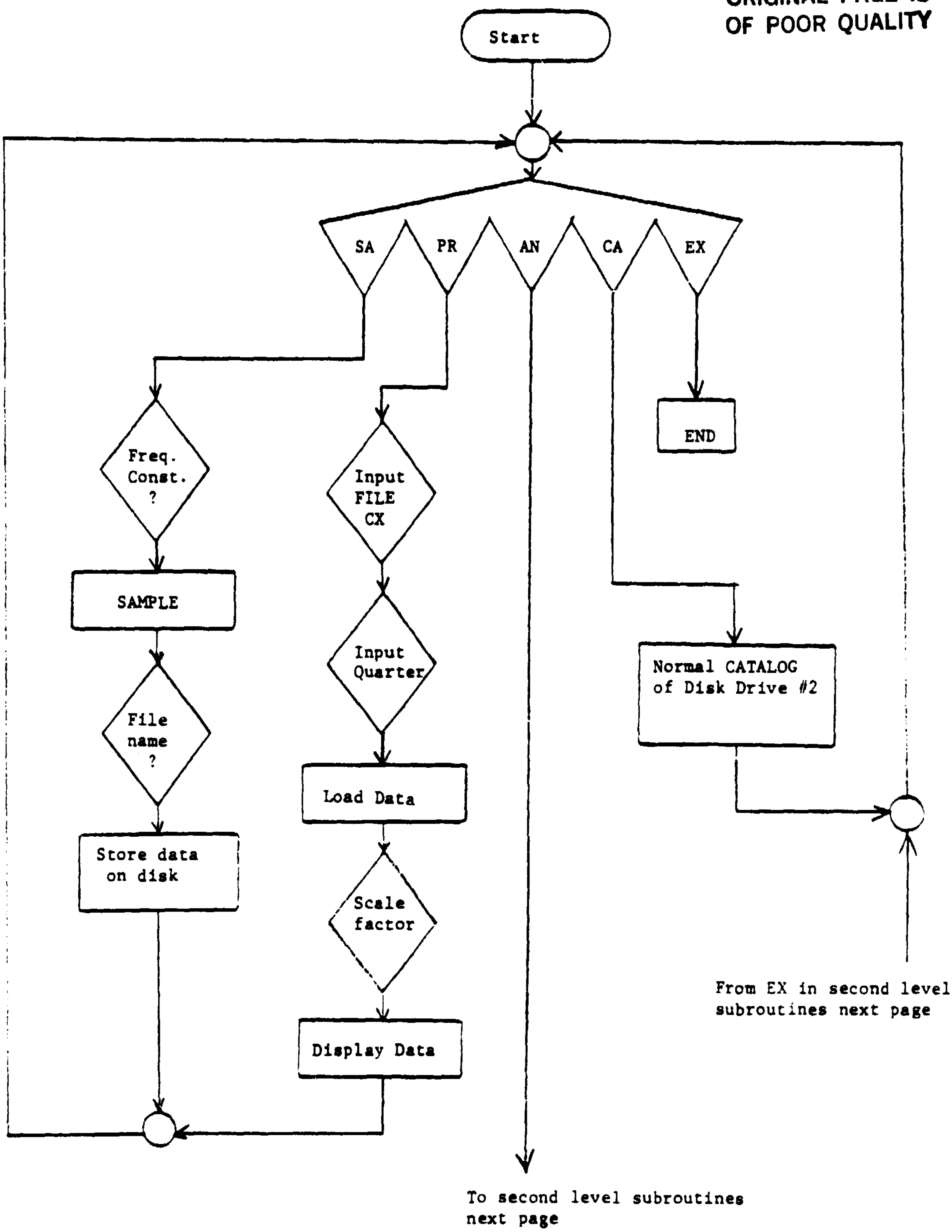
If a DOS error occurs while DAISE is storing data on disk after sampling or loading data from disk for PREVIEW or ANALYSIS the corresponding error message will be printed and control will be transferred to the first level subroutines.

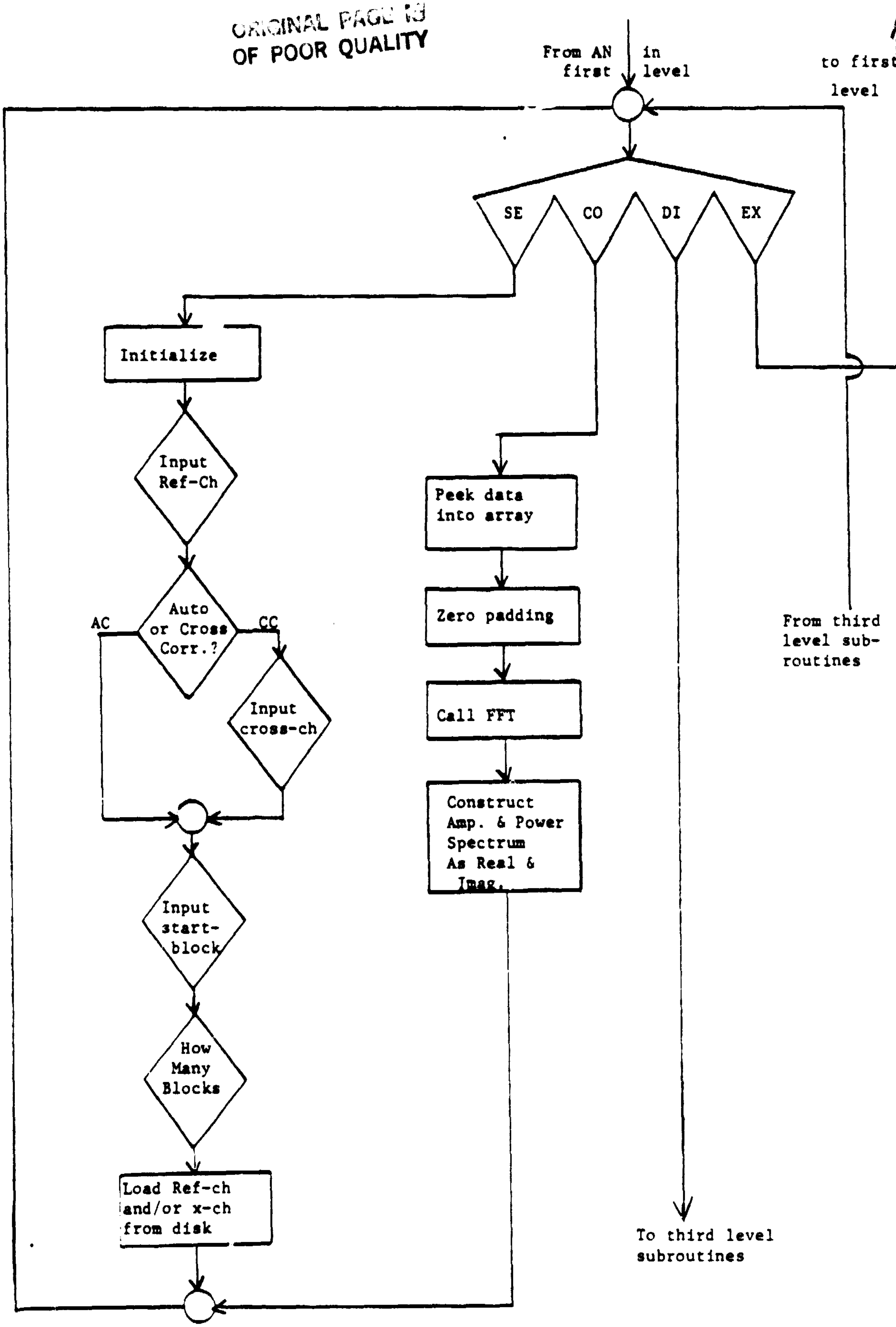
Error Messages:

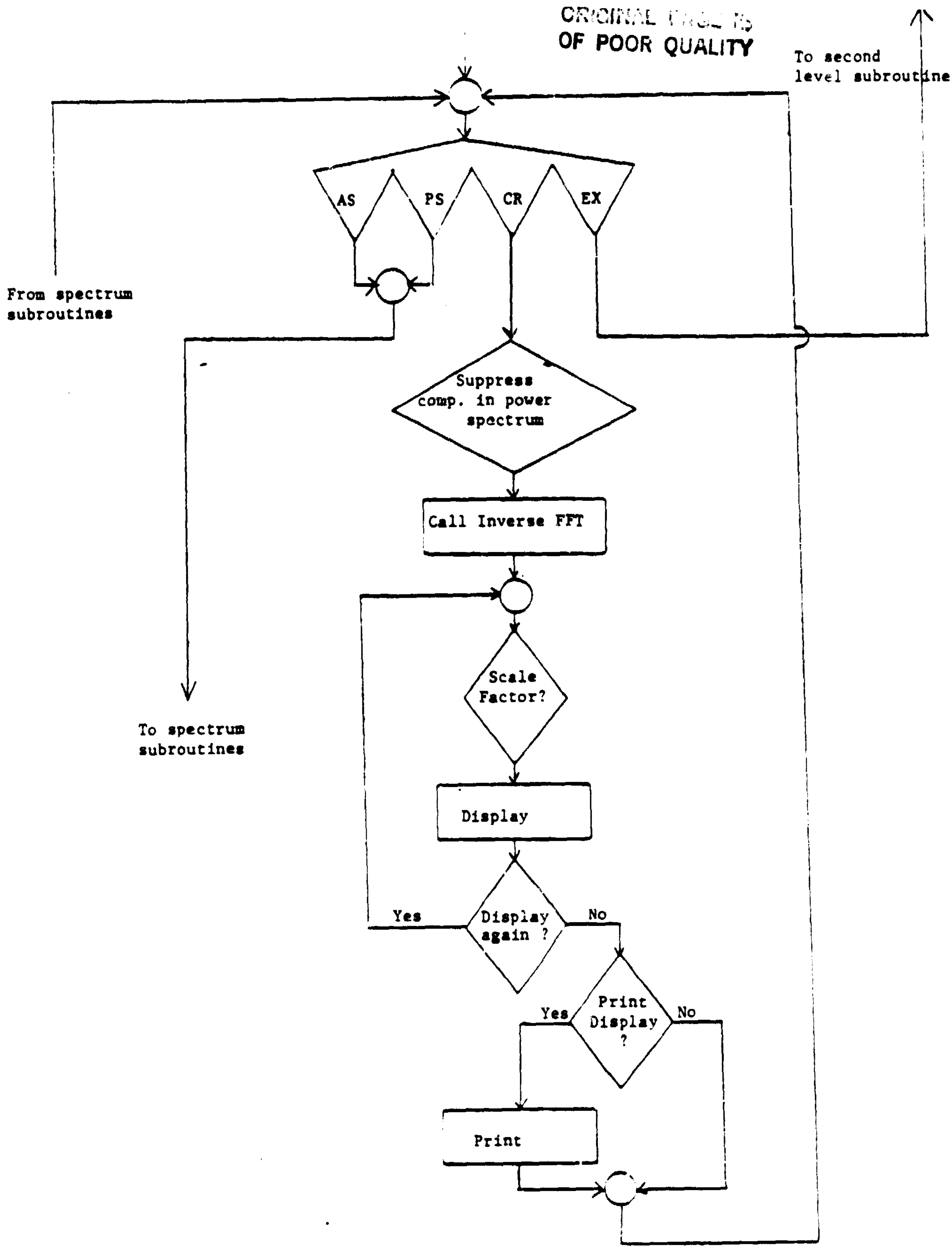
- "ERROR: DISKETTE IS WRITE PROTECTED"
- "ERROR: FILE NOT FOUND"
- "ERROR: DISKETTE VOLUME MISMATCH"
- "ERROR: I/O ERROR"
- "ERROR: DISK IS FULL"
- "ERROR: FILE IS LOCKED"
- "ERROR: BAD FILE NAME"
- "ERROR: UNKNOWN", (if error is not one of the above)

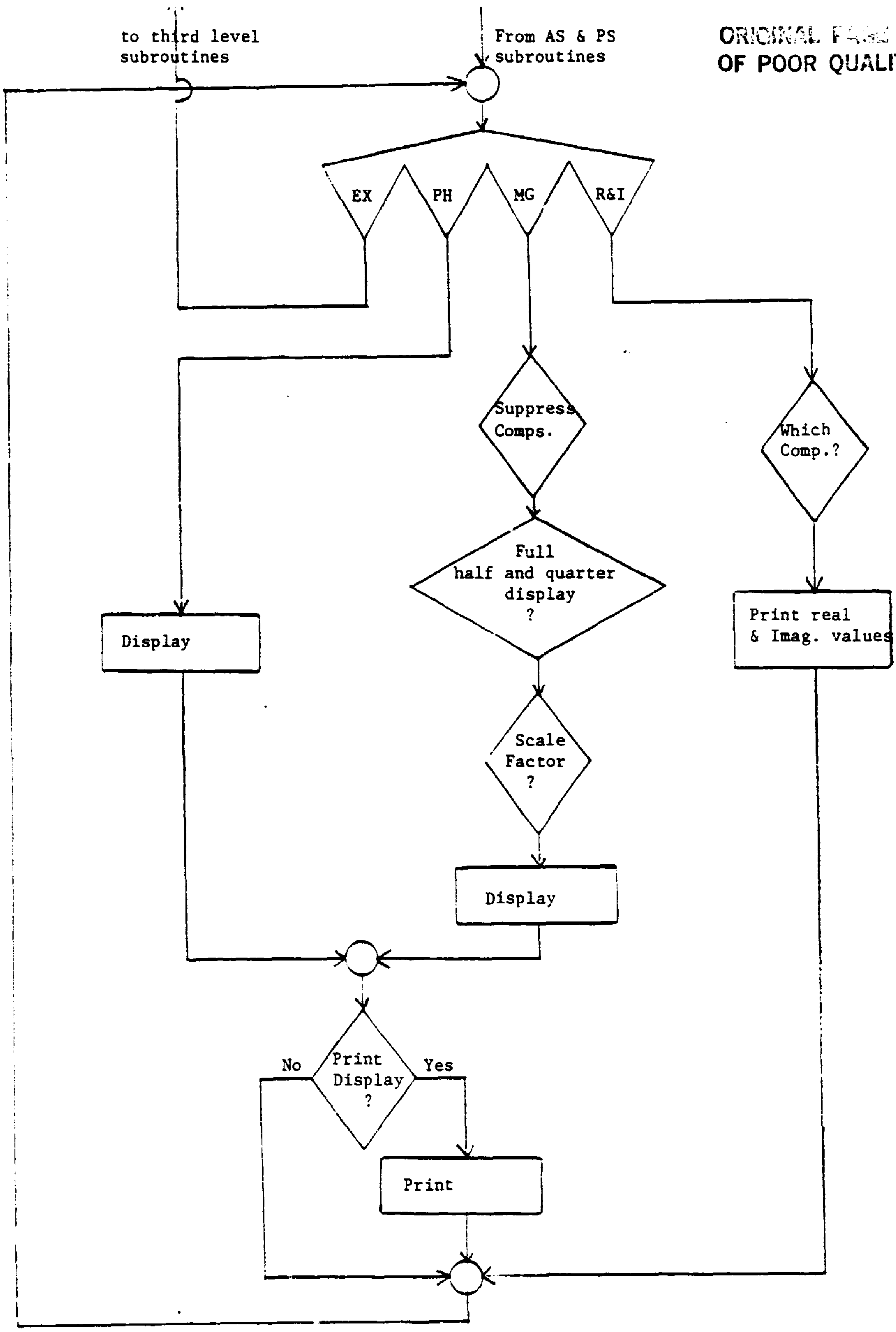
D. Flow Chart

ORIGINAL PAGE IS
OF POOR QUALITY




From AN first
in level
to first level
SE
CO
DI
EX
Initialize
Input Ref-Ch
Auto or Cross Corr.?
AC
CC
Input cross-ch
Input start-block
How Many Blocks
Load Ref-ch and/or x-ch from disk
Peek data into array
Zero padding
Call FFT
Construct Amp. & Power Spectrum As Real & Imag.
From third level sub-routines
To third level subroutines


To second
level subroutines
AS
PS
CR
EX
From spectrum
subroutines
Suppress
comp. in power
spectrum
Call Inverse FFT
Scale
Factor?
To spectrum
subroutines
Display
Yes
Display
again ?
No
Yes
Print
Display
?
No
Print


to third level subroutines
From AS & PS subroutines
EX
PH
MG
R&I
Suppress Comps.
Which Comp.?
Full half and quarter display ?
Display
Print real & Imag. values
Scale Factor ?
Display
Print Display ?
No
Yes
Print

E. Complete Listing


```
]LIST

10  REM
80 D$ = ""
90  ONERR  GOTO 400
100  DIM M(127): DIM P(127)
103  DIM ZR(128): DIM ZI(128)
105  DIM YR(128): DIM YI(128)
107  DIM AR(255): DIM AI(255)
120  PRINT D$"BLOAD ADC.0,A$300,D1"
140  PRINT "TYPE COMMAND SA, PR, AN, CA, EX, FOR:"
150  PRINT "SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT"
160  INPUT A$
170  IF A$ = "SA" THEN  GOSUB 500
180  IF A$ = "PR" THEN  GOSUB 1000
190  IF A$ = "AN" THEN  GOSUB 1500
200  IF A$ = "CA" THEN  TEXT : PRINT D$"CATALOG,D2": GOTO 140
210  IF A$ = "EX" THEN  GOTO 230
220  GOTO 140
230  END
400  REM  DOS ERROR DETECTION
405 DED =  PEEK (222)
410  ON DED GOTO 415,415,415,420,415,425,430,435,440,445,450,415,415,415,4
     15
415  PRINT "ERROR: UNKNOWN": GOTO 140
420  PRINT "ERROR: DISKETTE IS WRITE PROTECTED": GOTO 140
425  PRINT "ERROR: FILE NOT FOUND": GOTO 140
430  PRINT "ERROR: DISKETTE VOLUME MISMATCH": GOTO 140
435  PRINT "ERROR: I/O ERROR": GOTO 140
440  PRINT "ERROR: DISK IS FULL": GOTO 140
445  PRINT "ERROR: FILE IS LOCKED": GOTO 140
450  PRINT "ERROR: BAD FILE NAME": GOTO 140
500  REM   SAMPLE
505  PRINT "INPUT SAMPLING FREQUENCY CONSTANT"
510  INPUT SFD
515  IF SFD < 1 THEN  PRINT "ERROR: CONSTANTCAN NOT BE < 1, INPUT AGAIN": GOTO
     510
520  POKE 797,SFD
530  CALL 768
535  PRINT "TYPE FILE NAME:"
540  INPUT FI$
550 C1$ = FI$ + "-C1"
551 C2$ = FI$ + "-C2"
552 C3$ = FI$ + "-C3"
553 C4$ = FI$ + "-C4"
554 C5$ = FI$ + "-C5"
555 C6$ = FI$ + "-C6"
556 C7$ = FI$ + "-C7"
557 C8$ = FI$ + "-C8"
560  PRINT D$;"BSAVE";C1$;",A$7600,L1024,D2"
570  PRINT D$;"BSAVE";C2$;",A$7A00,L1024,D2"
580  PRINT D$;"BSAVE";C3$;",A$7E00,L1024,D2"
590  PRINT D$;"BSAVE";C4$;",A$8200,L1024,D2"
```

```
600  PRINT D$;"BSAVE";C5$;",A$8600,L1024,D2"
610  PRINT D$;"BSAVE";C6$;",A$8A00,L1024,D2"
620  PRINT D$;"BSAVE";C7$;",A$8E00,L1024,D2"
630  PRINT D$;"BSAVE";C8$;",A$9200,L1024,D2"
640  RETURN
700  PRINT "WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?"
705  INPUT PD$
710  IF PD$ = "Y" THEN  GOSUB 800: RETURN
715  IF PD$ = "N" THEN  RETURN
720  GOTO 700
800  REM  PRINT DSPLY
810  PR# 1
820 L$ = "": REM  CTRL Q
830  PRINT
835  POKE  - 12529,255
840  PRINT
845  POKE  - 12524,0
850  PRINT
855  POKE  - 12528,7
857 TA = T / 4
870  IF K$ = "CR" THEN  GOTO 955
890  IF K$ = "AS" THEN  GOTO 940
900  IF E = 99 THEN  GOTO 925
910  IF F$ = "PH" THEN  GOTO 920
915  PRINT "X-POWER***"RCH$" CROSS "XCH$"***"TA" AVG***SCALE="A: GOTO 970
920  PRINT "X-POWER***"RCH$" CROSS "XCH$"***"TA" AVG": GOTO 970
925  IF F$ = "PH" THEN  GOTO 935
930  PRINT "POWER SPEC.***"RCH$"***"TA" AVG***SCALE="A: GOTO 970
935  PRINT "PHASE OF POWER SPEC***"RCH$"***"TA" AVG": GOTO 970
940  IF F$ = "PH" THEN  GOTO 950
945  PRINT "AMPL. SPEC.***"RCH$"***"TA" AVG***SCALE="A: GOTO 970
950  PRINT "PHASE OF AMPL. SPEC***"RCH$"***"TA" AVG": GOTO 970
955  IF E = 99 THEN  GOTO 965
960  PRINT "X-CORR***"RCH$" CROSS "XCH$"***"TA" AVG***SCALE="U: GOTO 970
965  PRINT "CORR***"RCH$"***"TA" AVG***SCALE="U
970  PRINT
971  PRINT
972  PRINT
973  PRINT L$
974  PR# 0
975  RETURN
1000  REM   PREVIEW
1050  PRINT "DESIRED FILE AND CHANNEL?"
1055  INPUT RCH$
1070  PRINT "DESIRED QUARTER(1-4)?"
1080  INPUT Q
1082  IF Q < 1 OR Q > 4 THEN  PRINT "ERROR: QUARTER RANGE IS 1 TO 4, INPUT
      AGAIN": GOTO 1080
1085  GOSUB 4000
1090  GOSUB 4200
1095 W = 0
1100  GOSUB 1200
1110  PRINT "**** REAL DATA: "RCH$", QR-"Q" ****"
1160  RETURN
1200  REM   DSPLY REAL DATA OR CORR-FN
1220  HGR : HCOLOR= 7
1225  HPLOT 0,0 TO 0,159
1230  FOR Y = 159 TO 0 STEP  - 32
1235  HPLOT 0,Y TO 3,Y: NEXT
1240  IF W = 0 THEN  GOTO 1265
1245  HPLOT 0,79 TO 255,79
1250  FOR X = 0 TO 255 STEP 40
```

```
1255  HPLOT X,79 TO X,76
1260  NEXT X: GOTO 1302
1265  HPLOT 0,159 TO 255,159
1270  FOR X = 0 TO 255 STEP 40
1275  HPLOT X,159 TO X,156
1280  NEXT X
1302  PRINT "SCALING FACTOR?"
1304  INPUT U
1310  FOR X = 0 TO 255
1320 Y = 159 - H - AR(X) * .623 / U
1322  IF Y > 159 THEN  GOTO 1302
1324  IF Y < 0 THEN  GOTO 1302
1330  HPLOT X + 1,Y
1340  NEXT
1350  RETURN
1500  REM   SPECTRUM ANALYSIS
1550  PRINT "TYPE COMMAND SE, CO, DI, EX. FOR:"
1560  PRINT "SET-UP, COMPUTE, DISPLAY, EXIT"
1570  INPUT C$
1580  IF C$ = "SE" THEN  GOSUB 1650
1590  IF C$ = "CO" THEN  GOSUB 2100
1600  IF C$ = "DI" THEN  GOSUB 5000
1610  IF C$ = "EX" THEN  GOTO 1630
1620  GOTO 1550
1630  RETURN
1650  REM   SET-UP
1700  FOR X = 0 TO 128
1710 ZR(X) = 0
1720 ZI(X) = 0
1730 YR(X) = 0
1740 YI(X) = 0
1750  NEXT
1760  PRINT "INPUT REFRENCE CHANNEL"
1770  INPUT RCH$
1780  PRINT "TYPE COMMAND AC, CC, FOR:"
1790  PRINT "AUTO-CORRELATION, CROSS-CORRELATION"
1800  INPUT B$
1810  IF B$ = "AC" THEN E = 99: GOTO 1860
1820  IF B$ = "CC" THEN  GOTO 1840
1830  GOTO 1780
1840  PRINT "INPUT X-CHANNEL"
1850  INPUT XCH$
1860  PRINT "STARTING BLOCK(0-7)?"
1870  INPUT G
1875  IF G < 0 OR G > 7 THEN  PRINT "ERROR:YOUR INPUT RANGE IS 0 TO 7, INP
     UT AGAIN": GOTO 1860
1880  PRINT "HOW MANY BLOCKS(1-8)?"
1890  INPUT H
1892  IF H < 1 OR H > 8 THEN  PRINT "ERROR: YOUR INPUT RANGE IS 1 TO 8, IN
     PUT AGAIN": GOTO 1880
1895 T = 2 * H
1900  IF (G + H) >  = 9 THEN  PRINT "ERROR: DATA RANGE IS EXEEDED!": GOTO
     1860
1910  GOSUB 4000
1920  IF E = 99 THEN  GOTO 1940
1930  GOTO 1960
1940  RETURN
1950  REM   LOAD CROSS CHANNEL
1960  PRINT D$;"BLOAD";XCH$;",A$9200,D2"
1970  GOTO 1940
2100  REM   COMPUTE
2150 P = 256
```

```
2160  IF (G + H) >  = 9 THEN  PRINT "ERROR: DATA RANG IS EXEEDED!": GOTO 1
     550
2170 J = 36352 + (G - 1) * 128
2180  FOR Y = 1 TO H
2190 J = J + 128
2200  FOR I = 0 TO 255
2210 AR(I) =  PEEK (J + I)
2230  NEXT
2240  IF E = 99 THEN K = J: GOTO 2260
2250 K = J + 1024
2260  FOR I = 0 TO 127
2270 AI(I) =  PEEK (K + I)
2280 AI(I + 128) = 0
2285  NEXT
2290 FRD = 1
2300  GOSUB 3000
2302 ZR(0) = ZR(0) + AR(0) * AI(0)
2304 YR(0) = YR(0) + AR(0)
2310  FOR X = 1 TO 128
2320 R = (AR(X)) * (AI(P - X))
2330 S = (AR(P - X)) * (AI(X))
2340 ZR(X) = ZR(X) + (R + S) / 2
2350 R = (AR(P - X)) ^ 2 - (AR(X)) ^ 2
2360 S = (AI(P - X)) ^ 2 - (AI(X)) ^ 2
2370 ZI(X) = ZI(X) - (R + S) / 4
2380 R = AR(P - X) + AR(X)
2390 S = AI(X) - AI(P - X)
2400 YR(X) = YR(X) + R / 2
2410 YI(X) = YI(X) + S / 2
2420  NEXT X
2430  NEXT Y
2435 T = 2 * T
2440 G = G + H
2450  RETURN
3000  REM   FFT ROUTINE
3100 M = 8
3110 N = 2 ^ M
3120 N1 = 0:N2 = N - 1
3130  FOR N3 = 1 TO N2
3140 N4 = N
3150 N4 = N4 / 2
3160  IF N1 + N4 > N2 THEN  GOTO 3150
3170 N1 = N1 -  INT (N1 / N4) * N4 + N4
3180  IF N1 < N3 THEN  GOTO 3250
3190 T1 = AR(N3)
3200 AR(N3) = AR(N1)
3210 AR(N1) = T1
3220 T2 = AI(N3)
3230 AI(N3) = AI(N1)
3240 AI(N1) = T2
3250  NEXT N3
3260  REM   DO THE COMPLEX TRANSFORM
3270 N4 = 1
3280 N6 = 2 * N4
3290  FOR N3 = 0 TO N4 - 1
3300 A = FRD * N3 * 3.1415927 / N4
3310 C =  COS (A)
3320 S =  SIN (A)
3330  FOR N7 = N3 TO N - 1 STEP N6
3340 N8 = N7 + N4
3350 T1 = C * AR(N8) - S * AI(N8)
3360 T2 = C * AI(N8) + S * AR(N8)
```

```
3370 AR(N8) = AR(N7) - T1
3380 AI(N8) = AI(N7) - T2
3390 AR(N7) = AR(N7) + T1
3400 AI(N7) = AI(N7) + T2
3410  NEXT N7
3420  NEXT N3
3430 N4 = N6
3440  IF N4 < N THEN  GOTO 3280
3442  FOR X = 0 TO 255
3444 AR(X) = AR(X) / 32
3446 AI(X) = AI(X) / 32
3448  NEXT X
3450  RETURN
4000  REM   LOAD REF. CHANNEL
4050  PRINT D$;"BLOAD";RCH$;",A$8E00,D2"
4060  RETURN
4200  REM   LOAD REAL ARRAY WITH ONE QUARTER
4245 X = 36352
4250  ON Q GOTO 4260,4270,4280,4290
4260 J = X: GOTO 4300
4270 J = X + 256: GOTO 4300
4280 J = X + 512: GOTO 4300
4290 J = X + 768
4300  FOR I = 0 TO 255
4310 AR(I) =  PEEK (J + I)
4320  NEXT I
4330  RETURN
4745  IF SO$ = "Q" THEN SO = 8: GOTO 5748
5000  REM   DISPLAY
5050  PRINT "TYPE COMMAND PS, AS, CR, EX, FOR:"
5060  PRINT "POWER SPEC, AMPL. SPEC, CORRELATION, EXIT"
5070  INPUT K$
5080  IF K$ = "PS" THEN  GOTO 5155
5090  IF K$ = "AS" THEN  GOTO 5260
5100  IF K$ = "CR" THEN  GOTO 5850
5110  IF K$ = "EX" THEN  GOTO 5140
5120  GOTO 5050
5140  RETURN
5150  REM   POWER SPECTRUM
5155  REM
5160  FOR X = 0 TO 127
5165 M(X) =  SQR ((ZR(X)) ^ 2 + (ZI(X)) ^ 2)
5170  IF  ABS (ZI(X)) < T THEN  GOTO 5180
5175  GOTO 5190
5180  IF ZR(X) <  =  - T THEN P(X) = 3.1415927: GOTO 5230
5185 P(X) = 0: GOTO 5230
5190  IF  ABS (ZR(X)) < T THEN  GOTO 5200
5195  GOTO 5210
5200  IF ZI(X) >  = T THEN P(X) = .5 * 3.1415927: GOTO 5230
5205 P(X) =  - .5 * 3.1415927: GOTO 5230
5210  IF ZR(X) >  = T THEN P(X) =  ATN (ZI(X) / (ZR(X) + .000001)): GOTO 5
     230
5215  IF ZI(X) >  = T THEN P(X) = 3.141592 -  ATN (ZI(X) / ( - ZR(X))): GOTO
     5230
5220 P(X) =  - 3.1415927 -  ATN (ZI(X) / ( - ZR(X)))
5230  NEXT X
5240  GOSUB 5400
5250  GOTO 5050
5260  REM  REF-CH SPECTRUM
5265  REM
5267  FOR X = 0 TO 127
5270 M(X) =  SQR ((YR(X)) ^ 2 + (YI(X)) ^ 2)
```

```
5275  IF  ABS (YI(X)) < T THEN  GOTO 5285
5280  GOTO 5295
5285  IF YR(X) <  =  - T THEN P(X) = 3.1415927: GOTO 5340
5290 P(X) = 0: GOTO 5340
5295  IF  ABS (YR(X)) < T THEN  GOTO 5305
5300  GOTO 5315
5305  IF YI(X) >  = T THEN P(X) = .5 * 3.1415927: GOTO 5340
5310 P(X) =  - .5 * 3.1415927: GOTO 5340
5315  IF YR(X) >  = T THEN P(X) =  ATN (YI(X) / (YR(X) + .000001)): GOTO 5
    340
5320  IF YI(X) >  = T THEN P(X) = 3.1415927 -  ATN (YI(X) / ( - YR(X))): GOTO
    5340
5325 P(X) =  - 3.141592 -  ATN (YI(X) / ( - YR(X))): GOTO 5340
5340  NEXT
5350  GOSUB 5400
5360  GOTO 5050
5400  REM   PHASE & MAGNITUDE DSPLY
5450  PRINT "TYPE COMMAND PH, MG, R&I, EX"
5470  INPUT F$
5480  IF F$ = "PH" THEN  GOTO 5550
5490  IF F$ = "MG" THEN  GOTO 5650
5500  IF F$ = "EX" THEN  GOTO 5520
5505  IF F$ = "R&I" THEN  GOTO 5511
5510  GOTO 5450
5511  PRINT "WHICH SPECTRAL COMPONENT(0-127)?"
5513  INPUT WS
5514  IF WS < 0 OR WS > 127 THEN  PRINT "ERROR: COMPONENT RANGE IS 0 TO 12
    7, INPUT AGAIN": GOTO 5513
5515  IF K$ = "AS" THEN  PRINT "REAL PART: "YR(WS): PRINT "IM. PART: "YI(W
    S)
5517  PRINT "REAL PART: "ZR(WS): PRINT "IM. PART: "ZI(WS)
5519  GOTO 5450
5520  RETURN
5540  REM   PHASE
5550  HGR : HCOLOR= 7
5560  HPLOT 0,0 TO 0,159
5562  FOR Y = 144 TO 0 STEP  - 18
5564  HPLOT 0,Y TO 3,Y
5566  NEXT Y
5568  HPLOT 0,159 TO 272,159
5570  FOR X = 16 TO 272 STEP 8
5572  HPLOT X,159 TO X,156
5574  NEXT X
5575  GOSUB 5815
5576  HPLOT 16,72 TO 272,72
5578  FOR X = 0 TO 255 STEP 2
5579 Y = X / 2
5580 Z = 72 - P(Y) * 22.9
5582  HPLOT X + 16,72 TO X + 16,Z
5584  NEXT X
5612  IF K$ = "AS" THEN  PRINT "****** PHASE PLOT: "RCH$" ******": GOTO 56
    18
5614  IF E = 99 THEN  PRINT "******** POWER SPEC: "RCH$" ********": GOTO 5
    618
5616  PRINT "** X-POWER SPEC: "RCH$", "XCH$" **"
5618  GOSUB 700
5620  GOTO 5450
5640  REM   MAGNITUDE
5650  HGR : HCOLOR= 7
5660  HPLOT 0,0 TO 0,159
5662  FOR Y = 144 TO 0 STEP  - 8
5664  HPLOT 0,Y TO 3,Y
```

```
5666  NEXT Y
5668  HPLOT 0,159 TO 272,159
5670  FOR X = 16 TO 272 STEP 8
5672  HPLOT X,159 TO X,156
5674  NEXT X
5676  HPLOT 16,144 TO 272,144
5678  GOSUB 5815
5680  PRINT "SUPRESS SPECTRAL COMPONENTS(Y/N)?"
5690  INPUT E$
5700  IF E$ = "Y" THEN  GOTO 5722
5710  IF E$ = "N" THEN  GOTO 5741
5720  GOTO 5680
5722  PRINT "WHICH COMPONENT(0-127)?"
5724  INPUT CP
5725  IF CP < 0 OR CP > 127 THEN  PRINT "ERROR: COMPONENT RANGE IS 0 TO 12
     7, INPUT AGAIN": GOTO 5724
5726 M(CP) = 0
5728  GOTO 5680
5741  PRINT "FULL, HALF, OR QUARTER DSPLY(F/H/Q)?"
5742  INPUT SO$
5743  IF SO$ = "F" THEN SO = 2: GOTO 5748
5744  IF SO$ = "H" THEN SO = 4: GOTO 5748
5745  IF SO$ = "Q" THEN SO = 8: GOTO 5748
5746  GOTO 5741
5748  PRINT "SCALING FACTOR?"
5749  INPUT A
5750  FOR X = 0 TO 255 STEP SO
5755 Y = X / SO
5760 Z = 144 - M(Y) / A
5770  IF Z > 144 OR Z < 0 THEN  GOTO 5748
5790  HPLOT X + 16,144 TO X + 16,Z
5800  NEXT
5805  IF E$ = "Y" THEN M(0) = K
5807  IF K$ = "AS" THEN  PRINT "****** MAG. PLOT: "RCH$" ******": GOTO 561
     8
5810  GOTO 5614
5815  FOR Y = 158 TO 156 STEP  - 1
5820  HPLOT 1,Y TO 16,Y: NEXT
5825  FOR X = 1 TO 3
5830  HPLOT X,158 TO X,143
5835  NEXT
5840  RETURN
5850  REM  CORRELATION
5860  PRINT "SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?"
5865  INPUT SC$
5870  IF SC$ = "Y" THEN  GOTO 5880
5875  IF SC$ = "N" THEN  GOTO 5910
5878  GOTO 5860
5880  PRINT "WHICH COMPONENT(1-128)?"
5885  INPUT WC
5887  IF WC < 1 OR WC > 128 THEN  PRINT "ERROR: COMPONENT RANGE IS 1 TO 12
     8, INPUT AGAIN": GOTO 5885
5890 ZR(WC) = 0:ZI(WC) = 0
5895  GOTO 5860
5910 AR(0) = 0:AI(0) = 0
5920  FOR X = 1 TO 128
5930 Y = 256 - X
5940 AR(X) = ZR(X)
5950 AR(Y) = ZR(X)
5960 AI(Y) =  - ZI(X)
5970 AI(X) = ZI(X)
5980  NEXT
```

```
5990 FRD =  - 1
6000  GOSUB 3000
6005 W = 80
6006  GOSUB 1200
6008  IF E = 99 THEN  PRINT "****** AUTO-CORR: "RCH$" ******": GOTO 6012
6010  PRINT "*** X-CORR: "RCH$", "XCH$" ***"
6012  PRINT "DSPLY CORR-FN AGAIN(Y/N)?"
6014  INPUT P$
6016  IF P$ = "Y" THEN  GOTO 6006
6018  IF P$ = "N" THEN  GOTO 6020
6019  GOTO 6012
6020  GOSUB 700
6030  GOTO 5050
```

F. Demonstration Run

This Appendix consists of a listing of an actual run of DAISE printed by the SILENTYPE® printer. The user is urged to read and follow the execution carefully, since it demonstrates vertually all the capabilities of DAISE and the routes leading there as well as the effects of certain decisions taken during the execution. The raw data sampled is a 10 Hz burst sinesoidal signal with half duty cycle. It was picked up by all microphone systems using Globe microphones, hence the file name.

The sampling frequency constant was inputed as 15, implying 128 Hz frequency, that leaves us with the following resolutions:

$$\text{Frequency resolution} = \frac{128}{256} = .5 \text{ Hz}$$

$$\text{Time resolution} = \frac{1}{128} = .0078 \text{ seconds.}$$

<u>Notes</u>

1 DAISE can not print any raw data and what is presented on the next page was printed by a different program for demonstration purposes.

2 Whenever a scaling factor is inputed throughout the run, a HGR plot is displayed on the video screen and the message appearing after the scaling factor is what gets printed on the video screen underneath the display.

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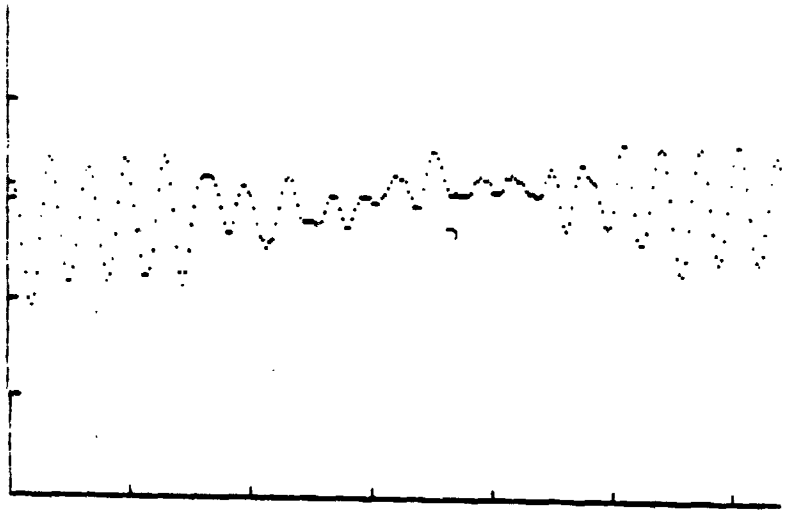
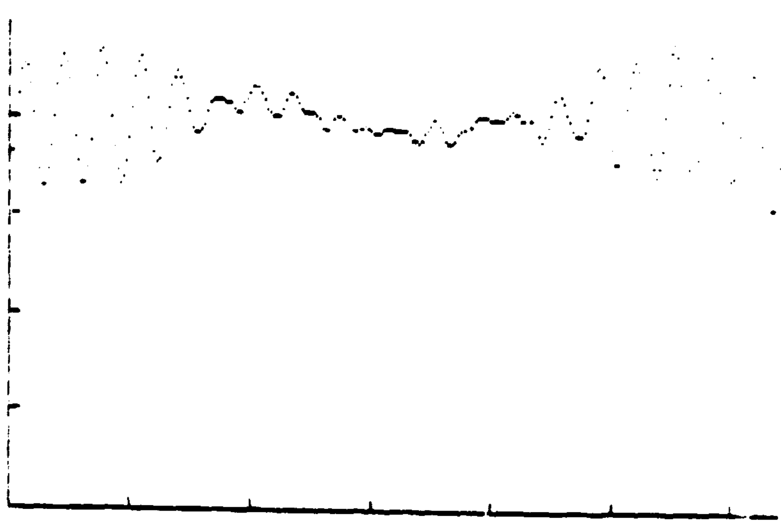
****REAL DATA: GLOB2-C1, QR-1 ****



****REAL DATA: GLOB2-C2, QR-1 ****



```
]EXEC MASTER,D1
]

]BRUN DAISE.OBJ,D1
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?SA
INPUT SAMPLING FREQUENCY CONSTANT
?15
TYPE FILE NAME:
?GLOB2
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?CA


DISK VOLUME 254

 A 002 HELLO
 B 006 GLOB2-C1
 B 006 GLOB2-C2
 B 006 GLOB2-C3
 B 006 GLOB2-C4
 B 006 GLOB2-C5
 B 006 GLOB2-C6
 B 006 GLOB2-C7
 B 006 GLOB2-C8
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?PR
DESIRED FILE AND CHANNEL?
?GLOB2-C1
DESIRED QUARTER(1-4)?
?1
SCALING FACTOR?
?1
**** REAL DATA: GLOB2-C1, QR-1 ****
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?PR
DESIRED FILE AND CHANNEL?
?GLOB2-C2
DESIRED QUARTER(1-4)?
?1
SCALING FACTOR?
?1
**** REAL DATA: GLOB2-C2, QR-1 ****
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?AN
TYPE COMMAND SE, CO, DI, EX, FOR:
SET-UP, COMPUTE, DISPLAY, EXIT
?SE
INPUT REFRENCE CHANNEL
?GLOB2-C1
TYPE COMMAND AC, CC, FOR:
AUTO-CORRELATION, CROSS-CORRELATION
?CC
INPUT X-CHANNEL
?GLOB2-C2
STARTING BLOCK(0-7)?
?0
HOW MANY BLOCKS(1-8)?
```

```
TYPE COMMAND SE, CO, DI, EX, FOR:
SET-UP, COMPUTE, DISPLAY, EXIT
?CO
TYPE COMMAND SE, CO, DI, EX, FOR:
SET-UP, COMPUTE, DISPLAY, EXIT
?DI
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?AS
TYPE COMMAND PH, MG, R&I, EX
?PH
****** PHASE PLOT: GLOB2-C1 ******
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

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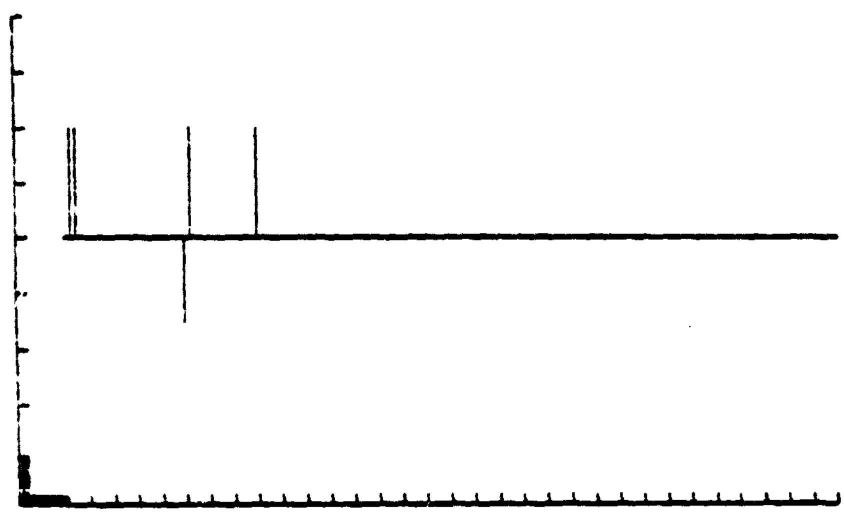
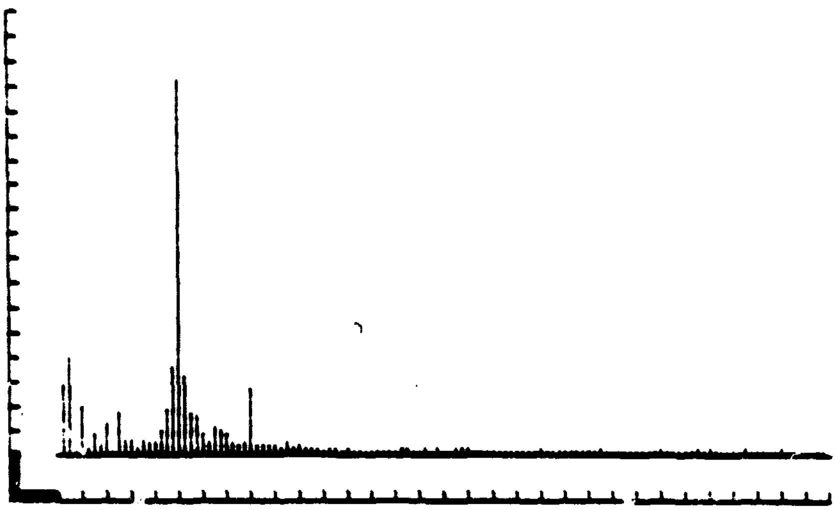
PHASE OF AMPL. SPEC***GLOB2-C1***4 AVG



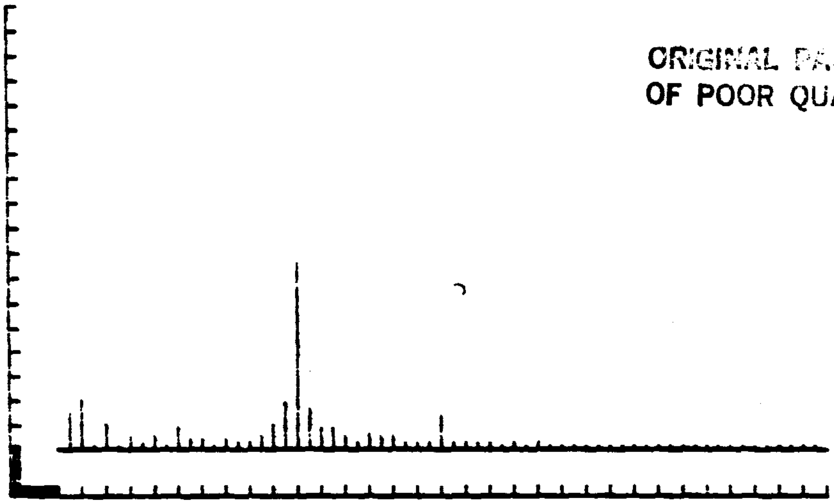
```
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(0-127)?
?0
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?F
SCALING FACTOR?
?1
****** MAG. PLOT: GLOB2-C1 ******
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

AMPL. SPEC.***GLOB2-C1***4 AVG***SCALE=1



```
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?H
SCALING FACTOR?
?.5
SCALING FACTOR?
?2
****** MAG. PLOT: GLOB2-C1 ******
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?N
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?H
SCALING FACTOR?
?2
****** MAG. PLOT: GLOB2-C1 ******
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

AMPL. SPEC.***GLOB2-C1***4 AVG***SCALE=2



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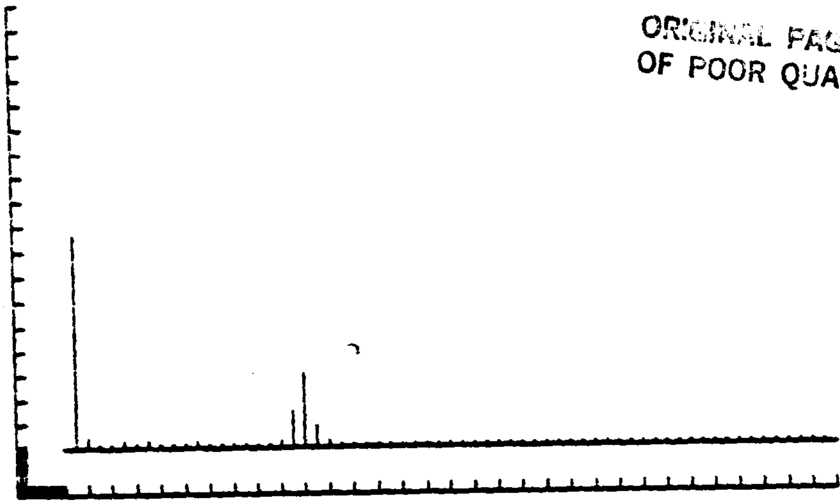
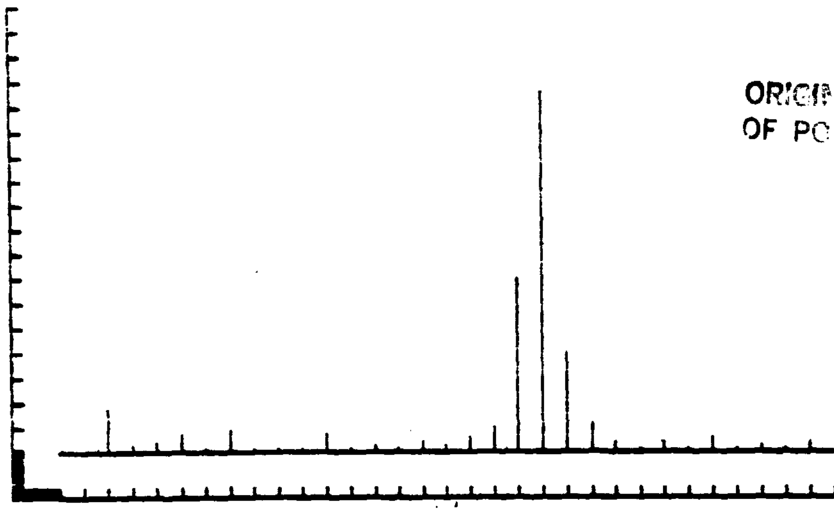
```
TYPE COMMAND PH, MG, R&I, EX
?EX
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?PS
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(0-127)?
?0
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?H
SCALING FACTOR?
?10
SCALING FACTOR?
?100
** X-POWER SPEC: GLOB2-C1, GLOB2-C2 **
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

X-POWER***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=100



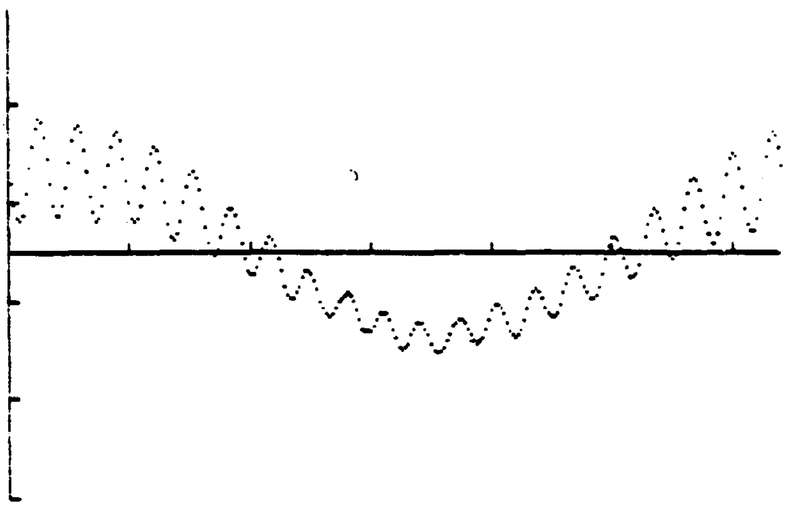

```
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(0-127)?
?1
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?Q
SCALING FACTOR?
?10
SCALING FACTOR?
?20
** X-POWER SPEC: GLOB2-C1, GLOB2-C2 **
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?N
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?Q
SCALING FACTOR?
?20
** X-POWER SPEC: GLOB2-C1, GLOB2-C2 **
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

X-POWER***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=20



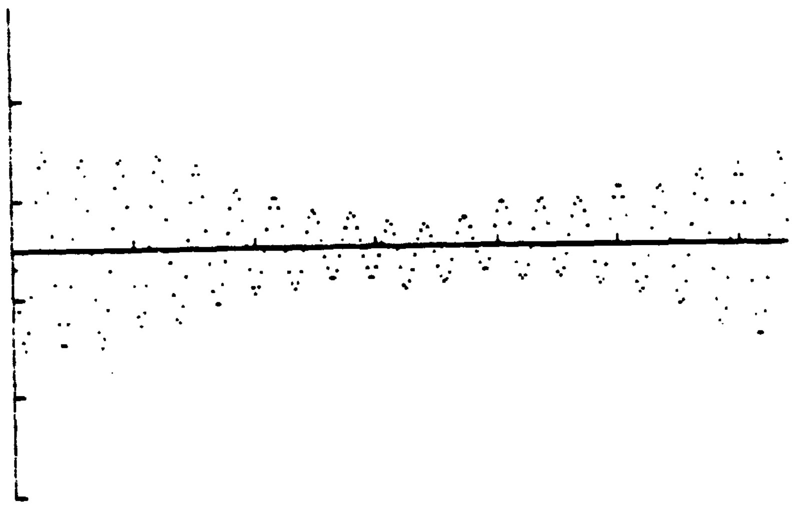

```
TYPE COMMAND PH, MG, R&I, EX
?R&I
WHICH SPECTRAL COMPONENT(0-127)?
?1
REAL PART: 6421.46912
IM. PART: 2501.65725
TYPE COMMAND PH, MG, R&I, EX
?R&I
WHICH SPECTRAL COMPONENT(0-127)?
?20
REAL PART: -1202.40875
IM. PART: -2001.91292
TYPE COMMAND PH, MG, R&I, EX
?EX
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?CR
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?N
SCALING FACTOR?
?1
SCALING FACTOR?
?4
SCALING FACTOR?
?10
*** X-CORR: GLOB2-C1, GLOB2-C2 ***
DSPLY CORR-FN AGAIN(Y/N)?
?Y
SCALING FACTOR?
?10
*** X-CORR: GLOB2-C1, GLOB2-C2 ***
DSPLY CORR-FN AGAIN(Y/N)?
?N
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

X-CORR***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=10



```
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?CR
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?1
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?N
SCALING FACTOR?
?5
*** X-CORR: GLOB2-C1, GLOB2-C2 ***
DSPLY CORR-FN AGAIN(Y/N)?
?N
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

X-CORR***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=5



```
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?CR
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?17
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?18
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?19
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?21
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?22
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(1-128)?
?23
SUPRESS ANY SPECTRAL COMPONENTS(Y/N)?
?N
```

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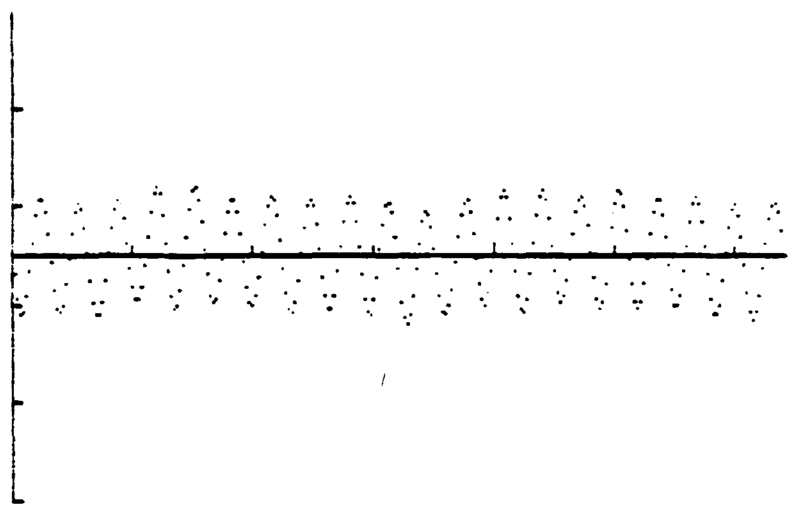
```
SCALING FACTOR?
?5
*** X-CORR: GLOB2-C1, GLOB2-C2 ***
DSPLY CORR-FN AGAIN(Y/N)?
?N
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

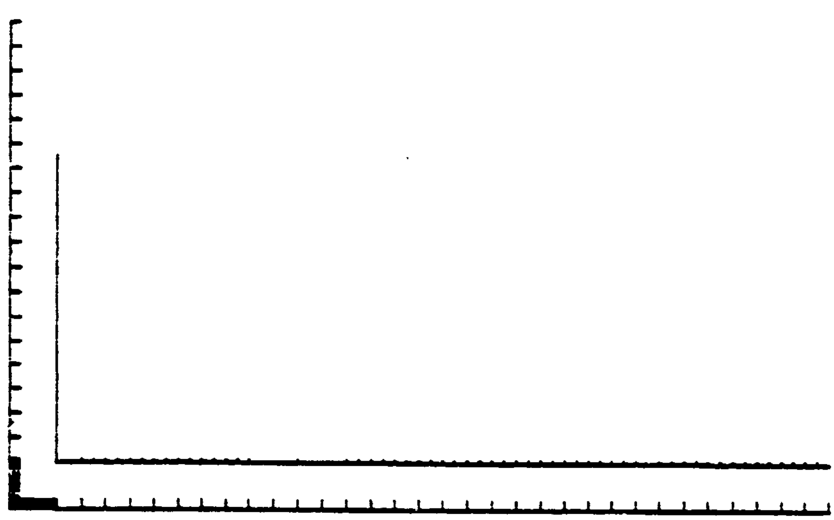
X-CORR***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=5



```
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?PS
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?H
```

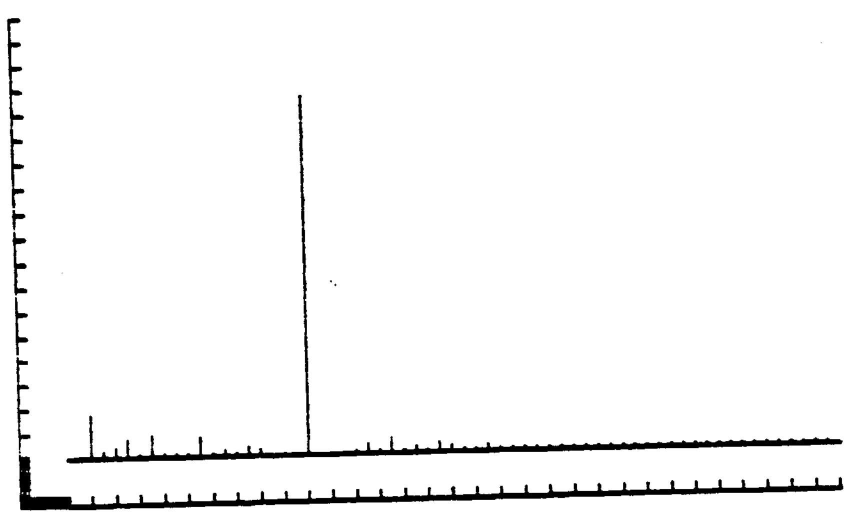
```
SCALING FACTOR?
?20
SCALING FACTOR?
?30
SCALING FACTOR?
?100
SCALING FACTOR?
?1000
SCALING FACTOR?
?4000
SCALING FACTOR?
?10000
** X-POWER SPEC: GLOB2-C1, GLOB2-C2 **
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```

X-POWER***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=10000



```
TYPE COMMAND PH, MG, R&I, EX
?MG
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?Y
WHICH COMPONENT(0-127)?
?0
SUPRESS SPECTRAL COMPONENTS(Y/N)?
?N
FULL, HALF, OR QUARTER DSPLY(F/H/Q)?
?H
SCALING FACTOR?
?20
** X-POWER SPEC: GLOB2-C1, GLOB2-C2 **
WOULD YOU LIKE TO PRINT THE DISPLAY(Y/N)?
?Y
```


X-POWER***GLOB2-C1 CROSS GLOB2-C2***4 AVG***SCALE=20



```
TYPE COMMAND PH, MG, R&I, EX
?EX
TYPE COMMAND PS, AS, CR, EX, FOR:
POWER SPEC, AMPL. SPEC, CORRELATION, EXIT
?EX
TYPE COMMAND SE, CO, DI, EX, FOR:
SET-UP, COMPUTE, DISPLAY, EXIT
?EX
TYPE COMMAND SA, PR, AN, CA, EX, FOR:
SAMPLE,PREVIEW,ANALYSIS,CATALOG,EXIT
?EX
```