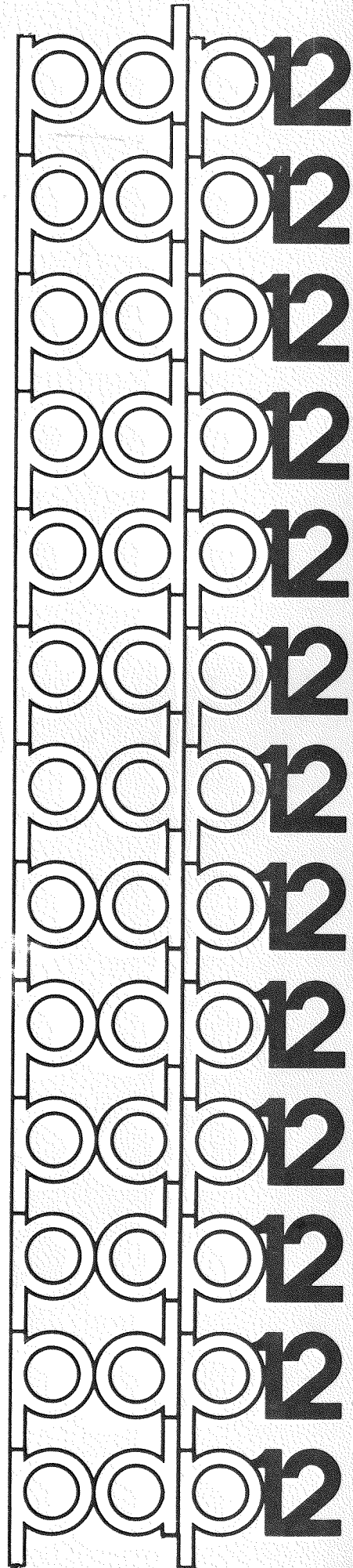
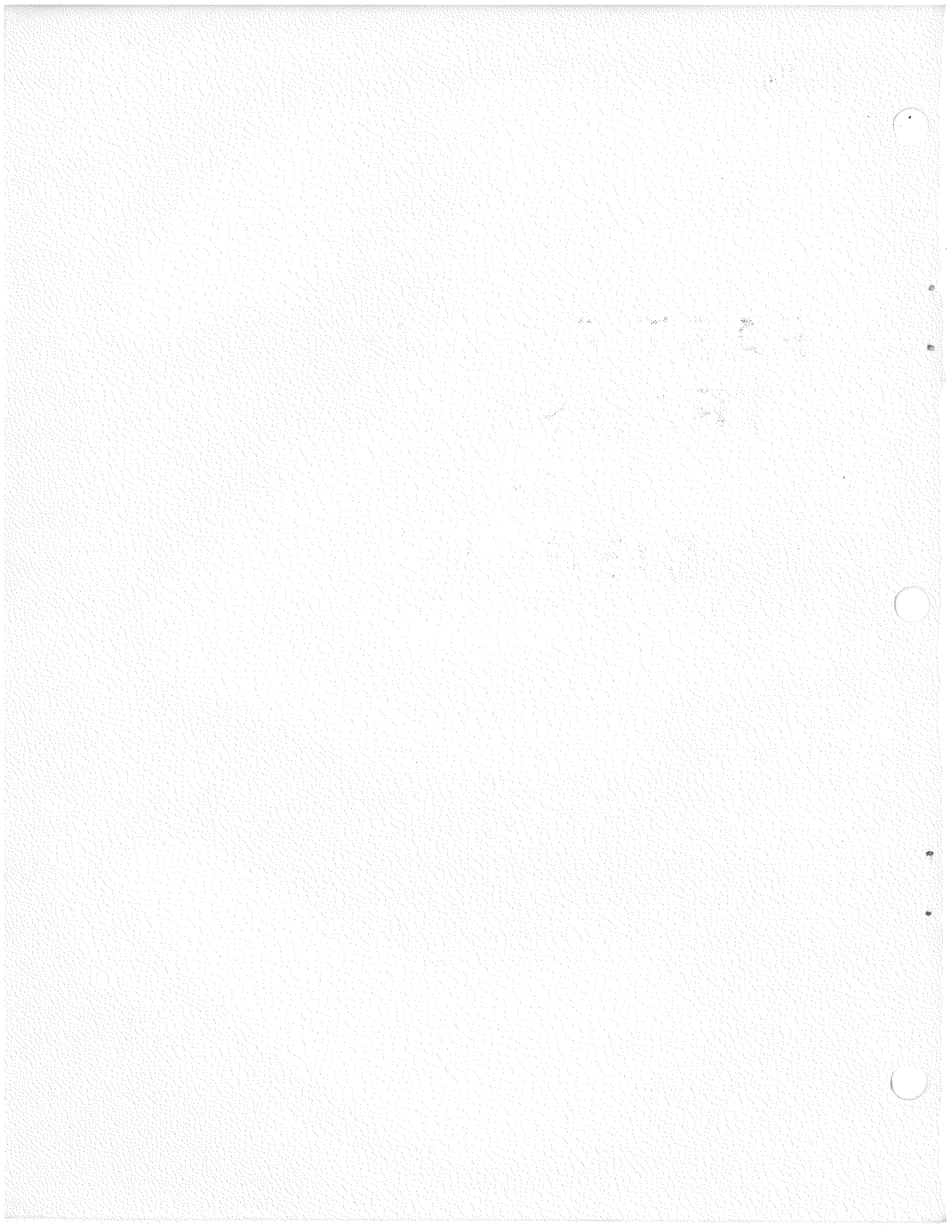


digital

FAST FOURIER TRANSFORM AND DISPLAY





FAST FOURIER TRANSFORM

AND

DISPLAY

PROGRAMMER'S REFERENCE MANUAL

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DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

DEC-12-AMFTA-A-D

1st Printing February, 1971

2nd Printing August, 1972

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ACKNOWLEDGMENT

The PDP-12 Fast Fourier Transform + Display program is an adaptation of a program written by James Rothman, of Digital Equipment Corporation. The algorithm is described briefly in Section 7.0 of this manual and in detail in DECUSCOPE, Volume 7, Number 3, available from DECUS Library, Digital Equipment Corporation, Maynard, Massachusetts.

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1.0 INTRODUCTION

The FFTD (Fast Fourier Transform + Display) program can perform a Fast Fourier Transform or Inverse Fast Fourier Transform on 4 to 1024 real or complex points which have been stored on a LAP6-DIAL¹ or data LINC-tape or disk. The real and imaginary parts of the input or output data and the magnitude of the output data may be displayed on the scope via a moving window. Transformed data may also be stored on a DIAL or data LINCtape or disk. In addition, the scale of the displayed data can be user-modified over twelve different ranges.

2.0 MINIMUM HARDWARE REQUIREMENTS

8K PDP-12B with EAE. !

3.0 OPERATING PROCEDURE

3.1 Loading FFTD

FFTD is a "load and go" program and is called from tape or disk by the DIAL command:

→LO FFTD, n)

where n is the tape (0-7) or disk (10-17) containing the program. A DIAL system tape must be on unit 0. (If a non-existent unit is addressed, NO is displayed on the scope. Press RETURN and issue the proper command.)

At any time during program operation, FFTD may be restarted by pressing the console keys: LINC mode, I/O PRESET, and START 20.

3.2 FFTD Displays

The first display is:

```
DISPLAY 1          SINGLE PRECISION FFT
                   INPUT ON DIAL UNIT? Y/N__
```

¹LAP6-DIAL is hereafter referred to as DIAL.

Type Y if the data file is on a tape or disk containing DIAL; type N if the file is on a data tape or disk. (A file copied from paper tape via PIP must be referenced as a data tape or disk.)

The final user replies to all the scope displays are terminated by pressing LINE FEED.

If the input is on a DIAL tape or disk, the second display is:

```
DISPLAY 2          UNIT NUMBER__  
                   FILE NAME_____
```

Specify the unit number, 0 to 7 for tape, and 10 to 17 for disk, where the file is located and press RETURN. Then type the file name, which may be 1 to 3 characters long and must begin with a non-numeric character and not contain a ?, /, \, or >. After typing the file name, press LINE FEED. Note that a file addressed by name on a DIAL tape or disk can not have a header block and must have been placed on the device only by the FFTD program. If a non-existent unit is requested, NO is displayed. To restart the program from LINctape, press STOP, I/O PRESET, and START 20. The program must be reloaded from an RK8 or RF08 disk.

The user is told if the file is not on the specified unit:

```
DISPLAY 3          CANNOT FIND  
                   HIT RETURN TO CONT
```

Press RETURN to bring back display 2

If the input is on a data tape or disk, the second display is:

```
DISPLAY 4          UNIT NUMBER__  
                   BLOCK NUMBER___
```

The unit may be any number from 0 to 7 for tape and 10 to 17 for disk. The block number must be an octal number from 0 to 777. If a data file with a header block is on a DIAL device, it may be accessed by this sequence (instead of the DIAL message). The correct block number is the value in the DIAL index plus one. After the file has been located, the calculation must be specified.

DISPLAY 5 HOW MANY PTS_____
 (4-1024 BY POWERS OF 2)
 REAL OR
 COMPLEX? R/C_

Powers of 2, from 2 to 10, are acceptable, permitting 4 to 1024 points. Type R if the data is real; type C if it is complex. (Refer to Section 4.0 for a description of data storage format.) If there is not enough room between the starting block number and the end of tape to hold the number of points specified, display 5 will reappear.

The calculation is further specified:

DISPLAY 6 FFT OR DISPLAY? F/D_
 TRANSFORM OR
 INVERSE? T/I_

If the data is just to be displayed, type D and press RETURN. Then type T if the data has most recently been transformed or I if it has not been manipulated at all or has been inversely transformed. Continue at display 7.

The next display is:

DISPLAY 7 OUTPUT ON DIAL UNIT? Y/N_

Type Y if output is to a DIAL tape or disk; type N if output is to a data tape or disk.

A reply of Y to display 7 (DIAL tape or disk) causes the display:

DISPLAY 8 UNIT NUMBER__
 FILE NAME_____

These answers have the same restrictions as the input display, display 2. If there is not enough space on the DIAL tape/disk to hold the output data, the next display is:

DISPLAY 9 NO SPACE
 HIT RETURN TO CONT

Press RETURN to bring back display 7.

If a file already exists with the specified name, the next display is:

DISPLAY 10 REPLACE? Y/N_

Type Y or N to replace or not to replace the file. A reply of N will cause display 8 to reappear. If the file is to be replaced, but the new file is larger than the old file, display 9 will reappear.

If output is to a data tape or disk, the next display is:

DISPLAY 11 UNIT NUMBER __
 BLK NUMBER ___

The answers have the same restrictions as the input display, display 4. If there is not enough space from the starting block number to the end of the tape to hold the output data, display 9 will reappear.

The program will now read in the data, perform a Fast Fourier Transform or Inverse Fast Fourier Transform, and write the results as complex data pairs onto the specified tape or disk.

When the transform is completed or if just displays are desired, the following message is displayed:

DISPLAY 12 WHICH DISPLAY?
 R(EAL)
 I(MAGINARY)
 M(MAGNITUDE)
 S(SCALE FACTOR)
 LINE FEED (RESTART)

Type R, I, M, or S and LINE FEED to obtain the desired display. The scale factor is displayed as a decimal number (\emptyset -12). (Refer to Section 6.0, Data Scaling, for an explanation of the scale factor.) (The magnitude, M, for $a+ib$ is $M = \sqrt{a^2+b^2}$.)

If the display is less than 512 points, it will be stationary and centered on the scope. If it contains 512 or more points, the display can be moved in either direction using A/D knob \emptyset .

A cursor which can be moved by rotating A/D knob 1 will ride along the curve. Associated with the cursor are four octal words displayed in the top left corner of the scope, one beneath the other. The first two words are the absolute 15-bit core address of the cursor point. The third word is the contents of the displayed core address, i.e., the actual 12-bit value in the data buffer of the data word that corresponds

to the cursor point. The fourth word is the scope Y coordinate of the cursor point. The fourth word is a relative value and depends upon the Y scale factor and Y offset. Because the data is scaled to nine bits prior to display, the fourth word or Y coordinate will range from 0001 to 1000, where 0001 corresponds to the bottom of the scope and 1000 to the top.

The curve can be expanded in the Y direction by typing a 1 or decreased by typing Q. Twelve different ranges are possible. As the display is enlarged, no check is made against losing significant digits of large values because the user may wish to expand small features of the display. Therefore, as the display is enlarged, large values may suddenly decrease in size as significant digits are lost.

The magnitude display is shown at half scale initially. If the values allow, the number 1 can be typed once to show the display at full scale.

Pressing RETURN will cause display 12 to reappear. As many displays as desired may be requested. Subsequent displays will be initially shown at the same range as the preceding display. Pressing LINE FEED without entering a character will cause display 1 to reappear.

4.0 EXAMPLE

This section provides examples of the displays which result from a transform performed on a square wave of 512 points and from an inverse transform performed on the resulting coefficients.

4.1 Input Display

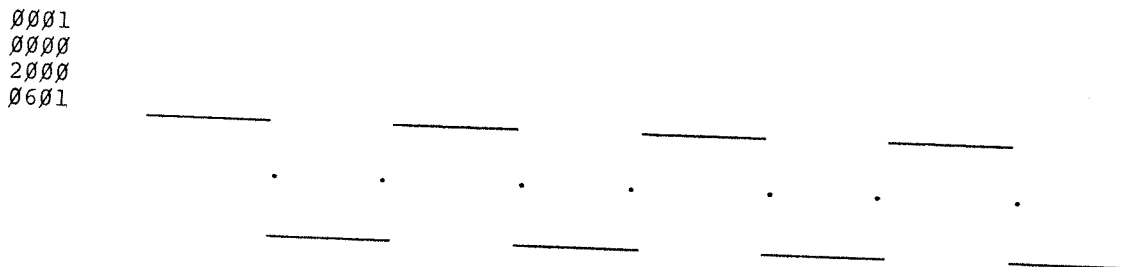
Consider a square wave¹ of 512 real points which has the following format on tape or disk:

Address	Value	
0	2000	} 77 points
77	1000	
100	0000	} 77 points
177	1000	

¹The displays shown on the following pages are adaptations and are for demonstration purposes only.

Address	Value	
277	2000	} 77 points
277	1000	
300	0000	} 77 points
377	1000	
400	2000	} 77 points
477	1000	
500	0000	} 77 points
577	1000	
600	2000	} 77 points
677	1000	
700	0000	} 77 points
777	1000	

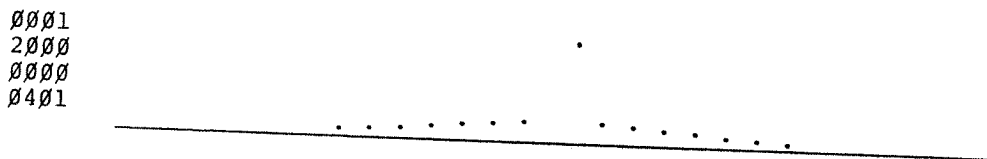
If the input is displayed, there will only be a REAL display. It will look as follows, assuming the cursor is to the extreme left and the display is not moving.



The first two values in the upper left hand corner are the address of the point on which the cursor is resting. When the cursor is at the extreme left, it indicates location 0000 of field 1. The third value is the contents of that memory location, in this case, 2000. The fourth value is the position of the cursor with respect to the bottom of the screen. [1 = bottom, 401 = X axis (middle), 1000 = top.]

4.2 Transform Displays

4.2.1 Real Display

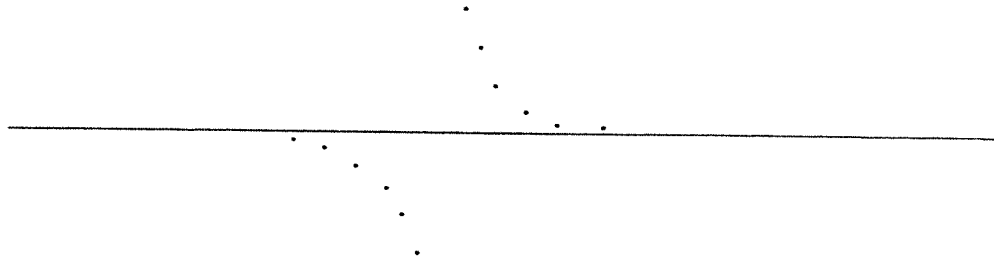


Moving the cursor to the highest point in the display will change the value display to: 0001
2400
2000
0601

This is the DC component of the wave.

4.2.2 Imaginary Display

0001
2000
0000
0401



Moving the cursor to the lowest point produces the values:

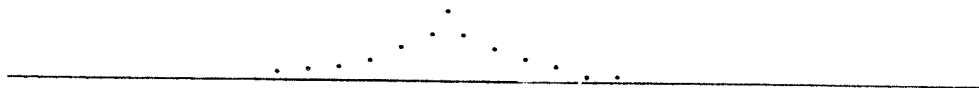
0001
2374
6567
0257

Moving the cursor to the highest point displays:

0001
2404
1214
0522

4.2.3 Magnitude Display

0001
2000
0000
0401



Moving the cursor to the highest point gives the following display:

0001
2400
1000
0501

Because the magnitude of maximum values causes overflow, a factor of 2 is removed during computation. Therefore, the values displayed are half scale; type the key "1" once to display the magnitude at full scale.

4.2.4 Scale Factor Display

The scale factor has a value of 1. To obtain the actual coefficients, rest the cursor on the desired point and shift right the third value of the corner display the number of bits equal to the scale factor. In this example, the highest value of the real display is 2000. Shifting it right by the scale factor (=1) yields 1000, the actual value of the DC component, which in binary is 001 000 000 000. Because the binary point is to the right of the sign bit, the actual value is $+0.01_2$.

4.3 Inverse Transform Displays

The output of the transfer was 512 complex points. The inverse yields the following displays:

4.3.1 Real Display

```

0001
0000
0764
0477
_____
. . . . .
_____

```

The third value, 0764, is a deviation from 1000, the exact value. At this time there are 2 scale factors involved. The relationship between the computed results and the original data is:

$$\text{results} = [(\text{original data}) * 2^{\text{sum of scale factors}}] / \# \text{ of points}$$

Reducing the equation for the first point yields:

$$\begin{aligned}
 1000_8 &= [(2000_8) * 2^8] / 1000_8 \\
 2^9 &= 2^{10} * 2^8 / 2^9 \\
 &= 2^9
 \end{aligned}$$

4.3.2 Imaginary Display

0001
1000
0007
0401

The values are very small and are the result of imprecision in the computations.

4.3.3 Magnitude Display

0001
0000
0372
0440

.

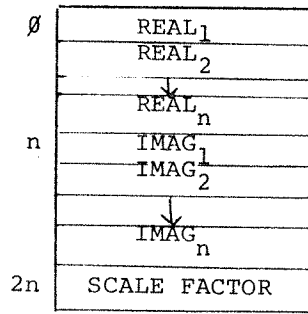
As in the magnitude display of the transform, the values displayed are half scale (displayed scale factor - 1). Because the imaginary components are essentially zero, the magnitude, when doubled, equals the real values.

4.3.4 Scale Factor Display

The scale factor has a value of 7. For the magnitude display, scale factor is 7-1 since display is already half scale.

5.0 DATA STORAGE

The data must be stored sequentially on tape or disk in a binary file starting at the beginning of a block. If the data is complex, the real parts are grouped together followed by the imaginary parts, if any. If there are none, the program will create imaginary parts of value zero. The input and output data are in the form of binary fractions. For output data, the location following the last imaginary part contains the scale factor (refer to Data Scaling, Section 6.0). A file of complex values are stored in the following format:



-only present if file is generated by the FFTD program.

6.0 DATA SCALING

All calculations in FFTD are done with single precision fixed point signed binary fractions. The binary point is located between bit \emptyset and bit 1, leaving an 11 bit signed mantissa. Bit \emptyset is used as a sign bit. Negative numbers are formed by taking the two's complement of the positive binary fraction, so all inputs must be scaled in magnitude to less than one. The outputs are also formatted as above.

In order to preserve precision, it is sometimes necessary to divide by 2 in a computation. As a result, a pseudo floating point format has been adopted in which a variable scale factor (or exponent) is imposed on all the Fourier coefficients. This scale factor or pseudo exponent is found in item SCAL after each transform has been completed. It is also stored after the last imaginary part on tape or disk. The values stored on tape or disk are the Fourier coefficients multiplied by 2^{SCAL} . Because in binary notation shifting a number right one bit is equivalent to dividing by two, to retrieve the coefficients themselves, shift each number right by the number of bits equal to the value of the scale factor. In the case of the inverse transform, the time samples are the values in memory multiplied by $2^{-\text{SCAL}}$. If, however, the inverse transform was performed on normalized transform data, the results are equal to $[(\text{original data}) * 2^n] / \text{no. of points}$ where n equals the sum of both scale factors. To retrieve the time samples, shift left each number by the value of the scale factor.

7.0 SUBROUTINES USED

Manipulation of the DIAL and data LINCtapes and disk is done using the program MILDRED (DEC-12-FZDA). The question and answer displays are handled by QANDA (DEC-12-FISA). The data displays are handled by DISPLAY

(DEC-12-FLSA). A modification of FFTS-C (DECUS #8-144) is used to perform the Fourier Transforms.

8.0 ALGORITHM DESCRIPTION

The Fast Fourier Transformation enables computation of the power spectrum of a time series in a minimum of time. Specifically, it permits the discrete Fourier transformation

$$S_j = \frac{1}{N} \left[\sum_{k=0}^{N-1} x_k e^{-2\pi i j k / N} \right] \quad \begin{matrix} j=0, 1, \dots, N-1 \\ i = \sqrt{-1} \end{matrix}$$

of a series on N equally spaced time samples (where N is a power of 2). The time required is proportional to $N \log_2 N$, whereas previous methods required times proportional to N^2 . This gives a reduction in computation time of $1 - \log_2 N / N$ or over 99 percent for $N=1024$. The algorithm makes use of the fact that

$$W^{k \equiv (k \bmod N)} \quad (\text{where } W = e^{-2\pi i / N})$$

to reduce the number of manipulations necessary for a transformation.

9.0 CORE CHART

Field 0

SEGMENT 0
 PAGE 0 - IFFT
 *400 - FFT
 *1400 - DISPLAY
 SEGMENT 1 - MILDRED
 SEGMENT 2 - MONITOR
 QANDA
 SEGMENT 3 - Data display code
 FDV table
 RWPARM table
 Questions
 Sine Table

Field 1

0 - Buffer - real parts
 2000 - Buffer - imaginary parts

10.0 PROGRAM REGION DESCRIPTION

10.1 Routines

- 0197 IFFT - Take the Inverse Fourier Transformation of the data in field 1. The results are in bit inverted order (refer to the SORTX routine).
- 0400 FFT - Take the Fourier Transformation of the data in field 1. The results are in bit inverted order (refer to the SORTX routine).
- 0701 SORTX - Sort the data from bit inverted order to sequential order. Bit inversion means simply the process of re-ordering the bits in a binary number. For instance, the binary number 001 bit inverted is just 100 (=4). For example, to locate S_5 in memory for a 16 point transformation ($N=16, n=4$), write 5 as a binary number of $n=4$ bits, $5_{10} = 0101_2$. Then reverse the order of these bits to 1010_2 . This means S_5 is stored in position 10. Physically, then, S_5 of the real parts is to be found in location $XRTAB+9$.
- 1000 MULTIP - Perform a rounded single precision signed multiply using EAE. The $CAL+1$ contains the address of the multiplicand. The AC contains the multiplier. Exit with the product in the AC.
- 1040 INVRT - Reverse the bits of the number contained in the AC.
- 1060 TRIGET - Fetch sine and cosine values. Specifically, if the $AC=K$ on entry, the values of $\sin(2\pi K/N)$ and $\cos(2\pi K/N)$ are fetched from an internal trig table. K must be $\geq N/2$. A register COSINE contains the cosine value and the AC contains the sine value on exit.
- ADDR - Perform a single precision add with rounding.

1200 IDORA - This subroutine generates a moving window display with a cursor riding on the curve. For more information refer to the DISPLAY document, DEC-12-FLSA-D.

4026 IFDIAL - Display the question: FROM DIAL UNIT? Y/N_ If the answer is Y, jump to UNTFIL; if N, jump to DATTAP; if neither, redisplay the question.

4044 UNTFIL - Jump to the subroutine ASK2 to display:

UNIT NUMBER__
FILE NAME_____

If the unit number is illegal, jump to ASK2 again to redisplay the question. If legal, jump to LOOKUP with the address of the File Description Vector (hereafter referred to as FDV) parameter list in the AC. If the file cannot be found, display the message:

CANNOT FIND
HIT RETURN TO CONT

When RETURN is hit, jump back to UNTFIL. If the file is found, jump to MOVINP.

4061 DATTAP - Jump to the subroutine ASK3 to display:

UNIT NUMBER__
BLK NUMBER___

If an illegal value is entered, jump back to DATTAP. If all the input is legal, fall through to MOVINP.

4063 MOVINP - Jump to FDV2RW to move the input information from the FDV to the read/write parameter list. Fall through to PTS.

4064 PTS - Display: NUMBER OF PTS_____
(4-1024 BY POWERS OF 2)
REAL OR
COMPLEX? R/C_

Set B1 to the address of the answer buffer, MPLIER to 12 and UPLEGL to -71 (-9) because the number of points is entered as a decimal value. Set the AC to the largest legal value, 20000, and jump to CONV. If the answer is an illegal value jump back to PTS; store the value in N and store its 1's complement in TEMP1. Since the number of points must be an integral power of 2, only one bit in TEMP1 may be set. Bit 11 is the exception to one bit being a power of 2. Check bit 11 first, then rotate the value adding up the number of bits set. If the total is not 1, jump back to PTS. Otherwise fall through to ROT1.

- 4136 ROT1 - Compute the power of 2 by rotating right the value in TEMP1 and stepping B2 until the bit that is set is encountered in bit 11. Fall through to STAMU.
- 4144 STAMU - Store the power of 2 in NU. If the power is less than 2, jump back to PTS. Otherwise load the AC with the number of points*2 and jump to NUMBKS to compute the number of blocks needed to hold the output. Store the value in FDV+7. Store it also in RWPARM+3 since, for complex data, the input and output data consist of the same number of blocks. If the answer to the second question is not R, jump to IFCOM. If it is R, the input consists of half as many words as the output. Load the AC with the value of N and jump to NUMBKS to compute the number of input blocks. Store the value in RWPARM+3. Set REALFG and jump to CKEND.
- 4023 IFCOM - If the answer is C, clear REALFG and fall through to CKEND. Otherwise jump back to PTS to redisplay the question.
- 4211 CKEND - If there is not enough room between the starting block number and the end of tape to hold the number of points specified, jump back to PTS. If

the number of output words is 4000 or greater, another block will be needed to hold the scale factor. Increment FDV+7. Fall through to IFFFT.

4231 IFFFT - Display: FFT OR DISPLAY? F/D_
TRANSFORM OR
INVERSE? T/I_

If the answer to the first question is D, set DISFLG to indicate that the data will only be displayed. If F, clear DISFLG to indicate that a Transform or Inverse Transform will be performed. If the answer to the second question is T, clear FTFLG; if I, set it. If DISFLG is set, jump to DISPLY to display the data. Otherwise, jump to OUTQES.

4273 OUTQES - Display the question: OUTPUT ON DIAL UNIT? Y/N_
If the answer is Y jump to OUTUNT; if N jump to ONDAT; otherwise redisplay the question.

4310 OUTUNT - Jump to the subroutine ASK2 to display:

UNIT NUMBER__
FILE NAME_____

If an illegal value is input, redisplay the question. Otherwise jump to ENTER with the address of the parameter list in the AC. If a file with the specified name already exists, jump to SAMNAM. If there is not enough space to hold the output data, jump to NOSPACE. If it is a new file and there is enough space to hold it, fall through to RDDATA.

4320 RDDATA - Clear 4000 words of field 1 and read in the input data. If REALFG is 0, the data is complex - move the imaginary parts to start at location 2000. If it is non-zero, the data is real and nothing need be done. Jump to PROC.

4357 PROC - If IFTFLG is 0, jump to FT to do a Transform. Otherwise, fall through to do an Inverse Transform.

- 4363 IFT - Jump to the subroutine IFFT to do an Inverse Transform on the input data. Then jump to the subroutine SORTX to sort the coefficients into sequential order from bit inverted order. Jump to STSCAL to store the scale factor which is equal to NU-SCAL. The data should be shifted by this value.
- 4365 FT - Jump to the subroutine FFT to transform the input data. Then jump to the subroutine SORTX to sort the coefficients into sequential order from bit inverted order. The scale factor is the value in SCAL and equals the number of bits by which the data should be shifted right. Fall through to STSCAL.
- 4367 STSCAL - Store the scale factor in the word following the last imaginary part. Move the imaginary parts from 2000 to immediately behind the real parts.
- 4377 NOWSTR - Jump to the subroutine FDV2RW to move the output parameters from the FDV to the read/write parameter list. Write the data onto the output tape and jump to DISPLY.
- 4423 NOSPAC - Jump to the subroutine ASK to display the message:

NO SPACE
HIT RETURN TO CONT

When RETURN is hit, jump to OUTQES.

- 4430 SAMNAM - Jump to the subroutine ASK to display:

ALREADY EXISTS
REPLACE? Y/N_

If the answer is Y, jump to REPL; if it is N, jump to OUTUNT. If it is neither, redisplay the question.

4446 REPL - Try to replace the existing file with the new file. If the new file is longer, jump to NOSPACE. If the replacement is successful, jump to RDDATA.

4452 ONDAT - Jump to the subroutine ASK3 to display:

UNIT NUMBER__
BLK NUMBER___

If an illegal value is entered, redisplay the question. If there is not enough space between the specified block number and the end of tape to hold the output data, jump to NOSPACE. Otherwise, jump to RDDATA.

10.2 Subroutines

4466 FDV2RW - Transfer the unit number, starting block number, and number of blocks from the FDV parameter list to the READ/WRITE parameter list.

4503 NUMBKS - Enter with the number of words in the AC. Convert this value to blocks by counting the number of times 400 can be subtracted from it before the value becomes negative. Return with the number of blocks in the AC.

4523 ASK2 - Jump to OCTL to set MPLIER to 10 and UPLEGL to -67(-7) because the unit number is input as an octal number.

Display: UNIT NUMBER__
FILE NAME_____

by jumping to the subroutine ASK with the address of QUES2 in the AC. Set B1 to the address of the answer buffer and jump to the subroutine CONV with the largest legal unit number, 17, in the AC. If the value is illegal, return to CALL+1. If legal, store it and the file name in the FDV parameter list. Fill the file name out to 8 characters with 77's. Return to CALL+2.

4572 ASK3 - Display: UNIT NUMBER __
BLK NUMBER _____

by jumping to the subroutine ASK with the address of QUES3 in the AC. Set B1 to the address of the answer buffer and jump to OCTL to set MPLIER to 10 and UPLEGL to -67(7) because the unit and block numbers are input in octal. Jump to subroutine CONV with the largest legal unit number, 17, in the AC. If the value is illegal, return to CALL+1. Otherwise, store it in word 0 of the FDV parameter list. B1 is now pointing to the block number. Jump to CONV with the largest legal block number, 777, in the AC. If the value is illegal, return to CALL+1. If legal, store it in word 6 of the FDV parameter list. Return to CALL+2.

4627 CONV - CONV is entered with the largest legal value in the AC and B1 pointing to the address - (1 half word) of the first character to be converted. Store the 1's complement of the largest legal value in TEMP2 and clear TEMP1. UPLEGL contains a -71(-9) or -67(-7) and MPLIER contains a 10 or 12 depending on whether the number to be converted is in decimal or octal. Extract a character and compare it against an ASCII 0 and the contents of UPLEGL. If it is a legal value, jump to MULPLY which will multiply the value in TEMP1 by the contents of MPLIER and add the digit being converted to it. Repeat the procedure until a character is found which is not between 0 and UPLEGL. If it is not a 34, 74, or 0, it is an illegal character: return to CALL+1. A 34 or 74 indicates the end of the input field; a 0 indicates the end of the input. Compare the converted value in TEMP1 against the maximum legal value in TEMP2. If the value is legal return to CALL+2; otherwise return to CALL+1.

4711 OCTL - OCTL sets MPLIER to 10 and UPLEGL to -67(-7) so that CONV will convert an octal number.

- 4720 ASK - ASK is entered with the address of the display in the AC. Store it in the parameter list and jump to QAINIT to display the message. Refresh the display until the answer is input. Return to the calling routine.
- 6001 DISPLY - This region is entered either after the Transform or Inverse Transform is completed or in response to a D in answer to the display: FFT OR DISPLAY? F/D_. Since the data is manipulated in preparation for each display it must be read in before each display. After reading in the data, display:
- WHICH DISPLAY?
R(EAL)
I(MAGINARY)
M(MAGNITUDE)
S(CALE FACTOR)
LINE FEED (RESTART)
- If the answer buffer contained \emptyset , just LINE FEED was hit: jump to IFDIAL to restart the program. Otherwise jump to WCHDIS.
- 6035 WCHDIS - Jump to DPIMAG, DPMAG, DPREAL, or DPSCAL if the answer was I, M, R, or S, respectively. Otherwise redisplay the question.
- 6055 DPIMAG - If REALFG is non-zero, the input is real and no Transform was performed. Therefore, there are no imaginary parts to display; redisplay the question. If REALFG is zero, check IFTFLG. If it equals zero, either an Inverse Transform was performed or the original data is just being displayed. In either case the data is in the right order. If IFTFLG is non-zero, a transform was performed. The positive half of the curve is first followed by the negative half and the signs are reversed. Swap the halves and reverse signs before jumping to PREPAR.
- 6117 DPREAL - Check IFTFLG for the same reason as in DPIMAG. The only difference is that the signs of the real parts are not reversed.

- 6130 PREPAR - If less than 1000 points are to be displayed, the display will not move and the points displayed will be centered on the scope. To achieve this, LEFTX is set to the 1's complement of $-1000 + (1000 - \# \text{ of points}) / 2$, MINPTS to the 2's complement of the number of points, and MVDIS to the instruction CLR. Jump to SHOWIT.
- 6147 GQ1000 - If 1000 or more points are to be displayed, the display will fill the scope and will move. To achieve this, LEFTX is set to the 1's complement of 1000, MINPTS to the 2's complement of 1000 and MVDIS to the instruction SCR 4. Fall through to SHOWIT.
- 6162 SHOWIT - Jump to the subroutine IDORA to display the data. The six parameters following the call to IDORA are in order: the memory field of the lower address, the lower address, the memory field of the higher address, the higher address, the Y offset of the display and the scale factor of the data. Both fields are always 1, the lower address is always 0. The higher address is set in the region DISPLY. The Y offset is always 0; therefore the baseline is half way up the scope. The scale factor is the instruction SCR plus the number of bits to scale the data right before displaying it. Since IDORA displays only the right nine bits, if the left three bits are significant, the data must be scaled right three before displaying it.
- 6171 RFRSH - Jump to RDORA to refresh repeatedly the display until a key on the teletype is hit. If the RETURN is hit, jump to REDPLY which jumps to DISPLY to redisplay the question: WHICH DISPLAY? If a 1 is entered, jump to LARGER to blow up the display. If a Q is hit, jump to SMALLR to decrease its size. If anything else is entered, ignore it.
- 6211 SMALLR - If the instruction at SIZE contains a shift of 11 bits, a bigger shift would be meaningless. Jump back to RFRSH. Otherwise, increment the value of the shift and jump to SHOWIT.

- 6216 LARGER - If the instruction at SIZE contains a shift of 0 bits, jump back to RFRSH. Otherwise decrement the value of the shift and jump to SHOWIT.
- 6226 DPSCAL - If REALFG is non-zero, only real parts are present, meaning this program did not create the file and therefore there is no scale factor. Return to DISPLY to redisplay the question. If REALFG is 0, the scale factor is stored after the last imaginary part. Convert it to ASCII decimal and display it.
- 6270 DPMAG - If REALFG is non-zero, the input data is real and no transform was performed; therefore the magnitude is the same as the real points. Redisplay the question: WHICH DISPLAY? Otherwise move the imaginary parts to location 20000. Set RELPTR and IMGPTR, which contain the effective address of the multipliers, to 60000 since the data begins at location 0 of their respective segments and is fractional. Fall through to NXTMAG.
- 6320 NXTMAG - Square a real part and store it. Square the imaginary part, add the square of the real part to it, jump to the subroutine SQRT to get the square root of the sum and store it in place of the real part. Repeat the process for each point. Then jump to SHOWIT to display the magnitude.
- 7116 MOVPTS - The subroutine MOVPTS moves values from one buffer (address -1 in l0) in field 1 to another (address -1 in l1). If CMPFLG equals 1, the values are complemented as they are moved. TEMPR contains the 2's complement of the number of values to move.
- 7132 MVRLMG - The subroutine MVRLMG is used to swap the first and second halves of the real or magnitude values. In the process they are moved from the buffer starting at location 0 to the one starting at 20000.
- 6375 FDV - The File Descriptor Vector parameter list is used by the LOOKUP, ENTER, and REPLACE sections of MILDRED. Word 0 contains the unit number, words 1-4 contain

the file name, word 5 contains a 2 indicating the file is binary, word 6 is the starting block number, and word 7 is the number of blocks. Word 6 is filled by LOOKUP, ENTER and REPLACE. Word 7 is filled by LOOKUP but must be supplied for ENTER and REPLACE.

6405 RWPARM - The Read/Write parameter list is used by the READ and WRITE sections of MILDRED. Bits 0-2 of word 0 contain the field, bits 9-11 contain the unit. Word 0 contains the starting address, word 1 the starting tape block number and word 2 the number of blocks.

7052 SQRT - The subroutine SQRT is entered with a value in the double precision location DPSQ. It returns with the square root in the AC.

10.3 Symbols

N	Number of words in computation
NU	Power of 2 of value of N
L	Index to show what array is being constructed
S	Gives spacing between node pairs in the Lth array
NOVER4	Storage for N/4
MAXNU	Power of 2 of largest table size (13)
MNOVR2	Storage for N/2
QR	Pointer to real part of X(Q)
QI	Pointer to imaginary part of X(Q)
PR	Pointer to real part of X(P)
PI	Pointer to imaginary part of X(P)
Q	Numerical index Q ($=0, 1, \dots, N-1$)
P	Numerical index P ($=0, \dots, N-1$)
K	Number in the node being operated on
C	Interrupts computation of Lth array every S passes
ADD2	Used by subroutine ADDR as data (addend) Used by monitor as a temporary location
TEMPR	Temporary storage register for real parts Used by monitor as a temporary location
SINE	Temporary storage for $\sin(S*PI*K/N)$ Used by monitor as a temporary location
COSINE	Temporary storage for $\cos(2*PI*K/N)$ Used by monitor as a temporary location
GR	Real part of product ($W^k*X(P)$) - temporary storage Used by monitor as a temporary location
GI	Imaginary part of product ($W^k*X(P)$) - temporary storage
SCAL	Pseudo exponent of Fourier coefficients
SHFLAG	If =1, add with shift; if =0, add without shift
SHFCHK	Indicates if all X's in an iteration are $<.5$
DISFLG	If $\neq 0$, the data will just be displayed
IFTFLG	If $\neq 0$, an Inverse Transform was performed
REALFG	If $\neq 0$, the data does not contain imaginary parts
DPSQ	Used to save the double precision squares of the real and imaginary parts during calculation of the magnitude.
CMPFLG	If =1, the subroutine MOVPTS will complement the values as it moves them

10.4 Beta Registers

Beta registers 1, 2, and 3 are used by the monitor in ASK2 and ASK3 as temporary pointers and counters. QANDA and MILDRED make more extensive use of the Beta registers.

11.0 ASSEMBLY INSTRUCTIONS

The FFTD program is assembled in three sections by assembling and saving each, then adding them together. The entire command sequence is:

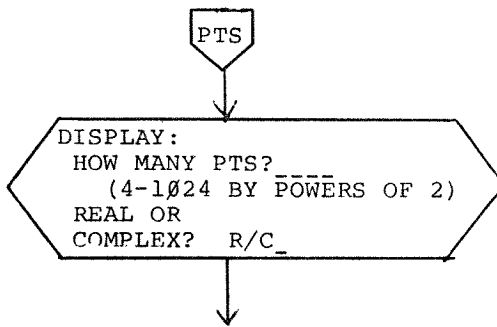
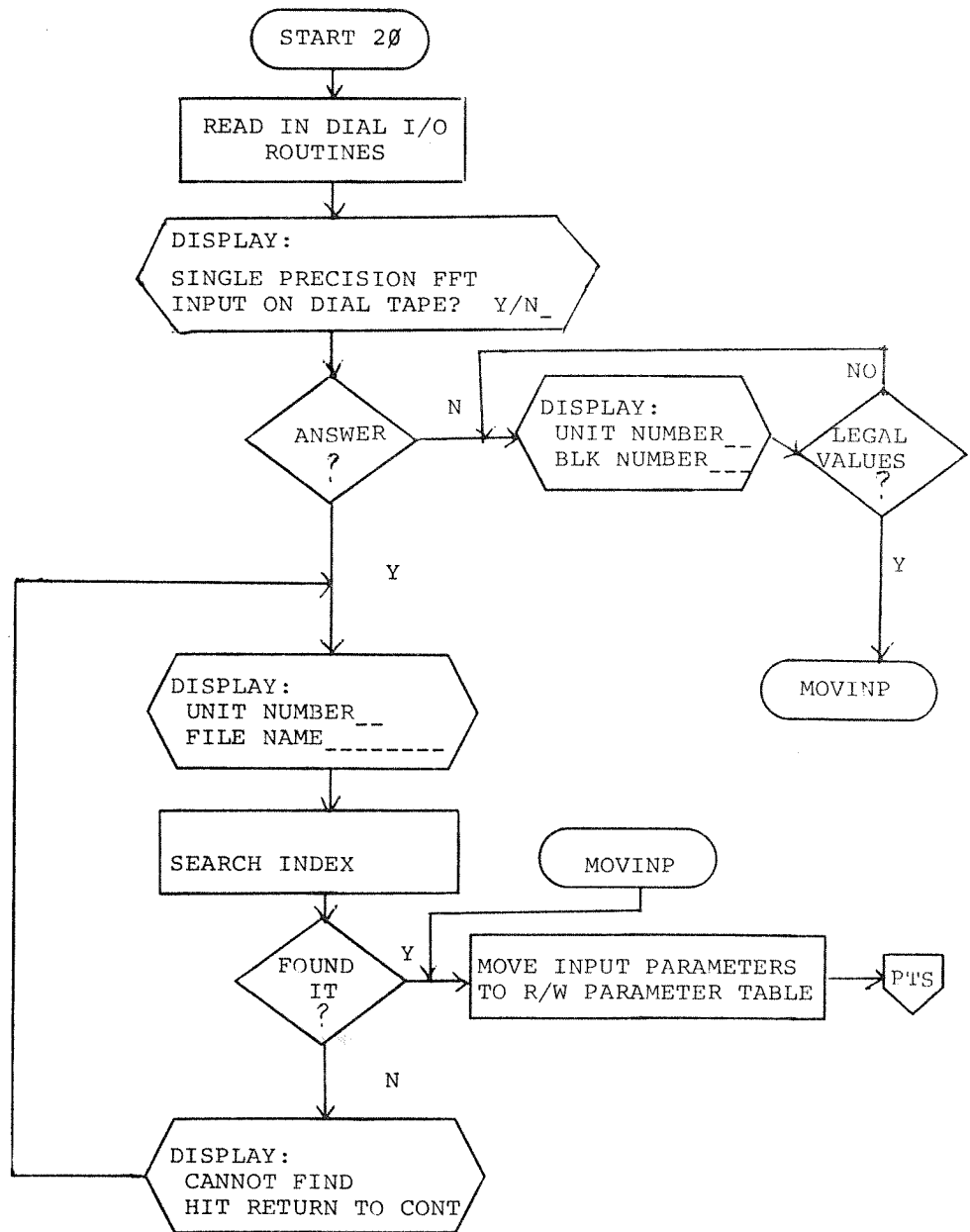
+AS MILQAN,n)	where n is the unit
+SB MILQAN,n)	containing the program
+AS SIN256,n)	
+SB SIN256,n)	
+AS FFTC-1)	(FFTC-1 chains to FFTC-2)
+SB FFTC-1)	
+ZE)	
+AB MILQAN,n)	
+AB SIN256,n)	
+AB FFTC-1,n)	
+SB FFTD,n,L)	(saves the whole program)

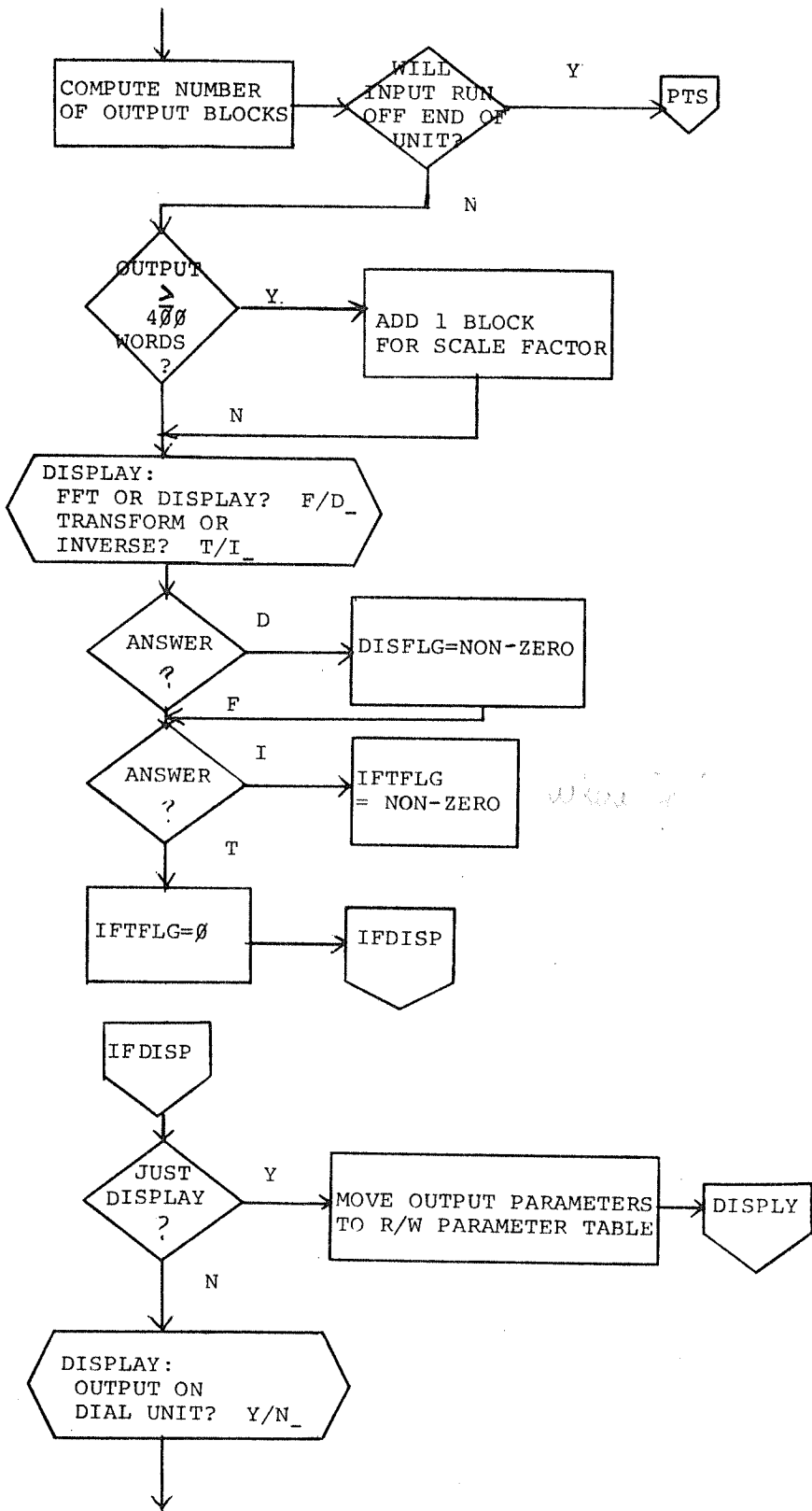
12.0 SYSTEM FLOWCHARTS

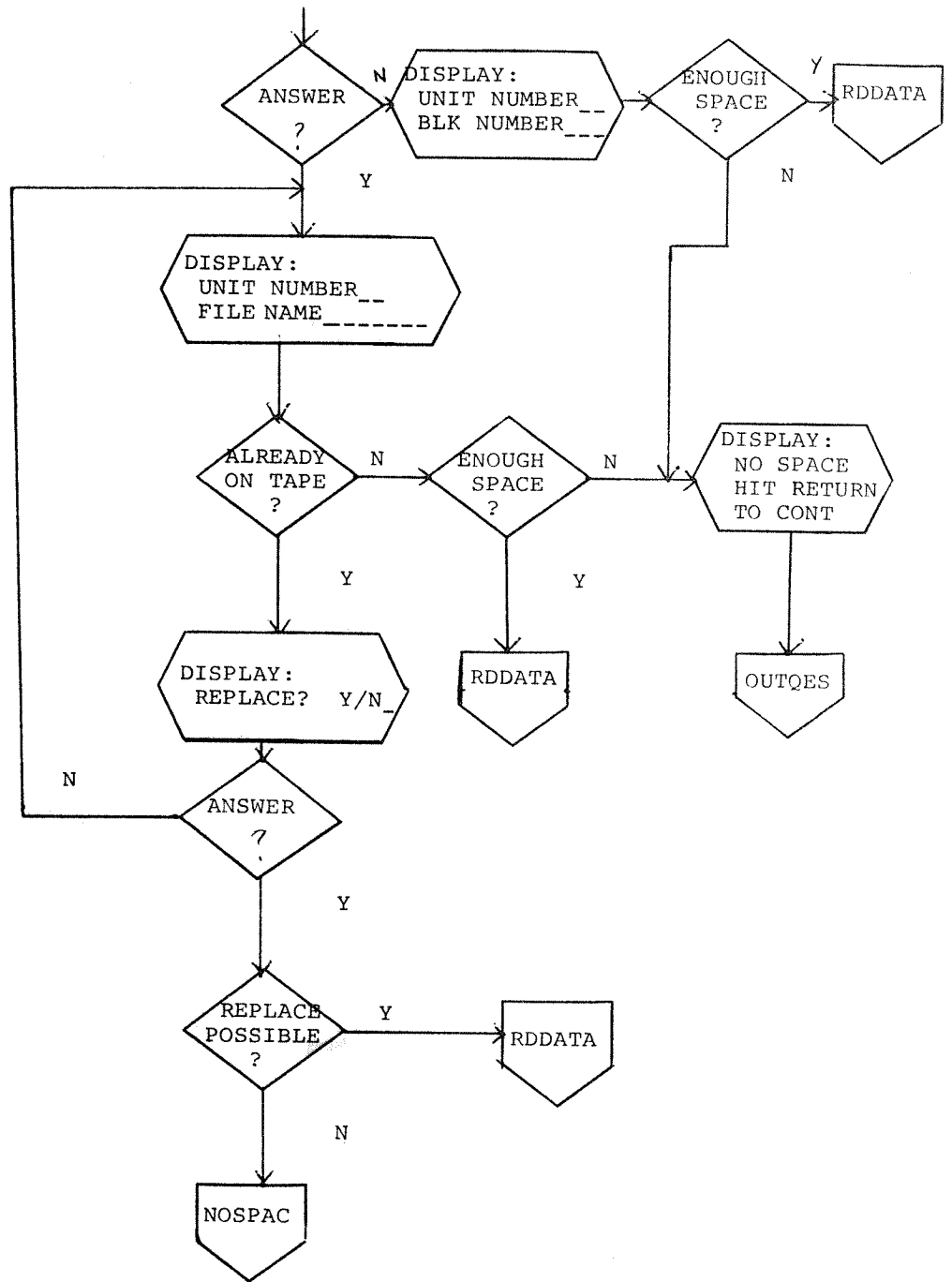
(Attached)

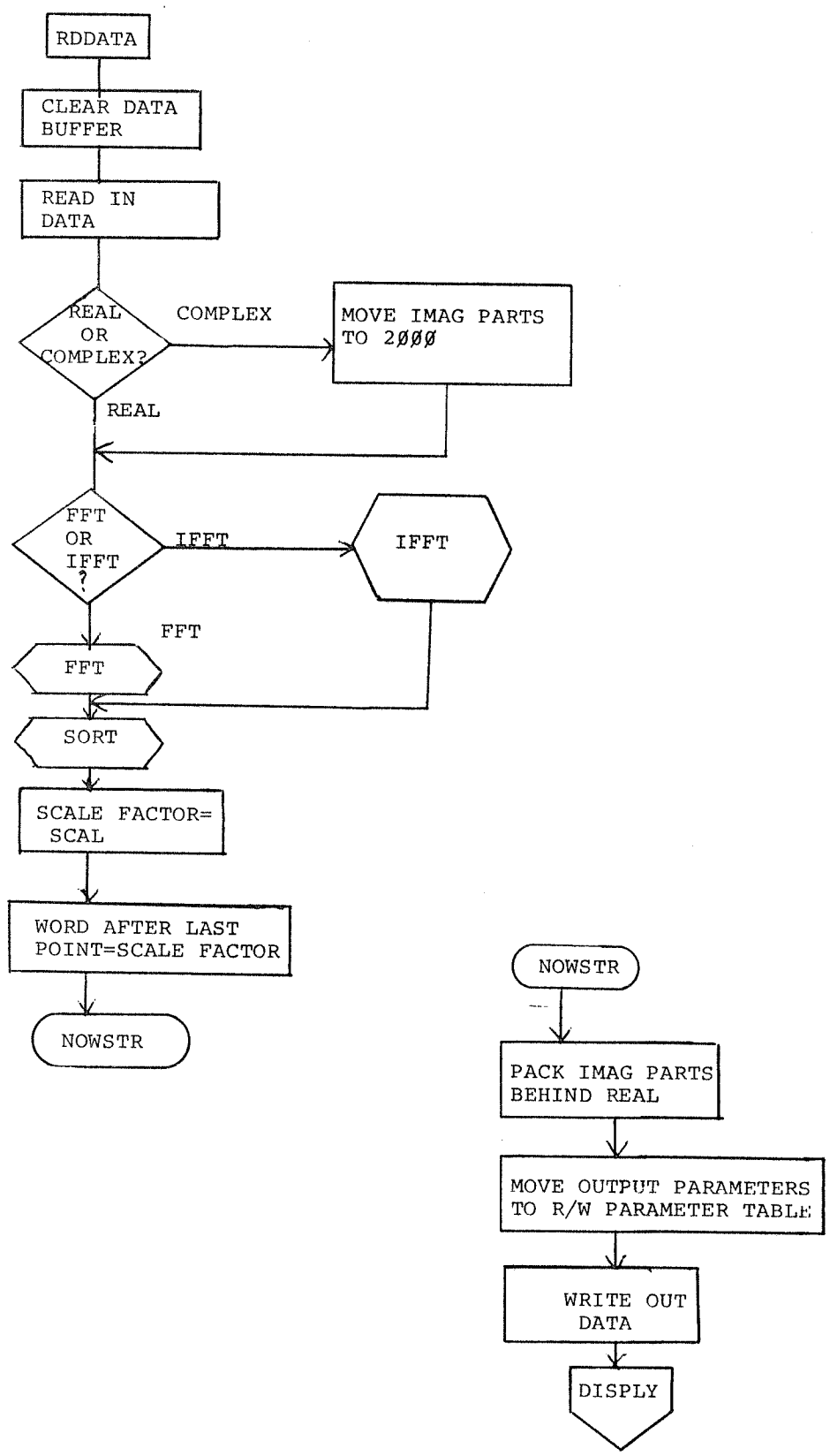
13.0 PROGRAM LISTING

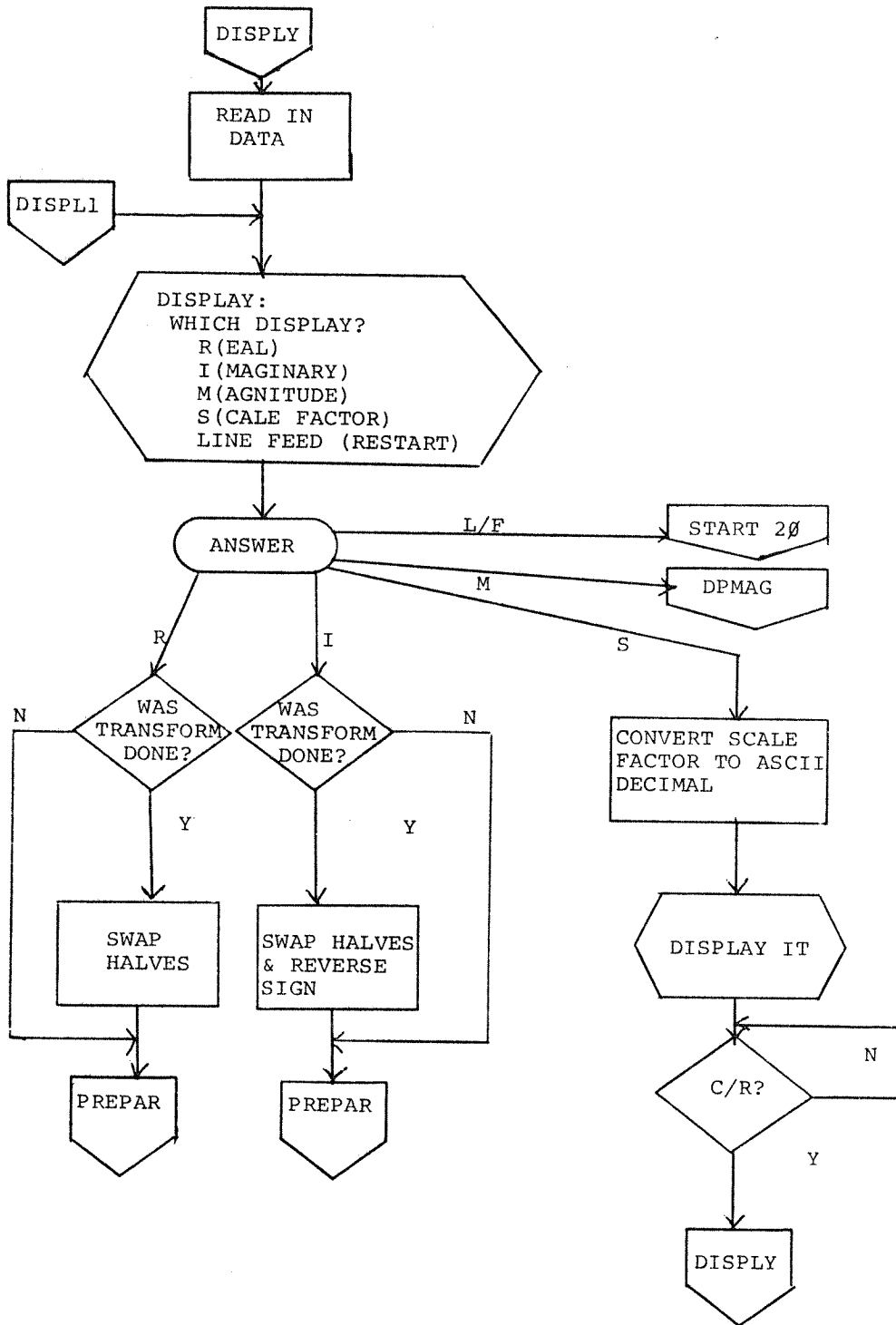
(Attached)

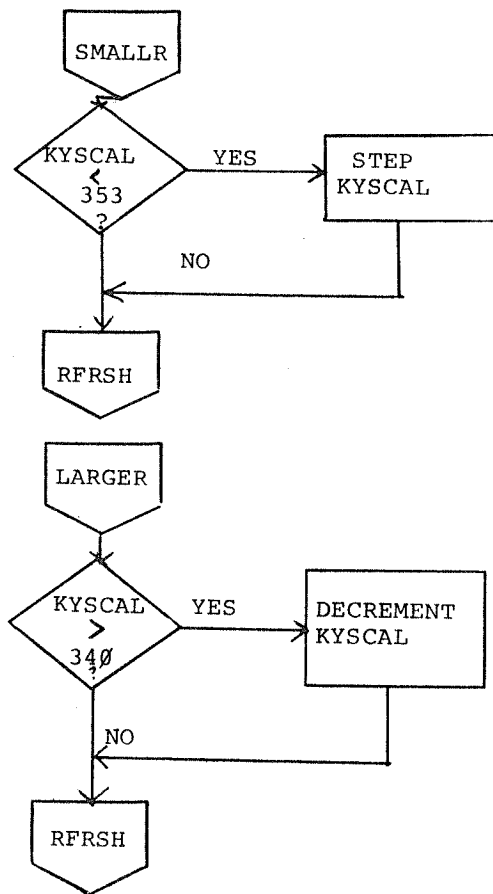
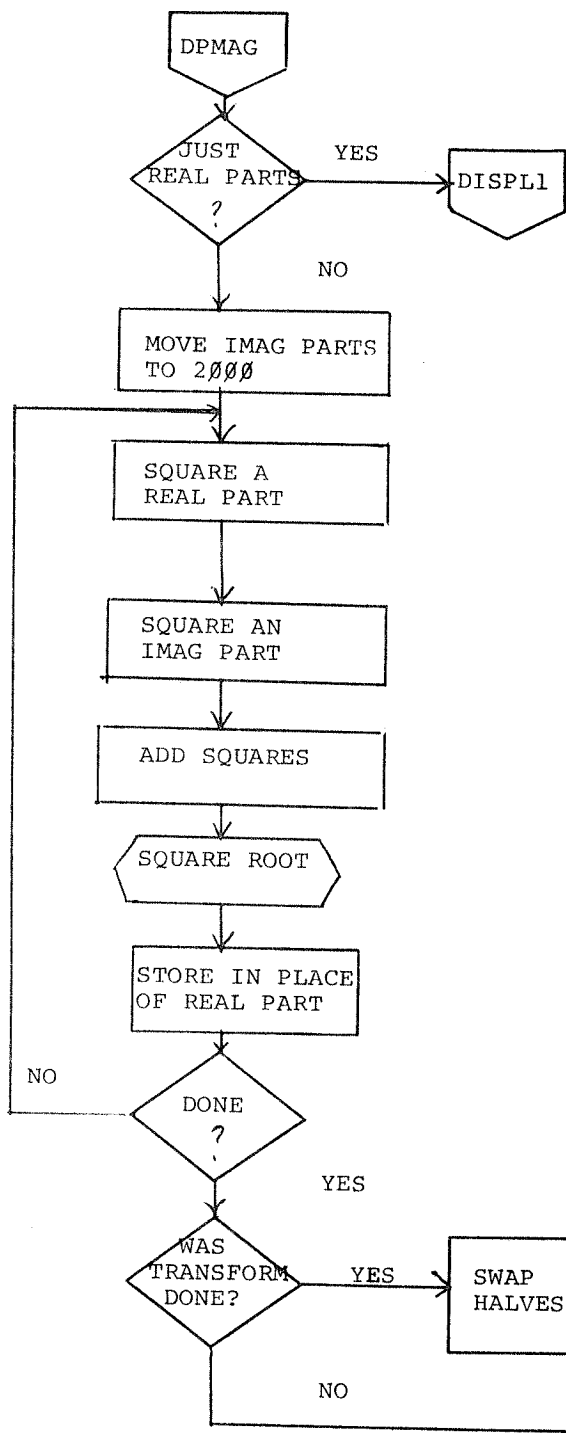


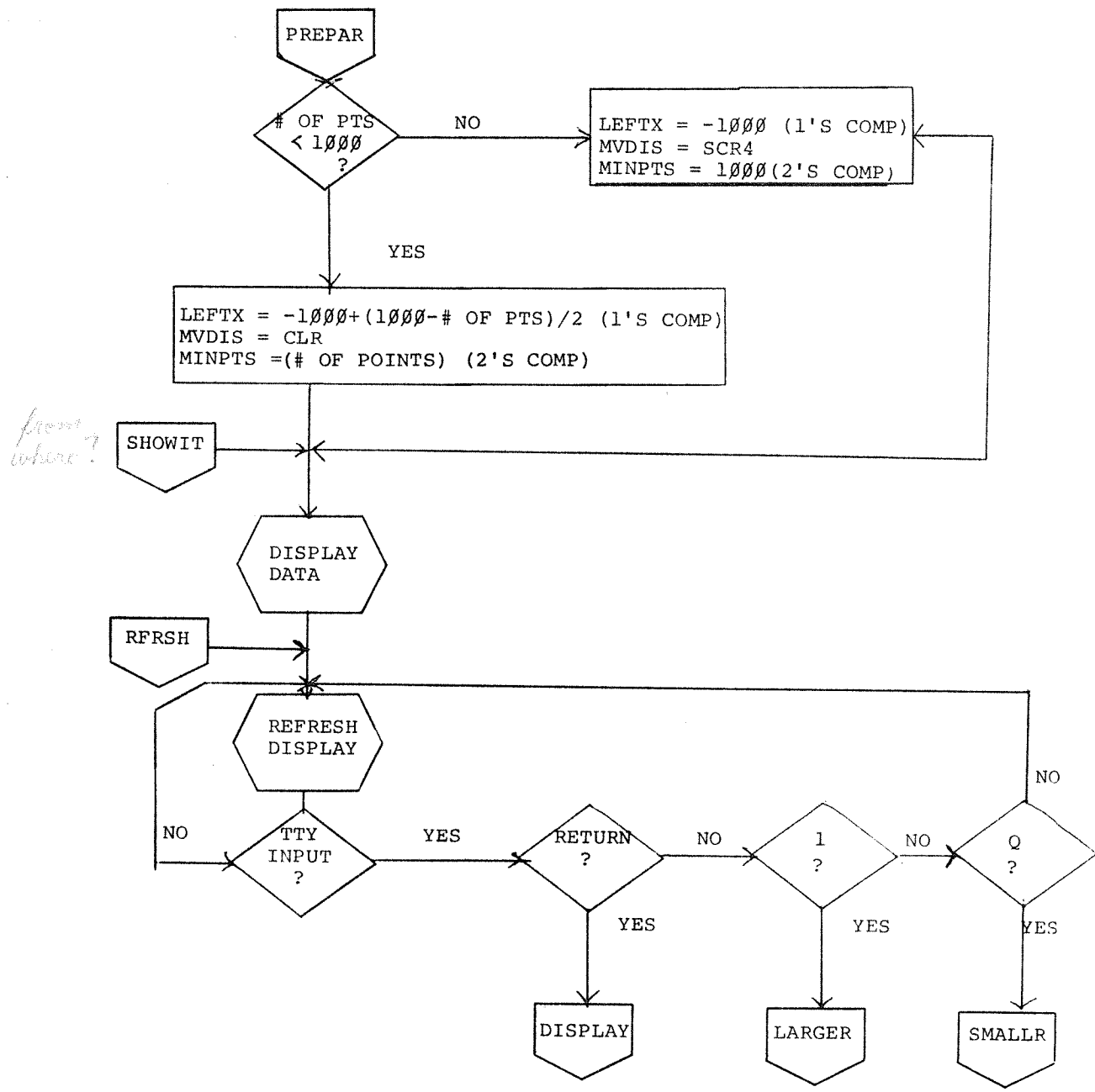












from where?


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0057
0060
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0065
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0070
0071
0072
0073
0074

/*20
/FFTS=REAL
/THIS IS A PROGRAM FOR CALCULATING THE
/FAST FOURIER TRANSFORMATION OF N REAL
/TIME SAMPLES WHICH ARE STORED ON DISK
/OR DATA TAPE OR DISK
/TO BE RUN ON A PDP-12 COMPUTER EQUIPPED WITH THE FOLLOWING MINIMUM HARDWARE:
/ 1) ASR 33 OR ASR 35 TELETYPE
/ 2) 8 K OF CORE MEMORY
/ 3) VR12 CRT DISPLAY
/
/COPYRIGHT 1970, DIGITAL EQUIPMENT CORPORATION
/ MAYNARD, MASS, 01754
/ TRANSFORM ALGORITHM
/ WRITTEN BY JAMES ROTHMAN == AUGUST, 1968
QARFSH=1053
GAINIT=1000
XRTAB=0
XITAB=2000
SINTAB=7347
CDF1=6211
CDF0=6201
PMODE
/PAGE ZERO
*3
/TABLE PARAMETERS
N, 0000
NU, 0004
L, 0005
S, 0006
F, 0007
/NUMBER OF POINTS IN COMPUTATION DIVIDED BY 2
/POWER OF TWO OF POINTS IN COMPUTATION (N=2*NU) MINUS 1
/INDEX TO SHOW WHAT ARRAY IS BEING CONSTRUCTED
/GIVES SPACING BETWEEN NODE PAIRS IN THE LTH ARRAY.
/USED FOR SCALING NODE POSITION TO GET NUMBER IN NODES.
/STORAGE FOR N/4
/LARGEST TABLE SIZE (POWER OF 2)
/STORAGE FOR -N/2
/POINTER TO REAL PART OF X(Q)
/POINTER TO IMAG, PART OF X(Q)
/POINTER TO REAL PART OF X(P)
/POINTER TO IMAG, PART OF X(P)
/NUMERICAL INDEX Q(=0,1,...,N-1)
/NUMERICAL INDEX P(=0,1,...,N-1)
/NUMBER IN THE NODE BEING OPERATED ON
/INTERRUPTS COMPUTATION OF LTH ARRAY EVERY S PASSES
/USED BY SUBROUTINE ADDR AS DATA (ADDEND)
/TEMPORARY STORAGE REGISTER FOR REAL PARTS
/TEMP. STORAGE FOR SIN (S*PI*K/N)
/TEMP. STORAGE FOR COS (2*PI*K/N)
/REAL PART OF PRODUCT (W*K)*X(P), TEMP STORAGE
/IMAG. PART OF (W*K)*X(P), TEMP STORAGE
/ADD C(AC) TO C(ADD2) AND SCALE RIGHT ONE IF NECESSARY.
/BIT INVERTED BUFFER SORTED
/WORD IN AC OF NU BITS IS BIT INVERTED
/FETCH SIN AND COS OF 2*PI*C(AC)/N
/DO FFT OF THE INPUT BUFFER
/DO INVERSE OF BUFFER

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0020
0021
0022
0023
0024
0025
0026
0027
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0031
0032
0033
0034
0035
0036
0037
0040
0041
0042
0043
0044
0045
0046
0047
0050
0051
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0053
0054
0055
0056
0057
0060
0061
0062
0063
0064
0065
0066
0067
0070
0071
0072
0073
0074

NOVER4, 0
MAXNU, BIGSNU
MNOVR2, 0
/INDEXING VARIABLES
QR, 0
QI, 0
PR, 0
PI, 0
Q, 0
P, 0
K, 0
/LOOP DELIMITERS
C, 0
/DATA VARIABLES
ADD2, 0
TEMPR, 0
SINE, 0
COSINE, 0
GR, 0
GI, 0
/SUBROUTINE CALL LIST
ADDR, 1135
SORT, 0701
INVERT, 1040
MULT, 1000
GETRIG, 1060
DOFFT, 0400
DOIFFT, 0147

```

```

0076 /INPUT BUFFER AND ...
0077 /DIFF IN ADDR OF REAL & IMAG PART TABLES
0100 /PSEUDO FLOATING POINT FORMAT FLAGS
0101 SCAL, 0
0102 SHFLAG, 1
0103 SHFCHK, 0
0104 /POINTERS TO SINE TABLE LOOK-UP SHIFTS
0105 SHIFT1, SHFT1
0106 SHIFT2, SHFT2
0107 SHIFT3, SHFT3
0110 /POINTERS TO INSTRUCTION "FLAG" LOCATIONS
0111 WORD, 0
0112 WORDP, 0
0113 FLIPCT, 0
0114 /
0115 RBUILD, BUILD
0116 RESETC, SETC
0117 RECHK, CHKPT
0120 M4000, -4000
0121 M1, -1
0122 M12, -12
0123 M10, -10
0124 GRET10, 6160
0125 LESS10, 4060
0126 M4, -4
0127 PDPMAG, DPMAG
0130 M11, -11
0131 M5, -5
0132 C6000, 6000
0133 M215, -215
0134 M321, -321
0135 M353, -353
0136 M340, -340
0137 M261, -261
0140 M400, -400
0141 C1777, 1777
0142 YSHFT, 0
0143 XCURHI, 0
0144 XCURLO, 0
0145 CORVAL, 0
0146 YCUR, 0
0147 COUNT, 0
0150 KIDORA, IDORA
0151 KRORA, RORA
0152 PSHWT, SHOWT
0153 PRFRSH, RFRSH
0154 PFDV7, FDV+7
0155 PMVDIS, MOVDIS
0156 PLEFTX, LEFTX
0157 PMRLMG, MVRLMG
0160 PMVPTS, MOVPTS
0161 CMPFLG, 0
0162 MINPTS, 0
0163 PRELFG, REALFG
0164 PIFLFG, IFTFLG
0165 PREAD, 7774
0166 PWRITE, 7775
0170 KYSCAL, YSCAL
0171 C1000, 1000
0172 C2000, 2000
0173 M1K, 6777
00000 DPSO, 0

```

0174
0175
0176
0177
0200
0201
0202

0143 0000
0144 0644
0145 0344
0146 0011

LDF4,
SCR4,
CCLR,

0 LMODE
LDF 4
SCR 4
CLR
PMODE
EJECT

```

0200 /THIS SUBROUTINE TAKES THE INVERSE FFT (IFFT) OF THE DATA IN THE BUFFER.
0204 /IT IS ASSUMED THAT THIS DATA IS STORED SEQUENTIAL ORDER.
0205 /THE RESULTS ARE STORED IN BIT INVERTED ORDER.
0206 /THE ALGORITHM USED IS AS FOLLOWS:
0207 /   THE NORMAL TRANSFORM IS PERFORMED, EXCEPT:
0210 /   ON FETCHING THE VALUE FOR IMCW*KJ, WHICH IS
0211 /   THE SIN(2*PI*K/N), THIS SIN VALUE IS NEGATED.
0212 /
0213 /THE REASONING FOR THIS IS AS FOLLOWS:
0214 /   A WEIGHTING FACTOR OF W+8-K) IS USED IN THE IFFT
0215 /   AND SINCE W*K AND W*(-K) ARE THE SAME EXCEPT THAT
0216 /   THEIR IMAGINARY PARTS HAVE OPPOSITE SIGNS, IT FOLLOWS
0217 /   THAT IMJW*KJ SHOULD BE REPLACED BY -IMCW*KJ.
0220 /
0221 /
0222 /
0223 /
0224 /
0225 /
0226 /
0227 /
0230 /
0231 /
0232 /
0233 /
0234 /
0235 /

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```

0147 0000
0150 7500
0151 1152
0152 3561
0153 4446
0154 6201
0155 1163
0156 3561
0157 6211
0160 5547
0161 0570
0162 7041
0163 7000

```

```

CLA CLL
TAD
DCA I
JMS I
CDF0
TAD
DCA I
CDF1
JMP I
SGNADJ, ADJSGN
CCIA, CIA
CNOP, NOP
EJECT

```

```

CCIA /NEGATE IMCW*KJ, GET CIA INSTRUCTION
SGNADJ /AND PUT AT LOCATION ADJSGN
DOFFT /DU FFT
CNOP /RE-INSTATE NOP AT ADJSGN FOR FFT,
SGNADJ /EXIT
IFFT /POINTER TO SIGN ADJUST INSTRUCTION

```

```

0236 *400 /COMPUTATION OF FIRST COMPLEX ARG FROM INPUT DATA
0237 /NUMBER OF INPUT POINTS IN "N" .L 2(N)IN"NU", FOR DETAILS OF ALGORITHM, SEE FLOWCHA
0238 FFT.
0241 0400 0000 CLA IAC CLL
0242 0401 7301 L
0243 0402 3005 DCA SCAL
0244 0403 3053 DCA
0245 0404 7001 IAC
0246 0405 3054 DCA SHFLAG
0247 0406 3055 DCA SHFCHK
0250 0407 1003 TAD N
0251 0410 7112 CLL RTR
0252 0411 3020 DCA NOVER4
0253 0412 1004 TAD NU
0254 0413 7041 CIA
0255 0414 1021 TAD MAXNU
0256 0415 3456 DCA I SHIF11
0257 0416 1456 TAD I SHIF11
0260 0417 3457 DCA I SHIF12
0261 0420 1457 TAD I SHIF12
0262 0421 3460 DCA I SHIF13
0263 0422 1003 TAD N
0264 0423 7110 CLL RAR
0265 0424 3006 DCA S
0266 0425 1006 TAD S
0267 0426 7041 CIA
0270 0427 3022 DCA MNOVR2
0271 0430 7040 CMA
0272 0431 1006 TAD S
0273 0432 1051 TAD XRL0C
0274 0433 3023 DCA QR
0275 0434 1004 TAD NU
0276 0435 7041 CIA
0277 0436 7001 IAC
0300 0437 3007 DCA LOOP1,
0301 0440 1023 TAD
0302 0441 1006 TAD
0303 0442 3025 DCA
0304 0443 1023 TAD
0305 0444 1052 TAD XLOCDF
0306 0445 3024 DCA QI
0307 0446 1025 TAD PR
0310 0447 1052 TAD XLOCDF
0311 0450 3026 DCA PI
0312 0451 6211 CDF1
0313 0452 1424 TAD I QI
0314 0453 3033 DCA ADD2
0315 0454 1426 TAD I PI
0316 0455 4441 JMS I ADDER
0317 0456 3034 DCA TEMPR
0320 0457 1424 TAD I QI
0321 0460 3033 DCA ADD2
0322 0461 1426 TAD I PI
0323 0462 7041 CIA
0324 0463 4441 JMS I ADDER
0325 0464 3426 DCA I PI
0326 0465 1034 TAD TEMPR
0327 0466 3424 DCA I QI
0330 0467 1423 TAD I QR
0331 0470 3033 DCA ADD2
0332 0471 1425 TAD I PR
0333 0472 4441 JMS I ADDER
0241 /LS=1
0242 /INITIALIZE FLOATING POINT FORMAT
0250 /INITIALIZE PROGRAM CONSTANTS
0260 /SK=N/2 IS SPACING OF NODE PAIRS IN FIRST ARRAY
0270 /ACC=-1
0271 /ACK=[N/2-1]*2
0272 /BEGINNING OF TABLE OF REAL PARTS.
0273 /Q<=N/2-1, QR POINTS TO WORD IN MEMORY, WHILE Q IS ACTUAL INDEX
0274 /F<=1-NU (=L-NU SINCE L=1)
0275 /QR=XRL0C+Q AT ALL TIMES.
0276 /P<=Q+N/2
0277 /XLOCDF=XILOC-XRLOC (XILOC=BEGIN, OF IMAG PARTS TABLE)
0278 /QR+XLOCDF=(S+XRLOC)+(XILOC-XRLOC)=XILOC+S=QI
0279 /QI=XILOC+Q AT ALL TIMES, QI POINTS TO IMAG. PART OF X(Q)
0280 /COMPUTE COMPLEX OPERATIONS X(P)<=X(Q)-X(P) AND X(Q)<=X(Q)+X(P)
0281 /BY REAL AND IMAGINARY PARTS.
0282 /IM(X(Q)) (IM () MEANS IMAGINARY PART)
0283 /MAKE IT ADDEND, DO IMAG. PARTS FIRST
0284 /IM(X(P))
0285 /FORM ADDITION IMX(P)+X(Q)]]=IMX(P)]+IMX(Q)] AND SCALE RIGHT
0286 /FOR SCALING, THEN STORE.
0287 /FORM DIFFERENCE IMX(Q)-X(P)]]=IMX(Q)]-IMX(P)]
0288 /PUT AWAY AT IMX(P)]
0289 /GET IMX(P)+X(Q)]
0290 /PUT AT IMX(Q)]], IMAGINARY PARTS DONE.
0291 /ADD REAL PARTS NEXT
0292 /RE=REAL PART
0293 /FORM RE=RE+IM(V)I+V(O)I-DE=DE+IM(V)I+V(O)I

```

```

0336 /GET RELX(Q)
0337 /RE=REAL PART
0340 /FORM RELX(Q)-(P)) (DIVIDED BY 2)
0341 /PUT AT RELX(P)
0342 /GET RELX(Q)+X(P)
0343 /PUT AT RELX(Q)),REAL PARTS DONE
0344 /Q=QR-XRLOC
0345 /AC IS Q
0346 /IS Q>0? (IE THE WHOLE ARRAY HAS NOT BEEN COVERED)
0347 /NO, Q=0, DONE WITH FIRST ARRAY, MOVE ON TO OTHERS
0350 /YES, Q<=Q-1, MOVE UP THIS ARRAY
0351 /OR EQUIVALENTLY, GR<=QR-1
0352 /DO NEXT NODE PAIR
0353 /L GIVES THE NUMBER OF THE VERTICAL ARRAY JUST BUILT
0354 /IS L=NU? (IE HAS THE LAST ARRAY BEEN COMPUTED?)
0355 /YES, DONE, RESULTS STORED IN BIT REVERSED ORDER
0356 /GET SCALE FACTOR AND ADJUST FOR PROPER
0357 /ADDITION ON NEXT ITERATION
0360 /L<=L+1, MOVE ON TO NEXT ARRAY
0361 /S GIVES SPACING BETWEEN NODE PAIRS, WHICH IS N/2*L
0362 /DIVIDE BY 2 AND PUT BACK, SO THAT ON THE LTH PASS THROUGH
0363 /S WILL=N/2*L, THE SPACING,
0364 /F<=F+1, ON LTH PASS, F WILL BE F=L-NU, THE SCALE FACTOR FOR K.
0365 /NOP FOR WHEN F=-1 TO PREVENT ERROR DUE TO SKIP
0366 /AC<=-1
0367 /P<=N-1, PR POINTS TO RELX(P=N-1))
0368 /C<=1, C BREAKS BUILD LOOP EVERY S ITERATIONS
0369 /SO AS TO AVOID RECOMPUTATION
0370 /PR=XRLOC+P
0371 /ACTUAL INDEX IS P:(0,1,,,,N-1)
0372 /BUILD ARRAY, F=L-NU, SHIFT "P"-F PLACES RIGHT (=NU-L)
0373 /SHIFT ZERO PLACES?
0374 /YES, LEAVE ALONE
0375 /F COMPLEMENTED IS -F-(1)=-F-1+1=-F-NU-L PLACES TO BE SHIFTED-1
0376 /GET NODE INDEX
0377 /SHIFT P RIGHT SHIFCT+1=-F-1+1=-F-NU-L PLACES
0378 /ACK=INTEGER PART [P*2*F]
0379 /NO ROTATION, JUST GET P=P*2*0
0380 /INVERT BIT ORDER AND PUT IN K (NUMBER IN PTH NODE)
0381 /SUBTRACT N/2 TO GET NUMBER IN Q (=K) (PS NODE PAIR,)
0382 /GET "L" AND IMAGINARY PARTS OF W*K.
0383 /SET CIA FOR DOING IFFT, NOP FOR FFT,
0384 /SIN(-PI*K/N)=-IM[W*K], COS IN REGISTER @OSINE.
0385 /COS IN REGISTER @OSINE.
0386 /COS IN REGISTER @OSINE.
0387 /COS IN REGISTER @OSINE.
0388 /COS IN REGISTER @OSINE.
0389 /COS IN REGISTER @OSINE.
0390 /COS IN REGISTER @OSINE.
0391 /COS IN REGISTER @OSINE.
0392 /COS IN REGISTER @OSINE.
0393 /COS IN REGISTER @OSINE.
0394 /COS IN REGISTER @OSINE.
0395 /COS IN REGISTER @OSINE.
0396 /COS IN REGISTER @OSINE.
0397 /COS IN REGISTER @OSINE.
0398 /COS IN REGISTER @OSINE.
0399 /COS IN REGISTER @OSINE.
0400 /COS IN REGISTER @OSINE.
0401 /COS IN REGISTER @OSINE.
0402 /COS IN REGISTER @OSINE.
0403 /COS IN REGISTER @OSINE.
0404 /COS IN REGISTER @OSINE.
0405 /COS IN REGISTER @OSINE.
0406 /COS IN REGISTER @OSINE.
0407 /COS IN REGISTER @OSINE.
0410 /COS IN REGISTER @OSINE.
0411 /COS IN REGISTER @OSINE.
0412 /COS IN REGISTER @OSINE.
0413 /COS IN REGISTER @OSINE.
0414 /COS IN REGISTER @OSINE.
0415 /COS IN REGISTER @OSINE.
0416 /COS IN REGISTER @OSINE.
0417 /COS IN REGISTER @OSINE.
0420 /COS IN REGISTER @OSINE.
0421 /COS IN REGISTER @OSINE.
0422 /COS IN REGISTER @OSINE.
0423 /COS IN REGISTER @OSINE.
0424 /COS IN REGISTER @OSINE.
0425 /COS IN REGISTER @OSINE.
0426 /COS IN REGISTER @OSINE.
0427 /COS IN REGISTER @OSINE.
0430 /COS IN REGISTER @OSINE.
0431 /COS IN REGISTER @OSINE.
0432 /COS IN REGISTER @OSINE.
0433 /COS IN REGISTER @OSINE.

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0434 0573 4444 JMS I MULT
0435 0574 0036 COSINE
0436 0575 3033 DCA ADD2
0437 0576 1426 TAD I PI
0440 0577 4444 JMS I MULT
0441 0600 0035 SINE
0442 0601 1033 TAD ADD2
0443 0602 3037 DCA GR
0444 /DO IMAG, PART NEXT=IM[X(P)]*COSINE-RE[X(P)]*SINE+IM[X(P)]*IM[W*K]
0445 TAD I PI
0446 JMS I MULT
0447 COSINE
0450 DCA ADD2
0451 0607 1425 TAD I PR
0452 0610 4444 JMS I MULT
0453 0611 0035 SINE
0454 0612 7041 CIA
0455 0613 1033 TAD ADD2
0456 0614 3040 DCA GI
0457 0615 1006 TAD S
0460 0616 7041 CIA
0461 0617 1025 TAD PR
0462 0620 3023 DCA QR
0463 0621 1023 TAD
0464 0622 1052 TAD XLOCDF
0465 0623 3024 DCA GI
0466 0624 1423 TAD I QR
0467 0625 3033 DCA ADD2
0470 0626 1037 TAD GR
0471 0627 7041 CIA
0472 0630 4441 JMS I ADDER
0473 0631 3425 DCA I PR
0474 0632 1424 TAD I QR
0475 0633 3033 DCA ADD2
0476 0634 1040 TAD GI
0477 0635 7041 CIA
0500 0636 4441 JMS I ADDER
0501 0637 3426 DCA I PI
0502 0640 1423 TAD I QR
0503 0641 3033 DCA ADD2
0504 0642 1037 TAD GR
0505 0643 4441 JMS I ADDER
0506 0644 3423 DCA I QR
0507 0645 1424 TAD I QR
0510 0646 3033 DCA ADD2
0511 0647 1040 TAD GI
0512 0650 4441 JMS I ADDER
0513 0651 3424 DCA I QR
0514 0652 7040 CMA
0515 0653 1030 TAD P
0516 0654 3030 DCA P
0517 0655 7040 CMA
0520 0656 1025 TAD PR
0521 0657 5025 DCA PR
0522 0660 1032 TAD C
0523 0661 7041 CIA
0524 0662 1006 TAD S
0525 0663 7640 SZA CLA
0526 0664 5277 JMP CNOTS
0527 0665 1030 TAD P
0530 0666 7040 CMA
0531 0667 1006 TAN S

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/DO REAL PART FIRST=RE[X(P)]*COSINE+IM[X(P)]*SINE
/RE[X(P)]*COSINE=RE[X(P)]*RE[W*K]
/IM[X(P)]*SINE FOR ADDITION LATER
/GET IM[X(P)]
/AC=IM[X(P)]*SINE=-IM[W*K]*IM[X(P)]
/AC=RE[W*K]*RE[X(P)]-IM[W*K]*IM[X(P)]=RE[X(P)]*W*K
/STORE AT GR
/AC=IM[X(P)]
/AC=IM[X(P)]
/AC=IM[X(P)]*COSINE=IM[P]*RE[W*K]
/STORE FOR LATER ADDITION
/AC=RE[X(P)]
/AC=RE[X(P)]*SINE=-RE[X(P)]*IM[W*K]
/AC=RE[X(P)]*IM[W*K]
/AC=IM[X(P)]*RE[W*K]+RE[X(P)]*IM[W*K]
/STORE AT GI, SO GI=IM[X(P)]*W*K AND GR=RE[X(P)]*W*K G=GR+I*GI
/LOCATE P NODE PAIR Q, LOCATED S=N/(2*L) UP ARRAY
/SO SET Q=P-S=INDEX OF NODE PAIR
/LOCATE X(Q) IN MEMORY BY FIXING POINTERS QR AND QI
/TO QS REAL AND IMAG PARTS RESPECTIVELY
/DO THE COMPLEX OPERATIONS: X(P)<=X(Q)-G;X(Q)<=X(Q)+G
/FIRST DO REAL PART OF X(P), GET RE[X(Q)] AND STORE
/GET RE[Q]
/SUBTRACT THEM,
/RE[X(P)]<=RE[X(Q)]-RE[Q]
/COMPUTE IMAG, PART OF X(P), GET IM[X(Q)]
/AND STORE
/GET IM[Q]
/AND SUBTRACT THEM,
/IM[X(P)]<=IM[X(Q)]-IM[Q],X(P) IS NOW DONE,
/NEXT COMPUTE X(Q), FIRST REAL PART
/GET RE[Q] AND STORE
/GET RE[Q] AND ADD TO FORM
/RE[X(Q)]+RE[Q],
/RE[X(Q)]<=RE[X(Q)]+RE[Q]
/NOW COMPUTE IMAG PART OF X(Q), GET IM[X(Q)]
/AND STORE
/GET IM[Q] AND ADD TO FORM
/IM[X(Q)]+IM[Q]
/IM[X(Q)]<=IM[X(Q)]+IM[Q], THE NEW NODE PAIR IS COMPUTED,
/MOVE UP ARRAY TO NEXT NODE, SET AC=-1
/TO FORM -1
/P<=P-1
/DO THE SAME FOR POINTER PR
/CHECK ON SPACING, IS A NODE WHICH HAS ALREADY BEEN COMPUTED
/ABOUT TO BE RE-DONE, OR EQUIVALENTLY,
/IS C=S?
/YES.
/NO, DO NEXT NODE PAIR
/YES, BUT ARE WE AT THE TOP OF THE ARRAY?
/OR, IS S=P+I? (P COMPLEMENTED=-P-1=-P+1)

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JMP I RECHK
TAD S
CIA PR
TAD PR
DCA PR
JMP I RESETC
ISZ C
JMP I RBUILD
Q
CMA
TAD
DCA
CIA
TAD
DCA
CIA
TAD
SPA SNA CLA
JMP SWAPED
TAD P
DCA XRLOC
PR
TAD Q
TAD XRLOC
DCA QR
TAD PR
TAD XLLOCDF
DCA PI
TAD QR
TAD XLLOCDF
DCA QI
TAD I PR
DCA TEMPR
TAD I QR
DCA I PR
TAD I TEMPR
DCA I QR
TAD I PI
DCA TEMPR
DCA I QI
TAD I PI
TAD TEMPR
DCA I QI
SWAPED, TAD Q
SZA CLA
JMP .+3
CDF0
JMP I SORTX
CMA Q
TAD Q
DCA Q
JMP REVERS
EJECT

/YES, DONE WITH THIS ARRAY, DO NEXT ONE,
/NO, MOVE PAST AREA THAT HAS ALREADY BEEN DONE, OR SET P TO P-S,
/ BY CHANGING THE POINTER TO RECX(P)]

/REINITIALIZE C TO 1 SINCE AN UNUSED AREA HAS BEEN ENTERED.
/CK=C*1, ANOTHER NODE PAIR HAS BEEN HANDLED.
/DO NEXT NODE PAIR IN THIS AREA.
/SUBROUTINE THAT
/SORTS OUT TRANSFORMS BY
/BIT INVERSION OF ADDRESS.
/QK=N-1, START FROM BOTTOM OF BUFFER
/PK=BIT INVERTED Q
/BIT INVERSION ROUTINE
/FORM Q=P

/IS PKQ?
/NO, HAVE ALREADY DONE THIS PAIR
/YES, SWAP ORDER
/FIRST SET UP SUBSCRIPT POINTERS FOR X(P) AND X(Q),

/EXCHANGE: X(P)<=X(Q) AND X(Q)<=X(P)
/EXCHANGE REAL PARTS, GET RECX(P)]
/STORE IT.
/GET RECX(Q)]
/MAKE IT RECX(P)]
/GET RECX(P)]
/MAKE IT RECX(Q)]
/EXCHANGE IMAGINARY PARTS, GET IMCX(P)]
/STORE IT.
/GET IMCX(Q)]
/MAKE IT IMCX(P)]
/GET IMCX(P)]
/MAKE IT IMCX(Q)]
/IS Q=0?, IE; ARE WE AT THE TOP OF THE ARRAY

/YES, DONE EXIT
/NO, Q<=Q-1, IE; MOVE UP THE ARRAY

/GO BACK AND CONTINUE

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06 *1000
0 /SIGNED S.P. MULTIPLY, USING THE
0 /ENTRY: AC=MULTIPLIER, C(CALL+1)=ADDR OF MULTIPLICAND, EXIT=AC=PRODUCT,
0624 /AN 11 BIT SIGNED BINARY FRAC
0625 MULTIP, 0 /AC=ARG1 (MULTIPLIER)
0626 CLL /ARG1>0?
0627 SPA
0630 CMA CML IAC /NO-MAKE POS-SET L=1 TO SHOW IT WAS NEG
0631 >MOL /LOAD INTO M0
0632 CDF0
0633 TAD I MULTIP /GET ADDR OF MULTIPLICAND
0634 DCA ARG2 /STORE
0635 TAD I ARG2 /AND RETRIEVE MULTIPLICAND ITSELF.
0636 ISZ /FOR EXIT AT CALL+2)
0637
0640 SPA /ARG2>0?
0641 CMA CML IAC /NO, MAKE POSITIVE, CHANGE LINK, SINCE -1+--1=1 AND -1+1=-1
0642 DCA ARG2 /PUT AWAY AT ARG2
0643 RAR
0644
0645 DCA /SIGN IN LINK, PUT INTO AC11 AND
0646 MUY /PUT AWAY AT SIGN (=1 IF -1 =0 IF 0)
0647 HLT /DO MULTIPLICATION
0650 >SHL /ARGUMENT 2 (MULTIPLICAND)
0651 0 /NORMALIZE BINARY POINT,
0652 DCA /SAVE HIGH ORDER, NOW ROUND OFF.
0653 TAD /SET AC11=M00, AC0-10=0
0654 >SHL
0655 0
0656 TAD ARG2
0657 SPA ARG2
0660 CLA CLL CMA RAR
0661 NOP
0662 SZL
0663 CMA IAC /POSITIVE SIGN?
0664 CDF1 /NO, NEGATE
0665 JMP I MULTIP /EXIT, SIGNED RESULT IN AC,
0666 0
0667 /BIT INVERSION ROUTINE
0670 /ENTRY: AC=WORD TO BE INVERTED; EXIT:AC=RESULT
0671 /NU CONTAINS THE NUME OF BITS IN THE WORD
0672 INVRT, 0
0673 DCA WORD /GET WORD TO BE INVERTED
0674 DCA WORDP /ZERO OBJECT REGISTER
0675 TAD NU /GET NUMBER OF BITS TO BE
0676 CIA /INVERTED AND USE TO LIMIT THE
0677 DCA FLIPCT /EXTENT OF LOOP
0678 TAD WORD /PULL OUT RIGHTMOST BIT OF WORD
0679 CLL RAR /RT MOST BIT NOW IN AC
0680 DCA WORD /PUT BACK SO A NEW BIT IS OPERATED ON EACH TIME)
0681 TAD WORDP /AND PUSH INTO WORDP FROM LEFT
0682 RAL
0683 DCA WORDP
0684 ISZ FLIPCT /ALL BITS DONE?
0685 JMP FLIP /NO, DO NEXT BIT
0686 TAD WORDP /YES, PICK UP RESULT
0687 JMP I INVRT /AND EXIT
0688 EJECT

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/THIS SUBROUTINE FETCHES THE VALUES OF SIN(2*PI*C(AC)/N)
/AND OF COS(2*PI*C(AC)/N) FOR C(AC) < N/2+1
/ENTRY: AC=INDEX OF LOOP UP
/EXIT : COS(2*PI*C(AC)/N) STORED AT "COSINE" AND
/ AC=VALUE OF SIN(2*PI*C(AC)/N),
TRIGET, 0
1060 0000
1061 6201 CDF0
1062 5031 DCA K
1063 7421 MQL
1064 1031 TAD TAD K
1065 7141 CLL CIA
1066 1020 TAD NOVER4
1067 3333 DCA NO4MIK
1070 7430 SZL
1071 5310 JMP QUAD1
1072 1333 TAD NO4MIK
1073 7041 CIA
1074 7417 LSR
1075 0000 0
1076 7413 SHL
1077 7402 HLT
1078 1050 TAD
1079 3334 DCA INDEX
1080 1734 TAD I INDEX
1081 7041 CIA
1082 3036 DCA COSINE
1083 1333 TAD NO4MIK
1084 1020 TAD NOVER4
1085 5322 JMP SINRET
1086 1333 TAD NO4MIK
1087 7417 LSR
1088 0000 0
1089 7413 SHL
1090 7402 HLT
1091 1050 TAD
1092 3334 DCA INDEX
1093 1734 TAD I INDEX
1094 3036 DCA COSINE
1095 1031 TAD
1096 7417 LSR
1097 0000 0
1098 7413 SHL
1099 7402 HLT
1100 1050 TAD
1101 3334 DCA INDEX
1102 1734 TAD I INDEX
1103 3036 DCA COSINE
1104 1031 TAD
1105 7417 LSR
1106 0000 0
1107 7413 SHL
1108 7402 HLT
1109 1050 TAD
1110 3334 DCA INDEX
1111 1734 TAD I INDEX
1112 3036 DCA COSINE
1113 1031 TAD
1114 7417 LSR
1115 0000 0
1116 7413 SHL
1117 7402 HLT
1118 1050 TAD
1119 3334 DCA INDEX
1120 1734 TAD I INDEX
1121 3036 DCA COSINE
1122 1031 TAD
1123 7417 LSR
1124 0000 0
1125 7402 SHL
1126 1050 TAD
1127 3334 DCA INDEX
1128 1734 TAD I INDEX
1129 6211 CDF1
1130 5660 JMP I
1131 0000 0
1132 0000 INDEX, 0
1133 0000
1134
/THIS ROUTINE PERFORMS A SINGLE PRECISION ADD WITH ROUNDING EACH ARGUMENT IS
/SHIFTED RIGHT ONCE TO PREVENT OVERFLOW OF BINARY POINT (IF NECESSARY)
/AND THEN CHECKED TO SEE IF IT CAN BE NORMALIZED AFTER ADDITION
/ENTRY: AC=ADDEND,C(ADD2)=AUGEND
/EXIT : -AC=RESULT, DIVIDED BY TWO IF NECESSARY.
ADDR, 0
1135 0000 DCA ADD1
1136 3374 TAD SHFLAG
1137 1054 SNA CLA
1140 7650 JMP ADDWOS
1141 5357 TAD ADD1
1142 1374 TAD ASR
1143 7415
1144
/SHOULD ADD BE DONE WITH SHIFT?
/NO, ADD WITH OUT SHIFT
/YES T ADDEND
/DO 1 SIGNED RIGHT SHIFT

```

1012									
1013	1145	3374	DCA	ADD1					
1014	1146	1033	TAD	ADD2					
1015	1147	7415	ASR						
1016	1150	0000	0						
1017	1151	3033	DCA	ADD2					
1020	1152	7501	MGA						
1021	1153	7004	RAL						
1022	1154	7060	CMA CML						
1023	1155	7720	SMA SNL CLA						
1024	1156	7001	IAC						
1025	1157	1374	ADDWOS, TAD	ADD1					
1026	1160	1033	TAD	ADD2					
1027	1161	5375	DCA	XSUM					
1030	1162	1375	TAD	XSUM					
1031	1163	7510	SPA						
1032	1164	7041	CIA						
1033	1165	7004	RAL						
1034	1166	7700	SMA CLA						
1035	1167	5372	JMP	NOTNOR					
1036	1170	7001	IAC						
1037	1171	3055	DCA	SHFCHK					
1040	1172	1375	NOTNOR, TAD	XSUM					
1041	1173	5735	JMP I	ADDR					
1042	1174	0000	ADD1, 0						
1043	1175	0000	XSUM, 0						
1044			EJECT						

```

/ =LO(ADD2)
/MQ(1)=LO(ADD(1))
/GET MQ
/LK=LO(ADD2); AC0K=LO(ADD1)
/COMPLEMENT BOTH,
/IF BOTH WERE=1 (NEITHER=0), INTRODUCE A CARRY.
/DO THE ADDITION,
/STORE THE RESULT
/CHECK TO SEE IF ALREADY NORMALIZED,
/IS IT POSITIVE?
/MAKE IT POSITIVE.
/GET BIT 1, WAS NORMALIZED IF #1
/NOT NORMALIZED, LEAVE SHFCHK ALONE,
/SET SHFCHK=1
/AND EXIT
/ADDEND STORAGE
/TEMP STORAGE FOR SUM

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/DEFINITIONS FOR EAE
DVI=7407
NMI=7411
SHL=7413
ASR=7415
LSR=7417
MQL=7421
MUY=7405
MOA=7501
CAM=7621
SCA=7441
SCL=7403
/ASSEMBLY PARAMETERS
BIGSNU=12 /LARGEST TRANSFORMATION HAS DIMENSION 2*10,
EJECT

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1065 /MOVING WINDOW DISPLAY SUBROUTINE
1066 /GET BOUNDS
1067 IDORA, 0000
1068 0 CLA CLL
1069 ACDF0, 6201 CDF 0
1070 TAD I IDORA /DATA BUFFER
1071 DCA I KMNFLD /15 BIT
1072 ISZ IDORA /LOWER BOUND
1073 TAD I IDORA /AT P+1, P+2
1074 DCA I KMNADR /MINFLD,MINADR
1075 ISZ IDORA
1076 TAD I IDORA /UPPER BOUND
1077 DCA I KMNADR /AT P+3, P+4
1078 ISZ IDORA
1079 TAD I IDORA /RDORA USES
1080 DCA I KMXADR /MAX+1
1081 RAL
1082 TAD I KMXFLD
1083 DCA I KMXFLD
1084 ISZ IDORA
1085 TAD I IDORA
1086 DCA YSHFT
1087 ISZ IDORA
1088 TAD I IDORA
1089 DCA I KYSCAL
1090 TAD I KMNFLD
1091 DCA I KBUFHI
1092 TAD I KMNADR
1093 DCA I KBUFLO
1094 JMP I IDORA
1095 KMNFLD, MINFLD
1096 KMNADR, MINADR
1097 KMXFLD, MAXFLD
1098 KMXADR, MAXADR
1099 KBUFHI, BUFHI
1100 KBUFLO, BUFLO
1101 P401, 401
1102 DSCLOC, TAD P401
1103 DCA VCOORD
1104 TAD XCURHI
1105 JMS DSCWD
1106 TAD XCURLD
1107 JMS DSCWD
1108 TAD CORVAL
1109 JMS DSCWD
1110 TAD YCUR
1111 TAD P401
1112 JMS DSCWD
1113 RTNCDF, 0
1114 JMP I RDORA
1115 0
1116 LINC
1117 LMODE
1118 STC TEMP
1119 STC XCORD
1120 SFA
1121 ROL I 5
1122 LDA I
1123 -20
1124 FOR HALF
1125
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1362	JMP OKEND	/RESET TO
1363	TAD MINADR	/LOWER BOUND
1364	DCA BUFTR	
1365	TAD MINFLD	
1366	DCA BOUND	
1367	JMP NXTDF	
1370	ISZ BUFTR	/CHK FOR FIELD
1371		/BOUNDARY
1372	JMP OKFLD	/ITS OK
1373	ISZ BOUND	/SET NXT FLD
1374	JMS SETDF	
1375	ISZ COUNT	/512 PNTS ?
1376	JMP NXTPNT	/NO
1377	JMP I ,*1	/DSC READ OUT
1400	DSCLOC	
1401	JMS BOUND	/CHK UPR BOUND
1402	MAXFLD, 2	
1403	MAXADR, 0	
1404	M70,	/HI WRAP ?
1405	SPA CLA	
1406	JMP SETFLD	/YES
1407	TAD MINFLD	/RESET TO
1410	DCA BUFHI	/LOWER BOUND
1411	TAD MINADR	
1412	JMP WRAP	
1413	/DOUBLE PRECISION ADD	
1414	/(DBLHI,DBLLO)*(BUFHI,BUFLO)	
1415	/RESULT IN (DBLHI,DBLLO)	
1416	/(BUFHI,BUFLO)=INITIAL SCOPE ADDRESS	
1417	DADD, 0	
1420	CLA CLL	
1421	TAD DBLLO	
1422	TAD BUFLO	
1423	DCA DBLLO	
1424	RAL	
1425	TAD DBLHI	
1426	TAD BUFHI	
1427	DCA DBLHI	
1430	JMP I DADD	
1431		
1432	/ADD -UPPER OR -LOWER BOUND	
1433	/TO (BUFHI,BUFLO)	
1434	/BOUND IS AT P+1,P+2 OF CALL	
1435		
1436	BOUND, 0	
1437	TAD I BOUND	/2S COM OF ARG
1440	CMA CLL	/TO DAC
1441	DCA DBLHI	
1442	ISZ BOUND	
1443	TAD I BOUND	
1444	CIA	
1445	SZL	
1446	ISZ DBLHI	
1447	NOP	
1450	M1000,	
1451	DCA DBLLO	
1452	JMS DADD	
1453	TAD DBLHI	
1454	DCA ENDHI	
1455	TAD DBLLO	/DAC HOLDS -NUM
1456	DCA ENDO	/TO END OF BUF
1457	TAD DBLHI	/NO MATTER F
		/LOW END WRA
		/TO CHK FOR

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/SET 8 F
/REL TO 0

JMP I BOUND
0
TAD BOUND
CLL RTL
RAL
TAD CCDF0
DCA ,+1
0
JMP I SETDF
DCA YCUR
TAD BOUND
DCA XCURHI
TAD BUFPTR
DCA XCURL0
TAD I BUFPTR
DCA CORVAL
TAD M70
DCA DBLLO
TAD YCUR
LINC
LMODE
SNS I 5
JMP FREE
DIS XCORD
POP
PMODE
ISZ DBLLO
JMP CURLOP
JMP CURRTN
0
/THese 5 GUYS MAY BE PAGE 0
BUFHI, 1
BUFLO, 0
ENDLO, 0
ENDHI, 0
DBLHI=SETDF
BUFPTR=DADD
XCORD=1
LMODE
CURSAM=SAM 1
WINSAM=SAM 0
FRESAM=SAM 5
SCALE=SCR
SC12BU=SCR 3
OF12BU=4000
CHAIN "FFTC-2"

/DISP CURSOR
/SAVE X,Y
/COORDINATES

/FREE CURSOR

/CURSOR KNOB
/WINDOW KNOB
/FREE CURSOR

/SCALE FACTOR
/12 BIT UNSIGNED
/Y OFFSET FOR
/12 BIT UNSIGNED

```

0000
0001

020

EJECT

```

0002 LMODE
0003 SEGMENT 2
0004 *20
0005 LDF 0647
0006 RDC 0700
0007 6322
0008 RDC 0700
0009 7323
0010 LDF 3
0011 IFDIAL, LDA I /INPUT FROM DIAL TAPE?
0012 QUES1+2000
0013 LIF 2
0014 JMP ASK
0015 LDH ANSWER+6000
0016 SAE I
0017 31
0018 SKP
0019 JMP UNTFIL /DIAL
0020 SAE I
0021 16
0022 JMP IFDIAL /ERROR
0023 JMP DATTAP
0024 /ASK FOR UNIT NO + FILE NAME
0025 UNTFIL, JMP ASK2
0026 : -1
0027 LIF 1
0028 LDA I
0029 FDV+2000
0030 JMP 20
0031 SKP MOVINP
0032 LIF 2
0033 LDA I
0034 MSG1+2000
0035 JMP ASK
0036 UNTFIL
0037 DATTAP, JMP ASK3
0038 MOVINP, JMP FDV2RW
0039 PTS, LDF 3
0040 LIF 2
0041 LDA I
0042 QUES4+2000
0043 JMP ASK
0044 SET I 1
0045 ANSWER+2000
0046 LDA I
0047 12
0048 STC MPLIER
0049 LDA I
0050 -71
0051 STC UPLEGL
0052 LDA I
0053 2000
0054 JMP CONV
0055 JMP PTS
0056 LDF 0
0057 STA
0058 N+2000
0059 LDF 3
0060 0043
0061 0043
0062 6523
0063 6044
0064 0601
0065 1020
0066 2375
0067 6020
0068 0456
0069 6063
0070 0602
0071 1020
0072 2760
0073 6720
0074 6044
0075 6572
0076 6061
0077 6466
0078 0643
0079 0602
0080 1020
0081 2521
0082 6720
0083 0061
0084 3043
0085 1020
0086 0012
0087 4701
0088 1020
0089 7706
0090 4645
0091 1020
0092 2000
0093 6627
0094 6064
0095 0640
0096 1040
0097 2003
0098 0643
0099 0047

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0104 0110 0111 0112 0113 0114 0115 0116 0117 0120 0121 0122 0123 0124 0125 0126 0127 0130 0131 0132 0133 0134 0135 0136 0137 0140 0141 0142 0143 0144 0145 0146 0147 0150 0151 0152 0153 0154 0155 0156 0157 0160 0161 0162 0163 0164 0165 0166 0167 0170 0171 0172 0173 0174 0175 0176 0177
0114 0115 0116 0117 0120 0121 0122 0123 0124 0125 0126 0127 0130 0131 0132 0133 0134 0135 0136 0137 0140 0141 0142 0143 0144 0145 0146 0147 0150 0151 0152 0153 0154 0155 0156 0157 0160 0161 0162 0163 0164 0165 0166 0167 0170 0171 0172 0173 0174 0175 0176 0177
TEMP1, SKP JUMP PTS SET I 2 -13 SRO TEMP1 JUMP,+3 ADA I 1 XSK I 2 JUMP ROTAT ADA I -1 COM AZE JUMP PTS STC 2 SRO TEMP1 SKP JUMP STAMU XSK I 2 JUMP ROT1 LDA 2 LDF 0 STA NU+2000 ADA I -1 APO JUMP PTS LDA N+2000 ROL 1 JUMP NUMBKS STA FDV+2007 STA RWPARM+2003 LDH ANSWER+2003 SAE I 22 JUMP IFCOM STA REALFG+2000 LDF 0 LDA N+2000 JUMP NUMBKS STA RWPARM+2003 JUMP CKEND SAE I 3 JUMP PTS /ERROR CLR STA REALFG+2000
TEMP1, SKP JUMP PTS SET I 2 -13 SRO TEMP1 JUMP,+3 ADA I 1 XSK I 2 JUMP ROTAT ADA I -1 COM AZE JUMP PTS STC 2 SRO TEMP1 SKP JUMP STAMU XSK I 2 JUMP ROT1 LDA 2 LDF 0 STA NU+2000 ADA I -1 APO JUMP PTS LDA N+2000 ROL 1 JUMP NUMBKS STA FDV+2007 STA RWPARM+2003 LDH ANSWER+2003 SAE I 22 JUMP IFCOM STA REALFG+2000 LDF 0 LDA N+2000 JUMP NUMBKS STA RWPARM+2003 JUMP CKEND SAE I 3 JUMP PTS /ERROR CLR STA REALFG+2000
/BIT 11=1 NOT POWER OF 2
/COUNT NO OF BITS SET
/>1-NOT POWER OF 2
/CLEAR
/DETERMINE POWER OF 2
/POWER<2
/NO OF PTS
/*2
/CONVERT TO BLKS
/NO OF BLKS FOR REAL & IMAG
/REAL-SET FLAG
/COMPUTE INPUT BLKS
/COMPLEX-CLEAR FLAG

```

```

0200 0212 2407 RMPARM+2002
0201 0213 1100 ADA
0202 0214 2410 RMPARM+2003
0203 0215 1120 ADA I
0204 0216 6777 -1000
0205 0217 0471 APO I
0206 0220 6064 JMP
0207 0221 0002 PDP
0210 0222 7200 PMODE
0211 0223 1003 CLA
0212 0224 7104 TAD N /ADD 1 BLK FOR SCALE FACTOR IF 400 WORDS OR MORE
0213 0225 1107 CLL RAL /NO OF OUTPUT WRDS = NO OF PTS*2
0214 0226 7700 TAD M400
0215 0227 2523 SMA CLA
0216 0228 6141 ISZ I PFDV7
0217 0229 6141 LINC
0220 0231 1020 LMODE
0221 0232 2625 LDA I /DO FFT OR JUST DISPLAY?
0222 0233 6720 QUES11+2000
0223 0234 1300 JMP ASK
0224 0235 7043 LDH
0225 0236 1460 ANSWER+6000
0226 0237 0004 SAE I
0227 0240 6244 JMP ,+4
0228 0241 1060 STA I
0229 0242 0000 DISFLG, 0 /NOT=0 JUST DISPLAY
0230 0243 6251 JMP FIF
0231 0244 1460 SAE I
0232 0245 0006 6
0233 0246 6231 JMP IFFFT /ERROR
0234 0247 0011 CLR
0235 0250 4242 STC DISFLG /=0 WILL DO TRANSFORM OR INVERSE
0236 0251 1300 LDH
0237 0252 7044 ANSWER+6001
0238 0253 1460 SAE I
0239 0254 0024 24
0240 0255 6261 JMP IFI
0241 0256 0011 CLR
0242 0257 4356 STC IFTFLG /DO FFT
0243 0260 6265 JMP IFDISP
0244 0261 1460 SAE I
0245 0262 0011 11
0246 0263 6231 JMP IFFFT
0247 0264 4356 STC IFTFLG /DO IFFT
0248 0265 2242 IFDISP, ADD DISFLG
0249 0266 0470 AZE I
0250 0267 6273 JMP
0251 0270 6466 JMP
0252 0271 0603 LIF 3
0253 0272 6001 JMP DISPLY
0254 0273 1020 /GET OUTPUT INFO
0255 0274 2571 OUTQES, LDA I
0256 0275 6720 QUES5+2000
0257 0276 1300 JMP ASK
0258 0277 7043 LDH
0259 0278 1460 ANSWER+6000
0260 0279 0031 SAE I
0261 0280 0456 31
0262 0281 6310 SKP
0263 0282 0304 JMP
0264 0283 1460 SAE I
0265 0284 1460 OUTUNT
0266 0285 1460
0267 0286 1460
0268 0287 1460
0269 0288 1460
0270 0289 1460
0271 0290 1460
0272 0291 1460
0273 0292 1460
0274 0293 1460
0275 0294 1460

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0300 0300 6273 JMP OUTGES /NO
0300 0307 6452 JMP ONDAT /ASK FOR UNIT NO & FILE NAME
0301 0310 6523 JMP ASK2 /ERROR
0302 0311 6310 JMP OUTUNT /ENTER IN INDEX
0303 0312 0601 LIF 1 /NAME ALREADY USED
0304 0313 1020 LDA I /NO SPACE
0305 0314 2375 FOV+2000 22 /CLEAR DATA BUFFER
0306 0315 6022 JMP SAMNAM
0307 0316 6430 JMP NOSPAC
0310 0317 6423 JMP /PDP
0311 0320 0002 RDDATA, PDP /PMODE
0312 0321 7240 CLA CMA
0313 0322 1051 TAD XRLOC
0314 0323 3010 DCA 10
0315 0324 1067 TAD M4000
0316 0325 3011 DCA 11
0317 0326 6211 CDF1
0320 0327 3410 DCA I 10
0321 0328 2011 ISZ 11
0322 0329 5327 JMP .-2
0323 0330 6201 COF0
0324 0331 6212 CIF 10 /READ IN DATA
0325 0332 4534 JMS I PREAD
0326 0333 6405 RWPARM
0327 0334 6201 CDF0
0330 0335 7200 CLA
0331 0336 1532 TAD I PRELFG /REAL OR COMPLEX
0332 0337 7640 SZA CLA /REAL
0333 0338 5357 JMP PROC /MOVE IMAG PARTS TO 2000
0334 0339 7040 CMA /OLD ADDR = NO OF PTS
0335 0340 1003 TAD N /NEW ADDR = 2000
0336 0341 3010 DCA 10
0337 0342 1110 TAD C1777
0340 0343 3011 DCA 11
0341 0344 1003 TAD N
0342 0345 3034 CIA /CTR
0343 0346 3130 DCA CMPFLG /DONT COMPLEMENT
0344 0347 4527 JMS I PMVPTS /MOVE THEM
0345 0348 5357 JMP PROC
0350 0351 0000 IFTFLG, 0 /0=FFT NON0=IFFT
0352 0352 3532 PROC, DCA I PRELFG /OUTPUT WILL BE COMPLEX REGARDLESS OF INPUT
0353 0353 1356 TAD IFTFLG /DO IFFT?
0354 0354 7650 SNA CLA /NO
0355 0355 5365 JMP FT
0356 0356 4447 JMS I DOIFFT
0357 0357 7410 SKP
0360 0360 4446 JMS I DOFFT
0361 0361 4442 JMS I SORT
0362 0362 1053 STSCAL, TAD SCAL /PUT IN SEQUENTIAL ORDER
0363 0363 6211 COF1 /SAVE
0364 0364 3034 DCA TAD N
0365 0365 1003 CLL RAL
0366 0366 7104 DCA COSINE /NO OF PTS*2
0367 0367 1034 TAD TEMPR
0370 0370 3436 DCA I COSINE /STORE SCAL - FACTOR AFTER DATA
0371 0371 1110 NOWSTR, TAD C1777 /OLD ADDR = 2000
0372 0372 1110 TAD
0373 0373 1110 TAD
0374 0374 1110 TAD

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0376
0 4402 7040
0 4403 1003
0 4404 3011
0401 4405 1003
0402 4406 7041
0403 4407 3034
0404 4410 3130
0405 4411 4527
0406 4412 6141
0407
0410 0413 6466
0411 0414 0002
0412
0413 4415 6212
0414 4416 4535
0415 4417 6405
0416 4420 6141
0417
0420 0421 0603
0421 0422 6001
0422 0423 0602
0423 0424 1020
0424 0425 3013
0425 0426 6720
0426 0427 6273
0427 0430 0602
0430 0431 1020
0431 0432 2612
0432
0433 0433 6720
0434 0434 1300
0435 0435 7043
0436 0436 1460
0437 0437 0031
0440 0440 0456
0441 0441 6446
0442 0442 1460
0443 0443 0016
0444 0444 6430
0445 0445 6310
0446 0446 0601
0447 0447 6024
0450 0450 6423
0451 0451 6320
0452 0452 0602
0453 0453 6572
0454 0454 6452
0455 0455 1000
0456 0456 2403
0457 0457 1100
0460 0460 2404
0461 0461 1120
0462 0462 6777
0463 0463 0471
0464 0464 6423
0465 0465 6320
0466
0467 0466 1000
0470 0467 2375
0471 0470 1040
0472 0471 2405

/NEW ADDP NO OF PTS
N
11
N
/CTR
/DONT COMPLEMENT
/PACK IMAG PARTS BEHIND REAL
TEMPR
CMPELG
PMVPTS
LINC
LMODE
JMP FDV2RW
PDP
PMODE
/WRITE OUT DATA
CIF 10
JMS I PWRITE
RWPARM
LINC
LMODE
LIF 3
JMP DISPLY
LIF 2
LDA I
MSG2+2000
JMP ASK
JMP OUTGES
LIF 2
LDA I
QUES6+2000
/ASK OUTPUT QUESTIONS AGAIN
/NAME ALREADY EXISTS
/REPLACE WITH NEW FILE?
ASK
LDH
ANSWER+6000
SAE I
31
SKP
JMP REPL
SAE I
16
JMP SAMNAM
JMP OUTUNT
LIF 1
JMP 24
JMP NOSPAC
JMP RDDATA
LIF 2
JMP ASK3
JMP ONDAT
LDA
FDV+2006
ADA
FDV+2007
ADA I
-1000
APO I
JMP NOSPAC
JMP RDDATA
/MOVE FDV PARAMETERS TO R-W LIST
/NOT ENOUGH BLKS LEFT
LDA
FDV2RW,
LDA
FDV+2000
STA
RWPARM+2000
/NO-ASK FOR NAME AGAIN
/ASK FOR UNIT/BLK NO
/ERROR
/BLK NO
/NO OF BLKS
/NO ENOUGH BLKS LEFT

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0476 0475 2407
0477 0476 1000
0500 0477 2404
0501 0500 1040
0502 0501 2410
0503 0502 6000
0504
0505 0503 4114
0510 0504 2000
0511 0505 4522
0512 0506 2114
0513 0507 0643
0514 0510 0061
0515 0511 0001
0516 0512 1120
0517 0513 7377
0520 0514 0451
0521 0515 6520
0522 0516 0221
0523 0517 6512
0524 0520 1000
0525 0521 0001
0526 0522 0000
0531 0523 1000
0532 0524 0000
0533 0525 4571
0534 0526 0602
0535 0527 6711
0536 0530 1020
0537 0531 2453
0540 0532 6720
0541 0533 0061
0542 0534 3043
0543 0535 1020
0544 0536 0017
0545 0537 5627
0546 0540 6571
0547 0541 1040
0550 0542 2375
0551 0543 0061
0552 0544 7044
0553 0545 0062
0554 0546 6375
0555 0547 0063
0556 0550 7767
0557 0551 1321
0560 0552 0470
0561 0553 6571
0562 0554 0456
0563 0555 1321
0564 0556 0450
0565 0557 6562
0566 0560 1320
0567 0561 7700
0570 0562 1362
0571 0563 0223
0572 0564 4555
0573 0565 0554
0574 0566 0555
0575 0567 0556
0576 0568 0557
0577 0569 0558
0578 0570 0559
0579 0571 0560
0580 0572 0561
0581 0573 0562
0582 0574 0563
0583 0575 0564
0584 0576 0565
0585 0577 0566
0586 0578 0567
0587 0579 0568
0588 0580 0569
0589 0581 0570
0590 0582 0571
0591 0583 0572
0592 0584 0573
0593 0585 0574
0594 0586 0575
0595 0587 0576
0596 0588 0577
0597 0589 0578
0598 0590 0579
0599 0591 0580
0600 0592 0581
0601 0593 0582
0602 0594 0583
0603 0595 0584
0604 0596 0585
0605 0597 0586
0606 0598 0587
0607 0599 0588
0608 0600 0589
0609 0601 0590
0610 0602 0591
0611 0603 0592
0612 0604 0593
0613 0605 0594
0614 0606 0595
0615 0607 0596
0616 0608 0597
0617 0609 0598
0618 0610 0599
0619 0611 0600
0620 0612 0601
0621 0613 0602
0622 0614 0603
0623 0615 0604
0624 0616 0605
0625 0617 0606
0626 0618 0607
0627 0619 0608
0628 0620 0609
0629 0621 0610
0630 0622 0611
0631 0623 0612
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0673 0665 0654
0674 0666 0655
0675 0667 0656
0676 0668 0657
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0678 0670 0659
0679 0671 0660
0680 0672 0661
0681 0673 0662
0682 0674 0663
0683 0675 0664
0684 0676 0665
0685 0677 0666
0686 0678 0667
0687 0679 0668
0688 0680 0669
0689 0681 0670
0690 0682 0671
0691 0683 0672
0692 0684 0673
0693 0685 0674
0694 0686 0675
0695 0687 0676
0696 0688 0677
0697 0689 0678
0698 0690 0679
0699 0691 0680
0700 0692 0681
0701 0693 0682
0702 0694 0683
0703 0695 0684
0704 0696 0685
0705 0697 0686
0706 0698 0687
0707 0699 0688
0708 0700 0689
0709 0701 0690
0710 0702 0691
0711 0703 0692
0712 0704 0693
0713 0705 0694
0714 0706 0695
0715 0707 0696
0716 0708 0697
0717 0709 0698
0718 0710 0699
0719 0711 0700
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0769 0761 0750
0770 0762 0751
0771 0763 0752
0772 0764 0753
0773 0765 0754
0774 0766 0755
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0776 0768 0757
0777 0769 0758
0778 0770 0759
0779 0771 0760
0780 0772 0761
0781 0773 0762
0782 0774 0763
0783 0775 0764
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0791 0783 0772
0792 0784 0773
0793 0785 0774
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0799 0791 0780
0800 0792 0781
0801 0793 0782
0802 0794 0783
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0806 0798 0787
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0808 0800 0789
0809 0801 0790
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0869 0861 0850
0870 0862 0851
0871 0863 0852
0872 0864 0853
0873 0865 0854
0874 0866 0855
0875 0867 0856
0876 0868 0857
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0878 0870 0859
0879 0871 0860
0880 0872 0861
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0895 0887 0876
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0900 0892 0881
0901 0893 0882
0902 0894 0883
0903 0895 0884
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0905 0897 0886
0906 0898 0887
0907 0899 0888
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0919 0911 0900
0920 0912 0901
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1001 0993 0982
1002 0994 0983
1003 0995 0984
1004 0996 0985
1005 0997 0986
1006 0998 0987
1007 0999 0988
1008 1000 0989
1009 1001 0990
1010 1002 0991
1011 1003 0992
1012 1004 0993
1013 1005 0994
1014 1006 0995
1015 1007 0996
1016 1008 0997
1017 1009 0998
1018 1010 0999
1019 1011 1000
1020 1012 1001
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05 0565 1020 LDA I
05 0566 0001 1
0576 0567 1140 ADM
0577 0570 0571 .+1
0600 0571 0000 ASK2X, 2
0601 /ASK FOR UNIT NUMBER + BLK NO AND CONVERT
0602 /STORE UNIT THRU B7
0603 /" BLK NO " B10
0604 ASK3, LDA
0605 1000 2
0606 0572 1000 STC ASK3X
0607 0573 0000 LIF 2
0608 0574 4626 LDA I
0609 0575 0602 GUES3+2000
0610 0576 1020 JMP ASK
0611 0577 2475 SET I 1
0612 0600 6720 ANSWER+2000
0613 0601 0061 JMP OCTL
0614 0602 3043 LDA I
0615 0603 6711 17
0616 0604 1020 JMP CONV
0617 0605 0017 JMP ASK3X
0618 0606 6627 STA
0619 0607 6626 FDV+2000
0620 0610 1040 SET I 1
0621 0611 2375 ANSWER+6001
0622 0612 0061 LDA I
0623 0613 7044 777
0624 0614 1020 JMP CONV
0625 0615 0777 JMP ASK3X
0626 0616 6627 STA
0627 0617 6626 FDV+2006
0628 0620 1040 LDA I
0629 0621 2403 1
0630 0622 1020 ADM
0631 0623 0001 .+1
0632 0624 1140 ASK3X, 0
0633 0625 0626 /CONVERT NUMBER IN ANSWER BUFFER TO BINARY
0634 /ENTER WITH MAX LEGAL VALUE IN AC
0635 /IF LEGAL - EXIT CALL+2 WITH VALUE IN AC
0636 CONV, COM
0637 0017 STC
0638 0630 4675 TEMP2 /COMPLEMENT MAX VALUE
0639 0631 4114 TEMPI
0640 0632 2000 /RETURN ADDR
0641 0633 4674 CONVER
0642 0634 1321 /GET A CHAR
0643 0635 0470 NXTCHR, LDH I 1
0644 0636 6660 AZE I
0645 0637 1120 JMP ERRCHK
0646 0640 7720 ADA I
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0651 0644 1120 LDH 1
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1365 1360 0000
1366 1361 0000
1367 1362 0000
1368 1363 0000
1369 1364 0000
1370 1365 0000
1371 1366 0000
1372 1367 0000
1373 1368 0000
1374 1369 0000
1375 1370 0000
1376 1371 0000
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1380 1375 0000
1381 1376 0000
1382 1377 0000
1383 1378 0000
1384 1379 0000
1385 1380 0000
1386 1381 0000
1387 1382 0000
1388 1383 0000
1389 1384 0000
1390 1385 0000
1391 1386 0000
1392 1387 0000
1393 1388 0000
1394 1389 0000
1395 1390 0000
1396 1391 0000
1397 1392 0000
1398 1393 0000
1399 1394 0000
1400 1395 0000
1401 1396 0000
1402 1397 0000
1403 1398 0000
1404 1399 0000
1405 1400 0000
1406 1401 0000
1407 1402 0000
1408 14
```


Address	Code	Label	Comment
0770	0770	LMODE	
0771	0771	#1	
0772	0772	DISPLY, POP	
0773	0773	PMODE	
0774	0774	CLA	
0775	0775	TAD	N
0776	0776	CLL	RAR
0777	0777	DCA	GR
1000	1000	TAD	GR
1001	1001	CIA	
1002	1002	DCA	ADD2
1003	1003	TAD	C2000
1004	1004	DCA	LOADDR
1005	1005	TAD	C1777
1006	1006	TAD	N
1007	1007	DCA	UPADDR
1010	1010	CIF	10
1011	1011	JMS	I
1012	1012	RWPARM	PREAD
1013	1013	LINC	
1014	1014	LMODE	
1015	1015	LDA	I
1016	1016	QUES	13+2000
1017	1017	LIF	2
1020	1020	JMP	ASK
1021	1021	LDH	
1022	1022	ANSWER	+6000
1023	1023	AZE	
1024	1024	JMP	.+3
1025	1025	LIF	2
1026	1026	JMP	IFDIAL
1027	1027	PDP	
1030	1030	PMODE	
1031	1031	TAD	M11
1032	1032	SNA	
1033	1033	JMP	DPIMAG
1034	1034	TAD	M4
1035	1035	SNA	
1036	1036	JMP	I
1037	1037	TAD	M5
1040	1040	SNA	
1041	1041	JMP	DPREAL
1042	1042	TAD	M1
1043	1043	SNA	CLA
1044	1044	JMP	I
1045	1045	LINC	
1046	1046	LMODE	
1047	1047	JMP	DISPL1
1050	1050	REALFG	0
1051	1051	PMODE	
1052	1052	PDPSCAL	
1053	1053	DPIMAG	
1054	1054	SZA	CLA
1055	1055	JMP	DISPER
1056	1056	TAD	I
1057	1057	SZA	CLA
1060	1060	JMP	NOSWPI
1061	1061	CMA	
1062	1062	TAD	N
1063	1063	DCA	10
1064	1064	TAD	GR
1065	1065		

/NO OF PTS/2

/-NO OF PTS/2

/LOWER ADDR OF DISPLAY

/UPPER ADDR OF DISPLAY

/READ IN DATA

/WHICH DISPLAY

/LINE FEED

/IMAG

/MAGNITUDE

/REAL

/SCALE FACTOR

/ERROR

/NO IMAG PARTS TO DISPLAY

/IF TRANSFORM WAS DONE, SWAP HALVES

/INVERSE WAS DONE

/OLD LOW ADDR OF 1ST 1/2 = NO OF PTS
/NEW LOW ADDR OF 1ST 1/2 = 2000 + NO OF PTS/2


```

1166
1167 * SHOWIT, JMS I KIDORA
1168 6162 4517 0001 /LOW ADD " " ELO
1169 6163 0001 / " " " "
1170 6164 0000 LOADOR, 0 /HIGH " " "
1171 6165 0001 1 / " " "
1172 6166 0000 UPADDR, 0 /Y OFFSET
1173 6167 0000 0 /SCALE
1174 2170 0345 LMODE
1175 SCR 3
1176 PMODE
1177 JMS I KRORA
1178 6171 4520 KSF
1179 6172 5031 JMP , -2
1180 6173 5371 KRB
1181 6174 6236 TAD M215
1182 6175 1102 TAD M215
1183 6176 7650 SNA CLA
1184 6177 5360 JMP REDPLY
1185 6200 6036 KRB
1186 6201 1106 TAD M261
1187 6202 7650 SNA CLA
1188 6203 5216 JMP LARGER
1189 6204 6036 KRB
1190 6205 1103 TAD M321
1191 6206 7650 SNA CLA
1192 6207 5211 JMP SMALLR
1193 6210 5522 JMP I PRFRSH
1194 6211 1536 SMALLR, TAD I KYSCAL
1195 6212 1104 TAD M353
1196 6213 7710 SPA CLA
1197 6214 2536 ISZ I KYSCAL
1198 6215 5522 JMP I PRFRSH
1199 6216 1536 LARGER, TAD I KYSCAL
1200 6217 1105 TAD M340
1201 6220 7750 SPA SNA CLA
1202 6221 5522 JMP I PRFRSH
1203 6222 7040 CMA
1204 6223 1536 TAD I KYSCAL
1205 6224 3536 DCA I KYSCAL
1206 6225 5522 JMP I PRFRSH
1207 /DISPLAY SCALE FACTOR
1208 DPSCAL, TAD I PRELFG
1209 6226 1532 SZA CLA
1210 6227 7640 JMP I PDSPER
1211 6230 5772 TAD N
1212 6231 1003 CLL RAL
1213 6232 7104 DCA TEMPR
1214 6233 3034 TEMPR
1215 6234 6211 CDF1
1216 6235 1434 TAD I TEMPR
1217 6236 1077 TAD M11
1218 6237 7740 SMA SZA CLA
1219 6240 5244 JMP GR9
1220 6241 1074 TAD LESS10
1221 6242 1434 TAD I TEMPR
1222 6243 5247 JMP SHOSCL
1223 6244 1071 TAD M12
1224 6245 1434 TAD I TEMPR
1225 6246 1073 TAD GRET10
1226 6247 6201 SHOSCL, CDF0
1227 6250 3266 DCA DPMAG-2
1228 6251 6141 I INC
1229
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1234
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```

JUST REAL MEANS I DIDNT MAKE FILE = NO SCALE FACTOR

ADDR = NO OF PTS*2

SPACE + ASCII SCALE FACTOR

10+SCALE FACTOR-10

STORE IN DISPLAY PARAMETERS


```

1420 /LOOKUP, ENTER PARAMETER LIST
1421 FDV, 0 /UNIT 0
1422 0375 0000 /FILE NAME - 8 CHAR
1423 0376 0000
1424 0377 0000
1425 0400 0000
1426 0401 0000
1427 0402 0002 /BINARY
1430 0403 0000 /BLK NO
1431 0404 0000 /NO OF BLKS
1432 /
1433 RWPARM, 0000 /UNIT
1434 0406 0020 /BUFFER ADDR
1435 0407 0000 /BLK NO
1436 0410 0000 /NO OF BLKS
1437 /
1440 LM MODE
1441 /QUESTIONS
1442 0411 4040
1443 0412 4040
1444 0413 4023
1445 0414 1116
1446 0415 0714
1447 0416 0540
1448 0417 2022
1449 0420 0503
1450 0421 1123
1451 0422 1117
1452 0423 1640
1453 0424 0606
1454 0425 2443
1455
1456 0426 4740
1457 0427 4347
1458
1459 0430 4043
1460 0431 0640
1461 0432 4011
1462 0433 1620
1463 0434 2524
1464 0435 4017
1465
1466 F INPUT ON
1467 0436 1643
1468
1469 0437 4740
1470 0440 4306
1471 0441 4040
1472 0442 0411
1473 0443 0114
1474 0444 4025
1475 0445 1611
1476 0446 2477
1477 0447 4031
1478 0450 5716
1479 0451 7461
1480 0452 3400
1481
1482 F DIAL UNIT? Y/N<1>Z
1483 QUES1. TEXT 2 SINGLE PRECISION FFT
1484 QUES2. TEXT 2
1485
1486 453 4043
1487 54 0625
1488 455 1611
1489 456 2440
1490

```

1450 0457 1625
1450 0460 1502
1450 0461 0522
1450 0462 7462
1451 0463 4347
1451
1451
1452 0464 4043
1452 0465 0606
1452 0466 1114
1452 0467 0540
1452 0470 1601
1452 0471 1505
1452 0472 4040
1452 0473 7470
1452 0474 3400
1452
1453
1454 0475 4043
1454 0476 0640
1454 0477 4025
1454 0500 1611
1454 0501 2440
1454 0502 1625
1454 0503 1502
1454 0504 0522
1454
1455 0505 7462
1455 0506 4347
1455
1456 0507 4043
1456 0510 0640
1456 0511 4002
1456 0512 1413
1456 0513 4016
1456 0514 2515
1456 0515 0205
1456 0516 2240
1456 0517 7463
1456 0520 3400
1456
1457
1460 0521 4043
1460 0522 0610
1460 0523 1727
1460 0524 4015
1460 0525 0116
1460 0526 3140
1460 0527 2024
1460 0530 2377
1460
1461 0531 7464
1461 0532 4347
1461
1462 0533 4043
1462 0534 4740
1462 0535 5064
1462 0536 5561
1462 0537 6062
1462 0540 6440
1462 0541 0231
1462 0542 4020

FUNIT NUMBER<2

FFILE NAME <8\Z
QUES3, TEXT Z

F UNIT NUMBER<2

F BLK NUMBER <3\Z
QUES4, TEXT Z

FLOW MANY PTS? <4

(4=1024 BY POWERS OF 2)

FREAL OR

FCOMPLEX? R/C<1\Z
QUES5, TEXT Z

F OUTPUT ON

F DIAL UNIT? Y/N<1\Z
QUES6, TEXT Z

F REPLACE? Y/N<1\Z
QUES11, TEXT Z

1462	0545	2340
1462	0546	1706
1462	0547	4062
1463	0550	5143
1463		
1464	0551	4740
1464	0552	4306
1464	0553	2205
1464	0554	0114
1464	0555	4017
1464		
1465	0556	2243
1465		
1466	0557	4740
1466	0560	4306
1466	0561	0317
1466	0562	1520
1466	0563	1405
1466	0564	3077
1466	0565	4022
1466	0566	5703
1466	0567	7461
1466	0570	3400
1466		
1467		
1470	0571	4306
1470	0572	4040
1470	0573	1725
1470	0574	2420
1470	0575	2524
1470	0576	4017
1470		
1471	0577	1643
1471	0600	0640
1471	0601	4004
1471	0602	1101
1471	0603	1440
1471	0604	2516
1471	0605	1124
1471	0606	7740
1471	0607	3157
1471	0610	1674
1471	0611	6134
1471		
1472	0612	4043
1473		
1473		
1474	0613	4740
1474	0614	4306
1474	0615	4022
1474	0616	0520
1474	0617	1401
1474	0620	0305
1474	0621	7740
1474	0622	3157
1474	0623	1674
1474	0624	6134
1474		
1475		
1476	-5	4306
1476	0626	0606

1470	0027	2440	
1476	0630	1722	
1476	0631	4004	
1476	0632	1123	
1476	0633	2014	
1476	0634	0131	
1476	0635	7740	
1476	0636	0657	
1476	0637	0474	
1477	0640	6143	
1477			
1500	0641	4740	
1500	0642	4347	
1500			
1501	0643	4043	
1501	0644	0624	
1501	0645	2201	
1501	0646	1623	
1501	0647	0617	
1501	0650	2215	
1501	0651	4017	
1501			
1502	0652	2243	
1502			
1503	0653	4740	
1503	0654	4306	
1503	0655	1116	
1503	0656	2605	
1503	0657	2223	
1503	0660	0577	
1503	0661	4024	
1503	0662	5711	
1503	0663	7461	
1503	0664	3400	
1503			
1504			
1505	0665	4306	
1505	0666	2710	
1505	0667	1103	
1505	0670	1040	
1505	0671	0411	
1505	0672	2320	
1505	0673	1401	
1505	0674	3177	
1505			
1506	0675	7461	
1506	0676	4347	
1506			
1507	0677	4043	
1507	0700	4740	
1507	0701	4040	
1507	0702	4040	
1507	0703	2250	
1507	0704	0501	
1507			
1510	0705	1451	
1510	0706	4347	
1510	0707	4040	
1510	0710	4040	
1510	0711	4011	
1510	0712	5015	
1510	0713	0107	

FFFT OR DISPLAY? F/D<1

FTRANSFORM OR

FINVERSE? T/I<1>\Z
 QUES13, TEXT Z

FHIGH DISPLAY?<1

R (EAL)

I (MAGINARY)

M (MAGNITUDE)

S (SCALE FACTOR)

LINE FEED (RESTART) \Z

/MESSAGES
MSG1, TEXT Z

F CANNOT FIND

1510	0715	0122
1511	0716	3151
1511	0717	4347
1511	0720	4040
1511	0721	4040
1511	0722	4015
1511	0723	5001
1511	0724	0716
1511	0725	1124
1511	0726	2504
1511	0727	0551
1512	0730	4347
1512	0731	4040
1512	0732	4040
1512	0733	4023
1512	0734	5003
1512	0735	0114
1512	0736	0540
1512	0737	0601
1512	0740	0324
1512	0741	1722
1512	0742	5143
1513	0743	4740
1513	0744	4040
1513	0745	4040
1513	0746	1411
1513	0747	1605
1513	0750	4006
1513	0751	0505
1513	0752	0450
1513	0753	2205
1513	0754	2324
1513	0755	0122
1513	0756	2451
1513	0757	3400
1513	0760	4347
1516	0761	4043
1517	0762	0640
1517	0763	4040
1517	0764	4003
1517	0765	0116
1517	0766	1617
1517	0767	2440
1517	0770	0611
1517	0771	1604
1520	0772	4347
1520	0773	4043
1521	0774	4740
1521	0775	4040
1521	0776	4040
1521	77	4040
1521	-000	4040
1521	1001	4010

1607	PHODE		
1610	/MOVE PTS FROM ONE AREA TO ANOTHER		
1611	/10 = OLD BUFFER		
1612	/11 = NEW "		
1613	/IF CMPFLG=1, COMPLEMENT VALUE		
1614	MOVPTS, 0	2000	
1615	CONF	7116	
1616	TAD	7117	
1617	CLL RAR	7120	
1620	TAD I	7121	
1621	SZL	7122	
1622	CIA I	7123	
1623	ISZ	7124	
1624	JMP	7125	
1625	CONF	7126	
1626	JMP I	7127	
1630	MOVPTS	7130	
1631		7131	
1632			
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1661			

7132	0000		
7133	7040	CMA	
7134	3010	DCA	
7135	1037	TAD	
7136	1110	TAD	
7137	3011	DCA	
7140	1033	TAD	
7141	3034	DCA	
7142	3130	DCA	
7143	4527	JMS I	
7144	7040	CMA	
7145	1037	TAD	
7146	3010	DCA	
7147	1110	TAD	
7150	3011	DCA	
7151	1033	TAD	
7152	3034	DCA	
7153	4527	JMS I	
7154	5732	JMP I	

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C1777			
11			
ADD2			
TEMPR			
CMPFLG			
PMVPTS			
GR			
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C1777			
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ADD2			
TEMPR			
CMPFLG			
PMVPTS			
JMS I			
JMP I			

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C1777			
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ADD2			
TEMPR			
CMPFLG			
PMVPTS			
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TEMPR			
CMPFLG			
PMVPTS			
JMS I			
JMP I			

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ADD2			
TEMPR			
CMPFLG			
PMVPTS			
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CMPFLG			
PMVPTS			
JMS I			
JMP I			

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JMS I			
JMP I			

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JMP I			

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CMPFLG			
PMVPTS			
JMS I			
JMP I			

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C1777			
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CMPFLG			
PMVPTS			
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JMP I			

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CMPFLG			
PMVPTS			
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TEMPR			
CMPFLG			
PMVPTS			
JMS I			
JMP I			

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TEMPR			
CMPFLG			
PMVPTS			
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TEMPR			
CMPFLG			
PMVPTS			
JMS I			
JMP I			

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ADD2			
TEMPR			
CMPFLG			
PMVPTS			
GR			
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C1777			
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ADD2			
TEMPR			
CMPFLG			
PMVPTS			
JMS I			
JMP I			

10			
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ACDF0 1202
ADDER 41
ADDR .35
ADDW0S 1157
ADD1 1174
ADD2 0033
ADJSGN 0570
ANSWER 7043
ARG2 1020
ASK 4720
ASKX 4740
ASK2 4523
ASK2X 4571
ASK3 4572
ASK3X 4626
ASR 7415
BIGSNU 0012
BOUND 1516
BUFHI 1574
BUFLO 1575
BUFPTR 1504
BUILD 0544
C 0032
CAM 7621
CCDF0 1401
CCIA 0162
CCLR 0146
CDF0 6201
CDF1 6211
CHKEND 4650
CHKHI 1473
CHKPT 0515
CKEND 4211
CMPFLG 0130
CNOP 0163
CNOIS 0677
CONT 1400
CONV 4627
CONVER 4674
CORVAL 0114
COSINE 0036
COUNT 0116
CSAM 1351
CURCNT 1573
CURDIS 1551
CURL0P 1563
CURRTN 1450
CURSAM 0101
C1000 0137
C1777 0110
C2000 0140
C6000 0101
DADD 1504
DATTAP 4061
DBLHI 1541
DBLLO 1547
DISFLG 4242
DISPER 6051
DISPLY 6001
DISPL1 6022

DOIFFT 0047
DPI MAG 6055
DPMAG 6270
DPREAL 6117
DPSCAL 6226
DPSQ 0142
DSCLOC 1244
DSCLOP 1275
DSCWD 1261
DVI 7407
ENDHI 1577
ENDLO 1576
ERRCHK 4660
F 0007
FDV 6375
FDV2RW 4466
FFT 0400
FIF 4251
FLIP 1046
FLIPCT 0063
FREE 1365
FRESAM 0105
FT 4365
GETRIG 0045
GI 0040
GQ1000 6147
GR 0037
GRET10 0073
GR9 6244
IDORA 1200
IFCOM 4203
IFDIAL 4026
IFDISP 4265
IFFFT 4231
IFFT 0147
IFI 4261
IFT 4363
IFTFLG 4356
IMGPTR 6336
INDEX 1134
INFILE 4555
INVERT 0043
INVRT 1040
K 0031
KBUFHI 1241
KBUFLO 1242
KIDORA 0117
KMNADR 1236
KMNFLD 1235
KMXADR 1240
KMXFLD 1237
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