516-47

Bell Laboratories

subject: Remote Data Plotting

date: March 3, 1971

from: H. Lycklama
E. J. Sitar

MEMORANDUM FOR FILE

Mini-computer users are often faced with the problem of finding a viable solution for a graphical display of a data set. This memorandum proposes a solution to this problem for those mini-computer users which have the ability to communicate data to the GE-635 computer at Murray Hill.

The method used is to build a data file in a prescribed sequence which can then be read by a simple Fortran program. This program, after reading the data, calls upon the plotting routine TPLØT to draw a specified graph. The flexibilities of TPLØT are kept by use of an option data card. The proposed data file sequence is as follows:

```
$ SNUMB
$ SGRADE
$ IDENT
$ SELECT        GRAPHICS/516PLØT
```

Data deck:

```
$ SELECT        CC/GRAPHB
$ ENDJØB
```

The data deck shall consist of the following:

1. Option cards
2. Titling and labeling cards (TTL, STL, YLB, XLB)
3. Card specifying number of different data sets
4. Card specifying number of points (N) in this data point set
5. Data set consisting of N(X,Y) pairs or N(X) points or N(Y) points

Data cards one to five are required for each individual plot. When data card three indicates more than one data point set cards four and five are required for each one. The options card contains the following variables:

LLX LLY NGL ARX ARY YREF LABØP	Grid selection options
KØ XMIN XMAX YMIN YMAX	Scaling options
KX KY ITYCUR NTT CHAR+	Curve drawing options

+ - This variable must be on a separate data card. The meaning of this variable is a function of the variable ITYCUR. See discussion below

DESCRIPTION OF VARIABLES

Titling and Labeling

TTL = A data card containing the desired title caption (72 character limit).

STL = A data card containing the desired subtitle (second line of title) caption (72 character limit). The subtitle array is also used as the only caption to title the second, third, and fourth graphs if they occur on the same sheet (frame) i.e., the multigraph option with LLY = 4, 5, or 6.

YLB = A data card containing the Y or vertical axis label (36 character limit).

XLB = A data card containing the X (horizontal) axis label (36 character limit).

Grid Options

LLX =
- 1 linear scale for X, X-data is in floating-point form
- 2 logarithmic scale for X, X-data is in floating-point form
- 3 linear scale for X, fixed-point input, X data is in integer form

The maximum number of decades obtainable in the X direction for a log scale is the integer part of $7.2 * |ARX|$. Only an integer number of decades is drawn.

LLY = 1 linear scale for Y, Y-data is in floating-point form

2 logarithmic scale for Y, Y-data is in floating-point form

3 linear scale for Y, fixed-point input, Y-data is in integer form

4 same as (1)
5 same as (2)
6 same as (3)

and in addition, if possible, the grid area and plotting occurs on the same sheet and below that grid established on the previous data set. The vertical separation between grid areas is controlled by YREF. The title for this second grid area is STL. If there is insufficient space on the frame for this additional grid then a diagnostic comment is printed and the additional grid is placed on a new frame.

NGL = Grid line option

1 draws all grid lines

2 draws horizontal grid lines plus vertical grid ticks

3 draws vertical grid lines plus horizontal grid ticks

4 draws outline only plus grid ticks on both axes

5 same as (4) plus the lines X = 0 and Y = 0 if they lie within the plotting area

ARX = X axis aspect ratio. If ARX is a fixed-point integer $\leq$ 2047 then no action is taken and the width of the grid area is set at 900 plotting units corresponding

to an X axis aspect ration of 1.0. If ARX is a floating-point number then it is interpreted as the X axis aspect ratio and is bounded to lie $0.4 \leq |ARX| \leq 1.0$. The width of the grid area is then equal to $900.*|ARX|$ units. For X axis aspect ratios less than unity the grid area is centered about the middle of the frame. The sign of ARX controls the direction of increasing X; a positive ARX gives X increasing to the right, while a negative ARX gives a decreasing X scale to the right. This applies for both linear and logarithmic scales, i.e., LLX = 1, 2, or 3.

ARY = Aspect ratio in Y direction. The grid area height is equal to $640*|ARY|$ plotting units. If a linear scale for Y (LLY = 1, 3, 4, or 6) is used then the aspect ratio is bounded as $0.25 \leq |ARY| \leq 1.407$. If a log scale for Y (LLY = 2 or 5) is used then the aspect ratio is bounded as $0.70 < |ARY| < 1.407$. If a square grid area is desired then |ARY| should be set at $1.407*|ARX|$ (the X direction aspect ratio). The sign of ARY controls the direction of increasing Y, a positive ARY gives an increasing Y scale upward, while a negative ARY gives a decreasing Y scale upward. This applies to both linear and logarithmic scales, i.e., LLY = 1, 2, 3, 4, 5, or 6.

YREF = Vertical reference point control. If YREF is a fixed-point integer $\leq$ 2047 no action is taken. If YREF is a floating-point number then this number is interpreted as the number of plotting units to be included between the top of the frame and the top of the grid area (this is where the title is printed). Normally this number is set at 51 units. Thus YREF can be used to override this minimum distance of 51 units if more space is desired. If YREF is less than 51.0 then no override occurs. This variable YREF, is also effective on increasing the vertical separation between grids when the multigraph options is used (LLY = 4, 5, or 6). Here the vertical separation will be equal to 11. + XMAX1F (51., YREF).

LABØP = 1 labels every other horizontal grid line (Effective only for linear scaling)

2 labels every horizontal grid line (Effective only for linear scaling)

3 indicates that no horizontal grid lines are to be labeled and assumes that the user has the Y-data in proper integer form for plotting. The Y-data should have values as follows:

$$0 > IY(I) > -[\,640.*|ARY|\,]$$

4 indicates that no vertical grid lines are to be labeled and assumes that the X-data is in integer form ready for plotting. The X-data should satisfy the following constraints:

[450.*(1. - | ARX |)] < IX(I) < [450.*(1. = | ARX |)] ,

5 indicates 3 and 4

Scaling Options

KØ = scaling option

KØ	X Scale	Y Scale
1	automatic	automatic
2	automatic	specified
3	specified	automatic
4	specified	specified

"Automatic" implies that the plotting routine TPLØT will scan the corresponding coordinate array and pick the maximum and minimum values for use as suggested scale extremes. "Specified" implies that TPLØT is to use the corresponding input MAX and MIN values as suggested scale extremes. The scaling routine will then use these suggested scale extremes as a starting point for determining the final scale extremes, the determination being affected also by scale readability, line density, aspect ratio, and the choice of linear or logarithmic scaling.

XMIN = The algebraically smallest (most negative or least positive if all X are positive) X value expected in the X data. Used only when KØ = 3 or 4.

XMAX = The algebraically greatest (most positive or least negative if all X are negative) X value expected in the X data. Used only when KØ = 3 or 4.

If KX = 2 then XMAX and XMIN apply to the array of the absolute magnitudes of the X data.

YMIN = The algebraically smallest Y value expected in the Y data. Used only when KØ = 2 or 4.

YMAX = The algebraically largest Y value expected in the Y data. Used only when KØ = 2 or 4.

If KY = 2 then YMAX and YMIN apply to the array of the absolute magnitudes of the Y data.

Curve Drawing Options

KX = 1 plots X

2 plots | X |

3 uses previous X data array as the X coordinate array. When this option is specified data card six must only contain Y data. It may be used only if the grid size is not changed in the X direction and if automatic scale selection (i.e., peak picking) is not to be performed on this X array.

4 denotes that there are multiple sets of Y data to be plotted for the same X data. Thus data card six must contain both X and Y data in first data set; subsequent data sets must contain only the new Y data.

KY = 1 plots Y

2 plots | Y |

3 uses previous Y data array as the Y coordinate array. When this option is chosen data card six only contains Y data. It may be used only if the grid size is not changed in the Y direction and if automatic scale selection is not to be performed on this Y array.

4 denotes that there are multiple sets of X data to be plotted for the same Y data. Thus data card six must contain both X and Y data in first data set; subsequent data sets must contain only the new X data.

ITYCUR = data presentation option as follows:

1 data points connected consecutively by straight lines to form a continuous curve.

2 same as (1) except curve is broken into about five segments and one character is plotted as an identifying label between each of the segments. The character will be A,B,C,...,H corresponding to the values of ISET = 1,2,3,...,8. If NPTS < 25 then the curve will be drawn as one long segment ((1) above) with the single identifying character placed 8 plotting units (0.08 inches) to the right of the last plotted point (X(NPTS), Y(NPTS)).

3 same as (2) except curve labeling is done with the leftmost BCD character in CHAR.

4 no vectors drawn; instead the leftmost BCD character in CHAR is plotted at each (X,Y) point.

5 data connected by straight lines in pairs as (X_1,Y_1) to (X_2,Y_2),(X_3,Y_3) to (X_4,Y_4) etc. to give the dashed line effect. The order of the values in the X and Y arrays is preserved, i.e., there is no rearrangement of values.

6 General dashed line option, CHAR is assumed to be a two (2) element array where CHAR (2) is a Fortran integer corresponding to the number of points in the repeated dashed pattern to be plotted and where CHAR(1) is a word whose first [CHAR(2) - 1] bits specify the connection pattern for adjacent data points.

7 General object drawing option. The subroutine, URSUBR, optionally supplied by the user is executed at each data point, i.e., at (X(I),Y(I)) for I = 1, NPTS.

NTT = Number of times each drawn curve is to be traced. This feature is used to add weight to a plotted line. NTT is bounded to lie $1 \leq NTT \leq 5$ by practical considerations.

CHAR = If ITYCUR is 3 or 4 then the character to be used is in Column 1 of the data card. If ITYCUR = 6 then CHAR is assumed to be a two(2) integer data element with CHAR (1) containing the connectivity information and CHAR (2) containing the number of points in the repeat pattern.

The particular data layout discussed here has been used in the Dept. 1383 DDP-516 time sharing system. A program to generate data in the proper format may be written in FSNAP - an interpretative calculating language designed to run on the DDP-516 time sharing system. The Appendix includes an example of a typical user interaction required to produce a plot on the GE machine. All user responses are underlined. A listing of the actual program is included with appropriate comments. The user specifies that he wishes to write his data in the file PLTFILE and that he wishes to generate data for 2.5 periods

of a sine curve. After execution of the program the user simply invokes GEPLØT to generate a plot on the GE machine and GELIST to obtain a list of the plot data file. The jobs generated are put on a queue and sent across to the GE computer via the 201 DATA-PHONE® link. As noted by the time of day data the actual plots are available to the user in less than ten minutes from the time at which they were sent to the GE computer. A list of the data file as well as the plots generated are included in the Appendix.

H. LYCKLAMA

MH-1383-HL
8231-EJS-JER

E. J. SITAR

Att.
Appendix

APPENDIX

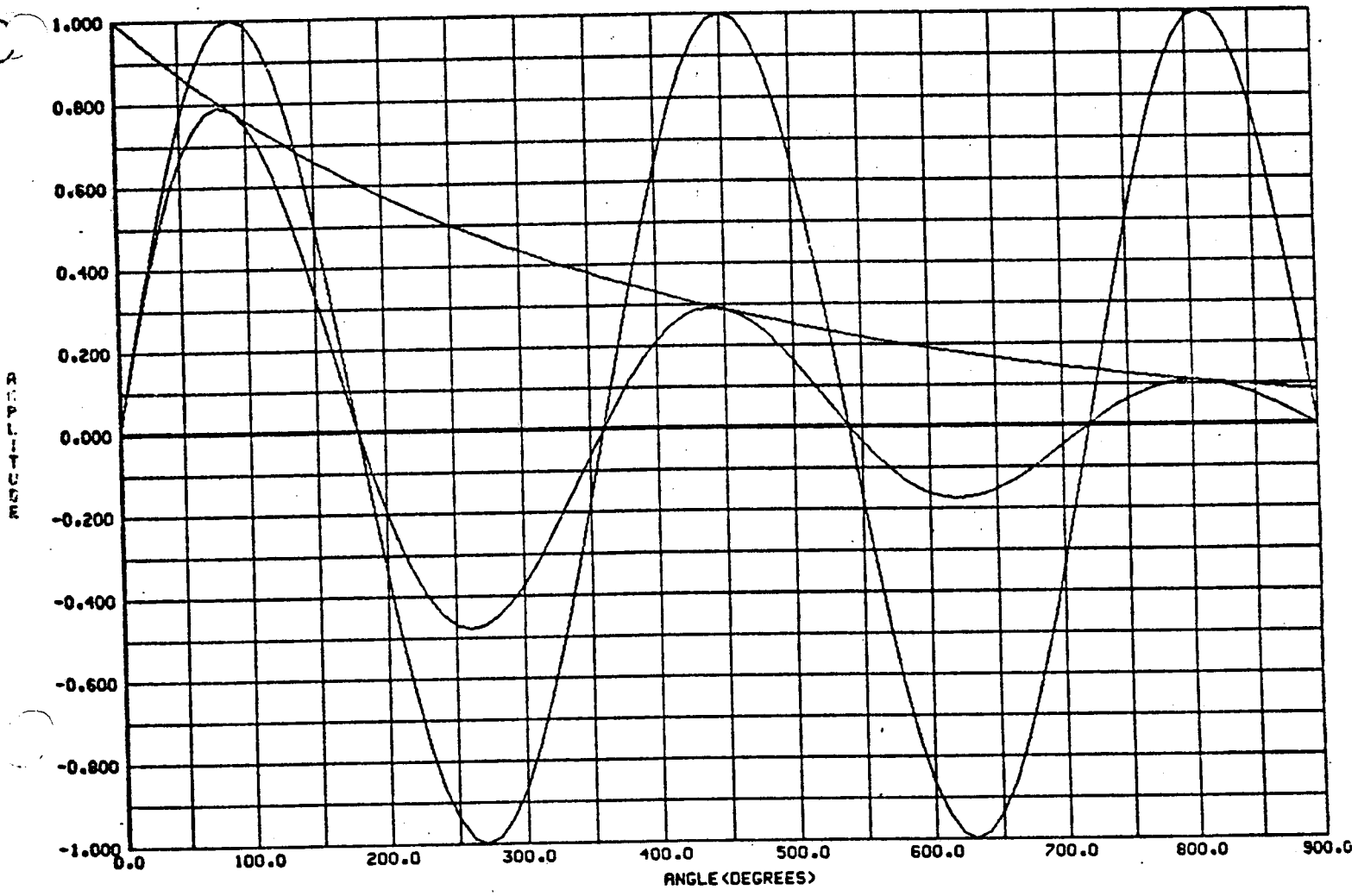
```
!516 TSS  03/15/71PM 09:22:59
PASSWORD? HL

PROGRAM? FSNAP

PROGRAM FILE? PLOT516
FSNAP- E

*EDIT
P1,99
001 \ LIST OF THE PL01 OPTIONS
002     WRITE "1 1 1 1.0 1.0 51.0 1 1 0.0 1.0 0.0 1.0 4 1 1 3 1" !
003     WRITE " DDP-516 REMOTE PLOT "!                    \TITLE
004     WRITE " DAMPED SINE WAVE "!                       \SUB-TITLE
005     WRITE " AMPLITUDE "!                              \Y AXIS LABEL
006     WRITE " ANGLE(DEGREES) "!                         \X AXIS LABEL
007     NCURV=3                                           \NUMBER OF CURVES
008     WRITE %4,NCURV !
009     ASK !"NUMBER OF PERIODS =" NPER
010     NPTS=INT(NPER*36+1)
011     PI=3.14159/180
012     ANGF=NPER*360                                     \NO. OF DATA PAIRS IN SET
013     WRITE NPTS !
014     FOR I=0,ANGF,10
015     SINE=SIN(I*PI)                                    \(X,Y) PAIRS
016     WRITE %5.1,I,%6.4,SINE
017     SS=40*INT((I+10)/40)-10;IF(SS=I)WRITE !
018     NEXT I                                            \NO. OF DATA POINTS
019     WRITE ! %4,NPTS !
020     FOR I=0,ANGF,10
021     DFCT=EXP(-I/360)                                  \Y POINTS
022     WRITE %6.4,DFCT
023     SS=80*INT((I+10)/80)-10;IF(SS=I)WRITE !
024     NEXT I                                            \NO. OF DATA POINTS
025     WRITE ! %4,NPTS !
026     FOR I=0,ANGF,10
```

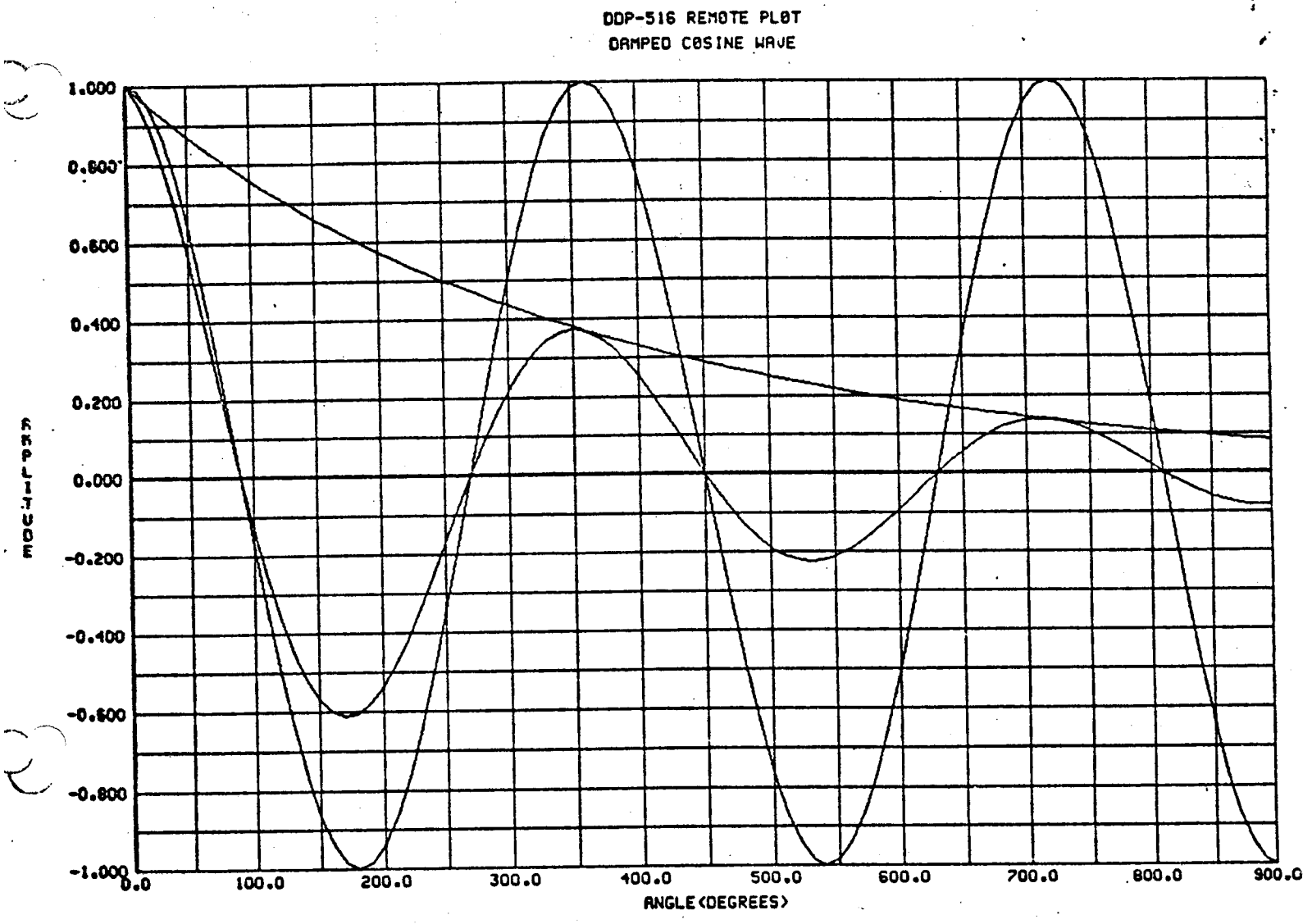
```
027   DSIN=EXP(-I/360)*SIN(I*PI)                          \Y POINTS
028   WRITE %6.4,DSIN
029   SS=80*INT((I+10)/80)-10;IF(SS=I)WRITE !
030   NEXT I
031   WRITE!"1 1 1 1.0 1.0 51.0 1 1 0.0 1.0 0.0 1.0 3 1 1 3 1" !
032   WRITE " DDP-516 REMOTE PLOT "!                      \TITLE
033   WRITE " DAMPED COSINE WAVE "!                       \SUB-TITLE
034   WRITE " AMPLITUDE "!                                \Y AXIS LABEL
035   WRITE " ANGLE(DEGREES) "!                           \X AXIS LABEL
036   WRITE %4,NCURV !                                    \NUMBER OF CURVES
037   WRITE NPTS !                                        \NO. OF DATA POINTS
038   FOR I=0,ANGF,10
039   COSINE=COS(I*PI)                                    \Y POINTS
040   WRITE %6.4,COSINE
041   SS=40*INT((I+10)/40)-10;IF(SS=I)WRITE !
042   NEXT I                                              \NO. OF DATA POINTS
043   WRITE ! %4,NPTS !
044   FOR I=0,ANGF,10
045   DFCT=EXP(-I/360)                                    \Y POINTS
046   WRITE %6.4,DFCT
047   SS=80*INT((I+10)/80)-10;IF(SS=I)WRITE !
048   NEXT I                                              \NO. OF DATA POINTS
049   WRITE ! %4,NPTS !
050   FOR I=0,ANGF,10
051   DCOS=EXP(-I/360)*COS(I*PI)                          \Y POINTS
052   WRITE %6.4,DCOS
053   SS=80*INT((I+10)/80)-10;IF(SS=I)WRITE !
054   NEXT I
055   STOP
056 <EOF>
X
FSNAP- G

OUTPUT FILE ? PLTFILE

NUMBER OF PERIODS =2.5
FSNAP- GEPLOT,PLTFILE

GE JOB ACCEPTED  7B047   03/15/71PM 09:33:10
FSNAP- GELIST,PLTFFILE@@@@ILE

GE JOB ACCEPTED  7B048   03/15/71PM 09:33:38
FSNAP- QUIT
QUIT 03/15/71PM 09:33:46
RYF
```

```
SNUMB = 7B048, ACTIVITY # = 01, REPORT CODE = 52, RECORD COUNT = 00112

1 1 1 1 1.0 1.0 51.0 1 1 0.0 1.0 0.0 1.0 4 1 1 3 1
2  DDP-516 REMOTE PLOT
3  DAMPED SINE WAVE
4  AMPLITUDE
5  ANGLE(DEGREES)
6     3
7     91
8      0.0   0.0000   10.0   0.1736   20.0   0.3420   30.0   0.5000
9     40.0   0.6428   50.0   0.7660   60.0   0.8660   70.0   0.9397
10    80.0   0.9848   90.0   1.0000  100.0   0.9848  110.0   0.9397
11   120.0   0.8660  130.0   0.7660  140.0   0.6428  150.0   0.5000
12   160.0   0.3420  170.0   0.1737  180.0   0.0000  190.0  -0.1736
13   200.0  -0.3420  210.0  -0.5000  220.0  -0.6428  230.0  -0.7660
14   240.0  -0.8660  250.0  -0.9397  260.0  -0.9848  270.0  -1.0000
15   280.0  -0.9848  290.0  -0.9397  300.0  -0.8660  310.0  -0.7660
16   320.0  -0.6428  330.0  -0.5000  340.0  -0.3420  350.0  -0.1737
17   360.0  -0.0000  370.0   0.1736  380.0   0.3420  390.0   0.5000
18   400.0   0.6428  410.0   0.7660  420.0   0.8660  430.0   0.9397
19   440.0   0.9848  450.0   1.0000  460.0   0.9848  470.0   0.9397
20   480.0   0.8660  490.0   0.7661  500.0   0.6428  510.0   0.5000
21   520.0   0.3420  530.0   0.1737  540.0   0.0000  550.0  -0.1736
22   560.0  -0.3420  570.0  -0.5000  580.0  -0.6428  590.0  -0.7660
23   600.0  -0.8660  610.0  -0.9397  620.0  -0.9848  630.0  -1.0000
24   640.0  -0.9848  650.0  -0.9397  660.0  -0.8660  670.0  -0.7661
25   680.0  -0.6428  690.0  -0.5000  700.0  -0.3420  710.0  -0.1737
26   720.0  -0.0000  730.0   0.1736  740.0   0.3420  750.0   0.5000
27   760.0   0.6428  770.0   0.7660  780.0   0.8660  790.0   0.9397
28   800.0   0.9848  810.0   1.0000  820.0   0.9848  830.0   0.9397
29   840.0   0.8660  850.0   0.7661  860.0   0.6428  870.0   0.5000
30   880.0   0.3420  890.0   0.1737  900.0   0.0000
31    91
32   1.0000  0.9726  0.9460  0.9200  0.8948  0.8703  0.8465  0.8233
33   0.8007  0.7788  0.7575  0.7367  0.7165  0.6969  0.6778  0.6592
34   0.6412  0.6236  0.6065  0.5899  0.5738  0.5580  0.5427  0.5279
35   0.5134  0.4994  0.4857  0.4724  0.4594  0.4468  0.4346  0.4227
36   0.4111  0.3998  0.3889  0.3782  0.3679  0.3578  0.3480  0.3385
37   0.3292  0.3202  0.3114  0.3029  0.2946  0.2865  0.2787  0.2710
38   0.2636  0.2564  0.2494  0.2425  0.2359  0.2294  0.2231  0.2170
39   0.2111  0.2053  0.1997  0.1942  0.1889  0.1837  0.1787  0.1738
40   0.1690  0.1644  0.1599  0.1555  0.1512  0.1471  0.1431  0.1391
41   0.1353  0.1316  0.1280  0.1245  0.1211  0.1178  0.1146  0.1114
42   0.1084  0.1054  0.1025  0.0997  0.0970  0.0943  0.0917  0.0892
43   0.0868  0.0844  0.0821
44    91
45   0.0000  0.1689  0.3235  0.4600  0.5752  0.6667  0.7331  0.7736
46   0.7886  0.7788  0.7460  0.6923  0.6205  0.5339  0.4357  0.3286
47   0.2193  0.1083  0.0000 -0.1024 -0.1962 -0.2790 -0.3489 -0.4044
48  -0.4446 -0.4692 -0.4783 -0.4724 -0.4524 -0.4199 -0.3764 -0.3238
49  -0.2643 -0.1999 -0.1330 -0.0657 -0.0000  0.0821  0.1190  0.1692
50   0.2116  0.2453  0.2697  0.2846  0.2901  0.2865  0.2744  0.2547
51   0.2283  0.1964  0.1603  0.1213  0.0807  0.0398  0.0000 -0.0377
52  -0.0722 -0.1026 -0.1283 -0.1488 -0.1636 -0.1726 -0.1760 -0.1738
53  -0.1664 -0.1545 -0.1385 -0.1191 -0.0972 -0.0736 -0.0489 -0.0242
54  -0.0000  0.0229  0.0438  0.0623  0.0778  0.0902  0.0992  0.1047
55   0.1067  0.1054  0.1010  0.0937  0.0840  0.0723  0.0590  0.0446
56   0.0297  0.0147  0.0000
57 1 1 1 1 1.0 1.0 51.0 1 1 0.0 1.0 0.0 1.0 5 1 1 3 1
58  DDP-516 REMOTE PLOT
59  DAMPED COSINE WAVE
60  AMPLITUDE
```

```
ANGLE(DEGREES)
    3
   91
  1.0000   0.9848   0.9397   0.8660
  0.7660   0.6428   0.5000   0.3420
  0.1736   0.0000  -0.1736  -0.3420
 -0.5000  -0.6428  -0.7660  -0.8660
 -0.9397  -0.9848  -1.0000  -0.9848
 -0.9397  -0.8660  -0.7660  -0.6428
 -0.5000  -0.3420  -0.1737  -0.0000
  0.1736   0.3420   0.5000   0.6428
  0.7660   0.8660   0.9397   0.9848
  1.0000   0.9848   0.9397   0.8660
  0.7660   0.6428   0.5000   0.3420
  0.1737   0.0000  -0.1736  -0.3420
 -0.5000  -0.6428  -0.7660  -0.8660
 -0.9397  -0.9848  -1.0000  -0.9848
 -0.9397  -0.8660  -0.7661  -0.6428
 -0.5000  -0.3420  -0.1737  -0.0000
  0.1736   0.3420   0.5000   0.6428
  0.7660   0.8660   0.9397   0.9848
  1.0000   0.9848   0.9397   0.8660
  0.7661   0.6428   0.5000   0.3420
  0.1737   0.0000  -0.1736  -0.3420
 -0.5000  -0.6428  -0.7660  -0.8660
 -0.9397  -0.9848  -1.0000
   91
  1.0000   0.9726   0.9460   0.9200   0.8948   0.8703   0.8465   0.8233
  0.8007   0.7788   0.7575   0.7367   0.7165   0.6969   0.6778   0.6592
  0.6412   0.6236   0.6065   0.5899   0.5738   0.5580   0.5427   0.5279
  0.5134   0.4994   0.4857   0.4724   0.4594   0.4468   0.4346   0.4227
  0.4111   0.3998   0.3889   0.3782   0.3679   0.3578   0.3480   0.3385
  0.3292   0.3202   0.3114   0.3029   0.2946   0.2865   0.2787   0.2710
  0.2636   0.2564   0.2494   0.2425   0.2359   0.2294   0.2231   0.2170
  0.2111   0.2053   0.1997   0.1942   0.1889   0.1837   0.1787   0.1738
  0.1690   0.1644   0.1599   0.1555   0.1512   0.1471   0.1431   0.1391
  0.1353   0.1316   0.1280   0.1245   0.1211   0.1178   0.1146   0.1114
  0.1084   0.1054   0.1025   0.0997   0.0970   0.0943   0.0917   0.0892
  0.0868   0.0844   0.0821
   91
  1.0000   0.9578   0.8889   0.7968   0.6855   0.5594   0.4232   0.2816
  0.1390   0.0000  -0.1315  -0.2520  -0.3583  -0.4480  -0.5192  -0.5709
 -0.6025  -0.6141  -0.6065  -0.5810  -0.5392  -0.4833  -0.4158  -0.3393
 -0.2567  -0.1708  -0.0843  -0.0000   0.0798   0.1528   0.2173   0.2717
  0.3149   0.3463   0.3654   0.3725   0.3679   0.3524   0.3270   0.2931
  0.2522   0.2058   0.1557   0.1036   0.0512   0.0000  -0.0484  -0.0927
 -0.1318  -0.1648  -0.1910  -0.2100  -0.2217  -0.2259  -0.2231  -0.2137
 -0.1983  -0.1778  -0.1530  -0.1248  -0.0944  -0.0628  -0.0310  -0.0000
  0.0293   0.0562   0.0799   0.1000   0.1159   0.1274   0.1344   0.1370
  0.1353   0.1296   0.1203   0.1078   0.0928   0.0757   0.0573   0.0381
  0.0188   0.0000  -0.0178  -0.0341  -0.0485  -0.0606  -0.0703  -0.0773
 -0.0815  -0.0831  -0.0821
```

DDP-516 REMOTE PLOT
DAMPED SINE WAVE




DDP-516 REMOTE PLOT
DAMPED COSINE WAVE
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
AMPLITUDE
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
ANGLE(DEGREES)