MITRON

Available to NASA Offices, NASA Centers, and NASA Contractors Only.

MITRON

RESEARCH & DEVELOPMENT CORPORATION

(NASA-CR-57260) DEVELOPMENT OF A TECHNIQUE FOR DETERMINATION OF COMPONENT SHOCK SPECIFICATIONS. VOLUME 3: DIGITAL COMPUTER PROGRAM FOR SHOCK AND FOURIER SPECTRA Final Report (Mitron Research and Development

N89-71017

Unclas

00/39 0216860

CASE FILE COPY

Development of a Technique for Determination of Component Shock Specifications /6/

FINAL REPORT - VOLUME III

Digital Computer Program for Shock and Fourier Spectra

Report No. 607-4-III

by

Maurice Gertel
Richard Holland

Prepared for: National Aeronautics & Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Contract No: NAS-8-11090

November 1964

MITRON

FOREWORD

This report is Volume III of a three volume final report presenting the results of work performed by MITRON Research and Development Corporation for NASA Marshall Space Flight Center under Contract No. NAS-8-11090 entitled "Development of a Technique for Determination of Component Shock Specifications". The three volumes comprising the final report are as follows:

Volume I	Methods for Specifying and Extrapolating Shock Conditions.
Volume II	Compilation of Four Coordinate Shock and Fourier Spectra for Simple and Complex Shock Motions.
Volume III	Digital Computer Program for Shock and Fourier Spectra.

This project was conducted by the Shock and Vibration Division of MITRON with Mr. Maurice Gertel as Principal Investigator and Mr. Richard Holland as Project Engineer. The program was under the overall cognizance of Messrs. Ronald E. Jewell and Thomas Coffin of NASA Marshall Space Flight Center, Propulsion and Vehicle Engineering Division, Structures Branch.

Available to NASA Offices, NASA Centers, and NASA Contractors Only.

TABLE OF CONTENTS

		PAGE NO.
	FOREWORD	i
III-1	INTRODUCTION	1
III-2	THE COMPUTER PROGRAM	2
III-3	ACKNOWLEDGEMENTS	7
III-4	PROGRAM LISTING	7

SYMBOLS

a	equivalent static acceleration	in./sec^2
a	Fourier acceleration component	in./sec^2
A	normalized acceleration	
d	relative deflection response	in.
d	Fourier deflection component	in.
c	damping coefficient	lb - sec/in.
c/c_c	fraction of critical damping	
D	normalized deflection (includes g= 386.4 in./sec^2)	in./sec^2
f(t)	function of time	
f_n	undamped natural frequency	cycles/sec (cps)
F	force	lb
F	Fourier operator	
g	acceleration of gravity	in./sec^2
G	peak acceleration in number of times gravity	
h	increment of time	sec
Im	imaginary part of	
j	$\sqrt{-1}$	
k	linear stiffness	lb/in.
m	mass	lb-sec^2/in.
n	number	
Re	real part of	
t	time	sec
T	natural period	sec
u	motion of the support	in.

SYMBOLS (Cont.)

$\ddot{U}(\omega)$	Fourier spectrum of $\ddot{u}(t)$	in./sec
$\ddot{U}_c(\omega)$	Fourier cosine spectrum of $\ddot{u}(t)$	in./sec
$\ddot{U}_s(\omega)$	Fourier sine spectrum of $\ddot{u}(t)$	in./sec
v	pseudo velocity response	in./sec
v	Fourier velocity component	in./sec
V	normalized velocity	
x	linear displacement in direction of X axis	in.
Z	impedance	lb-sec/in.
δ	relative response deflection	in.
δ_r	residual relative response deflection	in.
ζ	fraction of critical damping	
θ	phase angle	degrees
τ	period	sec
ω	forcing frequency-angular	rad/sec
ω_n	undamped natural frequency-angular	rad/sec
ω_d	damped natural freqiencies-angular	rad/sec

VOLUME III

III-1. INTRODUCTION

This volume of the Final Report on Contract No. NAS-8-11090 presents the shock analysis digital computer program, which was used to compute and plot the shock and Fourier spectra presented in Volume II. A brief description of the program with the basic numerical equations and a general list of its input requirements are stated.

The program has both printed and plotted output when used with a computing system consisting of the IBM 7094-II with the North American Computer Recorder Subroutines and the General Dynamics S-C 4020 Computer Recorder. The printed output is computed at each frequency increment and presents the following quantities:

Shock spectrum:

Maximum positive and negitive displacement response.

Maximum positive and negitive acceleration response.

Fourier spectrum (for zero damping only):

Absolute magnitude.

Real part.

Imaginary part.

Phase angle.

The plotted output is four graphs which consist of the following information:

Shock input time-history.

Shock spectrum (maximax).

Fourier spectrum (residual shock spectrum).

Fourier phase angle.

This report includes a Fortran listing of the computer program as used to prepare the graphs of Volume II.

III-2. THE COMPUTER PROGRAM

The computer program is written in Fortran II for the IBM 7094-II, with a 32,768 word core storage. An option is available to plot the output on the General Dynamics S-C 4020 Computer Recorder. The output is plotted with the use of the following subroutines: APRNTV, CAMRAV, CHSIZV, FRAMEV, GRIDIV, LINEV, NXV, NYV, RITE2V, SMXYV, TABL1V, TABL2V, and VCHARV. These subroutines are obtained from the North American Aviation Engineer's Computing Manual. The program functions are outlined on the following paragraphs.

The shock motion-time history to be analyzed can be completely arbitrary and tabulated or it may be idealized and computed internally. If computed internally, the five basic configurations are:

(a) Superimposed Decaying Sinusoids.

(b) Superimposed Decaying Cosines.

(c) Triangle with or without Dwell.

(d) Versed-sine with or without Dwell.

(e) Exponential with or without Dwell.

The program computes the response of a simple system for a specific value of damping and for each desired value of natural frequency, using the following recursion formulae:

$$\omega_n \delta_{n+1} = A_1 \omega_n \delta_n + A_2 \dot{\delta}_n + A_3 \ddot{u}_n + A_4 \Delta \ddot{u}_n \qquad \text{III-1}$$

$$\dot{\delta}_{n+1} = A_5 \omega_n \delta_n + A_6 \dot{\delta}_n + A_7 \ddot{u}_n + A_8 \Delta \ddot{u}_n \qquad \text{III-2}$$

Where

$$\delta_0 = \delta(0), \qquad \dot{\delta}_0 = \dot{\delta}(0)$$

$$A_1 = a + \zeta b, \qquad A_2 = b$$

$$A_3 = \frac{1}{\omega_n}(a + \zeta b - 1) = \frac{1}{\omega_n}(A_1 - 1)$$

$$A_4 = \frac{1}{\omega_n}\left\{\frac{1}{\omega_n h}\left[(1-2\zeta^2)b + 2\zeta^2(1-a)\right] - 1\right\}$$

$$A_5 = -b, \qquad A_6 = a - \zeta b, \qquad A_7 = -\frac{b}{\omega_n}$$

$$A_8 = \frac{1}{\omega_n^2 h}(a + \zeta b - 1) = \frac{A_3}{\omega_n h}$$

$$a = e^{-\zeta\omega_n h}\cos\omega_d h, \qquad b = \left(e^{-\zeta\omega_n h}\sin\omega_d h\right)\Big/\sqrt{1-\zeta^2}$$

$$\omega_d = \omega_n\sqrt{1-\zeta^2}, \qquad \zeta = \frac{c}{2\sqrt{km}}$$

$$\omega_n = \sqrt{k/m}, \qquad h = t_{n+1} - t_n$$

The maximum positive and negitive value of displacement and acceleration response are printed out for each increment of frequency. These values are plotted on dimensionless four coordinated graphs as the shock spectrum and the Fourier spectrum (also the residual shock spectrum).

The Fourier spectrum is computed by rewriting Equation III-1 and III-2 for zero damping. The values of displacement and velocity at $t = \tau$, computed by the recursion equation, are used to calculate the real and imaginary components of the Fourier spectrum.

$$F_c = -\omega_n \delta(\tau) \sin \omega_n \tau - \dot{\delta}(\tau) \cos \omega_n \tau \qquad \text{III-3}$$

$$F_s = \dot{\delta}(\tau) \sin \omega_n \tau - \omega_n \delta(\tau) \cos \omega_n \tau \qquad \text{III-4}$$

The magnitude and phase angle of the Fourier spectrum is obtained from Equation III-5 and III-6.

$$|F| = \sqrt{F_c^2 + F_s^2} \qquad \text{III-5}$$

$$\phi = \arctan \frac{F_s}{F_c} \qquad \text{III-6}$$

The program has the option of printing out the damped or undamped displacement response of a simple system with a specified natural frequency.

Using a General Dynamics SC-4020 Computer Recorder as an integral part of the computing system, the program's output generates the following graphs:

(a) Shock input time-history.

(b) Four coordinate dimensionless shock spectrum and Fourier spectrum.

(c) Four coordinate dimensionless damped shock spectrum.

(d) Fourier phase angle spectrum.

In addition to the tabulation of the shock motion, the following input data are required:

(a) Number of recrod groups to be analyzed.

(b) Serial record of first record.

(c) Number of records.

(d) Number of frequency ranges.

(e) Number of values of damping.

(f) Number of tabulated shock record points.

(g) Code for acceleration of velocity shock record.

(h) Code for units of input record.

(i) Code for units of tabulated output.

(j) Code for digitized or internally calculated record.

(k) Code for plotting output (if plotting is desired input shock record must be acceleration in units of in./sec ^{2}).

(l) Length of shock motion in seconds.

(m) Amplitude scale-factor for digitized record (if shock input is measured from an oscilloscope record).

(n) Digitized record bias (if shock input is measured from an oscilloscope record).

(o) Frequency at which response-time history is required (zero if not desired).

(p) Initial displacement.

(q) Initial velocity.

(r) Tabulation of damping values.

(s) Tabulation of initial frequency, frequency increments and number of frequencies.

If the shock record is calculated internally, the following is required (zero if digitized).

1. Type of shock input:

   Superimposed Decaying Sinusoids.

   Superimposed Decaying Cosines.

   Triangle with or without Dwell.

   Versed-sine with or without Dwell.

   Exponential with or without Dwell.

2. Number of superimposed sines or cosines - or - number of data cards to be read.

3. Peak value of shock record.

4. Reciprocal of number of half-cycles for half-life of sine or cosine - or - rise time.

5. For exponential: Rise and decay exponent.

III-3. ACKNOWLEDGEMENTS

The recursion equations used for the shock and Fourier spectra numerical evaluation described herein were developed by G.J. O' Hara of the Naval Research Laboratory, Washington, D. C. in NRL Report #5772 entitled "A Numerical Procedure For Shock and Fourier Analysis". The following program listing is based on work by W.A. McCool, while at NRL and The White Sands Missile Range as described in "A Digital Computer Program for the Analysis of Recorded Shock Motion", Army Missile Test Center, New Mexico, Data Report NR 23, May 1961.

III-4. PROGRAM LISTING

The following pages are the Fortran listing of the shock analysis digital computer program.

```
C       SHØCK RECØRD ANALYSIS       MITRØN R/D
C
C      SHØCK RECØRD ANALYSIS WITH THE ØPTIØN ØF CØMPUTING INPUT
C
C      IRG = NØ. ØF RECØRD GRØUPS
C      IFD(1) = SERIAL NØ. ØF FIRST RECØRD
C      IFD(2) = KR, NØ. ØF RECØRDS
C      IFD(3) = KF, NØ. ØF FREQUENCY RANGES
C      IFD(4) = KD, NØ. ØF VALUES ØF DAMPING
C       IFD(5) = M, NØ. ØF SHØCK RECØRD PØINTS
C      IFD(6) = 1 ØR 0 FØR VELØCITY ØR ACCELERATIØN SHØCK RECØRD,
C               RESPECTIVELY
C      IFD(7) = 1,2,3,4 FØR VELØCITY ØR ACCELERATIØN UNITS AS FØLLØWS
C           1 = FEET PER SECØND ØR FEET PER SECØND PER SECØND
C           2 = INCHES PER SECØND ØR INCHES PER SECØND PER SECØND
C           3 = CENTIMETERS PER SECØND ØR CENTIMETERS PER SECØND PER
C               SECØND
C           4 = G UNITS (ACCELERATIØN ØNLY)
C      IFD(8) = 1,2,3 FØR DISPLACEMENT ØR ACCELERATIØN UNITS AS FØLLØWS
C           1 = FEET ØR FEET PER SECØND PER SECØND
C           2 = INCHES ØR INCHES PER SECØND PER SECØND
C           3 = CENTIMETERS ØR CENTIMETERS PER SECØND PER SECØND
C      IFD(9) = INPUT FØRMAT FØR Z VALUES
C          -1 = Z VALUES CALCULATED INTERNALLY
C           0 = TEST INPUTS (FØRMAT(5F10.0))
C           1 = DATA INPUTS (FØRMAT(6I10))
C      IFD(10) = PLØTTING PRØGRAM (ACCELERATIØN INPUT IN IN/SEC/SEC ØNLY)
C               (IF DS(1,1)=58640. SHØCK TIME HISTØRY PLØT WILL BE IN G)
C           -1 = PLØT EITHER ZERØ DAMPING ØR DAMPED CASES
C            0 = NØ PLØTTING
C            1 = PLØT RESIDUAL VELØCITY AND MAXIMAX FØR ALL CASES
C      FD(1) = LENGTH ØF SHØCK RECØRD IN SECØNDS
C       FD(2) = SCALE-FACTØR
C       FD(3) = BIAS
C       FD(4) = FREQUENCY ØF ØSCILLATØR RESPØNSE VS. TIME PRINTØUT
C       FD(5) =
C       FD(6) = ØSCILLATØR SPRING INITIAL DISPLACEMENT
C       FD(7) = ØSCILLATØR SPRING INITIAL VELØCITY
C       FDD(I) = VALUES ØF DAMPING
C       FDF(I,1) = INITIAL (FIRST) FREQUENCY
C       FDF(I,2) = FREQUENCY INCREMENT
C       FDF(I,3) = NUMBER ØF FREQUENCIES IN ITH RANGE
C
C      THE FØLLØWING DS VALUES ARE ACCØRDING TØ WHETHER IFD(9) IS ØR
C                      IS NØT EQUAL TØ MINUS ØNE
C
C      WHEN IFD(9)=-1,Z VALUES ARE CALCULATED INTERNALLY
C
C      ITYPE = TYPE ØF SHØCK INPUT
C          1 = SUPERIMPØSED DECAYING SINUSØIDS
C          2 = SUPERIMPØSED DECAYING CØSINES
C          3 = TRIANGLE WITH ØR WITHØUT DWELL
C          4 = VERSED-SINE WITH ØR WITHØUT DWELL
C          5 = EXPØNENTIAL WITH ØR WITHØUT DWELL
C      NUM = NUMBER ØF SUPERIMPØSED SINES ØR CØSINES -ØR-
C            NUMBER ØF DATA CARDS TØ BE READ
C      ACCØRDING TØ FØRMAT (2I10)
C
```

```
C       DS(1,K) = PEAK VALUE ØF SHØCK INPUT (INCHES PER SECØND PER SECØND)
C       DS(2,K) = RECIPRØCAL ØF NUMBER ØF HALF CYCLES FØR HALF LIFE ØF
C                                                    SINE ØR CØSINE -ØR-
C                 RISE TIME (SECØNDS)
C       DS(3,K) = NATURAL FREQUENCY (CPS) -ØR-
C                 TIME ØF BEGINNING ØF DECAY (SECØNDS)
C       ACCØRDING TØ FØRMAT  (3E12.5)
C       ITYPE=3 AND ITYPE=4  -THEN- N=1 AND K=1
C       ITYPE=5  -THEN- N=2 AND K=1
C       DS(1,2) = RISE EXPØNENT   (EXPF(3.141592*DS(1,2)*T))
C       DS(2,2) = DECAY EXPØNENT
C       ACCØRDING TØ FØRMAT (3E12.5)
C
C       WHEN IFD(9) DØES NØT EQUAL MINUS ØNE AND
C       IFD(10) DØES NØT EQUAL ZERØ
C       DS(1) = TIME IN SECØNDS ØF FIRST FULL PERIØD



C       ACCØRDING TØ FØRMAT (5E12.5)
        DIMENSIØN DS(3,10),FD(10),IFD(10),FDD(10),FDF(20,3),Z(500),ZD(500)
       1,X(999),APMAX(500),ANMAX(500),APMAX(500),ANMAX(500),FMAG(500),FPH(
       2500),FC(500),FS(500),FPWR(500),FREQ(501),XTØ(500),VTØ(500),FMAGF2(
       3500),PLRV(500),PLMAXI(500),PLFR(500),PLFPH(500)
        CØMMØN Z,ZD,X,APMAX,ANMAX,APMAX,ANMAX,FMAG,FPH,FC,FS,FPWR,FREQ,
       1XTØ,VTØ,FMAGF2,PLRV,PLMAXI,PLFR,LMAX,LK
   10   FØRMAT(64H1                                          SHØCK   RECØRD
       1ANALYSIS//52H                                         RECØRD  NUMBER
       2I8///59H   THE SHØCK RECØRD TØ BE ANALYZED IS TABULATED AS FØLLØWS
       3 )
   13   FØRMAT( /69H            TIME                              VELØCITY  RE
       XCØRD  AMPLITUDE)
   14   FØRMAT (65H            SECØNDS                                FEET  P
       XER  SECØND)
   15   FØRMAT (66H            SECØNDS                               INCHES
       XPER  SECØND)
   16   FØRMAT (69H            SECØNDS                             CENTIMETER
       XS  PER  SECØND)
   17   FØRMAT(//71H            TIME                            ACCELERATIØN
       XRECØRD  AMPLITUDE)
   18   FØRMAT (72H            SECØNDS                            FEET  PER  SE
       XCØND  PER  SECØND)
   19   FØRMAT (71H            SECØNDS                           INCHES  PER  S
       XECØND PER SECØND)
   20   FØRMAT (76H            SECØNDS                         CENTIMETERS  PER
       X  SECØND  PER  SECØND)
   21   FØRMAT (61H            SECØNDS                                        G
       X UNITS)
   22   FØRMAT(//79H   THE SHØCK AND FØURIER SPECTRA ARE TABULATED WITH CØ
       1LUMN HEADINGS AS FØLLØWS //94H  FREQ = NATURAL FREQUENCY ØF THE SI
       2MPLE MASS-SPRING ØSCILLATØR IN CYCLES PER SECØND (C.P.S.)/60H  XP
       3MAX = MAXIMUM PØSITIVE SPRING DISPLACEMENT (ELØNGATIØN)/61H  XNMA
       4X = MAXIMUM NEGATIVE SPRING DISPLACEMENT (CØMPRESSIØN)/49H  APMAX
       5 = MAXIMUM ACCELERATIØN ACRØSS THE SPRING/49H  ANMAX = MAXIMUM DE
```

```
     6CELERATIØN ACRØSS THE SPRING,/74H  F(ØMEGA) = FØURIER SPECTRUM ØF
     7SHØCK RECØRD (ØMEGA = ANGULAR FREQUENCY),/31H  FMAG = MAGNITUDE ØF
     8 F(ØMEGA),/26H  FPH = PHASE ØF F(ØMEGA),/29H  FC = REAL PART ØF F(
     9ØMEGA),/34H  FS = IMAGINARY PART ØF F(ØMEGA),)
 23  FØRMAT (55H  FPWR = PØWER SPECTRUM ØF SHØCK RECØRD = FMAG SQUARED.
     X)
 24  FØRMAT(1H1,62H                                SHØCK  SPECTRUM   -   DAMPIN
     1G  RATIØ = F7.4//82H      FREQ              XPMAX          XNMAX
     2  APMAX          ANMAX          FMAGF2   )
 25  FØRMAT (72H     C.P.S.                    FEET
     X   FEET/SEC./SEC.)
 26  FØRMAT (73H     C.P.S.                   INCHES
     X  INCHES/SEC./SEC.)
 27  FØRMAT (72H     C.P.S.                     CM.
     X     CM./SEC./SEC.)
 29  FØRMAT (/)
 30  FØRMAT (59H1                                                FØURIER     SPEC
     1TRUM/74H      FREQ              FC              FS              FMAG
     2  FPH         FPWR)
 31  FØRMAT (78H     C.P.S.            FEET            FEET            FEET
     X  DEGREES  FEET SQUARED)
 32  FØRMAT (79H     C.P.S.           INCHES          INCHES          INCHES
     X  DEGREES INCHES SQUARED)
 33  FØRMAT (78H     C.P.S.             CM.             CM.             CM.
     X  DEGREES   CM. SQUARED)
 34  FØRMAT (83H     C.P.S.                    FEET    PER    SECØND
     X  DEGREES (FT./SEC.) SQUARED)
 35  FØRMAT (83H     C.P.S.                   INCHES    PER    SECØND
     X  DEGREES (IN./SEC.) SQUARED)
 36  FØRMAT (83H     C.P.S.                CENTIMETERS  PER  SECØND
     X  DEGREES (CM./SEC.) SQUARED)
 37  FØRMAT(/36H   INTEGRAL ØF VELØCITY SHØCK RECØRD E12.5,5H FEET)
 38  FØRMAT(/36H   INTEGRAL ØF VELØCITY SHØCK RECØRD E12.5,7H INCHES)
 39  FØRMAT(/36H   INTEGRAL ØF VELØCITY SHØCK RECØRD E12.5,12H CENTIMET
     XERS)
 40  FØRMAT(1H1,62H                                    ØSCILLATØR  RESPØNSE
     1 TØ  SHØCK//29H              DAMPING RATIØ =  F7.4,26H   ØSCILLATØR
     2 FREQUENCY =  F9.1,18H CYCLES PER SECØND//37H              TIME
     3    DISPLACEMENT)
 41  FØRMAT (33H              SECØNDS            FEET)
 42  FØRMAT (34H              SECØNDS           INCHES)
 43  FØRMAT (37H              SECØNDS         CENTIMETERS)
 44  FØRMAT (//21H             END ØF TAPE)
 45  FØRMAT (1H E12.4,E16.5,3E14.5)
 50  FØRMAT ( 10I7)
 51  FØRMAT ( 5E12.5)
 52  FØRMAT ( 5F10.0)
 53  FØRMAT ( 3E12.5)
 54  FØRMAT (6I10)
 55  FØRMAT (1H I6,E13.4,E17.4,4E13.4)
 56  FØRMAT (1H E12.4,E16.5,4E14.5)
 57  FØRMAT (1H E12.4,E16.5,2E14.5,F8.1,E14.5)
 58  FØRMAT (1H I6,E13.4,E17.4)
 59  FØRMAT (1H E12.4,E16.5,2E14.5,E22.5)
 60  FØRMAT (/40H   INTEGRAL ØF ACCELERATIØN SHØCK RECØRD E12.5,10H FEE
     XT/SEC.)
 61  FØRMAT (/40H   INTEGRAL ØF ACCELERATIØN SHØCK RECØRD E12.5,12H INC
```

```
      XHES/SEC.)
   62 FØRMAT (/40H   INTEGRAL ØF ACCELERATIØN SHØCK RECØRD E12.5,17H CEN
      XTIMETERS/SEC.)
   63 FØRMAT (/40H   INTEGRAL ØF ACCELERATIØN SHØCK RECØRD E12.5,14H  G-
      XSEC. UNITS)
      READ INPUT TAPE 5,50,IRG
      IF (IFD(10)) 301,302,301
  301 CALL CAMRAV(40)
      LK=0
F     TABL1V,TABL2V
  302 DØ 100 IG=1,IRG
      READ INPUT TAPE 5,50,(IFD(I),I=1,10)
      READ INPUT TAPE 5,51,(FD(I),I=1,10)
      KR=IFD(2)
      KF=IFD(3)
      KD=IFD(4)
      READ INPUT TAPE 5,51,(FDD(I),I=1,KD)
      READ INPUT TAPE 5,53,((FDF(I,J),J=1,3),I=1,KF)
      MM=IFD(5)-1
      W1=MM
      W2=FD(1)/W1
      M=IFD(5)
      XØ=FD(6)
      VØ=FD(7)
      TØ=FD(1)
      NRCD=IFD(1)
      SFT=FD(2)*FD(1)
      DØ 100 IR=1,KR
      TØØ=1.0
      XMAGN=1.0
      IF (IFD(9)) 400,170,171
  400 CALL CØMSH (Z,TØ,TØØ,W2,M,XMAGN,IFD,MM)
      GØ TØ 500
  170 READ INPUT TAPE 5,52,(Z(I),I=1,M)
      GØ TØ 172
  171 READ INPUT TAPE 5,54,(Z(I),I=1,M)
  172 DØ 101 I=1,M
  101 Z(I) =(Z(I) + FD(3))*FD(2)
  500 WRITE ØUTPUT TAPE 6,10,NRCD
      NRCD=NRCD+1
      KK1=IFD(7)
      IF (IFD(6)) 200,103,104
  104 WRITE ØUTPUT TAPE 6,13
      GØ TØ (105,106,107),KK1
  105 WRITE ØUTPUT TAPE 6,14
      GØ TØ 112
  106 WRITE ØUTPUT TAPE 6,15
      GØ TØ 112
  107 WRITE ØUTPUT TAPE 6,16
      GØ TØ 112
  103 WRITE ØUTPUT TAPE 6,17
      GØ TØ (108,109,110,111),KK1
  108 WRITE ØUTPUT TAPE 6,18
      GØ TØ 112
  109 WRITE ØUTPUT TAPE 6,19
      GØ TØ 112
  110 WRITE ØUTPUT TAPE 6,20
      GØ TØ 112
```

```
111  WRITE ØUTPUT TAPE 6,21
112  TIME=0.0
     DELTAT=W2*5.0
     MT=M/5
     DØ 113 I=1,MT
     II=5*I-5
     IJ=II+1
     IK=II+5
     WRITE ØUTPUT TAPE 6,55,II,TIME,(Z(J),J=IJ,IK)
113  TIME=TIME+DELTAT
     IF (M-IK) 200,115,114
114  II=5*I-5
     IJ=II+1
     WRITE ØUTPUT TAPE 6,55,II,TIME,(Z(J),J=IJ,M)
     IF (IFD(9)) 115,409,409
409  IF (IFD(10)) 410,115,410
410  CALL CHPLØT (M,Z,TØØ,XMAGN,FUG,MM,W2,IFD)
     GØ TØ 117
115  FUG=386.4
     IF (KK1-4) 119,117,200
117  DØ 118 I=1,M
118  Z(I)=Z(I)*FUG
119  IF (IFD(6)) 200,76,75
 75  ZØ=Z(1)
     Z(1)=Z(2)-Z(1)
     ZD(1)=Z(3)-Z(2)-Z(1)
     XA=FD(6)-(Z(2)-Z(1)/2.0-ZD(1)/12.0)*W2
     MMM=MM-1
     DØ 80 J=2,MMM
     JP=J+1
     Z(J)=Z(JP)-Z(J)
     ZD(J)=Z(J+2)-Z(JP)-Z(J)
  80 XA=XA-(Z(JP)-Z(J)/2.0-ZD(J)/12.0)*W2
     Z(JP)=Z(JP+1)-Z(JP)
     ZD(JP)=ZD(JP-1)
     XA=XA-(Z(JP+1)-Z(JP)/2.0-ZD(JP)/12.0)*W2
     ZTØ=Z(JP+1)
     GØ TØ (81,82,83),KK1
  81 WRITE ØUTPUT TAPE 6,37,XA
     GØ TØ 116
  82 WRITE ØUTPUT TAPE 6,38,XA
     GØ TØ 116
  83 WRITE ØUTPUT TAPE 6,39,XA
     GØ TØ 116
  76 ZD(1) = Z(2)-Z(1)
     VA = FD(7)-(Z(1)+ZD(1)*0.5)*W2
     DØ 85 J=2,MM
     JP=J+1
     ZD(J)=Z(JP)-Z(J)
  85 VA = VA-(Z(J)+ZD(J)*0.5)*W2
     ZTØ = 0.0
     ZØ=0.0
     GØ TØ (90,91,92,93),KK1
  90 WRITE ØUTPUT TAPE 6,60,VA
     GØ TØ 116
  91 WRITE ØUTPUT TAPE 6,61,VA
     GØ TØ 116
```

```
 92  WRITE OUTPUT TAPE 6,62,VA
     GO TO 116
 93  WRITE OUTPUT TAPE 6,63,VA
116  WRITE OUTPUT TAPE 6,22
     WRITE OUTPUT TAPE 6,23
     LL=0
     DO 100 ID=1,KD
     L=0
     LMAX=0
     DAMP=FDD(ID)
     WRITE OUTPUT TAPE 6,24,DAMP
     KK2=IFD(8)
     GO TO (122,123,124),KK2
122  WRITE OUTPUT TAPE 6,25
     GO TO 126
123  WRITE OUTPUT TAPE 6,26
     GO TO 126
124  WRITE OUTPUT TAPE 6,27
126  IF=0
     DO 121 I=1,KF
     FS1=FDF(I,1)
     FS2=FDF(I,2)
     NF=FDF(I,3)+0.1
     IN=IFD(6)
     CALL SHOCK (FS1,FS2,NF,X0,V0,Z0,T0,LT0,W2,MM,DAMP,IF,IN,L,LMAX,
    1XMAGN,T00)
     IF=IF+NF
     IF (DAMP-0.0001) 180,181,181
181  WRITE OUTPUT TAPE 6,45,(FREQ(II),XPMAX(II),XNMAX(II),APMAX(II),
    XANMAX(II),II=1,NF)
     GO TO 121
180  WRITE OUTPUT TAPE 6,56,(FREQ(II),XPMAX(II),XNMAX(II),APMAX(II),
    XANMAX(II),FMAGF(II),II=1,NF)
121  WRITE OUTPUT TAPE 6,29
     LL=1+LL
     IF (DAMP-.000001) 127,127,250
 250 IF (IFD(10)) 252,150,251
 251 IF (LL-1) 252,252,253
 252 CALL FCSSG (LK)
 253 DO 254 L=1,LMAX
 254 CALL LINEV (NXV(PLFR(L)),NYV(PLMAXI(L)),NXV(PLFR(L+1)),NYV(PLMAXI(
    1L+1)))
     GO TO 150
127  WRITE OUTPUT TAPE 6,30
     IF (IFD(6)) 200,129,130
130  GO TO (131,132,133),KK2
131  WRITE OUTPUT TAPE 6,31
     GO TO 137
132  WRITE OUTPUT TAPE 6,32
     GO TO 137
133  WRITE OUTPUT TAPE 6,33
     GO TO 137
129  GO TO (134,135,136),KK2
134  WRITE OUTPUT TAPE 6,34
     GO TO 137
135  WRITE OUTPUT TAPE 6,35
     GO TO 137
```

```
136   WRITE ØUTPUT TAPE 6,36
137   IF=0
      L=0
      DØ 140 I=1,KF
      FS1=FDF(I,1)
      FS2=FDF(I,2)
      NF=FDF(I,3)+0.1
      CALL FRQSPC (FS1,FS2,NF,TØ,ZTØ,IN,IF,SFT,L,PLFPH)
      IF=IF+NF
      DØ 141 K=1,NF
      IF (FMAG(K)-.000001*SFT) 138,139,139
138   WRITE ØUTPUT TAPE 6,59, FREQ(K),FC(K),FS(K),FMAG(K),FPWR(K)
      GØ TØ 141
139   WRITE ØUTPUT TAPE 6,57,FREQ(K),FC(K),FS(K),FMAG(K),FPH(K),FPWR(K)
141   CØNTINUE
140   WRITE ØUTPUT TAPE 6,29
      IF(IFD(10)) 142,150,142
142   CALL SMXYV (1,0)
      CALL GRID1V (1,0.1,100.0,-180.0,180.0,1.0,5.0,-0,2,0,4,5,4)
      CALL CHSIZV(3,4)
      CALL RITE2V(356,1011,1023,90,3,23,-1,23HFOURIER PHASE SPECTRUM    ,
     1 NL1)
      CALL CHSIZV(3,3)
      CALL RITE2V( 9,300,1023,180,2,23,-1,23HPHASE ANGLE  (DEGREES)
     1 ,NL2)
      CALL RITE2V(230,9,1023,90,2,34,-1,34H(NATURAL FREQUENCY)X(PULSE PE
     1RIØD),NL3)
      CALL VCHARV(90,2,880,0,61,TABL1V)
      CALL VCHARV(90,2,898,0,18,TABL2V)
      CALL LINEV(880,9,892,9)
      CALL LINEV(880,9,892,9)
      DØ 143 L=1,LMAX
143   CALL LINEV(NXV(PLFR(L)),NYV(PLFPH(L)),NXV(PLFR(L+1)),
     1 NYV(PLFPH(L+1)))
 227  IF (IFD(10)) 228,150,228
 228  CALL FCSSG (LK)
      DØ 229 L=1,LMAX
      CALL LINEV (NXV(PLFR(L)),NYV(PLRV(L)),NXV(PLFR(L+1)),NYV(PLRV(L+1)
     1))
 229  CALL LINEV (NXV(PLFR(L)),NYV(PLMAXI(L)),NXV(PLFR(L+1)),
     1NYV(PLMAXI(L+1)))
      IF (IFD(10)) 150,150,230
 230  CALL FCSSG (LK)
      DØ 231 L=1,LMAX
 231  CALL LINEV (NXV(PLFR(L)),NYV(PLMAXI(L)),NXV(PLFR(L+1)),
     1NYV(PLMAXI(L+1)))
150   IF (FD(4)-.000001)100,100,151
151   IF=0
      FS1=FD(4)
      FS2=0.0
      NF=1
      TIME=0.0
      CALL SHØCK (FS1,FS2,NF,XØ,VØ,AØ,TØ,ZTØ,W2,MM,DAMP,IF,IN,L,LMAX,
     1XMAGN,TØØ)
      WRITE ØUTPUT TAPE 6,40,DAMP,FS1
      GØ TØ (152,153,154),KK2
152   WRITE ØUTPUT TAPE 6,41
```

```
      GØ TØ 158
153   WRITE ØUTPUT TAPE 6,42
      GØ TØ 158
154   WRITE ØUTPUT TAPE 6,43
158   IF (DAMP-.000001) 156,156,157
156   MD=M
      GØ TØ 155
157   MD=M
155   DØ 160 J=1,MD
      JJ=J-1
      X(J) = X(J)/(FS1*6.283184)
      WRITE ØUTPUT TAPE 6,58,JJ,TIME,X(J)
160   TIME=TIME+W2
      WRITE ØUTPUT TAPE 6,29
100   CØNTINUE
      WRITE ØUTPUT TAPE 6, 44
      IF (IFD(10)) 720,200,720
720   CALL FCSSG (LK)
      CALL FRAMEV
 200  CALL EXIT
      END
```

```
*       CØMPUTE SHØCK RØUTINE
        SUBRØUTINE CØMSH (Z,TØ,TØØ,W2,M,XMAGN,IFD,MM)
C       WHEN IFD(9)=-1,Z VALUES ARE CALCULATED INTERNALLY
C
C       ITYPE = TYPE ØF SHØCK INPUT
C           1 = SUPERIMPØSED DECAYING SINUSØIDS
C           2 = SUPERIMPØSED DECAYING CØSINES
C           3 = TRIANGLE WITH ØF WITHØUT DWELL
C           4 = VERSED-SINE WITH ØR WITHØUT DWELL
C           5 = EXPØNENTIAL WITH ØR WITHØUT DWELL
C       NUM = NUMBER ØF SUPERIMPØSED SINES ØR CØSINES -ØR-
C             NUMBER ØF DATA CARDS TØ BE READ
C       ACCØRDING TØ FØRMAT (2I10)
C
C       DS(1,K) = PEAK VALUE ØF SHØCK INPUT (INCHES PER SECØND PER SECØND)
C       DS(2,K) = RECIPRØCAL ØF NUMBER ØF HALF CYCLES FØR HALF LIFE ØF
C                                                        SINE ØR CØSINE -ØR-
C                 RISE TIME (SECØNDS)
C       DS(3,K) = NATURAL FREQUENCY (CPS) -ØR-
C                 TIME ØF BEGINNING ØF DECAY (SECØNDS)
C       ACCØRDING TØ FØRMATE (3E12.5)
C       ITYPE=3 AND ITYPE=4  -THEN- N=1 AND K=1
C       ITYPE=5  -THEN- N=2 AND K=1
C       DS(1,2) = RISE EXPØNENT . (EXPF(3.141592*DS(1,2)*T))
C       DS(2,2) = DECAY EXPØNENT
C       ACCØRDING TØ FØRMAT (3E12.5)
        DIMENSIØN Z(500),IFD(10),DS(3,10),TT(10)
  400   READ INPUT TAPE 5,552,ITYPE,NUM
  552   FØRMAT (2I10)
        T=0.0
        XMAGN=0.0
        N=NUM
        READ INPUT TAPE 5,553,((DS(J,K),J=1,3),K=1,N)
  553   FØRMAT (3E12.5)
        XMAGN=DS(1,1)
        YBØT=0.0
        YTØP=1.1*XMAGN
        FDR=0.0001
        FDR2=1.0
        JFK2=10
        JFK3=10
        JFK4=10
        GØ TØ(405,410,430,450,470),ITYPE
  405   DØ 352 K=1,N
        IF (DS(2,K)) 500,351,350
  350   TT(K)=ATANF(3.141592/(0.6931472*DS(2,K)))/(6.283184*DS(3,K))
        GØ TØ 352
  351   TT(K)=1.570796/(6.283184*DS(3,K))
  352   CØNTINUE
        DØ 407 I=1,M
        Z(I)=0.0
        DØ 406 K=1,N
  406   Z(I)=Z(I)+DS(1,K)*EXPF((TT(K)-T)*2.0*0.6931472*DS(3,K)*DS(2,K))
       X *SINF(6.283184*DS(3,K)*T)/SINF(6.283184*DS(3,K)*TT(K))
  407   T=T+W2
        IF (IFD(10)) 416,500,416
  410   DØ 412 I=1,M
        Z(I)=0.0
```

```
      DØ 411 K=1,N
411   Z(I)=Z(I)+DS(1,K)*EXPF(-0.6931472*DS(3,K)*T*2.0*DS(2,K))*
     1 CØSF(6.283184*DS(3,K)*T)
412   T=T+W2
      IF (IFD(10)) 416,500,416
416   XJFK=TØ*DS(3,1)+1.0
      JFK=XJFK
      IF (XJFK-1.5) 417,417,418
417   JFK=1
      GØ TØ 422
418   IF (XJFK-7.0) 422,419,419
419   JFK=7
422   GØ TØ (424,426,426,426,426,426,428),JFK
424   TØØ=TØ
      YTØP=XMAGN
      GØ TØ 710
426   TØØ=1.0/DS(3,1)
      YBØT=-XMAGN
      YTØP=XMAGN
      FDR=0.0005
      GØ TØ 710
428   TØØ=1.0/DS(3,1)
      YBØT=-XMAGN
      YTØP=XMAGN
      FDR=0.0025
      JFK2=4
710   IF(N-2) 711,712,713
711   YTØP=1.1*YTØP
      FDR2=2.0
      JFK3=5
      JFK4=5
      GØ TØ 714
712   YTØP=1.4*YTØP
      YBØT=1.4*YBØT
      FDR2=5.0
      JFK3=2
      JFK4=4
      GØ TØ 714
713   YTØP=1.6*YTØP
      YBØT=1.6*YBØT
      FDR2=5.0
      JFK3=2
      JFK4=4
714   IF(XMAGN-38640.) 490,495,490
430   TØØ=TØ
      DØ 437 I=1,M
      IF (T-DS(2,1)) 431,433,432
 431  Z(I)=(DS(1,1)*T)/DS(2,1)
      GØ TØ 437
 432  IF (T-DS(3,1)) 433,434,434
 433  Z(I)=DS(1,1)
      GØ TØ 437
 434  IF (TØ-DS(3,1)) 436,436,435
 435  Z(I)=DS(1,1)*(1.0-(T-DS(3,1))/(TØ-DS(3,1)))
      GØ TØ 437
436   Z(I)=0.0
437   T=T+W2
      IF (IFD(10)) 438,500,438
```

```
438   IF (XMAGN-38640.) 490,495,490
450   TØØ=TØ
      DØ 459 I=1,M
      IF (T-DS(2,1)) 451,453,452
 451  Z(I)=0.5*DS(1,1)*(1.0-CØSF(3.141592*T/DS(2,1)))
      GØ TØ 459
 452  IF (T-DS(3,1)) 453,454,454
 453  Z(I)=DS(1,1)
      GØ TØ 459
 454  IF (TØ-DS(3,1)) 456,456,455
 455  Z(I)=0.5*DS(1,1)*(1.0-CØSF(3.141592+3.141592*(T-DS(3,1))
     1 /(TØ-DS(3,1))))
      GØ TØ 459
 456  Z(I)=0.0
 459  T=T+W2
      IF (IFD(10)) 460,500,460
460   IF (XMAGN-38640.) 490,495,490
470   TØØ=TØ
      DØ 479 I=1,M
      IF (T-DS(2,1)) 471,473,472
 471  Z(I)=DS(1,1)*(1.0-EXPF(3.141592*DS(1,2)*T/DS(2,1)))/(1.0-EXPF
     1 (3.141592*DS(1,2)))
      GØ TØ 479
 472  IF (T-DS(3,1)) 473,474,474
 473  Z(I)=DS(1,1)
      GØ TØ 479
 474  IF (TØ-DS(3,1)) 476,476,475
 475  Z(I)=DS(1,1)*(1.0-EXPF(3.141592*DS(2,2)*(1.0-(T-DS(3,1))/
     1  (TØ-DS(3,1)))))/(1.0-EXPF(3.141592*DS(2,2)))
      GØ TØ 479
 476  Z(I)=0.0
 479  T=T+W2
      IF (IFD(10)) 480,500,480
480   IF (XMAGN-38640.) 490,495,490
490   CALL SMXYV (0,0)
      FDR2=XMAGN/100.0
      CALL GRID1V(1,0.0,TØ,YBØT,YTØP,FDR,FDR2,-JFK2,10,JFK2,10,6,4)
      CALL CHSIZV(3,4)
      CALL RITE2V(330,1011,1023,90,2,24,-1,24HSHOCK INPUT TIME HISTORY ,
     1 NL1)
      CALL CHSIZV(3,3)
      CALL RITE2V(420,9,1023,90,1,15,-1,15HTIME  (SECONDS) ,NL3)
      CALL RITE2V(9,151,1023,180,1,44,-1,44HACCELERATION  (INCHES PER SE
     1COND PER SECOND) ,NL2)
      T2=0.0
      Z2=Z(1)
      DØ 491 L=2,MM
      T1=T2
      Z1=Z2
      T2=T1+W2
      Z2=Z(L)
491   CALL LINEV(NXV(T1),NYV(Z1),NXV(T2),NYV(Z2))
      Z3=Z(M)
      T3=TØ
      CALL LINEV(NXV(T2),NYV(Z2),NXV(T3),NYV(Z3))
      GØ TØ 500
495   YBØT=YBØT /386.4
```

```
      YTØP=YTØP /386.4
      CALL SMXYV (0,0)
      CALL GRID1V(1,0.0,TØ,YLOT,YTØP,FDR,FDR2,-JFK2,JFK3,JFK2,JFK4,4,4)
      CALL CHSIZV(2,2)
      CALL RITE2V(12,600,1023,180,2,1,-1,1H9,NL4)
      CALL CHSIZV(3,4)
      CALL RITE2V(330,1011,1023,90,2,24,-1,24HSHOCK INPUT TIME HISTORY ,
     1 NL1)
      CALL CHSIZV(3,3)
      CALL RITE2V(9,330,1023,180,1,17,-1,17HACCELERATION  ( ),NL2)
      CALL RITE2V(420,9,1023,90,1,15,-1,15HTIME  (SECONDS) ,NL3)
      T2=0.0
      Z2=Z(1)/386.4
      DØ 496 L=2,MM
      T1=T2
      Z1=Z2
      T2=T1+W2
      Z2=Z(L)/386.4
496   CALL LINEV(NXV(T1),NYV(Z1),NXV(T2),NYV(Z2))
      Z3=Z(M)/386.4
      T3=TØ
      CALL LINEV(NXV(T2),NYV(Z2),NXV(T3),NYV(Z3))
500   RETURN
      END
```

```
*       SHØCK PLØT RØUTINE
        SUBRØUTINE SHPLØT (M,Z,TØØ,XMAGN,FUG,MM,W2,IFD)
        RETURN
        END
```

```
*       SHØCK RØUTINE
C       SHØCK SUBRØUTINE
        SUBRØUTINE SHØCK (FS1,FS2,NF,XØ,VØ,ZØ,TØ,ZTØ,W2,MM,DAMP,IF,IN,L,
       1LMAX,XMAGN,TØØ)
        DIMENSIØN Z(500),ZD(500),X(999),XPMAX(500),XNMAX(500),APMAX(500),
       1ANMAX(500),FMAG(500),FC(500),FS(500),FPWR(500),FREQ(501),XTØ(500),
       2VTØ(500),FMAGF2(500),PLRV(500),PLMAXI(500),PLFR(500)
       3,FPH(500)
        CØMMØN Z,ZD,X,XPMAX,XNMAX,APMAX,ANMAX,FMAG,FPH,FC,FS,FPWR,FREQ,
       1XTØ,VTØ,FMAGF2,PLRV,PLMAXI,PLFR,LMAX,LK
        W3=6.283184*FS1
        W4=6.283184*FS2
        W6=W3*W2
        W7=W4*W2
        FREQ(1)=FS1
        IF (DAMP-.000001) 104,105,105
  105   W8=DAMP*W6
        W9=DAMP*W7
        W10=SQRTF(1.0-DAMP**2.0)
        W11=1.0-2.0*DAMP**2.0
        W12=W6*W10
        W13=W7*W10
  104   DØ 100 I=1,NF
        IF (DAMP-.000001) 106,107,107
  107   W16=EXPF(-W8)
        WJ=W16*CØSF(W12)
        WB=W16*SINF(W12)/W10
        W17=DAMP*WB
        WA=WJ+W17
        WE=-WB
        WF = WJ-W17
        IF(IN)160,160,161
  160   WC=(WA-1.0)/W3
        WD=((W11*WB+2.0*DAMP*(1.0-WJ))/W6-1.0)/W3
        WG=WE/W3
        WH=(WA-1.0)/(W3*W6)
        GØ TØ 172
  161   WC=(WA-1.0)/W6
        WD=((W11*WB+2.0*DAMP*(1.0-WJ))/W6-0.5*(1.0+WA))/W6
        WG=WE/W6
        WH = (0.5*WB+WC)/W6
  172   W8=W8+W9
        W12=W12+W13
        GØ TØ 151
  106   WA=CØSF(W6)
        WB=SINF(W6)
        WE=-WB
        WF = WA
        IF(IN)180,180,181
  180   WC=(WA-1.0)/W3
        WD=(WB/W6-1.0)/W3
        WG=WE/W3
        WH=(WA-1.0)/(W3*W6)
        GØ TØ 151
  181   WC=(WA-1.0)/W6
        WD=(WB/W6-0.5-0.5*WA)/W6
        WG=WE/W6
        WH = (0.5*WB+WC)/W6
```

```
151   X(1)=X0*W3
      V = V0-Z0
      XPMAX(I)=0.0
      XNMAX(I)=0.0
      DO 110 J=1,MM
      JP=J+1
      X(JP) = WA*X(J)+WB*V+WC*Z(J)+WD*ZD(J)
      V = WE*X(J)+WF*V+WG*Z(J)+WH*ZD(J)
      IF (X(JP)) 111,113,113
111   XNMAX(I)=MIN1F(XNMAX(I),X(JP))
      GO TO 110
113   XPMAX(I)=MAX1F(XPMAX(I),X(JP))
110   CONTINUE
      MI=I+IF
      XTO(MI)=X(JP)
      VTO(MI)=V
      FMAG=SQRTF(X(JP)**2.0+V**2.0)
      FMAGF2(I)=FMAG*W3
      W20=W3*TO
      IF (DAMP-0.000001) 116,117,117
 116  XNMAX(I)=MIN1F(-FMAG,XNMAX(I))
      XPMAX(I)=MAX1F(FMAG,XPMAX(I))
      GO TO 118
 117  W23=W10*W20
      W24=W10*W3
      W25=EXPF(-DAMP*W20)
      W26=W25*COSF(W23)
      W27=W25*SINF(W23)/W10
      W28=1.0-DAMP**2.0
      W29=W3*X0
      W30=V0-Z0
      W31=X(JP)-(W26+DAMP*W27)*W29-W27*W30
      W32=V+W27*W29-(W26-DAMP*W27)*W30
      W33=-(((W28*W27+DAMP*W26)*W31+W26*W32)/W25)/W25
      W34=(((W26-DAMP*W27)*W31-W27*W32)/W25)/W25
      W35=3.141592/W24
      W36=W29+DAMP*(W30-W33)+W28*W34
      IF (ABSF(W36)-0.000001) 200,201,201
 201  TT=ATANF(W10*(W30-W33-DAMP*W34)/W36)/W24
 204  IF (TT-TO) 202,203,203
 202  TT=TT+W35
      GO TO 204
 200  TT=1.570796/W24
 203  W37=W3*TT
      W38=EXPF(-DAMP*W37)
      W39=W24*TT
      W40=W38*COSF(W39)
      W41=W38*SINF(W39)/W10
      XTT1=(W29+W34)*W40+(DAMP*W29+W30-W33)*W41
      W42=W3*(TT+W35)
      W43=EXPF(-DAMP*W42)
      W44=W24*(TT+W35)
      W45=W43*COSF(W44)
      W46=W43*SINF(W44)/W10
      XTT2=(W29+W34)*W45+(DAMP*W29+W30-W33)*W46
      IF (XTT1) 205,118,207
 205  XNMAX(I)=MIN1F( XTT1,XNMAX(I))
```

```
      XPMAX(I)=MAX1F(XTT2,XPMAX(I))
      GØ TØ 118
  207 XPMAX(I)=MAX1F(XTT1,XPMAX(I))
      XNMAX(I)=MIN1F( XTT2,XNMAX(I))
  118 L=L+1
      LMAX=L-1
      PLFR(L)=(TØØ*W3)/6.283184
      PLRV(L)=FMAG/(XMAGN*TØØ)
      PLMAXI(L)=MAX1F(-XNMAX(I),XPMAX(I))
      PLMAXI(L)=PLMAXI(L)/(XMAGN*TØØ)
      IF(PLRV(L)-0.001) 119,120,120
  119 PLRV(L)=0.001
  120 IF(PLMAXI(L)-0.001) 121,122,122
  121 PLMAXI(L)=0.001
  122 APMAX(I)=XPMAX(I)*W3
      XPMAX(I)=XPMAX(I)/W3
      ANMAX(I)=XNMAX(I)*W3
      XNMAX(I)=XNMAX(I)/W3
      II=I+1
      FREQ(II)=FREQ(I)+FS2
      W3=W3+W4
  100 W6=W6+W7
      RETURN
      END
```

```
*       FREQ. SPEC. RØUTINE
C       FRQSPC SUBRØUTINE
        SUBRØUTINE FRQSPC (FS1,FS2,NF,TØ,ZTØ,IN,IF,SFT,L,PLFPH)
        DIMENSIØN Z(500),ZD(500),X(999),XPMAX(500),XNMAX(500),APMAX(500),
       1ANMAX(500),FMAG(500),FC(500),FS(500),FPWR(500),FREQ(501),XTØ(500),
       2VTØ(500),FMAGF2(500),PLRV(500),PLMAXI(500),PLFR(500)
       3,FPH(500),PLFPH(500)
        CØMMØN Z,ZD,X,XPMAX,XNMAX,APMAX,ANMAX,FMAG,FPH,FC,FS,FPWR,FREQ,
       1XTØ,VTØ,FMAGF2,PLRV,PLMAXI,PLFR,LMAX,LK
        W3=6.283184*FS1
        W4=6.283184*FS2
        FREQ(1)=FS1
        DØ 100 I=1,NF
        W20=W3*TØ
        W21=CØSF(W20)
        W22=SINF(W20)
        MI=I+IF
        FC(I)=(-XTØ(MI)*W21+(VTØ(MI)+ZTØ)*W22)
        FS(I)=(+XTØ(MI)*W22+(VTØ(MI)+ZTØ)*W21)
        FPWR(I)=(FC(I)**2.0+FS(I)**2.0)
        FMAG(I)=SQRTF(FPWR(I))
        IF (IN) 110,110,111
  110   W23=-FS(I)
        FS(I)=FC(I)
        FC(I)=W23
        GØ TØ 112
  111   FC(I)=FC(I)/W3
        FS(I)=FS(I)/W3
        FMAG(I)=FMAG(I)/W3
        FPWR(I)=FPWR(I)/(W3**2.0)
  112   IF (FMAG(I)-.000001*SFT) 105,106,106
  105   FMAG(I)=0.0
        FC(I)=0.0
        FS(I)=0.0
        FPWR(I)=0.0
        GØ TØ 151
  106   FCPH=FC(I)/FMAG(I)
        IF (ABSF(FCPH)-.000001) 120,121,121
  120   IF (FS(I)) 130,131,131
  130   FPH(I)=-90.0
        GØ TØ 151
  131   FPH(I)=90.0
        GØ TØ 151
  121   FTPH=FS(I)/FC(I)
        FPH(I)=360.0*ATANF(FTPH)/6.283184
        IF(FS(I)) 140,141,141
  140   IF(FC(I)) 150,151,151
  150   FPH(I)=-180.0+FPH(I)
        GØ TØ 151
  141   IF (FC(I)) 160,151,151
  160   FPH(I)=180.0+FPH(I)
  151   L=L+1
  153   PLFPH(L)=FPH(I)
  154   W3=W3+W4
        II=I+1
        FREQ(II)=FREQ(I)+FS2
  100   CØNTINUE
        RETURN
        END
```

```
*       FCSSG RØUTINE
C       FCSSG SUBRØUTINE
        SUBRØUTINE FCSSG (LK)
        DIMENSIØN AX(82),AXX(82),AY(82),AYY(82),
       XDX(82),DY(82),DXX(82),DYY(82)
        CALL SMXYV (1,1)
F       TABL1V,TABL2V
  420   CALL GRID1V (1,0.1,100.0,0.001,10.00,1.0,1.0,-0,0,0,0,5,6)
        CALL CHSIZV(3,4)
        CALL RITE2V(205,1011,1023,90,2,39,-1,39HFOUR COORDINATE FOURIER/SH
       1OCK SPECTRUM ,NL1)
        CALL CHSIZV(3,3)
        CALL RITE2V(9,314,1023,180,1,23,-1,23HVELOCITY PARAMETER   V ,NL2)
        CALL RITE2V(230,9,1023,90,1,34,-1,34H(NATURAL FREQUENCY)X(PULSE PE
       1RIOD),NL3)
        CALL VCHARV(90,2,880,0,61,TABL1V)
        CALL VCHARV(90,2,898,0,18,TABL2V)
        DØ 439 J=1,2
        CALL LINEV(880,9,892,9)
        CALL APRNTV( 9, 7,-5,5HD=1.0,97,107)
        CALL APRNTV( 9, 7,-5,5HD=10.,97,343)
        CALL APRNTV( 9, 7,-6,6HD=100.,97,577)
        CALL APRNTV( 9, 7,-8,8HD=1,000.,97,814)
        CALL APRNTV(-9, 7,-7,7H0.1=A  ,992,107)
        CALL APRNTV(-9, 7,-7,7H.01=A  ,992,343)
        CALL APRNTV(-9, 7,-8,8H.001=A  ,992,577)
        CALL APRNTV(-9, 7,-10,10H.000,1=A  ,992,814)
        CALL APRNTV(-9,-7,-5,5H1.0=D,377,86)
  439   CALL APRNTV( 9,-7,-7,7H  A=0.1,713,86)
        IF (LK) 350,350,365
  350   A=0.0001
        D=0.0001
        DØ 364 K=1,64,9
        B=A
        C=D
        DØ 364 J=1,9
        L=J+K
        A=A+B
        D=D+C
  354   IF (A-6.0) 355,355,357
  355   AX(L)=0.10
        AY(L)=A/0.6283184
        IF (A- 0.6) 356,356,358
  356   AYY(L)=0.001
        AXX(L)=A/0.006283184
        GØ TØ 359
  357   AY(L)=10.0
        AX(L)=A/62.83184
  358   AXX(L)=100.0
        AYY(L)=A/628.3184
  359   IF (D-0.6) 360,360,361
  360   DY(L)=0.001
        DX(L)=0.3864/(6.283184*D)
        GØ TØ 363
  361   DX(L)=0.10
        DY(L)=( 0.6283184*D)/386.4
        IF (D-6.000) 363,363,362
  362   DYY(L)=10.00
```

```
      DXX(L)=3864.00/(6.283184*D)
      GØ TØ 364
  363 DXX(L)=100.0
      DYY(L)=(628.3184*D)/386.4
  364 LK=1
  365 DØ 366 L=7,69
      CALL LINEV (NXV(AX(L)),NYV(AY(L)),NXV(AXX(L)),NYV(AYY(L)))
  366 CALL LINEV (NXV(DX(L)),NYV(DY(L)),NXV(DXX(L)),NYV(DYY(L)))
      RETURN
      END
```