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RESPONSE ARRAYS AND SENSITIVITY COEFFICIENTS FOR STANDARD CONFIGURATIONS OF THE USGS SHORT-PERIOD TELEMETERED SEISMIC SYSTEM

by

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Response Arrays and Sensitivity Coefficients for Standard Configurations of the USGS Short-period Telemetered Seismic System

by J. P. Eaton

Stewart and O'Neill (1) have described the USGS short-period telemetered seismic system in terms of its component parts and have written a computer program (RESPONSE) for calculating the response of the system in its various configurations. Each component is represented by a sensitivity factor multiplied by a frequency dependent factor. The frequency dependent factors can in turn be broken down into the product of elementary spectral elements that can be specified by four parameters: 1) characteristic frequency, 2) damping constant, 3) number of poles (roots of the characteristic equation), 4) low frequency falloff (powers of frequency).

For each principal component of the USGS seismic system Stewart and O'Neill ((1), Table 2) have tabulated the sensitivity factor and values of the four parameters that specify each spectral element for that component. These values were determined partly by experiment (fitting theoretical parameter-dependent curves to experimentally determined response curves) and partly from the specifications for the standard adjustment of the system. The response for a particular configuration of the entire system can be calculated by RESPONSE from the set of parameters (from (1), Table 2) that represents the system components in that configuration.

A common use of the system response curve is to determine the ground motion amplitude corresponding to a wavelet, characterized by its amplitude and apparent period, measured on the system recorder. The wavelet amplitude is divided by the system harmonic magnification corresponding to the apparent period of the wavelet. Thus, we need a simple means of determining the system's magnification for an arbitrary period within its passband (0.1 hz 50 hz).

In principle, RESPONSE could be invoked to calculate the magnification at the appropriate wave period, for a system made up of a specified set of components and characterized by the appropriate set of elementary spectral parameters, each time the need arises. Such a procedure would be unnecessarily complicated, however, considering the small number of standard system configurations actually used in routine work. These standard configurations are (Figure 1):

1) L4 seismometer, J402 preamp/VCO, Tricom discriminator, Siemens Oscillomink;

2) L4 seismometer, J402 preamp/VCO, J101B discriminator, Develocorder;

3) L4 seismometer, J402 preamp/VCO, Tricom discriminator, A/D convertor (Eclipse computer).

Within each of these standard configurations the only variation is the station-to-station difference in preamp/VCO attenuation, which affects the overall system gain, but not the shape of the response curve. Thus, we can specify the response of a particular system by indicating which standard configuration it conforms to and by specifying its preamp/VCO attenuation setting. A practical procedure for implementing the principles suggested above has been outlined by Eaton (2). We note that log magnification vs. log frequency plots for various configurations of the USGS system (Figure 2) are smoothly varying curves. If these curves are represented by arrays specifying magnification at discreet frequencies at intervals of δ log freq ≤ 0.1, then the magnification at intermediate frequencies can be obtained with suitable precision by simple interpolation (in terms of log freq) between array points. Furthermore, if the standard system response arrays are calculated for a standard "unit" response, then the response of various stations with different preamp/VCO attenuation settings can be obtained by multiplying the value obtained from the "unit" response array by appropriate attenuation-dependent sensitivity coefficients.

The overall system sensitivity factor (or amplitude factor), designated as AMP by Stewart and O'Neill (p. 17), can be calculated from the sensitivity factors for the individual components listed in (1), table 2.

(1) $AMP = G_{LE} * G_{SA} * D_{VCO} * D_{DSC} * L_{REC}$, where:

G_{LE} is the effective motor constant of the seismometer and L-pad (emf in volts, across the 10,000 ohm input impedance of the preamp, resulting from a seismometer-coil-to-frame velocity of 1 cm/sec). In the standard system using the L4 seismometer and L-pad, G_{LE} = 1.0 V/(cm/sec).

G_{SA} is the gain of the seismic preamp expressed as the ratio of output voltalge (across the VCO input) divided by input voltage. For various attenuation settings of the J402, G_{SA} is given by Stewart and O'Neill ((1), table 4, "Gain as an amplitude ratio--JVS").

D_{VCO} is the VCO sensitivity in the J402. In the standard adjustment it is set at $\pm$ 125 hz/$\pm$ 3.375 V or 37.04 hz/V.

D_{DSC} is the discriminator modulation sensitivity. In the standard adjustment it is set at $\pm$ 2.0V/$\pm$ 125 hz, or 0.0160 V/hz, in all of the discriminator types used with the system (Develco, J101A, J101B, Tricom, etc).

L_{REC} - Recorder (output medium) sensitivity.
In the standard adjustment, the sensitivities of the Develocorder (film read on the Geotech film viewer at x20 magnification) and the Siemens (for the 25 mv/mm setting) are the same: 4 cm/volt.
In the standard adjustment, the sensitivity of the A/D convertor in the Eclipse system is set at 511 counts/2.5V = 204.4 counts/volt.

It is convenient to separate the portion of the sensitivity factor depending on the amplification-transmission-recording portion of the system from that of the seismometer and L-pad.

(2) $$AMP = G_{LE} * A_R,$$

where

(3) $$A_R = G_{SA} * D_{VCO} * D_{DSC} * L_{REC} .$$

The procedure developed originally to calibrate the USGS seismic system is based on the use of a standard signal introduced at the preamp/VCO input in the field and recorded on the network recorders in the standard manner. The standard field calibration signal is a 10μV rms 5-hz sine wave (28.28μV peak to peak) at the preamp/VCO input. Because of the very low output impedance (2 ohms) of the calibration signal generator, the seismometer and its L-pad can remain attached to the system during calibration with no appreciable effect on the results. The frequency of the calibration signal (5 hz) was chosen to lie in the range of frequencies that is little affected by high-cut or low-cut filters in the amplification-transmission-recording system. The field calibration signal is applied to the system in its normal operating condition (including appropriate setting of the preamp/VCO attenuator); so the signal it produces on the recorder (C_{10}) is a direct measure of the amplification-transmission-recording sensitivity of the system: i.e., of A_R. C_{10} was originally defined in terms of the system configuration using the Develocorder and the Geotech Viewer (x20 magnification):

C_{10} = peak-to-peak signal in millimeters, on the Develocorder record read on the x20 viewer, produced by the 5-hz 10μV rms calibration signal at the preamp/VCO input.

The system response was separated into three factors:

1) Output of the seismometer (and L-pad) as a function of frequency,
2) Frequency-dependent response of the amplification-transmission-recording (Develocorder) system normalized to 1.0 at 5 hz,
3) Amplification-transmission-recording sensitivity factor.

A "unit" response curve corresponding to C_{10} = 1.0 mm was calculated and stored as an array of log M_1 vs. log F. To determine magnification M at frequency F for a station with arbitrary C_{10},

(4) $$M(F) = C_{10} * M_1(F),$$

where C_{10} is the "sensitivity coefficient" and where $M_1(F)$ is the "unit" response magnification obtained by interpolation from the log M_1 vs log F array.

In the original procedure C_{10} was obtained empirically. For a well-standardized system, however, we can calculate C_{10} as a function of the preamp/VCO attenuator setting. $A_R = G_{SA} * D_{VCO} * D_{DSC} * L_{REC}$ is the sensitivity factor for converting a signal at the preamp/VCO input (in volts) to a signal at the system output (in cm for the Develocorder or Siemens). By definition,

$$C_{10} = 28.28 \times 10^{-6} A_R$$

$$C_{10}(\text{unit}) = 0.1 \text{ cm} = 28.28 \times 10^{-6} A_R(\text{unit})$$

(5) $$A_R(\text{unit}) = 0.3536 \times 10^4 \text{ cm/V}$$

(6) $$AMP(\text{unit}) = G_{LE} \times A_R(\text{unit}) = 0.3536 * 10^4 \, G_{LE}$$

(7)

$$C_{10}(DB) = 28.28 \times 10^{-6} * A_R(DB) = 28.28 \times 10^{-6} * G_{SA}(DB) * D_{VCO} * D_{DSC} * L_{REC}$$

where DB indicates the attenuation setting on the amplifier.

For the standard system

$$D_{VCO} = 37.04 \text{ hz/V}$$

$$D_{DSC} = 0.0160 \text{ V/hz}$$

L_{REC} = 4.0 cm/V [Develocorder (x20 viewer) or Siemens (25 mv/mm)]

L_{REC} = 204.4 counts/V [Eclipse]

(8)

$C_{10}(DB) = 670.4 \times 10^{-6} \, G_{SA}(DB)$ mm [for the Develocorder or Siemens]

$C'_{10}(DB) = 16{,}760.0 \times 10^{-6} \, G_{SA}(DB)$ mv [for the Eclipse]

$C''_{10}(DB) = 3425.7 \times 10^{-6} \, G_{SA}(DB)$ counts [for the Eclipse]

Data on the gain of the J402 as a function of attenuator setting presented in (1), Table 4, permit us to calculate these co-efficients as a function of attenuator setting.

(J402 attenuator vs gain data from J. Van Schaack)

Attn(DB)	Gain(DB)	Gain	C_{10}(mm)	C'_{10}(mv)	C''_{10}(counts)
0	91.5	37,584	25.20	629.9	128.8
6	84.8	17,378	11.65	291.3	59.53
12	78.4	8,318	5.576	139.4	28.49
18	72.4	4,169	2.795	69.87	14.28
24	66.4	2,089	1.400	35.01	7.156
30	60.4	1,047	0.7019	17.55	3.587
36	54.4	525	0.3520	8.80	1.798
42	48.4	263	0.1763	4.41	0.9014
48	42.4	132	0.0885	2.21	0.4522
"unit" (26.9)	(63.5)	1,492	1.0	25.00	5.110

We note that for "unit" system gain, for which $C_{10} = C_{10}$(unit) = 1 mm, the 10μV rms 5-hz sine wave produces a signal amplitude of 1.0 mm (p-p) on the Develocorder (x20 Viewer magnification) and on the Siemens (25 mv/mm), and 25.0 mv (p-p) or 5.11 counts (p-p) on the Eclipse. Thus, for the standard adjustment of the Develocorder, Siemens, and Eclipse A/D converter, we can reduce "amplitudes" measured in mv or counts to the equivalent amplitude in mm as follows:

$$A(mv)/25.0 = A(mm),$$

$$A(counts)/5.11 = A(mm).$$

If we adopt the convention that all amplitudes are expressed in mm(p-p) [equivalent to the Siemens record], then the same C_{10}(DB) coefficients can be used for all system configurations that conform to the system standards for G_{SA}, D_{VCO}, D_{DSC} , and L_{REC}.

The program RESPONSE has been modified slightly to calculate values of log M(F) as well as M(F) for a set of frequencies separated by uniform steps in log F. This program (RSPNS) can readily be used to calculate unit response (log M_1 vs log F) arrays for various configurations of the system. Such arrays were calculated for the standard configuration with the Develocorder for the standard configuration with the Siemens recorder and for two configurations employing 12 db/octave high-cut filters and the Siemens recorder. Plots of these curves, along with a C_{10}(DB) table that applies to all four curves, are shown in Figure 2. The sets of input parameters required by RSPNS to generate these arrays are listed below.

Develocorder (unit response)

AMP = 0.3536×10^4 (G_{LE} = 1.0, AMP(unit) = 0.3536×10^4)

Spectral elements and their parameters

LTYPE	LN	F	B	COMMENTS
2	3	1.000	0.80	SEISMOMETER
2	2	0.095	1.00	AMPLIFIER
2	0	44.00	1.00	"
2	0	60.00	1.00	J101B DISC
2	0	130.00	0.70	"
2	0	15.50	0.70	DEVELOCORDER
1	1	0.530		"

Scaling factors

KD	WL	WF
3	0.100	0.05

LTYPE = 1 (single) or 2 (double) poles

LN = low-frequency falloff

F = characteristic frequency

B = damping constant (for double pole)

KD = number of decades for which response is calculated

WL = lowest frequency (hz) for which response is calculated

WF = log frequency increments between computed points

Siemens (unit response)

AMP = 0.3536×10^4

LTYPE	LN	F	B	COMMENTS
2	3	1.00	0.80	SEISMOMETER
2	2	0.095	1.00	AMPLFIER
2	0	44.00	1.00	"
1	0	45.10		TRICOM DISC
2	0	46.70	0.89	"
2	0	52.70	0.55	"

Scaling factor

KD	WL	WF
3	0.10	0.05

Siemens (unit response, 16-hz 12 db/oct hi-cut filter)

Same as Siemens (unit response) above, except one additional spectral element following the 3rd TRICOM element

LTYPE	LN	F	B	COMMENTS
2	0	16.00	0.50	16HZ 12DB HI CUT FILT

Siemens (unit response, 5-hz 12 db/oct hi-cut filter)

Same as Siemens (unit response), except one additional spectral element following the third TRICOM element

LTYPE	LN	F	B	COMMENTS
2	0	5.00	0.50	5HZ 12DB HI CUT FILT

References

(1) Stewart, S. W., and O'Neill, M. E., 1980, Calculation of the frequency response of the USGS telemetered short-period seismic system: U.S. Geological Survey Open-File Report 80- .

(2) Eaton, J. P., 1975, Harmonic magnification of the complete telemetered seismic system, from seismometer to film viewer screen: U.S. Geological Survey Open-File Report 75-99.

Figure Captions

Figure 1

Block diagram of the USGS telemetered short-period seismograph system.

Figure 2

USGS seismic system "unit" response curves for configurations employing

1) Develocorder with J101B dislcriminators
2) Siemens with TRICOM discriminators
3) Siemens with 16-hz 12 db/octave high-cut filter
4) Siemens with 5-hz 12 db/octave high-cut filter.

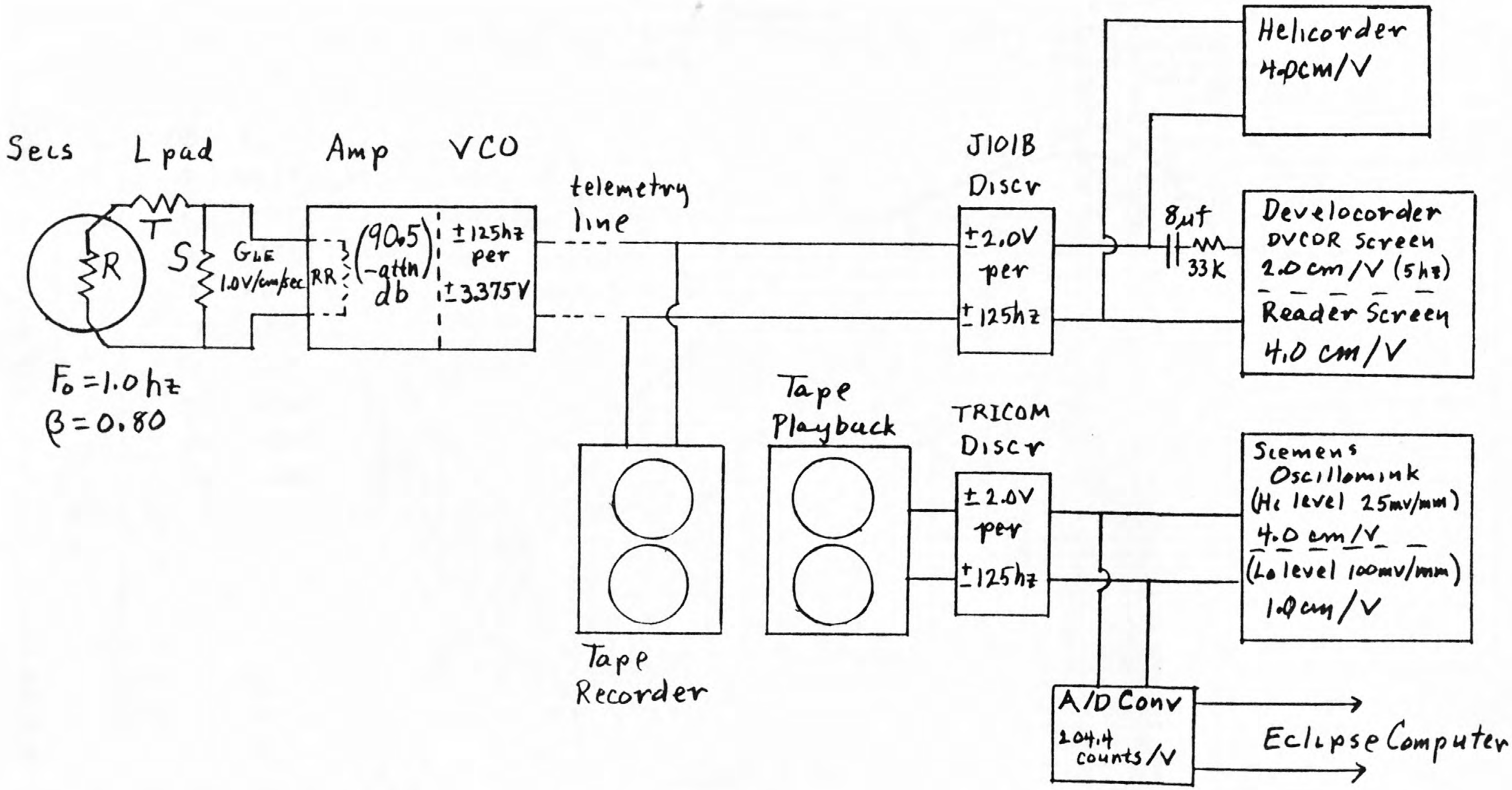
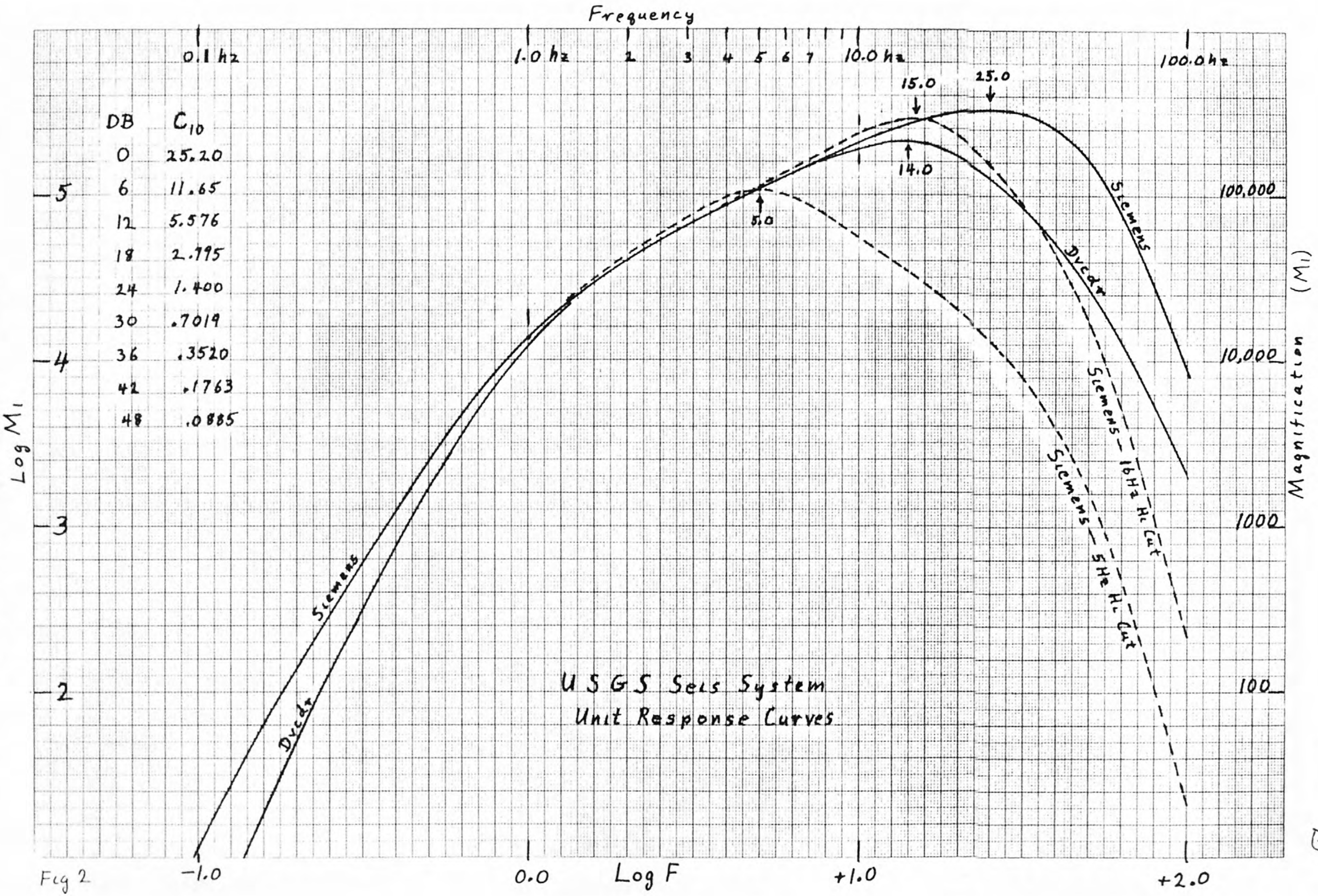

Secs
L pad
Amp
VCO
telemetry line
R
T
S
G_{LE} 1.0V/cm/sec
RR
(90.5 - attn) db
±125hz per ±3.375V
F_0 = 1.0 hz
β = 0.80
J101B Discr
±2.0V per ±125hz
Helicorder 4.0cm/V
8μf
33K
Develocorder
DVCOR Screen 2.0 cm/V (5hz)
Reader Screen 4.0 cm/V
Tape Recorder
Tape Playback
TRICOM Discr
±2.0V per ±125hz
Siemens Oscillomink
(Hi level 25mv/mm)
4.0 cm/V
(Lo level 100mv/mm)
1.0 cm/V
A/D Conv
204.4 counts/V
Eclipse Computer

Fig 1



DB	C_{10}
0	25.20
6	11.65
12	5.576
18	2.795
24	1.400
30	.7019
36	.3520
42	.1763
48	.0885

Fig 2

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$                                                                  $
$  Requested 01/09/80  1032.7 pst Wed                              $
$  Output    01/09/80  1032.8 pst Wed                              $
$                                                                  $
$                                                                  $
$  printer queue 3            prta                                 $
$                                                                  $
$  6 pages                                                         $
$                                                                  $
$  327 lines at $1.35 per 1000 lines                               $
$                                                                  $
$  Charge to JEaton.Calnet.a                                 0.44  $
$                                                                  $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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6/

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PROGRAM RESPONSE
SEPTEMBER 1979--- MARY O'NEILL ALLEN


THIS PROGRAM COMPUTES RESPONSE SPECTRA FROM GIVEN POLES.


EXPLANATION OF THE COMPUTATIONS
  MANY FUNCTIONS OF INTEREST IN SEISMOLOGY CAN BE APPROXIMATED BY
  SIMPLE, EXPLICIT ALGEBRAIC EXPRESSIONS.  IN THE FREQUENCY DOMAIN
  THESE FUNCTIONS HAVE THE FORM
  G = WW**NL*I**(NL-N)/((WW-AL(1)*(WW-AL(2))---(WW-AL(N))), WHERE
  G = COMPLEX SPECTRUM.
  WW = ANGULAR FREQUENCY IN RADIANS/SECOND.
  I = SQRT(-1.).
  N = INTEGER CONSTANT = NUMBER OF POLES OF THE SPECTRUM.
  NL = INTEGER CONSTANT = POWER OF THE LOW-FREQUENCY FALLOFF OF
    THE AMPLITUDE SPECTRUM.
  AL(J) = COMPLEX CONSTANTS = POLES OF THE SPECTRUM.
  TO PRODUCE REAL, CAUSAL TIME-DOMAIN FUNCTIONS, THE POLES AL(J) MUST
  BE PURELY IMAGINARY, AL(J) = I*Y(J), OR MUST OCCUR IN PAIRS,
  AL(J) = +X(J)+I*Y(J), AL(J+1) = -X(J)+I*Y(J), WHERE X(J) AND Y(J)
  ARE REAL, POSITIVE NUMBERS.
  OTHER FUNCTIONS IN THIS PROGRAM RELATED TO G ARE AS FOLLOWS--
  GM = AMPLITUDE SPECTRUM = ABS(G).
  GP = PHASE SPECTRUM.
  GMN = NORMALIZED AMPLITUDE SPECTRUM.
  WK = FREQUENCY IN HERTZ.


INPUT DATA

  CARD 1
    COL 1-80   TITLE   FORMAT(20A4)

  CARD 2
    THIS CARD SPECIFIES THE AMPLITUDE FACTOR FOR THE RESPONSE CURVE.
    COL 1-10   AMP   FORMAT(E10.4)

  CARDS 3 TO KK+2
    THESE CARDS GIVE THE PARAMETERS OF THE SPECTRAL ELEMENTS THAT
      MAKE UP THE COMPLETE SYSTEM RESPONSE.
    COL 1-5   LTYPE   FORMAT(I5)
      LTYPE = 1 OR 2.
        LTYPE = 1 SPECIFIES A SPECTRAL ELEMENT WITH ONE POLE;
        LTYPE = 2 SPECIFIES A SPECTRAL ELEMENT WITH TWO POLES.
        NOTE: THE SUM OF LTYPE = N.
    COL 6-10   LN   FORMAT(I5)
      LN: POWER OF THE LOW-FREQUENCY FALLOFF OF THE SPECTRAL ELEMENT.
        NOTE: THE SUM OF LN = NL.
    COL 11-20   F   FORMAT(F10.4)
      F = CORNER FREQUENCY IN HERTZ.
        F IS EQUIVALENT TO THE NATURAL FREQUENCY OF A HARMONIC
        OSCILLATOR.
    COL 21-30   B   FORMAT(F10.4)
      B = REAL, POSITIVE CONSTANT CHARACTERIZING THE SHAPE OF THE
        SPECTRAL ELEMENT WHEN LTYPE = 2.  B IS EQUIVALENT TO THE
        DAMPING CONSTANT OF A HARMONIC OSCILLATOR.
        WHEN LTYPE = 1, B CAN BE LEFT BLANK.
    COL 36-75   LABEL   FORMAT(8A4)
```

```
    LABEL = COMMENTS ASSOCIATED WITH SPECTRAL ELEMENT.

 CARD KK+3
   BLANK CARD.

 CARD KK+4
   THIS CARD SPECIFIES THE SCALING FACTORS FOR THE SPECTRUM.
   COL 1-5   KD   FORMAT(I5)
     KD = NUMBER OF DECADES OF FREQUENCY.
   COL 6-15   WL   FORMAT(F10.3)
     WL = LOWEST FREQUENCY IN HERTZ.  WL MUST BE SOME POWER OF TEN,
       FOR EXAMPLE, .1, 1., OR 10.
   COL 16-25   WF   FORMAT(F10.3)
     WF = LOG FREQUENCY INCREMENT BETWEEN COMPUTED SPECTRAL POINTS;
      EG 0.05 FOR 20 POINTS PER DECADE OR 0.10 FOR 10.

 CARD KK+5
   THIS CARD SPECIFIES IF ANOTHER DATA SET IS TO FOLLOW.
   COL 1-5   IEND   FORMAT(I5)
     IEND = AN INTEGER .NE. 0 IF ANOTHER DATA SET FOLLOWS OR A BLANK
       IF NO DATA SET FOLLOWS.


   COMPLEX I
   COMPLEX AL(20)
   REAL C(20)
   REAL GM(200)
   REAL GMN(200)
   REAL GP(200)
   REAL WK(200)
   DIMENSION LABEL(10)
   DIMENSION TITLE(20)


   I=(0.,1.)
   PI=3.1415927

 1 FORMAT(//)
 2 CONTINUE

EAD INPUT PARAMETERS.

   READ(5,3) TITLE
 3 FORMAT(20A4)
   WRITE(6,4) TITLE
 4 FORMAT('1',20A4)
   READ(5,5) AMP
 5 FORMAT(E10.4)
   WRITE(6,6) AMP
 6 FORMAT(//'    AMP =',E10.4,'        AMPLITUDE FACTOR')
   WRITE(6,10)
10 FORMAT(//,' LTYPE    LN        F           B          COMMENTS',/)
   J=0
   NL=0
12 CONTINUE
   READ(5,13) LTYPE,LN,F,B,LABEL
13 FORMAT(2I5,2F10.4,5X,10A4)
   IF(LTYPE.EQ.0) GO TO 20
   IF(LTYPE.EQ.2) GO TO 15
   WRITE(6,14) LTYPE,LN,F,LABEL
```

```
   14 FORMAT(2I6,F12.4,17X,10A4)
      NL=NL+LN
      J=J+1
      AL(J)=I*2.*PI*F
      C(J)=1.
      IF(LN.EQ.0) C(J)=2.*PI*F
      GO TO 12
   15 WRITE(6,16) LTYPE,LN,F,B,LABEL
   16 FORMAT(2I6,2F12.4,5X,10A4)
      NL=NL+LN
      IF(B.GT.1.) GO TO 18
      J=J+1
      AL(J)=2.*PI*F*(I*B+SQRT((1.-B)*(1.+B)))
      C(J)=1.
      IF(LN.EQ.0) C(J)=2*PI*F
      J=J+1
      AL(J)=2.*PI*F*(I*B-SQRT((1.-B)*(1.+B)))
      C(J)=1.
      IF(LN.EQ.0) C(J)=2*PI*F
      GO TO 12
   18 CONTINUE
      J=J+1
      AL(J)=2.*PI*F*I*(B+SQRT((B-1.)*(B+1.)))
      C(J)=1.
      IF(LN.EQ.0) C(J)=2*PI*F
      J=J+1
      AL(J)=2.*PI*F*I*(B-SQRT((B-1.)*(B+1.)))
      C(J)=1.
      IF(LN.EQ.0) C(J)=2*PI*F
      GO TO 12
   20 CONTINUE
      N=J
      C(1)=C(1)*AMP
      WRITE(6,21) N
   21 FORMAT(//,'    N =',I3,'      NUMBER OF POLES')
      WRITE(6,22) NL
   22 FORMAT(/,'    NL =',I3,'      POWER OF LOW-FREQUENCY FALLOFF',/)
      WRITE(6,1000)
 1000 FORMAT(//,'     J                  AL                        C',//)
      DO 1002 J=1,N
      WRITE(6,1001) J,AL(J),C(J)
 1001 FORMAT(I5,2F12.4,5X,F13.3)
 1002 CONTINUE
      WRITE(6,1100)
      WRITE(6,1101)
      WRITE(6,1106)
 1100 FORMAT(/,'        J = NUMBER OF POLE.')
 1101 FORMAT('        AL = COMPLEX NUMBER GIVING POLE POSITION IN RADIANS
     C/SECOND.')
 1106 FORMAT('        C = AMPLITUDE CONSTANT ASSOCIATED WITH AL.')
C
C READ SCALING FACTORS.
C
      WRITE(6,32)
   32 FORMAT(/,'    SCALING FACTORS FOR SPECTRUM',/)
      READ(5,35) KD,WL,WF
   35 FORMAT(I5,2F10.3)
      WRITE(6,36) KD
   36 FORMAT('        KD = ',I3,'            KD = NUMBER OF DECADES OF FR
     1EQUENCY.')
```

```
      WRITE(6,37) WL
   37 FORMAT('          WL =',F10.3,'       WL = LOWEST FREQUENCY IN HERTZ.'
     1)
      WRITE(6,38) WF
   38 FORMAT('          WF =',F10.3,'       WF = LOG FREQUENCY INCREMENT',
     1' BETWEEN POINTS')
      WRITE(6,1)
C
C     COMPUTE THE RESPONSE SPECTRUM.
C
      CALL SP(N,NL,AL,C,GM,GP,WK,KD,WL,WF,KS)
      CALL NORM(GM,GMN,GMMAX,KS,KMAX)
      CALL PTSP(GM,GMN,GP,WK,KD,WL,WF,KS)
  200 CONTINUE
C
C     CHECK IF MORE DATA FOLLOWS.
C
      WRITE(6,1)
      READ(5,205) IEND
  205 FORMAT(I5)
      WRITE(6,210) IEND
  210 FORMAT('    IEND =',I5)
      IF (IEND.EQ.0) GO TO 300
      GO TO 2
  300 CONTINUE
      END
      SUBROUTINE SP(N,NL,AL,C,GM,GP,WK,KD,WL,WF,KS)
C
C     THIS SUBROUTINE COMPUTES AN AMPLITUDE SPECTRUM AND A PHASE SPECTRUM
C       FROM GIVEN POLES.
C
C       N--NUMBER OF POLES OF THE SPECTRUM.
C       NL--LOW-FREQUENCY FALLOFF OF THE SPECTRUM.
C       AL(J)--POLES OF THE SPECTRUM.
C       C(J)--CONSTANT ASSOCIATED WITH AL(J).
C       GM(K)--AMPLITUDE SPECTRUM.
C       GP(K)--PHASE SPECTRUM.
C       WK(K)--FREQUENCY IN HERTZ.
C       KD--NUMBER OF DECADES OF FREQUENCY.
C       WL--LOWEST FREQUENCY IN HERTZ.  WL MUST BE SOME POWER OF TEN.
C       WF--LOG FREQUENCY INCREMENT BETWEEN COMPUTED SPECTRAL POINTS
C       KS--NUMBER OF SPECTRAL POINTS.  THIS NUMBER IS COMPUTED IN THE
C         SUBROUTINE.
C
      COMPLEX I
      COMPLEX AL(20)
      COMPLEX G
      REAL C(20)
      REAL GM(200)
      REAL GP(200)
      REAL WK(200)
C
      I=(0.,1.)
      PI=3.1415927
C
C     COMPUTE FREQUENCY VALUES WK(K).
C
      XKD=FLOAT(KD)
      WLL=ALOG10(WL)
      WLM=WLL+XKD
```

```
      NW=0
   10 NW=NW+1
      NW1=FLOAT(NW-1)
      WLX=WLL+NW1*WF
      IF(WLX .GT. WLM) GO TO 15
      WK(NW)=EXP(2.30258*WLX)
      GO TO 10
   15 KS=NW-1

C COMPUTE AMPLITUDE SPECTRUM GM(K) AND PHASE SPECTRUM GP(K).

      DO 40 K=1,KS
      WW=2.*PI*WK(K)
      G=WW**NL*I**(NL-N)
      DO 30 J=1,N
      G=G*C(J)/(WW-AL(J))
   30 CONTINUE
      GM(K)=CABS(G)
      GR=REAL(G)
      GI=AIMAG(G)
      GP(K)=ATAN(GI/GR)
      IF(GR.LT.0.) GP(K)=GP(K)+PI
      IF(GP(K).LT.0.) GP(K)=GP(K)+2.*PI
   40 CONTINUE
      RETURN
      END
      SUBROUTINE NORM(A,AN,AMAX,MM,MMAX)

C THIS SUBROUTINE COMPUTES NORMALIZED VALUES OF A FUNCTION.

C   A(M)--VALUES OF FUNCTION.
C   AN(M)--NORMALIZED VALUES OF FUNCTION.
C   AMAX--MAXIMUM ABSOLUTE VALUE OF A(M).
C   MM--NUMBER OF POINTS.
C   MMAX--POINT NUMBER CORRESPONDING TO AMAX.

      REAL A(500)
      REAL AN(500)

      AMAX=0.
      MMAX=0
      DO 10 M=1,MM
      AA=ABS(A(M))
      IF(AA.LE.AMAX) GO TO 10
      AMAX=AA
      MMAX=M
   10 CONTINUE
      DO 20 M=1,MM
      AN(M)=A(M)/AMAX
   20 CONTINUE
      RETURN
      END
      SUBROUTINE PTSP(GM,GMN,GP,WK,KD,WL,WF,KS)

C THIS SUBROUTINE PRINTS THE COMPUTED VALUES OF THE AMPLITUDE SPECTRUM
C   AND THE PHASE SPECTRUM PLUS THE NORMALIZED VALUES OF THE AMPLITUDE
C   SPECTRUM.

C   GM(K)--AMPLITUDE SPECTRUM.
C   GMN(K)--NORMALIZED AMPLITUDE SPECTRUM.
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```
GP(K)--PHASE SPECTRUM.
WK(K)--FREQUENCY IN HERTZ.
KS--NUMBER OF SPECTRAL POINTS.

  REAL GM(200)
  REAL GMN(200)
  REAL GP(200)
  REAL WK(200)

  WRITE(6,2)
2 FORMAT('1    AMPLITUDE SPECTRUM')
  WRITE(6,5)
5 FORMAT(//,'     K      WK(HZ)          GM              GMN             GP',
 1'        LOG(WK)        LOG(GM)')
  XKD=FLOAT(KD)
  WLL=ALOG10(WL)
  DO 20 K=1,KS
  NW1=FLOAT(K-1)
  WLX=WLL+NW1*WF
  XLGM=ALOG10(GM(K))
  WRITE(6,10) K,WK(K),GM(K),GMN(K),GP(K),WLX,XLGM
20 CONTINUE
10 FORMAT(1X,I3,3X,F8.3,3E12.4,3X,F8.3,1E14.5)
  WRITE(6,25)
25 FORMAT(//)
  RETURN
  END
```

```
 ******
**     *
**              ****                   **
**     ******    **    * *****  ****** ******
**          **   **    **   ** **    **  **
**     *******   **    **   ** *******   **
**   * **   **   **    **   ** **        **
 ****** *******  ****  **   **  ******   **
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01/09/80 1032.8 pst Wed prta USGS; Menlo Park, California

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     ** ********
     ** **
     ** **              **
     ** *******  ****** ******  ******  * *****
     ** **           **   **   **    ** **    **
**   ** **       *******  **   **    ** **    **
**   ** **      **    **  **   **    ** **    **
 ****** ******** *******  **    ******  **    **
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USGS - SIEMENS (C10=1.00 5 HZ HI CUT)

0.3536E+04

2	3	1.00	0.80	SEISMOMETER
2	2	0.095	1.00	AMPLIFIER
2	0	44.00	1.00	AMPLIFIER
1	0	45.10		TRI COM DISC
2	0	46.70	0.89	TRI COM DISC
2	0	52.70	0.55	TRI COM DISC
2	0	5.00	0.50	5 HZ 12DB HI CUT FILTER

3 0.10 0.05

USGS - DVCDR (C10=1.0)

AMP =0.3536E+04 AMPLITUDE FACTOR

LTYPE	LN	F	B	COMMENTS
2	3	1.0000	0.8000	SEISMOMETER
2	2	0.0950	1.0000	AMPLIFIER
2	0	44.0000	1.0000	AMPLIFIER
2	0	60.0000	1.0000	J101B DISC
2	0	130.0000	0.7000	J101B DISC
2	0	15.5000	0.7000	DEVELOCORDER
1	1	0.5300		DEVELOCORDER

N = 13 NUMBER OF POLES

NL = 6 POWER OF LOW-FREQUENCY FALLOFF

J	AL		C
1	3.7699	5.0265	3536.000
2	-3.7699	5.0265	1.000
3	0.0000	0.5969	1.000
4	0.0000	0.5969	1.000
5	0.0000	276.4602	276.460
6	0.0000	276.4602	276.460
7	0.0000	376.9911	376.991
8	0.0000	376.9911	376.991
9	583.3219	571.7699	816.814
10	-583.3219	571.7699	816.814
11	69.5499	68.1726	97.389
12	-69.5499	68.1726	97.389
13	0.0000	3.3301	1.000

J = NUMBER OF POLE.
AL = COMPLEX NUMBER GIVING POLE POSITION IN RADIANS/SECOND.
C = AMPLITUDE CONSTANT ASSOCIATED WITH AL.

SCALING FACTORS FOR SPECTRUM

KD = 3 KD = NUMBER OF DECADES OF FREQUENCY.
WL = 0.100 WL = LOWEST FREQUENCY IN HERTZ.
WF = 0.050 WF = LOG FREQUENCY INCREMENT BETWEEN POINTS

AMPLITUDE SPECTRUM

K	WK(HZ)	GM	GMN	GP	LOG(WK)	LOG(GM)
1	0.100	0.2159E+01	0.1033E-04	0.1155E+01	-1.000	0.33427E+00
2	0.112	0.3772E+01	0.1805E-04	0.9965E+00	-0.950	0.57660E+00
3	0.126	0.6498E+01	0.3109E-04	0.8351E+00	-0.900	0.81278E+00
4	0.141	0.1104E+02	0.5281E-04	0.6716E+00	-0.850	0.10430E+01
5	0.158	0.1851E+02	0.8854E-04	0.5064E+00	-0.800	0.12673E+01
6	0.178	0.3063E+02	0.1465E-03	0.3398E+00	-0.750	0.14862E+01
7	0.200	0.5009E+02	0.2396E-03	0.1718E+00	-0.700	0.16998E+01
8	0.224	0.8097E+02	0.3874E-03	0.2090E-02	-0.650	0.19083E+01
9	0.251	0.1294E+03	0.6191E-03	0.6113E+01	-0.600	0.21120E+01
10	0.282	0.2046E+03	0.9786E-03	0.5938E+01	-0.550	0.23108E+01
11	0.316	0.3198E+03	0.1530E-02	0.5760E+01	-0.500	0.25049E+01
12	0.355	0.4942E+03	0.2364E-02	0.5577E+01	-0.450	0.26939E+01
13	0.398	0.7547E+03	0.3610E-02	0.5388E+01	-0.400	0.28778E+01
14	0.447	0.1138E+04	0.5442E-02	0.5193E+01	-0.350	0.30560E+01
15	0.501	0.1691E+04	0.8088E-02	0.4991E+01	-0.300	0.32280E+01
16	0.562	0.2473E+04	0.1183E-01	0.4781E+01	-0.250	0.33932E+01
17	0.631	0.3554E+04	0.1700E-01	0.4563E+01	-0.200	0.35507E+01
18	0.708	0.5007E+04	0.2395E-01	0.4338E+01	-0.150	0.36996E+01
19	0.794	0.6897E+04	0.3300E-01	0.4108E+01	-0.100	0.38387E+01
20	0.891	0.9273E+04	0.4436E-01	0.3873E+01	-0.050	0.39672E+01
21	1.000	0.1215E+05	0.5813E-01	0.3638E+01	0.000	0.40846E+01
22	1.122	0.1552E+05	0.7424E-01	0.3407E+01	0.050	0.41909E+01
23	1.259	0.1935E+05	0.9255E-01	0.3181E+01	0.100	0.42866E+01
24	1.413	0.2360E+05	0.1129E+00	0.2966E+01	0.150	0.43729E+01
25	1.585	0.2826E+05	0.1352E+00	0.2761E+01	0.200	0.44512E+01
26	1.778	0.3333E+05	0.1595E+00	0.2568E+01	0.250	0.45229E+01
27	1.995	0.3885E+05	0.1858E+00	0.2385E+01	0.300	0.45893E+01
28	2.239	0.4485E+05	0.2146E+00	0.2213E+01	0.350	0.46518E+01
29	2.512	0.5142E+05	0.2460E+00	0.2049E+01	0.400	0.47111E+01
30	2.818	0.5861E+05	0.2804E+00	0.1890E+01	0.450	0.47680E+01
31	3.162	0.6652E+05	0.3182E+00	0.1737E+01	0.500	0.48230E+01
32	3.548	0.7523E+05	0.3599E+00	0.1585E+01	0.550	0.48764E+01
33	3.981	0.8481E+05	0.4057E+00	0.1433E+01	0.600	0.49284E+01
34	4.467	0.9535E+05	0.4561E+00	0.1278E+01	0.650	0.49793E+01
35	5.012	0.1069E+06	0.5114E+00	0.1119E+01	0.700	0.50289E+01
36	5.623	0.1195E+06	0.5715E+00	0.9533E+00	0.750	0.50772E+01
37	6.310	0.1330E+06	0.6362E+00	0.7775E+00	0.800	0.51238E+01
38	7.079	0.1473E+06	0.7049E+00	0.5891E+00	0.850	0.51683E+01
39	7.943	0.1621E+06	0.7757E+00	0.3854E+00	0.900	0.52099E+01
40	8.912	0.1768E+06	0.8458E+00	0.1635E+00	0.950	0.52475E+01
41	10.000	0.1903E+06	0.9105E+00	0.6204E+01	1.000	0.52795E+01
42	11.220	0.2013E+06	0.9631E+00	0.5939E+01	1.050	0.53039E+01
43	12.589	0.2081E+06	0.9955E+00	0.5651E+01	1.100	0.53183E+01
44	14.125	0.2090E+06	0.1000E+01	0.5343E+01	1.150	0.53202E+01
45	15.849	0.2031E+06	0.9717E+00	0.5018E+01	1.200	0.53077E+01
46	17.783	0.1905E+06	0.9113E+00	0.4682E+01	1.250	0.52799E+01
47	19.952	0.1724E+06	0.8250E+00	0.4340E+01	1.300	0.52366E+01
48	22.387	0.1510E+06	0.7224E+00	0.3995E+01	1.350	0.51790E+01
49	25.119	0.1282E+06	0.6134E+00	0.3649E+01	1.400	0.51079E+01
50	28.184	0.1058E+06	0.5062E+00	0.3303E+01	1.450	0.50246E+01
51	31.623	0.8500E+05	0.4066E+00	0.2957E+01	1.500	0.49294E+01
52	35.481	0.6648E+05	0.3181E+00	0.2608E+01	1.550	0.48227E+01
53	39.810	0.5062E+05	0.2422E+00	0.2257E+01	1.600	0.47043E+01
54	44.668	0.3750E+05	0.1794E+00	0.1904E+01	1.650	0.45740E+01
55	50.118	0.2701E+05	0.1292E+00	0.1548E+01	1.700	0.44315E+01
56	56.234	0.1890E+05	0.9043E-01	0.1189E+01	1.750	0.42765E+01
57	63.095	0.1284E+05	0.6144E-01	0.8286E+00	1.800	0.41086E+01
58	70.794	0.8464E+04	0.4049E-01	0.4662E+00	1.850	0.39276E+01
59	79.432	0.5405E+04	0.2586E-01	0.1022E+00	1.900	0.37328E+01
60	89.124	0.3339E+04	0.1597E-01	0.6020E+01	1.950	0.35236E+01
61	99.999	0.1990E+04	0.9521E-02	0.5656E+01	2.000	0.32989E+01

USGS - SIEMENS (C10 = 1.0)

AMP =0.3536E+04 AMPLITUDE FACTOR

LTYPE	LN	F	B	COMMENTS
2	3	1.0000	0.8000	SEISMOMETER
2	2	0.0950	1.0000	AMPLIFIER
2	0	44.0000	1.0000	AMPLIFIER
1	0	45.1000		TRI COM DISC
2	0	46.7000	0.8900	TRI COM DISC
2	0	52.7000	0.5500	TRI COM DISC

N = 11 NUMBER OF POLES

NL = 5 POWER OF LOW-FREQUENCY FALLOFF

J	AL		C
1	3.7699	5.0265	3536.000
2	-3.7699	5.0265	1.000
3	0.0000	0.5969	1.000
4	0.0000	0.5969	1.000
5	0.0000	276.4602	276.460
6	0.0000	276.4602	276.460
7	0.0000	283.3717	283.372
8	133.7901	261.1480	293.425
9	-133.7901	261.1480	293.425
10	276.5430	182.1181	331.124
11	-276.5430	182.1181	331.124

J = NUMBER OF POLE.
AL = COMPLEX NUMBER GIVING POLE POSITION IN RADIANS/SECOND.
C = AMPLITUDE CONSTANT ASSOCIATED WITH AL.

SCALING FACTORS FOR SPECTRUM

KD = 3 KD = NUMBER OF DECADES OF FREQUENCY.
WL = 0.100 WL = LOWEST FREQUENCY IN HERTZ.
WF = 0.050 WF = LOG FREQUENCY INCREMENT BETWEEN POINTS

AMPLITUDE SPECTRUM

K	WK(HZ)	GM	GMN	GP	LOG(WK)	LOG(GM)
1	0.100	0.1164E+02	0.3528E-04	0.6059E+01	-1.000	0.10661E+01
2	0.112	0.1821E+02	0.5518E-04	0.5923E+01	-0.950	0.12604E+01
3	0.126	0.2812E+02	0.8519E-04	0.5787E+01	-0.900	0.14490E+01
4	0.141	0.4287E+02	0.1299E-03	0.5652E+01	-0.850	0.16321E+01
5	0.158	0.6460E+02	0.1957E-03	0.5518E+01	-0.800	0.18102E+01
6	0.178	0.9630E+02	0.2918E-03	0.5385E+01	-0.750	0.19836E+01
7	0.200	0.1422E+03	0.4307E-03	0.5255E+01	-0.700	0.21528E+01
8	0.224	0.2081E+03	0.6304E-03	0.5126E+01	-0.650	0.23182E+01
9	0.251	0.3022E+03	0.9154E-03	0.4999E+01	-0.600	0.24802E+01
10	0.282	0.4357E+03	0.1320E-02	0.4871E+01	-0.550	0.26392E+01
11	0.316	0.6241E+03	0.1891E-02	0.4744E+01	-0.500	0.27953E+01
12	0.355	0.8884E+03	0.2691E-02	0.4615E+01	-0.450	0.29486E+01
13	0.398	0.1257E+04	0.3807E-02	0.4483E+01	-0.400	0.30992E+01
14	0.447	0.1765E+04	0.5348E-02	0.4346E+01	-0.350	0.32468E+01
15	0.501	0.2460E+04	0.7454E-02	0.4204E+01	-0.300	0.33910E+01
16	0.562	0.3398E+04	0.1030E-01	0.4055E+01	-0.250	0.35312E+01
17	0.631	0.4641E+04	0.1406E-01	0.3898E+01	-0.200	0.36666E+01
18	0.708	0.6254E+04	0.1895E-01	0.3734E+01	-0.150	0.37961E+01
19	0.794	0.8291E+04	0.2512E-01	0.3562E+01	-0.100	0.39186E+01
20	0.891	0.1079E+05	0.3268E-01	0.3384E+01	-0.050	0.40329E+01
21	1.000	0.1375E+05	0.4166E-01	0.3204E+01	0.000	0.41383E+01
22	1.122	0.1716E+05	0.5199E-01	0.3025E+01	0.050	0.42345E+01
23	1.259	0.2099E+05	0.6358E-01	0.2850E+01	0.100	0.43219E+01
24	1.413	0.2520E+05	0.7634E-01	0.2682E+01	0.150	0.44014E+01
25	1.585	0.2979E+05	0.9024E-01	0.2523E+01	0.200	0.44740E+01
26	1.778	0.3476E+05	0.1053E+00	0.2373E+01	0.250	0.45411E+01
27	1.995	0.4017E+05	0.1217E+00	0.2233E+01	0.300	0.46039E+01
28	2.239	0.4606E+05	0.1395E+00	0.2101E+01	0.350	0.46633E+01
29	2.512	0.5251E+05	0.1591E+00	0.1976E+01	0.400	0.47202E+01
30	2.818	0.5959E+05	0.1805E+00	0.1858E+01	0.450	0.47752E+01
31	3.162	0.6739E+05	0.2042E+00	0.1743E+01	0.500	0.48286E+01
32	3.548	0.7599E+05	0.2302E+00	0.1631E+01	0.550	0.48808E+01
33	3.981	0.8550E+05	0.2590E+00	0.1520E+01	0.600	0.49320E+01
34	4.467	0.9600E+05	0.2909E+00	0.1409E+01	0.650	0.49823E+01
35	5.012	0.1076E+06	0.3259E+00	0.1296E+01	0.700	0.50318E+01
36	5.623	0.1203E+06	0.3646E+00	0.1180E+01	0.750	0.50804E+01
37	6.310	0.1343E+06	0.4069E+00	0.1058E+01	0.800	0.51281E+01
38	7.079	0.1496E+06	0.4532E+00	0.9307E+00	0.850	0.51749E+01
39	7.943	0.1662E+06	0.5034E+00	0.7948E+00	0.900	0.52205E+01
40	8.912	0.1840E+06	0.5574E+00	0.6490E+00	0.950	0.52648E+01
41	10.000	0.2029E+06	0.6148E+00	0.4916E+00	1.000	0.53073E+01
42	11.220	0.2228E+06	0.6750E+00	0.3207E+00	1.050	0.53479E+01
43	12.589	0.2432E+06	0.7368E+00	0.1343E+00	1.100	0.53860E+01
44	14.125	0.2636E+06	0.7986E+00	0.6213E+01	1.150	0.54210E+01
45	15.849	0.2833E+06	0.8582E+00	0.5990E+01	1.200	0.54522E+01
46	17.783	0.3011E+06	0.9123E+00	0.5744E+01	1.250	0.54787E+01
47	19.952	0.3159E+06	0.9572E+00	0.5474E+01	1.300	0.54996E+01
48	22.387	0.3262E+06	0.9881E+00	0.5177E+01	1.350	0.55134E+01
49	25.119	0.3301E+06	0.1000E+01	0.4851E+01	1.400	0.55186E+01
50	28.184	0.3259E+06	0.9874E+00	0.4494E+01	1.450	0.55131E+01
51	31.623	0.3122E+06	0.9458E+00	0.4103E+01	1.500	0.54944E+01
52	35.481	0.2878E+06	0.8718E+00	0.3678E+01	1.550	0.54590E+01
53	39.810	0.2528E+06	0.7659E+00	0.3218E+01	1.600	0.54028E+01
54	44.668	0.2091E+06	0.6336E+00	0.2729E+01	1.650	0.53204E+01
55	50.118	0.1610E+06	0.4879E+00	0.2221E+01	1.700	0.52069E+01
56	56.234	0.1147E+06	0.3474E+00	0.1711E+01	1.750	0.50594E+01
57	63.095	0.7565E+05	0.2292E+00	0.1218E+01	1.800	0.48788E+01
58	70.794	0.4674E+05	0.1416E+00	0.7577E+00	1.850	0.46697E+01
59	79.432	0.2742E+05	0.8307E-01	0.3375E+00	1.900	0.44380E+01
60	89.124	0.1548E+05	0.4688E-01	0.6243E+01	1.950	0.41896E+01
61	99.999	0.8490E+04	0.2572E-01	0.5905E+01	2.000	0.39289E+01

USGS - SIEMENS (C10=1.00 16 HZ HI CUT)

AMP =0.3536E+04 AMPLITUDE FACTOR

LTYPE	LN	F	B	COMMENTS
2	3	1.0000	0.8000	SEISMOMETER
2	2	0.0950	1.0000	AMPLIFIER
2	0	44.0000	1.0000	AMPLIFIER
1	0	45.1000		TRI COM DISC
2	0	46.7000	0.8900	TRI COM DISC
2	0	52.7000	0.5500	TRI COM DISC
2	0	16.0000	0.5000	16 HZ 12DB HI CUT FILTER

N = 13 NUMBER OF POLES

NL = 5 POWER OF LOW-FREQUENCY FALLOFF

J	AL		C
1	3.7699	5.0265	3536.000
2	-3.7699	5.0265	1.000
3	0.0000	0.5969	1.000
4	0.0000	0.5969	1.000
5	0.0000	276.4602	276.460
6	0.0000	276.4602	276.460
7	0.0000	283.3717	283.372
8	133.7901	261.1480	293.425
9	-133.7901	261.1480	293.425
10	276.5430	182.1181	331.124
11	-276.5430	182.1181	331.124
12	87.0624	50.2655	100.531
13	-87.0624	50.2655	100.531

J = NUMBER OF POLE.
AL = COMPLEX NUMBER GIVING POLE POSITION IN RADIANS/SECOND.
C = AMPLITUDE CONSTANT ASSOCIATED WITH AL.

SCALING FACTORS FOR SPECTRUM

KD = 3 KD = NUMBER OF DECADES OF FREQUENCY.
WL = 0.100 WL = LOWEST FREQUENCY IN HERTZ.
WF = 0.050 WF = LOG FREQUENCY INCREMENT BETWEEN POINTS

AMPLITUDE SPECTRUM

K	WK(HZ)	GM	GMN	GP	LOG(WK)	LOG(GM)
1	0.100	0.1165E+02	0.4020E-04	0.6053E+01	-1.000	0.10661E+01
2	0.112	0.1821E+02	0.6288E-04	0.5916E+01	-0.950	0.12604E+01
3	0.126	0.2812E+02	0.9707E-04	0.5780E+01	-0.900	0.14490E+01
4	0.141	0.4287E+02	0.1480E-03	0.5643E+01	-0.850	0.16321E+01
5	0.158	0.6460E+02	0.2230E-03	0.5508E+01	-0.800	0.18102E+01
6	0.178	0.9631E+02	0.3325E-03	0.5374E+01	-0.750	0.19837E+01
7	0.200	0.1422E+03	0.4908E-03	0.5242E+01	-0.700	0.21529E+01
8	0.224	0.2081E+03	0.7184E-03	0.5112E+01	-0.650	0.23183E+01
9	0.251	0.3022E+03	0.1043E-02	0.4983E+01	-0.600	0.24803E+01
10	0.282	0.4358E+03	0.1504E-02	0.4854E+01	-0.550	0.26392E+01
11	0.316	0.6242E+03	0.2155E-02	0.4724E+01	-0.500	0.27953E+01
12	0.355	0.8886E+03	0.3067E-02	0.4593E+01	-0.450	0.29487E+01
13	0.398	0.1257E+04	0.4339E-02	0.4458E+01	-0.400	0.30993E+01
14	0.447	0.1766E+04	0.6096E-02	0.4318E+01	-0.350	0.32469E+01
15	0.501	0.2462E+04	0.8497E-02	0.4173E+01	-0.300	0.33912E+01
16	0.562	0.3400E+04	0.1174E-01	0.4020E+01	-0.250	0.35315E+01
17	0.631	0.4645E+04	0.1603E-01	0.3859E+01	-0.200	0.36670E+01
18	0.708	0.6260E+04	0.2161E-01	0.3689E+01	-0.150	0.37966E+01
19	0.794	0.8301E+04	0.2865E-01	0.3512E+01	-0.100	0.39191E+01
20	0.891	0.1080E+05	0.3729E-01	0.3329E+01	-0.050	0.40336E+01
21	1.000	0.1378E+05	0.4756E-01	0.3142E+01	0.000	0.41391E+01
22	1.122	0.1720E+05	0.5938E-01	0.2955E+01	0.050	0.42356E+01
23	1.259	0.2105E+05	0.7267E-01	0.2771E+01	0.100	0.43233E+01
24	1.413	0.2530E+05	0.8732E-01	0.2594E+01	0.150	0.44030E+01
25	1.585	0.2993E+05	0.1033E+00	0.2423E+01	0.200	0.44761E+01
26	1.778	0.3498E+05	0.1207E+00	0.2261E+01	0.250	0.45438E+01
27	1.995	0.4048E+05	0.1397E+00	0.2107E+01	0.300	0.46073E+01
28	2.239	0.4651E+05	0.1606E+00	0.1959E+01	0.350	0.46675E+01
29	2.512	0.5315E+05	0.1835E+00	0.1817E+01	0.400	0.47255E+01
30	2.818	0.6050E+05	0.2089E+00	0.1678E+01	0.450	0.47818E+01
31	3.162	0.6869E+05	0.2371E+00	0.1540E+01	0.500	0.48369E+01
32	3.548	0.7783E+05	0.2687E+00	0.1402E+01	0.550	0.48912E+01
33	3.981	0.8810E+05	0.3041E+00	0.1261E+01	0.600	0.49450E+01
34	4.467	0.9965E+05	0.3440E+00	0.1115E+01	0.650	0.49985E+01
35	5.012	0.1127E+06	0.3890E+00	0.9618E+00	0.700	0.50519E+01
36	5.623	0.1274E+06	0.4399E+00	0.7984E+00	0.750	0.51053E+01
37	6.310	0.1441E+06	0.4975E+00	0.6216E+00	0.800	0.51587E+01
38	7.079	0.1630E+06	0.5626E+00	0.4277E+00	0.850	0.52121E+01
39	7.943	0.1841E+06	0.6356E+00	0.2122E+00	0.900	0.52651E+01
40	8.912	0.2075E+06	0.7163E+00	0.6253E+01	0.950	0.53170E+01
41	10.000	0.2325E+06	0.8025E+00	0.5977E+01	1.000	0.53664E+01
42	11.220	0.2572E+06	0.8880E+00	0.5660E+01	1.050	0.54103E+01
43	12.589	0.2782E+06	0.9604E+00	0.5297E+01	1.100	0.54444E+01
44	14.125	0.2897E+06	0.1000E+01	0.4883E+01	1.150	0.54619E+01
45	15.849	0.2859E+06	0.9870E+00	0.4438E+01	1.200	0.54562E+01
46	17.783	0.2651E+06	0.9150E+00	0.3965E+01	1.250	0.54234E+01
47	19.952	0.2315E+06	0.7990E+00	0.3484E+01	1.300	0.53645E+01
48	22.387	0.1924E+06	0.6640E+00	0.3006E+01	1.350	0.52841E+01
49	25.119	0.1537E+06	0.5307E+00	0.2530E+01	1.400	0.51868E+01
50	28.184	0.1188E+06	0.4102E+00	0.2050E+01	1.450	0.50749E+01
51	31.623	0.8882E+05	0.3066E+00	0.1559E+01	1.500	0.49485E+01
52	35.481	0.6392E+05	0.2207E+00	0.1051E+01	1.550	0.48057E+01
53	39.810	0.4391E+05	0.1516E+00	0.5238E+00	1.600	0.46426E+01
54	44.668	0.2847E+05	0.9828E-01	0.6261E+01	1.650	0.44544E+01
55	50.118	0.1722E+05	0.5944E-01	0.5704E+01	1.700	0.42360E+01
56	56.234	0.9648E+04	0.3331E-01	0.5153E+01	1.750	0.39845E+01
57	63.095	0.5018E+04	0.1732E-01	0.4625E+01	1.800	0.37006E+01
58	70.794	0.2447E+04	0.8449E-02	0.4133E+01	1.850	0.33887E+01
59	79.432	0.1135E+04	0.3917E-02	0.3686E+01	1.900	0.30549E+01
60	89.124	0.5067E+03	0.1749E-02	0.3284E+01	1.950	0.27048E+01
61	99.999	0.2201E+03	0.7599E-03	0.2926E+01	2.000	0.23427E+01

USGS - SIEMENS (C10=1.00 5 HZ HI CUT)

AMP =0.3536E+04 AMPLITUDE FACTOR

LTYPE	LN	F	B	COMMENTS
2	3	1.0000	0.8000	SEISMOMETER
2	2	0.0950	1.0000	AMPLIFIER
2	0	44.0000	1.0000	AMPLIFIER
1	0	45.1000		TRI COM DISC
2	0	46.7000	0.8900	TRI COM DISC
2	0	52.7000	0.5500	TRI COM DISC
2	0	5.0000	0.5000	5 HZ 12DB HI CUT FILTER

N = 13 NUMBER OF POLES

NL = 5 POWER OF LOW-FREQUENCY FALLOFF

J	AL		C
1	3.7699	5.0265	3536.000
2	-3.7699	5.0265	1.000
3	0.0000	0.5969	1.000
4	0.0000	0.5969	1.000
5	0.0000	276.4602	276.460
6	0.0000	276.4602	276.460
7	0.0000	283.3717	283.372
8	133.7901	261.1480	293.425
9	-133.7901	261.1480	293.425
10	276.5430	182.1181	331.124
11	-276.5430	182.1181	331.124
12	27.2070	15.7080	31.416
13	-27.2070	15.7080	31.416

J = NUMBER OF POLE.
AL = COMPLEX NUMBER GIVING POLE POSITION IN RADIANS/SECOND.
C = AMPLITUDE CONSTANT ASSOCIATED WITH AL.

SCALING FACTORS FOR SPECTRUM

KD = 3 KD = NUMBER OF DECADES OF FREQUENCY.
WL = 0.100 WL = LOWEST FREQUENCY IN HERTZ.
WF = 0.050 WF = LOG FREQUENCY INCREMENT BETWEEN POINTS

K	WK(HZ)	GM	GMN	GP	LOG(WK)	LOG(GM)
1	0.100	0.1165E+02	0.1085E-03	0.6039E+01	-1.000	0.10662E+01
2	0.112	0.1822E+02	0.1697E-03	0.5901E+01	-0.950	0.12605E+01
3	0.126	0.2813E+02	0.2621E-03	0.5762E+01	-0.900	0.14491E+01
4	0.141	0.4288E+02	0.3996E-03	0.5624E+01	-0.850	0.16323E+01
5	0.158	0.6463E+02	0.6021E-03	0.5486E+01	-0.800	0.18104E+01
6	0.178	0.9636E+02	0.8978E-03	0.5350E+01	-0.750	0.19839E+01
7	0.200	0.1423E+03	0.1326E-02	0.5215E+01	-0.700	0.21532E+01
8	0.224	0.2083E+03	0.1941E-02	0.5081E+01	-0.650	0.23187E+01
9	0.251	0.3025E+03	0.2819E-02	0.4948E+01	-0.600	0.24808E+01
10	0.282	0.4364E+03	0.4066E-02	0.4815E+01	-0.550	0.26399E+01
11	0.316	0.6253E+03	0.5826E-02	0.4680E+01	-0.500	0.27961E+01
12	0.355	0.8906E+03	0.8298E-02	0.4543E+01	-0.450	0.29497E+01
13	0.398	0.1260E+04	0.1174E-01	0.4403E+01	-0.400	0.31005E+01
14	0.447	0.1772E+04	0.1651E-01	0.4256E+01	-0.350	0.32485E+01
15	0.501	0.2473E+04	0.2304E-01	0.4103E+01	-0.300	0.33932E+01
16	0.562	0.3420E+04	0.3186E-01	0.3942E+01	-0.250	0.35340E+01
17	0.631	0.4678E+04	0.4359E-01	0.3771E+01	-0.200	0.36701E+01
18	0.708	0.6316E+04	0.5885E-01	0.3590E+01	-0.150	0.38004E+01
19	0.794	0.8394E+04	0.7821E-01	0.3400E+01	-0.100	0.39240E+01
20	0.891	0.1096E+05	0.1021E+00	0.3202E+01	-0.050	0.40397E+01
21	1.000	0.1402E+05	0.1306E+00	0.2999E+01	0.000	0.41468E+01
22	1.122	0.1759E+05	0.1638E+00	0.2793E+01	0.050	0.42452E+01
23	1.259	0.2164E+05	0.2016E+00	0.2588E+01	0.100	0.43352E+01
24	1.413	0.2618E+05	0.2439E+00	0.2384E+01	0.150	0.44179E+01
25	1.585	0.3123E+05	0.2910E+00	0.2184E+01	0.200	0.44946E+01
26	1.778	0.3686E+05	0.3434E+00	0.1987E+01	0.250	0.45665E+01
27	1.995	0.4316E+05	0.4022E+00	0.1790E+01	0.300	0.46351E+01
28	2.239	0.5027E+05	0.4683E+00	0.1591E+01	0.350	0.47013E+01
29	2.512	0.5829E+05	0.5431E+00	0.1385E+01	0.400	0.47656E+01
30	2.818	0.6733E+05	0.6273E+00	0.1167E+01	0.450	0.48282E+01
31	3.162	0.7730E+05	0.7202E+00	0.9311E+00	0.500	0.48882E+01
32	3.548	0.8775E+05	0.8176E+00	0.6706E+00	0.550	0.49432E+01
33	3.981	0.9757E+05	0.9090E+00	0.3803E+00	0.600	0.49893E+01
34	4.467	0.1048E+06	0.9766E+00	0.6054E-01	0.650	0.50204E+01
35	5.012	0.1073E+06	0.1000E+01	0.6004E+01	0.700	0.50307E+01
36	5.623	0.1041E+06	0.9703E+00	0.5661E+01	0.750	0.50176E+01
37	6.310	0.9635E+05	0.8977E+00	0.5332E+01	0.800	0.49839E+01
38	7.079	0.8616E+05	0.8028E+00	0.5026E+01	0.850	0.49353E+01
39	7.943	0.7548E+05	0.7033E+00	0.4743E+01	0.900	0.48778E+01
40	8.912	0.6538E+05	0.6092E+00	0.4477E+01	0.950	0.48155E+01
41	10.000	0.5628E+05	0.5244E+00	0.4221E+01	1.000	0.47504E+01
42	11.220	0.4825E+05	0.4495E+00	0.3970E+01	1.050	0.46835E+01
43	12.589	0.4120E+05	0.3838E+00	0.3716E+01	1.100	0.46149E+01
44	14.125	0.3500E+05	0.3261E+00	0.3456E+01	1.150	0.45441E+01
45	15.849	0.2955E+05	0.2753E+00	0.3185E+01	1.200	0.44705E+01
46	17.783	0.2472E+05	0.2303E+00	0.2899E+01	1.250	0.43931E+01
47	19.952	0.2045E+05	0.1905E+00	0.2594E+01	1.300	0.43107E+01
48	22.387	0.1667E+05	0.1553E+00	0.2266E+01	1.350	0.42219E+01
49	25.119	0.1333E+05	0.1242E+00	0.1914E+01	1.400	0.41250E+01
50	28.184	0.1042E+05	0.9707E-01	0.1534E+01	1.450	0.40178E+01
51	31.623	0.7901E+04	0.7362E-01	0.1123E+01	1.500	0.38977E+01
52	35.481	0.5771E+04	0.5377E-01	0.6791E+00	1.550	0.37613E+01
53	39.810	0.4019E+04	0.3744E-01	0.2037E+00	1.600	0.36041E+01
54	44.668	0.2637E+04	0.2457E-01	0.5984E+01	1.650	0.34210E+01
55	50.118	0.1611E+04	0.1501E-01	0.5463E+01	1.700	0.32070E+01
56	56.234	0.9101E+03	0.8479E-02	0.4942E+01	1.750	0.29591E+01
57	63.095	0.4766E+03	0.4440E-02	0.4439E+01	1.800	0.26781E+01
58	70.794	0.2337E+03	0.2178E-02	0.3970E+01	1.850	0.23687E+01
59	79.432	0.1089E+03	0.1014E-02	0.3542E+01	1.900	0.20369E+01
60	89.124	0.4878E+02	0.4545E-03	0.3157E+01	1.950	0.16833E+01
61	99.999	0.2125E+02	0.1980E-03	0.2813E+01	2.000	0.13274E+01